# What is the meaning of ophiolites?

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Ophiolites are claimed to be pieces of ocean crust and upper mantle that have been thrust up onto continental crust and are now found in mountains, mainly along continental margins. <sup>1,2</sup> An ideal ophiolite suite consists from bottom to top of peridotite, gabbro, sheeted dikes, basalt with pillow lavas and sedimentary rocks. The peridotite is considered to be an upper mantle

rock, while the remainder of the sequence consists of ocean crustal layers.

Starting at the bottom of ocean crust, layer 3 is gabbro; followed by layer 2B, the sheeted dikes, which are closely-spaced nearly vertical dikes of diabase (an intrusive basalt); layer 2A, which is the extrusive basalt that is suppose to flow from mid ocean ridges: and layer 1, the sediments. Ophiolites can be over 10 km thick and sometimes of large scale, such as the impressive arc-shaped Oman ophiolite that is about 150 km wide and 550 km long (figure 1).3,4

## Ophiolite conundrums

The origin of ophiolites has long been the subject of controversy.<sup>5</sup> A favoured hypothesis is that the ocean crust was generated at midocean ridges (MORs), spread out from the MORs and, after colliding with continents, forced up and over the continental crust, in some cases for possibly

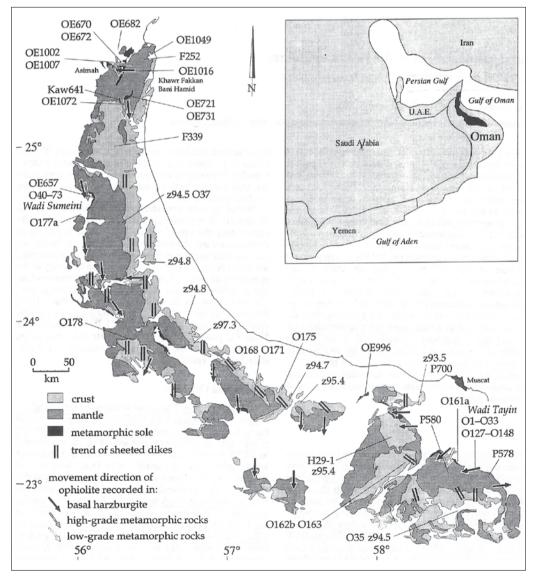
hundreds of kilometres. Ophiolites sometimes possess high temperature metamorphic rocks at their bases,<sup>6</sup> and the grade of metamorphism decreases downward below the base.<sup>7</sup>

Research on ophiolites in the 1980s and 1990s revealed that they are much more complicated than first thought. Major parts of the 'ideal' sequence are frequently missing, especially the sheeted dikes and the sedimentary rocks. The basalt can also vary from thin to absent. Although the structure is similar to that of ocean crust, supposedly generated at MORs, the geochemistry of ophiolites often does not match that environment. A revolution in thought has occurred

and most geologists now believe that ophiolites were mostly generated near 'subduction zones'.

Another problem is that there are no locations where ophiolites are currently being 'slammed' against continental crust. In other words there are no modern analogues,<sup>8</sup> which is again contrary to uniformitarian ideals (although not against actualism). It also makes it difficult to develop a thorough understanding of the proposed mechanism.

In truth there does not seem to be any credible mechanism for emplacement (obduction). As Dewey writes, 'no credible mechanisms



**Figure 1.** Oman ophiolite, also called the Samail ophiolite. (From Hacker et al., <sup>3</sup> p. 1,231).

have yet been devised for ophiolite obduction from ocean ridges onto rifted continental margins.'9 In regard to the Oman ophiolite, believed to have thrust 200 km westward onto a passive continental margin, Hacker and colleagues are understandably mystified:

'The emplacement of oceanic lithosphere [crust and upper mantle] onto continents remains one of the great mysteries of plate tectonics—how does ophiolitic material with a density of 3.0–3.3 g/cm³ rise from its natural depths of ≥2.5 km beneath the ocean surface to elevations more than 1 km above sea level on continents with densities of 2.7–2.8 g/cm³?'10

Ophiolites are also found in other contexts besides continental margin mountain belts. They have been recovered from what are called forearcs, island arcs and back-arc basins (figure 2).11 The forearc is the part of the subduction zone facing the deep-sea trench, while the island arc is the volcanic rocks that supposedly well up from a depth of about 125 km within subduction zones. The backarc basin is on the other side of the island arc away from the trench. For instance, Japan is an island arc. The Sea of Japan is considered a backarc basin associated with the Japan subduction zone, and the adjacent Pacific Ocean slope is called the forearc. Furthermore, ophiolites can be dismembered and deformed and mixed with a wide variety of other rocks, as found in California.12 Ophiolites have been classified into seven types, reflecting the different structural architecture, geochemistry, supposed evolutionary path and different tectonic environments 13

### **Another surprise**

If all these mysteries are not enough, another recent surprise was the finding of microdiamonds and coesite, an ultrahigh-pressure (UHP) mineral of quartz, in chromitites of the Luobusa ophiolite, Tibet. 14 Chromitites are

