

Amphibole-biotite-pyroxene relations in calc-alkaline and alkaline igneous systems: algebraic transformations and chemographic projections for compositional variations, rock classification and norm calculations

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Amphibole, biotite and pyroxene represent the most common mafic minerals in igneous rocks ranging from calc-alkaline silicic to alkaline silica-undersaturated types. These minerals and feldspars are related by numerous compositional colinearities, and their phase relations are controlled by activity of H_2O and heteromorphic relations as a function of temperature and pressure. Since magma differentiation and crystallization processes are mainly governed by crystal-liquid relations, there is need for chemographically and algebraically consistent transformations between whole-rock chemical and mineralogical composition space. Principal applications are norm calculations and nomenclature, projections of natural multicomponent data for classification and genetic interpretation, or reduction of complex compositions for comparison with experimental phase equilibria in simple synthetic systems. This study has two principal objectives: (i) development of algebraically consistent projections, from portrayal of general variations successively to subspaces between critical divides where heteromorphic relations can be addressed chemographically, and (ii) refinement of normative calculation algorithms to provide improved dissection of mineralogical composition space. We will highlight the following examples and their applications: (i) The von Wolff diagram illustrating general variations in the silica–feldspathoid–mafic mineral space has been redesigned to be geometrically consistent and algebraically valid from peraluminous to peralkaline compositions; (ii) Several subsystems of the $KAlO_2$ – CaO – MgO – FeO – Al_2O_3 (+ SiO_2 – H_2O) space are explored for biotite–amphibole–pyroxene relations and compatibilities, with reference to various mesonormative algorithms; (iii) Pseudoternary projections from clinopyroxene and olivine are developed to assess phase compatibilities between feldspars, feldspathoids, melilite and hydrous mafic silicates as a function of silica activity. These approaches aim at providing rigorous algebraic and geometric transformations for hierarchical approach to series and rock classification, variation analysis and genetic interpretation.