Petrography and chemistry of zircons from the Chaltén Plutonic Complex and implication on the interpretation of U-Pb zircon ages

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The absolute geochronology of the Chaltén Plutonic Complex (CHPC), located in the Southernmost Andes, has a strong influence on the geodynamic interpretation of Patagonia. In addition, the textural and chemical features of zircons from the different plutonic units of this composite intrusion provide important constraints for understanding the growth of zircons in magmas with variable degree of differentiation. These features should be taken into account for the interpretation of zircon ages, since increasing precision of ages is obtained thanks to the development of the U-Pb CA-TIMS dating techniques during the last decades.

The CHPC is a calc-alkaline (arc related) intrusion, which was emplaced at upper crustal levels (3.5 to 2 kbar). The zircon ages (16.90 ± 0.05 to 16.37 ± 0.02 Ma) are consistent with the relative geochronology inferred from field relationships. Where undulated ductile contacts are observed, the age difference cannot be resolved. In the case of brecciated contacts a minimum age difference of 80ky was obtained, which is at the limit of the obtained precission (±40ky).

The petrographic textures of zircons from mafic rocks indicate crystallization in isolated pockets, i.e. interstitial. The application of the Ti-in-zircon thermometer yield constistently low temperatures (~760°C). This indicates that most zircons from these samples might have crystallize near solidus temperatures and consequently post-date the emplacement. In contrast, the textures of zircons from granitic rocks indicate a more protracted crystallization. The chemistry (LA-ICP-MS analysis) of zircons from granitic rocks displays systematic variation of U/Th and U/Ta ratios between core and rim. This pattern can be correlated with the observed variations of calculated temperatures and Ce^{III}/Ce^{IV} ratios. These features suggest that in granitic melts there could be several episodes of zircon crystallization at different temperatures. These temperatures are 100° to 200° higher than the solidus, which implies that many zircons might have crystallize prior to the emplacement (antecryst).

Predicting the character of future eruptions: Insights from single crystal analyses

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While the science of predicting volcanic eruptions is becoming a viable practice, few constraints exist as to the chemical nature of future eruptions, especially regarding the composition and character of the magma or magmas to be erupted. Usually compositional assessments can only be undertaken post-eruption. However, volcanoes characterized by a variety of volcanic products (i.e. a variety of erupted rock compositions) that erupt in short geological time periods (e.g. <10ky), may allow for assessing magma composition/ character prior to when an eruption actually occurs. Baitoushan volcano, located along the China/North Korean border, is known for the largest rhyolitic, caldera forming eruption in the last 2000 years and has shown signs of recent seismic activity. Baitoushan is characterized by at least three recent eruptions (<5000 ka) involving at least four distinctive highly evolved magma compositions. Following a detailed approach involving Sr and Pb isotopes of single mineral crystals, we have identified specific mineral populations that cannot have originated from host magmas, but rather, must have originated from magmas seen only in later eruptions. These populations become more common in subsequent eruptions until they become the dominant mineral population in the latest-erupted magmas. Results suggest the presence of crystals in older erupted materials up to 5000 years prior to eruptions where these crystals are the dominant population. Results are consistent with a magma residence age of ~10 ky and document the first time in which crystals associated with future magmatic activity are observed in materials from earlier eruptions. In addition, isotope variations in selected crystals suggest open system processes occurring ~3000 years prior to eruption in highly viscous, high-silica rhyolites. Ultimately, detailed crystal evaluations offer compositional constraints of magmas resident under volcanoes 1000s of years prior to their eventual eruption.