TECHNICAL RESPONSE

OCEANOGRAPHY

Response to Comment on "Glacial cycles drive variations in the production of oceanic crust"

John W. Crowley,[1,2]* Richard F. Katz,[1]† Peter Huybers,[2] Charles H. Langmuir,[2] Sung-Hyun Park[3]†

Goff comments that faulting is important for creation of abyssal hills and is the dominant process at slow-spreading ridges. We respond that faulting is indeed important but cannot alone explain the bathymetric signal predicted by our models and observed at the Australian-Antarctic Ridge. We show that for intermediate- to fast-spreading ridges, abyssal hill spacing is consistent with the periodicity of the obliquity cycle.

We appreciate Goff's Comment (*1*) and the opportunity to reemphasize a point that may have been lost to some readers of our paper [Crowley *et al.* (*2*)]: Faulting is an important and ubiquitous process in abyssal hill creation, particularly at slow-spreading ridges. However, our paper also shows, through modeling and observations, that sea level has a substantial effect on melt delivery to ocean ridges and an influence on the fabric of the sea floor. The greater importance of faulting at slow-spreading ridges led us to consider bathymetry at a faster-spreading ridge, where the subaxial lithosphere is thin and the magma supply is robust.

Because of the balance between faulting and magma supply, intermediate- and faster-spreading ridges offer the best opportunity to detect crustal thickness variations driven by glacial cycles. Goff's figure can be used to emphasize this point. In Fig. 1 here, we add a line to his figure 1 indicating the predominant spacing that would be produced by 40,000-year periodicity. At slow spreading rates, there is no correspondence between this line and the spacing data. At intermediate and fast spreading rates, however, both the absolute value and the relative increase in spacing are in accord with the Milankovitch periodicity. Goff also notes this slight increase. As he states, "no other plausible explanation for this observation has been offered." It would be premature, however, to rule out other speculative mechanisms that might relate fault-generated bathymetry to sea-level change.

Although we are thus in overall agreement with the Comment, it should be noted that the characteristic width determined by the von Kármán spectral model may not be an apt statistical measure of the variability in bathymetry. As noted by Goff and Jordan (*3*), the von Kármán spectral model assumes power-law scaling that rolls off to white at a corner frequency and does not provide a very good approximation in the presence of periodicities. Furthermore, our detection of excess spectral energy at Milankovitch bands involves prewhitening, which in this case systematically deemphasizes lower-frequency contributions. Those lower-frequency contributions are expected to influence characteristic width estimates and cause some disconnect between our results and Goff's results.

Finally, it should be noted that faulting may be mechanically coupled with temporal variations in magma supply. Ito and Behn (*4*) found that fault spacing depends on the periodicity of cycles between magmatic and tectonic extension at ~100,000 years and greater periods. If this is the case, the admittance structure from our paper would need to be modified. Ultimately, a more complete model is needed that consistently combines faulting, glacially induced variations in magma supply, and variations caused by other processes (e.g., mantle fertility or instabilities in the melting regime).

We are in broad agreement with Goff's Comment that faulting is dominant at slow-spreading ridges and that the hypothesis of sea-level–induced changes in magma production is currently the most plausible explanation for spectral energy at Milankovitch frequencies found in bathymetry at faster-spreading ridges.

[1]Department of Earth Sciences, University of Oxford, Oxford, UK. [2]Department of Earth and Planetary Sciences, Harvard University, Cambridge, USA. [3]Division of Polar Earth-System Sciences, Korea Polar Research Institute, Incheon, Korea. *Present address: Engineering Seismology Group Canada, Kingston, Canada. **†Corresponding author. E-mail: richard.katz@earth.ox.ac.uk (R.F.K.); shpark314@kopri.re.kr (S.-H.P.)**

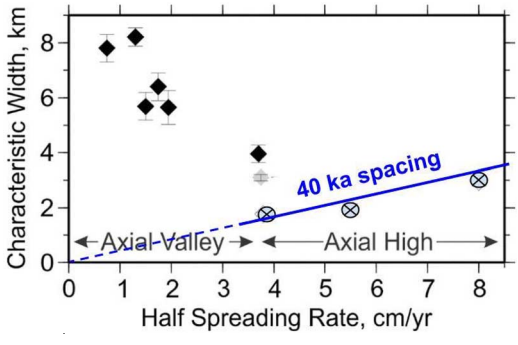

Fig. 1. Characteristic width of abyssal hills versus half-spreading rate. Adapted from figure 1 of Goff's Comment. The line indicates the predominant spacing that would be produced by a 40,000-year periodicity.

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