Overview of Hole CM1 in the Oman Drilling Project Phase 2: Crust-Mantle boundary

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Direct observation of the transition between the Earth’s crust and mantle has been a major quest of geoscientists for more than half a century, even before the development of plate tectonic theory in the 1960s. Oceanic crust is thinner (about 7 km) than continental crust (about 40 km), so our quest has focused on the oceans. One of the primary goals for four generations of international ocean drilling ships, culminating with the state-of-the-art, Japanese Drilling Vessel “Chikyu”, has been to drill through intact oceanic crust to reach this critical horizon, which has never been directly observed.

A “preview” can be obtained from blocks of oceanic crust and upper mantle that are thrust onto the continents by plate tectonics, and exposed by faulting and erosion. The largest and best-preserved block is the “Samail ophiolite”, in the Sultanate of Oman and the United Arab Emirates. Scientific drilling of the Samail ophiolite (Oman Drilling Project; OmanDP) had been conducted from December 2016 to March 2018 (Kelemen et al., 2013, *Scientific Drilling J.* **15,** 64-71, doi: 10.2204/iodp.sd.15.10.2013). OmanDP is an international collaboration supported by the International Continental Scientific Drilling Program (ICDP), the Deep Carbon Observatory, NSF, IODP, JAMSTEC, and the European, Japanese, German and Swiss Science Foundations, with in-kind support in Oman from the Ministry of Regional Municipalities and Water Resources, Public Authority of Mining, Sultan Qaboos University, and the German University of Technology.

OmanDP Hole CM1A drilled the crust-mantle boundary from 15 November 2017 to 13 December 2018, representing the ICDP Expedition 5057 Site 7. The Hole CM1 is located at 22°54.433’N, 58°20.15′E and 622 m above sea level in Wadi Zeeb of Wadi Tayin massif in the Samail ophiolite, ~80 km south of Muscat, the capital of Oman, and ~30 km NNW of the frontier town of Ibra.

A succession of layered olivine gabbro through massive dunite to harzburgite was recovered over a cored interval of 404.15 m at Site CM1. The upper cores comprise a mafic unit of 160 m of mostly olivine gabbro overlying ~150 m of dunite and ~75 m of harzburgite, with a compositionally gradational zone of 15m between dunite and harzburgite. The upper mafic parts are compositionally heterogeneous, dominantly layered olivine gabbro, but with anorthosite, troctolite, wehrlite and dunite layers. Some layers are irregular with cross-cutting features, but well graded decimetric layers grading progressively upward from olivine-rich troctolite or wehrlite into olivine gabbro are observed several times. Dunites appear from the depth of 118m downward and some dunites cut layering in olivine gabbro from 129 m. A clear-cut

contact between olivine gabbro and cross-cutting dunite is present at 160 m. Dunites dominate downward to 309 m, with a few gabbros cutting dunites, as in Core 108 at the depth of 251 m (Figure). The lower boundary of dunite above harzburgite is compositionally gradational from 313 to 328 meters, with irregular variations in pyroxene content. There is massive harzburgite below 328 m.

There are many different hypotheses concerning the genesis of dunites in the crust-mantle transition zone. The Oman Drilling Project recovered the first continuous cores from layered gabbro through dunite to harzburgite. Are these dunites igneous cumulates deposited in dikes and sills? Products of reactive porous flow, with pyroxene and plagioclase dissolution in olivine-saturated magmas? Residua of partial melting, perhaps due to incorporation of seawater into magmas at the base of the crust? Or a combination of all three? In turn, the answer to these questions determines the inferred composition of primary magmas that form igneous oceanic crust, and the temperature of the convecting upper mantle.

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