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Mineral Chemistry and Crystallization History of the Tazmamart Gabbroic Intrusion: Petrogenetic Constraints from the Eastern High Atlas (Morocco)

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The intrusive magmatic complexes exposed along the anticlinal ridge of the Eastern High Atlas belong to the Peri-Atlantic Alkaline Province, generated by the reactivation of inherited Hercynian structures following the breakup of Pangea. This Jurassic–Cretaceous magmatism is well documented along the Central High Atlas, unlike the eastern part along the Rich–Talssinte axis, particularly within the Mougueur–El Bour inlier. Within this tectonomagmatic framework, the Tazmamart intrusion represents a key gabbroic body situated on the southern flank of the Eastern High Atlas, approximately 20 km east of Rich. It crops out as an E–W-elongated, triangular pluton measuring ~1.6 km in length and 650 m in width, bounded by E–W and NE–SW fault systems.

Petrographic observations show that the intrusion consists of olivine/biotite/Ti-Fe oxide–bearing gabbro, diorite, and late-stage syenitic veins and apophyses. The mafic assemblage includes olivine (Fo_{58}–Fa_{42}), clinopyroxene ($Wo_{49}En_{36}$–$Wo_{39}En_{48}$), plagioclase ($An_{61}Ab_{38}$–$An_{18}Ab_{77}$), biotite (X_{Mg} = 0.4–0.6), and Ti-Fe oxides, with apatite as a common accessory phase. Primary minerals exhibit mild alteration to saussurite and epidote. Despite the overall mafic character, small amounts of intercumulate K-feldspar ($Or_{78.6–49.2}$) occur together with Ti-biotite and Ti-Fe oxides, marking a late crystallization stage.

Geothermobarometric calculations show that the gabbroic rocks crystallized at temperatures of 1204–1234.6°C and pressures of 2.5–5.6 kbar based on clinopyroxene thermobarometry. Titanium-in-biotite thermometry yields temperatures of 725.9–793.7 °C, while plagioclase–K-feldspar thermometry indicates crystallization between 690 and 901.7 These results define a multi-stage magmatic evolution from high-temperature mafic crystallization to lower-temperature late felsic phases, reflecting the progressive differentiation of the Tazmamart magma chamber within the broader Peri-Atlantic alkaline magmatic system.