Volatile Recycling in the Lesser Antilles Arc: Processes and Consequences

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Motivation: Volatiles, such as water, CO_2, and sulphur, not only make Earth a unique, life-supporting planet but also lubricate the dynamics of plate tectonics. At subduction zones, where they are transported into the planet's interior in oceanic plates, volatiles contribute to violent volcanism and earthquakes but also help build both new continental material and valuable metal deposits. This transport is not well understood and what we do know comes mainly from studying subduction of the Pacific Plate. However, we expect the Atlantic Plate to carry more water in more varied ways than the Pacific because it formed differently, by slow-spreading.

VoiLA's Aims: Perform the first integrated analysis of an Atlantic subduction zone to identify and quantify where volatiles are held in the subducting plate, where they are released from that plate, and how they are transported from there through the mantle wedge to the volcanic arc. We aimed to map volatile pathways through the Lesser Antilles subduction zone by collecting new geophysical datasets, complemented by novel geochemical and petrological analyses, and integrate these into numerical models for comparison with the observed seismic and volcanic activity, and with similar studies of other (Pacific) subduction zones.

Scientific Highlights:

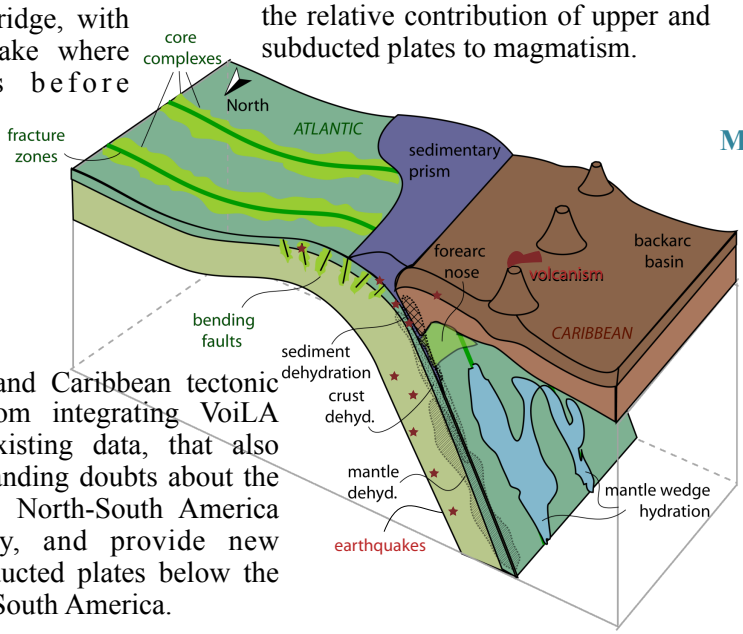
Incoming plate

First images of Atlantic lithosphere distant from the spreading ridge reveal uptake of water strongly linked to structures formed at the ridge, with more fluid intake where plate bends before subduction.

Arc Structure and Magmatism

Integrated petrological and geophysical data yield a new model of crust below the arc, reveal fluid-linked variations in structure, and resolve long-standing doubts about the relative contribution of upper and subducted plates to magmatism.

New geochemical data show magmas contain more water than most Pacific zones, with a strong fingerprint for water derived from deep within the subducted plate, which correlates with variation of mantle wedge structure and seismicity.



Mantle Wedge and Plate Coupling

First integrated seismic and modelling studies of the Antillean mantle wedge reveal strongly variable fluid presence, correlated with magmatic productivity.

Geophysical imaging reveals unusually deep coupling between the upper and subducting plates, with implications for arc position and seismicity, and for how viscosity of the interface and mantle control plate coupling

Tectonics

New regional and Caribbean tectonic frameworks from integrating VoiLA results with existing data, that also resolve long standing doubts about the location of the North-South America plate boundary, and provide new images of subducted plates below the Caribbean and South America.

Impact: New earthquake catalogue with improved locations. New local seismic velocity model for routine earthquake locations. Detailed reconstruction of 30 year evolution of Kick'em Jenny underwater volcano. Highly successful final workshop with strong engagement and attendance from local observatories, members of Antillean universities, regional partners as well as top international scientists. Throughout the project outreach activities were held including, general audience talks, school demonstrations, open days, twitter, and website.

Training: 5 PDRAs (directly funded), 5 PhDs and 4 MScs (matched funding), 2 MSci, 9 students joined cruise

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