Preface: Special Issue on Ophiolites and Oceanic Lithosphere

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INTRODUCTION
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Special Section:
Ophiolites and Oceanic Lithosphere, with a focus on the Samail ophiolite in Oman

Preface: Special Issue on Ophiolites and Oceanic Lithosphere

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Abstract With this Preface, we provide background information, a scientific overview of topics, and an annotated bibliography of the 63 papers published in the Journal of Geophysical Research (JGR) Special Issue on "Ophiolites and Oceanic Lithosphere, with a Focus on the Samail Ophiolite," collected online at https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9356.SAMAIL1. Topics covered in the Special Issue include formation and alteration of igneous ocean crust at submarine spreading centers, subduction zone mass transfer at the leading edge of the mantle wedge, the tectonic emplacement and evolution of ophiolites, processes of alteration and weathering of tectonically exhumed mantle peridotite, and the subsurface biosphere in the peridotite weathering environment. The bibliography, in the form of a supplementary Excel spreadsheet with links to each paper, is organized by topic, but can be sorted by first author, order of publication, specific Oman Drilling Project boreholes, and other factors.

Plain Language Summary This is a Preface for a Special Issue of papers on "ophiolites"—fragments of oceanic crust and upper mantle, thrust onto continental margins—and related studies of oceanic "lithosphere"—data on submarine, oceanic crust and mantle in situ. The Issue includes papers on the formation and alteration of igneous crust at tectonic spreading centers, the thrusting of ophiolites over and onto continental margins, accompanied by an influx of fluids derived from underthrust materials, weathering of tectonically exhumed rocks from the Earth's mantle (both in ophiolites and on the seafloor), and the subsurface microbial biosphere associated with this weathering.

Key Points:

- In understanding processes that form and modify oceanic lithosphere, the Samail ophiolite is an essential complement for seagoing studies
- Study of the base of the Samail ophiolite provides key insights on mass transfer at the leading edge of the mantle wedge
- Ongoing alteration of mantle peridotite generates highly reduced, alkaline fluids, and hosts an important subsurface microbial ecosystem

Supporting Information:

Supporting Information may be found in the online version of this article.

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1. Dedication

On the 41st anniversary of the publication of the Journal of Geophysical Research Special Issue on the Oman Ophiolite, we dedicate this Special Issue to Françoise Boudier, Bob Coleman, Cliff Hopson, and Adolphe Nicolas, who led the way in process-oriented studies of the Samail ophiolite, looking past debates on the tectonic provenance of ophiolites to foster ground-breaking research on mantle melting and melt transport, crustal formation and hydrothermal alteration at oceanic spreading centers. We are indebted to them for their extensive observations, their creative ideas, and their example of a lifetime devoted to scientific research.

2. Introduction

Creating this Special Issue was motivated by several factors. First, we wished to celebrate and extend the remarkable legacy established by the 1981 JGR Special Issue on the Oman Ophiolite, edited by Coleman and Hopson (1981). Since then there have been many books and volumes of collected papers with a substantial focus on the Samail ophiolite (e.g., Boudier & Juteau, 2000; Boudier & Nicolas, 1988; Lippard et al., 1986; Nicolas, 1989; Peters et al., 1991; Robertson et al., 1990; Rollinson et al., 2014), but only a few have contained the backbone of data-rich, observational studies of the Samail ophiolite that characterized the 1981 Issue. We aspired to achieve a similar, quantitative, and comprehensive approach with this Special Issue, 41 years later. Many thanks to the authors of these many papers.

