Paleontological evidence for Late Cambrian in the Arburese area, SW Sardinia

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[Preuves paléontologiques d'un âge Cambrien supérieur dans la région d'Arburese, SW de la Sardaigne]

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Summary: New palynological investigations allowed a better definition of the age of terrigenous deposits of the Monte Fonnesu tectonic Unit, exposed in the Arburese area (SW Sardinia). The section investigated consists of a coarsening upwards positive sequence, up to 10 m thick, that is made up of quartz-arenitic sandstones and light gray quartzite beds (0.5 m thick), interbedded with thin beds of black shale. In the lower part of the section, two quartzitic levels are rich in lingulid (brachiopods) shell fragments. This is the first report of macrofossils from the Monte Fonnesu Unit. Samples collected for palynological analyses in the black shale at the base and at the top of the lowest quartzitic level yielded a Late Cambrian acritarch microflora that can be correlated with the *Peltura* trilobite Superzone. The Late Cambrian age assigned to the lower part of the sequence allows us to define more precisely the age of Mt. Fonnesu sandstone, which in consequence is bracketed between the Late Cambrian and the Early Ordovician.

Key Words: Sardinia; Lower Paleozoic; Late Cambrian; *Peltura* trilobite Zone; lingulids; acritarchs

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Mots-Clefs : Sardaigne ; Paléozoïque inférieur ; Cambrien supérieur ; Zone à trilobite *Peltura* ; lingulides ; acritarches

Introduction

This paper describes the first finding of lingulid-bearing quarztites in a Lower Paleozoic low-grade metamorphosed succession of the Nappe zone (southwestern Sardinia). These quartzites have been dated using acritarchs.

From a regional standpoint three parallel NW-SE trending orogenic zones have been identified in the Variscan Sardinian chain. They were delimited on the basis of the relative degree of deformation and metamorphism of each zone and its stratigraphic sequence. They are the: (i) External zone, (ii) Nappe zone and (iii) Axial zone. Deformation and metamorphic grade increase northeastward from the External zone to the Axial zone (CARMIGNANI *et alii*, 1994, and Fig. 1).

The Nappe zone is made up of several southwest-facing tectonic units of low metamorphic grade (anchizone - epizone) each with a very similar lithostratigraphic sequence. The sequence starts with Middle Cambrian-Early Ordovician metasandstone, phyllite and quartzite, followed upward by transgressive Upper Ordovician (Caradoc). It continues with Silurian graptolite-bearing black shale, phyllite, and *Orthoceras*-bearing limestone, in turn covered by Devonian nodular limestone rich in tentaculites and Climeniida. The sequence terminates with Lower Carboniferous Culm-like flysch deposits containing olistoliths of Devonian limestone (CARMIGNANI *et alii*, 1994).

