Pre-Arc, Near-Trench, Magmatism During Subduction Initiation at the Young (< 2 Ma) Matthew and Hunter Subduction Zone

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Abstract

The Matthew and Hunter (M&H) area, in the South-West Pacific, was formerly interpreted as a transform boundary at the southern termination of the New Hebrides Subduction Zone. But new data collected during three voyages of RV Southern Surveyor (2004-2009), combined with detailed analysis of seismicity and GPS kinematics, shows it is a distinct subduction zone initiated only 2 Ma ago. In fact, M&H is the youngest known volcanically-active intra-oceanic subduction system. We demonstrate that the M&H subduction zone is a modern example of an immature subduction system at the particular stage of pre-arc, near-trench magmatism. It is not yet forming an arc but the proto-forearc. Indeed volcanism occurs much closer to the trench than volcanism at mature subduction zones. Also M&H hosts an exceptionally diverse range of magma compositions, which erupted contemporaneously and are spatially juxtaposed. Pb isotopic compositions and contents of LILE and REE indicate melting of upwelling asthenospheric mantle (Indian MORB) and subducted oceanic crust (Pacific MORB of the South Fiji Basin) and the mixing of these two components. It is worth noting that the present day proto-forearc of the M&H subduction zone corresponds to an area where highly contrasting terranes are juxtaposed: remnants of the old Vitiaz Arc crust, domains of classical backarc basin type oceanic accretion, and what we call Subduction Initiation Terranes (SITER). Such live observations of a growing forearc are rare. They should give insights into the study of fossil forearcs such as SSZ ophiolites but also the IBM forearc.

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ABSTRACT

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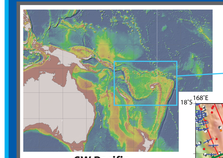
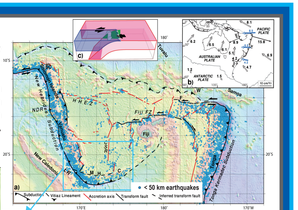
Patriat et al., 2019. Subduction Initiation Terranes exposed at the front of a 2 Ma volcanically-active subduction zone. *EPSL*, 508, 30-40, doi:10.1016/j.epsl.2018.12.011

Patriat et al., 2015. Propagation of back-arc extension into the arc lithosphere in the southern New Hebrides volcanic arc, *Gcubed*, 16, 3142–3159, doi:10.1002/2015GC005717.

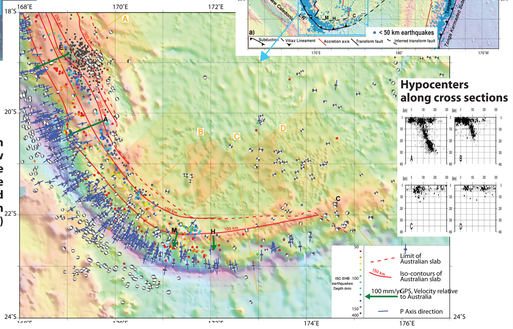
Tectonic setting

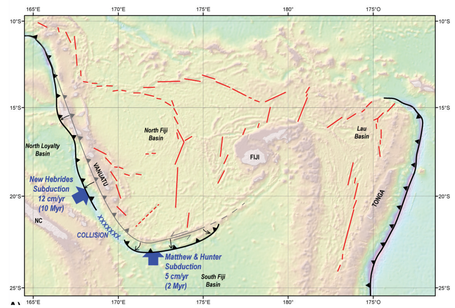


Simplified present-day geodynamic map of the New Hebrides and Matthew-Hunter subduction systems (modern trenches shown in black).



