# What is an Ophiolite?

Ophiolites have long been regarded as remnants of ancient oceanic crust formed at spreading centres that have been thrust up on land.

The Troodos ophiolite in Cyprus has been studied extensively since the 1950s. Geochemical signatures of the rocks from Troodos indicate that the ophiolite formed at a spreading centre above a subduction zone as illustrated in Figure 1.

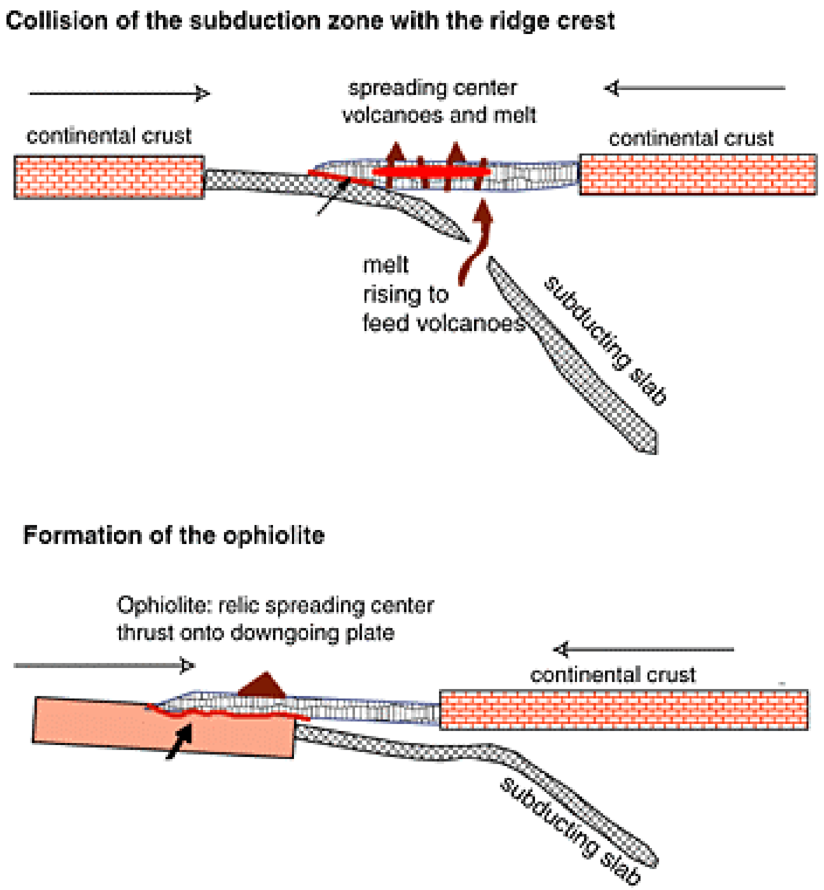


Figure 1. Top panel shows the spreading center colliding with a subduction zone. As the two plates continue to converge the spreading center is thrust on top of the downgoing plate to form the ophiolite. Modified from: "Birth, death, and resurrection: The life cycle of suprasubduction zone ophiolites, by John W. Shervais

Well preserved ophiolites have layers of rocks that are thought to be very similar to those of ocean crust. Starting from the base of the crust and moving upwards these layers are gabbro, sheeted dikes, and pillow basalts (lavas).

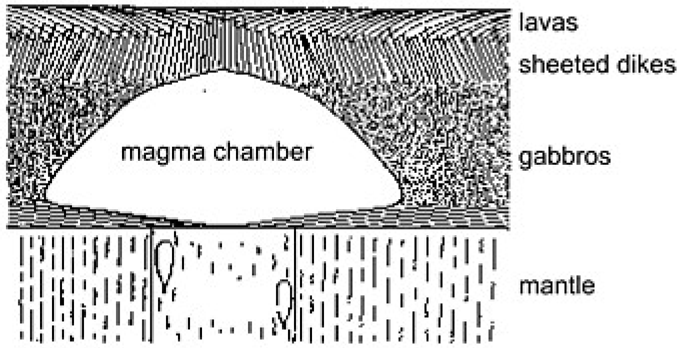


Figure 2. A cartoon from a 1974 paper by J. Cann shows the basic rock layers exposed in an ophiolite. The same layers were proposed for the ocean crust. The mantle is below the crust.

The most unique feature of this sequence of rocks is the sheeted dike layer. Dikes are conduits for magma to reach the seafloor to erupt and form pillows. Each dike is thought to intrude and split the last dike emplaced. It was recognized early on in the study of ophiolites that the sheeted dike complex had to be formed in an environment where the crust was being cracked and was moving apart (extending) such as found at mid-ocean ridges.