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Second, we were aware of the comprehensive data set on the Wadi Gideah crustal section in the ophiolite, collected by a group led by Jürgen Koepke, and we wished to provide a venue where this exceptional set of papers could be published, together and in context. Indeed, three scientific boreholes were cored in the Wadi Gideah to complement the Koepke group's observations. In addition, there have been other detailed studies of oceanic crustal outcrops in this general region. Moreover, for comparison, it is important to include papers on oceanic crust formed in other tectonic settings. Collectively, this focus on the origin and evolution of oceanic crust and the underlying, uppermost mantle accounts for 23 of the papers in this Special Issue (Allard et al., 2021; Belgrano et al., 2021; Boulanger et al., 2021; Carbotte et al., 2021; Carter et al., 2022; Casini et al., 2021; Crotteau et al., 2021; Ferrando et al., 2021; France et al., 2021; Garbe-Schönberg et al., 2022; Grambling et al., 2022; Greenberger et al., 2021; Hatakeyama et al., 2021; Klaessens et al., 2021; Koepke et al., 2022; Kourim et al., 2022; Mock, Ildefonse, Müller, & Koepke, 2021; Mock, Neave, et al., 2021; Müller et al., 2022; VanTongeren et al., 2021; Weber et al., 2021; Xu et al., 2021; Zhang et al., 2021).

Third, the preparation of the papers for this Issue occurred during the culmination of the Oman Drilling Project (OmanDP, http://publications.iodp.org/other/Oman/OmanDP.html). We hoped to collect a comprehensive set of papers reporting on the results of that project. OmanDP was a collective effort on the part of more than 200 scientists from 20 countries who provided more than 10 person-years of effort at drill sites and onboard the International Ocean Drilling Program (IODP) Drilling Vessel Chikyu for core logging. OmanDP was funded by the Sloan Foundation, the International Continental Scientific Drilling Program (ICDP), the US National Science Foundation (NSF), the Japanese Marine Science and Technology Center (JAMSTEC), the Japanese Society for the Promotion of Science (JSPS), the IODP, the US National Aeronautics and Space Administration (NASA), and the scientific research foundations of the EU, Germany and Switzerland, plus support from scientists' home institutions. We are also grateful for in-kind assistance from the Omani Ministry of Regional Municipalities and Water Resources, the Public Authority for Mining, Sultan Qaboos University, the German University of Technology in Oman, and Petroleum Development Oman (PDO). OmanDP sampled nine cored boreholes, and drilled another six rotary holes, extending 300–400 m below the surface. Core recovery was consistently ∼100%, producing about 3.2 km of core. Geophysical observations in and around some of the boreholes are ongoing. Twenty-four of the papers in this Special Issue focus on observations from OmanDP (Beinlich et al., 2020; Carter et al., 2022; Crotteau et al., 2021; de Obeso et al., 2022; Ellison et al., 2021; France et al., 2021; Godard et al., 2021; Grambling et al., 2022; Greenberger et al., 2021; Hatakeyama et al., 2021; Hong et al., 2022; Katayama et al., 2020; Kelemen et al., 2021, 2022; Klaessens et al., 2021; Kotowski et al., 2021; Kourim et al., 2022; Malvoisin et al., 2020; Menzel et al., 2020; Nothaft, Templeton, Boyd, et al., 2021; Nothaft, Templeton, Rhim, et al., 2021; Okazaki et al., 2021; Templeton et al., 2021; Ternieten et al., 2021a). In addition, of course, many papers have been published in other journals, and research on OmanDP data and samples is ongoing (with another special issue underway in *Lithos*).

Fourth, we've been inspired by recent studies of mass transfer through the basal thrusts of ophiolites, with the realization that these faults originated as subduction zones, so that study of these sites can provide unique observations that constrain subsurface processes that are generally inaccessible to geologists and geochemists. Nine papers in this Special Issue present studies on this and related topics (Al-Khirbash and Ahmed, 2021; Ali et al., 2021; Beinlich et al., 2020; de Obeso et al., 2022; Godard et al., 2021; Kelemen et al., 2022; Kotowski et al., 2021; Menzel et al., 2020; Okazaki et al., 2021).

