

Rare-metal Fertility of Agpaitic Syenites in the Northern Eastern Mexican Alkaline Province

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Alkaline magmatism in the Eastern Mexican Alkaline Province (EMAP) extends from the Gulf of Mexico to the Mexico-USA border, yet its northern sector remains poorly evaluated for rare-metal mineralization. This study documents the mineralogy, petrogenesis, and rare-metal fertility of alkaline complexes in the Sierra Maderas del Carmen region, northeastern Mexico, focusing on eudialyte-group-mineral (EGM)-rich syenites that represent the most prospective lithologies for Zr-Nb-REE mineralization. Magmatism defines an evolutionary sequence from alkali gabbros and intermediate intrusions to silica-saturated and silica-undersaturated syenites, which derived from OIB-like mantle melts emplaced in an intracontinental setting. EGM-rich syenites occur as narrow dikes, sills, and small intrusions, locally forming skarn aureoles along the contacts with carbonate host rocks. Five syenite types are recognized in the area, ranging from fine-grained agpaitic to transitional agpaitic assemblages dominated by EGM, aegirine-augite, K-feldspar, and sodalite $\pm$ analcime, reflecting advanced magmatic differentiation under dry, reducing conditions. These conditions promoted increasing peralkalinity and the concentration of Zr, Nb, REE, Th, and Ti in late magmatic to magmatic-hydrothermal assemblages. Microchemical analyses reveal a diverse rare-metal mineral suite including EGM, britholite-(Ce), thorite, pyrochlore, ancylite-(Ce), gittinsite, and baddeleyite occurring within syenites and associated skarns. Emplacement ages of these complexes (~48–28 Ma) coincide regionally with slab detachment of the Farallon Plate beneath northeastern Mexico, linking intraplate alkaline magmatism to rare-metal fertility. These results highlight the EMAP as an underexplored province with significant potential for rare-metal mineralization.