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Geochemistry and petrogenesis of Fe-Ti-(P)-bearing layered mafic intrusions and associated Fe–Ti–(P) oxide deposit in the North Eastern Desert, Egypt.

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The present study represents detailed mineralogical and geochemical investigations on the gabbroic lithologies and the hosted Fe-Ti-(P) oxide ores of the Abu Murrat area in the Northern Eastern Desert (NED) of Egypt. The studied gabbros consist of pyroxene-, pyroxene-hornblende-, hornblende-, biotite-hornblende gabbro, and leucogabbro. These lithologies host oxide ores in disseminated (25–35 vol.%), semi-massive (50–60 vol.%), and massive (75–85 vol.%) forms, primarily comprising titanomagnetite with less amounts of ilmenite and apatite, beside silicate gangue minerals. Geochemical analyses reveal evidence of extensive fractional crystallization (e.g., high apatite content (P_2O_5 >5.46 wt%), low Mg# (22–44), and An31–43). The presence of granodiorite xenoliths, the dominance of orthopyroxene as a mafic phase, and LREE enrichment suggest significant crustal contamination during magma evolution. The low SiO_2, high FeOt, and TiO_2, beside moderately enriched trace elements and relatively fractionated REE patterns, with the absence of a positive Eu anomaly, implying a ferrobasaltic parental melt. The low concentrations of Cr (42–110 ppm) and Ni (10–43 ppm), with high Fe-Ti content, indicate low mantle potential temperatures and partial melting within a mantle plume head due to adiabatic decompression. Therefore, a continental rift setting under a high fO_2, with crystallization conditions estimated at ~800–1150°C and 2–5 kbar was suggested. These conditions, implying that Fe-Ti-(P) oxide mineralization was formed by liquid immiscibility during the late stages of Fe-rich melt evolution.