Global (latitudinal) variation in submarine channel sinuosity

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Peacock et al. (2012) propose that submarine channel sinuosity correlates with latitude, and conclude that this correlation results from modification of the turbidity flow field by the Coriolis force. However, a closer look at the data and simple physical arguments suggest that slope and the nature of sediment supply cannot be discounted as the major factors controlling the development of submarine channel sinuosity. [We use the following abbreviations herein: sinuosity, S — valley slope, S — channel slope, θ — latitude, F — Coriolis force, F — centrifugal force, U — flow velocity, r — radius of curvature, R — Rossby number (with length scale r)].

(1) As F and F act on all channel bends, not just the most sinuous ones, restricting the data set to peak values is not justified. Statistical analysis and scatterplots of S, θ, and F for individual bends suggest that there is a link between all three variables (Table 1, Fig. 1). Although neither Pearson R, nor the R-squared values are large for these linear regressions, the correlations are all statistically significant (Table 1). Thus, this more complete data set does not contradict the idea that S has an influence over θ; nor does a correlation between θ and F necessarily point to a direct causal relationship.

(2) In both the Amazon (Pirmez and Flood, 1995) and Zaire (Babonneau et al., 2002) channels, σ is variable and related to S. Including other systems would weaken the correlation between θ and peak σ; for example, half-wave-length sinuosities in channels of the Danube Fan (Popescu et al., 2001) and in Knight Inlet, British Columbia (Conway et al., 2012) reach a maximum value of 4.7 and 3.6, respectively. These channels are located at ~44°N and 51°N, questioning the link between θ and σ.

(3) At very high and low values of S, high σ cannot develop because instabilities are suppressed and S approaches zero, respectively. The underlying assumption of investigating the influence of S on peak σ (Peacock et al., 2012) is that every system has a peak σ value that corresponds to an optimal S for sinuosity development. However, it is likely that many of these channel segments are too steep or too gently dipping to have a peak σ representative of the optimal S; and the data in Clark and Pickering (1996) are too noisy for reliably identifying this value.

(4) The potential effects of F on σ could be better understood if parameters other than θ were kept relatively constant. Comparing systems with a large variability in slope, tectonic setting, sediment source, and dominant grain size introduces additional factors likely to influence the variation in σ. Channels that are fed by large rivers tend to have larger sinuosities (Fig. 1); and the lack of such systems at high latitudes probably causes the weak correlation between θ and σ (Table 1).

(5) The impact of F on turbidity currents flowing through sinuous submarine channels can be measured through the Ro, the ratio between F and F. Taking θ = 75° as an extreme, and r = 2000 m, typical of many submarine channels, gives Ro = 7.1 for U = 2 m/s. Thus, for this kind of flow, F is seven times smaller than the centrifugal force, even at high latitudes. F becomes dominant for slow-moving flows in the largest bends of very wide channels, such as the Northwest Atlantic Mid-Ocean Channel, but in typical submarine channels it is unlikely to affect the higher-density, faster-moving lower parts of gravity flows, which are probably driving the development of sinuosity (Pirmez and Imran, 2003).

REFERENCES CITED