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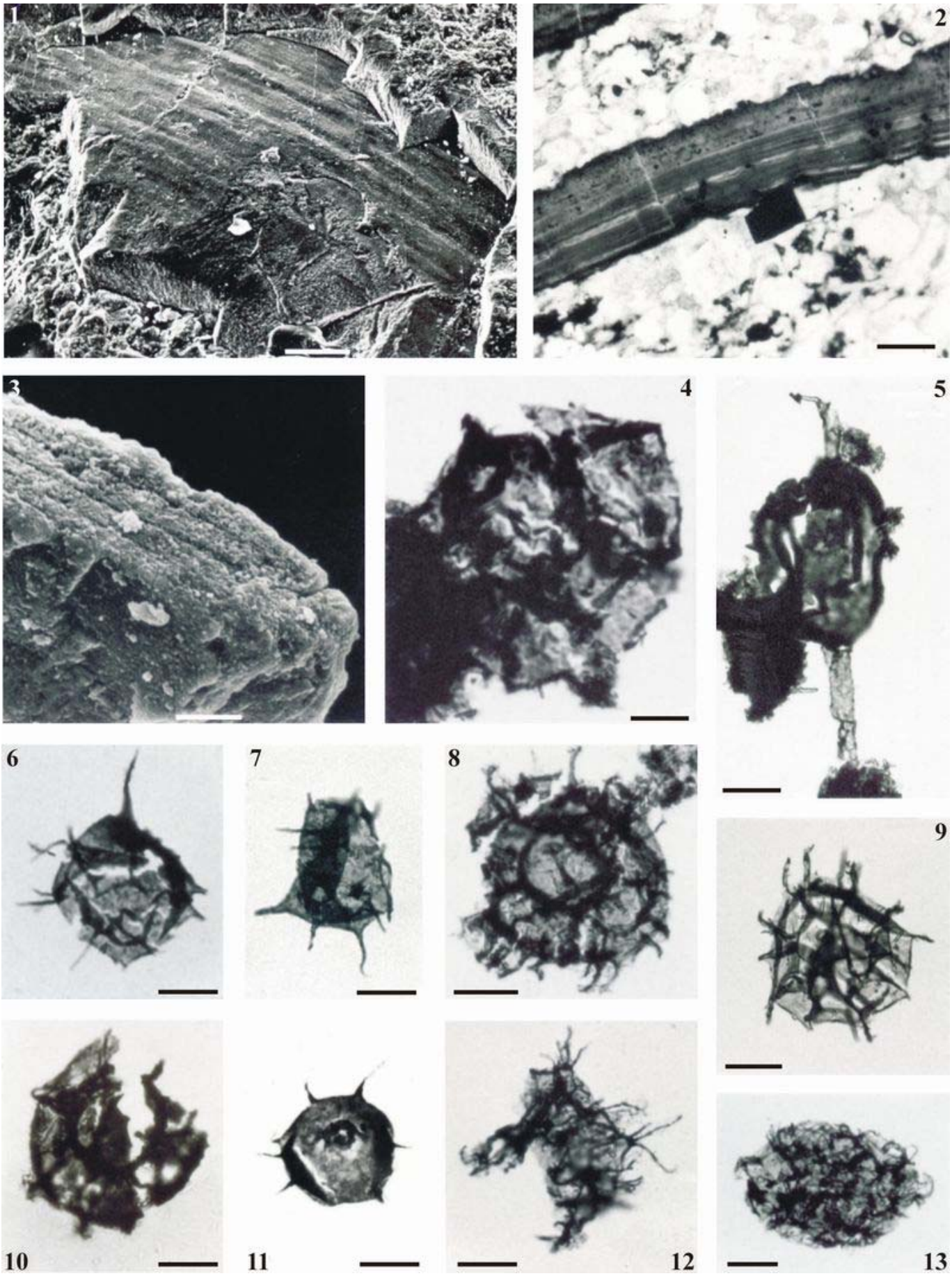
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◀ **Plate 1:** Scale bars= 10 µm if not otherwise stated.
Fig. 1.- Enlargement of the surface of a shell fragment showing the ornamentation. SEM, Sample M3, bar is 100 µm.
Fig. 2.- A shell fragment in optical view, showing the laminate structure. Thin section, Sample M3, bar is 100 µm.
Fig. 3.- An enlarged laminated fragment (almost four laminae). SEM, Sample M3.
Fig. 4.- *Cristallinium cambriense* (SLAVIKOVÁ) VANGUESTAINE, 1978. Sample AR1, slide AR1/TOT-2.
Fig. 5.- *Lusatia dendroidea* BURMANN, 1970. Sample AR1, slide AR1/TOT-2.
Fig. 6.- *Dasydiacrodium caudatum* VANGUESTAINE, 1973. Sample AR3, slide AR3/TOT-2.
Fig. 7.- *Dasydiacrodium obsonum* MARTIN *in* MARTIN & DEAN, 1988. Sample AR3, slide AR3/TOT-2.
Fig. 8.- *Stelliferidium* sp. Sample AR1, slide AR1/TOT-4.
Fig. 9.- *Timofeevia phosphoritica* VANGUESTAINE, 1978. Sample AR3, slide AR3/TOT-2.
Fig. 10.- ? *Timofeevia pentagonalis* (VANGUESTAINE, 1974) VANGUESTAINE, 1978. Sample AR1, slide AR1/TOT-1.
Fig. 11.- *Impluviculus multiangularis* (UMNOVA *in* UMNOVA & VANDERFLIT, 1971) VOLKOVA 1990. Sample AR3, slide AR3/TOT-2.
Fig. 12.- *Vulcanisphaera africana* DEUNFF, 1961. Sample AR3, slide AR3/TOT-1.
Fig. 13.- *Vulcanisphaera turbata* MARTIN *in* MARTIN & DEAN, 1981. Sample AR1, slide AR1/TOT-5.

