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The generation and architecture of crustal rhyolitic reservoirs: insights from the Kilgore Tuff eruption

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The Heise volcanic field is the most recent and complete cycle of volcanism preceding the still active Yellowstone volcanic field. Isotopic and geochronological studies of the Kilgore Tuff, the largest eruption produced by the Heise volcanic field, suggest that the assembly of separated reservoirs of eruptible magma preceded this super eruption (Watts et al., 2011, Wotzlaw et al., 2014). The buoyancy associated to this process may have been sufficient to trigger the eruption (Caricchi et al., 2014, Wotzlaw et al., 2014). Geophysical imaging of present day Yellowstone magmatic system also shows the existence of several isolated and potentially melt-rich regions within a highly crystallised magmatic mush (Miller and Smith, 1999). Additionally, recently, the presence of a basaltic lower-crustal magma body providing the link between this shallow mushy magma reservoir and the mantle plume has been revealed (Huang and al., 2015).

While recent studies suggest that the merging of multiple pockets of eruptible magma may be commonly preceding super-eruptions (Ellis et al., 2014; Wotzlaw et al., 2014), no detailed geochemical, petrographic and petrological work along the stratigraphy of the deposits of these large eruptions has been performed to bolster this interpretation. This, together with the possibility that the sequence of events that preceded the eruption of the Kilgore Tuff may be similar to those that will occur before a future Yellowstone super-eruption, are the main motivations of this study.

New geochemical data on the Kilgore Tuff were acquired along stratigraphic profiles. Whole-rock and high-spatial resolution analyses of matrix glass, feldspars, pyroxenes, zircons and melt inclusions were carried out for several stratigraphic layers of two Kilgore Tuff deposits on the south-east and north-west rim of the Heise caldera.

The analyses reveal that the deposit is heterogeneous along the stratigraphy with significant variations of glass matrix composition both in term of major and trace elements, as well as differences in mineral chemistry. These variations are not continuous from the base to the top of the deposits.

Pre-eruptive pressure, temperature and water content for the samples collected at various stratigraphic levels were estimated using rhyolite-MELTS simulations, two-feldspar thermometry, clinopyroxene-liquid thermobarometery, zircon saturation thermometry. The results suggests that the reservoir that fed the Kilgore Tuff eruption had a complex architecture with isolated melt-rich pockets dispersed at various depths and located at different distance from the cadera rims that were sampled discontinuously during the eruption.

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