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Primitive troctolites and gabbros from ultraslow ridges

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Sampling lower crust at the mid-ocean ridges is often done in tectonic windows at slow-spreading ridges, but typically requires drilling at fast-spreading ridges. Geochemical data for lower crustal rocks from the slow-spreading ridges around the world shown a large range of compositions, however, primitive rocks are often missing. These are required, though; to mass balance moderately differentiated mid-ocean ridge basalt and evolved gabbros back to a primary magma composition. This is probably because tectonic windows sampled at slow-spreading ridges are largely at segment ends; particularly inside-corner highs at ridge-transform intersections. At the ultraslow Gakkel ridge and parts of the Southwest Indian Ridge, gabbros from the mid-points of magmatic segments were found exposed along long-lived normal faults at rift valley walls. Lower crustal gabbros from these ultraslow ridges have been analyzed in this study. This study is limited to dredges that recovered solely gabbro, or sampled it with diabase dikes, to avoid gabbroic veins and small intrusions of likely upper mantle provenance commonly found in areas where mantle is outcropping on the sea floor.

Thus, our study is limited to material with a high probability of representing the crustal evolution of MORB magmas. A feature of particular interest is that unlike material dredge near transform faults, our samples include numerous primitive troctolites and troctolitic gabbro. These are generally fine-, to medium-grained as typically found in crustal sections in well-preserved ophiolites, and many samples often preserve igneous lamination or layering. Our samples were also frequently dredged with diabase dikes, with contacts between troctolitic gabbros and dikes preserved in some samples. This indicates that, unlike ophiolites, primitive gabbro and troctolites are often emplaced to the highest levels in or near the dike-gabbro transition at ultraslow spreading ridges near segment centers. A similar result was also found during ODP Leg 209, where dikes and primitive gabbros were also sampled together at Site 1275 (Kelemen et al.,

2004) and at the Kane Megamullion near the Mid-Atlantic Ridge (Dick et al., 2005), and even more recently near the top of the 1405-m gabbro section at the Atlantis Massif on the MAR during IODP Legs 304 and 305).

Samples analyzed so far include whole-rock molar {Mg x 100/(Mg+Fe*)} ranging from 86 to 49, and Na_2O contents as high as 4.2%. As these ridges are ultraslow spreading, high Na_8 is expected in the parental magma, which is estimated at 3.3% by regressing spatially associated basalts following Klein and Langmuir (1987). Although oxides are present in small quantities in most samples, significant amounts of ilmenite and titanomagnetite are only seen in the evolved ferrogabbros, which have a high TiO_2 content. The troctolites have a correspondingly low TiO_2-content. TiO_2 is significantly less than those from ODP Hole 735B at Atlantis Bank, Southwest Indian Ridge where there is evidence for large scale late permeable melt flow and melt-rock reaction in the section. As a consequence, our samples are likely not only parental to erupted MORB, but also lack significant post-cumulus modification and hybridization by later melts. This makes them ideal for major and trace element modeling to constrain the evolution of MORB and the character of the parental magmas at these ultraslow ridges.