The Paleozoic basement of the Arburese area: the Monte Fonnesu Unit

In the Arburese area (SW Sardinia), where the outcrop to be described is located, Paleozoic basement consists of five southwest-facing tectonic units (MAZZARINI & PERTUSATI, 1991) unconformably covered by Mesozoic and Cenozoic sedimentary and volcanic deposits (Fig. 2). These tectonic units are made up of low-grade metamorphic (anchizone-epizone) Upper Cambrian to Devonian sedimentary successions, very similar to those of the tectonic units of central and southern Sardinia described above (CARMIGNANI *et alii*, 1994).

Late Hercynian and Alpine brittle deformation affected all of these stacked units. NW-SE strike-slip faults of late Hercynian age are often associated with mineralized seams. There are also normal faults related to the emplacement of late Hercynian granites. Alpine deformation consists of important E-W trending normal faults (MAZZARINI & PERTUSATI, 1991).

The Monte Fonnesu Unit (MFU, Fig. 2 and Fig. 3) crops out at the top of the tectonic pile. It consists mainly of terrigenous deposits, made up of alternating micaceous sandstones, grey quartzite, siltite and greenish-grey shale, that represent outer fan and basin plain depositional environments (BARCA *et alii*, 1982a; MAZZARINI & PERTUSATI, 1991). An Early Ordovician age, based on the palynological (acritarchs) content (BARCA & MARINI, 1980; BARCA *et alii*, 1982b; PITTAU, 1985) has been proposed for the terrigenous portion of the MFU.

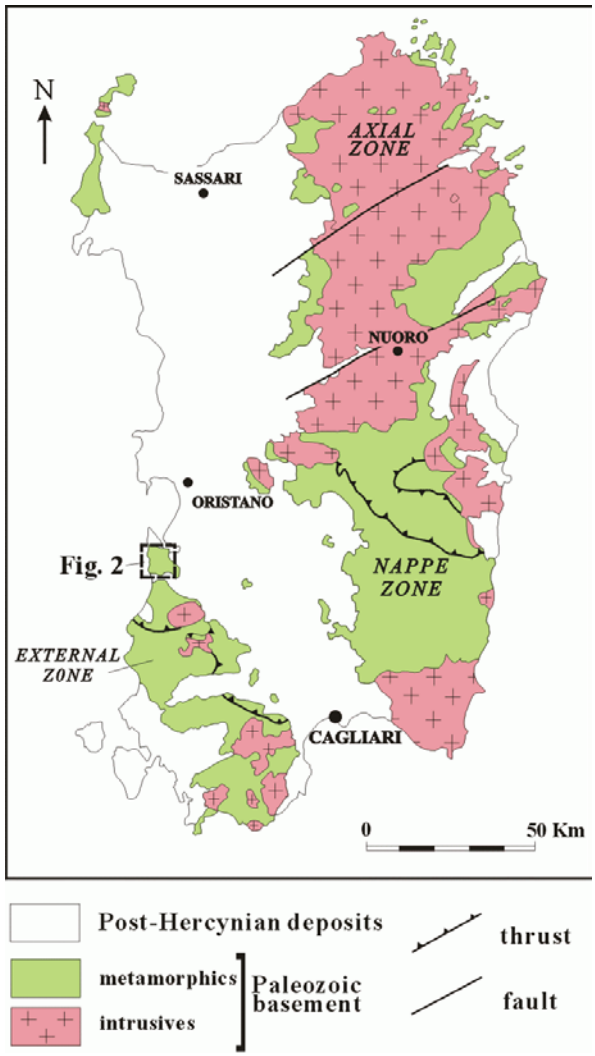

Figure 1: Distribution of Palaeozoic basement in Sardinia (simplified after CARMIGNANI *et alii*, 1994).

The MFU is folded isoclinally with a northward-directed gently dipping syn-metamorphic foliation parallel to the original sedimentary bedding. Metamorphic assemblages, mainly of white mica and chlorite, are indicative of a lower greenschist facies. Later phases of deformation consist of open to concentric folds with upright crenulation cleavage developed (MAZZARINI & PERTUSATI, 1991).

Rio de Tremolia section

The outcrop that provided the fossils for this report is a 10 m thick sequence in the MFU. It is located along the Rio de Tremolia, near the coast, about 35 km south-southwest of the town of Oristano (Fig. 3). The sampled section (Fig. 4) is a coarsening upwards-positive sequence, ranging up to 3 m in thickness. It consists of quartz-arenitic sandstone and light gray shell-fragment-rich quartzite beds, about 0.5 m thick, interbedded with thin black shales. In the section, the shaly levels decrease progressively in thickness and disappear in the

upper portion. The occurrence of sedimentary structures (asymmetric ripples and concave low angle cross bedding) suggests a tidal-intertidal depositional environment for this part of the terrigenous sequence, with minor episodes of deeper marine environment, as indicated by the deposition of shales.

