Micro-Seismicity to the South of the Louisville Ridge-Tonga Trench Collision Zone: New Insight into Processes Controlling Seismic Gaps and Subduction Erosion

Yingchen Liu[1], Dietrich Lange[1], Ingo Grevemeyer[1]

[1] GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

Introduction

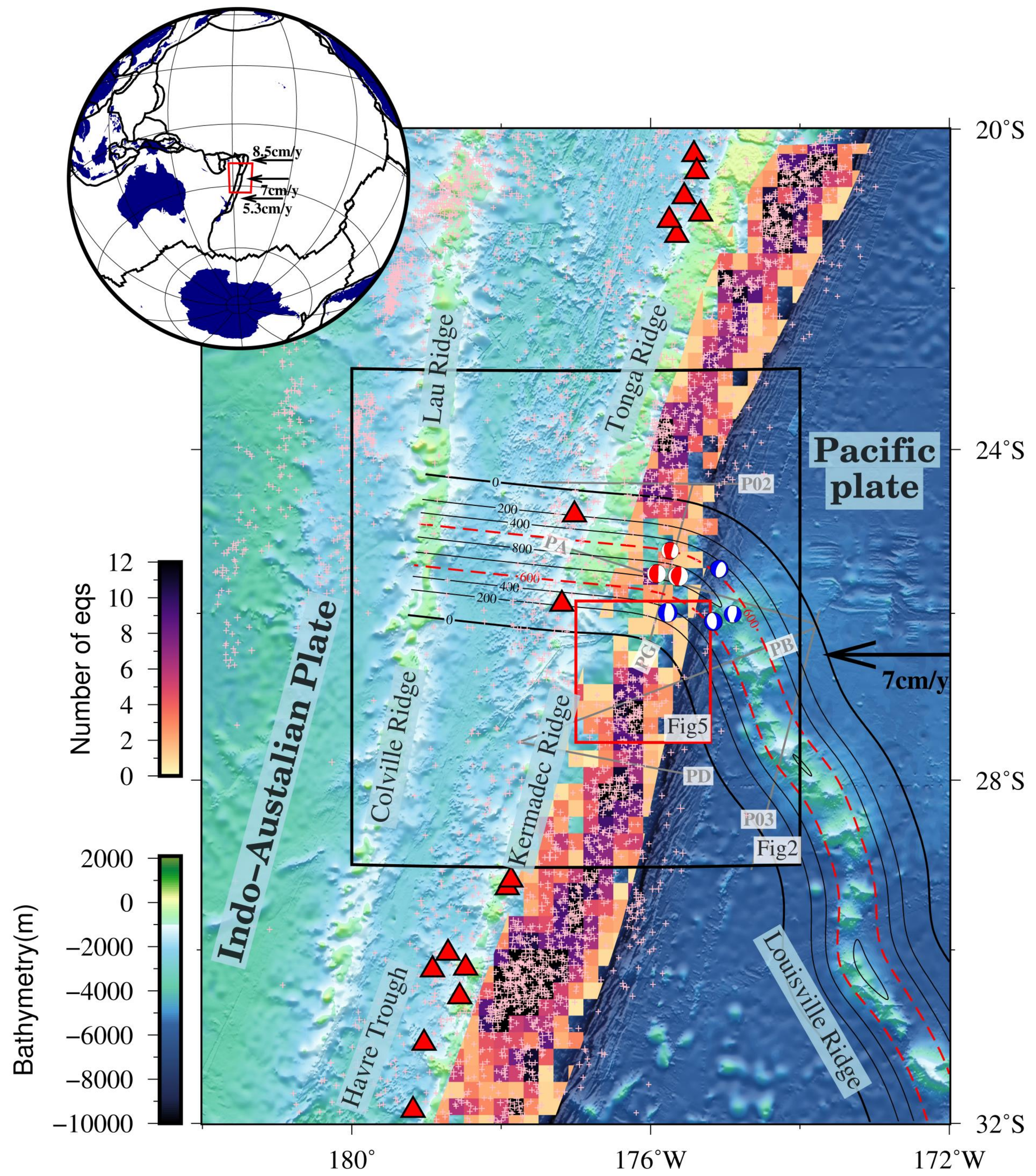

Figure 1: Tectonic setting of the Tonga-Kermadec subduction zone

The Louisville seismic gap associated with the subduction of the Louisville Ridge (LR) along the Tonga-Kermadec trench is a globally prominent feature. Due to the lack of near-field seismic monitoring, the earthquake potential and seismic behavior in this region have long been an enigma. In this study, we investigate the micro-earthquake activity of the Louisville