The Atlantis Bank Batholith, SW Indian Ridge, the Link Between Lower Crustal Accretion at High and Low Melt Supply

*Henry J Dick[1]

1. Woods Hole Oceanographic Institution

Atlantis Bank, an enormous elevated wave-cut platform shoaling to 700-m water depth, exposes a gabbro batholith that accreted in the lower ocean crust at ~18.4 mm/yr from 13.4 to 10.5 Ma on the SW Indian Ridge. It is situated in a region of anomalously elevated topography (~1 km) that extends from the Atlantis II to the Melville Transform (Yu and Dick, 2019). It overlies, and is intruded into fertile mantle lherzolite exposed along the wall of the Atlantis II Transform, representing near steady-state accretion of the lower crust (Dick et al., 2019a). There is a transform parallel three-hole transect extending for 2.2 km down its axis: including recently drilled 809-m deep IODP Hole U1473A, 158-m ODP Hole 1105A, and 1508-m ODP Hole 735B. With extensive seafloor mapping, it provides the first 3-D view of the upper levels of a 660-km^2 section of the lower crust. It is laterally and vertically zoned to dominantly oxide rich gabbros in its uppermost levels, representing a complex interplay of cyclic intrusion, and ongoing deformation, with km-scale upward and lateral permeable migration of interstitial melt. Transform wall dives over the gabbro-peridotite contact found only evolved gabbro intruded directly into the mantle near the transform. There was no high-level melt lens, and dikes cut the gabbros at the dike-gabbro transition. These gabbros crystallized at depth, and then were emplaced into the zone of diking by diapiric rise of a crystal mush, followed by crystal-plastic deformation and faulting. The residues to mass balance the crust to a parent melt composition then lie at depth below the center of the massif –likely near the crust-mantle boundary. Thus, MORB’ s erupted to the seafloor from >1,508 m below seafloor.

The batholith represents dynamic accretion, where extension across the plate boundary is accomplished by a combination of intrusion hypersolidus and sub-solidus crystal-plastic deformation at intermediate depth, and brittle deformation and dike intrusion at higher levels. It has as much in common with crust formed at the East Pacific Rise as it does with typical crust at the Mid-Atlantic Ridge. At the former lower crustal accretion is largely passive by direct intrusion of melt, and likely crystal-mush flow, with extension largely accommodated above the dike-gabbro transition by dike intrusion and brittle deformation. Melt lenses exist at the base of the crust, from where they are intruded to the seafloor with only minor modification occurring in a melt lens overlying a crystal mush zone at the dike-gabbro transition. Due to the melt lens, the dikes are generally cut by the gabbros. Hydrous alteration beneath the axis is very limited. Atlantis Bank is similar to the EPR in that a substantial portion of extension is accommodated by direct intrusion of melt, crystal mush flow, and both the EPR and the Atlantis Bank sections have undergone extensive km-scale late-stage melt transport that modified the overlying gabbros. Like the EPR, magmas are intruded to the seafloor directly from near the base of the crust.

By contrast, MAR lower crust drilled at 23°N and Atlantis Massif experienced little high-temperature crystal-plastic deformation and limited late-stage melt transport. They contain primitive cumulates, and represent episodic intrusion, melt storage, and crystallization of parental MORB in thin crust below the dike-gabbro transition. Primitive gabbros and therefore storage of primitive melt occurred at all levels. Due to only episodic magmatism, individual intrusions crystallized rapidly, so that unlike Atlantis Bank, there were only short periods where extension could be accommodated by high-temperature crystal-plastic deformation, and tectonic extension was by brittle deformation. Consequently, greenschist facies alteration dominates down Hole 1309D at Atlantis Massif, as compared to largely high-temperature

