Forum Comment

doi:10.1130/G33548C.1

Global (latitudinal) variation in submarine channel sinuosity

Zoltán Sylvester[1], Carlos Pirmez[2], Alessandro Cantelli[1], and Zane R. Jobe[1]
[1]Shell Research and Development, Houston, Texas 77025, USA
[2]Shell Nigeria E&P Company, Lagos, Nigeria

Peakall 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: σ—sinuosity, S_v—valley slope, S_c—channel slope, θ—latitude, F_c—Coriolis force, F_{cf}—centrifugal force, U—flow velocity, r—radius of curvature, Ro_r—Rossby number (with length scale r)].

(1) As F_c and F_{cf} act on all channel bends, not just the most sinuous ones, restricting the data set to peak σ values is not justified. Statistical analysis and scatterplots of σ, S_v, and θ 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_v has an influence over σ; nor does a correlation between θ and σ 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_v. Including other systems would weaken the correlation between θ and peak σ; for example, half-wavelength 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_v, high σ cannot develop because instabilities are suppressed and S_c approaches zero, respectively. The underlying assumption of investigating the influence of S_v on peak σ (Peakall et al., 2012) is that every system has a peak σ value that corresponds to an S_v optimal 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_v; and the data in Clark and Pickering (1996) are too noisy for reliably identifying this value.

(4) The potential effects of F_c 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_c on turbidity currents flowing through sinuous submarine channels can be measured through the Ro_r, the ratio between F_{cf} and F_c. Taking θ = 75° as an extreme, and r = 2000 m, typical of many submarine channels, gives Ro_r = 7.1 for U = 2 m/s. Thus, for this kind of flow, F_c is seven times smaller than the centrifugal force, even at high latitudes. F_c 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).

TABLE 1. STRENGTH AND SIGNIFICANCE OF LINEAR CORRELATION BETWEEN θ, σ, AND Sv

	n	Pearson R	R^2	p-value
Latitude (θ) and sinuosity (σ)	292	−0.347	0.121	$<10^{-6}$
Slope (S_v) and sinuosity (σ)	268	−0.277	0.077	10^{-6}
Latitude (θ) and slope (S_v)	268	0.203	0.041	0.00045

Note: Data from Clark and Pickering (1996), Pirmez and Flood (1995), and σ values measured from maps in Popescu et al. (2001). We calculated p-values using the bootstrap technique (resampling with replacement), as none of the variables is normally distributed and parametric methods are not applicable. n = number of data points.

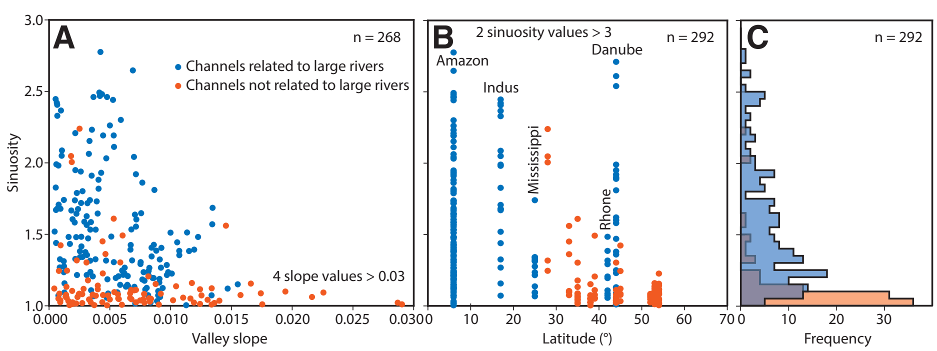

Figure 1. A: Scatterplot of sinuosity versus valley slope. B: Scatterplot of sinuosity versus latitude. C: Histogram of sinuosity values. Data sources same as in Table 1. Blue and orange colors show whether the channel is related to a large river (Indus, Mississippi, Rhone, Danube, and Amazon channels) or not (the rest of the data points).

REFERENCES CITED

Babonneau, N., Savoye, B., Cremer, M., and Klein, B., 2002, Morphology and architecture of the present canyon and channel system of the Zaire deep-sea fan: Marine and Petroleum Geology, v. 19, p. 445–467, doi:10.1016/S0264-8172(02)00009-0.

Clark, J.D., and Pickering, K.T., 1996, Submarine Channels: Process and Architecture: London, Vallis Press, 231 p.

Conway, K.W., Barrie, J.V., Picard, K., and Bornhold, B.D., 2012, Submarine channel evolution: Active channels in fjords, British Columbia, Canada: Geo-Marine Letters, doi:10.1007/s00367-012-0280-4.

Peakall, J., Kane, I.A., Masson, D.G., Keevil, G., McCaffrey, W., and Corney, R., 2012, Global (latitudinal) variation in submarine channel sinuosity: Geology, v. 40, p. 11–14, doi:10.1130/G32295.1.

Pirmez, C., and Flood, R., 1995, Morphology and structure of Amazon Channel: Proceedings of the Ocean Drilling Program, Initial reports: College Station, Texas, Ocean Drilling Program, v. 155, p. 23–45.

Pirmez, C., and Imran, J., 2003, Reconstruction of turbidity currents in Amazon Channel: Marine and Petroleum Geology, v. 20, p. 823–849, doi:10.1016/j.marpetgeo.2003.03.005.

Popescu, I., Lericolais, G., Panin, N., Wong, H., and Droz, L., 2001, Late Quaternary channel avulsions on the Danube deep-sea fan, Black Sea: Marine Geology, v. 179, p. 25–37, doi:10.1016/S0025-3227(01)00197-9.