seismic gap and its southern area using a local network of ocean bottom seismometers (OBS). Over six months of OBS deployment, we recorded 398 regional (Figure 4) and 171 local (Figure 7) well-located earthquakes across the outer rise, forearc basin, magmatic arc, and back-arc basin of the southern Tonga subduction zone. The local earthquake catalog obtained from this study provides an excellent perspective into the near-field seismic behaviors of the Louisville seismic gap and its southern erosive regions, enhancing our understanding of the controlling processes of seismic gaps and subduction erosion.

Data and Method

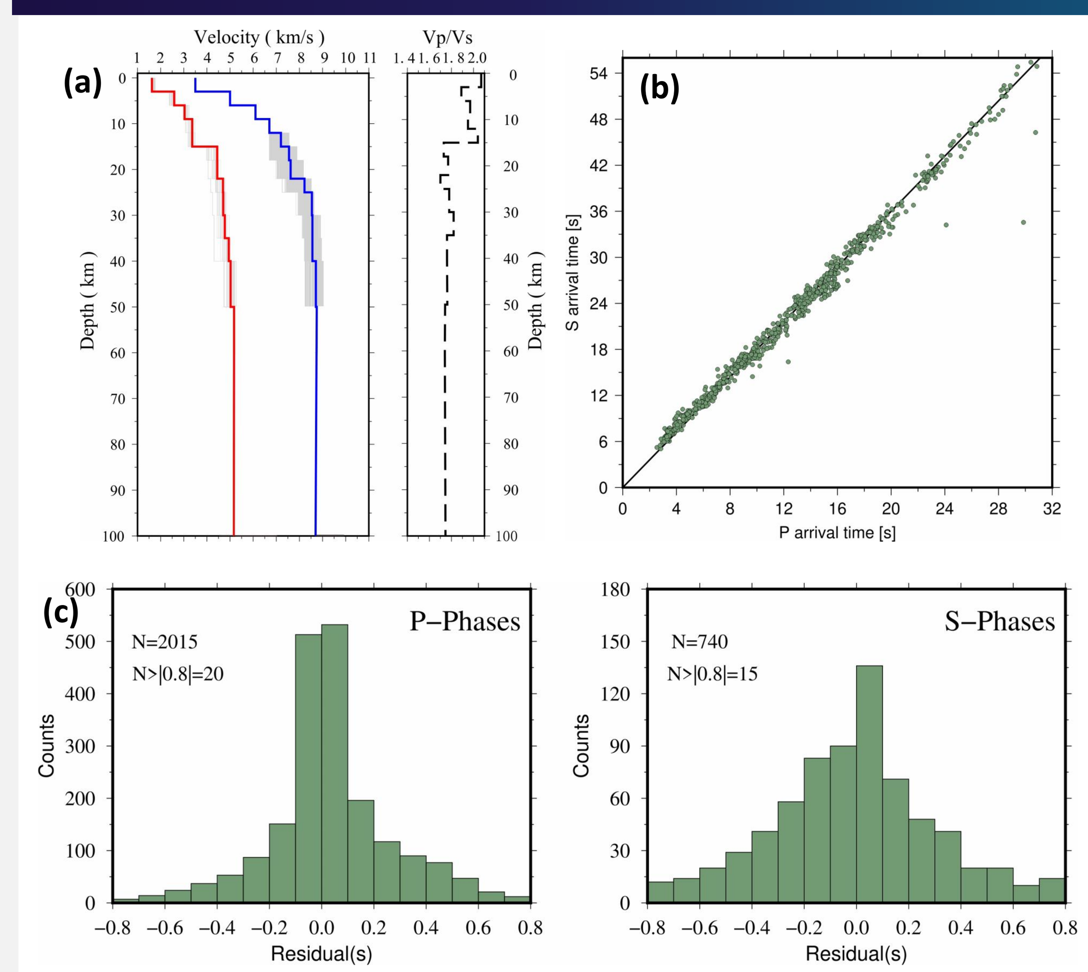

Figure 2: (a) Local 1-D velocity model; (b) Wadati plot; (c) Residual distribution

