



The oxidation state of primary MOR-Basalts before degassing of C-H-S-O species indicates an oxidized source regions buffered by sulphur-sulphate equilibrium

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The Earth's mantle redox state regulates the igneous inputs of volcanic gases in the atmosphere and probably controls the depth of mantle weakening by redox melting. Capturing the processes that control basalt oxidation state and how the latter is connected to their mantle sources is a central topic in planetary sciences. Mid-Ocean Ridge Basalts, constituting 80% of the extrusive rocks, are widely used for this purpose.

But MOR-basalts are considerably degassed. In particular, they have lost most of their primary CO_2 by open system degassing and it is unclear if this can importantly affect their redox state. In order to reconstruct their primary volatile contents and their primary oxidation states, we simulate here their degassing considering primary undegassed MORB being variably enriched in H_2O and CO_2 . Our results indicate that clear relationships between MORB oxidation state and their volatile enrichments are triggered by degassing: Volatile-rich melts degas more CO_2 , H_2O and SO_2 , which triggers a more pronounced decrease in $\text{Fe}^{3+}/\text{Fe}_{\text{tot}}$. The reduction associated to degassing is relatively small, but it explains well recently reported geochemical observations relating geochemical enrichments and MORBs oxidation state. The oxidation state of MORBs as retrieved from their post-eruption $\text{Fe}^{3+}/\text{Fe}_{\text{tot}}$ therefore underestimates the oxidation state of their source regions by about 0.3-0.8 log-units; the degree of underestimation correlating with the amount of initial CO_2 and H_2O . The source regions of MORBs must buffer $f\text{O}_2$ s that are centred on FMQ+1 just after melt extraction from the mantle.

This $f\text{O}_2$ range corresponds to the region where the sulphide-sulphate equilibrium in basalts is the dominant redox buffer, and we therefore propose that the fact most basalts erupting on Earth since the Archean have a constant $f\text{O}_2$ of FMQ reflects the redox buffering by sulphur during partial melting. Prior to melting, the deep subsolidus mantle must be equilibrated with higher $f\text{O}_2$ as oxidized species (Fe^{3+} , S^{6+}) are all incompatible. The mantle sourcing MORBs is more oxidized than previously established and is rather controlled by sulphide-sulphate equilibria than buffered by graphite- CO_2 equilibrium