Kinematics of the southern termination of the New Hebrides Subduction Zone as revealed by P axis of the earthquakes (blue bars) and GPS measurements (green arrows)

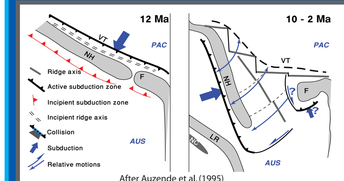




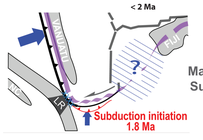
Tectonic interpretation

Present Day Tectonics

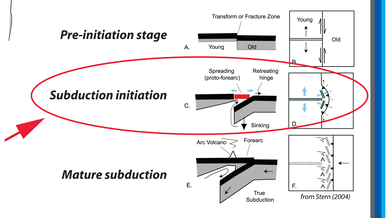
Subduction Initiation less than 2 Myr ago



After Auzende et al. (1995)



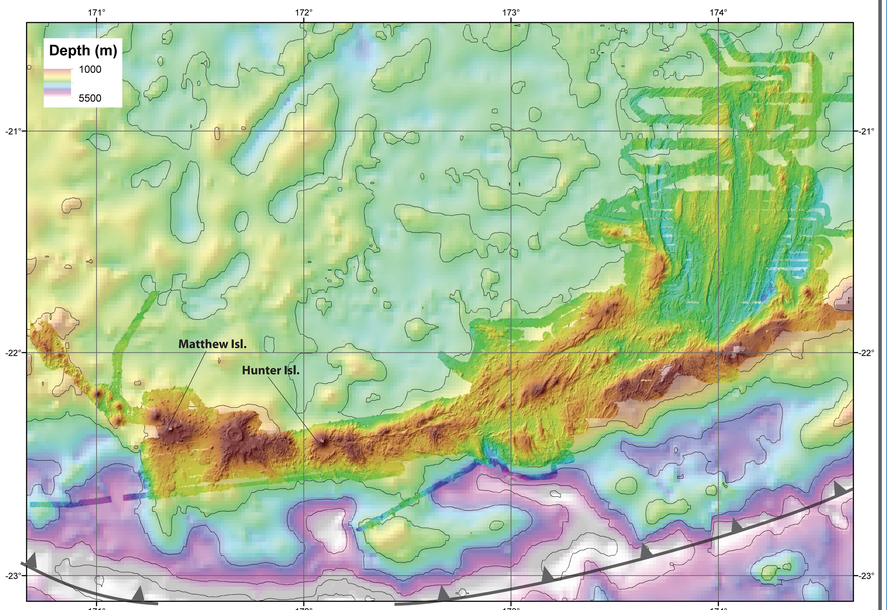
Matthew & Hunter Subduction Zone



Geodynamic evolution of the North Fiji Basin

Subduction infancy model of Stern and Bloomer (1992)

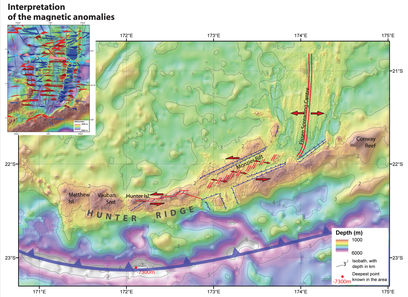
Morphology of the seabed: Deformation of the SSZ plate



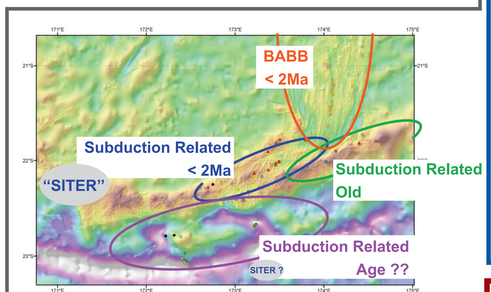
Morphology of the Hunter Ridge (multibeam and satellite bathymetry).

Remnants of Old Vitiaz Arc sheared and rifted
Backarc spreading (BABB type) & Near trench spreading (Subduction Initiation Terrane)

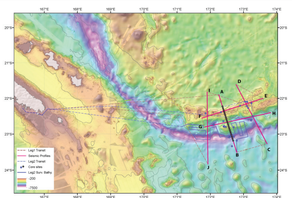
Interpretation of the magnetic anomalies



Deformation of the Upper Plate



Juxtaposition of Contrasting Terranes, including «Subduction Initiation Terranes» (SITER)



