Paper Number: 903

Phase Equilibria in High- and Ultrahigh-pressure Eclogites

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Phase relations of basic rocks under high pressure (HP) and ultrahigh pressure (UHP) metamorphic conditions are modelled on the basis of a MORB composition. The calculated pseudosections predict that basic rocks will contain glaucophane, garnet, omphacite, lawsonite, phengite, quartz with or without talc under HP lawsonite eclogite subfacies conditions (1.8–2.8 GPa, 500–600 °C). In these assemblages, the pyrope content (Xpy) in garnet is mostly controlled by variations in temperature, grossular content (Xgr) is strongly controlled by pressure, and the silica content (Si-) in phengite increases linearly with pressure. As the P–T conditions for these given isopleths are only subtly affected by common variations in bulk-rock compositions, the P–T pseudosections potentially present a robust geothermobarometric method for natural glaucophane-bearing eclogites. The maximum Xpy content may define the temperature peak (Tmax) and the minimum Xgr content constrains the pressure peak (Pmax) conditions. An isothermal decompression of these lawsonite-bearing assemblages would result in epidote- bearing assemblages through dehydration reactions such as lawsonite + omphacite = glaucophane + epidote + H2O, releasing a large amount of bound fluid. Thus, most natural HP epidote eclogites may have experienced a metamorphic stage of lawsonite stability.

Under low-T UHP conditions (> 2.8 GPa, 550–650 °C), basic rocks are predicted to contain garnet, omphacite, lawsonite, phengite, coesite and talc. In this assemblage, the Xpy contents steadily increase as temperature rises and the Si-in phengite increases linearly with pressure. However, the Xgr content changes very slowly as pressure changes. The peak P–T conditions for low-T UHP eclogites can be determined using the isopleths of maximum Xpy and Si-in phengite in P–T pseudosections. An isothermal decompression of these low-T UHP eclogites at temperature i.e. 600 °C would result in disappearance of lawsonite and talc of the peak stage, but appearance of glaucophane, epidote and kyanite, forming the mineral assemblages involving garnet + omphacite + glaucophane + epidote ± kyanite + quartz/coesite + phengite commonly observed. Moreover, garnet in the low-T UHP eclogites is characteristic of growth zoning with its rims containing lower Xgr and higher Xpy contents.

Under medium-T UHP conditions (> 2.8 GPa and >650 °C), basic rocks are predicted commonly to contain garnet + omphacite + lawsonite + phengite + coesite. In this assemblage, the Xpy in garnet mostly depends on bulk compositions, whereas the Xgr in garnet and the Si-contents in phengite regularly increase, respectively, as temperature and pressure rise, and thus, can provide robust thermobarometric constraints. Decompression of the eclogites with lawsonite in the peak stage is inferred to be dominated by lawsonite dehydration, resulting in increase in the mode of anhydrous minerals, or further eclogitization, and formation of epidote porphyroblasts and kyanite-bearing quartz veins in eclogite. As lawsonite dehydration can facilitate evolution of assemblages under fluid-present conditions, it is hard for the UHP eclogites with lawsonite to retain evidence of their real peak P–T conditions.