Data Acquisition

- July 2007 to December 2007,
- 18 OBS (9 broadband) and 1 OBH
- 171 local (Figure 7) and 398 regional (Figure 4) well-located earthquakes

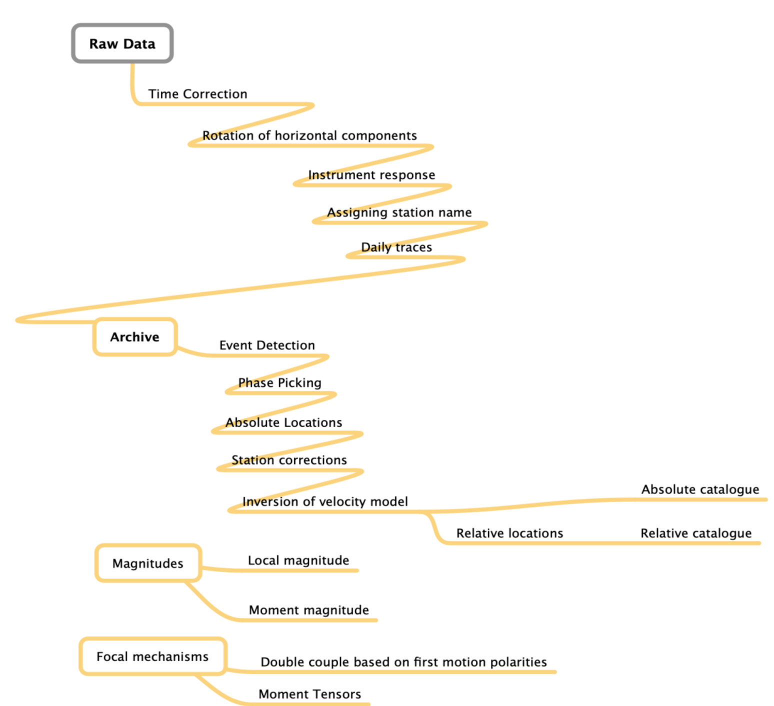

Figure 3: Data process flow

Structure and Deformation of the Seismic gap