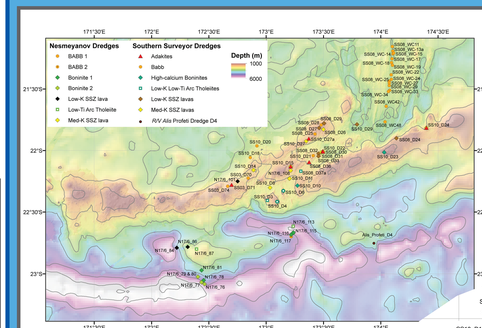
Future Work

MHUFIN scientific cruise: Geophysical & Geochemical assessment of a Forearc under construction

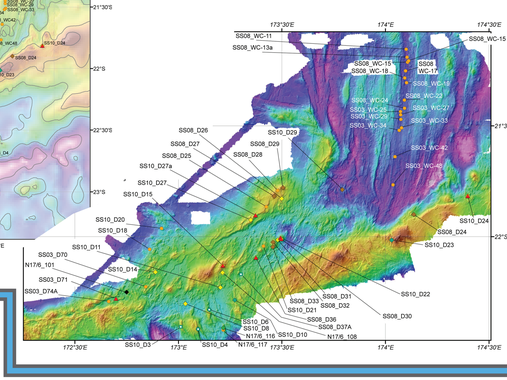
- Deep structure of the subduction (Wide Angle & Multi Channel Reflection Seismic)
- Thermal structure (heat flow measurement)
- Dynamics and origin of fluids (Pore Fluid Sampling from Sediment Cores)
- Other ? (Long term OBS network, …)

Geochemistry

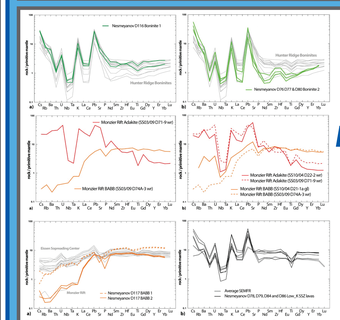
Sampling



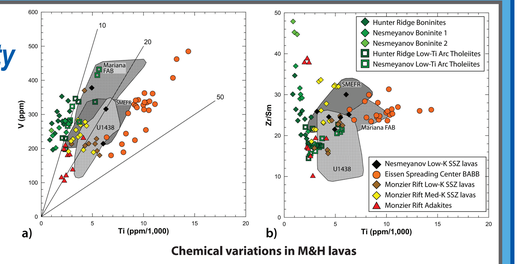
Location and nature of dredged samples



Diversity



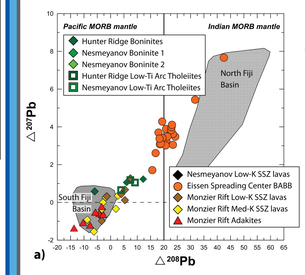
Primitive Mantle normalized trace element abundance patterns



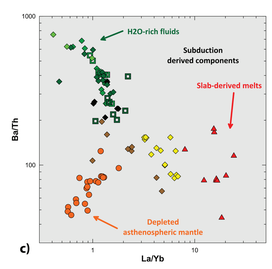
Chemical variations in M&H lavas

Pre-Arc magmatism :
High diversity of lavas (Adakites, BABB, Boninites, Low- to Medium-K SSZ...)
Contemporaneously erupting and spatially juxtaposed

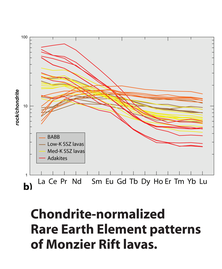
Mixing



$\Delta^{207}Pb$ vs $\Delta^{208}Pb$ of M&H lavas compared to South Fiji Basin oceanic crust



Ba/Th vs La/Yb values for M&H lavas



Chondrite-normalized Rare Earth Element patterns of Monzier Rift lavas.

Melting of upwelling asthenospheric mantle (Indian MORB)
Melting of subducted oceanic crust (Pacific MORB of South Fiji Basin)
Mixing of these two components

Present day Matthew and Hunter area = Future Forearc of the Subduction Zone

Juxtaposition of contrasting Terranes :

- **Old, pre-initiation, Terranes (here Remnants of Vitiaz Arc)**
- **< 2 Ma BABB type Terranes**
- **< 2 Ma Subduction Initiation Terranes (SITERs)**