ME24B-0939 Hydrothermal Activity Along Back-Arc Spreading Centers: The Importance of Arc Proximity

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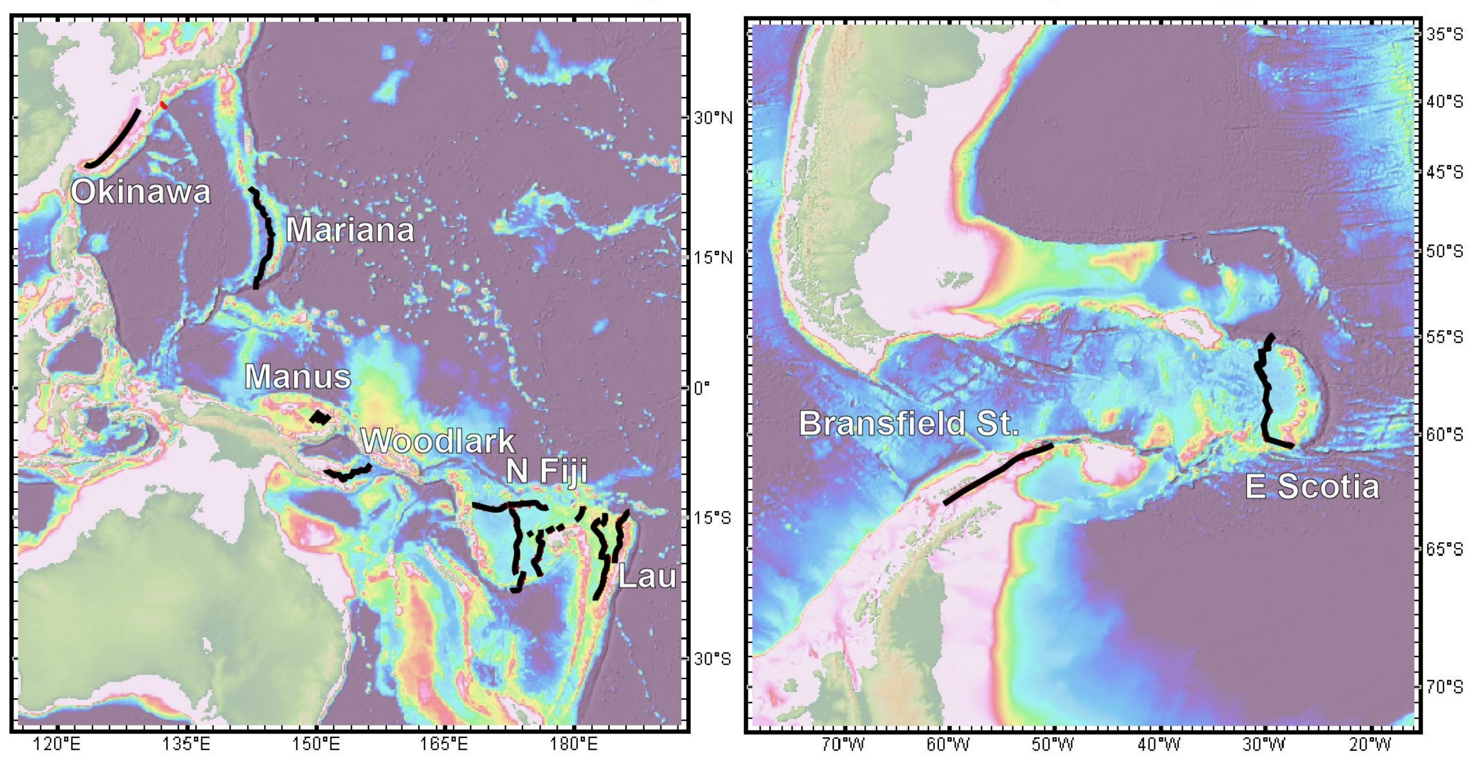
The 11,000 km of back-arc spreading centers (BASCs) form a distinct class of ocean spreading ridges distinguished by interactions with an adjacent subduction zone (1). These characteristics can affect the population and distribution of hydrothermal activity compared to mid-ocean ridges. Although exploration quality varies greatly among BASCs (2,3), present data suggest that the mean spatial density of hydrothermal activity varies little between mid-ocean ridges and BASCs (4). On both BASCs and mid-ocean ridges, however, the spatial density of hydrothermal sites mapped by high-quality water-column surveys is 2–7× greater than predicted by the existing trend of site density vs. spreading rate. Re-examination of hydrothermal data from well-surveyed BASCs supports the generalization that hydrothermal site density increases on segments <70-90 km from an adjacent arc. This limit is roughly the proposed distance within which additional magma can be supplied by hydrous flux melting in a subducting plate, as evidenced by a higher mean axial elevation compared to more distal segments (4).

