Structural analysis of the Osa Mélange: Implications for Active Seismogenesis in the Middle America Subduction Zone

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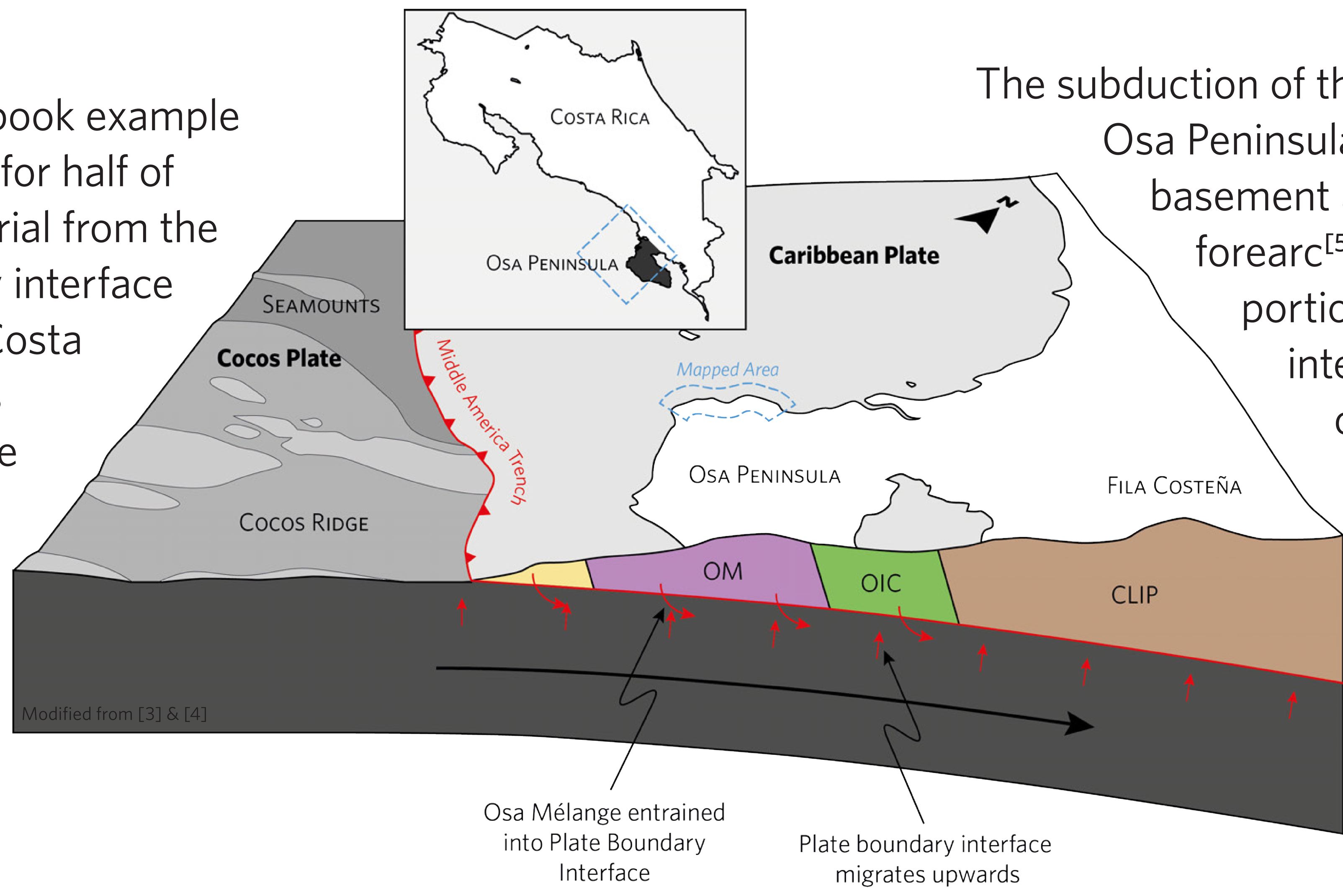
Introduction

