Geothermometry/Oxybarometry on Gabbros and Basalts from IODP Hole 1256D Monitored by Fe-Ti-Oxides

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We analyzed coexisting pairs of magnetite and ilmenite in basalts and gabbros from IODP Hole 1256D (equatorial eastern pacific, 15 Ma old crust formed at the East Pacific Rise) to constrain the temperature and oxygen fugacity evolution of a superfast spreading MOR. The drill core of Hole 1256D provides the first complete reference section of an upper oceanic crust from the uppermost lava flows down to the plutonic complex. Chemical compositions of the Fe-Ti oxides were obtained by electron microprobe analysis. The petrographic record of the whole section reveals that all processes reflecting the metamorphic-magmatic evolution of the crust involve formation of, or reactions with Fe-Ti oxides. While ilmenite coexisting with magnetite is only present in the uppermost unit of the extrusives, the lowermost ˜60m of the sheeted dikes ("granoblastic dikes"), which are thermally overprinted, always contain coexisting pairs of magnetite and ilmenite (Koepke et al, 2008). Their chemical compositions are differing significantly from those of the fresh rocks from the upper section. Magnetite of the granoblastic dikes approaches the composition of pure magnetite with ulvospinel contents from 8 to 18 mol%, while titanomagnetites of the fresh lavas and dikes have ulvospinel contents between 61 and 74 mol%. Applying the Two-oxide geothermo-oxybarometer of Sauerzapf et al. (2008), we estimated an equilibrium temperature of 912°C for the uppermost basalt and an oxygen fugacity of NNO = - 1.1 log units (NNO corresponds to the oxygen fugacity defined by the Ni-NiO buffer). We observed an increase of oxygen fugacity within the granoblastic dikes of nearly 4 log units to highly oxidizing conditions and re-equilibrium temperatures of 543-649°C, implying that either the water activity increased during metamorphism or seawater-derived fluids oxidized the material in an hydrothermal alteration stage prior to the granoblastic overprint. Further studies on stable iron isotopes could proof the influence of seawater in the root zone of the sheeted dike complex. Also first measurements on ilmenite / magnetite assemblages in the related gabbros were done, showing magmatic temperatures of ˜1000°C and more reducing conditions (NNO-0.2) than in the granoblastic dikes. However, the gabbros were affected by secondary hydrothermal alteration processes, which are expressed by exsolution effects in both ilmenite and magnetite, showing re-equilibrium temperatures of ˜600°C and NNO of +2.0 to +2.8.

References

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