Fifth, there has been a recent surge of interest in weathering and low temperature hydrothermal alteration of mantle peridotite, stimulated in part by the recognition that these environments provide habitable conditions that can sustain several types of chemosynthetic microbial ecosystems. The geochemical gradients that are established within the serpentinite-hosted groundwaters may also be analogous to the conditions suitable for the origin of life on this and other planets. There also is an intrinsic fascination with these active, far from equilibrium chemical systems. And, it has become evident that there is significant uptake of CO_2 from migrating fluids, during weathering of mantle peridotite, and during subduction zone mass transfer (previous paragraph), which can create a globally significant reservoir for carbon in the mantle lithosphere. A supportive community of researchers has grown around these topics, embodied in part by the annual Serpentine Days conferences in Europe. This overall topic is the subject of 24 of the papers in this Special Issue (Bernasconi et al., 2021; Cook, Blank, Rietze, et al., 2021; Cook, Blank, Suzuki, et al., 2021; Cooperdock et al., 2020; de Obeso et al., 2021; Ellison et al., 2021; O. Evans et al., 2020; Hong et al., 2022; Howells et al., 2022; Katayama et al., 2020; Kelemen et al., 2021; Leong et al., 2021; Malvoisin et al., 2020; Monnin et al., 2021; Nothaft, Templeton, Boyd, et al., 2021; Nothaft, Templeton, Rhim,

et al., 2021; Renard, 2021; Sabuda et al., 2021; Schwarzenbach, Vogel, et al., 2021; Schwarzenbach, Vrijmoed, et al., 2021; Templeton et al., 2021; Ternieten et al., 2021a, 2021b; Yoshida et al., 2020).

And finally, studies of the Samail ophiolite have been greatly enriched by ongoing research on the processes of ophiolite emplacement, and related deformation within and surrounding ophiolites. We are delighted that seven papers in this Special Issue address these new data (Cox et al., 2021; A. D. Evans et al., 2021; Garber et al., 2021; Ninkabou et al., 2021; Pilia et al., 2021; Rioux, Benoit, et al., 2021; Rioux, Garber, et al., 2021), though of course much recent work on this topic has also been published elsewhere.

3. Ophiolites and Oceanic Lithosphere

The formation and evolution of oceanic lithosphere at spreading centers, together with its ultimate destruction at subduction zones, are the most important igneous and metamorphic processes on Earth, creating and recycling more than 60% of the Earth's crust on short geological timescales (<200 million years) and forming the locus of thermal and chemical exchange between the solid Earth, the oceans, and the atmosphere. Study of these processes is hampered by a lack of access to outcrops of oceanic lower crust and upper mantle, on the seafloor and in subduction zones. Recognition that "ophiolites"—fragments of mafic crust and depleted upper mantle—were fragments of oceanic lithosphere, formed at spreading centers and then thrust onto the continental margins along subduction zones (e.g., Coleman, 1971, 1977; Dewey & Bird, 1971; Dickinson, 1971; Gass, 1968) offered a unique opportunity to study these otherwise hidden regions in three dimensions. The igneous "stratigraphy" of the Samail ophiolite in Oman—the world's largest ophiolite—has a layered structure that closely resembles the regular, layered seismic velocity structure of the Pacific crust (e.g., Christensen, 1978; Christensen & Salisbury, 1975; Christensen & Smewing, 1981). Both the ophiolite and Pacific crust formed at a fast spreading rate (e.g., Rioux et al., 2012; Tilton et al., 1981). These inferences underlie most of the papers in the 1981 JGR Special Issue. Indeed, to this day, the widely accepted interpretation of the layered structure of the Pacific crust, in terms of a layer of lavas, overlying a layer of sheeted dikes, overlying a lower crust composed of gabbroic rocks, in turn overlying residual mantle peridotites, rests largely on a foundation of observations from the Samail ophiolite.

Early on, it became evident that most or all ophiolites had characteristics that are different from "normal" oceanic crust created at the mid-ocean ridges (e.g., Miyashiro, 1973). The crustal sections in most ophiolites are systematically thinner than Pacific crust, and the lavas in ophiolites have major and trace element characteristics that are consistently different from virtually all lavas sampled from "normal" mid-ocean ridges. In particular, all ophiolite lavas—including those in the Samail ophiolite—systematically have lower Nb/Th ratios than mid-ocean ridge lavas (e.g., Pearce & Peate, 1995), and most ophiolite lava series also show major and minor element chemical differentiation trends that are different from those of mid-ocean ridge lavas (e.g., for Oman, MacLeod et al., 2013; Pearce et al., 1981). These differences have led to a vigorous, ongoing dialog regarding the tectonic provenance of ophiolites, and how ophiolites might differ from "normal" oceanic crust. Discussion of this topic continues to this day (Shervais, 2022).

