Chlorite Geothermometry: A Review

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Abstract: Chlorite minerals, found in a great variety of rocks and geological environments, display a wide range of chemical compositions and a variety of polytypes, which reflect the physicochemical conditions under which they formed. Of particular importance for studies dealing with ore deposit genesis, metamorphism, hydrothermal alteration or diagenesis is the paleotemperature of chlorite crystallization. However, in order to understand the relationship between chlorite composition and formation temperature and hence use chlorite as a geothermometer, one must determine how other parameters influence chlorite composition. These parameters may include fO_2 and pH of the solution and Fe/(Fe + Mg) and bulk mineral composition of the host rock.

Four approaches to chlorite geothermometry, one structural and three compositional, have been proposed in the past: 1) a polytype method based on the (largely qualitative) observation that structural changes in chlorite may be partly temperature-dependent (Hayes, 1970); 2) an empirical calibration between the tetrahedral aluminum occupancy in chlorites and measured temperature in geothermal systems (Cathelineau, 1988), which has subsequently been modified by several workers; 3) a six-component chlorite solid solution model based upon equilibrium between chlorite and an aqueous solution, which uses thermodynamic properties calibrated with data from geothermal and hydrothermal systems (Walshe, 1986); and 4) a theoretical method based on the intersection of chlorite-carbonate reactions and the CO_2-H_2O miscibility surface in temperature-XCO_2 space, which requires that the composition of a coexisting carbonate phase (dolomite, ankerite, Fe-calcite or siderite) be known or estimated (Hutcheon, 1990). These four approaches are reviewed and the different calculation methods for the compositional geothermometers are applied to a selection of chlorite analyses from the literature. Results of this comparative exercise indicate that no single chlorite geothermometer performs satisfactorily over the whole range of natural conditions (different temperatures, coexisting assemblages, Fe/(Fe + Mg), fO_2, etc.). Therefore, chlorite geothermometry should be used with caution and only in combination with alternative methods of estimating paleotemperatures.

Key Words: Chlorite • Composition • Geothermometry • Polytype • Review

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