Cyprus lies on part of the complex suture zone between the Eurasian and African Plates.


Figure 3. Map of the eastern Mediterranean created at www.map.com.
The Island of Cyprus is seen south of Turkey.

The opening and closing of ocean basins has produced a very complicated series of terrains in the East Mediterranean area. This includes the North Anatolian Fault that runs through Turkey and has been very active in the past few years. Currently Cyprus sits above a subduction zone which is subducting to the north. The Troodos ophiolite belongs to the mid-Cretaceous, and formed ~91 my ago. A belt of ophiolites of this age stretches far to the east, ending with the well known Samail ophiolite in Oman. Uplift of Troodos to its present position took place episodically, but was initiated ~20 My ago.

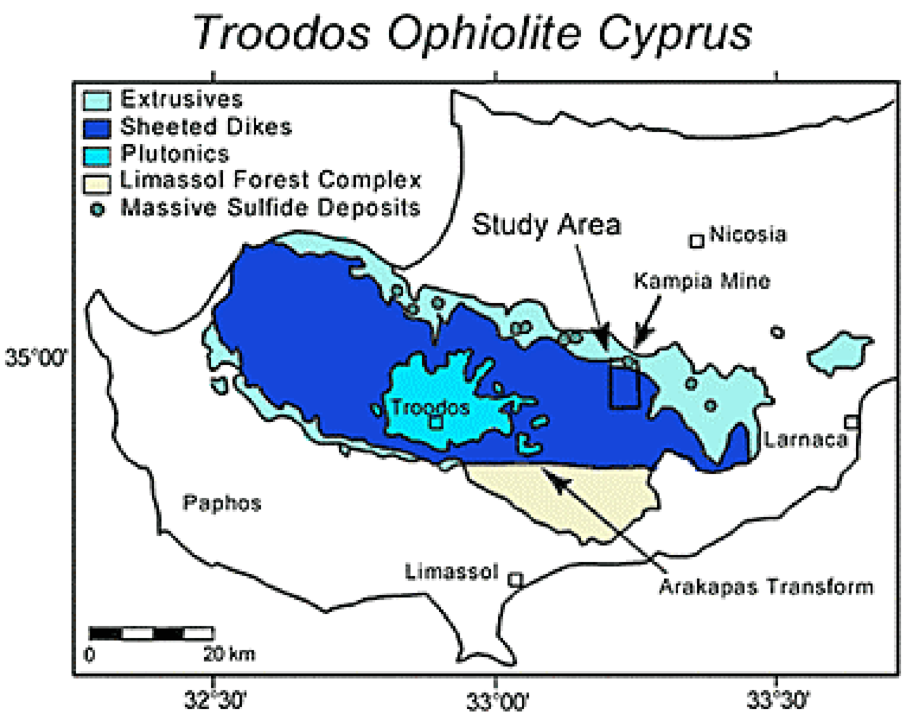


Figure 4. Map of the Troodos Ophiolite that forms part of the Island of Cyprus. The figure is taken from Staudigel et al., 1999.

In the oceans, crustal layers are defined by seismic reflection and refraction studies. This is because marine scientists have not as of yet drilled through the entire ocean crust (~7 km) and therefore, there is no direct evidence for the composition of the layers.

