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Fast reactivation of crystal mush beneath the long-dormant Late Pleistocene Ciomadul volcano, eastern-central Europe

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Long-dormant volcanoes (quiescence time is several 100's to 10.000's years between eruptions) pose a particular hazard, since the long repose time decreases the awareness and there is also a lack of monitoring. The dacitic Ciomadul Volcanic Complex in eastern-central Europe is an excellent example of such volcanoes. It is in a quiescent state for 30 kyr, yet combined geophysical, zircon geochronological, electrical conductivity experiment, petrologic and thermal modeling results suggest that there is still a magma reservoir with significant melt content beneath it. This crystal mush magma reservoir could have a lifetime for more than 300 kyr. Thus, Ciomadul has been categorized as a PAMS volcano, i.e. a volcano with Potentially Active Magma Storage.

Understanding the reactivation timescale of such volcanoes is crucial, and therefore we conducted a detailed petrologic study of a 130 ka lava dome rock. This dacitic rock contains a wide range of mineral phases, including plagioclase, amphibole and biotite phenocrysts as well as accessory phases of apatite, titanite, zircon, quartz, K-feldspar, olivine, clinopyroxene and FeTi oxides. Felsic and mafic crystal clots are common and they represent a long-standing low temperature granodioritic shallow crustal crystal mush and an ascending hot mafic magma, respectively. Both the plagioclases and the amphiboles show complex zoning and have a bimodal compositional character even within single crystals. Geothermobarometry results imply 700-750 oC temperature for the felsic crystal mush and a strong reheating by >200 oC before the eruption. We conducted a detailed study of plagioclase phenocrysts involving high-resolution line measurements. In many cases, we found an abrupt strong increase of Fe and Sr at the outermost 10-20 micron wide crystal rim (FeO is 0.1-0.15 wt%, SrO is 0.2-0.3 wt% in most of the crystals, but they increase to 0.3-0.35 wt% and 0.45-0.7 wt%, respectively at the rim) suggesting a mafic magma influence and fast reactivation timescale. Following resorption, rim growth at plagioclases and diffusive re-equilibration could have happened within days of the mafic recharge event. Magma ascent rate was estimated based on the decompression reaction zones around amphiboles, and we got 6-10 days for the ascent from the shallow magma reservoir resided at 7-11 km depth. Thus, long dormancy or seemingly inactive state of PAMS volcanoes could change quickly what has to be considered in hazard assessments.

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