EGU25-20726, updated on 28 Nov 2025
https://doi.org/10.5194/egusphere-egu25-20726
EGU General Assembly 2025

Pressure effects on the differentiation of basaltic magmas: insights from the synorogenic Beja Layered Gabbroic Sequence (Portugal) and implications for oxide-ore forming processes

Manuel Antunes Dias[1], Ana Jesus[1], António Mateus[1,2], António Oliveira[1], and Bruno Bartolomeu[1]
[1]Instituto Dom Luiz, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal
[2]Departamento de Geologia, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal

The Beja Igneous Complex (BIC) is a major geological feature of the SW Iberian Variscides, extending for over 100 km along the southern border of the Ossa-Morena Zone. The formation of the BIC occurred during the main collisional stages of the Variscan Orogeny. The Layered Gabbroic Sequence (LGS) corresponds to the most primitive member of the BIC, hosting various occurrences of Fe-Ti(-V) oxide mineralization within olivine leucogabbros. The early stages of LGS crystallization are recorded by the Soberanas troctolites (SB I) and gabbronorites (SB II; εNd_{350} = +6.75; $^{87}Sr/^{86}Sr_{350}$ = 0.7043), Odivelas ferro-gabbros (ODV I; εNd_{350} = +1.81; $^{87}Sr/^{86}Sr_{350}$ = 0.7049) and Torrão ferro-diorites (TOR; εNd_{350} = +2.42; $^{87}Sr/^{86}Sr_{350}$ = 0.7045). The formation of ODV I ferro-gabbros and massive oxide accumulations has been envisaged as a consequence of extensive differentiation (Fo_{88-54}; An_{89-41}) from oxidized (ΔFMQ = +1.7) primitive basaltic parental magmas, derived from SB I, to more reduced conditions (ΔFMQ = +0.5). Pressure estimates for the emplacement and main fractionation events are 4.5 kbar. The nearby exposed TOR ferro-diorites share many geochemical similarities with the most isotopically primitive SB II gabbronorites, namely sub-parallel REE and trace element patterns. Geochemical modeling shows that 20-30% fractionation of a typical mafic mineral assemblage comprising cpx + ol (± amp) + spn from magmas represented by the SB II gabbronorites can plausibly generate the TOR ferro-diorites. Although median amp-plg pressure estimates for the TOR ferro-diorites are comparable with those obtained for SB II and ODV I gabbroic rocks, the amp-only pressure estimates provided by amphibole phenocrysts in TOR ferro-diorites yield pressure values of 6 to 7 kbar. These “high-pressure amphiboles” suggest that the parental SB II magmas should already have significant amounts of dissolved H_2O (> 3.5 wt%). Under such high-pressure conditions, fractionation of plagioclase is inhibited, explaining the lack of negative Eu and Sr anomalies in these rocks. Estimation of fO_2 conditions for ferro-diorites is precluded by late, sub-solidus re-equilibration of coexisting magnetite and ilmenite, possibly related to free O_2 liberation during amphibole crystallization.

While deriving from similar parental magmas, the ODV I ferro-gabbros and TOR ferro-diorites record distinct differentiation conditions. High-pressure fractionation of primary basaltic magmas promotes the enrichment of dissolved H_2O due to increased solubility, deviating the composition of residual melts towards the stability field of amphibole. Conversely, lower-pressure evolution of

similar magmas generates a typical “dry” tholeiitic differentiation path, resulting in stronger Fe and Ti enrichment and so the potential to generate massive oxide accumulations, as recorded in ODV I ferro-gabbros. These findings highlight the role of pressure in generating significantly different products from the same primary basaltic magma.

Co-funded by the EU SEMACRET GA#101057741 and FCT I.P./MCTES through national funds (PIDDAC): UID/50019/2025 and LA/P/0068/2020 https://doi.org/10.54499/LA/P/0068/2020).