Supplementary Material

1 BUOYANT FEATURES BUOYANCY CALCULATION ON EARTH

Buoyant features in the Pacific and Indian oceans are typically associated with a bathymetric rise of 1-2 km (Table S1). Using a typical plate cooling model and assuming isostasy (e.g. McKenzie et al., 2005), such excess topography requires an excess positive buoyancy of between $2.2{\cdot}10^6$ and $4.4{\cdot}10^6$ kg/m^2, irrespective of the age of the background plate. Excess buoyancy can also be calculated from estimates of buoyant feature crustal thickness (following Cloos, 1993; Gutscher et al., 2000; Rudaviciute, 2015) (Table S2). For the shown isostatic calculation, we used a density difference between the lithosphere and the mantle of 77 kg/m^3 and plate thickness of 79 km, typical of 66 Ma plate (following McKenzie et al., 2005). This yields a density difference of 29 and 58 kg/m^3 and excess positive buoyancy of $2.29{\cdot}10^6$ and $4.58{\cdot}10^6$ kg/m^2, for 1 and 2 km rise, respectively, similar to the range of buoyancies estimated using isostasy and plate cooling model above.

Our choice of ridge buoyancies for our high- and low-buoyancy ridge models was based on the calculation above. For our HB cases we used an excess positive buoyancy of $3.5{\cdot}10^6$ kg/m^2, typical of bathymetric rise of ∼1.5 km. However, we found that this value was already high for our HB_C_Young case and resulted in a ridge which was difficult to subduct using our models. We therefore chose to use an excess positive buoyancy of $1.75{\cdot}10^6$ kg/m^2, typical of bathymetric rise of ∼0.75 km, for our LB cases to examine the impact of ridges with low positive buoyancy.

To calculate ridge density we distribute the excess positive buoyancy across the 70 km thickness of the 'Old' plate, which yields a density difference of 25 and 50 kg/m^3. For the 45 km thick 'Young' plate models, these same buoyancies yield a density difference of 37.5 kg/m^3 and 75 kg/m^3. The highest positive buoyancy value for the HB_C_Young case results in a ridge which is lighter than the mantle. Our compilation also shows that typical ridge widths are between around 200-300 km (and wider for plateaus and other buoyant features), i.e. our modelled ridges are on the narrow end of this range.

Name	Plate	Surface area [km×km]	Crustal thickness [km]	Rise [km]	Age [Ma]	Reference
Agulhas Plateau	Indian	600×400	20	2.5	100	Parsiegla et al. (2008)
Benham Rise	Philippine	300×400	15	2	48-26	Barretto et al. (2020)
Caribbean Plateau	Caribbean	3500×1000	15-20	-	92-88	Whattam and Stern (2015)
Carnegie Ridge	Cocos (Farallon)	1350×300	19	2	23	Sallarès et al. (2005)
Cocos Ridge	Cocos (Farallon)	1000×250	21	2	25	Walther (2003)
Hess Rise	Pacific	550×1350	15-20	1-2	110-100	Bai et al. (2019)
Manihiki Plateau	Pacific	1000×800	15-25	2-3	125	Timm et al. (2011)
Nazca Ridge	Nazca (Farallon)	1000×200	20	1.5	65	Hampel (2002)
Ninetyeast Ridge	Indo-Australian	5600×200	-	2	77	Krishna et al. (2012)
Ogasawara Plateau	Pacific	300×600	10	2-3	80	Tsuji et al. (2007)
Ontong Java Plateau	Pacific	2300×1100	30	2.5	120	Korenaga (2005)
Roo Rise	Indo-Australian	200×250	11.5	2-2.5	125-155	Kopp et al. (2006)
Shatsky Rise	Pacific	2000×600	30	2-3	128-145	Zhang et al. (2017)
Tuamotu Plateau	Pacific	1150×1300	21	2-3	50	Patriat et al. (2002)

Table S1. Properties of buoyant features in the Pacific and Indian oceans.

	ρ [kg/m^3]	Thickness [km] Plate	1 km rise	2 km rise
Water	1000	2	1	0
Crust	3000	7	13	19
Mantle lithosphere	3377	72	66	60
Asthenosphere	3300	0	1	2
Plate ρ (crust and lithosphere) [kg/m^3]		3344	3315	3286
Ridge-plate $\Delta\rho$ [kg/m^3]			29	58

Table S2. Isostatical calculation for 1 and 2 km bathymetric rise for 66 Ma oceanic plate. Plate thickness (lithosphere and crust) assumed to be constant. Mantle lithosphere density and depth following McKenzie et al. (2005).

