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Experimental phase-equilibrium study of Al- and Ti-contents of calcic amphibole in MORB—A semiquantitative thermobarometer

W.G. ERNST* AND JUN LIU

Department of Geological and Environmental Sciences, Stanford University, Stanford, California 94305-2115, U.S.A.

ABSTRACT

Calcic amphiboles were synthesized from a natural mid-ocean ridge basalt (MORB) in 39 experiments representing 24 sets of pressure-temperature (P-T) conditions ranging from 650–950 °C, 0.8–2.2 GPa, at f_{O_2} controlled by the fayalite-magnetite-quartz (FMQ) buffer, and $P_{\text{aqueous fluid}} = P_{\text{total}}$. Experiments lasted up to 1630 h at low temperatures; in all cases, synthesized hornblendes were coarse-grained (5–7 × 10–15 μm) and chemically homogeneous. Over the investigated pressure range, Ca-amphibole coexisting with phases rich in Al and Ti gradually changes composition from sodic-calcic, Si-rich at low temperatures to calcic, Si-poor at high temperatures: it is barroisite at 650 °C, edenite at 700 °C, and pargasite at 800–950 °C. Electron microprobe data were combined with 41 comparable analyses from the literature for Ca-amphiboles synthesized from MORBs at intermediate f_{O_2} in order to erect a petrogenetic grid for the experimental range 0.0–2.2 GPa, 450–1050 °C. Isopleths for Al_2O_3 in Ca-amphibole exhibit markedly negative P-T slopes, indicating increasing Al_2O_3 contents with both P and T. In contrast, TiO_2 isopleths are nearly independent of P, demonstrating that TiO_2 in Ca-amphibole increases almost exclusively as a function of T. For natural metabasaltic assemblages that contain coexisting Al-rich and Ti-rich phases, and closely approached chemical equilibrium under crustal or uppermost mantle conditions, this semiquantitative petrogenetic grid allows the simultaneous assignment of attendant P and T employing Ca-amphibole Al_2O_3 and TiO_2 contents. However, during slow cooling, natural Ca-amphiboles may exsolve TiO_2 as rutile, titanite, and/or ilmenite, but in general do not redistribute Al_2O_3, so this thermobarometer must be applied with caution to inhomogeneous specimens.