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Evolution of crust vs. mantle contributions to continental arc granitoids within a few Myr: evidence from zircon Hf-O isotopes and high-precision U-Pb dating in the Famatinian Arc, Argentina

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The presence of a thick continental crust makes Earth a unique planet in the solar system. During post-Archaean times, with the onset of plate tectonics, processes by which continents form is a complex function of juvenile growth and recycling of pre-existing crust. Indeed, post-Archean mantle-derived magmas commonly intrude pre-existing, felsic continental crust. As a result, the origin of upper crustal granitoids, the most accessible products of planetary differentiation, is either accounted for by the melting of the pre-existing mid- to lower crust or the differentiation of mantle-derived mafic magmas. It is therefore critical to identify the relative contribution of these two different granite-forming processes in a given magmatic province, as well as how this relative contribution evolves over time, to assess crustal growth and/or recycling. To shed some light on this question, we used the combination of oxygen, hafnium and uranium-lead isotopic systems in zircons from granitoids of the Ordovician Famatinian Arc (Argentina) representing a typical crust-forming geotectonic setting. While the lower crustal section of Valle Fertíl, representing the basal level of the Famatinian crust, is already well studied, little is known on the timing and nature of igneous processes that built up the mid- and upper crust.

From our study, we observe a systematic co-variation of the O and Hf isotopic signatures of zircon in the mid- to upper crustal rocks, from a clearly crustal footprint (granodiorites with zircon $\delta^{18}O$ of ca. +8 ‰; εHf_t of ca. –3) to a mantle-like signature (granites and rhyolites: zircon $\delta^{18}O$ of ca. +5 ‰; εHf_t of ca. +5). Moreover, the high-precision (ID-TIMS) U-Pb dating obtained from the same zircons seem to record a progressive building of the Ordovician continental crust lasting for ca. 13Myrs from 483 to 470 Myrs ago. The results overlap with published ID-TIMS U-Pb data for the Famatinian lower crust, clustering at 470 Myrs, which confirms that the Famatinian Arc was a transcrustal magmatic system ultimately fed by mantle-derived magmas. In details, the oldest granitoids (483 Myrs) show the strongest crustal Hf-O isotopic fingerprint while the younger ones define a continuous range from this end-member towards the mantle signature. These results could be explained by (i) continuous ingrowth and “self-shielding” of lower crustal mafic intrusions progressively decreasing crustal melting or contamination of ascending mafic magma from a homogenous mantle source; (ii) progressive defertilization of an enriched lithospheric mantle or a strongly slab-enriched mantle wedge. The fact that the earliest (483 Myr-old) granitoids also show a more significant crustal contribution (ASI >1.1, inherited zircon cores) supports the first scenario.

In this case, the combination of Hf-O isotopic studies as well as high precision U-Pb dating for the Famatinian arc comply with a progressive building of a magmatic column where a certain amount of time is needed for the system to mature and eventually reach mantle dominated processes in the formation of granites and so, new continental crust.