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Fingerprinting carbonic fluid movement in crust inferred from the morphology and carbon isotope geochemistry of graphite

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The major carbon reservoirs in the crust are carbonate, graphite and carbonic fluids. However the movement of carbon in the crust is mostly as carbonic fluids. Carbonic fluids originate either by the decarbonation of carbonate rocks or by the oxidation of organic material during metamorphism, though mantle derived carbonic fluids can not be neglected. Carbonic fluids are commonly generated during prograde metamorphism. In contrast, the carbon fixation in crustal rocks occurs in the form of deposition of carbonate and graphite during cooling and uplift of crustal rocks. There are several difficulties in delineating a source for carbon, because crustal carbon is mostly derived from recycled materials. Tracing the movement of carbon in crustal regimes is usually made possible using carbon isotope studies. Here I present some unique examples of fingerprinting carbonic fluid movement under crustal conditions by integrating morphology and carbon isotopic characteristics of graphite in different tectonic environments.

In middle to lower crustal regimes, migmatites are common. During partial melting of graphite-bearing metapelites coarsening of graphite as well as formation of radial crystals are visible features that suggest high temperature of crystallization. The carbon isotopic composition of graphite in restite and leucosome and the isotopic zonation with heavier core and lighter rim, is clearly indicative of fluid pooling and deposition of graphite from carbonic fluids.

Another typical example of movement of carbon in the middle crust is graphite-bearing granitic veins in high-grade metamorphic terrains. In such cases, carbonic fluids move along granitic melts and graphite is precipitated on preexisting crystals. The newly deposited graphite occurs as box works of skeletal graphite and has depleted carbon isotopic composition.

A third case investigated is in regionally metamorphosed marbles. Here the assemblage itself has carbonate and graphite and in such a situation the carbonic fluid entering the rocks will alter carbon and oxygen isotopes of carbonate as well as precipitate graphite. Morphological studies have shown that simple metamorphism produces well formed polygonal graphite which is in isotopic equilibrium with carbonate, where as those affected by fluid infiltration display micrometer scale overgrowth structures. The later marbles show scattered carbon isotopic composition for both graphite and calcite.

These case studies suggest that morphological characterization coupled with carbon isotope studies in micrometer scale can shed light to the movement of carbonic fluids in crustal regimes.