Santorini Volcano plumbing system: constraints from melt inclusion volatile contents

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Santorini Volcano has a long history of explosive volcanism, involving alternations of plinian and interplinian eruptions, in two 180,000 year explosive cycles. At least four plinian eruptions generated calderas, the last occurring in the late 17th century BC (Minoan eruption).

We have measured H20 and CO2 contents of melt inclusions trapped in phenocrysts from the rhyodacitic products of the Minoan eruption, from an eruption of primitive basalt discharged prior to the Minoan, and from the dacitic products of the post-Minoan Kameni intracaldera volcano. The analyses were carried out by Secondary Ion Mass Spectrometry and/or by micro-Raman spectroscopy on melt inclusions that were carefully chosen to ensure (1) complete isolation from the crystal exterior, and (2) an absence of any textural evidence for leakage.

Six melt inclusions in Fo85 olivines from the pre-Minoan basalt contain 2.8 to 3.2 wt percent H20 and 240 to 390 ppm CO2. Twenty eight melt inclusions trapped in plagioclase (An37-60) from the four explosive phases of the Minoan eruption contain 3.3 to 6.1 wt percent H2O and 15 to 90 ppm CO2; the highest H2O contents are preserved in melt inclusions from the first eruptive phase, and the lowest from the fourth phase. Four inclusions in plagioclase (An48-56) in pumices from the 726 AD eruption of the Kameni volcano yielded 2.6 to 3.8 wt percent H2O and about 10 ppm CO2. All the analysed inclusions give H20+CO2 saturation pressures within a limited range (1.0 to 2.3 kb), showing that all the magmas concerned were stored in the mid to upper crust prior to eruption. However, these pressures are minimum estimates of total pressures, since they assume volatile saturation. Indeed the data for the Minoan eruption suggest that the rhyodacitic magma was undersaturated in H20+CO2, as also concluded from a recent phase-equilibria study (Cadoux et al, 2013). The highest saturation pressure for Minoan magma comes from melt inclusions from the first eruptive phase, whereas the lowest pressures come from inclusions from the fourth phase. Assuming top-downward magma withdrawal during the eruption, the simplest interpretation is that the Minoan rhyodacite was undersaturated in H2O+CO2 at all but perhaps the uppermost (first-erupted) levels. Analyses of other units from the second explosive cycle are in progress, and will be presented as part of a growing database on Santorini volatile contents and compositions.