1. Global distribution of explored back-arc spreading centers

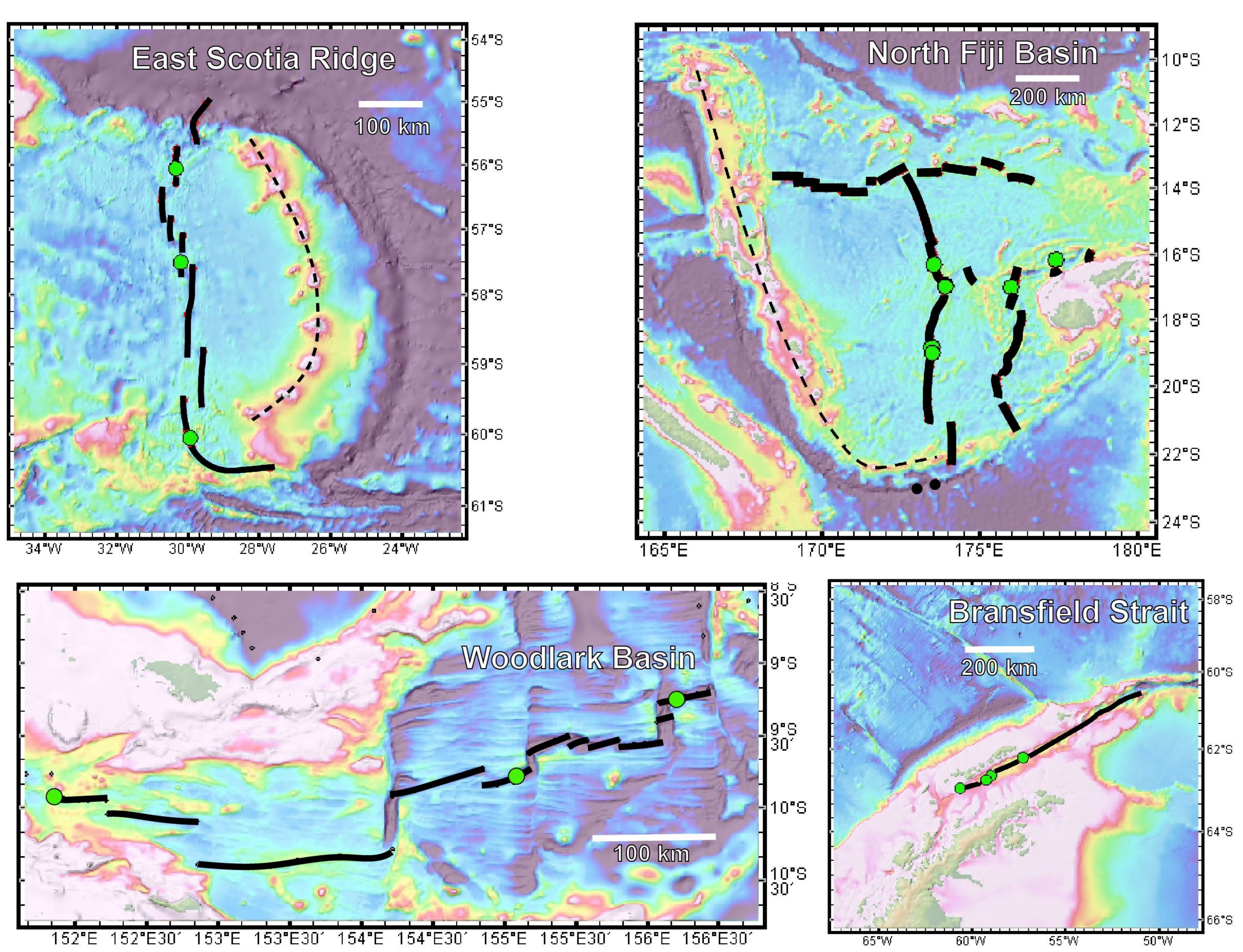


Maps generated by GeoMapApp (http://www.geomapapp.org)

BASCs	Total length (km)	Surveyed length (km)	Sites per 100 km surveyed	Spreading rate (mm/yr)	% Surveyed	Survey type
Adjacent active arc						
Mariana	1300	600	3.2	41	46	1*
N Fiji	2635	685	1.0	37	26	2/3
East Scotia	600	204	1.5	68	34	1
Lau	855	807	14.5	60	96	1*
Manus	365	314	3.5	69	86	1*
Okinawa Trough	1066	53	22.5	40	5	1
No adjacent active arc						
Bransfield Strait	530	435	0.9	7	82	2
Woodlark	549	500	0.6	31	91	2

Survey type: 1* = densely surveyed w/chemical sensor (Oxidation Reduction Potential); 1 = densely surveyed w/optical sensor only; 2 = moderately surveyed (mostly vertical casts); 3 = poorly surveyed (widely spaced vertical casts)

