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Eruption and emplacement mechanisms of the Holocene Pucon Ignimbrite, Volcan Villarrica, Chile

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The Pucon Ignimbrite eruption of Volcan Villarrica discharged about 1 km3 of basaltic andesite magma and 0.8 km3 of accidental lithic debris 3510 +/- 60 14C yr BP in three explosive phases: an initial violent strombolian to subplinian fallout phase, an initial pyroclastic flow phase P1 and a volumetrically dominant pyroclastic flow phase P2. Discharge during P1 took place as repeated explosions, generating a sequence of well defined pyroclastic flow units limited to the northern and western sectors. Phase 2 was more continuous and intense, impacted all sectors of the volcano, and emplaced pyroclastic flows up to >20 km from the present-day summit. The eruption terminated with the emplacement of a pyroclastic surge all over the volcanic edifice, followed by pyroclastic flows down the northern flank. Degassing pipes rooted on charcoal in P1 ignimbrite are systematically cross-cut by the base of the P2 ignimbrite, showing that there was a pause between the two phases sufficiently long for complete devolatilization of wood.

The eruption products were studied sedimentologically, texturally and chemically in order to constrain the eruption mechanism. The magma is uniformly basaltic andesite with a few percent of phenocrysts, bulk SiO2 decreasing by about 2 wt% from the airfall to the top of P2. Lithics erupted during the airfall and P1 phases consist of igneous rocks, mostly lavas. The ratio of fresh to altered lavas decreases upwards through the P1 ignimbrite, suggesting that maximum fragmentation depth increased with time during phase P1. Following the pause, the P2 pyroclastic flows discharged basement granite, both as free clasts and as variably melted xenoliths within pyroclasts. Fragmentation is inferred to have been deeper during the more violent P2 phase than during P1, with stoping of granite into the magma beneath the fragmentation surface.

Vesicularities of juvenile scoria range from 20 to 75 vol% at all levels in the deposit except in the airfall, where they are more uniformly vesicular. This and the abundance of lithics are suggestive of a strong phreatomagmatic component to the eruption. However several lines of evidence are more consistent with a variable degassing origin for the vesicularity variation: (1) less vesicular scoriae are more microlite-rich than more vesicular scoriae, (2) the wide vesicularity range is present even in relatively lithic-poor horizons, so that the two features are decoupled, (3) contents of volatiles in groundmass glasses are uniformly low, implying that even poorly vesicular pyroclasts were outgassed at shallow levels. Eruption is inferred to have been driven essentially by gas exsolution from initially volatile-rich magma, low viscosity permitting variable vesicle collapse and outgassing. The large amount of lithic debris (mainly from the volcanic edifice) is tentatively attributed to explosive melting of a summit glacier and frozen groundwater causing conduit spalling. In this interpretation, phreatomagmatism caused the high lithic content of the Pucon products, but was not the principal motor of explosive eruption.