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Petrogenesis and Geochemical Features of Peralkaline A-type Granites: reconciling insights from comendite and pantellerite - peralkaline rhyolitic systems

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The alkalinity of igneous rocks, determined by the ratio of alkalis (Na_2O+K_2O) to silica concentration, offers insights into parental magmas, source depths, tectonic settings, and their potential for economic mineralization. Peralkaline A-type granites and rhyolites (A/NK: 0-1, A/CNK: 0-1.0) are evolved igneous suites that develop in various extensional settings, ranging from continental to oceanic environments. Peralkaline rhyolites are classified based on Al_2O_3 and FeO_t contents into comendite (FeO_t 1.5-5.7 wt.%, Al_2O_3 10.5-15.4 wt.%, FeO_t/MgO <10) and pantellerite (FeO_t 5.2-7.5 wt.%, Al_2O_3 9.1-10.2 wt.%, FeO_t/MgO >10-20). The alkalinity of igneous rocks can be determined using the Rittmann serial index [$\sigma = (Na_2O+K_2O)^2/(SiO_2-43)$], with igneous rocks categorized into calcic ($\sigma \leq 1.2$), calc-alkalic ($1.2 < \sigma < 3.5$), alkali-calcic ($3.5 < \sigma < 8.8$), and alkalic ($\sigma \geq 8.8$) series. The GEOROC database with comendites (n=630) and pantellerites (n=546) shows they have high alkalinity, with comendites exhibiting a σ value of 3.04±1.28 and pantellerites a σ value of 3.83±1.49. Alkalinity is used along with Agpatitic Index (AI; molar $(Na_2O+K_2O)/Al_2O_3$), with AI >1 indicative of peralkaline granite and rhyolite, as well as Ti/V >100. Other geochemical features of pantellerite and comendite include their elevated concentrations of Th (10–100 ppm), Zr (100–2500 ppm); peralkaline rhyolites, characterized by Y+Nb >60 ppm, Ta+Yb >6 ppm, Nb/Y >0.7, and Ta/Yb ~ 0.9, belong to the A-type within-plate suite. Pantellerites and comendites display mantle-derived A-type features with Nb/Y ranging from 0.27–18.3 to 0.2–5.57 in comendites and pantellerites, respectively, reflecting variable mantle influence, fractional crystallization, and crustal interaction in rift settings. Their alkalic nature is confirmed by FeOt/(FeOt+MgO) >0.8, FeOt/MnO >10, Zr/TiO_2 >0.1, Zr+Nb+Ce+Y >450 ppm, Nb >30 ppm, Ce >100 ppm, Th >20 ppm, Eu/Eu* = 0.23, and Ga/Al > 0.00025. In peralkaline magmatic systems, fO_2 influences melt-crystal assemblages, with comendite forming under higher fO_2 than pantellerite; both represent endmembers of bimodal intraplate suites, derived from trachyte magmas through fractional crystallization at crustal pressures near the fayalite–magnetite–quartz (FMQ) buffer. Petrogenesis of comendite and pantellerite is thought to be emplaced in intraplate settings, derived from low-degree partial melting of enriched mantle and/or likely experiencing considerable fractional crystallization during ascent.