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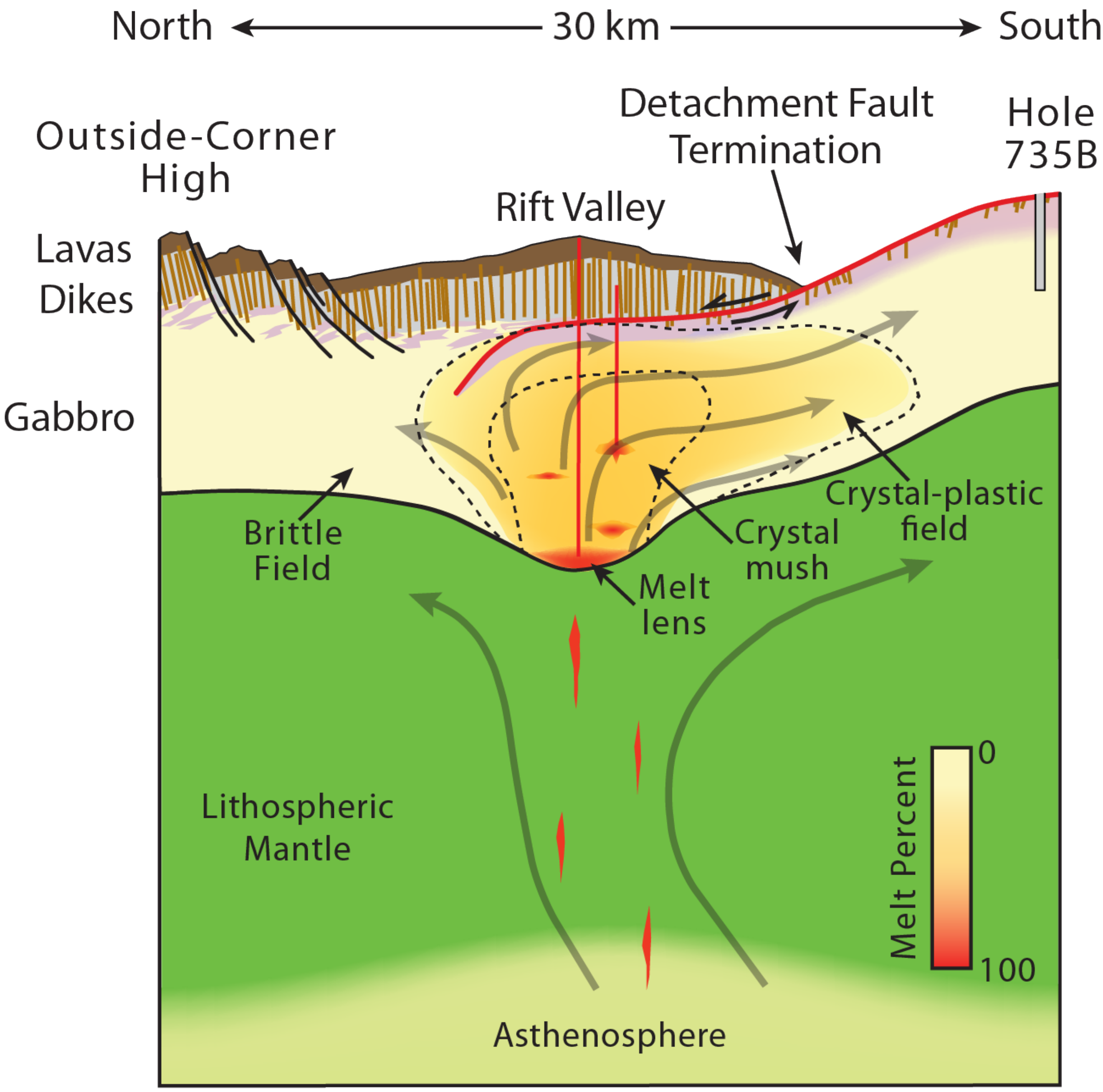
high-level amphibolite to granulite facies alteration at Atlantis Bank. There was no km-scale permeable melt transport and systematic enrichment of the upper levels of the massif in Fe and Ti to form massive oxide gabbros, as found at Atlantis Bank. Like the MAR localities, Atlantis Bank had no melt lens, and the dikes cut the gabbros as a result.

Keywords: Lower Ocean Crust, Gabbro, Melt Transport



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