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Are there tonalites and tonalites? Disentangling the processes and sources of tonalites from the Adamello Batholith (Italian Alps)

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Tonalitic rocks are a lithology recurrently observed in plutons of continental arcs. They represent the result of fractionation and assimilation in various proportions. Their mineralogy and chemistry look very similar despite the fact that the parental melts may originate from different sources, undergo different fractionation paths and be contaminated by different crustal components.

Our study focuses on the 43-33 Ma Adamello batholith in the Italian Alps with focus on the tonalites of the central and northern parts of the batholith. The Adamello is the product of the final stage of subduction prior to collision. Our work confirms that the entire upper-crustal batholith was built over a period of 10 m.y. based on U-Pb dating by LA-SF-ICP-MS on zircon, and the whole batholith was due to pulse assembly of tonalitic melts generated in the lower crust. Crustal values of radiogenic isotopes and progressively heavier δ18O from 6 to 10‰ oxygen isotopes are due to derivation from metasedimentary crustal sources or crustal contamination that is not simply increasing from SW to NE. A systematic negative trend between whole-rock Nd and Sr isotopes with decreasing age is observable until the second last Avio unit, suggesting a genetic link between these tonalites. This temporal trend is supported by a decrease in epsilon Hf in zircon and oxygen isotopes of zircons and the estimated magma increases in north-eastern direction. The youngest Presanella unit, however, reverts to the trend towards more mantle-like values for all isotopes. Moreover, δD in amphiboles for this last unit diverges as well compared to the oldest unit since the value is around -90‰ in contrast to more mantle like values of -70 to -80‰ for the rest of the units.

These data suggest that 1) The oldest tonalites are the product of fractional crystallization of mantle-derived magmas whereas with decreasing age the importance of crustal melting becomes increasingly important. 2) The changes recorded by all methods imply a higher proportion of mantle material incorporated into the melts at 34 Ma. 3) The hydrogen isotope analyses let us think of a change in the oxygen fugacity and sources of water. The magma at the origin of the young Presanella unit was probably drier due to its deeper origin. The volatiles coming from the melt have a minimal impact since the amount of volatiles released from the crust becomes proportionally much important. The result leads to the lightest δD value recorded on the Adamello (i.e. -95 to -100‰).
We propose that the temporal and spatial geochemical change between Avio and Presanella units is the consequence of slab break-off at the termination of the Alpine subduction, leading to hot mantle upwelling and crustal melting and assimilation, increasing with time.