REFERENCES

Bai, Y., Gui, Z., Li, M., Dong, D., Wu, S., and Wang, Z. (2019). Crustal thickness over the NW Pacific and its tectonic implications. *Journal of Asian Earth Sciences* 185, 104050. doi:10.1016/j.jseaes.2019.104050

Barretto, J., Wood, R., and Milsom, J. (2020). Benham Rise unveiled: Morphology and structure of an Eocene large igneous province in the West Philippine Basin. *Marine Geology* 419, 106052. doi:10.1016/j.margeo.2019.106052

Cloos, M. (1993). Lithospheric buoyancy and collisional orogenesis: subduction of oceanic plateaus, continental margins, island arcs, spreading ridges, and seamounts. *Geological Society of America Bulletin* 105, 715–737. doi:10.1130/0016-7606(1993)105⟨0715:LBACOS⟩2.3.CO;2

Gutscher, M.-A., Spakman, W., Bijwaard, H., and Engdahl, E. R. (2000). Geodynamics of flat subduction: Seismicity and tomographic constraints from the Andean margin. *Tectonics* 19, 814–833. doi:10.1029/1999TC001152

Hampel, A. (2002). The migration history of the Nazca Ridge along the Peruvian active margin: A re-evaluation. *Earth and Planetary Science Letters* 203, 665–679. doi:10.1016/S0012-821X(02)00859-2

Kopp, H., Flueh, E. R., Petersen, C. J., Weinrebe, W., Wittwer, A., and Scientists, M. (2006). The Java margin revisited: Evidence for subduction erosion off Java. *Earth and Planetary Science Letters* 242, 130–142. doi:10.1016/j.epsl.2005.11.036

Korenaga, J. (2005). Why did not the Ontong Java Plateau form subaerially? *Earth and Planetary Science Letters* 234, 385–399. doi:10.1016/j.epsl.2005.03.011

Krishna, K. S., Abraham, H., Sager, W. W., Pringle, M. S., Frey, F., Gopala Rao, D., et al. (2012). Tectonics of the Ninetyeast Ridge derived from spreading records in adjacent oceanic basins and age constraints of the ridge. *Journal of Geophysical Research: Solid Earth* 117, 1–19. doi:10.1029/2011JB008805

McKenzie, D., Jackson, J., and Priestley, K. (2005). Thermal structure of oceanic and continental lithosphere. *Earth and Planetary Science Letters* 233, 337–349. doi:10.1016/j.epsl.2005.02.005

Parsiegla, N., Gohl, K., and Uenzelmann-neben, G. (2008). The Agulhas Plateau: Structure and evolution of a Large Igneous Province. *Geophysical Journal International* 174, 336–350. doi:10.1111/j.1365-246X.2008.03808.x

Patriat, M., Klingelhoefer, F., Aslanian, D., Contrucci, I., Gutscher, M. A., Talandier, J., et al. (2002). Deep crustal structure of the Tuamotu plateau and Tahiti (French Polynesia) based on seismic refraction data. *Geophysical Research Letters* 29. doi:10.1029/2001GL013913

Rudaviciute, K. (2015). *On the role of variable buoyant ridge width and obliquity on subduction*. Msci thesis, Imperial College London, London

Sallarès, V., Charvis, P., Flueh, E. R., Bialas, J., Agudelo, W., Anglade, A., et al. (2005). Seismic structure of the Carnegie ridge and the nature of the Galápagos hotspot. *Geophysical Journal International* 161, 763–788. doi:10.1111/j.1365-246X.2005.02592.x

Timm, C., Hoernle, K., Werner, R., Hauff, F., van den Bogaard, P., Michael, P., et al. (2011). Age and geochemistry of the oceanic Manihiki Plateau, SW Pacific: New evidence for a plume origin. *Earth and Planetary Science Letters* 304, 135–146. doi:10.1016/j.epsl.2011.01.025

Tsuji, T., Nakamura, Y., Tokuyama, H., Coffin, M. F., and Koda, K. (2007). Oceanic crust and Moho of the Pacific Plate in the eastern Ogasawara Plateau region. *Island Arc* 16, 361–373. doi:10.1111/j.1440-1738.2007.00589.x

Walther, C. H. E. (2003). The crustal structure of the Cocos ridge off Costa Rica. *Journal of Geophysical Research: Solid Earth* 108, 1–21. doi:10.1029/2001jb000888

Whattam, S. A. and Stern, R. J. (2015). Late Cretaceous plume-induced subduction initiation along the southern margin of the Caribbean and NW South America: The first documented example with implications for the onset of plate tectonics. *Gondwana Research* 27, 38–63. doi:10.1016/j.gr.2014.07.011

Zhang, J., Sager, W. W., and Durkin, W. J. (2017). Morphology of Shatsky Rise oceanic plateau from high resolution bathymetry. *Marine Geophysical Research* 38, 169–185. doi:10.1007/s11001-016-9272-5