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On the limits and limitations of the ophiolite - mid-ocean ridge analogy: Oman vs the East Pacific Rise

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Throughout the near half century since Ian Gass proposed that ophiolite complexes formed by a process directly analogous to seafloor spreading, the study of ophiolites has been central to the development of our conceptual understanding of the mechanisms of formation of oceanic lithosphere at mid-ocean ridges. This role has been affected little by the recognition – on the basis of their geochemistry – that most ophiolites must have formed by spreading above subduction zones rather than at 'proper' open-ocean mid-ocean ridges. Why? – because we will never be able to gain access to the internal structure of modern ocean lithosphere to the extent we can by walking over the largest and best-preserved ophiolites (e.g. Cyprus, Oman, Newfoundland etc.). Ophiolites will always provide vital insights into the mechanisms of formation of lithosphere formed at submarine volcanic spreading centres. To what extent, however, can we be confident that what we learn from ophiolite studies is directly applicable to modern open-ocean mid-ocean ridges? Exactly how far can we press the analogy?

To a first order it is reasonable to assume that the physical processes of crustal formation at an open-ocean mid-ocean ridge and at a supra-subduction zone spreading centre should be closely comparable: the presence of an organised sheeted dyke complex, representing 100% extension accompanied by magmatism, is convincing evidence for seafloor spreading. But does this mean the processes of crustal formation are identical in these different geodynamic environments?

In this presentation we compare the 'crown jewel' of ophiolites, Oman, with the East Pacific Rise to explore the veracity of the widely-held belief that Oman represents a direct analogue for lithosphere formed at a fast-spreading (open-ocean) mid-ocean ridge. Whereas the mantle source of the axial volcanic suite in Oman is very similar to that of mid-ocean ridge basalt, we have recently shown (MacLeod et al. 2013, Geology v.41, p.459-462) that the magmas were generated in the presence of water, from which we deduce that the ophiolite was very probably formed by a short-lived spreading episode immediately following subduction initiation.

We here compare and contrast more than 25 years of our own observations and data from Oman with a unique suite of samples we recently collected from the Hess Deep rift valley (the first ever complete crustal section recovered from a modern fast-spreading ridge), examining the extent to which the presence of water and the unstable geodynamic environment during the generation of the Oman ophiolite have had a material effect on the internal structure and composition of the crust thus produced. We here demonstrate that, although the physical processes of crustal generation at the Oman and East Pacific Rise spreading ridges are similar overall, systematic differences in crustal structure exist. We discuss the significant implications these have for our models of crustal accretion based solely on ophiolite observations.