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Mafic–Felsic Bimodality and TTG Formation through Intracrustal Basalt Melting

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How Archaean tonalite–trondhjemite–granodiorites (TTGs) formed remains a long-debated question central to early Earth geodynamics. TTGs from the Lake Inari terrain, Fennoscandia define a coherent mafic–felsic system in which the felsic compositions are reproduced by ~18% partial melting of basaltic crust. The associated low-Mg, low-Ti subalkaline basalts were metamorphosed under upper amphibolite facies conditions and geochemically resemble intraplate magmas rather than arc-related basalts. Elevated Th/Nb ratios define a continuous melting trend from basalt to TTG and arise from differential incompatibility of Th and Nb during partial melting. Dy/Dy*–Dy/Yb relationships indicate dominant amphibole control on MREE behavior, producing characteristic MREE concavity without requiring garnet-only control. The bimodal HREE content observed in TTGs may be directly linked to the garnet content of their basaltic protoliths, which does not uniquely reflect formation depth but may also reflect source mineralogy in specific conditions. Systematic coupled depletion of Ti, Nb and Co in TTGs relative to basalts identifies ilmenite, rather than rutile, as the principal residual oxide phase. At the inferred melt fraction, Co behaves compatibly, inconsistent with rutile control but consistent with ilmenite stability at mid-crustal pressures. Together, the data define an intracrustal melting system in which amphibole-, garnet- and ilmenite-bearing residues reproduce the characteristic geochemical signatures of TTGs. Features commonly interpreted as tectonic indicators—elevated Th/Nb, strong HREE depletion and negative Nb anomalies—are explained by mineralogical partitioning during melting of heterogeneous basaltic crust in a hot Archaean lithosphere.