



Smithian (Early Triassic) ammonoids from Crittenden Springs, Elko County, Nevada: taxonomy, biostratigraphy and biogeography.

James F. Jenks, Arnaud Brayard

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James F. Jenks, Arnaud Brayard. Smithian (Early Triassic) ammonoids from Crittenden Springs, Elko County, Nevada: taxonomy, biostratigraphy and biogeography.. New Mexico Museum of Natural History and Science Bulletin, 2018, 78, pp.1-175. <hal-01715492>

HAL Id: hal-01715492

<https://hal.science/hal-01715492v1>

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Bulletin 78

New Mexico Museum of Natural History & Science

A Division of the

DEPARTMENT OF CULTURAL AFFAIRS

**SMITHIAN (EARLY TRIASSIC) AMMONOIDS FROM
CRITTENDEN SPRINGS,
ELKO COUNTY, NEVADA: TAXONOMY,
BIOSTRATIGRAPHY AND BIOGEOGRAPHY**



by

JAMES F. JENKS AND ARNAUD BRAYARD

Albuquerque, 2018

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New Mexico Museum of Natural History & Science
Albuquerque, 2018

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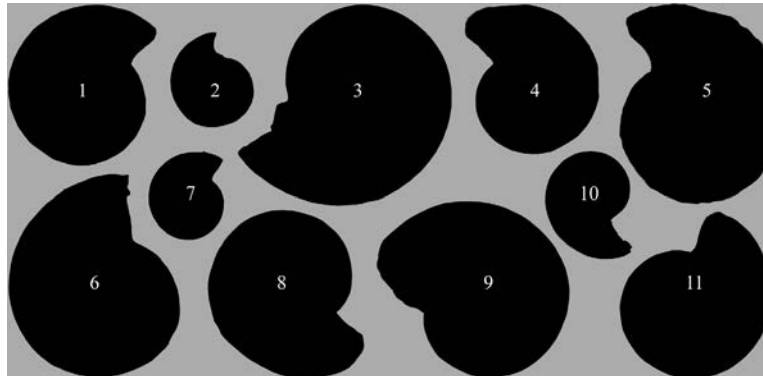
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Cover illustration: Crittenden Springs Early Triassic (Smithian) ammonoids: 1-*Paranannites aspenensis* Hyatt and Smith, 2-*Inyoites stokesi* Kummel and Steele, 3-*Anaflemingites silberlingi* Kummel and Steele, 4-*Crittendenites jattioti* n. gen., n. sp., 5-*Arctoprionites resseri* (Mathews), 6-*Churkites noblei* Jenks, 7-*Dieneroceras* cf. *D. dieneri* (Hyatt and Smith), 8-*Preflorianites toulai* (Smith), 9-*Galfettites lucasi* Jenks et al., 10-*Hemiprionites roberti* Jenks et al., 11-*Dieneroceras subquadratum* (Smith)

Original Printing

ISSN: 1524-4156

Available from the New Mexico Museum of Natural History and Science,
1801 Mountain Road NW, Albuquerque, NM 87104; Telephone (505) 841-2800;
Fax (505) 841-2866; www.nmnaturalhistory.org

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TABLE OF CONTENTS

Abstract	1
Introduction	1
Locality and geological context	2
Biostratigraphy	5
History of Smithian biostratigraphy in the low paleolatitude western USA basin	5
Smithian Transgression	6
Crittenden Springs Ammonoid Succession	6
Correlation with Utah and Nevada Successions	7
Panthalassic Correlation	9
Systematic Paleontology	10
Order Ceratitida Hyatt, 1884	10
Superfamily Otocerataceae Hyatt, 1900	10
Family Anderssonoceratidae Ruzhencev, 1959	10
Genus <i>Proharpoceras</i> Chao, 1950	10
<i>Proharpoceras carinatitabulatum</i> Chao, 1950	10
Superfamily Xenodisaceae Frech, 1902	10
Kashmiritidae Spath, 1934	10
Genus <i>Kashmirites</i> Diener, 1913	10
<i>Kashmirites</i> cf. <i>K. guangxiense</i> Brayard and Bucher, 2008	10
Genus <i>Preflorianites</i> Spath, 1930	12
<i>Preflorianites toulai</i> (Smith, 1932)	12
<i>Preflorianites</i> cf. <i>P. radians</i> (Chao, 1959)	15
Family Xenoceltitidae Spath, 1930	19
Genus <i>Condensoceras</i> n. gen.	19
<i>Condensoceras youngi</i> (Kummel and Steele, 1962)	21
Genus <i>Xenoceltites</i> Spath, 1930	21
<i>Xenoceltites subevolutus</i> Spath, 1930	21
Genus <i>Glyptophiceras</i> Spath, 1930	24
<i>Glyptophiceras</i> cf. <i>G. sinuatum</i> (Waagen, 1895)	24
Superfamily Meekocerataceae Waagen, 1895	27
Family Proptychitidae Waagen, 1895	27
Genus <i>Pseudaspidites</i> Spath, 1934	27
<i>Pseudaspidites silberlingi</i> Jenks et al., 2010	27
Genus <i>Guodunites</i> Brayard and Bucher, 2008	29
<i>Guodunites</i> cf. <i>monneti</i> Brayard and Bucher, 2000	29
Genus <i>Gambleites</i> n. gen.	32
<i>Gambleites eichhorni</i> n. sp.	32
Family Galfettitidae Brühwiler and Bucher, 2012	32
Genus <i>Galfettites</i> Brayard and Bucher, 2008	32
<i>Galfettites lucasi</i> Jenks et al., 2010	32
Genus <i>Montelloites</i> n. gen.	33

<i>Montelloites stephensi</i> n. sp.	33
Family Flemingitidae Hyatt, 1900	35
Genus <i>Anaflemingites</i> Kummel and Steele, 1962	35
<i>Anaflemingites silberlingi</i> Kummel and Steele, 1962	35
Genus <i>Euflemingites</i> Spath, 1934	36
<i>Euflemingites cirratus</i> (White, 1880)	36
Family Dieneroceratidae Kummel, 1952	38
Genus <i>Dieneroceras</i> Spath, 1934	38
<i>Dieneroceras dieneri</i> (Hyatt and Smith, 1905)	38
<i>Dieneroceras</i> cf. <i>D. dieneri</i> (Hyatt and Smith, 1905)	39
<i>Dieneroceras knechti</i> (Hyatt and Smith, 1905)	41
<i>Dieneroceras subquadratum</i> (Smith, 1932)	41
Family Crittendenidae n. fam.	43
Genus <i>Crittendenites</i> n. gen.	45
<i>Crittendenites jattioti</i> n. sp.	47
Family Arctoceratidae Arthaber, 1911	49
Genus <i>Arctoceras</i> Hyatt, 1900	49
<i>Arctoceras tuberculatum</i> (Smith, 1932)	49
<i>Arctoceras rubyae</i> n. sp.	54
Genus <i>Churkites</i> Okuneva, 1990	56
<i>Churkites noblei</i> Jenks, 2007	56
Family Inyoitidae Spath, 1934	56
Genus <i>Inyoites</i> Hyatt and Smith, 1905	56
<i>Inyoites oweni</i> Hyatt and Smith, 1905	56
<i>Inyoites stokesi</i> Kummel and Steele, 1962	59
Family Lanceolitidae Spath, 1934	62
Genus <i>Lanceolites</i> Hyatt and Smith, 1905	62
<i>Lanceolites compactus</i> Hyatt and Smith, 1905	62
Family Ussuriidae Spath, 1930	62
Genus <i>Parussuria</i> Spath, 1934	62
<i>Parussuria compressa</i> (Hyatt and Smith, 1905)	62
Family Prionitidae Hyatt, 1900	64
Genus <i>Meekoceras</i> Hyatt (in White, 1879)	64
<i>Meekoceras gracilitatis</i> White, 1879	64
<i>Meekoceras millardense</i> Brayard et al. 2013	67
<i>Meekoceras</i> aff. <i>M. olivieri</i> Brayard et al. 2013	68
<i>Meekoceras bylundi</i> n. sp.	68
Genus <i>Acutomeekoceras</i> Jenks et al., 2010	71
<i>Acutomeekoceras rieberi</i> Jenks et al., 2010	71
Genus <i>Anasibirites</i> Mojsisovics, 1896	73
<i>Anasibirites kingianus</i> (Waagen, 1895)	73
<i>Anasibirites multiformis</i> Welter, 1922	79
Genus <i>Hemiprionites</i> Spath, 1929	81
<i>Hemiprionites typus</i> (Waagen, 1895)	81
<i>Hemiprionites walcotti</i> (Mathews, 1929)	81
<i>Hemiprionites roberti</i> Jenks et al., 2010	83
Genus <i>Wasatchites</i> Mathews, 1929	87
<i>Wasatchites perrini</i> Mathews, 1929	87
<i>Wasatchites</i> cf. <i>W. distractus</i> (Waagen, 1895)	89

Genus <i>Arctoprionites</i> (Frebold, 1930)	92
<i>Arctoprionites resseri</i> (Mathews, 1929)	92
Family Paranannitidae Spath, 1930	96
Genus <i>Paranannites</i> Hyatt and Smith, 1905	96
<i>Paranannites aspenensis</i> Hyatt and Smith	96
Genus <i>Owenites</i> Hyatt and Smith, 1905	96
<i>Owenites koeneni</i> Hyatt and Smith, 1905	96
<i>Owenites carpenteri</i> Smith, 1932	99
Genus <i>Steckites</i> Brühwiler et al., 2012	100
<i>Steckites</i> cf. <i>S. brevus</i> Brühwiler et al., 2012	100
Family Melagathiceratidae Tozer, 1971	103
Genus <i>Juvenites</i> Smith, 1927	103
<i>Juvenites septentrionalis</i> Smith, 1932	103
<i>Juvenites spathi</i> (Frebold, 1930)	107
? <i>Juvenites</i> sp. indet.	111
Genus <i>Ussurijuvenites</i> Smyshlyaeva and Zakharov, 2012	111
<i>Ussurijuvenites</i> cf. <i>U. artyomensis</i> Smyshlyaeva and Zakharov, 2012	111
Superfamily Sagecerataceae Hyatt, 1884	111
Family Hedenstroemiidae Waagen, 1895	111
Genus <i>Pseudosageceras</i> Diener, 1895	111
<i>Pseudosageceras multilobatum</i> Noetling, 1905	111
<i>Pseudosageceras augustum</i> (Brayard and Bucher, 2008)	114
Genus: <i>Mesohedenstroemia</i> Chao, 1959	114
<i>Mesohedenstroemia kwangsiana</i> Chao, 1959	114
Genus <i>Hedenstroemia</i> Waagen, 1895	114
<i>Hedenstroemia kossmati</i> Hyatt and Smith, 1905	114
Genus <i>Cordillerites</i> Hyatt and Smith, 1905	116
<i>Cordillerites angulatus</i> Hyatt & Smith, 1905	116
Family Aspenitidae Spath, 1934	118
Genus <i>Aspenites</i> Hyatt and Smith, 1905	118
<i>Aspenites acutus</i> Hyatt and Smith, 1905	118
<i>Aspenites weitschati</i> n. sp.	121
Genus <i>Pseudaspenites</i> Spath, 1934	123
<i>Pseudaspenites balinii</i> Jenks et al., 2010	123
Family Incertae Sedis	126
Genus <i>Elkoceras</i> n. gen.	126
<i>Elkoceras spathi</i> (Kummel and Steele, 1962)	126
Genus et species indet. A	128
Genus et species indet. B	128
Genus et species indet. C	130
Genus et species indet. D	130
Acknowledgments	130
References	130
Appendix	134

SMITHIAN (EARLY TRIASSIC) AMMONOIDS FROM CRITTENDEN SPRINGS, ELKO COUNTY, NEVADA: TAXONOMY, BIOSTRATIGRAPHY AND BIOGEOGRAPHY

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Abstract—We present a comprehensive monographic treatment of all currently known Smithian (Early Triassic) ammonoid taxa from Crittenden Springs. Extensive collection efforts from numerous stratigraphically discontinuous, condensed outcrops over a period spanning four decades has yielded a total of 60 taxa. This activity has also resulted in the recognition of a new biostratigraphic succession unique to Crittenden Springs, consisting of 12 ammonoid intervals that normally occur within a typical ~1 m thick condensed outcrop. Ammonoids of early Smithian age are reported for the first time from this locality. Intraspecific variation of the more abundant taxa is documented and illustrated. Early and middle Smithian ammonoid biostratigraphy is shown to correlate reasonably well with the latest early and nearly the entire middle Smithian portion of the newly reported Utah and Nevada successions as well as most Tethyan and western Panthalassic localities. Late Smithian biostratigraphy correlates well with both the Utah and Nevada successions as well as all major worldwide localities. The latest late Smithian ammonoid fauna also contains well preserved, undoubted members of the *Glyptophiceras sinuatum* fauna, originally reported from the Tethyan realm. At least nine taxa from Crittenden Springs (e.g., *Preflorianites* cf. *P. radians*, *Mesohedenstroemia kwangsiana* and *Wasatchites* cf. *W. distractus*), while common to several Tethyan localities, have not yet been reported from Utah, Nevada or other western USA localities. Many of the newly described taxa further confirm the paleoequatorial nature of ammonoid faunas from Crittenden Springs as well as the low paleolatitude faunal exchange that occurred between opposite sides of the Panthalassic Ocean during Smithian time. One new family, the Crittendenitidae is erected, whose composition includes *Crittendenites* n. gen. and *Wyomingites* Hyatt, 1900. Newly described taxa (three genera and six species) include a proptychitid, *Gambleites eichhorni* n. gen., n. sp., a galfettitid, *Montelloites stephensi* n. gen., n. sp., a crittendenitid, *Crittendenites jattioti* n. gen., n. sp., an arctoceratid, *Arctoceras rubyae* n. sp., a prionitid, *Meekoceras bylundi* n. sp. and an aspenitid, *Aspenites weitschati* n. sp. Additionally, two new genera (*Condensoceras* n. gen. and *Elkoceras* n. gen.) are erected for previously described taxa, the xenoceltitid “*Xenoceltites*” *youngi* (Kummel and Steele) and family Incertae Sedis, “*Dieneroceras*” *spathi* (Kummel and Steele), respectively. Also included are seven newly reported taxa, e.g., *Proharpoceras carinatitabulatum*, *Meekoceras millardense*, *Meekoceras* cf. *M. olivieri*, *Kashmirites* cf. *K. guangxiense* and *Glyptophiceras* cf. *G. sinuatum*.

INTRODUCTION

Recent work has demonstrated that Early Triassic ammonoids achieved a diversity level higher than their pre-extinction level in less than one million years following the end-Permian mass extinction about 252 million years ago (Ovtcharova et al., 2006; Galfetti et al., 2007; Brayard et al., 2009a, 2009c, 2013; Jattiot et al., 2017). This remarkable recovery, of which a sizeable portion took place during the global evolutionary radiation that occurred in the Smithian, has now been documented for numerous low and mid-paleolatitude Tethyan and western Panthalassic localities where successions are much expanded, e.g., South China (Brayard and Bucher, 2008); Tulong, Tibet (Brühwiler et al., 2010a); Oman (Brühwiler et al., 2012a); Salt Range, Pakistan (Brühwiler et al., 2011, 2012b); Spiti, India (Brühwiler et al., 2010b, 2012c); South Primorye (Shigeta et al., 2009); and Vietnam (Shigeta et al., 2014). This rapid proliferation in Smithian ammonoid diversity has also been recorded in the low paleolatitude, western USA basin, of which the most notable is the recent works in Utah and Nevada that document much expanded ammonoid successions spanning much of the early Smithian and the entire middle and late Smithian, similar to the Tethyan and western Panthalassic realms (Brayard et al., 2009a, 2013; Stephen et al., 2010; Jattiot et al., 2017). These subdivisions facilitate correlation of the sequences with other western USA sites as well as major worldwide localities. Crittenden Springs, another site within the western USA basin, also records this rapid increase in Smithian ammonoid diversity, but its ammonoid record is confined to numerous, laterally discontinuous, condensed outcrops or beds (hereafter referred to as bed or beds), most of which are only 1 to 1.2 m thick (Jenks, 2007; Jenks et al., 2010). Nevertheless, ammonoid preservation

for the most part is excellent, and, consequently, the site has received increasing attention in recent years. The oldest early Smithian ammonoid faunas found in the Utah sequence are not present, but it does contain many if not most of the taxa found in the latest early, middle and late Smithian. Indeed, its middle and late Smithian faunal record includes several taxa common to Tethyan localities but not yet reported from the Utah and Nevada sequences or other parts of the western USA basin.

Ammonoids from Crittenden Springs have been long renowned for the excellent preservation of the shell or test, which often preserves unique features such as relic color patterns and healed injuries (Kummel and Steele, 1962; Jenks, 2007; Jenks et al., 2010). Though less obvious, well preserved shell structures of primary organic composition are also preserved. These include the black layer and associated wrinkle layer as well as the black apertural band (Klug et al., 2007). Given the abundant, well preserved ammonoids that were purportedly found scattered around the outcrop area when Crittenden Springs was first discovered in the early 1950s, it is somewhat surprising that conodonts were the first fossils to receive serious attention from professional workers (Muller, 1956). Kummel and Steele (1962) were the first to document the locality’s ammonoid fauna and they commented that it “is by all odds the finest preserved *Meekoceras* fauna known.” They indicated that the ammonoids occurred in three distinct beds (designated as units “a”, “d” and “g”) over a stratigraphic distance of 175 ft (~53 m) (Kummel and Steele, 1962). Silberling and Tozer visited the site and clarified the stratigraphy when they recognized that the three beds were actually a repetition of the same bed by faulting (Silberling and Tozer, 1968). However, they also recorded the occurrence of the late Smithian ammonoids *Anasibirites* and *Wasatchites*

near the bottom of unit “g,” a most troubling finding, since this occurrence was in violation of established Smithian ammonoid biostratigraphy (Silberling and Tozer, 1968). Tozer (1972), in his study of the shell structure of Triassic ammonoids, commented on the superb preservation of the Crittenden Springs ammonoid fauna and illustrated a specimen of *Owenites koeneni* Hyatt and Smith whose shell exhibited transverse color patterns. Then, in the late 1980’s an extensive investigation led by Royal Mapes (Ohio University), which included bulldozer excavation to uncover fresh exposures, revealed that this phenomenon was by no means limited to just *Owenites koeneni*. In fact, several taxa were found to exhibit either transverse or longitudinal relic color patterns as well as false color patterns (Mapes and Sneek, 1987; Mapes and Davis, 1996; Gardner, 2000; Gardner and Mapes, 2000). Also preserved on many specimens is evidence of sub-lethal shell damage (see Figs. 6Q-R, 62C-E, 78D-F, 87D-F, 90I-J and 116D-F) caused by various types of predators as well as the subsequent repair of these injuries (H. Keupp, personal commun. 1997). Indeed, some specimens even show evidence of multiple healed injuries (see Figs. 46G-H and 79J-L).

With regard to the orientation of the fossiliferous beds, Jenks (2007) recognized and presented evidence that shows they are overturned, thus placing their biostratigraphic record in the proper sequence. Also in the same work, a new acute-ventered arctoceratid, *Churkites noblei*, was described from the uppermost middle Smithian. Then, Jenks et al. (2010) documented an additional five newly described middle Smithian ammonoid taxa from Crittenden Springs consisting of one new genus (*Acutomeekoceras*) and five new species (*Acutomeekoceras rieberi*, *Pseudaspidites silberlingi*, *Galfettites lucasi*, *Hemiprionites roberti* and *Pseudaspenites balinii*) together with three newly reported middle Smithian taxa (?*Juvenites* sp. indet. [*Ussurijuvenites* cf. *U. artyomensis* in present work], *Meekoceras* cf. *M. gracilitatis* [*Meekoceras bylundi* n. sp. in present work] and *Guodunites* cf. *G. monneti*) and one latest late Smithian taxon (*Pseudosageceras augustum*). *Hemiprionites roberti* from the latest middle Smithian likely represents a direct evolutionary link to the relatively low-diversity but abundant late Smithian prionitid ammonoid fauna (Jenks et al., 2010; Jattiot et al., 2017).

The present work consists of a monographic review of all currently known ammonoid taxa from the classic Crittenden Springs locality. Included in this assessment are an additional six newly described taxa, one new ammonoid family (Crittendenitidae) and two new genera (*Elkoceras* and *Condensoceras*) erected for previously described taxa (“*Dieneroceras*” *spathi* [Kummel and Steele] and “*Xenoceltites*” *youngi* [Kummel and Steele]), respectively. Newly described taxa include three new genera (*Gambleites* n. gen., *Montelloites* n. gen. and *Crittendenites* n. gen.) and six new species (a proptychitid, *Gambleites eichhorni* n. gen., n. sp., a galfettitid, *Montelloites stephensi* n. gen., n. sp., a crittendenitid, *Crittendenites jattioti* n. gen., n. sp., an arctoceratid, *Arctoceras rubyae* n. sp., a prionitid, *Meekoceras bylundi* n. sp. and an aspenitid, *Aspenites weitschati* n. sp.). This work brings to 12 the total number of newly described taxa from Crittenden Springs since the work of Kummel and Steele (1962); in addition, seven taxa are newly reported from the locality. Crittenden Springs is unique not only for its fossil preservation, but its ammonoid diversity is recognized as rather different and significantly greater than other western USA localities. This observation is supported as nine of its ammonoid taxa, while identical or very similar to Tethyan forms, have not yet been reported from other western USA localities. This unusually high diversity also well demonstrates the paleoequatorial nature of the Crittenden Springs ammonoid fauna as well as the low paleolatitude faunal exchange that occurred between opposite sides of the Panthalassic Ocean (Brayard et al., 2007, 2013;

Jenks et al., 2010).

One of the authors (JFJ) has amassed a huge collection of Smithian ammonoids from Crittenden Springs. This intense collecting activity over a period of some 40 years has obviously resulted in the discovery of many rare forms, both new to science and newly reported, most of which would not have been found by simple casual collecting. Such a large collection has also made it possible to define and illustrate intraspecific variation for the more abundant taxa.

LOCALITY AND GEOLOGICAL CONTEXT

Located about 29 km north of Montello in Elko County, Nevada, the classic, more southerly of the two Early Triassic ammonoid sites referred to as Crittenden Springs by Kummel and Steele (1962) originally consisted of numerous laterally discontinuous, condensed beds located on two adjacent, S-SE facing hillsides immediately north of the Long Canyon road in the W1/2SW1/4 Sec 3, T42N, R69E, about 2 km northeast of the abandoned ranch at the head end of Crittenden Reservoir (Figs. 1 and 2). Also included within the classic site are several laterally discontinuous, condensed beds on a 160 m-long ridge that trends N-NE from the two hillsides just north of the road. Somewhat surprisingly, a small, isolated fossiliferous exposure was discovered in 1988 by a visiting gold company geologist on the hillside on the south side of Long Canyon, directly south of the classic site.

Rocks formerly assigned to the Thaynes Formation in this particular area of northeastern Nevada actually bear little if any resemblance to those of the formation’s type section

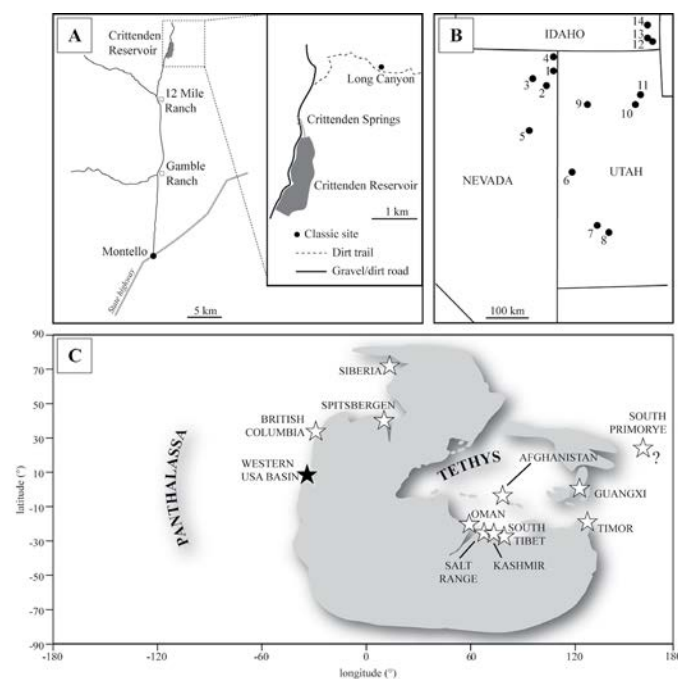


FIGURE 1. **A**, Generalized map showing location of the classic Crittenden Springs site. **B**, Location of Crittenden Springs area in relation to other western USA Lower Triassic localities mentioned in text: 1) Crittenden Springs (classic site), 2) Immigrant Canyon, 3) Winecup Ranch, 4) Trout Creek-Jay Creek area, 5) Palomino Ridge-Phelen Ranch area, 6) Confusion Range, 7) Mineral Mountains, 8) Pahvant Range, 9) Thumb Ridge, Grayback Hills, 10) Fort Douglas, 11) Lower Weber Canyon, 12) Bear Lake Hot Springs, 13) Paris Canyon and 14) Georgetown. **C**, Early Triassic paleoposition of the western USA basin (black star). White stars indicate world-wide localities discussed in text. (A and B modified from Jenks et al., 2010; C modified from Jattiot et al., 2017).

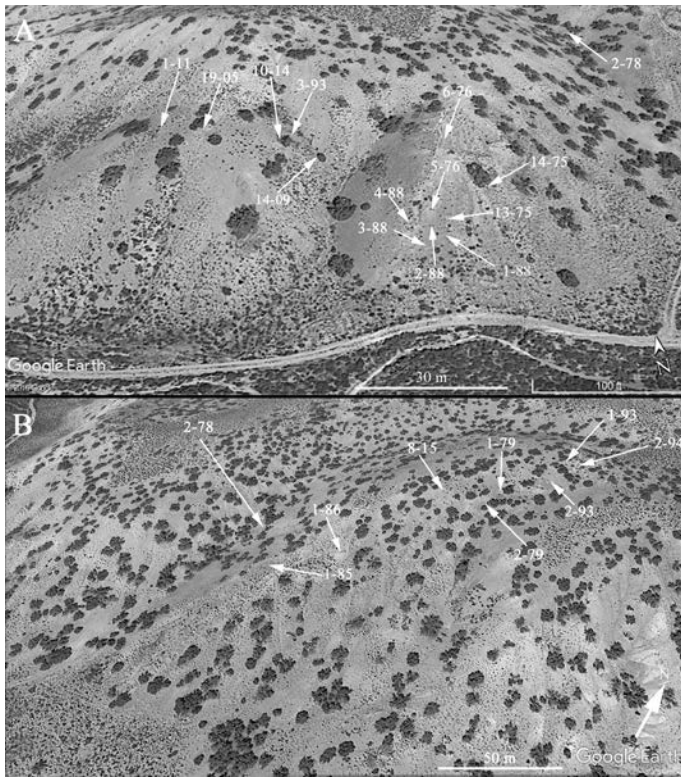


FIGURE 2. Google Earth images showing approximate locations of fossiliferous beds at the classic Crittenden Springs ammonoid locality. **A**, hillsides immediately north of the Long Canyon road, and **B**, ridge trending N-NE from a point just east of the easternmost hill in **A**. Numbers represent first author's bed identification - last two digits in each number represent year in which bed was discovered. Most beds have been completely removed and original locations are covered by scree. JJ5-76 and JJ2-88 in **A** still exist, but further excavation of 5-76 is precluded by excessive overburden and 2-88 is covered by excessive scree from excavation of 5-76. JJ1-79, 2-79 and 2-93 in **B** still exist (Fig. 3). Note: JJ2-78 is shown in both images to help orient the viewer.

in the Wasatch Range near Park City, Utah or the relatively homogenous successions in SE Idaho (e.g., Kummel, 1954). Hence, in this work these rocks are simply referred to the Thaynes Group (*sensu* Lucas et al., 2007). Lower Triassic marine sediments, consisting of the Dinwoody Formation (Griesbachian and Dienerian), which disconformably overlies Permian black cherts, and the overlying Thaynes Group of Smithian and Spathian age, crop out in the Long Canyon area and extend to the northeast for about 8 km, covering an area of about 33 km² (Clark, 1957; Mullen, 1985). As described by Paull (1980), two units of the ~300 m thick Dinwoody Formation are recognized at Long Canyon. Olive-grey shales with abundant flattened bivalves (*Claraia* sp.) dominate the lower part, while more resistant siltstone and limestone beds containing numerous molluscs and linguloid brachiopods dominate the upper part (Mullen, 1985).

The Dinwoody Formation is in gradational contact with the overlying Thaynes Group, whose base is arbitrarily placed at the bottom of the fossiliferous limestone beds containing the middle and late Smithian ammonoid faunas (Clark, 1957). Overlying these ammonoid beds is an incomplete, ~750 m thick unit of the Thaynes Group consisting of, in ascending order, a relatively thin, platy and shaly calcareous gray-black limestone, a yellow-brown, calcareous siltstone and limestone unit, and a rather massive gray, crystalline limestone characterized by

numerous *Pentacrinus* crinoid columnals (Mullen, 1985; Jenks et al., 2010). Abundant flattened, unidentifiable ammonoids of probable early Spathian age occur throughout a ~2 m thick horizon within a thick platy siltstone interval in the calcareous siltstone and limestone unit about 220 m northwest of the classic Crittenden Springs ammonoid locality. The upper portion of the Thaynes Group is not exposed in the immediate area, and outcrops are largely truncated by faulting on the northern and western margins (Mullen, 1985; Jenks et al., 2010). Outcrops of the Dinwoody Formation and Thaynes Group are highly faulted in places, but the attitude of most beds is similar in that they generally strike N-NE and dip at varying angles to the W-NW (Mullen, 1985; Jenks et al., 2010).

As reported by Jenks (2007) and Jenks et al. (2010), the 1+ m thick beds containing the *Meekoceras* and *Anasibirites* ammonoid assemblages are not stratigraphically and laterally continuous. Instead, they consist of isolated portions of varying length, most of which dip more or less to the W-NW. Mullen (1985) suggested that these beds were lenticular, but available evidence does not support this premise. At the classic collecting area on the two S-SE facing hillsides immediately north of the Long Canyon road, each hillside originally contained numerous stratigraphically discontinuous beds, most of which were more or less on strike with each other. This same discontinuous, outcrop pattern was also repeated on the ridge that trends to the northeast from the localities alongside the road. Nearly all of these discontinuous beds were found to be overturned with the *Anasibirites* fauna at the bottom. Only three beds have been found in the correct orientation. Furthermore, it was apparent that most of the fossiliferous beds were bounded by obvious "fault gouge" material (Jenks, 2007). This observation became all the more evident when the site was bulldozed in 1988 for the purpose of exposing additional fossiliferous beds. During the 40 years since the site was first visited by JFJ, collectors either have removed the majority of the beds or most of those that remain have been dug so far back into the hillside so that the amount of overburden now precludes further excavation.

Figure 2 provides two Google Earth images showing the approximate original location of most of the beds as well as the first author's identification numbers. Bulldozer excavation in 1988 obscured the original location of many of the beds, and other sites are completely covered with scree. Table 1 gives a general description of each bed, including its approximate original size, orientation, ammonoid content, overall preservation and current status. Over the years, JJ5-76 proved to be one of the most prolific beds for both ammonoid preservation and diversity, but it is no longer accessible because of excessive overburden. JJ2-79 (Fig. 3A), located high on the N-NE trending ridge, still exists and is perhaps the thickest bed (~1.3 m) of all those encountered at the classic locality. Likewise, JJ1-79 (Fig. 3B), located a short distance north of 2-79, also still exists, but is incomplete, consisting only of the *Aspenites weitschati* n. sp. through the *Condensoceras youngi* n. gen. intervals. Figure 3C shows well-preserved ammonoids of the *A. weitschati* n. sp. interval on top of JJ1-79.

A typical condensed bed consists of several intervals of differing thickness and lithology, some of which contain one or more ammonoid types that are characteristic of that particular interval. This contrast in interval thickness, lithology and fossil content is generally similar from bed to bed, but exceptions are not uncommon. For instance, bed thickness can vary widely, and, in some cases, a particular interval may be much thinner or missing altogether. Likewise, it is not uncommon for the lithology of a particular interval to differ somewhat from bed to bed. Certain intervals are noted for excellent ammonoid preservation, but in some cases the variation in lithology greatly affects the quality of preservation. Similarly, the lithology in other intervals is such that preservation is nearly always extremely poor, rendering

TABLE 1. Inventory of stratigraphically discontinuous fossiliferous beds at classic Crittenden Springs site (includes only those worked on by first author). All beds overturned unless otherwise indicated.

ID	Original size (est) (length x thickness)	Status	Comments
13-75	2.5-m x 1-m	Completely excavated, site covered by scree.	All intervals represented. Preservation usually good in all intervals except early Smithian.
14-75	1-m x 0.5-m	Completely excavated, site covered by scree.	Bed not overturned. <i>A. weitschati</i> through <i>C. youngi</i> intervals only. Preservation good.
5-76	4-m x 1.2-m	Still exists, further excavation precluded by excessive overburden.	Exceptionally large bed, required nearly 20 yrs to excavate. All intervals represented. Preservation usually good in all intervals except early Smithian.
6-76	4-m x 0.5-m	Still exists, further excavation precluded by excessive overburden.	<i>A. weitschati</i> through <i>C. youngi</i> intervals only. Excavation severely limited by bed dipping steeply under black calcareous shale.
2-78	2-m x 0.5-m	Completely excavated.	<i>O. koeneni</i> through <i>A. weitschati</i> intervals only. Nearly entire bed excavated by others (?).
1-79	3-m x 0.75-m	Still exists.	<i>A. weitschati</i> through <i>C. youngi</i> intervals. Good preservation. <i>A. weitschati</i> interval well developed. Yielded several <i>A. multiformis</i> lenses, one of which contained large <i>Arctoprioceras resseri</i> specimen (Fig. 87A-C)
2-79	2.5-m x 1.3-m	Still exists.	All intervals represented but preservation is poor in much of bed. <i>C. jattioti</i> interval yields well-preserved <i>Preflorianites toulai</i> specimens.
1-85	1.5-m x 0.67-m	Completely excavated, site covered by scree.	<i>O. koeneni</i> through <i>C. youngi</i> intervals only. Preservation usually good. Numerous <i>Hemiprioceras roberti</i> specimens from <i>C. jattioti</i> interval.
1-86	1-m x 0.5-m	Completely excavated, site covered by scree.	<i>O. koeneni</i> through <i>C. youngi</i> intervals only. Good preservation. Included several <i>A. multiformis</i> lenses, one of which contained <i>A. kingianus</i> specimen (Fig. 74A-C) and large <i>Wasatchites perrini</i> specimen (Fig. 83A-C).
1-88	1.5-m x 1-m	Completely excavated, site covered by scree.	All intervals represented. Good preservation in all intervals except early Smithian. <i>P. toulai</i> interval yielded several <i>P. toulai</i> and <i>P. cf. P. radians</i> specimens with longitudinal color bands.
2-88	2.5-m x 0.67-m	Still exists but covered by excessive scree from excavation of 5-76.	<i>A. rubryae</i> through <i>C. jattioti</i> intervals. Preservation usually good. Yielded many well-preserved <i>Owenites koeneni</i> specimens with transverse color bands.
3-88	0.5-m x 0.67-m	Completely excavated, site covered by scree.	<i>O. koeneni</i> through <i>P. toulai</i> intervals. Poor preservation.
4-88	0.5-m x 0.25-m	Completely excavated, site covered by scree.	<i>O. koeneni</i> through <i>C. jattioti</i> intervals. Preservation good. Yielded large <i>A. tuberculatum</i> specimen (Fig. 45A-C).
1-93	0.5-m x 0.15-m	Completely excavated, site covered by scree.	Bed not overturned. <i>A. multiformis</i> lense through <i>C. youngi</i> intervals. Preservation good. Yielded several <i>Wasatchites</i> cf. <i>W. distractus</i> specimens (Fig. 84)
2-93	2-m x 0.67-m	Still exists.	<i>M. gracilitatis</i> through <i>C. youngi</i> intervals. Preservation highly variable. <i>A. multiformis</i> lenses present, but most specimens covered by thick yellow-orange iron oxidation (Limonite).
3-93	1.5-m x 0.67-m	Completely excavated.	Bed not overturned. <i>O. koeneni</i> through <i>C. youngi</i> intervals. Good preservation. <i>P. toulai</i> interval yielded numerous specimens of <i>P. toulai</i> and <i>P. cf. P. radians</i> with longitudinal color patterns.
2-94	0.67-m x 0.5-m	Completely excavated.	<i>G. lucasi</i> (?) through <i>C. youngi</i> intervals. Good preservation. Numerous <i>I. stokesi</i> and one fragment of <i>I. oweni</i> .
19-05	1.5-m x 0.5-m	Nearly all excavated.	<i>A. weitschati</i> and (?). Different lithology. Most of bed excavated by others.
14-09	0.75-m x 0.33-m	Not in-situ	<i>G. lucasi</i> (?) through <i>C. youngi</i> intervals. Bed dug out by others (probably from vicinity of 3-93) and rolled down hill. Unusually thick <i>A. multiformis</i> lense contained large <i>H. typus</i> specimen (Fig. 77I-K).
1-11	0.75-m x 0.33-m	Completely excavated.	<i>A. weitschati</i> through <i>C. youngi</i> intervals. Preservation mostly poor. Yielded fragment of <i>I. oweni</i> .
10-14	0.5-m x 0.8-m	Completely excavated.	All intervals represented except <i>G. lucasi</i> through <i>C. jattioti</i> . Most are much thinner than normal. Yielded fairly well preserved early Smithian ammonoids. Early Smithian biostratigraphy primarily based on this bed.
8-15	0.67-m x 0.33-m	Completely excavated.	<i>P. toulai</i> through <i>C. jattioti</i> intervals. Preservation good.

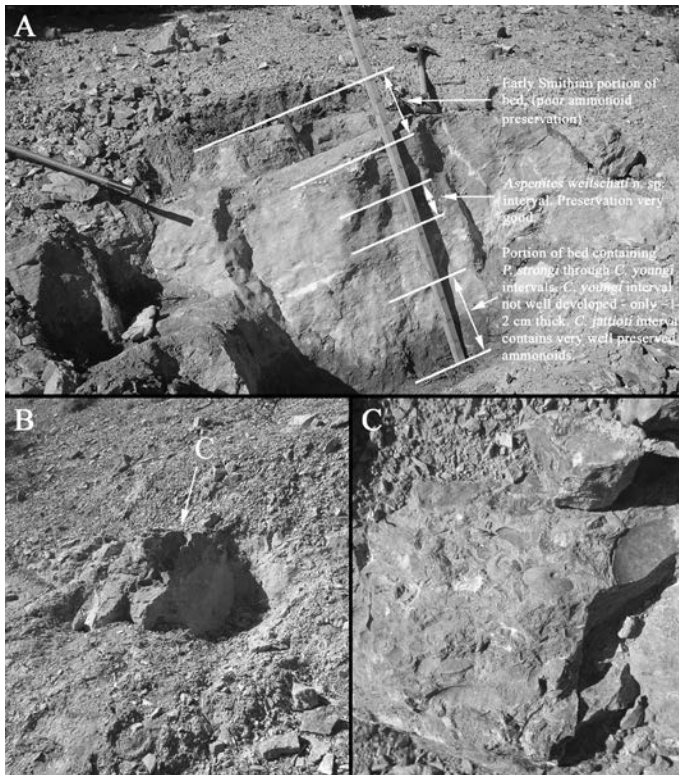


FIGURE 3. Overturned beds JJ2-79 in **A** and JJ1-79 in **B**. Upper surface of 1-79 with *A. weitschati* n. sp. interval ammonoids shown in **C**. JJ2-79 is thickest bed encountered in the classic Crittenden Springs area (~1.3 m). All fossiliferous intervals are probably represented, but poor ammonoid preservation in much of the bed precludes recognition of some intervals. No *A. multiformis* interval lenses have been found. *Preflorianites toulai* specimen (Fig. 6Q-S) came from this bed. 1-79 (~80 cm thick) is incomplete and includes only the *A. weitschati* n. sp. through *C. youngi* n. gen. intervals. *Anasibirites multiformis* interval lenses are present and the *C. youngi* n. gen. interval is well developed. *Hemiprionites typus* specimen (Fig. 77A-C) came from an *A. multiformis* lense at the bottom of the bed. All interval boundaries are approximate. Measuring stick in **A** is graduated in 10 cm increments.

ammonoid identification either very difficult or impossible. This is especially true for the stratigraphically lowest intervals, and, consequently, these portions have not received much attention over the years. However, the recent discovery of a bed with somewhat better fossil preservation in these particular levels has confirmed for the first time the long suspected presence of an early Smithian ammonoid fauna.

Even though nearly all of these fossiliferous laterally discontinuous beds are overturned (Jenks, 2007), this realization actually presented a new conundrum because the overall succession appears to be in the proper sequence; that is, the attitude of nearly all of the discontinuous beds within the lower part of the Thaynes Group as well as the underlying Dinwoody and Permian Phosphoria Formations is such that the sequence appears normal. The exact tectonic setting of the area thus remains to be determined.

BIOSTRATIGRAPHY

History of Smithian BSiostratigraphy in the Low Paleolatitude Eastern Panthalassic Western USA Basin

Until recently, Smithian ammonoids in the eastern Panthalassic low paleolatitude western USA basin were referred

to two subdivisions, namely the formal *Meekoceras gracilitatis* Zone of middle Smithian age and the informal late Smithian “*Anasibirites* beds” (Kummel and Steele, 1962; Silberling and Tozer, 1968; Jenks 2007, 2010; Brayard et al., 2013). The *Meekoceras gracilitatis* Zone has been in use since Peale (1879) first introduced the term “*Meekoceras* Zone” for the *Meekoceras gracilitatis* fauna-containing beds in southeastern Idaho. Smith (1932), in turn, divided the “*Meekoceras*” Zone into the interregional *Pseudosageceras multilobatum* subzone, which represents the *Meekoceras* fauna of southeastern Idaho, and two younger subdivisions, the *Owenites* subzone and the *Anasibirites* subzone. Then, Kummel and Steele (1962) abandoned Smith’s tripartite interregional scheme, and, in so doing, they considered the “*Pseudosageceras multilobatum*” and “*Owenites*” subzones to be integral parts of the *Meekoceras gracilitatis* Zone, and they elevated the “*Anasibirites*” subzone to a distinct full zone. Silberling and Tozer (1968) did not accept the full zonal status of the *Anasibirites* fauna; their main objections included the “then unexplained” occurrence of the *Anasibirites* fauna below the *Meekoceras* fauna at Crittenden Springs (Baetcke and Lawrence, 1965; Silberling and Tozer, 1968) and a general lack of knowledge for their time regarding the differentiation between the two faunas, both from a faunal and stratigraphic standpoint (Silberling and Tozer, 1968). Hence, the two subdivision scheme for the western USA basin remained in use for the next ~45 years.

Brayard et al. (2013), avoided the use of formal zones and, instead, subdivided the much expanded Smithian succession of central and southern Utah into 10 new ammonoid assemblages or “beds” (encompassing 12 subdivisions), utilizing a “bed-by-bed” collecting procedure. This method results in much more refined successions (see for instance the wide-ranging studies of the Northern Indian Margin localities by Brühwiler et al., 2010a, 2011, 2012b, 2012c). The numerous assemblages present in these successions usually enable much more precise correlation of Tethyan and other western Panthalassic localities with the low paleolatitude western USA sequences than is possible with the *Meekoceras gracilitatis* Zone.

Similarly, Jattiot et al. (2017) carefully sampled several expanded Smithian sections in the Palomino Ridge area of northeastern Nevada and constructed a comprehensive composite section consisting of numerous ammonoid assemblages. These biochronological data, together with those from the nearby Utah successions (Brayard et al., 2013), were then analyzed by the Unitary Association method (Guex, 1991), which created a new ammonoid sequence for the western USA basin consisting of six formal Unitary Association Zones for the Smithian, divided as follows: three UAZ’s for the early Smithian, one for the entire middle Smithian, one for the early late Smithian and a hypothetical zone for the latest late Smithian (Jattiot et al., 2017). These six UA Zones were then correlated with the much expanded Smithian UAZ sequence (14 UAZ’s) developed by Brühwiler et al. (2010) for the three Northern Indian Margin localities (Jattiot et al., 2017).

Although the *Meekoceras gracilitatis* Zone still retains some practical value in certain instances, its limitations tend to outweigh its usefulness for precise correlation purposes, especially in the low paleolatitudes. As both Brayard et al. (2013) and Jattiot et al. (2017) have pointed out, *M. gracilitatis* is a relatively long-ranging species that first occurs in the late early Smithian and then spans the entire middle Smithian. This longevity renders the zone’s value for precise biostratigraphical correlation less than ideal. Indeed, at many locations the *M. gracilitatis* Zone contains taxa that enable it to be subdivided into subzones and beds with rather precise trans-Panthalassic correlatives (Brayard et al., 2009a, 2013; Jenks et al., 2010; Stephen et al., 2010). Brayard et al. (2013) also commented on the ease with which *M. gracilitatis* can be misidentified,

especially if badly weathered. In fact, its whorl section and general shape resemble several Smithian ammonoids as well as a few Dienerian and Spathian taxa, and several instances can be found in the literature that illustrate this point (Brayard et al., 2013).

On the other hand, in some instances the long recognized *M. gracilitatis* Zone still has practical usefulness when less than precise correlation is required. Jenks (2010) recently demonstrated that it is somewhat useful for reasonably close correlation between opposite sides of Panthalassa (e.g., South China, South Primorye) and between low and high latitudes (British Columbia and the Canadian Arctic). Indeed, the common occurrences of several ammonoid genera on each side of the Panthalassa corroborate the significant faunal exchange that occurred during early and middle Smithian time (Brayard et al., 2007b, 2009b; Jenks et al., 2010). And, finally, the zone retains practical use with regard to its type area, the *Meekoceras* beds of southeastern Idaho. Accordingly, significant research-oriented ammonoid collection activity has occurred at many of the SE Idaho locations in recent years with the eventual aim of revising the area's ammonoid taxonomy and biostratigraphy (Brayard et al., ongoing work).

Smithian Transgression

The extensive work of Brayard et al. (2013) in sampling the numerous ammonoid successions throughout the southern half of Utah has resulted in a much refined description of the Smithian sea's hypothetical pathway as it advanced from its open marine depositional origin in northern Utah-southeastern Idaho down through central and southern Utah. The increase in relative sea level reached its maximum extent during deposition of the late Smithian *Anasibirites* beds (e.g., Lucas et al., 2007), which are found in all Utah sections, but are especially well developed in the southwestern most and southeastern most parts of the basin (Brayard et al., 2013). Consequently, this transgression created in some areas a much expanded (80 to 100 m thick) Smithian succession consisting of 12 ammonoid subdivisions that span most of the early Smithian and the entire middle and late Smithian (Brayard et al., 2013). Recent work by Jattiot et al. (2017) has shown that the same phenomenon also produced at least one greatly expanded Smithian succession of similar thickness and ammonoid diversity in neighboring northeastern Nevada, namely the Palomino Ridge section north of Curry. However, a potential paleotopographical barrier apparently restricted access to areas further north such as the Wine Cup and Immigrant Canyon successions (Fig. 1B). Ammonoids are quite scarce in the Wine Cup section, and those that have been found apparently represent a somewhat obscure, not readily identifiable middle and late Smithian fauna and thus far, only ammonoids of late Spathian age and possibly younger have been found in the Immigrant Canyon section. In contrast, the extremely condensed but highly fossiliferous beds at Crittenden Springs indicate that this particular area apparently existed as a relatively isolated paleo-high with a very low sedimentation rate. Indeed, most of the representative ammonoid taxa reported from 10 of the 12 ammonoid subdivisions in the stratigraphically highest 70 to 80 m of Utah's Confusion and Pahvant Range sections exist more or less in the same stratigraphic order in the 1 to 1.2 m thick condensed Crittenden Springs beds. The same observation is true for many of the reported taxa from the ~56 m thick composite section at Palomino Ridge (Jattiot et al., 2017). Brayard et al. (2013) indicated that the Smithian transgression did not reach the Crittenden Springs area until deposition of the *Owenites* beds. However, the recent discovery of at least two of the early Smithian diagnostic taxa reported from Utah in the stratigraphically lowest portions of the bed, namely *Meekoceras millardense* and *Meekoceras* aff. *M. olivieri*, confirms that open marine conditions reached Crittenden Springs earlier (late early

Smithian) than previously thought.

Crittenden Springs Ammonoid Succession

Presented below is a description of the 12 biostratigraphic intervals in ascending chronological order that comprise a typical 1.2 m thick condensed bed. Bedding planes do exist between some intervals, but not all. Each interval is characterized either by a unique ammonoid(s) or the first appearance of an ammonoid in the succession. It must be emphasized that this succession is unique to the classic Crittenden Springs locality; due to the condensed nature of the beds, some of these intervals lack a characteristic taxon, and instead, are based on the first appearance (FA) of an ammonoid rather than the more biostratigraphically useful restricted taxon or assemblage concept.

As mentioned earlier, interval thickness varies somewhat between condensed beds, and, in some instances, one or more intervals may be missing entirely or significantly reduced in thickness. It is merely coincidental that the number of intervals (12) in the Crittenden Springs succession is the same as that reported for the Utah Smithian succession by Brayard et al. (2013). Some of the Crittenden Springs intervals correlate directly with counterparts in the Utah and Nevada successions, while others correlate only in a general sense or not at all. Figure 4 presents a composite ammonoid distribution chart for these intervals in a typical, overturned bed. Middle and late Smithian ammonoid distribution is largely based on complete beds 5-76, 13-75 and 1-88, but a few incomplete beds such as 1-79, 2-88, 3-93, 2-94 and 1-11 have also contributed data. The early Smithian portion is primarily based on JJ10-14 and to a lesser extent on JJ5-76 (Fig. 2, Table 1).

- *Meekoceras millardense* FA interval: First appearance of *M. millardense*. ~8 cm thick, preservation nearly always extremely poor.

- *Meekoceras* aff. *M. olivieri* FA interval: First appearance of *M. aff. M. olivieri*. ~10 cm thick, preservation nearly always extremely poor.

- *Arctoceras rubyae* n. sp. FA interval: First appearance of *A. rubyae* n. sp. ~12 cm thick, preservation usually very poor.

- *Meekoceras gracilitatis* FA interval: First appearance of *M. gracilitatis*. ~10 cm thick, preservation usually very poor.

- *Owenites* interval or "beds."
 - *Owenites koeneni* FA interval: First appearance of *O. koeneni*. ~10 cm thick, preservation highly variable.

- *Aspenites weitschati* n. sp. interval: *Aspenites weitschati* n. sp. is common, much more abundant than in underlying *O. koeneni* FA interval. ~14 cm thick, preservation usually excellent.

- *Galfettites lucasi* interval: ~20 cm thick, preservation ranges from fair to very good.

- *Preflorianites toulai* interval: ~11 cm thick, preservation ranges from fair to very good. Specimens of *Preflorianites toulai* and *Preflorianites* cf. *P. radians*, with longitudinal color patterns occur only in this interval.

- *Crittendenites jattioti* n. gen., n. sp. interval: ~14 cm thick. Preservation usually very good.

- *Inyoites oweni* interval: ~5 cm thick. Preservation ranges from fair to very good. Interval sometimes characterized by numerous shell fragments from body chambers of *Churkites noblei* lying on top of each other in book-page fashion.

- *Anasibirites* interval or "beds."

- *Anasibirites multiformis* interval: Prionitid fauna is found only in very rare lenses, which occur between top of latest middle Smithian *Inyoites oweni* interval and overlying *Condensoceras youngi* interval. Lenses are usually only 2 to 3 cm thick, but can be much thicker. Preservation ranges from poor to very good.

- *Condensoceras youngi* interval: ~8 cm thick, preservation ranges from fair to very good. Interval lies directly

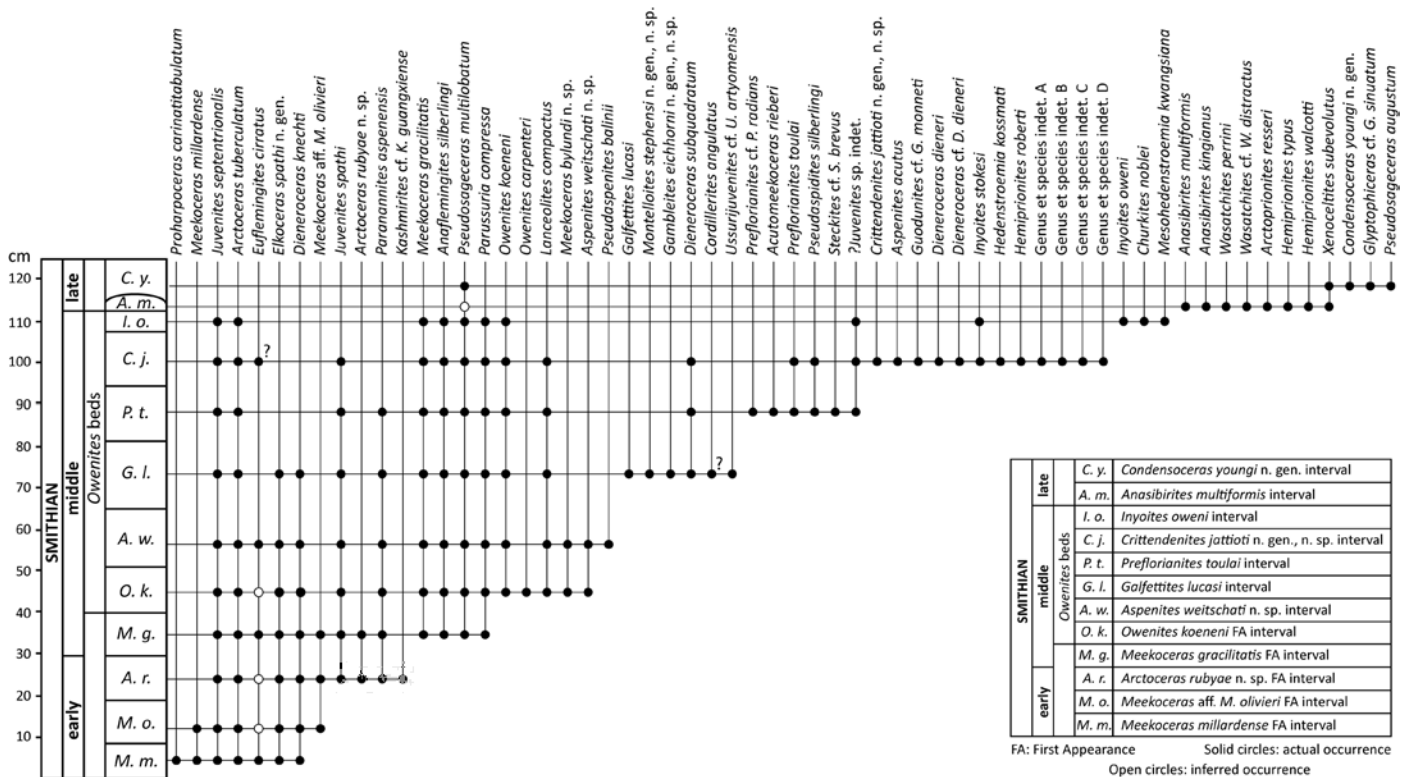


FIGURE 4. Distribution of ammonoid taxa in a composite 1.2+ m thick condensed bed consisting of early, middle and late Smithian ammonoid intervals (shown in biostratigraphically upright position). Solid circles represent actual occurrences; open circles, inferred occurrences.

on top of *Inyoites oweni* interval without stratigraphic separation.

Correlation with Utah and Nevada successions

Comparison of the condensed Crittenden Springs succession with the much expanded Utah sequence of Brayard et al. (2013) is relatively straightforward because the Utah sequence is presented as a succession of designated fossiliferous beds, each containing a distinctive ammonoid assemblage. Although some of the Utah beds have no direct correlation with intervals of the Crittenden Springs sequence, a broad or general correlation can be deduced from most of the beds/intervals in each succession. In contrast, biochronological data yielded by application of the Unitary Association method to the Palomino Ridge, Nevada succession cannot be easily compared with the Crittenden Springs data because of the extensive condensation of its biostratigraphic record. Consequently, comparison of these sequences is possible only in a very general and broad sense (Fig. 5).

Taxa reported from the earliest Utah Smithian *Vercherites undulatus* beds (Mineral Mountains), and *Radioceras aff. evolvens* beds (Pahvant Range) have not been found at Crittenden Springs, but the eponymous taxa of the next two higher Utah subdivisions, the *Meekoceras olivieri* and *Meekoceras millardense* beds, both from the Pahvant Range, do occur at the bottom of some of the condensed beds, although not in the same order, with *M. aff. M. olivieri* occurring above *M. millardense*. This observed diachronism indicates that: (i) both taxa have co-existed in some places, (ii) the stratigraphic order observed locally in Utah is incomplete, and consequently, (iii) the formal subdivision between the two taxa in Utah must be either confirmed or revised. This portion of the Crittenden Springs interval also correlates in a very rough manner with the Utah/Nevada UAZ₁ because of the shared occurrence of *Meekoceras olivieri*.

The next higher Utah horizon, the *Preflorianites*-

Kashmirites beds (Confusion and Pahvant Ranges), which supposedly occupies a position near or slightly below the early/middle Smithian boundary (Brayard et al., 2013), does not directly correlate with the corresponding next higher level (*Arctoceras rubyae* n. sp. FA interval) at Crittenden Springs or Palomino Ridge (Utah/Nevada UAZ₂) other than for the shared occurrence of *A. tuberculatum*. However, this is the only level in which *A. tuberculatum* occurs in the Utah succession, whereas at Crittenden Springs, it is abundant throughout the entire early and middle Smithian sequence. Furthermore, *Arctoceras rubyae* n. sp., a distinctively compressed new species of *Arctoceras* unknown in Utah and Nevada, makes its first appearance at about the same stratigraphic level at Crittenden Springs. A rough correlation also exists between the Utah/Nevada UAZ₂ and the next higher interval at Crittenden Springs, each of which documents the first occurrence of *Meekoceras gracilitatis*. Some taxa from the *Preflorianites*-*Kashmirites* beds are problematic. For instance, *Kashmirites cf. K. guangxiense* is very rare at Crittenden Springs and *Preflorianites toulai*, which occurs only in the late early Smithian beds in Utah, is found only in the late middle Smithian at Crittenden Springs and in Utah/Nevada UAZ₃.

The *Inyoites beaverensis* beds (Pahvant Range, Confusion Range and Mineral Mountains) and the *Flemingites* sp. indet. bed (Pahvant Range) have no apparent direct correlatives at Crittenden Springs, but the first appearance interval of *M. gracilitatis* may be roughly equivalent. *Inyoites beaverensis*, a characteristic species of the latest early Smithian UAZ₃, is somewhat problematic in that *Inyoites stokesi* occurs only in the latest middle Smithian at Crittenden Springs.

A broad correlation exists between the middle Smithian UAZ₄ of Utah and Nevada and the *Owenites*-containing intervals at Crittenden Springs, all of which contain the long-ranging taxon *O. koeneni*. *Owenites* is also widespread in Utah (Brayard et al., 2013). Both the Utah and Nevada successions also contain

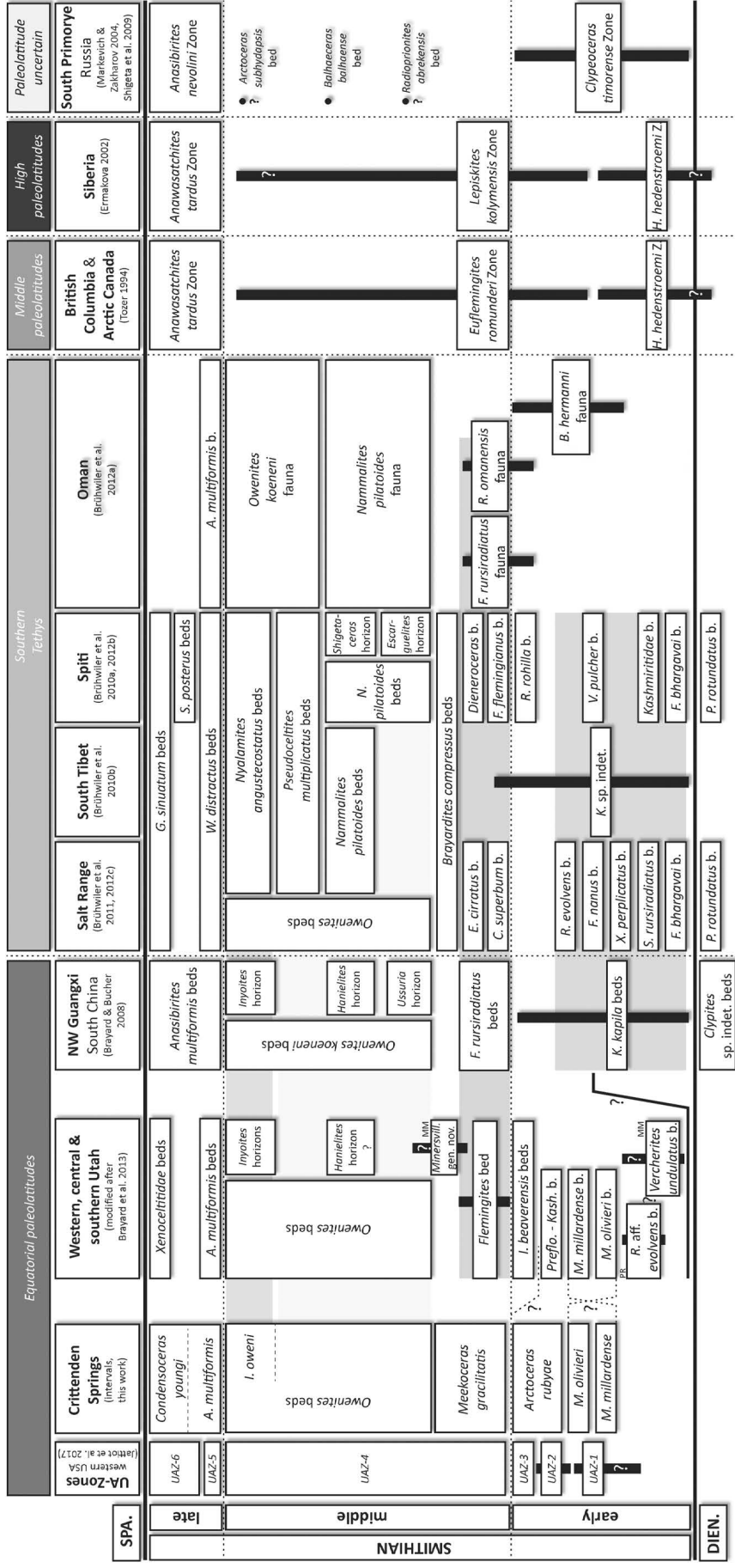


FIGURE 5. Biostratigraphic subdivision of Smithian ammonoids at Crittenden Springs and correlation with other low, mid and high paleolatitude successions. *Owenites* beds consist of *O. koeneni*, *A. weitschati*, *G. lucasi*, *P. toulai*, *C. jattioti* and *I. oweni* intervals, in ascending order. *M. millardense*, *M. olivieri*, *A. rubryae*, *M. gracilitatis* and *O. koeneni* represent First Appearance intervals for their respective eponymous taxa. Adapted from Jenks et al. (2010), Brayard et al. (2013) and Jattiot et al. (2017).

Panthalassic Correlation

a well-developed *Inyoites* horizon with abundant specimens in the uppermost *Owenites* beds (Brayard et al., 2013; Jattiot et al., 2017). *Inyoites oweni* also occurs in the uppermost *Owenites* interval at Crittenden Springs, albeit it is very rare with only two fragmentary specimens found. *Churkites noblei* is an excellent marker taxon for this horizon, but it is also problematic. It occurs only in the relatively thin *Inyoites oweni* interval, but is not common, whereas in the Confusion Range of Utah it is abundant and has a somewhat wider stratigraphic range (Brayard et al., 2013). Both the *Owenites* intervals at Crittenden Springs and the Utah/Nevada UAZ₄ are well known for their extremely diverse ammonoid assemblages (Brayard et al., 2013; Jattiot et al., 2017). However, the succession of intervals containing *Owenites koeneni* at Crittenden Springs also includes many newly described or newly reported taxa not yet documented from Utah and Nevada or other western USA localities. Newly described taxa include from Jenks et al. (2010): *Galfettites lucasi*, *Acutomeekoceras rieberi*, *Hemiprionites roberti*, *Pseudaspidites silberlingi* and *Pseudaspenites balinii*, and from this work, *Aspenites weitschati* n. sp., *Meekoceras bylundi* n. sp., *Crittendenites jattioti* n. gen., n. sp., *Gambleites eichhorni* n. gen., n. sp. and *Montelloites stephensi* n. gen., n. sp. Newly reported taxa not yet found in Utah or other parts of the western USA basin include from Jenks et al. (2010) *Ussurijuvenites* cf. *U. artyomensis* Smyshlyaeva and Zakharov, and from this work *Mesohedenstroemia kwangsiana* Chao.

The *Anasibirites* beds, which occur in all Utah sections and at Palomino Ridge (UAZ₅) with some degree of stratigraphic separation from the underlying *Inyoites* beds when present, represents a low-diversity ammonoid fauna during the global end-Smithian extinction event (Brayard et al., 2013; Jattiot et al., 2016). At Crittenden Springs this fauna, consisting of *Anasibirites*, *Wasatchites*, *Arctoprionites*, *Hemiprionites* and occasionally *Xenoceltites subevolatus*, is found only in usually thin (2-3 cm) lenses that occur rarely, without stratigraphic separation, between the top of the *Inyoites oweni* interval and the overlying continuous 8 cm thick *Condensoceras youngi* n. gen. interval (Jenks, 2007; Jenks et al., 2010). That the fauna is condensed is evident from specimens occurring at the very top of the lenses that are corroded laterally (see Figs. 78G-I, M-O; 86D-F), some quite severely (Jenks, 2007).

The 8 cm thick *Condensoceras youngi* n. gen. interval at Crittenden Springs contains abundant, well preserved specimens of *Condensoceras youngi* (Kummel and Steele), *Xenoceltites subevolatus*, *Pseudosageceras augustum* and *Glyptophiceras* cf. *G. sinuatum*, of which the last taxon has not yet been reported from other western US localities. In contrast and somewhat surprisingly, the horizon representing the *Condensoceras youngi* interval is not well developed in Utah, especially given the abundant widespread occurrences of the *Anasibirites* beds. Brayard et al. (2013) did document beds in the Mineral Mountains of Utah that contain extremely poorly preserved specimens of *Xenoceltitidae* gen. indet. A and *Hedenstroemiidae* gen. indet. A, which may in fact be *P. augustum* (Jattiot et al., 2017). These beds of latest Smithian age probably correlate with the *Condensoceras youngi* n. sp. interval at Crittenden Springs (Brayard et al., 2013). Jattiot et al. (2017) reported undoubted specimens of *Pseudosageceras augustum* from beds overlying the *Anasibirites* fauna (UAZ₆) at Palomino Ridge, thus confirming the existence of a *G. sinuatum* equivalent horizon at this locality (Jattiot et al., 2017). Nevertheless, the lack of confirmed specimens of *P. augustum* from Utah precluded Jattiot et al. (2017) from creating a formal sixth UAZ for this latest late Smithian interval. However, the recent discovery of definite *P. augustum* specimens from the latest late Smithian in the Grayback Hills in Utah's west desert indeed validates the existence of a sixth UAZ (authors' personal observations).

As with the Utah and Nevada successions, it is very difficult to correlate with any degree of confidence the early Smithian portion of the sequence at Crittenden Springs with Tethyan and other western Panthalassic localities as well as other western USA localities. As Brayard et al. (2013) and other workers have suggested, part of this problem is probably due to the dominance of endemic and latitudinally restricted faunas during the early Smithian (Brayard et al., 2006, 2007b, 2009b; Jenks, 2007; Jenks et al., 2010). Assignment of the *Meekoceras millardense* interval at Crittenden Springs to the early Smithian is supported somewhat by the presence of *Euflemingites cirratus*. However, even though *Euflemingites* is generally considered to be of early Smithian age (Brühwiler et al., 2011), the taxon is problematic in that, based on the first author's collecting experience, it ranges well up into the middle Smithian at Crittenden Springs. Furthermore, it is an integral component of the middle Smithian *Meekoceras gracilitatis* Zone of southeastern Idaho (authors' pers. observations).

Fairly precise global correlation of most of the middle Smithian at Crittenden Springs is facilitated by the presence of many low paleolatitude genera that are common to opposite sides of Panthalassa (Brayard et al., 2006; Jenks, 2007; Jenks et al., 2010). Recent work has shown that many genera from the *Owenites* beds or equivalents (i.e., *Aspenites*, *Lanceolites*, *Inyoites*, *Preflorianites*, *Xenoceltites*, *Juvenites*, *Dieneroceras*, *Anaflemingites*, *Arctoceras*, *Paranannites* and *Guodunites*) are common to Crittenden Springs (Jenks, 2007; Jenks et al., 2010), Utah (Stephen et al., 2010; Brayard et al., 2013) and other western USA localities as well as such western Panthalassic localities as South China (Brayard and Bucher, 2008), Oman (Brühwiler et al., 2012a), South Tibet (Brühwiler et al., 2010a), the Salt Range (Brühwiler et al., 2012b), Spiti, India (Brühwiler et al., 2012c), South Primorye (Shigeta and Zakharov, 2009) and northeastern Vietnam (Shigeta and Nguyen, 2014). Reasonably precise global correlation of the middle Smithian fauna at Crittenden Springs is further supported by the common occurrence of several genera from the *Owenites koeneni*-containing intervals not yet reported from Utah or other western USA localities. These include *Pseudaspidites* and *Galfettites* from Oman (Brühwiler et al., 2012a), *Ussurijuvenites* from South Primorye (Smyshlyaeva and Zakharov, 2015), *Mesohedenstroemia* and *Aspenites weitschati* n. sp. from South China (Brayard and Bucher, 2008) and *Pseudaspenites* from South China (Brayard and Bucher, 2008), Oman (Brühwiler et al., 2012a) and Spiti, India (Brühwiler et al., 2012c). A reasonable degree of correlation also exists between the low-paleolatitude *Owenites koeneni*-containing intervals at Crittenden Springs and equivalent beds of mid-paleolatitude South Primorye. Although *Owenites koeneni* does not occur at Abrek Bay, it does co-occur with the middle Smithian taxon *Balhaeceras balhaense* Shigeta and Zakharov (2009) in other sections in South Primorye (Y. Shigeta, personal commun. 2015; Zakharov, 1968; Shigeta and Zakharov, 2009). Shigeta and Zakharov (2009) also document the occurrence of *Arctoceras* in their *Arctoceras subhydapsis* bed, which, according to Markevich and Zakharov (2004), occurs immediately below the *Anasibirites nevolini* Zone in other South Primorye sections. Crittenden Springs also correlates quite well with the middle Smithian *Owenites koeneni* beds of Northeastern Vietnam (Shigeta and Nguyen, 2014). Shared genera include *Dieneroceras*, *Preflorianites*, *Anaflemingites*, *Juvenites*, *Parussuria* and *Guodunites* (Shigeta and Nguyen, 2014).

Ammonoid faunas during the late Smithian were highly cosmopolitan, and, thus, the *Anasibirites* beds at Crittenden Springs correlate quite precisely with all worldwide localities for this time interval. Furthermore, the *Condensoceras youngi* n. sp. interval, despite its lack of stratigraphic separation from

the *Anasibirites*-containing lenses, correlates very well with the latest late Smithian *Glyptophiceras sinuatum* beds of South Tibet (Brühwiler et al., 2010a), the Salt Range (Brühwiler et al., 2012b) and Spiti, India (Brühwiler et al., 2012c) as well as the *Anasibirites multiformis* beds of Guangxi, South China (Brayard and Bucher, 2008).

SYSTEMATIC PALEONTOLOGY

Systematic descriptions are mainly based on the classification scheme of Tozer (1981, 1994), but modifications by Brayard and Bucher (2008), Brühwiler et al. (2010a), Brühwiler and Bucher (2012a, b) as well as the taxonomic revision of the genus *Anasibirites* by Jattiot et al. (2016) are also incorporated. In addition, a new family, the Crittendenitidae, is erected. Morphological measurements are expressed using the four classic geometrical parameters of the shell: diameter (D), whorl height (H), whorl width (W) and umbilical diameter (U). Absolute values of H, W and U are plotted versus diameter as are the ratios H/D, W/D and U/D. Terminology used to express type of coiling (whorl involution) is taken from Haggart (1989, table 8.1). All type specimens from Crittenden Springs described in Jenks (2007), Jenks et al. (2010) and this work are deposited in the New Mexico Museum of Natural History and Science (NMMNHS) in Albuquerque. Unless otherwise noted, all other specimens from Crittenden Springs reside in the first author's private collection, which has been bequeathed to NMMNHS.

Order CERATITIDA Hyatt, 1884

Superfamily OTOCERATAEAE Hyatt, 1900

Family ANDERSSONOCERATIDAE Ruzhencev, 1959

Genus *Proharpoceras* Chao, 1950

Type species: *Proharpoceras carinatitabulatum* Chao, 1950

Proharpoceras carinatitabulatum Chao, 1950

Figure 6A-C

1950 *Proharpoceras carinatitabulatus* Chao, p. 8, pl. 1, fig. 8a-b.

1950 *Tuyangites marginalis* Chao, p. 9, pl. 1, fig. 9.

1959 *Proharpoceras carinatitabulatum* Chao, p. 324, pl. 43, figs. 1-7.

1959 *Tuyangites marginalis* Chao, p. 327, pl. 43, figs. 17-18.

1968 *Proharpoceras carinatitabulatum* Chao, Zakharov, p. 147, pl. 29, fig. 6.

2007 *Proharpoceras carinatitabulatum* Chao, Brayard et al., p. 178, fig. 3a-s, y-z.

2008 *Proharpoceras carinatitabulatum* Chao, Brayard and Bucher, p. 80, pl. 38, figs. 5-9.

2012a *Proharpoceras carinatitabulatum* Chao, Brühwiler et al., p. 14, pl. 1, fig. 1a-c.

2017 *Proharpoceras carinatitabulatum* Chao, Jattiot et al., p. 45, pl. 18, figs. M-O.

Material: One poorly preserved, slightly deformed specimen, 2453C (illustrated).

Description: Small (~ 3 cm), moderately evolute, slightly depressed platycone with parallel to slightly convex flanks, tabulate venter with a distinctive raised median keel and a quadratic to slightly sub-trapezoidal whorl section. Maximum whorl width just below ventrolateral shoulders. Wide, relatively shallow umbilicus with slightly oblique wall and barely discernable shoulders. Body chamber length unknown, but at least one whorl in length. Poor preservation has obliterated all traces of ornamentation. Suture line not preserved.

Measurements: See APPENDIX, p. 134.

Discussion: Although poorly preserved, the specimen's morphological features, and, in particular, its distinctive raised median keel, leave little doubt as to its attribution to *Proharpoceras carinatitabulatum*. The taxon is relatively rare and, this is only the second reported occurrence from western USA localities. Jattiot et al. (2017) documented its occurrence

at Palomino Ridge, Nevada. Until now, it had been reported from only three Tethyan localities, namely South China (Chao, 1950; Brayard and Bucher, 2008), South Primorye (Zakharov, 1968) and Oman (Blendinger, 1995; Brühwiler et al., 2012a). According to Brayard et al. (2007a), the genus *Proharpoceras* is a representative of the superfamily Otocerataceae, but their character analysis demonstrated that there is no supposedly obvious direct link with the Griesbachian Otoceratidae. Instead, the genus is a probable derivative of the late Permian Anderssonoceratidae, another family within the Otocerataceae, which clearly survived the Permian-Triassic mass extinction but eventually went extinct at the end of the Smithian (Brayard et al., 2007a; Brayard and Bucher, 2008).

In contrast to our poorly preserved example, well preserved specimens from South China and Oman exhibit a tricarinate venter consisting of the raised median keel and hollow lateral keels arising from the ventral shoulders (Brayard et al., 2007a). Ornamentation on these specimens includes biconvex growth lines with a backward projected, sharply pointed bend centered on the lateral keel (Brayard et al., 2007a).

Occurrence: Found only in the early Smithian *M. millardense* FA interval. This differs from the stratigraphic level of the Palomino Ridge specimen, which came from one of the highest beds in UAZ₄ (Jattiot et al., 2017), and the Tethyan specimens, which were collected from the middle Smithian "*Owenites koeneni*" beds (Brayard et al., 2007a; Brayard and Bucher, 2008; Brühwiler et al., 2012a). Such differing stratigraphic occurrences make this taxon a long-ranging species of the Smithian.

Superfamily XENODISCACEAE Frech, 1902

Family KASHMIRITIDAE Spath, 1934

Genus *Kashmirites* Diener, 1913

Type species: *Celtites armatus* Waagen, 1895

Kashmirites cf. *K. guangxiense* Brayard and Bucher, 2008

Figure 6D-J

2008 *Kashmirites guangxiense* Brayard and Bucher, p. 16, pl. 1, figs. 1-10.

Material: Two measured specimens, 638C and 2042C (both illustrated).

Description: Medium sized, very evolute shell with gently convex flanks and tabulate venter on inner whorls grading to slightly subtabulate on mature whorl with rounded but distinct ventral shoulders. Whorl section sub-quadrangle and robust with width nearly as great as height. Maximum whorl width at about 50% of height. Shallow, fairly wide umbilicus with fairly low, gently inclined wall and broadly rounded shoulders. Body chamber length not known but at least 2/3 whorl. Ornamentation consists only of barely visible radial growth lines and very weak but wide and distant, radial, bundled or band-type ribs arising above umbilical shoulder and fading on ventral shoulders. Suture line ceratitic, simple with high ventral saddle and slightly lower but wider lateral saddle.

Measurements: See APPENDIX, p. 134.

Discussion: *Kashmirites* cf. *K. guangxiense* differs from the type specimens from South China, as illustrated by Brayard and Bucher (2008), by its significantly more evolute coiling, its slightly less robust subquadrangle whorl section and its more distant ribs. These authors state that *K. guangxiense* exhibits a wide range of variation; this observation may explain the slight difference in width of our two specimens, which otherwise are nearly identical. The present specimens are close to *Kashmirites* cf. *K. nivalis* and *K. nivalis* (Diener, 1897) from the Salt Range and Spiti (Brühwiler et al., 2012b, c, respectively), but differ by their slightly more robust whorl section and slightly weaker ribbing. Our specimens are also quite similar in morphology to *Dieneroceras subquadratum* from Crittenden Springs, but their

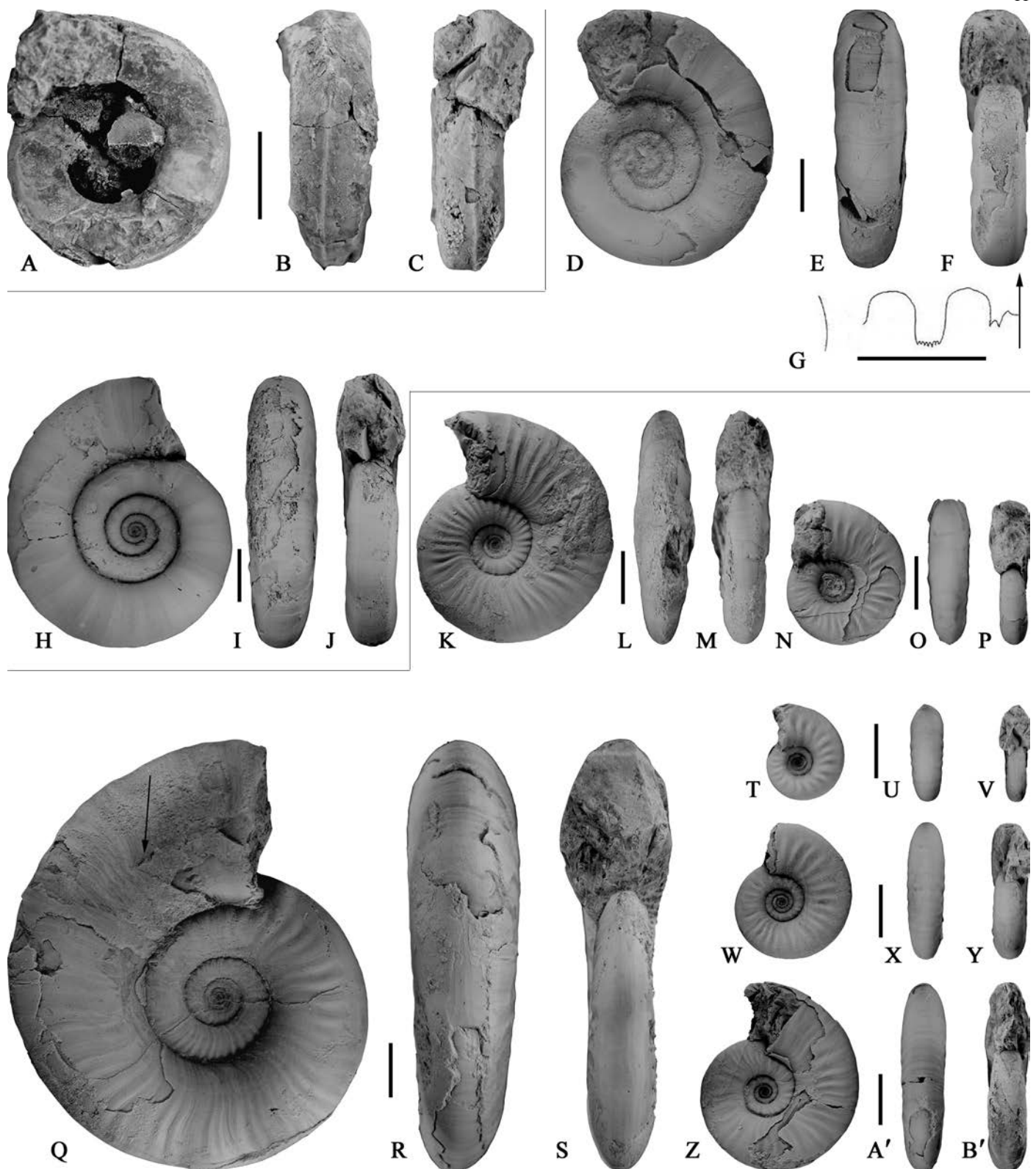


FIGURE 6. *Proharpoceras carinatitubulatum* Chao. **A-C**, 2453C, 10-14, *M. m.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-J**, *Kashmirites* cf. *K. guangxiense* Brayard and Bucher, 5-76, *A. r.*, in **D-G**, 2042C, in **D**, lateral, **E**, ventral, and **F**, apertural views. **G**, suture line, $H = 1.5$ cm. **H-J**, 638C, in **H**, lateral, **I**, ventral and **J**, apertural views. **K-B'**, *Preflorianites toulai* (Smith), *C. j.*, in **K-M**, 2199C-16, 2-93, in **K**, lateral, **L**, ventral and **M**, ventral views. **N-P**, 2199C-28, 2-93, in **N**, lateral, **O**, ventral and **P**, apertural views. **Q-S**, 2531C, 2-79, in **Q**, lateral (arrow indicates healed injury), **R**, ventral view and **S**, apertural views. **T-V**, 2199C-5, 2-93, in **T**, lateral, **U**, ventral and **V**, apertural views. **W-Y**, 2199C-27, 1-88, in **W**, lateral, **X**, ventral and **Y**, apertural views. **Z-B'**, 2199C-15, 2-93, in **Z**, lateral, **A'**, ventral and **B'**, apertural views. All scale bars = 1 cm.

suture line is somewhat less complex (much simpler umbilical series), and they occur much lower (early Smithian) in the succession.

Occurrence: *Kashmirites* cf. *K. guangxiense* is very rare and has been found only in the *A. rubyae* n. sp. FA interval at Crittenden Springs.

Genus *Preflorianites* Spath, 1930

Type species: *Danubites strongi* Hyatt and Smith, 1905

***Preflorianites toulai* (Smith, 1932)**

Figures 6K-B', 7-8, 10

1905 *Danubites strongi* Hyatt and Smith, p. 165, pl. 9, figs. 4-10.

?1922 *Xenodiscus bittneri* Welter, p. 106, pl. 4, figs. 7, 8.

1932 *Preflorianites strongi* (Hyatt and Smith), Smith, p. 85, pl. 9, figs. 4-10.

1932 *Xenodiscus toulai* Smith, p. 45, pl. 25, figs. 1-3; pl. 53, figs. 9-12.

1932 *Proteusites rotundus* Smith, p. 102, pl. 53, figs. 5-8.

1962 *Preflorianites toulai* (Smith), Kummel and Steele, p. 669, pl. 100, figs. 18-20; pl. 102, fig. 5.

1995 *Preflorianites toulai* (Smith), Shevryev, p. 26, pl. 2, fig. 4.

2000 *Dieneroceras subquadratum* (Smith), Gardner and Mapes, p. 114, fig. 4, p. 116, 117, pl. 1, figs. 3, 4, 6.

2007 *Preflorianites toulai* (Smith), Jenks et al., p. 42, pl. 3, fig. F.

?2013 *Preflorianites toulai* (Smith), Brayard et al., p. 161, fig. a-h.

2017 *Preflorianites toulai* (Smith), Jattiot et al., p. 14, pl. 1, figs. AE-AK.

Material: 117 measured specimens (54 from *C. jattioti* interval and 63 from *P. toulai* interval). Includes 22 illustrated specimens, 14 from *C. jattioti* interval (2199C-16, 2199C-28, 2199C-5, 2199C-27, 2199C-15, 2531C, 695C, 116C, 244C, 2199C-7, 2197C, 746C, 2198C and 2199C-4) and eight specimens from *P. toulai* interval (2193C-1, 933C, 2193C-6, 2193C-5, 2196C, 705C, 2194C and 2193C-10). Type series of *Danubites strongi* Hyatt and Smith and *Xenodiscus toulai* Smith are also illustrated.

Description: Medium sized, fairly evolute, compressed shell with gently convex flanks and arched to rounded venter with rounded, indistinct shoulders. Whorl section varies from ovoid on more compressed specimens to nearly sub rectangular on more robust forms. Convergence of flank contour gradually increases from point of maximum whorl width (40-45% of height) until ventral shoulder area is reached. Umbilicus shallow with inclined wall and broadly rounded shoulder. Body chamber length not known, but at least 2/3 whorl. Ornamentation consists of highly variable ribbing, but most specimens exhibit dense, sinuous or biconcave ribs that arise high on umbilical shoulder, become strongest at mid-flank, then fade rapidly low on ventral shoulder before crossing venter in greatly diminished strength. Ribbing present on inner whorls and most of body chamber, but intensity tends to diminish slightly on last portion of body chamber. Well preserved specimens display distinctive growth lines that follow same trajectory as ribs. Many of the better preserved specimens from the *Preflorianites toulai* interval exhibit a longitudinal color pattern consisting of a light colored, distinctive band positioned at about mid-flank, whose width varies from specimen to specimen but generally occupies about 25 to 30% of the flank (Gardner and Mapes, 2000). Suture line ceratitic with asymmetrical saddles and well indented lobes.

Measurements: See Figure 9 and APPENDIX, p. 134.

Discussion: That the geometric morphology of the genus *Preflorianites* (Spath, 1934) has been somewhat misconstrued is obvious from an examination of hand-drawn illustrations of the taxon's holotype in Hyatt and Smith (1905) and Spath (1934).

The genus *Preflorianites* was erected by Spath (1934) based on *Danubites strongi* from Union Wash, California as the type species, but his illustration (p. 132, fig. 36) strongly suggests that he never personally examined the holotype. Instead, he apparently relied on the hand-drawn illustration in Hyatt and Smith (1905, pl. 9, figs. 4-6), which shows a nearly angular venter (Fig. 10A). Spath's (1934) hand-drawn illustration showing a fastigate venter further mischaracterized the holotype (Fig. 10B). These two illustrations have been the source of much confusion over the years. A recent examination of the holotype as well as the paratype by the first author has revealed that, indeed, the illustrated portion of the holotype's venter is neither angular nor fastigate, but instead is only slightly arched (Fig. 10C-E). Furthermore, the holotype's venter becomes more rounded just a short adapical distance from the illustrated portion. Prior to this clarification, Brayard et al. (2013) had suggested that *P. toulai* might be synonymized with *P. strongi* were it not for this probable "false characterization." Brayard et al. (2013) further commented that based on collecting experience of (A.B.) at Union Wash, *P. toulai* specimens were found to be abundant, but none exhibited the peculiar angular venter shown in the hand-drawn illustrations. Because the *P. strongi* type series is based on only two specimens, both of which are relatively dissimilar in terms of geometry, we consider the holotype to be an extreme variant that may not be representative of the taxon. This specimen is much more evolute and robust than *P. toulai* ($U/D=0.44$ vs. a range of 0.28 to 0.38, and $W/D=0.36$ vs. a range of 0.23 to 0.35 for 117 specimens). In actuality, its coiling geometry is much closer to *P. radians* Chao, 1959 than *P. toulai*. In short, *P. strongi* is poorly known even though it serves as a type species; additional collecting is thus required from the Union Wash locality to determine its range of intraspecific variation. Based on these observations, we consider *P. toulai* to be a valid taxon.

Preflorianites toulai (Smith, 1932) was erected based on a deformed specimen (holotype, Fig. 10H-J) from Union Wash, California, and, a partial but relatively well-preserved specimen (paratype, Fig. 10K-M) from southeast Idaho. The holotype's relatively poor preservation and distortion makes it difficult to compare with the Crittenden Springs specimens, but the shell geometry (scatter diagram, Fig. 9) and ornamentation of both specimens, especially the paratype, are nearly identical to the present specimens. *Preflorianites toulai* occurs in both the *Crittendenites jattioti* n. gen., n. sp. and the underlying *Preflorianites toulai* intervals, but specimens with the longitudinal color patterns occur only in the lower interval. This discrepancy is somewhat problematic in that the overall preservation of specimens in the upper interval appears to be better than those in the lower interval. This phenomenon can only be attributed to taphonomic processes during diagenesis (Gardner and Mapes, 2000).

Preflorianites toulai from Crittenden Springs differs from specimens attributed to *P. toulai* from the Confusion and Pahvant Ranges of Utah by Brayard et al. (2013) by its more involute coiling, elongated ovoid or sub-rectangular whorl section and slightly sinuous style of ribbing. Furthermore, the Utah material is reported only from the late early Smithian portion of the succession, whereas the Nevada specimens occur only in the late middle Smithian. Accordingly, Jattiot et al. (2017) questioned the attribution of the Utah specimens to *P. toulai*, and instead suggests that based on their coiling and whorl shape, they may be assignable to the early Smithian genus *Kashmirites*. *Preflorianites toulai* from Crittenden Springs differs from *Preflorianites* cf. *P. radians* by its obviously more involute coiling and higher whorls.

Occurrence: *Preflorianites toulai* occurs in the *P. toulai* and overlying *C. jattioti* n. gen., n. sp. intervals.

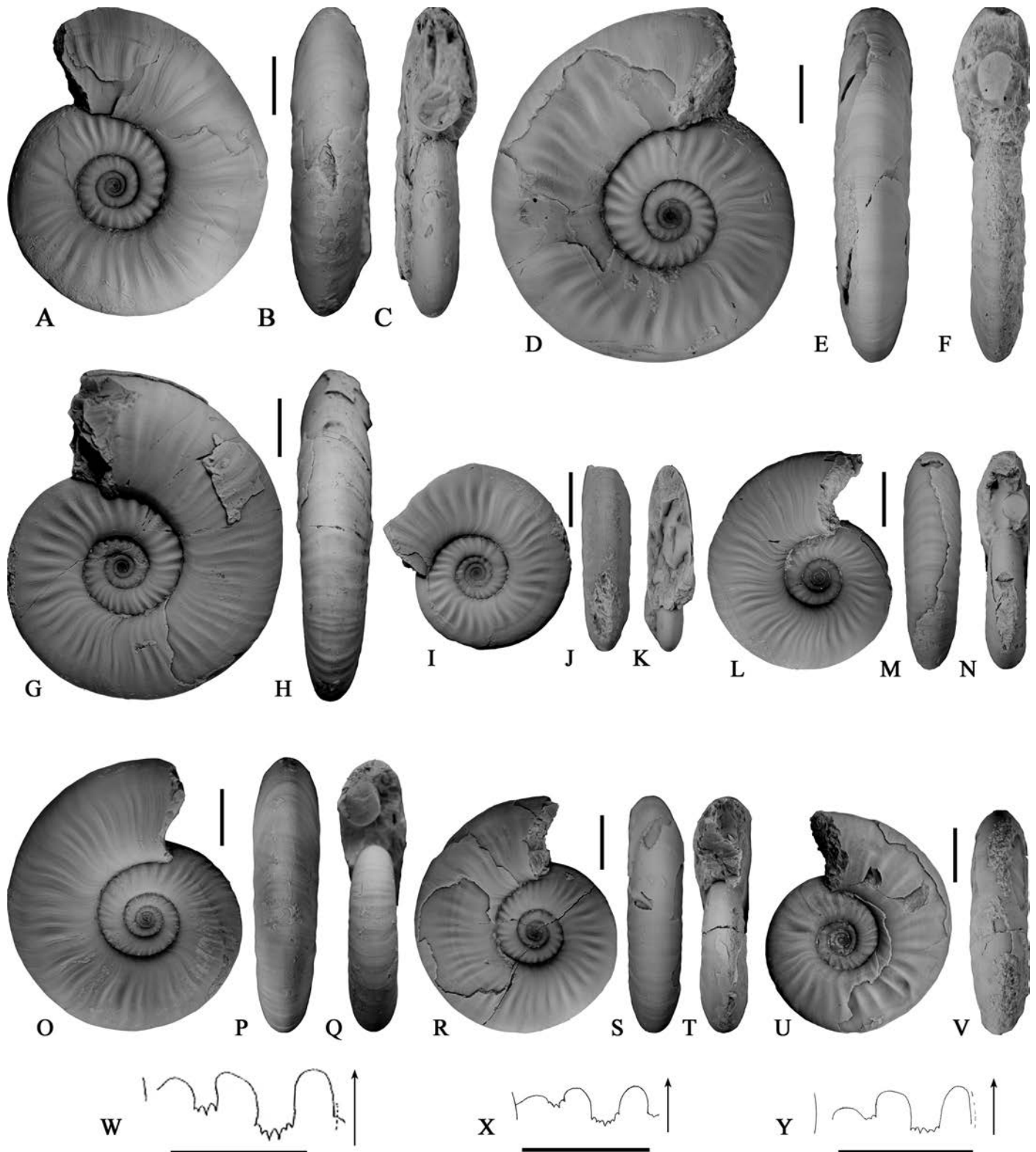


FIGURE 7. *Preflorianites toulai* (Smith), *C. j.* A-C, 695C, 1-88, in A, lateral, B, ventral and C, apertural views. D-F, 116C, 1-88, in D, lateral, E, ventral and F, apertural views. G-H, 244C, 13-75, in G, lateral and H, ventral views. I-K, 2199C-7, 2-93, in I, lateral, J, ventral and K, apertural views. L-N, 2197C, 2-93, in L, lateral, M, ventral and N, apertural views. O-Q, 746C, 1-88, in O, lateral, P, ventral and Q, apertural views. R-T, 2198C, 1-88, in R, lateral, S, ventral and T, apertural views. U-V, 2199C-4, 2-93, in U, lateral and V, ventral views. W-Y, suture lines, in W, 2199C-44, H = 1.3 cm, 5-76, X, 2197C, H = 0.95 cm, 2-93, and Y, 2199C-45, H = 1.07 cm, 5-76. All scale bars = 1 cm.

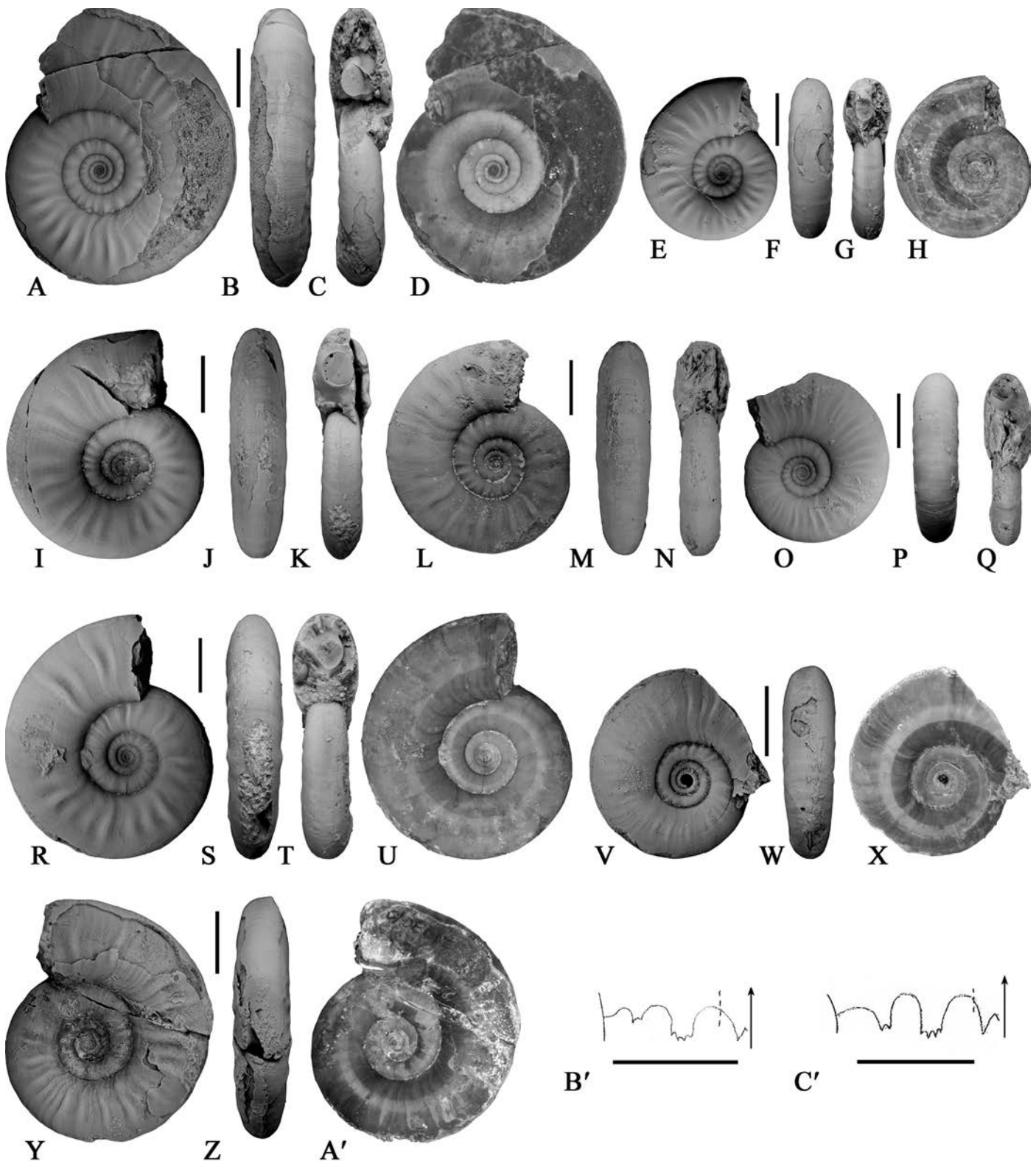


FIGURE 8. *Prefflorianites toulai* (Smith), *P. t.* A-D, 2193C-1, 3-93, in A, lateral, B, ventral, C, apertural and D, lateral (unwhitened) views. E-H, 933C, 3-93, in E, lateral, F, ventral, G, apertural and H, lateral (unwhitened) views. I-K, 2193C-6, 1-88, in I, lateral, J, ventral and K, apertural views. L-N, 2193C-5, 3-93, in L, lateral, M, ventral and N, apertural views. O-Q, 2196C, 3-93, in O, lateral, P, ventral and Q, apertural views. R-U, 705C, 1-88, in R, lateral, S, ventral, T, apertural and U, lateral (unwhitened) views. V-X, 2194C, 3-93, in V, lateral, W, ventral and X, lateral (unwhitened) views. Y-A', 2193C-10, 3-93, in Y, lateral, Z, ventral and A', lateral (unwhitened) views. B'-C', suture lines in B', 2193C-62, H = 0.97 cm, 3-93, and C', 2193C-28, H = 1.2 cm, 1-88. All scale bars = 1 cm.

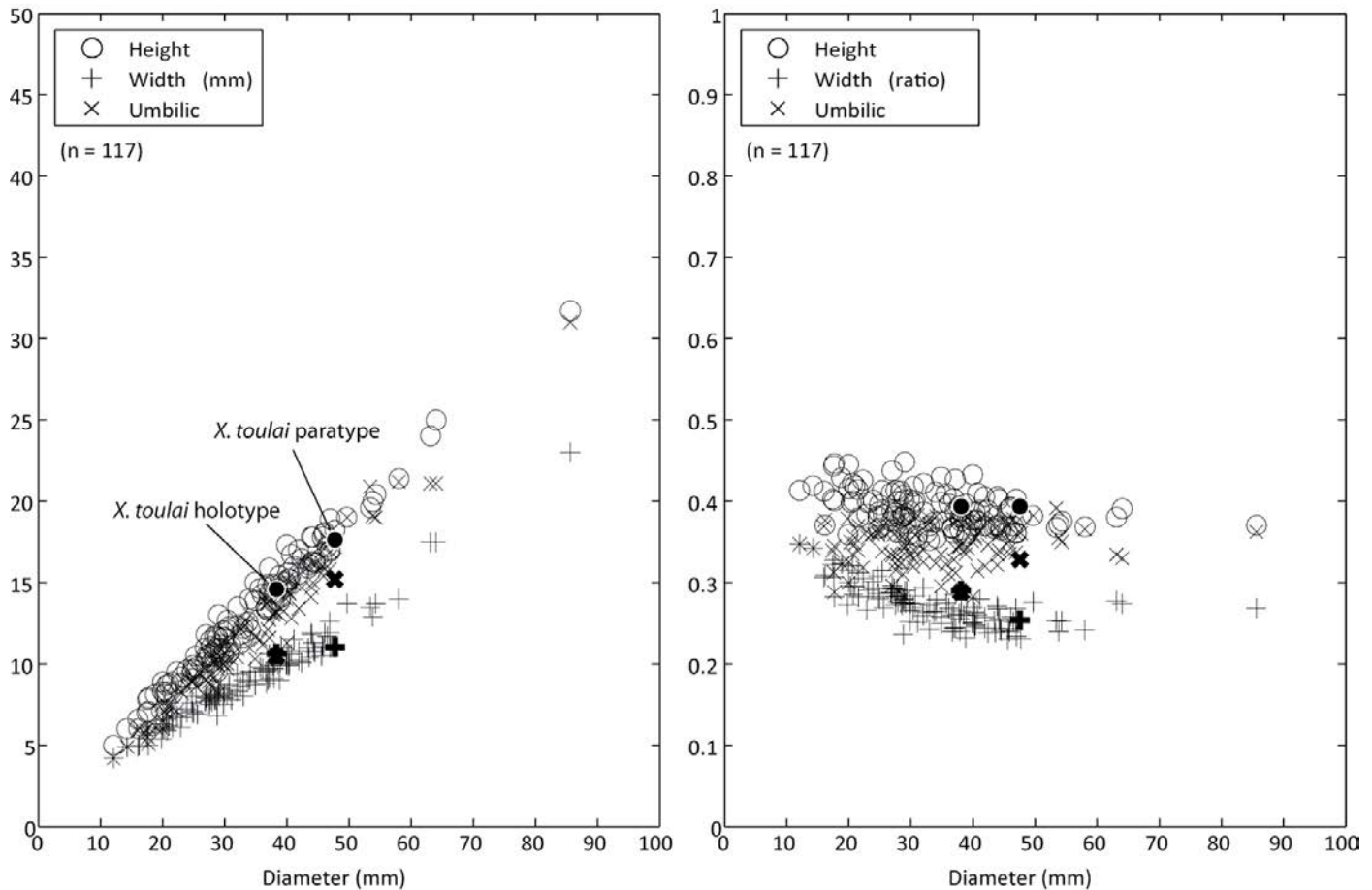


FIGURE 9. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Preflorianites toulai* (63 specimens from *P. t.* interval and 54 from *C. j.* interval), with type specimens of *Xenodiscus toulai* Smith, 1932 included for comparison.

***Preflorianites* cf. *P. radians* Chao, 1959**
Figures 11, 12

- ?1905 *Xenodiscus bittneri* Hyatt and Smith, p.123, pl. 20, figs. 5-15; pl. 21, figs. 1-13.
- ?1922 *Xenodiscus bittneri* Hyatt and Smith, Welter, p. 106, pl. 4, figs. 8, 9.
- 1959 *Preflorianites radians* Chao, p. 196, pl. 3, figs. 6-8.
- ?1968 *Preflorianites* cf. *radians* Chao, Zakharov, p. 137, pl. 27, figs. 5-6.
- 2008 *Preflorianites* cf. *P. radians* Chao, Brayard and Bucher, p. 17, pl. 2, figs. 5-11; fig. 18.
- 2008 *Pseudoceltites*? *angustecostatus* (Welter, 1922), Brayard and Bucher, p. 18, pl. 3, figs. 1-7; fig. 19.
- 2012a *Preflorianites radians* Chao, Brühwiler and Bucher, p. 15, pl. 1, figs. 8, 9; pl. 2, figs. 1-7.
- 2012c *Preflorianites* cf. *radians* Chao, Brühwiler et al., p. 132, fig. 13A-E.
- 2014 *Preflorianites radians* Chao, Shigeta and Nguyen, p. 66, figs. 46, 47.

Material: 50 measured specimens from *P. toulai* interval. Includes 11 illustrated specimens (2191C-36, 2200C, 243C, 2191C-17, 2191C-33, 2191C-24, 2193C-24, 886C, 278C, 704C and 703C).

Description: Medium sized, very evolute, compressed shell with near-serpenticonic coiling, gently convex flanks, low arched to rounded venter and rounded, indistinct shoulders. Flank contour convergence gradually increases from point of maximum width (40-45% of height) until broadly rounded, indistinctive ventral shoulder is reached. Fairly wide, relatively

shallow umbilicus with inclined wall and broadly rounded shoulders. Body chamber length not known, but at least 3/4 whorl. Ornamentation consists of variable but fairly dense, radial to slightly sinuous, rounded ribs that arise at top of umbilical shoulder and then fade completely on upper flank. Ribbing is present on inner whorls and most of body chamber but intensity tends to diminish slightly on last portion of body chamber. Well preserved specimens exhibit distinctive growth lines that follow the same trajectory as the ribs. Many of the better preserved specimens exhibit a longitudinal color pattern consisting of a light colored, distinctive band positioned at about mid-flank, whose width varies from specimen to specimen but generally occupies about 25 to 30% of the flank (Gardner and Mapes, 2000). Suture line ceratitic with asymmetrical saddles and well indented lobes.

Measurements: See Figure 13 and APPENDIX, p. 137.

Discussion: Up till now, specimens attributed to *Preflorianites radians* have been reported from South China (Chao, 1959; Brayard and Bucher, 2008), Oman (Brühwiler et al., 2012a), Spiti (Brühwiler et al., 2012c) and Vietnam (Shigeta and Nguyen, 2014), but never from western USA localities. At Crittenden Springs, *Preflorianites* cf. *P. radians* occurs in the late middle Smithian *Preflorianites toulai* interval together with the eponymous taxon, both of which exhibit similar longitudinal color patterns on their flanks. The type specimens (holotype and paratype, Fig. 10N-P) of *P. radians* Chao, 1959 appear to fit reasonably well (Fig. 13) within the intraspecific variation of the present *P. cf. P. radians* specimens. Brayard et al. (2013) synonymized *P. radians* with *P. toulai*, but this action was partly influenced by the very evolute coiling geometry of specimens from the late early Smithian (*Preflorianites*-*Kashmirites* beds)

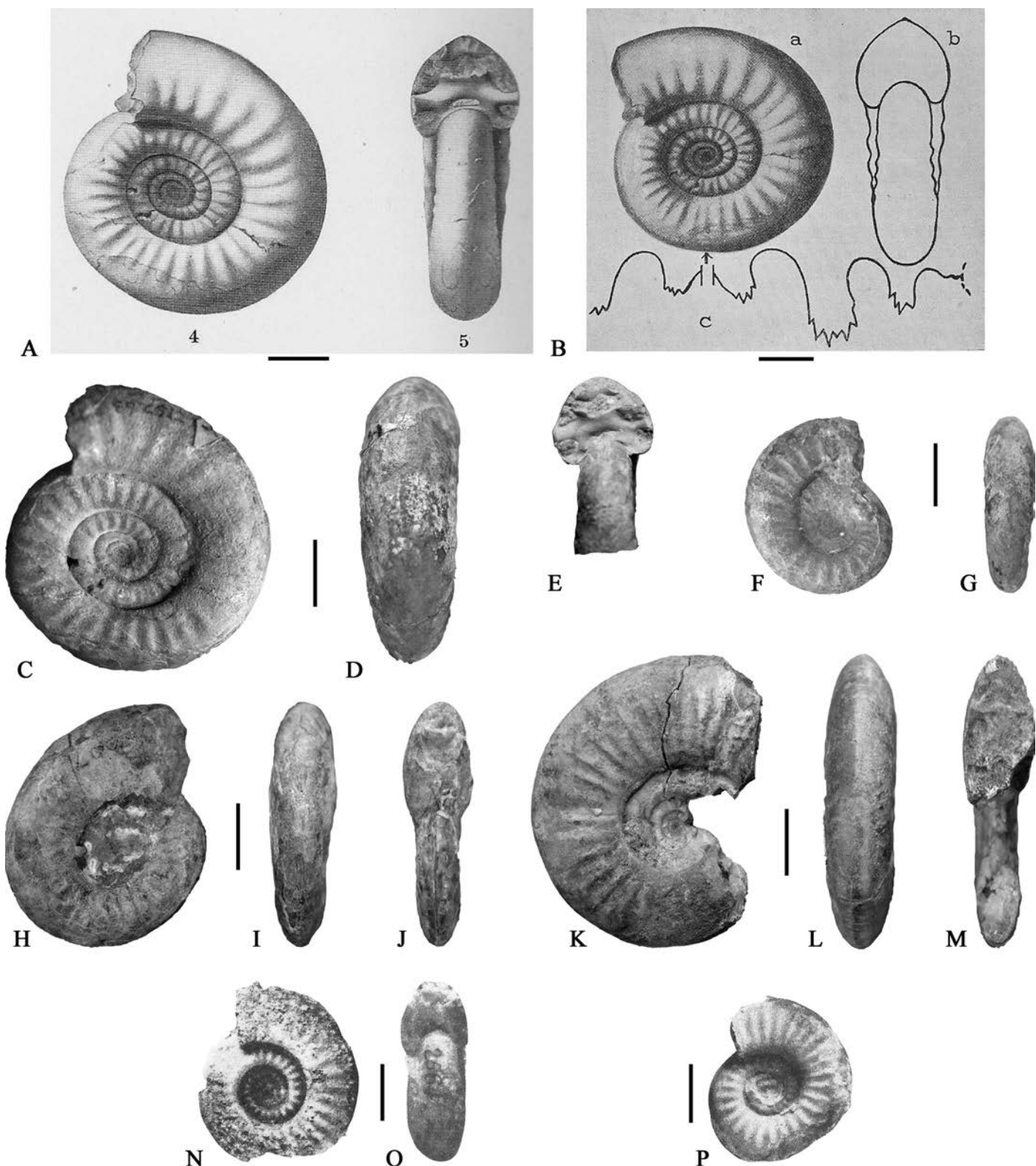


FIGURE 10. Type Specimens, **A-B**, *Danubites strongi* Hyatt and Smith, holotype, (USNM 75263), type species of *Preflorianites*, from *Meekoceras* beds, Union Wash, California as illustrated by hand-drawn figures in **A**, Hyatt and Smith, 1905, pl. 9, figs. 4, 5. **B**, Spath, 1934, p. 132, fig. 36, a-c. **C-E**, photos of holotype by first author, in **C**, lateral, **D**, ventral and **E**, apertural views. **F-G**, *Danubites strongi* Hyatt and Smith, paratype, (USNM317237), from *Meekoceras* beds, Union Wash, California, in **F**, lateral and **G**, ventral views. **H-J**, *Xenodiscus toulai* Smith, holotype, (USNM 75007), from *Meekoceras* beds, Union Wash, California, in **H**, lateral, **I**, ventral and **J**, apertural views. **K-M**, *Xenodiscus toulai* Smith, paratype, (USNM 74928), from *Meekoceras* beds, southeastern Idaho, in **K**, lateral, **L**, ventral and **M**, apertural views. **N-O**, *Preflorianites radians* Chao, holotype, (Nanjing 12564), in **N**, lateral and **O**, apertural views. **P**, *Preflorianites radians* Chao, paratype, (Nanjing 12563), in **P**, lateral view. All scale bars = 1 cm.

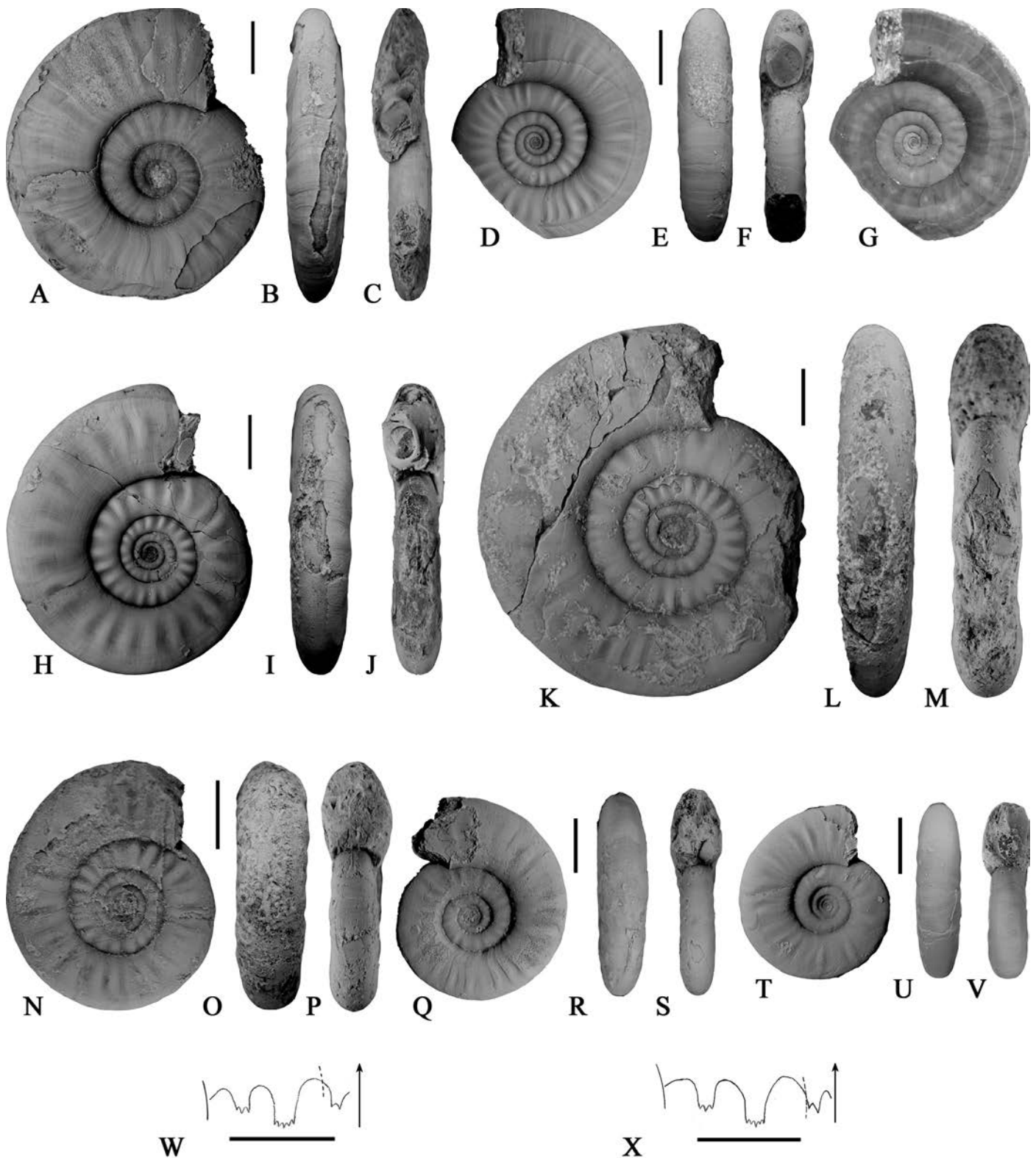


FIGURE 11. *Preflorianites* cf. *P. radians* Chao, *P. t.* unless otherwise indicated. **A-C**, 2191C-36, 3-93, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-G**, 2200C, 3-93, in **D**, lateral, **E**, ventral, **F**, apertural and **G**, lateral (unwhitened) views. **H-J**, 243C, (found as float), in **H**, lateral, **I**, ventral and **J**, apertural views. **K-M**, 2191C-17, (found as float) in **K**, lateral, **L**, ventral and **M**, apertural views. **N-P**, 2191C-33, 1-88, in **N**, lateral, **O**, ventral and **P**, apertural views. **Q-S**, 2191C-24, 1-88, in **Q**, lateral, **R**, ventral and **S**, apertural views. **T-V**, 2193C-24, 5-76, in **T**, lateral, **U**, ventral and **V**, apertural views. **W-X**, suture lines, in **W**, 2191C-36, H = 1.16 cm, 3-93, and **X**, 2191C-4, H = 1.38 cm, 1-88. All scale bars = 1 cm.