However, since the Samail ophiolite formed at submarine spreading center with a fast-spreading rate, and has large scale crustal layering (lavas, dikes, gabbros, peridotite) identical in both nature and thickness to most of the crust formed at the East Pacific Rise as exposed in tectonic windows, many scientists studying the ophiolite have adopted the perspective that Samail observations provide essential insights into processes common to both the ophiolite and Pacific crust. Moreover, while at least two highly distinct magma series formed substantial fractions of the northern massifs of the ophiolite, the southern massifs formed predominantly from primitive, tholeiitic, mantle-derived, basaltic magmas that closely resembled primitive mid-ocean ridge basalts (MORBs) in almost every respect (e.g., Pearce & Peate, 1995). It is true that, even in the southern massifs, mantle spinel Cr/Al ratios extend to values slightly higher than the highest observed in peridotites dredged from mid-ocean ridges (e.g., Hanghøj et al., 2010; Le Mée et al., 2004; Monnier et al., 2006), and plagioclase Ca/Na ratios extend to higher values than plagioclase in most mid-ocean ridge gabbros (though see Kelemen et al., 2007, Figure F4). Also, Samail and Wadi Tayin massif lavas fractionated to form Ti poor, Si-rich andesites and dacites that are not observed at mid-ocean ridges (MacLeod et al., 2013). All of these data point to a parental magma with 1–2 wt% H_2O, perhaps five times higher than in primitive MORB. However, these differences define a spectrum of variation, not a bimodal distribution, and they are unlikely to have caused distinctively different processes in the origin and evolution of Pacific versus Samail lithosphere. Most of the 23 papers on crustal genesis and alteration in this

Special Issue (cited in Section 2) adopt this approach. They should be viewed in the context of an ongoing dialectic, in which sea-going investigations are motivated by ophiolite observations, and vice versa.

In this context, Samail studies have discovered and constrained processes that are inferred to occur at most intermediate- to fast-spreading mid-ocean ridges. Samail data have been used to support both sides of a long-standing debate on formation of oceanic lower crustal gabbros, either via (a) most crystallization in a shallow melt lens, followed by transportation of a crystal-rich mush downward and outward to form the lower crust (gabbro glacier, e.g., Nicolas et al., 1988; Phipps Morgan & Chen, 1993; Quick & Denlinger, 1993; Sleep, 1975), or (b) most crystallization in small melt lenses emplaced at the depth where they are now formed (*sheeted sills*). These end-members have combined in various hybrid models in which the "upper gabbros" might have been transported via a "glacier" whereas the "lower gabbros" crystallized in situ. Indeed, even the original papers proposing the "sheeted sills" hypothesis included a hybrid origin for Samail ophiolite lower crust, with a thin "glacier" just beneath the sheeted dikes (Kelemen et al., 1997; Korenaga & Kelemen, 1997). Closely related to the gabbro glacier versus sheeted sill issue is the rate and location of hydrothermal cooling in the lower crust, with concepts spanning the range from an end-member in which (a) only the lavas and sheeted dikes are rapidly cooled by vigorous hydrothermal convection near the axis of the spreading center, while the lower crust is slowly cooled off axis, mainly by conduction, over hundreds of thousands of years (e.g., Coogan et al., 2002; Phipps Morgan & Chen, 1993) to an end-member in which (b) both the upper and lower crust are rapidly cooled by vigorous hydrothermal convection at a nearly constant rate, within a few kilometers of the axis (e.g., Garrido et al., 2001; VanTongeren et al., 2008). Intermediate hypotheses include ideas about rapid hydrothermal convection in near-axis faults extending to the base of the crust, surrounded by less permeable, less altered, more slowly cooled gabbros (e.g., Coogan et al., 2006; Zihlmann et al., 2018). Most of the papers on crustal genesis and alteration in this Special Issue address one or both of these general topics.