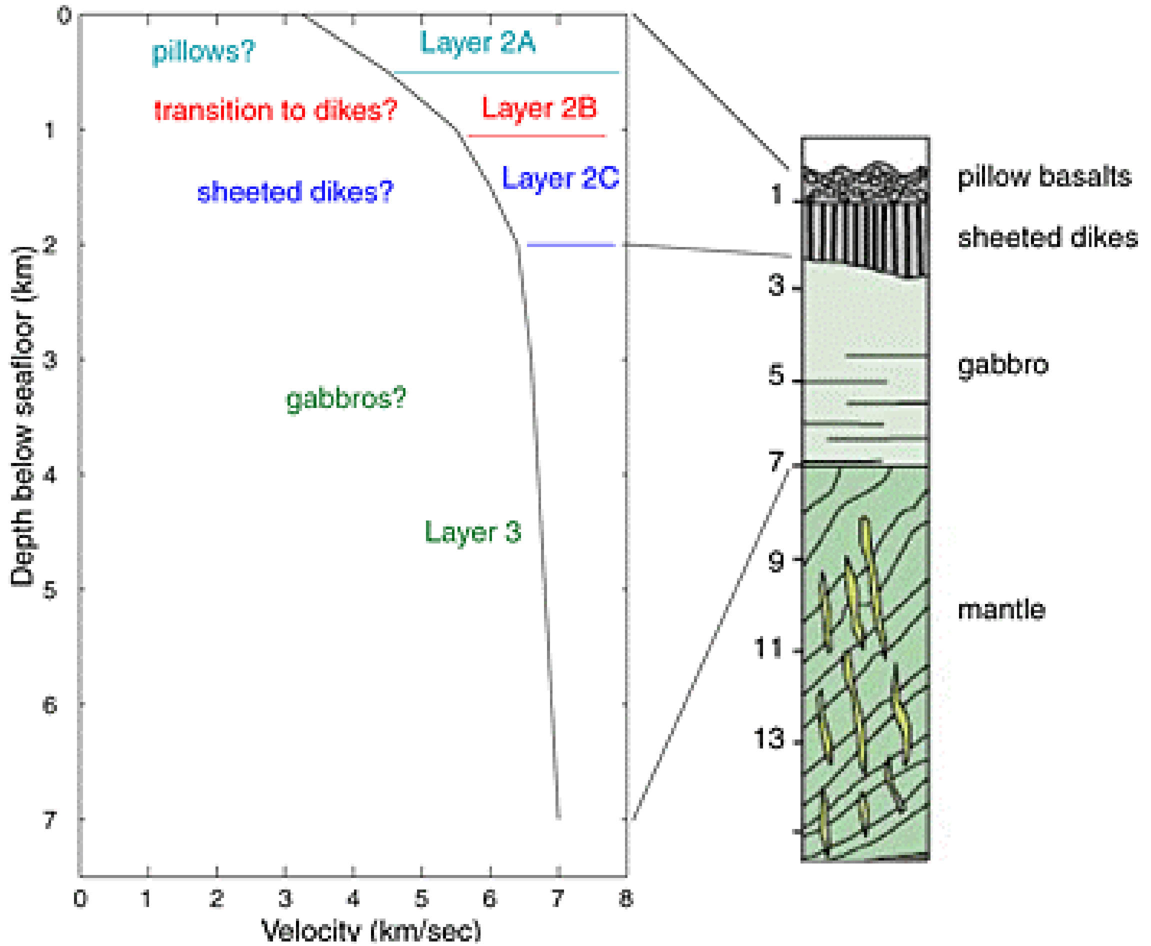


Figure 5. Seismic velocity is plotted on the horizontal axis versus depth below the seafloor on the vertical axis. The different seismic layers are marked on the plot with geologic interpretations of the rock units. The layers are defined by velocities and velocity gradients. Cross section through a typical ophiolite sequence is shown to the right.

***Layer 1*** is composed of sediments that rain down on the seafloor. Layer 1 is not marked on Figure 5 but the sediments are on top of Layer 2.

***Layer 2*** is considered to be the volcanic layer. In the 1970s it was proposed that layer 2 should be subdivided into 3 layers. These divisions are commonly used in the scientific literature.

***Layer 2A*** has velocities of ~3.5 km/s and is commonly associated with extrusive volcanics

***Layer 2B*** has velocities between 4.8-5.5 km/s and is commonly associated with the transition from extrusives to dikes

***Layer 2C*** has velocities between 5.8-6.2 km/s and is commonly associated with dikes

***Layer 3*** has seismic velocities between 6.5 – 7.0 km/s. Layer 3 is called the oceanic layer and it is presumed to be gabbroic in composition, but it might be sepentinized peridotite.

Scientists must be careful about relating the seismic layers to real rocks though, as seismic velocities are controlled mostly by crustal bulk porosity and not rock type.

Figure 6. Picture of a hillside in Cyprus. The vertical slabs of rock are dikes intruding into lavas that erupted on the seafloor. This section represents the transition from lavas to sheeted dikes and is thought to correspond to seismic Layer 2B as seen in Figure 5. Taken from the RIDGE field school in Cyprus.

Ophiolites provide us with a glimpse beneath the seafloor to understand crustal structure. What we know about oceanic crustal structure has been learned from analyzing drill cores, from views of the seafloor from a small porthole in a submarine, and inferred from geophysical data. Although it is important to be cautious about making parallels between ophiolites and ocean crust, the opportunity to walk around far below the ocean floor on ophiolites gives crucial insights into processes taking place in the ocean crust.