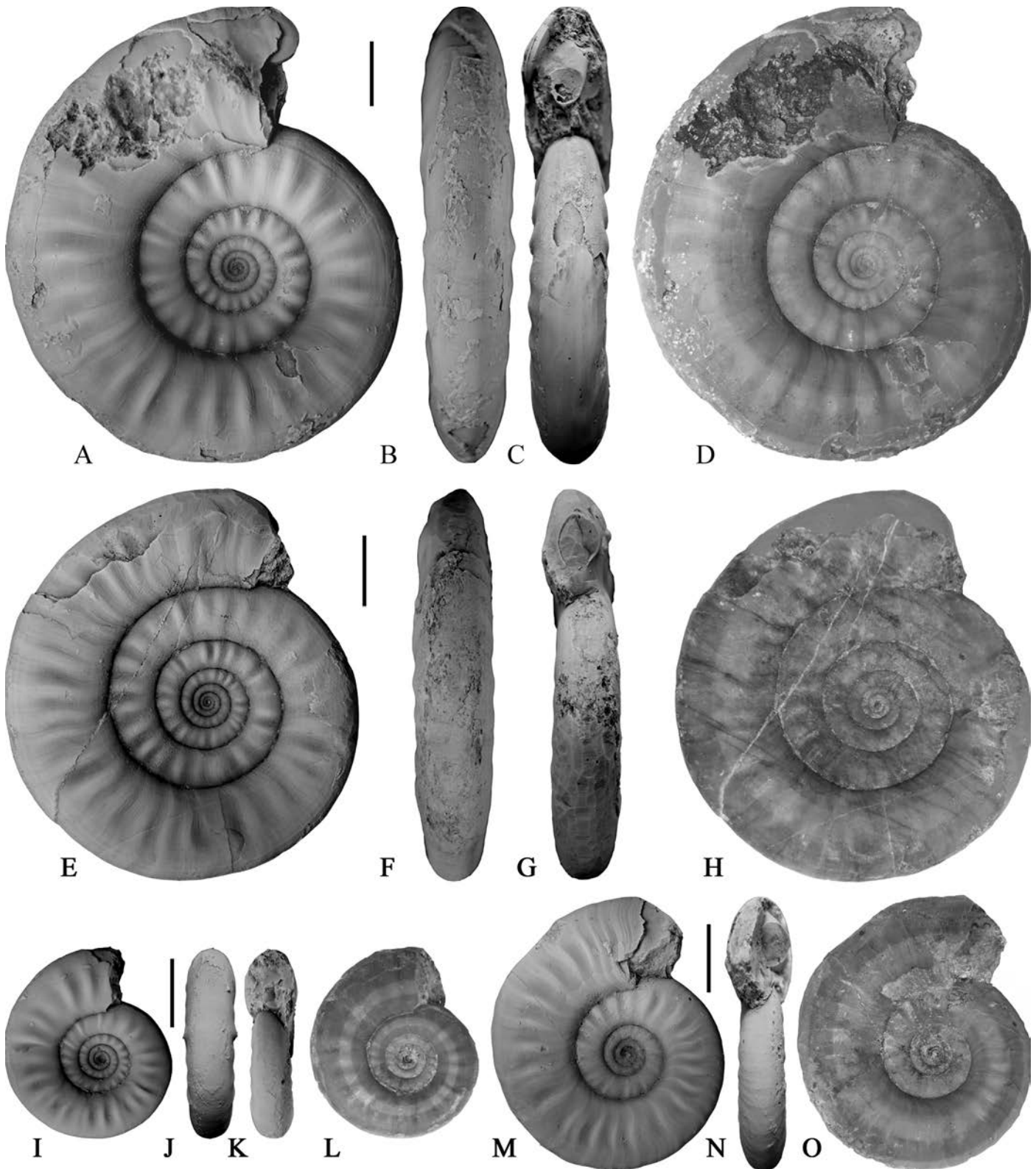


FIGURE 12. *Preflorianites* cf. *P. radians* Chao, *P. t.* **A-D**, 886C, 1-88, in **A**, lateral, **B**, ventral, **C**, apertural and **D**, lateral (unwhitened) views. **E-H**, 278C, 13-75, in **E**, lateral, **F**, ventral, **G**, apertural and **H**, lateral (unwhitened) views. **I-L**, 704C, 1-88, in **I**, lateral, **J**, ventral, **K**, apertural and **L**, lateral (unwhitened) views. **M-O**, 703C, 1-88, in **M**, lateral, **N**, apertural and **O**, lateral (unwhitened) views. All scale bars = 1 cm.

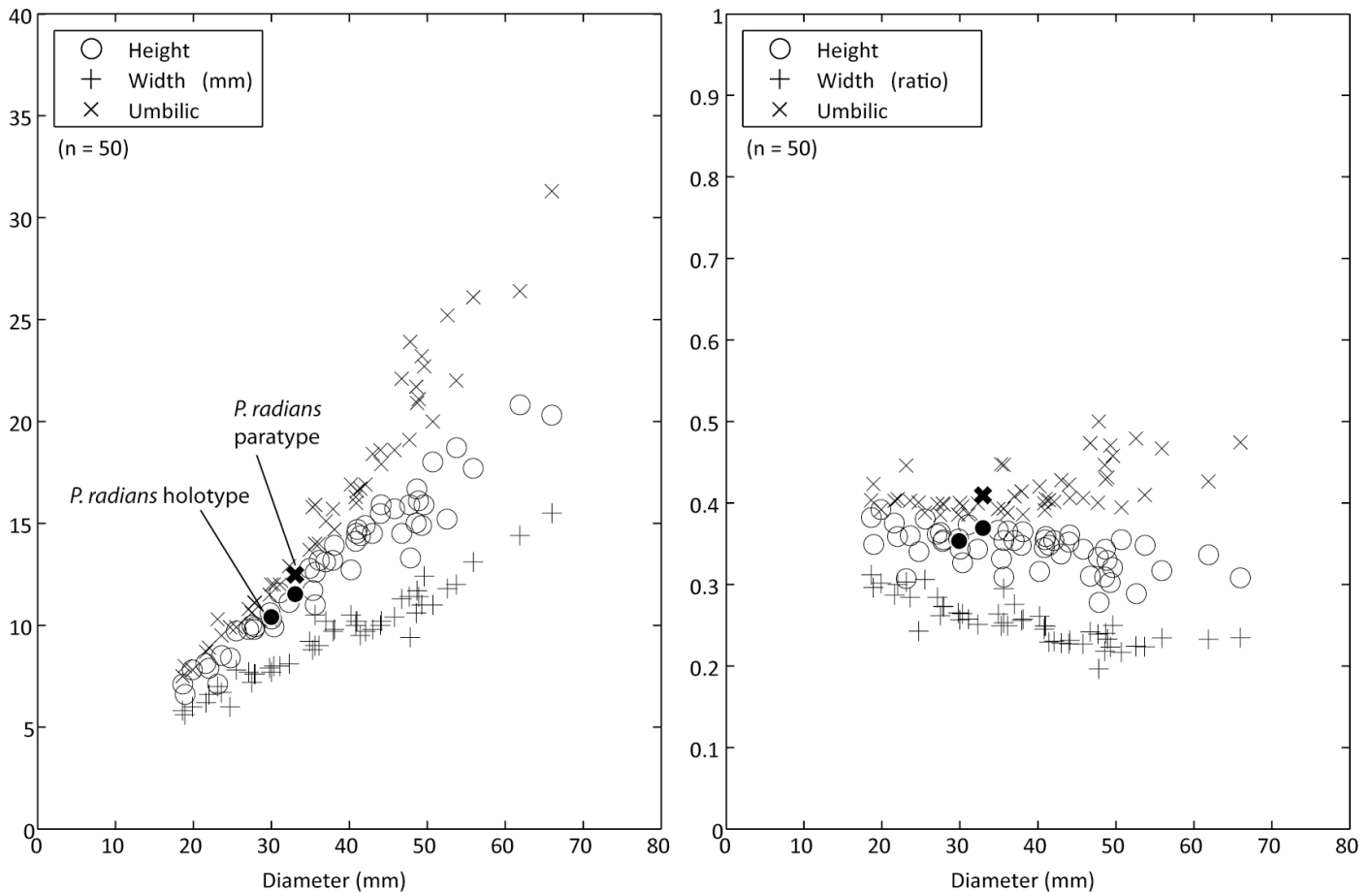


FIGURE 13. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Preflorianites* cf. *P. radians* from *P. t.* interval, with type specimens of *P. radians* from South China included for comparison.

in the Confusion Range that they attributed to *P. toulai* (see Discussion, *P. toulai*).

The *P. toulai*-*P. cf. P. radians* group (167 specimens) from the *C. jattioti* and *P. toulai* intervals can be more or less accurately divided into two groups based only on differences in whorl involution, and more precisely by U/D measurement. The existence of these two distinct but slightly overlapping morphological groups, is well illustrated by the scatter diagram comparison of U/D for *P. toulai* vs. *P. cf. P. radians* shown in Figure 14 (type specimens of *D. strongi*, *X. toulai* and *P. radians* included for comparison). The same observation is also evident in the U/D box plot diagram (Fig. 15) for the two taxa. This conclusion supports the work of Brayard and Bucher (2008) in South China, Brühwiler et al. (2012a) in Oman and Jattiot et al. (2017) in Nevada, all of whom consider *P. toulai* and *P. radians* to be valid taxa.

The presence of the similar longitudinal color bands on the two *Preflorianites* subgroups leads to the intriguing possibility that the two taxa represent sexual dimorphs, but reports of this phenomenon in Triassic ammonoids are extremely rare, especially compared to younger Mesozoic ammonoids and even Permian ammonoids. Ulrich's report (2009) of dimorphism among Middle Triassic *Ceratites* is one of the few recognized cases of true dimorphism, but it must have existed in other Triassic ammonoids as well (Klug et al., 2015). Dimorphism may be involved with the two taxa, but the intensive study required to support such a claim is beyond the scope of this work.

According to Jattiot et al. (2017), mature shells of *P. toulai* are generally presumed to be slightly smaller than *P. radians* from South China (Brayard and Bucher, 2008) and Oman (Brühwiler

et al., 2012a). However, just the opposite relationship is true for the *P. toulai*-*P. cf. P. radians* group from Crittenden Springs. *Preflorianites* cf. *P. radians* differs from *P. toulai* primarily by its more evolute coiling and lower whorl height, and from the holotype of *D. strongi* by its much less robust whorl section (W/D 0.20 to 0.31 vs. 0.36) and slightly more involute coiling of nearly all specimens. Even though *P. cf. P. radians* appears nearly identical to *P. radians*, we prefer to avoid a definite assignment, mainly because our smaller specimens attributed to *P. cf. P. radians* appear to be slightly more evolute than similarly sized examples from South China (Brayard and Bucher, 2008) and Oman (Brühwiler et al., 2012a).

Occurrence: *Preflorianites* cf. *P. radians* occurs only in the *P. toulai* interval.

Family XENOCELTITIDAE Spath, 1930

Genus *Condensoceras* n. gen.

Type species: *Xenoceltites youngi* Kummel and Steele, 1962

Composition of the genus: Type species only.

Etymology: Name derived from the Latin word *condenso*, which refers to the condensed nature of the Smithian ammonoid beds at Crittenden Springs, especially the late Smithian portion.

Diagnosis: Small to medium sized, fairly evolute, compressed, high-whorled discoidal shell with slightly convex flanks, highly arched to narrowly rounded venter and relatively shallow umbilical area with inclined wall and gently rounded shoulders. Most shells without ornamentation on inner whorls, but some exhibit distant, very low, blunt, indistinct ribs as in *Xenoceltites subevolutus*. Distinctive radial, slightly sinuous growth lines on outer whorls sometimes become bunched into

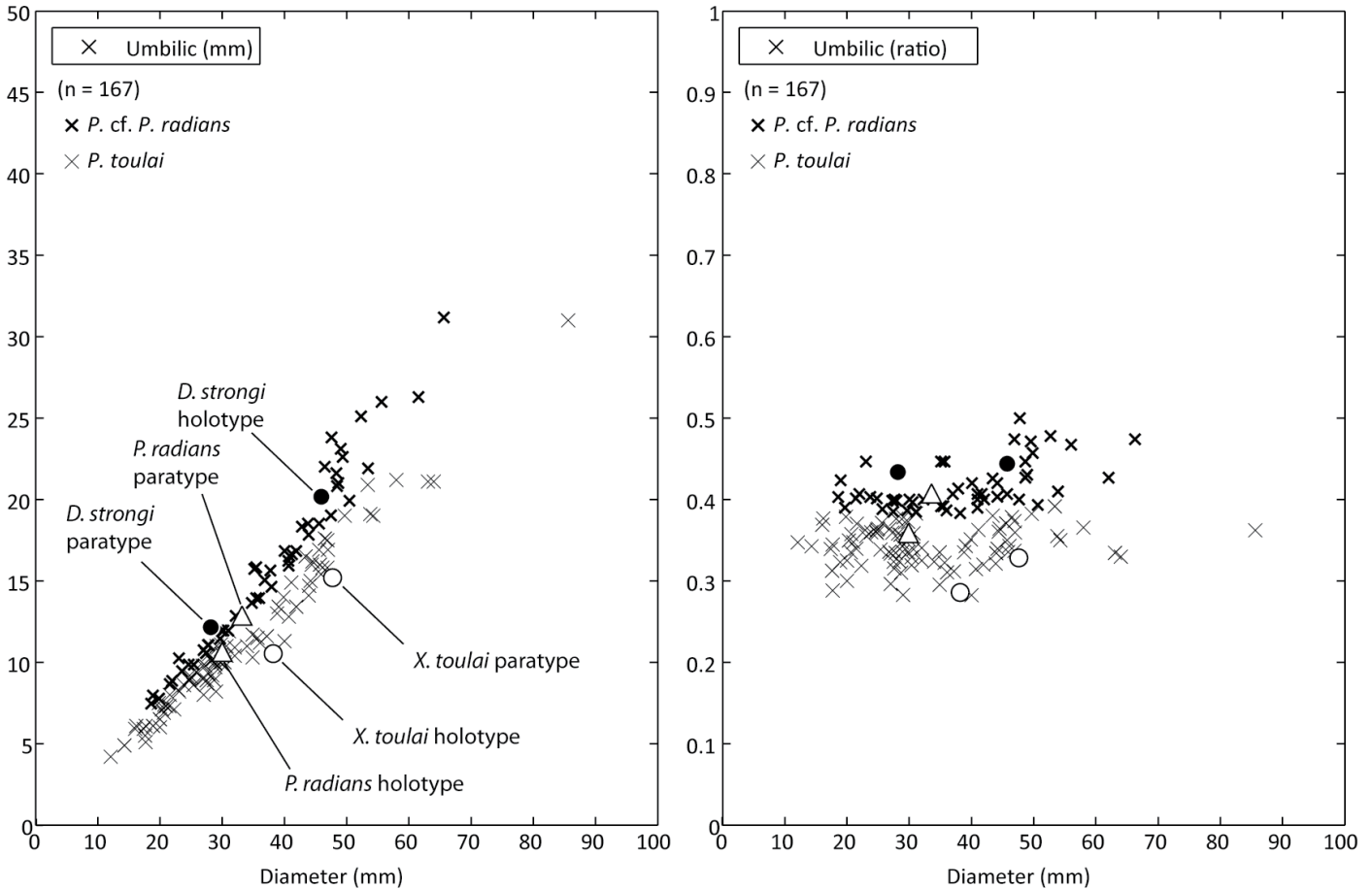


FIGURE 14. Scatter diagram comparison of U and U/D for *P. cf. P. radians* (n = 50, from *P. t.* interval) vs. *P. toulai* (n = 117, from *P. t.* and *C. j.* intervals), with type specimens of *D. strongi*, *X. toulai* and *P. radians* included for comparison.

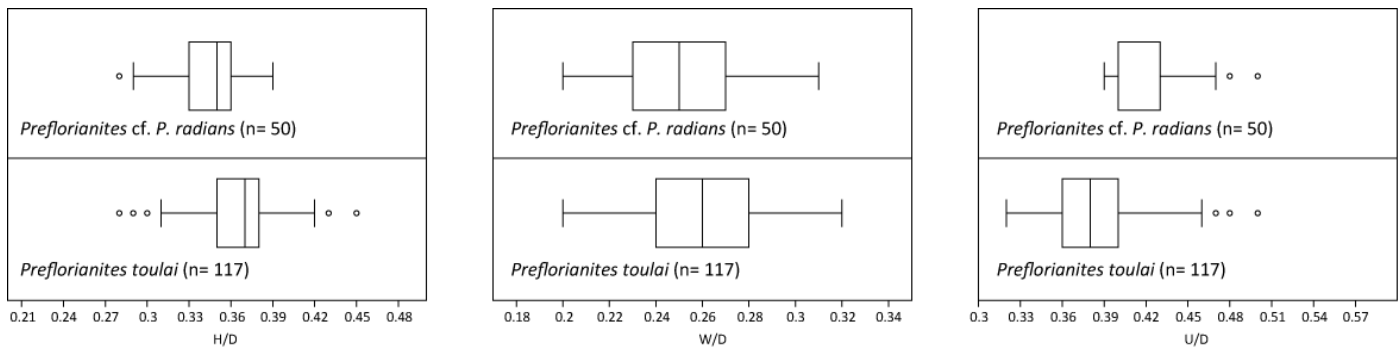


FIGURE 15. Box plot comparison of H/D, W/D and U/D for *P. cf. P. radians* (all from *P. t.* interval) vs. *P. toulai* (from *P. t.* and *C. j.* intervals).

very weak, radial, narrow band-type ribs separated by weak, shallow constrictions that become somewhat more prominent on venter.

Discussion: The genus *Xenoceltites*, erected by Spath (1934) with *X. subevolutus* as the type species, was established in part for specimens characterized by serpenticonic coiling, distant bulges on the inner whorls and irregular costa that usually produce constrictions on the outer whorl. Kummel and Steele (1962) attributed their new taxon *X. youngi* to the genus *Xenoceltites* based on the presence of indistinct blunt ribs on the inner whorls of two of their three type specimens and an overall similarity to *Xenoceltites subevolutus*. The ammonoid is very abundant but occurs only in the latest late Smithian *Condensoceras youngi* n. gen. interval together with

Xenoceltites subevolutus, *Glyptophraceras* cf. *G. sinuatum* and *Pseudosageceras augustum*. An examination of the three type specimens of *X. youngi* by the first author revealed that they are somewhat weathered and almost surely were collected as float. This observation combined with a careful reading of their taxonomic remarks (Kummel and Steele, 1962, p. 672) leads us to conclude that they almost certainly were not aware of the actual stratigraphic origin of their new taxon. Upon comparison of sub-adult and mature specimens attributed to *C. youngi* n. gen. and *X. subevolutus* from Crittenden Springs, it soon becomes apparent that *C. youngi* n. gen. consistently exhibits a significantly higher whorl and narrower umbilicus than *X. subevolutus*; thus, its coiling is definitely closer to platyconic than serpenticonic. Nevertheless, this differentiation

can be difficult for juvenile specimens; the coiling geometry of the early ontogenetic stage of *C. youngi* n. gen. is closer to serpenticonic but soon becomes platyconic with the addition of one or two whorls. These observations are supported by the scatter diagram comparison of U/D for the two taxa (Fig. 19) and the box plot comparison (Fig. 20), both of which show two distinct populations. *Condensoceras youngi* n. gen. is retained in the family Xenoceltitidae because of the presence of blunt, distant ribs on the inner whorls of some specimens, the presence of weak band-type ribs and constrictions on the flank and venter, and the similarity of its suture line to *Xenoceltites*.

***Condensoceras youngi* (Kummel and Steele, 1962)
Figures 16, 17**

- 1962 *Xenoceltites youngi* Kummel and Steele, p. 671, pl. 102, figs. 3, 4.
2008 *Xenoceltites pauciradiatus* Brayard and Bucher, p. 23, pl. 6, figs. 7-9.
2014 *Xenoceltites variocostatus* Brayard and Bucher, Shigeta, Y. and Nguyen, H. D., p. 72, fig. 48:1-12; fig. 49:1-26; fig. 50:1-12; fig. 51:15-16 only.

Material: 86 measured specimens. Includes 17 illustrated specimens (275C, 2542C-4, 2542C-61, 2542C-32, 2542C-47, 2542C-23, 2542C-8, 2542C-77, 2542C-79, 2542C-1, 2542C-5, 2542C-15, 2542C-85, 2542C-48, 2542C-84, 2542C-59 and 2542C-31). Holotype (MCZ 5266) is also illustrated.

Description: Small to medium sized, fairly evolute, high-whorled, compressed shell with nearly parallel but slightly convex flanks that converge without distinctive shoulders to venter that ranges from narrowly rounded to highly arched. Whorl section varies from semi-ovoid on more compressed specimens to sub-rectangular on thicker specimens, with maximum width at about 1/2 of whorl height. Whorl overlap generally about one third. Body chamber length not known but at least 2/3 whorl. Fairly narrow to moderately wide, shallow umbilicus with gently inclined wall and broadly rounded shoulder. Ornamentation consists of distant, very low but obvious, blunt, radial ribs on inner whorls of some specimens. Most specimens lack obvious ribs on inner whorls, but magnification reveals the presence of very weak ribs on nearly all shells. Dense, radial, slightly sinuous growth lines present on all ontogenetic stages, but those on outer whorl sometimes become bunched into very weak, narrow band-type ribs separated by weak, shallow constrictions that become somewhat more prominent on venter. Suture line ceratitic, typical of Xenoceltitidae with second lateral saddle slightly higher than first and deep lateral lobe.

Measurements: See Figure 18 and APPENDIX, p. 138.

Discussion: Nearly all the specimens attributed to *Xenoceltites variocostatus* from the late Smithian *X. variocostatus* beds in northeastern Vietnam by Shigeta and Nguyen (2014) are identical to *C. youngi* n. gen. in every respect. Indeed, the coiling geometry and ornamentation of these specimens make it impossible to separate them from *C. youngi* n. gen. Likewise, the whorl section, coiling geometry and weak tuberculation on the inner whorls of specimens of *Xenoceltites pauciradiatus* Brayard and Bucher (2008) from the *A. multiformis* beds of South China are virtually identical to *C. youngi* n. gen. Consequently, all of the above specimens are synonymized with *C. youngi* n. gen.

Occurrence: *Condensoceras youngi* n. gen. is very abundant and occurs only in the latest late Smithian *C. youngi* n. gen. interval.

Genus *Xenoceltites* Spath, 1930

Type species: *Xenoceltites subevolatus* = *Xenodiscus* cf. *comptoni* (non Diener) Frebold, 1930
Xenoceltites subevolatus Spath, 1930

Figure 21

- 1930 *Xenoceltites subevolatus* Spath, p. 12.

- 1930 *Lecanites* cf. *L. ophioneus* Waagen, Frebold, p. 12, pl. 3, figs. 4, 4a, 5.
1930 *Xenodiscus* cf. *X. comptoni* Diener, Frebold, p. 14, pl. 3, figs. 1-3.
1932 *Xenodiscus rotula* Waagen, Smith, p. 45, pl. 79, figs. 5, 6.
1934 *Xenoceltites spitsbergensis* Spath, p. 128, pl. 9, figs. 1, 2; pl. 11, figs. 5, 7, 8.
1934 *Xenoceltites gregoryi* Spath, p. 129, pl. 5, fig. 3; pl. 6, figs. 4, 5; pl. 11, figs. 3, 4, 6.
1934 *Xenoceltites subevolatus* Spath, p. 130, pl. 2, fig. 2; pl. 8, fig. 2; pl. 9, fig. 4, pl. 11, fig. 2.
1961 *Xenoceltites subevolatus* Spath, Tozer, p. 53, pl. 16, fig. 1.
1978 *Xenoceltites subevolatus* Spath, Zakharov, pl. 11, fig. 17.
1978 *Xenoceltites spitsbergensis* Spath, Weitschat and Lehmann, p. 94, pl. 11, figs. 3b, 4, 5.
1978 *Xenoceltites subevolatus* Spath, Weitschat and Lehmann, p. 95, pl. 11, figs. 1, 2, 3a.
1990 *Xenoceltites subevolatus* Spath, Dagys and Ermakova, p. 23, pl. 5, fig. 4.
1994 *Xenoceltites subevolatus* Spath, Tozer, p. 52, pl. 36, figs. 3-8.
2015 *Xenoceltites subevolatus* Spath, Piazza, p. 48, pl. 1, figs. a-c.
2017 *Xenoceltites subevolatus* Spath, Jattiot, p. , pl. 1, figs. P-AD.

Material: 32 measured specimens (nine from an *Anasibirites multiformis* lense and 23 from the *Condensoceras youngi* n. gen. interval). Includes 14 illustrated specimens, eight from *C. youngi* n. gen. interval and six from *A. multiformis* lens.

Description: Small to medium sized, fairly evolute, compressed shell characterized by near-serpenticonic coiling with whorls embracing about one third or less of preceding whorl. Flanks nearly parallel but slightly convex, converging without distinct shoulders to narrowly rounded to arched venter. Whorl section ranges from ovoid to sub-rectangular with maximum width at about 45-50% of height. Body chamber length unknown but at least 2/3 whorl. Umbilicus moderately wide and shallow with oblique wall and well-rounded shoulders. Ornamentation highly variable. Inner whorls of most specimens exhibit distant, very low but obvious, blunt, radial to slightly prosiradiate ribs that arise on umbilical shoulder. Ribbing density and strength on ultimate whorl highly variable. Ribs usually become slightly more prosiradiate, project strongly on indistinct ventral shoulders and then cross venter in an adoral curve, forming distinct constrictions on venter of some specimens. Ribbing strength generally fades on final 1/4 whorl of most specimens. Well preserved specimens exhibit distinctive growth lines parallel to ribbing, especially on ultimate whorl. Suture lines not exposed on present specimens.

Measurements: See Figure 22 and APPENDIX, p. 139.

Discussion: Numerous workers (Dagys and Ermakova, 1990; Piazza, 2015; Jattiot et al., 2017), upon recognizing the similarity and overlapping intraspecific variation of various late Smithian Boreal species attributed to *Xenoceltites*, namely *X. subevolatus*, *X. gregoryi* and *X. spitsbergensis*, have recommended treating the latter two as synonyms of *X. subevolatus*. We agree with their interpretation and treat *X. gregoryi* and *X. spitsbergensis* as synonyms of *X. subevolatus*.

Brayard and Bucher (2008) and Jattiot et al. (2017) emphasized that all late Smithian species of *Xenoceltites* overlap morphologically and exhibit an extremely wide range of intraspecific variation in terms of both whorl shape and ornamentation. This observation also applies to our relatively large data set (32 specimens) of *X. subevolatus*, and it is impossible to separate these specimens from those collected from other western USA localities, e.g., Cottonwood Canyon and Palomino Ridge, Nevada, and Lower Weber Canyon and Fort Douglas, Utah.

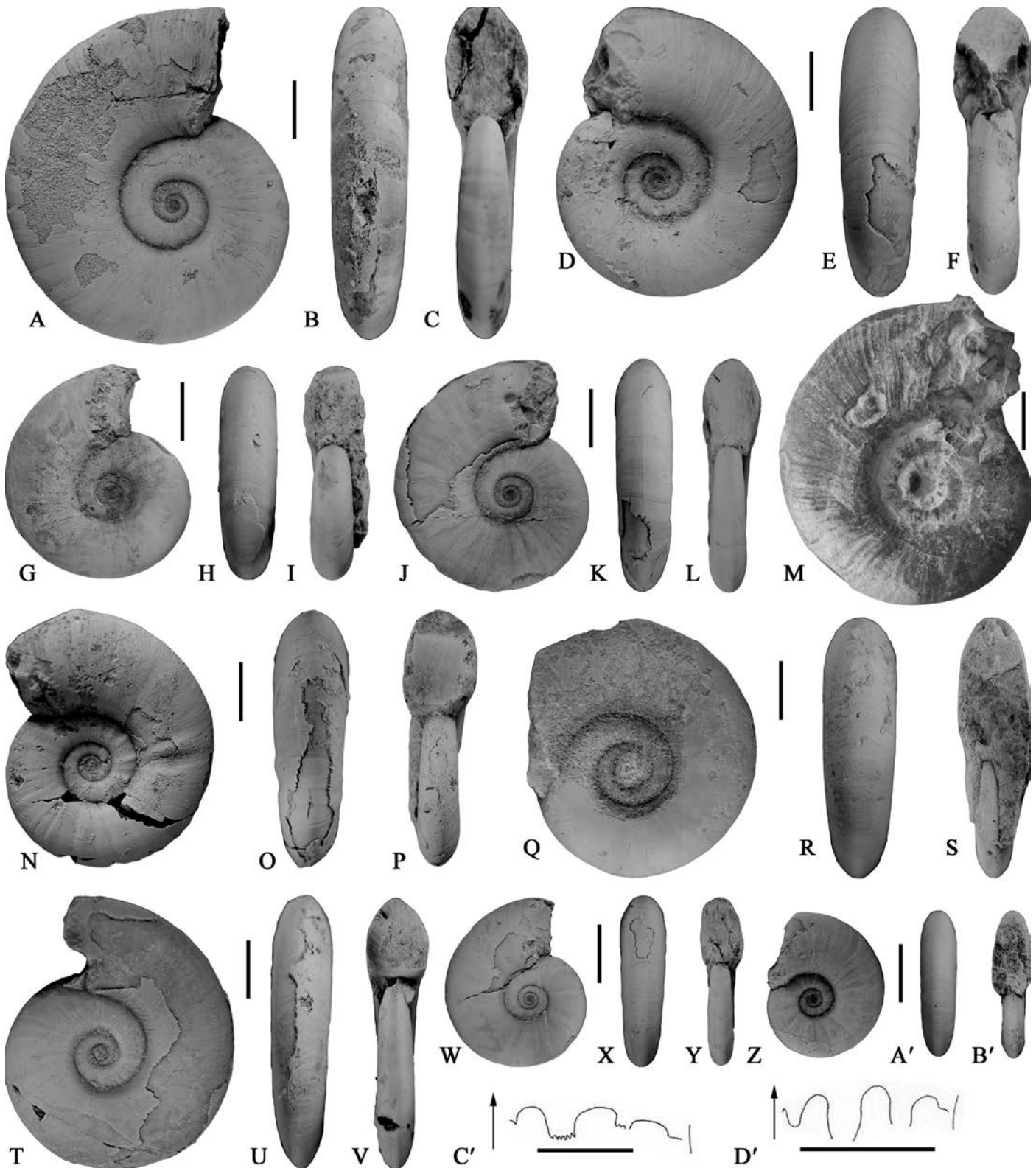


FIGURE 16. *Condensoceras youngi* n. gen. (Kummel and Steele), *C. y.* **A-C**, 275C, 13-75, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2542C-4, 13-75, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2542C-61, 5-76, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2542C-32, 1-88, in **J**, lateral, **K**, ventral and **L**, apertural views. **M**, Holotype (MCZ 5266), lateral view. **N-P**, 2542C-47, 5-76, in **N**, lateral, **O**, ventral and **P**, apertural views. **Q-S**, 2542C-23, 5-76, in **Q**, lateral, **R**, ventral and **S**, apertural views. **T-V**, 2542C-8, 13-75, in **T**, lateral, **U**, ventral and **V**, apertural views. **W-Y**, 2542C-77, 5-76, in **W**, lateral, **X**, ventral and **Y**, apertural views. **Z-B'**, 2542C-79, 5-76, in **Z**, lateral, **A'**, ventral and **B'**, apertural views. **C'-D'**, suture lines, in **C'**, 2542C-85, H = 1.7 cm, 5-76. **D'**, 2542C-84, H = 1.2 cm, 1-88. All scale bars = 1 cm.

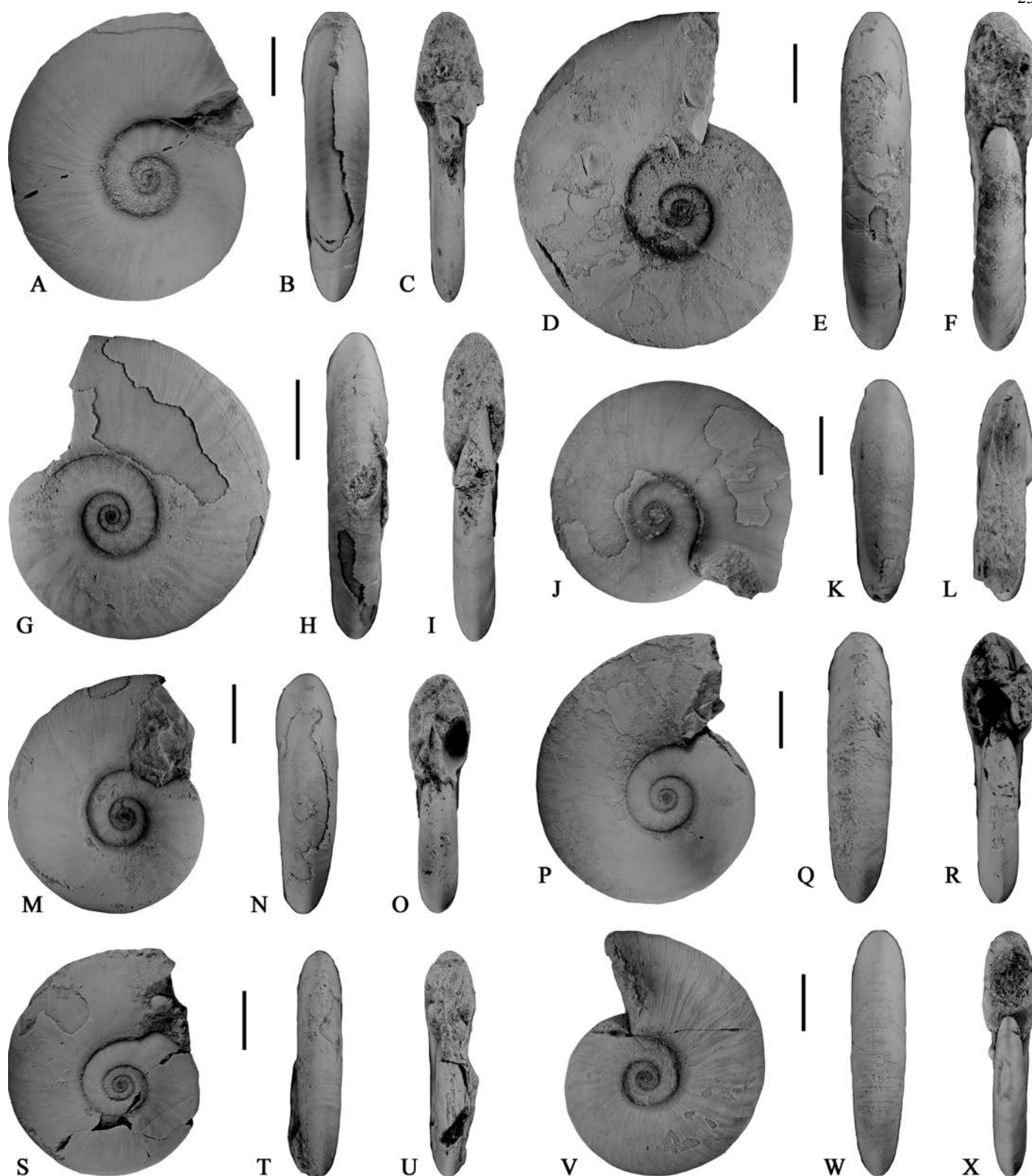


FIGURE 17. **A-U**, *Condensoceras youngi* n. gen. (Kummel and Steele), *C. y.* **A-C**, 2542C-1, 5-76, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2542C-5, 5-76, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2542C-15, 13-75, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2542C-85, 5-76, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2542C-48, 5-76, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2542C-84, 1-88, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 2542C-59, 2-94, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-X**, 2542C-31, 2-94, in **V**, lateral, **W**, ventral and **X**, apertural views. All scale bars = 1 cm.

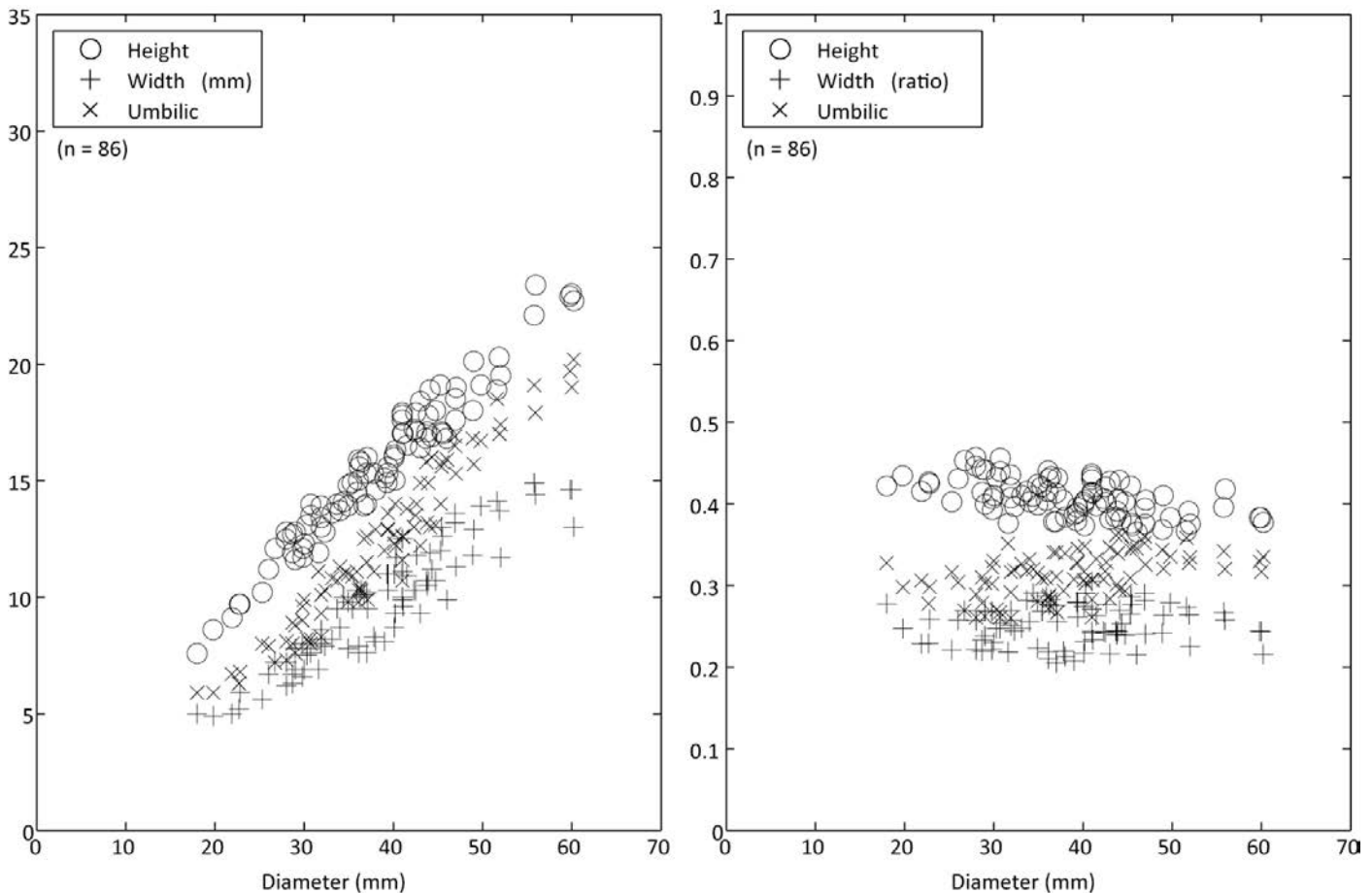


FIGURE 18. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Condensoceras youngi* n. gen. All specimens from *C. y.* interval.

Brayard and Bucher (2008) erected *Xenoceltites variocostatus* from South China based on the “extremely variocostate” ribbing of its inner whorls and an apparent widely variable coiling geometry, i.e., whorl height to diameter relationship. According to these authors, *X. variocostatus* differs from *X. subevolatus* primarily because it exhibits an extremely variable coiling geometry at all ontogenetic stages (Brayard and Bucher, 2008). Jattiot et al. (2017, p. 11), however, consider this attribution to be problematic, and they suggest that “*X. variocostatus* should be assigned to a distinct genus” in part, because most of the smaller-sized illustrated specimens exhibit a much wider conch than any known late Smithian *Xenoceltites*. Nevertheless, *X. variocostatus* has been recognized as a valid taxon for *Xenoceltites* specimens from the Salt Range and Spiti (Brühwiler et al., 2012b, 2012c). Larger specimens of *X. variocostatus* appear to be either very similar in coiling geometry to *C. youngi* n. gen. (see holotype of *X. variocostatus*, Brayard and Bucher, 2008, pl. 5, fig. 1a-d) or intermediate between *C. youngi* n. gen. and *X. subevolatus*, while smaller specimens tend to be more similar to *X. subevolatus*. Although the same relationship is more or less true for *C. youngi* n. gen., *X. variocostatus* tends to become slightly more involute with increasing diameter when compared to *C. youngi* n. gen. In summary, we consider *X. variocostatus* to be a valid taxon, but additional material is needed to verify this assumption, because it is not well represented by specimens in the mid-size range. This conclusion is supported by the box plot comparison (Fig. 20) of *C. youngi* n. gen. and *X. subevolatus* from Crittenden Springs and specimens of *X. variocostatus* from Vietnam and South China. The specimens of *X. variocostatus* from Vietnam match well with *C. youngi* n. gen., but those from South China

are somewhat different from both the Vietnam specimens and *C. youngi* n. gen.

The difficulty encountered in differentiating and setting taxonomic boundaries between widespread late Smithian xenoceltitid species, e.g., *X. subevolatus*, *C. youngi* n. gen., *X. variocostatus* and *G. sinuatum*, leads one to contemplate whether all of the specimens involved may possibly belong to one large, all-encompassing genus with extremely wide intraspecific variation. Such a hypothesis would be difficult to prove; at the very least, abundant, well-preserved specimens would be needed from all locations. *Xenoceltites subevolatus* differs from *X. variocostatus* by its consistent near-serpenticonic coiling geometry.

At Crittenden Springs *Xenoceltites subevolatus* occurs in both the *Anasibirites multiformis* interval (lenses) and the overlying *Condensoceras youngi* n. gen. interval, but is far more abundant in the latter. Interestingly, as is evident in Figure 21, specimens from the lenses sometimes exhibit more distinctive ornamentation than those from the overlying interval. This observation, however, is considered to be of little significance and is simply attributed to intraspecific variation.

Occurrence: *Xenoceltites subevolatus* is fairly common in the *C. youngi* n. gen. interval but quite rare in the *A. multiformis* lense interval.

Genus *Glyptopheras* Spath, 1930
Type species: *Xenodiscus aequicostatus* Diener, 1913 (=
***Dinarites sinuatus* Waagen, 1895)**
***Glyptopheras* cf. *G. sinuatum* (Waagen, 1895)**
Figure 23

1895 *Dinarites sinuatus* Waagen, p. 33, pl. 10, figs. 4.

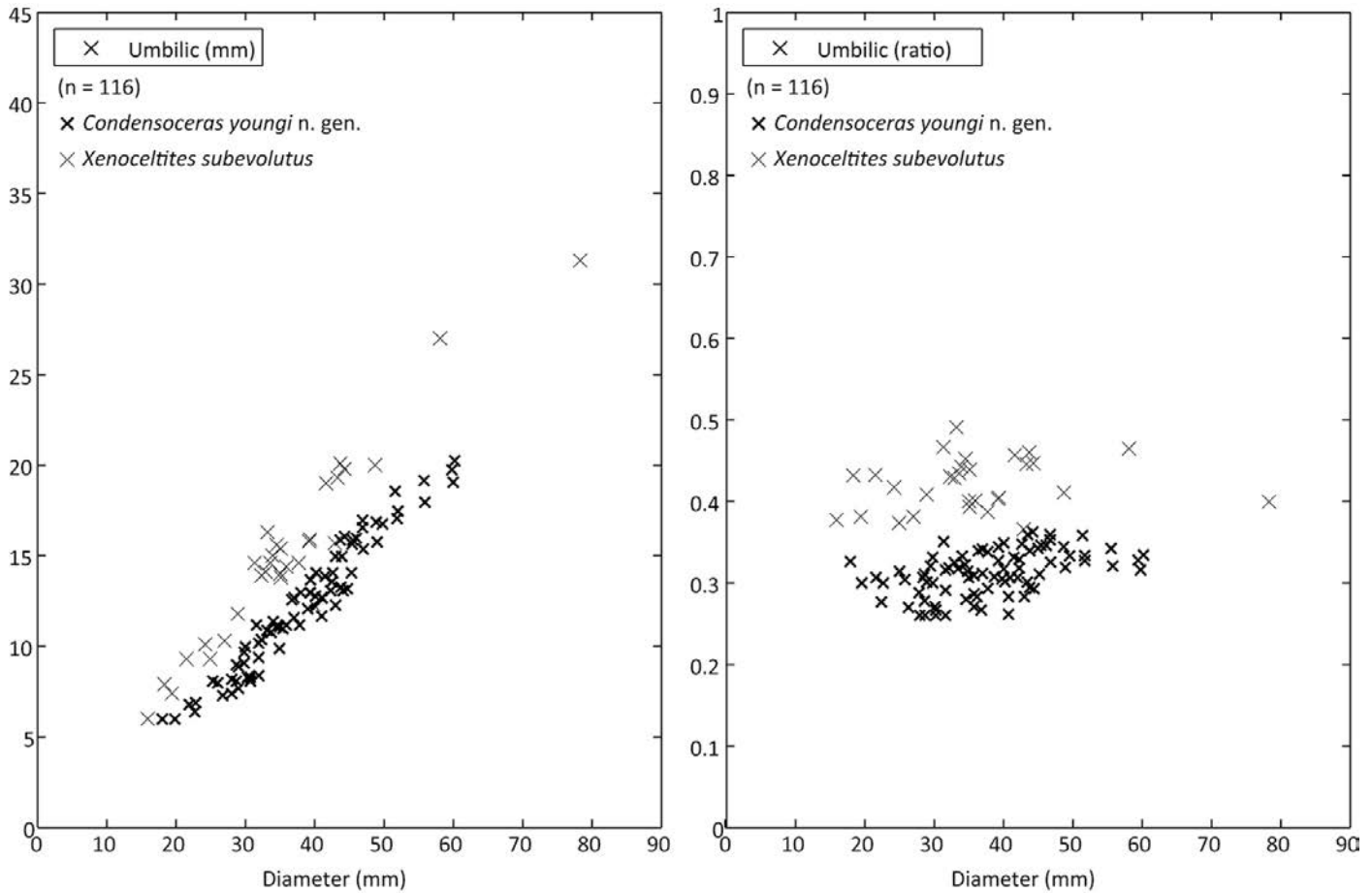


FIGURE 19. Scatter diagram comparison of U and U/D for *Condensoceras youngi* n. gen. (n = 86, all from *C. y.* interval) vs. *Xenoceltites subevolutus* (n = 32: 23 specimens from *C. y.* interval and 9 from *A. m.* interval).

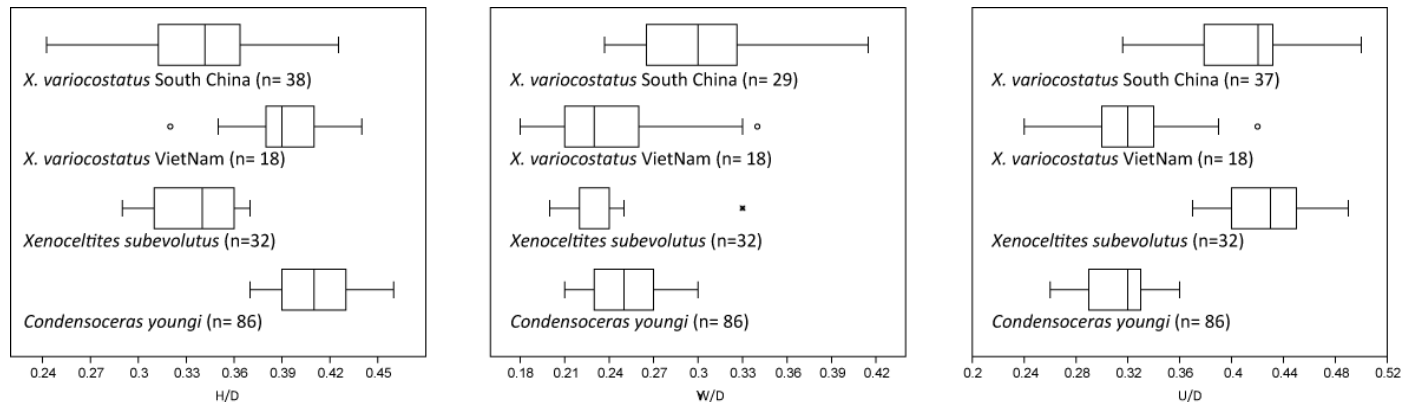


FIGURE 20. Box plot comparison of H/D, W/D and U/D for *Condensoceras youngi* n. gen. (n = 86) and *Xenoceltites subevolutus* (n = 32) from Crittenden Springs, and specimens of *Xenoceltites variocostatus* Brayard and Bucher from South China and Vietnam.

?1913 *Xenodiscus* cf. *lissarensis* Diener, p. 5, pl. 1, fig. 11.
 1913 *Xenodiscus aequicostatus* Diener, p. 6, pl. 2, fig. 10.
 1913 *Xenodiscus salomonii* Diener, p. 7, pl. 2, fig. 5.
 1913 *Xenodiscus althothae* Diener, p. 8, pl. 2, figs. 6, 11.
 1913 *Xenodiscus* cf. *ellipticus* Diener, p. 9, pl. 3, fig. 1.
 1913 *Xenodiscus comptoni* Diener, p. 10, pl. 2, fig. 7.
 ?1913 *Xenodiscus* cf. *rotula* Waagen, Diener, p. 11, pl. 3, fig. 2.
 1913 *Xenodiscus* cf. *ophioneus* Waagen, Diener, p. 12, pl. 2, figs. 8-9.
 ?1913 *Xenodiscus* cf. *sitala* Diener, p. 14, pl. 3, fig. 3.
 1966 *Xenoceltites sinuatus* Waagen, Kummel, p. 389, pl. 1, figs. 1-2.

?1966 *Xenoceltites sinuatus* Waagen, Kummel, p. 389, pl. 1, figs. 3-4.
 1978 *Xenoceltites pulcher* Guex, p. 112, pl. 7, fig. 8.
 2010a *Glyptophraceras sinuatum* (Waagen), Brühwiler et al., p. 409, fig. 6: 1-7.
 2012b *Glyptophraceras sinuatum* (Waagen), Brühwiler and Bucher, p. 34, figs. 24AH-AO, 26A-T.
 2012c *Glyptophraceras sinuatum* (Waagen), Brühwiler et al., p. 134, fig. 13AB-AK.

Material: Seven measured specimens - all are illustrated (2551C, 2146C, 250C, 2548C, 2549C, 2547C and 2546C).

Description: Fairly small sized, fairly evolute, compressed

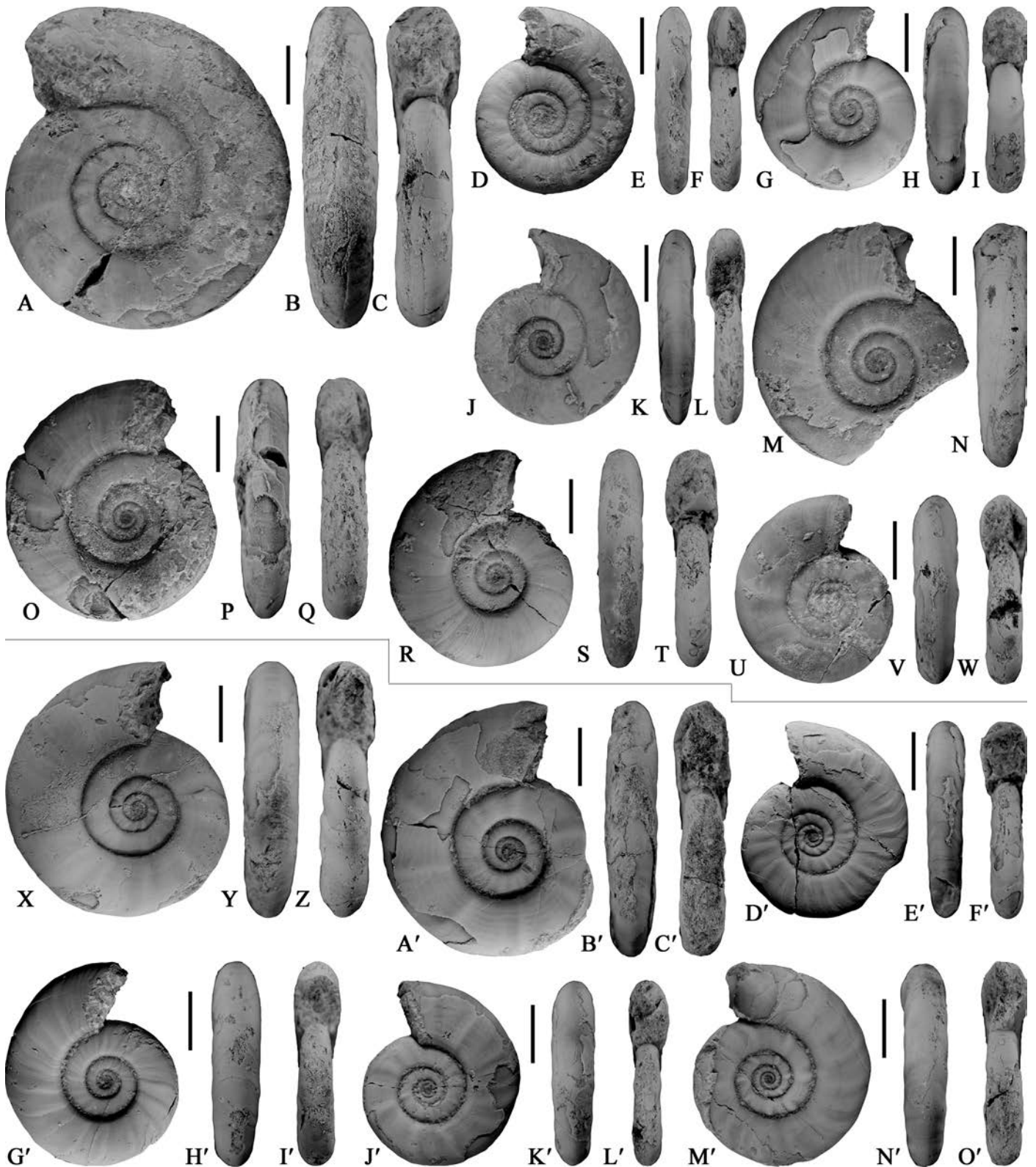


FIGURE 21. **A-W**, *Xenocelites subevolatus* Spath, *C. y.* **A-C**, 2543C-2, 5-76, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2543C-17, 5-76, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2543C-3, 1-88, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2543C-8, 13-75, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-N**, 2543C-6, 5-76, in **M**, lateral and **N**, ventral views. **O-Q**, 2543C-13, 13-75, in **O**, lateral, **P**, ventral and **Q**, apertural views. **R-T**, 2543C-14, 1-88, in **R**, lateral, **S**, ventral and **T**, apertural views. **U-W**, 2543C-12, 13-75, in **U**, lateral, **V**, ventral and **W**, apertural views. **X-O'**, *X. subevolatus* Spath, from a single *A.m.* lense, 5-76, in **X-Z**, 2138C, in **X**, lateral, **Y**, ventral and **Z**, apertural views. **A'-C'**, 2139C, in **A'**, lateral, **B'**, ventral and **C'**, apertural views. **D'-F'**, 2144C, in **D'**, lateral, **E'**, ventral and **F'**, apertural views. **G'-I'**, 2141C, in **G'**, lateral, **H'**, ventral and **I'**, apertural views. **J'-L'**, 2142C, in **J'**, lateral, **K'**, ventral and **L'**, apertural views. **M'-O'**, in 2140C, in **M'**, lateral, **N'**, ventral and **O'**, apertural views. All scale bars = 1 cm.

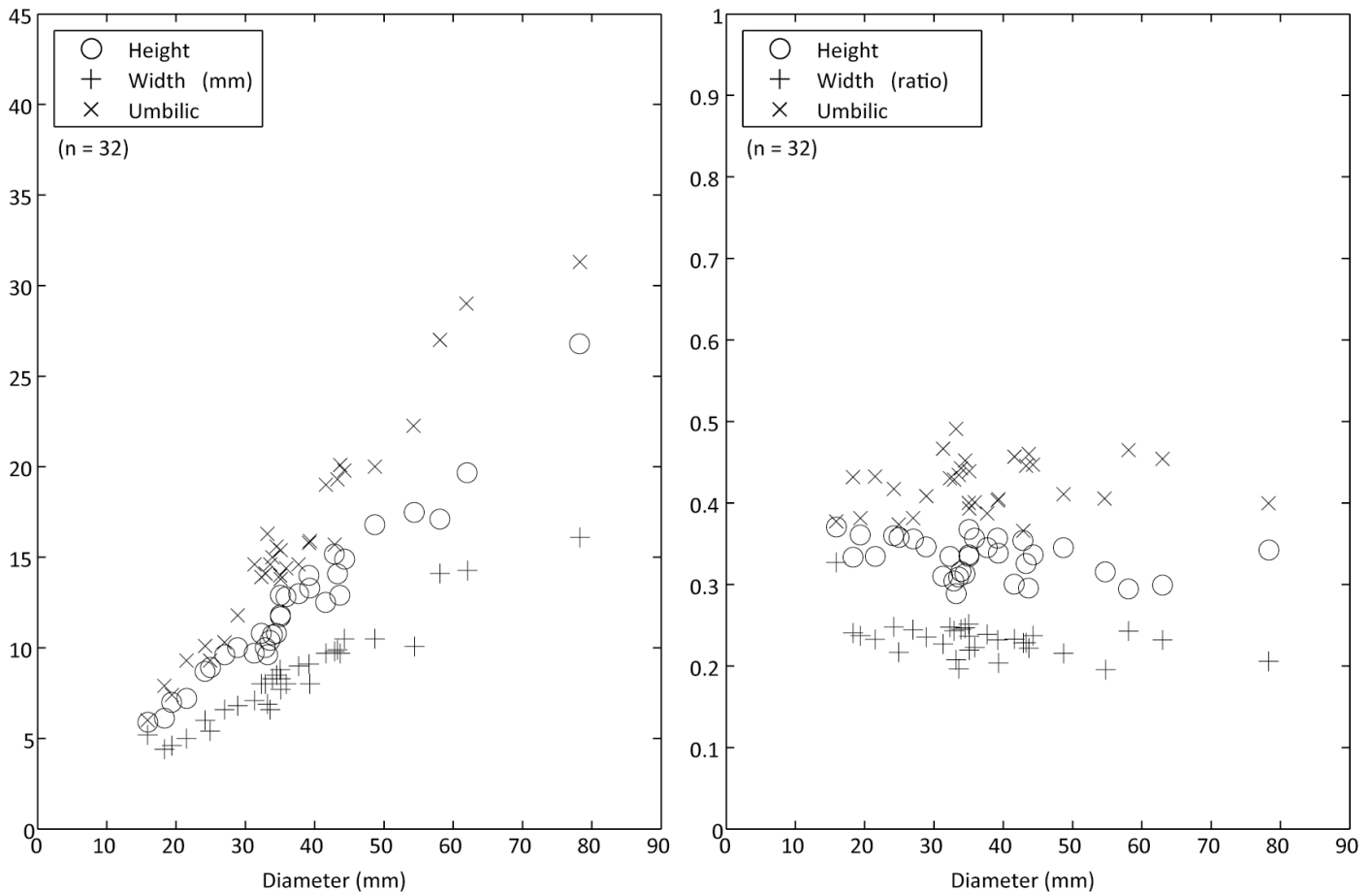


FIGURE 22. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Xenoceltites subevolutus*. (23 specimens from *C. y.* interval and 9 from *A. m.* interval).

shell characterized by near-serpenticonic coiling, with whorls embracing about one third or less of preceding whorl. Flanks nearly parallel but slightly convex, converging without distinct shoulders to narrowly rounded to arched venter. Whorl section varies from ovoid to sub-rectangular with maximum width at about 45% of height. Umbilicus moderately wide and fairly shallow, with steeply inclined wall and well-rounded shoulders. Ornamentation highly variable—inner whorls bear distant, radial to prosiradiate ribs that vary greatly in strength from specimen to specimen. Adult whorls exhibit extremely variable ribbing that ranges from distant, strong and concave to dense, weak and slightly prosiradiate or sinuous. Ribs on some adult specimens form very strong, obvious projection at ventral shoulder. Ribs generally fade above ventral shoulder, but some cross venter in greatly diminished strength. Faint, dense growth lines more or less parallel to ribbing visible on well-preserved specimens. Suture lines not exposed on present specimens.

Measurements: See Figure 24 and APPENDIX, p. 139.

Discussion: According to Brühwiler et al. (2010a, 2012b), *Glyptophraceras sinuatum* exhibits an extremely wide range of intraspecific variation, and the same observation is generally true for our specimens (Fig. 24). For all practical purposes, the shell parameters and coiling geometry of the present *G. cf. G. sinuatum* specimens are very similar to those of *Xenoceltites subevolutus* from Crittenden Springs, and it can be difficult to differentiate among some of the smooth variants of these taxa. However, as stated by Brühwiler et al. (2010a), the distinctively stronger ornamentation exhibited by most specimens of *G. sinuatum* supposedly sets it apart, and the same observation holds true for our material, even though the ribbing on most specimens is not as strong as that of the illustrated specimens

from the Salt Range and Spiti (Brühwiler et al., 2012b, 2012c). The ribs on some of our more robustly ornamented specimens (e.g., Fig. 23G-I, M-N, Q-R) exhibit a strong projection on the ventral shoulder, similar to the Salt Range and Spiti material, but it is not as obvious when viewed ventrally as in the Tethyan specimens. This strong forward projection is generally not seen on the more robust *X. subevolutus* specimens, whose ribs tend to cross the venter in a more radial direction. We utilized the same ornamental characteristic to differentiate among the smoother variants of the taxa, but admittedly, this method is problematic. Indeed, the intraspecific overlap between smooth variants of both taxa is real. Considerably more material would be needed from all locations in order to explore the hypothesis of a single large group. We prefer to avoid a firm assignment of our specimens to *G. sinuatum* primarily because of their somewhat weaker ornamentation as compared to the Tethyan material.

Occurrence: *Glyptophraceras cf. G. sinuatum* is rare at Crittenden Springs and occurs only in the *C. youngi* n. gen. interval. This is the first report of the taxon in the western USA.

Superfamily MEEKOCERATAEAE Waagen, 1895

Family PROPTYCHITIDAE Waagen, 1895

Genus *Pseudaspidites* Spath, 1934

Type species: *Aspidites muthianus* Krafft and Diener, 1909

***Pseudaspidites silberlingi* Jenks et al., 2010**

Figures 25, 26A-I

2010 *Pseudaspidites silberlingi* Jenks et al., p. 10, fig. 8A-I, fig. 9A-H.

Material: 10 measured specimens, including type series (four specimens). Illustrated specimens include holotype (NMMNH P-51301), 2537C, 694C, 2123C, 693C and paratype

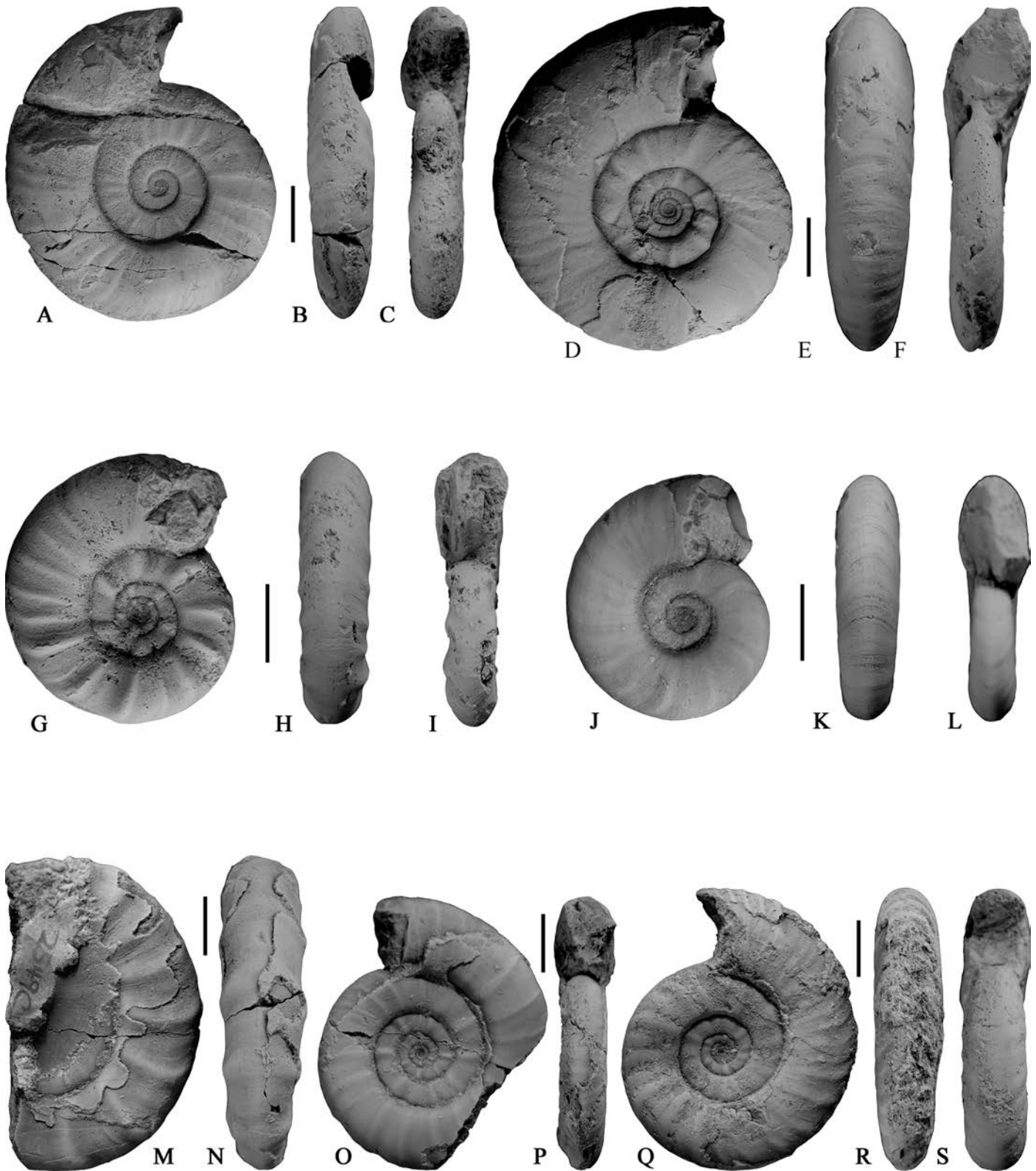


FIGURE 23. *Glyptophiceras* cf. *G. sinuatum* (Waagen), *C. y.* **A-C**, 2146C, 5-76, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2551C, plaster cast) in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 250C, 5-76, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2548C, 13-75, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-N**, 2549C, 5-76, in **M**, lateral and **N**, ventral views. **O-P**, 2547C, 5-76, in **O**, lateral and **P**, apertural views. **Q-S**, 2546C, 1-88, in **Q**, lateral, **R**, ventral, and **S**, apertural views. All scale bars = 1 cm.

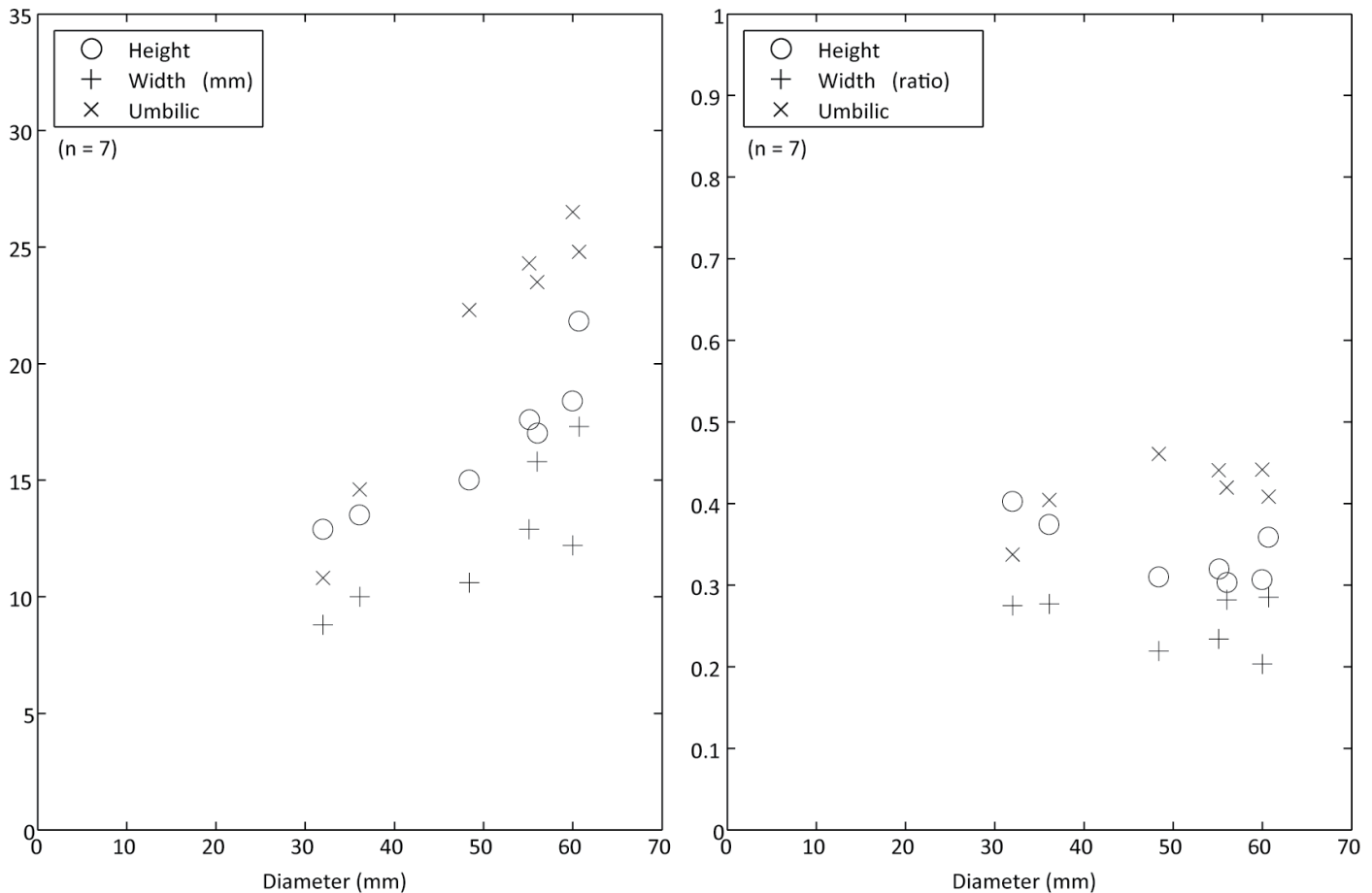


FIGURE 24. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Glyptophiceras* cf. *G. sinuatum*. All specimens from *C. y.* interval.

(NMMNH P-60166).

Description: Large sized, fairly involute, compressed, high whorled platycone with highly arched venter without distinct ventral shoulders. Whorl expansion rate usually quite high (2.6–2.75) with slight egressive coiling present on some specimens. Flanks very broadly convex, nearly parallel with maximum whorl width at ~ mid flank, forming flattened ellipsoidal whorl section. Body chamber length unknown, specimens at hand are phragmocones. Umbilicus narrow but somewhat variable in width (U/D ranges from 0.16 to 0.24, Fig. 27), with abruptly rounded shoulders and high, nearly vertical wall on inner whorls of phragmocone, becoming slightly less steep and somewhat more evolute on mature phragmocone whorls. Ornamentation consists of fine but distinctive rursiradiate growth lines that arise on umbilical wall, cross shoulder and then become radial to slightly sinuous on flank before crossing venter in straight line. Faintly visible strigation on flanks, and venter combines with growth lines to form delicate reticulate sculpture. Some growth lines form very low intensity, fold-like ribs on mid-flank. Suture line ceratitic with slightly asymmetrical saddles bending toward the umbilicus, some of which exhibit phylloid characteristics, and a long auxiliary series.

Measurements: See Figure 27 and APPENDIX, p. 140.

Discussion: *Pseudaspidites silberlingi* exhibits a fairly wide variation in coiling geometry as demonstrated by the difference in values for the degree of involution (H/U ranges from 1.98 to 3.45). This divergence, which becomes readily apparent upon examination of the specimens illustrated in Figure 25 (see also scatter diagrams in Fig. 27), is partially due to egressive coiling and would probably even be greater if the body chambers were preserved. *Pseudaspidites silberlingi* differs from the type

species by its more compressed conch, slightly less involute coiling and somewhat less complex suture line. Kummel and Steele (1962) erected a new taxon, *P. wheeleri*, with the type series based on Smith's *Clypeoceras muthianum* (Krafft) specimens from southeastern Idaho (Smith, 1932, pl. 27, figs. 1-6) and a very poorly preserved specimen from Crittenden Springs. *Pseudaspidites silberlingi* differs from these specimens by its much more evolute coiling and less complex suture line. Finally, *P. silberlingi* differs from the following taxa by the same features: *P. planus* from Oman (Brühwiler et al., 2012a), *P. muthianus* from South China (Brayard and Bucher, 2008), *Spiri* (Brühwiler et al., 2012c) and northeastern Viet Nam (Shigeta and Nguyen, 2014); and from *P. cf. P. muthianus* from Oman (Brühwiler et al., 2012a) and the Salt Range (Brühwiler et al., 2012b).

Occurrence: *Pseudaspidites silberlingi*, which is relatively rare, is found only in the *C. jattioti* n. gen., n. sp. and *P. toulai* intervals.

Genus *Guodunites* Brayard and Bucher, 2008
Type species: *Guodunites monneti* Brayard and Bucher, 2008

***Guodunites* cf. *monneti* Brayard and Bucher, 2008**
Figure 26J-M

2008 *Guodunites monneti* Brayard and Bucher, p. 83, pl. 44, figs. 1-2.

2010 *Guodunites* cf. *monneti* Brayard and Bucher, Jenks et al., p. 10, fig. 6E-H only, not figs. 6A-D, 7A-C, D-F.

2017 *Guodunites monneti* Brayard and Bucher, Jattiot et al., p. 18, pl. 4, figs. A-K.

Material: One measured specimen, 2000C (illustrated).

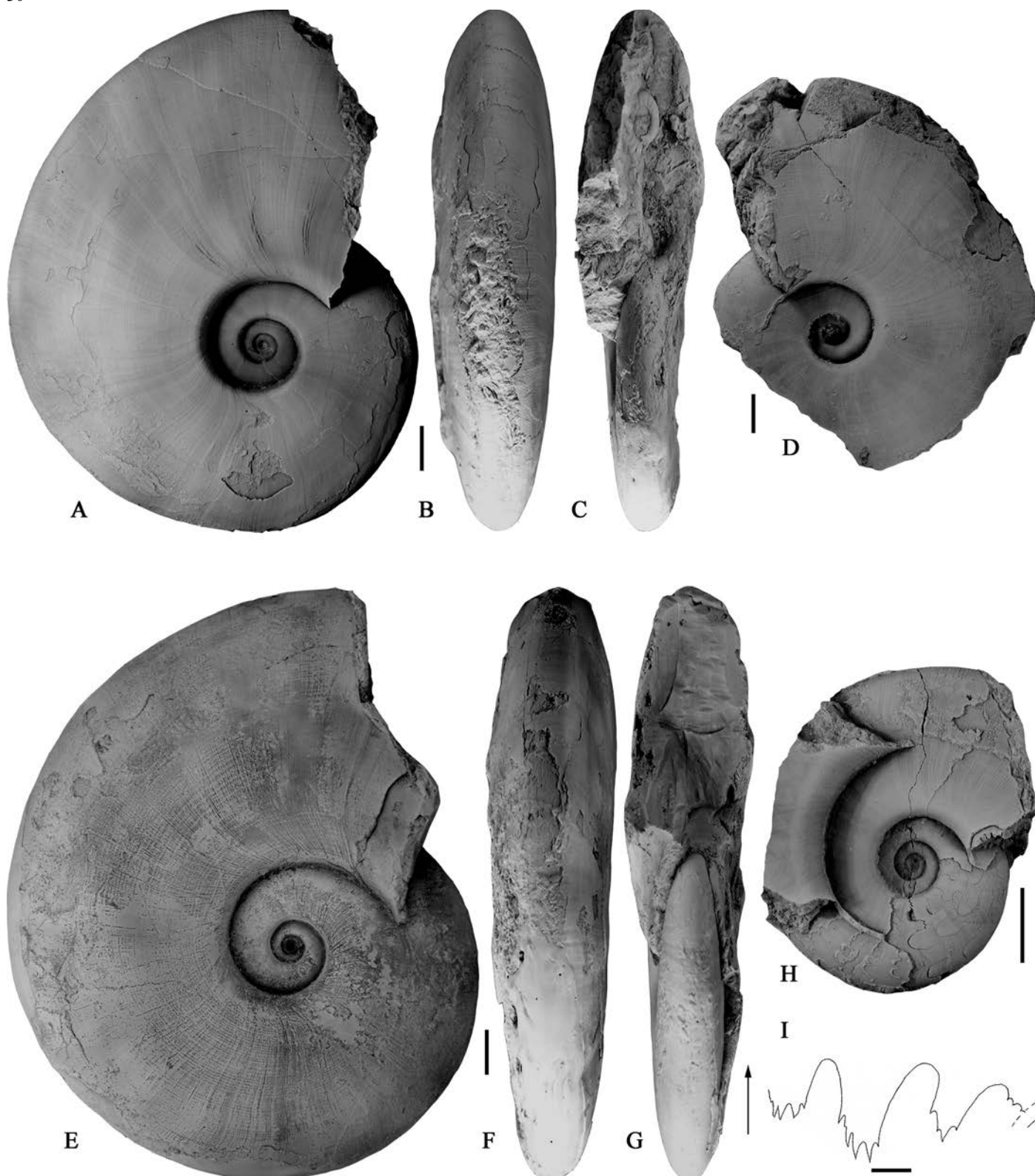


FIGURE 25. *Pseudaspidites silberlingi* Jenks et al. **A-C**, NMMNH P-51301, holotype, 13-75, *P. t.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D**, 2537C, 8-15, *C. j.*, in **D**, lateral view. **E-G**, 694C, 1-88, *P. t.*, in **E**, lateral **F**, ventral and **G**, apertural views. **H**, 2123C, 5-76, *P. t.*, in **H**, lateral view. **I**, suture line, 694C, H = 6.9, cm, 1-88, *P. t.* All scale bars = 1 cm.

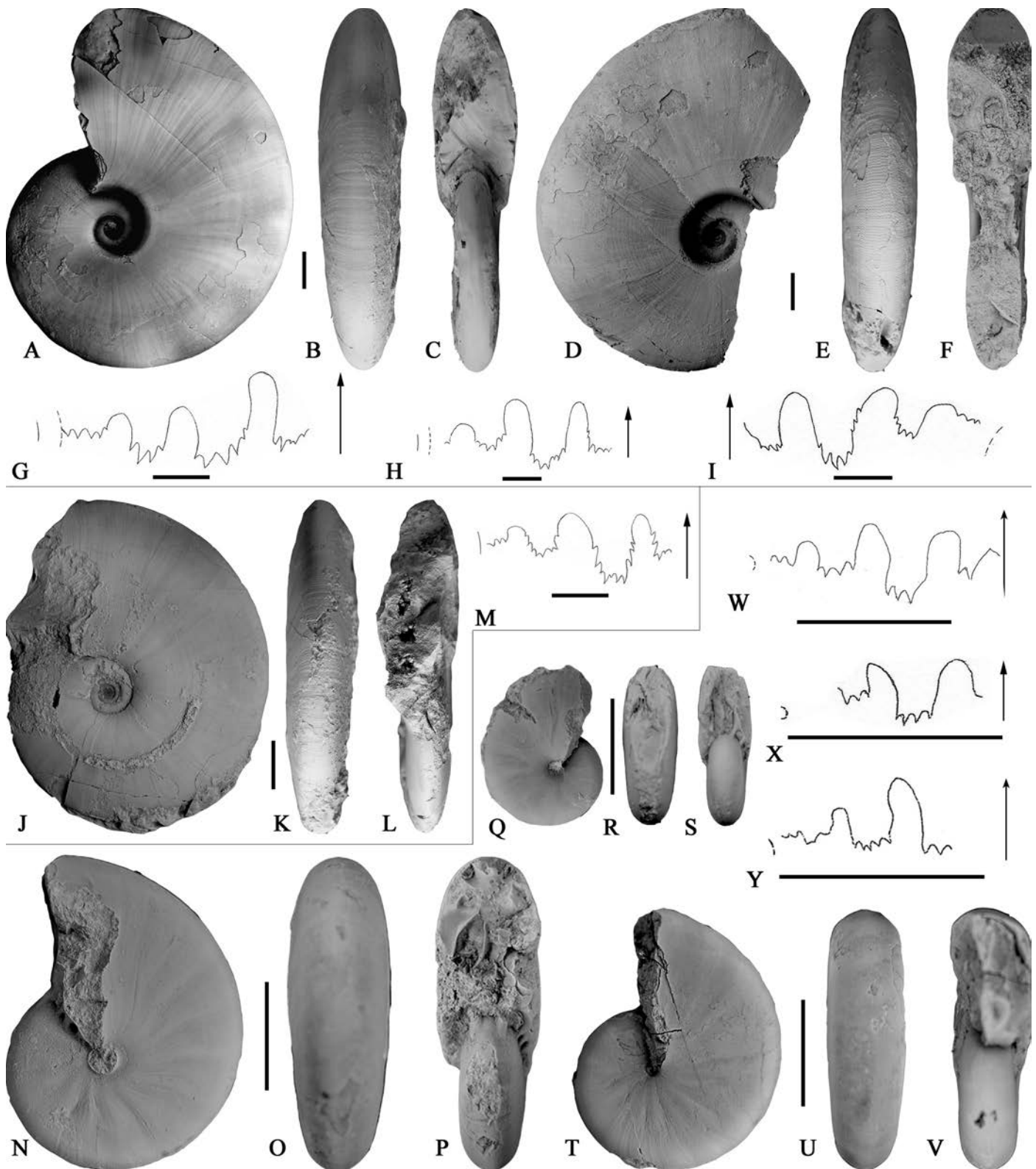


FIGURE 26. **A-I**, *Pseudaspidites silberlingi* Jenks et al. **A-C**, 693C, 1-88, *C. j.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, NMMNH P-60166, paratype, 5-76, *C. j.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, suture lines, in **G**, P-51301, holotype, H = 4.85 cm, 13-75, *P. t.* **H**, 1999C, H = 5.4 cm, 5-76, *P. t.* **I**, 2135C, H = 4.1 cm, 5-76, *C. j.* **J-M**, *Guodunites* cf. *G. monneti* Brayard & Bucher, 2000C, 1-88, *C. j.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M**, suture line, 2000C, H = 3.55 cm. **N-Y**, *Gambleites eichhorni* n. gen., n. sp., 5-76, *G. l.* **N-P**, NMMNH P-79155, holotype, in **N**, lateral, **O**, ventral and **P**, apertural views. **Q-S**, NMMNH P-79157, paratype, in **Q**, lateral, **R**, ventral and **S**, apertural views. **T-V**, NMMNH P-79156, paratype, in **T**, lateral, **U**, ventral and **V**, apertural views. **W-Y**, suture lines, in **W**, NMMNH P-79155, H = 1.6 cm. **X**, NMMNH P-79157, H = 0.9 cm. **Y**, 2246C, NMMNH P-79156, H = 1.0 cm. All scale bars = 1 cm.

Description: Medium sized, moderate to fairly involute, very compressed shell with narrowly rounded venter without discernable shoulders and convex flanks with maximum width at about 40-45% of whorl height. Convexity of flank increases more rapidly near umbilicus, meeting seam without perceptible shoulders at angle varying from quite steep on juvenile whorls to relatively low on mature whorls. Umbilicus varies from shallow on adolescent whorls to somewhat crateriform on juvenile whorls. Mature whorl missing, but trace of its umbilical seam indicates considerable egressive coiling. Body chamber length unknown, specimen is entirely phragmocone. Ornamentation consists of very fine strigation and fine, slightly biconcave growth lines projecting forward slightly near venter. Strigation and growth lines combine to form very fine, delicate reticulate sculpture. Suture line ceratitic, but approaching near sub-ammonitic in complexity with moderately indented lobes and indentations partially ascending sides of saddles; less complex than specimens from South China and Oman.

Measurements: See APPENDIX, p. 140.

Discussion: *Guodunites* cf. *G. monneti* is extremely rare at Crittenden Springs, and its recognition is complicated by its relatively close morphological similarity to *Anaflemingites silberlingi* in terms of whorl section and general conch shape. Ongoing work has resulted in an improved understanding of the intraspecific variation of *A. silberlingi*, and, consequently, three of the specimens assigned to *Guodunites* cf. *G. monneti* in Jenks et al. (2010, figs. 6A-D, 7A-C, D-F) have been placed in synonymy with *Anaflemingites silberlingi*. The present specimen's morphology is reasonably close to specimens of *G. monneti* from the type area in South China (Brayard and Bucher, 2008) and from Oman (Brühwiler et al., 2012a), but differs by its somewhat less crateriform umbilical region, more narrowly rounded venter, more egressive coiling of its mature whorl, lack of distinctive radial lirae and slightly less complex suture line.

Occurrence: Present specimen was collected from the *C. jattioti* n. gen. n. sp. interval.

Genus *Gambleites* n. gen.

Type species: *Gambleites eichhorni* n. sp.

Composition of the genus: Type species only.

Etymology: Named for the Gamble Ranch, located about 11 km north of Montello, Nevada.

Diagnosis: Small, extremely involute, compressed proptychitid with slightly convex flanks, nearly occluded umbilicus, near circular venter and flattened ellipsoidal whorl section with maximum width at about 40% of whorl height. Ornamentation includes only barely perceptible, sinuous, fold-type ribs arising above umbilical shoulder and fading completely high on flank.

Discussion: *Gambleites* n. gen. is morphologically similar to *Xiaoqioceras involutus* Brayard and Bucher (2008) from South China, and, were it not for its completely different suture line, it conceivably could be placed within *Xiaoqioceras* as a new species. However, its suture line is far more representative of true Proptychitidae than that of *X. involutus*, which is rather simple with its small saddles, broadly denticulated lobes and broad trifid first lateral lobe. Aside from its suture line, *Gambleites eichhorni* n. gen., n. sp. only differs from *X. involutus* from South China by the slightly lower expansion rate of its whorl width. Similarly, specimens of *X. involutus* from Spiti, its only other reported Tethyan occurrence (Brühwiler et al., 2012c), also differ from *Gambleites eichhorni* n. gen., n. sp. by their more rapidly expanding whorl width as well as their slightly greater whorl height expansion rate. Interestingly, the simplified suture lines of both *Xiaoqioceras* species are nearly identical. *Gambleites eichhorni* n. gen., n. sp. differs from ?*Xiaoqioceras americanum* Brayard et al. (2013) from the Confusion Range of Utah by its significantly more involute coiling and its suture

line, which is more similar to that of the Tethyan taxa.

Gambleites eichhorni n. sp.

Figure 26N-Y

Type series: Three specimens: Holotype, specimen NMMNH P-79155 (Fig. 26N-P); paratypes, two specimens: NMMNH P-79156 (Fig. 26T-V), NMMNH P-79157 (Fig. 26Q-S). Type specimens deposited in the NMMNHS.

Etymology: Named in honor of Larry C. Eichhorn of Lewistown, Montana.

Diagnosis: As for the genus.

Description: Small, extremely involute, compressed proptychitid with nearly parallel but slightly convex flanks and nearly circular venter without distinct shoulders. Flattened ellipsoidal whorl section with maximum whorl width at about 40% of whorl height. Flank contour nearly flat from top of umbilical shoulder to point of maximum whorl width, then very slightly convex to about 90% whorl height, then converges rapidly to circular venter. Umbilicus very small, nearly occluded with near vertical wall and abruptly rounded shoulder. Ornamentation consists only of dense, very weak, nearly imperceptible, sinuous, fold-type ribs arising above umbilical shoulder and fading completely at 80-85% whorl height. Growth lines not apparent. Suture line ceratitic, typical of proptychitids with asymmetrical saddles turned slightly towards umbilicus and a relatively long auxiliary series.

Measurements: See APPENDIX, p. 140.

Discussion: As for the genus.

Occurrence: *Gambleites eichhorni* n. gen., n. sp., which is very rare at Crittenden Springs, has been found only in the *G. lucasi* interval.

Family Galfettitidae Brühwiler and Bucher, 2012

Genus *Galfettites* Brayard and Bucher, 2008

Type species: *Galfettites simplicitalis* Brayard and Bucher, 2008

Galfettites lucasi Jenks et al., 2010

Figure 28A-N

2007 *Anaflemingites silberlingi* Kummel and Steele, Jenks et al., p. 40, pl. 1, figs. A-B.

2010 *Galfettites lucasi* Jenks et al., p. 15, figs. 12A-C, D-G; 13A-D, E-H, I-J.

Material: Five measured specimens, including type series (three specimens). Illustrated specimens include 90C, holotype (NMMNH P-60170), paratype (NMMNH P-60171) and 2021C.

Description: Fairly large, very evolute, very compressed shell with narrow, tabulate venter, subangular ventral shoulders and gently convex flanks. Whorl section sub-rectangular with maximum width at about one half of whorl height. Flank contour very gently convex, nearly parallel from top of umbilical shoulder to point of maximum width, then gradually converges toward narrow venter. Wide, shallow umbilicus with low, nearly perpendicular wall on juvenile whorls, becoming slightly less steep on ultimate whorl. Body chamber length unknown, present specimens are phragmocones. Ornamentation consists only of fairly dense, barely perceptible, slightly sinuous, radial folds that arise just above umbilical shoulder, project forward slightly on more tapered portion of flank and fade completely just below ventral shoulder. Suture line ceratitic with moderately wide lobes and narrow, somewhat tapered saddles. Second lateral saddle asymmetrical, turned slightly toward umbilicus.

Measurements: See Figure 29 and APPENDIX, p. 140.

Discussion: Brayard and Bucher (2008) erected the new taxon *Galfettites simplicitalis* based on a few large but somewhat poorly preserved, very compressed and evolute, morphologically unique specimens from South China, which they placed in the Flemingitidae because of their similarity in shape to certain members of the family, such as *Rohillites*. Then,

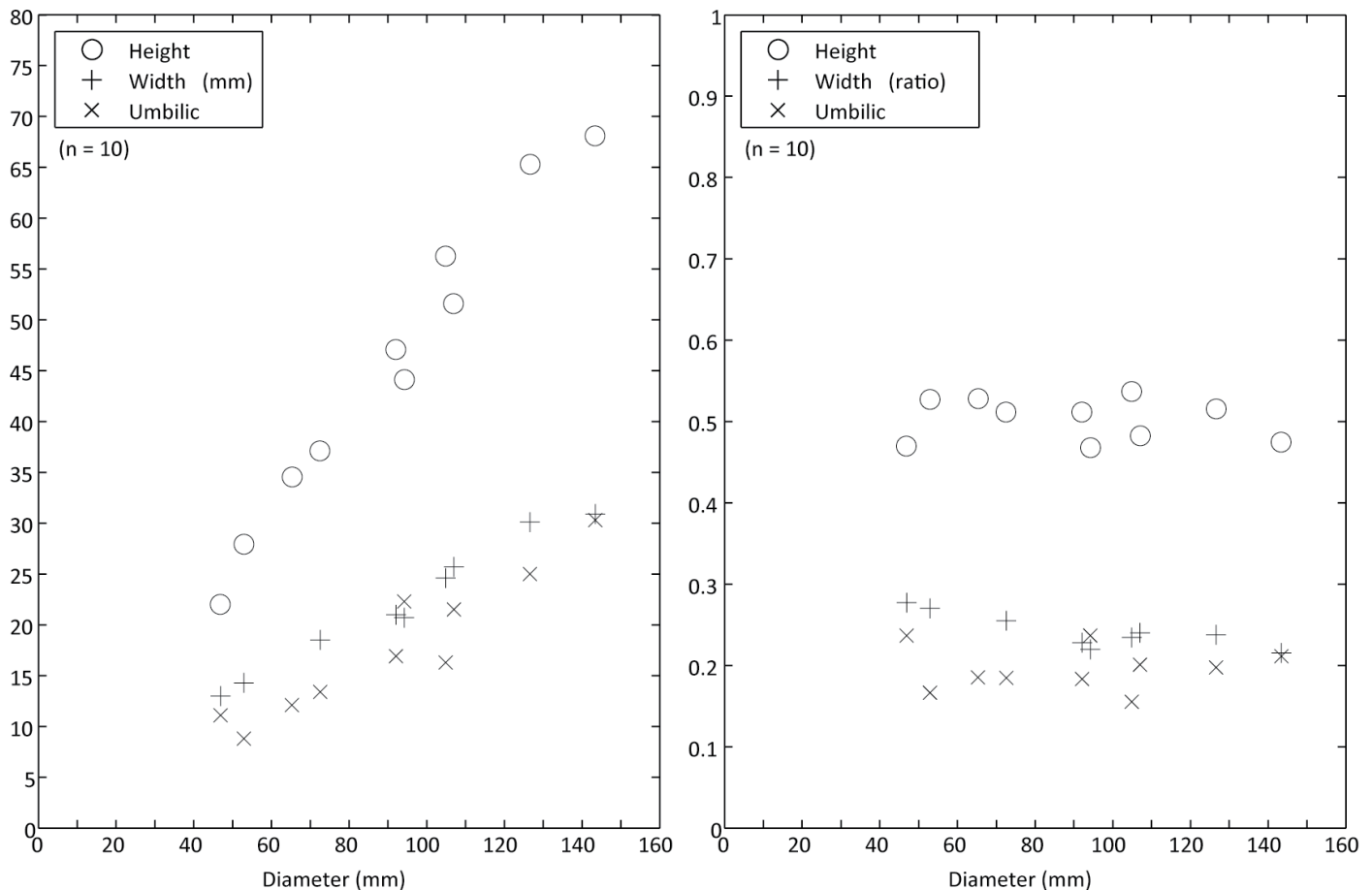


FIGURE 27. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Pseudaspidites silberlingi*. All specimens from *P. t.* and *C. j.* intervals.

Brühwiler et al. (2012a) discovered well preserved material in Oman, some of which enabled them to clarify the description of *G. simplicitatis*, while other specimens led to description of two new species of *Galfettites* as well as a new related genus, *Safraites*. More importantly, the new Oman material together with new collections from Pakistan (Brühwiler et al., 2012b), demonstrated a lack of affinity with the Flemingitidae and instead, led Brühwiler et al. (2012a) to erect a new family, the Galfettitidae, to which they also assigned several other previously described taxa (see Brühwiler et al., 2012a for composition of the family). Different species of *Galfettites* all share a similar compressed, evolute shell geometry, and most share a suture line that includes a distinctive trigonal second lateral saddle. Interestingly, as seen in Figure 29, the five *G. lucasi* specimens maintain nearly the same proportions of shell geometry over their relatively large size range. Although the trans-Panthalassic taxon *Galfettites lucasi* is morphologically very similar to *G. simplicitatis*, it differs by its slightly more involute coiling and its ornamentation consisting of barely perceptible, fairly dense, slightly sinuous, radial folds, which are in subtle contrast with the delicate concave folds of the type species. Perhaps most importantly, the suture line of *G. lucasi*, while similar to that of the type species, does not include a trigonal second lateral saddle.

Occurrence: *Galfettites lucasi* is rare at Crittenden Springs, occurring only in the *G. lucasi* interval.

Genus *Montelloites* n. gen.

Type species: *Montelloites stephensi* n. sp.

Composition of the genus: Type species only.

Etymology: Named for the nearby community of

Montello, Nevada.

Diagnosis: Small, very compressed, moderately evolute Galfettitidae with slightly convex, nearly parallel flanks for almost entire height of whorl, tabulate venter, sub-angular ventral shoulders and fairly shallow umbilicus with abruptly rounded shoulders. Maximum whorl width at about 35% of whorl height. Ornamentation consists only of very weak but fairly dense, radial fold-type ribs arising just above umbilical shoulder and fading just below ventral shoulder.

Discussion: Although *Montelloites* n. gen. shares some of the diagnostic characteristics of the genus *Galfettites*, we here set it apart as a new genus because it exhibits subtle but significant differences in shell geometry, and its suture line is quite different. *Montelloites stephensi* n. gen., n. sp. is more involute, and its whorl section is characterized by very gently convex, nearly parallel flanks for almost the entire height of its whorl. In contrast, the flanks of *Galfettites* taxa are nearly flat and parallel for only about 2/3 of their whorl height, after which they converge much more rapidly toward a distinctively narrower venter in relation to whorl width. Furthermore, most species of *Galfettites* exhibit a distinctively tapered, trigonal-tipped 2nd lateral saddle, a feature not observed in *M. stephensi* n. gen., n. sp. However, the suture line of *M. stephensi* n. gen., n. sp., which is characterized by relatively high saddles and an asymmetrical 2nd lateral saddle tilted toward the umbilicus, still fits well within the galfettitids.

Montelloites stephensi n. sp.

Figure 28O-V

?2012a Galfettitidae gen. indet. Brühwiler et al., p. 29, pl. 16, figs. 2a-d.

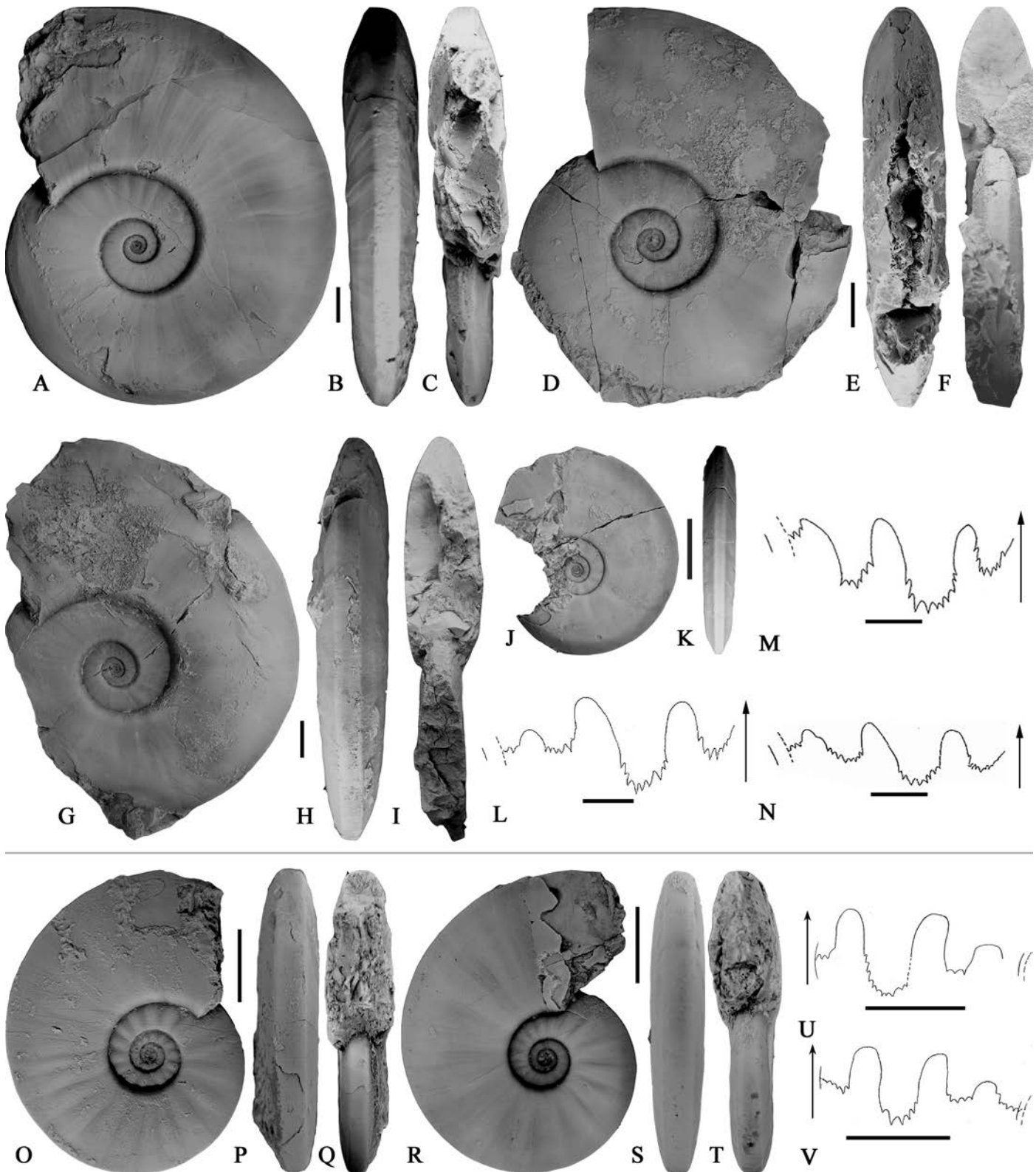


FIGURE 28. **A-N**, *Galfettites lucasi* Jenks et al., *G. l.* **A-C**, 90C, 13-75, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, NMMNH P-60170, holotype, 1-88, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, NMMNH P-60171, paratype, 13-75, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-K**, 2021C, (juvenile specimen), 5-76, in **J**, lateral and **K**, ventral views. **L-N**, suture lines in **L**, P-60171, H = 4.9 cm, 13-75. **M**, P-60170, H = 4.0 cm, 1-88. **N**, NMMNH P-60172, paratype, H = 4.1 cm, 5-76. **O-V**, *Montelloites stephensi* n. gen., n. sp. **O-Q**, NMMNH P-79158, holotype, float, in **O**, lateral, **P**, ventral and **Q**, apertural views. **R-T**, NMMNH P-79159, paratype, 1-88, *G. l.*, in **R**, lateral, **S**, ventral and **T**, apertural views. **U-V**, suture lines in, **U**, NMMNH P-79158, H = 1.9 cm. **V**, NMMNH P-79159, H = 1.7 cm. All scale bars = 1 cm.

?2012c ?*Galfettites* sp. indet. Brühwiler et al., p. 137, figs. 15AO-BI.
 2017 ?*Galfettites* sp. indet., Jattiot et al., p. 40, pl. 18, figs. P-AE.

Type series: Two specimens: Holotype, specimen NMMNH P-79158 (Figure 28O-Q, U); paratypes, one specimen: NMMNH P-79159 (Figure 28R-T, V).

Etymology: Named in honor of Daniel A. Stephen, Utah Valley University, Orem, Utah.

Diagnosis: As for the genus.

Description: Small sized, moderately evolute, very compressed platyconic shell with tabulate venter, subangular ventral shoulders and sub-quadrate whorl section with maximum width at about 35% of whorl height. Flanks very slightly convex, almost parallel for nearly entire height of whorl, after which they gently converge to venter that is significantly wider in relation to whorl width than that of *Galfettites*. Umbilicus shallow and fairly narrow with very steep wall and abruptly rounded shoulder. Ornamentation consists of fairly dense but very weak, radial fold-type ribs arising just above umbilical shoulder and fading rapidly before reaching ventral shoulder. Paratype exhibits very fine, faintly visible growth lines following same trajectory as fold-type ribs. Suture line ceratitic with high saddles, wide 1st lateral lobe and asymmetrical 2nd lateral lobe tilted towards the umbilicus.

Measurements: See APPENDIX, p. 140.

Discussion: Specimens recently described as ?*Galfettites* sp. indet. by Jattiot et al. (2017) from the upper part of UA Zone 4 at Palomino Ridge, Nevada appear to be very similar to *M. stephensi* n. gen., n. sp. in terms of size, whorl section, overall conch shape and suture line. Some of the illustrated specimens may be slightly more involute, but on average, they are nearly indistinguishable from the Crittenden Springs specimens. Hence, we herein synonymize them with *M. stephensi* n. gen., n. sp. A single specimen from Oman illustrated as *Galfettitidae* gen. indet. by Brühwiler et al. (2012a, p. 29, pl. 16, fig. 2a-d) does not conform to *Galfettites* as outlined in the above discussion of the genus, but instead, is almost morphologically identical to the present specimens of *M. stephensi* n. gen., n. sp., the only difference being its slightly more involute coiling. This specimen, which is similar in size to the present specimens and with a comparable suture line, is therefore synonymized with *Montelloites stephensi* n. gen., n. sp. Likewise, six similarly sized specimens from Spiti, described as ?*Galfettites* sp. indet. by Brühwiler et al. (2012c, p. 137, fig. 15AO-BI), are nearly identical to the present specimens and are here synonymized with *M. stephensi* n. gen., n. sp.

Specimens of *Urdoceras tulongensis* Brühwiler et al. (2010a) from South Tibet and Spiti (Brühwiler et al., 2012c) are similar in shell geometry to *M. stephensi* n. gen., n. sp., but differ by their more inflated whorl sections. Specimens from Spiti illustrated as *Galfettites omani* (Brühwiler et al., 2012c) are also similar, but differ by their more inflated conch and more evolute coiling.

Occurrence: *Montelloites stephensi* n. gen., n. sp. is very rare. Only two specimens have been found; NMMNH P-79158 (holotype) found as float in scree below 5-76, NMMNH P-79159 (paratype) found in *G. lucasi* interval.

Family FLEMINGITIDAE Hyatt, 1900

Genus *Anaflemingites* Kummel and Steele, 1962

Type species: *Anaflemingites silberlingi* Kummel and Steele, 1962

Anaflemingites silberlingi Kummel and Steele, 1962

Figure 30E-L

1962 *Anaflemingites silberlingi* Kummel and Steele, p. 667, pl. 102, fig. 10.

2010 *Anaflemingites silberlingi* Kummel and Steele, Jenks et al., p. 23, figs. 14, 16-18.

2010 *Guodunites* cf. *G. monneti* Brayard and Bucher, Jenks et al., p. 10, figs. 6A-D, 7A-C, D-F.

2013 *Anaflemingites* aff. *silberlingi* Kummel and Steele, Brayard et al., p. 177, fig. 40a-c.

2017 *Anaflemingites* cf. *silberlingi* Kummel and Steele, Jattiot et al., p. 21, pl. 5, figs. AB-AI.

Material: 24 measured specimens. Includes two illustrated specimens (144C and 2121C).

Description: Fairly large, moderate to fairly evolute compressed shell with convex flanks and somewhat flattened elliptical whorl section with maximum width at ~ 50% of whorl height. Flank contour gradually inflates from umbilical shoulder to point of maximum whorl width and then converges more rapidly to venter, without distinct ventral shoulders. Venter varies from narrowly rounded on more compressed specimens to more broadly rounded on slightly inflated specimens. Wide, shallow umbilicus with low, gently sloped wall (~45°) on most specimens and broadly rounded shoulders. Slope angle increases slightly (~60°) and umbilical diameter decreases somewhat on a few more inflated specimens, but shoulder remains broadly rounded. Taxon exhibits fairly wide intraspecific variation in terms of umbilical diameter (Fig. 31). Body chamber length unknown, nearly all specimens are phragmocones. Ornamentation consists of fine strigation, whose intensity varies from barely perceptible on some specimens to very distinct but fine on others, together with slightly biconcave growth lines that combine to form a reticulate sculpture. On a few specimens, bundled growth lines form fairly dense, low intensity, slightly sinuous ribs that arise just above umbilical shoulder and fade high on flank. Suture line ceratitic with very broad, well indented first lateral lobe and relatively narrow saddles, with the first lateral saddle being especially narrow.

Measurements: See Figure 31 and APPENDIX, p. 141.

Discussion: Kummel and Steele (1962) did not illustrate ventral and apertural views of their new taxon *Anaflemingites silberlingi*, which they based on a single, somewhat weathered specimen. This failure to adequately illustrate the specimen (holotype) combined with their description of its ventral area as having rounded but well-marked ventral shoulders and a subtabulate venter, was the source of considerable confusion regarding the taxon. Jenks et al. (2010) examined and illustrated the holotype, which in fact has a narrowly rounded venter without discernable shoulders. See Jenks et al. (2010) for a thorough discussion of the taxon as well as *Anaflemingites russelli* (Smith) from southeastern Idaho.

Morphologically, *Anaflemingites silberlingi* and *A. russelli* are nearly identical, but *A. russelli* differs by its distinctive, coarser strigation, which is present on only a few specimens, and its suture line, which is fairly typical of *Flemingites* with its near symmetrical, well-rounded, nearly phylloid saddles that are more or less equal in width or slightly wider than the moderately indented lobes. *Anaflemingites hochulii* Brayard and Bucher differs from *A. silberlingi* by its subtabulate venter with abruptly rounded shoulders on its juvenile whorls, its less convex, nearly parallel flanks on mature specimens, its strigation that is present only near the venter, its much more conspicuous folds and growth lines and the significantly narrower lobes of its suture line (Brayard and Bucher, 2008). *Anaflemingites* aff. *A. silberlingi* from the Pahvant and Confusion Ranges, Utah (Brayard et al., 2013) primarily differs from *A. silberlingi* by the much wider ventral portion of its whorl and a lack of strigation.

Occurrence: *Anaflemingites silberlingi* is fairly common and occurs from the *M. gracilitatis* FA through the *I. oweni* intervals.

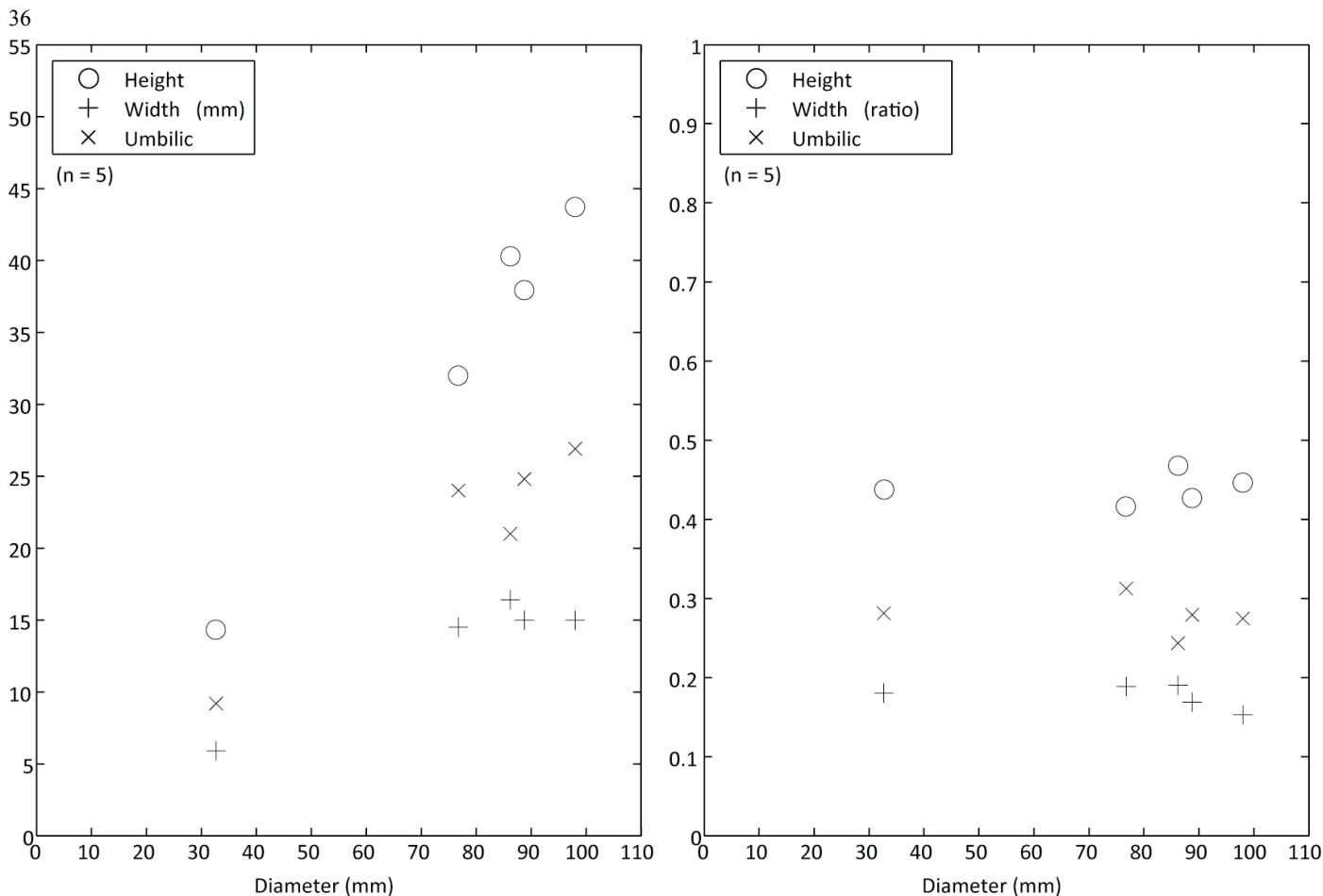


FIGURE 29. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Galfettites lucasi*. All specimens from *G. l.* interval.

Genus *Euflemingites* Spath, 1934

Type species: *Flemingites guyerdetiformis* Welter, 1922

Euflemingites cirratus (White), 1880

Figure 30A-D

- 1880 *Arcestes cirratus* White, p. 116.
 1932 *Flemingites cirratus* (White), Smith, p. 53, pl. 20, fig. 1, pl. 26, figs. 1-12.
 ?1947 *Flemingites prynadai* Kiparisova, p. 135, pl. 29, fig. 1, pl. 30, fig. 1, text-fig. 18.
 ?1954 *Flemingites prynadai* Kiparisova, Kiparisova and Krishtofovich, p. 18, pl. 8, fig. 1.
 1959 *Euflemingites tsotengensis* Chao, p. 209, pl. 5, figs. 1, 2.
 ?1961 *Flemingites prynadai* Kiparisova, Kiparisova, p. 76, pl. 15, fig. 1a-b, text-fig. 36.
 1967 *Euflemingites* cf. *cirratus* (White), Tozer, p. 19, 50, 74.
 1970 *Euflemingites* cf. *cirratus* (White), Korchinskaya, p. 82, pl. 2, fig. 1.
 1979 *Euflemingites cirratus* (White), Nichols and Silberling, p. B3, pl. 3, figs. 1-3.
 1982 *Euflemingites* cf. *cirratus* (White), Korchinskaya, pl. 5, fig. 1, pl. 6, fig. 3.
 1994 *Euflemingites cirratus* (White), Tozer, p. 72, pl. 22, fig. 13, pl. 23, figs. 4-5, 21b.
 ?2004 *Euflemingites* cf. *tsotengensis* Chao, Tong et al., p. 200, pl. 2, figs. 13-15.
 ?2007 *Euflemingites* sp., Krystyn et al., pl. 4, figs. 1-2.
 ?2009 *Euflemingites prynadai* Kiparisova, Shigeta and Zakharov, p. 100, figs. 87-90.
 2011 *Euflemingites cirratus* (White), Brühwiler et al., p. 197, pl. 2, figs. 1-4.
 ?2014 *Euflemingites* sp. indet., Shigeta and Nguyen, p. 98, fig.

68, 2.

Material: One very large, well preserved but somewhat laterally deformed specimen (321C, illustrated).