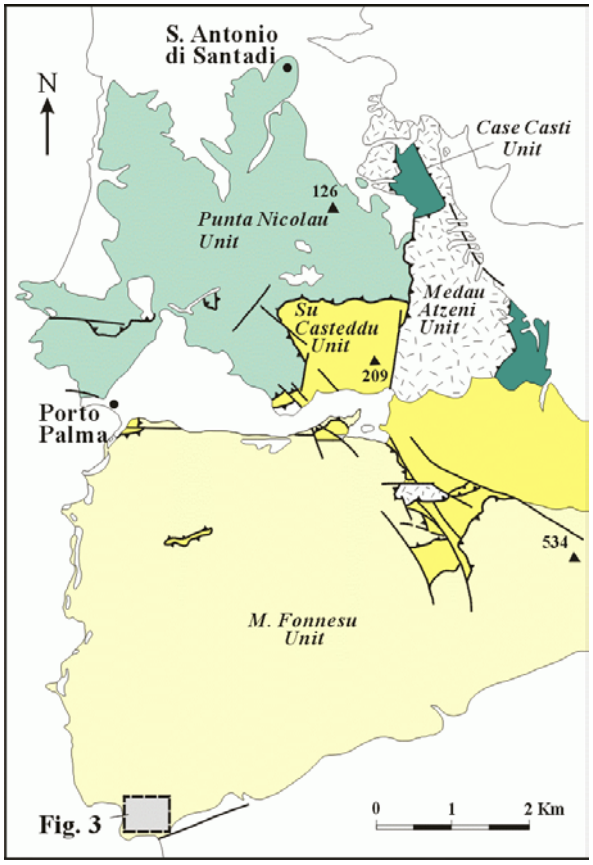

Figure 2: Tectonic sketch map of the Arburese area (simplified after MAZZARINI & PERTUSATI, 1991).

Fossil record

Macrofossil content - In the two shell fragment-rich quartzitic levels, samples (M13 and M3 in Fig. 4) were collected for paleontological analysis. The fossiliferous content consists of collophanitic laminate fragments, with weakly arcuate shapes. In the upper quarzitic level, they are concentrated in thin layers. Detailed observation carried out with the scanning electronic microscope (SEM) to define the structure and ornamentation of the laminate fragments shows that they are composed of more than three laminae and in addition, that the rarely preserved shell ornamentation consists of arcuate parallel striae (Plate 1, Figs. 1-3).

Thus, the composition, ornamentation and laminate structures of the shells clearly indicate that they are lingulid (inarticulate brachiopod) fragments.

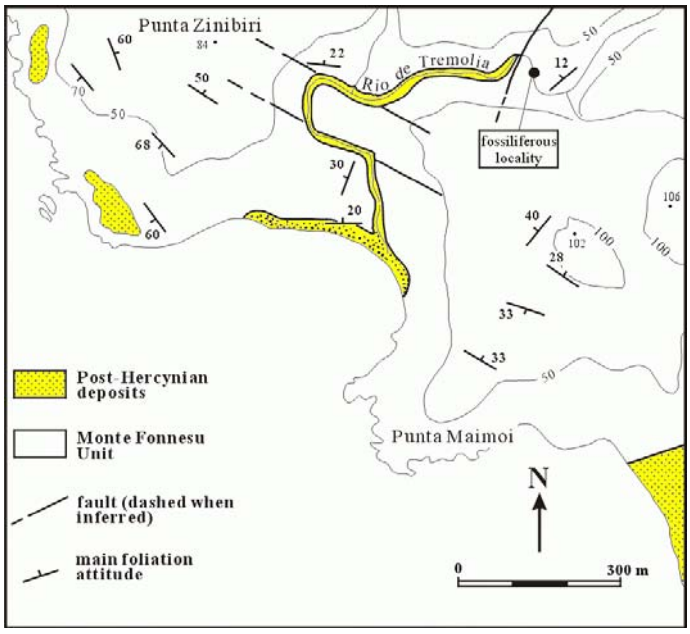

Figure 3: Geologic sketch map of the area studied.

