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Application of the Linkam TS1400 X-Y heating stage to MI studies

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The volatile (H_2O, CO_2, SO_2, etc.) content in a magma chamber beneath a volcano determines the energy of the volcanic eruption. The only direct way to determine what the volatile content in the melt was before an eruption is by measuring the volatile abundances in melt inclusions (MI). For this reason, in the last decades the number of publications describing the use of melt inclusions (MI) to determine the pre-eruptive volatile contents of magmas has increased significantly. Unfortunately, MI are often partially or totally recrystallized as found, depending on the MI P-T path following trapping. In order to rehomogenize the melt and to obtain the original volatile content of MI, many researchers use a heating stage equipped with a quenching system and mounted on an optical microscope (e.g. the Vernadsky stage). In this study we tested the recently developed Linkam TS1400 XY heating stage to homogenize crystallized MI.

In this study, several experiments have been performed on recrystallized melt inclusions (MI) contained in phenocrysts from eruptions in the Phlegrean Volcanic District (PVD), and from the Sarno eruption at Monte Somma-Vesuvius in Southern Italy. Recrystallized MI from the PVD are hosted in olivine, clinopyroxene and sanidine. These phenocrysts were contained in trachybasalt to trachyte magmas which can be high in volatile contents. Recrystallized MI from the Sarno eruption are hosted in clinopyroxenes which have formed from a basaltic magma. The Sarno eruption is considered to be one of the most explosive eruptions in all the Somma-Vesuvius history.

During the heating experiment, a constant flow of argon gas was introduced into the sample chamber at a flow rate of 0.5 liter/min (± 5 %). The heating rates used for these experiments were as follows: 100 °C/min from 25 to 900 °C; 50 °C/min from 900 to 1000 °C; 25 °C/min from 1000 to 1100 °C; 10°C/min from 1100 to 1200 °C; 5 °C/min from 1200 to 1340 °C. These heating rates were used to produce equilibrium melting and minimize diffusion of components out of most MI.

In all experiments, it was possible to homogenize the MI and, importantly, to quench the melt to a glass after homogenization. In some experiments, the sample was heated to around 1340 °C. At that temperature, the field of view became darkish-red in colour and it was difficult to observe the MI behaviour. At lower temperatures the optics were excellent. The quality of the optics at high temperature depends on two factors: the thickness of the phenocryst and the volume percentage of inclusions (solid and or melt) relative to the volume of the phenocryst.

In most of the experiments, the MIs were homogenized completely (crystals + bubbles) and remained homogeneous during quenching to room temperature to produce a glass. In some cases, the MI were heated to relatively high temperature and the solids all melted but the bubble did not dissolve back into the melt before the optics deteriorated and it was no longer possible to observe the MI behaviour. When the MI was quenched, the single bubble remained in the MI and grew larger during cooling. The bubble in these MI may represent a trapped vapour bubble (i.e. the MI trapped a volatile-saturated melt plus a vapour bubble) and thus the bubble should not be expected to dissolve back into melt.

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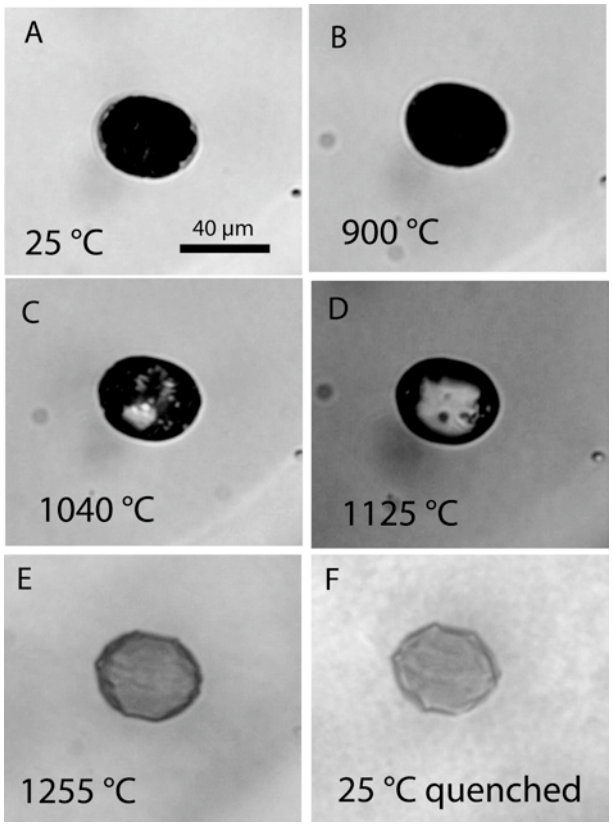

Fig.1. Heating experiment performed on an olivine phenocryst from a scoriae sample from the Solchiaro eruption of the Phlegrean volcanic district (PVD). The MI is around 40 µm in diameter and has an ellipsoidal shape. A) At room temperature (25 °C), the MI is partially recrystallized. Some daughter crystals are visible at the olivine-MI interface. B) At 900 °C daughter crystals at the olivine/inclusion interface are smaller relative to those at room temperature. C) At 1040 °C it is possible to distinguish between vapour bubbles, solid and melt phases. D) At 1125 °C, the melt inclusion contains mostly a silicate melt phase. A vapour bubble is clearly observed at this temperature. E) At 1255 °C, the MI contains 100% silicate melt. Note that at this temperature the MI assumes a negative crystal shape. Also, the "wrinkles" at the MI-host interface reflect dissolution of olivine into the melt. F) After homogenization at 1262 °C, the MI was quenched to a homogenous glass. During the quenching some crystallization of olivine at the olivine/glass interface may have occurred.

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