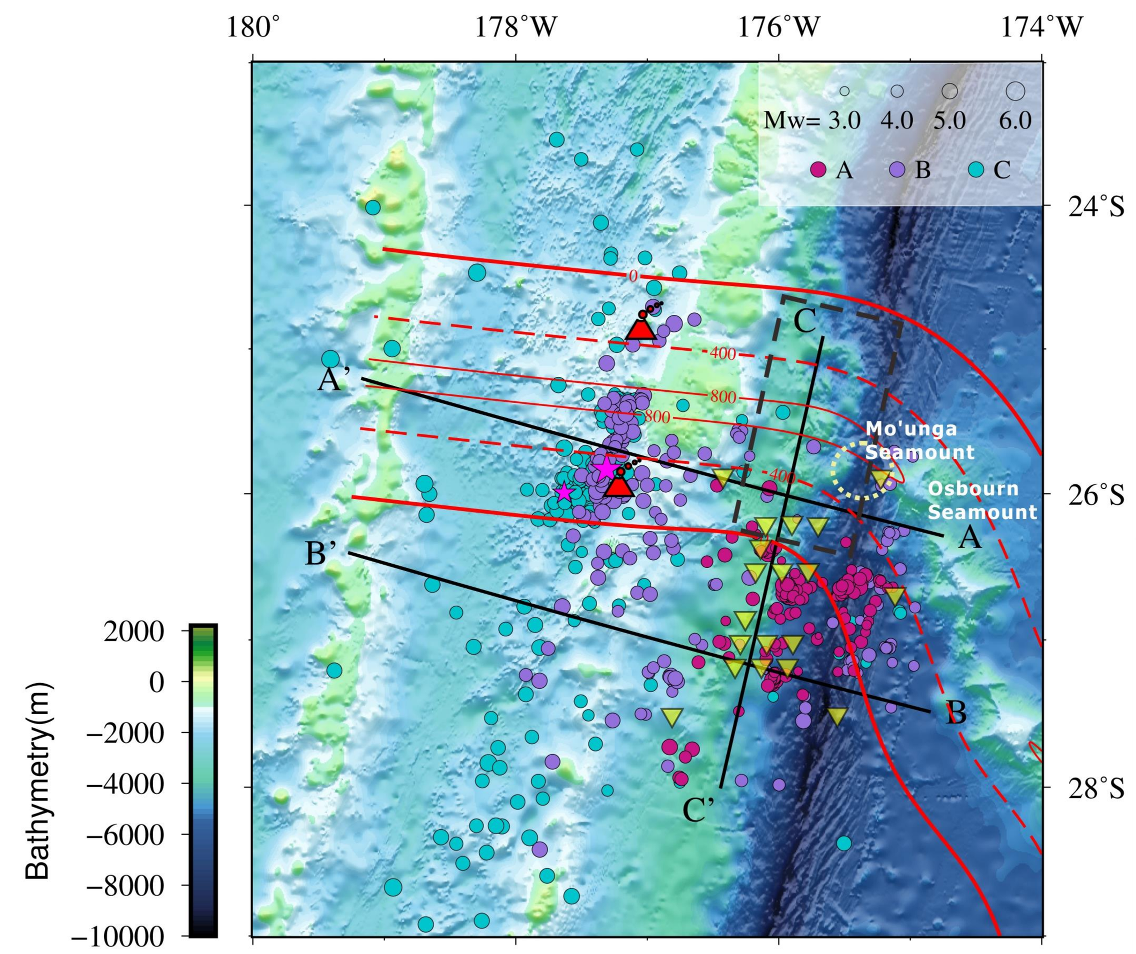

Figure 4: Regional Seismicity distribution in a map view

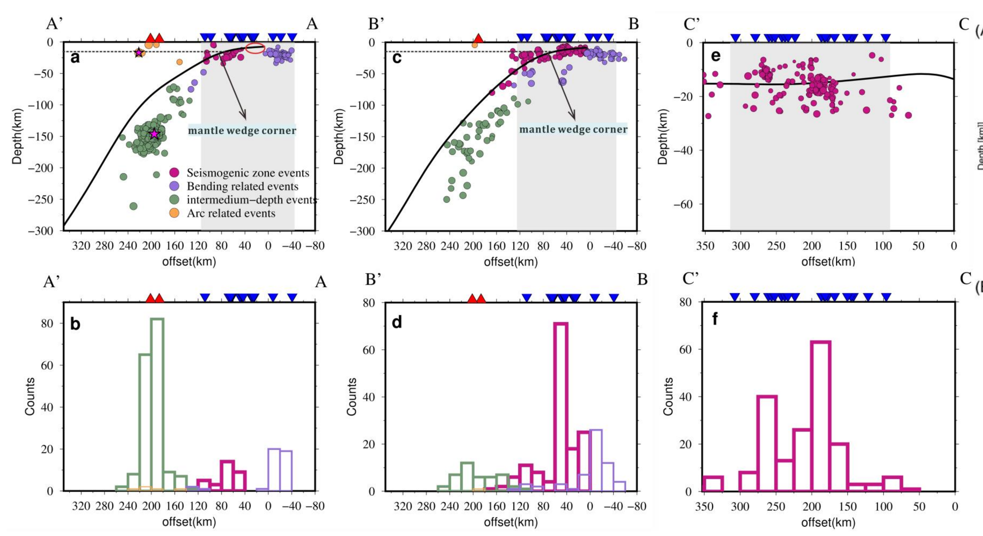

Figure 5: Cross-sections of and the histogram of the number of events along the profiles in Fig 4