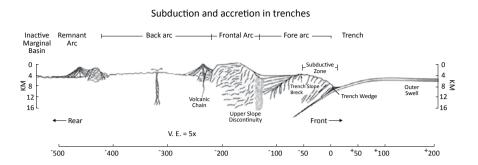


Figure 2. Ideal subduction zone. (After Karig and Sharman<sup>24</sup>).

igneous rocks composed mostly of the mineral chromite. The microdiamonds and coesite require minimum pressures of 2.8 and 4 GPa (Gigapascals), respectively, to form, representing depths of 80 to 120 km down in the upper mantle. Not only that, the coesite 'crystals' have the external shape of another high pressure phase of quartz called stishovite, which means that the rock must have formed at pressures greater than 9 GPa, which corresponds to a depth greater than 250 km! Since ophiolites are believed to have formed at shallow levels, such UHP minerals have placed a great burden on the traditional uniformitarian interpretations of ophiolites:

'The depths in Earth implied by these UHP minerals are in stark contrast to those generally accepted for the formation of ophiolites and their included chromitites.' 15

Thus, ophiolites, or at least the Luobusa ophiolite, join the ranks of other UHP and HP (high pressure) terranes, which are commonly found in mountainous regions across the earth.16 These minerals require very rapid exhumation from depths greater than 100 km. Of course uniformitarians consider a rapid rise to be in the range of a few cm/yr, but this is mainly an assumption. The UHP and HP minerals require a much more rapid vertical tectonic shift. Otherwise, if the rise is too slow, the UHP and HP minerals would transform to low pressure equivalents.

Another possibility is that the microdiamonds and UHP and HP

minerals are caused by meteorite impacts, since they are associated with known impact craters:

'An astrobleme impact, either on land or in the ocean (see Glikson, 1999), would allow the UHP phases to have been overprinted on the preexisting oceanic lithosphere [crust and upper mantle] and therefore no reinterpretation of ophiolite origin is required. Such an origin would also simplify explanation of the perfect preservation of the coesite as a consequence of rapid cooling after shock metamorphism and allow interpretation of the amorphous phase as a quenched impact melt.'15

This impact hypothesis is straightforward and does not demand exotic mechanisms, such as ophiolites being forced down to depths greater than 250 km and then rapidly back up. However, the uniformitarian scientists dismiss this obvious possibility because there is no independent evidence of meteorite impact for the Luobusa ophiolite since the peridotites, gabbros and pillow lavas show no evidence of shock metamorphism. So, they advance the idea that the UHP minerals originated deep in the upper mantle, possibly with the ophiolite forced down in a subduction zone and returned to the surface by rapid exhumation. However, there are many problems with this interpretation: the fact that there are unmetamorphosed gabbros and pillow lavas in this ophiolite is not indicative of great burial.

## What are creationists to make of ophiolites?

Ophiolites represent a bit of a conundrum to creationists as well. We cannot dismiss them as rare because they are widespread across the earth. 17 It is difficult to relate ophiolites to the Catastrophic Plate Tectonic (CPT) model because ophiolites are not often found in plate collision zones, 18 an obvious possibility for an emplacement mechanism. Furthermore, their radiometric ages are often older than the Mesozoic and Cenozoic, the time the current ocean crust is believed to have formed by CPT. Ophiolites are mostly younger than 1 billion years with the oldest believed to be about 2 billion vears old within the uniformitarian timescale.19 However, there is now a claim of a 3.8 billion-year-old ophiolite in southwest Greenland.20 So, ophiolites occur throughout the geological column, and according to the CPT model would mostly represent pre-CPT ocean crust.21 These dates assume that creationists can accept radiometric dates in a relative sense, which is possible,22 but requires more research to confirm.

Ophiolites likely represent real ocean crust and upper mantle material from some time in the recent past; some have been used with great success to estimate many properties of current ocean crust.<sup>23</sup> I suggest that ophiolites represent pre-Flood ocean crust. If this is the case, is it possible that the current ocean crust is really pre-Flood ocean crust and upper mantle? This would mean the current ocean crust and upper mantle were *not* formed during the Flood, according to the CPT model.

Furthermore, the catastrophe of the Flood is a much more worthy mechanism for emplacement of ophiolites than the uniformitarian model, assuming the overthrust mechanism and distances of displacement are more or less correct. Given that microdiamonds and UHP and HP minerals are now found in ophiolites, I would favour the impact origin in which pre-Flood ocean crust is

forced up and onto what are considered continental rocks. The arc shape of the Oman ophiolite (figure 1) is suggestive of a large impact. However, many other ophiolites are not arc shaped. The reason why other ophiolites in mountains, such as the Luobusa ophiolite in Tibet, are not suggestive of an impact could be because of the chaos of numerous impacts, the extreme tectonics, and huge erosion and rapid deposition during the Genesis Flood. Ophiolites dated during the Mesozoic and Cenozoic could represent mid to late Flood impacts.

I am seeking to develop a creationist model for ophiolite emplacement that is compatible with the Flood. Such deductions are obviously controversial, and I welcome differences of opinion and encourage those who disagree to express their thoughts on these mysterious ophiolites.

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