Description - Present specimen: Very large, fairly evolute, fairly compressed shell with nearly parallel flanks and near circular venter without discernable shoulders. Whorls nearly as broad as high, with W/H ranging from 0.93 to 0.97 on ultimate whorl. Moderately wide, deep umbilicus with near vertical wall and abruptly rounded shoulders. Body chamber length unknown, but at least one third whorl. Ornamentation consists of very coarse spiral ridges on entire shell as well as obvious rursiradiate to radial folds on inner coils, gradually fading in intensity until disappearing at ~50% of ultimate whorl. Spacing of spiral ridges varies gradually from very closely spaced at mid-venter to maximum spacing at umbilical shoulder. Number of spiral ridges from mid-venter to umbilical seam fairly constant at ~22 on ultimate whorl. Suture line ceratitic, characteristic of flemingitids with slightly phylloid saddles and very wide, strongly indented first lateral lobe.

Measurements: See APPENDIX, p. 141.

Discussion: Notwithstanding its distinctive morphology and ornamentation, *Euflemingites cirratus* was never adequately illustrated, neither by White (1880) nor Smith (1932). White (1880) based his new taxon (*Arcestes cirratus*) on a very poorly preserved type specimen from the *Meekoceras* beds of southeastern Idaho, which he did not figure (Smith, 1932). Later, Smith (1932) illustrated a few better preserved specimens from the same area, but he failed to include ventral and apertural views or provide measurements for the larger specimens. Fortunately, Smith (1932) included diameter-based height, width and umbilical width ratios, but it is not clear to which

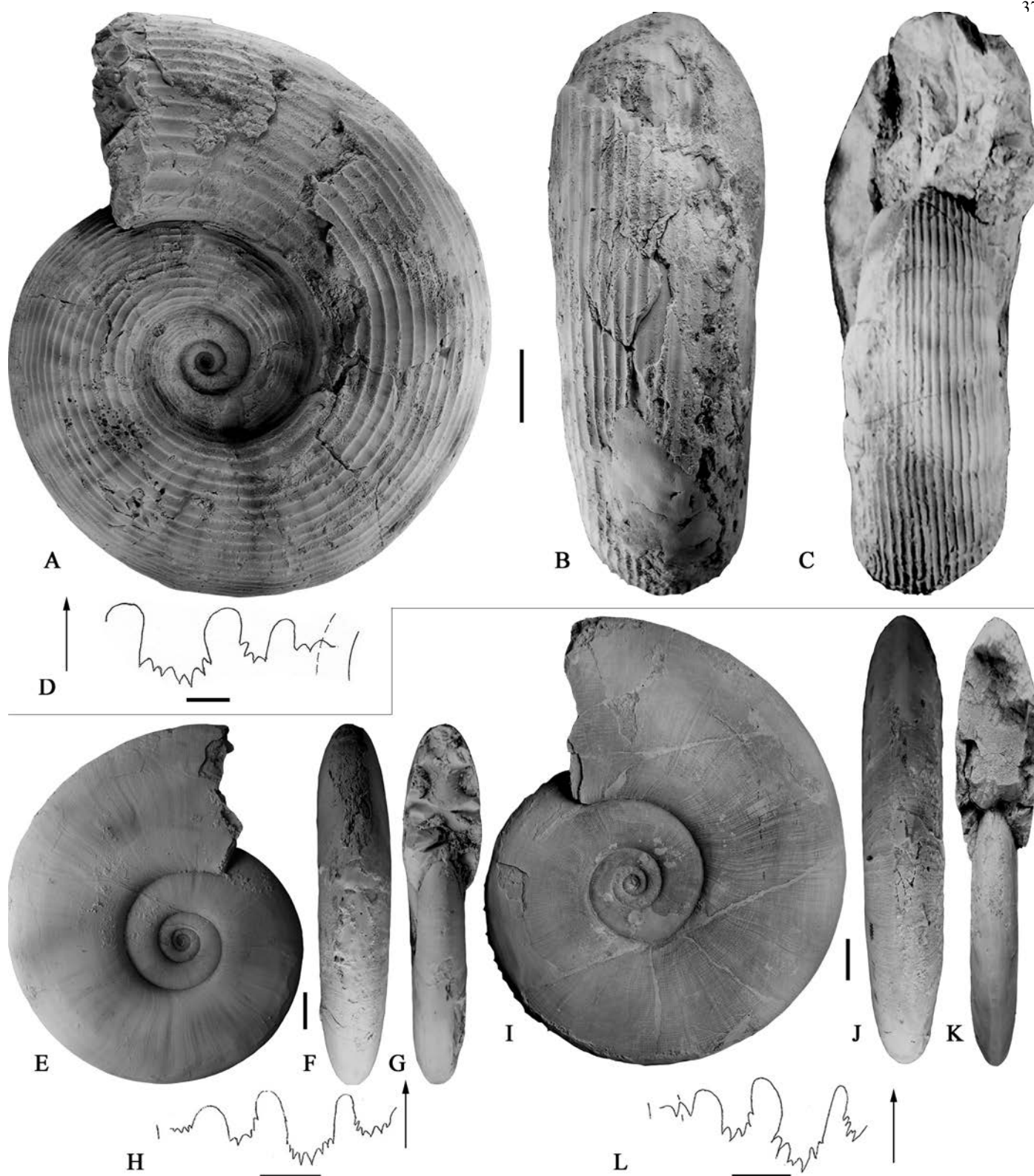


FIGURE 30. **A-D**, *Euflamingites cirratus* (White), 321C, 13-75, *C. j.*, in **A**, lateral, **B**, ventral and **C**, apertural views. Scale bar = 3 cm. **D**, suture line, H = 5.5 cm. **E-H**, *Anaflemingites silberlingi* Kummel & Steele, 144C, 1-88, *G. l.*, in **E**, lateral, **F**, ventral and **G**, apertural views. **H**, suture line, H = 3.7 cm. **I-L**, 2121C, 5-76, *A. w.*, in **I**, lateral, **J**, ventral and **K**, apertural views. **L**, suture line, H = 4.3 cm. Scale bars = 1 cm unless otherwise indicated.

specimen he refers or if these are average based. His whorl height and umbilical diameter ratios are reasonably close to those of our specimen, but his W/H ratio of 0.50 indicates our specimen has a significantly thicker whorl section ($W/H=0.87$ to 0.97). This disparity is assumed to be the result of intraspecific variation. However, *Euflemingites cirratus* is relatively rare in the *Meekoceras* beds of southeastern Idaho as well as at Crittenden Springs, and consequently, very little is known regarding its range of intraspecific variation. The density of the spiral ridges on our specimen (~22) appear to agree well with Smith's (1932) larger specimens, but it is not known whether this density is really typical of the species or even if it is size and geometry dependent.

In addition to Crittenden Springs and southeastern Idaho, *Euflemingites cirratus* is now also known from the *Vercherites undulatus* beds in the Mineral Mountains of west-central Utah (Kevin Bylund, personal commun. 2014). The taxon has also been reported from Arctic Canada and northeastern British Columbia (Tozer, 1994), the Chulitna Terrane in Alaska (Nichols and Silberling, 1979), Spitsbergen (Korchinskaya, 1970, 1982), the Salt Range of Pakistan (Brühwiler et al., 2011) and now from South China, following Brühwiler et al.'s (2011) placement of *E. tsotengensis* Chao 1959 in synonymy with *E. cirratus*.

In contrast with Smith's (1932) more compressed specimens from Idaho, the shell geometry of the present specimen of *Euflemingites cirratus* from Crittenden Springs differs only slightly from *E. romunderi* Tozer from Arctic Canada. Its whorls are only slightly more compressed ($W/D=0.32$ to 0.36 vs 0.38 to 0.40), and not quite as high (0.37 vs. 0.40 to 0.43), and it lacks discernable ventral shoulders, but the most significant difference is its denser spiral ridges, ~22 vs 15 (Tozer 1961). *Euflemingites guyerdetiformis* (Welter 1922) from Timor differs from *E. cirratus* by its significantly denser spiral ornamentation (Spath 1934), and its venter, contrary to Spath's (1934) statement, is subtabulate rather than arched (R. Jattiot, ongoing work). According to Shigeta and Zakharov (2009), *E. prynadai* from Abrek Bay, South Primorye also differs from *E. cirratus* only by its denser spiral ridges (25). However, these authors question whether this relatively small difference in spiral ridges is really diagnostic and they emphasize the need for additional material to define the intraspecific variation of both taxa. Furthermore, Brühwiler et al. (2011) commented on the similarity of *E. prynadai* with *E. cirratus* and stated that it only differs by its larger size. *Euflemingites artymensis* Smyshlyayeva (2010), which is based on a single, slightly smaller specimen, is reasonably close to the present specimen in shell geometry, but differs by its more distant spiral ridges (17).

Occurrence: *Euflemingites cirratus*, which is usually thought to be of early Smithian age, is extremely rare at Crittenden Springs. It has been found in the early Smithian *M. millardense* FA interval and the early middle Smithian *M. gracilitatis* FA interval. However, it also has been found in the *C. jattioti* n. gen., n. sp interval, which is of late middle Smithian age. Its existence so high in the succession also perplexed E.T. Tozer, who remarked following a visit to Crittenden Springs in 1964, "At Crittenden Springs, *Euflemingites* (elsewhere characteristic of the early Smithian) is at about, if not exactly, the same level as *Wasatchites* (Tardus Zone)" (Tozer, 1971, p. 1016).

Family DIENEROCERATIDAE Kummel, 1952

Genus *Dieneroceras* Spath, 1934

Type species: *Ophiceras dieneri* Hyatt and Smith, 1905
Dieneroceras dieneri (Hyatt and Smith, 1905)

Figure 32

1905 *Ophiceras dieneri* Hyatt and Smith, p. 118, pl. 8, figs. 16-29.

?1905 *Xenaspis marcouri* Hyatt and Smith, p. 116, pl. 7, figs. 26-33.

1932 *Ophiceras dieneri* Hyatt and Smith, Smith, p. 48, pl. 8, figs. 16-29.

?1932 *Xenodiscus (Xenaspis) marcouri* Hyatt and Smith, Smith, p. 47, pl. 7, figs. 26-33.

1955 *Ophiceras iwaiense* Sakagami, p. 135, pl. 1, figs. 1-9.

1955 *Ophiceras* sp. Sakagami, p. 136, pl. 1, figs. 10-11.

?1959 *Kariceltites indicus* Jeannet, p. 30, pl. 7, figs. 10-12; pl. 8, fig. 15.

1960 *Dieneroceras iwaiense* Kummel and Sakagami, p. 4, pl. 1, figs. 3-5; pl. 2, figs. 7-9.

?1961 *Dieneroceras dieneri* (Hyatt and Smith), Kiparisova, p. 47, pl. 9, fig. 2.

?1961 *Dieneroceras chaoi* Kiparisova, p. 48, pl. 9, figs. 3-6.

?1961 *Dieneroceras caucasicum* Popov, p. 41, pl. 6, fig. 1.

?1965 *Dieneroceras* cf. *dieneri* (Hyatt and Smith), Kuenzi, p. 369, pl. 53, figs. 13-18, text-figs. 3-4.

1968 *Dieneroceras dieneri* (Hyatt and Smith), Nakazawa and Bando, p. 93, pl. 4, figs. 1-6.

1968 *Dieneroceras* aff. *chaoi* Nakazawa and Bando, p. 95, pl. 4, figs. 7, 8; pl. 5, fig. 1.

?v1973 *Dieneroceras knechti* (Hyatt and Smith), Collignon, p. 131, pl. 1, figs. 2, 3.

?v1973 *Dieneroceras chaoi* Kiparisova, Collignon, p. 132, pl. 1, figs. 6-8.

?1995 *Dieneroceras caucasicum* Popov, Shevyrev, p. 25, pl. 1, figs. 3-5.

?1995 *Dieneroceras magnum* Shevyrev, p. 26, pl. 1, fig. 6.

2010 *Wyomingites arnoldi* (Hyatt and Smith), Stephen et al., figs. 5c, d.

2012a *Dieneroceras dieneri* (Hyatt and Smith), Brühwiler and Bucher, p. 20, pl. 8, figs. 1-4; pl. 9, figs. 1-7; pl. 10, figs. 1-3.

2013 *Dieneroceras dieneri* (Hyatt and Smith), Brayard et al., p. 173, pl. 36, figs. a-s.

2017 *Dieneroceras dieneri* (Hyatt and Smith), Jattiot et al., p. 19, pl. 5, figs. A-S.

Material: 13 measured specimens. Includes eight illustrated specimens (2189C-3, 2189C-10, 2189C-7, 2189C-6, 2189C-5, 2189C-9, 2318C and 2319C).

Description: Small, very evolute, compressed shell with barely embracing whorls, slightly convex flanks and tabulate venter with abruptly rounded shoulders. Whorl section subrectangular with maximum width at ~40% of whorl height. Whorl width varies slightly, 0.21 to 0.33 of diameter. Umbilicus fairly wide and shallow with low, inclined wall (~45°) and gently rounded shoulders on outer whorl. Umbilical wall slightly steeper on inner whorls. Body chamber length not known, but at least ½ volution. No visible ornamentation other than barely perceptible, distant, radial fold-type ribs and very faint radial growth lines on two of the larger, well preserved specimens. No spiral strigation present. Suture line ceratitic and very simple, with two saddles, first of which is lower than second, and fairly wide, finely denticulated first lateral lobe.

Measurements: See Figure 33 and APPENDIX, p. 141.

Discussion: The genus *Dieneroceras* Spath, 1934 and species assigned to it continue to generate controversy even today, some 80+ years after its erection. Brayard and Bucher (2008) aptly discussed the problems associated with certain species attributed to *Dieneroceras* as well as its familial designation, which has eluded agreement among various workers over the years. Spath (1934) based *Dieneroceras* on *Ophiceras dieneri* Hyatt and Smith, the type species, which in itself is not without controversy. In their description of the taxon, Hyatt and Smith (1905) stated that its venter was "flat and rather narrow," but this morphological feature is not readily apparent in the drawings of the holotype and other illustrated specimens (pl. 8, figs. 16-29). Also, according to Hyatt and Smith (1905), the type specimens are adorned with spiral strigation; however, the present specimens do not exhibit this feature, even those that

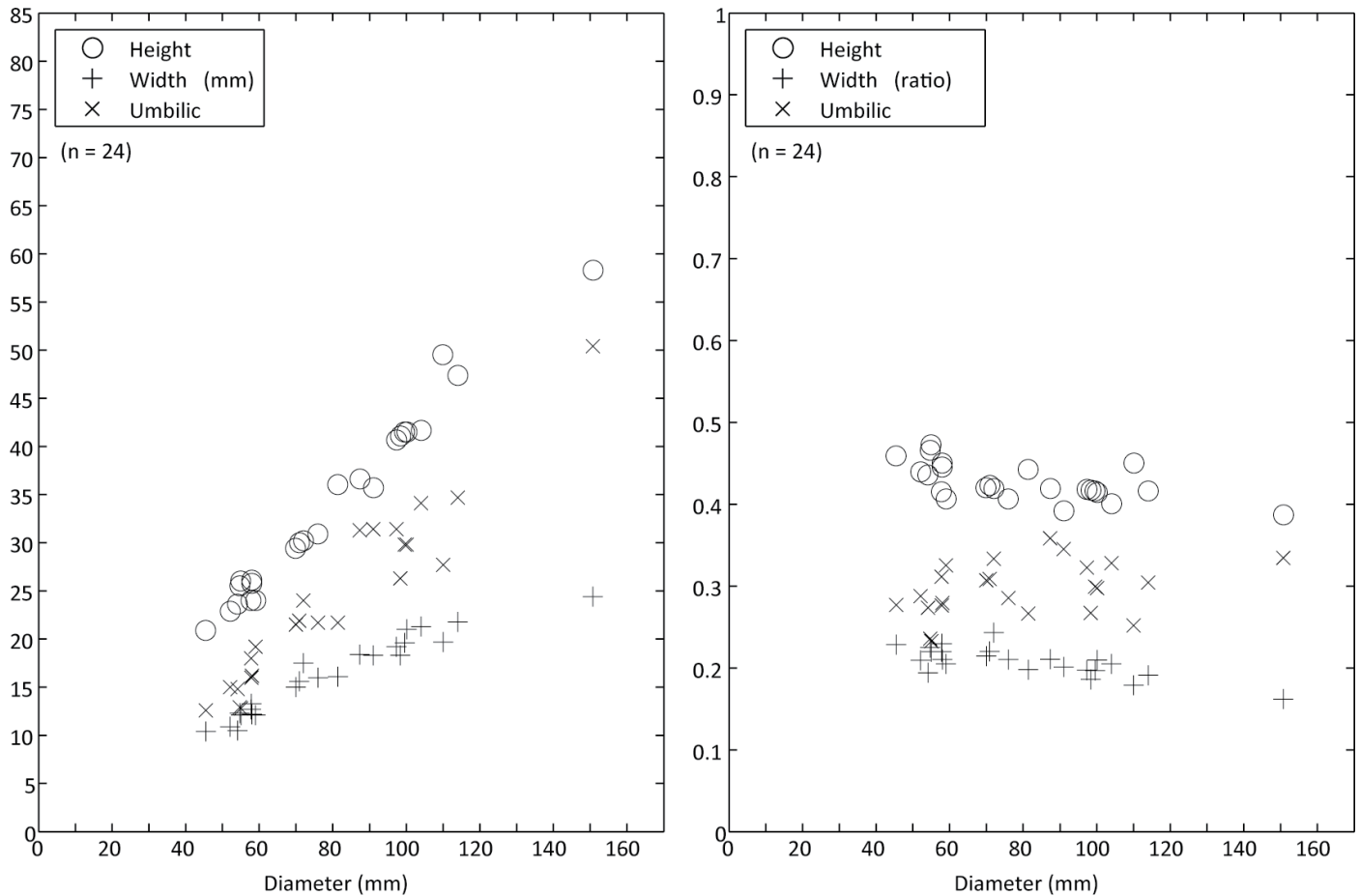


FIGURE 31. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Anaflemingites silberlingi*. All specimens from *M. g.* through *I. o.* intervals.

are well preserved. Based on the collecting experience of both authors in the *Meekoceras* beds of southeastern Idaho, we do not consider the presence or absence of strigation to be diagnostic for this particular taxon.

Dieneroceras dieneri differs from: (1) *D. cf. D. dieneri* from Crittenden Springs by its slightly more evolute coiling, more abruptly rounded ventral shoulders and somewhat simpler suture line; (2) *D. knechti* from Crittenden Springs by its tabulate venter and ceratitic suture line; and (3) *D. subquadratum* from Crittenden Springs by its thinner whorl section, more pronounced tabulate venter, slightly less convex flanks and much less obvious radial, fold-type ribs (see box plot comparison [Fig. 40] of *D. dieneri* and the above three taxa). *Dieneroceras dieneri* also differs from *D. tientungense* from South China (Brayard and Bucher, 2008) and *D. cf. D. tientungense* from Spiti (Brühwiler et al., 2012c) by its consistently tabulate venter and absence of strigation. See Brayard et al. (2013) for a thorough comparison of additional taxa attributed to *Dieneroceras* from various worldwide localities.

Occurrence: *Dieneroceras dieneri* is relatively rare at Crittenden Springs and has been found only in the *C. jattioti* interval.

***Dieneroceras cf. D. dieneri* (Hyatt and Smith, 1905)**
Figure 34

Material: 32 measured specimens. Includes nine illustrated specimens (923C, 930C, 2190C-2, 2190C-1, 2190C-23, 311C, 2190C-13, 2190C-17 and 2190C-6).

Description: Small, fairly evolute, compressed shell with slightly convex flanks and subtabulate to tabulate venter

with rounded shoulders. Whorl section subquadrate with maximum width at ~ 45% of whorl height. Umbilicus fairly wide and shallow with low, steeply inclined wall (> 45°) and gently rounded shoulders. Body chamber length not known, but at least 1/3 volution. No visible ornamentation on present specimens other than very fine radial growth lines, some of which are bundled into barely perceptible, fold type ribs on a few specimens. No spiral strigation present. Suture line ceratitic and simple with two fairly large saddles and well indented first lateral lobe.

Measurements: See Figure 35 and APPENDIX, p. 142.

Discussion: *Dieneroceras cf. D. dieneri* differs from *D. dieneri* by its slightly less evolute coiling, slightly more embracing whorls, marginally more rounded ventral shoulders and somewhat different suture line, which exhibits a narrower first lateral lobe and higher first lateral saddle. *Dieneroceras cf. D. dieneri* differs from *D. subquadratum* by its thinner whorl section and near lack of obvious fold-type ribs. *Dieneroceras knechti* is similar in plan view, but its rounded venter and goniatitic suture line set it apart. Superficially, *Dieneroceras cf. D. dieneri* is similar in terms of geometric proportions and coiling geometry to the new xenoceltid taxon *Palominoceras nevadanum* erected by Jattiot et al. (2017) from Palomino Ridge, Nevada, but its subtabulate to tabulate venter and resultant subquadrate whorl section differs slightly from the xenoceltid-like whorl section formed by the rounded to subtabulate venter of the new taxon.

Occurrence: *Dieneroceras cf. D. dieneri* is rare and occurs only in the *C. jattioti* interval.

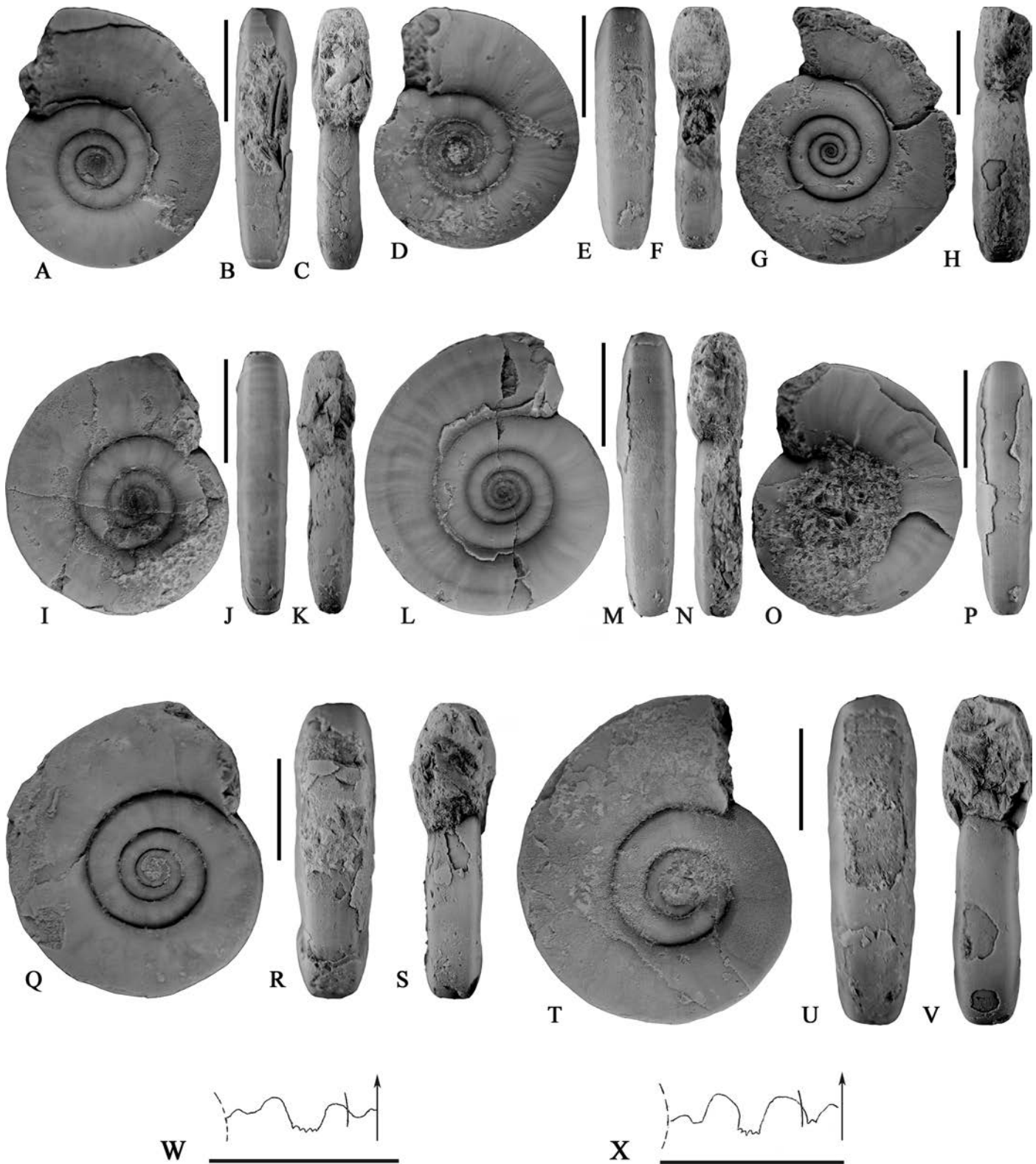


FIGURE 32. *Dieneroceras dieneri* (Hyatt & Smith), *C. j.* A-C, 2189C-3, 5-76, in A, lateral, B, ventral and C, apertural views. D-F, 2189C-10, 2-93, in D, lateral, E, ventral and F, apertural views. G-H, 2189C-7, 5-76, in G, lateral and H, apertural views. I-K, 2189C-6, 2-94, in I, lateral, J, ventral and K, apertural views. L-N, 2189C-5, 2-94, in L, lateral, M, ventral and N, apertural views. O-P, 2189C-9, 2-93, in O, lateral and P, ventral views. Q-S, 2318C, 5-76, in Q, lateral, R, ventral and S, apertural views. T-V, 2319C, 5-76, in T, lateral, U, ventral and V, apertural views. W-X, suture lines, in W, 2189C-3, H = 6.5 mm, 5-76. X, 2318C, H = 7.3 mm, 5-76. All scale bars = 1 cm.

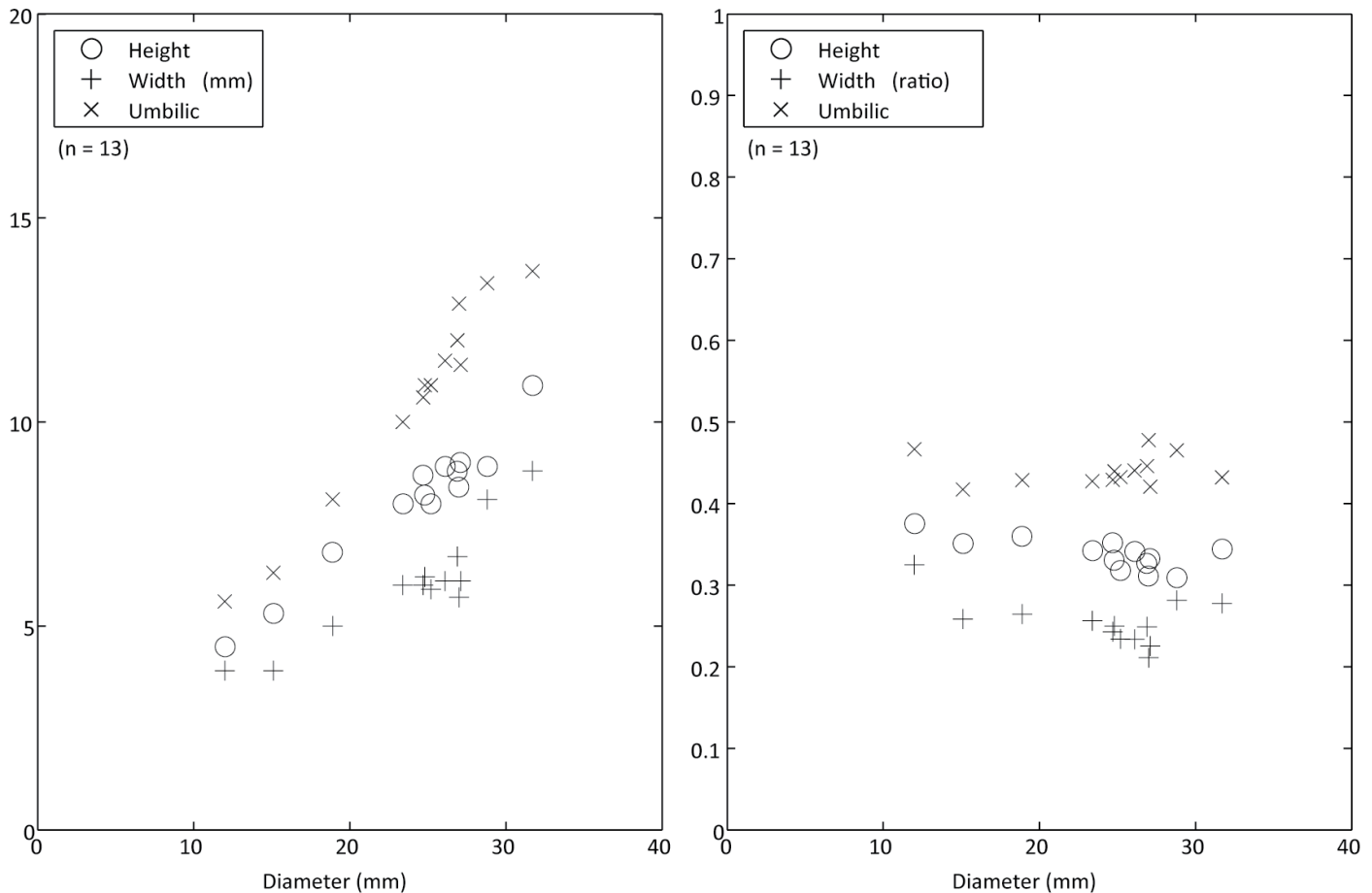


FIGURE 33. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Dieneroceras dieneri*. All specimens from *C. j.* interval.

***Dieneroceras knechti* (Hyatt and Smith, 1905)**

Figure 36

- 1905 *Lecanites knechti* Hyatt and Smith, p. 138, pl. 9, figs. 11-16.
 1915 *Proavites knechti* Diener, p. 228.
 1932 *Lecanites* (*Paralecanites*) *knechti* Hyatt and Smith, Smith, p. 41, pl. 9, figs. 11-16; pl. 28, figs. 1-7.
 1934 "*Lecanites*" *knechti* Spath, p. 88, 93, 123, 134.
 1962 *Dieneroceras knechti* (Hyatt and Smith), Kummel and Steele, p. 662, pl. 99, figs. 14, 15.
 2000 *Dieneroceras knechti* (Hyatt and Smith), Gardner and Mapes, p. 116, pl. 1, fig. 1.
 2017 *Dieneroceras knechti* (Hyatt and Smith), Jattiot et al., p. 21, pl. 5, figs. T-AA.

Material: 44 measured specimens. Includes 11 illustrated specimens (699C, 276C, 2238C, 2242C-1, 2242C-28, 2242C-37, 2242C-36, 2242C-13, 2242C-12, 2239C and 2240C).

Description: Small, very evolute, compressed serpenticonic shell with barely embracing whorls and convex flanks convergent upon arched to narrowly rounded venter without discernable shoulders. Whorl section semioval with maximum width at about 50% of height. Umbilicus fairly wide with gently sloped (~45°) wall and broadly rounded shoulders. Body chamber length unknown but at least 2/3 of volution. Most specimens bear no obvious ornamentation, but a few larger, well preserved specimens exhibit fine, dense, slightly biconcave growth lines. Suture line goniatitic with large, smooth first lateral lobe and much smaller smooth lobe on umbilical wall.

Measurements: See Figure 37 and APPENDIX, p. 143.

Discussion: Kummel and Steele (1962) attributed

Lecanites knechti Hyatt and Smith, 1905, to *Dieneroceras* and differentiated it from *D. dieneri* (ceratitic suture line), which is nearly identical in plan view, by its arched to narrowly rounded venter and goniatitic suture line. Broad agreement now exists among workers that *D. dieneri* is characterized by a subtabulate to tabulate venter. Brühwiler et al. (2012a) synonymized *D. knechti* with *D. cf. D. dieneri* from Oman, but the narrowly rounded venter of *D. knechti* clearly sets it apart from the Omani taxon with its subtabulate venter. *Dieneroceras subquadratum* (Smith) differs from *D. knechti* by its subtabulate to tabulate venter, quadrangular whorl section and ceratitic suture line. *Elkoceras* "*Dieneroceras*" *spathi* (Kummel and Steele) differs from *D. knechti* by its more compressed whorl section, more involute coiling and ceratitic suture line.

Occurrence: Common in all levels from the *M. millardense* FA interval through the *G. lucasi* interval.

***Dieneroceras subquadratum* (Smith, 1932)**

Figure 38

- 1932 *Ophiceras subquadratum* Smith, p. 50, pl. 54, figs. 18-24.
 1932 *Ophiceras parvum* Smith, p. 49, pl. 54, figs. 25-30.
 1962 *Dieneroceras subquadratum* (Smith), Kummel and Steele, p. 664, pl. 99, figs. 12, 13, 24, 25.

Material: 16 measured specimens (12 from Jenks collection, 4 from MCZ collection). Includes eight illustrated specimens (303C, 890C, 891C, 2218C-7, 2218C-4, 2218C-3, 2043C and 2218C-8).

Description: Fairly small, fairly evolute, compressed dieneroceratid with convex flanks, subtabulate venter and rounded shoulders on larger specimens. Venter on smaller



FIGURE 34. *Dieneroceras* cf. *D. dieneri* (Hyatt and Smith), 2-94, *C. j.* **A-C**, 923C, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 930C, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2190C-2, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2190C-1, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2190C-23, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 311C, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 2190C-13, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-X**, 2190C-17, in **V**, lateral, **W**, ventral and **X**, apertural views. **Y-A'**, 2190C-6, in **Y**, lateral, **Z**, ventral and **A'**, apertural views. **B'-D'**, suture lines, in **B'**, 2190C-2, $H = 1.2$ cm. **C'**, 2190C-1, $H = 1.15$ cm and **D'**, 930C, $H = 1.3$ cm. All scale bars = 1 cm.

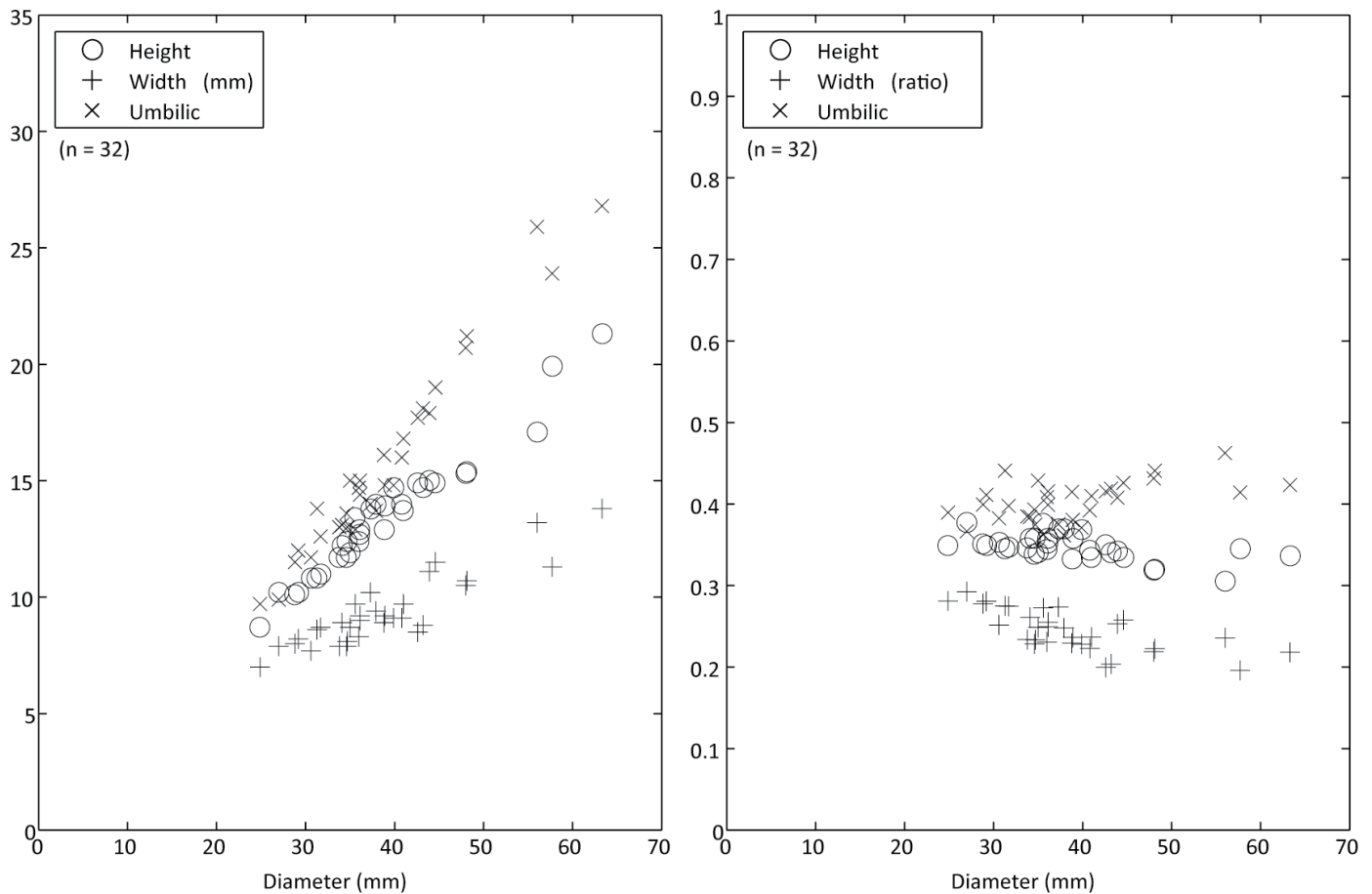


FIGURE 35. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Dieneroceras* cf. *D. dieneri*. All specimens from *C. j.* interval.

specimens tends to be more tabulate and shoulders more angular. Whorl section subquadrate and robust with height slightly greater than width (avg. $W/H = 0.77$) and maximum width at about 55% of whorl height. Umbilicus moderately wide and fairly shallow with gently inclined wall and rounded shoulders. Body chamber length unknown but at least $\frac{1}{2}$ volution. Ornamentation consists of distant radial folds arising above umbilical shoulder and fading below ventral shoulder. Folds tend to gradually lose strength and become denser on body chamber. Larger, well preserved specimens exhibit sinuous growth lines that tend to become bundled on body chamber. Suture line ceratitic, characterized by wide, well denticulated first lateral lobe, a narrower second lateral lobe and two large lateral saddles.

Measurements: See Figure 39 and APPENDIX, p. 144.

Discussion: *Dieneroceras subquadratum* differs from *D. dieneri* from Crittenden Springs (this work) and Utah (Brayard et al., 2013) by its thicker, more robust whorl section, slightly more involute coiling and its obviously more intense radial folds. *Dieneroceras subquadratum* differs from *Dieneroceras* cf. *D. dieneri* from Oman (Brühwiler et al., 2012a) by the same disparities, plus its venter is more obviously subtabulate, and finally *D. subquadratum* differs from *D. tientungense* Chao from South China and *D. cf. D. tientungense* from Spiti (Brayard and Bucher, 2008; Brühwiler et al., 2012c, respectively) by its thicker, more robust whorl section, slightly more involute coiling, more intense radial folds and lack of strigation.

Occurrence: *Dieneroceras subquadratum* is relatively rare and occurs from the *G. lucasi* interval through the *C. jattioti* n. gen., n. sp. interval.

Family Crittendenidae n. fam.

Etymology: Named for Crittenden Springs, located about 31 km north of Montello, Nevada

Type genus: *Crittendenites* n. gen., this work.

Composition of the family: *Crittendenites* n. gen., *Wyomingites* Hyatt, 1900.

Diagnosis: Compressed Ceratitidae with subtabulate to tabulate venter, angular to rounded shoulders, slightly convex, nearly parallel flanks, fairly narrow to moderately wide umbilicus with low, inclined wall and suture line with asymmetrical lobes and fairly wide saddles.

Discussion: The present specimens are relatively intriguing in that they cannot be attributed to known genera, much less assigned to an established family. Certain of their morphological features bear some resemblance to the galfettitid *Galfettites* as well as the former dieneroceratid *Wyomingites*, but taken overall, they do not fit well within either genus, or even *Dieneroceras* itself. While the flanks of *Crittendenites* n. gen. are nearly parallel, the outer flanks of *Galfettites* converge much more rapidly towards a distinctively narrow venter; and whereas the sub-rectangular whorl section of *Crittendenites* n. gen. is similar to *Wyomingites*, its coiling is much more involute. Any resemblance of *Crittendenites* n. gen. to *Dieneroceras* Spath (1934) is purely superficial, because this genus is based on much more evolute, near-serpenticonic forms with relatively little embracing whorls. The suture line of *Crittendenites* n. gen., characterized by asymmetrical lobes and wide saddles, is very similar to the *Dieneroceras*-*Wyomingites* group, but differs substantially from that of *Galfettites*, with its narrow saddles, some of which are tapered and exhibit indentations climbing

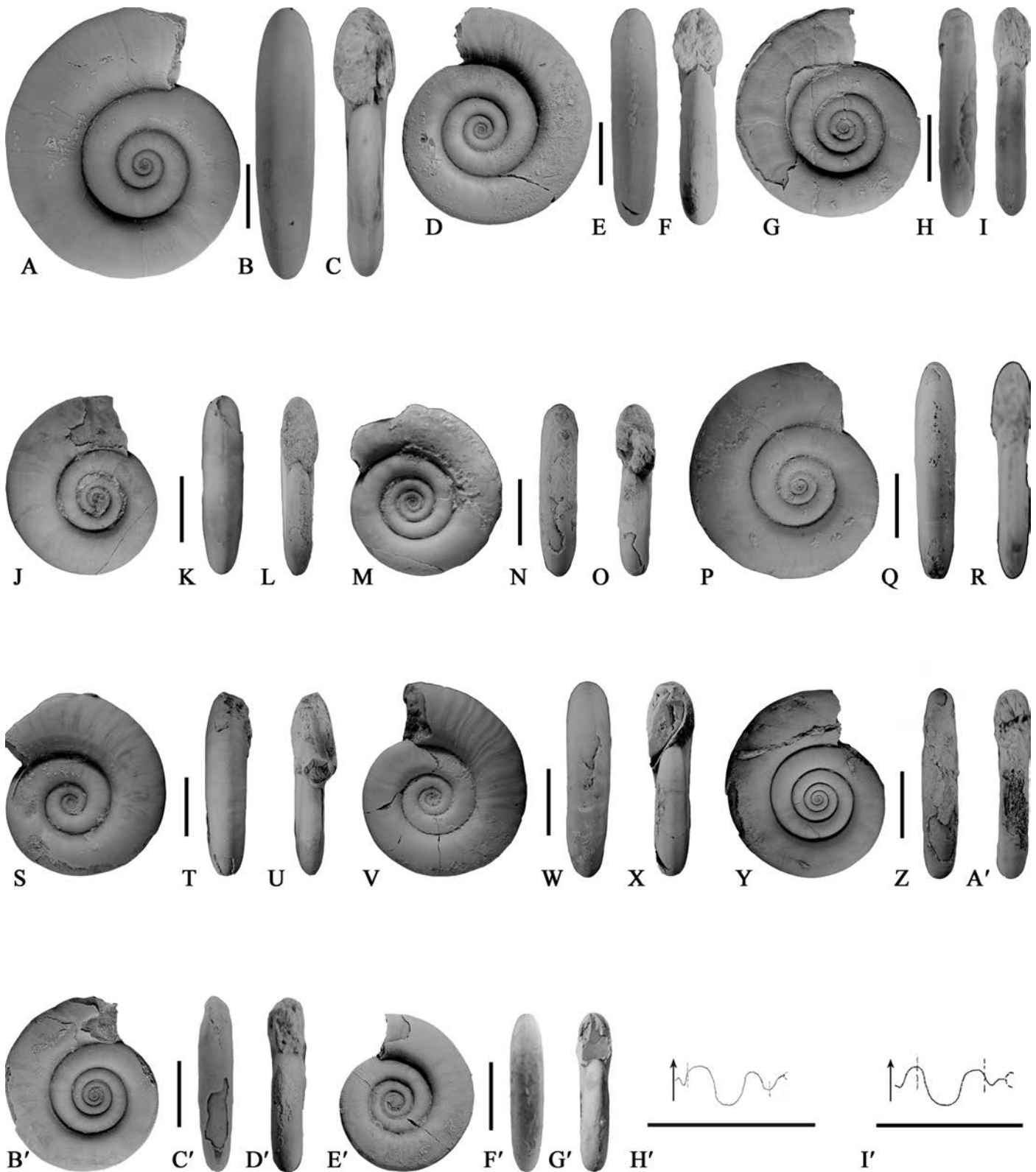


FIGURE 36. *Dieneroceras knechti* (Hyatt and Smith). A-C, 699C, 2-88, A. w., in A, lateral, B, ventral and C, apertural views. D-F, 276C, 5-76, A. w., in D, lateral, E, ventral and F, apertural views. G-I, 2238C, 2-88, A. w., in G, lateral, H, ventral and I, apertural views. J-L, 2242C-1, 5-76, G. l., in J, lateral, K, ventral and L, apertural views. M-O, 2242C-28, 5-76, G. l., in M, lateral, N, ventral and O, apertural views. P-R, 2242C-37, 2-88, A. w., in P, lateral, Q, ventral and R, apertural views. S-U, 2242C-36, 1-88, A. w., in S, lateral, T, ventral and U, apertural views. V-X, 2242C-13, 5-76, A. w., in V, lateral, W, ventral and X, apertural views. Y-A', 2242C-12, 1-88, A. w., in Y, lateral, Z, ventral and A', apertural views. B'-D', 2239C, 5-76, A. w., in B', lateral, C', ventral and D', apertural views. E'-G', 2240C, 5-76, A. w., in E', lateral, F', ventral and G', apertural views. H'-I', suture lines, in H', 2242C-28, H = 0.53 cm, 5-76, G. l. I', 2242C-29, H = 0.55 cm, 1-88, G. l. All scale bars = 1 cm.

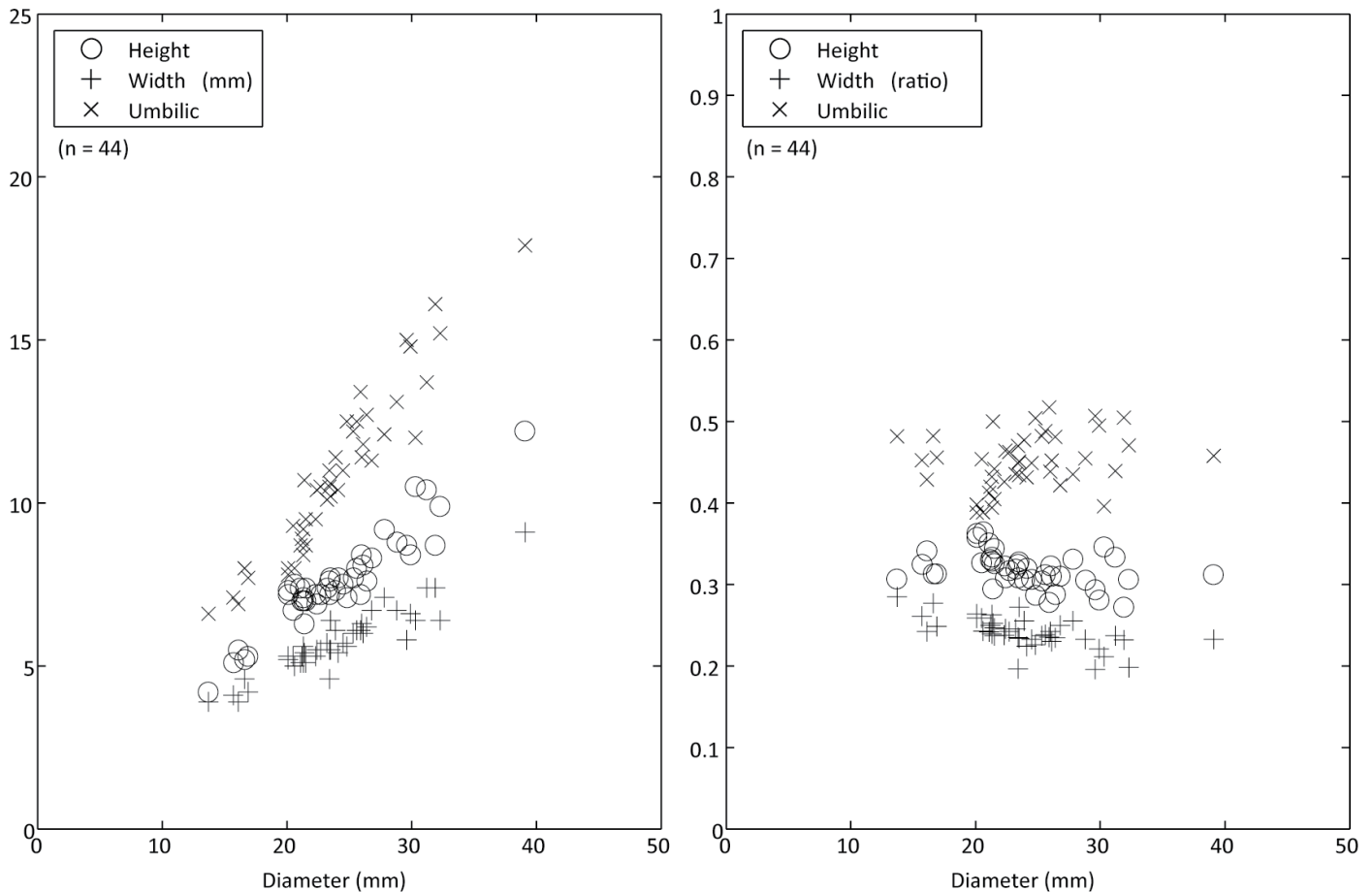


FIGURE 37. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Dieneroceras knechti*. All specimens from *M. m.* through *G. l.* intervals.

partway up the sides.

Based on the relatively large sampled data set consisting of 33 specimens, which are well preserved and exhibit relatively little intraspecific variation (Fig. 42), these forms clearly represent a distinct group. Thus, the new family Crittendenidae is here established, whose composition includes the new genus *Crittendenites* and the genus *Wyomingites*. These genera include the following shared features: 1) tabulate to subtabulate venter with angular to rounded shoulders; 2) slightly convex to nearly parallel flanks; 3) fairly narrow to moderately wide umbilicus with fairly low, gently to steeply inclined wall; 4) fairly distant, low intensity, radial fold-type ribs; and 5) suture line with asymmetrical lobes and wide saddles.

As pointed out by Brayard and Bucher (2008), agreement among Triassic workers regarding the familial attribution of *Wyomingites* has proven to be elusive over the years. This may be in part due to the confusion between Waagen (1895) and Hyatt (1900), each unaware of the other's intentions, surrounding the origin of the genus *Wyomingites* Hyatt, 1900, based on its type species *Meekoceras aplanatum* White, 1879. Smith (1932) placed the taxon in the Flemingitidae because of the presence of strigation on some specimens, but then Tozer (1981) synonymized *Dieneroceras* with *Wyomingites* and placed it in the family Meekoceratidae. Brayard and Bucher (2008) refuted this designation, and instead, tentatively placed it in the Dieneroceratidae, based on its relative similarity in shape and near identical suture line to the genus *Dieneroceras*. However, upon careful examination, it is apparent that *W. aplanatus* has a much larger shell, and its whorls are slightly higher and somewhat more embracing than both *D. dieneri* and *D. cf. D. dieneri* from Crittenden Springs, and, thus, its coiling

is more involute. Hence, we consider the overall morphology of *W. aplanatus* to be closer to *C. jattioti* n. gen., n. sp. than to *Dieneroceras*. *Wyomingites aplanatus* is here considered to be a valid species, but its geographic range is probably restricted to southeastern Idaho (author's personal observations).

Genus *Crittendenites* n. gen.

Type species: *Crittendenites jattioti* n. sp.

Composition of the genus: Type species only.

Etymology: As for the family.

Diagnosis: Small, fairly evolute, compressed shell with nearly parallel flanks, subtabulate to tabulate venter and subrectangular whorl section. Umbilicus moderately wide with low, inclined wall and rounded shoulders. Ornamentation consists of very weak, fairly dense, radial, slightly sinuous fold-type ribs.

Discussion: Although *Crittendenites jattioti* n. gen., n. sp. is superficially similar to the new Crittenden Springs galfettitid *Montelloites stephensi* n. gen., n. sp., it differs by its slightly thicker whorl section, more evolute coiling and most importantly, its suture line, which does not exhibit features typical of the galfettitid family, as does *M. stephensi*. However, the suture line of *C. jattioti* n. gen., n. sp. is quite close to representatives of *Wyomingites* from southeastern Idaho. *Crittendenites jattioti* n. gen., n. sp. is also similar in shape to *Dieneroceras* cf. *D. dieneri* from Crittenden Springs, but it differs by its more involute coiling and its higher whorl, which forms a more elongated subrectangular whorl section (Figs. 43, 44). Likewise, *C. jattioti* n. gen., n. sp. differs from *W. aplanatus* from SE Idaho by the same features, plus its venter is subtabulate with rounded shoulders, as compared to the Idaho specimens, which have distinctively tabulate venters with angular shoulders. *Crittendenites jattioti*

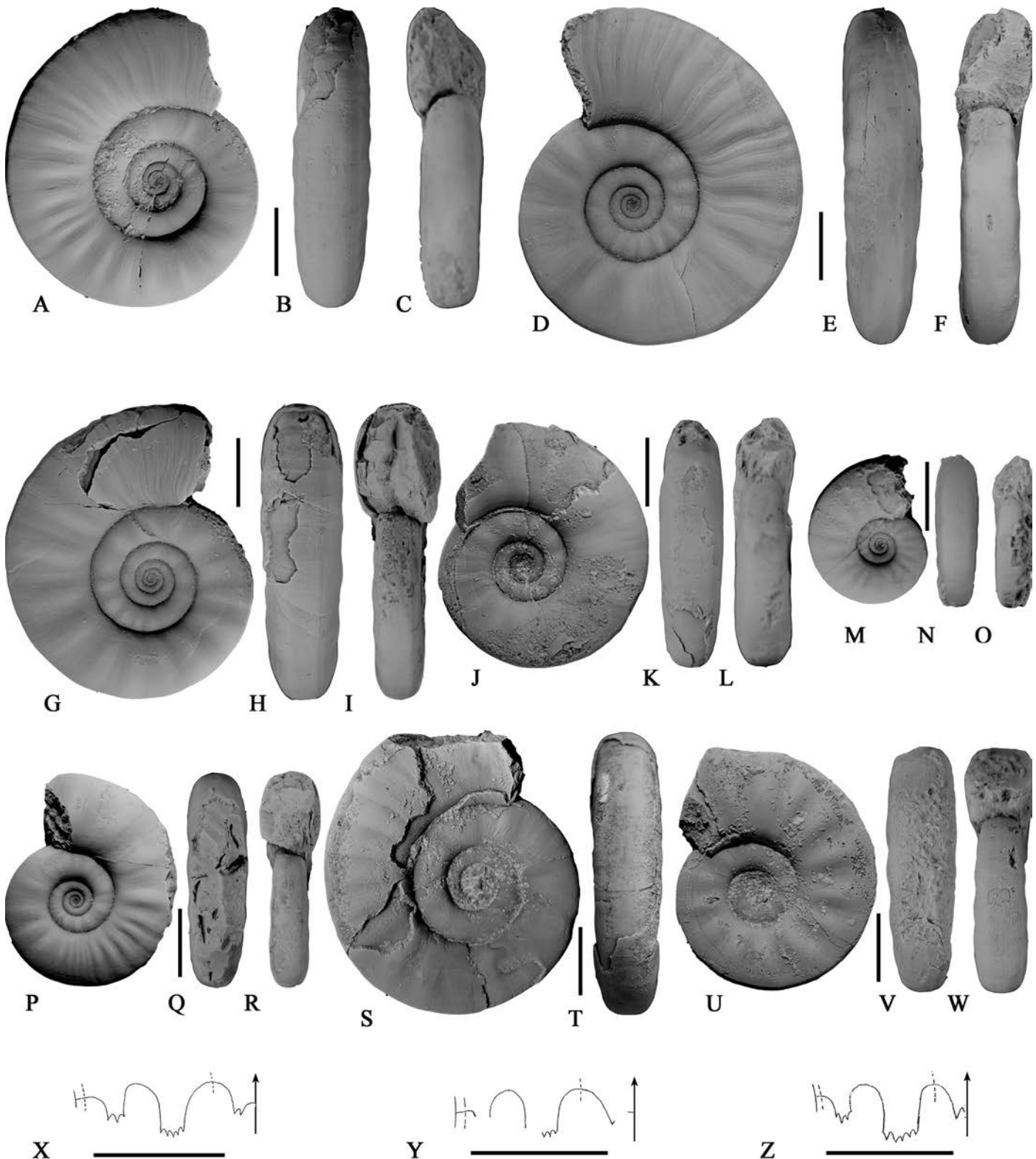


FIGURE 38. *Dieneroceras subquadratum* (Smith). A-C, 303C, 13-75, *C. j.*, in A, lateral, B, ventral and C, apertural views. D-F, 890C, 5-76, *G. l.*, in D, lateral, E, ventral and F, apertural views. G-I, 891C, 5-76, *C. j.*, in G, lateral, H, ventral and I, apertural views. J-L, 2218C-7, 5-76, *C. j.*, in J, lateral, K, ventral and L, apertural views. M-O, 2218C-4, 13-75, *C. j.*, in M, lateral, N, ventral and O, apertural views. P-R, 2218C-3, 5-76, *C. j.*, in P, lateral, Q, ventral and R, apertural views. S-T, 2043C, 5-76, *G. l.*, in S, lateral and T, ventral views. U-W, 2218C-8, 13-75, *G. l.*, in U, lateral, V, ventral and W, apertural views. X-Z, suture lines, in X, 890C, H=1.1 cm, Y, 303C, H = 1.1 cm and Z, 2043C, H = 0.9 cm. All scale bars = 1 cm.

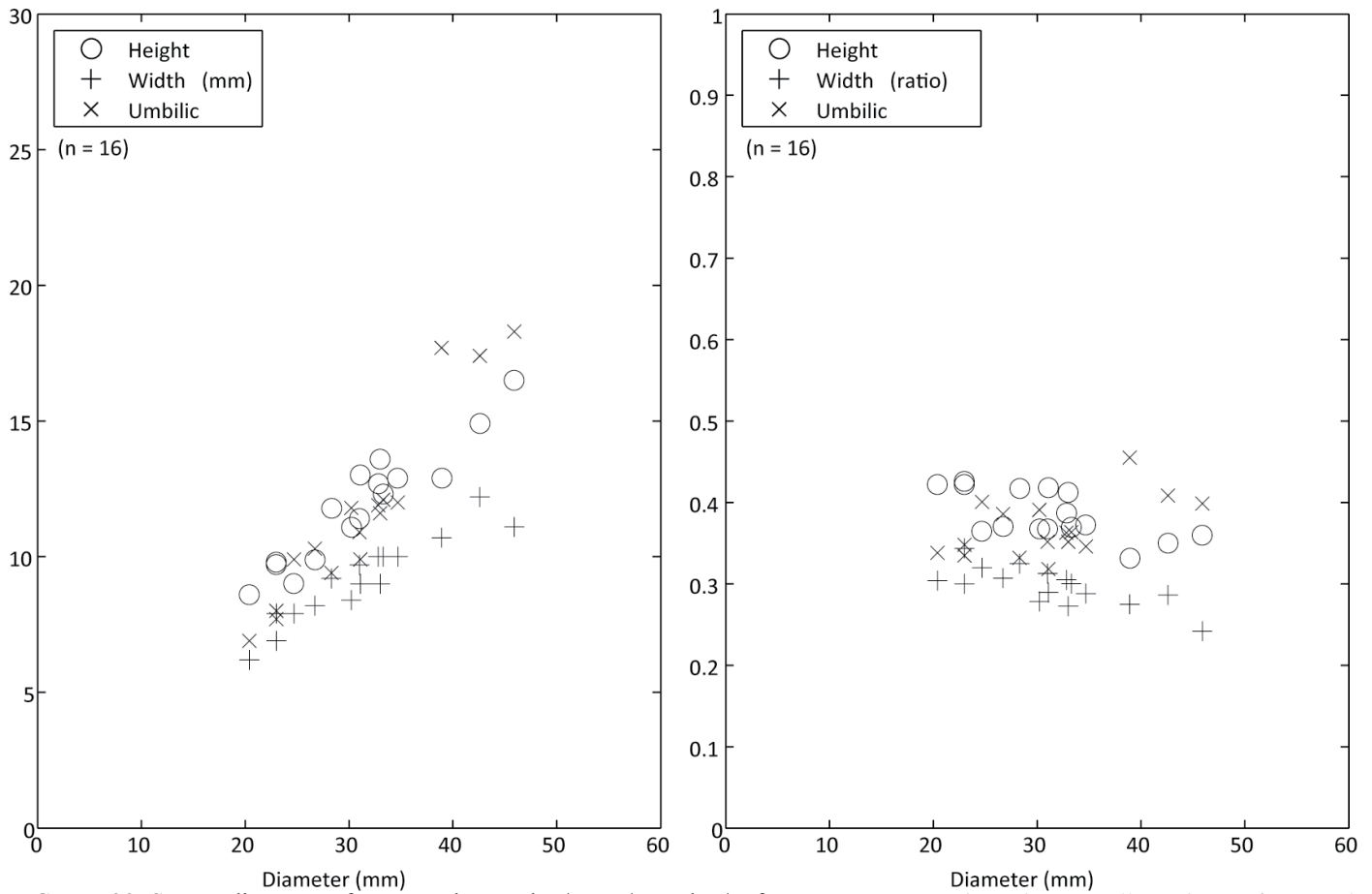


FIGURE 39. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Dieneroceras subquadratum*. All specimens from *G. l.* through *C. j.* intervals.

n. gen., n. sp. and most *Dieneroceras* taxa also share a very similar suture line, but the Dieneroceratidae are characterized by a distinctive shell geometry that includes serpenticonic coiling with little-embracing whorls.

***Crittendenites jattioti* n. sp.**

Figure 41

Type Series: Four specimens: Holotype, specimen NMMNH P-79160 (Figure 41A-C); paratypes, three specimens:

NMMNH P-79161 (Figure 41S-U), NMMNH P-79162 (Figure 41J-L, NMMNH P-79163, Figure 41G-I. Type specimens reposit in the NMMNHS. Other measured specimens: 29. Other illustrated specimens (six) include 2187C-6, 2187C-26, 249C, 2187C-7, 2187C-24 and 2187C-9.

Etymology: Named in honor of Romain Jattiot, Paleontological Institute and Museum, University of Zürich, Zürich, Switzerland.

Diagnosis: As for the genus.

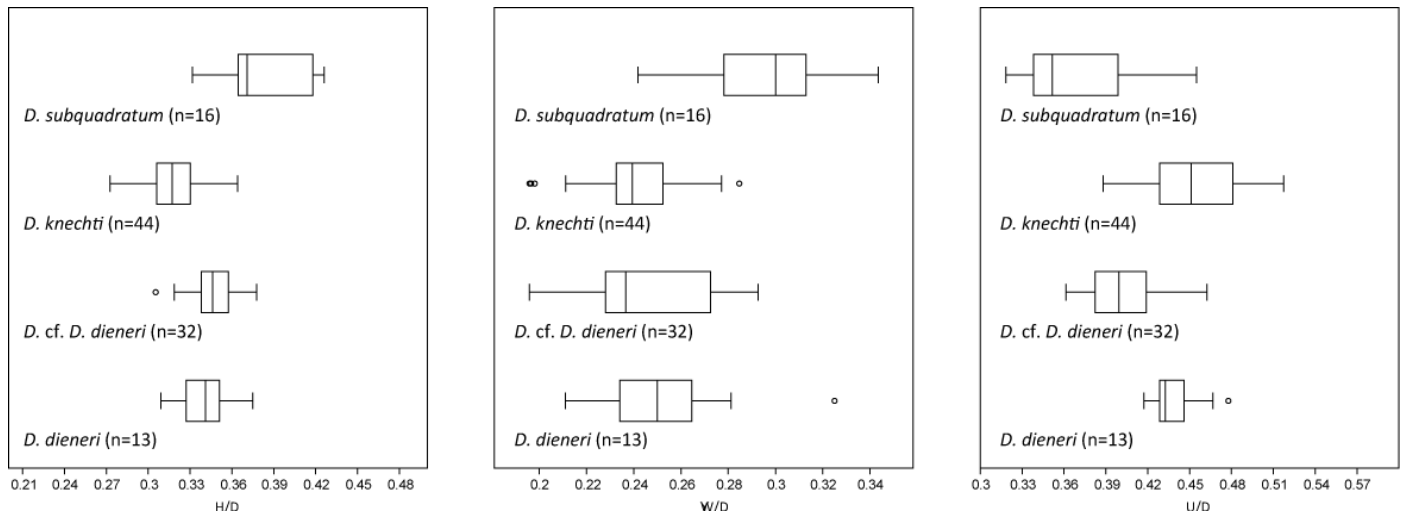


FIGURE 40. Box plot comparison of H/D, W/D and U/D for *Dieneroceras dieneri* vs. other *Dieneroceras* taxa from Crittenden Springs.

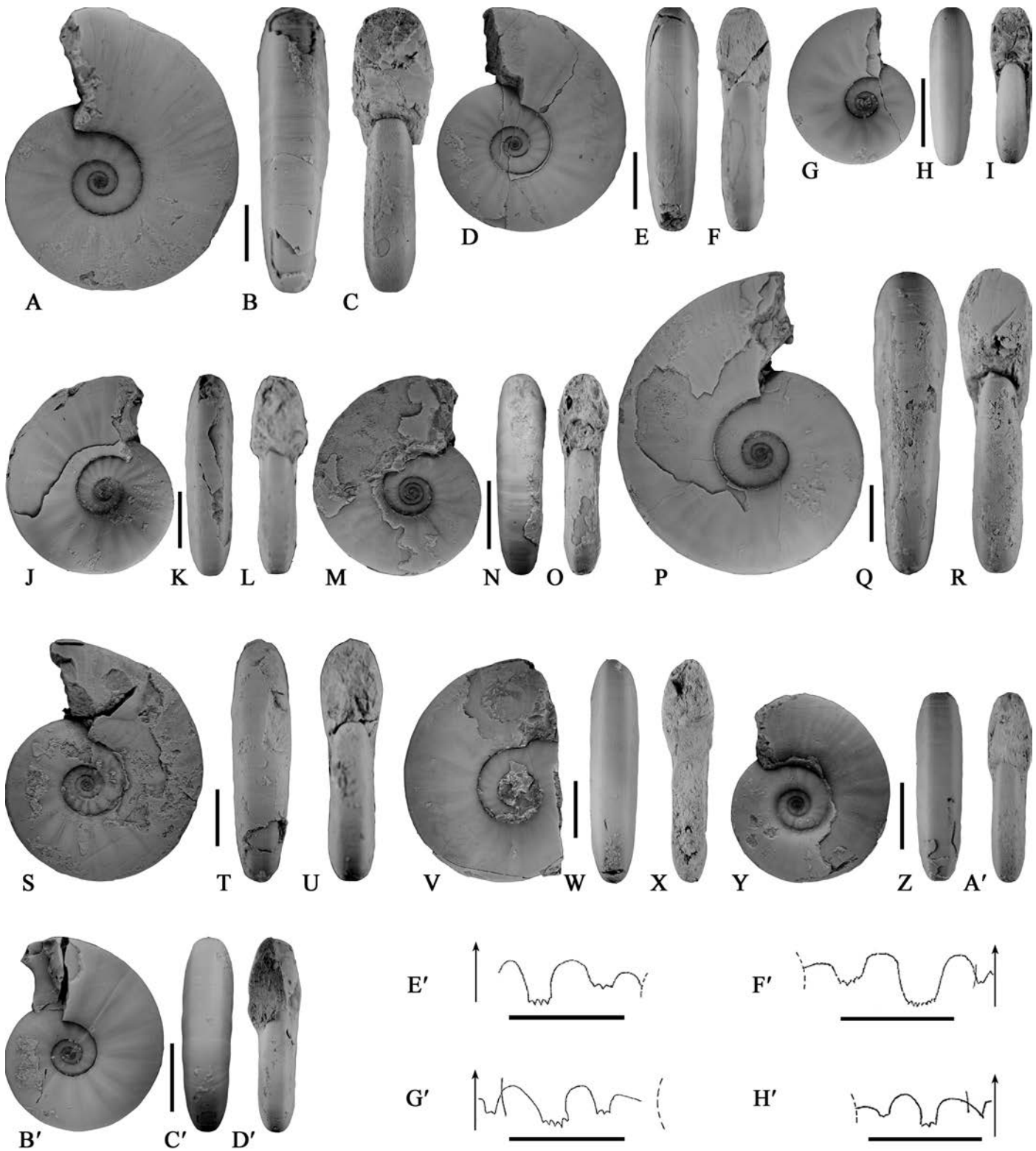


FIGURE 41. *Crittendenites jattioti* n. gen., n. sp., *C. j.* **A-C**, NMMNH P-79160, holotype, 2-93, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2187C-6, 5-76, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, NMMNH P-79163, paratype, 2-93, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, NMMNH P-79162, paratype, 1-88, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2187C-26, 2-94, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 249C, 5-76, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, NMMNH P-79161, paratype, 5-76, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-X**, 2187C-7, 2-94, in **V**, lateral, **W**, ventral and **X**, apertural views. **Y-A'**, 2187C-24, 5-76, in **Y**, lateral, **Z**, ventral and **A'**, apertural views. **B'-D'**, 2187C-9, 2-93, in **B'**, lateral, **C'**, ventral and **D'**, apertural views. **E'-H'**, suture lines, in **E'**, 2187C-23, H = 1.3 cm, 2-93. **F'**, 2187C-11, H = 1.4 cm, 1-11. **G'**, 2187C-13, H = 1.3 cm, 2-94. **H'**, 2187C-25, H = 1.0 cm, 5-76. All scale bars = 1 cm.

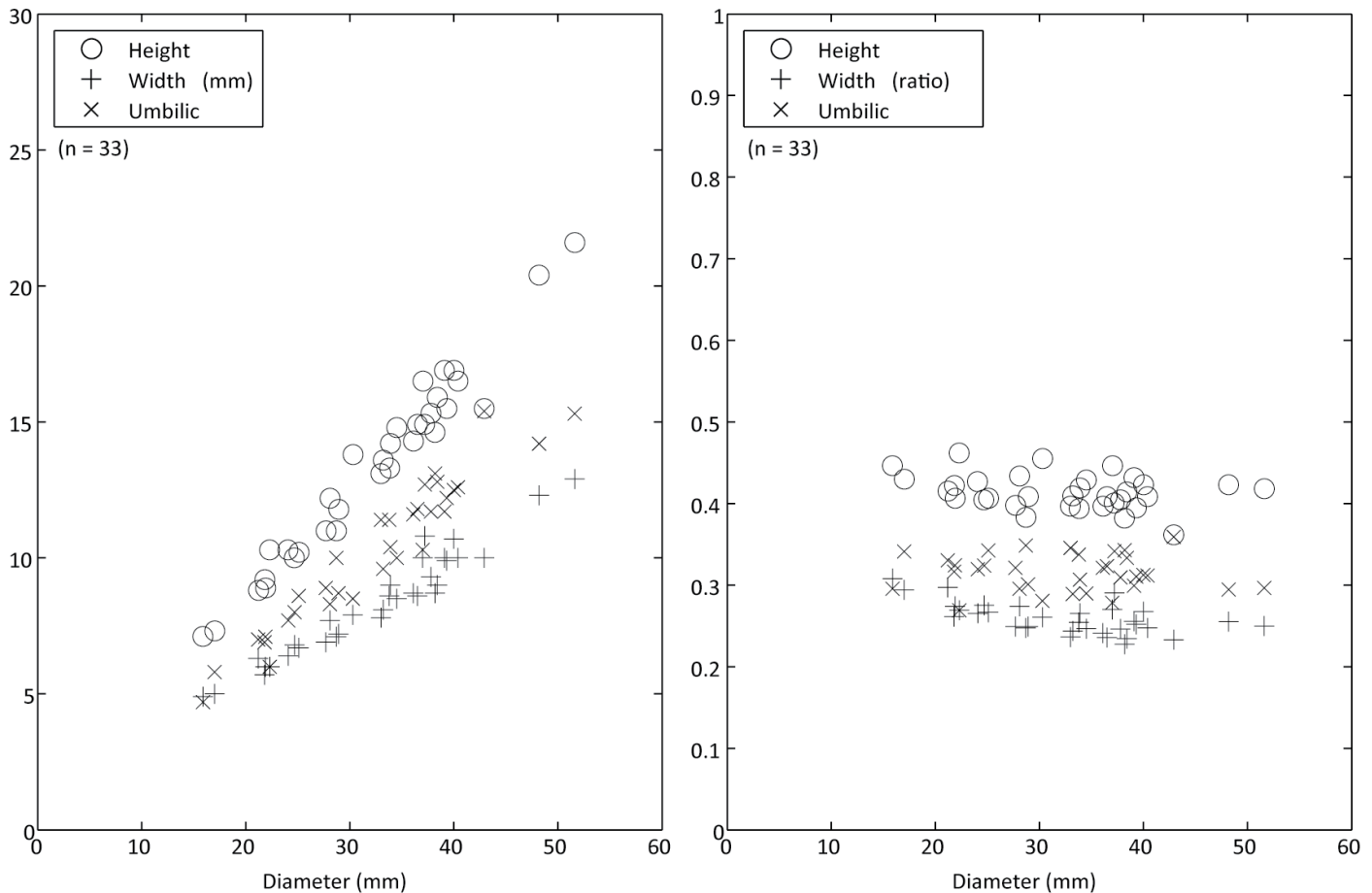


FIGURE 42. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Crittendenites jattioti* n. gen., n. sp. All specimens from *C. j.* interval.

Description: Small, moderate to fairly evolute, compressed platycone with slightly convex, nearly parallel flanks, subtabulate to tabulate venter with rounded shoulders and subrectangular whorl section. Maximum width at about 45% of whorl height. Body chamber length unknown, but at least nearly 2/3 of a whorl. Umbilicus moderately wide and fairly shallow with low, inclined wall and rounded shoulders. Ornamentation consists of barely perceptible to weak but obvious, fairly dense, radial, slightly sinuous fold-type ribs arising at top of umbilical shoulder, continuing across flank and crossing venter with decreased intensity. Well preserved specimens exhibit dense, radial, slightly sinuous growth lines, especially on body chamber, some of which appear weakly bundled. Suture line ceratitic with asymmetrical lobes and fairly wide saddles.

Measurements: See Figure 42 and APPENDIX, p. 144.

Discussion: As for the genus.

Occurrence: Taxon is fairly common, but occurs only in the *C. jattioti* n. gen., n. sp. interval.

Family ARCTOCERATIDAE Arthaber, 1911

Genus *Arctoceras* Hyatt, 1900 (in Zittel, 1900)

Type species: *Ceratites polaris* Mojsisovics, 1886

***Arctoceras tuberculatum* (Smith, 1932)**

Figures 45A-E, 46A-K, 47

1932 *Meekoceras* (*Koninckites*) *tuberculatum* Smith, p. 62, pl. 50, figs. 1-4.

1962 *Arctoceras tuberculatum* (Smith), Kummel and Steele, p. 697, pl. 104, figs. 1-8.

1979 *Arctoceras tuberculatum* (Smith), Nichols and Silberling, pl. 1, figs. 5-9.

?1994 *Arctoceras gigas* Tozer, p. 75, pl. 26, figs. 4-6.

2010 *Arctoceras tuberculatum* (Smith), Jenks et al., internal frontspiece.

2013 *Arctoceras tuberculatum* (Smith), Brayard et al., fig. 45a-c.

2017 *Arctoceras tuberculatum* (Smith), Jattiot et al., p. 23, pl. 7, figs. A-I.

Material: 76 measured specimens. Includes seven illustrated specimens (280C, 686C, 687C, 688C, 724C, 2261C-66 and 1778C)

Description: Very large, fairly evolute, compressed shell with parallel or very gently convex flanks. Whorl section subquadrate with maximum width at about mid-flank. Venter varies from narrowly rounded to circular on most specimens, and even broadly rounded on a few mature shells (Fig. 47C-D). Umbilicus wide and moderately deep with abruptly rounded shoulders. Slope of umbilical wall nearly vertical on most juvenile and adolescent whorls but becomes progressively less steep on mature whorls of most specimens (Fig. 45A). On a few large-sized variants, umbilical wall remains steep or nearly vertical throughout ontogeny (Fig. 47A-B). Body chamber length unknown, but at least 1/2 whorl. Ornamentation consists of weak to strong tuberculation on umbilical shoulders, varying greatly in density even on adolescent whorls, but nearly always becoming much denser and bullate-like on mature whorls. Flanks adorned with ribs that vary greatly in frequency, width and strength. Ribs tend to originate with umbilical tuberculation, travel across flank somewhat sinuously in a radial or slightly rursiradial direction, and then project forward almost imperceptibly onto ventral shoulder before fading completely. An increase in density of umbilical tuberculation generally results in an increase in ribbing density with a corresponding decrease in strength. Well

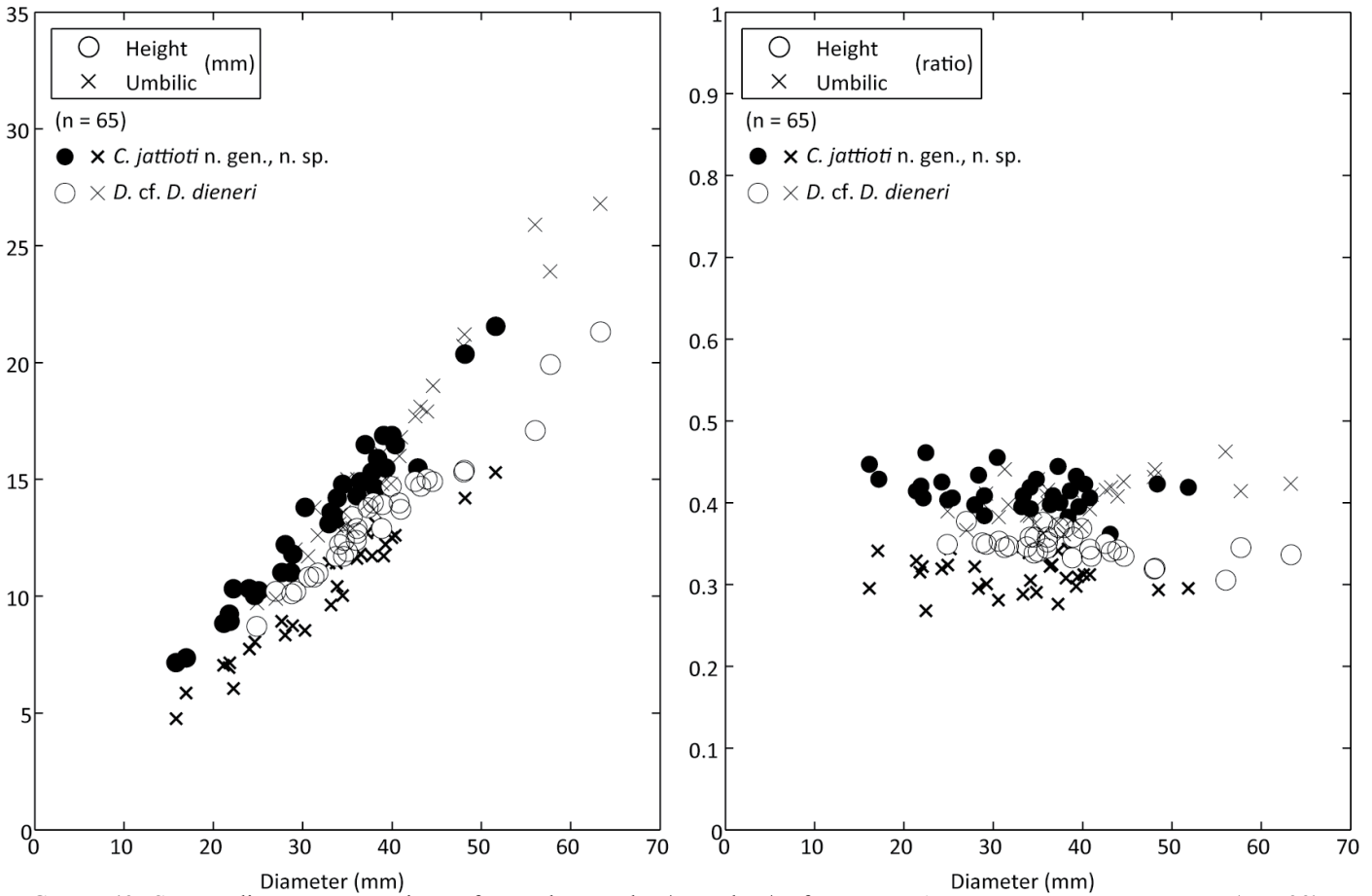


FIGURE 43. Scatter diagram comparison of H and U, and H/D and U/D for *Crittendenites jattioti* n. gen., n. sp. (n = 33) vs. *Dieneroceras* cf. *D. dieneri* (n = 32). All specimens from *C. j.* interval.

preserved shells exhibit fine strigation that combines with radial growth lines to form a delicate reticulate sculpture. Suture line ceratitic with well-rounded saddles, deeply indented lobes and relatively short auxiliary series.

Measurements: See Figure 48 and APPENDIX, p. 145.

Discussion: *Arctoceras* appears to exist as two distinct morphological groups at Crittenden Springs; the first and by far the most abundant group consists of the normally robust *Arctoceras tuberculatum*, which occurs throughout the succession (late early Smithian through latest middle Smithian). The second group, represented by the new but slightly older taxon *Arctoceras rubyae* n. sp., consists of a few extremely compressed shells that thus far, have only been found in the latest early Smithian *Arctoceras rubyae* n. sp. FA and earliest

middle Smithian *Meekoceras gracilitatis* FA intervals.

Arctoceras tuberculatum is rare in Utah and has been reported only from early Smithian levels in the Confusion and Pahvant Ranges (Brayard et al., 2013). A few fragmentary specimens have been found in the early middle Smithian at Palomino Ridge, Nevada (Jattiot et al., 2017), and although hitherto unreported from southeastern Idaho, a few specimens have been found in the “*Meekoceras* beds” at nearly all sections thus far sampled (e. g., Bear Lake Hot Springs and Georgetown; Brayard et al., ongoing work). In addition, several different species are now recognized from such various worldwide localities as the Canadian Arctic, Spitsbergen, South China, Pakistan and South Primorye.

Submeekoceras mushbachanum (White) differs from

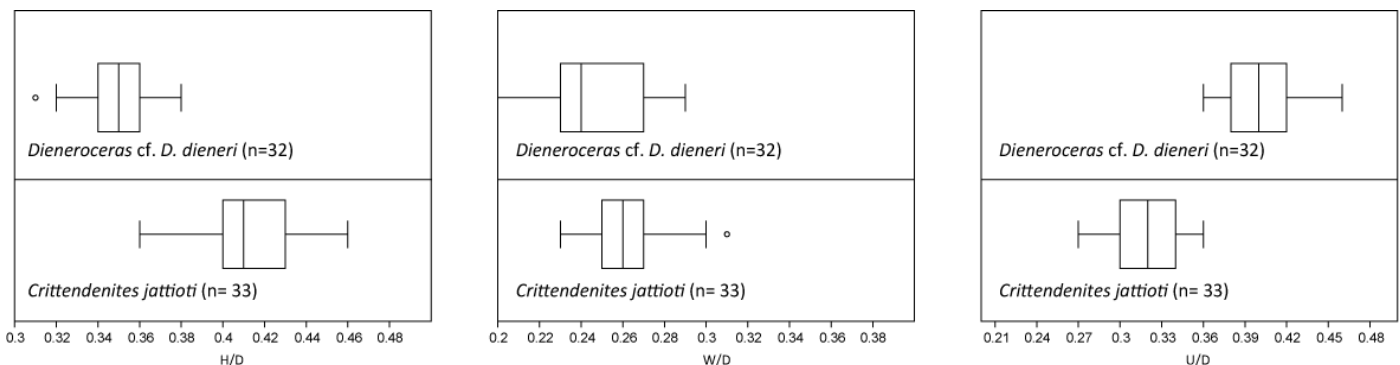


FIGURE 44. Box plot comparison of H/D and U/D for *Crittendenites jattioti* n. gen., n. sp. (n = 33) vs. *Dieneroceras* cf. *D. dieneri* (n = 32).

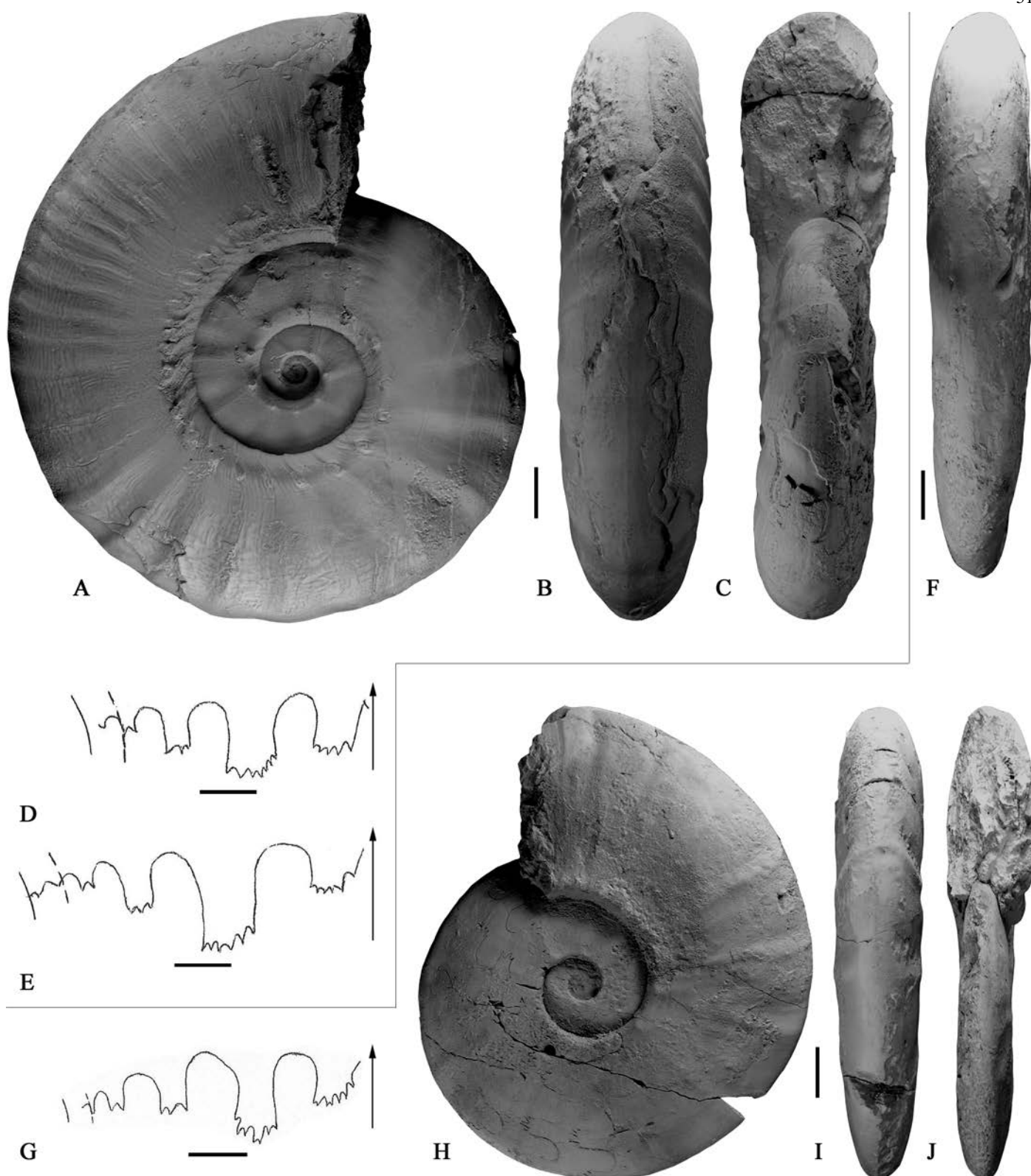


FIGURE 45. **A-E**, *Arctoceras tuberculatum* (Smith). **A-C**, 280C, 4-88, *P. t.*, in **A**, lateral, **B**, ventral and **C**, apertural views, ($W/H = 0.73$, $W/D = 0.28$, $U/D = 0.33$). **D-E**, suture lines in **D**, 2261C-1, $H = 4.2$ cm. **E**, 1771C, $H = 5.3$ cm, 5-76, *C. j.* **F-J**, *Arctoceras rubyae* n. sp., in **F**, 1779C, 13-75, *A. r.*, ventral view. ($W/H = 0.49$, $W/D = 0.20$). **G**, suture line, NMMNH P-79164, $H = 4.7$ cm, 10-14, *A. r.* **H-J**, NMMNH P-79164, holotype, 10-14, *A. r.*, in **H**, lateral, **I**, ventral and **J**, apertural views, ($W/H = 0.49$, $W/D = 0.20$, $U/D = 0.27$). Scale bars = 2 cm for ammonoids, 1 cm for suture lines.

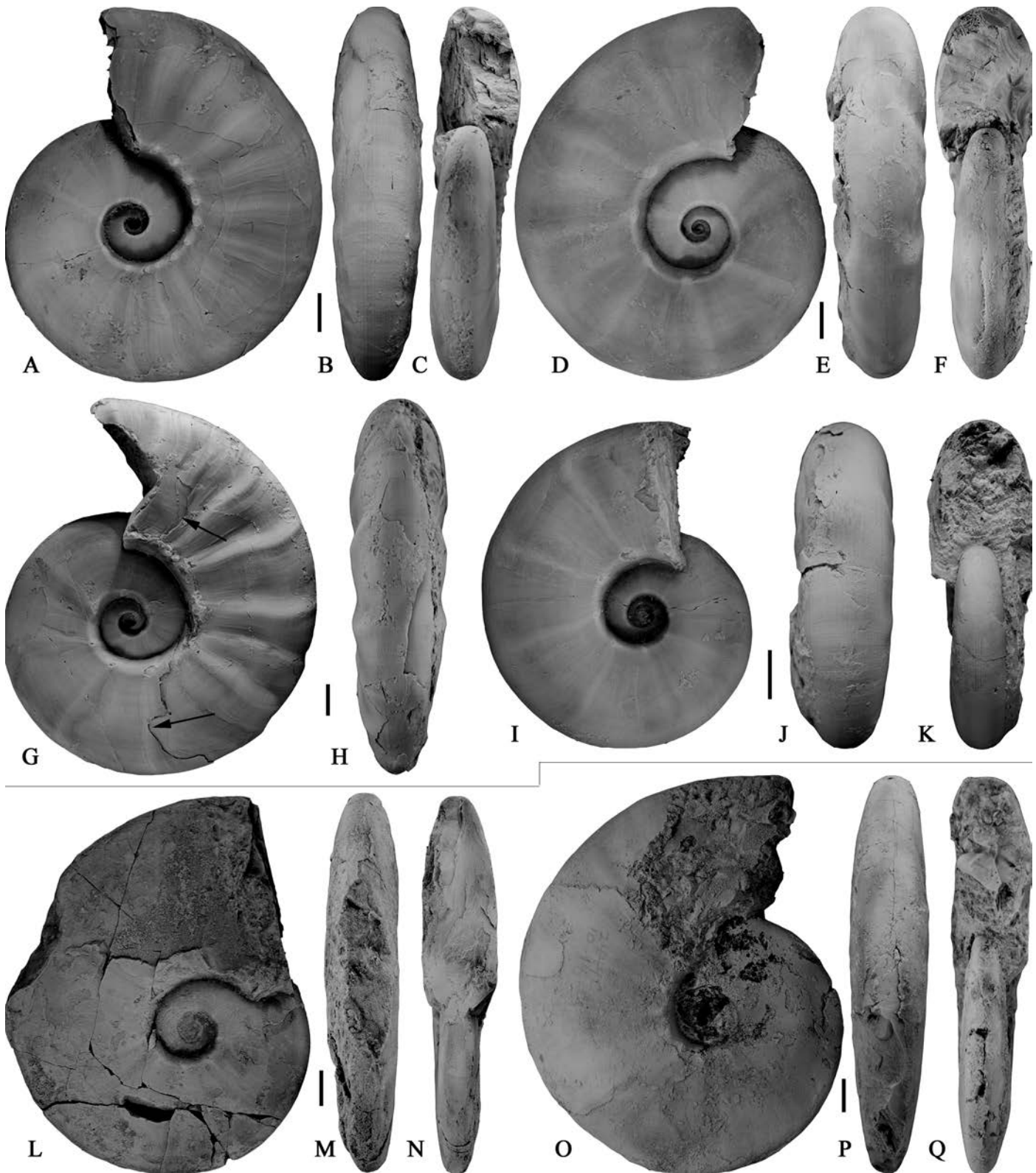


FIGURE 46. **A-K**, *Arctoceras tuberculatum* (Smith), in **A-C**, 686C, 1-88, *C. j.*, in **A**, lateral, **B**, ventral and **C**, apertural views, ($W/H = 0.60$, $W/D = 0.26$, $U/D = 0.26$). **D-F**, 687C, 1-88, *G. l.*, in **D**, lateral, **E**, ventral and **F**, apertural views, ($W/H = 0.62$, $W/D = 0.25$, $U/D = 0.28$). **G-H**, 688C, 1-88, *C. j.*, in **G**, lateral (arrows indicate healed injuries) and **H**, ventral views, ($W/H = 0.66$, $W/D = 0.27$, $U/D = 0.29$). **I-K**, 724C, 1-88, *A. w.*, in **I**, lateral, **J**, ventral and **K**, apertural views, ($W/H = 0.70$, $W/D = 0.31$, $U/D = 0.23$). **L-Q**, *Arctoceras rubyae* n. sp., in **L-N**, NMMNH P-79165, paratype, 13-75, *A. r.*, in **L**, lateral, **M**, ventral and **N**, apertural views, ($W/H = 0.43$, $W/D = 0.21$, $U/D = 0.20$). **O-Q**, NMMNH P-79166, paratype, 10-14, *A. r.*, in **O**, lateral, **P**, ventral and **Q**, apertural views, ($W/H = 0.49$, $W/D = 0.22$, $U/D = 0.20$). All scale bars = 1 cm.

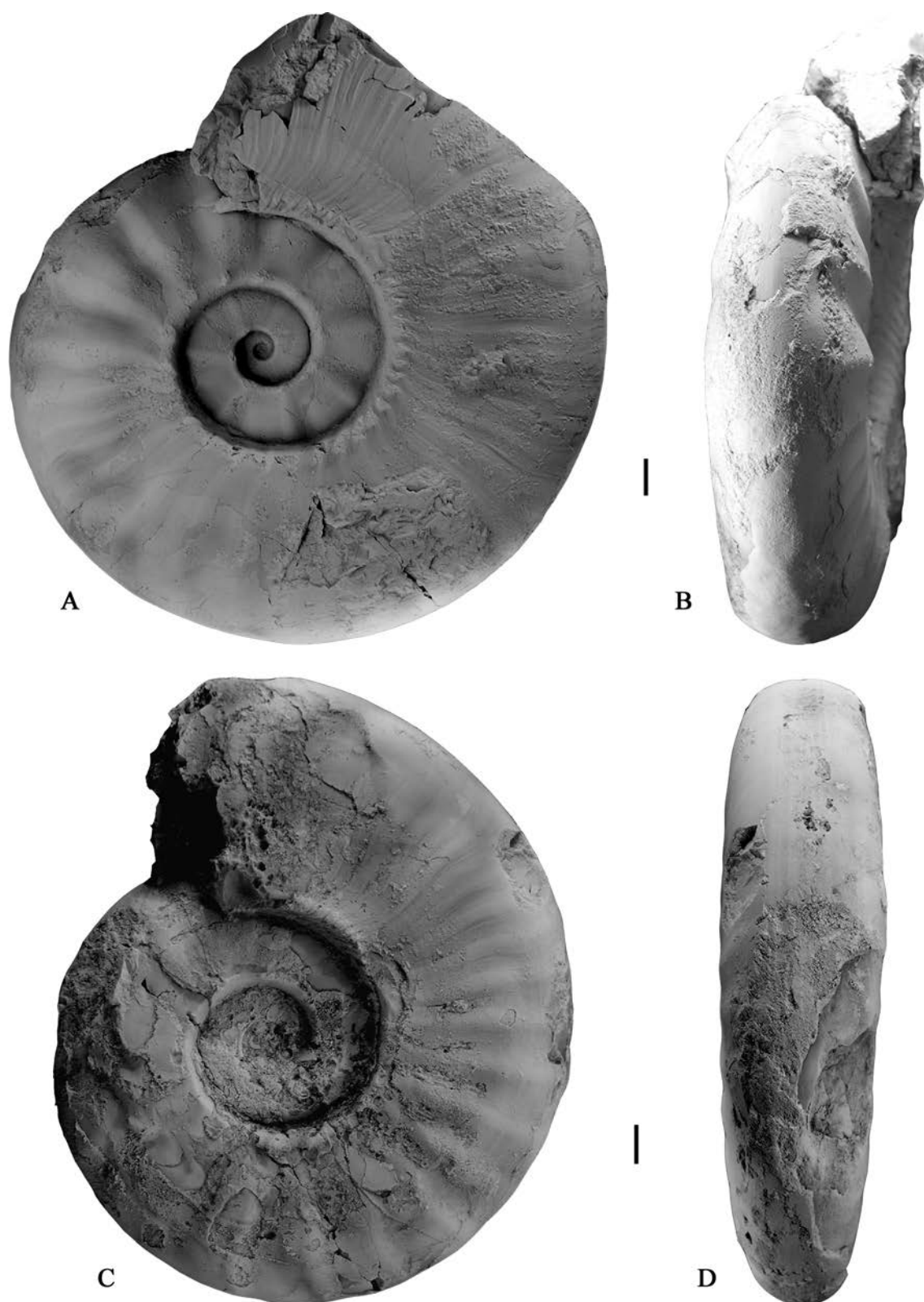


FIGURE 47. *Arctoceras tuberculatum* (Smith), 5-76. **A-B**, 2261C-66, *P. t.*, in **A**, lateral and **B**, apertural view (view is slightly oblique to highlight vertical slope of umbilical wall). **C-D**, 1778C, *C. j.*, in **C**, lateral and **D**, ventral view. All scale bars = 1 cm.

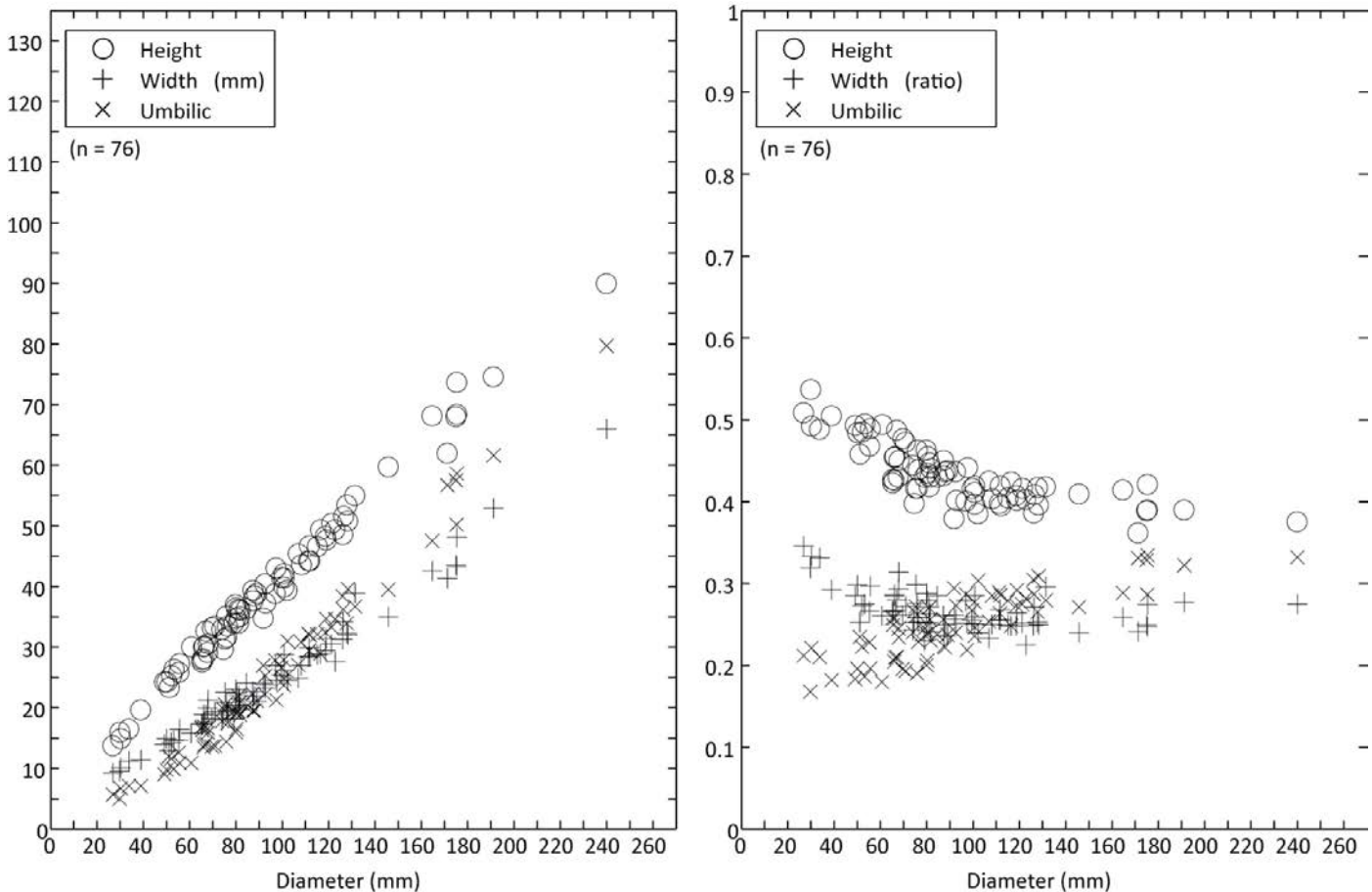


FIGURE 48. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Arctoceras tuberculatum*. Specimens from all middle Smithian intervals.

Arctoceras tuberculatum by its lack of umbilical tuberculation, and, according to Spath (1934), the presence of narrower saddles in its suture line. *Arctoceras blomstrandii* (Lindström, 1865) from Spitsbergen (Weitschat and Lehmann, 1978; Kummel, 1961) and Arctic Canada (Tozer, 1994) resembles *A. tuberculatum* in general form and ornamentation (style of ribbing and umbilical tuberculation), but it appears to be slightly more involute (Brayard et al., 2013). The morphological features of *Arctoceras gigas* (Tozer, 1994), also from the Canadian Arctic, appear to fit well within the intraspecific variation of *A. tuberculatum* and may be conspecific, but a definitive conclusion cannot be reached since the taxon is known from only a few very poorly preserved specimens. *Arctoceras strigatus* Brayard and Bucher, 2008 from South China differs from *A. tuberculatum* by its distinctive strigation and lack of umbilical tuberculation, and *Arctoceras schalteggeri* Brühwiler et al., 2011 from the Salt Range of Pakistan, differs by its different ribbing style and lack of umbilical tuberculation. *Arctoceras septentrionale* (Diener, 1895) from South Primorye, as illustrated in Shigeta and Zakharov (2009), is much more involute than *A. tuberculatum* and lacks umbilical tuberculation, but Shigeta (personal commun., 2017) points out that larger, mature whorls of *A. septentrionale* as illustrated in Zakharov (1968) do exhibit umbilical tuberculation similar to *A. tuberculatum*. *Arctoceras subhydapsis* (Kiparisova, 1961), also from South Primorye, appears very similar to *A. tuberculatum*, but is described as having a wider umbilicus (Shigeta and Zakharov, 2009).

Occurrence: *Arctoceras tuberculatum* is common at Crittenden Springs, occurring in all intervals from the late early Smithian through the latest middle Smithian.

Arctoceras rubyae n. sp. Figures 45F-J, 46L-Q

Type series: Three specimens: Holotype, specimen NMMNH P-79164 (Figure 45G-J); paratypes, two specimens: NMMNH P-79165 (Figure 46L-N), NMMNH P-79166 (Figure 46O-Q). Type series reposit in the NMMNH. Other specimens: One measured specimen excluded from type series (1779C, Figure 45F), but included in species.

Etymology: Species named in honor of Ruby Jenks of West Jordan, Utah.

Diagnosis: Large, fairly evolute, extremely compressed arctoceratid with sub-rectangular whorl section characterized by slightly convex flanks, narrowly rounded to subtabulate venter and fairly narrow umbilicus with low, steeply inclined wall and abruptly rounded shoulders. Ornamentation consists only of weak but obvious tuberculation on umbilical shoulder and very low intensity, fold-type radial ribs. Suture line ceratitic, typical of arctoceratids.

Description: Large, fairly evolute, extremely compressed shell with narrowly rounded venter on early whorls becoming broadly rounded to subtabulate on mature whorls. Flanks nearly parallel but gently convex, forming a sub-rectangular whorl section with maximum width at ~ 45% of whorl height. Body chamber length unknown but at least one half whorl. Umbilicus fairly narrow and relatively shallow with near vertical wall on early whorls becoming slightly less inclined on mature whorls, with abruptly rounded shoulders at all stages. Ornamentation consists of weak but obvious tuberculation on umbilical shoulder, similar to *Arctoceras tuberculatum*. Holotype bears weak but noticeable, wide, fold-type radial ribs. In contrast,

ribbing is not apparent on paratypes. Presence of fine strigation is not apparent because of relatively poor preservation. Suture line ceratitic, similar to *A. tuberculatum*, with high, broad saddles, well indented lobes and relatively short auxiliary series.

Measurements: See Figure 49 and APPENDIX, p. 146.

Discussion: *Arctoceras rubyae* n. sp. differs from *A. tuberculatum* and apparently from all other known species of *Arctoceras* primarily by its much more compressed whorl section. The whorl width-to-diameter ratio (W/D) for *A. rubyae* n. sp. varies from 0.20 to 0.22, whereas the same value for *A. tuberculatum* ranges from 0.24 to 0.35, based on a measured data set consisting of 76 specimens. This variation is especially obvious upon comparison of the specimens of *A. tuberculatum* and *A. rubyae* n. sp. illustrated in Figures 45 and 46, and the box plots of W/D and W/H for both taxa in Figure 50. *Arctoceras rubyae* n. sp. also differs from *A. tuberculatum* by its more narrowly rounded to subtabulate venter, slightly smaller umbilical diameter, shallower umbilicus, somewhat weaker tuberculation on the umbilical shoulders and less intense

ribbing, if present at all. *Arctoceras rubyae* n. sp. differs from *Submeekoceras mushbachanum* (White) from southeastern Idaho by the presence of tuberculation on its umbilical shoulder and a slightly more compressed whorl section. *Arctoceras blomstrandii* (Lindström) from the Canadian Arctic (Tozer, 1994) and Spitsbergen (Weitschat and Lehmann, 1978; Kummel, 1961) is similar to *A. rubyae* n. sp. in conch geometry and ornamentation (ribbing style and umbilical tuberculation), but its coiling appears to be slightly more involute (Brayard et al., 2013). Both *A. strigatus* Brayard and Bucher (2008) from South China and *A. schalteggeri* Brühwiler et al. (2011) from the Salt Range lack umbilical tuberculation, and the former exhibits coarse strigation on its flanks. *Arctoceras septentrionale* (Diener, 1895) from South Primorye is similar to *A. rubyae* n. sp. in coiling geometry, but is considerably more depressed and exhibits umbilical tuberculation only on larger, mature whorls (Shigeta and Zakharov, 2009; Shigeta, personal commun., 2017). *Arctoceras subhydapsis* (Kiparisova, 1961), also from South Primorye, is much closer to *A. tuberculatum* in both whorl

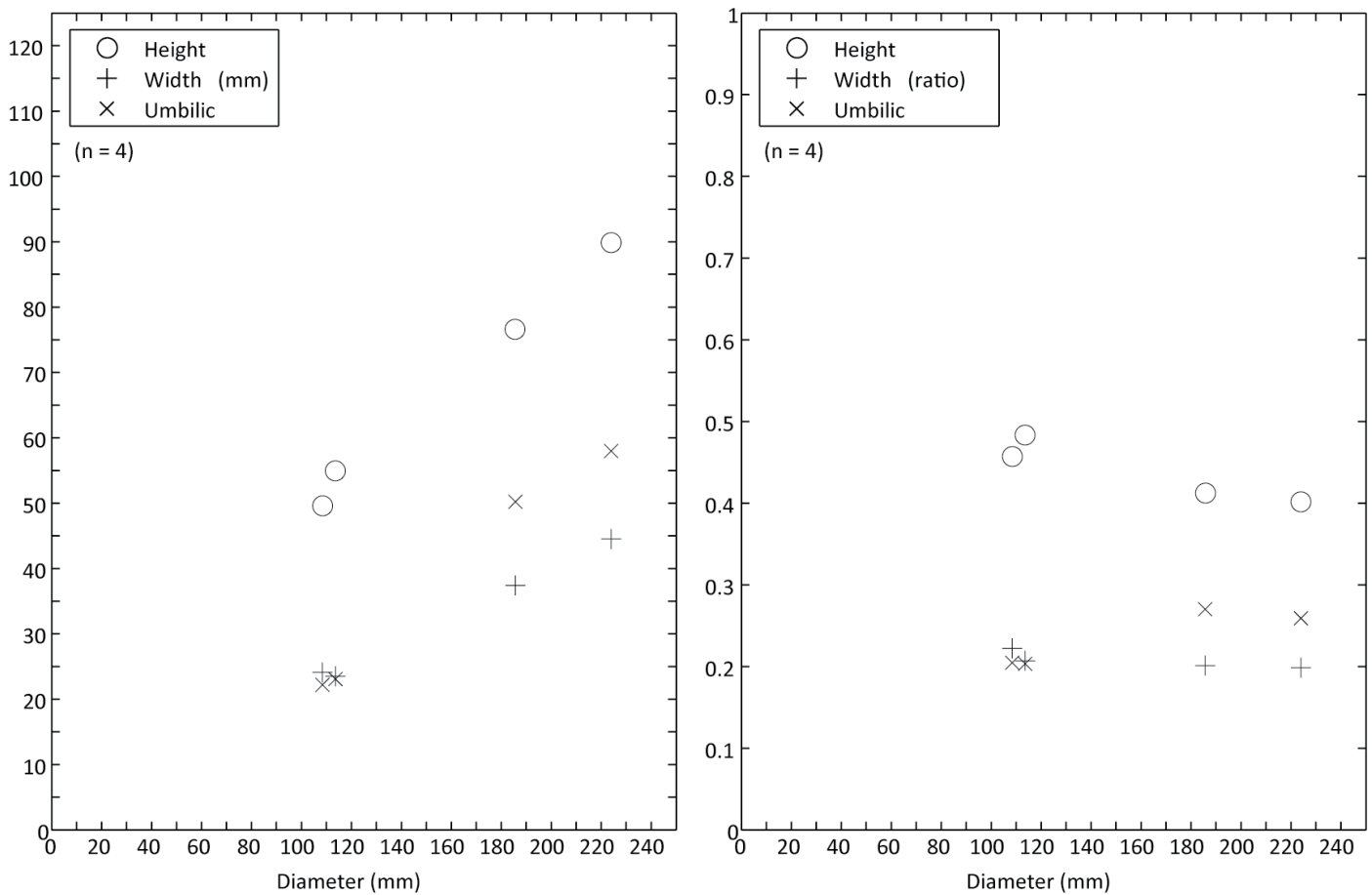


FIGURE 49. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Arctoceras rubyae* n. sp. All specimens from *A. r.* and *M. g.* intervals.

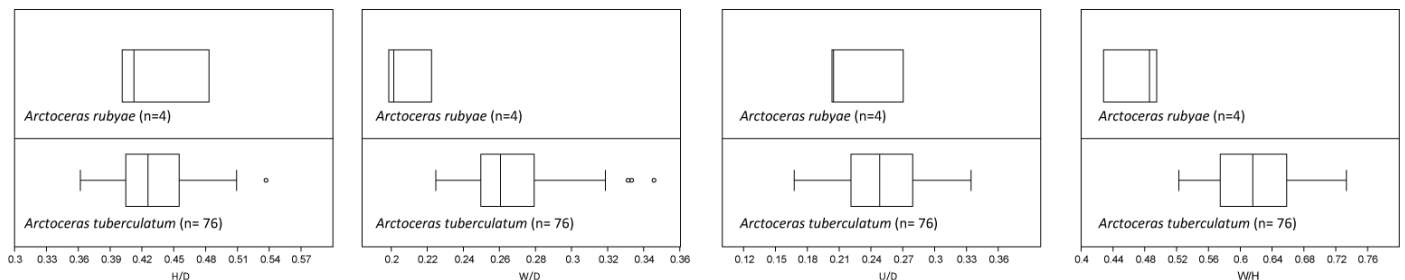


FIGURE 50. Box plot comparison of H/D, W/D, U/D and W/H for *Arctoceras tuberculatum* vs. *A. rubyae* n. sp.

width and ornamentation than *A. rubyae* n. sp. (Shigeta and Zakharov, 2009). Finally, *A. rubyae* n. sp. differs from *Churkites noblei* Jenks by its much more compressed whorl section and its broadly rounded to subtabulate venter on mature specimens.

Admittedly, *Arctoceras rubyae* n. sp., based on only four specimens, is not well known. However, this supposed scarcity probably does not represent its true abundance. Preservation in the two intervals in which the new taxon has been found is generally extremely poor, and, consequently, not much attention has been devoted to this particular portion of the condensed bed. Three of the present specimens came from a single bed in which these two intervals exhibited much better preservation than normal.

Occurrence: *Arctoceras rubyae* n. sp. has been found only in the late early Smithian *A. rubyae* n. sp. FA interval and the early middle Smithian *M. gracilitatis* FA interval.

Genus *Churkites* Okuneva, 1990

Type species: *Churkites egregius* Zharnikova and Okuneva (in Okuneva, 1990)

Churkites noblei Jenks, 2007

Figures 51, 52

2000 *Arctoceras* sp. Gardner and Mapes, pl. 2, fig. 1.

v2007 *Churkites noblei* Jenks, p. 83, figs. 2, 4, 7-9.

v2010 *Churkites noblei* Jenks, Stephen et al., figs. 5i, j.

v2013 *Churkites noblei* Jenks, Brayard et al., p. 178, figs. 42, 43.

2017 *Churkites noblei* Jenks, Jattiot et al., p. 22, pl. 6, figs. A-K.

Material: Eleven measured specimens plus two fragmentary specimens. Includes type series (five specimens). Illustrated specimens include NMMNH P-55141 (holotype), NMMNH P-55143 (paratype, suture line), NMMNH P-55142 (paratype, suture line), 400C, 1777C, 2535C and 2482C.

Description: Very large, fairly evolute, compressed, high-whorled arctoceratid with gently convex flanks slowly converging to narrowly rounded venter on juvenile and adolescent whorls. Venter on mature whorls ranges from very narrowly or abruptly rounded to distinctively acute or angular (see transition in Fig. 52G1-4). Ovoid whorl section with maximum width at about mid-flank. Wide umbilicus with moderately high, inclined wall and abruptly rounded shoulders. Umbilical wall quite steep on early whorls but gradually becoming less inclined throughout ontogeny. Ontogenetic point of transition to acute venter not size dependent, varying from phragmocone on some specimens to body chamber on others. Body chamber length unknown but at least ½ whorl. Ornamentation consists of weak to strong tuberculation on umbilical shoulders, varying greatly in density but becoming denser on mature whorls and more bullate on some specimens. Flanks of some adult shells relatively smooth, but others bear radial to slightly sinuous ribs that vary greatly in strength, width and frequency. Origination of most ribs associated with umbilical tuberculation. Ribs fade away rapidly on ventral shoulders. Well preserved shells exhibit fine strigation that combines with radial growth lines to form a delicate reticulate sculpture. Suture line ceratitic, consisting of well-denticulated ventral, first and second lateral lobes, as well as short auxiliary series. Width of lobes gradually decreases towards umbilicus. First lateral saddle wide and well rounded, while second lateral saddle is somewhat narrower but still well rounded.

Measurements: See Figure 53 and APPENDIX, p. 147.

Discussion: The genus *Churkites* (type species, *C. egregius* Zharnikova and Okuneva, in Okuneva, 1990) and an additional species, *C. syaskoi* Zakharov and Shigeta, 2004, were erected for acute-ventered arctoceratids from the Anasibirites nevolini Zone in South Primorye and the Bolshie Churki Range in Southern Khabarovsk. Shigeta and Kumagae (2015) recently synonymized *C. syaskoi* with *C. egregius* following an intensive investigation of *Churkites* from several localities in South

Primorye. Although *C. noblei* is similar to *C. egregius*, it does exhibit significant differences. Namely, its umbilical wall is not near as steep and its whorl section tends to be ovoid whereas that of the Russian taxon varies from ovoid on smaller specimens to trapezoidal on larger shells (Okuneva, 1990; Shigeta, personal commun., 2007). Also, the venter of *C. egregius* consistently becomes acute at a significantly smaller diameter than *C. noblei* (Shigeta, personal commun., 2007). Larger diameter shells of *C. noblei* appear to be slightly more involute than comparable sized *C. egregius*. Finally, the style of ribbing is significantly different on the Russian taxon. Although it also varies somewhat in strength, *C. egregius* tends to bear denser, stronger radial ribs that project forward strongly on the ventral shoulder and then rapidly fade away before reaching the acute venter (Shigeta, personal commun., 2007). The suture line of *C. egregius* is slightly different in that it exhibits lobes with more denticulation and a more complex auxiliary series than *C. noblei*.