2. Back-arc ridges: not well surveyed, no or distant adjacent arc

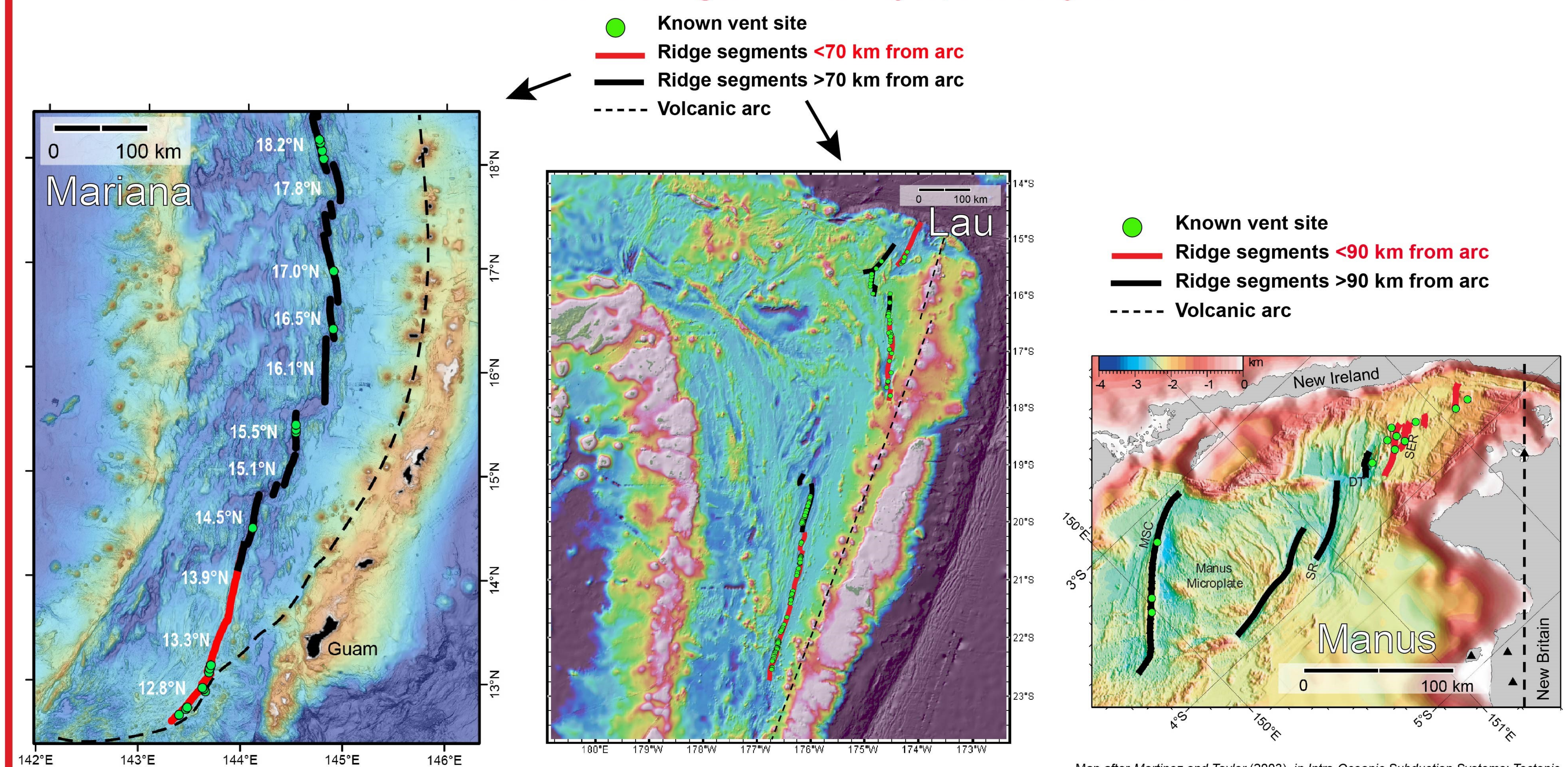


Maps generated by GeoMapApp (http://www.geomapapp.org)
Vents sites from InterRidge (https://vents-data.interridge.org)

Known vent site
Ridge segments
Volcanic arc

These BASCs have been explored primarily with vertical casts employing optical sensors. This technique can miss some high-temperature sites and most low-temperature sites.

