Modeling the shortening history of a fault-tip fold using structural and geomorphic records of deformation

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Yakeng fold

At the surface, the Yakeng anticline manifests as a gentle endocore resulting from the folding of a large-scale, south-dipping albite tectonic (Ts). This structural surface is generally well preserved, although south-flowing rivers dissect it in a number of locations, forming steep, narrow gorges. One of these rivers, (east Qilaiing river) formed and abandoned a partially preserved albite tectonic (Ts). Since then, ongoing deformation has folded and uplifted Ts, bringing fault 31.5 below the modern river (Pousson, 2003).

Seismic imaging (Huben-Pernot et al., 2001) means that the width of the structural fold is more than twice that of the emergent Ts, because the latter is buried under sediments on the outer flanks of the anticline. At the depth of amplification of fission gases decreases downwards, consistent with the geometry of a fault-tip fold growing above a 5-km-deep basin depression (Klein, 2001). In the overpass of the Otjo-Maseke Jáchima formation, Giovani-Mene and Suzan (2000), using measurements of thickness relief area, estimated the mean finite shortening to be 1.2, and showed that folded reflections L3 to L4 are protective.

Based on the observed original geometries of the synorogenic synclines, we estimate the respective magnitudes of cumulative shortening and use these values to estimate deformation models parameters consistent with the observed finite geometry. The resulting folding model is used to estimate the cumulative shortening experienced by the geomorphic markers Ts and Ts.

Anjihai fold

The surface fold is about 7 km wide, and exposes conglomerates of the Kiny

Folds geometry

* Synthetic data
* Geometric surveys

Time constraints:

* Magnetostratigraphy
* OBS dating
* Cosmogenic dating
* Radiocarbon dating

Sedimentary rates

Our geometric modeling does not directly provide timing information. It does, however, constrain cumulative shortening as a function of stratigraphic depth, which can then be converted to ages using the recent magnetostratigraphic study of Groen et al. (2002) and Charreau (2006). These studies show evidence for remarkably constant sedimentation rates over the past 16 My. Between the modern surface and the synorogenic fold, the stratigraphic section is constrained by seismic data (Deb et al., 2000), average sedimentation rates are very similar to the respective magnetostratigraphic data since 11.5 My. The available magnetostratigraphic data from the study area (sedimentation rate 0.1-0.5 mm/yr at Ts and 0.5-0.9 mm/yr at Jingu-Hji) may be extrapolated over millions of years, possibly to 15.4 My. Plisseen times, consistent with sedimentary rates of 0.05 mm/yr near Yakeng and 0.27 mm/yr near Anjihai.

Discussion

The study of these data examples highlights some simple interactions between folding, sedimentation and erosion. Topographic relief can only occur where and when tectonic uplift is faster than sedimentation. The surface fold is a function of the spatial distribution of uplift. As long as the hydrographic system has enough erosive power to weep sediment back and forth, the system seeks to restore equilibrium in a narrow gorge because it does not have enough stream power to erode identically the uplifted rocks, relief builds up above the core of the anticline (c), producing something similar to the current situation of Yakeng. Eventually, the fold ridge is expected to undergo secondary erosion driven by its own relief, as observed in the exposed core of Anjihai.

Topographic relief width is a function of the spatial distribution of uplift, and the sedimentation rates. Shortly after the initial relief of the fold width should equal the width of the area where the uplift rate is greater than the sedimentation rate. Using our parameterized deformation models for the Yakeng and Anjihai folds, we can plot this predicted emergent width as a function of the ratio between the shortening and sedimentation rates. The ratio for the Anjihai fold with similar magnetostratigraphic sedimentation rates yields first-order estimate of the mean shortening rate across shelf rivers (Xu, 1.04 Myr at Anjihai and 1.55 Myr at Yakeng). This ratio is much smaller than the long-term average. While the precise consistency of the fold-width method will depend on our ability to understand the complex interaction of the post-emergent sedimentation regime, surface fold width stands out as a remarkably sensitive measurement, governed as it is by competition between two important geomorphic processes.