Petrology of the 2015 eruption of Calbuco volcano, Chile

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The Calbuco volcano (41°20'S-72°37'W) is one of the ~ 20 historically active stratovolcanoes in the Southern Volcanic Zone (SVZ; 33-46°S) of the Andes. It is represented by a truncated cone that covers an area of 150 km^2. Twelve historical eruptions have been described since 1792, including the recent eruption of April 22-23, 2015. In addition, more than 40 major deposits from pyroclastic density currents and pumice fallouts were recognized intercalated in sedimentary rocks from postglacial times (< 13 ky). The activity of Calbuco is divided into 4 stages during which eruptive products alternated between basaltic andesite, andesite and dacite.

On April 22nd 2015, an intense explosive eruption was observed with a (sub)plinian column of 15 km above the crater level. Another more energetic eruption occurred on April 23rd 2015 and lasted for 6 hours. The erupted volume is estimated at 0.38 km^3 (0.15 km^3 dense rock equivalent), with approximately 90% corresponding to tephra fall deposits and the other 10% to pyroclastic density current deposits. The tephra fallout deposits were distributed mainly to the NE of the volcano and reached a thickness of 52 cm at 6 km from the vent. Pyroclastic density currents were generated in the main valleys around the volcano, reaching up to 6 km from the vent.

We collected 27 samples in the NE and SW of the volcano. Most samples are beige-brown scoria lapillis with particle sizes ranging from less than 1 mm to 3 mm. Pumiceous bombs, up to 25 cm in size, were also collected in the pyroclastic density current deposits. Under the microscope, samples are fresh, highly vacuolar and crystal-rich. Crystals are strongly dominated by plagioclase, olivine and pyroxenes. Fe-Ti oxide minerals are subordinate and amphibole was observed in a single sample. Some samples contain minor olivine represented by highly corroded and partly dissolved anhedral crystals. The matrix is either fined-grained and dominated by plagioclase, pyroxene and Fe-Ti oxides, or quenched as a glass.

Bulk-rock compositions were obtained for major and trace elements. They show little variability, as expressed by the SiO_2 content that ranges between 53 and 58 wt.%. All samples plot at the limit between basaltic andesite and andesite in classification diagrams. Trace elements also show little variability. In many samples, it was possible to measure the glass composition in situ for major and trace elements. The glass is significantly enriched (61-76 wt.% SiO_2) compared to bulk-rock data. However, it should be noted that the most evolved compositions were observed as small pockets of glass between crystals and most probably represent the very late-stage of crystallization.

Crystal compositions were obtained for plagioclase, clinopyroxene and orthopyroxene. Plagioclase compositions show a strong bimodal distribution with crystal cores ranging from An_{80} to An_{92} [An = molar Ca/(Ca+Na)] and crystal rims ranging from An_{30} to An_{80}. Clinopyroxene crystals show a unimodal distribution between Mg#70 and 80 [Mg#= molar Mg/(Mg+ Fe^{2+})]] while orthopyroxene displays a more complicated distribution with three different modes at Mg#67, Mg#69 and Mg#72. Trace elements also show intra-crystal variability but further work is needed to fully interpret the data.

In the following part of this project, we will use the relationship between bulk-rock and glass compositions, as well as the mineral compositions to estimate the conditions of magma storage prior to eruption. We will also use these data to estimate how the plumbing system beneath Calbuco might look like. Finally, we will address an important question in petrology that concerns the formation of andesite: Do andesitic samples represent melt compositions or do they form by crystal accumulation in a dacitic melt?