3. Back-arc ridges: well-surveyed, close adjacent arc

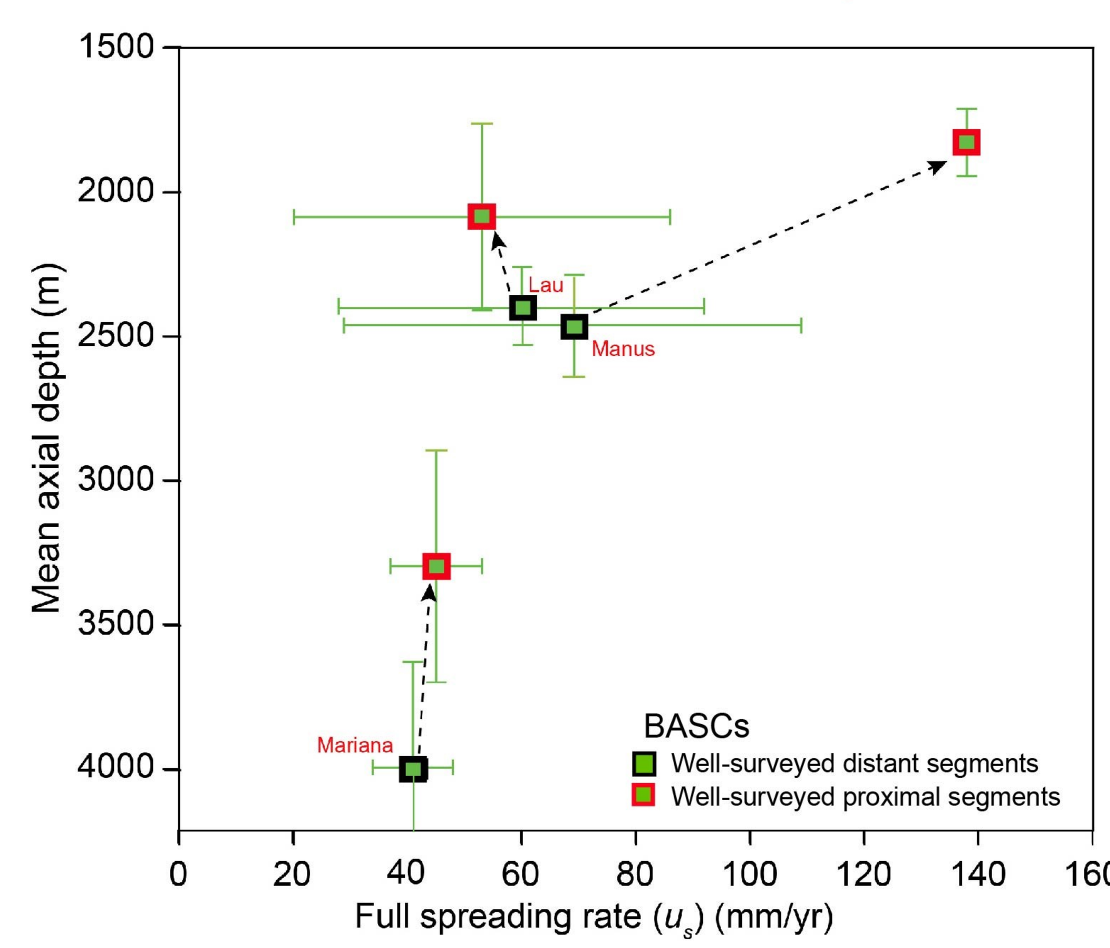


Maps generated by GeoMapApp (http://www.geomapapp.org)
Vents sites from InterRidge (https://vents-data.interridge.org), modified as described in *Baker et al.* (2016) *Geochem. Geophys. Geosyst.*

Map after *Martinez and Taylor* (2003), *in Intra-Oceanic Subduction Systems: Tectonic and Magmatic Processes*, Special Publication, vol. 219, Geological Society, London. Vent sites from InterRidge (https://vents-data.interridge.org), modified as described in *Baker et al.* (2016) *Geochem. Geophys. Geosyst.*.