Jenks (2007) pointed out that the morphology and ornamentation of *C. noblei* resemble *Arctoceras tuberculatum* more than the Russian forms of *Churkites* and given the cross-Panthalassic faunal exchange that occurred during the Early Triassic (Brayard et al., 2006), it is plausible that *C. noblei* is an ancestor of the Russian forms. In accordance, Shigeta and Kumagae (2015) suggested that *C. noblei* evolved from *Arctoceras tuberculatum* on the eastern side of Panthalassa during the latest middle Smithian and then migrated to the western side where it evolved into *C. egregius* during the late Smithian. Interestingly, *Churkites* is one of just a few taxa that cross the middle/late Smithian boundary. See Jenks (2007) for a more in depth description and discussion of *C. noblei*.

Occurrence: *Churkites noblei* is uncommon at Crittenden Springs and occurs only in the latest middle Smithian *Inyoites oweni* interval (Jenks, 2007; Jenks et al., 2010). In contrast, the taxon is abundant in the Confusion and Pahvant Ranges of Utah where it occurs throughout a somewhat wider stratigraphical range in the late middle Smithian (Brayard et al., 2013). It also occurs in the Mineral Mountains near Minersville, Utah and in the Torrey area, Utah, where it is reportedly rare (Brayard et al., 2013). The taxon has also been reported from Palomino Ridge, Nevada (Jattiot et al., 2017).

Family INYOITIDAE Spath, 1934

Genus *Inyoites* Hyatt and Smith, 1905

Type species: *Inyoites oweni* Hyatt and Smith, 1905

Inyoites oweni Hyatt and Smith, 1905

Figure 54Q-T

1905 *Inyoites oweni* Hyatt and Smith, p. 134, pl. 6, figs. 1-16; pl. 69, figs. 1-9; pl. 78, figs., 1-8.

1932 *Inyoites oweni* Hyatt and Smith, Smith, p. 80, pl. 6, figs. 1-16, pl. 40, figs. 1-8, pl. 69, figs. 1-9.

1934 *Inyoites oweni* Hyatt and Smith, Spath, p. 138, fig. 37.

1968 *Inyoites spicini* Zakharov, p. 151, pl. 30, fig. 2.

1973 *Inyoites oweni* Hyatt and Smith, Collignon, p. 12, pl. 1, fig. 9.

?1995 *Inyoites oweni* Hyatt and Smith, Shevyrev, p. 34, pl. 3, figs 2-4.

2010 *Inyoites oweni* Hyatt and Smith, Stephen et al., figs. 5a, b. 2012a *Inyoites oweni* Hyatt and Smith, Brühwiler et al., p. 34, pl. 21, figs. 1-6.

?2012a *Inyoites* sp. indet., Brühwiler et al., p. 35, pl. 21, figs. 8a-c.

2013 *Inyoites oweni* Hyatt and Smith, Brayard et al., p. 185, fig. 49a-t.

2017 *Inyoites oweni* Hyatt and Smith, Jattiot et al., p. 24, pl. 8, figs. A-G.

Material: Two fragmentary specimens, 2184C and 2434C, both are illustrated.

Description: Medium sized, moderately involute, very

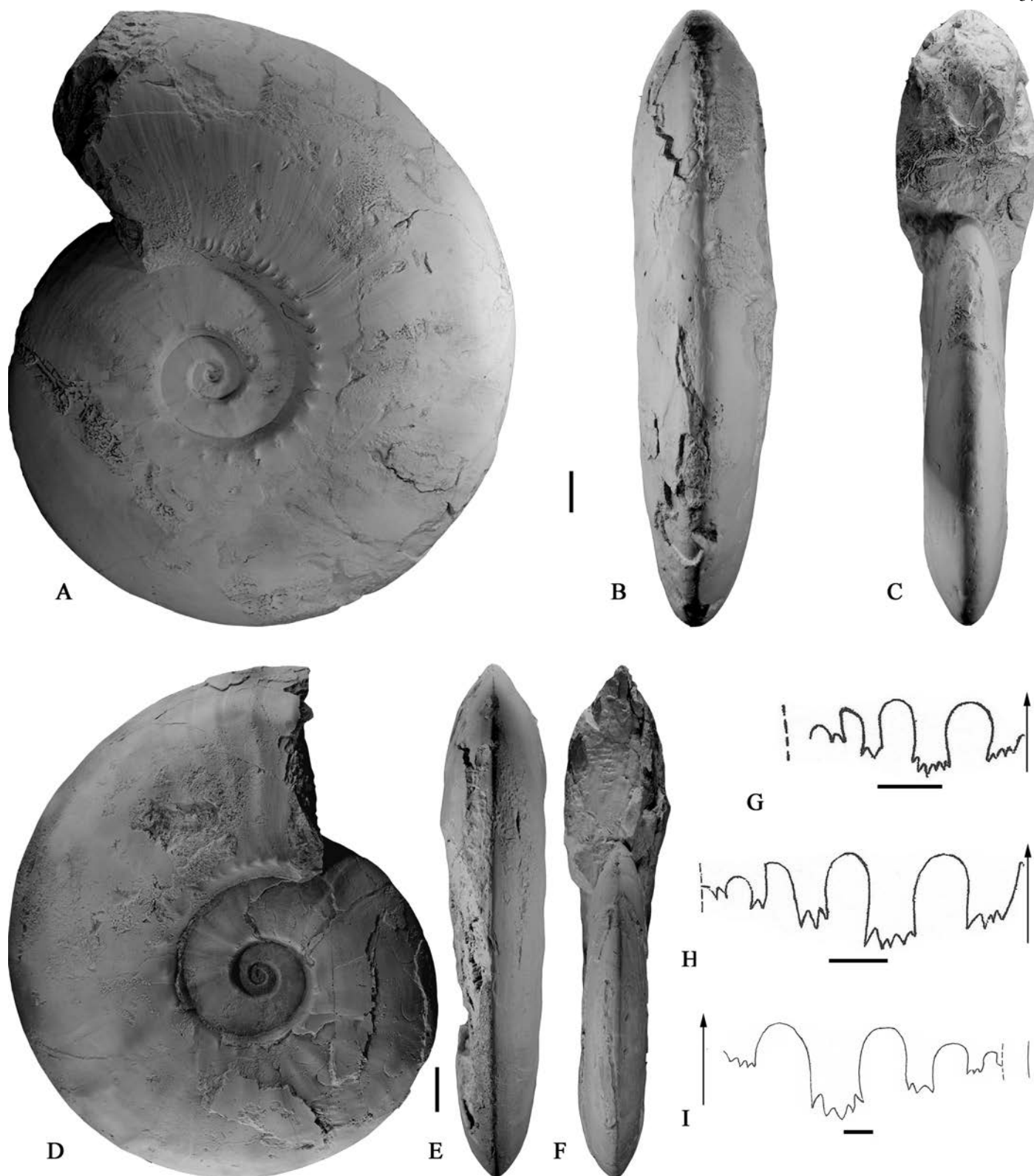


FIGURE 51. *Churkites noblei* Jenks, *I. o.* **A-C**, 400C, 13-75, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 1777C, 5-76, in **D**, lateral, **E**, ventral, and **F**, apertural views. **G-I**, suture lines, in **G**, NMMNH P-55143, paratype, H = 3.7 cm, 5-76. **H**, NMMNH P-55142, paratype, H = 6.4 cm, 13-75. **I**, 400C, H = 10.6 cm. Scale bars = 2 cm for ammonoids, 1 cm for suture lines.

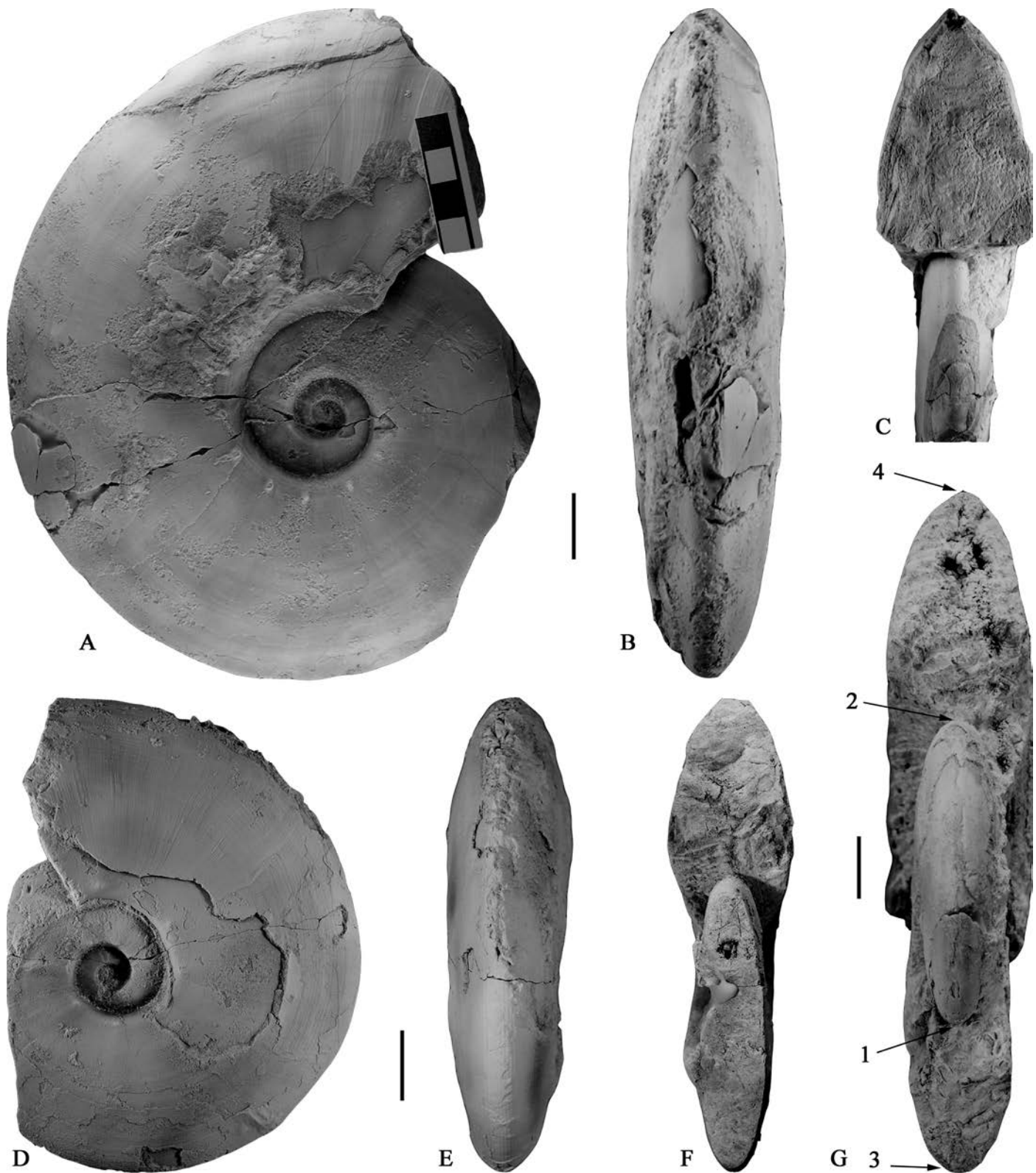


FIGURE 52. *Churkites noblei* Jenks, *I. o.* A-C, NMMNH P-55141, holotype, 5-76, in A, lateral, B, ventral and C, apertural views. D-F, 2535C, 5-76, in D, lateral, E, ventral and F, apertural views. G, 2482C, 10-14, ventral view showing transition from rounded to acute venter (1-4). Scale bars = 2 cm for A-C and D-F, and 1 cm for G.

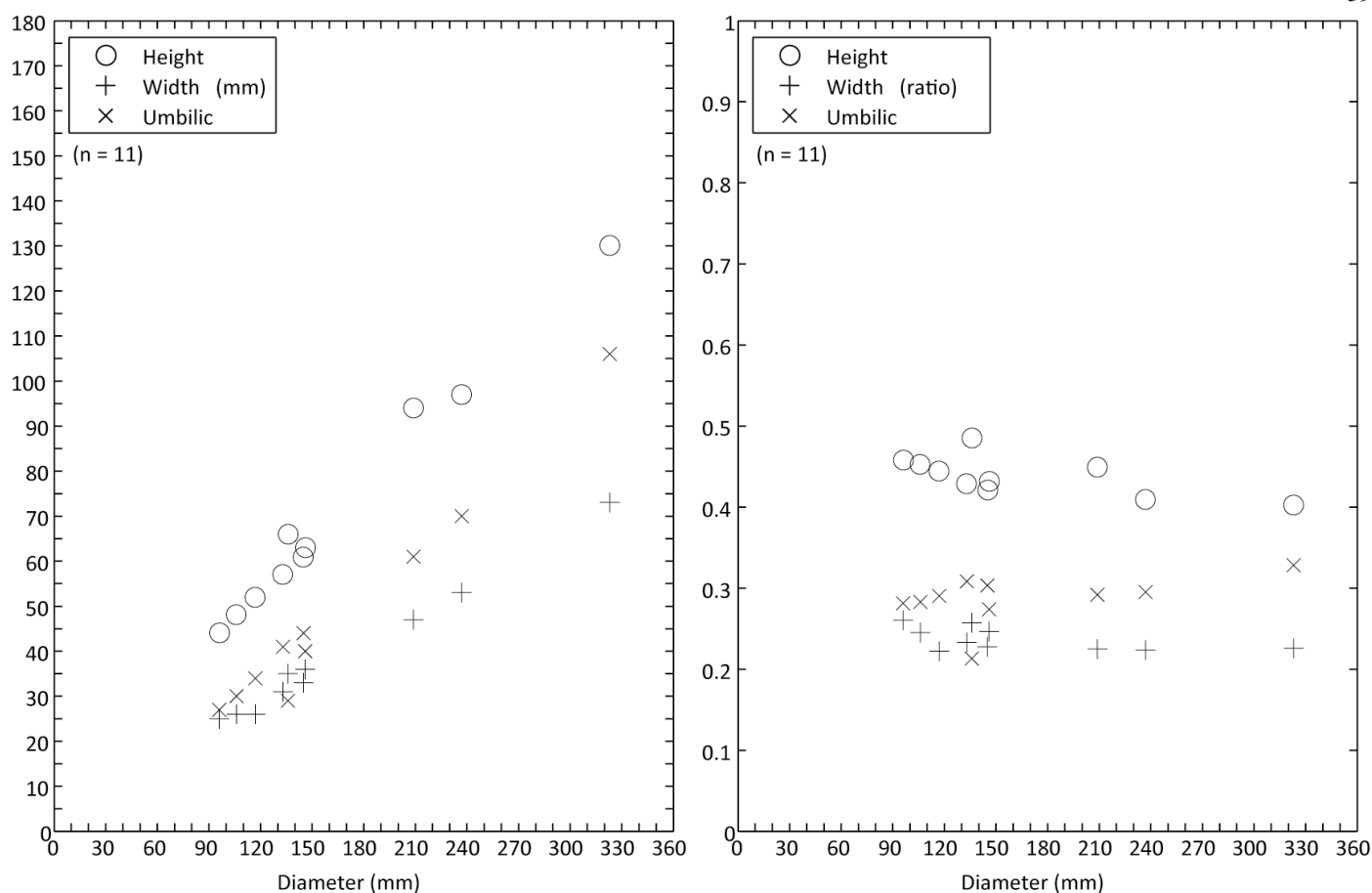


FIGURE 53. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Churkites noblei*. All specimens from *I. o.* interval.

compressed shell with barely perceptible, broadly rounded ventral shoulder and acute, lanceolate venter with a distinct high keel. Flank contour gently convex from umbilical shoulder to ventral shoulder, then converges rapidly to venter. Maximum whorl width at $\sim 1/3$ of whorl height. Wide, shallow umbilicus with moderately inclined, fairly low wall and rounded shoulder, becoming somewhat steeper with abruptly rounded shoulder on mature whorls. Ornamentation consists of dense, radial but very slightly sinuous, fold-type ribs that arise above umbilical seam, become most pronounced on inner flank and then gradually fade in strength until they disappear below ventral shoulder. Very dense radial lirae fill interspaces between ribs, becoming very distinctive and slightly sinuous on outer flank and keel. Ribs vary greatly in strength and density from specimen to specimen, and direction also varies from slightly prosiradate to rursiradate. Faint strigation visible on flank of one specimen. Suture line not exposed on present specimens.

Measurements: See APPENDIX, p. 147.

Discussion: *Inyoites oweni* has a somewhat wider and more abundant distribution in the western USA basin than in the Tethys or western Panthalassa, but the level in which the taxon occurs at Crittenden Springs (*I. o.* interval) is not well developed; it is missing from some beds and significantly reduced in thickness in others. Consequently, *I. oweni* is very rare – only two fragmentary specimens have been found. In contrast, the taxon is common at Union Wash, California, its type locality, and is an abundant component in the *Inyoites* horizon in the Confusion and Pahvant Ranges and Mineral Mountains of Utah (Brayard et al., 2013). Somewhat surprisingly, it is abundant in the Cottonwood Canyon-Palomino Ridge sections of northeastern Nevada (Jattiot et al., 2017), about 150 km SSW of Crittenden

Springs, and it also has been found in the Wine Cup section, only 48 km SW of Crittenden Springs.

In the Tethys, *Inyoites oweni* has been reported from the *Owenites* beds of Afghanistan (Collignon, 1973), the Caucasus (Shevyrev, 1995) and Oman (Brühwiler et al., 2012a). *Inyoites krystyni*, described by Brayard and Bucher (2008) from the *Owenites* beds of South China, differs from *Inyoites oweni* by its much larger size, more evolute coiling and weaker ornamentation (Brayard et al., 2013). *Inyoites stokesi* Kummel and Steele differs from *Inyoites oweni* by its more evolute coiling, lack of a lanceolate ventral region, much lower and weaker keel and weaker ornamentation.

Occurrence: *Inyoites oweni* is very rare at Crittenden Springs, occurring only in the latest middle Smithian *I. oweni* interval.

Inyoites stokesi Kummel and Steele, 1962 Figure 54A-P

1962 *Inyoites stokesi* Kummel and Steele, p. 672, pl. 99, figs. 19-22.

?1973 *Inyoites stokesi* Kummel and Steele, Collignon, p. 137, pl. 1:10, 10a.2008

?2008 *Subvishnuites stokesi* (Kummel and Steele), Brayard and Bucher, p. 60, pl. 29: 8a-d, table 1.

Material: 22 measured specimens (Jenks collection) plus holotype and one paratype. Illustrated specimens (6) include 2182C, 924C, 111C, 2183C-8, MCZ 106931 (holotype) and MCZ 106932 (paratype).

Description: Small, moderate to fairly involute, very compressed shell with very gently convex, nearly parallel flanks, converging rapidly from broadly rounded ventral shoulder to

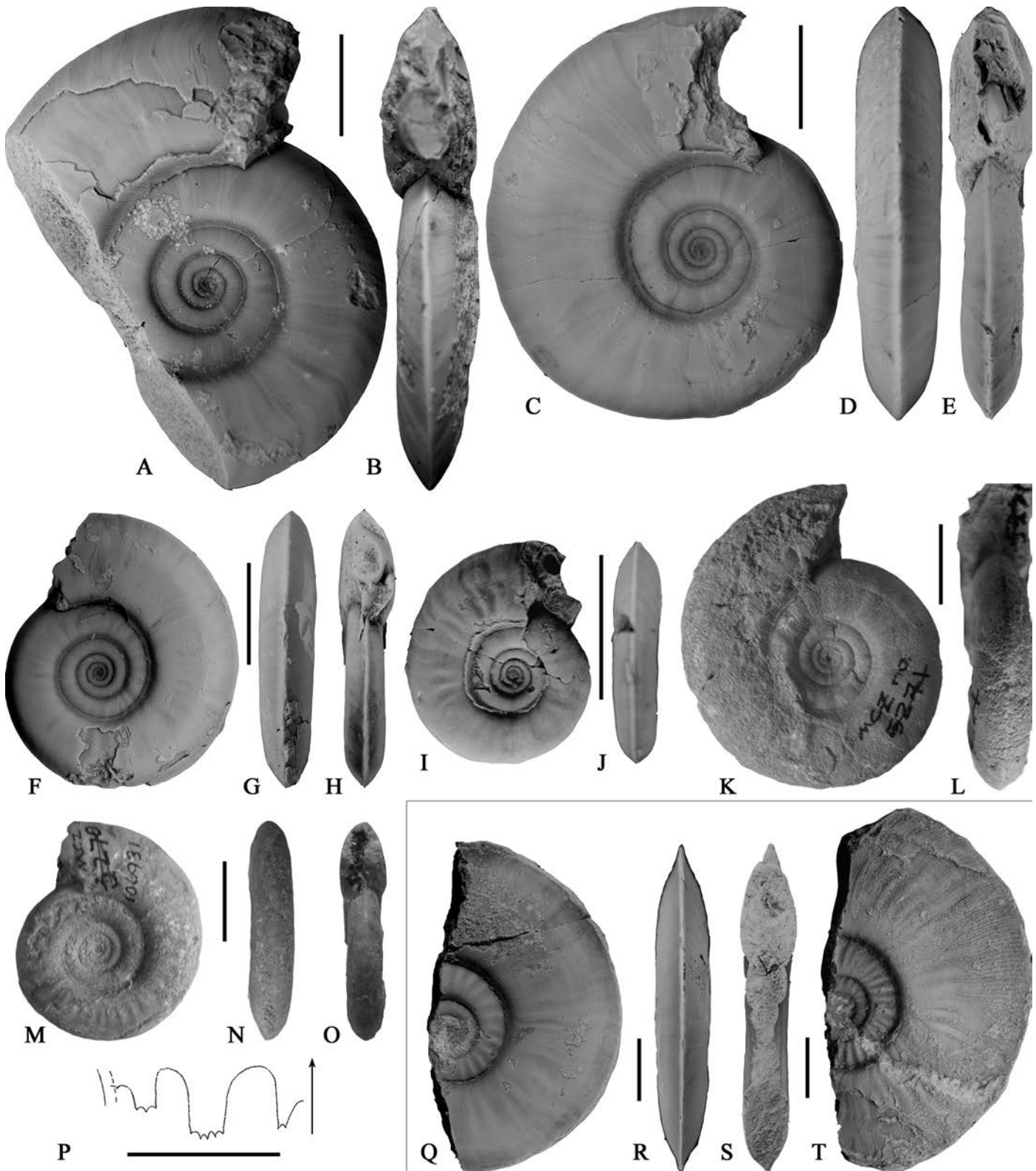


FIGURE 54. **A-P**, *Inyoites stokesi* Kummel & Steele, *I. o.* **A-B**, 2182C, 2-94, in **A**, lateral and **B**, apertural views. **C-E**, 924C, 2-94, in **C**, lateral, **D**, ventral and **E**, apertural views. **F-H**, 111C, 2-79, in **F**, lateral, **G**, ventral and **H**, apertural views. **I-J**, 2183C-8, 2-94, in **I**, lateral and **J**, ventral views. **K-L**, MCZ 106932, paratype, in **K**, lateral, and **L**, apertural views. **M-O**, MCZ 106931, holotype, in **M**, lateral, **N**, ventral and **O**, apertural views. **P**, suture line, 496C, H = 1.14 cm, 2-79. **Q-T**, *Inyoites oweni* Hyatt & Smith, *I. o.*, in **Q-S**, 2184C, 2-94, in **Q**, lateral, **R**, ventral, and **S**, apertural views. **T**, 2434C, 1-11, lateral view. All scale bars = 1 cm.

a very acute, angular venter adorned with a very low, barely perceptible keel. Wide, shallow umbilicus with low, moderately inclined wall and rounded shoulder. Ornamentation consists of dense radial to slightly rursiradiate, somewhat sinuous growth lines, projected forward slightly at ventral shoulder, then crossing venter. Some smaller specimens exhibit very low intensity radial to rursiradiate fold-type ribs, arising above umbilical shoulder, becoming slightly sinuous, and projecting forward on ventral shoulder before fading below venter. Suture line ceratitic with relatively long, wide first lateral lobe and rounded saddles.

Measurements: See Figure 55 and APPENDIX, p. 147.

Discussion: Kummel and Steele (1962) attributed their new species to *Inyoites*, but Brayard and Bucher (2008) reassigned it to *Subvishnuites* Spath (1930) because of its overall similarity in shape to this genus and its apparent lack of a keel. This synonymy is understandable given the rather poor and

weathered preservation of the type specimens, especially the holotype (Kummel and Steele, 1962, pl. 99, figs. 19-20, MCZ 106931). The morphology of this particular specimen (Figure 54M-O), which has been altered by weathering to the point that its acute venter is unrecognizable for most of its periphery, indeed suggests an affinity with *Subvishnuites*. The paratype (MCZ 106932) is also weathered but much less severely (Figure 54K-L). Its morphology (coiling, nearly parallel flanks, acute venter, character of umbilicus – shoulder and slope of wall) is nearly identical to the present well-preserved specimens, but any indication of the presence of a keel has been removed by weathering. At first glance, the occurrence of a keel on many of the present specimens is not readily apparent, but close examination with a hand lens reveals that a very low, weak keel is indeed present on all specimens. This observation lends support to the conclusion that the *I. stokesi* group should not

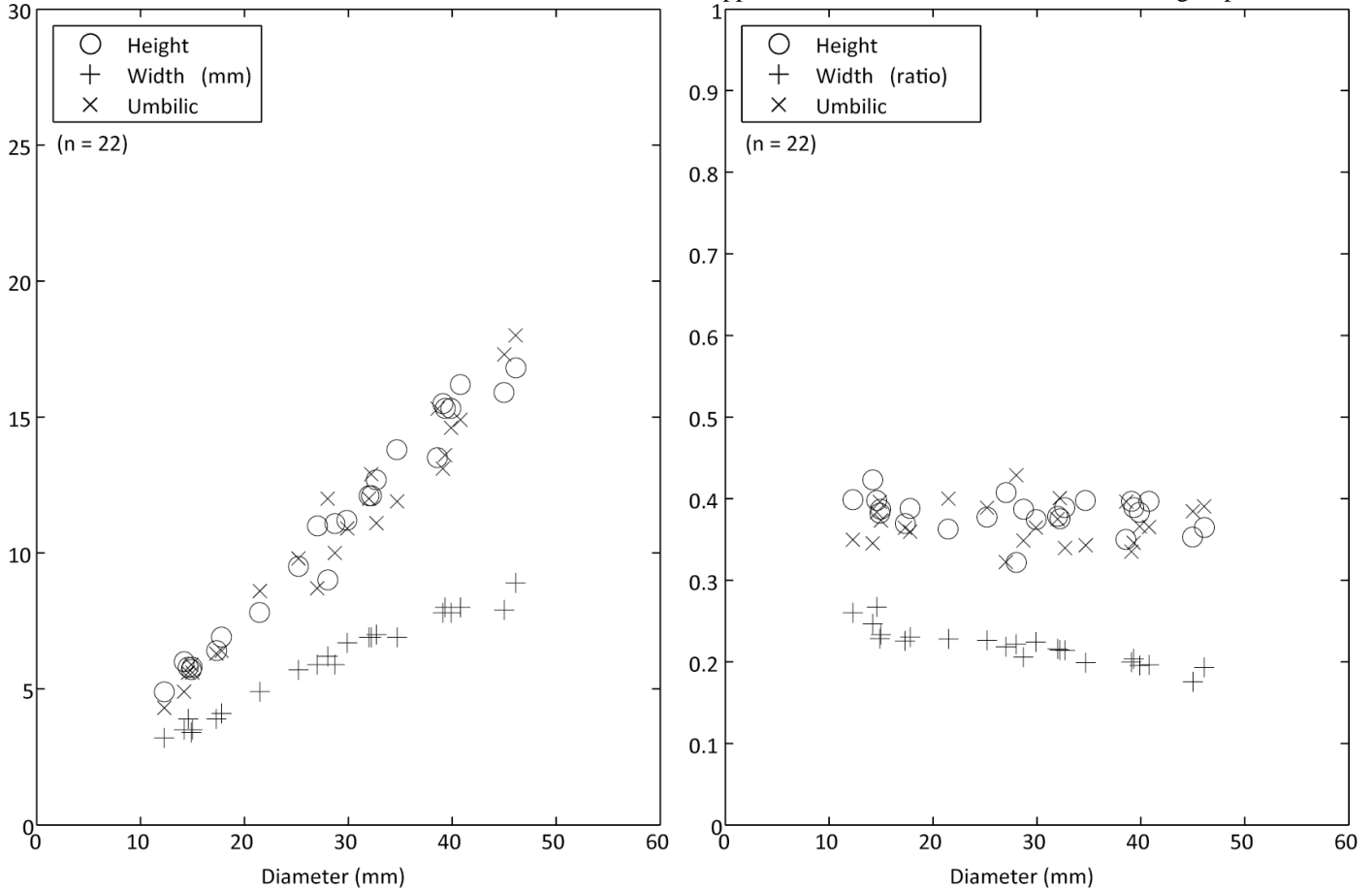


FIGURE 55. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Inyoites stokesi*. All specimens from *C. j.* and *I. o.* intervals.

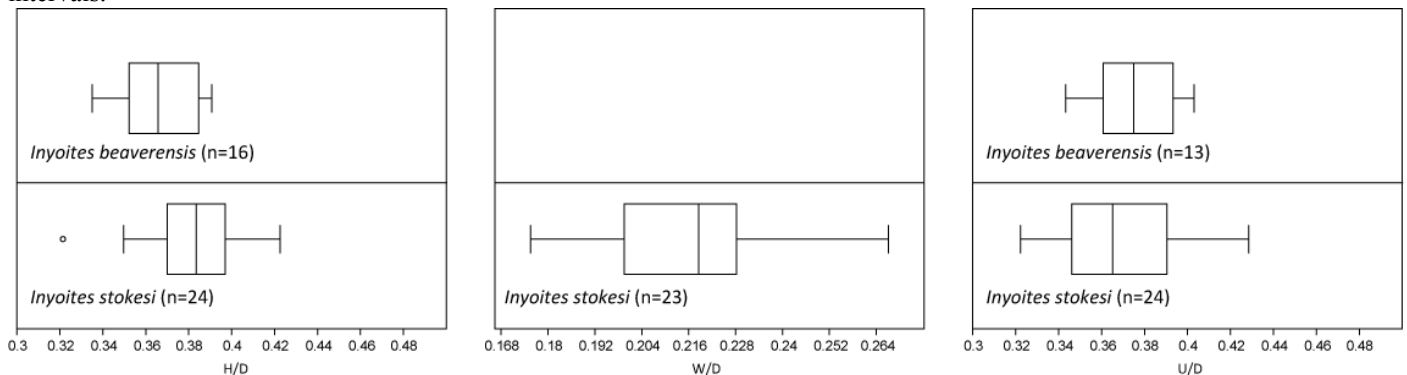


FIGURE 56. Box plot comparison of H/D, W/D and U/D for *I. stokesi* vs. *I. beaverensis* specimens from Utah (see Brayard et al., 2013).

be confused with *Subvishnuites*, e.g., *S. welteri* Spath, which is described as having an acute venter without a keel.

Inyoites stokesi obviously differs from *I. oweni*, with which it occurs, by the latter's characteristic lanceolate ventral region and high distinctive keel as well as its slightly more involute coiling. In terms of the classic geometric parameters, *I. stokesi* is practically indistinguishable from *Inyoites beaverensis* Brayard et al. (2013) from the Confusion Range of Utah (see box plot comparison, Fig. 56), but the keel of *I. beaverensis*, although weak compared to *I. oweni*, is obviously higher than that of *I. stokesi*, and it also is much older (late early Smithian). The former observation is considered significant given that the Utah specimens still retain an obvious keel in spite of their generally poor preservation. *Inyoites* sp. indet. (Jattiot et al., 2017), based on three poorly preserved specimens from Palomino Ridge, Nevada, is similar in age to *I. stokesi* (late middle Smithian) and also appears to be relatively close in conch shape, but it too exhibits a ventral keel similar in height to *I. beaverensis*. Finally, because the gross height and character of the ventral keel are considered to be diagnostic features, *Inyoites stokesi* with its low, nearly imperceptible ventral keel is herein considered to be a valid species.

Occurrence: *Inyoites stokesi* is found only in the *C. jattioti* n. gen., n. sp. and *I. oweni* intervals.

Family LANCEOLITIDAE Spath, 1934

Genus *Lanceolites* Hyatt and Smith, 1905

Type species: *Lanceolites compactus* Hyatt and Smith, 1905

Lanceolites compactus Hyatt and Smith, 1905

Figure 57

- 1905 *Lanceolites compactus* Hyatt and Smith, p. 113, pl. 4, figs. 4-10, pl. 5, figs. 7-9, pl. 78, figs. 9-11.
 1932 *Lanceolites compactus* Hyatt and Smith, Smith, p. 90, pl. 4, figs. 4-10, pl. 5, figs. 7-9, pl. 21, figs. 21-23, pl. 28, figs. 17-20, pl. 40, figs. 9-11, pl. 60, fig. 10.
 1962 *Lanceolites compactus* Hyatt and Smith, Kummel and Steele, p. 692, pl. 102, figs. 6-9.
 ?1979 *Lanceolites compactus* Hyatt and Smith, Nichols and Silberling, pl. 2, figs. 39-43.
 1995 *Lanceolites compactus* Hyatt and Smith, Shevryev, p. 39, pl. 2, figs. 1-2.
 2008 *Lanceolites compactus* Hyatt and Smith, Brayard and Bucher, p. 61, pl. 30, fig. 5, text-fig. 53.
 2012a *Lanceolites compactus* Hyatt and Smith, Brühwiler et al., p. 38, pl. 20, figs. 4-6.
 2017 *Lanceolites compactus* Hyatt and Smith, Jattiot et al., p. 26, pl. 9, figs. A-M.

Material: 20 measured specimens. Includes eight illustrated specimens (2454C-16, 2454C-17, 293C, 2454C-12, 2454C-6, 296C, 744C and 2454C-7).

Description: Medium sized, oxyconic-like shell with weakly convex flanks gently converging toward relatively narrow, concave, weakly bicarinate venter with sharply angular shoulders. Some very small juvenile shells have a tabulate venter. Maximum whorl width at about 1/3 of whorl height. No ornamentation visible on most specimens, but a few have barely visible, prosiradiate, slightly sinuous growth lines and distant, very low intensity fold-type ribs, following the same path as the growth lines. Suture line sub-ammonitic with broad, deep first lateral lobe that is characteristic of genus.

Measurements: See Figure 58 and APPENDIX, p. 148.

Discussion: Smith (1932) established a new species, *L. bicarinatus*, based on rare specimens from Union Wash, California and Phelan Ranch, Nevada that exhibited a more compressed whorl section and a narrower, bicarinate venter. The presence of a bicarinate venter is really not diagnostic, because *L. compactus* also exhibits a bicarinate venter that varies in strength from specimen to specimen. Measurements for a few

specimens reported by Brayard and Bucher (2008), Brühwiler et al. (2012a) and Shevryev (1995) tend to confirm the two species distinction, but the validity of the new taxon has been called into doubt, first by Kummel and Steele (1962), who considered it to be an extremely compressed variant, and then by Brayard et al. (2013), who based their uncertainty on a relatively small number of specimens from Utah. In essence, no particular locality has yielded sufficient specimens to resolve this controversy, and, unfortunately, the material from Crittenden Springs contributes nothing towards its resolution.

Occurrence: *Lanceolites compactus* occurs from the *O. koeneni* FA interval through the *C. jattioti* n. gen., n. sp. interval. Small specimens are relatively common, but larger specimens are rare.

Family USSURIIDAE Spath, 1930

Genus *Parussuria* Spath, 1934

Type species: *Ussuria compressa* Hyatt and Smith, 1905

Parussuria compressa (Hyatt and Smith, 1905)

Figures 59, 60

- 1905 *Ussuria compressa* Hyatt and Smith, p. 89, pl. 3, figs. 6-11.
 ?1905 *Ussuria waageni* Hyatt and Smith, p. 90, pl. 65, figs. 1-5; pl. 66, figs. 1-12; pl. 67, figs. 1, 2; pl. 85, figs. 1-8.
 ?1927 *Ussuria waageni* Hyatt and Smith, pl. 21, figs. 24-40.
 1932 *Ussuria compressa* Hyatt and Smith, Smith, p. 93, figs. 6-11.
 1934 *Parussuria compressa* (Hyatt and Smith), Spath, p. 213, figs. c, d.
 1962 *Parussuria compressa* (Hyatt and Smith), Kummel and Steele, p. 690, p. 99, fig. 23, pl. 102, fig. 11.
 ?1962 *Pseudaspidites wheeleri* Kummel and Steele, p. 673, pl. 101, fig. 1.
 ?1968 *Parussuria semenovi* Zakharov, p. 59, pl. 5, fig. 4.
 1995 *Parussuria compressa* (Hyatt and Smith), Shevryev, p. 37, pl. 4, fig. 6, text-fig. 16.
 2008 *Parussuria compressa* (Hyatt and Smith), Brayard and Bucher, p. 56, pl. 12, fig. 17.
 2012a *Parussuria compressa* (Hyatt and Smith), Brühwiler and Bucher, p. 31, pl. 18, figs. 8-14.
 2013 *Parussuria compressa* (Hyatt and Smith), Brayard et al., p. 191, pl. 57, figs. a-f.
 2014 *Parussuria compressa* (Hyatt and Smith), Shigeta and Nguyen, p. 112, figs. 80, 81.
 2017 *Parussuria compressa* (Hyatt and Smith), Jattiot et al., p. 27, pl. 9, figs. N-S.

Material: 40 measured specimens. Illustrated specimens (eight) include 160C, 2243C-22, 722C, 2243C-30, 2247C, 2243C-5, 2243C-34 and 104C.

Description: Large, very involute, compressed oxycone with gently convex flanks converging to a narrowly rounded venter. Whorl section sub-triangular, with maximum width at 15 to 20% of whorl height. Whorl inflation varies slightly, with more inflated shells exhibiting a more bluntly rounded venter (Fig. 59O-Q). Umbilicus appears to be nearly occluded, but this taxon exhibits an umbilical modification consisting of a plug covered by a unique lid or cover that is composed of primary shell material. On well-preserved shells, the cover disguises the presence of the plug as well as the open umbilicus. When the plug is removed, the very narrow umbilicus is seen to have a nearly vertical wall with angular shoulders and slightly egressive coiling. Ornamentation consists only of very fine, radial growth lines and barely perceptible, wide fold-like or bundled ribs. Strigations visible on some specimens. Suture line ammonitic, typical of ussuriids.

Measurements: See Figure 61 and APPENDIX, p. 148.

Discussion: *Parussuria compressa*, originally described from the Lower Triassic beds of California, is now known to occur in northeastern Nevada and Utah (Kummel and Steele, 1962; Brayard et al., 2013; Jattiot et al., 2017; this work), and

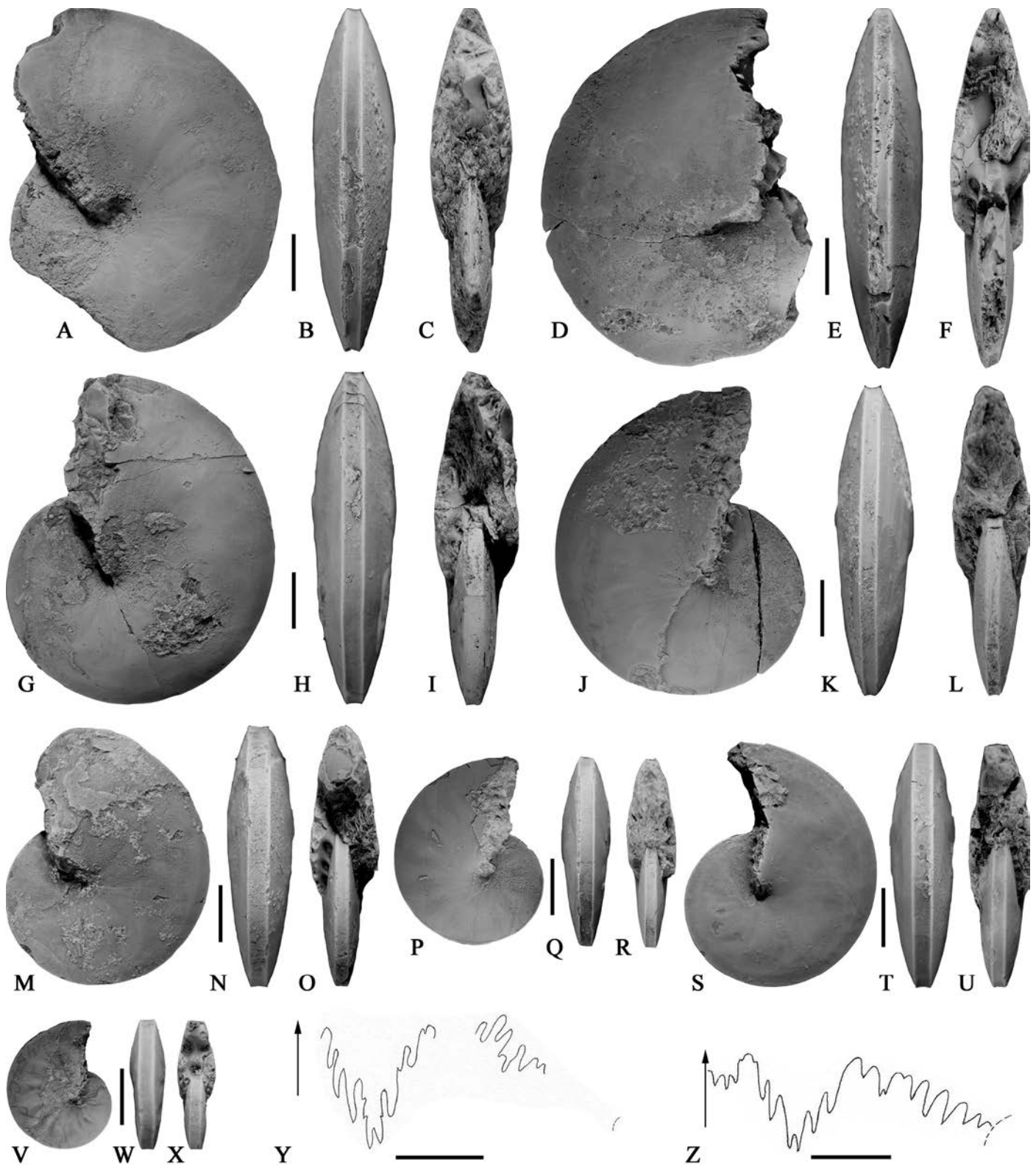


FIGURE 57. *Lanceolites compactus* Hyatt & Smith. **A-C**, 2454C-16, 3-93, *P. t.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2454C-17, 5-76, *G. l.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 293C, 13-75, *G. l.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2454C-12, 5-76, *O. k.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2454C-6, 5-76, *G. l.*, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 296C, 13-75, *C. j.*, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 744C, 5-76, *G. l.*, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-X**, 2454C-7, 1-88, *A. w.*, in **V**, lateral, **W**, ventral and **X**, apertural views. **Y-Z**, suture lines, in **Y**, 2454C-16, H = 3.8 cm. **Z**, from Kummel & Steele (1962, Text-Fig. 17-F). All scale bars = 1 cm.

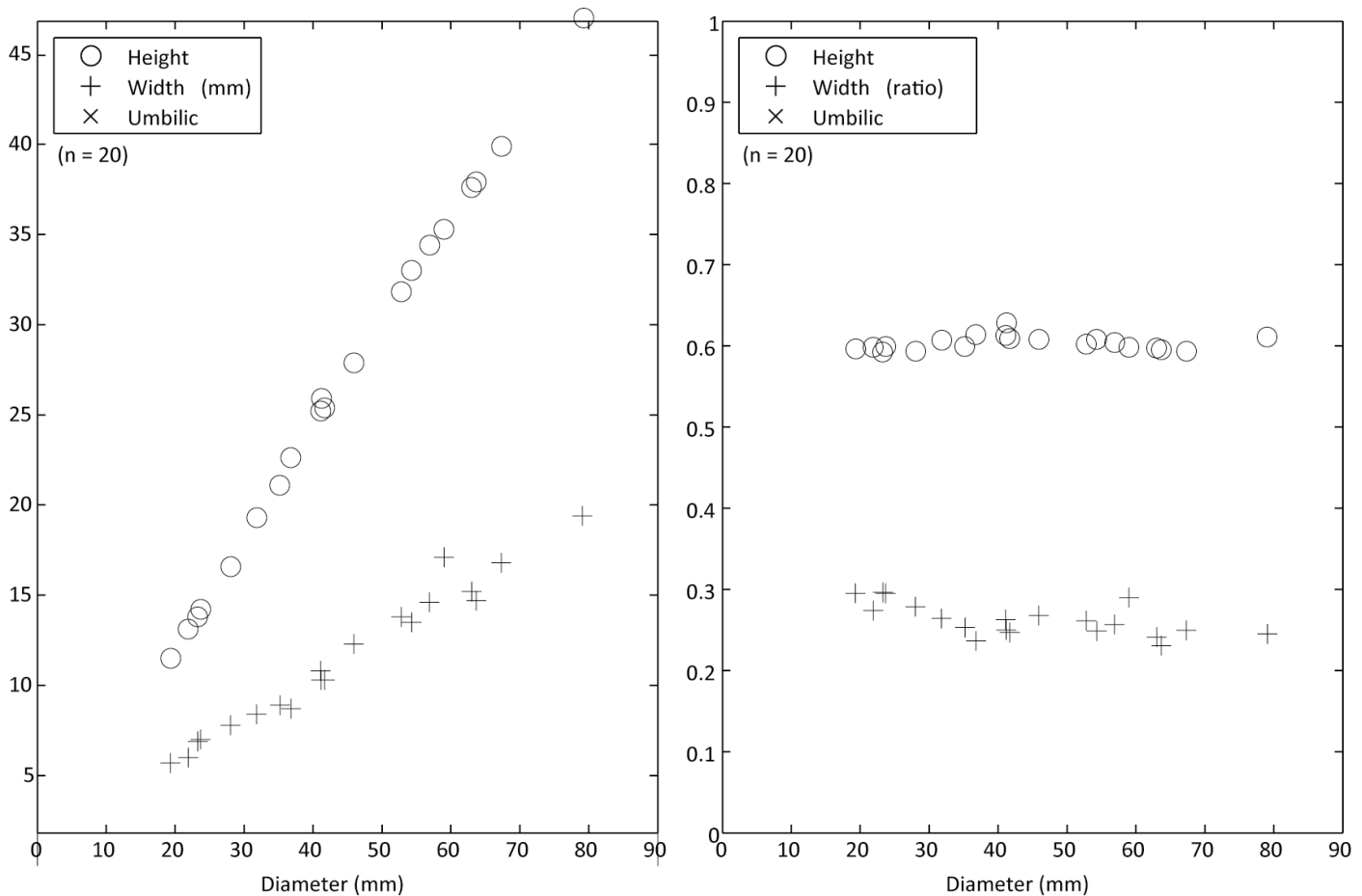


FIGURE 58. Scatter diagrams of H and W, and H/D and W/D for *Lanceolites compactus*. All specimens from *O. k.* through *C. j.* intervals

identical specimens have been collected from numerous sections in southeastern Idaho, some of which exhibit strigation. *Ussuria waageni* Hyatt and Smith, 1905, which is morphologically very similar to *P. compressa*, was described from southeastern Idaho and apparently differs by its supposed larger juvenile whorl section and absence of strigation (Hyatt and Smith, 1905; Smith, 1932; Brayard et al., 2013). We suggest that *U. waageni* is a synonym of *P. compressa*, but stress the need for additional material from Idaho and especially California.

Figure 60A-E, F-J reveals that the cover or lid on both specimens is invisible to the naked eye and is still invisible in the close-up (G) of specimen F-J, while it is just barely visible in the close-up (B) of the smaller specimen. Assisting in this disguise is the presence of growth lines on the cover that renders it indistinguishable from the adjoining lateral shell. The mechanism by which this ammonoid closed its umbilicus is not yet totally understood nor is the function of the modification. An increase in swimming ability due to the modification's streamlining of the shell has been shown to be negligible because of the oxyconic shell forms' already low drag coefficient (Jacobs and Chamberlain 1996). One intriguing possibility is that this type of modification may have evolved on some ammonoid taxa to prevent epizoan encrustation of their umbilical areas. One such case has been reported whereby epizoan bivalves encrusted the umbilical region of several early Dienerian ammonoid taxa from Nevada, subsequently causing severe growth disturbances to the umbilical wall of the ultimate whorl (Ware et al., 2011). See Jenks et al. (2014) for a more in depth discussion of the umbilical modification of *P. compressa*.

Occurrence: *Parussuria compressa* is common throughout most of the succession at Crittenden Springs, beginning with the

M. gracilitatis FA interval and continuing through the *I. oweni* interval.

Family PRIONITIDAE Hyatt, 1900
Genus Meekoceras Hyatt (in White, 1879)
Type species: Meekoceras gracilitatis White, 1879
Meekoceras gracilitatis White, 1879
Figures 62, 63A-L

- 1879 *Meekoceras gracilitatis* White, p. 114.
- 1880 *Meekoceras gracilitatis* White, p. 115, pl. 31, fig. 2.
- 1902 *Prionolobus gracilitatis* Frech, p. 631, fig. 2.
- 1904 *Meekoceras gracilitatis* White, Smith, p. 370, pl. 42, only fig. 1, pl. 43, figs. 3-4.
- 1905 *Meekoceras gracilitatis* White, Hyatt and Smith, p. 143, pl. 12, figs. 1-13, pl. 13, figs. 1-18, pl. 14, figs. 1-8, pl. 70, figs. 4-7.
- 1908 *Aspidites gracilitatis* Frech, pl. 61, figs. 6a-b.
- 1915 *Meekoceras gracilitatis* White, Diener, p. 191
- 1925 *Meekoceras gracilitatis* White, Diener, p. 82, pl. 24, fig. 1.
- 1927 *Meekoceras gracilitatis* White, Girty in Mansfield, p. 90, pl. 30, figs. 46-47.
- 1932 *Meekoceras gracilitatis* White, Smith, p. 57, pl. 12, figs. 1-13, pl. 13, figs. 1-18, pl. 14, figs. 1-8, pl. 36, figs. 19-28, pl. 37, figs. 1-7, pl. 38, figs. 1-6, pl. 70, figs. 4-7.
- 1932 *Meekoceras arthaberi* Smith, p. 56, pl. 32, figs. 26-33.
- 1932 *Meekoceras sylvanum* Smith, p. 59, pl. 33, figs. 1-14.
- 1932 *Meekoceras elkoense* Smith, p. 56, pl. 55, figures 14-16.
- 1934 *Meekoceras gracilitatis* White, Spath, p. 246, 247, fig. 3.
- 1961 *Meekoceras gracilitatis* White, Tozer, p. 65, pl. 15, fig. 6, pl. 17, figs. 1-3, pl. 18, figs. 4-6.
- 1962 *Meekoceras gracilitatis* White, Kummel and Steele, p.

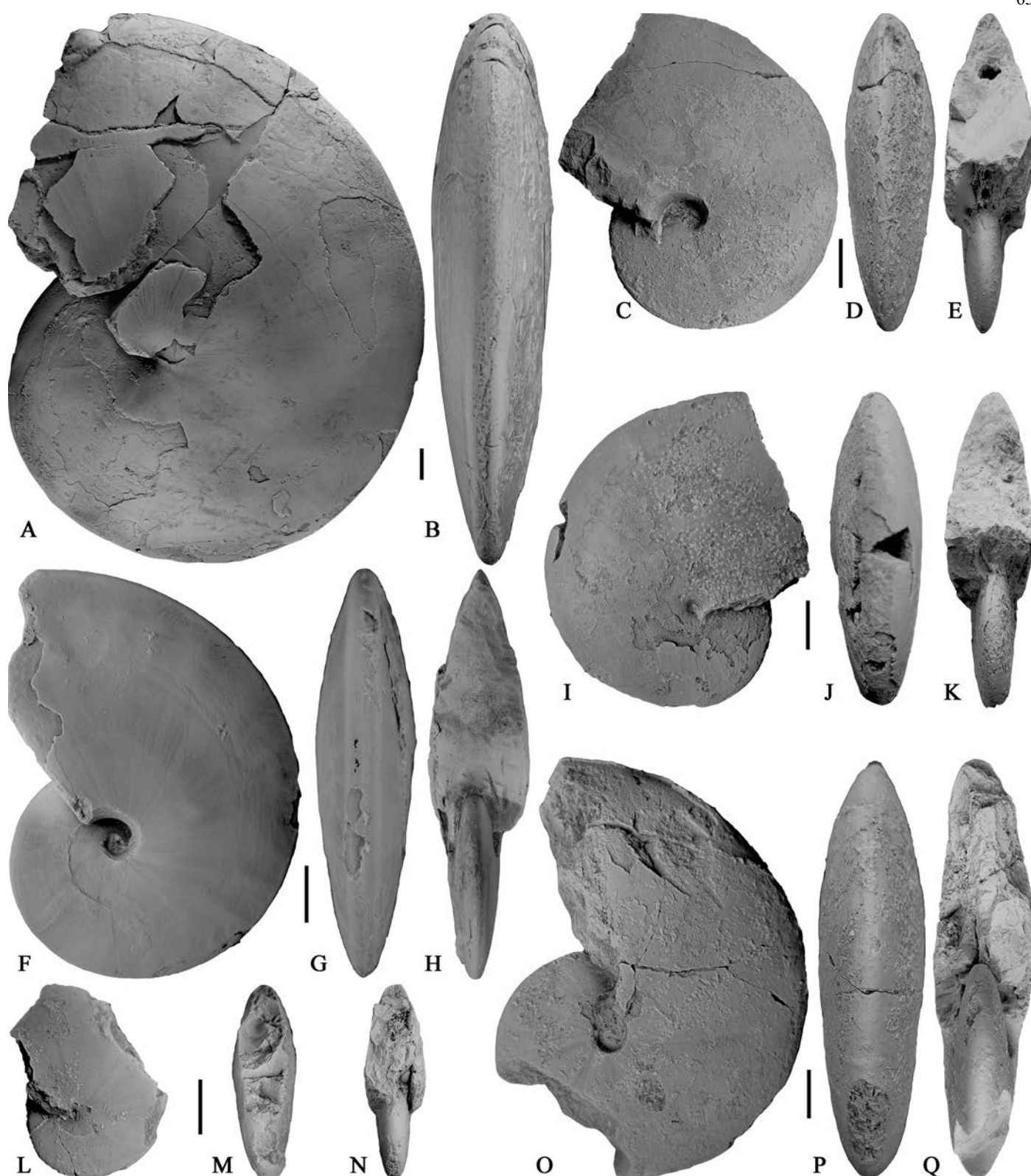


FIGURE 59. *Parussuria compressa* (Hyatt & Smith). A-B, 160C, 13-75, *C. j.*, in A, lateral and B, ventral views. C-E, 2243C-22, 5-76, *O. k.*, in C, lateral, D, ventral and E, apertural views. F-H, 722C, 1-88, *A. w.*, in F, lateral, G, ventral and H, apertural views. I-K, 2243C-30, 1-88, *M. g.*, in I, lateral, J, ventral and K, apertural views. L-N, 2247C, 5-76, *A. w.*, in L, lateral, M, ventral and N, apertural views. O-Q, 2243C-5, 5-76, *M. g.*, in O, lateral, P, ventral and Q, apertural views. All scale bars = 1 cm.

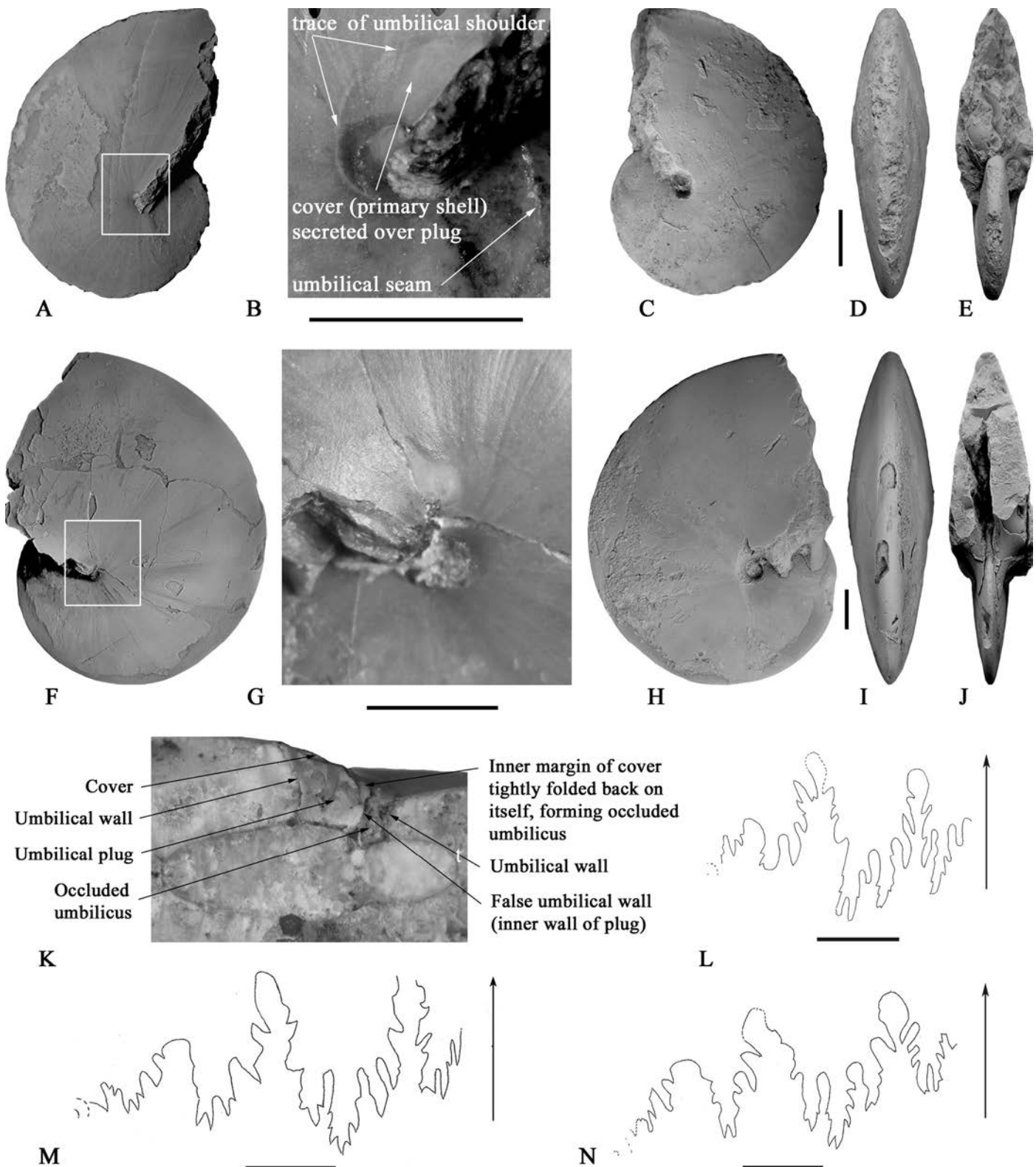


FIGURE 60. *Parussuria compressa* (Hyatt & Smith). **A-E**, 2243C-34, 5-76, *G. l.*, in **A**, lateral view (right side), **B**, close-up of umbilical region in **A** showing primary shell growth over umbilical plug. **C**, lateral (left side with umbilical plug removed), **D**, ventral and **E**, apertural views. **F-J**, 104C, 1-88, *A. w.*, in **F**, lateral (left side), **G**, close up of umbilical region in **F**, revealing that the presence of an open umbilicus and umbilical plug is concealed by the growth of primary shell (cover) over the plug, **H** lateral (right side with umbilical plug removed), **I**, ventral and **J**, apertural views. **K**, 2243C-12, 5-76, *O. k.*, cross-sectioned specimen showing structure of umbilical plug and cover. **L-N**, suture lines, in **L**, 2243C-16, H = 3.3 cm, 5-76, *M. g.* **M**, 2243C-7, H = 4.6 cm, 5-76, *M. g.* **N**, 2243C-3, H = 4.0 cm, 13-75, *C. j.* All scale bars = 1 cm.

- 693, pl. 103, figs. 1-6.
 1968 *Meekoceras gracilitatis* White, Kummel and Erben, p. 129, pl. 20, figs. 1-3, 8-13.
 1979 *Meekoceras gracilitatis* White, Nichols and Silberling, p. B3, pl. 1, figs. 1-4.
 1990 *Meekoceras gracilitatis* White, Dagys and Ermakova, p. 35, pl. 6, fig. 5, pl. 7, fig. 1, pl. 8, figs. 1, 2.
 ?1994 *Meekoceras gracilitatis* White, Tozer, p. 70, pl. 21, fig. 2
 non 1995 *Meekoceras gracilitatis* White, Shevyrev, p. 29, pl. 2, fig. 3.
 2013 *Meekoceras gracilitatis* White, Brayard et al., p. 200, fig. 68a-j.
 2017 *Meekoceras gracilitatis* White, Jattiot et al., p. 35, pl. 15, figs. A-U.

Material: 175 measured specimens. Includes eight illustrated specimens (103C, 2388C-1, 2389C, 2390C, 2388C-33, 620C, 683C and 2058C).

Description: Moderately large, fairly involute, compressed shell with gently convex flanks converging to a narrow sulcate venter with angular shoulders that is bicarinate on juvenile and most adolescent shells. Whorl section sub-trapezoidal, with maximum width at about 40-45% of whorl height. Whorl compression varies significantly (W/H ranges from 0.41 to 0.51 for similarly sized mature shells and 0.39 to 0.54 for the entire data set), but the more inflated specimens are not common. Venter on nearly all specimens transitions from sulcate to tabulate at diameter ~95 mm and eventually becomes subtabulate with abruptly rounded shoulders on mature shells. Transition also occurs rarely at smaller diameters (~88 mm, Fig. 63J-L). Only a very few shells retain sulcate venter throughout ontogeny. Umbilical width highly variable (U/D ranges from 0.10 to 0.21), but some of this variation is caused by egressive coiling, which can vary greatly between shells. Umbilicus moderately deep, characterized by inclined wall and gently rounded shoulders. Ornamentation on well preserved specimens consists of obvious growth lines that traverse flank in a distinctively sinuous manner and then cross venter at a 90° angle. On some specimens, growth lines form low intensity, barely perceptible bundled ribs (Fig. 63J-L) that arise just above umbilical shoulder and fade at about 75% of whorl height. On rare specimens (Fig. 62C-E), fairly dense, barely perceptible, low, fold-like ribs arise on umbilical shoulder, become significantly wider as they traverse flank and then fade at about 80% of whorl height. Interspacing between these ribs resemble constrictions. Suture line ceratitic with broad saddles and well indented lobes. Second lateral saddle usually slanted towards umbilicus.

Measurements: See Figure 64 and APPENDIX, p. 149.

Discussion: Smith (1932) described two additional species of *Meekoceras* from the classic *Meekoceras* beds of southeastern Idaho (*M. arthaberi* and *M. sylvanum*) and another species from his "Owenites subzone" at the Phelan Ranch, Nevada locality (*M. elkoense*), none of which can be separated from *M. gracilitatis*, given its wide range of intraspecific variation. Based on both authors' collecting experience at these localities, these taxa are herein synonymized with *M. gracilitatis*. A third species erected by Smith (1932) from the *Meekoceras* beds of southeastern Idaho, *Meekoceras cristatum*, is considered a valid taxon, based on its unique ribbing style that occasionally imparts a distinctive corrugated surface to its venter (Brayard et al., 2013 and collecting experience of both authors). Shevyrev (1995) attributed ammonoids from the Caucasus to *M. gracilitatis*; however, this assignment is questionable because the specimens have a quadrangular whorl section that is too thick, an umbilicus that is too deep, and they lack a sulcate venter (Brayard et al., 2013). Zakharov (1968) erected *M. subcristatum* from South Primorye, but this taxon differs from *M. gracilitatis* mainly by its thicker whorl section and tabulate or subtabulate venter. *Meekoceras gracilitatis* specimens from Utah differ slightly

from the Crittenden Springs taxon by the nature of their ventral surface, which, according to Brayard et al. (2013), is always sulcate, even on larger specimens. This difference is simply attributed to regional intraspecific variation. Tozer (1994) suggested that the *M. gracilitatis* specimens from Crittenden Springs illustrated by Kummel and Steele (1962, p. 693, pl. 103, figs. 1-6) probably represent a different species because their suture line is characterized by a relatively wide U2 lobe, which contrasts with the narrower lobe of specimens from Ellesmere Island and the type locality in southeastern Idaho. Again, this variance is also attributed to regional intraspecific variation.

Upon examination of the ~ 100 specimens of *Meekoceras gracilitatis* from all western USA localities in the Museum of Comparative Zoology collection, Kummel and Steele (1962) suggested the presence of a dimorphic pair, based on the amount of inflation of the outer whorl and characteristics of the umbilical region. They recognized that most of their specimens exhibited a compressed morphology with slightly convex flanks, a steeper umbilical wall with more angular shoulders and a sulcate venter as illustrated in Kummel and Steele (1962, pl. 103, figs. 1-2, 4-6) and the present work (Fig. 62A-B, C-E; Fig. 63D-F). In contrast, they recognized a few specimens characterized by much more inflated outer whorls (living chamber), more highly convex flanks, a much wider tabulate venter with subangular shoulders and a slightly larger umbilicus with a noticeably less steep wall angle, as illustrated in Kummel and Steele (1962, pl. 103, fig. 3) and the present work (Fig. 62F-H; Figs. 63A-C, G-I, J-L). We recognize the validity of many of Kummel and Steele's (1962) observations in our much larger data set, but not all, especially with regard to large, mature shells. For example, the venter on nearly all of the more compressed specimens becomes tabulate when a diameter of 95 mm is reached and even subtabulate at larger diameters for many specimens. Although the slope of the umbilical wall does seem to vary according to Kummel and Steele's (1962) observations at smaller diameters (adolescent and smaller mature shells), this relationship seems to break down for larger mature shells, where any difference in wall angle between compressed and inflated specimens is virtually undetectable. Their observation that the more inflated shells have a slightly wider umbilicus seems to be valid for most of the inflated specimens, but not all. In summary, the observations of Kummel and Steele (1962) are most likely attributable to intraspecific variation, but nevertheless, their suggestion of dimorphism still warrants a more extensive investigation, which is beyond the scope of this work.

Occurrence: *Meekoceras gracilitatis* is common in all levels beginning with the *M. gracilitatis* FA interval and continuing through the entire middle Smithian succession.

Meekoceras millardense Brayard et al., 2013

Figure 65

2013 *Meekoceras millardense* Brayard et al., p. 204, fig. 73, a-g

Material: Five measured specimens and one small unmeasurable specimen. Includes four illustrated specimen (2437C, 2438C, 2446C and 2439C).

Description: Medium sized, very involute, very compressed shell with slightly convex flanks converging to a tabulate venter with angular shoulders on juvenile and pre-adolescent shells and subtabulate venter with bluntly rounded shoulders on mature shells. Whorl compression varies from 0.38 to 0.43 for five measureable specimens. Whorl section sub-trapezoidal, with maximum width at 35 to 40% of whorl height. Umbilicus nearly occluded. No ornamentation visible on our specimens. Suture line ceratitic, similar to *M. gracilitatis*.

Measurements: See Figure 66 and APPENDIX, p. 153.

Discussion: Most of our specimens are at least twice as large as the type specimens from Utah (Brayard et al., 2013), and their preservation is obviously much better. The only obvious

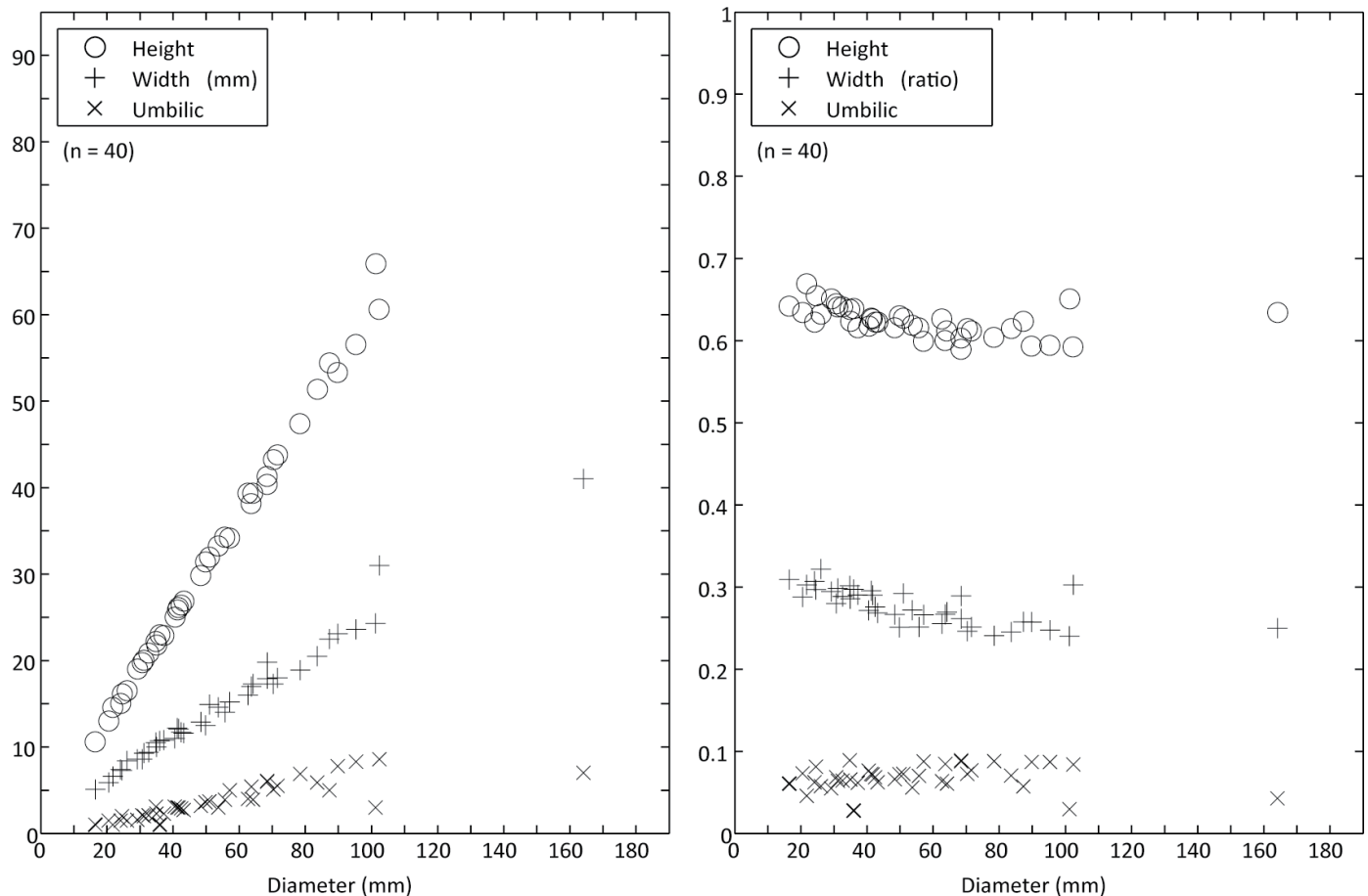


FIGURE 61. Scatter diagrams of H and W, and H/D and W/D for *Parussuria compressa*. All specimens from *M. g.* through *I. o.* intervals.

difference other than size is the subtabulate venter on the living chamber of our larger specimens (Fig. 65A-C). The suture line of at least one of our specimens (Fig. 65L) is somewhat similar to that of *Hedenstroemia*, but nearly all hedenstroemiids from the eastern Panthalassic localities are characterized by a sulcate venter, which contrasts with the tabulate venter of our specimens.

Meekoceras millardense differs from *M. gracilitatis* and *M. bylundi* n. sp. by its nearly occluded umbilicus and lack of a sulcate venter, and from *M. aff. M. olivieri* by its nearly occluded umbilicus.

Occurrence: *Meekoceras millardense* primarily occurs in the *M. millardense* FA interval, but one specimen was found in the overlying *M. aff. M. olivieri* FA interval.

***Meekoceras aff. M. olivieri* Brayard et al., 2013**
Figure 67

2013 *Meekoceras olivieri* Brayard et al., p. 204, fig. 71, a-l.

2017 *Meekoceras olivieri* Brayard et al., Jattiot et al., p. 36, pl. 16, figs. A-D.

Material: Seven specimens plus one unmeasurable specimen. Illustrated specimens (five) include 2440C, 2445C, 2452C, 2451C and 2441C.

Description: Medium sized, fairly involute, compressed shell with convex flanks converging to a tabulate venter, with angular shoulders on smaller shells, becoming slightly subtabulate with less angular shoulders on larger shells. Whorl section sub-trapezoidal with maximum width at about 50% of whorl height. Whorl compression for six shells ranges from 0.50 to 0.53, with one less compressed shell at 0.46. Largest specimen (Fig. 67A-C) obviously inflated. Umbilicus similar

to *M. gracilitatis*, but with less egressive coiling. Because of poor preservation, no visible ornamentation other than sinuous growth lines on part of one specimen, identical to those of *M. gracilitatis*. Suture line similar to *M. gracilitatis*.

Measurements: See Figure 68 and APPENDIX, p. 153.

Discussion: While the present specimens are basically similar to the type specimens in that they both have a tabulate venter at smaller sizes, they differ by the character of the type specimens' venter on larger shells, which becomes noticeably arched with indistinct shoulders. This difference is considered significant and precludes a firm assignment of our specimens to *Meekoceras olivieri*. Also, our largest specimen doesn't exhibit the "large folds" reported by Brayard et al. (2013) on their larger specimens, but this lack of ornamentation may be partly due to the relatively poor preservation of our material. *M. gracilitatis* differs from *M. aff. M. olivieri* by its sulcate venter, which is always present on juvenile and most adolescent shells. On average, our specimens are slightly more inflated than *M. gracilitatis*.

Occurrence: *Meekoceras aff. M. olivieri* is fairly common in the *M. aff. M. olivieri* FA interval, but also occurs in the overlying *A. rubyae* FA and *M. gracilitatis* FA intervals.

***Meekoceras bylundi* n. sp.**
Figures 69-71

2010 *Meekoceras* cf. *M. gracilitatis* White, Jenks et al., p. 15, fig. 10A-D

Type Series: Three specimens: Holotype, NMMNH P-79167 (Figure 69D-F); paratypes, two specimens: NMMNH P-79168 (Figure 70A-C), NMMNH P-79169 (Figure 69A-C).

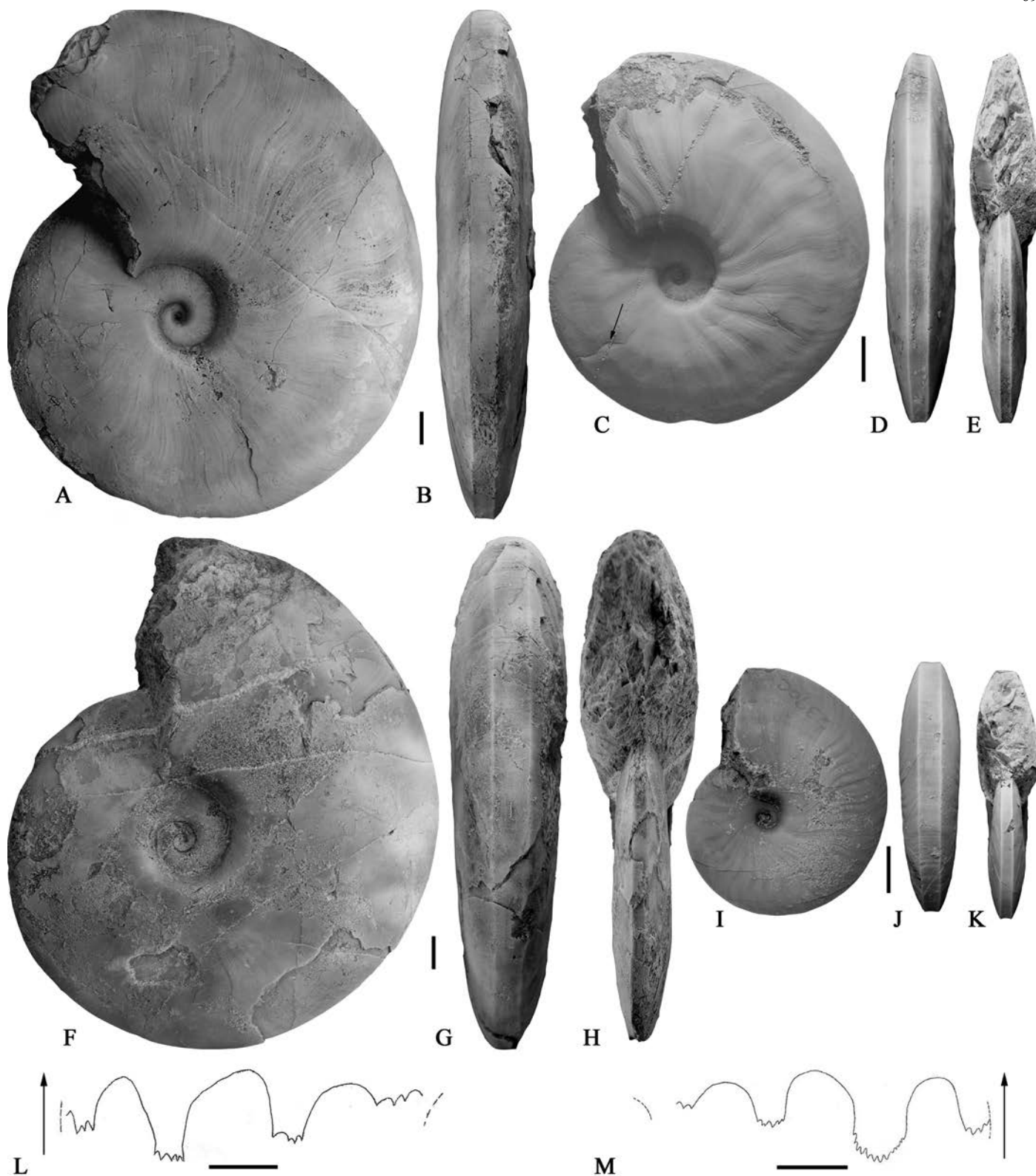


FIGURE 62. *Meekoceras gracilitatis* White. **A-B**, 103C, 5-76, *I. o.* (compressed adult specimen) in **A**, lateral and **B**, ventral views, $W/H = 0.41$. **C-E**, 2388C-1, 13-75, *O. k.* (compressed sub-adult specimen with low intensity ribbing) in **C**, lateral (arrow indicates healed injury), **D**, ventral and **E**, apertural views, $W/H = 0.43$. **F-H**, 2389C, 5-76, *C. j.* (inflated adult specimen) in **F**, lateral, **G**, ventral and **H**, apertural views, $W/H = 0.51$. **I-K**, 2390C, 5-76, *C. j.* (inflated juvenile specimen) in **I**, lateral, **J**, ventral and **K**, apertural views, $W/H = 0.48$. **L-M**, suture lines in **L**, 2389C, $H = 5.4$ cm. **M**, 2388C-3, $H = 4.7$ cm, 1-88, *G. l.* All scale bars = 1 cm.

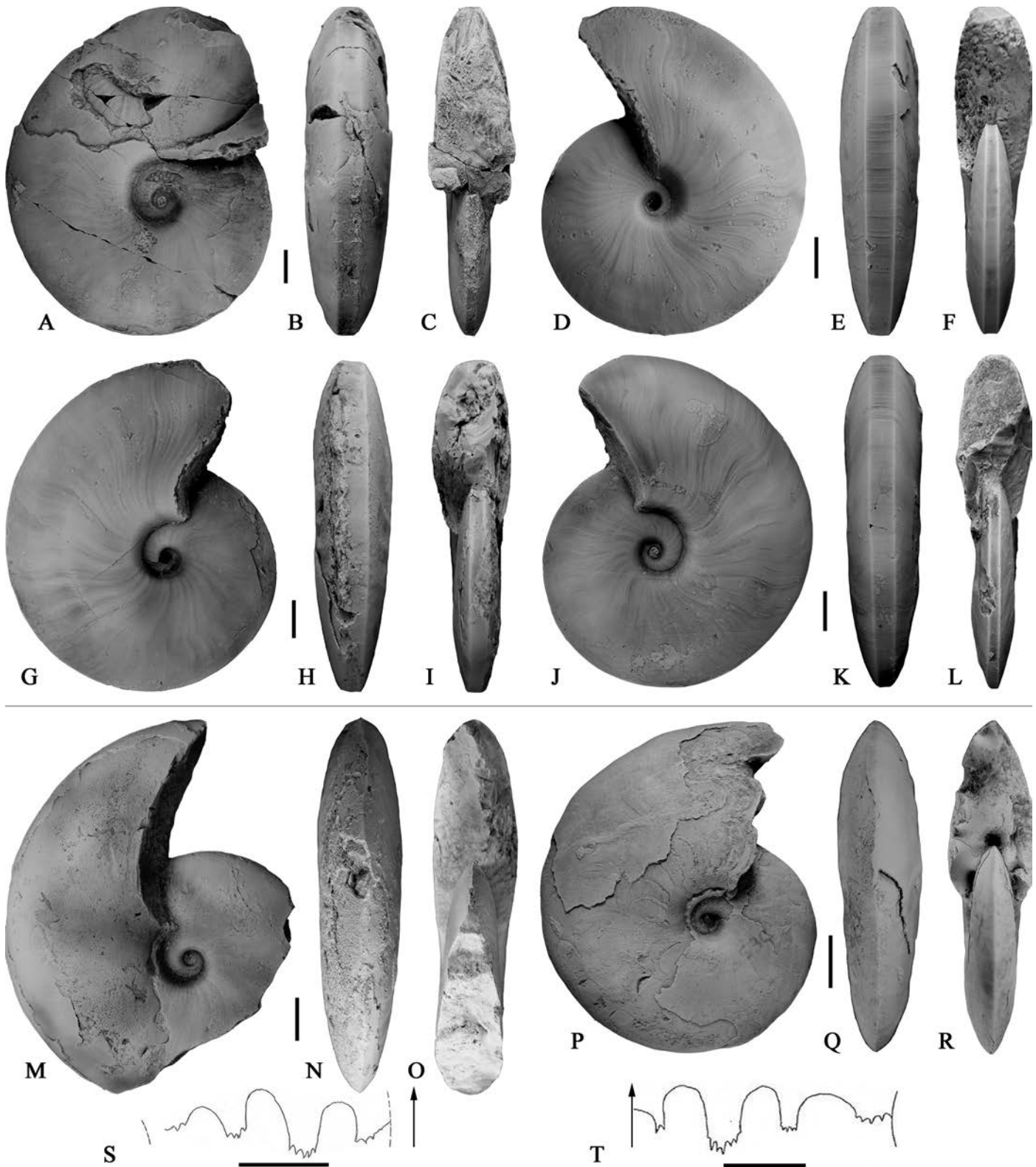


FIGURE 63. **A-L**, *Meekoceras gracilitatis* White, in **A-C**, 2388C-33, 3-93, *P. t.* (inflated sub-adult specimen) in **A**, lateral, **B**, ventral and **C**, apertural views, W/H = 0.50. Specimens **D-F** through **J-L** exhibit increasingly evolute coiling. **D-F**, 620C, 1-88, *C. j.*, in **D**, lateral, **E**, ventral and **F**, apertural views (U/D = 0.13). **G-I**, 683C, 1-88, *P. t.*, in **G**, lateral, **H**, ventral and **I**, apertural views (U/D = 0.16). **J-L**, 2058C, 1-88, *A. w.*, in **J**, lateral, **K**, ventral and **L**, apertural views (U/D = 0.19). **M-T**, *Acutomeekoceras rieberi* Jenks et al., in **M-O**, NMMNH P-60169, holotype, 3-93, *P. t.*, in **M**, lateral, **N**, ventral, and **O**, apertural views. **P-R**, 2553C, *Meekoceras* beds, southeastern Idaho, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-T**, suture lines, in **S**, NMMNH P-60169, H = 2.7 cm. **T**, 2553C, H = 3.0 cm. Specimen 2553C courtesy of Ed Chatelain, Valdosta State University, Valdosta, Georgia. All scale bars = 1 cm.

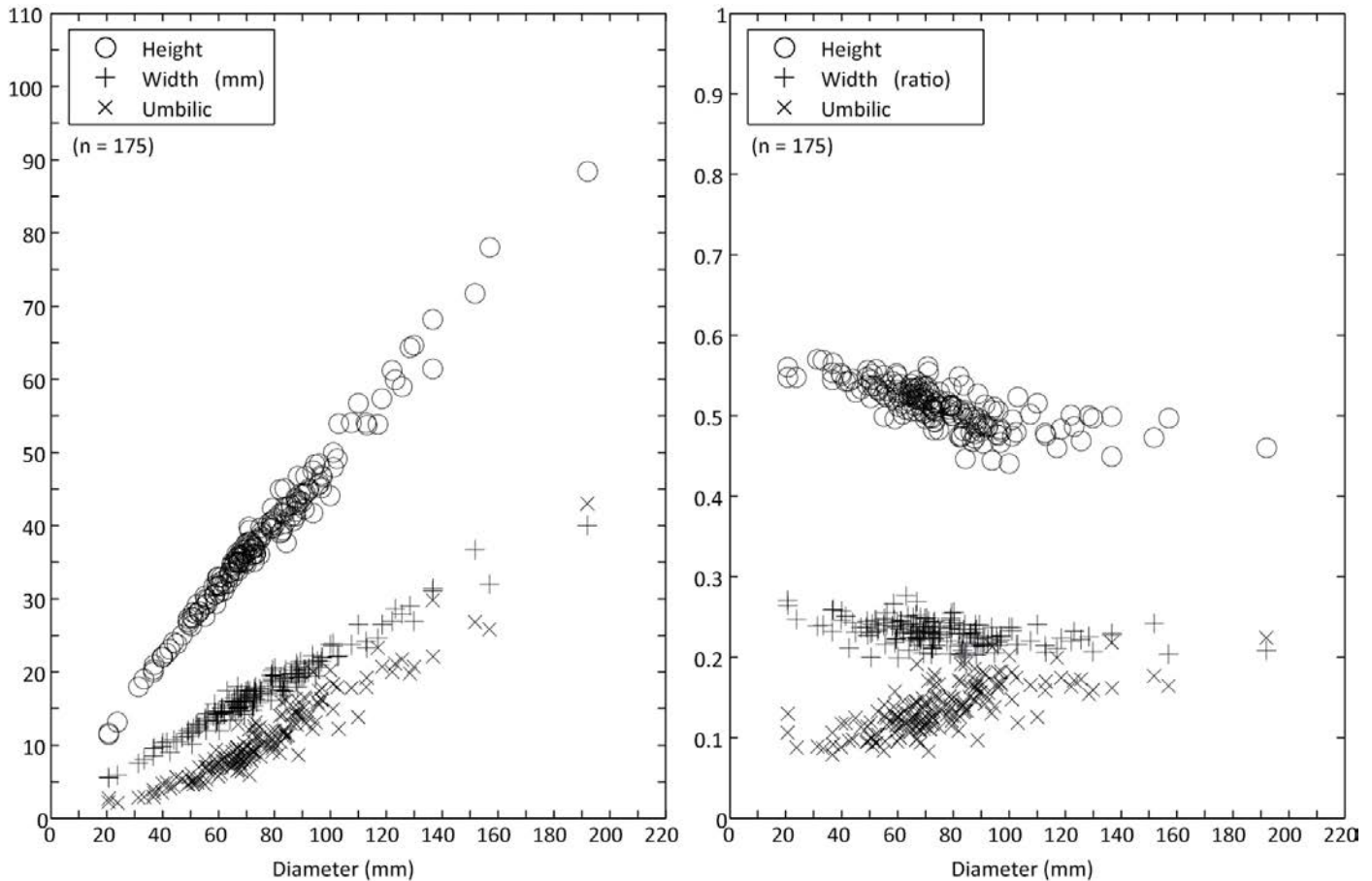


FIGURE 64. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Meekoceras gracilitatis*. All specimens from *M. g.* through *I. o.* intervals.

Other specimens: two measured specimens (2466C, Figure 34D-F and 2520C, Figure 35A-C) and one fragmentary specimen (2536C, Figure 35D-E, unmeasurable) included in species, but excluded from type series.

Etymology: Species named in honor of Kevin Bylund of Spanish Fork, Utah.

Diagnosis: Large, fairly evolute, compressed meekoceratid characterized by convex flanks, sulcate venter on juvenile and adolescent whorls and tabulate to subtabulate venter on most mature whorls, and a consistently much wider umbilical diameter than *Meekoceras gracilitatis*.

Description: Moderately large, fairly evolute, compressed meekoceratid with convex flanks sloping towards fairly narrow venter, which, on adolescent portion of shell, is always sulcate with sharply angular shoulders. Venter on body chamber varies from faintly sulcate with angular shoulders on one large and one medium sized shell to subtabulate with bluntly rounded shoulders on four large shells. Whorl section thinly subtrapezoidal with maximum width at about 45% of whorl height. Body chamber length unknown, but at least one half whorl for present specimens. Fairly shallow, wide umbilicus characterized by slightly more steeply inclined wall with gently rounded shoulders on inner whorls, becoming less steep with gently rounded shoulders on body chamber of mature specimens. Ornamentation includes barely perceptible, variable width, prosiradiate or slightly sinuous fold-type ribs that arise just above umbilical shoulder and fade on ventral shoulder. Growth lines not visible, even on well preserved shell. Suture line ceratitic with broad rounded saddles and weekly indented lobes.

Measurements: See Figure 72 and APPENDIX, p. 153.

Discussion: *Meekoceras bylundi* n. sp. differs from

M. gracilitatis and *M. aff. M. olivieri* primarily by its significantly greater umbilical width and to a lesser extent by its slightly shallower umbilicus. The specimen (NMMNH P-79169, paratype, this work) shown in Figure 69A-C, which was illustrated in Jenks et al. (2010) as *Meekoceras* cf. *M. gracilitatis*, was considered to be either an extreme variant of *M. gracilitatis* or possibly a new species of the genus. However, the conservative option was chosen at the time because no other specimens were available; since then, five additional specimens have been found. As demonstrated by the box plot analysis in Figure 73, *Meekoceras bylundi* n. sp. clearly does not fall within the intraspecific variation of *M. gracilitatis* from Crittenden Springs. This observation also holds true for representatives of *M. gracilitatis* from southeastern Idaho.

Occurrence: *Meekoceras bylundi* n. sp. is rare at Crittenden Springs. The *A. weitschati* n. sp. interval has yielded five specimens and one specimen was found in the underlying *O. koeneni* FA interval.

Genus *Acutomeekoceras* Jenks et al., 2010

Type species: *Acutomeekoceras rieberi* Jenks et al., 2010

Acutomeekoceras rieberi Jenks et al., 2010

Figure 63M-T

2010 *Acutomeekoceras rieberi* Jenks et al., p. 15, figs. 10E-H.

Material: Two measured specimens – one from Crittenden Springs (holotype, NMMNH P-60169) and the second from the “*Meekoceras* beds,” Bear Lake Hot Springs, Idaho (courtesy of Ed Chatelain, Valdosta State University, Valdosta, Georgia).

Description: Medium sized, fairly involute, compressed shell with convex flanks converging gently to acute venter without distinct shoulders. Maximum whorl width at slightly

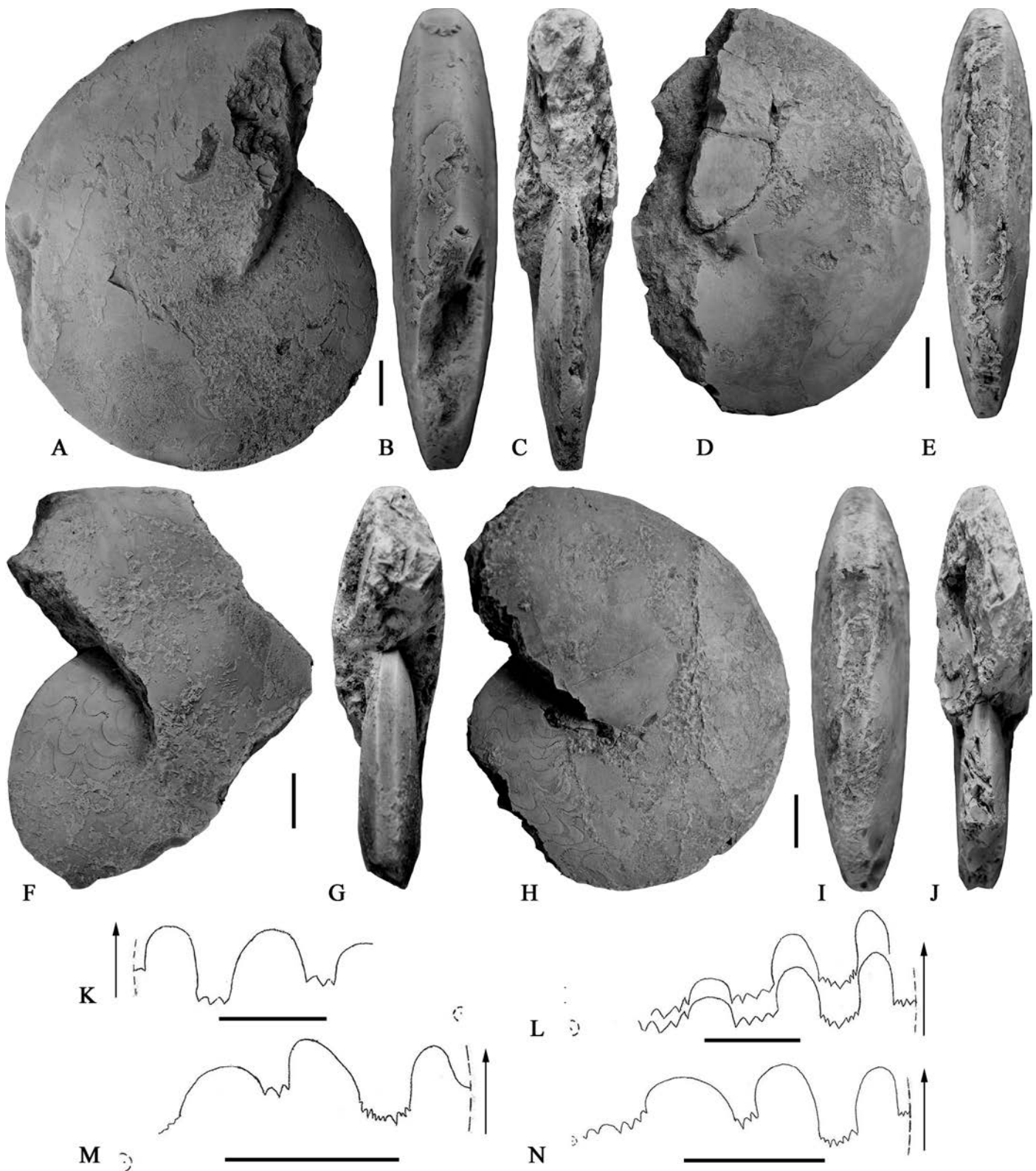


FIGURE 65. *Meekoceras millardense* Brayard et al, 10-14. **A-C**, 2437C, *M. m.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-E**, 2438C, *M. m.*, in **D**, lateral and **E**, ventral views. **F-G**, 2446C, *M. o.*, in **F**, lateral and **G**, apertural views. **H-J**, in 2439C, *M. m.*, in **H**, lateral, **I**, ventral and **J**, apertural views. **K-N**, suture lines in **K**, 2437C, H = 3.1 cm. **L**, 2438C, H = 3.6 cm. **M**, 2439C, H = 2.0 cm. **N**, 2446C, H = 2.35 cm. All scale bars = 1 cm.

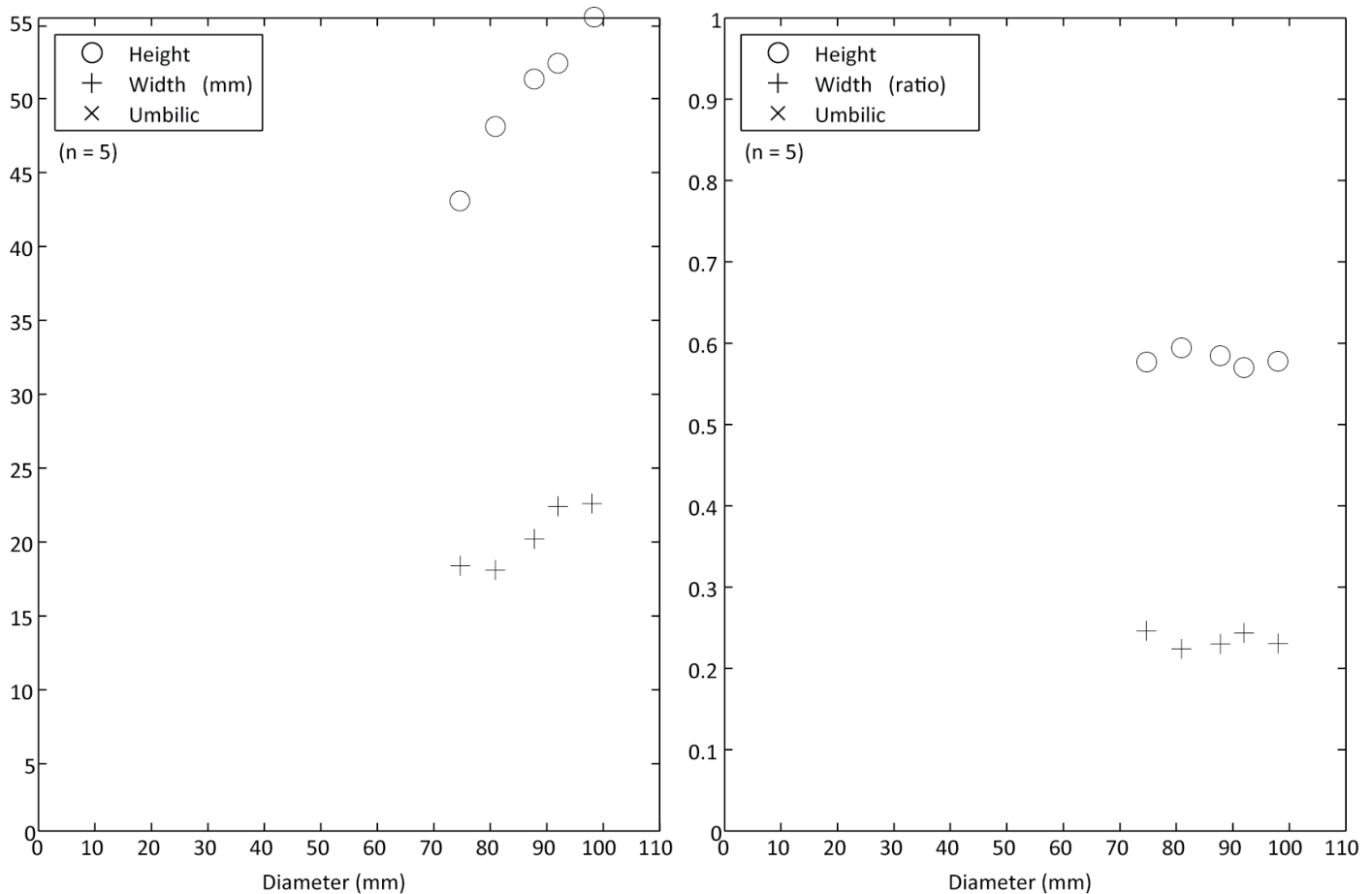


FIGURE 66. Scatter diagrams of H and W, and H/D and W/D for *Meekoceras millardense*. All specimens from *M. m.* and *M. o.* intervals.

less than $\frac{1}{2}$ of whorl height. Flank contour broadly convex from umbilical shoulder to point of maximum width, then converging more rapidly to acute venter. Venter moderately acute on body chamber, becoming more sharply acute in apical direction. Narrow umbilicus with tightly rounded shoulders and moderately high, steep wall on juvenile whorls, becoming less inclined on mature whorl. Exhibits egressive coiling, typical of most meekoceratids. Length of body chamber unknown, but at least one half whorl. Test missing from body chamber, but phragmocone bears sinuous growth lines. Suture line ceratitic with broad, rounded saddles and weakly indented lobes. Second lateral saddle partly asymmetrical.

Measurements: See APPENDIX, p. 153.

Discussion: When viewed laterally, *Acutomeekoceras rieberi* is indistinguishable from *Meekoceras gracilitatis*, but its distinctive venter sets it apart from this taxon and presumably from the family Meekoceratidae. However, aside from its peculiar acute venter, its morphology and suture line are identical to *M. gracilitatis*. We are not aware of another Smithian ammonoid that even remotely resembles this shell form, other than possibly *Owenites koeneni*, but this taxon is much smaller, and its suture line is completely different. *Acutomeekoceras rieberi* may simply be a very rare, extreme variant of *M. gracilitatis*, but even the most compressed forms of this taxon do not exhibit a venter that approaches the acuteness of the present specimens. Furthermore, the possibility of the original Crittenden Springs specimen being a pathologic variant was also considered, even though the shell exhibited no obvious signs of repaired injuries or asymmetrical abnormalities. Regardless of its origin, its *M. gracilitatis*-like lateral form combined with an acute venter supported its documentation as a new taxon,

even if based on only a single specimen. The erection of this new taxon was recently vindicated when we acquired a second specimen collected from the “*Meekoceras* beds” of southeastern Idaho. This particular specimen is virtually identical to the type specimen in terms of geometric parameters and suture line.

Occurrence: Extremely rare. The single specimen from Crittenden Springs was found in the *P. toulai* interval. Taxon is now known to also occur, albeit extremely rare, in the “*Meekoceras* beds” of southeastern Idaho.

Genus *Anasibirites* Mojsisovics, 1896

Type species: *Sibirites kingianus* Waagen, 1895

Anasibirites kingianus (Waagen, 1895)

Figure 74A-C

2016 *Anasibirites kingianus* (Waagen, 1895), Jattiot et al., p. 29, figs. 4, 6-9, 10A-M, 12, 15-18 [reader should refer to Jattiot et al. (2016) for a comprehensive synonymy list].

2017 *Anasibirites kingianus* (Waagen, 1895), Jattiot et al., p. 29, pl. 11, figs. A-F.

Material: One measured, well preserved specimen, 34C (illustrated).

Description: (Based on taxonomic revision of *Anasibirites* by Jattiot et al., 2016).

Medium sized, fairly involute platyconic shell with gently convex flanks converging to highly variable-shaped venter. Early whorls (<20 mm) exhibit evolute coiling with a typically quadrate whorl section that becomes more compressed as shell grows larger (>20 mm). Mature shells characterized by fairly compressed whorl section and highly variable venter, ranging from tabulate with angular shoulders to arched with rounded

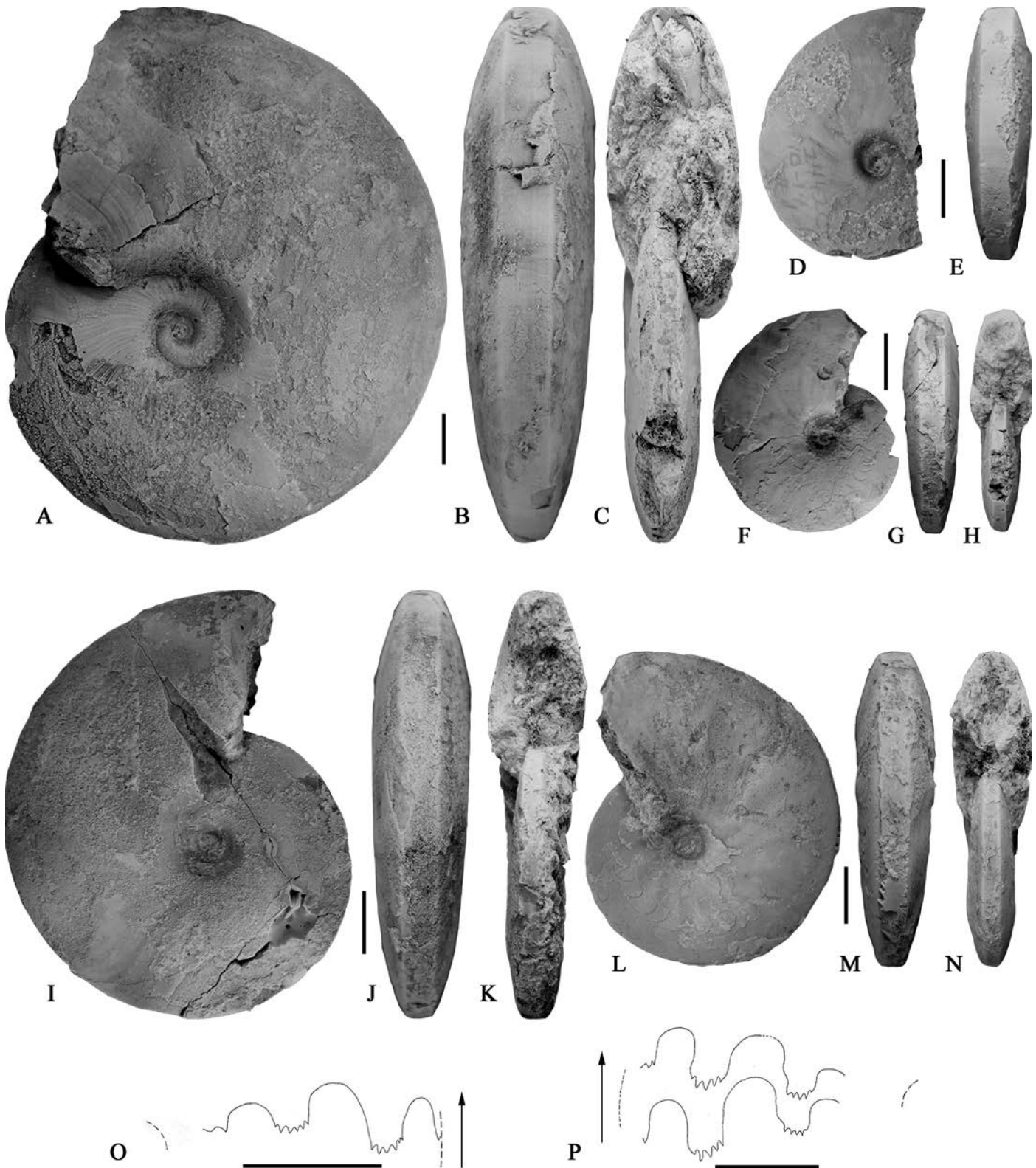


FIGURE 67. *Meekoceras* aff. *M. olivieri* Brayard et al. 10-14. **A-C**, 2440C, *A. r.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-E**, 2445C, *M. m.*, in **D**, lateral and **E**, ventral views. **F-H**, 2452C, *M. o.*, in **F**, lateral, **G**, ventral and **H**, apertural views. **I-K**, 2451C, *M. o.*, in **I**, lateral, **J**, ventral and **K**, apertural views. **L-N**, 2441C, *M. o.*, in **L**, lateral, **M**, ventral and **N**, apertural views. **O-P**, suture lines in **O**, 2449C, H = 2.1 cm, *M. o.* **P**, 2450C, H = 2.6 cm, *A. r.* All scale bars = 1 cm.

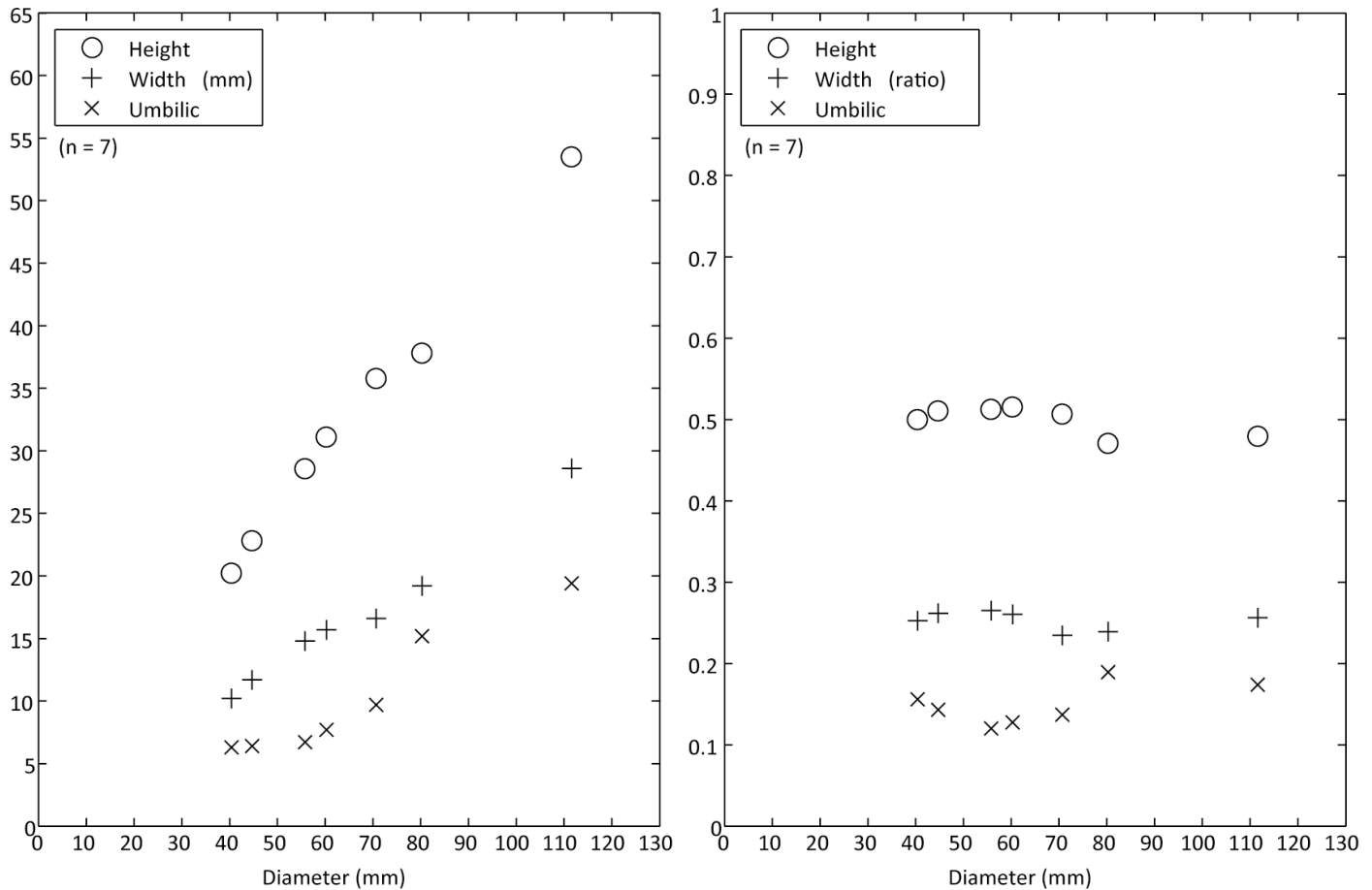


FIGURE 68. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Meekoceras* aff. *M. olivieri*. All specimens from *M. o.*, *A. r.* and *M. g.* intervals.

shoulders. Umbilicus fairly narrow and moderately deep with oblique wall and rounded shoulders. Taxon characterized by allometric growth, with evolute, somewhat depressed early whorls and compressed, more involute mature whorls. Ornamentation on inner whorls (<20 mm) consists of megastriae (rib-like structures formed by temporary halts in shell growth) that vary greatly in magnitude, becoming denser and weaker as shell grows larger (>20 mm). Diameter at which this change occurs is highly variable. Megastriae gradually disappear on mature shell, and growth lines become obvious. Some mature conchs develop noticeable, low intensity true ribs, which sometimes become greatly intensified on ventral shoulders and venter (Fig. 74A-C). Suture line ceratitic, typical of species with deep lateral lobes and broad, rounded saddles.

Measurements: See APPENDIX, p. 154.

Discussion: That the genus *Anasibirites* Mojsisovics, 1896 exhibits an extraordinarily wide range of intraspecific variation in both conch shape and ornamentation is evident by the fact that at least 32 specific taxa have been attributed to the taxon, primarily by two workers, Waagen (1895) and Mathews (1929). Kummel and Erben (1968), among others, recognized this extremely wide range of variation and synonymized all previously described species with the type species, *A. kingianus*. However, this all-inclusive synonymy was not widely accepted by Triassic workers, and, then, following a comprehensive review of the numerous types of ornamentation and umbilical characteristics, Brayard and Bucher (2008) suggested the existence of only four species, namely *A. kingianus* (Waagen, 1895), *A. pluriformis* Guex, 1978, *A. multiformis* Welter, 1922 and *A. nevolini* Burij and Zharnikova, 1968. Their analysis was

admittedly constrained, however, by the lack of measurement data for many of the previously described species (Brayard and Bucher, 2008). Subsequently, Jattiot et al. (2016) conducted an extensive investigation of a huge collection of well-preserved *Anasibirites* specimens (~900) from Timor and concluded that the genus includes only two valid species, namely *A. kingianus* and *A. multiformis*. Jattiot et al. (2016) synonymized *A. angulosus* and *A. nevolini* with *A. kingianus*. *A. pluriformis* was determined to be a middle Smithian arctoceratid by Brühwiler and Bucher (2012b), rather than a late Smithian prionitid. An important contribution of Jattiot et al.'s (2016) work is the recognition of the role played by megastriae in the taxonomic revision of *Anasibirites* and its use in differentiation between *A. kingianus* and *A. multiformis*. Accordingly, *A. kingianus*, which had long been considered to have wide-spread occurrences in low paleolatitude eastern Panthalassic localities, was actually shown to be quite rare (Jattiot et al., 2016). Indeed, Crittenden Springs has produced only one diagnostic specimen, and specimens from central and southern Utah attributed to *A. kingianus* by Brayard et al. (2013) are actually *A. multiformis* (Jattiot et al., 2016). Likewise, based on the first author's extensive collecting experience in the *Anasibirites* beds at Georgetown, Idaho, *A. kingianus* has not yet been found at this locality either. In contrast, the *Anasibirites* beds at Fort Douglas, Utah have produced several specimens (Mathews, 1929; Jattiot et al., 2016). On a world-wide basis, *A. kingianus* occurs in the Boreal Realm (Canada, Siberia and Spitsbergen) as well as the Salt Range, Spiti, Afghanistan, South China, Oman, South Primorye and Japan; conversely, *A. multiformis* has not yet been recorded from many of these localities, including the Boreal

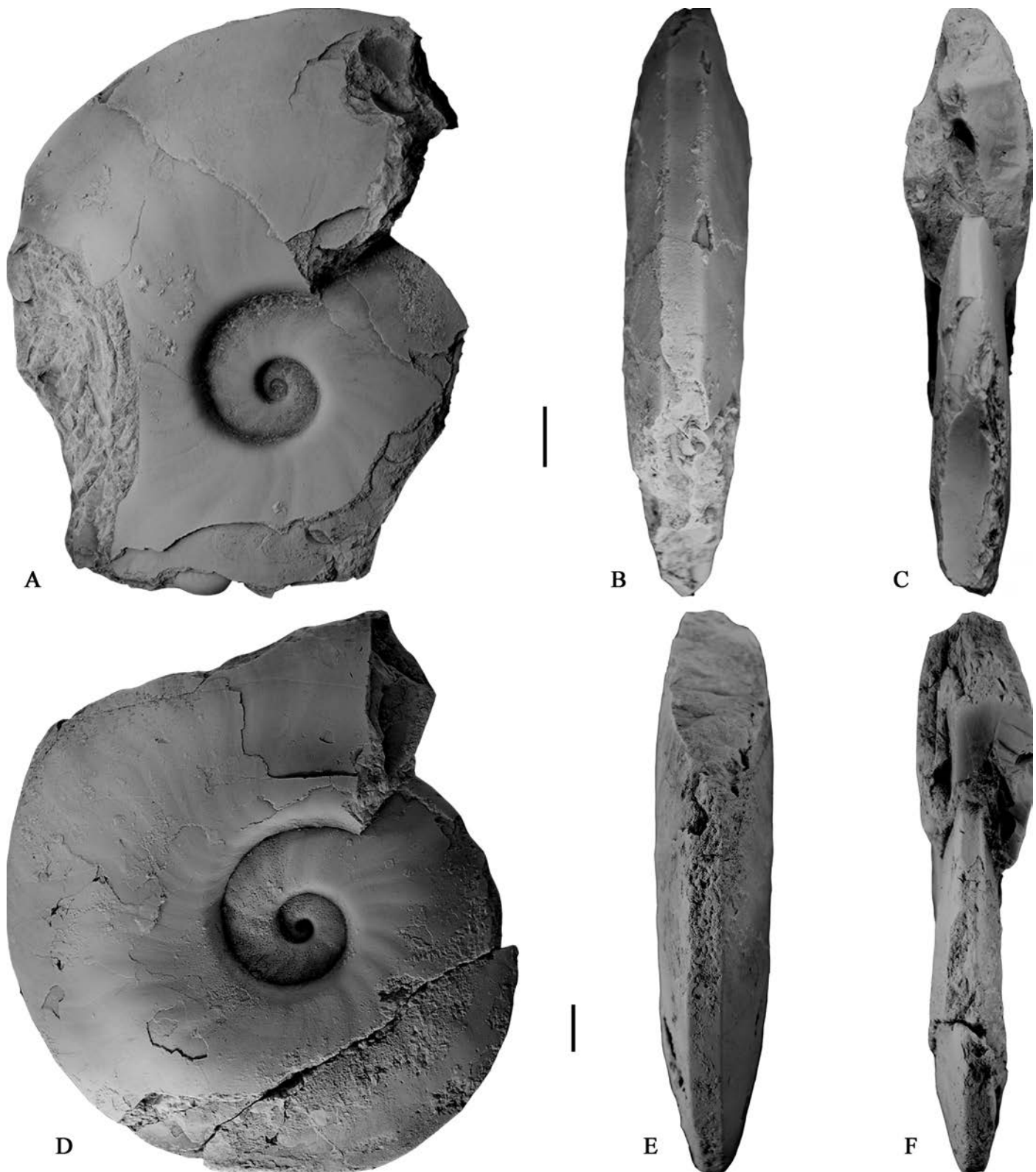


FIGURE 69. *Meekoceras bylundi* n. sp. **A-C**, NMMNH P-79169, paratype, 1-88, A. w., in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, NMMNH P-79167, holotype, 10-14, A. w., in **D**, lateral, **E**, ventral and **F**, apertural views. Scale bars = 1 cm.