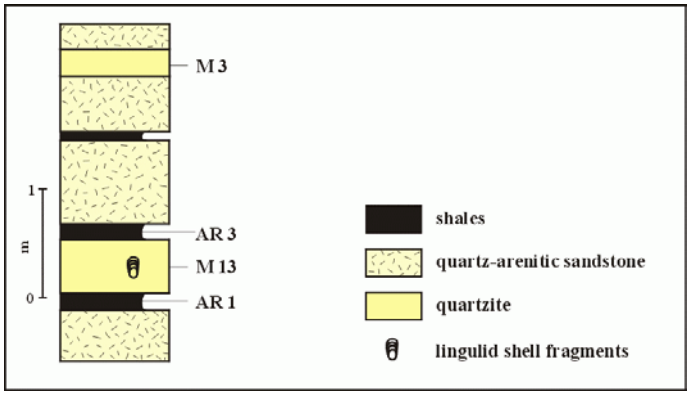

Figure 4: Schematic lithostratigraphy of the section sampled.

Palynological content - Six samples for palynological analysis were collected in the black shales. Approximately 50 g of each sample were processed using standard palynological techniques. Neither oxidation nor alkali treatment was used. Slides are stored in the Department of Earth Sciences of Pisa (Italy).

Only two samples (AR1 and AR3 in Fig. 4) located at the base and at the top of the lowest quartzitic level (M13) yielded a poorly preserved acritarch microflora (Plate 1, Figs. 4-13).

In the lowermost sample (AR1) *Acanthodiacrodium* spp., *Cristallinium cambriense* (SLAVIKOVÁ) VANGUESTAINE, 1978, *Lusatia dendroidea* BURMANN, 1970, *Stelliferidium* spp., ? *Timofeevia pentagonalis* (VANGUESTAINE) VANGUESTAINE, 1978, and *Vulcanisphaera turbata* MARTIN *in* MARTIN & DEAN, 1981, were recognized.

In the uppermost sample (AR3) *Acanthodiacrodium* spp., *Cymatiogalea virgulta* MARTIN *in* MARTIN & DEAN, 1988, *Dasydiacrodium caudatum* VANGUESTAINE, 1973, *Dasydiacrodium obsonum* MARTIN *in* MARTIN & DEAN, 1988, *Impluviculus multiangularis* (UMNOVA *in* UMNOVA & VANDERFLIT) VOLKOVA, 1990, *Ladogella* sp., *Lusatia dendroidea*, *Timofeevia phosphoritica* VANGUESTAINE, 1978, *Stelliferidium* sp. and *Vulcanisphaera africana* DEUNFF, 1961, are present.

Discussion and conclusions

According to the biostratigraphic scheme of PARSONS & ANDERSON (2000), based on Upper Cambrian successions from Random Island (eastern Newfoundland), *Cymatiogalea virgulta*, *Dasydiacrodium caudatum* and *Vulcanisphaera turbata* do not range higher than the RA5 microflora, that has been correlated with the *Protopeltura praecursor* and *Peltura minor* trilobite Zones.

Also found in the RA5 microflora are *Impluviculus multiangularis*, *Ladogella* sp. and the form of *Lusatia dendroidea* with two processes (described as *Orthosphaeridium*? *extensum* in PARSONS & ANDERSON, 2000, see taxonomical remarks in ALBANI *et alii*, in press).

Similar assemblages have been recorded in Upper Cambrian sediments of the East European Platform (VOLKOVA, 1990), the Rocroi Massif, northern France (RIBECAI & VANGUESTAINE, 1993) and in the Cantabrian Zone, North Spain (ALBANI *et alii*, in press).

Late Cambrian palynological records in Sardinia have been reported previously only from the Nappe zone (ALBANI *et alii*, 1985; DI MILIA, 1991, DI MILIA *et alii*, 1993). The microflora occupies a range in age from the *Agnostus pisiformis* (?) trilobite Zone to the *Parabolina spinulosa* trilobite Zone. A Late or possible latest Cambrian age has been hypothesized for the S. Vito Sandstones (Sarrabus Unit, BARCA *et alii*, 1982a, 1984) but the assemblage recorded lacks the species that characterize this interval.

In conclusion, the section studied here represents the first find of lingulid-rich quartzites in the Sardinian Paleozoic basement. The Late Cambrian age assigned to this sequence allows us to define more precisely the age of Mt. Fonnesu sandstone, now bracketed in age between the Late Cambrian and the Early Ordovician. In addition, based on acritarch assemblages, the interval corresponding to the *Peltura* trilobite Zone of the Upper Cambrian is recognized for the first time there.

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