4. Subduction Zone Mass Transfer at the Leading Edge of the Mantle Wedge

It has long been recognized that "metamorphic soles" beneath many ophiolites record temperature and pressure conditions in the thrust fault(s) that consumed oceanic lithosphere and then emplaced ophiolites on continental margins (e.g., Boudier et al., 1982; Church & Stevens, 1971; Dewey & Bird, 1971; Malpas et al., 1973). With that said, metamorphic temperatures in the soles generally correspond to granulite facies conditions ~800°C, with pressures ranging from 0.89 to 1.4 GPa (e.g., Ghent & Stout, 1981; Kotowski et al., 2021; Soret et al., 2017), rather than the blueschist facies conditions thought to be typical of steady-state geotherms in established subduction zones consuming old oceanic crust (e.g., Coleman, 1971; Dickinson, 1971; Ernst, 1971; Peacock, 1996). This, and the observation that metamorphic sole ages and ophiolite crustal ages are often very similar, has given rise to the hypothesis that metamorphic soles form during initiation of subduction in young, hot oceanic lithosphere (e.g., Hacker, 1990, 1991, 1994; Jones et al., 1991; Smith & Spray, 1984; Spray, 1983). Recently, Agard and colleagues have added the idea that metamorphic soles record the earliest, hottest stages of subduction initiation, which were followed by cooling and evolution toward a steady state subduction geotherm (e.g., Agard et al., 2016, 2020; Soret et al., 2022).

In any case, metamorphic soles lie along faults that initiated as plate-scale, low angle thrust faults subducting oceanic crust, sediments, and ultimately continental crust beneath the mantle section of ophiolites. Thus, the mantle section of ophiolites can be regarded as having formed the "leading edge of the mantle wedge" (Falk & Kelemen, 2015; Kelemen & Manning, 2015; Kelemen et al., 2013) for millions to tens of millions of years in many cases. Thus, these rocks may preserve a record of mass transfer from subducting material into the forearc mantle (e.g., Boskabadi et al., 2020; Deschamps et al., 2010; Förster et al., 2017; Li & Lee, 2006; Menzel et al., 2018; Nozaka, 2014; Peacock, 1987; Peng et al., 2020; Sachan et al., 2007; Scambelluri et al., 2016, 2022; Schwarzenbach et al., 2018; Sideridis et al., 2022; Spandler et al., 2008; Ulrich et al., 2020; Wu et al., 2021; Zhao et al., 2021).

Based on this reasoning, Oman Drilling Project Hole BT1B was sited to drill carbonated peridotites (listvenites) and their host rocks, serpentinized mantle peridotites, just above the basal thrust of the Samail ophiolite. Six papers in this Special Issue (cited in Section 2) report on studies of core from Hole BT1B and samples from the surrounding area, interpreting their results in terms of carbon mass transfer from subducting sediments into the overlying mantle wedge at the base of the Samail ophiolite mantle section. Structural and geochronological data

supporting this approach are summarized in several papers (e.g., Falk & Kelemen, 2015; Kelemen et al., 2022; Menzel et al., 2022).

However, the hypothesis that listvenites and other features at the base of the ophiolite record subduction zone mass transfer is controversial, with some workers advocating for a younger origin for Samail listvenites (Peer Review File for Menzel et al., 2022; Scharf et al., 2022), in a debate that is likely to continue for some time. Indeed, in Oman and elsewhere, the basal thrust of ophiolites has often been reactivated and cut by post-emplacement deformation, potentially with associated hydrothermal alteration, and so it may be challenging to fully disentangle their histories. Meanwhile, thermodynamic, numerical modeling, and experimental studies (e.g., Falk & Kelemen, 2015; Kelemen et al., 2022; Sieber et al., 2018; Stewart & Ague, 2020) continue to demonstrate the likelihood of substantial mass transfer from subducting material into the leading edge of the mantle wedge, particularly in cases in which deeper fluids migrate up a subduction channel (e.g., de Obeso et al., 2022), and this is likely to be recorded in the mantle section of ophiolites, together with other, similar processes that occur after ophiolite emplacement.

