Report of Research Activity

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Location: Earthquake Research Institute (ERI), University of Tokyo
Dates: July 2 – Aug 5 and Aug 21 – Sep 3, 2017
ERI host: Asst. Prof. Kiyoshi Baba

The purpose of my stay at ERI was to initiate a research collaboration regarding the Hawaiian plume and its interaction with the Pacific lithosphere during the time when the Hawaii-Emperor bend formed. The cause of this bend has been debated and two possible scenarios are being discussed. In the first scenario, the bend is due to a change in Pacific plate motion over the Hawaii plume, but the hotspot has additionally moved, such that the Emperor Chain is longer than it would be otherwise (Figure 1, left). In the second scenario, the bend is entirely due to a change in hotspot motion (Figure 1, right). The first scenario is highly favoured by Torsvik et al. (2017). However, here we intend to make predictions for both scenarios, which should become testable once suitable observation data are available. These predictions can be obtained through numerical models, and it is planned to collect observational data in a field experiment led by Prof. Baba and other ERI members, using ocean bottom seismometers and electro-magnetometers in the area of the bend.

The numerical models are being carried out with the ASPECT code; an example for setup and results for the Tristan hotspot is shown in Figure 2. As we discussed during the stay, both the flow field due to interaction of the plume with the lithosphere and large-scale mantle flow, and melt production are relevant model outputs:

- The time-integrated effect of mantle flow will lead to deformation, causing seismic and electric anisotropy. This can be predicted for the two scenarios and compared to observations to be obtained in the field experiment.
- Melting does not only occur above the plume, but also when mantle flows across an oceanic fracture zone from thicker to thinner lithosphere, or the plate moves over the mantle. Hence we expect that different plate motion scenarios will also lead to different melt distributions. This may not only cause surface volcanism but perhaps also lithospheric underplating, which could be detected in the field experiment.

To facilitate discussion, I gave two seminar talks at ERI: On July 27, I presented results of the numerical model obtained so far for other plumes (Tristan, Reunion, Iceland, Kerguelen). On August 24 I discussed the cause of the Hawaii-Emperor bend, under special consideration of the new results by Torsvik et al. (2017). On the first topic, I also presented seminars at Tohoku University's Research Center for Prediction of Earthquakes & Volcanic Eruptions on July 7th, and at the Earth-Life Science Institute at TITech on July 14th; the second topic I also presented informally during a visit to JAMSTEC's Department of Deep Earth Structure and Dynamics Research on 30th of August. Furthermore, I attended the IAG-IASPEI meeting in Kobe, giving a presentation on the relation of subduction and true polar wander in the IAG symposium on Earth rotation and geodynamics. During the first part of my stay at ERI I was accompanied by my daughter, who used the time mostly for digital painting, some of it inspired by Japanese scenery. An example is included in Figure 2.