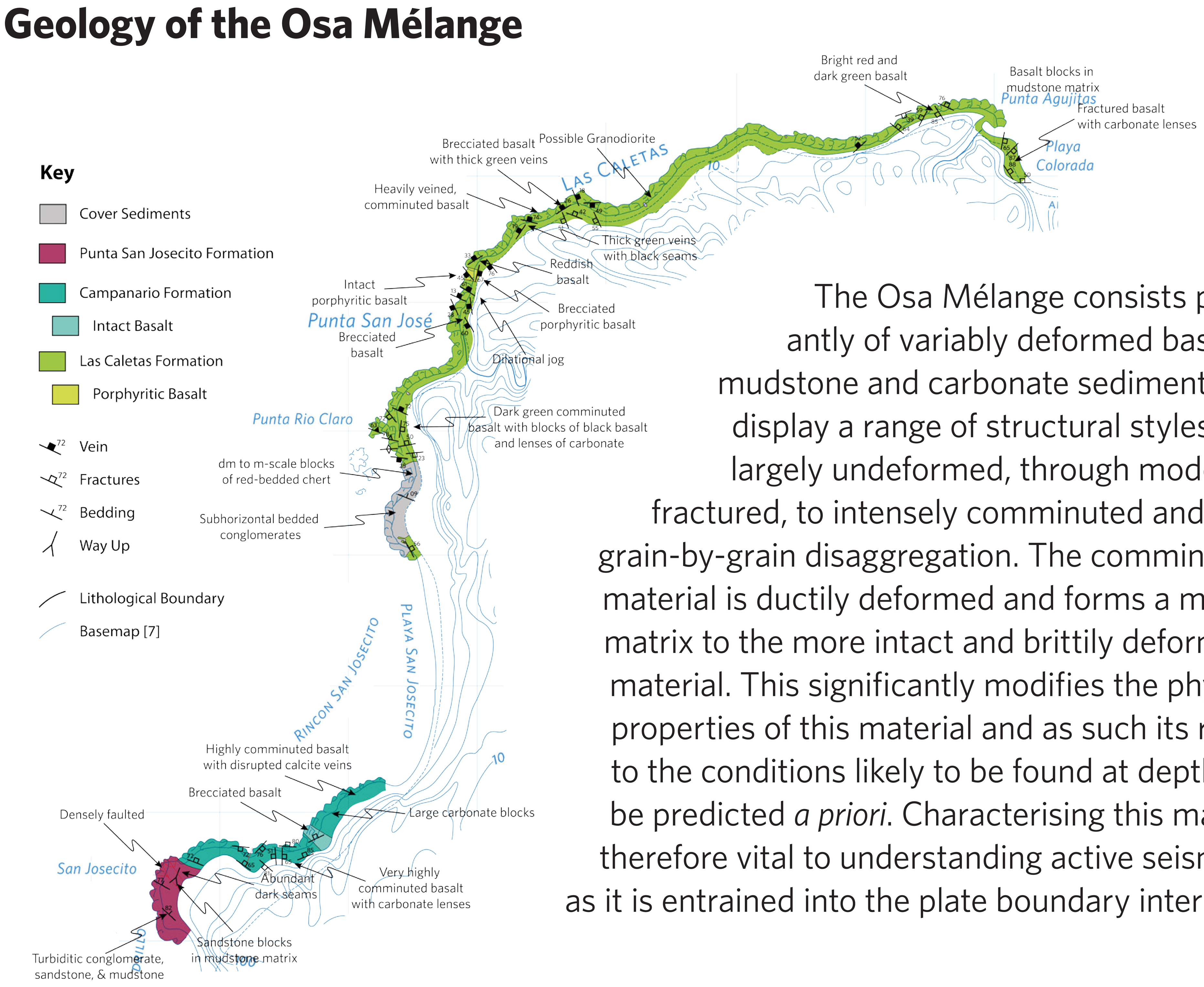
The Middle America subduction zone is a textbook example of the subduction erosion process, accounting for half of modern subduction zones, which causes material from the forearc to be entrained into the plate boundary interface as it migrates upwards[1]. The Osa Peninsula, Costa Rica, lies above the seismogenic portion of this subduction zone and exposes material from the forearc basement, the Osa Mélange, which forms the hanging wall at depth.

Offshore Osa Peninsula is uniquely within reach of modern drilling technologies at the depth of seismic nucleation and is the target of the CRISP expedition[2].



The subduction of the Cocos Ridge directly beneath the Osa Peninsula has resulted in major uplift of the Osa basement and tectonic erosion from the base of the forearc[5]. The Osa Mélange forms the outermost portion of this basement and was formed by intense disruption and accretion of a series of Galapagos-derived seamounts[4]. This fabric is likely to exert a major control on the nucleation and propogation of earthquakes within this subduction zone.

Geology of the Osa Mélange



The Osa Mélange consists predominantly of variably deformed basalt, mudstone and carbonate sediments, which display a range of structural styles, from being largely undeformed, through moderately fractured, to intensely comminuted and displaying grain-by-grain disaggregation. The comminuted material is ductily deformed and forms a mechanical matrix to the more intact and brittily deformed material. This significantly modifies the physical properties of this material and as such its response to the conditions likely to be found at depth cannot be predicted *a priori*. Characterising this material is therefore vital to understanding active seismogenesis as it is entrained into the plate boundary interface.

Early Stages of Brecciation in Basalt. Basalt is densely fractured and in places fracture networks have developed into a mechanical matrix and clasts of the wall rock are rotated and become rounded through abrasion.

Well Developed Brecciation in Basalt. Basalt is pervasively broken into sub-angular – rounded clasts forming a clast-supported tectonic breccia. The proportion of clay-rich, comminuted basalt matrix increases with deformation.

Intense Comminution in Basalt. Isolated clasts of intact basalt within a matrix of intensely comminuted basalt-derived material. Both clasts and matrix are strongly altered to clay.

Dense Fracturing in Mudstone. Mudstone also exhibits similar dense fracturing to the basalt.

Well Developed Brecciation in Mudstone. Increased fracture density and width results in brecciation similar to that seen in the basalt.

All basalt is pervasively deformed. Least deformed basalt is still pervasively fractured. Some fracturing may be primary (hyaloclastite).

Different mechanical behaviour between similar lithologies. Blocks of brittle fractured basalt within matrix of ductily deformed comminuted basalt.

Transport appears to be minimal. Intense brecciation occurs without significant disruption to jig-saw fit of clasts, suggesting chemical alteration accompanied physical abrasion.

Comminuted basalt acts as mechanical matrix. Comminuted basalt flows into cracks in adjacent units and forms matrix around dismembered blocks.

Fossil Earthquakes. The presence of a dilational jog containing an implosion breccia and possible pseudotachylites indicates palaeoseismicity in this unit.

Future Work

The relative influence of the seafloor and subduction zone metamorphism on the alteration of this material will be assessed by geochemical analysis of veins.

Experimental analysis of the physical properties, deformation style and failure mode envelopes in conditions close to those at the plate boundary interface will be conducted on material spanning the spectrum from hyaloclastite to comminuted basalt. This will be used to define the effect of this prior fabric on subsequent deformation within the plate boundary interface with a focus on whether the deformation is brittle or ductile and how its localisation evolves.

The results of this research will inform the planned drilling project to sample this subduction zone at depth.

References

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