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Mössbauer spectroscopy of omphacite and garnet pairs from eclogites: Application to geothermobarometry

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ABSTRACT

Cation partition among coexisting minerals has been widely applied to eclogite thermometry, but an accurate estimation of Fe^{3+} content compared to total Fe is crucial in obtaining reasonable temperatures for petrologic studies. Room-temperature Mössbauer spectroscopy was measured for garnet-omphacite pairs in high-pressure (HP) and ultrahigh-pressure (UHP) eclogites from the Dabie terrane in east-central China. The results show very low $Fe^{3+}/\Sigma Fe$ ratios of 0.026 to 0.082 in garnet but high $Fe^{3+}/\Sigma Fe$ ratios of 0.240 to 0.689 in omphacite. The hyperfine parameters of minerals record the HP-UHP conditions that the eclogites experienced. Fe^{2+} in clinopyroxenes with low Na + Ca contents in their M2 sites shows pressure-induced occupation in M1 site. The quadrupole splitting of Fe^{2+} in HP-UHP garnets (3.61 to 3.77 mm/s) and omphacites (2.77 to 3.06 mm/s) are among the highest values ever reported, indicating effectively pressure-regulated polyhedral sites. After the Fe^{3+} was corrected, Fe^{2+}-Mg partitioning not only significantly narrow the ranges relative to those without Fe^{3+} correction, but also yield temperatures about 8 to 370 ºC lower than the uncorrected temperatures for the same garnet-pyroxene pairs. The recalculated temperatures are constrained to narrow ranges of 477 to 647 °C for quartz-bearing eclogites and 624 to 843 °C for coesite-bearing eclogites. These maximum values provide close proxies to peak metamorphic temperatures provided that the retrograde exchange of Fe-Mg cations by diffusion between minerals during exhumation is taken into account.