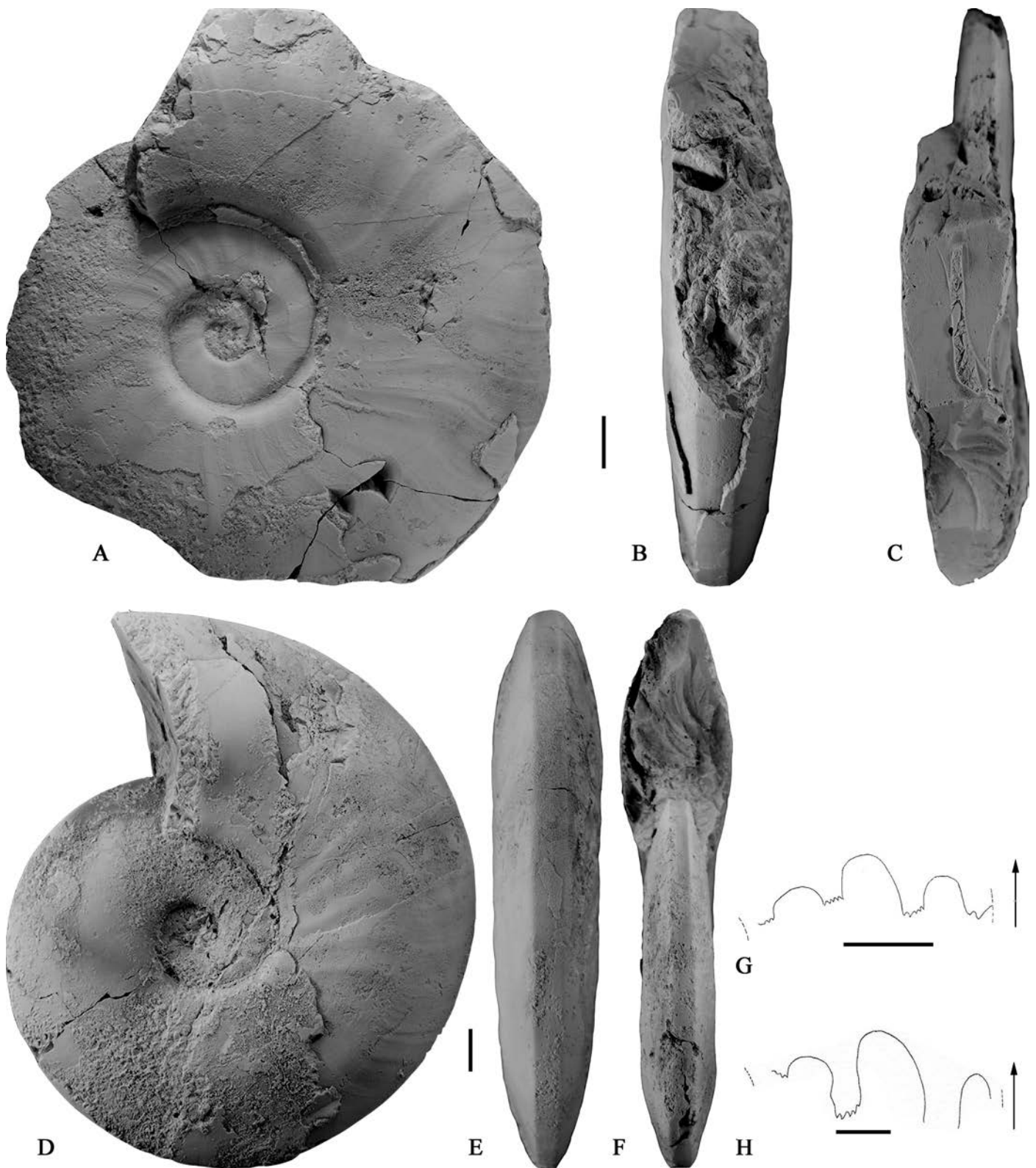


FIGURE 70. *Meekoceras bylundi* n. sp. **A-C**, NMMNH P-79168, paratype, 10-14, A. w., in **A**, lateral, **B**, ventral and **C**, apertural views. **D-E**, 2466C, 10-14, O. k., in **D**, lateral, **E**, ventral and **F**, apertural views. **G-H**, suture lines in **G**, NMMNH P-79169, H = 2.7cm, 1-88, A. w. **H**, NMMNH P-79168, H = 4.8 cm, 10-14, A. w. All scale bars = 1 cm.



FIGURE 71. *Meekoceras bylundi* n. sp. **A-C**, 2520C, 2-79, *A. w.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-E**, 2536C, 10-14, *A. w.*, in **D**, lateral and **E**, ventral views. Scale bars = 2 cm.

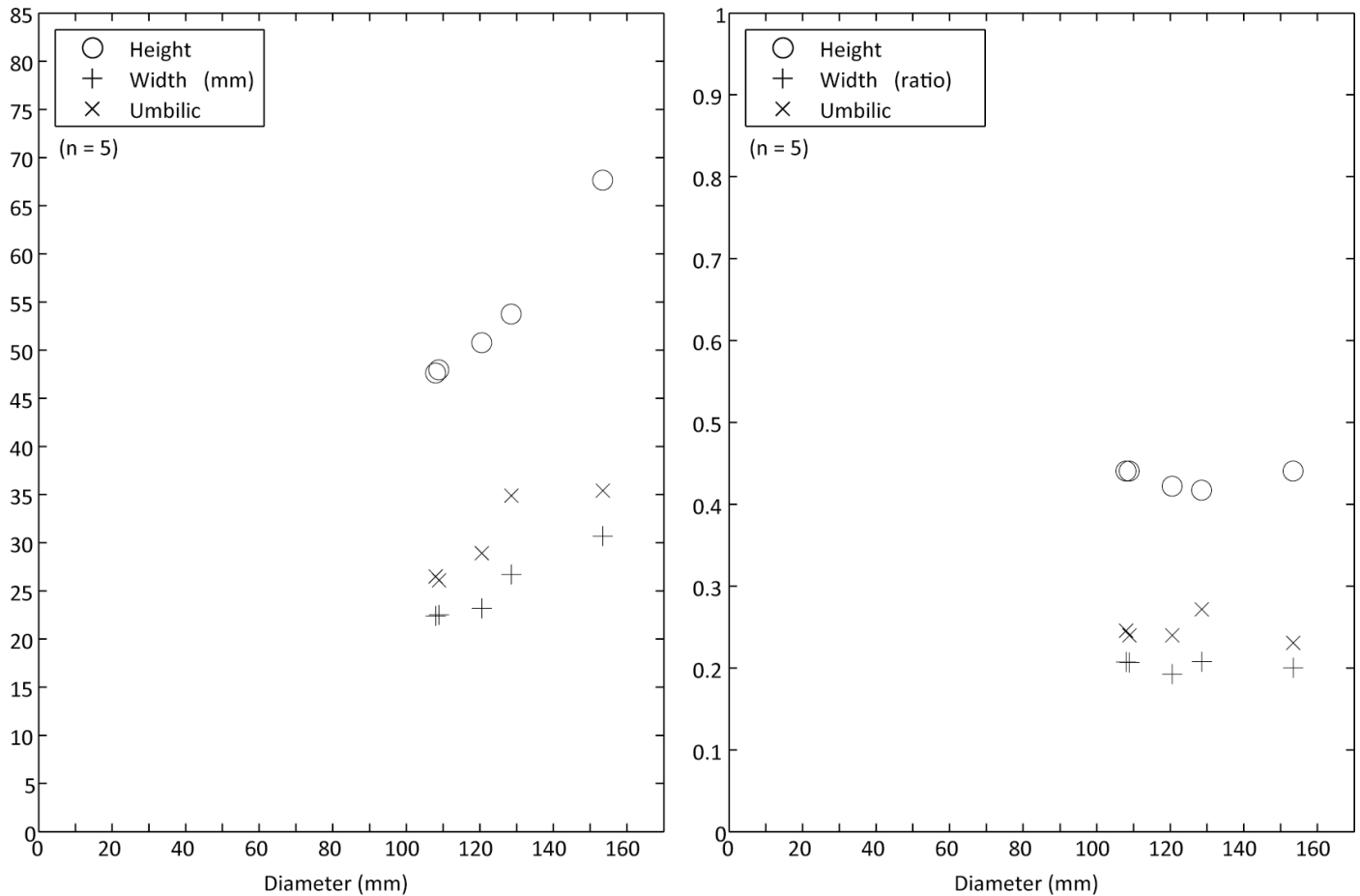


FIGURE 72. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Meekoceras bylundi* n. sp. All specimens from *O. k.* and *A. w.* intervals.

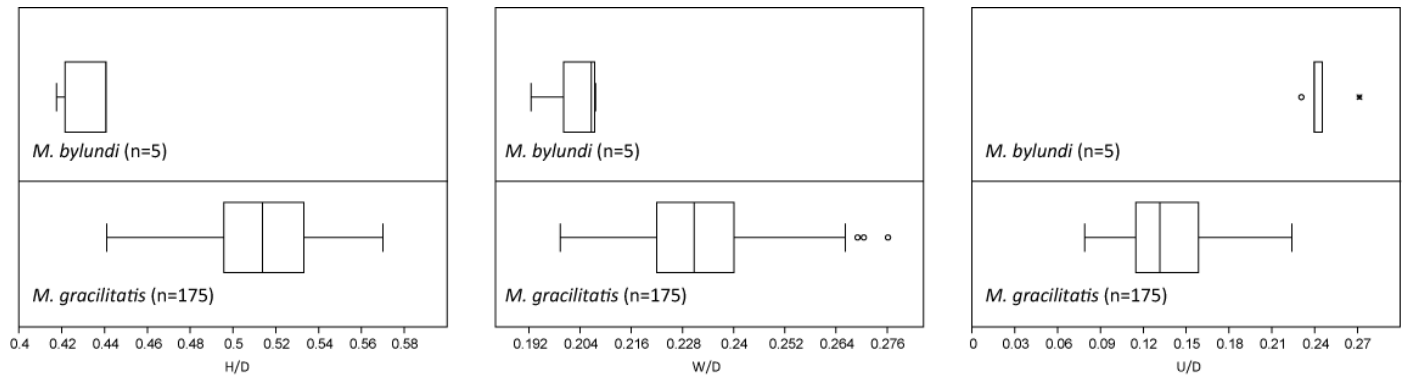


FIGURE 73. Box plot comparison of H/D, W/D and U/D for *Meekoceras bylundi* n. sp. vs. *Meekoceras gracilitatis*.

Realm, Salt Range, Spiti and Afghanistan (Jattiot et al., 2016).

Occurrence: Present specimen collected from *A. multiformis* interval (lense), Crittenden Springs, Nevada.

Anasibirites multiformis Welter, 1922

Figures 74D-F, G(4, 5), 75

2016 *Anasibirites multiformis* Welter, Jattiot et al., p. 30, figs. 10N-S, 21-23 [reader should refer to Jattiot et al. (2016) for a complete synonymy list].

2017 *Anasibirites multiformis* Welter, Jattiot et al., p. 30, pl. 11, figs. G-AA.

Material: Nine measured specimens and two additional specimens in a slab of matrix - all specimens are illustrated - 1402C, 24C-(4,5), 1398C, 1393C, 1403C, 1395C, 1396C,

2458C, 1397C and 1404C.

Description: (Based on taxonomic revision of *Anasibirites* by Jattiot et al., 2016). Medium sized, moderate to fairly involute shell with very slightly concave, nearly parallel flanks forming a sub-rectangular whorl section. Venter tabulate to subtabulate with angular shoulders on inner whorls and subtabulate with abruptly rounded shoulders on most mature specimens. A few larger specimens exhibit a broadly rounded venter on body chamber with barely discernable shoulders. Umbilicus relatively shallow with inclined wall and rounded shoulder, becoming slightly less inclined on mature whorls. Umbilical width (U/D) varies from 0.14 to 0.25. Taxon characterized by nearly isometric growth. Ornamentation typically consists of low intensity, dense megastriae at all ontogenetic stages. A few

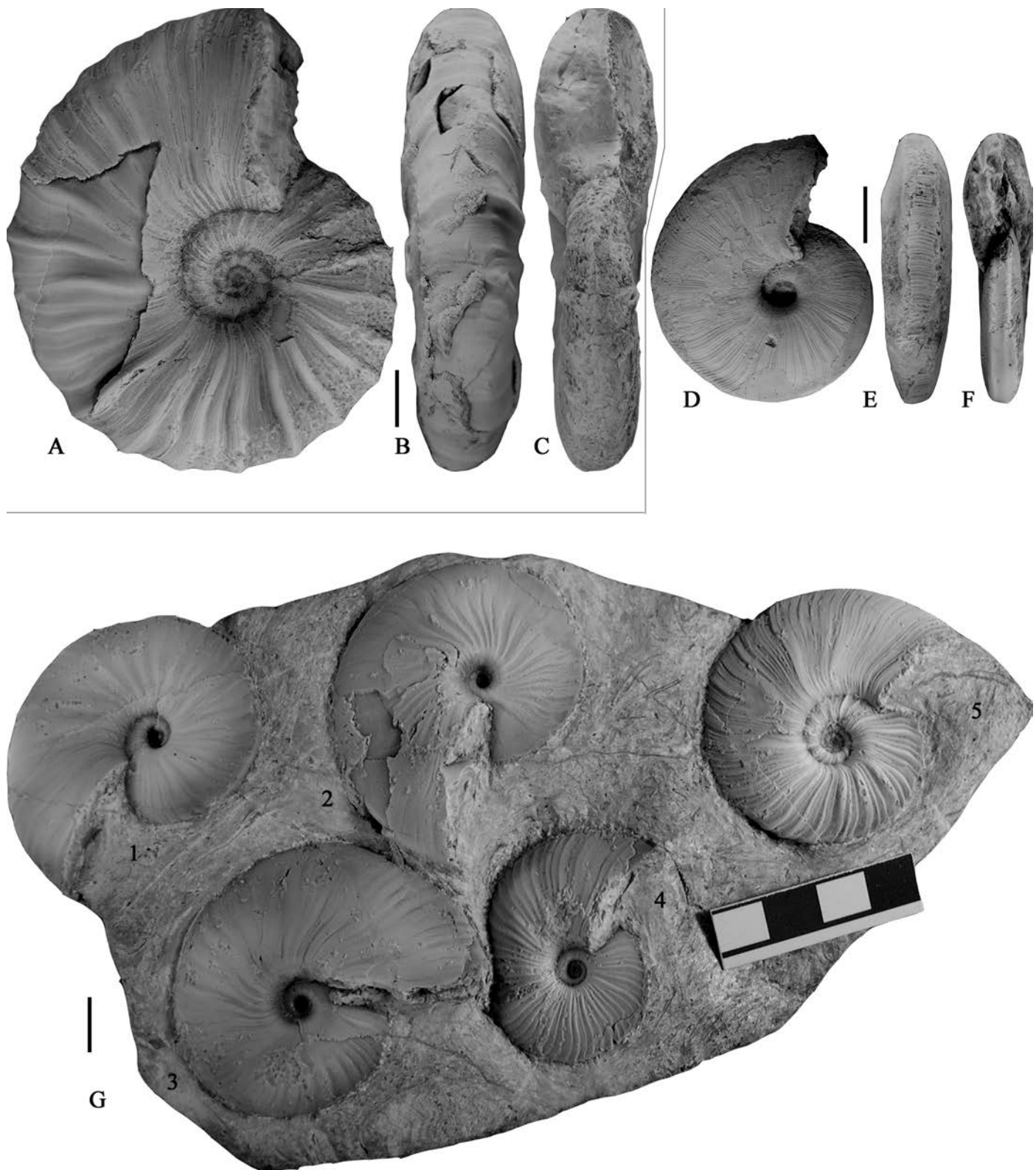


FIGURE 74. A-C, *Anasibirites kingianus* (Waagen), 1-86, A. m. A-C, 34C, in A, lateral, B, ventral and C, apertural views. D-G, *Anasibirites multiformis* Welter, in D-F, 1402C, in D, lateral, E, ventral and F, apertural views. G, 24C, slab with *Hemiprionites typus*, (1, 2 and 3) and *Anasibirites multiformis*, (4, 5). All scale bars = 1 cm.

shells exhibit periodic megastriae of slightly greater magnitude throughout ontogeny (Figs. 74G(5), 75J-L). Suture line ceratitic, generally identical to that of *A. kingianus*, with deep lateral lobes and broad, rounded saddles.

Measurements: See Figure 76 and APPENDIX, p. 154.

Discussion: As mentioned earlier, *Anasibirites multiformis* is by far the dominant *Anasibirites* taxon in the low paleolatitude, eastern Panthalassic basin (Jattiot et al., 2017). Extremely rare specimens exhibit true ribs together with megastriae on both the inner whorls and body chamber (see specimens from Lower Weber Canyon, Utah in Jattiot et al., 2016, figs. 22B, 23C), but specimens possessing these features have not yet been found at Crittenden Springs. At times, it can be difficult to differentiate between the two *Anasibirites* species, but the most useful distinguishing characteristic is the presence of megastriae at all growth stages on *A. multiformis*, and its absence on the body chamber of *A. kingianus*.

Occurrence: *Anasibirites multiformis* is common in the *A. multiformis* interval (lenses) at Crittenden Springs, but the lenses themselves are quite rare.

Genus Hemiprionites Spath, 1929

Type species: *Goniodiscus typus* Waagen, 1895

***Hemiprionites typus* (Waagen, 1895)**

Figures 77, 78, 79A-P

- 1895 *Goniodiscus typus* Waagen, p. 128, pl. 9, figs. 7-10.
 1929 *Goniodiscus typus* Waagen, Mathews, p. 31, pl. 5, figs. 12-21.
 1929 *Goniodiscus americanus* Mathews, p. 32, pl. 5, figs. 22-27.
 1929 *Goniodiscus shumardi* Mathews, p. 33, pl. 6, figs. 11-14.
 1929 *Goniodiscus utahensis* Mathews, p. 33, pl. 6, figs. 29-31.
 1929 *Goniodiscus ornatus* Mathews, p. 34, pl. 6, figs. 6-10.
 1929 *Goniodiscus slocomi* Mathews, p. 34, pl. 6, figs. 15-17.
 1929 *Goniodiscus butleri* Mathews, p. 35, pl. 6, figs. 18-21.
 1932 *Anasibirites typus* (Mathews), Smith, p. 76, pl. 80, figs. 6-8.
 1932 *Anasibirites utahensis* (Mathews), Smith, p. 77, pl. 80, figs. 9, 10.
 1932 *Anasibirites ornatus* (Mathews), Smith, p. 75, pl. 80, figs. 11, 12.
 1934 *Hemiprionites typus* (Mathews), Spath, p. 331, figs. 114a-c.
 2008 *Hemiprionites* cf. *H. butleri* (Mathews), Brayard and Bucher, p. 58, pl. 29, figs. 1, 4, 7, text-fig. 50.
 2012b *Hemiprionites typus* (Waagen), Brühwiler and Bucher, p. 103, figs. 89A-AH.
 2013 *Hemiprionites* cf. *H. typus* (Waagen), Brayard et al., p. 197, fig. 66.
 2017 *Hemiprionites typus* (Waagen), Jattiot et al., p. 31, pl. 12, figs. A-M, pl. 13, figs. A-X.

Material: 25 measured specimens. Includes 15 illustrated specimens (648C, 2462C, 2539C, 2464C, 698C, 1406C, 1409C, 224C, 1412C, 1408C, 267C, 1411C, 1405C, 655C and 2538C).

Description: (Based on taxonomic revision of *Hemiprionites* by Jattiot et al., 2017). Compressed shell exhibiting variable involution and egressive coiling of mature whorls, more pronounced on some specimens than others. Whorl overlap generally about 2/3, but can approach 80% on a few shells. Flanks slightly convex with tabulate venter and angular shoulders throughout ontogeny on most specimens, but a few larger shells exhibit a slightly subtabulate venter with abruptly rounded shoulders on mature whorls (Fig. 77A-C, I-K; Fig. 78A-C). Whorl section generally sub-rectangular with maximum width varying from 40 to 45% of whorl height. Body chamber length about 2/3 of whorl. Minute depression on outer edge of flank immediately below shoulder may or may not be present. If present, venter may be slightly sulcate or even bicarinate if depression is deep. Narrow, deep umbilicus with

rounded shoulders and very steep, high wall on earlier whorls, becoming gently inclined (as much as ~45°) on some mature whorls. Ornamentation consists of highly variable, flexuous, slightly biconcave growth lines, some of which are bundled into very low intensity, radial ribs that more or less follow trajectory of growth lines. Rib density varies greatly between specimens, and ribs on some shells form distinctive crenulated ventral shoulders. Suture line ceratitic but highly variable with tapered first and second lateral saddles.

Measurements: See Figure 80 and APPENDIX, p. 154.

Discussion: In addition to documenting the occurrence of the type species (*G. typus* Waagen) at Fort Douglas, Utah, Mathews (1929) also erected seven new species of *Goniodiscus*, which well illustrates the now recognized extremely wide range of intraspecific variation present in *H. typus* as well as the typological approach to taxonomy so prevalent in Mathew's time. Brayard and Bucher (2008) synonymized all Mathew's taxa with the type species with the exception of *H. butleri* and *H. walcotti*, and erected one new taxon from South China, *H. klugi*. Later, Jattiot et al. (2017), synonymized *H. butleri* with *H. typus*, and *H. klugi* with *H. walcotti*, thus leaving only two valid late Smithian taxa (*H. typus* and *H. walcotti*) and one middle Smithian taxon, *Hemiprionites roberti* Jenks et al., 2010.

Aided by a large collection from Timor and numerous specimens from Palomino Ridge, Nevada, Jattiot et al. (2017) aptly demonstrated that the minute depression just below the ventral shoulder long thought to be characteristic of *H. typus*, is not a diagnostic feature. Basically, they found that *H. typus* specimens do not always exhibit this depression, and the geometric shell parameters of those with and without the feature are identical (Jattiot et al., 2017). Interestingly, only a few specimens from Crittenden Springs exhibit this depression, and, for those that do, it is not nearly as noticeable as it is on specimens from Palomino Ridge, Nevada (Jattiot et al., 2017, pl. 13).

Hemiprionites typus differs from *H. walcotti* by its wider venter, wider umbilicus, more egressive coiling of the mature stage and the occasional presence of a minute depression just below the ventral shoulder. *Hemiprionites roberti* differs from *H. typus* by its funnel shaped umbilicus and lack of egressive coiling.

Note presence of sub-lethal shell injuries in Figures 78D-F and 79J-L. These injuries and their subsequent repairs have significantly altered the pattern of shell growth in the ventral area, e.g., the venter on the body chamber in Figure 79J-L has become broadly rounded.

Occurrence: *Hemiprionites typus* commonly occurs in the *A. multiformis* interval (lenses) at Crittenden Springs, but the lenses themselves are quite rare.

***Hemiprionites walcotti* (Mathews, 1929)**

Figure 79Q-V

- 1922 *Anasibirites multiformis* Welter, p. 17, figs. 4-7, 11-14.
 1929 *Goniodiscus walcotti* Mathews, p. 32, pl. 6, figs. 1-5.
 1934 *Hemiprionites timorensis* Spath, p. 331.
 2008 *Hemiprionites* cf. *H. butleri* (Mathews), Brayard and Bucher, p. 58, pl. 29, figs. 2, 3, 6 only.
 2008 *Hemiprionites klugi* Brayard and Bucher, p. 59, pl. 30, figs. 1-4.
 2012a *Hemiprionites* cf. *H. butleri* (Mathews), Brühwiler and Bucher, p. 33, pl. 19, figs. 10 only.
 2012b *Anasibirites angulosus* (Waagen), Brühwiler and Bucher, p. 103, figs. 87H-J, N-P only.
 2012b *Hemiprionites klugi* Brayard and Bucher, Brühwiler and Bucher, p. 103, figs. 87Q-AB.
 2017 *Hemiprionites walcotti* (Mathews), Jattiot et al., p. 34, pl. 14, figs. A-Y.

Material: Two measured specimens, 2461C and 2463C

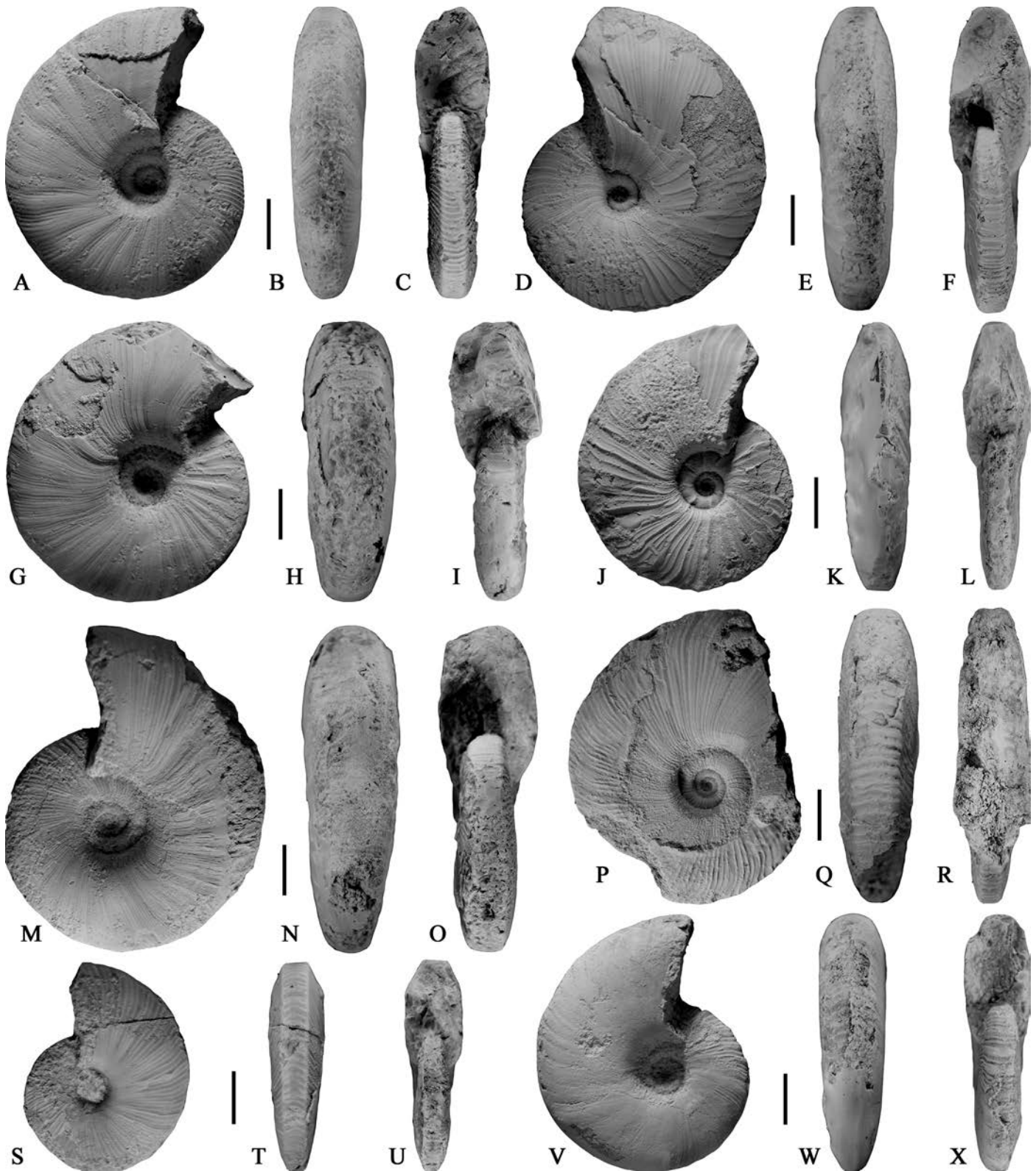


FIGURE 75. *Anasibirites multiformis* Welter, A. m. A-C, 1398C, 1-86, in A, lateral, B, ventral and C, apertural views. D-E, 1393C, 1-86, in D, lateral, E, ventral and F, apertural views. G-I, 1403C, 5-76, in G, lateral, H, ventral and I, apertural views. J-L, 1395C, 1-86, in J, lateral, K, ventral and L, apertural views. M-O, 1396C, 5-76, in M, lateral, N, ventral and O, apertural views. P-R, 2458C, float, in P, lateral, Q, ventral and R, apertural views. S-U, 1397C, 5-76, in S, lateral, T, ventral and U, apertural views. V-X, 1404C, 1-86, in V, lateral, W, ventral and X, apertural views. All scale bars = 1 cm.

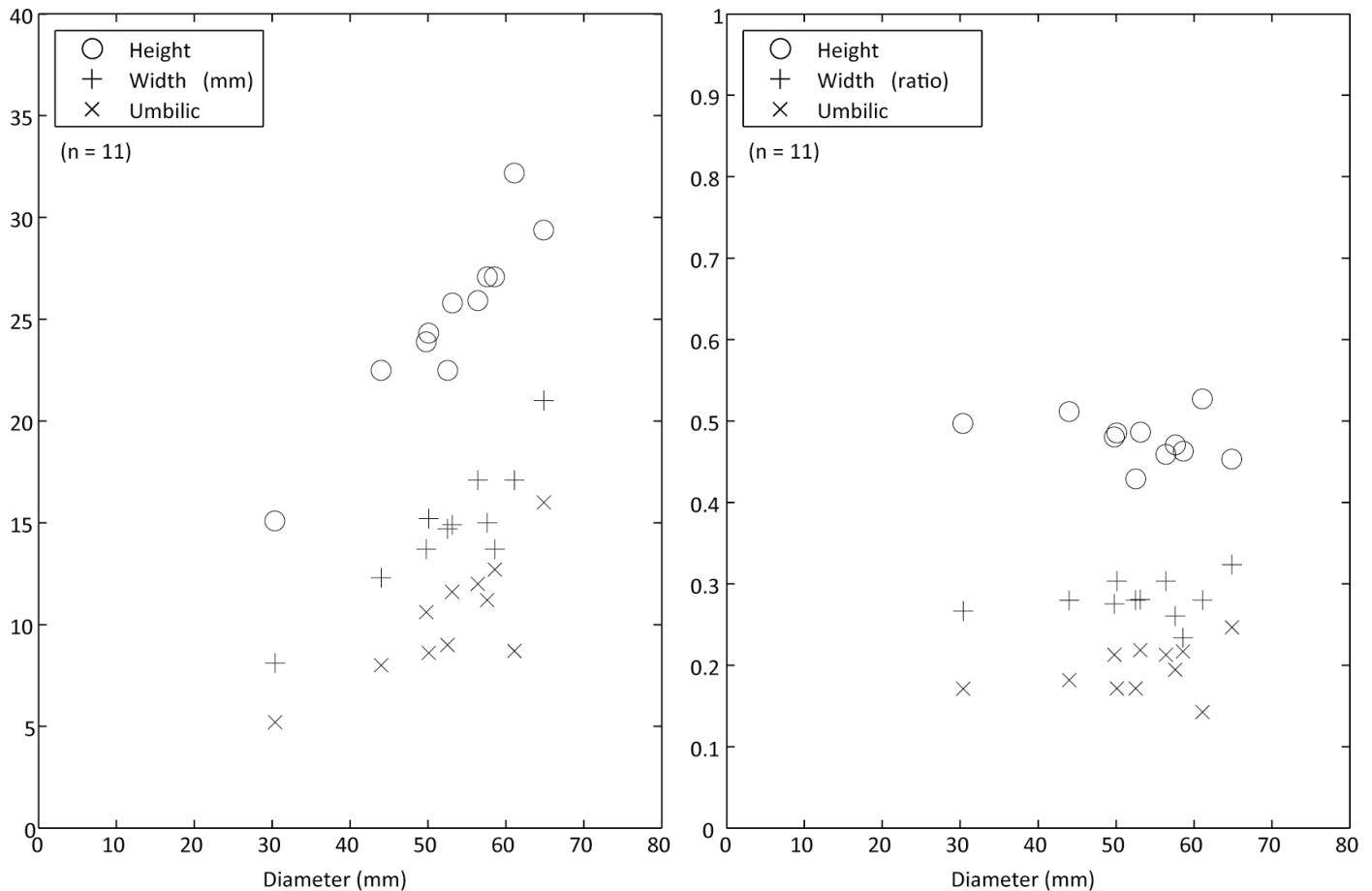


FIGURE 76. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Anasibirites multiformis*. All specimens from *A. m.* interval.

(Figs. 79Q-S, T-V).

Description: Compressed, high-whorled shell with involute coiling of juvenile whorls, becoming slightly egressive on mature whorls, but much less so than *H. typus*. Whorl section sub-rectangular with slightly convex flanks, gently converging to narrow tabulate venter on most specimens, with angular shoulders. A few specimens exhibit very low keels with a slightly sulcate venter. Maximum whorl width at ~45% of height. Narrow, deep umbilicus with steeply inclined wall and broadly rounded shoulder. Ornamentation consists only of barely visible, slightly flexuous growth lines and fairly dense but very low intensity, fold-type ribs following same trajectory as growth lines. Suture line not visible on present specimens.

Measurements: See APPENDIX, p. 155.

Discussion: *Hemiprionites walcotti* differs from *H. typus* by its more involute coiling, higher whorls, narrower venter, lack of a minute depression just below the ventral shoulder and less egressive coiling of the mature stage. *Hemiprionites roberti* differs from *H. walcotti* by its funnel-shaped umbilicus and lack of egressive coiling. *Hemiprionites walcotti* is far less abundant at Crittenden Springs than *H. typus*.

Occurrence: Very rarely found in the *A. multiformis* interval (lenses).

Hemiprionites roberti Jenks et al., 2010

Figure 81

2010 *Hemiprionites roberti* Jenks et al., p. 24, figs. 21, 22.

Material: 17 measured specimens (includes five type specimens). Illustrated specimens (seven) include NMMNH P-60173 (holotype), NMMNH P-60174 (paratype), NMMNH P-60175 (paratype), NMMNH P-60202 (paratype), 1987C, 30C

and 1991C,

Description: Very involute, compressed shell with slightly convex flanks forming a sub-rectangular whorl section. Maximum width at about 1/3 of whorl height. Venter varies from tabulate with angular shoulders on juveniles and sub-adults to subtabulate with narrowly rounded shoulders on mature whorls. Narrow (U/D ~0.15), deep, funnel-shaped umbilicus characterized by high, steeply inclined wall. Umbilical seam rests on narrowly rounded shoulder of each preceding whorl throughout ontogeny. No trace of egressive coiling. Body chamber length unknown but at least one-half whorl. Ornamentation consists of fine, prosiradiate, slightly sinuous growth lines on flanks that cross venter in very slight convex curve. Growth lines occasionally form very low intensity, somewhat dense fold-type ribs that arise just above umbilical shoulder and fade away at about 2/3 of whorl height. Suture line ceratitic with tapered, slightly asymmetrical first and second lateral saddles. Third lateral saddle varies from broad and rounded to slightly tapered and asymmetrical. Lobes weakly indented, first lateral lobe moderately deep.

Measurements: See Figure 82 and APPENDIX, p. 155.

Discussion: *Hemiprionites roberti*, with its narrow, funnel-shaped umbilicus and absence of egressive coiling of its mature whorls, differs significantly from the type species and *H. walcotti*. Moreover, the subtabulate venter on its mature whorls and its lack of a bicarinate venter further set it apart. Yet, its suture line leaves little doubt as to its proper attribution to *Hemiprionites*. Indeed, the suture line of one of the paratypes (NMMNH P-60174, Fig. 81D-F, W) is very similar to that of one of the type specimens of *H. typus* (Waagen, 1895, pl. 9, fig. 9).

Hemiprionites roberti, which occurs only in the late middle

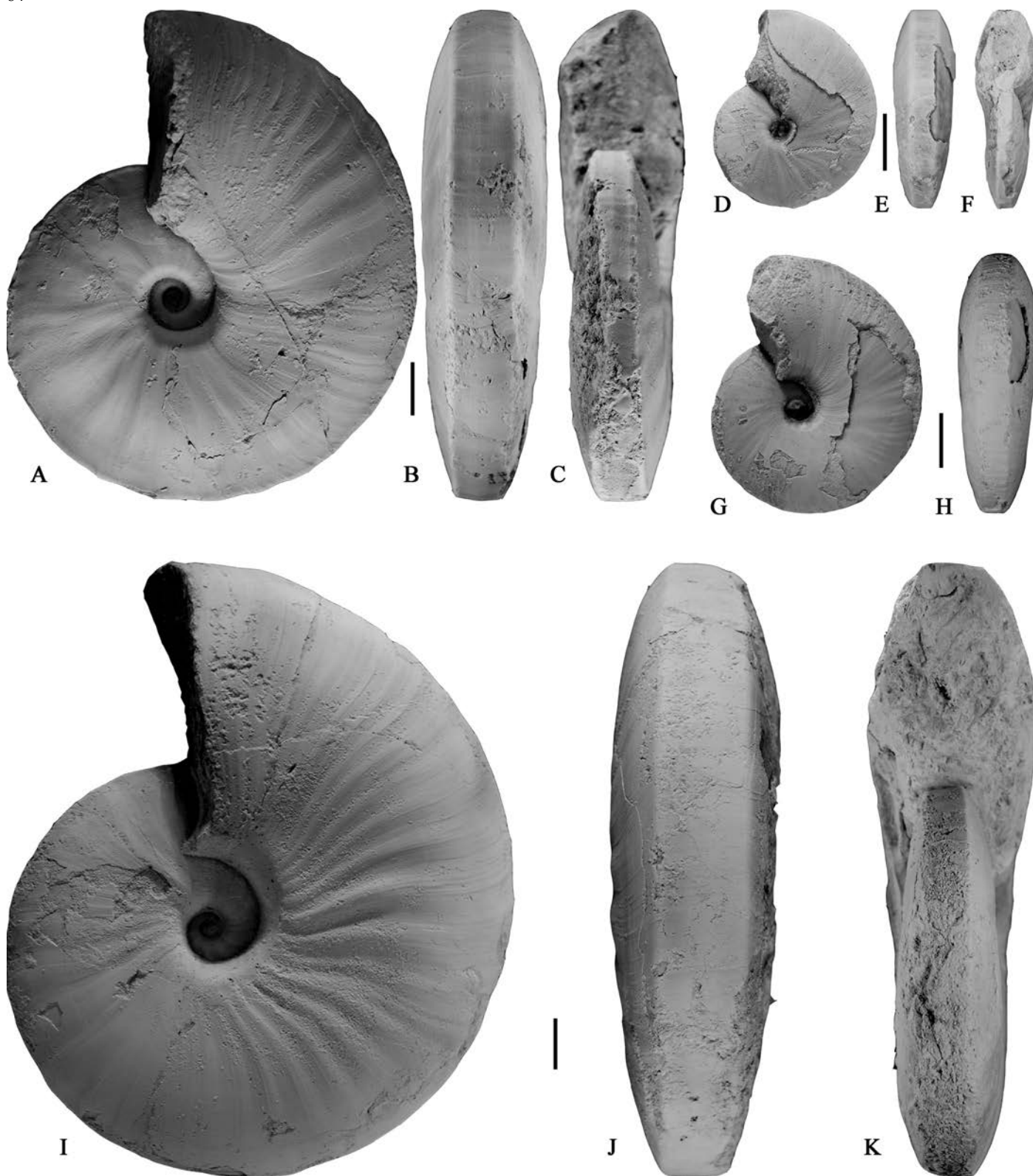


FIGURE 77. *Hemiprionites typus* (Waagen), *A. m.* **A-C**, 648C, 1-79, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2462C, 1-86, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-H**, 2539C, 1-86, in **G**, lateral and **H**, ventral views. **I-K**, 2464C, 14-09, in **I**, lateral, **J**, ventral and **K**, apertural views. All scale bars = 1 cm.

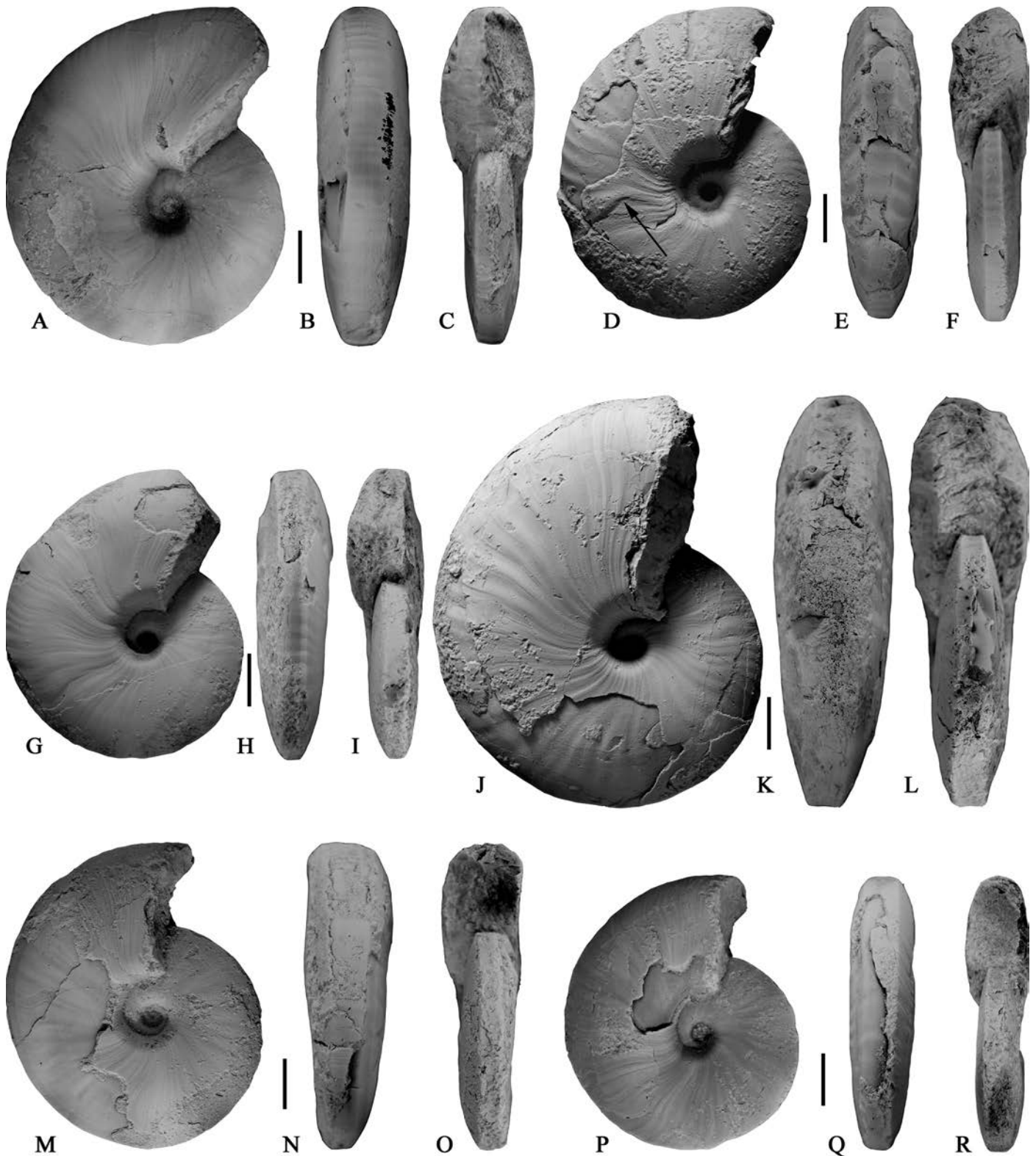


FIGURE 78. *Hemiprionites typus* (Waagen), *A. m.* A-C, 698C, 1-86, in A, lateral, B, ventral and C, apertural views. D-F, 1406C, 1-86, in D, lateral (arrow indicates healed injury; note effect on ensuing shell growth pattern), E, ventral and F, apertural views. G-I, 1409C, 2-93, in G, lateral, H, ventral and I, apertural views. J-L, 224C, 5-76, in J, lateral, K, ventral and L, apertural views. M-O, 1412C, 1-86, in M, lateral, N, ventral and O, apertural views. P-R, 1408C, 2-93, in P, lateral, Q, ventral and R, apertural views. All scale bars = 1 cm.

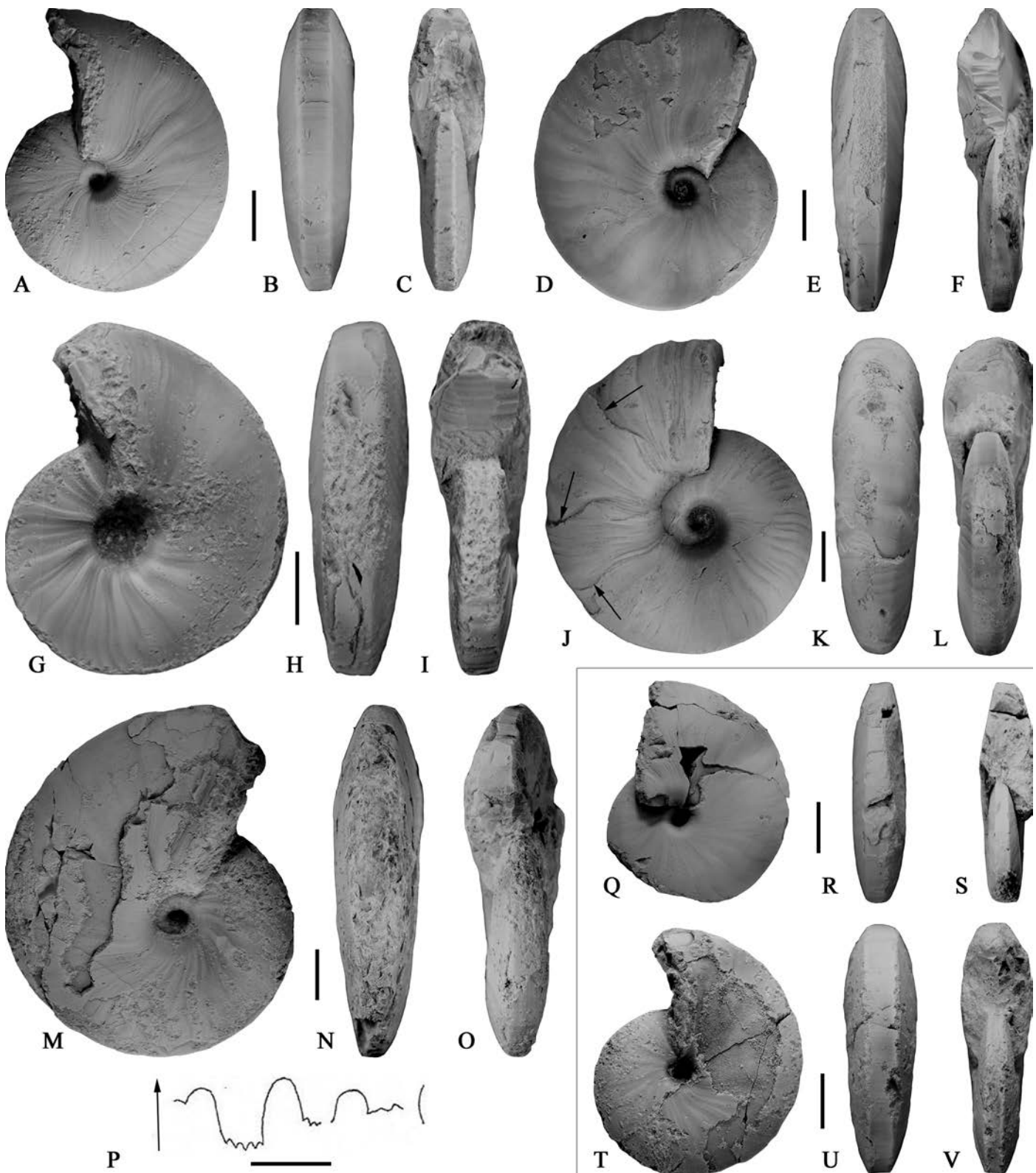


FIGURE 79. **A-P**, *Hemiprionites typus* (Waagen), *A. m.* **A-C**, 267C, 1-86, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 1411C, 1-86, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 1405C, 1-86, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 655C, 1-86, in **J**, lateral (arrows indicate healed injuries; note effect on ensuing shell growth pattern), **K**, ventral and **L**, apertural views. **M-O**, 2538C, 14-09, in **M**, lateral, **N**, ventral and **O**, apertural views. **P**, suture line, 2541C, H = 2.8 cm, 5-76. **Q-V**, *Hemiprionites walcotti* (Mathews), in **Q-S**, 2461C, 5-76, in **Q**, lateral, **R**, ventral and **S**, apertural views. **T-V**, 2463C, 2-93, in **T**, lateral, **U**, ventral and **V**, apertural views. All scale bars = 1 cm.

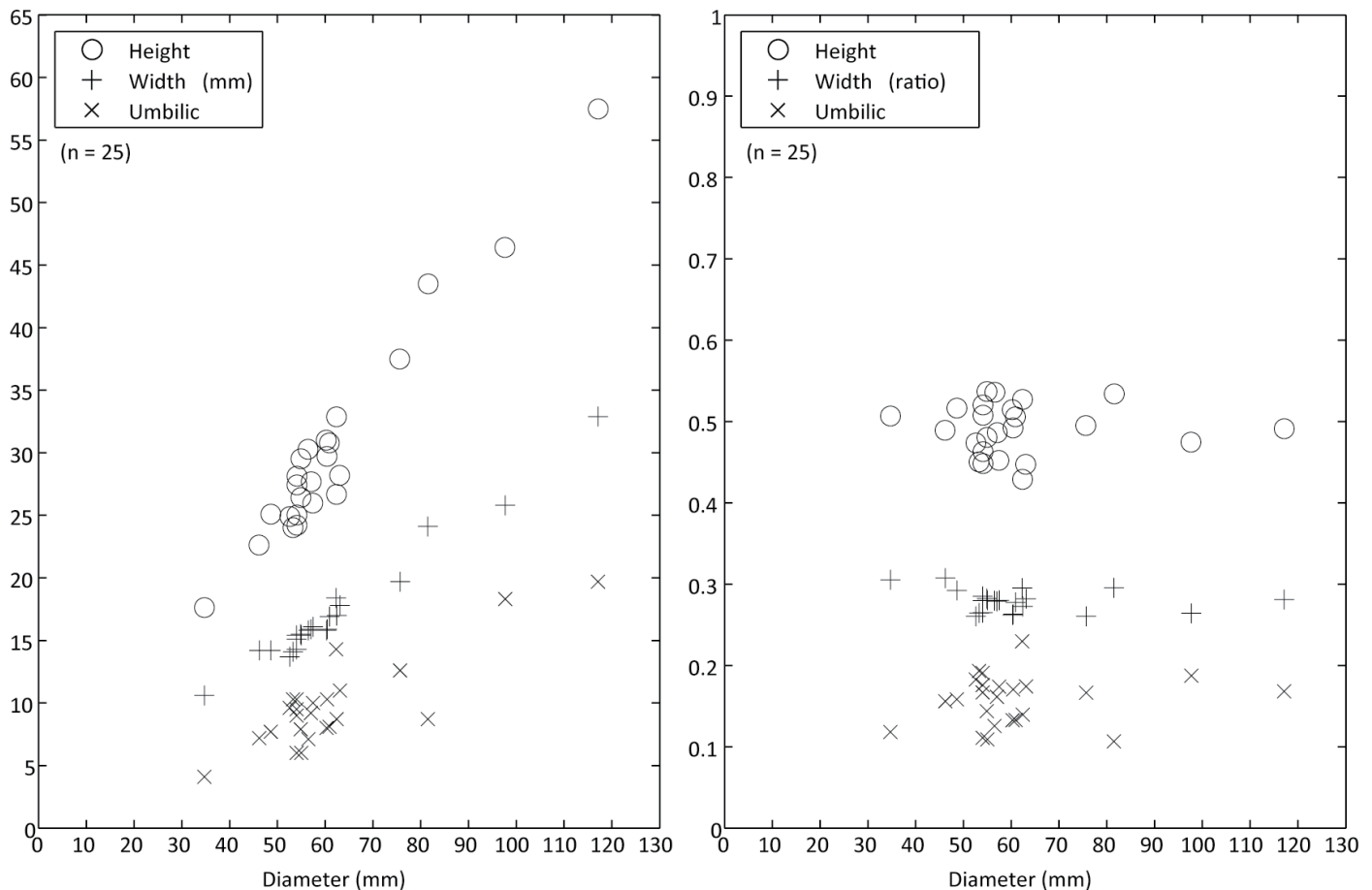


FIGURE 80. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Hemiprionites typus*. All specimens from A. m. interval.

Smithian, may represent a significant evolutionary link to the late Smithian members of the prionitid family. This taxon, together with middle Smithian *Meekoceras gracilitatis*, provides the only currently recognized connection with this near-dominant ammonoid group of the late Smithian. And thus far, Crittenden Springs is the only world-wide site that has yielded such a middle Smithian link other than for the common occurrence of *M. gracilitatis* in the Tethys and most other western USA localities.

Occurrence: *Hemiprionites roberti* is relatively rare and occurs only in the late middle Smithian *C. jattioti* n. gen., n. sp. interval.

Genus *Wasatchites* Mathews, 1929
Type species: *Wasatchites perrini* Mathews, 1929
Wasatchites perrini Mathews, 1929

Figure 83

- 1929 *Wasatchites perrini* Mathews, p. 40, pl. 9, figs. 1-9.
 1929 *Wasatchites meeki* Mathews, p. 41., pl. 7, figs. 1-3, pl. 8, figs. 11-14.
 1929 *Wasatchites magnus* Mathews, p. 41, pl. 11, figs. 1, 2.
 1929 *Wasatchites quadratus* Mathews, p. 42, pl. 7, figs. 23-25.
 1929 *Kashmirites wasatchensis* Mathews, p. 37, pl. 6, figs. 26-28.
 ?1929 *Kashmirites thornei* Mathews, p. 38, pl. 6, figs. 22-25.
 ?1929 *Kashmirites gilberti* Mathews, p. 38, pl. 7, figs. 4-8.
 1929 *Keyserlingites seerleyi* Mathews, p. 39, pl. 8, figs. 8-10.
 1932 *Kashmirites meeki* (Mathews), Smith, p. 67, pl. 81, figs. 1, 2.
 1932 *Kashmirites wasatchensis* (Mathews), Smith, p. 69, pl. 81, figs. 3-5.
 1932 *Kashmirites perrini* (Mathews), Smith, p. 67, pl. 81, figs.

6-8.

- 1932 *Kashmirites seerleyi* (Mathews), Smith, p. 68, pl. 81, figs. 11, 12.
 1961 *Wasatchites tardus* (McLearn), Tozer, p. 71, pl. 19, figs. 1a-b (only)
 1994 *Wasatchites perrini* Mathews, Tozer, p. 79, pl. 29, figs. 5a-c; pl. 35, figs. 2-4.
 2010 *Wasatchites perrini* Mathews, Stephen et al., fig. 7c.
 2013 *Wasatchites perrini* Mathews, Brayard et al., p. 191, figs. 13d, 59.
 2017 *Wasatchites perrini* Mathews, Jattiot et al., p. 28, pl. 10, figs. A-L.

Material: Two measured specimens, 42C and 2457C, both of which are illustrated.

Description: (Based on present specimens): Compressed, fairly evolute shell with tabulate venter and angular shoulders on phragmocone, becoming slightly subtabulate with abruptly rounded shoulders on larger mature body chambers. Whorl section sub-trapezoidal with slightly convex flanks; maximum width at about 45% of height. Whorl overlap varies between 1/3 and 1/2. Body chamber length unknown but at least 1/3 whorl. Moderately wide umbilicus with fairly high, steeply inclined wall and broadly rounded shoulder on early whorls, becoming noticeably less inclined on body chamber. Ornamentation consists of fairly dense fold-type ribs on inner whorls of phragmocone that arise on umbilical shoulder, become slightly projected as they cross shoulder and then form minute tubercles on top of shoulder before continuing across exposed flank in diminishing strength. Ribs become less dense and fade in intensity on umbilical shoulders of ultimate whorl of phragmocone. Tubercles at top of shoulder become more

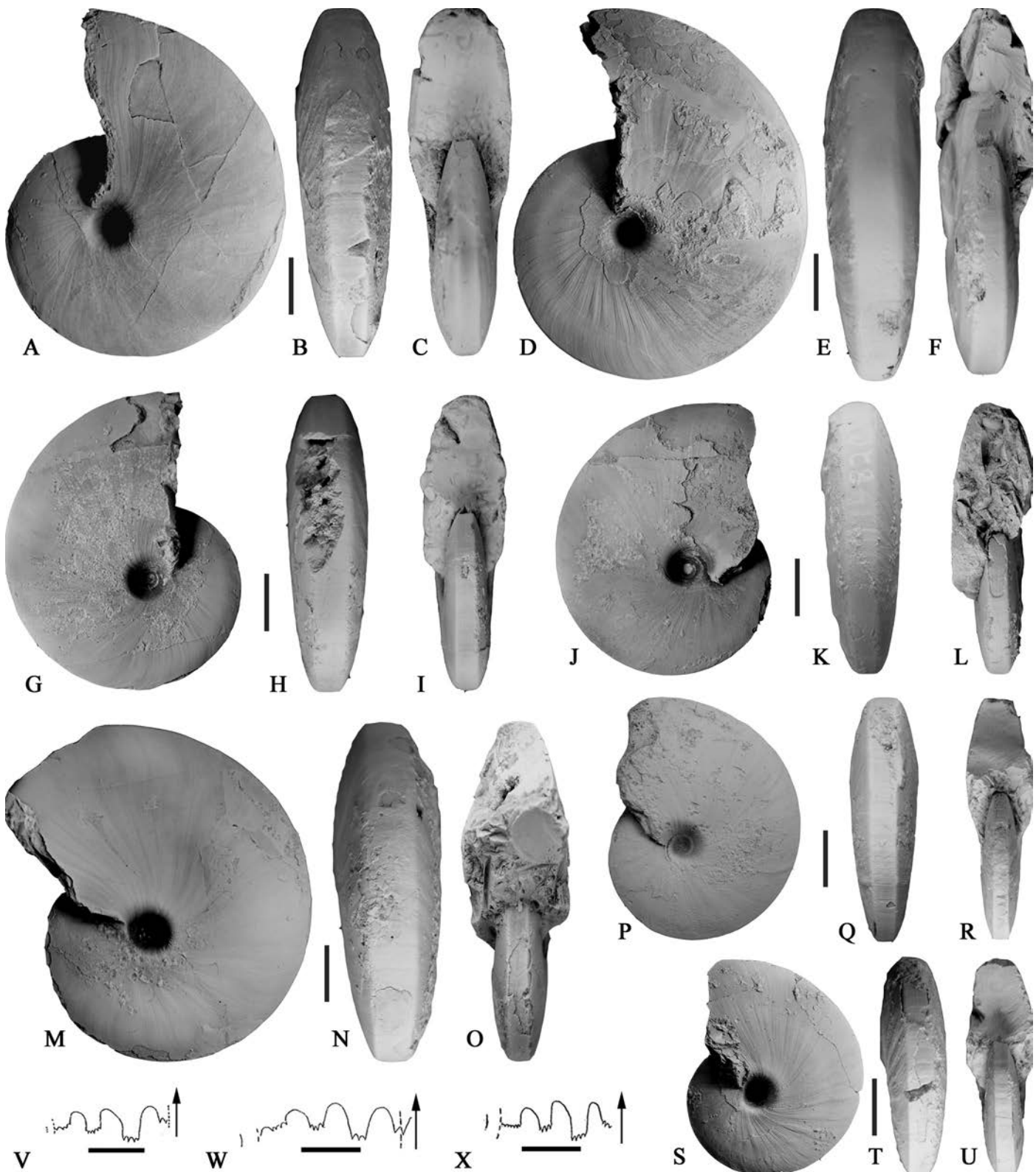


FIGURE 81. *Hemiprionites roberti* Jenks et al., 1-85, *C. j.* A-C, NMMNH P-60173, holotype, in A, lateral, B, ventral and C, apertural views. D-F, NMMNH P-60174, paratype, in D, lateral, E, ventral and F, apertural views. G-I, 1987C, in G, lateral, H, ventral and I, apertural views. J-L, NMMNH P-60175, paratype, in J, lateral, K, ventral and L, apertural views. M-O, 30C, in M, lateral, N, ventral and O, apertural views. P-R, NMMNH P-60202, paratype, in P, lateral, Q, ventral and R, apertural views. S-U, 1991C, in S, lateral, T, ventral and U, apertural views. V-X, suture lines in V, NMMNH P-60173, holotype, H = 21.9 mm. W, NMMNH P-60174, paratype, H = 28.8-mm. X, NMMNH P-60201, paratype, H = 21.6 mm. All scale bars = 1 cm.

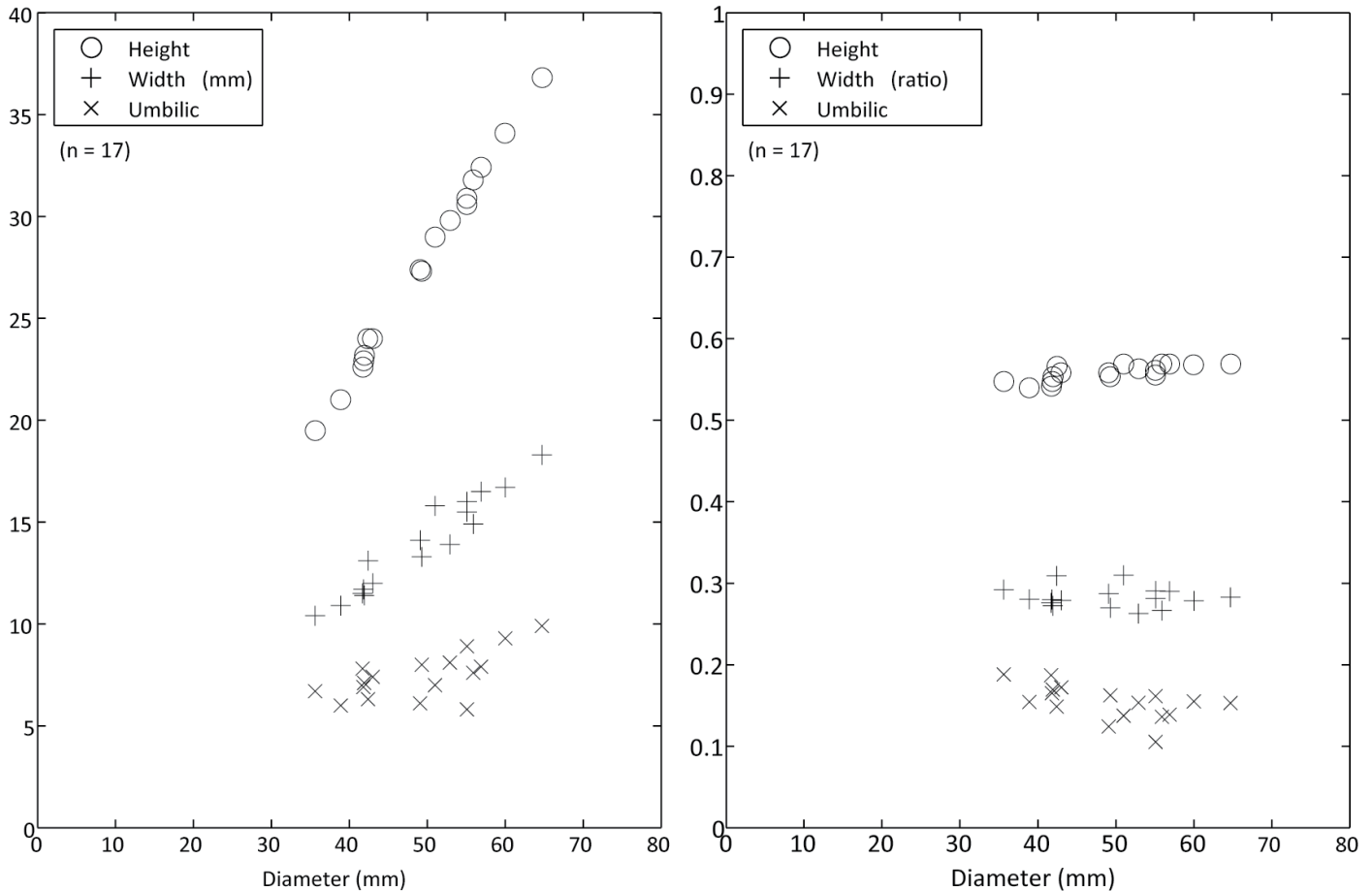


FIGURE 82. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Hemiprionites roberti*. All specimens from C. j. interval.

distant, but rapidly gain strength, becoming more spine-like before transitioning to high, robust, bullate-like tubercles on body chamber. Fold-type ribs, most of which bifurcate on flank immediately above tubercle, and others arising in interspaces, continue to ventral shoulder where they gain strength and project forward slightly, becoming slightly clavate-like before crossing venter in diminished strength, producing slight corrugated effect. Tuberculation diminishes dramatically from very robust to barely perceptible over just the last 1/4 whorl of the largest specimen. Largest specimen exhibits conspicuous growth lines that follow same trajectory as ribs. Suture line not exposed on present specimens.

Measurements: See APPENDIX, p. 155.

Discussion: *Wasatchites* undoubtedly exhibits an extremely wide intraspecific variation in both shell form and ornamentation as demonstrated by Mathews' (1929) attribution of eight species to his new genus. Brayard et al. (2013) recognized this wide variation and synonymized all Mathews' taxa with the type species. *Wasatchites* is not well known at Crittenden Springs, and, although the present two specimens represent a broad size range, they do not necessarily demonstrate the wide variation in ornamentation present in the taxon. According to Brayard et al. (2013), *Wasatchites* is relatively rare in central and eastern Utah. This observation is also true for the *Anasibirites* beds at the classic Fort Douglas, Utah site as well as at the Lower Weber Canyon, Utah and Georgetown, Idaho sites.

Wasatchites distractus (Waagen), until now known only from the Tethys, is a well known taxon because of the extensive work of Brühwiler et al. (2012b, c) in the Salt Range and Spiti. It differs from *W. perrini* by the positioning of its tubercles closer to mid-flank, its more radially directed ribs, and, perhaps

most important, its subtabulate to broadly rounded venter at all growth stages. Other species attributed to *Wasatchites*, e. g., *W. tridentinus* Spath from Spitsbergen and British Columbia, *W. deleeni* McLearn and *W. procurvus* McLearn, both from British Columbia, supposedly differ from the type species by exhibiting strong bullae on only 1/2 of a whorl, having fewer bullae on the phragmocone combined with a more ovoid whorl section, and possessing distinctive ribs that cross the venter with a conspicuous forward projected curvature. Of the latter taxa, only *W. tridentinus* from Spitsbergen is well known from a large collection. A few workers (Dagys and Ermakova, 1990; Piazza, 2015, p. 64) have suggested the possibility that these three taxa may be conspecific with *W. perrini*. This suggestion may indeed have merit, but it will remain unconfirmed until larger collections become available.

Occurrence: *Wasatchites perrini* very rarely occurs in the A. *multiformis* interval (lenses) at Crittenden Springs.

Wasatchites cf. *W. distractus* (Waagen, 1895) Figure 84

- 1895 *Acrochordiceras distractum* Waagen, p. 94, pl. 3, figs. 4a-c.
- 1895 *Acrochordiceras coronatum* Waagen, p. 96, pl. 3, figs. 5a-c.
- 1895 *Acrochordiceras* cf. *damesi* Noetling, Waagen, p. 97, pl. 4, fig. 5a-b.
- 1895 *Acrochordiceras compressum* Waagen, p. 98, pl. 4, fig. 4a-c.
- ?1909 *Sibirites* sp. indet. Krafft and Diener, p. 138, pl. 28, fig. 4a-c.
- ?1978 *Stephanites corona* Waagen, Guex, pl. 5, fig. 2.

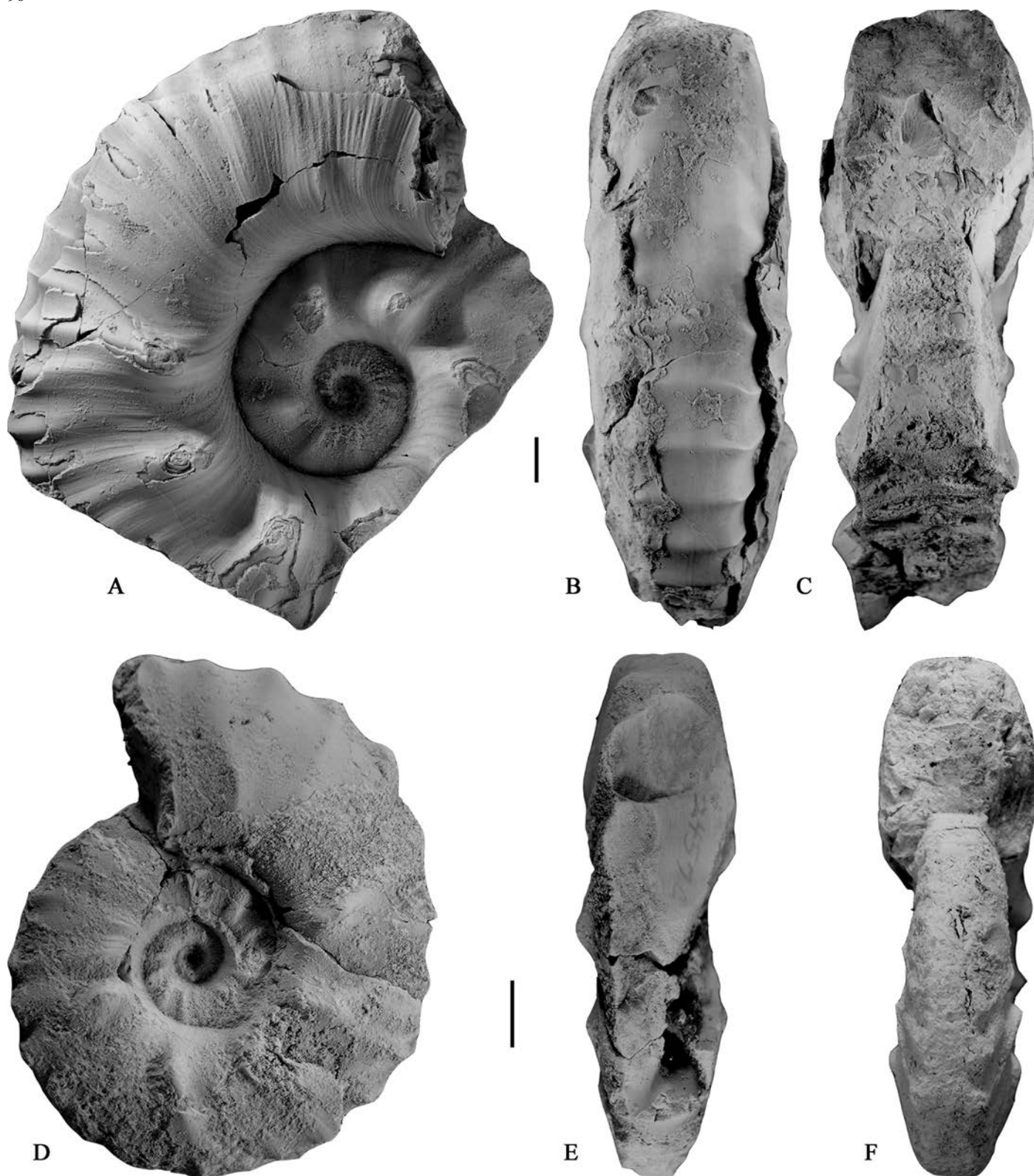


FIGURE 83. *Wasatchites perrini* Mathews, A. m. A-C, 1279C, 1-86, in A, lateral, B, ventral and C, apertural views. D-F, 2457C, 5-76, in D, lateral, E, ventral and F, apertural views. Scale bars = 1 cm.

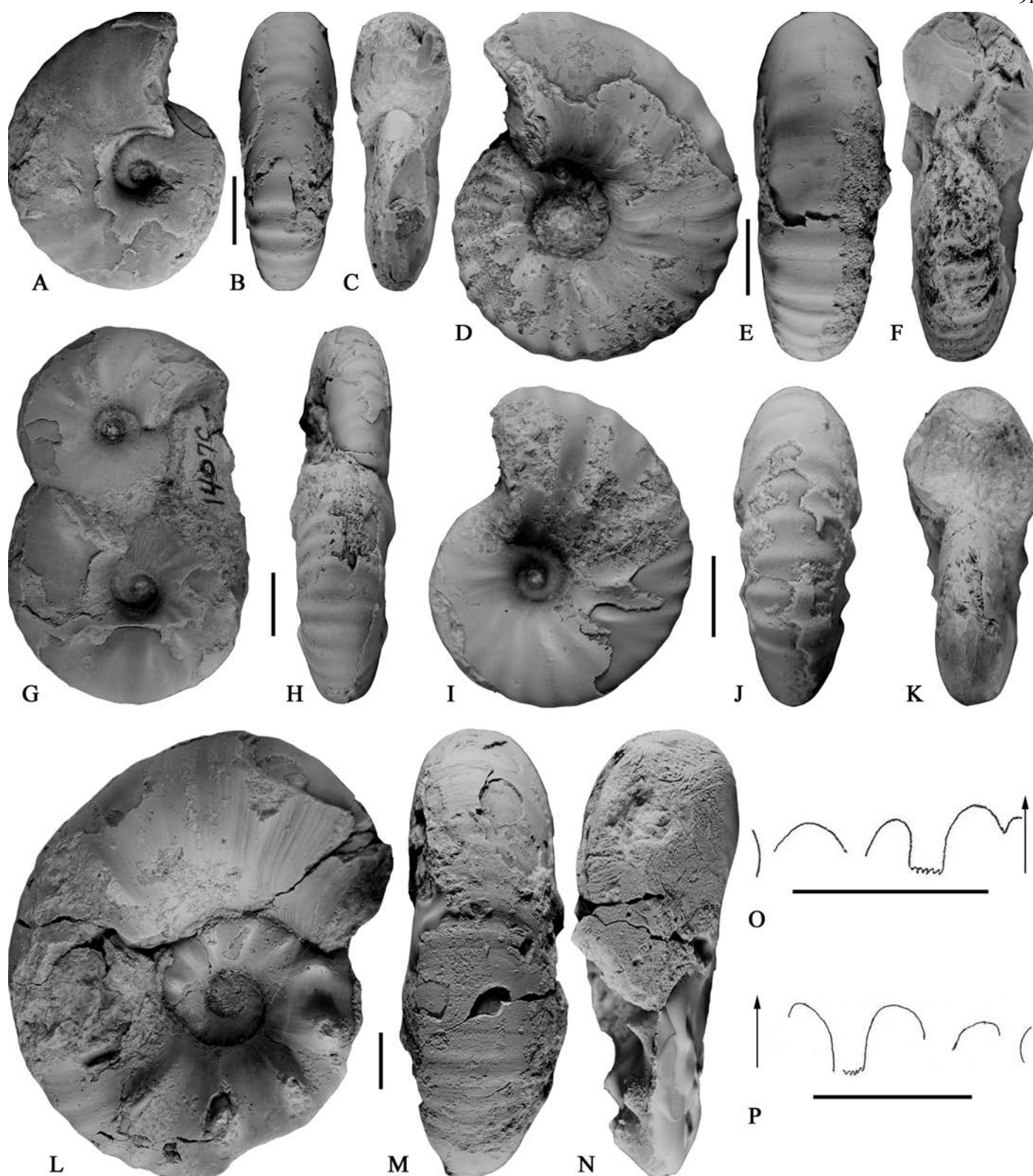


FIGURE 84. *Wasatchites* cf. *W. distractus* (Waagen), 1-93, A. m. A-C, 1401C, in A, lateral, B, ventral and C, apertural views. D-F, 921C, in D, lateral, E, ventral and F, apertural views. G-H, 1407C, in G, lateral and H, ventral views. I-K, 1399C, in I, lateral, J, ventral and K, apertural views. L-N, 1400C, in L, lateral, M, ventral and N, apertural views. O-P, suture lines, in O, 1407C, small specimen, H = 1.1 cm. P, 1407C, large specimen, H = 1.5 cm. All scale bars = 1 cm.

2010a *Wasatchites distractus* (Waagen), Brühwiler et al., p.

423, fig. 15: 1.

2012b *Wasatchites distractus* (Waagen), Brühwiler and Bucher, p. 97, figs. 81M-U, 82A-X.

2012c *Wasatchites distractus* (Waagen), Brühwiler et al., p.152, fig. 32A-Z.

Material: Six measured specimens. All are illustrated.

Description: Fairly involute, compressed shell with slight egressive coiling of mature whorl. Venter ranges from tabulate with angular shoulders on smallest juvenile phragmocone (D ~ 20 mm) to narrowly rounded with indistinct shoulders on some larger juvenile shells (D ~ 40 mm) to broadly arched with indistinct shoulders on present mature specimen (D ~ 85 mm). Whorl section sub-trapezoidal with slightly convex flanks; maximum whorl width at about 45% of height. Whorl overlap ranges from ~1/2 to 2/3. Body chamber length not known but at least 1/2 whorl. Fairly narrow, moderately deep umbilicus with high, steeply inclined wall and well-rounded shoulders on juvenile shells, becoming less inclined on mature whorl. Ornamentation on phragmocone of juvenile shells consists of fairly dense, fold-type, radial to slightly projected ribs that arise on umbilical shoulder, become strongest at about 1/3 to 1/2 flank height and lose strength on outer flank before crossing rounded venter in gentle undulations. Ribs gradually gain strength on outer whorl of phragmocone and body chamber, forming small but obvious tubercles at ~40 to 50% of flank height, after which they continue to ventral shoulder and cross venter in ever increasingly distinctive undulations, especially on shells with more narrowly rounded venters. Ribbing and tuberculation pattern similar on large mature specimen, but tubercles gradually become stronger and more bullate-like over the entire phragmocone and a portion

of the body chamber, before completely fading over just the last 1/4 whorl. Suture line ceratitic with deep first lateral lobe and broad, rounded saddles.

Measurements: See Figure 85 and APPENDIX, p. 155.

Discussion: This is the first report of specimens reasonably close to *Wasatchites distractus* from western USA sites. Until now, the taxon has been documented only from the Tethyan Realm, namely the Salt Range (Waagen, 1895; Brühwiler et al., 2012b), Spiti (Brühwiler et al., 2012c) and South Tibet (Brühwiler et al., 2010a). Our specimens, with their rounded to subtabulate venters at all growth stages, more radially directed ribs and location of tubercles near mid-flank, are very close to those illustrated in Brühwiler et al. (2012b, 2012c), but the much stronger tuberculation on the Tethyan material precludes a firm assignment to *W. distractus*.

Occurrence: *Wasatchites* cf. *W. distractus* is very rare at Crittenden Springs. All specimens were found within a single *A. multiformis* interval lense.

Genus *Arctoprionites* (Frebold, 1930)

Type species: *Goniodiscus nodosus* Frebold, 1930

Arctoprionites resseri (Mathews, 1929)

Figures 86, 87

1929 *Kashmirites resseri* Mathews, p. 38, pl. 8, figs. 4-7.

1932 *Kashmirites resseri* Mathews, Smith, p. 67, pl. 81, figs. 9, 10.

1961 *Arctoprionites* sp. indet., Tozer, pl. 20, fig. 1.

v1962 *Arctoprionites* sp. indet., Kummel and Steele, p. 699, pl. 101, fig. 2.

1994 *Arctoprionites williamsi* Tozer, p. 83, pl. 34, figs. 1-4.

2013 *Arctoprionites resseri* (Mathews), Brayard et al., p. 198,

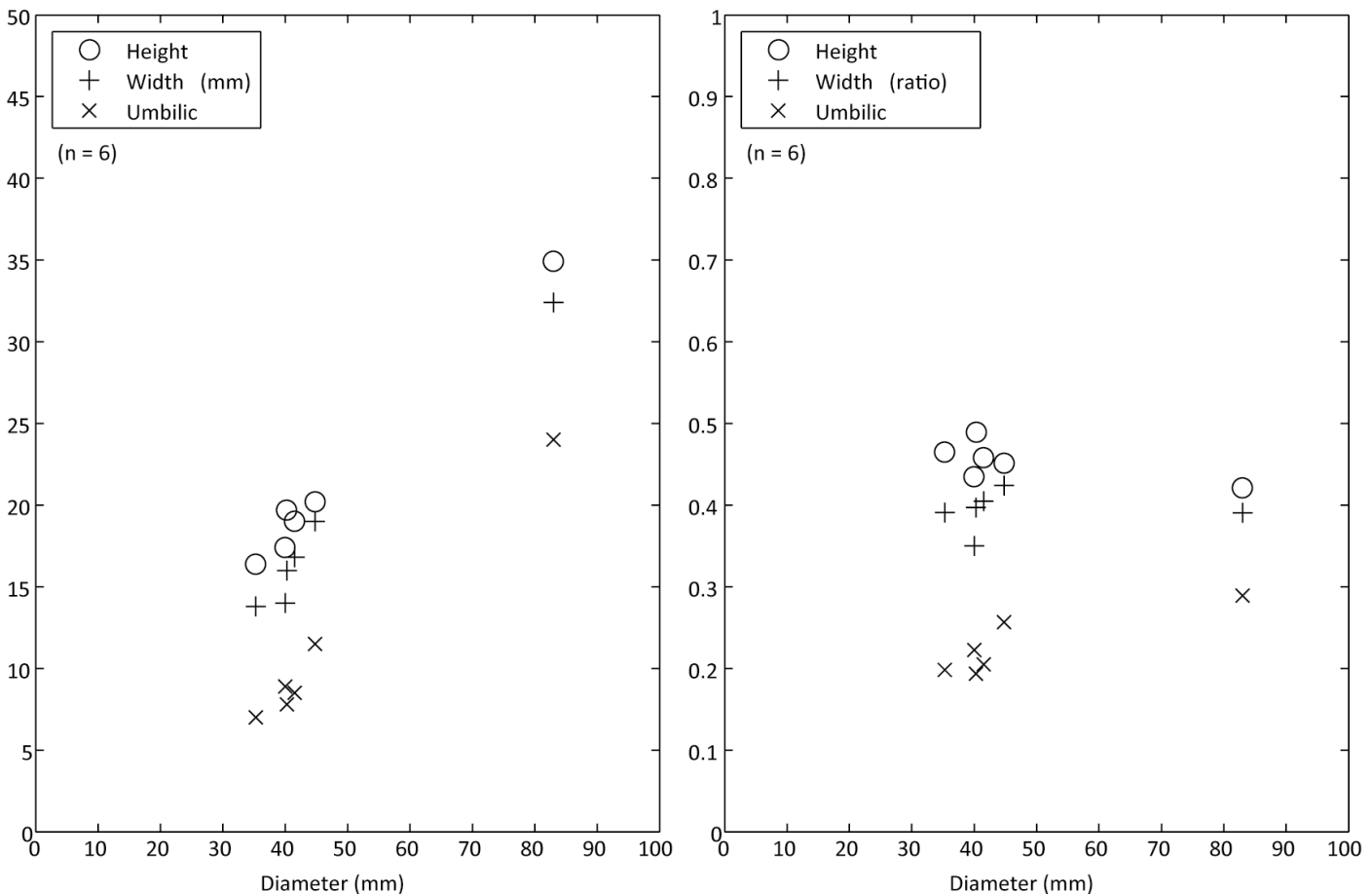


FIGURE 85. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Wasatchites* cf. *W. distractus*. All specimens from *A. m.* interval.

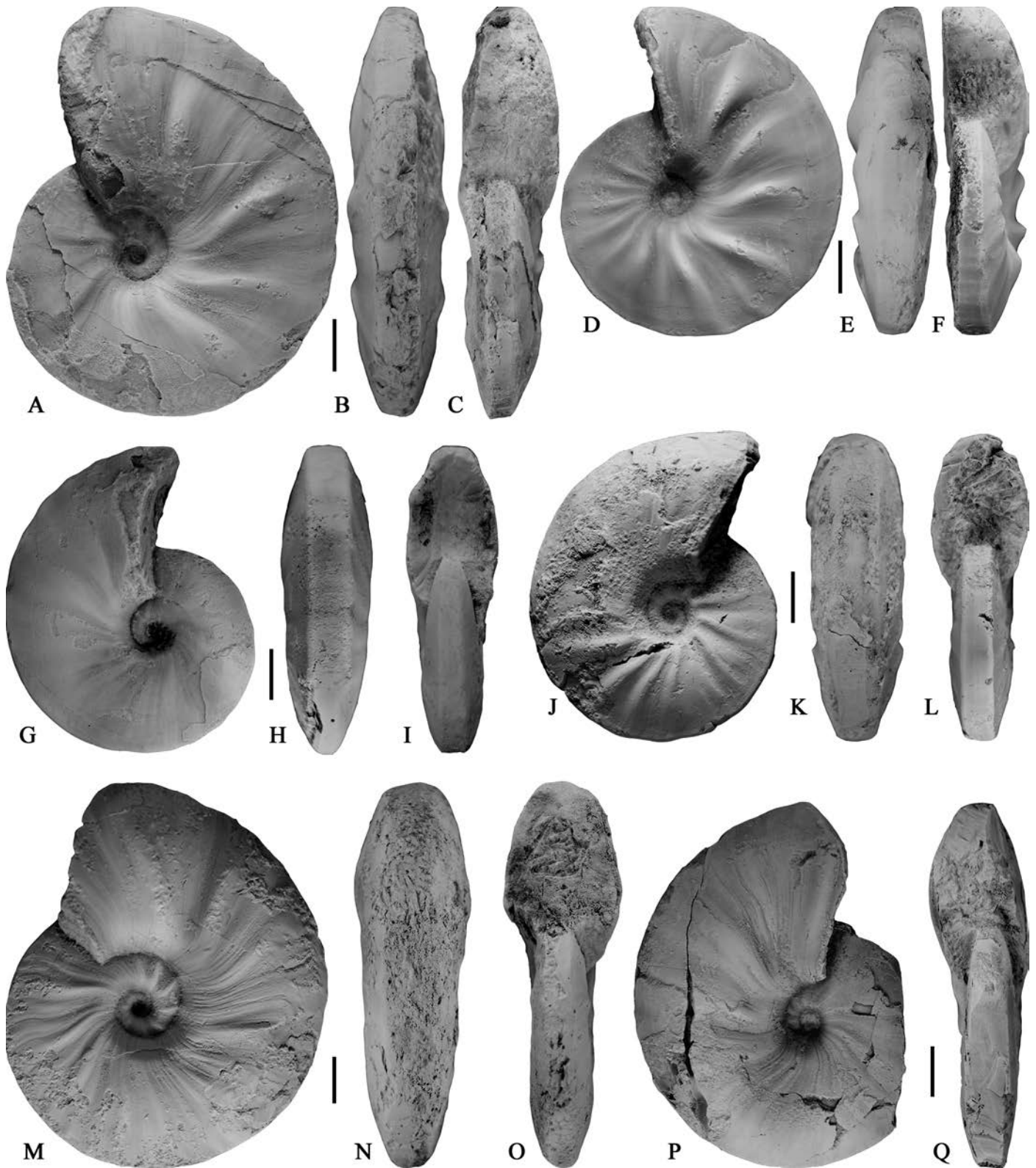


FIGURE 86. *Arctoprionites resseri* (Mathews), *A. m.* A-C, 654C, 2-93, in A, lateral, B, ventral and C, apertural views. D-F, 656C, 1-86, in D, lateral, E, ventral and F, apertural views. G-I, 1415C, 5-76, in G, lateral, H, ventral, and I, apertural views. J-L, 885C, 5-76, in J, lateral, K, ventral and L, apertural views. M-O, 128C, 1-85, in M, lateral, N, ventral and O, apertural views. P-Q, 2471C, 1-85, in P, lateral and Q, apertural views. All scale bars = 1 cm.

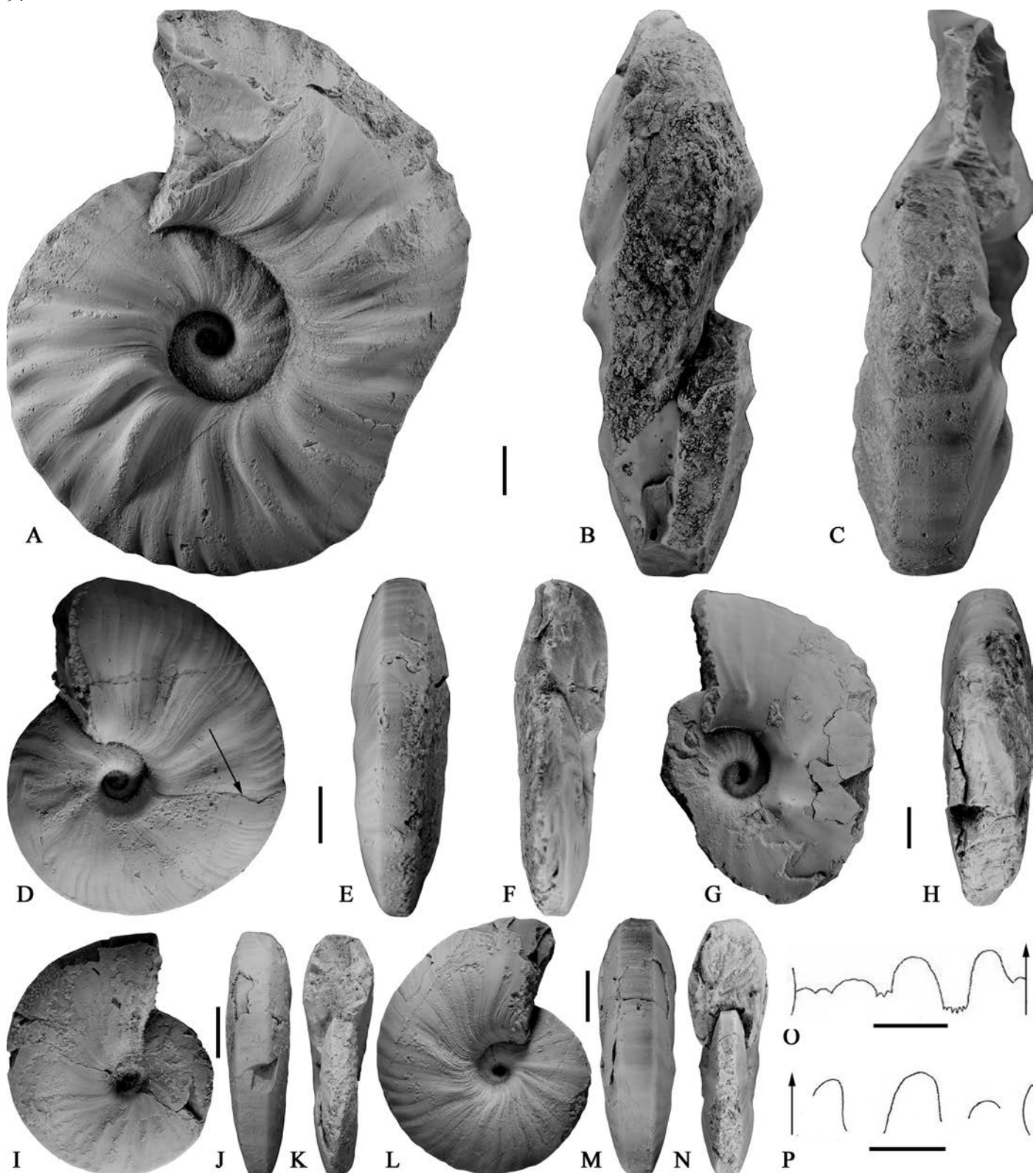


FIGURE 87. *Arctoprionites resseri* (Mathews), *A. m.* A-C, 2470C, 1-79, in A, lateral, B, ventral and C, apertural views. D-F, 743C, 1-86, in D, lateral, E, ventral and F, apertural views. G-H, 2456C, 1-93, in G, lateral and H, ventral views. I-K, 2459C, 5-76, in I, lateral, J, ventral and K, apertural views. L-N, 1413C, 1-86, in L, lateral, M, ventral and N, apertural views. O-P, suture lines in O, 2456C, H = 2.7 cm, 1-93. P, 1410C, H = 2.3 cm, 2-93. All scale bars = 1 cm.

fig. 67.

2017 *Arctoprionites resseri* (Mathews), Jattiot et al., p. 34, pl. 12, figs. N-X.

Material: 12 measured specimens. Includes 11 illustrated specimens (654C, 656C, 1415C, 885C, 128C, 2471C, 2470C, 743C, 2456C, 2459C and 1413C).

Description: Moderately involute, compressed prionitid characterized by slight egressive coiling of mature whorls. Whorl section sub-trapezoidal with slightly convex flanks and tabulate venter with angular shoulders on juvenile and adolescent whorls; venter either remains tabulate with bluntly angular shoulders on mature whorls or becomes slightly subtabulate with abruptly rounded shoulders. Maximum thickness at about 40 to 45% of height. Body chamber length unknown but at least $\frac{1}{2}$ whorl. Umbilicus fairly narrow and deep with steeply inclined wall and abruptly rounded shoulders on juvenile and adolescent whorls, becoming less inclined with broadly rounded shoulders on mature whorls. Ornamentation consists of highly variable, slightly projected, bullate-like, slightly sinuous (on some larger specimens), elongated ribs that arise above umbilical shoulder, become especially prominent near mid-flank (especially on body chamber) and fade rapidly in strength on outer flank. On some specimens, these ribs continue on in greatly diminished strength to ventral shoulder where they tend to form crenulations and then continue across venter (Fig. 87A-C). Most specimens exhibit growth lines that more or less parallel ribs and cross venter in a distinctive manner. Suture line ceratitic, typical of prionitids, with deep first lateral lobe and broad, rounded saddles.

Measurements: See Figure 88 and APPENDIX, p. 156.

Discussion: Mathews (1929) apparently based *A. resseri* on two specimens (pl. 8, figs. 4-7), of which the holotype (figs.

4-6) more or less agrees in general form and ornamentation with most of the present specimens, except for the presence of the distinct depression on its outer flank, just below the ventral shoulder. This feature has not been observed on specimens from Crittenden Springs, even on those that are better preserved. In contrast, the characteristic is reported on specimens from Utah (Brayard et al., 2013) and Palomino Ridge, Nevada (Jattiot et al., 2017). As observed in Figures 86 and 87, the present specimens exhibit considerable variation in the intensity, positioning and style of their bullate ribs. Some become most prominent at about mid-flank, while others attain their greatest strength and height closer to the umbilical shoulder. Some are slightly more projected and sinuous than others, and their strength can vary significantly – indeed, it can be difficult to separate much less adorned specimens of *A. resseri* from *H. typus*.

In terms of conch shape and coiling, *Arctoprionites resseri* and *A. nodosus* (Frebold) are very similar, if not identical. *A. resseri* supposedly differs from *A. nodosus* by the more umbilicate position of its bullate ribs (Brayard et al., 2013; Piazza, 2015), but, as mentioned above, this observation is not always diagnostic of *A. resseri*. Specimens from Crittenden Springs appear to differ from illustrations of *A. nodosus* in Frebold (1930) primarily by the shape of its bullate ribs. For *A. resseri*, the bullate ribs becomes significantly projected on the umbilical shoulder or slightly above, which is much sooner than on *A. nodosus*, and then continue more or less straight or very slightly sinuous until they fade higher on the flank. In contrast, the bullate ribs of *A. nodosus* tend to travel in a more radial direction from the umbilical shoulder almost to the highest point of the bullae, from where they then gradually project forward. Furthermore, the bullate ribs of *A. nodosus*, while equal or greater in height to those of *A. resseri*, seem to be significantly

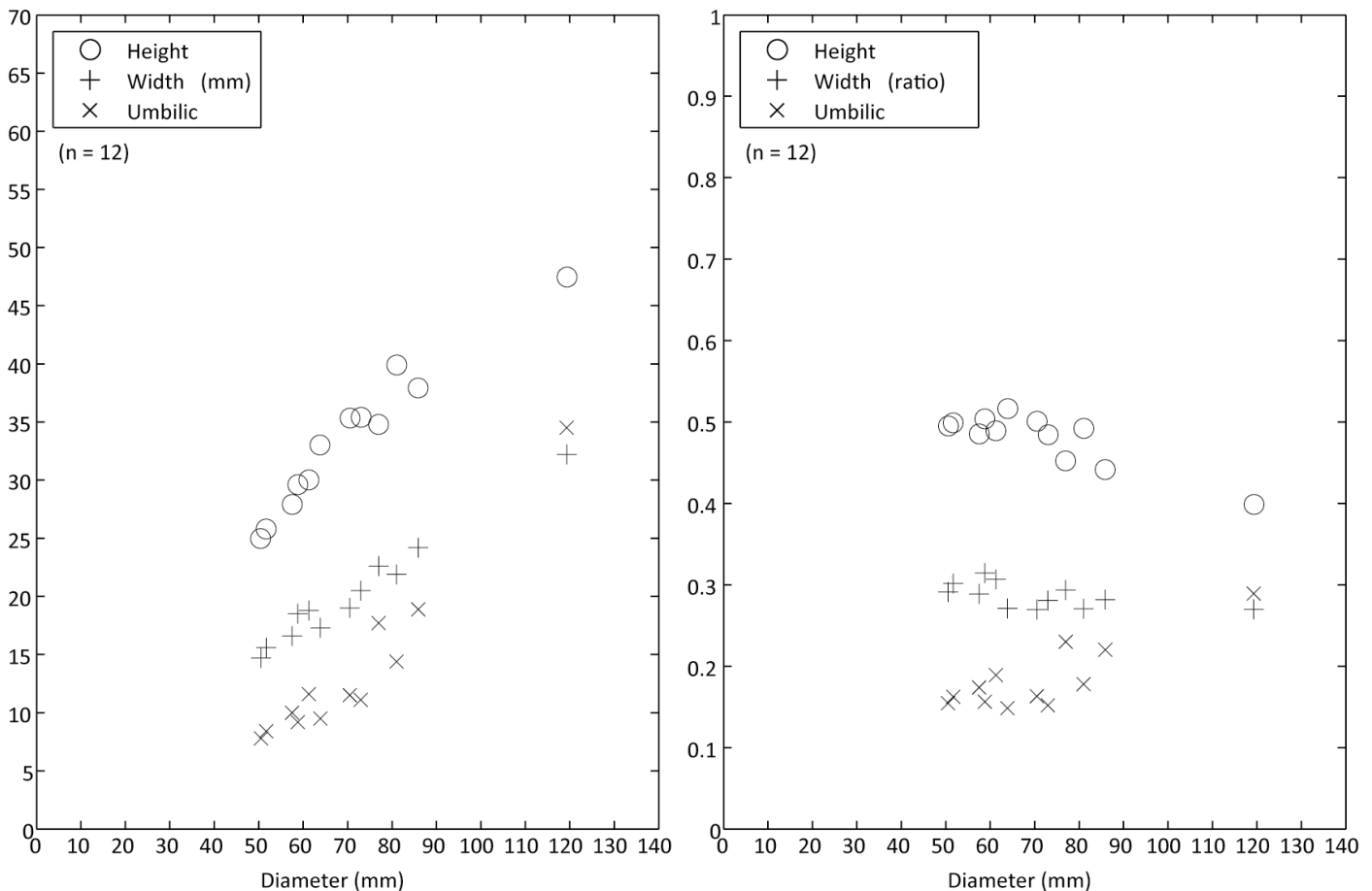


FIGURE 88. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Arctoprionites resseri*. All specimens from *A. m.* interval.

thinner, which gives their apex a sharper or acute appearance. This observation contrasts with the more rounded nature of the bullate ribs on the Crittenden Springs specimens.

Tozer (1994) described *Arctoprionites williamsi* from northeastern British Columbia and differentiated it from *A. nodosus* by its less elevated, more umbilicate-positioned bullate ribs, and from *A. resseri* by its more elevated bullate ribs. However, Tozer's (1994) illustrated specimens fit well within the intraspecific variation exhibited by the Crittenden Springs material; thus, we concur with Brayard et al. (2013) and Piazza (2015) and synonymize *A. williamsi* with *A. resseri*. The specimen described as *Arctoprionites* sp. indet. from Crittenden Springs by Kummel and Steele (1962, pl. 101, fig. 2) is also synonymized with *A. resseri*.

Occurrence: *Arctoprionites resseri* is relatively rare in the *A. multiformis* interval (lenses) at Crittenden Springs.

Family PARANANNITIDAE Spath, 1930

Genus *Paranannites* Hyatt and Smith, 1905

Type species: *Paranannites aspenensis* Hyatt and Smith, 1905

Paranannites aspenensis Hyatt and Smith Figures 89, 90

- 1905 *Paranannites aspenensis* Hyatt and Smith, p. 81, pl. 8, figs. 1-15, pl. 73, figs. 1-30.
1908 *Paranannites aspenensis* Hyatt and Smith, Frech, p. 494, pl. 62, figs. 3a-c.
1932 *Paranannites aspenensis* Hyatt and Smith, Smith, p. 98, pl. 8, figs. 1-15, pl. 73, figs. 1-30.
1932 *Paranannites columbianus* Smith, p. 99, pl. 32, figs. 11-25.
1932 *Paranannites compressus* Smith, p. 99, pl. 31, figs. 19-21.
1932 *Paranannites pertenuis* Smith, p. 99, pl. 31, figs. 13-15.
1934 *Paranannites aspenensis* Hyatt and Smith, Spath, p. 190, pl. 14, figs. 6a-c.
1957 *Paranannites aspenensis* Hyatt and Smith, Kummel, in Arkell et al., p. L138, figs. 172: 7a-c.
1962 *Paranannites mulleri* Kummel and Steele, p. 680, pl. 100, figs. 21-31.
1962 *Paranannites aspenensis* Hyatt and Smith, Kummel and Steele, p. 676, pl. 100, figs. 14-17.
1962 *Prospiringites slossi* Kummel and Steele, p. 683, pl. 101, figs. 8-9 only.
2017 *Paranannites* cf. *P. baudi* Brühwiler and Bucher, Jattiot et al., p. 37, pl. 17, figs. D-J.
2017 *Paranannites aspenensis* Hyatt and Smith, Jattiot et al., p. 37, pl. 17, figs. A-C.

Material: 185 measured specimens. Includes 27 illustrated specimens (2253C-85, 2253C-101, 2253C-141, 2253C-107, 2253C-132, 2253C-127, 2253C-126, 2253C-98, 2253C-38, 2253C-144, 2253C-26, 2253C-80, 2253C-87, 2253C-40, 2253C-74, 2253C-31, 274C, 288C, 2253C-14, 2253C-70, 2253C-10, 2253C-47, 2253C-45, 2253C-60, 2253C-19, 2253C-11 and 2253C-104).

Description: Moderate to fairly involute, compressed globular shell with broadly convex flanks for about 2/3 of whorl height, then converging more rapidly, forming sub-ellipsoidal whorl section. Venter rounded to arched without distinct shoulders. Maximum whorl width just above umbilical shoulder. Width and character of umbilicus varies widely, from very narrow (U/D=0.09) and tightly coiled to wide (U/D=0.26), more or less funnel-shaped inner whorls and much more open, egressively coiled mature whorl. High, vertical umbilical wall on inner whorls, becoming slightly less steep on mature whorl, with abruptly rounded shoulder on all growth stages. Ornamentation highly variable, ranging from faint radial growth lines on smaller specimens to radial, then slightly forward projecting, plicate type ribs arising on umbilical shoulder of some larger specimens, increasing somewhat in width and intensity on

outer flank, becoming more noticeable as they cross venter. Rib interspaces sometimes resemble narrow to wide constrictions. Ornamentation style varies widely in strength from specimen to specimen. Suture line ceratitic, resembling *O. koeneni*, but with fewer umbilical saddles.

Measurements: See Figure 91 and APPENDIX, p. 156.

Discussion: Kummel and Steele (1962) erected their new Crittenden Springs taxon *Paranannites mulleri* based primarily on the "excentrumbilication" of the outer whorl. According to these workers, the morphology of the juvenile and adolescent stages of *P. mulleri* is essentially identical to *P. aspenensis*, and the ornamentation exhibited by both species is identical at all growth stages, as are the suture lines (Kummel and Steele, 1962). Nevertheless, Kummel and Steele (1962) differentiated the two species mainly on the egressive coiling nature of the mature outer whorl of *P. mulleri*, which obviously produces a more evolute conch. They reported the occurrence of *P. mulleri* only in their beds "d" and "g," whereas bed "a" produced only *P. aspenensis*, a biostratigraphic relationship that led them to suggest that *P. mulleri* was a direct ancestor of *P. aspenensis* (Kummel and Steele, 1962). It is now known that Kummel and Steele's (1962) "beds" all represent three different outcrops. After nearly 60 years, it is impossible to know exactly from which beds their specimens were collected, and there were certainly more than three exposures on the three hillsides immediately north of the Long Canyon road. Based on the first author's collecting experience at this locality, both species occur throughout nearly the entire condensed succession, although *P. mulleri* is more prevalent from the *Aspenites weitschati* through the *Preflorianites toulai* intervals. Figures 89 and 90 show a more or less gradual change in umbilical width (U/D) beginning with typical *P. aspenensis* specimens (Fig. 89) and transitioning to *P. mulleri*-like forms in Figure 90. It is obvious that these specimens represent a highly variable population group (see Fig. 91), both in the character and width of the umbilicus, conch morphology and ornamentation. Therefore, *P. mulleri* is herein synonymized with *P. aspenensis*.

Paranannites aspenensis differs from: 1) *P. aff. P. aspenensis* from South China by its larger size, narrower umbilicus and more compressed conch (Brayard and Bucher, 2008); 2) *Paranannites ovum* Brayard and Bucher, 2008, from South China by its much smaller mature size and more distinctive ornamentation; 3) *Paranannites dubius* Brayard and Bucher, 2008, from South China by its wider umbilicus, much more distinctive ornamentation and somewhat more complex suture line; 4) *Paranannites baudi* Brühwiler et al., 2012a, from Oman by its more compressed conch, narrower umbilicus and more distinctive ornamentation; 5) *Paranannites* sp. indet. from Spiti primarily by its more compressed shell (Brühwiler et al., 2012c); and, finally, 6) *Paranannites* sp. indet. from northeastern Vietnam appears to be quite similar to *P. aspenensis* in overall shape, but the number of available specimens is insufficient to make a definitive assignment, and their preservation precludes an accurate assessment of their ornamentation (Shigeta and Nguyen, 2014).

Occurrence: *Paranannites aspenensis* is common at Crittenden Springs and occurs from the *A. rubyae* n. sp. FA interval through the *P. toulai* interval.

Genus *Owenites* Hyatt and Smith, 1905

Type species: *Owenites koeneni* Hyatt and Smith, 1905

Owenites koeneni Hyatt and Smith, 1905

Figures 92, 93A-C'

- 1905 *Owenites koeneni* Hyatt and Smith, p. 83, pl. 10, figs. 1-22.
1915 *Owenites koeneni* Hyatt and Smith, Diener, p. 214.
1932 *Owenites koeneni* Hyatt and Smith, Smith, p. 100, pl. 10, figs. 1-22.
1932 *Owenites egrediens* Welter, Smith, p. 100, pl. 52, figs. 6-8.

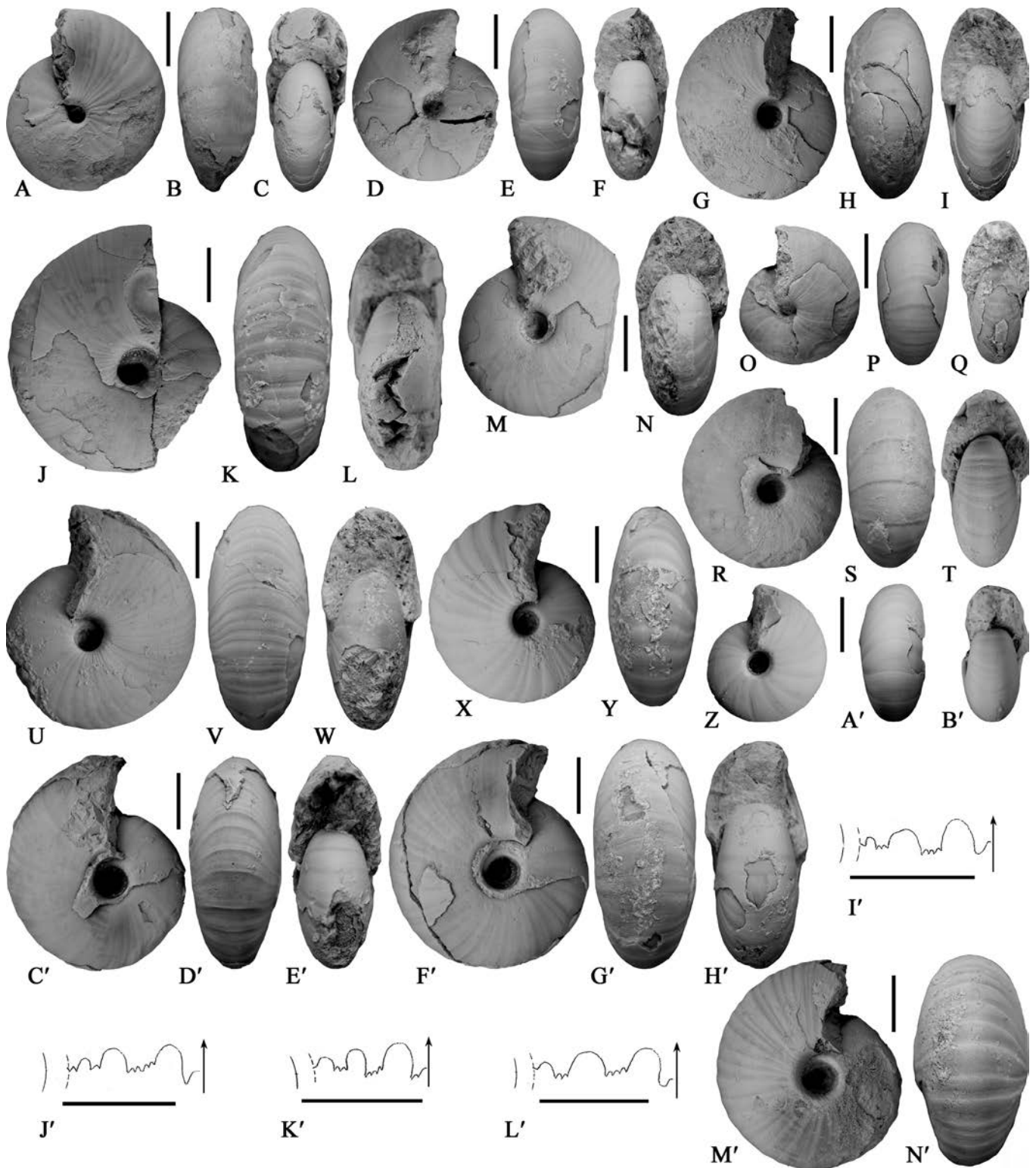


FIGURE 89. *Paranannites aspenensis* Hyatt and Smith. **A-C**, 2253C-85, (0.09), 5-76, *O. k.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2253C-101, (0.12), 13-75, *A. w.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2253C-141, (0.13), 1-88, *G. l.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2253C-107, (0.13), 13-75, *G. l.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-N**, 2253C-132, (0.13), 5-76, *P. t.*, in **M**, lateral and **N**, apertural views. **O-Q**, 2253C-127, (0.12), 5-76, *P. t.*, in **O**, lateral, **P**, ventral and **Q**, apertural views. **R-T**, 2253C-126, (0.15), 5-76, *G. l.*, in **R**, lateral, **S**, ventral and **T**, apertural views. **U-W**, 2253C-98 (0.14), 5-76, *A. w.*, in **U**, lateral, **V**, ventral and **W**, apertural views. **X-Y**, 2253C-38, (0.15), 1-88, *A. w.*, in **X**, lateral and **Y**, ventral views. **Z-B'**, 2253C-144, (0.16), 1-88, *A. w.*, in **Z**, lateral, **A'**, ventral and **B'**, apertural views. **C'-E'**, 2253C-26, (0.16), 3-93, *P. t.*, in **C'**, lateral, **D'**, ventral and **E'**, apertural views. **F'-H'**, 2253C-80, (0.17), 3-93, *P. t.*, in **F'**, lateral, **G'**, ventral and **H'**, apertural views. **M'-N'**, 2253D-87, (0.17), 5-76, *M. g.*, in **M'**, lateral and **N'**, ventral views. **I'-L'**, suture lines, in **I'**, 2253C-132, $H = 1.07$ cm, 5-76, *P. t.* **J'** 2253C-143, $H = 1.2$ cm, 5-76, *G. l.* **K'** 2253C-11, $H = 0.97$ cm, 5-76, *O. k.* **L'**, 2253C-104, $H = 1.33$ cm, 5-76, *M. g.* Number within parentheses following specimen ID represents U/D ratio. All scale bars = 1 cm.