5. Weathering of Mantle Peridotite

Twenty-four of the papers in this Special Issue (cited in Section 2) address various aspects of low temperature weathering/alteration of mantle peridotite and associated biogeochemical activity. Three relatively recent developments led to increased interest in this topic, in the Samail ophiolite and at many other sites encompassed in this issue, such as the Atlantis Massif along the mid-Atlantic ridge as well as several continental sites in California, Italy, and Turkey. First, there has been widespread recognition that highly reducing environments and large redox gradients produced during serpentinization (e.g., Frost, 1985; Neal & Stanger, 1983, 1984, 1985) can stabilize hydrocarbons and provide energy for microbial chemosynthesis, leading to an explosion of hypotheses concerning the scale and function of the subsurface biosphere, abiotic hydrocarbon genesis, and the origin of life on this and other planets (e.g., Berndt et al., 1996; Fisk & Giovannoni, 1999; Foustoukos & Seyfried, 2004; Horita & Berndt, 1999; McCollom, 1999, 2007; Schulte et al., 2006; Shock, 1997; Shock et al., 1995; Sleep et al., 2004; Varnes et al., 2003). There also is intense interest in determining whether or not mineral, isotopic or organic biosignatures can be produced and preserved within serpentinite rocks and fluids, in order to aid in the search for life in analogous systems on Mars, Europa and Enceladus.

Second, reaction between surface waters and altering peridotite forms abundant carbonate veins, stripping carbon from aqueous fluids and producing Ca-OH rich waters that emerge in springs and combine with CO_2 to form travertine deposits on the surface (e.g., Barnes & O'Neil, 1969; Bruni et al., 2002; Clark & Fontes, 1990). Indeed, these processes sometimes even cause 100% replacement of peridotite by listvenites (carbonate + quartz assemblages e.g., Falk & Kelemen, 2015; Halls & Zhao, 1995; Hansen et al., 2005; Naldrett, 1966; Schandl & Naldrett, 1992; Schandl & Wicks, 1991). It has been proposed that these processes may produce a significant mineralized carbon reservoir on this and other planets (e.g., Kelemen & Manning, 2015), and that these spontaneous, natural processes could potentially be emulated in accelerated systems for engineered, in situ carbon capture and storage (e.g., Kelemen & Matter, 2008).

Third, there is renewed interest on volume changes associated with alteration of peridotite, as originally addressed by MacDonald and Fyfe (1985), O'Hanley (1992) and Evans (2004), and on the ways in which these volume changes may be accommodated (Iyer et al., 2008; Jamtveit et al., 2009; Kelemen & Hirth, 2012; Rudge et al., 2010).

One or more of these three topics are addressed by the 24 papers on low temperature weathering/alteration of peridotite, including cracking due to volume change during serpentinization of olivine, and the seven papers on listvenite formation in this Special Issue, as cited in Section 2.

6. Perspectives on Future Work

Proposals and workshops leading up to the Oman Drilling Project outlined several topics of fundamental research which have not been fully addressed in this Special Issue, which we hope will be among the investigations of OmanDP core and boreholes that lie ahead. Some of these topics are uniquely well suited to studies of drill core and/or boreholes, as has been amply demonstrated by scientific ocean drilling.

