ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

ed560.stepup@u-paris.fr

Subject title: **Anatomy of sedimented Andaman Transform Fault and Ridge-Transform Intersection**

Advisor: **Singh, Satish, Professor, singh@ipgp.fr**
Devangan, Pawan, National Institute of Oceanography, Goa, India, pdewangan@nio.res.in
Host lab/Team:
IPGP- Marine Geosciences – UMR7154

Financing: IPG Paris/Université Paris Cité/NIO Goa

Presentation of the subject: (Maximum 2 pages)

Transform faults (TF) are one of the main plate boundaries on Earth. They accommodate lateral motion between two adjoining plates and hence, in principle, they neither create nor destroy any crust. On the continents, they pass through populated areas and can produce large earthquakes, causing devastation. Although we have a good understanding of this boundary on the surface and earthquake behaviour along them, but their deep structures remain poorly understood. In the oceans, they represent first order discontinuities segmenting oceans spreading ridges. As they separate younger lithospheres across them, we have good knowledge of their thermal structure, hence the rheology, which means one can predict earthquake locations, magnitudes and periodicity (McGuire et al., 2005). It was also found that 80% of energy along oceanic TFs are released aseismically, and the TFs are segmented into locked and aseismic regions (McGuire et al., 2012). Furthermore, their structures can be easily mapped using marine geophysical techniques (Gregory et al., 2021; Wang et al., 2022). Moreover, a recent study suggests that both extension and volcanism occur along TF and the crust is thickened at Ridge-Transform Intersections (RTI) (Grevemeyer et al., 2021). However, it is rather difficult to use the oceanic TF results to predict the seismic behaviour of TFs on the continent.

Andaman TF in the Andaman Sea is a unique active TF that separates oceanic crust on one side and continental/arc crust on the other side along a part of its section, which makes it an ideal candidate to study the link between oceanic and continental transform faults. Furthermore, the Andaman TF is sedimented and hence records the time evolution of the TF. We have access to both processed and raw seismic reflection data across the Andaman TF. The preliminary analysis of these data clearly shows the time evolution. Furthermore, we also have access to recently acquired bathymetry data (Yatheesh et al., 2021) along the TF, allowing to obtain 3D view of the TF. Furthermore, Directorate General of Hydrocarbon (DGH), India, has acquired extensive seismic reflection data covering the TF and the neighbouring RTIs, which could be available to this project.

In this project we propose to analyse and interpret these data along with the earthquake and bathymetry data. The preliminary analysis of the earthquake data suggest that strike-slip earthquakes predominantly occur along the ocean-ocean segment of the TF and normal earthquakes occur along the ocean-continent segment. We shall first start interpreting the depth converted processed seismic reflection data along with bathymetry and earthquake data to build the initial conceptual model of the TF and identify the region that require further advanced processing of the pre-stack data. For advanced processing, we first propose to extrapolate the surface seismic data to the seafloor, as if both sources and receivers were deployed on the seafloor (Arnulf et al., 2012). This technique allows to remove diffraction noise from the seafloor and brings out refraction arrivals close to zero offsets. We shall pick the first refraction arrivals to obtain a high-resolution seismic velocity using a tomographic approach and then perform full waveform inversion to obtain fine-scale velocity structures (Shipp and Singh, 2002). We might consider performing geodynamical modelling to understand the deformation (faulting and subsidence) along the TF (e.g., Tian et al., 2024). Finally, we shall interpret these results to understand the formation and evolution of the TF and RTI and then shed light on the neighbouring continental transform faults, such as the Sagaing Fault in Myanmar and the Sumatra Fault on mainland Sumatra.

A student with strong background in quantitative geophysics and with interest in geology and geodynamics are encouraged to apply. The student will receive training in advanced seismic data analysis (e.g., tomography, full waveform inversion), critical analysis of a variety of geological/geophysical data and writing of papers. As most of the data belongs to Indian organisations, the main data analysis will be performed at NIO Goa. The second part of the analysis and interpretation will be carried out at IPG Paris. We are in the process of exploring if the student can obtain a Dual (or Joint) PhD Degree from NIO and IPG Paris.

References:

Arnulf, A., Harding, A.J, Singh, S.C., Kent, G., Crawford, W. (2012). Fine-scale velocity structure of layer 2A from full waveform inversion of downward continued seismic reflection data at the Lucky Strike Volcano, Mid-Atlantic Ridge, *G.R.L.*, 39, L08303.

Gregory, E., Singh, S.C, Marjanovic, M., Wang, Z. (2021). Serpentinized peridotite versus thick mafic crust at the Romanche oceanic transform fault, *Geology*, https://doi.org/10.1130/G49097.1

Grevemeyer, I. et al. (2021). Extensional tectonics and two-stage crustal accretion at oceanic transform faults, *Nature*, 591, 402-407, https://www.nature.com/articles/s41586-021-03278-9

McGuire, J. et al. (2005). Foreshock sequences and short-term earthquake predictability on East Pacific Rise transform faults, *Nature*, 434, 457-461.

McGuire, J. et al. (2012). Variations in earthquake rupture properties along the Gofar transform fault, East Pacific Rise, *Nature Geoscience*, DOI: 10.1038/NGEO1454

Shipp, R.M. & Singh, S.C. (2002). Two-dimensional full wavefield inversion of wide-aperture marine seismic data, *Geophys. J. Int*, **151**, 324-344.

Tian, X. et al. (2024). Magmatism controls global oceanic transform fault topography, *Nature Communications*, 15, 1914. https://www.nature.com/articles/s41467-024-46197-9

Yatheesh, V. et al. (2021). Morphotectonic signatures and revised timing of Andaman Backarc Basin, Northeast Indian Ocean, *Tectonophysics,* 820, 229108. https://doi. org/10.1016/j.tecto.2021.229108

Wang, Z. Singh, S.C., Prigent, C., Gregory, E., Marjanovic, M. (2022). Deep hydration and lithospheric thinning at transform plate boundaries, *Nature Geoscience* **15**, 741-746. https://www.nature.com/articles/s41561-022-01003-3