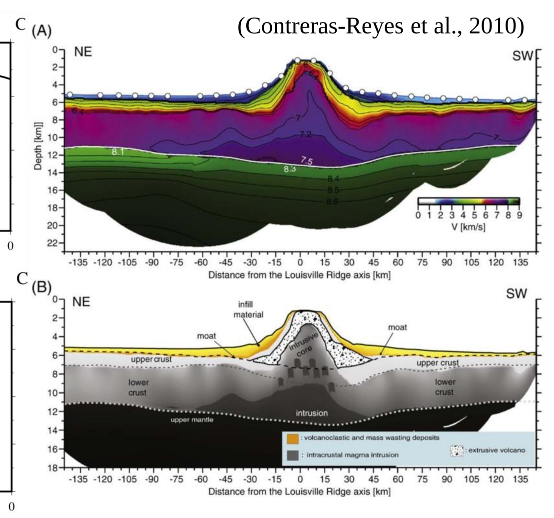

Figure 6: Velocity structure of Louisville Guyot

- Seismic gap is confirmed in moment magnitude from 2.5 to 5.5
- The extent of the seismic gap corresponds well with the flexural moat of Louisville Ridge

☐ Pervasive fracturing induced by the subducting seamount, combined with the dewatering of pore fluids from volcaniclastic materials in the flexural moat during the early stages of subduction contribute to the formation of the Louisville seismic gap

Depths of Outer Rise Earthquakes and their Implication for Intermediate Depth Seismicity

- In the outer rise, local seismicity is active at focal depths of 5 to 20 km, but reaches up to 25 km into the upper mantle (Figure 8).
- The maximum depth of faulting may outline the base of mantle hydration, which agrees with the potential second band of seismicity in the double seismic zone of extensive intermediate-depth earthquakes (Figure 5c).

☐ The scarcity of intraplate thrust earthquakes in the outer rise, coupled with the ongoing occurrence of bending-related earthquakes, might suggest a generally weakly coupled forearc.

