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Late Silurian–Early Devonian A-Type Magmatism in New Brunswick: Geochemical Signatures and REE mineralization

DR. FAZILAT YOUSEFI[1], PROF. DAVID R. LENTZ, PHD[2] AND KATHLEEN G. THORNE[3]

[1]University of New Brunswick (UNB)
[2]University of New Brunswick
[3]Natural Resources and Energy Development

New Brunswick hosts temporally equivalent Late Silurian–Early Devonian A-type intrusions in both its northern and southwestern sectors, collectively defining a coherent, province-wide alkaline magmatic system along the northern Appalachian margin. These intrusions record post-orogenic extensional magmatism and illustrate the evolution of mantle-derived melts variably modified by crustal interaction and prolonged fractional crystallization. In southwestern New Brunswick, the Welsford, Parks Brook, and Jake Lee peralkaline granites (418–412 Ma) intrude along a NE-trending paleosuture and exhibit mineral assemblages dominated by quartz, alkali feldspar, sodic plagioclase, and locally riebeckite. Their high agpaitic indices (AI > 1) and Rittmann serial indices spanning alkali-calcic to alkalic fields confirm strong alkaline affinity. Geochemically, they are enriched in HFSE and REE (Zr+Nb+Ce+Y > 450 ppm; Y+Nb > 60 ppm; Nb > 30 ppm; Ce > 100 ppm; Ga/Al > 0.00025) and display pronounced negative Eu anomalies (Eu/Eu* ≈ 0.23–0.26). Elevated FeOt (1.5–9.4 wt.%) and FeOt/(FeOt+MgO) > 0.8 indicate ferroan A-type character, evolving from mantle-dominated A1-type compositions toward more crustally influenced A2-type signatures (Nb/Y ≤ 0.8). These features indicate derivation from low-degree partial melting of an enriched mantle source followed by extensive fractional crystallization near the fayalite-magnetite-quartz buffer. In northern New Brunswick, the Benjamin River Iron Oxide-Apatite (IOA) system (~418 Ma) represents a mineralized expression of this alkaline continuum. Hosted within the bimodal Dickie Brook plutonic suite (gabbro–diorite–monzogranite), the felsic endmember monzogranites display crustal A-type characteristics (FeOt/(FeOt+MgO) > 0.8; Zr/TiO_2 > 0.1; Zr+Nb+Ce+Y > 450 ppm; Zr > 688; Eu/Eu* = 0.59). Pegmatitic apatite–magnetite–clinopyroxene (nelsonite) dykes contain up to 1.3 wt.% ΣREE+Y, with apatite hosting 1.6–5.2 wt.% ΣREE_2O_3 and significant Y, F, and Cl. Textural and geochemical evidence for coupled dissolution-reprecipitation and hematization indicates late magmatic-hydrothermal modification, enhancing REE concentration during volatile-rich differentiation and possible silicate-oxide immiscibility. These northern and southwestern intrusions define a unified A-type magmatic province in which enriched mantle melting, redox evolution, and prolonged differentiation controlled both peralkaline granite emplacement and REE-rich IOA mineralization, underscoring significant critical metal potential across New Brunswick.