Graphitization and calcite-graphite carbon isotope exchange in low temperature marbles

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The partitioning of stable isotopes of carbon between coexisting calcite and graphite is sensitive to temperature and, as a pressure-independent system, is a useful geothermometer in metamorphic rocks. Differing versions of the calcite-graphite thermometer strongly diverge below temperatures of 600° C. This study investigates the calcite-graphite exchange in marble subjected to regional metamorphism at temperatures of 450-500° C based on calcite-dolomite geothermometry. The study area lies in southern Ontario, in the Belmont Domain of the Elsevir Terrane, Grenville Province--an area also referred to as the Hastings Low, which includes the lowest grade of metamorphism in the southern Grenville. Samples taken for this study are from outcrops located at least 2 km from mapped igneous intrusions in an effort to avoid thermal aureoles.

Calcite in 39 samples and graphite in 30 samples have been analyzed. The $\delta^{18}O$ values of the calcite range from 18.09 to 29.76 ‰, while $\delta^{13}C$ values of carbonates range from -1.82 to 5.48 ‰ and $\delta^{13}C$ values of bulk graphite range from -2.89 to -16.62 ‰ (one outlier at +3.32 ‰ is not considered further). Δcc-gr values (Δcc-gr = $\delta^{13}C$ calcite - $\delta^{13}C$ graphite) for 26 samples are in the range of 4.66 to 19.89 ‰ (one outlier at 2.16‰ is not considered further). These correspond to temperatures of 620 to 235°C, respectively, using the formulation of Dunn & Valley (1992). The lower Δcc-gr values yield reasonable temperatures for this area, but we believe the larger values represent incomplete exchange of the isotopically light organic matter precursor with surrounding calcite due to sluggish self-diffusion within graphite grains. We have attempted to examine different size fractions of graphite within single samples to determine if isotopic zoning is present. Three samples have been analyzed. In all three, graphite grains <5 μm are significantly lighter than graphite grains 5-10 and 10-15 μm in size. This suggests that coarsening promotes isotopic exchange and that the finest graphite fraction is furthest from isotopic equilibrium.