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The Torres del Paine intrusion as a model for a shallow magma chamber

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The shallow magmatic Torres del Paine Intrusive Complex (TPIC) belongs to a series of sub-volcanic and plutonic igneous bodies in Southern Chile and Argentina. This trench-parallel belt is located in a transitional position between the Patagonia Batholith in the West, and the alkaline Cenozoic plateau lavas in the East. While volumetrically small amounts of magmatism started around 28 my ago in the Torres del Paine area, and a second period occurred between 17-16 Ma, it peaked with the TPIC 12.59-12.43 Ma ago. The spectacular cliffs of the Torres del Paine National park provide a unique opportunity to study the evolution of a very shallow magma chamber and the interaction with its host rocks. Intrusion depth can be estimated based on contact metamorphic assemblages and granite solidus thermobarometry to 750$\pm$250 bars, corresponding to an intrusion depth of ca. 3km, ca. 500m above the base of the intrusion. Hornblende thermobarometry in mafic rocks agrees well with these estimates (Leuthold et al., 2014).

The TPIC is composed of a granitic laccolith emplaced over 90ka (Michel et al., 2008) in 3 major, several 100m thick sheets, forming an overall thickness of nearly 2 km. Contacts are sharp between sheets, with the oldest sheet on the top and the youngest on the bottom (Michel et al., 2008). The granitic laccolith is under-plated by a ca. 400m thick mafic laccolith, built up over ca. 50ka (Leuthold et al. 2012), constructed from the bottom up. Granitic and mafic sheets are themselves composed of multiple metric to decametric pulses, mostly with ductile contacts between them, resulting in outcrop patterns resembling braided stream sediments.

The contact of the TPIC with the Cretaceous flysch sediments document intrusion mechanism. Pre-existing sub-horizontal fold axes are rotated in the roof of the TPIC, clearly demonstrating ballooning of the roof; no ballooning was observed in the footwall of the intrusion. Extension during ballooning of the roof is indicated by dykes emanating from the roof of the intrusion into the host rocks. The dykes are perpendicular to the contact, radially shooting into the country rocks. Since the oldest granite is found in the roof, it is also permeated by dykes of successive intrusions.

Contact metamorphism can be used to constrain the granite intrusion temperature to ca. 1000°C. Intrusion occurred in multiple pulses along the granite-host rock contact, in rapid succession, before significant cooling occurred in the aureole. Hydration of the biotite and feldspar of the immature sediments in the outer aureole contributed significantly to the overall thermal signature of the host-rock-TPIC system. In contrast, stable isotopes do not document significant fluid circulation.

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