These include

- Detailed studies of the amplitude and length scale of "cryptic" chemical variation in lower crustal gabbros, which would provide key constraints on the mode of melt transport during formation of igneous cumulates as previously done for a limited set of samples from the Samail ophiolite by Browning (1984) and by Korenaga & Kelemen (1997, 1998).
- Revisiting the classic studies of Gregory and Taylor (1981) and Bosch et al. (2004), building on the whole core mineralogy studies of the crust (Crotteau et al., 2021; Greenberger et al., 2021) and mantle (Okazaki et al., 2021) in this issue, to constrain the extent of water/rock reaction during hydrothermal alteration of the lower crust using oxygen and strontium isotopes, extending past work in terms of the number of samples, and by including "matrix" samples (as in Gregory & Taylor, 1981), veins (Bosch et al., 2004), and fault zones (e.g., Zihlmann et al., 2018), to provide abundance-weighted estimates of the water/rock ratio and cooling power of hydrothermal convection in oceanic lower crust.
- Time series studies of borehole water composition, temperature, and gas flux. As outlined by Kelemen et al. (2021) drilling introduced cold, neutral pH, oxidized water into subsurface aquifers, which have gradually evolved back to more alkaline, reduced compositions. There is much to be learned by studying the rate at which borehole water returns to a steady-state composition, via advection, diffusion, and reaction with surrounding rocks as a function of depth in both peridotite- and gabbro-hosted boreholes.
- Completion and interpretation of downhole logging data, including video, to determine fracture spacing and orientation, combined with comprehensive reorientation of core in a geographical reference frame, to enable detailed studies of structural features in core as related to regional features such as the paleo-seafloor, the crust-mantle transition zone, and the basal thrust of the ophiolite.
- Detailed assessment of the controls on the distribution and activity of the subsurface serpentinite-hosted biosphere. As outlined by Templeton et al. (2021), there are notably high cell densities detected in Oman BA cores and fluids. This observation stands in strong contrast to lower cellular abundances in other low-temperature serpentinizing systems, such as the hydrated lower crustal gabbros at the Atlantis Bank (Wee et al., 2021) and in altered gabbro and peridotite cores recovered from the Atlantis Massif (Früh-Green et al., 2018, 2022). It is timely to assess how the geochemical dynamics in the Samail ophiolite sustain substantial biological activity, by detailed assessment of the locations where microorganisms inhabit reaction zones within the cores, as well as by conducting continued groundwater monitoring and assessment of the microbial community structure, function, and activity at the "active serpentinization" sites.
- More drilling! A variety of things may have been "missed" in OmanDP boreholes so far. For example, we encountered a high temperature fault within the mantle-crust transition zone (MTZ). It seems that the fault does not have a lot of displacement, but drilling the MTZ at another site could be fruitful. As another example, we hypothesize that there must be fault zones carrying a substantial flux of oxidized, carbon-rich water into highly reducing, alkaline, peridotite-hosted aquifers at depth. However, these focused mixing zones were not sampled in OmanDP.

7. Table of Contents Arranged by Topic: Supplementary Table

A sortable Table of Contents for the JGR Special Issue on Ophiolites and Oceanic Lithosphere, is provided in Table S1 for this Preface. As configured, the spreadsheet is sorted according to overall topic and then by locale or rock type. The Table is sortable, so that one can arrange the list of papers in the order that they appear at https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9356.SAMAIL1, or alphabetically by author, or by the date when they were first published online. One can also sort collections of papers reporting observations from a specific OmanDP drill site and its environs. Finally, color coding provides a cross-cutting classification of papers by the geological processes that they address.

8. Conclusion

In concluding, we would like to once more draw attention to our dedication of this special issue to Françoise Boudier, Bob Coleman, Cliff Hopson and Adolphe Nicolas, who laid the groundwork for process-oriented studies of the Samail ophiolite with global significance for understanding oceanic spreading ridges and subduction zones.

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Though we can never aspire to the kind of discoveries they achieved, not long after the discovery of plate tectonics, the Guest Associate Editors hope that this Special Issue can serve as a similar launching pad for future research. Actually, the 1981 JGR Special Issue on the Oman Ophiolite appeared at a time of diminishing interest in ophiolites as a window into mid-ocean ridge processes, as the complexities of their relationship to "normal" oceanic crust became clearer. But the Issue was rediscovered during an exciting time in the 1990s when a broad swath of the geoscience community focused on general processes at spreading centers, stimulated by theoretical advances in understanding polybaric decompression melting in the mantle, reactive melt transport, the three-dimensional seismic structure of the crust at mid-ocean ridges, and chemical exchange between the crust and the oceans. The surge in interest was complemented by major research funding from the US RIDGE Initiative, InterRidge in Europe, and corresponding efforts around the world.

The tide of interest seemed to withdraw again at the start of the new century, when many of us were happy to move on to studying subduction processes, supported by the NSF MARGINS Initiative and similar funding worldwide. And now, we live in a very different world, with earth scientists pulled in many directions by competing motivations to understand and address the problem of global climate change, on the one hand, and the enduring fascination of basic scientific research on the other. There are some potential synergies between these different efforts.

We hope this Special Issue will help to maintain interest in research on the formation and evolution of oceanic lithosphere, in the near future and perhaps even more so when the tide comes in again.

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