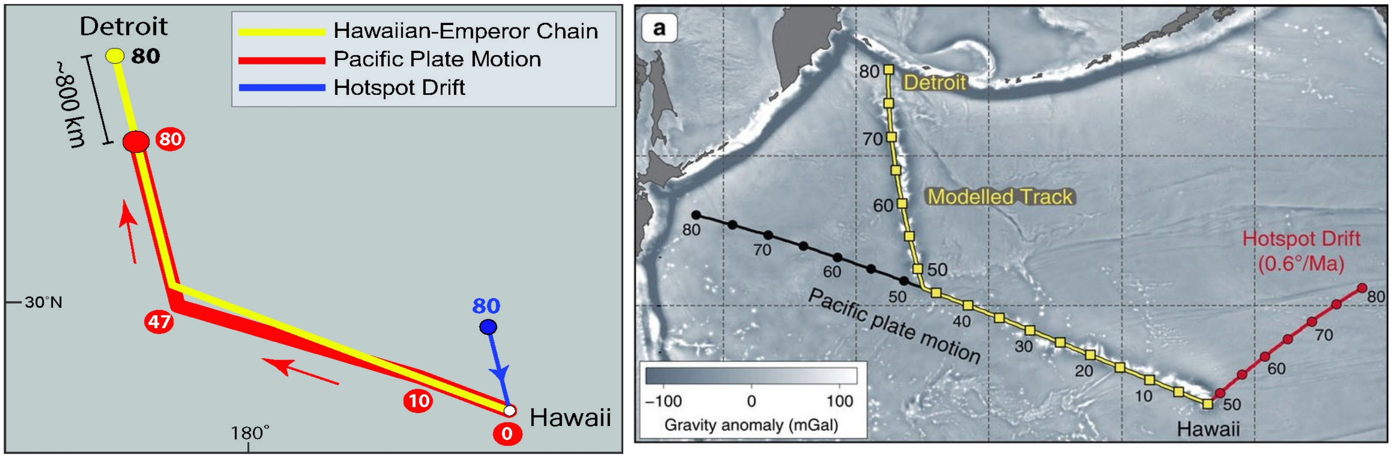

Figure 1: Two different scenarios for the formation of the Hawaii-Emperor Bend. Left panel: The bend between the Hawaiian chain (0-47 Ma) and the Emperor chain (47-80 Ma) is caused by a change in plate motion, and the hotspot has gradually drifted south- to southeastward. Cartoon created by Trond Torsvik. Right panel: Pacific plate motion has not changed, and the bend is due to the abrupt ceasing at 47 Ma of rapid hotspot motion before that. Figure from *Torsvik et al. (2017)*.

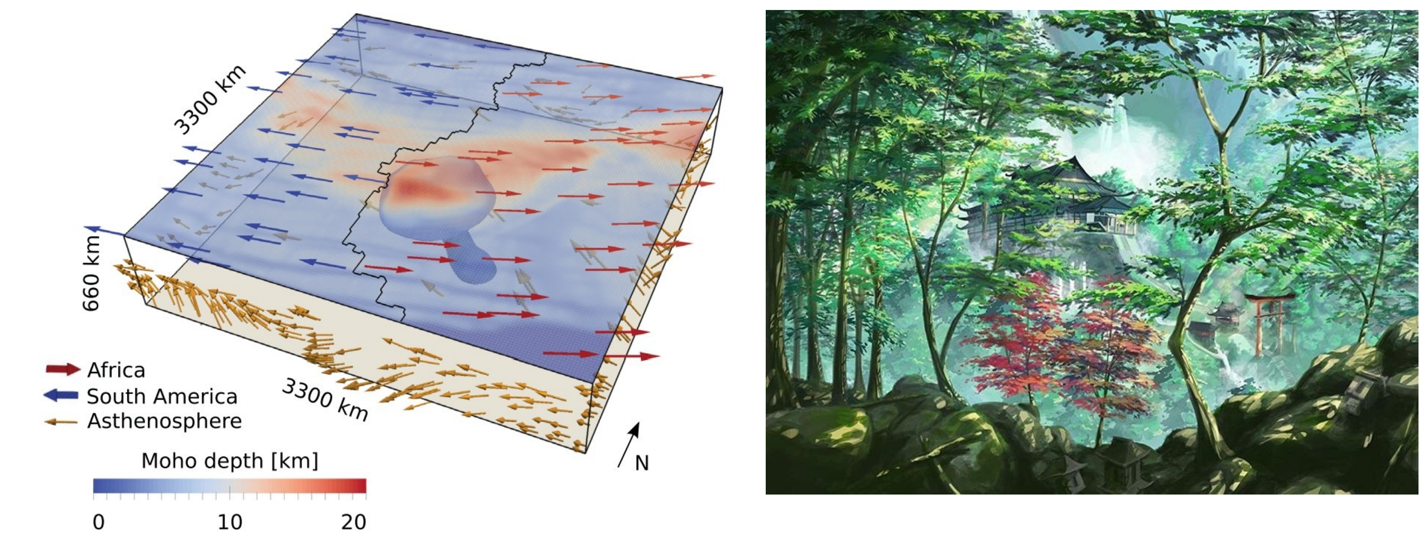

Figure 2: Left: Setup of numerical model, shown here for the Tristan hotspot. Plume influx is imposed at the bottom of the model box, large-scale mantle flow at its sides and the bottom elsewhere, and prescribed plate motions on top. The plume leads to melting and crust production (indicated here as variable Moho depth), thus creating a hotspot track. Figure from *Gassmöller et al. (2016)*. Right: Japan-inspired scenery painted by Alisha Steinberger at ERI.

Further reading:

Gassmöller, R., Dannberg, J., Bredow, E., Steinberger, B., and Torsvik, T.H. (2016), Major influence of plume-ridge interaction, lithosphere thickness variations and global mantle flow on hotspot volcanism - the example of Tristan, Geochem. Geophys. Geosyst., 17, 1454-1479.

Torsvik, T.H., Doubrovine, P.V., Steinberger, B., Gaina, C., Spakman, W., and Domeier, M. (2017), Pacific plate motion change caused the Hawaiian-Emperor Bend, Nat. Commun., 8, 15660.