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How to build an explosive reservoir: primitive magma fractionation primes shallow felsic mush for volatile saturation

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Magmas are stored in the crust as crystal mushes, solid-dominant bodies consisting of a connected crystal framework and interstitial melt. However, a fundamental question exists around understanding how these rheologically locked bodies can then be remobilised and primed for eruption. One way of remobilising a mush is through the behaviour of exsolved magmatic volatiles, which can migrate through crystal-dominant regions of the reservoir and accumulate in melt-dominant domains, creating regions of overpressure [1,2]. Determining the spatial distribution of volatiles throughout the magmatic system is therefore an important factor in understanding its eruptive behaviour.

We applied this hypothesis to the Diego Hernandez Formation (DHF), Tenerife, using the volatile budgets of apatite inclusions. Our findings show the existence of a shallow, water-saturated phonolite mush outgassing into a melt-rich cap at the reservoir roof, where the accumulation of exsolved volatiles primed the system to erupt. The phonolite was water-saturated throughout its fractionation history, raising the question of when saturation first occurred in the magmatic system.

To investigate volatile evolution in the deeper magmatic system we examine the volatile states of a suite of plutonic nodules from the DHF, which represent wider differentiation processes under Tenerife. These nodules represent a compositional range from pyroxenite to syenite. Our apatite volatile data show that with progressive fractional crystallisation of a primitive parental melt, magmatic volatiles became increasingly enriched while the system remained water-undersaturated. Furthermore, a continuous geochemical evolution from the plutonic nodules to the erupted phonolite points to a genetic relationship whereby the phonolite reservoir was produced by successive magma fractionation in the primitive regions of the reservoir. Therefore, prior volatile enrichment through successive fractionation and melt segregation can explain why the phonolite reservoir is initially water-saturated. This continual process of volatile exsolution and accumulation within the phonolite reservoir is what we believe predisposes the system to explosive volcanic activity.

Our preliminary data highlight the importance of considering the behaviour of magmatic volatiles throughout a magmatic system, rather than only the shallow, evolved reservoir.

[1] Parmigiani et al. (2016), *Nature 532(7600), 492-495*. [2] Degruyter et al. (2019), *Philosophical Transactions A: Mathematical, Physical and Engineering Sciences 377(2139).*