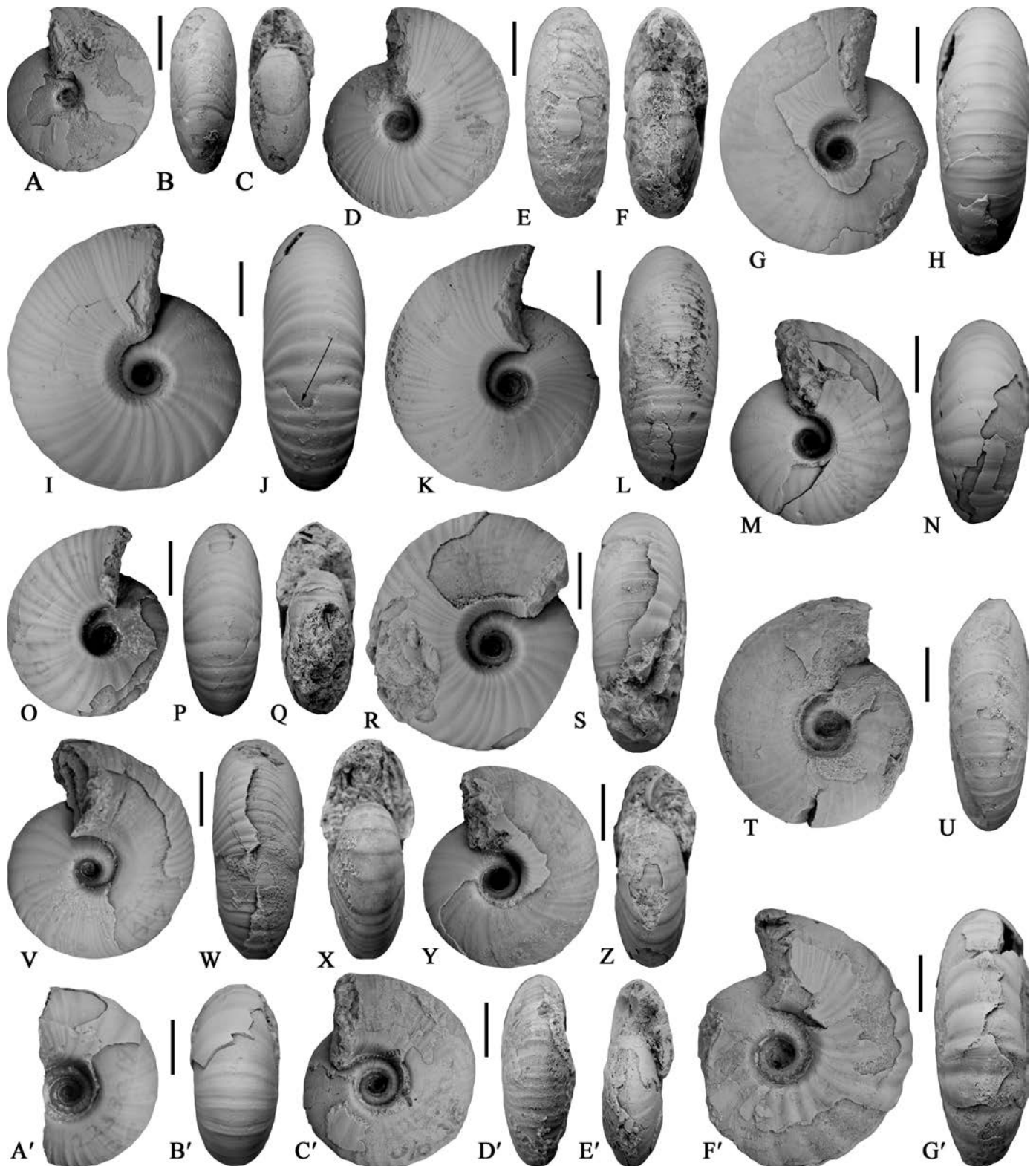


FIGURE 90. *Paranannites aspenensis* Hyatt and Smith. **A-C**, 2253C-40, (0.18), 5-76, *O. k.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2253C-74, (0.18), 3-93, *P. t.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-H**, 2253C-31, (0.19), 5-76, *A. w.*, in **G**, lateral and **H**, ventral views. **I-J**, 274C, (0.19), 13-75, *G. l.*, in **I**, lateral and **J**, ventral views (arrow indicates healed injury). **K-L**, 288C, (0.20), 5-76, *G. l.*, in **K**, lateral and **L**, ventral views. **M-N**, 2253C-14, (0.20), 5-76, *G. l.*, in **M**, lateral and **N**, ventral views. **O-Q**, 2253C-70, (0.21), in 3-93, *P. t.*, **O**, lateral, **P**, ventral and **Q**, apertural views. **R-S**, 2253C-10, (0.22), 5-76, *G. l.*, in **R**, lateral and **S**, ventral views. **T-U**, 2253C-60, (0.24), 5-76, *M. g.*, in **T**, lateral and **U**, ventral views. **V-X**, 2253C-47, (0.23), 1-88, *G. l.*, in **V**, lateral, **W**, ventral and **X**, apertural views. **Y-Z**, 2253C-45, (0.23), 13-75, *G. l.*, in **Y**, lateral and **Z**, apertural views. **A'-B'**, 2253C-19, (0.26), 13-75, *M. g.*, in **A'**, lateral and **B'**, ventral views. **C'-E'**, 2253C-11, (0.26), 5-76, *O. k.*, in **C'**, lateral, **D'**, ventral and **E'**, apertural views. **F'-G'**, 2253C-104, (0.26), 5-76, *M. g.*, in **F'**, lateral and **G'**, ventral views. Number within parentheses following specimen ID represents U/D ratio. All scale bars = 1 cm.

- 1932 *Owenites zitteli* Smith, p. 101, pl. 52, figs. 1-5.
 1934 *Owenites koeneni* Hyatt and Smith, Spath, p. 185, fig. 57a-c.
 1947 *Owenites* aff. *egrediens* Welter, Kiparisova, p. 139, pl. 32, figs. 1-3.
 1955 *Kingites shimizui* Sakagami, p. 138, pl. 2, figs. 2a-c.
 1957 *Owenites koeneni* Hyatt and Smith, Kummel in Arkell et al., p. 138, fig. 171: 8a-b.
 1959 *Owenites costatus* Chao, p. 249, pl. 22, figs. 10-18, 22, 23, text-fig. 26c.
 1959 *Owenites pakungensis* Chao, p. 248, pl. 21, figs. 6-8.
 1959 *Owenites pakungensis* var. *compressus* Chao, p. 248, pl. 21, figs. 4, 5.
 1959 *Pseudowenites oxynotus* Chao, p. 252, pl. 23, figs. 1-16, text-figs. 27a-d.
 ?1959 *Owenites* cf. *O. koeneni* Hyatt and Smith, Kummel, p. 441, figs. 2-4.
 1959 *Owenites shimizui* Sakagami, Kummel, p. 430.
 1960 *Owenites shimizui* Sakagami, Kummel and Sakagami, p. 6, pl. 5, figs. 5, 6.
 1962 *Owenites koeneni* Hyatt and Smith, Kummel and Steele, p. 674, pl. 101, figs. 3-7.
 1962 *Owenites koeneni* Hyatt and Smith, Popov, p. 44, p. 6, fig. 6.
 1965 *Owenites koeneni* Hyatt and Smith, Kuenzi, p. 374, pl. 53, figs. 1-6.
 1966 *Owenites koeneni* Hyatt and Smith, Hada, p. 112, pl. 4, figs. 2-4.
 ?1968 *Owenites koeneni* Hyatt and Smith, Kummel and Erben, p. 121, fig. 12, pl. 19, figs. 10-15.
 1968 *Owenites carinatus* Shevyrev, p. 189, pl. 16, fig. 1.
 1968 *Owenites koeneni* Hyatt and Smith, Zakharov, p. 94, pl. 18, figs. 1-3.
 1973 *Owenites koeneni* Hyatt and Smith, Collignon, p. 139, pl. 4, figs. 2-3.
 1979 *Owenites koeneni* Hyatt and Smith, Nichols and Silberling, pl. 1, figs. 17, 18.
 1981 *Owenites koeneni* Hyatt and Smith, Bando, p. 158, pl. 17, fig. 7.
 1984 *Owenites carinatus* Shevyrev, Vu Khuc, p. 81, pl. 6, figs. 1-4.
 1984 *Pseudowenites oxynotus* Chao, Vu Khuc, p. 82, pl. 7, figs. 3, 4.
 1987 *Owenites koeneni* Hyatt and Smith, Mapes and Sneek, p. 302, text-fig. 2B, pl. 42, figs. 5-15, text-fig. 3A-C.
 1990 *Owenites koeneni* Hyatt and Smith, Shevyrev, p. 118, pl. 1, fig. 5.
 1995 *Owenites koeneni* Hyatt and Smith, Shevyrev, p. 51, pl. 5, figs. 1-3.
 2000 *Owenites koeneni* Hyatt and Smith, Gardner and Mapes, pl. 1, fig. 7.
 2004 *Owenites pakungensis* Chao, Tong et al., p. 199, pl. 2, figs. 9-10, fig. 7.
 2008 *Owenites koeneni* Hyatt and Smith, Brayard and Bucher, p. 67, pl. 36, figs. 1-8.
 2010a *Owenites koeneni* Hyatt and Smith, Brühwiler et al., p. 426, fig. 15: 9a-b.
 2012a *Owenites koeneni* Hyatt and Smith, Brühwiler and Bucher, p. 43, pl. 25, figs. 1-6.
 2013 *Owenites koeneni* Hyatt and Smith, Brayard et al., p. 204, fig. 74a-i.
 2014 *Owenites koeneni* Hyatt and Smith, Shigeta and Nguyen, p. 126, figs. 89-96.
 2017 *Owenites koeneni* Hyatt and Smith, Jattiot et al., p. 38, pl. 17K-AD.

Material: 160 measured specimens. Includes 18 illustrated specimens (650C, 2220C-22, 2220C-93, 20C, 2219C, 2220C-

105, 720C, 2220C-112, 2220C-86, 2220C-103, 2220C-100, 2220C-23, 2220C-77, 721C, 2220C-27, 2225C, 2220C-67 and 2221C-5).

Description: Fairly small (maximum size 6.7 cm) compressed, involute shell characterized by an inflated lenticular whorl section with maximum width at umbilical shoulder. Venter on mature shells ranges from narrowly rounded to highly arched on more inflated specimens, to very angular or abruptly rounded, faintly resembling a keel on more compressed specimens. Body chamber length about one whorl. Umbilicus of mature shells characterized by extremely wide variation in width with low, gently inclined wall and broadly rounded shoulders. Appearance of umbilicus on mature shells varies from near-conical shape to more openly coiled with succeeding whorl resting on flank of preceding whorl. Most mature shells exhibit some degree of egressive coiling of the ultimate whorl. Nearly all juvenile and a few adolescent shells characterized by closed or occluded umbilicus, becoming more openly coiled on succeeding whorls. Ornamentation on mature shells consists of dense, prosiradiate growth lines that project forward high on flank and cross keel-like structure on venter. Growth lines also tend to form barely perceptible folds bordered by minute constrictions. Some well-preserved shells exhibit distinct transverse relic color bands such as those still visible on the “whitened” specimen illustrated in Figure 92S and on the “unwhitened” specimen in Figure 93T-U. Suture line ceratitic, typical of Paranannitidae with several saddles and weakly indented lobes.

Measurements: See Figure 94 and APPENDIX, p. 160.

Discussion: As demonstrated by the illustrated specimens and graphically (Fig. 94), *Owenites koeneni* exhibits an extremely wide range of intraspecific variation, especially in its mature form. The width of the umbilicus (U/D) is shown to vary significantly in similar sized mature specimens, ranging from 0.19 to 0.33 (Fig. 92M-O), and ventral shape varies from sharply acute to very abruptly rounded with a faint keel to narrowly rounded or even highly arched on some greatly inflated specimens (Figs. 92P-R and 93D-F, G-I).

Nearly all juvenile specimens (< 2 cm in diameter) and a few adolescents ranging up to a diameter of 3 cm exhibit a nearly closed umbilicus, and many appear to be occluded, especially juveniles. This ontogenetic stage is illustrated in Figure 93Z-A', in which the specimen's body chamber and part of the phragmocone have been removed to reveal a 2 cm diameter juvenile shell with a nearly closed umbilicus. These small shells, as well as adolescent specimens, also exhibit a wide variation in whorl compression and ventral shape, similar to the variation seen in mature specimens. Specimens whose shells are very compressed tend to have a nearly closed umbilicus, while somewhat depressed specimens exhibit a wider umbilicus.

Owenites koeneni is known for its worldwide low paleolatitude distribution. In the western USA, its distribution includes its type area in Union Wash, California (Smith, 1932), all sections encompassing the “*Meekoceras* beds” in southeastern Idaho, Phelan Ranch, Nevada (Kummel and Steele, 1962), Crittenden Springs, Nevada (Kummel and Steele, 1962; Jenks et al., 2010, this work), Palomino Ridge, Nevada (Jattiot et al., 2017), Utah (Brayard et al., 2013) and Washington (Kuenzi, 1965). On the western side of Panthalassa, it is known from Tethyan localities far too numerous to mention here.

Occurrence: *Owenites koeneni* is common in all intervals comprising the *Owenites* beds at Crittenden Springs. Somewhat surprisingly, the taxon is rare in all Utah sections (Brayard et al., 2013).

***Owenites carpenteri* Smith, 1932 Figure 93D'-F'**

- 1932 *Owenites carpenteri* Smith, p. 100, pl. 54, figs. 31-34.
 1966 *Owenites carpenteri* Smith, Hada, p. 112, pl. 4, fig. 1a-e.

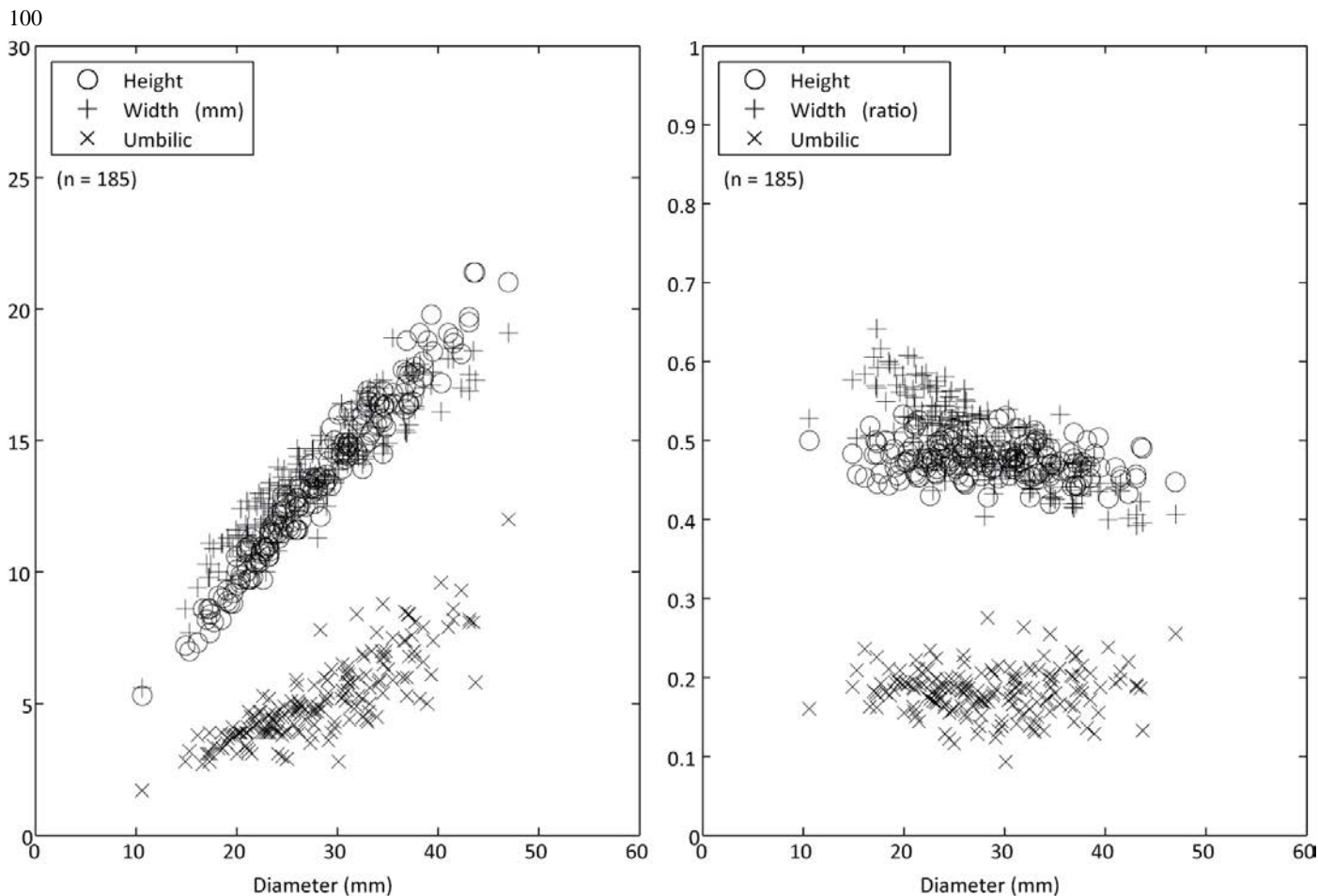


FIGURE 91. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Paranannites aspenensis*. All specimens from A. r. through P. t. intervals.

1968 *Owenites costatus* Chao, Kummel and Erben, p. 122, fig. 121.

1973 *Owenites carpenteri* Smith, Collignon, p. 139, pl. 4, figs. 5-6.

2008 *Owenites carpenteri* Smith, Brayard and Bucher, p. 70, pl. 43, figs. 15-16.

2010a *Owenites carpenteri* Smith, Brühwiler et al., p. rw6, fig. 16:7-8.

2012a *Owenites carpenteri* Smith, Brühwiler and Bucher, p. 44, pl. 25, figs. 7-8.

2013 *Owenites carpenteri* Smith, Brayard et al., p. 208, fig. 75a-f.

2017 *Owenites carpenteri* Smith, Jattiot et al., p. 39, pl. 17, figs. AE-AF.

Material: Three measured specimens, 2221C-10, 2221C-17 and 2221C-25. 2221C-17 is illustrated.

Description: Small, extremely involute, compressed shell with an abruptly rounded to angular venter and inflated lenticular whorl section with maximum width at umbilical shoulder. Umbilicus occluded. Ornamentation varies from a smooth shell to barely visible prosiradiate, bundled growth lines and weak folds. Suture line not exposed on present specimens.

Measurements: See APPENDIX, p. 163.

Discussion: *Owenites carpenteri*, a rare taxon whose range of intraspecific variation is not known, was erected by Smith (1932) based on only two specimens from his *Owenites* subzone in Union Wash, Inyo County, California. Since then, no additional specimens have been documented or illustrated from the type locality. Furthermore, the taxon had never been reported from other western USA localities until Brayard et al. (2013) attributed two somewhat poorly preserved specimens

from Utah to *O. carpenteri*. In contrast, *O. carpenteri* has been reported from several western Panthalassic or Tethyan localities, including Malaysia (Hada, 1966), Afghanistan (Kummel and Erben, 1968; Collignon, 1973), South China (Brayard and Bucher, 2008), Tulong, South Tibet (Brühwiler et al., 2010a) and Oman (Brühwiler et al., 2012a). Many of these specimens fall well within the intraspecific variation of *O. koeneni*, and Brayard et al.'s (2013) assignment of the Utah specimens to *O. carpenteri* seems questionable given the extremely wide variation exhibited by *O. koeneni*, as is evident in this work. The same observation is true for the single specimen reported from Palomino Ridge (Jattiot et al., 2017). Were it not for the distinctive radial ribs adorning the holotype, it would seem prudent to synonymize *O. carpenteri* with *O. koeneni*. However, until additional material is collected from the type area, *O. carpenteri* must remain a valid taxon. The questionable attribution of our three specimens to *O. carpenteri* is based primarily on their closed, nearly occluded umbilicus. One specimen bears faintly visible radial growth lines and minute constrictions.

Occurrence: Specimens were collected from the *O. koeneni* FA interval.

Genus *Steckites* Brühwiler et al., 2012

Type species: *Steckites brevis* Brühwiler et al., 2012

Steckites cf. *S. brevis* Brühwiler et al., 2012

Figure 93G'-M'

2012c *Steckites brevis* Brühwiler et al., p. 161, fig. 35AV-BC.

Material: Two measured specimens, 2222C and 2257C. Both are illustrated.

Description: Small, fairly involute, compressed shell with ovoid to sub-rectangular whorl section and rounded to narrowly

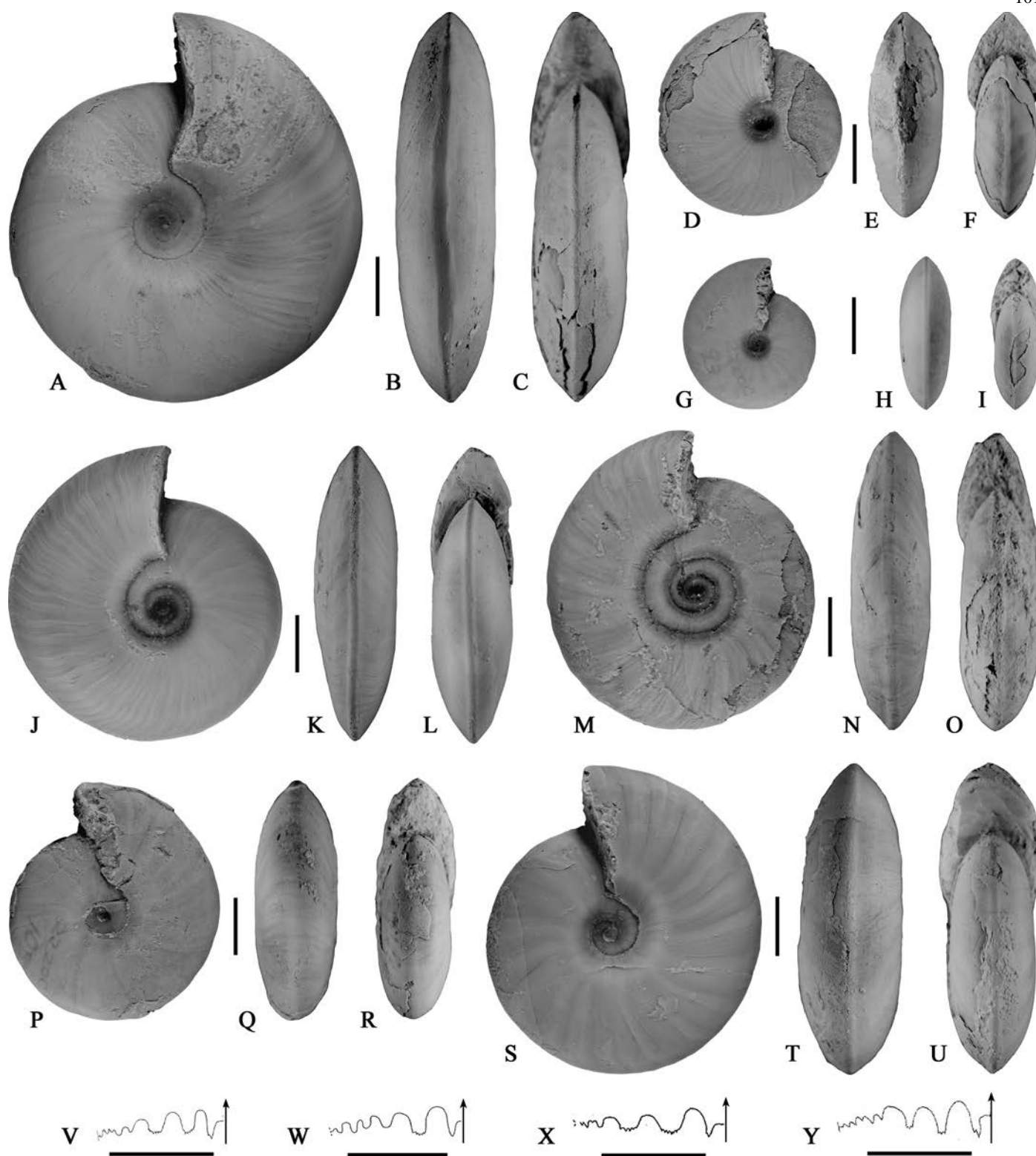


FIGURE 92. *Owenites koeneni* Hyatt & Smith. **A-C**, 650C, 5-76, *P. t.*, in **A**, lateral (relic transverse color bands partially visible through white coating), **B**, ventral and **C**, apertural views. **D-F**, 2220C-22, 5-76, *G. l.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2220C-93, 1-88, *O. k.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 20C, 2-88, *G. l.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2219C, 5-76, *O. k.*, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2220C-105, 5-76, *P. t.*, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 720C, 5-76, *P. t.*, in **S**, lateral (relic transverse color bands are visible through white coating), **T**, ventral and **U**, apertural views. **V-Y**, suture lines, in **V**, 2220C-22, H = 1.22 cm, 5-76, *G. l.* **W**, 2220C-62, H = 1.30 cm, 5-76, *C. j.* **X**, 2220C-109, H = 1.45 cm, 13-75, *O. k.* **Y**, 2220C-1, H = 1.53 cm, 3-93, *P. t.* All scale bars = 1 cm.

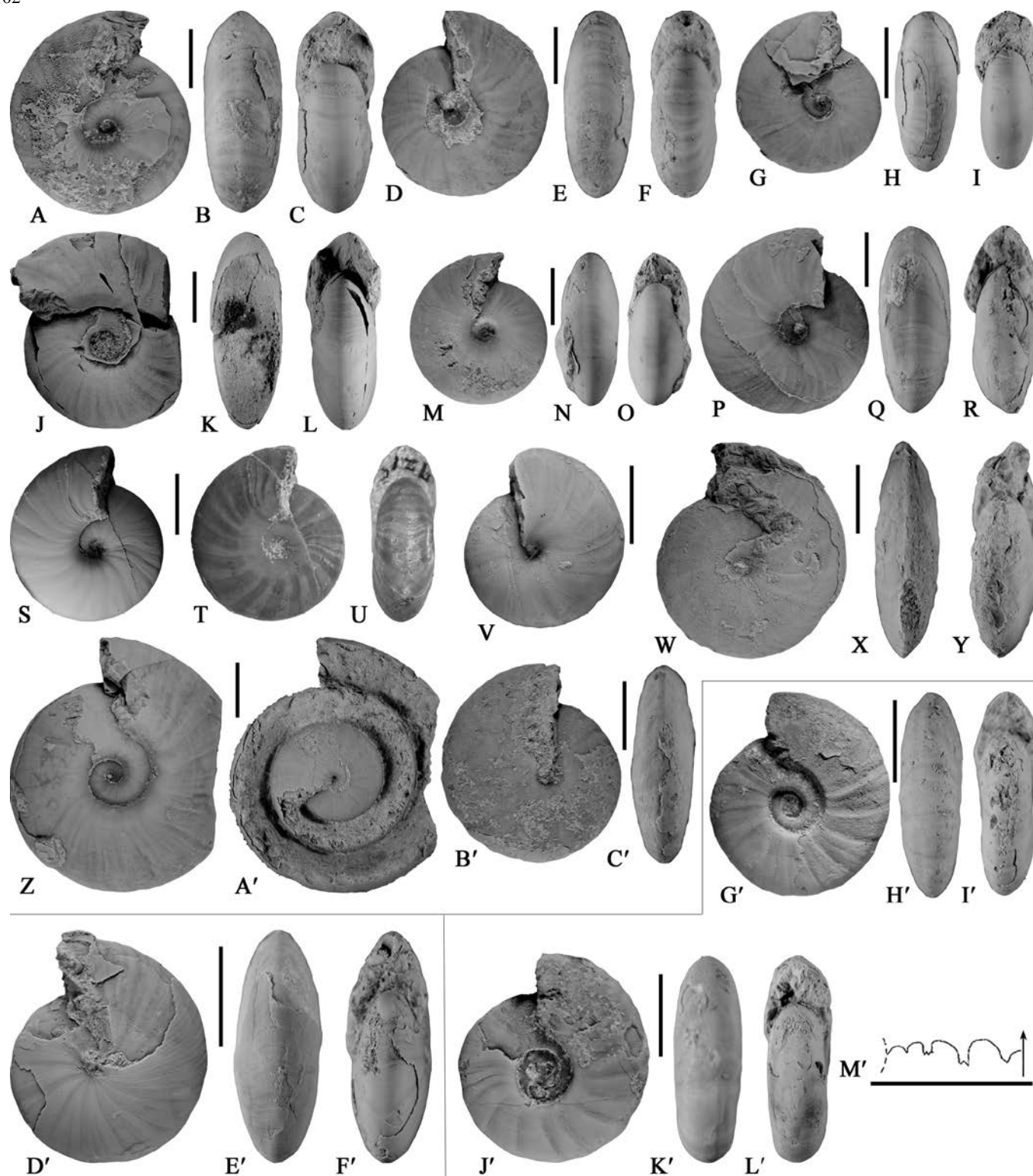


FIGURE 93. **A-C'**, *Owenites koeneni* Hyatt & Smith. **A-C**, 2220C-112, 2-88, *A. w.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2220C-86, 3-93, *P. t.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2220C-103, 1-88, *A. w.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2220C-100, 5-76, *G. l.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2220C-23, 13-75, *O. k.*, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2220C-77, 5-76, *O. k.*, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 721C, 2-88, *A. w.*, in **S**, lateral, **T**, unwhitened lateral view showing relic transverse color bands, and **U**, unwhitened apertural view showing relic transverse color bands. **V**, 2221C-27, 5-76, *G. l.*, in **V**, lateral view. **W-Y**, 2225C, 5-76, *C. j.*, in **W**, lateral, **X**, ventral and **Y**, apertural views. **Z-A'**, 2220C-67, 5-76, *P. t.*, in **Z**, lateral view and **A'**, lateral view with body chamber and part of phragmocone removed, revealing an *O. carpenteri*-like phragmocone whorl. **B'-C'**, 2221C-5, 5-76, *O. k.*, in **B'**, lateral and **C'**, ventral views. **D'-F'**, *Owenites carpenteri* Smith, 2221C-17, 2-88, *O. k.*, in **D'**, lateral view, **E'**, ventral view, and **F'**, apertural views. **G'-M'**, *Steckites* cf. *S. brevis* Brühwiler et al., 2222C, 5-76, *P. t.*, in **G'**, lateral, **H'**, ventral and **I'**, apertural views. **J'-M'**, 2257C, 5-76, *P. t.*, in **J'**, lateral, **K'**, ventral, and **L'**, apertural views and **M'**, suture line, H = 0.68 cm. All scale bars = 1 cm.

arched venter without distinctive shoulders. Whorl overlap about 2/3. Umbilicus fairly narrow and shallow with steeply inclined wall and abruptly rounded shoulders. Ornamentation consists of barely noticeable, distant, slightly prosiradial, narrow ribs that arise on the umbilical shoulder, travel across the flank and fade slightly before crossing the venter. Interspaces appear as constrictions. Suture line ceratitic, similar to *Owenites koeneni*, but with a much shorter auxiliary series.

Measurements: See APPENDIX, p. 163.

Discussion: Brühwiler et al. (2012) erected the genus *Steckites* based only on the type species, *S. brevis*, for a few shells from Spiti that resembled *O. koeneni*, but whose suture line exhibited a much shorter auxiliary series. In terms of conch geometry alone, *S. brevis* tends to fit within the intraspecific variation of *O. koeneni* (especially the more inflated specimens), but its distinctive suture line sets it apart. While the present specimens are somewhat more evolute than *S. brevis*, their overall morphology resembles the new taxon, and the suture line of specimen 2257C (Fig. 93M') with its short auxiliary series is very similar. Specimen 2222C (Fig. 93G'-I') is somewhat similar to *Owenites simplex* Welter, but this taxon differs by its more evolute coiling, subangular to angular venter and lower whorl height. Furthermore, an ongoing study of a very large collection of Smithian ammonoids from Timor has led to the conclusion that *O. simplex* is exclusively a Tethyan taxon (R. Jattiot, personal commun. 2017). Therefore, we attribute our specimens to *S. cf. S. brevis*.

Occurrence: Very rare, both specimens were found in the *P. toulai* interval.

Family MELAGATHICERATIDAE Tozer, 1971

Genus *Juvenites* Smith, 1927

Type species: *Juvenites krafftii* Smith, 1927

Juvenites septentrionalis Smith, 1932

Figures 95, 96A-H

1932 *Juvenites septentrionalis* Smith, p. 110, pl. 31, figs. 31-40.

1932 *Juvenites sanctorum* Smith, p. 110, pl. 31, figs. 22-30.

1962 *Juvenites septentrionalis* Smith, p. 687, pl. 100, figs. 1-11.

?1978 *Juvenites* sp. indet., Guex, pl. 5, fig. 3.

2008 *Juvenites procurvus* Brayard and Bucher, p. 32, pl. 22, figs. 6-12.

2008 *Juvenites* cf. *krafftii* Smith, Brayard and Bucher, p. 32, pl. 9, figs. 20-23.

2012a *Juvenites procurvus* Brühwiler et al., p. 41, pl. 22, figs. 10-11.

2012b *Juvenites* cf. *krafftii* Smith, Brühwiler et al., p. 105, fig. 89. BB-BF.

2012c *Juvenites procurvus* Brühwiler et al., p. 163, fig. 37, AK-AP.

Material: 138 measured specimens. Includes 19 illustrated specimens (2259C-84, 2259C-92, 2259C-65, 2259C-109, 2259C-129, 2259C-130, 2259C-6, 2259C-131, 2259C-53, 2259C-20, 2259C-18, 260C, 2259C-107, 285, 2259C-49, 2259C-13, 2259C-46, 2259C-1 and 2259C-77).

Description: Small, fairly to moderately involute (whorl overlap varies from ~1/3 to 1/2), depressed, thinly discoidal shell with ventral portion varying from arched with indiscernible shoulders to nearly subtabulate with broadly rounded shoulders. Lateral areas on forms with arched to circular venter characterized

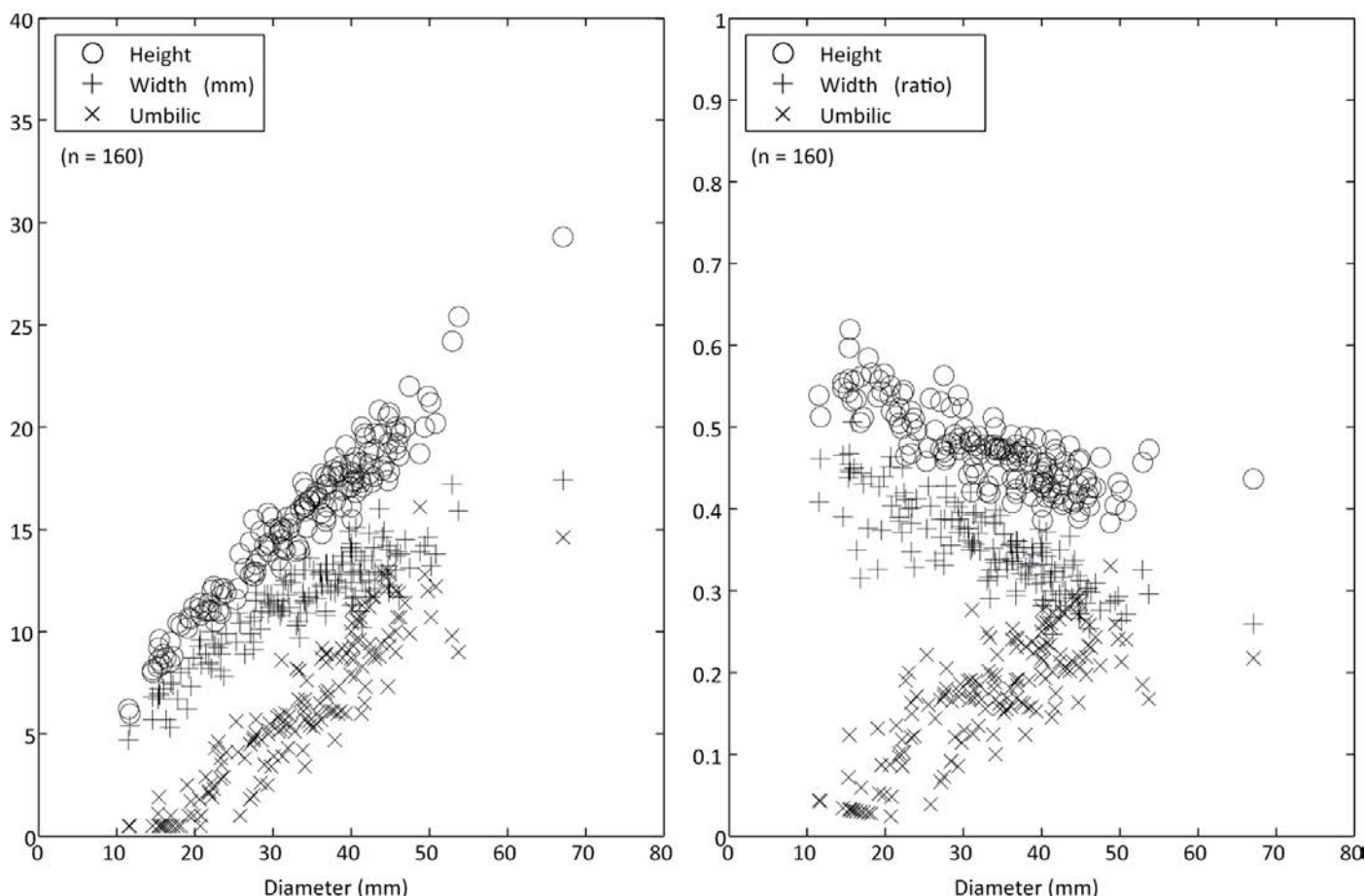


FIGURE 94. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Owenites koeneni*. All specimens from *O. k.* through *I. o.* intervals.

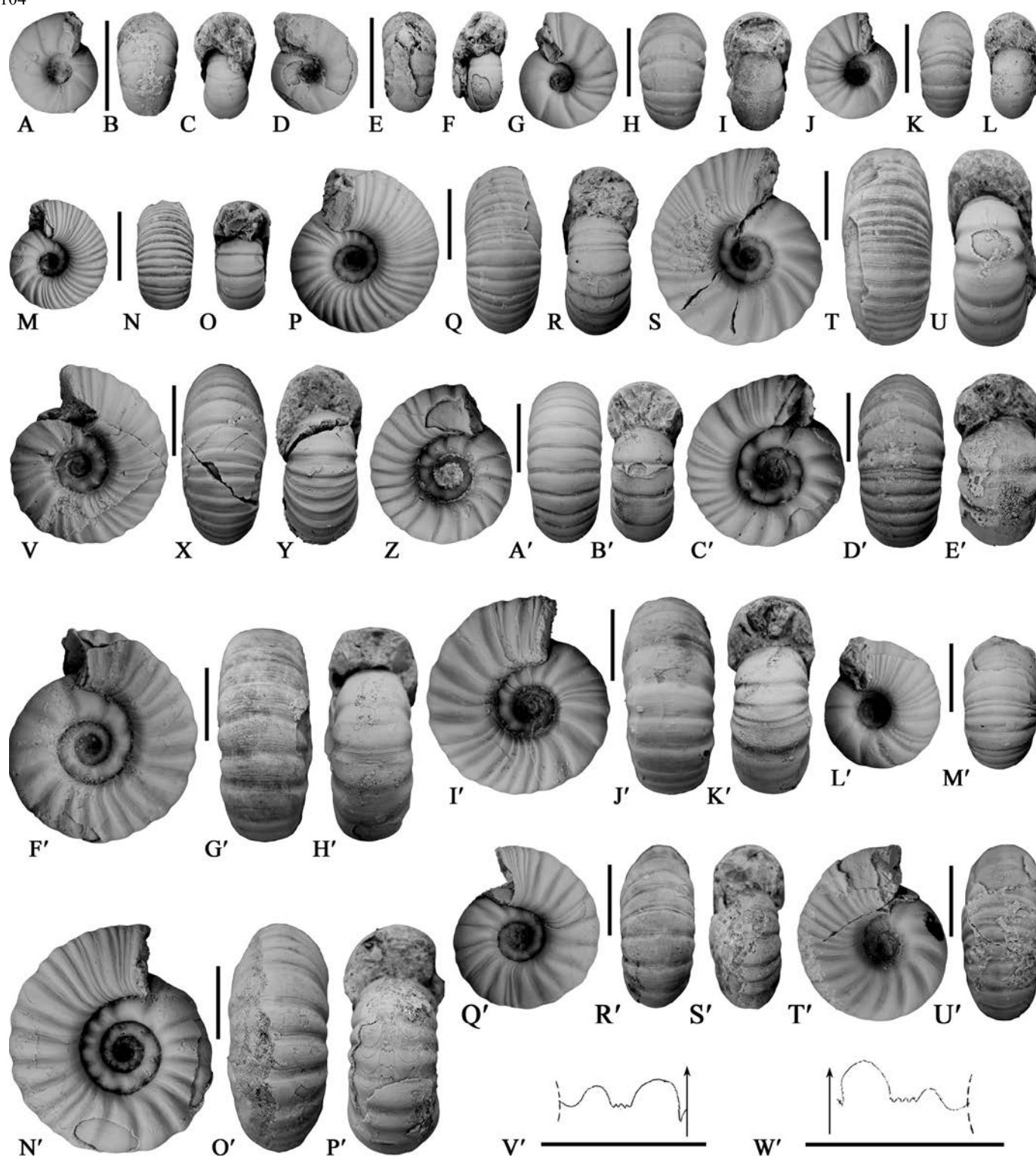


FIGURE 95. *Juvenites septentrionalis* Smith. **A-C**, 2259C-84, 5-76, float, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2259C-92, 5-76, *M. g.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2259C-65, 5-76, *M. g.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2259C-109, 5-76, *A. w.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2259C-129, 1-88, *P. t.*, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2259C-130, 5-76, *O. k.*, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 2259C-6, 1-88, *A. w.*, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-Y**, 2259C-131, 2-94, *I. o.*, in **V**, lateral, **W**, ventral and **Y**, apertural views. **Z-B'**, 2259C-53, 1-88, *A. w.*, in **Z**, lateral, **A'**, ventral and **B'**, apertural views. **C'-E'**, 2259C-20, 5-76, float, in **C'**, lateral, **D'**, ventral and **E'**, apertural views. **F'-H'**, 2259C-18, 5-76, *O. k.*, in **F'**, lateral, **G'**, ventral and **H'**, apertural views. **I'-K'**, 260C, 5-76, *C. j.*, in **I'**, lateral, **J'**, ventral and **K'**, apertural views. **L'-M'**, 2259C-107, 2-88, *O. k.*, in **L'**, lateral and **M'**, ventral views. **N'-P'**, 285C, 5-76, *O. k.*, in **N'**, lateral, **O'**, ventral and **P'**, apertural views. **Q'-S'**, 2259C-49, 1-88, float, in **Q'**, lateral, **R'**, ventral and **S'**, apertural views. **T'-U'**, 2259C-13, 1-79, *A. w.*, in **T'**, lateral and **U'**, ventral views. **V'-W'**, suture lines in **V'**, 260C, H = 0.78 cm, 5-76, *C. j.* **W'**, 285C, H = 0.70 cm, 5-76, *O. k.* All scale bars = 1 cm.

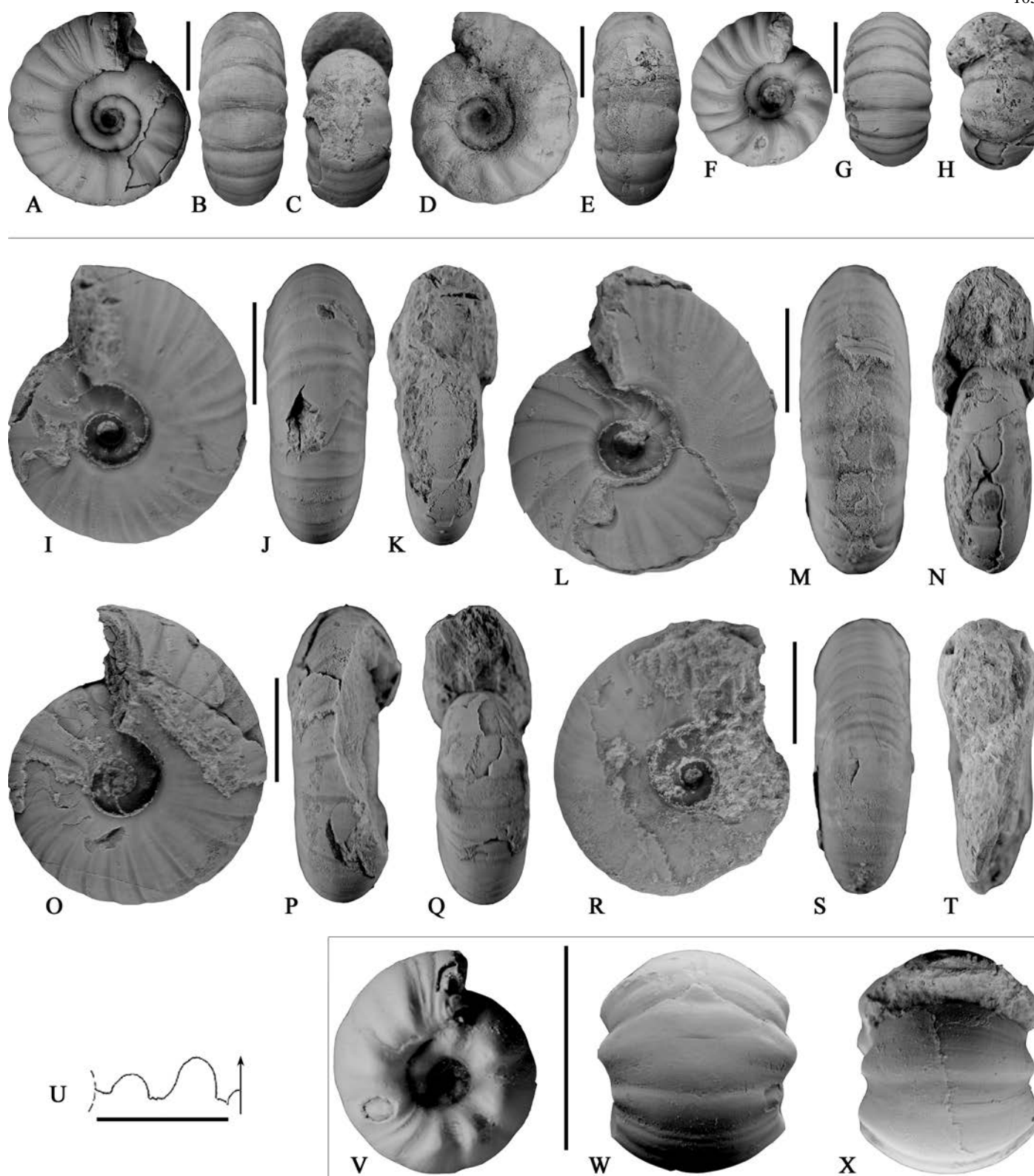


FIGURE 96. **A-H**, *Juvenites septentrionalis* Smith. **A-C**, 2259C-46, 13-75, *M. g.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-E**, 2259C-1, 5-76, *A. r.*, in **D**, lateral and **E**, ventral views. **F-H**, 2259C-77, 1-88, *G. l.*, in **F**, lateral, **G**, ventral and **H**, apertural views. **I-U**, *?Juvenites* sp. indet. **I-K**, 2256C, 5-76, *P. t.*, in **I**, lateral, **J**, ventral and **K**, apertural views. **L-N**, 2255C, 5-76, *C. j.*, in **L**, lateral, **M**, ventral and **N**, apertural views. **O-Q**, 2254C, 5-76, *P. t.*, in **O**, lateral, **P**, ventral and **Q**, apertural views. **R-T**, 2258C, 5-76, *P. t.*, in **R**, lateral, **S**, ventral and **T**, apertural views. **U**, suture line, 2254C, H = 0.83 cm, 5-76, *P. t.* **V-X**, *Ussurijuvenites* cf. *U. artyomensis* Smyshlyaeva & Zakharov, 747C, 2-88, *G. l.*, in **V**, lateral, **W**, ventral and **X**, apertural views. All scale bars = 1 cm.

by decreasing convergence as umbilical shoulder is approached. Lateral areas slightly convex on forms with subtabulate venter. Maximum whorl width located at top of umbilical shoulder. Umbilicus relatively deep with nearly vertical wall and abruptly rounded shoulders. Ornamentation consists of slightly forward projected constrictions beginning on umbilical shoulder and crossing venter with near equal intensity. Well preserved specimens exhibit faintly visible growth lines following same trajectory as constrictions. Density and intensity of constrictions highly variable between specimens, and sometimes even on the same specimen. Usually, constrictions become denser and less intense as aperture is approached. Suture line ceratitic with broad first lateral saddle and finely indented lateral lobe.

Measurements: See Figure 97 and APPENDIX, p. 164.

Discussion: The illustrated specimens well demonstrate the notable intraspecific variation exhibited by *Juvenites septentrionalis* not only in shape (Fig. 97), but especially in ornamentation. Variation in shell geometry ranges from ovate to subquadrate as is apparent in mature specimens (Figs. 95 F'-H', N'-P'), and the contrast in style of constrictions in terms of both density and intensity is obvious when comparing specimens illustrated in Figures 95M-O, P-R, Z-B', F'-H' and I'-K'. It is not uncommon for constrictions to become denser and less intense as the aperture is approached, but as seen in Figure 95I'-K', constrictions on the ultimate whorl become slightly denser and less intense at about 250°, but then become more distant and stronger again before finally reaching the aperture. Also, the degree to which constrictions are projected forward is seen to vary in some specimens.

Juvenites procurvus Brayard and Bucher, 2008, was erected based on seven specimens from South China, which

exhibit straight, strongly forward projected constrictions that supposedly become denser on the body chamber than those of *J. septentrionalis*. The taxon has also been reported from Oman (Brühwiler et al., 2012a, two specimens) and Spiti (Brühwiler et al., 2012c, two specimens). Taking into account the wide intraspecific variation exhibited by *J. septentrionalis*, a careful comparison of the illustrated specimens in these works with our large data set leads to the conclusion that the taxon is virtually indistinguishable from *J. septentrionalis*, both in terms of shell geometry and ornamentation. Thus, *J. procurvus* is here synonymized with *J. septentrionalis*.

Specimens assigned to *Juvenites* cf. *J. krafftii* Smith from South China by Brayard and Bucher (2008) and from the Salt Range by Brühwiler et al. (2012b) fit well within the intraspecific variation of *J. septentrionalis* Smith. Hence, these specimens are also synonymized with *J. septentrionalis*.

Specimens definitely attributable to *Juvenites thermanum* (Smith) have not yet been found at Crittenden Springs, which leads one to ponder whether or not it is a valid taxon. An examination of the type specimens does little to help – they are mainly small, thumbnail sized, poorly preserved phragmocones. Kummel and Steele (1962) reported only two depressed specimens that could be considered conspecific with the type specimens, but they still questioned their attribution. Brayard et al. (2013) asserted that *J. thermanum* is more involute and depressed than *J. septentrionalis*. This conclusion may well be correct, but material attributed to *J. cf. J. thermanum* from Utah and to *J. thermanum* from Palomino Ridge, Nevada by Brayard et al. (2013) and Jattiot et al. (2017), respectively, fit within the intraspecific variation of *J. septentrionalis* in terms of geometric proportions. However, the constrictions on these specimens

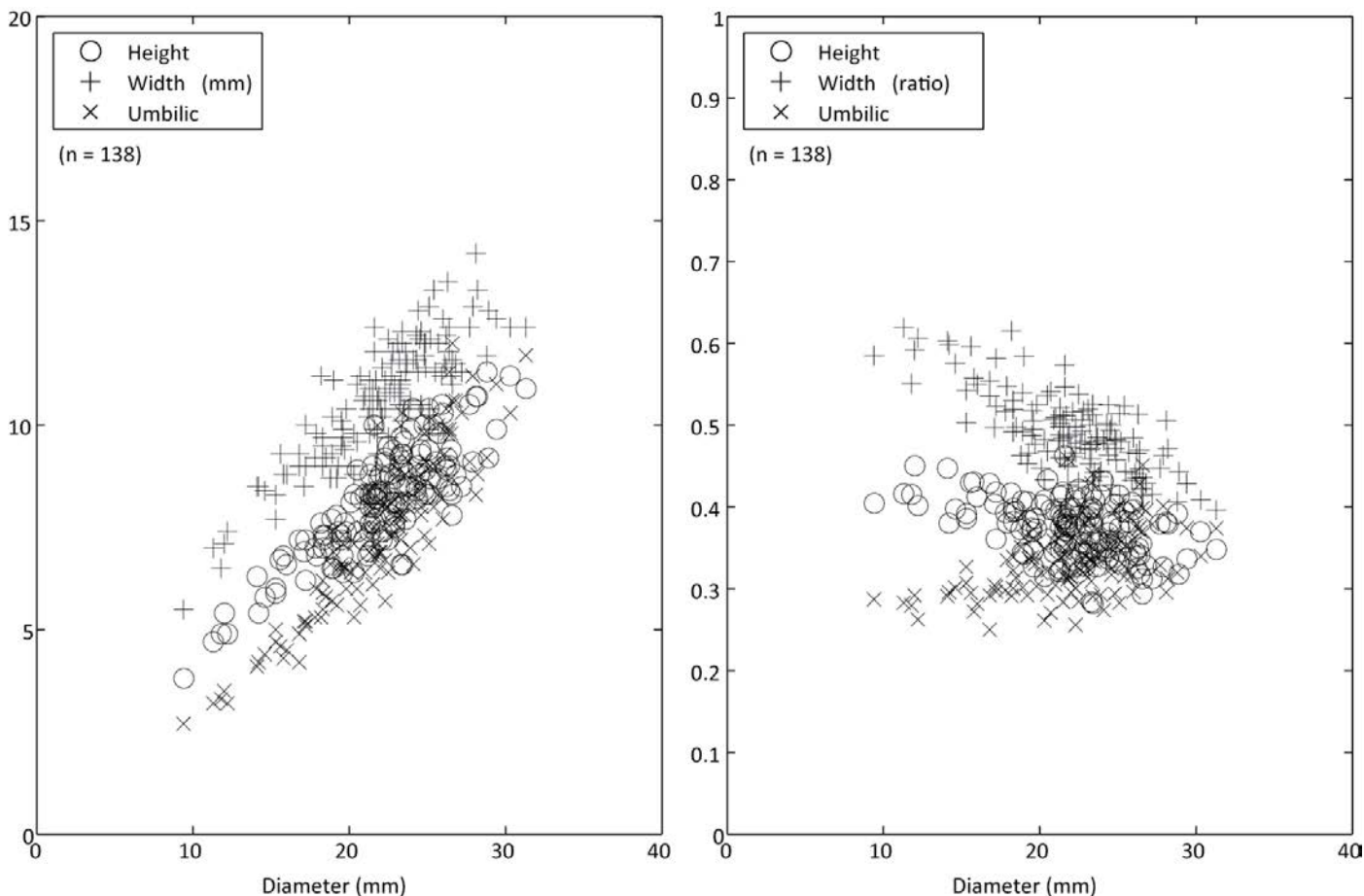


FIGURE 97. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Juvenites septentrionalis*. Specimens from all middle Smithian intervals.

tend to be more distant and not as distinct or deep as those of *J. septentrionalis*. This observation generally holds true for most other illustrated specimens of this taxon as well. Nevertheless, it is still entirely possible that *J. thermarum* falls within the intraspecific variation of *J. septentrionalis*, but this supposition cannot be resolved until a sufficient number of *J. thermarum* specimens, preferably from most other western USA localities, become available. This quandary well illustrates the need for a thorough revision of species assigned to *Juvenites*.

Occurrence: *Juvenites septentrionalis* is abundant at Crittenden Springs, occurring in all early and middle Smithian intervals.

***Juvenites spathi* (Frebold, 1930)
Figures 98, 99**

- 1930 *Prospiringites spathi* Frebold, p. 20, pl. 4, figs. 2, 3, 3a.
1934 *Prospiringites spathi* Frebold, Spath, p. 195, pl. 13, figs. 1, 2.
1959 *Prospiringites kwangianus* Chao, p. 296, pl. 28, figs. 17, 18.
1959 *Prospiringites sinensis* Chao, p. 297, pl. 27, figs. 14-17, text-fig. 40a.
?1961 *Prospiringites spathi* Frebold, Tozer, p. 58, pl. 13, figs. 1, 2.
1962 *Prospiringites slossi* Kummel and Steele, p. 683, p. 101, figs. 5, 10-17 only.
?1982 *Prospiringites spathi* Frebold, Korchinskaya, pl. 5, fig. 2.
1994 *Paranannites spathi* (Frebold), Tozer, p. 77, pl. 36, figs. 1, 2.
2008 *Paranannites spathi* (Frebold), Brayard and Bucher, p. 63, pl. 35, figs. 10-19.
2010a *Paranannites spathi* (Frebold), Brühwiler et al., p. 426, figs. 16 (1, 2).
2012a *Juvenites spathi* Frebold, Brühwiler and Bucher, p. 38, pl. 22, figs. 12-17.
2012c *Juvenites* cf. *spathi* Frebold, Brühwiler et al., p. 161, figs. 37A-O.
?2013 *Juvenites* aff. *spathi* Frebold, Brayard et al., p. 166, fig. 27a-c.
2014 *Paranannites sinensis* (Chao), Shigeta and Nguyen, p. 120, figs. 85-87.
2017 *Juvenites spathi* Frebold, Jattiot et al., p. 17, pl. 3, figs. AF-AW.

Material: 192 measured specimens. Includes 17 illustrated specimens (2320C-3, 286C, 2320C-43, 723C, 269C, 131C, 697C, 702C, 2320C-181, 2320C-44, 2320C-110, 2320C-79, 2320C-84, 2320C-166, 2320C-164, 2320C-111 and 2320C-180).

Description: Fairly small, depressed, moderate to fairly involute, sub-globular shell with convex flanks converging gradually from abruptly rounded umbilical shoulder to venter that varies from rounded to highly arched. Fairly narrow to moderately wide, deep umbilicus, varying from near smooth, funnel-shaped on some specimens (with near total whorl overlap) to a narrow “step-down” pattern on others. Umbilical wall generally steep, but slope decreases somewhat on mature whorl of some specimens. Body chamber length about one complete volution. Ornamentation consists of growth lines and constrictions that vary widely in density, pattern and strength from specimen to specimen and sometimes on the same specimen. Constrictions generally travel rursiradiately across umbilical wall, strengthen on umbilical shoulder and then project slightly forward in crossing flank and venter. Suture line ceratitic with two lateral saddles and finely denticulated lobes and a third, smaller saddle, generally on the umbilical shoulder.

Measurements: See Figure 100 and APPENDIX, p. 167.

Discussion: Kummel and Steele (1962) recognized the similarity of their abundant sub-globular specimens from Crittenden Springs with *Prospiringites austini*, a taxon erected by Hyatt and Smith (1905) from the “*Meekoceras* Zone” at Union Wash, California. However, they elected to erect a new taxon, *Prospiringites slossi* for the Crittenden Springs specimens (Kummel and Steele, 1962) because *P. austini* was based only on a single, poorly preserved immature specimen. This action was taken despite their acknowledgement that *Prospiringites spathi* Frebold, 1930, from Spitsbergen was “remarkably similar” to *P. slossi* and “likewise appears to show considerable variation in its main morphological characters” (Kummel and Steele, 1962, p. 687). That *Prospiringites spathi* exhibits an extremely wide intraspecific variation is especially apparent when examining the large number of specimens in our data set. While a fair amount of variation in geometric morphology is obvious (Fig. 100), the most striking differences occur in umbilical features, and, especially in the style of constrictions. Some specimens, especially those with near total whorl overlap, have a smooth funnel-shaped umbilicus, while others with a steeper umbilical wall exhibit a narrower “step-down” style. Some shells also exhibit a small amount of egressive coiling of the ultimate whorl. On some specimens, constrictions may gain significant strength on the umbilical shoulder, thus producing the perception of umbilical nodes (Fig. 98P-R). On other specimens, constrictions become increasingly more distant and gain significant strength (or depth) when crossing the flank and venter, producing the appearance of bulbous-type ribs (Fig. 98J-L). Constriction density on the same specimen can also vary widely (Fig. 98G-I; constrictions on the ultimate whorl of this specimen transition from distant to dense and then distant again nearer the aperture).

Tozer (1994) pointed out that *Prospiringites* is a Spathian genus with its own characteristic whorl section and suture line, and subsequently reassigned *Prospiringites spathi* Frebold to the middle Smithian genus *Paranannites*. This generic assignment was generally accepted by Triassic workers until Brühwiler et al. (2012a) demonstrated that *Paranannites* typically represents more compressed, more involute sub-globular species such as *P. aspenensis*, and, accordingly, reassigned the species *P. spathi* to *Juvenites*.

One of the diagnostic traits of *Juvenites spathi* (Frebold) has long been considered to be a sub-acute venter and sub-trigonal whorl section. However, ongoing work by Jattiot on extremely well preserved material from Timor suggest that this trait is present only on some variants, while others, especially larger sized specimens, exhibit an arched venter (Jattiot et al., 2017). Jattiot et al. (2017) also stated that the most characteristic feature of *J. spathi* is actually its crateriform/funnel-shaped umbilicus and bluntly angular umbilical shoulders. The extremely wide intraspecific variation of *J. spathi* (Frebold) has led several workers (e.g., Brayard and Bucher [2008] in South China, Brühwiler et al. [2010a, 2012a, 2012b, 2012c] in South Tibet, Oman, the Salt Range and Spiti, respectively, Brayard et al. [2013] in Utah and most recently Jattiot et al. [2017] at Palomino Ridge, Nevada) to synonymize various more or less endemic taxa with *J. spathi*. As shown in Figure 101, specimens of *Juvenites spathi* (Frebold) from Oman, South China and Palomino Ridge, Nevada fit reasonably well within our data set. This observation is especially true for specimens from Spitsbergen, the taxon’s type locality. Thus, we here follow their lead and synonymize *Prospiringites slossi* Kummel and Steele with *Juvenites spathi* (Frebold).

Occurrence: At Crittenden Springs, *Juvenites spathi* (Frebold) is common from the *A. rubyae* n. sp. FA interval through the *C. jattioti* n. gen., n. sp. interval.

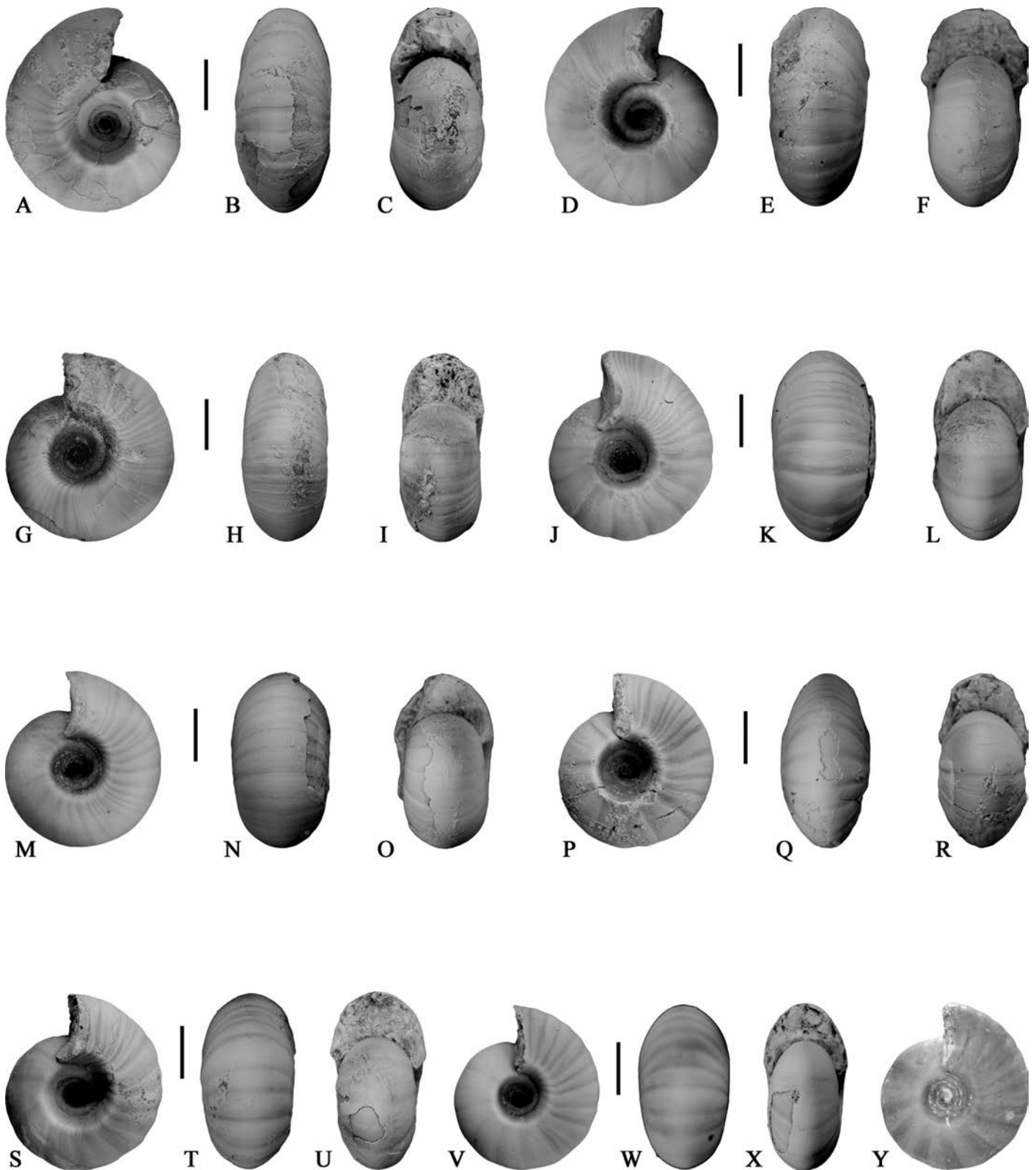


FIGURE 98. *Juvenites spathi* (Frebold). A-C, 2320C-3, 5-76, *P. t.*, in A, lateral, B, ventral, C, apertural views. D-F, 286C, 5-76, *G. l.*, in D, lateral, E, ventral and F, apertural views. G-I, 2320C-43, 1-88, *A. w.*, in G, lateral, H, ventral and I, apertural views. J-L, 723C, 2-88, *C. j.*, in J, lateral, K, ventral and L, apertural views. M-O, 269C, 2-78, *P. t.*, in M, lateral, N, ventral and O, apertural views. P-R, 131C, 1-88, *A. w.*, in P, lateral, Q, ventral and R, apertural views. S-U, 697C, 5-76, *G. l.*, in S, lateral, T, ventral and U, apertural views. V-Y, 702C, 1-88, *G. l.*, in V, lateral, W, ventral, X, apertural views and Y, lateral unwhitened view showing "false color patterns". All scale bars = 1 cm.

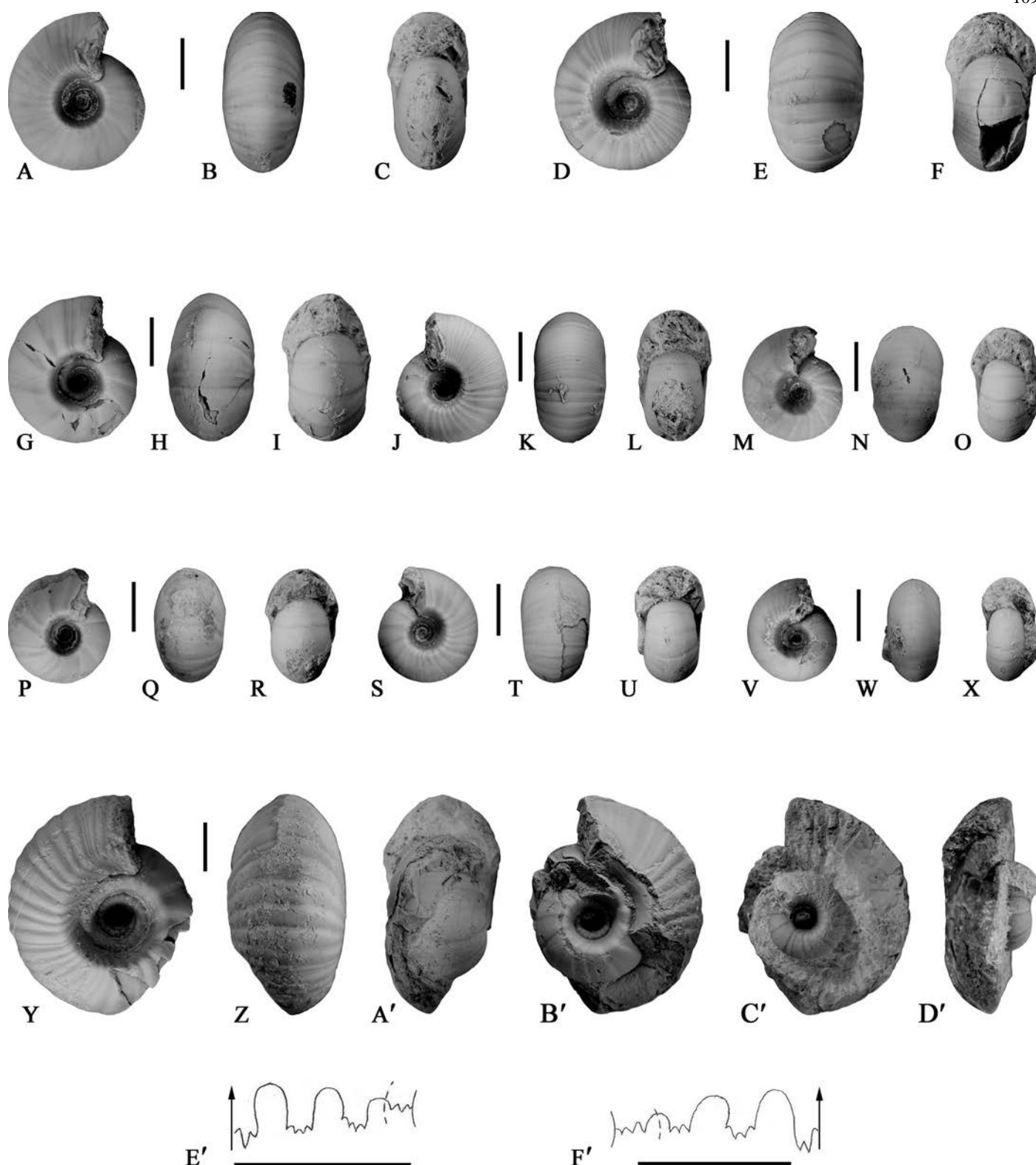


FIGURE 99. *Juvenites spathi* (Frebold). **A-C**, 2320C-181, 1-88, *G. l.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2320C-44, 1-88, *G. l.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2320C-110, 3-93, *P. t.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2320C-79, 1-79, *P. t.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, 2320C-84, 5-76, float, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2320C-166, 5-76, *O. k.*, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, 2320C-164, 3-93, *P. t.*, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-X**, 2320C-111, 5-76, float, in **V**, lateral, **W**, ventral and **X**, apertural views. **Y-D'**, 2320C-180, 3-93, *P. t.*, in **Y**, right side lateral, **Z**, ventral and **A'**, apertural views, **B'**, lateral view, left side, **C'**, lateral view, left side with one complete whorl removed and **D'**, apertural view of newly exposed whorl. **E'-F'**, suture lines, in **E'**, 2320C-93, H = 0.95 cm, 5-76, *M. g.* **F'**, 2320C-8, H = 0.89 cm, 5-76, *A. r.* All scale bars = 1 cm.

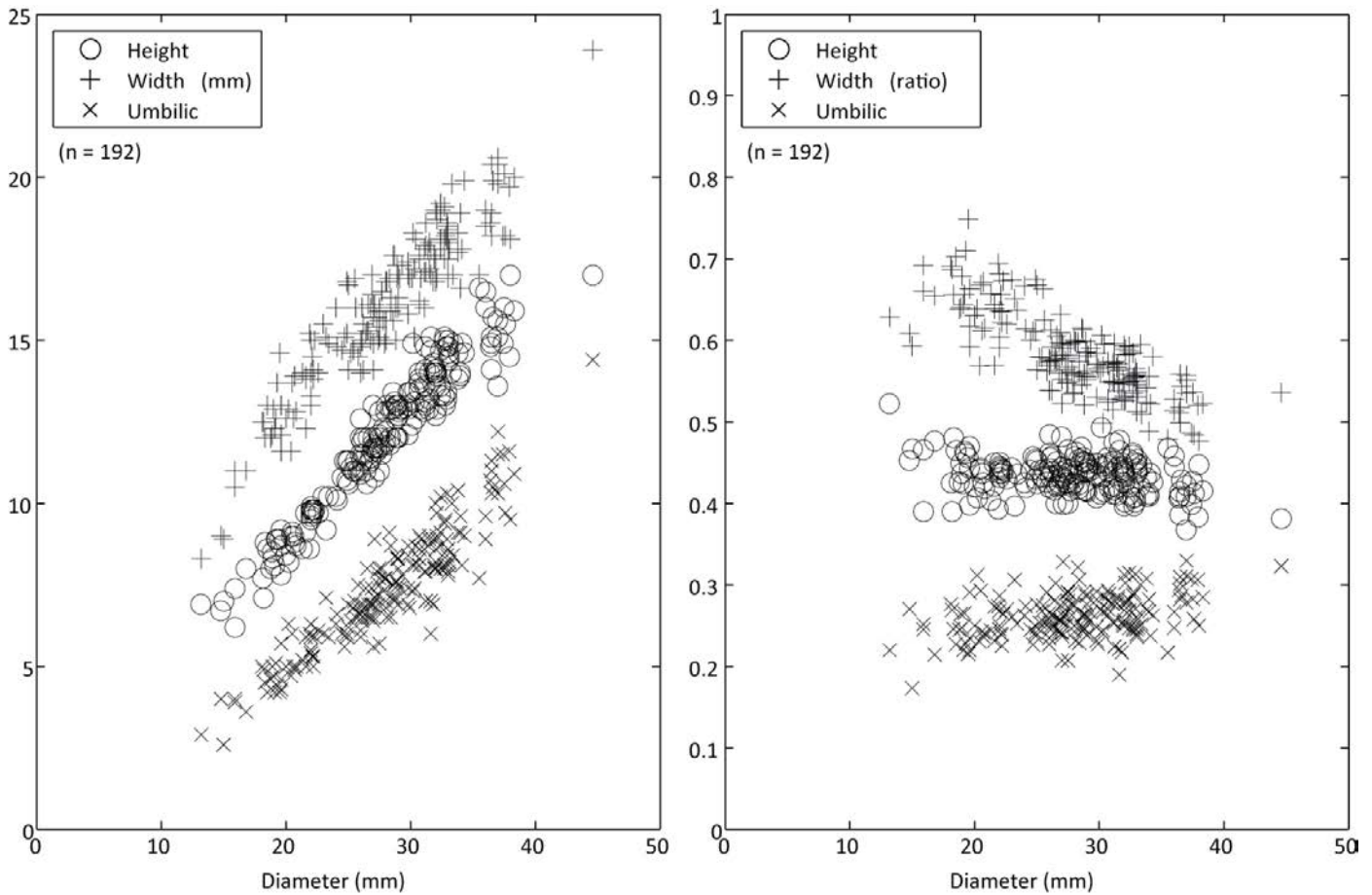


FIGURE 100. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Juvenites spathi*. All specimens from A. r. through C. j. intervals.

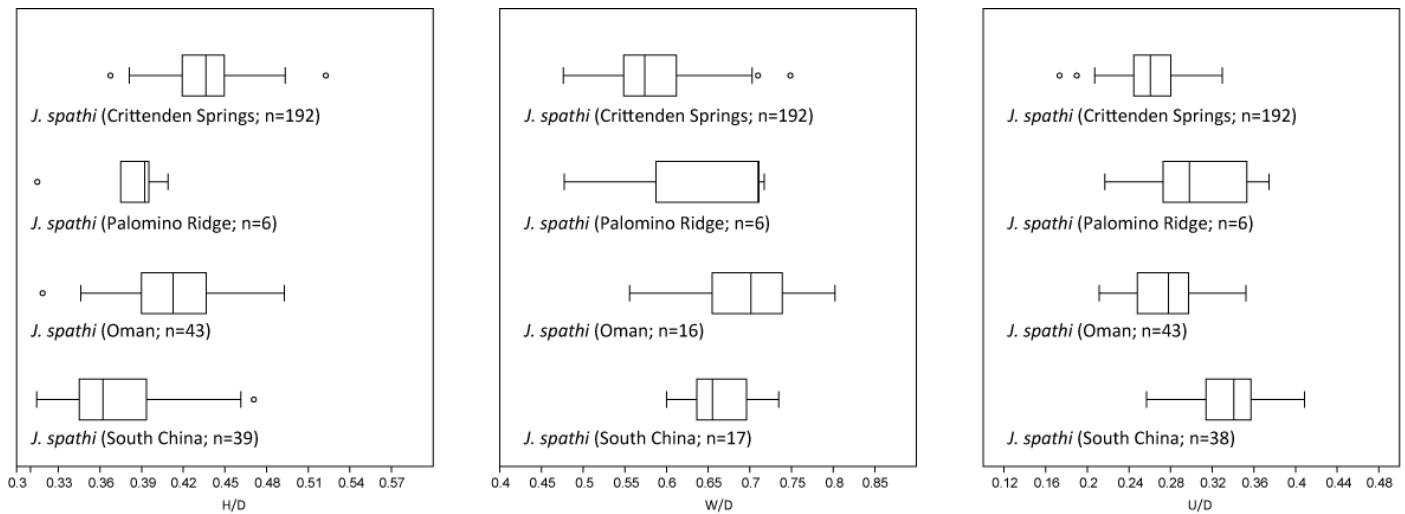


FIGURE 101. Box plot comparison of H/D, W/D and U/D for *Juvenites spathi* from Crittenden Springs vs. *J. spathi* from other localities.

Genus *Ussurijuvenites* Smyshlyaeva and Zakharov, 2012
Type species: *Ussurijuvenites artyomensis* Smyshlyaeva and Zakharov, 2012
Ussurijuvenites cf. *U. artyomensis* Smyshlyaeva and Zakharov, 2012
Figure 96V-X

2010 ?*Juvenites* sp. indet., Jenks et al., p. 7, fig. 5A-C.

2012 *Ussurijuvenites artyomensis* Smyshlyaeva and Zakharov, p. 146, pl. 4, figs. 4-11.

Material: One illustrated specimen, 747C.

Description: Very small, fairly involute, very depressed cadiconic juvenitid characterized by broadly arched venter gradually converging to rounded umbilical shoulder. Whorl width approximately 2.3 times height. Relatively narrow, deep umbilicus (U/D ~1/3) with moderately high, steeply inclined wall. Body chamber length unknown. Ornamentation consists of distant, shallow constrictions running straight across broadly rounded venter that become much deeper on umbilical shoulder, forming distinct, blunt tubercles or nodes on shoulder on either side of constriction. A few faint growth lines are visible running parallel to constrictions. Suture line not known.

Measurements: See APPENDIX, p. 167.

Discussion: The present specimen was described in open nomenclature (Jenks et al., 2010) because the possibility could not be ignored that it was simply an extremely depressed variant of *J. septentrionalis* or even a pathological variant. However, the whorl depression ratio (H/W) for the now much expanded data set for *J. septentrionalis* ranges from a low of 0.54 to a high of 1.01, for an average of 0.77, which is in stark contrast with the present specimen's H/W ratio of 0.42. Therefore, it clearly does not fall within the range of intraspecific variation of *J. septentrionalis*. Then, Smyshlyaeva and Zakharov (2012) erected a new juvenitid genus from South Primorye, *Ussurijuvenites*, composed of two species, *U. popovi* and *U. artyomensis*, of which *U. artyomensis* is very similar to the present specimen. Both taxa are similar, but *Ussurijuvenites popovi* is not as depressed as *U. artyomensis*, and it has a ceratitic suture line, whereas that of *U. artyomensis* is goniatitic according to the authors (Smyshlyaeva and Zakharov, 2012, fig. 2a, b). In terms of shell geometry, the present specimen cannot be separated from *U. artyomensis*, and its ornamentation is also nearly identical. However, a definitive assignment to *U. artyomensis* is avoided because the present specimen's suture line is not known, and the range of intraspecific variation is unknown. *Ussurijuvenites* cf. *U. artyomensis* differs from *U. popovi* by its significantly more depressed whorl section, and the constrictions on its ventral surface appear to be shallower.

Occurrence: Very rare – present specimen found in *G. lucasi* interval.

?*Juvenites* sp. indet.
Figure 96I-U

Material: Five specimens, 2254C, 2255C, 2256C, 2258C and 2435C. All are illustrated except 2435C.

Description: Small, fairly involute, slightly compressed juvenitid characterized by ellipsoidal whorl section with maximum width at ~30% of whorl height. Venter slightly arched without discernable shoulders. Flanks slightly convex, gradually converging to arched venter from point of maximum width. Umbilicus moderately deep with steep wall and gently rounded shoulder. Body chamber length about 2/3 whorl. Ornamentation consists of fairly dense (~15/half whorl), very shallow, radial constrictions, beginning just above umbilical shoulder and becoming slightly deeper and more obvious when crossing venter. Suture line ceratitic, similar to *Juvenites septentrionalis*, with fairly broad first later saddle and finely indented first lateral lobe.

Measurements: See APPENDIX, p. 167.

Discussion: Although ?*Juvenites* sp. indet. is similar to *J. septentrionalis*, it exhibits subtle differences that set it apart. First, its whorl section is slightly compressed, whereas that of *J. septentrionalis* is consistently depressed (H/W < 1), and, secondly, careful examination of our large data set reveals that its constrictions are consistently shallower. Its shell geometry is somewhat suggestive of the more compressed forms of *Paranannites aspenensis*, but this taxon's suture line is significantly different, containing additional elements. Finally, its conch bears some resemblance to *Steckites* cf. *S. brevis*, but this taxon is more compressed, with a narrowly rounded to arched venter, and its suture line also contains more elements.

Occurrence: Very rare, present specimens found in the *P. toulai*, *C. jattioti* n. gen., n. sp. and *I. oweni* intervals.

Superfamily SAGECERATACEAE Hyatt, 1884

Family HEDENSTROEMIIDAE Waagen, 1895

Genus *Pseudosageceras* Diener, 1895

Type species: *Pseudosageceras* sp. indet. Diener, 1895

***Pseudosageceras multilobatum* Noetling, 1905**

Figure 102A-M

- 1905 *Pseudosageceras multilobatum* Noetling, pl. 25, fig. 1, pl. 26, fig. 3.
 1905 *Pseudosageceras intermontanum* Hyatt and Smith, p. 99, pl. 4, figs. 1-3; pl. 5, figs. 1-6; pl. 63, figs. 1, 2.
 1909 *Pseudosageceras multilobatum* Noetling, Krafft and Diener, p. 145, pl. 21, fig. 5.
 1911 *Pseudosageceras drinense* Arthaber, p. 201, pl. 17, figs. 6, 7.
 1911 *Pseudosageceras multilobatum* Noetling, Wanner, p. 181, pl. 7, fig. 4.
 1922 *Pseudosageceras multilobatum* Noetling, Welter, p. 94, fig. 3.
 1929 *Pseudosageceras intermontanum* Hyatt and Smith, Mathews, p. 3, pl. 1, figs. 18-22.
 1932 *Pseudosageceras multilobatum* Noetling, Smith, p. 87-89, pl. 4, figs. 1-3; pl. 5, figs. 1-6; pl. 25, figs. 7-16, pl. 60, fig. 32; pl. 63, figs. 1-6.
 1933 *Pseudosageceras multilobatum* Noetling, Collignon, p. 56-58, pl. 11, fig. 2.
 1934 *Pseudosageceras multilobatum* Noetling, Spath, p. 54, fig. 6a.
 1947 *Pseudosageceras multilobatum* Noetling, Kiparisova, p. 127, pl. 25, figs. 3, 4.
 1947 *Pseudosageceras multilobatum* var. *giganteum*, Kiparisova, p. 127, pl. 26, figs. 2-5.
 1948 *Pseudosageceras* cf. *P. clavisellatum* Diener, 1913, Renz and Renz, p. 90, pl. 16, fig. 3.
 1948 *Pseudosageceras drinense* Arthaber, Renz and Renz, p. 92, pl. 16, fig. 6.
 1948 *Pseudosageceras intermontanum* Hyatt and Smith, Renz and Renz, p. 90, pl. 16, figs. 4, 7.
 1959 *Pseudosageceras multilobatum* Noetling, Chao, p. 183, pl. 1, figs. 9, 12.
 1959 *Pseudosageceras tsotengense* Chao, p. 184, pl. 1, figs. 7, 8, text-fig. 5b.
 1959 *Pseudosageceras curvatum* Chao, p. 185, pl. 1, figs. 13, 14, text-fig. 5a.
 ?1959 *Pseudosageceras multilobatum* var. nov., Jeannet, p. 30, pl. 6, fig. 1.
 1961 *Pseudosageceras schamarense* Kiparisova, p. 31, pl. 7, fig. 3.
 1961 *Pseudosageceras multilobatum* var. *gigantea* Popov, p. 13, pl. 2, figs. 1, 2.
 non 1962 *Pseudosageceras multilobatum* Noetling, Kummel and Steele, p. 701, pl. 102, figs. 1, 2.
 ?1966 *Pseudosageceras multilobatum* Noetling, Hada, p. 112, pl. 4, fig. 6.

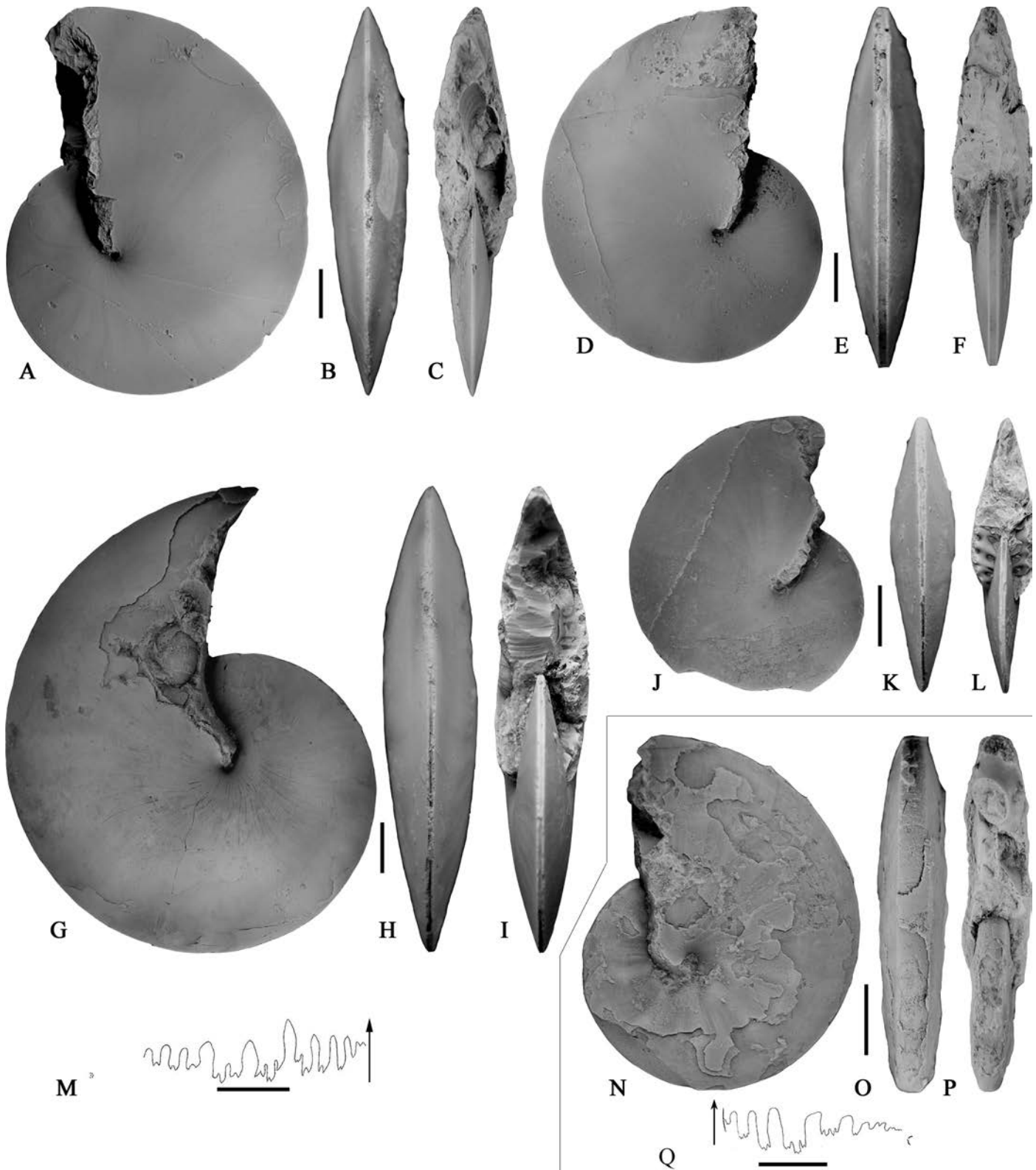


FIGURE 102. *Pseudosageceras multilobatum* Noetling. **A-C**, 252C, 5-76, *O. k.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 692C, 2-88, *G. l.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 113C, 1-88, *A. w.*, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2321C-11, 1-88, *A. W.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M**, suture line, 2321C-29, H = 4.0 cm, 5-76, *G. l.* **N-P**, *Cordillerites angulatus* Hyatt and Smith, 162C, float, possibly from *G. l.*, in **N**, lateral, **O**, ventral and **P**, apertural views. **Q**, suture line, H = 2.85 cm. All scale bars = 1 cm.

- ?1968 *Pseudosageceras multilobatum* Noetling, Kummel and Erben, p. 112, pl. 19, fig. 9.
 1968 *Pseudosageceras multilobatum* Noetling, Shevyrev, p. 791, pl. 1, figs. 1, 2.
 ?1973 *Pseudosageceras multilobatum* Noetling, Collignon, p. 5, pl. 1, fig. 1.
 ?1978 *Pseudosageceras multilobatum* Noetling, Weitschat and Lehmann, p. 95, pl. 10, figs. 2a-b.
 1984 *Pseudosageceras multilobatum* Noetling, Vu Khuc, p. 26, pl. 1, fig. 1.
 1994 *Pseudosageceras multilobatum* Noetling, Tozer, p. 83, pl. 18, figs. 1a, b; p. 384, fig. 17.
 v2008 *Pseudosageceras multilobatum* Noetling, Brayard and Bucher, p. 70, pl. 37, figs. 1-5.
 2009 *Pseudosageceras multilobatum* Noetling, Shigeta and Zakharov, p. 140, figs. 129, 130.
 v2010 *Pseudosageceras multilobatum* Noetling, Stephen et al., figs. 6c, d, h.
 v2010a *Pseudosageceras multilobatum* Noetling, Brühwiler et al., p. 429, fig. 16: 14.
 v2012a *Pseudosageceras multilobatum* Noetling, Brühwiler and Bucher, p. 47, pl. 26, fig. 4.
 v2012b *Pseudosageceras multilobatum* Noetling, Brühwiler and Bucher, p. 109, figs. 95A-N.
 v2013 *Pseudosageceras multilobatum* Noetling, Brayard et al., p. 208, fig. 77a-f.
 2014 *Pseudosageceras multilobatum* Noetling, Shigeta and Nguyen, p. 137, figs. 98, 99.
 2017 *Pseudosageceras multilobatum* Noetling, Jattiot et al., p. 41, pl. 19, figs. A-I.

Material: 30 measured specimens. Includes four illustrated

specimens (252C, 692C, 113C and 2321C-11).

Description: Involute, compressed oxyconic shell with extremely narrow, bicarinate venter and occluded umbilicus. Weakly convex flanks gradually converge toward venter from point of maximum whorl width (~25% of whorl height). Flanks devoid of ornamentation, but well preserved shells exhibit barely perceptible prosiradiate, sinuous growth lines (visible in Fig. 102G). Suture line typical of hedenstroemiids, with numerous adventitious lobes, several bifid lateral lobes and two very complex lateral lobes.

Measurements: See Figure 103 and APPENDIX, p. 170.

Discussion: *Pseudosageceras multilobatum* is remarkably cosmopolitan, exhibiting a world-wide distribution. It is also one of the longest surviving taxa of the Early Triassic, with occurrences ranging from the Dienerian (Tozer, 1994) through the early Spathian (Kummel, 1969). As shown in Figure 103, the taxon exhibits very little intraspecific variation, the only obvious variation being the width of the venter. In fact, the ventral width of the specimen shown in Figure 102D-F is such that it could be mistaken for *Lanceolites compactus*; however, its suture line confirms its attribution to *P. multilobatum*. In contrast, the venters of some specimens are so thin (Fig. 102A-C) that they appear acute to the naked eye. However, close examination of these particular specimens with a hand lens reveals the presence of a delicate bicarinate venter, at least on mature whorls with preserved shell material. Jattiot et al. (2017) report that a few rare specimens from Palomino Ridge, Nevada exhibit an acute venter, and the same observation also applies to a few exceptionally well preserved but rare specimens from Timor (R. Jattiot, personal commun. 2017); this feature has not yet been observed on specimens from Crittenden Springs. *Pseudosageceras multilobatum* is a fairly common component

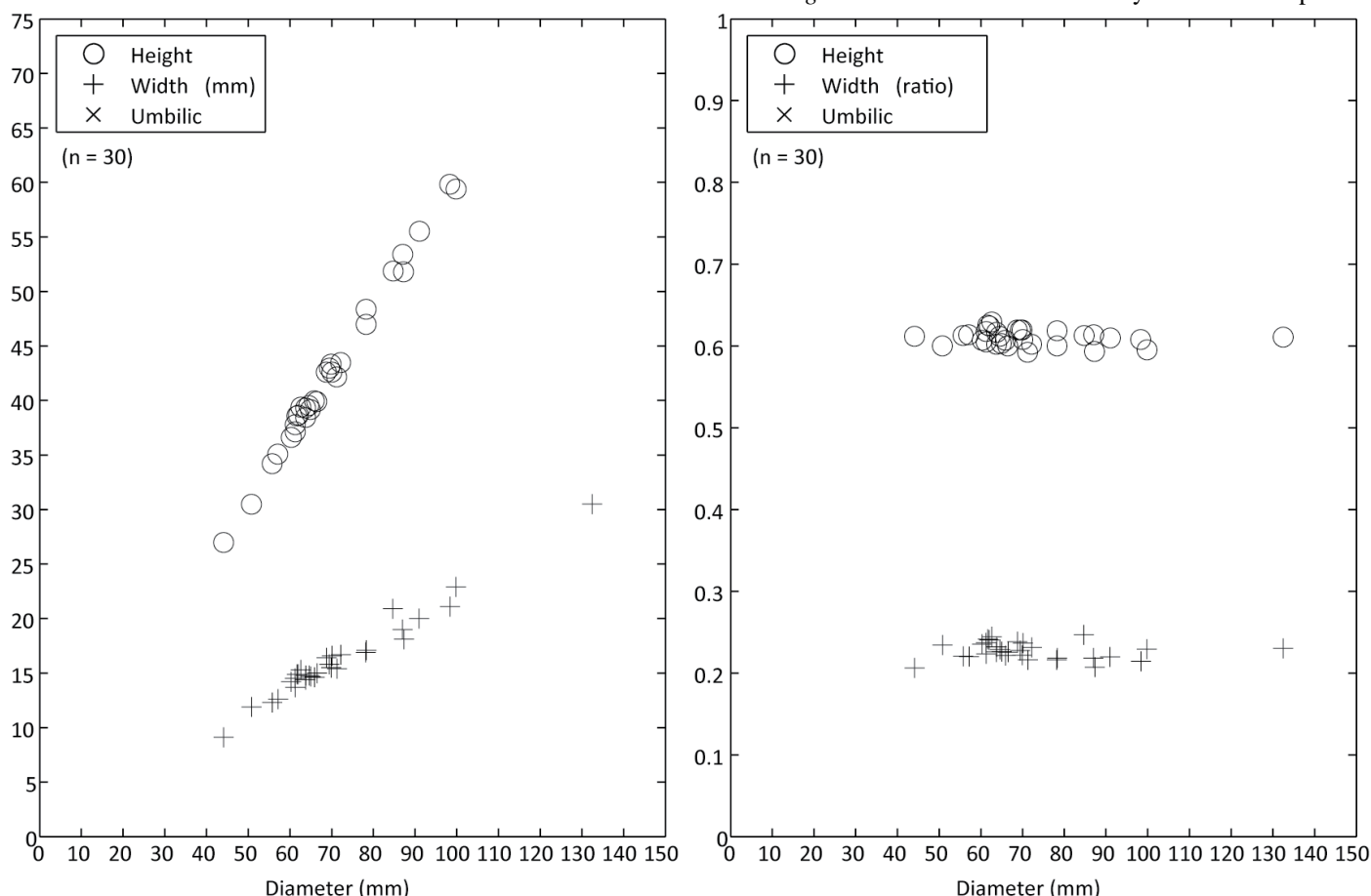


FIGURE 103. Scatter diagrams of H and W, and H/D and W/D for *Pseudosageceras multilobatum*. All specimens from *M. g.* through *C. y.* intervals.

of the “*Meekoceras* beds” in southeastern Idaho. Surprisingly, it is extremely rare in all the recently studied Utah sections – only one measureable specimen has been reported (Brayard et al., 2013).

Occurrence: *Pseudosageceras multilobatum* is fairly common at Crittenden Springs, occurring from the *M. gracilitatis* FA interval through the *C. youngi* n. gen. interval.

***Pseudosageceras augustum* (Brayard and Bucher, 2008)**

Figure 104

v2008 *Hedenstroemia augusta* Brayard and Bucher, p. 72, pl. 39, figs. 1-11, text-fig. 63.

v2010 *Pseudosageceras augustum* (Brayard and Bucher), Jenks et al., p.35, fig. 24

2010a *Pseudosageceras augustum* (Brayard and Bucher), Brühwiler et al., p. 429, fig. 16: 10-11.

2012c *Pseudosageceras augustum* (Brayard and Bucher), Brühwiler et al., p. 171, fig. 41Z-AI.

2017 *Pseudosageceras augustum* (Brayard and Bucher), Jattiot et al., p. 43, pl. 19, figs. J-N.

Material: Eight specimens, of which seven are measurable. Includes six illustrated specimens (292C, 2185C, 2544C, 649C, 2186C and 2550C).

Description: Very involute, compressed oxyconic shell with occluded umbilicus, very narrow bicarinate venter (tabulate on internal mold) and slightly convex flank with maximum width at about one half of whorl height. Flank contour resembles that of aspenitids with depressed umbilical region; depressed area surrounding umbilicus appears nearly flat and parallel, but actually is very gradually sloped upwards from occluded umbilicus to point of maximum width from which it gradually changes to downward slope and converges at increasing angle to bicarinate venter. Length of body chamber unknown, but at least one third whorl. Ornamentation consists only of fine but distinct growth lines that are sinuous on inner half of flank and slightly biconcave on outer half. Suture line only partially preserved on one of our specimens. Visible portion is ceratitic and complex, similar to the type specimen (Brayard and Bucher, 2008), with several adventitious lobes and a long auxiliary series.

Measurements: See Figure 105 and APPENDIX, p. 170.

Discussion: The stratigraphic occurrence and overall morphology of our specimens, with their aspenitid-like flanks, widely depressed umbilical region, bicarinate venter and sinuous, slightly biconcave growth lines, leave little doubt as to their attribution to *Pseudosageceras augustum*. Brayard and Bucher (2008) report that the flanks of larger specimens of *P. augustum* transition from an aspenitid-like contour to a much more convex form, similar to *P. multilobatum*. This phenomenon is not apparent on our specimens, even though two of them are comparable in size to two of their larger illustrated specimens, one of which resembles *P. multilobatum*. This is the third reported occurrence of *P. augustum* from western USA localities; Jattiot et al. (2017) recently reported the taxon from the *Anasibirites* beds at Palomino Ridge, Nevada, and unmistakable specimens have been collected by both authors from the *Anasibirites* beds in the Grayback Hills Quadrangle, Tooele County, Utah.

Occurrence: *Pseudosageceras augustum* is very rare at Crittenden Springs, occurring only in the brownish-black *C. youngi* n. gen. interval at the top of the late Smithian portion of the bed, with *Condensoceras youngi*, *Xenoceltites subevolatus*, *Glyptophraceras* cf. *G. sinuatum* and *Pseudosageceras multilobatum*.

Genus: *Mesohedenstroemia* Chao, 1959

Type species: *Mesohedenstroemia kwangsiana* Chao, 1959
***Mesohedenstroemia kwangsiana* Chao, 1959**

Figure 106A-L

?1895 *Parakymatites discoides* n. gen. et. sp. Waagen, p. 214,

pl. 36: 3.

v1959 *Mesohedenstroemia kwangsiana* gen. et sp. nov. Chao, p. 266, pl. 34, 1-18, text-fig. 33b-d.

v1959 *Mesohedenstroemia inflata* sp. nov. Chao, p. 267, pl. 35: 4-8, text-fig. 33a.

v2008 *Mesohedenstroemia kwangsiana* Chao, Brayard and Bucher, p. 75, pl. 41:1-8, fig. 66.

Material: Four measured specimens. All are illustrated - 2147C, 2432C, 2433C and 2473C.

Description: Relatively small, very involute, compressed discoidal shell with gently convex flanks and a wide, tabulate venter with angular shoulders. Whorl section subquadrate with maximum width at about 40% of whorl height. Umbilicus narrow and deep with very steep, nearly vertical wall and abruptly rounded shoulders. Body chamber length unknown, the present specimens are mainly phragmocones. Ornamentation consists only of barely perceptible slightly sinuous, radial growth lines that project forward slightly on outer flank. Suture line ceratitic with one adventitious lobe and deep first lateral lobe.

Measurements: See Figure 107 and APPENDIX, p. 171.

Discussion: This is the only reported occurrence of *Mesohedenstroemia kwangsiana* from eastern Panthalassic localities. Morphologically, our specimens are nearly identical to those illustrated by Brayard and Bucher (2008, pl. 41, figs. 1-8) and they fit very well within the intraspecific variation of the taxon as illustrated by the scatter diagrams (Fig. 108) for 272 specimens from South China (Brayard and Bucher, 2008, fig. 66). Also, the suture line, with its one adventitious lobe and deep first lateral lobe, is remarkably similar.

Mesohedenstroemia kwangsiana differs significantly from the two *hedenstroemiid* species from the “*Meekoceras* beds” of southeastern Idaho (*Hedenstroemia hyatti* Smith, 1932 and *H. kossmati* Hyatt and Smith, 1905) by its broader whorl section and much wider, tabulate venter. The taxon also differs from the two specimens of *H. kossmati* from Crittenden Springs by the same variations.

Occurrence: *Mesohedenstroemia kwangsiana* is very rare at Crittenden Springs, occurring only in the *I. oweni* interval.

Genus *Hedenstroemia* Waagen, 1895

Type species: *Ceratites hedenstroemi* Keyserling, 1845
***Hedenstroemia kossmati* Hyatt and Smith, 1905**

Figure 106M-T

1905 *Hedenstroemia kossmati* Hyatt and Smith, p. 101, pl. 67, figs. 3-7; pl. 84, figs. 1-10.

1932 *Hedenstroemia kossmati* Hyatt and Smith, Smith, p. 78, pl. 28, figs.11-16; pl. 41, figs. 1-10; pl. 67, figs. 3-7.

1932 *Hedenstroemia hyatti* Smith, p. 78, pl. 27, figs. 13-18.

v2010 Proptychitid gen. et sp. indet., Stephen et al., p. 247, fig. 4, G-I.

2013 *Hedenstroemia kossmati* Hyatt and Smith, Brayard et al., p. 210, fig. 79.

2017 *Hedenstroemia kossmati* Hyatt and Smith, Jattiot et al., p. 40, pl. 18, figs. 1-L.

Material: Two measured specimens (2476C and 2477C). Both are illustrated.

Description: Very involute, compressed discoidal shell with gently convex flanks converging towards angular ventral shoulders and narrow sulcate venter. Whorl section narrow, subquadrate with maximum width slightly below mid-flank. Umbilicus narrow, deep, with steep walls and rounded shoulders on phragmocone, but becomes somewhat wider, with slight egression of mature body chamber and a more inclined umbilical wall. Body chamber length unknown, but at least one half whorl for the present specimens. Ornamentation consists only of faintly visible sinuous, biconcave growth lines. Suture line ceratitic and complex, with adventitious elements (not visible on



FIGURE 104. *Pseudosageceras augustum* (Brayard and Bucher), C. y. **A-C**, 292C, 13-75, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-E**, 2185C, 5-76, in **D**, lateral and **E**, apertural views. **F-H**, 2544C, 2-94, in **F**, lateral, **G**, ventral and **H**, apertural views. **I-K**, 649C, 13-75, in **I**, lateral, **J**, ventral and **K**, apertural views. **L**, 2186C, 5-76, in lateral view. **M-O**, 2550C, 2-94, in **M**, lateral, **N**, ventral and **O**, apertural views. **P**, suture line, 649C, H = 3.2 cm. All scale bars = 1 cm.

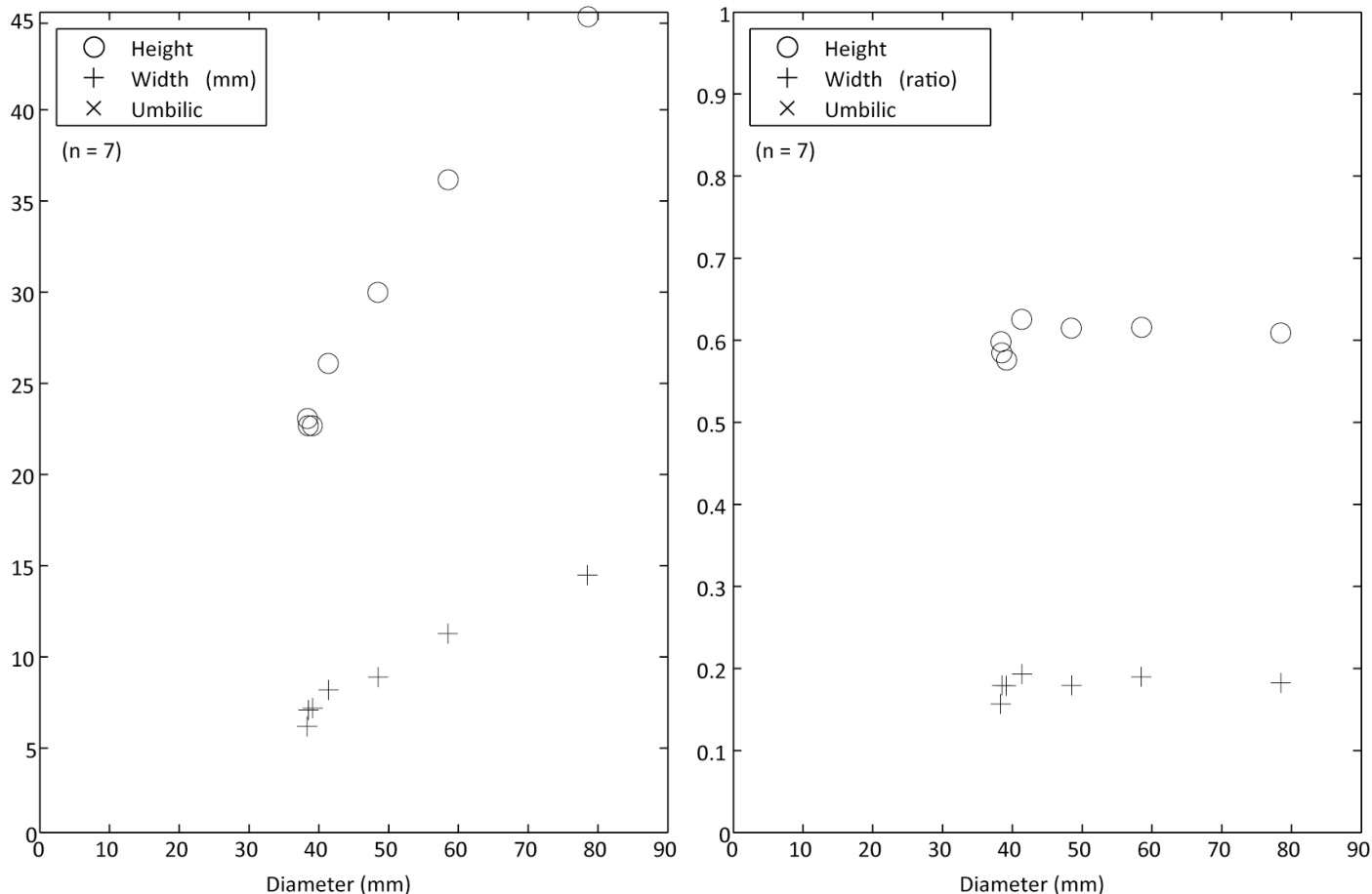


FIGURE 105. Scatter diagrams of H and W, and H/D and W/D for *Pseudosageceras augustum*. All specimens from *C. y.* interval.

present specimens) and a long auxiliary series.

Measurements: See APPENDIX, p. 171.

Discussion: Although Hyatt and Smith (1905) based *Hedenstroemia kossmati* on material from the *Meekoceras* beds of southeastern Idaho, relatively little is known about the taxon from its type area as well as from other western USA localities. Brayard et al. (2013) report that it is fairly common in the *Owenites* beds in the Confusion Range (Utah), but preservation at this locality is generally not good. According to Jattiot et al. (2017), several specimens have been found in UAZ₄ (late middle Smithian) at Palomino Ridge, Nevada, but their preservation is also poor. Hyatt and Smith (1905) stated that “the species was probably found by JP Smith in the *Meekoceras* Zone of Union Wash, California,” but, if so, the specimens have never been illustrated. *Hedenstroemia kossmati* is not well known at Crittenden Springs, with only two specimens found, and these could easily be mistaken for an involute variant of *Meekoceras gracilitatis* with typical egressive coiling of the ultimate whorl, were it not for their suture lines. While they do not exhibit the many adventitious elements that are characteristic of the type specimens, they do possess an unusually long auxiliary series, a feature also typical of the type material but not *Meekoceras gracilitatis*. The reader should refer to Brayard et al. (2013) for a more thorough review of *H. kossmati*.

Occurrence: *Hedenstroemia kossmati* is rare at Crittenden Springs and has been found only in the *C. jattioti* n. gen., n. sp. interval.

Genus *Cordillerites* Hyatt and Smith, 1905

Type species: *Cordillerites angulatus* Hyatt & Smith, 1905

Cordillerites angulatus Hyatt & Smith, 1905

Figure 102N-Q

- 1905 *Cordillerites angulatus* Hyatt and Smith, p. 110, pl. 2, figs. 1-8; pl. 68, figs. 1-10; pl. 71, figs. 1-6; pl. 85, figs. 14-20.
- 1908 *Cordillerites angulatus* Hyatt and Smith, Frech, pl. 63, fig. 2.
- 1911 *Hedenstroemia skipetarensis* Arthaber, p. 208, pl. 17, fig. 13.
- 1932 *Cordillerites angulatus* Hyatt and Smith, Smith, p. 96, pl. 2, figs. 1-8, pl. 42, figs. 14-20, pl. 60, fig. 14, p. 68, figs. 1-10, pl. 71, figs. 1-6.
- 1934 *Cordillerites angulatus* Hyatt and Smith, Spath, 1934, p. 61.
- 1934 *Epihedenstroemia skipetarensis* (Arthaber), Spath, p. 222, fig. 71.
- 1948 *Cordillerites* cf. *C. angulatus* Hyatt and Smith, Renz and Renz, p. 88, pl. 16, fig. 9a, b.
- 1959 *Cordillerites kwangsiensis* Chao, p. 33, 188, pl. 44, figs. 7, 8, text-fig. 6b.
- 1959 *Cordillerites orientalis* Chao, p. 34, 188, pl. 1, figs. 10, 11, text-fig. 6a.
- 1965 *Pseudosageceras bicarinatum* Tozer, p. 16, pl. 2, figs. 8a-d, text-fig. 1.
- 1969 *Cordillerites angulatus* Hyatt and Smith, Kummel, p. 364, pl. 20, figs. 5, 6; pl. 51,
- ?1994 *Cordillerites bicarinatum* (Tozer), Tozer, 1994, p. 85, pl. 37, figs. 8a-d.

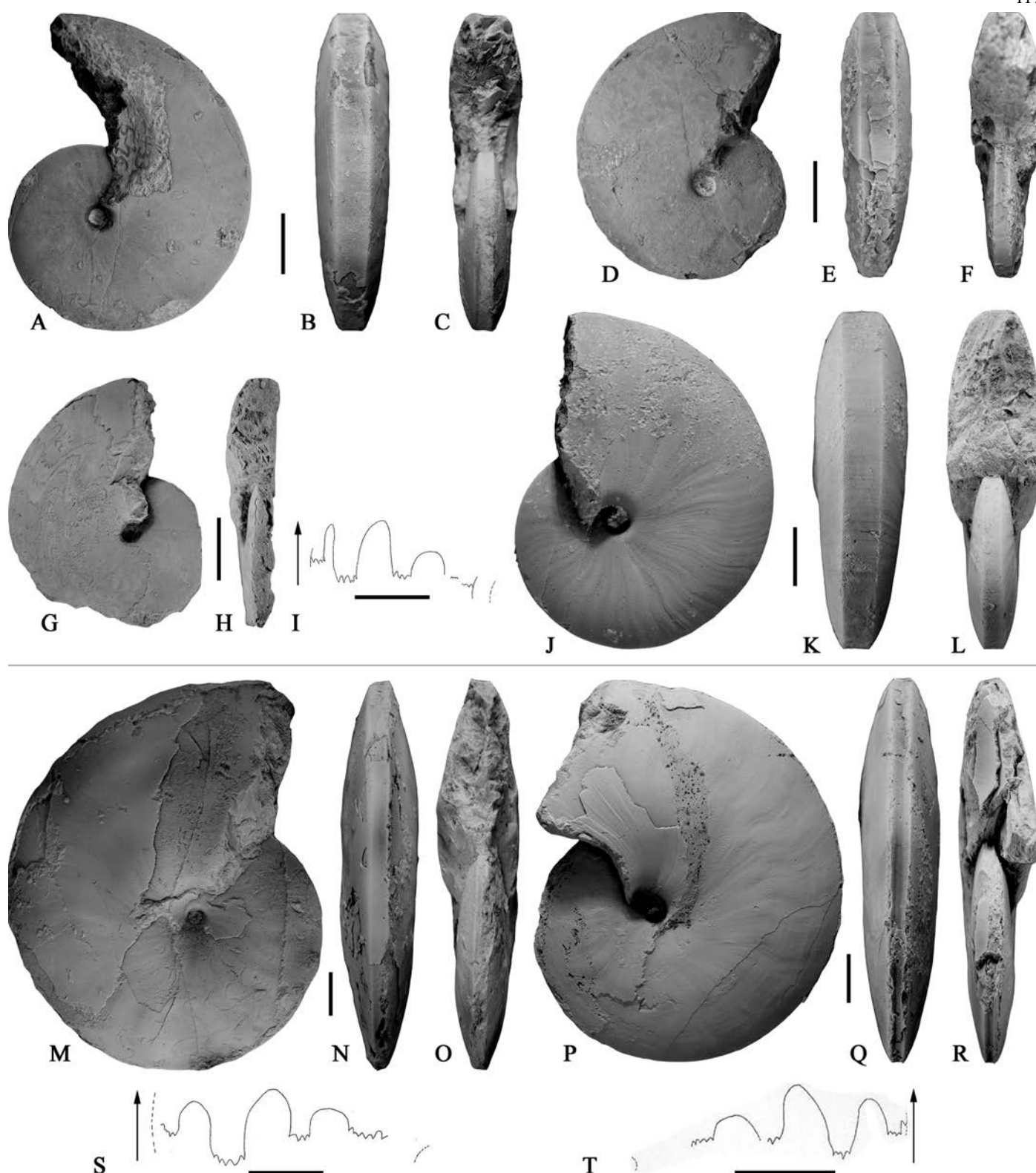


FIGURE 106. **A-L**, *Mesohedenstroemia kwangsiana* Chao. **A-C**, 2433C, 5-76, *I. o.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D-F**, 2432C, 1-11, *I. o.*, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, 2147C, 5-76, float (probably from *I. o.* interval), in **G**, lateral and **H**, apertural views. **I**, suture line, H = 2.25 cm. **J-L**, 2473C, 2-79, *I. o.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-T**, *Hedenstroemia kossmati* Hyatt and Smith, 5-76, *C. j.*, in **M-O**, 2477C, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2476C, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-T**, suture lines, in **S**, 2477C, H = 3.4 cm. **T**, 2476C, H = 2.8 cm. All scale bars = 1 cm.

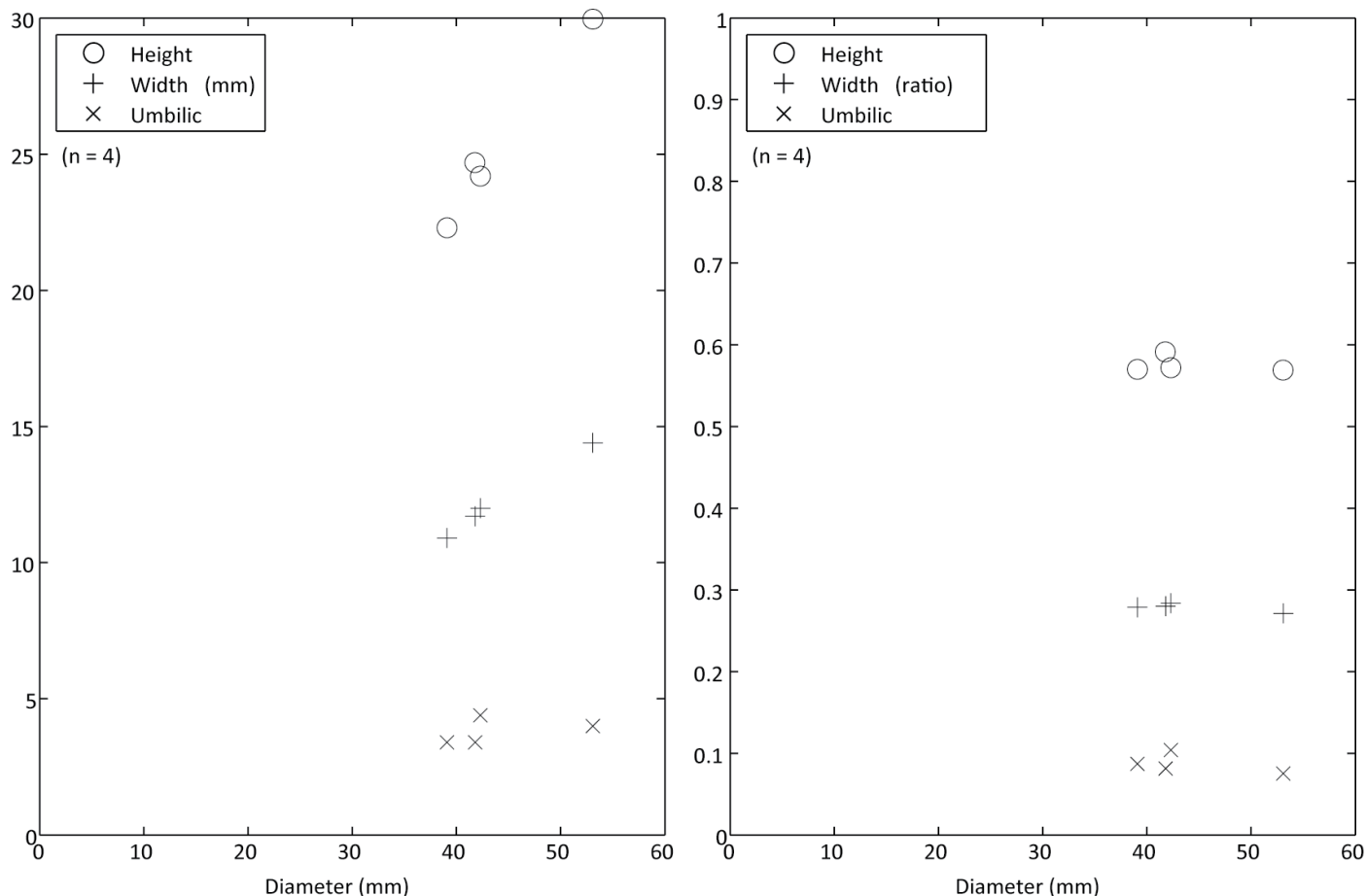


FIGURE 107. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Mesohedenstroemia kwangiana*. All specimens from *I. o.* interval.