Conceptional Model

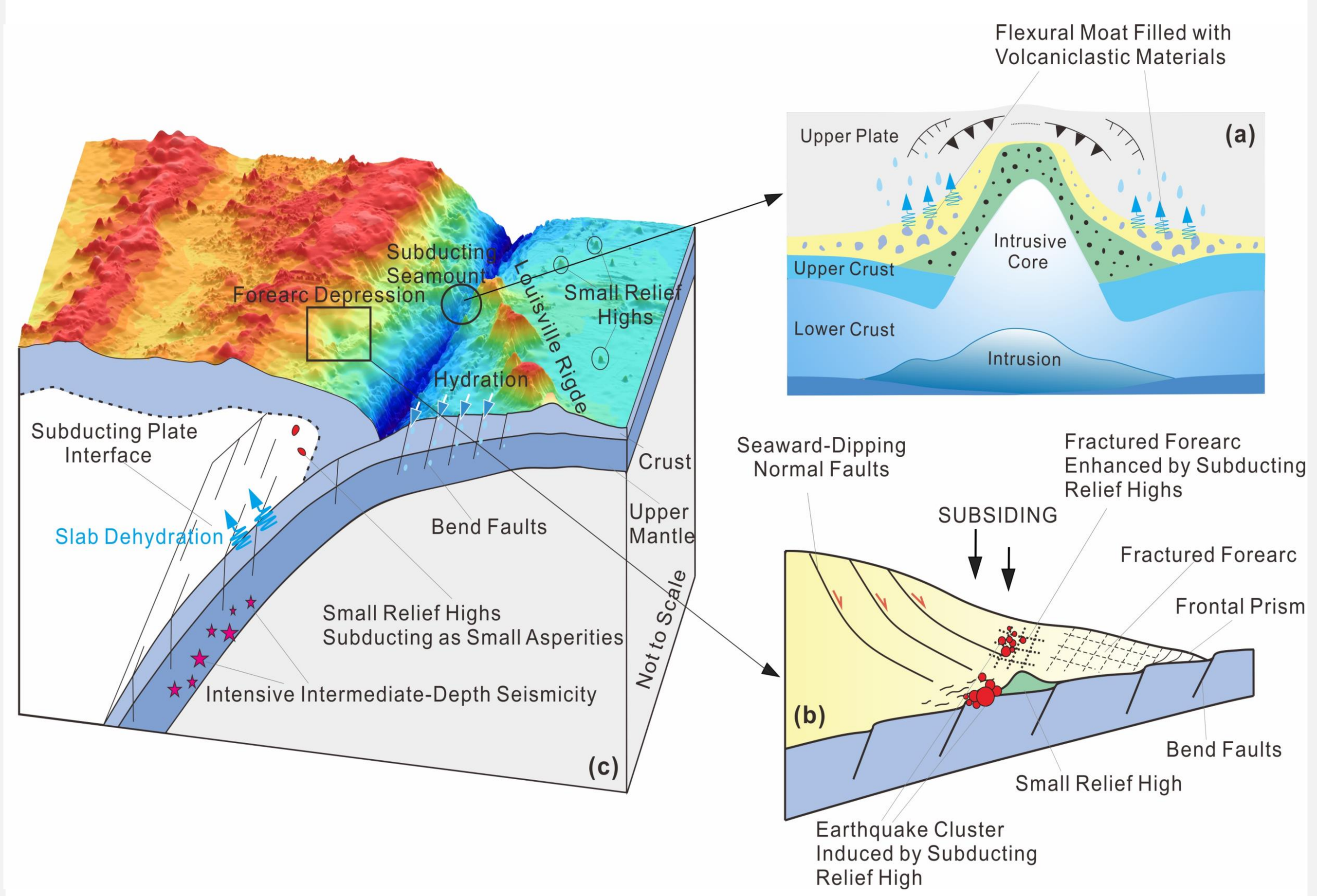

Figure 9: Conceptual model a) Mechanisms for seismic gap formation; (b) Basal erosion; and (c) Overview structure of the study area.

