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Inferring surface deformation from the form and slope of large-scale river basins : examples from Mars and the Earth.

S. Castelltort (1) and S. Pochat (2)

(1) ETH zurich, Department of Earth Sciences, Zurich, Switzerland (sebastien.castelltort@erdw.ethz.ch, +41 1 632 1422), (2) LPG-UMR 6112, Université de Nantes, Nantes, France, (stephane.pochat@univ-nantes.fr, +33 2 51 12 52 68)

By studying nearly un-dissected surfaces on Earth it has been shown that there exists a relationship between the slope of a given surface prior to drainage initiation and the form of the river basin that such a surface develops. Essentially, steeper slopes develop narrower basins. Thus, in a dissected river basin, if remains of the initial surface are preserved and one can estimate their current slope, it is theoretically possible to tell whether the river basin has been tilted, or deformed, since its initial development.

For example, if a river basin acquires its form on a very gentle slope and is subsequently tilted, its form will not be in equilibrium with its new steeper slope.

The shape of a basin can be measured by its width to length aspect ratio. However this requires enclosing a basin having a possibly complex shape within a simple rectangle and there is no unique way of doing so.

Instead, we employ the *convergence angle* of river basins, defined in Castelltort et al. (submitted) as the angle α that determines the width-to-length (respectively W and L) aspect ratio of the basin following $\tan\alpha = W/2L$. To measure the convergence angle α we use a method based on calculating *source-outlet vectors*. For every point in a drainage basin, the source-outlet vector is defined as the vector between the current pixel and the global basin outlet. In a rectangular basin, the convergence angle is such that half of the source-outlet vectors possess an azimuth given between +α and –α of the mean basin azimuth. The convergence angle is thus given by a fraction of 0.674 of the standard deviation σ in order to represent half of the data (equivalent to a 50% confidence interval). We compute the standard deviation of the azimuths of all the source-outlet vectors for each basin to obtain the convergence angle according to $\alpha = 0.674\sigma$. The convergence angle is thus a characteristic measure of how wide or narrow a basin is. A large and a small convergence angle correspond respectively to a wide and a narrow basin. The advantage of this method is that it gives a one-number measure of basin form for basins having very different and complex boundaries, and that it can be easily implemented with digital datasets.

The regional slope is computed as the slope of a plane fitted (least squares) to the topography. Here the slope of a best fit plane through the topography is considered the simplest way to represent the steepness of a weakly dissected river basin. Excessively dissected basins (poor correlation between best fit plane and actual surface) are excluded from the analysis.

By comparing surfaces taken from deformed areas in Earth orogenic belts (SRTM1 and SRTM3) with tilted surfaces on Mars (MOLA) we show that the surface of Mars has probably been tectonically quiet since the development of its river basins.