Material: One measured specimen, 162C. Illustrated.

Description: Extremely involute, very compressed platycone with relatively wide subtabulate to nearly tabulate venter, angular ventral shoulders and closed umbilicus. Flanks very gently convex, nearly parallel, forming a quadrate whorl section with maximum width at about one third of whorl height. Expansion rate of whorl width very low. Length of body chamber unknown – specimen is nearly all phragmocone. Ornamentation consists of faintly visible radial growth lines as well as distant, low intensity radial folds, strongest on early whorl, arising low on flank just above closed umbilicus and gaining maximum strength at about 2/3 of flank height, giving appearance of a weak node, from which point they rapidly fade. Radial folds lose intensity rapidly towards end of phragmocone. Suture line ceratitic, typical for hedenstroemiids, very similar to that illustrated for type material from southeastern Idaho (Hyatt and Smith, 1905; Smith, 1932).

Measurements: See APPENDIX, p. 171.

Discussion: *Cordillerites angulatus* is a taxon not well known in western USA localities even though its type locality is the “*Meekoceras* beds” of southeastern Idaho. This is the first report of the taxon outside its type locality. The present specimen, with its very gently convex, nearly parallel flanks and subsequent very low whorl width expansion rate, is somewhat more compressed than the larger specimens illustrated by Hyatt and Smith (1905, pl. 68, figs. 1-3, 4-6). However, its other features agree well with *C. angulatus*. Tozer (1965, 1994) differentiated a new species of *Cordillerites*, *C. bicarinatum*, based on a single specimen, which has raised ventral keels on a portion of its outer whorl, a feature hitherto never reported in *C. angulatus*. This taxon is probably synonymous with *C.*

angulatus, but the presence of the raised keels prevents a definite attribution. *Cordillerites angulatus* differs from *Cordillerites antrum* Brayard and Bucher (2008) from South China by its slightly more compressed whorl section, lack of a bicarinate venter on smaller specimens and subtabulate to rounded venter on larger specimens.

Occurrence: Stratigraphic origin uncertain, specimen found as float. Location, matrix and preservation suggest specimen may have come from the *G. lucasi* interval.

Family ASPENTIDAE Spath, 1934

Genus *Aspenites* Hyatt and Smith, 1905

Type species: *Aspenites acutus* Hyatt and Smith, 1905

Aspenites acutus Hyatt and Smith, 1905

Figures 109, 115A-D

1905 *Aspenites acutus* sp. nov. Hyatt and Smith, p. 96, pl. 2: 9-13; pl. 3: 1-5.

?1909 *Hedenstroemia acuta* Krafft, Krafft and Diener, p. 157, pl. 9: 2a-d.

1915 *Aspenites acuta* Hyatt and Smith, Diener, p. 59, fig. 20.

1922 *Aspenites acutus* Hyatt and Smith, Welter, p. 98, fig. 7.

1922 *Aspenites laevis* sp. nov., Welter, p. 99, pl. 1: 4-5.

1932 *Aspenites acutus* Hyatt and Smith, Smith, p. 86, pl. 2: 9-13; pl. 3: 1-5; pl. 30: 1-26; pl. 60: 4-6.

1932 *Aspenites laevis* Welter, Smith, p. 86, pl. 28: 28-33.

1932 *Aspenites obtusus* Smith, p. 86, pl. 31: 8-10.

1934 *Aspenites acutus* Hyatt and Smith, Spath, p. 229, figs. 75, 76.

?1934 *Parahedenstroemia acuta* (Krafft), Spath, p. 221, figs. 70.

1957 *Aspenites acutus* Hyatt and Smith, Kummel, p. L142, fig. 173: 1a-c

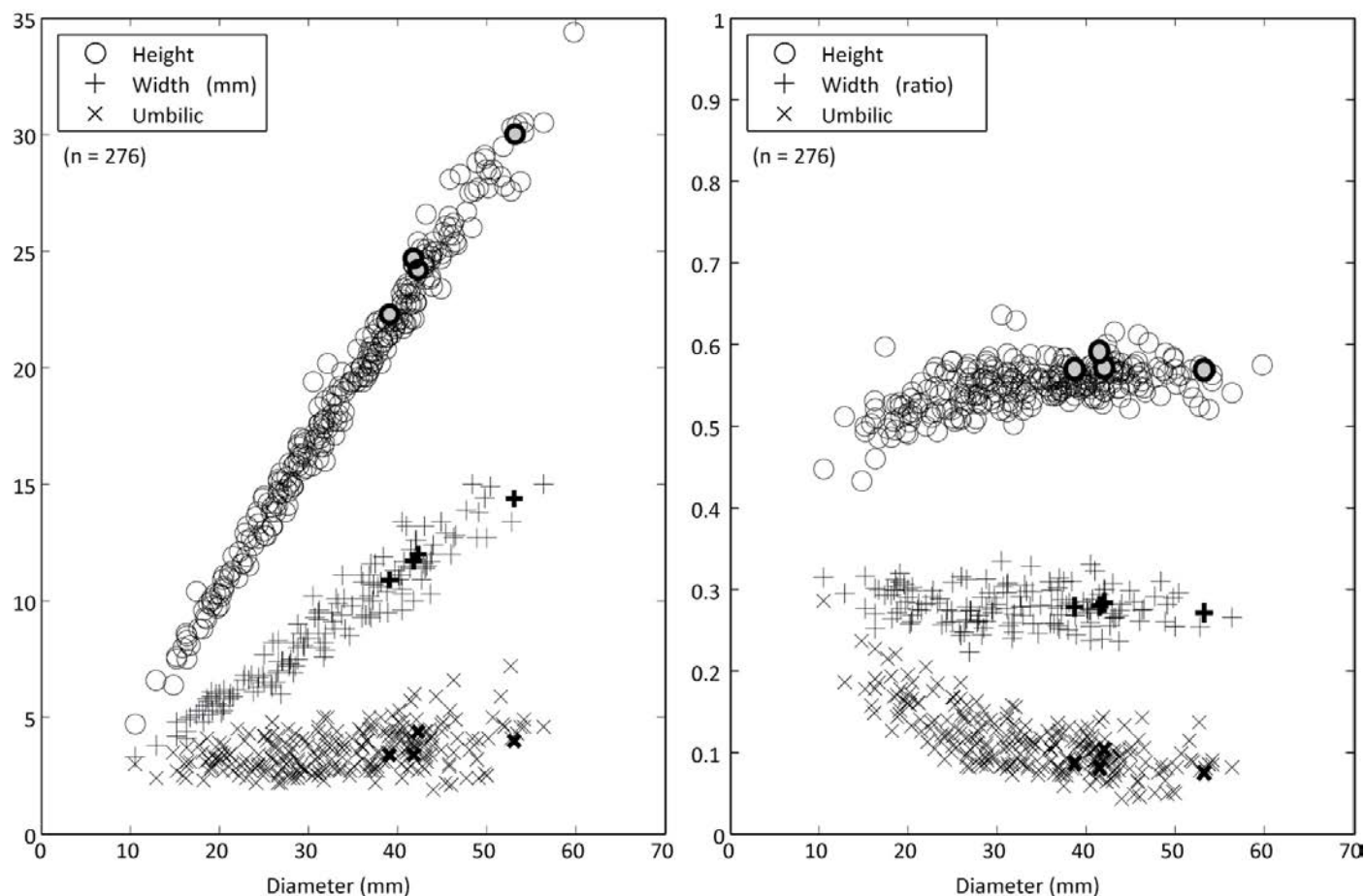


FIGURE 108. Scatter diagram comparison of H, W and U, and H/D, W/D and U/D for *Mesohedenstroemia kwangsiana* from Crittenden Springs vs. *M. kwangsiana* from South China.

- v1959 *Aspenites acutus* Hyatt and Smith, Chao, pl. 35: 12-18, 23, text-fig. 34a.
 1959 *Aspenites laevis* Welter, Chao, p. 270, pl. 35, figs. 9-11, text-fig. 34b.
 1962 *Aspenites acutus* Hyatt and Smith, Kummel and Steele, p. 692, pl. 99, figs. 16-17.
 1962 *Hemiaspenites obtusus* (Smith), Kummel and Steele, p. 666, pl. 99, fig. 18.
 1979 *Aspenites* cf. *acutus* Hyatt and Smith, Nichols and Silberling, pl. 1, figs. 10-11.
 1979 *Aspenites acutus* Hyatt and Smith, Nichols and Silberling, pl. 1, figs. 12-14.
 v2008 *Aspenites acutus* Hyatt and Smith, Brayard and Bucher, p. 77, pl. 42, figs. 1-9.
 2010 *Aspenites acutus* Hyatt and Smith, Stephen et al., fig. 4f.
 2010a *Aspenites acutus* Hyatt and Smith, Brühwiler et al., p. 429, fig. 16 (12, 13).
 2012a *Aspenites acutus* Hyatt and Smith, Brühwiler et al., p. 48, pl. 26, figs. 1, 2.
 2012c *Aspenites acutus* Hyatt and Smith, Brühwiler et al., p. 164, figs. 41A-M.
 v2013 *Aspenites acutus* Hyatt and Smith, Brayard et al., p. 212, fig. 81a-j.
 2014 *Aspenites acutus* Hyatt and Smith, Shigeta and Nguyen, p. 136, fig. 97: 1-5.
 2015 *Aspenites radiatus* Smyshlyaeva and Zakharov, p. 113, pl. 1: figs. 1a-b, 2.
 2017 *Aspenites acutus* Hyatt and Smith, Jattiot et al., p. 44, pl. 18, figs. A-H.

Material: 39 measured specimens. Includes nine illustrated

specimens (893C, 927C, 2179C-6, 2179C-15, 226C, 2179C-26, 2179C-13, 2179C-8 and 2179C-14)

Description: Medium sized (max diameter ~ 7.7 cm), involute, very compressed, oxycone with sharply acute, keeled venter and occluded umbilicus. Lateral shell surface characterized by relatively large, depressed circular region surrounding umbilicus. Flank contour rises from umbilicus in a very gentle more or less straight line until point of maximum whorl width is reached at about mid-flank, after which contour becomes gently convex and then converges more rapidly, without ventral shoulders, towards acute venter. Juvenile shells characterized by significantly greater whorl width with respect to diameter than sub-adult and adult forms (Fig. 109P-A'). Ornamentation consists only of highly variable, low intensity, radial falcoid or biconcave folds and growth lines that originate near umbilicus, then become strongest on lower half of flank but fade rapidly on convex portion. Suture line ceratitic with numerous adventitious elements and a long auxiliary series.

Measurements: See Figure 110 and APPENDIX, p. 171.

Discussion: *Aspenites acutus* is a widely occurring, long-ranging (early to middle Smithian) low-paleolatitude taxon that has been reported from several Tethyan localities, including South China (Brayard and Bucher, 2008), Oman (Brühwiler et al., 2012a), Spiti, India (Brühwiler et al., 2012c) and Vietnam (Shigeta and Nguyen, 2014). It also occurs abundantly in a few eastern Panthalassic sites, including northeastern Nevada and southeastern Idaho, and rare occurrences have been reported from the Chulitna terrane (low paleolatitude origin) of south-central Alaska (Nichols and Silberling, 1979). Surprisingly, it is rare in Utah – only one measureable specimen reported (Brayard et al., 2013).

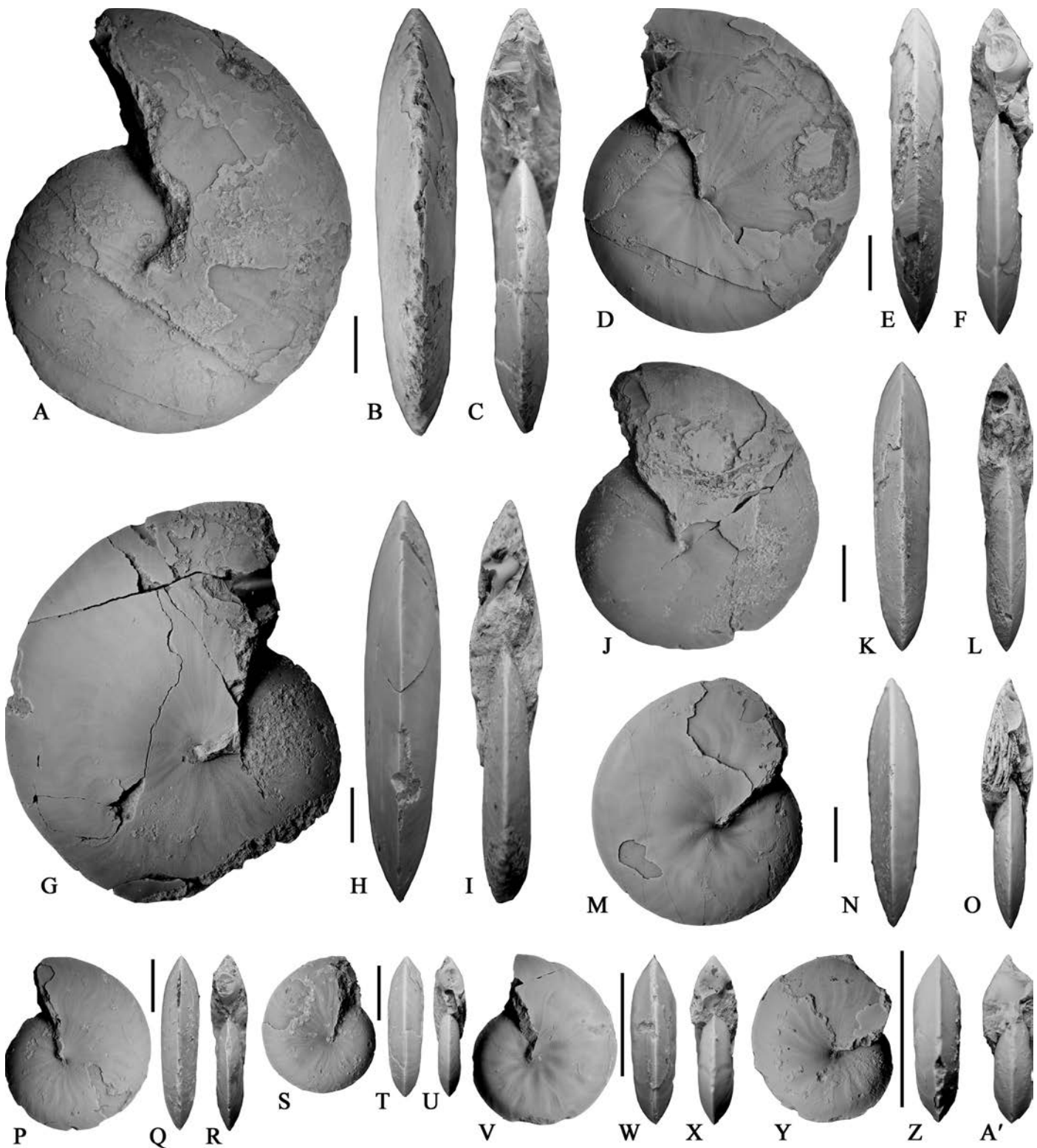


FIGURE 109. *Aspenites acutus* Hyatt & Smith, *C. j.* A-C, 893C, 5-76, in A, lateral, B, ventral and C, apertural views. D-F, 927C, 2-94, in D, lateral, E, ventral and F, apertural views. G-I, 2179C-6, 1-88, in G, lateral, H, ventral and I, apertural views. J-L, 2179C-15, 2-94, in J, lateral, K, ventral and L, apertural views. M-O, 226C, 1-88, in M, lateral, N, ventral, and O, apertural views. P-R, 2179C-26, 2-94, in P, lateral, Q, ventral and R, apertural views. S-U, 2179C-13, 2-94, in S, lateral, T, ventral and U, apertural views. V-X, 2179C-8, 2-94, in V, lateral, W, ventral and X, apertural views. Y-A', 2179C-14, 2-94, in Y, lateral, Z, ventral and A', apertural views. All scale bars = 1 cm.

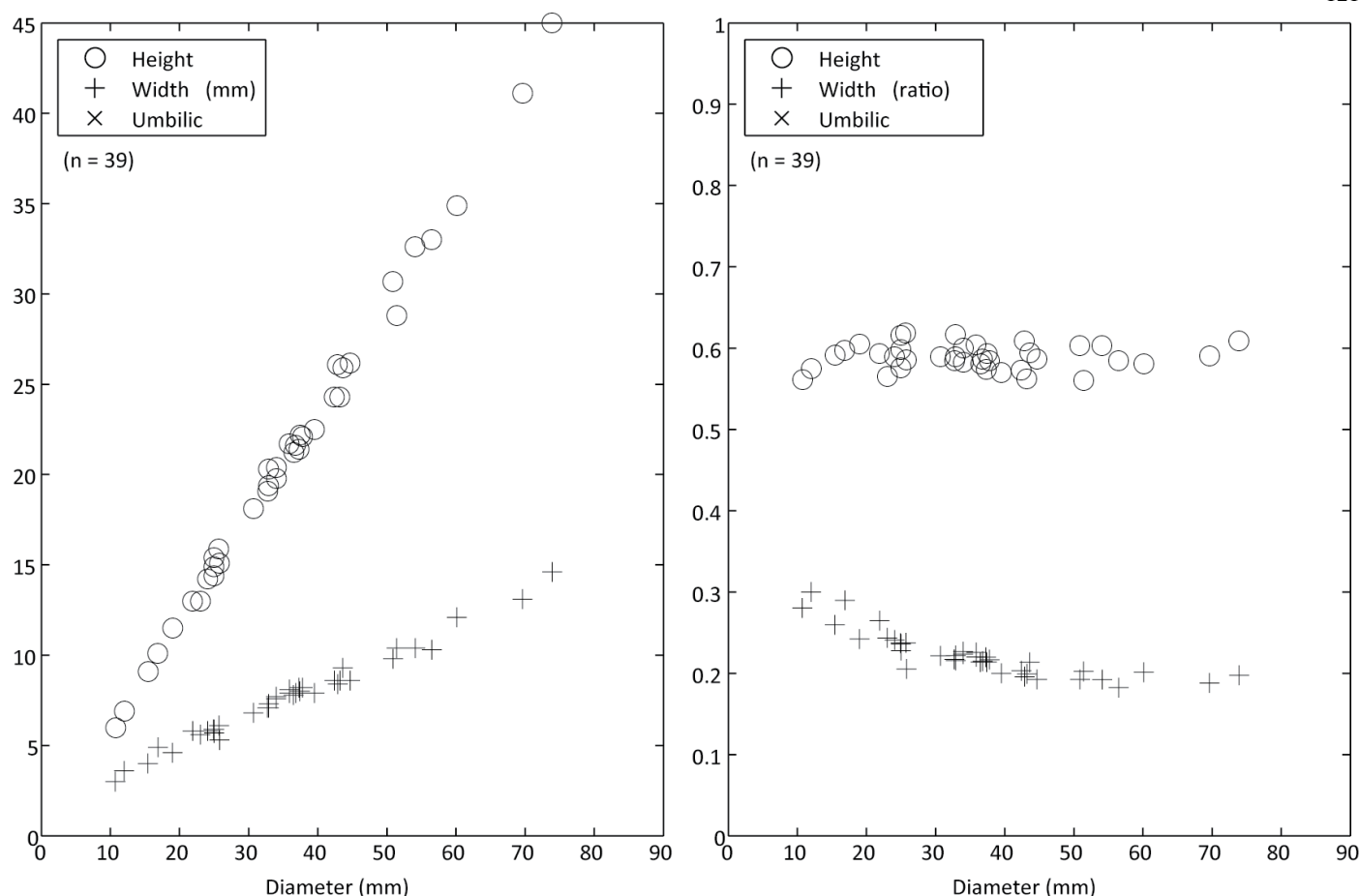


FIGURE 110. Scatter diagrams of H and W, and H/D and W/D for *Aspenites acutus*. All specimens from *C. j.* interval.

Brayard and Bucher (2008), in a thorough review of the taxon, synonymized *Aspenites laevis* Welter, 1922 and *Hemiaspenites obtusus* (Smith, 1932) with *A. acutus*. Kummel and Steele (1962) erected the genus *Hemiaspenites* based on a single poorly preserved and weathered fragmental specimen that exhibited a suture line supposedly different from typical *A. acutus*. Smyshlyaeva and Zakharov (2015) erected a new species from South Primorye, *Aspenites radiatus*, based on only two specimens, of which the holotype is a 5.4 cm long partial whorl fragment. These authors compared their new species to the holotype and an immature specimen of *A. acutus* (Hyatt and Smith, 1905, pl. 3, figs. 1, 2 and pl. 2, figs. 9-13) and stated that it bears "more strongly developed radial folds bending towards the aperture in the upper third of the outer whorl." These ornamental features fall well within the intraspecific variation of *A. acutus*; thus, *A. radiatus* is synonymized with *A. acutus*.

Aspenites acutus differs from *Pseudaspenites balinii* Jenks et al., 2010 from Crittenden Springs and other species of *Pseudaspenites* (*P. layeriformis* [Welter, 1922], *P. evolutus* Brayard and Bucher, 2008, and *P. tenuis* [Chao, 1959]) primarily by its occluded umbilicus.

Occurrence: *Aspenites acutus* occurs only in the *C. jattioti* n. gen., n. sp. interval at Crittenden Springs.

Aspenites weitschati n. sp.

Figures 111, 115E-I

v1962 *Pseudosageceras multilobatum* Noetling. Kummel and Steele, p. 701, pl. 102, figs. 1, 2.

?2008 ?*Aspenites* sp. indet., Brayard and Bucher, p. 78, pl. 42, figs. 10-11.

2010 *Aspenites* cf. *acutus* Hyatt and Smith, Jenks et al., p. 5, fig. 3.

?2012a *Aspenites acutus* Hyatt & Smith, Brühwiler et al., p. 48, pl. 26, fig. 1 only.

Type Series: Six specimens: Holotype, NMMNH P-79170, Figure 111A-C; paratype, NMMNH P-79171, Figure 111G-I; paratype, NMMNH P-79172, Figure 111M-O; paratype, NMMNH P-79173, Figure 111S-U; paratype, NMMNH P-79174, suture line, Figure 115I; paratype, NMMNH P-79175, suture line, Figure 115G.

Material: 47 measured specimens (includes type series). Illustrated specimens (nine) include 164C, 609C, 2180C-3, 2180C-39, 2181C, 2180C-19, 2180C-14, 2180C-13 and 2180C-41.

Etymology: Species named in honor of the late Wolfgang Weitschat of Hamburg, Germany.

Diagnosis: Large diameter, involute, extremely compressed oxycone with depressed umbilical region, sharply acute, keeled venter and occluded umbilicus. Suture line of nearly all specimens contains a trifid lateral lobe.

Description: Very large diameter (max size, at least 13 cm), involute, extremely compressed aspenitid with high, sharply acute, keeled venter and occluded umbilicus. Lateral shell surface characterized by relatively large depressed, circular region surrounding umbilicus (see Figure 111A). Flank contour rises very gently from umbilicus in a more or less straight line and then turns slightly convex just below point of maximum whorl width (~58% flank height). Gentle convex contour continues until ~70% of flank height, after which contour becomes straight or very slightly concave until sharply acute venter is reached. Juvenile shells characterized by greater whorl width with respect to diameter than sub-adult and adult forms (Fig. 111S-Y). Ornamentation consists only of highly variable, low

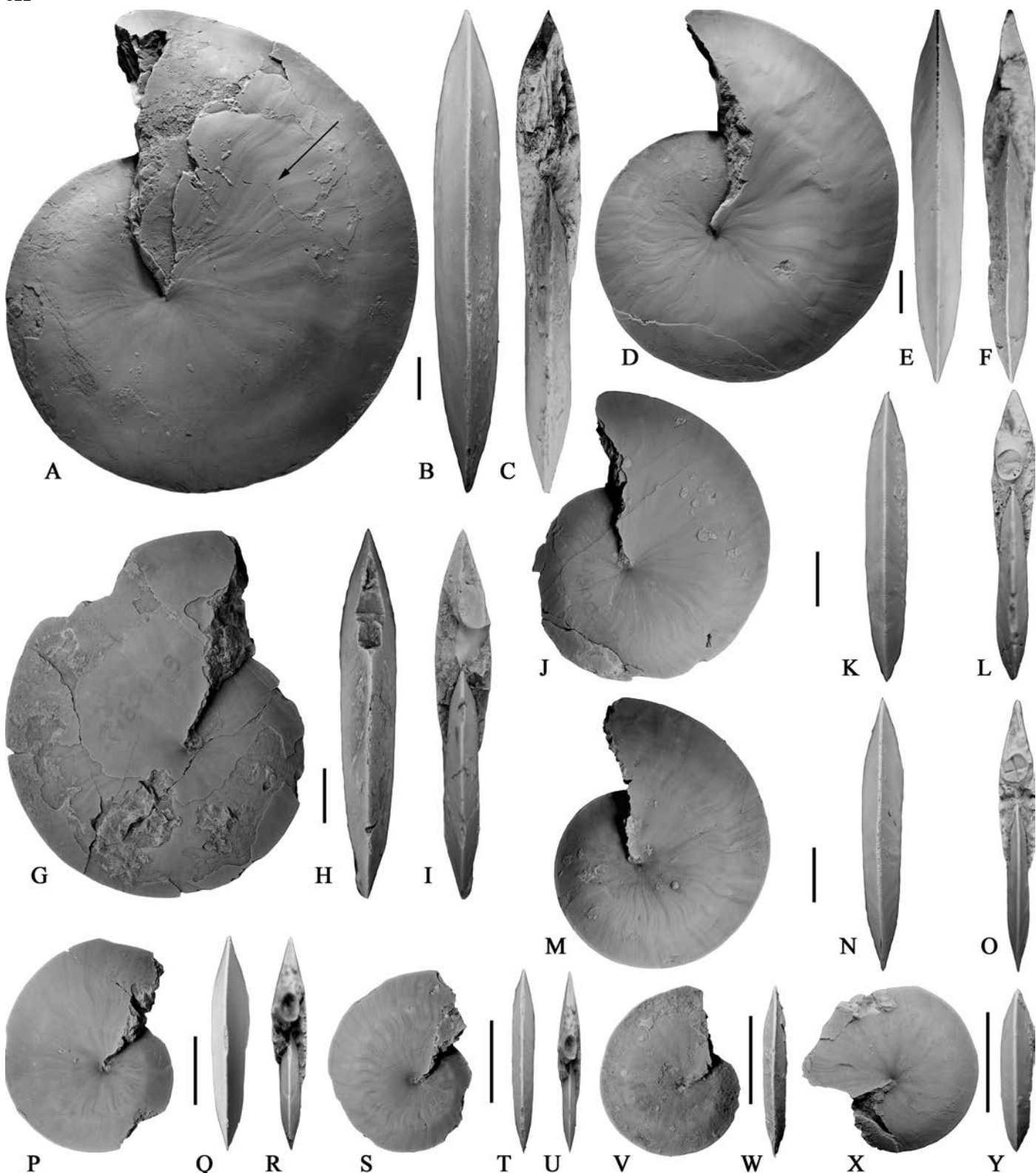


FIGURE 111. *Aspenites weitschati* n. sp., *A. w.* **A-C**, NMMNH P-79170, holotype, 13-75, in **A**, lateral (arrow indicates approximate point of maximum whorl width = boundary of large depressed circular region surrounding umbilicus), **B**, ventral and **C**, apertural views. **D-F**, 609C, 5-76, in **D**, lateral, **E**, ventral and **F**, apertural views. **G-I**, NMMNH P-79171, paratype, 5-76, in **G**, lateral, **H**, ventral and **I**, apertural views. **J-L**, 2180C-39, 1-79, in **J**, lateral, **K**, ventral and **L**, apertural views. **M-O**, NMMNH P-79172, paratype, 5-76, in **M**, lateral, **N**, ventral and **O**, apertural views. **P-R**, 2180C-19, 13-75, in **P**, lateral, **Q**, ventral and **R**, apertural views. **S-U**, NMMNH P-79173, paratype, 5-76, in **S**, lateral, **T**, ventral and **U**, apertural views. **V-W**, 2180C-13, 1-88, in **V**, lateral and **W**, ventral views. **X-Y**, 2180C-41, 1-88, in **X**, lateral and **Y**, ventral views. All scale bars = 1 cm.

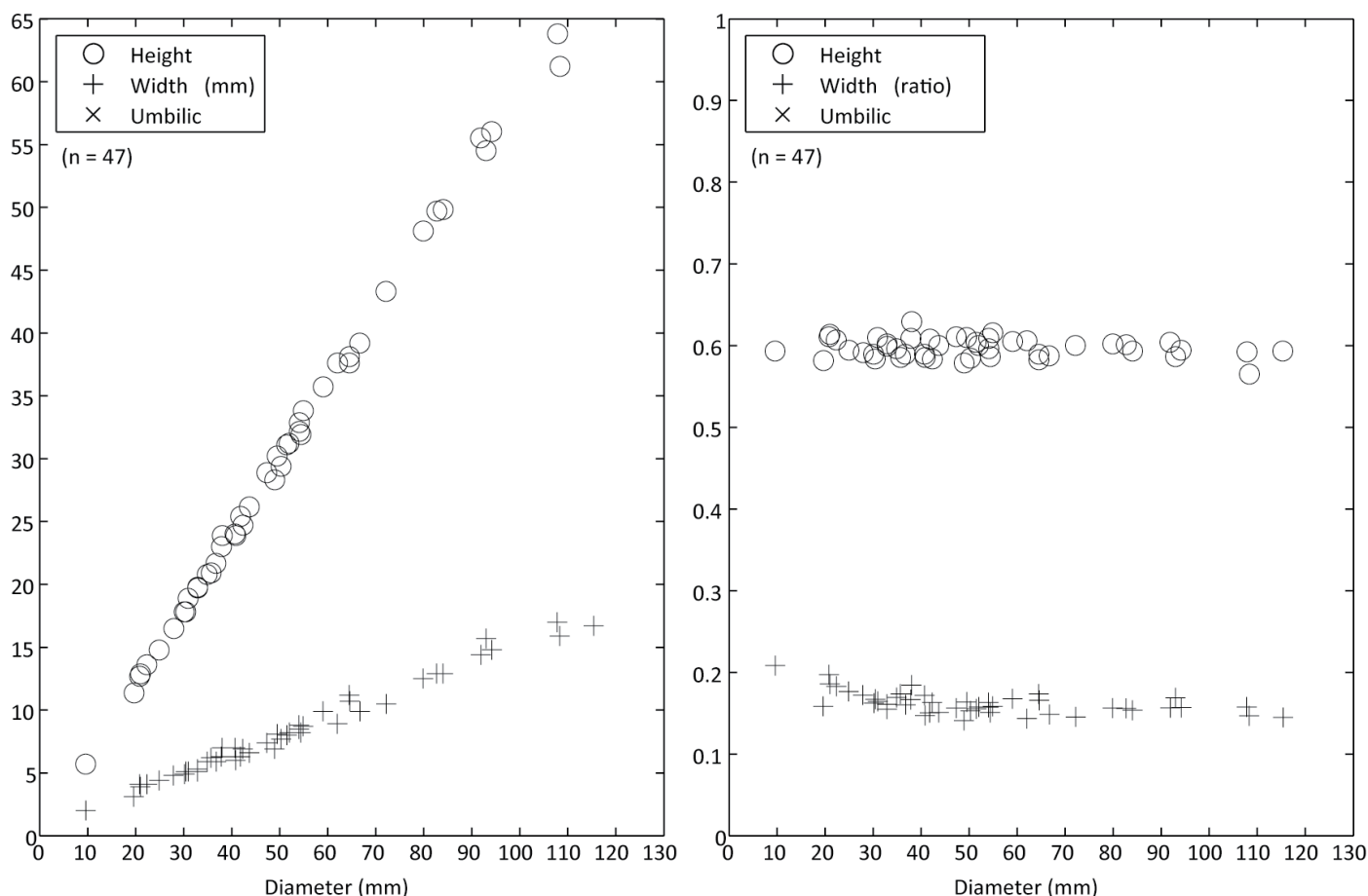


FIGURE 112. Scatter diagrams of H and W, and H/D and W/D for *Aspenites weitschati* n. sp. All specimens from *O. k.* and *A. w.* intervals.

intensity, radial falcoid or biconcave folds and growth lines that originate near umbilicus, become strongest at about mid-flank, and fade rapidly on outer flank, where contour becomes straight or concave. Suture line ceratitic with at least three adventitious elements, a trifid first lateral lobe and a long auxiliary series.

Measurements: See Figure 112 and APPENDIX, p. 172.

Discussion: Although the morphologies of *Aspenites acutus* and *A. weitschati* n. sp. are similar, *A. weitschati* n. sp. differs mainly by its more compressed shell and much larger adult size. As shown in the scatter diagram comparison (Fig. 113), the W/D plot and W/D vs D ratios for *Aspenites weitschati* n. sp. are significantly less than *A. acutus* throughout all growth stages. This observation is also supported by the box plot comparison shown in Figure 114. *Aspenites weitschati* n. sp. has a somewhat higher keel than *A. acutus*, and the contour of its lateral surface near the venter is straight or very slightly concave, whereas the equivalent portion of the shell for *A. acutus* is convex. Although similar, the suture line of *A. weitschati* n. sp. is more complex with several adventitious elements and a well-developed auxiliary series (Fig. 115). More importantly, nearly all specimens of *A. weitschati* n. sp. exhibit a trifid first lateral lobe, a feature not seen in specimens of *A. acutus* from Crittenden Springs. Finally, *A. acutus* and *A. weitschati* n. sp. do not occur together in the same horizon (see Fig. 4).

Spath (1934) erected the genus *Parahedenstroemia*, with *Hedenstroemia acuta* as the type species, based on a single specimen from Spiti, India that Diener (Krafft and Diener, 1909) somewhat hesitatingly assigned to *Hedenstroemia*. This specimen, with a W/D ratio of 0.18, appears to be morphologically closer to *A. acutus* than *A. weitschati* n. sp., and

its suture line, although somewhat simpler, also seems closer to *A. acutus*. Additional material is needed to determine if Spath's new taxon is valid or if the specimen should be placed within *Aspenites* (Brayard et al., 2013).

Brayard and Bucher (2008) assigned three quite large, fragmental adult body chambers from South China to ?*Aspenites* sp. indet. based only on their aspenitid-like shape and acutely keeled venter. These specimens bear some similarity to the body chambers of larger *A. weitschati* specimens, but a precise assignment is impossible due to their fragmental nature and unknown suture line. Brühwiler et al. (2012a) attributed two specimens from Oman to *Aspenites acutus*. These specimens also appear morphologically very close to *A. weitschati* n. sp., but again, a precise identification is precluded because their suture lines are not preserved.

Based on the above observations, the morphological characteristics of *Aspenites weitschati* n. sp. and its unique suture line are considered to be sufficiently different from *A. acutus* so that the erection of a new species is justified.

Occurrence: *Aspenites weitschati* n. sp. is fairly common at Crittenden Springs. The most prolific occurrence is in the *A. weitschati* n. sp. interval, but a few specimens have been found in the underlying *O. koeneni* FA interval.

Genus *Pseudaspenites* Spath, 1934

Type species: *Aspenites layeriformis* Welter, 1922

Pseudaspenites balinii Jenks et al., 2010

Figure 115J-M

2010 *Pseudaspenites balinii* Jenks et al., p. 35, fig. 5D-G.

Material: One specimen: Holotype, NMMNH P-60203. Illustrated.

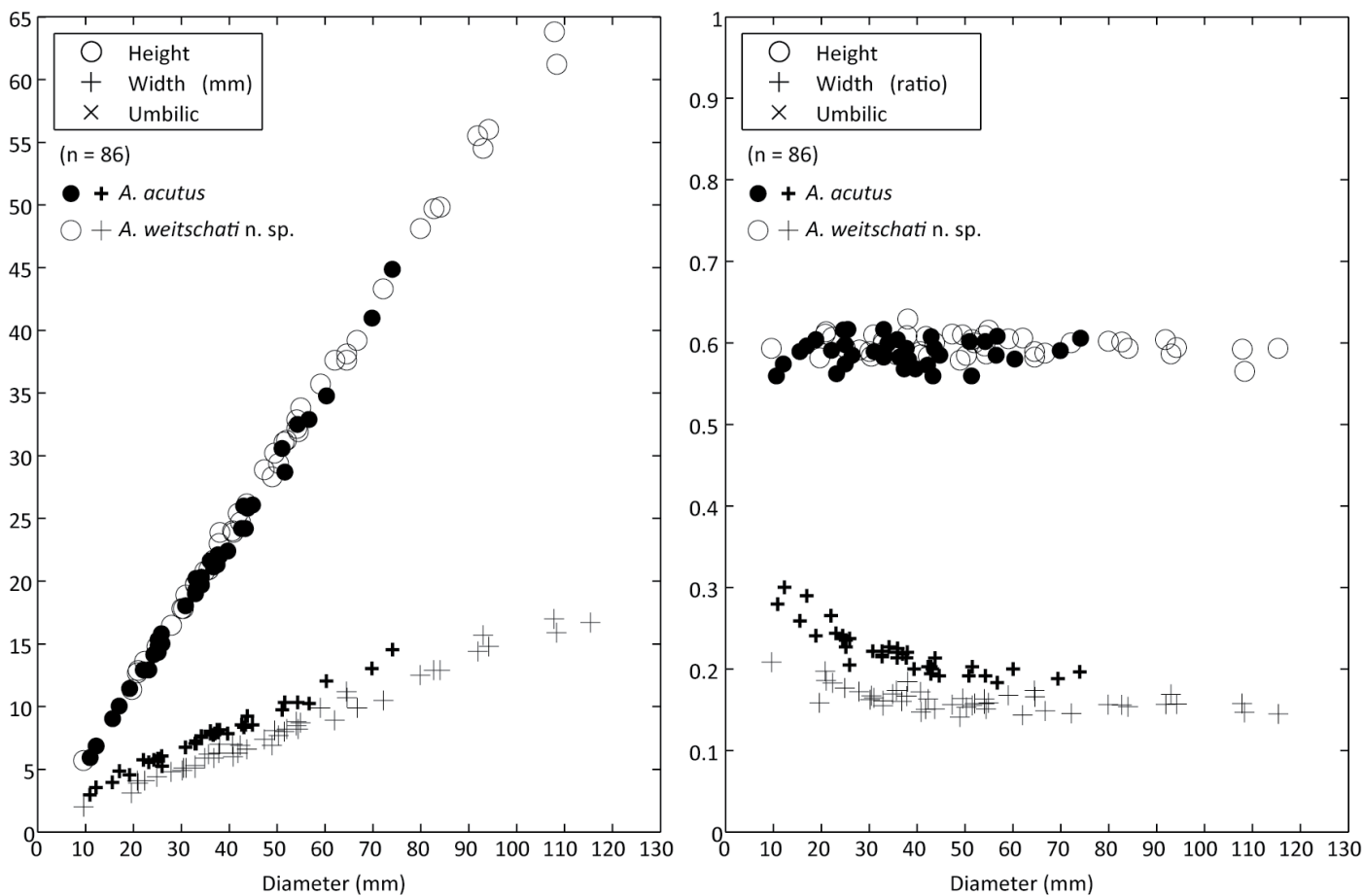


FIGURE 113. Scatter diagram comparison of H and W, and H/D and W/D for *Aspenites acutus* vs. *A. weitschati* n. sp.

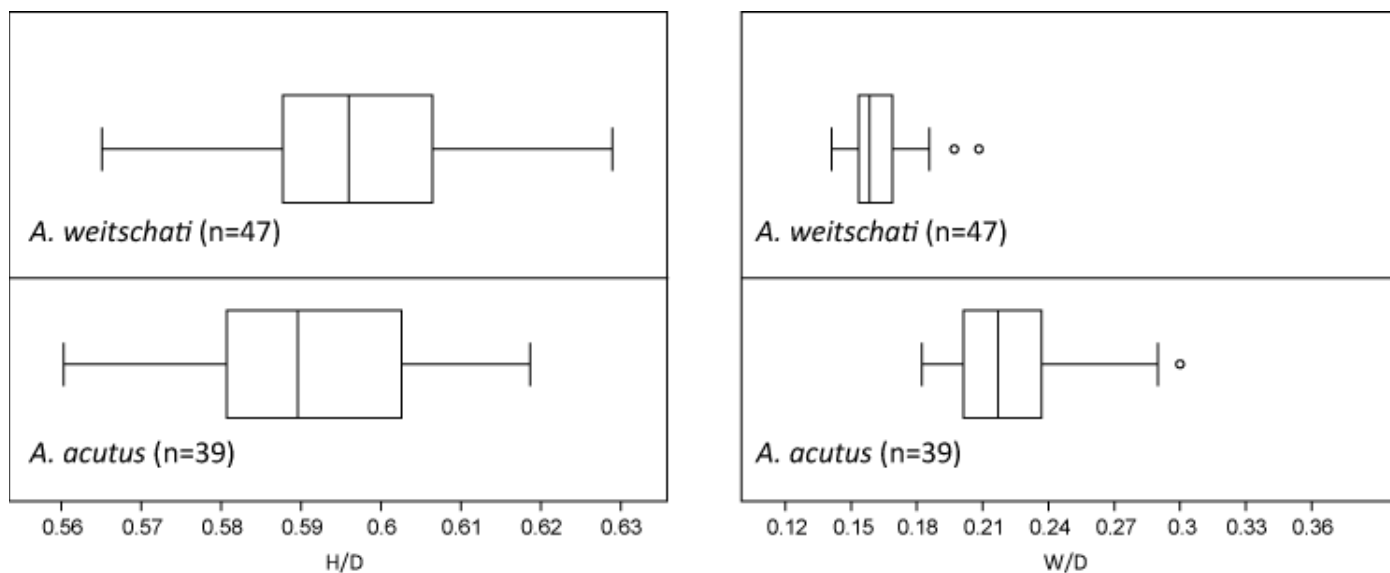


FIGURE 114. Box plot comparison of H/D and W/D for *Aspenites acutus* vs. *A. weitschati* n. sp.

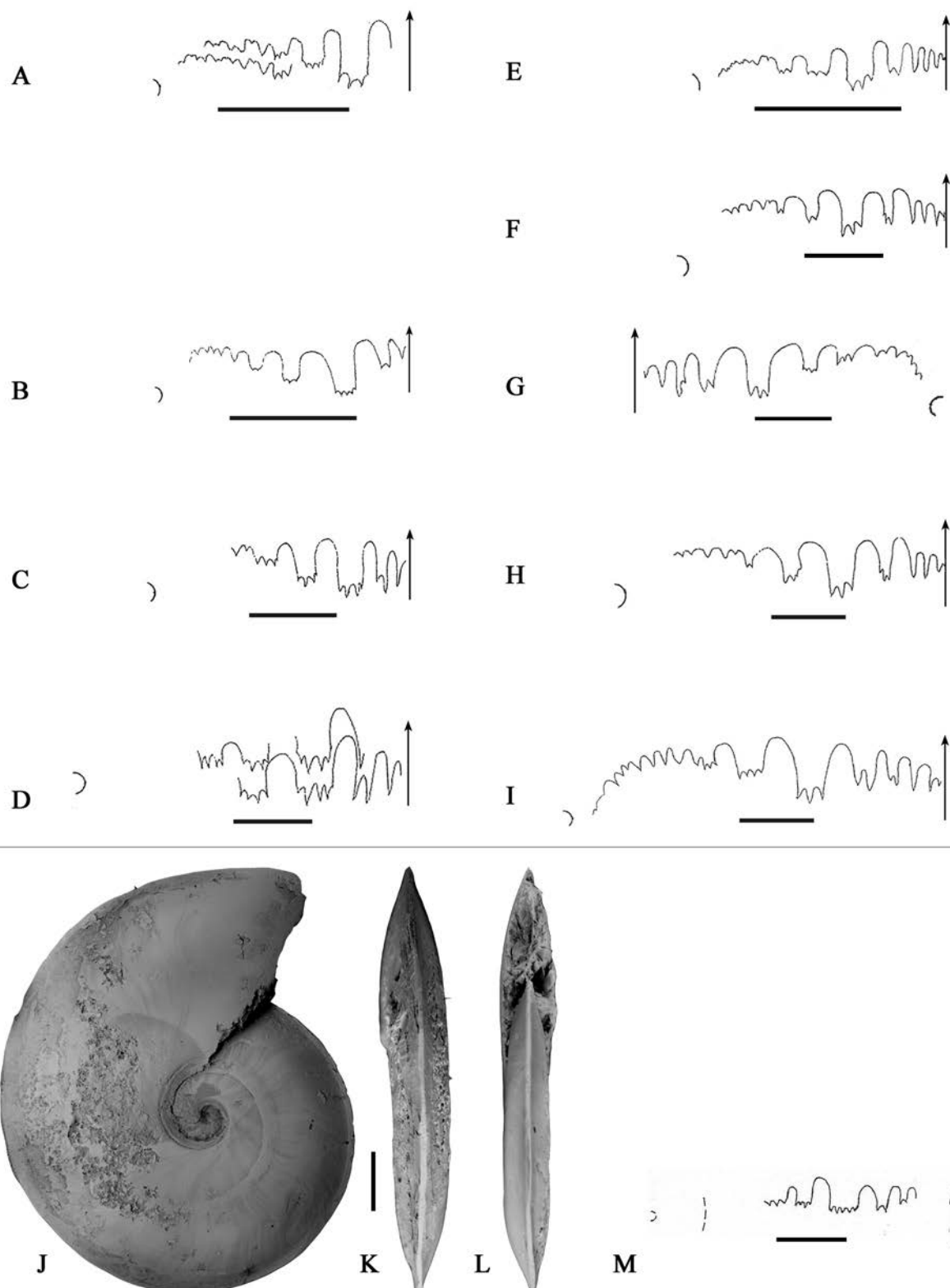


FIGURE 115. Suture line comparison, *Aspenites acutus* and *Aspenites weitschati* n. sp. **A-D**, *Aspenites acutus*, in **A**, 2179C-30, H = 1.9 cm, 5-76, *C. j.* **B**, 2179C-15, H = 2.0 cm, 2-94, *C. j.* **C**, 2179C-6, H = 3.0 cm, 1-88, *C. j.* **D**, 2179C-6, H = 4.1 cm. **E-I**, *Aspenites weitschati* n. sp., in **E**, 2180C-37, H = 1.7 cm, 5-76, *A. w.* **F**, 2180C-38, H = 3.3 cm, 1-88, *A. w.* **G**, NMMNH P-79175, paratype, H = 3.7 cm, 5-76, *O. k.* **H**, 2180C-38, H = 4.25 cm, 1-88, *A. w.* **I**, NMMNH P-79174, paratype, H = 5.0 cm, 5-76, *A. w.* **J-M**, *Pseudaspenites balini* Jenks et al, P-60203, holotype, 1-88, *A. w.*, in **J**, lateral, **K**, ventral and **L**, apertural views. **M**, suture line, H = 3.6 cm. All scale bars = 1 cm.

Description: Involute, very compressed, somewhat egressively coiled oxycone with sharply acute keeled venter and aspenitid-like whorl section with maximum thickness at slightly less than one half of whorl height. Very shallow, narrow ($U/D = 0.15$) umbilicus with low-angled wall and gently rounded but distinct shoulders. Body chamber length unknown; specimen is entirely phragmocone. Ornamentation consists of barely noticeable, fairly dense, forward projected, sinuous folds that arise near umbilical shoulder and fade rapidly on converging outer portion of flank. Suture line not completely known, but visible portion is ceratitic with at least two adventitious saddles, fairly broad, weakly indented lobes and slightly asymmetrical saddles.

Measurements: See APPENDIX, p. 173.

Discussion: This is the first reported occurrence of *Pseudaspenites* from eastern Panthalassic localities. Worldwide, the genus is not all that common and until now has been reported only from two Tethyan locations, namely the type locality in Timor (Welter, 1922) and northwestern Guangxi, South China, where Brayard and Bucher (2008) found *P. layeriformis* (Welter), *P. tenuis* (Chao, 1959) and also described a new species, *P. evolutus*. The whorl section of *P. balinii*, while similar to *P. tenuis*, is more compressed than *P. layeriformis* and *P. evolutus*, and its coiling is slightly more involute than *P. evolutus* and *P. tenuis* but slightly less involute than *P. layeriformis*. While *Pseudaspenites balinii*, *P. layeriformis* and *P. evolutus* all have keeled venters, *P. tenuis* lacks a keel. The suture line of *P. balinii*, with at least two adventitious saddles, appears to be intermediate to the specimens from South China and Timor. See Jenks et al. (2010) for a more thorough description and discussion of *P. balinii*.

Occurrence: *Pseudaspenites balinii* is very rare, one specimen found in the *A. weitschati* interval.

Family INCERTAE SEDIS

Genus *Elkoceras* n. gen.

Type species: *Dieneroceras spathi* Kummel and Steele, 1962

Composition of the genus: Type species only.

Etymology: Name derived from Elko County, Nevada.

Diagnosis: Fairly small, fairly evolute, compressed shell with high whorls and gently convex flanks, converging on narrowly rounded venter without distinct shoulders. Fairly shallow, moderately wide umbilicus with steeply inclined walls and well-rounded shoulders. Most shells ornamented only with fine, dense prosiradiate to sinuous growth lines that cover flank and venter. Growth lines on a few shells become weakly bunched, forming very weak, barely visible, dense sinuous ribs on flank, while others exhibit distant, low intensity, prosiradiate to sinuous ribs, fading high on flank without crossing venter. Some extremely well-preserved specimens exhibit relic, dark longitudinal color bands on umbilical wall and venter (Fig. 116P, Q). Suture line ceratitic with two low, broadly rounded saddles and two narrow, well-denticulated lobes.

Discussion: That the genus *Dieneroceras* Spath, 1934 has had somewhat of a troubled past was first demonstrated by Spath (1934, p. 124), when he commented that “the genus may not, at present, seem very satisfactorily established.” Tozer (1969, p. 354), upon examining plaster casts of the genus’ type specimens (*Ophiceras dieneri* Hyatt and Smith), stated that they exhibit distinct ventral shoulders and a tabulate venter, together with a strigate sculpture. This was a most troubling finding, because these features certainly are not evident from the hand-drawn illustrations of the type specimen in Hyatt and Smith (1905) and Smith (1932). These observations apparently led Tozer (1969, 1981, p. 406) to suggest that *Dieneroceras* should be synonymized with *Wyomingites*, but this proposal has never been widely accepted by Triassic workers, and both genera remain valid taxa today. Agreement on the familial attribution

of *Dieneroceras* has also proved elusive, e.g. Flemingitidae by Spath 1934 and Smith 1932; Dieneroceratidae by Kummel 1952; and Meekoceratidae by Tozer 1981 (Brayard and Bucher, 2008). See Brayard and Bucher (2008) for a more thorough discussion of the controversy surrounding the genus *Dieneroceras*.

It is fairly obvious from Spath’s (1934) description of his new genus that he intended it to include only those forms that exhibit serpenticonic coiling. Indeed, several workers (e.g. Tozer, 1969; Brayard and Bucher, 2008) have questioned Kummel and Steele’s (1962) assignment of *D. spathi* to the genus *Dieneroceras* because the high-whorled Crittenden Springs specimens are much more involute than the genus’ type species, *D. dieneri*, and their coiling is not serpenticonic. Subsequently, Tozer, in his unpublished Triassic ammonoid contribution for the new Cephalopoda, Ammonoidea, Treatise on Invertebrate Paleontology, proposed that a new genus, *Elkoceras*, be erected with *Dieneroceras spathi* Kummel and Steele, 1962 as the type species, and attributed its familial association to Popov’s (1961) Nordophiceratidae. Although we herein agree with the need for a new genus, we do have reservations regarding Tozer’s familial assignment. Hence, our treatment of it as *Incertae sedis*. According to Tozer (unpublished), the Nordophiceratidae (Popov, 1961) include a few early to mid Spathian, rather featureless Meekocerataceae ammonoid genera from northeastern Siberia that exhibit similarities with Xenodiscidae, Xenoceltitidae and Ophiceratidae. One such relevant taxon, *Ceratites euomphalus* (Keyserling), which is the type species of the genus *Bajarunia* erected by Dagys (1983), is nearly identical to *E. spathi* n. gen. in conch form and growth line pattern, but it apparently lacks the characteristic low intensity ribbing present on some *E. spathi* n. gen. specimens, and its suture line has much higher saddles. *Bajarunia* is now known to be a common component of the early Spathian *Columbites* beds. e.g., *B. pilata* (Hyatt and Smith) of southeastern Idaho (Guex et al., 2010; Jenks et al., 2013), but it has not yet been reported from the Smithian in any of the eastern Panthalassic basins, and furthermore, its familial assignment has not yet been widely accepted by all Triassic workers; e.g., Guex et al. (2010) treated the genus as *Incertae sedis*. We recognize that Tozer’s (unpublished) familial recommendation may be justified; however, several of the eastern Panthalassic localities contain similar “ophiceratid-like” forms, each of which seems to be unique to a particular area. Therefore, until additional material becomes available for study, we consider the familial association of *E. spathi* n. gen. to be uncertain.

Elkoceras spathi (Kummel and Steele, 1962)

Figure 116

1932 *Ophiceras sakuntala* Diener, Smith, p. 50, pl. 54, figs. 1-17, pl. 56, figs. 13-18.

1962 *Dieneroceras spathi* Kummel and Steele, p. 659, pl. 99, figs. 5-11.

2007 *Dieneroceras spathi* Kummel and Steele, Jenks et al., pl. 1H

Material: 92 measured specimens. Includes 10 illustrated specimens (701C, 2236C, 2237C, 240C, 700C, 928C, 2241C-15, 2241C-38, 2241C-4 and 2241C-55).

Description: Fairly small, moderately evolute, high-whorled, compressed shell characterized by slightly egressive coiling and slightly convex flanks that rapidly converge high on flank to narrowly rounded venter without distinct shoulders. Whorl section compressed ovoid to sub-trapezoidal with maximum width at 35-40% of height. Body chamber length about 1/2 whorl. Relatively shallow umbilicus with width ranging from moderately wide ($U/D=35-40\%$) on mature shells to slightly narrower (25-35%) on juvenile and sub-adult shells. Umbilical wall steeply inclined with well-rounded shoulders. Many shells exhibit no obvious ornamentation other than fine but distinctive, dense, prosiradiate to sinuous growth lines covering entire flank

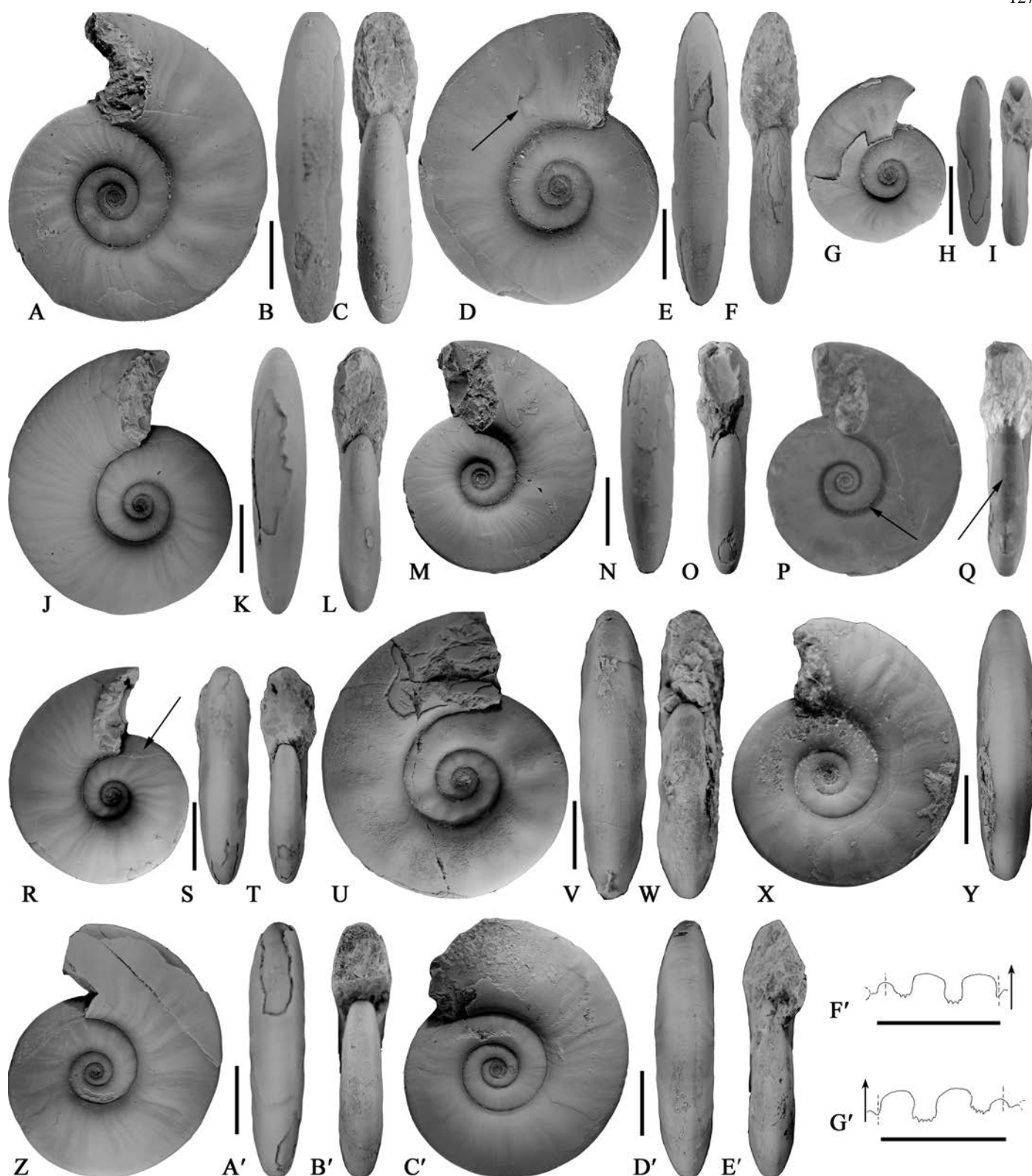


FIGURE 116. *Elcoceras spathi* (Kummel & Steele), A. w. A-C, 701C, 1-88, in A, lateral, B, ventral and C, apertural views. D-F, 2236C, 1-88, in D, lateral (arrow indicates healed injury), E, ventral and F, apertural views. G-I, 2237C, 1-88, in G, lateral, H, ventral and I, apertural views. J-L, 240C, 5-76, in J, lateral, K, ventral and L, apertural views. M-Q, 700C, 1-88, in M, lateral, N, ventral, and O, apertural views, P, unwhitened lateral view (arrow indicates relic color band on umbilical wall) and Q, unwhitened ventral view (arrow indicates relic color band on venter). R-T, 928C, 2-88, in R, lateral (arrow indicates wrinkle layer), S, ventral and T, apertural views. U-W, 2241C-15, 5-76, in U, lateral, V, ventral and W, apertural views. X-Y, 2241C-38, 13-75, in X, lateral and Y, apertural views. Z-B', 2241C-4, 1-79, in Z, lateral, A', ventral and B', apertural views. C'-E', 2241C-55, 5-76, in C', lateral, D', ventral and E', apertural views. F'-G', suture lines, in F', 2241C-48, H = 1.0 cm, 5-76. G', 2241C-74, H = 1.1 cm, 2-79. All scale bars = 1 cm.

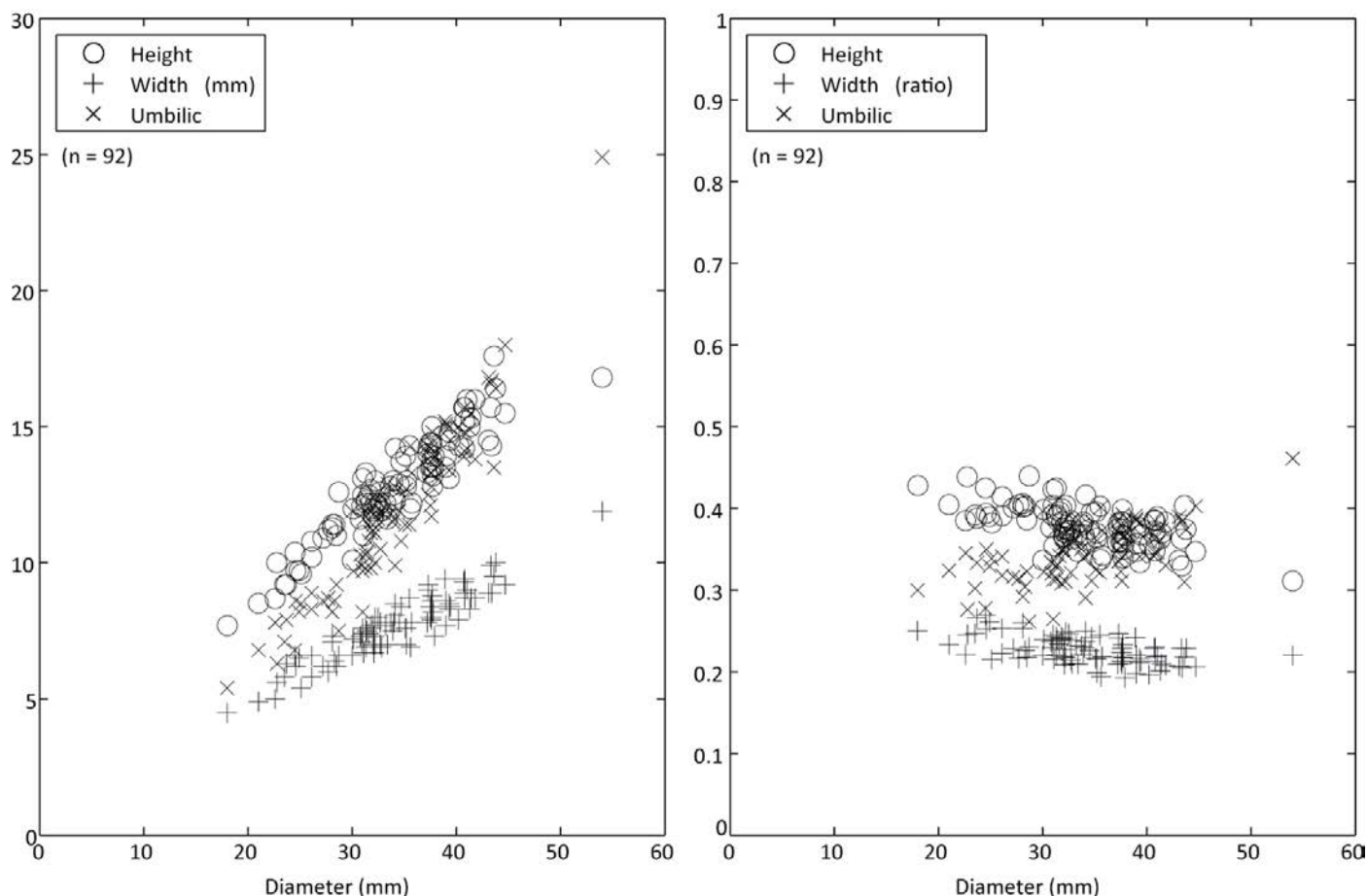


FIGURE 117. Scatter diagrams of H, W and U, and H/D, W/D and U/D for *Elcoceras spathi* n. gen. All specimens from *M. m.* through *G. l.* intervals.

and venter, some of which become slightly bunched, forming very weak, barely visible, dense, sinuous ribs. A few shells are characterized by distant, low intensity but obvious, prosiradiate to sinuous ribs that project high on flank and then fade without crossing venter. A few, very well-preserved specimens preserve relic, dark longitudinal color bands on umbilical wall and venter (Fig. 116P-Q). Suture line ceratitic with two wide but relatively low lateral saddles with broadly rounded tops and two narrow, well denticulated lateral lobes.

Measurements: See Figure 117 and APPENDIX, p. 173.

Discussion: As for the genus.

Occurrence: *Elcoceras spathi* n. gen. occurs from the *M. millardense* FA interval through the *G. lucasi* interval, but is most prevalent in the *A. weitschati* n. sp. interval, where its preservation is usually excellent.

Genus et species indet. A Figure 118A-I

Occurrence: Very rare. Two fairly well preserved specimens and one poorly preserved specimen, all from *C. jattioti* n. gen., n. sp. interval.

Description: Small to medium sized, fairly involute, high whorled, compressed shell with nearly parallel but slightly convex flanks that rapidly converge without distinct shoulders to narrowly rounded venter. Whorl section ovoid to sub-rectangular with maximum thickness at 40-45% of whorl height. Fairly narrow, shallow umbilicus with relatively low, steeply inclined wall and well-rounded shoulders. Body chamber length unknown, all specimens are phragmocones. Ornamentation consists only of dense, fine but distinctive radial, slightly sinuous growth lines that project forward slightly high

on the flank. Specimen illustrated in Figure 118E-G exhibits fine strigation on venter that combines with growth lines to form reticulate sculpture. Suture line ceratitic with second lateral saddle strongly tapered towards umbilicus.

Measurements: See APPENDIX, p. 175.

Discussion: The overall conch shape of the present specimens and the presence of strigation on the venter suggest an affinity with the flemingitids, and although they bear some resemblance to *Anaflemingites silberlingi*, the flanks of this taxon are usually more convex, and its umbilical wall is generally not as steep. Additionally, even though they share similar U/D values, the present specimens are significantly more involute, with a whorl overlap of about 2/3. This contrasts with *A. silberlingi*, whose whorl overlap is about 1/3. Additional material is needed to describe this taxon properly.

Genus et species indet. B Figure 118J-L

Occurrence: Very rare. One small, fairly well preserved specimen from the *C. jattioti* n. gen., n. sp. interval.

Description: Small sized, fairly evolute, compressed shell with nearly flat, parallel flanks that gradually converge without distinctive shoulders to narrowly rounded venter. Whorl section sub-rectangular with maximum width at about 45% of whorl height. Moderately wide, shallow umbilicus with fairly low, steeply inclined wall and well-rounded shoulders. Whorl overlap is about 2/3. Body chamber length not known, specimen is a phragmocone. No visible ornamentation on ultimate whorl other than very fine, weakly visible, radial growth lines. Inner whorls exhibit distant, extremely weak ribs. Suture line ceratitic with long, narrow, phylloid-like saddles.

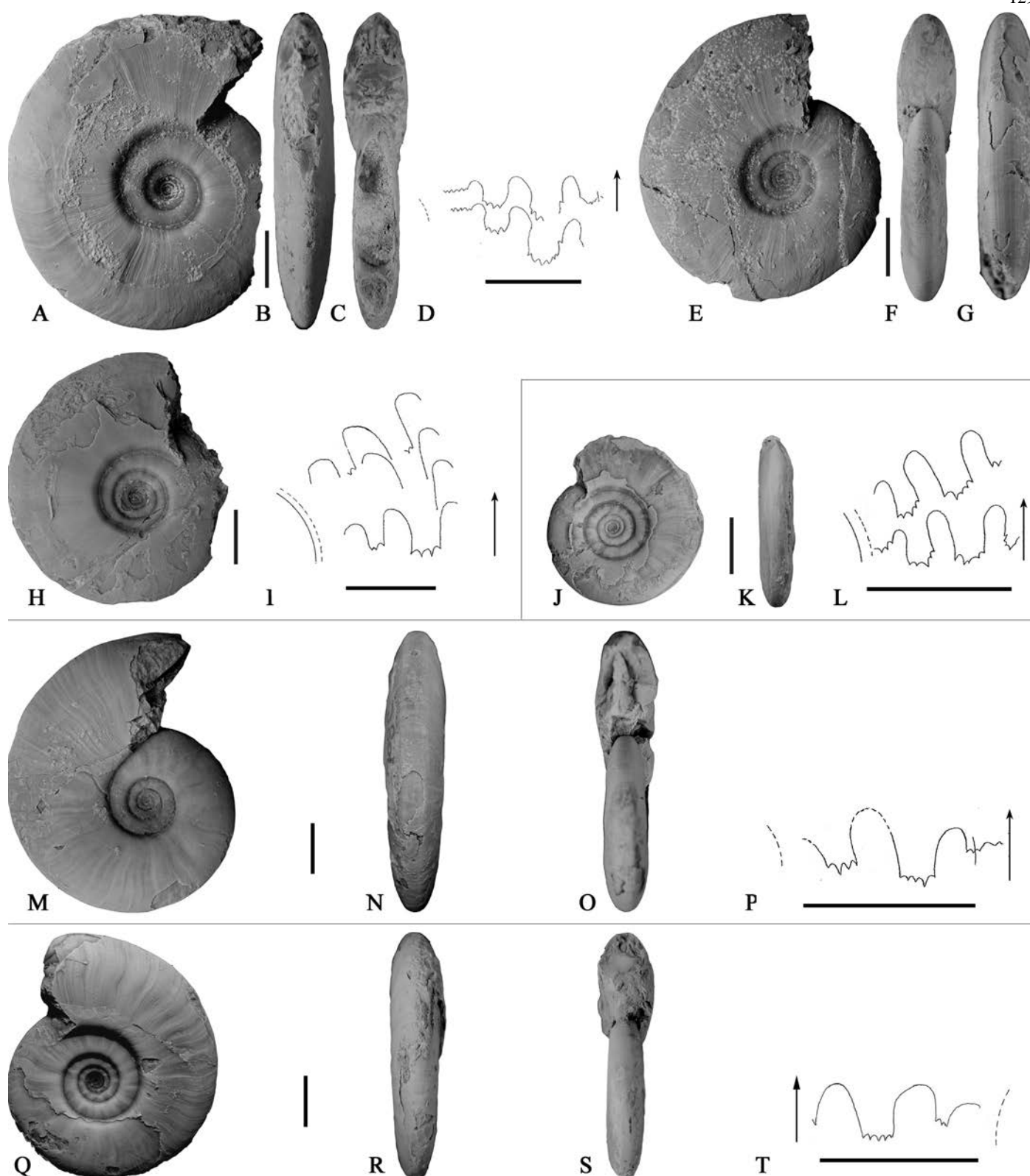


FIGURE 118. **A-I**, Genus et species indet. **A**, in **A-D**, 1484C, 5-76, *C. j.*, in **A**, lateral, **B**, ventral and **C**, apertural views. **D**, suture line, $H = 1.8$ cm. **E-G**, 2249C, 5-76, *C. j.*, in **E**, lateral, **F**, ventral and **G**, apertural views. **H-I**, 2235C, 2-94, *C. j.*, in **H**, lateral view and **I**, suture line, $H = 1.8$ cm. **J-L**, Genus et species indet. **B**, 2234C, 2-94, *C. j.*, in **J**, lateral and **K**, ventral views. **L**, suture line, $H = 1.0$ cm. **M-P**, Genus et species indet. **C**, 708C, 5-76, *C. j.*, in **M**, lateral, **N**, ventral and **O**, apertural views. **P**, suture line, $H = 1.24$ cm. **Q-T**, Genus et species indet. **D**, 610C, 5-76, *C. j.*, in **Q**, lateral, **R**, ventral and **S**, apertural views. **T**, suture line, $H = 1.0$ cm. All scale bars = 1 cm.

Measurements: See APPENDIX, p. 175.

Discussion: The specimen's suture line bears some resemblance to flemingitids with its narrow, phylloid-like saddles, but the near-serpenticonic coiling and weak ribbing on the inner whorls is also suggestive of xenoceltitids. Additional material is needed.

Genus et species indet. C

Figure 118M-P

Occurrence: Very rare. One well-preserved specimen from *C. jattioti* n. gen., n. sp. interval.

Description: Small to medium sized, fairly evolute, high-whorled, compressed shell with gently convex flanks converging to well-rounded ventral shoulders and sub-tabulate venter. Whorl section ovoid to sub-rectangular with maximum thickness at about 50% of whorl height. Fairly narrow to moderately wide umbilicus with relatively low, steeply inclined wall and well-rounded shoulders. Whorl overlap is between 1/3 and 1/2. Body chamber length not known but at least ½ whorl. Ornamentation consists of fine but distinctive growth lines, slightly rursiradiate on umbilical wall, then becoming radial and slightly sinuous. Growth lines tend to be bundled into fairly dense, narrow but barely perceptible, sinuous ribs that arise low on flank and fade before reaching ventral shoulder. Very weak strigation present on upper flank and venter, visible only under magnification. Suture line ceratitic with wide, well-rounded saddles and fairly wide first lateral lobe.

Measurements: See APPENDIX, p. 175.

Discussion: In terms of overall conch shape, the present specimen bears some resemblance to the co-occurring new taxon *Crittendenites jattioti* n. gen., n. sp., but subtle differences are apparent. The present specimen's flanks are slightly more convex, thus producing a noticeably more inflated whorl section with a narrower venter in relation to whorl width. Moreover, the growth lines of the present specimen, while similar in trajectory, tend to be more distinct and slightly more sinuous. Additional material is needed to properly determine this taxon's identity.

Genus et species indet. D

Figure 118Q-T

Occurrence: Very rare. One fairly well preserved specimen from *C. jattioti* n. gen., n. sp. interval.

Description: Small to medium sized, fairly evolute, high whorled, compressed shell with nearly parallel, slightly convex flanks that converge to narrowly rounded venter without distinctive shoulders. Whorl overlap ~50%. Whorl section varies from slightly ovoid to sub-quadrate with maximum width at ~45% of height. Moderately wide, fairly shallow umbilicus with steeply inclined wall and well-rounded shoulders. Body chamber length about 2/3 whorl. Ornamentation on present specimen consists of dense, fine but distinctive growth lines, rursiradiate on umbilical wall, transitioning to radial just above umbilical shoulder, becoming slightly sinuous higher on flank, and then slightly projected when crossing venter. Some growth lines on body chamber are bundled into very low intensity, barely visible, fairly dense ribs that follow trajectory of growth lines. Ribbing on inner whorls more noticeable, arising just above umbilical shoulder and becoming stronger at mid-flank before disappearing under umbilical seam. Suture line ceratitic with wide first lateral saddle and lobe.

Measurements: See APPENDIX, p. 175.

Discussion: When viewed laterally, the present specimen closely resembles Smith's (1932) holotype of *Xenodiscus intermontanus* (pl. 24, figs. 10, 11) from southeastern Idaho. Brayard et al. (2013) synonymized this form and *X. nivalis* Smith with *X. cordilleranus*, a taxon that exhibits wide intraspecific variation, especially with regard to ornamentation. The present specimen exhibits features that are similar to the smooth variant

of *Xenoceltites cordilleranus*, e.g., overall general appearance, noticeable ribbing on its inner whorls and similar suture line, but its significantly more compressed whorl section precludes us from attributing it to this taxon, at least until additional specimens become available. Hence, our treatment of it as Genus et species indet.

ACKNOWLEDGMENTS

The first author greatly appreciates the patience and support of his wife Ruby Jenks during the preparation of this work. The first author is also particularly grateful to Arnaud Brayard, Romain Jattiot, Yasunari Shigeta, Kevin Bylund and Dan Stephen for numerous stimulating discussions regarding Triassic ammonoids and biostratigraphy over the past few years. Dan Levin (USNM, Washington, D.C.), Randall Irmis and Carrie Levitt-Bussian of the NHMU (Curator of Paleontology and Paleontology Collections Manager, respectively) are acknowledged for their help in securing the loan of ammonoid type specimens and the use of their facilities at the NHMU. Fossil localities at the classic Crittenden Springs site lie partly on privately owned land of the Winecup-Gamble Ranch and on US public land (Bureau of Land Management). We are grateful to both entities for allowing access to the fossil sites. This work is a contribution to the ANR project AFTER (ANR-13-JS06-0001-01). An anonymous reviewer, Yasunari Shigeta and Spencer G. Lucas are thanked for the many helpful suggestions that have greatly improved the monograph.

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APPENDIX

Presented below are classic geometric shell measurements (diameter [D], width [W], height [H] and umbilical diameter [U]) for all ammonoid specimens comprising the 60 taxa covered in this work. All specimens are from Crittenden Springs unless otherwise noted. Estimated values are shaded gray.

<i>Proharpoceras carinatitabulatum</i> Chao, n = 1 (from <i>M. millardense</i> FA interval)							
Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2453C	29.3	10.4	8.3	12.2	0.35	0.28	0.42

<i>Kashmirites</i> cf. <i>K. guangxiense</i> Brayard and Bucher, n = 2 (from <i>A. rubyae</i> n. sp. FA interval)							
Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
638C	52.3	14.0	16.9	22.9	0.27	0.32	0.44
2042C	50.3	15.0	17.7	21.9	0.30	0.35	0.44

<i>Preflorianites toulai</i> (Hyatt and Smith), n = 117 (from <i>P. toulai</i> and <i>C. jattioti</i> intervals)							
Number	Dmm	W	H	U	W/D	H/D	U/D
2193C-1	47.7	11.0	18.2	17.2	0.23	0.38	0.36
705C	43.6	10.4	16.1	16.0	0.24	0.37	0.37
2191C-15	42.4	10.1	16.5	14.7	0.24	0.39	0.35
2191C-9	41.9	10.2	15.5	16.1	0.24	0.37	0.38
2193C-10	40.4	10.0	15.2	14.3	0.25	0.38	0.35
2193C-8	40.3	10.6	15.6	14.4	0.26	0.39	0.36
2191C-23	40.3	9.9	15.2	15.0	0.25	0.38	0.37
2191C-19	40.0	10.0	14.8	15.2	0.25	0.37	0.38
2191C-32	38.9	10.1	13.9	14.8	0.26	0.36	0.38
2191C-21	38.5	10.0	14.6	14.8	0.26	0.38	0.38
2193C-62	38.1	10.1	14.3	13.2	0.27	0.38	0.35
2193C-11	37.9	9.1	13.8	14.5	0.24	0.36	0.38
2193C-21	37.9	9.7	14.4	13.1	0.26	0.38	0.35
2193C-6	37.8	9.9	14.9	13.0	0.26	0.39	0.34
2193C-13	37.2	9.1	14.4	12.7	0.24	0.39	0.34
2193C-3	36.9	9.6	14.9	12.1	0.26	0.40	0.33
2191C-27	36.9	9.0	13.3	13.7	0.24	0.36	0.37
2193C-12	36.7	8.8	13.5	13.7	0.24	0.37	0.37
2193C-5	36.6	9.5	13.4	14.0	0.26	0.37	0.38
2193C-23	34.1	9.5	12.1	13.0	0.28	0.35	0.38
2193C-27	33.7	8.9	12.6	12.5	0.26	0.37	0.37
2193C-2	33.0	9.0	12.2	12.3	0.27	0.37	0.37
2193C-39	33.0	8.0	11.6	12.5	0.24	0.35	0.38
2193C-9	32.6	8.6	11.8	12.1	0.26	0.36	0.37
2193C-28	32.0	8.3	12.4	10.9	0.26	0.39	0.34
2193C-45	31.1	7.8	11.1	11.9	0.25	0.36	0.38
2193C-29	30.7	8.4	12.3	10.4	0.27	0.40	0.34
2193C-46	30.7	8.7	10.7	11.0	0.28	0.35	0.36
2193C-40	30.4	8.2	12.1	10.0	0.27	0.40	0.33
2193C-30	29.9	8.2	11.6	10.5	0.27	0.39	0.35
2196C	29.8	7.9	12.0	10.0	0.27	0.40	0.34
2191C-28	29.8	7.5	10.7	11.1	0.25	0.36	0.37

<i>Preflorianites toulai</i> (Hyatt and Smith), n = 117 (from <i>P. toulai</i> and <i>C. jattioti</i> intervals)							
Number	Dmm	W	H	U	W/D	H/D	U/D
933C	29.3	8.5	10.9	10.9	0.29	0.37	0.37
2193C-31	29.1	8.0	11.2	11.0	0.27	0.38	0.38
2193C-25	28.9	8.1	11.6	9.7	0.28	0.40	0.34
2193C-43	28.9	8.1	11.0	9.9	0.28	0.38	0.34
2193C-26	28.6	7.8	10.9	10.2	0.27	0.38	0.36
2193C-48	28.2	8.0	10.7	10.1	0.28	0.38	0.36
2193C-42	27.9	7.7	10.1	10.5	0.28	0.36	0.38
2193C-35	27.8	8.1	11.1	9.3	0.29	0.40	0.33
2193C -49	27.5	7.5	10.6	8.9	0.27	0.39	0.32
2193C-34	27.3	8.0	10.4	9.8	0.29	0.38	0.36
2193C-17	26.9	7.7	10.1	9.8	0.29	0.38	0.36
2194C	26.8	7.7	11.0	9.0	0.29	0.41	0.34
2193C-38	25.6	6.9	9.8	9.5	0.27	0.38	0.37
2193C-53	25.0	7.0	9.9	9.1	0.28	0.40	0.36
2193C-51	24.8	7.1	9.1	9.0	0.29	0.37	0.36
2193C-57	24.8	7.0	9.6	8.9	0.28	0.39	0.36
2193C-37	24.7	7.6	9.4	8.9	0.31	0.38	0.36
2193C-20	23.9	7.0	9.6	8.6	0.29	0.40	0.36
2193C-59	23.9	7.2	9.6	8.6	0.30	0.40	0.36
2193C-19	23.1	6.7	9.2	8.2	0.29	0.40	0.35
2193C-56	22.9	6.1	8.8	8.3	0.27	0.38	0.36
2193C-54	22.3	6.8	9.5	7.1	0.30	0.43	0.32
2193C-55	21.6	6.1	8.2	8.0	0.28	0.38	0.37
2193C-58	21.5	6.7	8.9	7.3	0.31	0.41	0.34
2193C-15	21.0	6.2	8.8	7.3	0.30	0.42	0.35
2193C-16	20.3	6.0	8.1	7.1	0.30	0.40	0.35
2193C-33	20.0	6.3	8.9	6.5	0.32	0.45	0.33
2193C-60	19.8	5.4	7.1	7.5	0.27	0.36	0.38
2193C-61	16.2	5.0	6.0	6.1	0.31	0.37	0.38
2193C-32	16.0	4.9	6.6	5.9	0.31	0.41	0.37
2191C-38	46.5	11.7	17.2	17.6	0.25	0.37	0.38
2531C	85.6	23.0	31.7	31.0	0.27	0.37	0.36
2530C	64.0	17.5	25.0	21.1	0.27	0.39	0.33
2199C-1	63.1	17.5	24.0	21.1	0.28	0.38	0.33
116C	58.0	14.0	21.4	21.2	0.24	0.37	0.37
244C	54.3	13.7	20.4	19.0	0.25	0.38	0.35
2199C-17	53.8	12.9	20.0	19.1	0.24	0.37	0.36
2199C-9	53.4	13.5	19.6	20.9	0.25	0.37	0.39
306C	49.7	13.7	19.0	19.0	0.28	0.38	0.38
2199C-2	47.0	11.0	17.0	16.9	0.23	0.36	0.36
746C	46.9	12.6	18.9	15.8	0.27	0.40	0.34
2199C-11	46.9	11.9	16.9	17.5	0.25	0.36	0.37
695C	46.1	11.9	18.1	15.8	0.26	0.39	0.34
2199C-24	45.9	11.0	18.0	15.4	0.24	0.39	0.34
2199C-3	45.7	11.1	17.8	16.0	0.24	0.39	0.35
2199C-10	45.6	10.5	16.5	16.9	0.23	0.36	0.37
2199C-22	44.5	10.7	16.2	16.2	0.24	0.36	0.36

***Preflorianites toulai* (Hyatt and Smith), n = 117**
(from *P. toulai* and *C. jattioti* intervals)

Number	Dmm	W	H	U	W/D	H/D	U/D
2199C-44	44.4	10.8	16.3	16.0	0.24	0.37	0.36
2199C-13	44.2	11.3	17.8	15.0	0.26	0.40	0.34
2199C-39	44.0	11.8	16.3	14.7	0.27	0.37	0.33
2199C-16	43.9	11.9	17.8	14.1	0.27	0.41	0.32
2199C-6	43.4	11.0	15.9	16.5	0.25	0.37	0.38
2199C-31	41.9	10.8	17.0	13.4	0.26	0.41	0.32
2198C	41.1	11.5	16.0	14.9	0.28	0.39	0.36
2199C-35	40.7	10.6	16.7	12.8	0.26	0.41	0.31
2199C-12	40.0	10.8	17.3	11.3	0.27	0.43	0.28
2199C-23	39.9	10.0	15.0	14.0	0.25	0.38	0.35
2199C-4	39.1	11.0	14.1	13.4	0.28	0.36	0.34
2199C-14	38.8	9.0	15.4	13.0	0.23	0.40	0.34
2197C	37.2	10.6	15.9	11.6	0.28	0.43	0.31
2199C-45	36.1	9.7	14.3	11.2	0.27	0.40	0.31
2199C-25	35.7	9.8	14.6	11.5	0.27	0.41	0.32
2199C-29	34.9	9.0	13.9	11.7	0.26	0.40	0.34
2199C-34	34.9	8.7	15.0	10.3	0.25	0.43	0.30
2199C-7	34.0	9.0	14.0	11.0	0.26	0.41	0.32
2199C-32	32.0	9.4	13.5	10.4	0.29	0.42	0.33
2199C-21	30.4	8.1	12.7	9.7	0.27	0.42	0.32
2199C-33	29.0	8.4	13.0	8.2	0.29	0.45	0.28
2199C-20	28.8	6.8	9.5	10.0	0.24	0.33	0.35
2199C-28	28.7	8.0	11.7	8.9	0.28	0.41	0.31
2199C-15	28.4	7.8	11.7	9.2	0.27	0.41	0.32
2199C-19	27.6	7.8	11.4	8.7	0.28	0.41	0.32
2199C-30	27.0	7.9	10.5	9.0	0.29	0.39	0.33
2199C-37	27.0	8.0	11.8	8.0	0.30	0.44	0.30
2199C-27	25.4	8.0	10.5	8.6	0.31	0.41	0.34
2199C-41	20.7	5.9	8.3	7.4	0.29	0.40	0.36
2199C-8	20.6	6.6	8.7	6.9	0.32	0.42	0.33
2199C-26	20.0	6.0	8.3	6.0	0.30	0.42	0.30
2199C-5	18.9	6.1	8.1	6.1	0.32	0.43	0.32
2199C-36	17.7	5.0	7.9	5.1	0.28	0.45	0.29
2199C-38	17.7	5.8	7.1	6.1	0.33	0.40	0.34
2199C-18	17.6	5.4	7.8	5.5	0.31	0.44	0.31
2199C-42	17.4	5.6	7.0	5.9	0.32	0.40	0.34
2199C-43	14.3	4.9	6.0	4.9	0.34	0.42	0.34
2199C-40	12.1	4.2	5.0	4.2	0.35	0.41	0.35

<i>Preflorianites</i> cf. <i>P. radians</i> Chao, n = 50 (from <i>P. toulai</i> interval)							
Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2191C-17	66.0	15.5	20.3	31.3	0.23	0.31	0.47
886C	61.9	14.4	20.8	26.4	0.23	0.34	0.43
2191C-6	55.9	13.1	17.7	26.1	0.23	0.32	0.47
2191C-1	53.7	12.0	18.7	22.0	0.22	0.35	0.41
278C	52.6	11.8	15.2	25.2	0.22	0.29	0.48
2191C-36	50.7	11.0	18.0	20.0	0.22	0.36	0.39
2191C-2	49.6	12.4	15.9	22.7	0.25	0.32	0.46
2191C-13	49.3	11.0	14.9	23.2	0.22	0.30	0.47
243C	48.9	11.4	16.1	21.1	0.23	0.33	0.43
2191C-11	48.7	11.7	16.7	20.9	0.24	0.34	0.43
2191C-7	48.6	10.6	15.0	21.7	0.22	0.31	0.45
2192C	47.8	9.4	13.3	23.9	0.20	0.28	0.50
2191C-5	47.7	11.4	15.9	19.1	0.24	0.33	0.40
2191C-3	46.7	11.3	14.5	22.1	0.24	0.31	0.47
2191C-25	45.8	10.4	15.7	18.6	0.23	0.34	0.41
2191C-10	44.1	10.2	15.9	17.9	0.23	0.36	0.41
2191C-12	44.0	10.0	15.5	18.6	0.23	0.35	0.42
2191C-14	43.0	9.8	14.5	18.4	0.23	0.34	0.43
2191C-16	42.1	9.7	14.9	16.9	0.23	0.35	0.40
2191C-8	41.4	9.5	14.4	16.7	0.23	0.35	0.40
2191C-26	41.0	10.2	14.7	16.6	0.25	0.36	0.40
2191C-20	40.9	10.2	14.5	16.0	0.25	0.35	0.39
2191C-37	40.8	10.0	14.1	16.3	0.25	0.35	0.40
2191C-34	40.2	10.5	12.7	16.9	0.26	0.32	0.42
703C	38.1	9.8	13.9	14.7	0.26	0.36	0.39
2191C-4	37.9	9.7	13.2	15.7	0.26	0.35	0.41
2191C-31	37.0	10.2	13.1	15.1	0.28	0.35	0.41
2193C-7	36.1	9.0	13.2	14.0	0.25	0.37	0.39
2191C-24	35.6	9.0	12.6	14.0	0.25	0.35	0.39
2191C-33	35.6	10.5	11.0	15.9	0.29	0.31	0.45
2200C	35.3	8.8	11.7	15.8	0.25	0.33	0.45
2191C-22	34.9	9.2	12.8	13.7	0.26	0.37	0.39
2191C-18	32.3	8.1	11.1	12.9	0.25	0.34	0.40
2193C-47	31.1	8.0	11.6	12.0	0.26	0.37	0.39
2193C-41	30.3	8.0	9.9	12.0	0.26	0.33	0.40
2193C-50	30.0	7.7	10.3	12.0	0.26	0.34	0.40
2193C-24	29.8	7.9	10.6	11.5	0.27	0.36	0.39
2193C-44	27.9	7.6	9.9	11.1	0.27	0.35	0.40
704C	27.8	7.6	9.8	11.1	0.27	0.35	0.40
2195C	27.5	7.2	10.0	10.6	0.26	0.36	0.39
2191C-35	27.1	7.7	9.8	10.8	0.28	0.36	0.40
2193C-36	25.5	7.8	9.7	9.9	0.31	0.38	0.39
2191C-30	24.7	6.0	8.4	9.9	0.24	0.34	0.40
2193C-4	23.6	6.7	8.5	9.5	0.28	0.36	0.40
2191C-29	23.1	7.0	7.1	10.3	0.30	0.31	0.45
2193C-52	22.0	6.6	7.9	8.9	0.30	0.36	0.40
2193C-22	21.6	6.2	8.1	8.7	0.29	0.38	0.40
2193C-14	19.9	6.0	7.8	7.8	0.30	0.39	0.39
2191C-39	18.9	5.6	6.6	8.0	0.30	0.35	0.42
2193C-18	18.6	5.8	7.1	7.5	0.31	0.38	0.40

***Condensoceras youngi* n. gen. (Kummel and Steele), n = 86**
(from *C. youngi* n. gen. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
275C	59.8	14.6	22.9	19.7	0.24	0.38	0.33
2542C-1	52.0	11.7	19.5	17.4	0.23	0.38	0.33
2	49.0	12.9	20.1	15.7	0.26	0.41	0.32
3	39.3	11.0	14.9	12.9	0.28	0.38	0.33
4	51.6	14.1	18.9	18.5	0.27	0.37	0.36
5	60.2	13.0	22.7	20.2	0.22	0.38	0.34
6	44.7	10.7	18.0	13.1	0.24	0.40	0.29
7	31.9	8.0	13.0	10.1	0.25	0.41	0.32
8	48.9	11.8	18.0	16.8	0.24	0.37	0.34
9	60.0	14.6	23.0	19.0	0.24	0.38	0.32
10	42.5	10.3	17.9	13.5	0.24	0.42	0.32
11	36.4	10.3	15.8	10.3	0.28	0.43	0.28
12	43.8	10.5	17.1	13.2	0.24	0.39	0.30
13	41.0	9.9	17.9	10.7	0.24	0.44	0.26
14	36.1	7.9	15.0	9.8	0.22	0.42	0.27
15	37.0	7.6	15.3	11.5	0.21	0.41	0.31
16	42.3	10.3	17.2	13.0	0.24	0.41	0.31
17	55.9	14.4	23.4	17.9	0.26	0.42	0.32
18	39.0	8.1	15.1	12.0	0.21	0.39	0.31
19	45.5	12.6	17.0	15.8	0.28	0.37	0.35
20	37.8	8.3	15.3	11.1	0.22	0.40	0.29
21	39.4	11.0	15.3	13.6	0.28	0.39	0.35
22	35.9	10.3	14.5	11.1	0.29	0.40	0.31
23	46.9	13.6	17.6	16.9	0.29	0.38	0.36
24	28.0	7.2	12.5	8.1	0.26	0.45	0.29
25	31.9	8.6	13.4	9.3	0.27	0.42	0.29
26	41.1	9.6	17.0	12.6	0.23	0.41	0.31
27	28.0	6.2	12.8	7.3	0.22	0.46	0.26
28	55.8	14.9	22.1	19.1	0.27	0.40	0.34
29	43.0	9.3	16.4	14.9	0.22	0.38	0.35
31	43.0	9.3	18.4	12.2	0.22	0.43	0.28
32	40.1	11.0	16.0	12.7	0.27	0.40	0.32
33	35.4	9.5	14.9	10.9	0.27	0.42	0.31
34	34.4	10.0	14.1	11.0	0.29	0.41	0.32
35	34.9	9.8	14.8	11.0	0.28	0.42	0.32
36	34.0	8.7	13.7	11.3	0.26	0.40	0.33
37	36.7	10.1	13.9	12.5	0.28	0.38	0.34
38	29.8	6.6	12.1	9.0	0.22	0.41	0.30
39	30.7	7.8	13.5	8.2	0.25	0.44	0.27
40	33.7	9.5	14.0	10.7	0.28	0.42	0.32
41	30.3	7.5	13.1	8.2	0.25	0.43	0.27
42	21.9	5.0	9.1	6.7	0.23	0.42	0.31
43	25.3	5.6	10.2	8.0	0.22	0.40	0.32
44	46.9	13.2	18.5	16.5	0.28	0.39	0.35
45	43.9	10.7	17.8	14.9	0.24	0.41	0.34
46	46.0	9.9	16.8	15.9	0.22	0.37	0.35
47	45.4	13.0	17.1	15.6	0.29	0.38	0.34
48	41.5	10.9	16.5	13.8	0.26	0.40	0.33
49	51.9	13.7	20.3	17.0	0.26	0.39	0.33
50	29.8	8.0	11.7	9.6	0.27	0.39	0.32
51	31.9	8.2	13.9	8.3	0.26	0.44	0.26
52	40.3	11.7	16.3	12.2	0.29	0.40	0.30
53	32.3	7.9	12.8	10.3	0.24	0.40	0.32
54	30.0	6.9	12.3	9.9	0.23	0.41	0.33
55	36.2	10.0	15.6	10.4	0.28	0.43	0.29
56	44.3	11.2	16.9	16.0	0.25	0.38	0.36
57	18.0	5.0	7.6	5.9	0.28	0.42	0.33
58	38.0	8.1	14.6	12.9	0.21	0.38	0.34
59	40.2	9.3	15.0	14.0	0.23	0.37	0.35
60	26.7	7.2	12.1	7.2	0.27	0.45	0.27
61	37.0	10.2	14.0	12.6	0.28	0.38	0.34
62	41.0	10.0	17.6	11.6	0.24	0.43	0.28
63	34.9	7.8	13.9	9.8	0.22	0.40	0.28
64	39.4	10.3	15.6	12.9	0.26	0.40	0.33
65	30.7	7.6	14.0	8.0	0.25	0.46	0.26
66	28.7	6.3	12.7	8.0	0.22	0.44	0.28
67	42.6	11.8	17.1	14.0	0.28	0.40	0.33
68	29.0	6.9	12.8	7.6	0.24	0.44	0.26
69	22.7	5.2	9.7	6.3	0.23	0.43	0.28
70	40.1	8.7	16.1	12.3	0.22	0.40	0.31
71	45.3	12.0	19.1	14.0	0.26	0.42	0.31
72	31.6	6.9	11.9	11.1	0.22	0.38	0.35

***Condensoceras youngi* n. gen. (Kummel and Steele), n = 86**
(from *C. youngi* n. gen. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
73	37.1	9.5	16.0	9.9	0.26	0.43	0.27
74	41.0	12.5	17.0	12.6	0.30	0.41	0.31
75	36.1	7.6	15.9	10.3	0.21	0.44	0.29
76	28.7	6.7	11.9	8.9	0.23	0.41	0.31
77	29.0	7.8	11.6	8.8	0.27	0.40	0.30
78	22.8	5.9	9.7	6.8	0.26	0.43	0.30
79	26.0	6.7	11.2	7.9	0.26	0.43	0.30
80	19.8	4.9	8.6	5.9	0.25	0.43	0.30
81	44.1	11.9	18.9	13.0	0.27	0.43	0.29
82	49.8	13.9	19.1	16.7	0.28	0.38	0.34
83	43.7	10.7	16.8	15.8	0.24	0.38	0.36
84	47.0	11.3	19.0	15.3	0.24	0.40	0.33
85	41.0	11.1	17.8	11.6	0.27	0.43	0.28
86	33.1	8.2	13.6	10.8	0.25	0.41	0.33

***Xenoceltites subevolatus* Spath, n = 32**
(2543C-1 through 20, 2543C-30, 2545C and 2203C from *C. youngi* n. gen. interval, n = 23;
remainder from a single *A. multiformis* lense, n = 9)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2543C-1	78.3	16.1	26.8	31.3	0.21	0.34	0.40
2	58.1	14.1	17.1	27.0	0.24	0.29	0.46
3	33.9	8.3	10.7	15.0	0.24	0.32	0.44
4	27.0	6.6	9.6	10.3	0.24	0.36	0.38
5	35.0	8.8	11.7	14.0	0.25	0.33	0.40
6	39.3	8.0	13.3	15.9	0.20	0.34	0.40
7	43.7	9.7	12.9	20.1	0.22	0.30	0.46
8	33.6	6.6	10.4	14.6	0.20	0.31	0.43
9	48.7	10.5	16.8	20.0	0.22	0.34	0.41
10	42.9	9.8	15.2	15.7	0.23	0.35	0.37
11	24.2	6.0	8.7	10.1	0.25	0.36	0.42
12	32.9	8.0	10.0	14.1	0.24	0.30	0.43
13	41.6	9.7	12.5	19.0	0.23	0.30	0.46
14	35.9	8.0	12.8	14.4	0.22	0.36	0.40
15	28.9	6.8	10.0	11.8	0.24	0.35	0.41
16	35.1	7.7	12.9	13.8	0.22	0.37	0.39
17	33.2	6.9	9.6	16.3	0.21	0.29	0.49
18	18.3	4.4	6.1	7.9	0.24	0.33	0.43
19	37.7	9.0	13.0	14.6	0.24	0.34	0.39
20	21.5	5.0	7.2	9.3	0.23	0.33	0.43
30	15.9	5.2	5.9	6.0	0.33	0.37	0.38
2138C	43.3	9.9	14.1	19.3	0.23	0.33	0.45
2139C	44.3	10.5	14.9	19.8	0.24	0.34	0.45
2140C	34.5	8.5	10.8	15.6	0.25	0.31	0.45
2141C	35.1	8.3	11.8	15.4	0.24	0.34	0.44
2142C	32.3	8.0	10.8	13.9	0.25	0.33	0.43
2143C a	24.9	5.4	8.9	9.3	0.22	0.36	0.37
2143C b	19.4	4.6	7.0	7.4	0.24	0.36	0.38
2144C	31.3	7.1	9.7	14.6	0.23	0.31	0.47
2145C	39.2	9.1	14.0	15.8	0.23	0.36	0.40
2545C	63.0	14.2	19.0	28.1	0.23	0.30	0.45
2203C	54.1	10.3	17.2	22.3	0.19	0.32	0.41

***Glyptohiceras* cf. *G. sinuatum* Spath, n = 7**
(from *C. youngi* n. gen. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2546C	55.1	12.9	17.6	24.3	0.23	0.32	0.44
2547C	48.4	10.6	15.0	22.3	0.22	0.31	0.46
2551C	60.7	17.3	21.8	24.8	0.29	0.36	0.41
2548C	32.0	8.8	12.9	10.8	0.28	0.40	0.34
2146C	60.0	12.2	18.4	26.5	0.20	0.31	0.44
250C	36.1	10.0	13.5	14.6	0.28	0.37	0.40
2549C	56.0	15.8	17.0	23.5	0.28	0.30	0.42

***Pseudaspidites silberlingi* Jenks et al., n = 10**
(from *P. toulai* and *C. jattioti* n. gen., n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-51301	126.6	30.1	65.3	25.0	0.24	0.52	0.20
693C	104.9	24.6	56.3	16.3	0.23	0.54	0.16
NMMNH P-60166	92.1	21.0	47.1	16.9	0.23	0.51	0.18
NMMNH P-60167	65.3	-	34.5	12.1	-	0.53	0.19
NMMNH P-60168	52.9	14.3	27.9	8.8	0.27	0.53	0.17
694C	143.4	30.9	68.1	30.3	0.22	0.47	0.21
1999C	94.2	20.7	44.1	22.3	0.22	0.47	0.24
2134C	107.0	25.7	51.6	21.5	0.24	0.48	0.20
2130C	72.6	18.5	37.1	13.4	0.25	0.51	0.18
2123C	46.9	13.0	22.0	11.1	0.28	0.47	0.24

***Guodunites* cf. *G. monneti* Brayard and Bucher, n = 1**
(from *C. jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2000C	72.5	14.3	36.7	13.2	0.20	0.51	0.18

***Gambleites eichhorni* n. gen., n. sp., n = 3**
(from *G. lucasi* interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-79155, holotype	27.0	9.0	17.1	1.0	0.33	0.63	0.04
NMMNH P-79157, paratype	22.9	7.0	14.1	0.75	0.31	0.62	0.03
NMMNH P-79156, paratype	17.3	6.7	10.3	0.75	0.39	0.60	0.04

***Galfettites lucasi* Jenks et al., 2010, n = 5**
(from *G. lucasi* interval. All specimens incomplete – measurements obtained at less than maximum diameter)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-60170	76.8	14.5	32.0	24.0	0.19	0.42	0.31
NMMNH P-60171	88.8	15.0	37.9	24.8	0.17	0.43	0.28
NMMNH P-60172	86.2	16.4	40.3	21.0	0.19	0.47	0.24
90C	98.0	15.0	43.7	26.9	0.15	0.45	0.27
2021C	32.7	5.9	14.3	9.2	0.18	0.44	0.28

***Montelloites stephensi* n. gen., n. sp., n = 2**
(from *G. lucasi* interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-79158, holotype	41.7	9.7	18.8	12.0	0.23	0.45	0.29
NMMNH P-79159, paratype	38.8	7.6	18.1	10.0	0.20	0.47	0.26

***Anaflemingites silberlingi* Kummel and Steele, n = 24**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2105C	150.7	24.4	58.3	50.4	0.16	0.39	0.33
2121C	114.0	21.8	47.4	34.7	0.19	0.42	0.30
645C	110.0	19.7	49.5	27.7	0.18	0.45	0.25
2119C	104.0	21.3	41.7	34.1	0.21	0.40	0.33
2136C	100.1	21.0	41.5	29.8	0.21	0.41	0.30
2108C	99.6	19.6	41.5	29.8	0.20	0.42	0.30
2116C	98.4	18.3	41.1	26.3	0.19	0.42	0.27
144C	97.3	19.2	40.7	31.4	0.20	0.42	0.32
2111C	91.0	18.3	35.7	31.4	0.20	0.39	0.35
MCZ 106044, holotype	87.3	18.4	36.6	31.3	0.21	0.42	0.36
2114C	81.4	16.1	36.0	21.7	0.20	0.44	0.27
2124C	76.0	16.0	30.9	21.7	0.21	0.41	0.29
2112C	72.0	17.5	30.2	24.0	0.24	0.42	0.33
2129C	70.9	15.6	30.0	21.9	0.22	0.42	0.31
2118C	70.0	15.0	29.4	21.5	0.21	0.42	0.31
2127C	59.0	12.1	24.0	19.2	0.21	0.41	0.33
2113C	58.0	12.2	25.8	16.2	0.21	0.45	0.28
2133C	57.9	13.3	26.1	16.0	0.23	0.45	0.28
2117C	57.8	12.7	24.0	18.0	0.22	0.42	0.31
2115C	55.0	12.1	26.0	12.8	0.22	0.47	0.23
2126C	54.7	12.3	25.5	12.9	0.22	0.47	0.24
2131C	54.1	10.5	23.6	14.8	0.19	0.44	0.27
2125C	52.1	10.9	22.9	15.0	0.21	0.44	0.29
2122C	45.5	10.4	20.9	12.6	0.23	0.46	0.28

***Euflemingites cirratus* (White), n = 1**
(from *C. jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
321C	228	82.4	85.2	76.0	0.36	0.37	0.33

***Dieneroceras dieneri* (Hyatt & Smith), n = 13**
(from *C. jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2319C	31.7	8.8	10.9	13.7	0.28	0.34	0.43
2318C	28.8	8.1	8.9	13.4	0.28	0.31	0.47
2189C-8	27.1	6.1	9.0	11.4	0.23	0.33	0.42
2189C-5	27.0	5.7	8.4	12.9	0.21	0.31	0.48
2189C-11	26.9	6.7	8.8	12.0	0.25	0.33	0.45
2189C-9	26.1	6.1	8.9	11.5	0.23	0.34	0.44
2189C-6	25.2	5.9	8.0	10.9	0.23	0.32	0.43
2189C-7	24.8	6.2	8.2	10.9	0.25	0.33	0.44
2189C-3	24.7	6.0	8.7	10.6	0.24	0.35	0.43
2189C-10	23.4	6.0	8.0	10.0	0.26	0.34	0.43
2189C-4	18.9	5.0	6.8	8.1	0.26	0.36	0.43
2189C-12	15.1	3.9	5.3	6.3	0.26	0.35	0.42
2189C-13	12.0	3.9	4.5	5.6	0.33	0.38	0.47

***Dieneroceras* cf. *D. dieneri* (Hyatt and Smith), n = 32**
(from *C. jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
923C	63.3	13.8	21.3	26.8	0.22	0.34	0.42
2190C-20	57.7	11.3	19.9	23.9	0.20	0.34	0.41
709C	56.0	13.2	17.1	25.9	0.24	0.31	0.46
311C	48.1	10.7	15.4	21.2	0.22	0.32	0.44
930C	48.0	10.5	15.3	20.7	0.22	0.32	0.43
2190C-3	44.6	11.5	14.9	19.0	0.26	0.33	0.43
2190C-14	43.9	11.1	15.0	17.9	0.25	0.34	0.41
2190C-1	43.2	8.8	14.7	18.1	0.20	0.34	0.42
2190C-2 *	42.6	8.5	14.9	17.7	0.20	0.35	0.42
2190C-15	41.0	9.7	13.7	16.8	0.24	0.33	0.41
2190C-13	40.8	9.1	14.0	16.0	0.22	0.34	0.39
2190C-24	39.9	9.1	14.7	14.8	0.23	0.37	0.37
2190C-6	38.9	9.2	13.9	14.8	0.24	0.36	0.38
2190C-11	38.8	8.9	12.9	16.1	0.23	0.33	0.41
2190C-17	37.9	9.4	14.0	13.7	0.25	0.37	0.36
2190C-26	37.3	10.2	13.8	14.0	0.27	0.37	0.38
2190C-4	36.1	9.2	12.9	14.4	0.25	0.36	0.40
2190C-9	36.1	9.0	12.7	15.0	0.25	0.35	0.42
2190C-5	36.0	8.3	12.4	14.7	0.23	0.34	0.41
2190C-16	35.6	9.7	13.4	12.9	0.27	0.38	0.36
2190C-10	35.0	8.7	11.9	15.0	0.25	0.34	0.43
2190C-19 *	34.7	8.1	12.4	13.0	0.23	0.36	0.37
2190C-18	34.6	7.9	11.7	13.6	0.23	0.34	0.39
2190C-12	34.1	8.9	12.2	13.1	0.26	0.36	0.38
2190C-22	33.8	7.9	11.7	13.0	0.23	0.35	0.38
2190C-25	31.7	8.7	11.0	12.6	0.27	0.35	0.40
2190C-8	31.3	8.6	10.8	13.8	0.27	0.35	0.44
2190C-23	30.6	7.7	10.8	11.7	0.25	0.35	0.38
2190C-27	29.2	8.2	10.2	12.0	0.28	0.35	0.41
2190C-7	28.8	8.0	10.1	11.5	0.28	0.35	0.40
2190C-21	27.0	7.9	10.2	9.9	0.29	0.38	0.37
2190C-28	24.9	7.0	8.7	9.7	0.28	0.35	0.39

***Dieneroceras knechti* (Hyatt & Smith), n = 44**
(from *M. millardense* FA through *G. lucasi* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
699C	39.1	9.1	12.2	17.9	0.23	0.31	0.46
2242C-37	32.3	6.4	9.9	15.2	0.20	0.31	0.47
276C	31.9	7.4	8.7	16.1	0.23	0.27	0.50
2242C-14	31.2	7.4	10.4	13.7	0.24	0.33	0.44
2242C-2	30.3	6.4	10.5	12.0	0.21	0.35	0.40
2242C-21	29.9	6.6	8.4	14.8	0.22	0.28	0.49
2238C	29.6	5.8	8.7	15.0	0.20	0.29	0.51
2242C-13	28.8	6.7	8.8	13.1	0.23	0.31	0.45
2242C-24	27.8	7.1	9.2	12.1	0.26	0.33	0.44
2242C-36	26.8	6.7	8.3	11.3	0.25	0.31	0.42
2242C-11	26.4	6.2	7.6	12.7	0.23	0.29	0.48
2242C-1	26.1	6.0	8.1	11.8	0.23	0.31	0.45
2242C-34	26.0	6.3	8.4	11.4	0.24	0.32	0.44
2242C-12	25.9	6.1	7.2	13.4	0.24	0.28	0.52
2242C-29	25.6	6.1	8.0	12.5	0.24	0.31	0.49
2242C-28	25.3	6.0	7.7	12.2	0.24	0.30	0.48
2239C	24.8	5.6	7.1	12.5	0.23	0.29	0.50
2242C-17	24.5	5.7	7.5	11.0	0.23	0.31	0.45
2242C-32	24.1	5.4	7.7	10.4	0.22	0.32	0.43
2242C-30	23.9	6.1	7.3	11.4	0.26	0.31	0.48
2242C-27	23.5	5.5	7.7	10.2	0.23	0.33	0.43
2242C-31	23.5	6.4	7.7	10.6	0.27	0.33	0.45
2242C-16	23.4	5.5	7.2	11.0	0.24	0.31	0.47
2242C-18	23.4	4.6	7.6	10.5	0.20	0.32	0.45
2242C-19	23.2	5.7	7.4	10.1	0.25	0.32	0.44
2242C-4	22.7	5.5	7.2	10.5	0.24	0.32	0.46
2240C	22.4	5.5	6.9	10.4	0.25	0.31	0.46
2242C-3	22.3	5.3	7.2	9.5	0.24	0.32	0.43
2242C-23	21.5	5.1	7.4	8.7	0.24	0.34	0.40
2242C-25	21.5	5.3	7.0	9.5	0.25	0.33	0.44
2242C-7	21.4	5.4	6.3	10.7	0.25	0.29	0.50
2242C-6	21.3	5.6	7.1	8.4	0.26	0.33	0.39
2242C-39	21.3	5.1	7.0	9.2	0.24	0.33	0.43
2242C-33	21.2	5.3	7.0	8.9	0.25	0.33	0.42
2242C-35	21.1	5.1	7.4	8.7	0.24	0.35	0.41
2242C-26	20.6	5.0	7.5	8.0	0.24	0.36	0.39
2242C-10	20.5	5.3	6.7	9.3	0.26	0.33	0.45
2242C-9	20.1	5.3	7.3	8.0	0.26	0.36	0.40
2242C-20	20.1	5.2	7.2	7.8	0.26	0.36	0.39
2242C-22	16.9	4.2	5.3	7.7	0.25	0.31	0.46
2242C-38	16.6	4.6	5.2	8.0	0.28	0.31	0.48
2242C-15	16.1	3.9	5.5	6.9	0.24	0.34	0.43
2242C-8	15.7	4.1	5.1	7.1	0.26	0.32	0.45
2242C-5	13.7	3.9	4.2	6.6	0.28	0.31	0.48

***Dieneroceras subquadratum* (Smith), n = 16**
(12 from Jenks collection, 4 from MCZ collection)
(from *G. lucasi* through *C. jattioti* n. gen., n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
890C	45.9	11.1	16.5	18.3	0.24	0.36	0.40
891C	42.6	12.2	14.9	17.4	0.29	0.35	0.41
303C	38.9	10.7	12.9	17.7	0.28	0.33	0.46
MCZ 106965-1	34.7	10.0	12.9	12.0	0.29	0.37	0.35
MCZ 106963	33.3	10.0	12.3	12.1	0.30	0.37	0.36
2218C-8	33.0	9.0	13.6	11.6	0.27	0.41	0.35
2218C-7	32.8	10.0	12.7	11.9	0.30	0.39	0.36
2218C-1	31.1	9.0	13.0	9.9	0.29	0.42	0.32
MCZ 106965-2	31.0	9.7	11.4	10.9	0.31	0.37	0.35
2218C-3	30.2	8.4	11.1	11.8	0.28	0.37	0.39
2218C-2	28.3	9.2	11.8	9.4	0.33	0.42	0.33
2218C-5	26.7	8.2	9.9	10.3	0.31	0.37	0.39
2218C-6	24.7	7.9	9.0	9.9	0.32	0.36	0.40
MCZ 106964	23.0	6.9	9.7	8.0	0.30	0.42	0.35
2218C-9	23.0	7.9	9.8	7.7	0.34	0.43	0.33
2218C-4	20.4	6.2	8.6	6.9	0.30	0.42	0.34

***Crittendenites jattioti* n. gen., n. sp., n = 33**
(from *C. jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
249C	51.6	12.9	21.6	15.3	0.25	0.42	0.30
NMMNH P-79160, holotype	48.2	12.3	20.4	14.2	0.26	0.42	0.29
2187C-23	42.9	10.0	15.5	15.4	0.23	0.36	0.36
NMMNH P-79161, paratype	40.4	10.0	16.5	12.6	0.25	0.41	0.31
2187C-14	40.0	10.7	16.9	12.5	0.27	0.42	0.31
2187C-28	39.3	9.9	15.5	12.2	0.25	0.39	0.31
2187C-11	39.1	10.0	16.9	11.7	0.26	0.43	0.30
2187C-7	38.4	9.0	15.9	12.8	0.23	0.41	0.33
2187C-22	38.2	8.7	14.6	13.1	0.23	0.38	0.34
597C	37.8	9.3	15.3	11.7	0.25	0.40	0.31
2187C-10	37.2	10.8	14.9	12.7	0.29	0.40	0.34
2187C-12	37.0	10.0	16.5	10.3	0.27	0.45	0.28
2187C-6	36.5	8.6	14.9	11.8	0.24	0.41	0.32
2250C	36.1	8.7	14.3	11.6	0.24	0.40	0.32
NMMNH P-79162, paratype	34.5	8.5	14.8	10.0	0.25	0.43	0.29
2187C-13	33.9	9.0	14.2	10.4	0.27	0.42	0.31
2187C-20	33.8	8.6	13.3	11.4	0.25	0.39	0.34
2187C-29	33.2	8.1	13.6	9.6	0.24	0.41	0.29
2187C-24	33.0	7.8	13.1	11.4	0.24	0.40	0.35
2187C-2	30.3	7.9	13.8	8.5	0.26	0.46	0.28
2187C-26	28.9	7.2	11.8	8.7	0.25	0.41	0.30
2187C-25	28.7	7.1	11.0	10.0	0.25	0.38	0.35
2187C-9	28.1	7.7	12.2	8.3	0.27	0.43	0.30
2187C-19	27.7	6.9	11.0	8.9	0.25	0.40	0.32
2187C-18	25.1	6.7	10.2	8.6	0.27	0.41	0.34
2187C-27	24.7	6.8	10.0	8.0	0.28	0.40	0.32
2187C-17	24.1	6.4	10.3	7.7	0.27	0.43	0.32

