Emplacement processes of off-axis large submarine lava field in the Oman Ophiolite

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Large submarine lava with thicknesses >100 m and volumes exceeding a few km^3 are not uncommon volcanic constructs of mid-ocean ridges and around Hawaii Islands, yet details of the physical processes of eruption of these large lava flows are poorly understood. The V3 flow of the Oman ophiolite extruded at 90 Ma far off the paleospreading axis as thick lava flows with a minimum areal extent of >11 km by 1.5 km and the maximum thickness >270 m, yielding an estimated volume >1.2 km^3.The V3 flow was fed by a thick feeder dike in the SW of the flow field and buried off-axial fault-bounded basins with a thick sedimentary cover. The upper V3 flow field consist of compound lobes that merge upstream into larger and thicker sheet-like lava. Welding of flow lobes formed domal structures of columnar joints with narrowing joint spacing and banded lava crust with erosive coarse-grained lenticular dolerite embedded in fine-grained convex dolerite. Cooling rate determines the relationships among joint spacing, crystal number density and the degree of flow-lobe welding/coalescence. Faster cooling prohibits welded flow lobes to merge into an inflating single larger lobe but formed superposed welded flow lobes with well developed columnar jointing. On the contrary, higher supply rate of lava and slower cooling enabled flow lobes to merge and subsequently inflate to form a larger sheet flow or to become a part of the major lobe, which are now preserved as massive core.

Low-T hydrothermal alteration and weathering slightly modified the bulk compositions as indicated by moderate albitization of plagioclase and partial replacement of titanomagnetite and clinopyroxene by titanite and chlorite, respectively. However, strong positive correlations among incompatible HFSEs and REEs and relatively good correlations with major elements besides LILEs and Pb show that these elements were less mobile and preserve primary characteristics. MgO varies from 8 to 4 wt% with a moderate enrichment and a decrease in FeO. Modelling by MELTS demonstrates that fractionation of olivine, clinopyroxene and plagioclase, the major phases in the groundmass of the lava, at a pressure of the paleowater depth is responsible for the major and trace element variations of the flow. Stratigraphic variation in the bulk compositions show a notable enrichment in MgO and depletion in incompatible elements in the lowermost core, consistent with accumulation of olivine phenocrysts. Enrichment in incompatible elements in the uppermost core of the flow is in accordance with the model that the last solidified, residual melt resided in this horizon. The V3 flow shows 20-50 times enrichment in Th and depleted HREEs compared to primitive mantle, similar to differentiated EMORBs.