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Using petrology to constrain the onset and migration of the Lesser Antilles subduction: Insights from zircon and amphibole from Saint Martin

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Volcanism and magmatism can provide insights on evolving geodynamic processes such as the onset and migration of subduction. The island of St Martin is unique in hosting outcrops of both volcanic and plutonic rocks and a conspicuous volcano-sedimentary sequence, providing a unique archive of the poorly understood onset of volcanism in the northern the Lesser Antilles. Saint Martin preserves a significant portion of Eocene and Oligocene volcanism missing elsewhere in the arc. Recent studies focused on the plutonic stage report zircon ages spanning about 10 Ma, but the full volcanic-plutonic record remains incompletely studied and dated.

We present a composite record combining zircon U-Pb geochronology and geochemistry with amphibole thermobarometry and chemometry from plutonic and volcanic samples to understand Eastern Caribbean subduction evolution through time. Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry, we have dated and analysed trace elements in zircons from 6 key samples and obtained weighted mean $^{206}Pb/^{238}U$ ages from 52.04 ± 0.52 Ma (MSWD = 0.81) to 23.21 ± 0.25/0.30 Ma (95% c.i. /ext., MSWD = 1.4), documenting an unprecedented 30 Ma of magmatic evolution.We collected major element concentrations in amphiboles from the same 6 key samples and from gabbroic cumulates, and performed thermobarometry and chemometry to trace the evolution of the magmatic plumbing system architecture over its entire duration. The system underwent significant changes in the melt crystallization temperature, with fluctuating temperatures ranging from 792 ± 32 °C to 941 ± 46 °C ($\bar{x} \pm 2\sigma$). Amphibole barometry reveals relatively constant pressures over time: 3.8 ± 1.9 kbar ($\bar{x} \pm 2\sigma$) in the lower Eocene, followed by slight decreases in the Oligocene to 2.1 ± 0.4 kbar ($\bar{x} \pm 2\sigma$) at 27 Ma and 2.2 ± 0.32 kbar ($\bar{x} \pm 2\sigma$) at ~ 23 Ma.These results may reflect alternating periods of “hot” and “cold” upper crust, prior to the subsequent migration of the arc.

Our work adds absolute time constraints and provide the first comprehensive thermobarometric and geochemistry framework on early nothern Caribbean subduction dynamics, with implications for subduction initiation and migration.