***Crittendenites jattioti* n. gen., n. sp., n = 33**
(from *C. jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-79163, paratype	22.3	6.0	10.3	6.0	0.27	0.46	0.27
2187C-15	21.9	6.0	8.9	7.1	0.27	0.41	0.32
2187C-21	21.8	5.7	9.2	6.9	0.26	0.42	0.32
2187C-3	21.2	6.3	8.8	7.0	0.30	0.42	0.33
2187C-16	17.0	5.0	7.3	5.8	0.29	0.43	0.34
2187C-4	15.9	4.9	7.1	4.7	0.31	0.45	0.30

***Arctoceras tuberculatum* (Smith), n = 76**
(from *M. millardense* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
280C	240	66.0	90.0	79.7	0.28	0.38	0.33
724C	67.9	21.3	30.6	15.9	0.31	0.45	0.23
1771C	175.2	43.3	73.7	50.2	0.25	0.42	0.29
1778C	175.0	43.6	68.0	57.5	0.25	0.39	0.33
295C	115.1	28.7	46.6	32.1	0.25	0.40	0.28
685C	81.0	20.4	36.2	19.4	0.25	0.45	0.24
687C	108.1	27.0	43.6	30.8	0.25	0.40	0.28
686C	87.1	22.7	37.6	22.3	0.26	0.43	0.26
688C	126.3	34.2	51.6	36.2	0.27	0.41	0.29
888C	89.0	21.0	38.9	21.1	0.24	0.44	0.24
2261C-1	175.3	48.1	68.4	58.6	0.27	0.39	0.33
2261C-2	171.3	41.3	62.0	56.7	0.24	0.36	0.33
2261C-3	111.8	28.5	44.2	32.0	0.25	0.40	0.29
2261C-4	126.0	31.3	48.6	38.4	0.25	0.39	0.30
2261C-5	111.2	28.4	44.2	32.2	0.26	0.40	0.29
2261C-6	145.7	35.0	59.7	39.5	0.24	0.41	0.27
2261C-7	81.8	19.7	36.0	18.8	0.24	0.44	0.23
2261C-8	116.4	28.9	49.4	28.9	0.25	0.42	0.25
2261C-9	111.6	29.9	46.8	29.4	0.27	0.42	0.26
2261C-10	102.2	24.5	39.4	31.0	0.24	0.39	0.30
2261C-11	91.8	24.0	34.8	27.0	0.26	0.38	0.29
2261C-12	51.1	12.9	23.4	12.0	0.25	0.46	0.23
2261C-13	79.1	18.2	34.0	19.4	0.23	0.43	0.25
2261C-14	122.8	27.6	49.4	34.6	0.22	0.40	0.28
2261C-15	100.6	26.1	42.2	23.7	0.26	0.42	0.24
2261C-16	81.1	22.0	33.9	21.9	0.27	0.42	0.27
2261C-17	99.6	25.4	41.5	26.6	0.26	0.42	0.27
2261C-18	96.9	27.0	38.8	27.8	0.28	0.40	0.29
2261C-19	97.4	24.5	43.0	21.3	0.25	0.44	0.22
2261C-20	118.9	31.4	47.7	34.7	0.26	0.40	0.29
2261C-21	100.6	25.2	39.9	27.9	0.25	0.40	0.28
2261C-22	75.8	20.9	35.1	14.4	0.28	0.46	0.19
2261C-23	87.9	21.9	38.4	19.5	0.25	0.44	0.22
2261C-24	106.8	24.9	45.4	27.1	0.23	0.43	0.25
2261C-25	100.7	28.7	41.4	24.8	0.29	0.41	0.25
2261C-26	92.7	23.8	37.2	25.3	0.26	0.40	0.27

***Arctoceras tuberculatum* (Smith), n = 76**
(from *M. millardense* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2261C-27	121.2	30.5	50.4	33.3	0.25	0.42	0.27
2261C-28	127.9	32.3	53.4	33.9	0.25	0.42	0.27
2261C-29	128.3	32.0	50.8	39.6	0.25	0.40	0.31
2261C-30	87.4	20.6	39.4	19.5	0.24	0.45	0.22
2261C-31	70.9	19.3	33.5	13.7	0.27	0.47	0.19
2261C-32	92.5	23.2	40.4	22.2	0.25	0.44	0.24
2261C-33	80.0	23.0	34.8	19.1	0.29	0.44	0.24
2261C-34	69.6	18.2	33.2	13.6	0.26	0.48	0.20
2261C-35	80.2	22.4	36.5	16.5	0.28	0.46	0.21
2261C-36	118.7	29.5	48.3	32.4	0.25	0.41	0.27
2261C-37	81.4	21.4	35.0	20.8	0.26	0.43	0.26
2261C-38	84.5	24.1	36.3	20.1	0.29	0.43	0.24
2261C-39	131.4	38.9	55.0	36.7	0.30	0.42	0.28
2261C-40	79.9	20.1	37.0	16.0	0.25	0.46	0.20
2261C-41	67.8	19.9	29.1	16.6	0.29	0.43	0.24
2261C-42	74.5	18.8	29.6	19.8	0.25	0.40	0.27
2261C-43	75.9	19.6	31.6	19.9	0.26	0.42	0.26
2261C-44	67.1	18.8	32.7	14.1	0.28	0.49	0.21
2261C-45	65.4	17.4	27.9	16.3	0.27	0.43	0.25
2261C-46	55.6	16.5	27.2	10.9	0.30	0.49	0.20
2261C-47	60.7	15.8	30.0	10.9	0.26	0.49	0.18
2261C-48	49.1	14.0	24.2	9.0	0.29	0.49	0.18
2261C-49	50.0	14.9	24.2	9.8	0.30	0.48	0.20
2261C-50	53.1	14.6	26.3	9.9	0.27	0.50	0.19
2261C-51	66.0	18.9	30.0	13.5	0.29	0.45	0.20
2261C-52	74.0	18.0	32.9	17.8	0.24	0.44	0.24
2261C-53	33.8	11.2	16.5	7.1	0.33	0.49	0.21
2261C-54	52.1	14.2	25.3	11.6	0.27	0.49	0.22
2261C-55	26.9	9.3	13.7	5.7	0.35	0.51	0.21
2261C-56	55.3	14.7	25.9	12.6	0.27	0.47	0.23
2261C-57	164.7	42.6	68.2	47.5	0.26	0.41	0.29
2261C-58	75.4	22.5	31.4	20.5	0.30	0.42	0.27
2261C-59	39.0	11.4	19.7	7.1	0.29	0.51	0.18
2261C-60	30.3	10.1	14.9	6.7	0.33	0.49	0.22
2261C-61	29.8	9.5	16.0	5.0	0.32	0.54	0.17
2261C-62	66.4	17.7	30.2	13.9	0.27	0.45	0.21
2261C-63	65.2	17.3	27.6	16.8	0.27	0.42	0.26
2261C-64	66.0	18.8	28.1	17.0	0.28	0.43	0.26
2261C-65	76.4	19.3	33.5	17.5	0.25	0.44	0.23
2261C-66	191.2	52.9	74.6	61.6	0.28	0.39	0.32

***Arctoceras rubyae* n. sp., n = 4**
(from *A. rubyae* n. sp. FA and *M. gracilitatis* FA intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-79165, paratype	113.6	23.5	54.9	23.1	0.21	0.48	0.20
1779C	224	44.5	89.9	58.0	0.20	0.40	0.26
NMMNH P-79164, holotype	185.7	37.4	76.6	50.2	0.20	0.41	0.27
NMMNH P-79166, paratype	108.4	24.1	49.6	22.2	0.22	0.46	0.20

***Churkites noblei* Jenks, n = 11 plus two fragmentary specimens
(from *Inyoites oweni* interval)**

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-55141 (holotype)	209	47	94	61	0.23	0.45	0.29
55143 (paratype)	146	36	63	40	0.25	0.43	0.27
55144 (paratype)	106	26	48	30	0.25	0.45	0.28
55145 (paratype)	133	31	57	41	0.23	0.43	0.31
400C	323	73	130	106	0.23	0.40	0.33
1772C	96	25	44	27	0.26	0.46	0.28
1775C	117	26	52	34	0.22	0.44	0.29
1777C	237	53	97	70	0.22	0.41	0.30
1774C	145	33	61	44	0.23	0.42	0.30
1776C	-	35	76	45	-	-	-
2535C	136	35	66	29	0.26	0.49	0.21
2482C	108	-	-	-	-	-	-
NMMNH P-55142 (paratype)	-	45	74	-	-	-	-

***Inyoites oweni* Hyatt and Smith, n = 2 (one not measureable)
(from *Inyoites oweni* interval)**

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2184C	54	9.7	19.5	19.8	0.18	0.36	0.37

***Inyoites stokesi* Kummel and Steele, n = 22 plus holotype and paratype
(22 specimens [Jenks collection] from *C. jattioti* n. gen., n. sp. and *I. oweni* intervals)**

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2182C	46.1	8.9	16.8	18.0	0.19	0.36	0.39
2183C-14	45.0	7.9	15.9	17.3	0.18	0.35	0.38
496C	40.8	8.0	16.2	14.9	0.20	0.40	0.37
1216C	39.9	7.8	15.3	14.6	0.20	0.38	0.37
924C	39.3	8.0	15.3	13.6	0.20	0.39	0.35
2183C-13	39.1	7.8	15.5	13.1	0.20	0.40	0.34
MCZ 5272, paratype	38.6	-	13.5	15.3	-	0.35	0.40
2183C-7	34.7	6.9	13.8	11.9	0.20	0.40	0.34
2183C-4	32.7	7.0	12.7	11.1	0.21	0.39	0.34
2183C-1	32.2	6.9	12.1	12.9	0.21	0.38	0.40
2183C-2	32.0	6.9	12.1	12.0	0.22	0.38	0.38
2183C-16	29.9	6.7	11.2	10.9	0.22	0.37	0.36
171C	28.7	5.9	11.1	10.0	0.21	0.39	0.35
MCZ 5270, holotype	28.0	6.2	9.0	12.0	0.22	0.32	0.43
2183C-5	27.0	5.9	11.0	8.7	0.22	0.41	0.32
111C	25.2	5.7	9.5	9.8	0.23	0.38	0.39
2183C-12	21.5	4.9	7.8	8.6	0.23	0.36	0.40
2183C-11	17.8	4.1	6.9	6.4	0.23	0.39	0.36
2183C-10	17.3	3.9	6.4	6.3	0.23	0.37	0.36
2183C-3	15.0	3.5	5.8	5.6	0.23	0.39	0.37
2183C-8	14.9	3.4	5.7	5.9	0.23	0.38	0.40
2183C-15	14.6	3.9	5.8	5.6	0.27	0.40	0.38
2183C-6	14.2	3.5	6.0	4.9	0.25	0.42	0.35
2183C-9	12.3	3.2	4.9	4.3	0.26	0.40	0.35

***Lanceolites compactus* Hyatt & Smith, n = 20**
(from *O. koeneni* FA through *C. jattioti* n. gen., n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
293C	56.9	14.6	34.4	-	0.26	0.60	-
296C	31.8	8.4	19.3	-	0.26	0.61	-
744C	41.1	10.8	25.2	-	0.26	0.61	-
2454C-1	79.1	19.4	48.3	-	0.25	0.61	-
2454C-2	67.3	16.8	39.9	-	0.25	0.59	-
2454C-3	19.3	5.7	11.5	-	0.30	0.60	-
2454C-4	23.3	6.9	13.8	-	0.30	0.59	-
2454C-5	23.7	7.0	14.2	-	0.30	0.60	-
2454C-6	45.9	12.3	27.9	-	0.27	0.61	-
2454C-7	21.9	6.0	13.1	-	0.27	0.60	-
2454C-8	28.0	7.8	16.6	-	0.28	0.59	-
2454C-9	35.2	8.9	21.1	-	0.25	0.60	-
2454C-10	36.8	8.7	22.6	-	0.24	0.61	-
2454C-11	54.3	13.5	33.0	-	0.25	0.61	-
2454C-12	52.8	13.8	31.8	-	0.26	0.60	-
2454C-13	41.7	10.3	25.4	-	0.25	0.61	-
2454C-14	41.2	10.3	25.9	-	0.25	0.63	-
2454C-15	59.0	17.1	35.3	-	0.29	0.60	-
2454C-16	63.0	15.2	37.6	-	0.24	0.60	-
2454C-17	63.7	14.7	37.9	-	0.23	0.59	-

***Parussuria compressa* (Hyatt & Smith), n = 40**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	D mm	W	H	U	W/D	H/D	U/D
160C	164.1	41.0	104.0	7.0	0.25	0.63	0.04
2243C-6	102.4	31.0	60.6	8.6	0.30	0.59	0.08
2243C-1	101.2	24.3	65.9	3.0	0.24	0.65	0.03
2243C-4	95.3	23.6	56.6	8.3	0.25	0.59	0.09
2243C-9	89.8	23.1	53.3	7.8	0.26	0.59	0.09
104C	87.3	22.5	54.4	5.0	0.26	0.62	0.06
2243C-2	83.6	20.5	51.4	5.9	0.25	0.61	0.07
2243C-3	78.5	18.9	47.4	6.9	0.24	0.60	0.09
2243C-12	71.6	18.0	43.8	5.5	0.25	0.61	0.08
2243C-7	70.3	17.3	43.2	5.1	0.25	0.61	0.07
2243C-5	68.5	19.8	40.4	6.1	0.29	0.59	0.09
722C	68.5	17.9	41.3	6.0	0.26	0.60	0.09
2243C-22	63.7	17.0	38.2	5.4	0.27	0.60	0.08
2243C-8	64.2	17.3	39.3	3.9	0.27	0.61	0.06
2243C-30	62.7	16.0	39.3	4.0	0.26	0.62	0.06
2243C-16	57.1	15.2	34.2	5.0	0.27	0.60	0.09
2243C-11	55.7	14.0	34.3	3.9	0.25	0.62	0.07
2243C-27	53.7	14.6	33.2	3.0	0.27	0.62	0.06
2243C-23	49.8	12.5	31.4	3.6	0.25	0.63	0.07
2243C-34	48.4	12.9	29.8	3.2	0.27	0.62	0.07
2243C-24	51.0	14.9	32.0	3.7	0.29	0.63	0.07
2243C-31	43.2	11.6	26.9	2.7	0.27	0.62	0.06
2243C-18	41.7	12.1	26.1	3.0	0.29	0.63	0.07
2243C-32	42.4	11.7	26.4	2.9	0.28	0.62	0.07

***Parussuria compressa* (Hyatt & Smith), n = 40**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	D mm	W	H	U	W/D	H/D	U/D
2243C-13	41.3	12.2	25.9	3.0	0.30	0.63	0.07
2243C-10	40.5	11.0	25.0	3.1	0.27	0.62	0.08
2243C-21	37.2	10.8	22.9	2.3	0.29	0.62	0.06
2247C	36.0	10.7	23.0	1.0	0.30	0.64	0.03
2243C-17	34.8	10.5	22.2	3.1	0.30	0.64	0.09
2243C-35	35.0	10.0	21.8	2.3	0.29	0.62	0.07
2243C-28	32.6	9.4	20.9	2.1	0.29	0.64	0.06
2243C-33	31.2	9.3	20.0	2.0	0.30	0.64	0.06
2243C-26	30.7	8.6	19.8	2.1	0.28	0.64	0.07
2243C-14	29.2	8.6	19.0	1.6	0.29	0.65	0.05
2243C-19	26.1	8.4	16.5	1.5	0.32	0.63	0.06
2243C-29	24.6	7.3	16.1	2.0	0.30	0.65	0.08
2243C-25	24.1	7.4	15.0	1.5	0.31	0.62	0.06
2243C-15	21.8	6.6	14.6	1.0	0.30	0.67	0.05
2243C-20	20.5	5.9	13.0	1.5	0.29	0.63	0.07
2243C-36	16.5	5.1	10.6	1.0	0.31	0.64	0.06

***Meekoceras gracilitatis* White, n = 175**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2044C	192	40	88.4	43	0.21	0.46	0.22
103C	157	32.0	78.0	25.8	0.20	0.50	0.16
2052C	129.9	26.9	64.6	20.7	0.21	0.50	0.16
2085C	128.5	29.0	64.3	19.8	0.23	0.50	0.15
2051C	123.2	28.6	59.9	21.1	0.23	0.49	0.17
2055C	122.2	26.9	61.2	20.0	0.22	0.50	0.16
2057C	117.0	24.6	53.8	23.3	0.21	0.46	0.20
2056C	113.0	23.3	53.7	19.2	0.21	0.48	0.17
2047C	112.8	24.2	54.0	17.9	0.22	0.48	0.16
2045C	110.0	26.5	56.7	13.8	0.24	0.52	0.13
2072C	101.0	23.5	50.0	14.9	0.23	0.50	0.15
2049C	107.6	23.7	54.0	17.8	0.22	0.50	0.17
2046C	103.0	22.2	53.9	12.2	0.22	0.52	0.12
2079C	66.9	18.0	35.0	12.8	0.27	0.52	0.19
2054C	97.1	21.9	46.6	17.7	0.23	0.48	0.18
2059C	97.0	22.0	46.9	16.1	0.23	0.48	0.17
2073C	90.6	20.3	44.3	15.1	0.22	0.49	0.17
2053C	95.9	20.6	48.5	15.5	0.22	0.51	0.16
2081C	94.7	19.4	48.3	13.1	0.21	0.51	0.14
2090C	93.9	21.2	41.7	20.0	0.24	0.44	0.21
2050C	91.1	19.8	46.8	12.9	0.22	0.51	0.14
2078C	91.1	20.3	44.4	16.3	0.22	0.49	0.18
683C	89.3	21.4	44.3	13.9	0.24	0.50	0.16
2077C	88.9	19.2	43.3	15.0	0.22	0.49	0.17
2069C	88.6	19.8	46.7	8.6	0.22	0.53	0.10
2048C	88.2	17.9	43.2	14.1	0.20	0.49	0.16
2058C	87.6	20.2	41.3	16.3	0.23	0.47	0.19
2062C	85.9	19.7	42.8	12.9	0.23	0.50	0.15

***Meekoceras gracilitatis* White, n = 175**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2098C	83.8	16.8	40.3	11.8	0.20	0.48	0.14
620C	83.7	19.6	45.0	11.0	0.23	0.54	0.13
2071C	83.6	19.1	41.6	12.1	0.23	0.50	0.15
2074C	81.9	18.8	44.9	8.9	0.23	0.55	0.11
2100C	79.4	19.0	40.7	9.6	0.24	0.51	0.12
2103C	71.6	16.1	37.8	7.9	0.22	0.53	0.11
2082C	78.9	19.4	40.4	10.7	0.25	0.51	0.14
684C	74.7	17.7	38.1	11.1	0.24	0.51	0.15
594C	73.7	15.8	38.1	11.3	0.21	0.52	0.15
2068C	73.3	17.9	36.1	13.1	0.24	0.49	0.18
2064C	73.2	16.3	36.1	12.1	0.22	0.49	0.17
2070C	72.8	17.7	35.1	12.6	0.24	0.48	0.17
2076C	70.4	17.5	37.7	8.4	0.25	0.54	0.12
2066C	65.7	16.4	35.1	7.7	0.25	0.53	0.12
2060C	69.8	17.3	37.4	8.0	0.25	0.54	0.12
2087C	69.3	14.2	36.6	7.7	0.21	0.53	0.11
2096C	69.8	16.1	35.1	10.0	0.23	0.50	0.14
2067C	69.1	16.0	36.1	9.4	0.23	0.52	0.14
2063C	69.0	15.8	34.9	10.3	0.23	0.51	0.15
2086C	66.6	16.8	35.5	9.6	0.25	0.53	0.14
2088C	67.1	15.0	35.9	6.6	0.22	0.54	0.10
2104C	67.9	15.3	36.0	7.4	0.23	0.53	0.11
2061C	63.7	15.3	33.0	8.3	0.24	0.52	0.13
2083C	66.2	14.6	33.9	9.3	0.22	0.51	0.14
2084C	65.8	15.9	34.9	8.1	0.24	0.53	0.12
2092C	65.0	15.0	32.9	9.1	0.23	0.51	0.14
2065C	63.7	16.0	33.5	8.3	0.25	0.53	0.13
2094C	62.0	14.4	31.1	9.0	0.23	0.50	0.15
2091C	59.9	14.2	32.9	5.7	0.24	0.55	0.10
2075C	58.2	13.9	31.6	6.9	0.24	0.54	0.12
2099C	55.6	12.0	30.0	5.3	0.22	0.54	0.10
2097C	52.0	12.8	27.9	5.4	0.25	0.54	0.10
2102C	42.6	9.0	23.1	4.1	0.21	0.54	0.10
2095C	37.0	9.6	20.9	3.4	0.26	0.57	0.09
2101C	36.7	9.5	20.0	3.9	0.26	0.55	0.11
2093C	36.7	8.5	20.3	2.9	0.23	0.55	0.08
2389C	151.8	36.7	71.7	26.8	0.24	0.47	0.18
2390C	56.1	14.3	29.8	6.5	0.25	0.53	0.12
2391C	79.3	20.2	42.4	9.1	0.25	0.53	0.11
2388C-1	82.7	16.8	39.1	15.8	0.20	0.47	0.19
2388C-2	136.7	31.4	68.2	22.1	0.23	0.50	0.16
2388C-3	136.6	31.1	61.4	29.8	0.23	0.45	0.22
2388C-4	102.5	22.1	49.1	17.9	0.22	0.48	0.17
2388C-5	82.0	17.5	38.9	14.0	0.21	0.47	0.17
2388C-6	71.7	16.5	37.3	7.9	0.23	0.52	0.11
2388C-7	125.7	27.9	58.9	21.7	0.22	0.47	0.17
2388C-8	87.5	19.6	43.7	12.9	0.22	0.50	0.15

***Meekoceras gracilitatis* White, n = 175**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2388C-9	92.1	19.9	44.7	13.8	0.22	0.49	0.15
2388C-10	77.7	17.1	40.2	10.0	0.22	0.52	0.13
2388C-11	86.2	19.8	41.3	14.1	0.23	0.48	0.16
2388C-12	58.6	15.6	30.6	8.1	0.27	0.52	0.14
2388C-13	72.9	16.3	37.1	9.1	0.22	0.51	0.12
2388C-14	96.8	21.4	45.2	16.3	0.22	0.47	0.17
2388C-15	56.0	13.4	29.3	7.0	0.24	0.52	0.13
2388C-16	89.9	19.3	43.2	14.1	0.21	0.48	0.16
2388C-17	86.8	19.7	40.6	15.1	0.23	0.47	0.17
2388C-18	72.6	15.3	36.9	9.0	0.21	0.51	0.12
2388C-19	78.8	16.1	40.0	11.0	0.20	0.51	0.14
2388C-20	72.1	14.7	35.9	9.1	0.20	0.50	0.13
2388C-21	82.3	19.3	41.7	10.4	0.23	0.51	0.13
2388C-22	80.3	19.5	41.0	10.2	0.24	0.51	0.13
2388C-23	84.8	18.5	42.6	11.3	0.22	0.50	0.13
2388C-24	71.7	16.4	36.7	9.5	0.23	0.51	0.13
2388C-25	84.0	20.2	42.6	11.2	0.24	0.51	0.13
2388C-26	80.2	20.5	40.1	12.0	0.26	0.50	0.15
2388C-27	53.1	12.5	28.2	5.5	0.24	0.53	0.10
2388C-28	71.1	16.5	39.4	5.9	0.23	0.55	0.08
2388C-29	79.4	18.8	39.7	10.1	0.24	0.50	0.13
2388C-30	75.0	16.8	39.7	8.4	0.22	0.53	0.11
2388C-31	70.0	16.4	34.7	9.9	0.23	0.50	0.14
2388C-32	73.6	17.0	37.9	11.0	0.23	0.51	0.15
2388C-33	101.0	23.9	47.9	18.3	0.24	0.47	0.18
2388C-34	79.0	19.6	40.4	10.7	0.25	0.51	0.14
2388C-35	84.2	17.3	37.6	16.1	0.21	0.45	0.19
2388C-36	70.9	16.9	39.8	12.1	0.24	0.56	0.17
2388C-37	83.0	17.9	39.4	14.1	0.22	0.47	0.17
2388C-38	79.2	18.1	40.7	11.7	0.23	0.51	0.15
2388C-39	74.7	17.0	36.0	12.4	0.23	0.48	0.17
2388C-40	58.9	14.5	30.6	7.5	0.25	0.52	0.13
2388C-41	60.2	12.0	30.8	7.5	0.20	0.51	0.12
2388C-42	72.5	16.6	37.1	8.5	0.23	0.51	0.12
2388C-43	67.1	14.9	34.9	8.4	0.22	0.52	0.13
2388C-44	50.5	10.1	27.5	5.0	0.20	.54	0.10
2388C-45	68.2	17.0	35.6	8.2	0.25	0.52	0.12
2388C-46	60.8	14.3	31.8	6.1	0.24	0.52	0.10
2388C-47	31.4	7.5	17.9	2.8	0.24	0.56	0.09
2388C-48	93.7	22.2	47.5	12.2	0.24	0.51	0.13
2388C-49	87.9	21.1	43.5	12.8	0.24	0.49	0.15
2388C-50	88.2	20.7	42.8	14.5	0.23	0.49	0.16
2388C-51	90.7	19.4	42.3	16.5	0.21	0.47	0.18
2388C-52	69.9	16.6	36.2	8.9	0.24	0.52	0.13
2388C-53	95.4	21.5	45.5	15.9	0.23	0.48	0.17
2388C-54	92.4	20.6	45.0	14.4	0.22	0.49	0.16
2388C-55	64.6	14.5	34.5	6.9	0.22	0.53	0.11

***Meekoceras gracilitatis* White, n = 175**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2388C-56	69.4	16.3	36.2	8.4	0.23	0.52	0.12
2388C-57	63.0	17.4	32.0	7.4	0.28	0.51	0.12
2388C-58	59.4	13.2	32.0	7.3	0.22	0.54	0.12
2388C-59	66.6	15.5	36.2	6.5	0.23	0.54	0.10
2388C-60	64.9	15.6	35.0	7.2	0.24	0.54	0.11
2388C-61	46.9	11.1	25.0	5.3	0.24	0.53	0.11
2388C-62	96.0	21.0	45.7	17.4	0.22	0.48	0.18
2388C-63	59.8	14.2	31.8	6.5	0.24	0.53	0.11
2388C-64	75.3	17.4	39.0	10.2	0.23	0.52	0.14
2388C-65	59.9	14.6	31.6	7.6	0.24	0.53	0.13
2388C-66	59.1	12.9	29.3	9.3	0.22	0.50	0.16
2388C-67	100.0	23.7	44.1	20.2	0.24	0.44	0.20
2388C-68	72.4	15.3	36.0	10.5	0.21	0.50	0.15
2388C-69	55.1	13.2	30.3	4.6	0.24	0.55	0.08
2388C-70	41.5	10.4	22.5	4.9	0.25	0.54	0.12
2388C-71	78.6	18.5	39.6	11.9	0.24	0.50	0.15
2388C-72	71.1	17.4	37.7	8.7	0.24	0.53	0.12
2388C-73	87.7	18.7	41.9	14.3	0.21	0.48	0.16
2388C-74	64.1	13.4	33.6	7.4	0.21	0.52	0.12
2388C-75	65.0	15.0	34.2	8.0	0.23	0.53	0.12
2388C-76	51.0	11.8	28.1	5.1	0.23	0.55	0.10
2388C-77	33.4	8.0	19.0	2.9	0.24	0.57	0.09
2388C-78	62.2	14.3	32.0	8.3	0.23	0.51	0.13
2388C-79	118.6	26.5	57.3	20.7	0.22	0.48	0.17
2388C-80	83.3	17.4	41.8	11.7	0.21	0.50	0.14
2388C-81	68.3	15.2	36.7	6.4	0.22	0.54	0.09
2388C-82	67.0	15.1	34.9	7.6	0.23	0.52	0.11
2388C-83	61.4	15.0	32.4	7.9	0.24	0.53	0.13
2388C-84	66.8	15.9	33.8	9.7	0.24	0.51	0.15
2388C-85	65.5	15.0	34.5	8.3	0.23	0.53	0.13
2388C-86	45.0	10.4	23.8	5.6	0.23	0.53	0.12
2388C-87	75.2	17.4	38.5	9.9	0.23	0.51	0.13
2388C-88	73.0	17.3	36.9	9.7	0.24	0.51	0.13
2388C-89	67.8	16.1	34.9	7.5	0.24	0.51	0.11
2388C-90	68.0	14.6	35.8	7.4	0.21	0.53	0.11
2388C-91	67.6	15.2	35.1	8.0	0.22	0.52	0.12
2388C-92	61.1	15.0	32.9	7.0	0.25	0.54	0.11
2388C-93	59.6	13.3	32.9	6.9	0.22	0.55	0.12
2388C-94	55.3	13.7	27.6	7.8	0.25	0.50	0.14
2388C-95	52.4	12.9	29.2	4.9	0.25	0.56	0.09
2388C-96	49.3	11.2	26.5	5.6	0.23	0.54	0.11
2388C-97	39.8	9.8	22.0	3.5	0.25	0.55	0.09
2388C-98	49.1	12.0	27.3	4.7	0.24	0.56	0.10
2388C-99	55.3	13.4	29.1	7.0	0.24	0.53	0.13
2388C-100	52.9	12.3	28.2	7.0	0.23	0.53	0.13
2388C-101	50.4	11.6	26.3	6.0	0.23	0.52	0.12
2388C-102	51.0	12.3	27.4	4.6	0.24	0.54	0.09

***Meekoceras gracilitatis* White, n = 175**
(from *M. gracilitatis* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2388C-103	48.9	11.6	26.8	4.6	0.24	0.55	0.09
2388C-104	44.0	10.7	24.0	4.3	0.24	0.55	0.10
2388C-105	40.0	10.3	22.0	4.7	0.26	0.55	0.12
2388C-106	20.8	5.5	11.4	2.7	0.26	0.55	0.13
2388C-107	20.7	5.6	11.6	2.2	0.27	0.56	0.11
2388C-108	23.9	5.9	13.1	2.1	0.25	0.55	0.09

***Meekoceras millardense* Brayard et al., n = 5 plus one fragmentary specimen**
(from *M. millardense* FA and *M. olivieri* FA intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2437C	98.0	22.6	56.6	-	0.23	0.58	-
2438C	80.9	18.1	48.1	-	0.22	0.59	-
2439C	74.7	18.4	43.1	-	0.25	0.58	-
2446C	87.8	20.2	51.3	-	0.23	0.58	-
2448C	92.0	22.4	52.4	-	0.24	0.57	-
2447C	-	-	35.4	-	-	-	-

***Meekoceras* aff. *M. olivieri* Brayard et al., n = 7**
(from *M. aff. olivieri* FA through *M. gracilitatis* FA intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2440C	111.6	28.6	53.5	19.4	0.26	0.48	0.17
2441C	55.8	14.8	28.6	6.7	0.27	0.51	0.12
2442C	40.4	10.2	20.2	6.3	0.25	0.50	0.16
2445C	44.7	11.7	22.8	6.4	0.26	0.51	0.14
2449C	60.3	15.7	31.1	7.7	0.26	0.52	0.13
2450C	80.3	19.2	37.8	15.2	0.24	0.47	0.19
2451C	70.7	16.6	35.8	9.7	0.23	0.51	0.14

***Meekoceras bylundi* n. sp., n = 5**
(from *O. koeneni* FA and *A. weitschati* intervals)

Specimen ID	D mm	W	H	U	W/D	H/D	U/D
NMMNH P-79169, paratype	108	22.4	47.6	26.5	0.21	0.44	0.25
2466C	128.6	26.7	53.7	34.9	0.21	0.42	0.27
NMMNH P-79167, holotype	120.5	23.2	50.8	28.9	0.19	0.42	0.24
NMMNH P-79168, paratype	108.9	22.5	48.0	26.1	0.21	0.44	0.24
2520C	153.4	30.7	67.6	35.4	0.20	0.44	0.23

***Acutomeekoceras rieberi* Jenks et al., n = 2**
one specimen (holotype) from Crittenden Springs (*P. toulai* interval) and one specimen from
***Meekoceras* beds of southeastern Idaho**

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-60169	77.7	17.0	41.6	9.2	0.22	0.54	0.12
2553C	63.6	16.0	32.1	9.1	0.25	0.50	0.14

***Anasibirites kingianus* (Waagen), n = 1**
(from *A. multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
34C	82.7	23.0	36.8	20.1	0.28	0.44	0.24

***Anasibirites multiformis* Welter, n = 11**
(from *A. multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
1396C	64.9	21.0	29.4	16.0	0.32	0.45	0.25
1403C	56.4	17.1	25.9	12.0	0.30	0.46	0.21
1393C	61.1	17.1	32.2	8.7	0.28	0.53	0.14
2458C	58.6	13.7	27.1	12.7	0.23	0.46	0.22
1398C	57.6	15.0	27.1	11.2	0.26	0.47	0.19
1395C	53.1	14.9	25.8	11.6	0.28	0.49	0.22
1402C	50.1	15.2	24.3	8.6	0.30	0.49	0.17
1404C	49.8	13.7	23.9	10.6	0.28	0.48	0.21
1397C	30.4	8.1	15.1	5.2	0.27	0.50	0.17
24C-4	44.0	12.3	22.5	8.0	0.28	0.51	0.18
24C-5	52.5	14.7	22.5	9.0	0.28	0.43	0.17

***Hemiprionites typus* (Waagen), n = 25**
(from *A. multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2464C	117.1	32.9	57.5	19.7	0.28	0.49	0.17
1394C	75.7	19.7	37.5	12.6	0.26	0.50	0.17
648C	97.7	25.8	46.4	18.3	0.26	0.47	0.19
224C	81.5	24.1	43.5	8.7	0.30	0.53	0.11
698C	63.1	17.8	28.2	11.0	0.28	0.45	0.17
2538C	62.4	17.0	32.9	8.7	0.27	0.53	0.14
1406C	60.4	15.9	29.7	10.3	0.26	0.49	0.17
2541C	60.9	16.9	30.8	8.1	0.28	0.51	0.13
2552C	60.3	15.8	31.0	8.0	0.26	0.51	0.13
2460C	54.0	15.1	27.4	9.0	0.28	0.51	0.17
1408C	53.3	14.1	24.0	10.3	0.26	0.45	0.19
2540C	52.6	13.7	24.9	9.6	0.26	0.47	0.18
1409C	57.0	15.9	27.7	9.2	0.28	0.49	0.16
1412C	54.0	14.3	24.2	10.3	0.26	0.45	0.19
1411C	56.5	15.8	30.3	7.1	0.28	0.54	0.13
267C	54.0	15.4	28.1	6.0	0.29	0.52	0.11
1414C	54.9	15.5	26.4	7.9	0.28	0.48	0.14
2539C	46.2	14.2	22.6	7.2	0.31	0.49	0.16
1405C	48.6	14.2	25.1	7.7	0.29	0.52	0.16
655C	62.3	18.4	26.7	14.3	0.30	0.43	0.23
2462C	34.7	10.6	17.6	4.1	0.31	0.51	0.12
24C-1	54.0	15.1	25.0	9.5	0.28	0.46	0.18
24C-2	55.0	15.4	29.5	6.0	0.28	0.54	0.11
24C-3	57.5	16.1	26.0	10.0	0.28	0.45	0.17
1417C	49.3	12.5	26.0-	6.1	0.25	0.53	0.12

***Hemiprionites walcotti* (Mathews), n = 2**
(from *A. multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2461C	37.1	9.4	21.1	2.9	0.25	0.57	0.08
2463C	42.6	12.5	23.1	4.1	0.29	0.54	0.10

***Hemiprionites roberti* Jenks et al., n = 17**
(from *C. jattioti* interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-60173	60.0	16.7	34.1	9.3	0.28	0.57	0.16
P-60174	55.9	14.9	31.8	7.6	0.27	0.57	0.14
P-60175	49.3	13.3	27.3	8.0	0.27	0.55	0.16
P-60201	49.1	14.1	27.4	6.1	0.29	0.56	0.12
P-60202	41.9	11.4	23.2	7.1	0.27	0.55	0.17
30C	56.9	16.5	32.4	7.9	0.29	0.57	0.14
1481C	42.4	13.1	24.0	6.3	0.31	0.57	0.15
1483C	41.8	11.7	22.9	6.9	0.28	0.55	0.17
1987C	52.9	13.9	29.8	8.1	0.26	0.56	0.15
1988C	51.0	15.8	29.0	7.0	0.31	0.57	0.14
1989C	43.0	12.0	24.0	7.4	0.28	0.56	0.17
1990C	64.7	18.3	36.8	9.9	0.28	0.57	0.15
1991C	35.6	10.4	19.5	6.7	0.29	0.55	0.19
1992C	41.7	11.5	22.6	7.8	0.28	0.54	0.19
2018C	55.1	15.5	30.9	8.9	0.28	0.56	0.16
2020C	38.9	10.9	21.0	6.0	0.28	0.54	0.15
2431C	55.1	16.0	30.6	5.8	0.29	0.56	0.11

***Wasatchites perrini* Mathews, n = 2**
(from *A. multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
1279C	160	45.7	57.8	55.1	0.29	0.36	0.34
2457C	80.3	23.8	30.9	25.4	0.30	0.38	0.32

***Wasatchites* cf. *W. distractus* (Waagen), n = 6**
(from *A. multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
1400C	83.0	32.4	34.9	24.0	0.39	0.42	0.29
921C	44.8	19.0	20.2	11.5	0.42	0.45	0.26
1399C	40.3	16.0	19.7	7.8	0.40	0.49	0.19
1401C	40.0	14.0	17.4	8.9	0.35	0.44	0.22
1407C (large)	41.5	16.8	19.0	8.5	0.40	0.46	0.20
1407C (small)	35.3	13.8	16.4	7.0	0.39	0.46	0.20

***Arctoprionites resseri* (Mathews), n = 12**
(from *Anasibirites multiformis* lense interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
128C	85.9	24.2	37.9	18.9	0.28	0.44	0.22
1415C	58.8	18.5	29.6	9.2	0.31	0.50	0.16
2471C	73.0	20.5	35.4	11.1	0.28	0.48	0.15
2459C	50.5	14.7	25.0	7.8	0.29	0.50	0.15
656C	63.9	17.3	33.0	9.5	0.27	0.52	0.15
654C	81.0	21.9	39.9	14.4	0.27	0.49	0.18
885C	61.3	18.8	30.0	11.6	0.31	0.49	0.19
1410C	70.5	19.0	35.3	11.5	0.27	0.50	0.16
2456C	77.0	22.6	34.8	17.7	0.29	0.45	0.23
1413C	51.7	15.6	25.8	8.4	0.30	0.50	0.16
743C	57.5	16.6	27.9	10.0	0.29	0.49	0.17
2470C	119.3	32.2	47.5	34.5	0.27	0.40	0.29

***Paranannites aspenensis* Hyatt & Smith, n = 185**
(from *A. rubyae* n. sp. FA through *P. toulai* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2253C-1	43.5	18.4	21.4	8.1	0.42	0.49	0.19
2253C-2	37.0	16.8	16.4	8.4	0.45	0.44	0.23
2253C-3	37.7	16.3	17.8	6.8	0.43	0.47	0.18
2253C-4	36.9	17.8	17.6	6.0	0.48	0.48	0.16
2253C-5	31.0	14.1	14.8	6.2	0.45	0.48	0.20
2253C-6	41.0	18.1	19.1	7.9	0.44	0.47	0.19
2253C-7	38.5	17.0	17.4	7.9	0.44	0.45	0.21
2253C-8	39.3	17.1	19.8	6.1	0.44	0.50	0.16
2253C-9	37.1	17.5	16.4	8.4	0.47	0.44	0.23
2253C-10	42.3	17.0	18.3	9.3	0.40	0.43	0.22
2253C-11	34.5	14.5	14.5	8.8	0.42	0.42	0.26
2253C-12	35.5	16.7	16.4	7.5	0.47	0.46	0.21
2253C-13	31.1	14.8	14.9	5.8	0.48	0.48	0.19
2253C-14	34.5	17.3	15.7	6.8	0.50	0.46	0.20
2253C-15	30.6	15.8	14.9	5.3	0.52	0.49	0.17
2253C-16	29.1	14.7	14.2	5.4	0.51	0.49	0.19
2253C-17	21.0	11.4	10.0	3.9	0.54	0.48	0.19
2253C-18	35.0	14.9	16.4	6.3	0.43	0.47	0.18
2253C-19	31.9	16.5	14.6	8.4	0.52	0.46	0.26
2253C-20	30.5	14.2	14.8	5.5	0.47	0.49	0.18
2253C-21	34.4	15.9	15.8	7.0	0.46	0.46	0.20
2253C-22	30.5	14.9	13.9	6.5	0.49	0.46	0.21
2253C-23	28.7	13.5	13.3	6.0	0.47	0.46	0.21
2253C-24	32.1	14.4	14.5	6.0	0.45	0.45	0.19
2253C-25	30.4	16.4	14.5	5.2	0.54	0.48	0.17
2253C-26	36.5	16.1	17.7	6.0	0.44	0.48	0.16
2253C-27	34.6	14.8	16.3	6.5	0.43	0.47	0.19
2253C-28	33.4	16.3	15.3	7.0	0.49	0.46	0.21
2253C-29	27.5	14.5	13.6	3.8	0.53	0.49	0.14
2253C-30	37.4	17.6	16.5	7.6	0.47	0.44	0.20
2253C-31	43.1	16.9	19.5	8.2	0.39	0.45	0.19

***Paranannites aspenensis* Hyatt & Smith, n = 185**
(from *A. rubyae* n. sp. FA through *P. toulai* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2253C-32	19.9	11.6	10.6	3.8	0.58	0.53	0.19
2253C-33	34.1	15.5	16.4	5.8	0.45	0.48	0.17
2253C-34	23.8	12.5	11.9	4.6	0.53	0.50	0.19
2253C-35	34.8	14.9	15.5	7.0	0.43	0.45	0.20
2253C-36	32.6	14.3	14.8	6.8	0.44	0.45	0.21
2253C-37	28.0	13.2	13.6	4.7	0.47	0.49	0.17
2253C-38	33.2	15.9	16.7	5.0	0.48	0.50	0.15
2253C-39	33.2	17.0	15.2	5.6	0.51	0.46	0.17
2253C-40	28.0	11.3	13.1	4.9	0.40	0.47	0.18
2253C-41	41.5	18.5	18.7	8.6	0.45	0.45	0.21
2253C-42	29.4	14.3	13.3	6.3	0.49	0.45	0.21
2253C-43	31.2	14.9	16.1	4.4	0.48	0.52	0.14
2253C-44	26.3	13.5	13.2	4.6	0.51	0.50	0.17
2253C-45	33.9	15.5	15.6	7.7	0.46	0.46	0.23
2253C-46	23.3	13.4	11.5	4.1	0.58	0.49	0.18
2253C-47	36.7	15.4	16.2	8.5	0.42	0.44	0.23
2253C-48	22.9	10.0	10.9	3.9	0.44	0.48	0.17
2253C-49	27.3	13.4	13.2	5.0	0.49	0.48	0.18
2253C-50	25.7	12.9	12.4	4.7	0.50	0.48	0.18
2253C-51	31.0	14.9	14.9	5.8	0.48	0.48	0.19
2253C-52	24.9	12.1	12.6	4.0	0.49	0.51	0.16
2253C-53	28.3	15.2	12.1	7.8	0.54	0.43	0.28
2253C-54	31.1	14.5	14.4	6.4	0.47	0.46	0.21
2253C-55	21.8	11.7	10.4	4.5	0.54	0.48	0.21
2253C-56	26.0	14.1	11.6	5.7	0.54	0.45	0.22
2253C-57	21.6	11.2	9.8	4.1	0.52	0.45	0.19
2253C-58	21.4	11.1	9.7	4.5	0.52	0.45	0.21
2253C-59	23.5	12.2	11.5	4.4	0.52	0.49	0.19
2253C-60	40.3	16.1	17.2	9.6	0.40	0.43	0.24
2253C-61	34.5	15.2	16.9	5.4	0.44	0.49	0.16
2253C-62	36.9	15.3	18.8	5.3	0.41	0.51	0.14
2253C-63	31.1	15.1	14.8	6.1	0.49	0.48	0.20
2253C-64	32.1	14.4	15.5	5.3	0.45	0.48	0.17
2253C-65	22.4	11.8	10.8	4.7	0.53	0.48	0.21
2253C-66	29.0	12.9	13.5	5.9	0.44	0.47	0.20
2253C-67	31.4	16.2	14.8	4.9	0.52	0.47	0.16
2253C-68	31.5	15.6	14.9	5.8	0.50	0.47	0.18
2253C-69	37.6	17.8	17.6	7.0	0.47	0.47	0.19
2253C-70	32.5	14.1	13.9	6.9	0.43	0.43	0.21
2253C-71	39.5	17.6	18.4	7.4	0.45	0.47	0.19
2253C-72	34.7	16.2	16.3	6.8	0.47	0.47	0.20
2253C-73	30.8	15.9	14.6	5.1	0.52	0.47	0.17
2253C-74	37.1	15.6	17.5	6.8	0.42	0.47	0.18
2253C-75	26.4	13.8	12.0	4.9	0.52	0.45	0.19
2253C-76	22.3	11.3	10.4	3.9	0.51	0.47	0.17
2253C-77	23.2	13.2	10.6	5.2	0.57	0.46	0.22
2253C-78	27.7	13.3	13.5	4.2	0.48	0.49	0.15

***Paranannites aspenensis* Hyatt & Smith, n = 185**
(from *A. rubyae* n. sp. FA through *P. toulai* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2253C-79	29.7	13.4	15.0	4.3	0.45	0.51	0.14
2253C-80	38.5	17.5	18.0	6.6	0.45	0.47	0.17
2253C-81	24.5	12.9	11.5	4.5	0.53	0.47	0.18
2253C-82	22.8	11.9	10.9	4.1	0.52	0.48	0.18
2253C-83	23.2	12.6	11.0	4.6	0.54	0.47	0.20
2253C-84	25.7	12.2	12.7	4.2	0.47	0.49	0.16
2253C-85	30.1	13.9	16.0	2.8	0.46	0.53	0.09
2253C-86	29.4	15.0	15.5	3.9	0.51	0.53	0.13
2253C-87	35.5	18.9	16.8	5.9	0.53	0.47	0.17
2253C-88	27.7	13.6	12.6	5.7	0.49	0.45	0.21
2253C-89	24.7	13.9	11.7	4.9	0.56	0.47	0.20
2253C-90	30.8	15.8	14.3	6.1	0.51	0.46	0.20
2253C-91	20.4	10.8	9.9	3.9	0.53	0.49	0.19
2253C-92	20.3	11.3	9.6	3.9	0.56	0.47	0.19
2253C-93	26.2	13.9	13.3	3.9	0.53	0.51	0.15
2253C-94	31.0	14.3	14.5	5.5	0.46	0.47	0.18
2253C-95	36.8	15.3	17.1	7.4	0.42	0.46	0.20
2253C-96	17.2	9.8	8.6	3.1	0.57	0.50	0.18
2253C-97	22.6	12.0	11.0	3.9	0.53	0.49	0.17
2253C-98	38.2	17.9	19.1	5.2	0.47	0.50	0.14
2253C-99	36.6	16.0	16.8	7.4	0.44	0.46	0.20
2253C-100	25.4	13.5	11.6	5.1	0.53	0.46	0.20
2253C-101	29.1	13.6	14.7	3.6	0.47	0.51	0.12
2253C-102	24.1	13.1	11.5	4.5	0.54	0.48	0.19
2253C-103	23.1	12.4	10.6	3.9	0.54	0.46	0.17
2253C-104	47.0	19.1	21.0	12.0	0.41	0.45	0.26
2253C-105	23.6	12.3	11.8	4.4	0.52	0.50	0.19
2253C-106	26.1	12.9	11.6	5.1	0.49	0.44	0.20
2253C-107	43.7	17.3	21.4	5.8	0.40	0.49	0.13
2253C-108	25.4	13.3	11.9	5.1	0.52	0.47	0.20
2253C-109	26.8	14.3	12.5	4.4	0.53	0.47	0.16
2253C-110	24.2	13.3	11.3	4.8	0.55	0.47	0.20
2253C-111	37.7	16.2	17.0	8.1	0.43	0.45	0.21
2253C-112	29.7	13.5	14.5	4.1	0.45	0.49	0.14
2253C-113	16.6	8.4	8.6	2.7	0.51	0.52	0.16
2253C-114	19.0	9.7	9.3	3.5	0.51	0.49	0.18
2253C-115	32.5	14.6	15.6	5.2	0.45	0.48	0.16
2253C-116	23.3	11.8	11.6	3.9	0.51	0.50	0.17
2253C-117	34.2	17.0	16.4	5.9	0.50	0.48	0.17
2253C-118	27.3	13.8	13.3	4.6	0.51	0.49	0.17
2253C-119	28.9	12.5	13.7	5.2	0.43	0.47	0.18
2253C-120	19.6	11.0	8.8	3.8	0.56	0.45	0.19
2253C-121	28.0	12.6	13.2	4.7	0.45	0.47	0.17
2253C-122	22.4	12.8	10.7	4.7	0.57	0.48	0.21
2253C-123	21.1	11.7	9.7	4.1	0.55	0.46	0.19
274C	43.1	17.5	19.7	8.1	0.41	0.46	0.19
288C	41.5	18.1	18.9	8.2	0.44	0.46	0.20

***Paranannites aspenensis* Hyatt & Smith, n = 185**
(from *A. rubyae* n. sp. FA through *P. toulai* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
499C	25.9	13.6	11.6	5.9	0.53	0.45	0.23
2253C-124	32.5	16.9	16.0	4.5	0.52	0.49	0.14
2253C-125	28.4	15.0	13.6	4.8	0.53	0.48	0.17
2253C-126	31.9	15.4	15.8	4.9	0.48	0.50	0.15
2253C-127	25.0	13.0	12.9	2.9	0.52	0.52	0.12
2253C-128	27.6	14.7	13.2	4.7	0.53	0.48	0.17
2253C-129	26.1	12.3	12.8	4.0	0.47	0.49	0.15
2253C-130	38.9	18.6	18.8	5.0	0.48	0.48	0.13
2253C-131	28.8	13.7	13.4	5.1	0.48	0.47	0.18
2253C-132	33.9	17.2	16.7	4.5	0.51	0.49	0.13
2253C-133	24.1	14.0	12.2	4.0	0.58	0.51	0.17
2253C-134	25.2	13.5	11.7	4.7	0.54	0.46	0.19
2253C-135	19.1	11.3	8.9	3.7	0.59	0.47	0.19
2253C-136	24.1	10.8	12.2	3.1	0.45	0.51	0.13
2253C-137	32.8	14.4	14.9	6.1	0.44	0.45	0.19
2253C-138	21.0	12.7	10.8	3.3	0.60	0.51	0.16
2253C-139	26.1	12.5	12.5	4.9	0.48	0.48	0.19
2253C-140	21.2	11.2	11.0	3.2	0.53	0.52	0.15
2253C-141	32.9	16.1	16.3	4.4	0.49	0.50	0.13
2253C-142	27.3	12.8	14.1	3.5	0.47	0.52	0.13
2253C-143	24.8	13.1	12.4	3.9	0.53	0.50	0.16
2253C-144	24.0	11.1	11.8	3.9	0.46	0.49	0.16
2253C-145	23.6	12.5	11.4	4.1	0.53	0.48	0.17
2253C-146	33.0	16.8	16.9	4.3	0.51	0.51	0.13
2253C-147	33.1	16.4	16.5	4.7	0.50	0.50	0.14
2253C-148	24.5	13.6	12.3	3.8	0.56	0.50	0.16
2253C-149	22.8	12.4	10.8	4.4	0.54	0.47	0.19
2253C-150	27.8	13.7	13.6	4.7	0.49	0.49	0.17
2253C-151	24.5	11.7	12.9	3.0	0.48	0.53	0.12
2253C-152	20.9	11.8	10.9	3.4	0.56	0.52	0.16
2253C-153	27.5	14.6	13.0	4.8	0.53	0.47	0.17
2253C-155	17.3	9.8	8.6	2.8	0.57	0.50	0.16
2253C-156	26.1	14.4	12.8	4.8	0.55	0.49	0.18
2253C-157	21.5	10.5	11.3	3.1	0.49	0.53	0.14
2253C-158	23.3	13.1	10.8	4.2	0.56	0.46	0.18
2253C-159	18.2	10.0	9.1	3.3	0.55	0.50	0.18
2253C-160	20.9	10.4	10.3	3.9	0.50	0.49	0.19
2253C-161	20.0	10.6	10.1	3.1	0.53	0.51	0.16
2253C-162	22.0	12.5	10.3	4.2	0.57	0.47	0.19
2253C-163	10.6	5.6	5.3	1.7	0.53	0.50	0.16
2253C-164	20.1	11.4	9.5	3.9	0.57	0.47	0.19
2253C-165	26.0	14.7	12.8	4.7	0.57	0.49	0.18
2253C-166	15.3	7.7	7.0	3.2	0.50	0.46	0.21
2253C-167	24.7	13.0	11.8	4.6	0.53	0.48	0.19
2253C-168	14.9	8.6	7.2	2.8	0.58	0.48	0.19
2253C-169	18.6	11.1	9.0	3.3	0.60	0.48	0.18
2253C-170	17.7	10.9	8.1	3.4	0.62	0.46	0.19

***Paranannites aspenensis* Hyatt & Smith, n = 185**
(from *A. rubyae* n. sp. FA through *P. toulai* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2253C-171	19.6	11.0	9.2	4.1	0.56	0.47	0.21
2253C-172	21.8	12.7	10.4	4.2	0.58	0.48	0.19
2253C-173	19.3	11.0	8.8	3.8	0.57	0.46	0.20
2253C-174	16.1	9.4	7.3	3.8	0.58	0.45	0.24
2253C-175	26.2	14.4	12.5	5.0	0.55	0.48	0.19
2253C-176	22.6	12.8	9.7	5.3	0.57	0.43	0.23
2253C-177	21.2	12.4	9.7	4.7	0.58	0.46	0.22
2253C-178	22.2	13.0	10.5	4.7	0.59	0.47	0.21
2253C-179	20.4	12.4	9.7	3.9	0.61	0.48	0.19
2253C-180	18.5	11.1	8.2	3.9	0.60	0.44	0.21
2253C-181	17.3	11.1	7.7	3.9	0.64	0.45	0.23
2253C-182	17.4	10.3	8.4	3.1	0.59	0.48	0.18
2253C-183	17.0	10.3	8.2	3.1	0.61	0.48	0.18

***Owenites koeneni* Hyatt and Smith, n = 160**
(from *O. koeneni* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
650C	67.1	17.4	29.3	14.6	0.26	0.44	0.22
2220C-28	53.7	15.9	25.4	9.0	0.30	0.47	0.17
720C	52.9	17.2	24.2	9.8	0.33	0.46	0.19
2220C-1	50.8	13.8	20.2	12.2	0.27	0.40	0.24
2220C-108	50.2	13.2	21.2	10.7	0.26	0.42	0.21
20C	49.8	14.6	21.5	12.0	0.29	0.43	0.24
2220C-4	49.4	14.2	20.0	12.8	0.29	0.40	0.26
2219C	48.8	13.9	18.7	16.1	0.28	0.38	0.33
2220C-27	47.5	13.1	22.0	9.9	0.28	0.46	0.21
11C	46.9	14.5	20.0	11.4	0.31	0.43	0.24
2220C-101	46.3	13.8	19.7	10.7	0.30	0.43	0.23
2220C-53	46.1	11.7	18.6	11.9	0.25	0.40	0.26
2220C-2	45.9	13.9	19.2	10.7	0.30	0.42	0.23
2220C-6	45.7	13.0	19.8	9.0	0.28	0.43	0.20
2220C-95	45.7	13.0	18.9	12.0	0.28	0.41	0.26
2220C-26	45.7	13.7	20.0	10.0	0.30	0.44	0.22
2220C-16	44.9	12.2	17.8	12.8	0.27	0.40	0.29
2220C-117	44.9	14.0	20.7	9.3	0.31	0.46	0.21
2220C-13	44.8	11.9	19.2	9.8	0.27	0.43	0.22
2220C-87	44.7	12.3	17.4	13.0	0.28	0.39	0.29
2220C-51	44.7	13.2	20.5	7.3	0.30	0.46	0.16
2220C-45	44.6	14.2	18.7	12.1	0.32	0.42	0.27
2220C-5	44.2	14.9	18.1	12.7	0.34	0.41	0.29
2220C-82	44.0	14.6	17.9	12.9	0.33	0.41	0.29
2220C-12	43.9	12.8	19.7	9.4	0.29	0.45	0.21
2220C-31	43.6	16.0	20.8	8.8	0.37	0.48	0.20
2220C-3	43.0	12.1	19.7	8.9	0.28	0.46	0.21
2220C-34	43.0	12.9	18.9	8.7	0.30	0.44	0.20
2220C-111	42.9	14.1	17.6	11.7	0.33	0.41	0.27
2220C-67	42.7	13.5	17.3	11.7	0.32	0.41	0.27

***Owenites koeneni* Hyatt and Smith, n = 160**
(from *O. koeneni* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2220C-55	42.4	11.7	18.2	9.4	0.28	0.43	0.22
2220C-68	42.3	14.8	18.8	9.0	0.35	0.44	0.21
2220C-33	42.3	12.5	17.7	11.2	0.30	0.42	0.26
2220C-113	41.8	12.0	19.5	7.3	0.29	0.47	0.17
2220C-54	41.7	13.5	19.7	6.5	0.32	0.47	0.16
2220C-104	41.4	12.4	18.3	8.3	0.30	0.44	0.20
2220C-110	41.4	10.2	17.1	11.3	0.25	0.41	0.27
2220C-102	41.3	13.7	20.0	6.0	0.33	0.48	0.15
2220C-76	41.2	12.8	17.3	10.7	0.31	0.42	0.26
2220C-106	41.1	13.0	17.5	9.6	0.32	0.43	0.23
2220C-116	41.1	11.0	17.5	10.5	0.27	0.43	0.26
2220C-73	40.6	13.9	18.3	9.6	0.34	0.45	0.24
2220C-100	40.6	15.1	16.8	10.6	0.37	0.41	0.26
2220C-63	40.5	11.7	18.5	7.8	0.29	0.46	0.19
2220C-109	40.3	12.9	17.4	9.3	0.32	0.43	0.23
2220C-18	40.1	13.9	15.5	11.1	0.35	0.39	0.28
2220C-65	40.2	11.6	17.7	8.6	0.29	0.44	0.21
2220C-71	40.1	11.3	17.3	10.4	0.28	0.43	0.26
2220C-49	40.0	14.3	17.8	8.7	0.36	0.45	0.22
2220C-9	40.0	12.4	16.1	10.0	0.31	0.40	0.25
2220C-29	40.0	13.3	17.1	10.0	0.33	0.43	0.25
2220C-105	39.9	14.1	18.2	7.9	0.35	0.46	0.20
2220C-118	39.7	14.9	17.1	9.1	0.38	0.43	0.23
2220C-11	39.3	12.1	19.1	6.0	0.31	0.49	0.15
2220C-69	38.9	13.4	16.9	8.7	0.34	0.43	0.22
2220C-8	38.8	13.7	16.1	9.2	0.35	0.41	0.24
2220C-42	38.7	12.8	18.1	6.1	0.33	0.47	0.16
2220C-84	38.4	12.8	17.6	7.3	0.33	0.46	0.19
2220C-83	38.3	12.2	17.8	6.0	0.32	0.46	0.16
2220C-81	38.0	12.5	16.4	8.8	0.33	0.43	0.23
2220C-90	37.9	11.9	18.5	4.7	0.31	0.49	0.12
2220C-38	37.7	13.3	17.9	6.1	0.35	0.47	0.16
2220C-37	37.4	12.0	17.6	6.1	0.32	0.47	0.16
222-C-96	37.0	12.3	17.2	7.1	0.33	0.46	0.19
2220C-74	36.9	12.8	16.9	6.8	0.35	0.46	0.18
2220C-114	36.9	13.3	16.1	8.9	0.36	0.44	0.24
2220C-43	36.8	13.3	15.6	8.5	0.36	0.42	0.23
2220C-52	36.8	13.0	17.6	6.2	0.35	0.48	0.17
2220C-72	36.7	11.0	17.2	7.0	0.30	0.47	0.19
2220C-75	36.7	10.8	15.4	8.9	0.29	0.42	0.24
2220C-50	36.3	12.2	14.8	9.2	0.34	0.41	0.25
2220C-17	36.2	12.3	15.8	8.7	0.34	0.44	0.24
2220C-22	36.1	12.9	17.7	5.7	0.36	0.49	0.16
2220C-15	36.0	12.8	16.5	6.5	0.36	0.46	0.18
2220C-80	35.6	11.6	16.6	6.0	0.33	0.47	0.17
2220C-115	35.5	11.9	16.8	5.5	0.34	0.47	0.15
2220C-99	35.2	13.0	16.6	5.3	0.37	0.47	0.15

***Owenites koeneni* Hyatt and Smith, n = 160**
(from *O. koeneni* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2220C-30	34.7	13.6	16.4	5.4	0.39	0.47	0.16
2220C-14	34.6	11.7	16.4	5.6	0.34	0.47	0.16
2220C-66	34.3	10.9	15.1	7.6	0.32	0.44	0.22
2220C-36	34.1	11.4	16.1	5.7	0.33	0.47	0.17
2220C-61	34.1	13.0	17.0	3.4	0.38	0.50	0.10
2220C-112	34.1	13.6	15.9	6.7	0.40	0.47	0.20
2220C-89	34.0	11.5	16.1	6.4	0.34	0.47	0.19
926C	33.9	13.0	16.2	6.1	0.38	0.48	0.18
2220C-19	33.8	11.9	17.3	4.2	0.35	0.51	0.12
2220C-59	33.5	10.9	16.0	6.6	0.33	0.48	0.20
2220C-88	33.4	9.7	14.0	8.1	0.29	0.42	0.24
2220C-20	33.2	10.5	14.2	6.7	0.32	0.43	0.20
2220C-62	33.0	10.3	13.9	8.2	0.31	0.42	0.25
2220C-56	32.8	12.8	15.7	5.1	0.39	0.48	0.16
2220C-86	32.3	12.4	15.3	5.4	0.38	0.47	0.17
2220C-94	32.1	11.2	15.0	5.9	0.35	0.47	0.18
2220C-47	31.9	11.8	15.6	4.3	0.37	0.49	0.13
2220C-40	31.6	12.5	14.0	6.0	0.40	0.44	0.19
2220C-97	31.4	11.2	15.0	5.3	0.36	0.48	0.17
2220C-77	31.3	12.3	14.1	5.6	0.39	0.45	0.18
2220C-64	31.2	11.2	14.5	3.9	0.36	0.46	0.13
2220C-10	31.1	11.0	13.1	8.6	0.35	0.42	0.28
2220C-35	30.9	10.8	14.9	5.2	0.35	0.48	0.17
2220C-70	30.9	13.0	15.1	5.9	0.42	0.49	0.19
2220C-78	30.7	11.1	14.8	5.1	0.36	0.48	0.17
2220C-107	30.6	11.5	13.5	5.8	0.38	0.44	0.19
2220C-48 *	30.1	11.3	15.0	3.9	0.38	0.50	0.13
2220C-21	29.8	11.8	15.6	3.4	0.40	0.52	0.11
2220C-79	29.6	11.2	14.2	5.5	0.38	0.48	0.19
2220C-25	29.4	11.4	14.3	5.0	0.39	0.49	0.17
2220C-46	29.4	10.9	13.9	5.2	0.37	0.47	0.18
2220C-7	28.9	11.8	14.2	3.5	0.41	0.49	0.12
2220C-32	28.5	11.0	13.7	4.7	0.39	0.48	0.16
721C	27.8	11.5	12.9	5.7	0.41	0.46	0.21
2220C-120	27.8	11.9	13.3	5.0	0.43	0.48	0.18
2220C-91	27.6	10.7	12.7	4.8	0.39	0.46	0.17
2220C-92	27.1	10.5	12.8	4.5	0.39	0.47	0.17
2220C-93	26.4	8.9	13.1	3.8	0.34	0.50	0.14
2220C-23	25.5	10.9	12.1	4.1	0.43	0.47	0.16
2220C-58	27.5	9.5	12.9	4.7	0.35	0.47	0.17
2220C-60	25.3	9.5	11.6	5.6	0.38	0.46	0.22
2220C-39	24.0	9.9	11.9	4.1	0.41	0.50	0.17
2221C-9	23.7	7.8	12.1	2.9	0.33	0.51	0.12
2220C-57	23.4	9.4	11.8	3.5	0.40	0.50	0.15
2220C-98	23.3	8.1	10.9	3.8	0.35	0.47	0.16
2221C-7	23.3	8.9	12.1	2.8	0.38	0.52	0.12
2220C-103	23.0	9.2	11.0	4.6	0.40	0.48	0.20

***Owenites koeneni* Hyatt and Smith, n = 160**
(from *O. koeneni* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2220C-41	22.6	9.3	10.5	4.3	0.41	0.46	0.19
2221C-11	22.4	9.4	12.2	2.3	0.42	0.54	0.10
2221C-12	22.1	8.2	11.0	2.6	0.37	0.50	0.12
2220C-85	21.8	8.4	11.4	2.1	0.39	0.52	0.10
2221C-23	21.8	8.5	11.0	2.2	0.39	0.50	0.10
2220C-24	21.4	8.9	11.0	2.9	0.42	0.51	0.14
2221C-16	19.0	6.2	10.2	2.5	0.33	0.54	0.13
2221C-22	15.4	7.2	8.6	1.9	0.47	0.56	0.12
2220C-44	29.3	11.8	15.8	2.5	0.40	0.54	0.09
2220C-119	28.4	10.1	14.9	2.6	0.36	0.52	0.09
2221C-5	27.5	9.1	15.5	2.0	0.33	0.56	0.07
2221C-15	27.1	9.9	14.4	1.8	0.37	0.53	0.07
118C	25.8	10.4	13.8	1.0	0.40	0.53	0.04
2221C-27	22.2	10.0	12.0	1.9	0.45	0.54	0.09
2221C-6	20.8	8.4	10.8	1.0	0.40	0.52	0.05
2221C-28	20.7	9.6	11.4	0.5	0.46	0.55	0.02
2221C-20	20.6	9.3	11.1	1.8	0.45	0.54	0.09
2221C-33	19.8	8.7	11.2	1.0	0.44	0.57	0.05
2221C-31	19.5	7.3	10.6	1.7	0.37	0.54	0.09
2221C-1	19.2	8.2	10.7	1.0	0.43	0.56	0.05
2221C-29	18.2	8.0	10.3	0.5	0.44	0.57	0.03
2221C-30	17.8	6.7	10.4	0.5	0.38	0.58	0.03
2221C-24	17.2	7.4	8.8	0.5	0.43	0.51	0.03
2221C-19	16.9	7.5	9.5	1.0	0.44	0.56	0.06
2221C-13	16.8	5.3	8.5	0.5	0.32	0.51	0.03
2221C-8	16.3	5.7	8.7	0.5	0.35	0.53	0.03
2221C-26	16.0	7.2	8.9	0.5	0.45	0.56	0.03
2221C-14	15.8	8.0	8.4	0.5	0.51	0.53	0.03
2221C-32	15.5	6.9	9.6	0.5	0.45	0.62	0.03
2221C-35	15.4	6.9	9.2	0.5	0.45	0.60	0.03
2221C-2	15.4	7.0	8.6	0.5	0.45	0.56	0.03
2221C-18	15.3	6.7	8.3	1.1	0.44	0.54	0.07
2221C-21	14.6	6.8	8.0	0.5	0.47	0.55	0.03
2221C-34	14.6	5.7	8.1	0.5	0.39	0.55	0.03
2221C-3	11.7	5.4	6.0	0.5	0.46	0.51	0.04
2221C-4	11.5	4.7	6.2	0.5	0.41	0.54	0.04

***Owenites carpenteri* Smith, n = 3**
(from *Owenites koeneni* FA interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2221C-10	19.7	9.6	11.6	-	0.49	0.59	-
2221C-17	22.1	8.8	12.0	-	0.40	0.54	-
2221C-25	20.9	10.0	10.9	-	0.48	0.52	-

***Steckites* cf. *S. brevis* Brühwiler et al., n = 2**
(from *P. toulai* interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2222C	24.9	7.9	9.0	7.6	0.32	0.36	0.31
2257C	24.8	8.2	10.1	6.9	0.33	0.41	0.28

***Juvenites septentrionalis* Smith, n = 138**
(from *M. millardense* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
260C	27.7	12.4	10.5	9.1	0.45	0.38	0.33
285C	29.4	12.6	9.9	11.0	0.43	0.34	0.37
282C	22.9	10.8	8.1	8.2	0.47	0.35	0.36
261C	24.1	11.6	10.4	6.6	0.48	0.43	0.27
264C	19.8	10.4	7.4	6.0	0.53	0.37	0.30
259C	25.1	10.4	8.3	10.1	0.41	0.33	0.40
262C	21.6	12.4	7.6	7.4	0.57	0.35	0.34
696C	28.1	14.2	10.7	8.3	0.51	0.38	0.30
2259C-1	31.3	12.4	10.9	11.7	0.40	0.35	0.37
2259C-2	26.2	12.2	8.5	10.4	0.47	0.32	0.40
2259C-3	25.1	9.9	9.4	7.1	0.39	0.37	0.28
2259C-4	25.7	9.8	8.7	10.0	0.38	0.34	0.39
2259C-5	26.6	11.6	8.3	12.0	0.44	0.31	0.45
2259C-6	28.2	13.3	10.7	8.8	0.47	0.38	0.31
2259C-7	25.1	12.0	8.7	8.9	0.48	0.35	0.35
2259C-8	25.4	13.3	10.0	8.0	0.52	0.39	0.31
2259C-9	24.3	11.6	8.4	8.9	0.48	0.35	0.37
2259C-10	26.5	11.2	9.4	9.8	0.42	0.35	0.37
2259C-11	24.9	12.0	8.3	9.1	0.48	0.33	0.37
2259C-12	19.2	8.7	7.8	5.6	0.45	0.41	0.29
2259C-13	22.3	11.1	9.2	5.7	0.50	0.41	0.26
2259C-14	23.6	11.8	8.1	8.8	0.50	0.34	0.37
2259C-15	21.3	10.9	7.4	8.0	0.51	0.35	0.38
2259C-16	26.8	11.5	8.8	10.6	0.43	0.33	0.40
2259C-17	24.8	12.0	10.0	7.3	0.48	0.40	0.29
2259C-18	28.9	12.8	9.2	2.2	0.44	0.32	0.42
2259C-19	17.2	10.0	6.2	5.2	0.58	0.36	0.30
2259C-20	23.4	12.3	6.6	10.3	0.53	0.28	0.44
2259C-21	23.6	11.3	7.7	9.2	0.48	0.33	0.39
2259C-22	12.0	7.1	5.4	3.5	0.59	0.45	0.29
2259C-23	20.5	11.0	8.9	6.0	0.54	0.43	0.29
2259C-24	25.7	12.0	9.8	8.3	0.47	0.38	0.32
2259C-25	26.1	11.5	9.0	9.3	0.44	0.34	0.36
2259C-26	26.3	13.5	9.2	9.8	0.51	0.35	0.37
2259C-27	26.2	11.4	8.9	9.9	0.44	0.34	0.38
2259C-28	21.3	10.7	8.0	7.2	0.50	0.38	0.34
2259C-29	22.5	12.1	9.5	6.4	0.54	0.42	0.28
2259C-30	19.6	9.9	6.4	7.3	0.51	0.33	0.37
2259C-31	25.9	11.2	10.5	8.2	0.43	0.41	0.32
2259C-32	20.3	9.8	8.3	5.3	0.48	0.41	0.26
2259C-33	26.6	11.0	7.8	10.6	0.41	0.29	0.40
2259C-34	26.0	12.6	10.3	7.7	0.48	0.40	0.30
2259C-35	21.2	10.2	6.8	8.4	0.48	0.32	0.40
2259C-36	24.6	10.5	9.3	8.0	0.43	0.38	0.33
2259C-37	23.3	11.1	6.6	10.0	0.48	0.28	0.43
2259C-38	21.8	9.3	8.4	7.1	0.43	0.39	0.33
2259C-39	30.3	12.4	11.2	10.3	0.41	0.37	0.34

***Juvenites septentrionalis* Smith, n = 138**
(from *M. millardense* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2259C-40	23.2	10.5	9.0	7.5	0.45	0.39	0.32
2259C-41	28.8	11.7	11.3	9.2	0.41	0.39	0.32
2259C-42	22.1	10.2	7.2	8.0	0.46	0.33	0.36
2259C-43	19.0	11.1	6.5	6.9	0.58	0.34	0.36
2259C-44	25.2	12.1	8.7	9.0	0.48	0.35	0.36
2259C-45	22.8	11.8	9.4	7.3	0.52	0.41	0.32
2259C-46	27.9	12.9	9.1	11.2	0.46	0.33	0.40
2259C-47	22.9	11.0	8.7	7.8	0.48	0.38	0.34
2259C-48	23.4	10.1	8.9	8.2	0.43	0.38	0.35
2259C-49	23.3	11.0	9.7	7.2	0.47	0.42	0.31
2259C-50	23.4	12.0	9.3	6.8	0.51	0.40	0.29
2259C-51	24.8	11.7	8.4	9.8	0.47	0.34	0.40
2259C-52	24.3	12.2	8.5	8.7	0.50	0.35	0.36
2259C-53	22.9	11.0	7.5	9.1	0.48	0.33	0.40
2259C-54	22.7	11.5	8.1	7.6	0.51	0.36	0.33
2259C-55	23.7	11.5	8.5	8.0	0.49	0.36	0.34
2259C-56	23.2	11.6	8.5	7.5	0.50	0.37	0.32
2259C-57	24.4	11.3	8.2	8.6	0.46	0.34	0.35
2259C-58	27.2	11.3	8.5	10.3	0.42	0.31	0.38
2259C-59	25.5	11.3	9.1	9.0	0.44	0.36	0.35
2259C-60	19.6	9.7	6.8	7.1	0.49	0.35	0.36
2259C-61	21.3	9.8	7.6	7.2	0.46	0.36	0.34
2259C-62	23.2	10.9	9.2	7.8	0.47	0.40	0.34
2259C-63	15.3	7.7	6.0	4.7	0.50	0.39	0.31
2259C-64	21.3	10.4	6.9	8.4	0.49	0.32	0.39
2259C-65	16.8	09.3	7.2	4.2	0.55	0.43	0.25
2259C-66	20.5	09.6	7.4	6.6	0.47	0.36	0.32
2259C-67	22.9	11.0	7.6	8.7	0.48	0.33	0.38
2259C-68	21.7	8.9	7.7	7.7	0.41	0.35	0.35
2259C-69	23.1	12.0	8.0	8.9	0.52	0.35	0.39
2259C-70	21.3	11.1	8.3	7.9	0.52	0.39	0.37
2259C-71	21.7	11.1	8.2	7.7	0.51	0.38	0.35
2259C-72	24.4	12.8	9.0	8.6	0.52	0.37	0.35
2259C-73	23.8	10.4	8.5	8.2	0.44	0.36	0.34
2259C-74	23.5	10.4	9.6	7.8	0.44	0.41	0.33
2259C-75	21.3	10.6	8.8	6.9	0.50	0.41	0.32
2259C-76	12.2	7.4	4.9	3.2	0.61	0.40	0.26
2259C-77	21.6	11.8	8.0	7.5	0.55	0.37	0.35
2259C-78	26.4	12.4	8.4	11.3	0.47	0.32	0.43
2259C-79	21.8	10.6	8.2	10.0	0.49	0.38	0.46
2259C-80	20.9	10.6	7.2	7.5	0.51	0.34	0.36
2259C-81	22.7	11.2	7.8	8.1	0.49	0.34	0.36
2259C-82	22.5	9.7	7.2	8.0	0.43	0.32	0.36
2259C-83	19.7	9.4	7.6	6.5	0.48	0.39	0.33
2259C-84	11.3	7.0	4.7	3.2	0.62	0.42	0.28
2259C-85	14.1	8.5	6.3	4.1	0.60	0.45	0.29
2259C-86	18.5	9.2	7.3	5.8	0.50	0.39	0.31

***Juvenites septentrionalis* Smith, n = 138**
(from *M. millardense* FA through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2259C-87	22.0	8.6	8.3	6.9	0.39	0.38	0.31
2259C-88	20.7	11.2	8.2	5.6	0.54	0.40	0.27
2259C-89	22.6	10.8	8.8	7.3	0.48	0.39	0.32
2259C-90	11.8	6.5	4.9	3.3	0.55	0.42	0.28
2259C-91	20.3	8.8	6.4	7.1	0.43	0.32	0.35
2259C-92	9.4	5.5	3.8	2.7	0.59	0.40	0.29
2259C-93	20.1	9.0	8.1	6.4	0.45	0.40	0.32
2259C-94	22.1	11.4	7.4	8.4	0.52	0.33	0.38
2259C-95	22.0	10.4	8.8	6.5	0.47	0.40	0.30
2259C-96	17.2	9.0	7.2	5.1	0.52	0.42	0.30
2259C-97	17.9	9.8	6.8	6.0	0.55	0.38	0.34
2259C-98	16.0	8.8	6.6	4.5	0.55	0.41	0.28
2259C-99	21.0	10.7	8.3	6.4	0.51	0.40	0.30
2259C-100	19.3	9.0	7.4	6.5	0.47	0.38	0.34
2259C-101	17.1	8.5	6.9	5.2	0.50	0.40	0.30
2259C-102	18.9	9.3	6.5	7.4	0.49	0.34	0.39
2259C-103	16.8	9.0	7.2	4.9	0.54	0.43	0.29
2259C-104	15.6	9.3	6.7	4.6	0.60	0.43	0.29
2259C-105	18.3	9.0	7.3	5.5	0.49	0.40	0.30
2259C-106	18.9	10.2	7.7	5.7	0.54	0.41	0.30
2259C-107	18.2	11.2	7.6	5.3	0.62	0.42	0.29
2259C-108	21.5	10.4	8.3	6.8	0.48	0.39	0.32
2259C-109	14.6	8.4	5.8	4.4	0.58	0.40	0.30
2259C-110	21.9	10.7	8.7	6.9	0.49	0.40	0.32
2259C-111	18.3	9.5	7.0	5.9	0.52	0.38	0.32
2259C-112	18.3	9.7	7.2	6.2	0.53	0.39	0.34
2259C-113	19.5	9.5	7.2	6.6	0.49	0.37	0.34
2259C-114	14.2	8.5	5.4	4.2	0.60	0.38	0.30
2259C-115	17.8	9.2	7.0	5.3	0.52	0.39	0.30
2259C-116	25.1	12.9	10.4	7.1	0.51	0.41	0.28
2259C-117	24.9	11.4	8.9	8.9	0.46	0.36	0.36
2259C-118	24.6	12.3	9.4	7.8	0.50	0.38	0.32
2259C-119	26.4	11.8	9.0	9.9	0.45	0.34	0.38
2259C-120	15.8	8.8	6.8	4.3	0.56	0.43	0.27
2259C-121	19.5	10.1	7.3	6.5	0.52	0.37	0.33
2259C-122	23.3	10.7	9.3	7.8	0.46	0.40	0.33
2259C-123	21.8	9.8	8.3	6.8	0.45	0.38	0.31
2259C-124	23.9	10.6	9.9	7.0	0.44	0.41	0.29
2259C-125	18.8	8.7	7.0	6.6	0.46	0.37	0.35
2259C-126	22.3	10.4	8.4	6.7	0.47	0.38	0.30
2259C-127	21.5	10.9	9.0	6.1	0.51	0.42	0.28
2259C-128	21.6	9.9	10.0	8.0	0.46	0.46	0.37
2259C-129	15.3	8.3	5.9	5.0	0.54	0.39	0.33
2259C-130	22.3	10.9	9.1	6.7	0.49	0.41	0.30
2259C-131	24.5	12.1	8.8	8.4	0.49	0.36	0.34

?Juvenites sp. indet., n = 5
(from *P. toulai* through *I. oweni* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2254C	27.8	10.8	11.3	7.9	0.39	0.41	0.28
2255C	28.9	10.5	10.9	8.4	0.36	0.38	0.29
2256C	24.9	9.9	10.3	7.1	0.40	0.41	0.29
2258C	27.9	10.2	10.4	8.1	0.37	0.37	0.29
2435C	25.0	9.4	9.2	8.3	0.38	0.37	0.33

***Ussurijuvenites* cf. *U. artyomensis* Smyshlyaeva and Zakharov, n = 1**
(from *G. lucasi* interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
747C	11.6	9.2	3.9	3.8	0.79	0.34	0.33

***Juvenites spathi* (Frebold), n = 192**
(from *A. rubyae* FA through *C. jattioti* n. gen., n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
269C	33.3	19.8	14.0	10.0	0.59	0.42	0.30
723C	36.0	19.0	16.0	9.6	0.53	0.44	0.27
702C	31.9	17.5	14.2	8.1	0.55	0.45	0.25
131C	33.1	17.8	14.5	8.2	0.54	0.44	0.25
286C	38.3	20.0	15.9	10.9	0.52	0.42	0.28
697C	32.4	18.9	14.7	9.1	0.58	0.45	0.28
2320C-1	37.9	19.7	14.5	11.6	0.52	0.38	0.31
2320C-2	31.1	17.8	12.8	8.6	0.57	0.41	0.28
2320C-3	37.4	18.2	14.9	11.5	0.49	0.40	0.31
2320C-4	30.7	16.2	13.5	8.3	0.53	0.44	0.27
2320C-5	29.8	15.8	13.4	7.4	0.53	0.45	0.25
2320C-6	32.7	18.1	13.3	9.4	0.55	0.41	0.29
2320C-7	29.8	15.8	12.9	6.9	0.53	0.43	0.23
2320C-8	28.0	16.8	12.2	7.7	0.60	0.44	0.28
2320C-9	37.0	19.8	15.6	10.3	0.54	0.42	0.28
2320C-10	31.2	17.9	13.0	7.9	0.57	0.42	0.25
2320C-11	34.1	17.8	14.9	8.1	0.52	0.44	0.24
2320C-12	33.0	18.4	14.6	7.9	0.56	0.44	0.24
2320C-13	35.5	17.0	16.6	7.7	0.48	0.47	0.22
2320C-14	26.8	15.0	11.3	6.5	0.56	0.42	0.24
2320C-15	25.5	16.9	11.0	7.0	0.66	0.43	0.27
2320C-16	32.1	18.9	13.9	8.9	0.59	0.43	0.28
2320C-17	27.9	14.9	11.8	7.7	0.53	0.42	0.28
2320C-18	37.6	18.2	15.5	9.7	0.48	0.41	0.26
2320C-19	33.0	18.5	14.8	7.8	0.56	0.45	0.24
2320C-20	31.1	16.0	13.6	7.9	0.51	0.44	0.25
2320C-21	32.4	18.1	13.6	8.0	0.56	0.42	0.25
2320C-22	36.5	18.9	15.1	10.3	0.52	0.41	0.28
2320C-23	30.8	16.9	12.9	8.9	0.55	0.42	0.29
2320C-24	27.1	16.0	11.7	7.1	0.59	0.43	0.26
2320C-25	30.1	16.9	12.4	8.1	0.56	0.41	0.27
2320C-26	36.4	18.6	14.8	10.7	0.51	0.41	0.29
2320C-27	28.4	15.9	12.0	8.7	0.56	0.42	0.31
2320C-28	26.8	16.0	11.4	6.9	0.60	0.43	0.26
2320C-29	33.0	16.9	15.0	8.1	0.51	0.45	0.25
2320C-30	30.3	17.2	13.1	8.1	0.57	0.43	0.27
2320C-31	32.0	17.5	14.0	8.0	0.55	0.44	0.25
2320C-32	32.0	17.0	14.1	8.2	0.53	0.44	0.26
2320C-33	32.4	19.2	13.3	10.2	0.59	0.41	0.31
2320C-34	31.1	17.1	13.1	8.6	0.55	0.42	0.28
2320C-35	28.4	16.3	12.9	6.5	0.57	0.45	0.23
2320C-36	37.0	20.6	15.1	11.5	0.56	0.41	0.31
2320C-37	28.7	17.6	13.1	7.0	0.61	0.46	0.24
2320C-38	32.0	16.8	13.6	8.6	0.53	0.43	0.27
2320C-39	32.4	17.8	13.6	8.7	0.55	0.42	0.27
2320C-40	31.8	16.8	14.3	6.9	0.53	0.45	0.22
2320C-41	26.0	14.9	10.9	6.9	0.57	0.42	0.27
2320C-42	33.8	18.3	14.6	9.1	0.54	0.43	0.27
2320C-43	36.5	18.2	14.9	11.0	0.50	0.41	0.30
2320C-44	30.4	18.1	12.6	8.7	0.60	0.41	0.29

***Juvenites spathi* (Frebold), n = 192**
(from *A. rubyae* FA through *C. jattioti* n. gen., n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2320C-45	37.0	20.4	13.6	12.2	0.55	0.37	0.33
2320C-46	29.0	16.1	13.0	8.0	0.56	0.45	0.28
2320C-47	22.0	15.0	9.9	5.4	0.68	0.45	0.25
2320C-48	29.8	17.4	13.0	8.7	0.58	0.44	0.29
2320C-49	31.9	17.6	14.0	8.0	0.55	0.44	0.25
2320C-50	23.2	15.1	9.2	7.1	0.65	0.40	0.31
2320C-51	36.0	18.5	16.5	8.9	0.51	0.46	0.25
2320C-52	30.2	18.3	14.9	7.3	0.61	0.49	0.24
2320C-53	33.4	17.0	14.9	8.4	0.51	0.45	0.25
2320C-54	31.2	18.6	14.1	7.0	0.60	0.45	0.22
2320C-55	30.7	16.1	14.0	8.1	0.52	0.46	0.26
2320C-56	24.0	16.0	10.2	6.3	0.67	0.43	0.26
2320C-57	27.3	15.4	11.7	7.2	0.56	0.43	0.26
2320C-58	26.9	16.4	11.8	7.4	0.61	0.44	0.28
2320C-59	28.3	16.9	11.8	9.1	0.60	0.42	0.32
2320C-60	29.9	16.9	13.4	6.8	0.57	0.45	0.23
2320C-61	29.3	17.3	12.9	7.8	0.59	0.44	0.27
2320C-62	30.7	17.6	13.7	9.0	0.57	0.45	0.29
2320C-63	27.1	16.1	10.8	8.9	0.59	0.40	0.33
2320C-64	27.0	15.7	12.0	6.9	0.58	0.44	0.26
2320C-65	24.9	16.8	10.7	6.0	0.67	0.43	0.24
232-C-66	25.8	14.5	11.0	7.5	0.56	0.43	0.29
2320C-67	25.0	16.7	10.6	6.9	0.67	0.42	0.28
2320C-68	27.0	14.1	11.7	6.5	0.52	0.43	0.24
2320C-69	23.4	14.9	10.2	5.9	0.64	0.44	0.25
2320C-70	27.0	14.9	12.0	6.4	0.55	0.44	0.24
2320C-71	27.8	15.6	12.3	7.3	0.56	0.44	0.26
2320C-72	26.0	14.0	12.6	6.1	0.54	0.48	0.23
2320C-73	20.5	13.7	9.1	6.0	0.67	0.44	0.29
2320C-74	19.6	13.0	9.2	4.6	0.66	0.47	0.23
2320C-75	24.5	14.7	10.8	6.0	0.60	0.44	0.24
2320C-76	26.6	15.3	12.0	6.5	0.58	0.45	0.24
2320C-77	26.6	16.1	11.2	6.9	0.61	0.42	0.26
2320C-78	20.2	12.9	8.2	6.3	0.64	0.41	0.31
2320C-79	25.0	14.1	11.3	6.2	0.56	0.45	0.25
2320C-80	28.8	15.0	12.6	7.6	0.52	0.44	0.26
2320C-81	22.0	13.3	9.8	5.5	0.60	0.45	0.25
2320C-82	26.0	15.0	10.9	6.6	0.58	0.42	0.25
2320C-83	22.0	13.0	9.7	6.3	0.59	0.44	0.29
2320C-84	21.6	13.8	9.1	5.9	0.64	0.42	0.27
2320C-85	21.6	12.3	9.7	5.0	0.57	0.45	0.23
2320C-86	19.2	12.6	8.9	5.1	0.66	0.46	0.27
2320C-87	18.9	12.1	8.5	5.0	0.64	0.45	0.26
2320C-88	18.2	12.5	7.1	4.9	0.69	0.39	0.27
2320C-89	18.8	12.0	8.0	4.6	0.64	0.43	0.24
2320C-90	19.1	12.3	8.1	4.2	0.64	0.42	0.22
2320C-91	28.6	15.6	12.9	7.1	0.55	0.45	0.25
2320C-92	32.9	18.3	14.8	8.4	0.56	0.45	0.26
2320C-93	22.2	14.1	9.7	5.0	0.64	0.44	0.23
2320C-94	27.5	16.0	12.8	5.7	0.58	0.47	0.21
2320C-95	32.1	16.9	12.9	9.7	0.53	0.40	0.30
2320C-96	32.4	19.0	14.7	8.0	0.59	0.45	0.25
2320C-97	28.9	17.3	13.0	7.6	0.60	0.45	0.26
2320C-98	24.7	15.1	11.3	5.6	0.61	0.46	0.23
2320C-99	26.0	14.9	11.5	6.7	0.57	0.44	0.26
2320C-100	32.9	18.1	13.4	10.3	0.55	0.41	0.31
2320C-101	18.1	12.5	7.7	5.0	0.69	0.43	0.28
2320C-102	28.8	16.0	13.0	7.1	0.56	0.45	0.25
2320C-103	19.5	14.6	8.9	4.2	0.75	0.46	0.22
2320C-104	22.1	14.5	9.8	5.3	0.66	0.44	0.24
2320C-105	26.2	14.1	12.0	6.9	0.54	0.46	0.26
2320C-106	28.6	17.6	13.4	7.5	0.62	0.47	0.26
2320C-107	31.6	17.0	15.1	6.0	0.54	0.48	0.19
2320C-108	28.8	16.1	12.0	8.4	0.56	0.42	0.29
2320C-109	24.9	15.2	11.3	5.9	0.61	0.45	0.24
232-C-110	27.7	16.5	11.5	8.0	0.60	0.42	0.29
2320C-111	19.6	11.6	7.8	5.7	0.59	0.40	0.29
2320C-112	30.7	17.5	13.8	8.6	0.57	0.45	0.28
2320C-113	20.7	13.9	8.8	4.9	0.67	0.43	0.24
2320C-114	34.3	19.9	14.6	9.0	0.58	0.43	0.26
2320C-115	22.0	14.0	9.6	5.4	0.64	0.44	0.25
2320C-116	18.5	13.0	8.6	4.2	0.70	0.46	0.23

***Juvenites spathi* (Frebold), n = 192**
(from *A. rubyae* FA through *C. jattioti* n. gen., n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2320C-117	27.4	15.0	12.1	6.9	0.55	0.44	0.25
2320C-118	23.0	15.5	10.2	6.0	0.67	0.44	0.26
2320C-119	19.6	12.1	8.7	4.3	0.62	0.44	0.22
2320C-120	20.6	12.6	9.0	5.0	0.61	0.44	0.24
2320C-121	27.3	15.7	11.6	7.9	0.58	0.42	0.29
2320C-122	36.6	19.9	15.7	10.5	0.54	0.43	0.29
2320C-123	26.5	15.3	10.6	8.0	0.58	0.40	0.30
2320C-124	32.0	19.0	12.7	10.0	0.59	0.40	0.31
2320C-125	37.5	20.1	16.0	10.6	0.54	0.43	0.28
2320C-126	32.9	18.6	13.2	8.9	0.57	0.40	0.27
2320C-127	32.1	18.7	14.0	9.0	0.58	0.44	0.28
2320C-128	29.0	16.0	12.8	6.9	0.55	0.44	0.24
2320C-129	21.6	13.9	9.7	5.0	0.64	0.45	0.23
2320C-130	31.6	17.8	14.7	7.0	0.56	0.47	0.22
2320C-131	22.2	13.8	9.8	5.3	0.62	0.44	0.24
2320C-132	26.0	14.8	12.0	5.9	0.57	0.46	0.23
2320C-133	26.2	15.5	11.5	6.9	0.59	0.44	0.26
2320C-134	27.5	15.9	11.7	7.7	0.58	0.43	0.28
2320C-135	28.1	16.8	13.0	6.5	0.60	0.46	0.23
2320C-136	31.4	17.8	12.9	8.7	0.57	0.41	0.28
2320C-137	20.4	11.6	9.0	4.7	0.57	0.44	0.23
2320C-138	26.9	17.0	11.6	6.9	0.63	0.43	0.26
2320C-139	26.4	15.2	11.0	7.4	0.58	0.42	0.28
2320C-140	19.0	12.9	8.3	4.7	0.68	0.44	0.25
2320C-141	29.0	16.3	12.0	8.3	0.56	0.41	0.29
2320C-142	26.1	15.0	11.9	6.5	0.57	0.46	0.25
2320C-143	25.4	14.7	11.0	6.8	0.58	0.43	0.27
2320C-144	28.9	16.9	12.0	8.3	0.58	0.42	0.29
2320C-145	34.0	16.6	13.9	9.1	0.49	0.41	0.27
2320C-146	29.1	16.9	12.9	7.4	0.58	0.44	0.25
2320C-147	29.0	17.0	12.7	7.5	0.59	0.44	0.26
2320C-148	28.0	15.0	12.8	6.8	0.54	0.46	0.24
2320C-149	33.8	17.7	13.8	10.4	0.52	0.41	0.31
2320C-150	36.5	20.4	14.1	11.3	0.56	0.39	0.31
2320C-151	38.0	18.1	17.0	9.5	0.48	0.45	0.25
2320C-152	31.5	17.2	14.0	9.0	0.55	0.44	0.29
2320C-153	31.5	18.0	13.2	8.9	0.57	0.42	0.28
2320C-154	21.9	15.2	8.6	6.0	0.69	0.39	0.27
2320C-155	22.3	15.0	9.8	5.9	0.67	0.44	0.26
2320C-156	32.7	17.5	15.1	8.1	0.54	0.46	0.25
2320C-157	20.8	12.8	8.7	5.0	0.62	0.42	0.24
2320C-158	19.3	13.7	8.9	4.4	0.71	0.46	0.23
2320C-159	31.2	17.1	14.8	7.9	0.55	0.47	0.25
2320C-160	27.0	16.1	13.0	5.6	0.60	0.48	0.21
2320C-161	29.8	17.0	12.1	8.4	0.57	0.41	0.28
2320C-162	34.0	18.9	14.0	9.6	0.56	0.41	0.28
2320C-163	27.5	15.1	11.0	8.0	0.55	0.40	0.29
2320C-164	22.0	14.0	9.5	5.9	0.64	0.43	0.27
2320C-165	27.5	15.6	12.0	7.5	0.57	0.44	0.27
2320C-166	21.3	14.0	8.6	5.2	0.66	0.40	0.24
2320C-167	28.0	15.6	11.9	7.0	0.56	0.43	0.25
2320C-168	33.0	17.5	15.0	8.1	0.53	0.45	0.25
2320C-169	25.2	14.6	11.1	6.4	0.58	0.44	0.25
2320C-170	24.1	14.8	10.1	6.6	0.61	0.42	0.27
2320C-171	32.7	19.1	15.0	8.0	0.58	0.46	0.24
2320C-172	16.8	11.0	8.0	3.6	0.65	0.48	0.21
2320C-173	15.0	8.9	7.0	2.6	0.59	0.47	0.17
2320C-174	15.9	11.0	6.2	4.0	0.69	0.39	0.25
2320C-175	15.9	10.5	7.4	3.9	0.66	0.47	0.25
2320C-176	20.0	12.6	8.4	5.0	0.63	0.42	0.25
2320C-177	18.3	12.0	8.8	4.5	0.66	0.48	0.25
2320C-178	14.8	9.0	6.7	4.0	0.61	0.45	0.27
2320C-179	13.2	8.3	6.9	2.9	0.63	0.52	0.22
2320C-180	44.6	23.9	17.0	14.4	0.54	0.38	0.32
2320C-181	30.3	15.1	13.5	7.4	0.50	0.45	0.24
2320C-182	22.6	14.0	9.7	6.1	0.62	0.43	0.27
2320C-183	32.8	18.2	13.0	9.5	0.55	0.40	0.29
2320C-184	26.1	16.0	11.3	6.4	0.61	0.43	0.25
2320C-185	25.6	16.0	11.3	6.5	0.63	0.44	0.25
2320C-186	33.0	18.0	14.4	8.6	0.55	0.44	0.26

<i>Pseudosageceras multilobatum</i> Noetling, n = 30 measureable specimens (from <i>M. gracilitatis</i> FA through <i>C. youngi</i> n. gen. intervals)							
Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
113C	87.0	19.0	53.4	-	0.22	0.61	-
252C	78.3	17.1	47.0	-	0.22	0.60	-
692C	69.4	15.8	43.0	-	0.23	0.62	-
2321C-1	84.7	20.9	51.9	-	0.25	0.61	-
2321C-2	61.3	13.7	37.1	-	0.22	0.61	-
2321C-3	99.8	22.9	59.4	-	0.23	0.60	-
2321C-4	78.2	16.9	48.4	-	0.22	0.62	-
2321C-5	91.0	20.0	55.5	-	0.22	0.61	-
2321C-6	57.2	12.6	35.1	-	0.22	0.61	-
2321C-7	65.0	14.7	39.2	-	0.23	0.60	-
2321C-8	66.5	15.0	39.9	-	0.23	0.60	-
2321C-9	87.3	18.1	51.8	-	0.21	0.59	-
2321C-10	62.0	14.9	38.7	-	0.24	0.62	-
2321C-11	44.1	9.1	27.0	-	0.21	0.61	-
2321C-12	70.1	16.6	42.6	-	0.24	0.61	-
2321C-13	69.9	15.5	43.3	-	0.22	0.62	-
2321C-14	65.9	14.6	40.0	-	0.22	0.61	-
2321C-15	55.8	12.3	34.2	-	0.22	0.61	-
2321C-16	72.2	16.7	43.5	-	0.23	0.60	-
2321C-17	50.8	11.9	30.5	-	0.23	0.60	-
2321C-18	64.6	14.8	39.5	-	0.23	0.61	-
2321C-19	98.4	21.1	59.8	-	0.21	0.61	-
2321C-20	62.6	15.3	39.4	-	0.24	0.63	-
2321C-21	68.8	16.4	42.6	-	0.24	0.62	-
2321C-22	63.8	14.8	38.4	-	0.23	0.60	-
2321C-23	71.3	15.4	42.2	-	0.22	0.59	-
2321C-24	61.2	14.5	37.8	-	0.24	0.62	-
2321C-25	63.7	14.4	39.3	-	0.23	0.62	-
2321C-26	60.3	14.2	36.6	-	0.24	0.61	-
2321C-27	61.7	14.9	38.6	-	0.24	0.63	-
2321C-28	132.5	30.5	80.9	-	0.23	0.61	-
2321C-29	Suture line reproduction only (H = 4.0 cm) – measurements not possible						

<i>Pseudosageceras augustum</i> (Brayard and Bucher), n = 7 measureable specimens (from <i>C. youngi</i> n. gen. interval)							
Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
292C	78.5	14.3	47.8	-	0.18	0.61	-
649C	58.5	11.1	36.0	-	0.19	0.62	-
1418C	48.5	8.7	29.8	-	0.18	0.61	-
2185C	41.4	8.0	25.9	-	0.19	0.63	-
2186C	38.5	6.9	22.5	-	0.18	0.58	-
2202C	39.1	7.0	22.5	-	0.18	0.58	-
2544C	38.3	6.0	22.9	-	0.16	0.60	-

***Mesohedenstroemia kwangsiana* Chao, n = 4**
(from *I. oweni* interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2147C	39.1	10.9	22.3	3.4	0.28	0.57	0.09
2432C	42.3	12.0	24.2	4.4	0.28	0.57	0.10
2433C	41.8	11.7	24.7	3.4	0.28	0.59	0.08
2473C	53.1	14.4	30.2	4.0	0.27	0.57	0.08

***Hedenstroemia kossmati* Hyatt and Smith, n = 2**
(from *C. jattioti* interval n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2476C	73.1	16.3	42.2	4.6	0.22	0.58	0.06
2477C	79.0	18.9	44.0	5.6	0.24	0.56	0.07

***Cordillerites angulatus* Hyatt and Smith, n = 1**
(found as float)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
162C	50.6	9.4	30.6	-	0.19	0.60	0

***Aspenites acutus* Hyatt and Smith, n = 39**
(from *Crittendenites jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2179C-33	73.9	14.6	45.0	-	0.20	0.61	-
893C	69.6	13.1	41.1	-	0.19	0.59	-
2179C-6	60.1	12.1	34.9	-	0.20	0.58	-
927C	56.5	10.3	33.0	-	0.18	0.58	-
2179C-34	54.1	10.4	32.6	-	0.19	0.60	-
2179C-24	51.4	10.4	28.8	-	0.20	0.56	-
2179C-15	50.9	9.8	30.7	-	0.19	0.60	-
2179C-29	44.7	8.6	26.2	-	0.19	0.59	-
226C	43.6	9.3	25.9	-	0.21	0.59	-
2179C-31	43.2	8.6	24.3	-	0.20	0.56	-
2179C-35	42.9	8.4	26.1	-	0.20	0.61	-
2179C-32	42.4	8.6	24.3	-	0.20	0.57	-
2179C-27	39.5	7.9	22.5	-	0.20	0.57	-
2179C-22	37.8	8.2	22.1	-	0.22	0.58	-
2179C-28	37.4	8.0	22.2	-	0.21	0.59	-
2179C-5	37.3	8.2	21.4	-	0.22	0.57	-
2179C-30	36.8	7.9	21.6	-	0.21	0.59	-
2179C-4	36.5	7.8	21.2	-	0.21	0.58	-
2179C-23	35.9	7.9	21.7	-	0.22	0.60	-
745C	35.9	8.1	21.7	-	0.23	0.60	-
2179C-1	34.0	7.6	19.8	-	0.22	0.58	-
2179C-9	34.0	7.7	20.4	-	0.23	0.60	-
2179C-20	32.9	7.3	19.4	-	0.22	0.59	-
2179C-21	32.9	7.1	20.3	-	0.22	0.62	-
2179C-10	32.7	7.1	19.1	-	0.22	0.58	-
2179C-26	30.7	6.8	18.1	-	0.22	0.59	-
2179C-18	25.8	5.3	15.1	-	0.21	0.59	-
2179C-11	25.7	6.1	15.9	-	0.24	0.62	-
2179C-7	25.0	5.7	14.4	-	0.23	0.58	-
2179C-16	25.0	5.9	15.4	-	0.24	0.62	-
2179C-25	24.9	5.9	14.9	-	0.24	0.60	-
2179C-13	24.1	5.8	14.2	-	0.24	0.59	-
2179C-2	23.0	5.6	13.0	-	0.24	0.57	-
2179C-3	21.9	5.8	13.0	-	0.26	0.59	-
2179C-12	19.0	4.6	11.5	-	0.24	0.61	-
2179C-8	16.9	4.9	10.1	-	0.29	0.60	-
2179C-19	15.4	4.0	9.1	-	0.26	0.59	-
2179C-17	12.0	3.6	6.9	-	0.30	0.58	-
2179C-14	10.7	3.0	6.0	-	0.28	0.56	-

***Aspenites weitschati* n. sp., n = 47**
(from *O.koeneni* FA and *A.weitschati* n. sp. intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-79174, paratype	115.4	16.7	68.5	-	0.14	0.59	-
NMMNH P-79170, holotype	108.3	15.9	61.2	-	0.15	0.57	-
2180C-44	107.8	17.0	63.8	-	0.16	0.59	-
2180C-2	94.2	14.8	56.0	-	0.16	0.59	-
2180C-1	93.0	15.7	54.5	-	0.17	0.59	-
2180C-45	91.9	14.4	55.5	-	0.16	0.60	-
2180C-6	84.0	12.9	49.8	-	0.15	0.59	-
609C	82.7	12.9	49.7	-	0.16	0.60	-
2180C-4	79.9	12.5	48.1	-	0.16	0.60	-
2180C-38	72.2	10.5	43.3	-	0.15	0.60	-
2180C-46	66.7	9.9	39.2	-	0.15	0.59	-
NMMNH P-79171, paratype	64.6	10.7	38.1	-	0.17	0.59	-
NMMNH P-79175, paratype	64.5	11.2	37.6	-	0.17	0.58	-
2180C-5	62.0	8.9	37.6	-	0.14	0.61	-
2180C-21	59.0	9.9	35.7	-	0.17	0.61	-
2180C-12	54.9	8.7	33.8	-	0.16	0.62	-
2180C-16	54.4	8.2	31.9	-	0.15	0.59	-
2180C-8	54.0	8.5	32.2	-	0.16	0.60	-
2180C-18	54.0	8.8	32.9	-	0.16	0.61	-
2180C-22	52.0	8.2	31.2	-	0.16	0.60	-
2180C-7	51.5	8.0	31.1	-	0.16	0.60	-
2180C-39	50.3	7.7	29.4	-	0.15	0.58	-
2180C-23	49.5	8.1	30.2	-	0.16	0.61	-
2180C-20	48.9	6.9	28.3	-	0.14	0.58	-
NMMNH P-79172, paratype	47.3	7.4	28.9	-	0.16	0.61	-
2180C-10	43.7	6.6	26.2	-	0.15	0.60	-
2180C-37	42.3	6.9	24.7	-	0.16	0.58	-
2180C-27	41.8	6.3	25.4	-	0.15	0.61	-
2180C-25	40.8	6.0	23.9	-	0.15	0.59	-
2180C-17	40.7	7.0	24.0	-	0.17	0.59	-
2180C-30	38.0	7.0	23.9	-	0.18	0.63	-
2180C-24	37.8	6.3	23.0	-	0.17	0.61	-
2180C-35	36.8	5.9	21.7	-	0.16	0.59	-
2180C-29	35.7	6.2	20.9	-	0.17	0.59	-
2180C-28	34.9	5.9	20.8	-	0.17	0.60	-
2180C-26	32.9	5.3	19.7	-	0.16	0.60	-
2180C-36	32.9	5.1	19.8	-	0.16	0.60	-
2180C-31	31.0	5.1	18.9	-	0.16	0.61	-
2180C-19	30.5	5.1	17.8	-	0.17	0.58	-
2180C-33	30.2	4.9	17.8	-	0.16	0.59	-
2180C-34	27.9	4.8	16.5	-	0.17	0.59	-
2180C-41	24.9	4.4	14.8	-	0.18	0.59	-
NMMNH P-79173, paratype	22.4	4.1	13.6	-	0.18	0.61	-
2180C-15	21.0	3.9	12.9	-	0.19	0.61	-
2180C-40	20.8	4.1	12.7	-	0.20	0.61	-
2180C-13	19.6	3.1	11.4	-	0.16	0.58	-
2180C-42	9.6	2.0	5.7	-	0.21	0.59	-

***Pseudaspenites balinii* Jenks et al., n = 1**
(from *A. weitschati* interval)

Number	Dmm	W	H	U	W/D	H/D	U/D
NMMNH P-60203	73.2	9.6	36.0	11.0	0.13	0.49	0.15

***Elkoceras spathi* (Kummel & Steele), n = 92**
(from *M. millardense* FA through *G. lucasi* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2241C-16	54.0	11.9	16.8	24.9	0.22	0.31	0.46
2241C-66	44.7	9.2	15.5	18.0	0.21	0.35	0.40
2241C-74	43.8	10.0	16.4	16.4	0.23	0.37	0.37
2241C-20	43.6	9.5	17.6	13.5	0.22	0.40	0.31
2241C-47	43.4	8.9	14.3	16.7	0.21	0.33	0.38
701C	43.3	9.9	15.7	16.6	0.23	0.36	0.38
2241C-53	43.1	8.9	14.5	16.8	0.21	0.34	0.39
2241C-2	41.8	8.7	16.0	13.8	0.21	0.38	0.33
2241C-55	41.4	8.7	15.3	15.5	0.21	0.37	0.37
2241C-7	41.3	8.3	15.0	14.9	0.20	0.36	0.36
2241C-76	41.0	9.0	16.0	14.2	0.22	0.39	0.35
2241C-67	40.8	8.9	15.2	14.8	0.22	0.37	0.36
2241C-70	40.8	9.4	15.7	14.1	0.23	0.38	0.35
2241C-71	40.8	8.7	14.2	15.7	0.21	0.35	0.38
2236C	40.7	9.3	15.7	13.9	0.23	0.39	0.34
2241C-79	40.2	7.9	14.3	15.0	0.20	0.36	0.37
2241C-9	39.4	8.4	14.5	14.5	0.21	0.37	0.37
2241C-57	39.3	8.5	14.8	13.4	0.22	0.38	0.34
2241C-60	39.3	8.3	13.1	15.0	0.21	0.33	0.38
2241C-11	39.0	7.7	13.9	15.0	0.20	0.36	0.38
2241C-59	39.0	8.6	13.9	15.1	0.22	0.36	0.39
2241C-15	38.9	9.4	13.5	15.2	0.24	0.35	0.39
2241C-73	37.9	7.3	13.9	13.9	0.19	0.37	0.37
2241C-64	37.8	8.2	13.5	13.8	0.22	0.36	0.37
2241C-6	37.7	8.2	13.2	14.4	0.22	0.35	0.38
2241C-63	37.7	8.8	12.8	14.8	0.23	0.34	0.39
2241C-5	37.6	8.6	13.8	13.3	0.23	0.37	0.35
240C	37.6	8.4	14.4	12.8	0.22	0.38	0.34
2241C-69	37.6	7.9	15.0	11.7	0.21	0.40	0.31
2241C-75	37.6	8.0	13.5	14.2	0.21	0.36	0.38
2241C-3	37.5	8.0	13.5	13.3	0.21	0.36	0.35
2241C-4	37.5	8.4	14.4	12.1	0.22	0.38	0.32
2241C-38	37.3	9.0	14.0	13.8	0.24	0.38	0.37
2241C-56	37.3	9.2	14.2	12.5	0.25	0.38	0.34
2241C-78	37.2	7.8	13.3	14.3	0.21	0.36	0.38
2241C-77	35.7	7.8	12.2	13.3	0.22	0.34	0.37
2241C-24	35.6	6.9	12.0	14.3	0.19	0.34	0.40
2241C-48	35.5	8.7	14.3	11.4	0.25	0.40	0.32
2241C-32	35.2	7.0	12.8	12.7	0.20	0.36	0.36
2241C-49	35.2	7.6	13.0	12.7	0.22	0.37	0.36
2241C-68	35.1	7.6	13.9	11.4	0.22	0.40	0.32
2241C-80	34.7	8.4	13.7	10.8	0.24	0.39	0.31

***Elkoceras spathi* (Kummel & Steele), n = 92**
(from *M. millardense* FA through *G. lucasi* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2241C-54	34.5	7.8	12.9	11.9	0.23	0.37	0.34
2241C-17	34.1	8.5	14.2	9.9	0.25	0.42	0.29
2241C-58	34.1	8.1	12.3	12.8	0.24	0.36	0.38
2241C-62	34.0	7.8	12.5	11.6	0.23	0.37	0.34
2241C-35	33.9	7.5	13.0	11.5	0.22	0.38	0.34
2241C-37	33.7	7.8	12.8	11.8	0.23	0.38	0.35
2241C-34	33.4	7.0	11.6	12.9	0.21	0.35	0.39
2241C-72	33.2	7.7	12.2	12.0	0.23	0.37	0.36
2241C-18	32.8	6.9	11.9	12.4	0.21	0.36	0.38
2241C-14	32.7	7.0	12.2	11.9	0.21	0.37	0.36
2241C-86	32.7	7.8	12.6	10.5	0.24	0.39	0.32
2241C-10	32.5	8.0	12.1	11.6	0.25	0.37	0.36
700C	32.2	8.0	13.0	10.0	0.25	0.40	0.31
2241C-61	32.2	7.0	12.2	11.1	0.22	0.38	0.34
2241C-42	32.1	6.7	11.7	12.0	0.21	0.36	0.37
2241C-33	32.1	7.3	11.9	11.8	0.23	0.37	0.37
2241C-65	32.0	7.7	12.0	11.2	0.24	0.38	0.35
2241C-81	32.0	7.0	11.7	11.4	0.22	0.37	0.36
2241C-1	31.8	7.7	12.2	11.1	0.24	0.38	0.35
2241C-84	31.8	7.6	12.7	9.8	0.24	0.40	0.31
2241C-12	31.6	7.4	12.5	10.8	0.23	0.40	0.34
2241C-51	31.4	7.5	12.3	10.4	0.24	0.39	0.33
2241C-8	31.3	6.9	12.2	10.3	0.22	0.39	0.33
2241C-21	31.3	7.6	13.3	9.8	0.24	0.42	0.31
2241C-82	31.1	6.7	11.0	11.6	0.22	0.35	0.37
2241C-50	31.0	7.6	12.5	9.7	0.25	0.40	0.31
2241C-85	31.0	7.4	13.1	8.2	0.24	0.42	0.26
2241C-26	30.9	7.1	12.1	9.9	0.23	0.39	0.32
2241C-87	30.8	7.3	11.6	10.3	0.24	0.38	0.33
2241C-83	30.1	7.2	12.0	9.7	0.24	0.40	0.32
2241C-41	30.0	6.6	10.1	11.9	0.22	0.34	0.40
2241C-25	28.7	6.6	12.6	7.5	0.23	0.44	0.26
2241C-28	28.5	6.2	11.0	9.2	0.22	0.39	0.32
2241C-19	28.3	6.4	11.4	8.6	0.23	0.40	0.30
2241C-13	28.1	7.1	11.3	8.2	0.25	0.40	0.29
2241C-30	28.1	7.3	11.4	8.2	0.26	0.41	0.29
2241C-36	27.7	6.0	11.2	8.7	0.22	0.40	0.31
2241C-52	27.2	6.2	10.9	8.6	0.23	0.40	0.32
2241C-22	26.1	5.8	10.8	8.3	0.22	0.41	0.32
2241C-27	26.1	6.6	10.2	8.9	0.25	0.39	0.34
2237C	25.1	5.4	9.6	8.5	0.22	0.38	0.34
2241C-40	24.9	6.5	9.7	8.2	0.26	0.39	0.33
2241C-31	24.6	6.2	9.7	8.6	0.25	0.39	0.35
2241C-43	24.5	6.6	10.4	6.8	0.27	0.42	0.28
2241C-39	23.7	6.3	9.2	7.9	0.27	0.39	0.33
2241C-29	23.5	5.8	9.2	7.1	0.25	0.39	0.30
2241C-23	22.8	5.6	10.0	6.3	0.25	0.44	0.28

***Elkoceras spathi* (Kummel & Steele), n = 92**
(from *M. millardense* FA through *G. lucasi* intervals)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
2241C-45	22.6	5.0	8.7	7.8	0.22	0.38	0.35
2241C-44	21.0	4.9	8.5	6.8	0.23	0.40	0.32
2241C-46	18.0	4.5	7.7	5.4	0.25	0.43	0.30

Genus et species indet. A, B, C and D
(from *Crittendenites jattioti* n. gen., n. sp. interval)

Specimen ID	Dmm	W	H	U	W/D	H/D	U/D
Genus et species indet. A, 1484C	56.2	11.5	22.8	16.1	0.20	0.41	0.29
Genus et species indet. A, 2249C	50.8	10.4	20.6	14.8	0.20	0.41	0.29
Genus et species indet. A, 2235C	43.8	-	18.5	13.3	-	0.42	0.30
Genus et species indet. B, 2234C	28.4	6.1	10.7	11.0	0.21	0.38	0.39
Genus et species indet. C, 708C	49.5	11.3	21.7	14.2	0.23	0.44	0.29
Genus et species indet. D, 610C	45.9	10.5	17.7	16.0	0.23	0.39	0.35