Basal Erosion to the South of the Seismic Gap

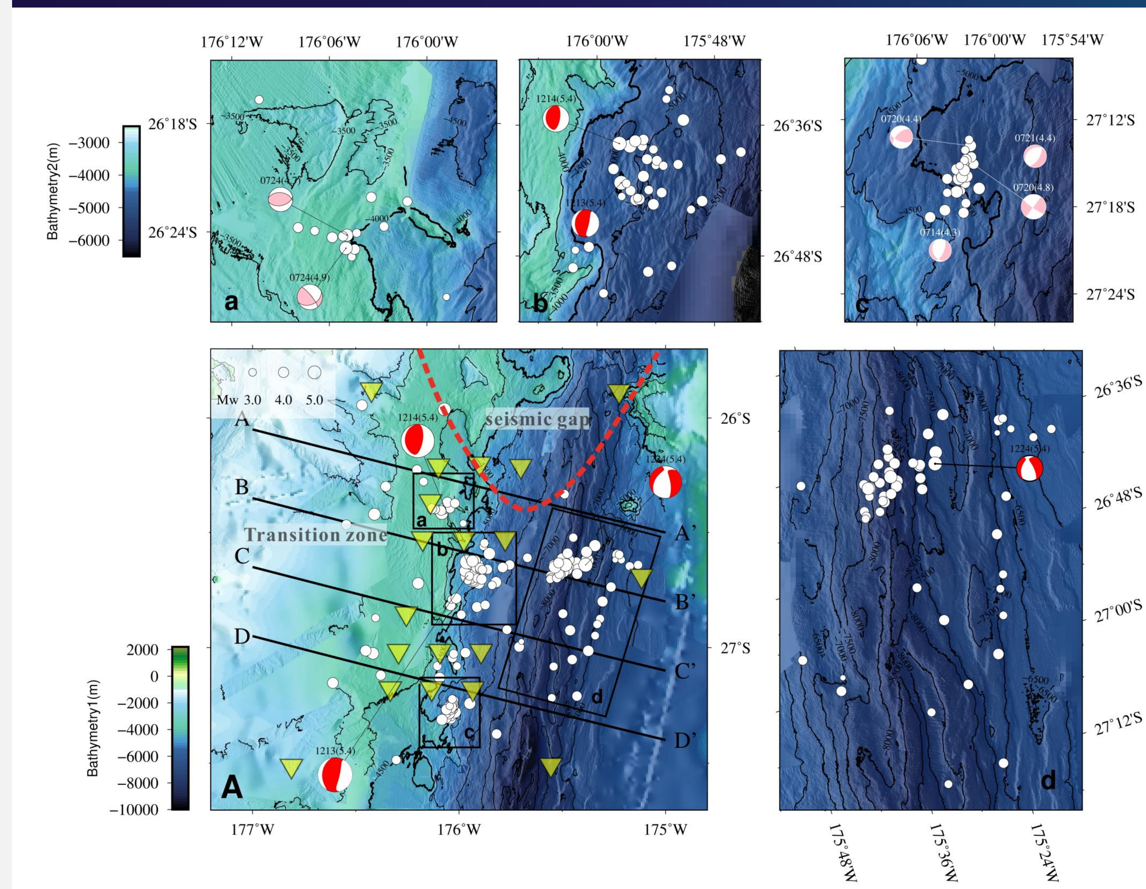

Figure 7: Distribution of local events in the seismic gap and the adjacent transition zone

- To the south of the seismic gap, seismicity distribution over the forearc shows a patchy characteristic dominated by three earthquake clusters that correspond well with morphological forearc depressions.

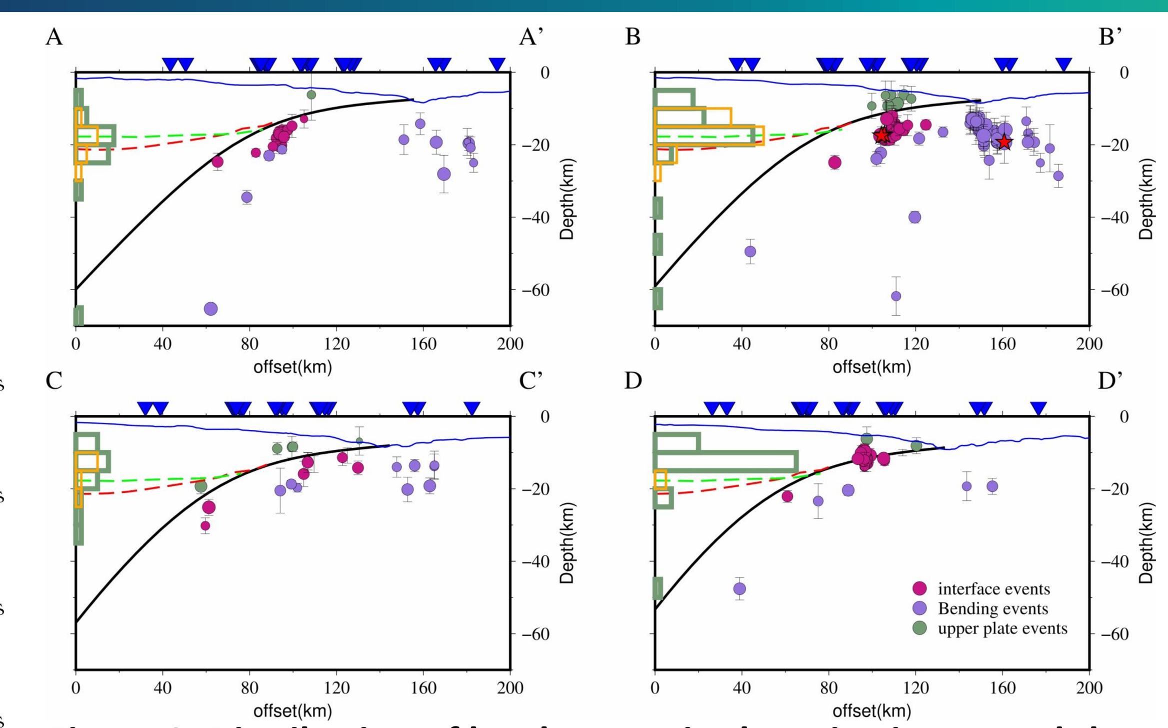

Figure 8: Distribution of local events in the seismic gap and the adjacent transition zone

- A deforming upper plate middle prism is revealed by upward-migrated aftershock sequences

➢ suggesting ongoing basal erosion.

Further Discussion are Welcome:
Contact: yinliu@geomar.de

References:

Contreras-Reyes, E., Grevemeyer, I., Watts, A. B., Planert, L., Flueh, E. R., & Peirce, C. (2010). Crustal intrusion beneath the Louisville hotspot track. Earth and Planetary Science Letters, 289(3–4), 323–333. https://doi.org/10.1016/j.epsl.2009.11.020