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Accretion of fast-spread lower oceanic crust: drill core GT1 from the ICDP Oman Drilling Project

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The Sumail Ophiolite at the northeastern coast of the Sultanate of Oman provides an ideal field laboratory for studies on fast-spread oceanic crust on land. Based on numerous campaigns in the past, the Oman Drilling Project (OmanDP) of the International Continental Scientific Drilling Program (ICDP) obtained nine 300 to 400 m long drill cores covering sections from the upper mantle to the dyke/gabbro transition zone. Drill core GT1 is located in the layered gabbros between ~1200 and ~800 m above the Moho transition zone (m.a.M.) and comprises of modally layered gabbro with cm-scale coherent bands of troctolite, anorthosite, and wehrlite. We prepared thin-sections with a small average spacing of <2 m and analyzed them by petrological, microstructural and geochemical methods. Clinopyroxene reveals Mg# (where Mg# = Mg/Mg+Fe x 100; molar basis) between 74 and 86, with some heavily altered olivine relicts between 70 and 83, and Ca# (where Ca# = Ca/Ca+Na x 100; molar basis) of plagioclase range from 68 to 87. The plots of these data show clear and consistently decreasing trends from the base of the drill core up section to a crustal height of 1070 m.a.M. where all fractionation indices show significant minima. Above 1070 m.a.M., the indices increase to their maxima. Clinopyroxene shows core/rim zonation in Mg# and TiO_2 content with more primitive core compositions. However, distinct zonation is only observed above the minima mentioned above. Besides this general fractionation trend from the core base to 1070 m.a.M., individual fractionation trends on the scale of several decameters can be defined along the core (e.g., 820 to 895, 890 to 970, and 1085 to 1110 m.a.M.). As a quantifier of the plagioclase fabric symmetry, we used the BA index which ranges from 0 for a purely foliated to 1 for a purely lineated fabric. We found that the rock fabric changes parallel the observed fractionation trend with significant lineation at the base of the core and evolving towards almost purely foliated fabrics up section to 1070 m.a.M., indicating either an intense compaction or weaker shearing, or both at 1070 m.a.M. A possible scenario creating the observed trends is an evolved melt entering the more primitive crystal mush at 1070 m.a.M. and crystallizing primary phases with significantly more evolved compositions. In such an environment, where the liquid/solid ratio is increased, minerals may be more sensitive to compaction and less affected by shearing which is possibly induced by convection of the upper mantle. Magmatic

deformation would therefore lead to a strong foliation with only a limited lineation component. Moreover, we interpret the observed decameter-scale fractionation trends, also being accompanied by slight changes in the fabric, as results of individual magma reservoirs crystallizing in-situ and leading to the accretion of the lower gabbros in Oman (e.g., [1]).

[1] Kelemen, P. B., Koga, K., & Shimizu, N. (1997). Geochemistry of gabbro sills in the crust-mantle transition zone of the Oman ophiolite: Implications for the origin of the oceanic lower crust. Earth and Planetary Science Letters, 146(3-4), 475-488.