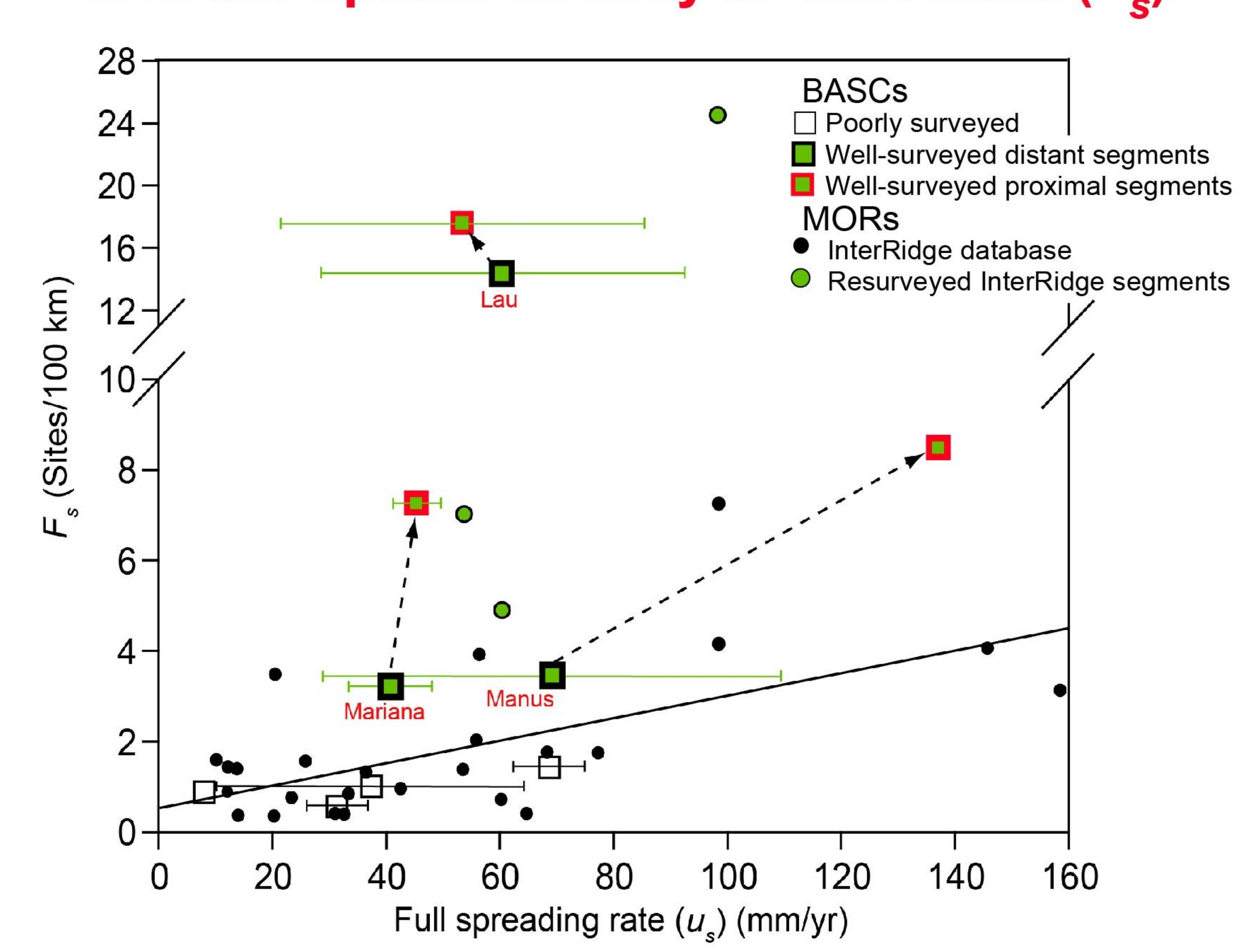
These BASCs have been explored primarily with continuous tows employing both optical and chemical sensors. This technique can identify both high- and low-temperature sites to a location precision of ~1 km. Hydrothermal sites are more concentrated on segments within <70-90 km of the adjacent arc. This distance limit correspondes to the distribution of the apparent magmatic budget along BASCs (*Martinez and Taylor* (2002) *Nature*; *Sleeper et al.* (2016) *JGR*)).

4A. Relationships between spreading rate and mean axial depth



Previous work has shown that spreading axes become shallower and more magmatically robust with arc proximity than expected based on spreading rate alone. For Lau, Manus and Mariana, the mean axial depth of the proximal segments (<70-90 km) is 13-25% shallower than segments more distant from the arc, with little dependence on spreading rate. Fig. 4B shows that this increased magmatic budget creates a corresponding increase in hydrothermal activity.

4B. Relationships between spreading rate and the spatial density of vent sites (F_s)



The F_s value (sites/100 km) of the proximal segments is 1.5-7.7× higher than segments more distant from the arc, regardless of spreading rate. The effect of arc-proximity is most clearly expressed on Manus and Mariana because proximal segments encompass <30% of the total explored length of those BASCs, but account for 50–70% of the active sites. Proximal segments are less influential on the overall Lau F_s because they encompass >60% of both total BASC length and vent sites.

5. Conclusions

- Back-arc ridges with high-quality hydrothermal surveys and an adjacent volcanic arc exhibit the highest spatial density of vent sites among back-arcs.
- On Lau, Mariana, and Manus back-arcs, vent site spatial density is highest where arc proximity (<~70-90 km) results in enhanced magma supply to the back-arc ridge.
- Confirmation of this hypothesis requires high-quality hydrothermal surveys on other back-arc ridges.