Structural concepts in extensional basin interpretation

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Lithospheric stretching is generally considered to be one of the most important mechanisms of subsidence and basin formation, especially at passive continental margins. In the upper part of the crust, the stretching is accomplished by normal faulting. Extensions of the magnitude proposed for typical basins (50-100%) require specific and unusual fault geometry, which may play a key role throughout subsequent basin development. We suggest that the structural concepts of large-extension faulting should be routinely applied in seismic interpretation of extensional basins.

The structural history of extensional basins is most conveniently considered in three phases:-

1.) Extensional Phase - The main extensional structures are of two types; a set of rotational, planar, or listric normal faults, and a perpendicular set of sub-vertical transfer faults. The normal faults are straight to gently curved, have low to moderate dips, and bound tilted basement blocks and syn-rift fill (with poor seismic data the dip of the syn-rift is commonly the best guide to fault orientation and position). The faults commonly dip the same way across the whole basin, but they may change dip across transfer faults. Large displacements (>1 km) are possible, making it unlikely that such faults die out over a short distance. However, they will generally terminate against transfer faults, which are accommodation structures analogous to oceanic transform faults. At rift-fill level, displacement across a transfer fault varies along its length, giving rise to discontinuous traces and unusual geometry (e.g., hinge faults). Seismic sections oblique to normal and transfer faults may give rise to unusual geometry, whose interpretation would be difficult without application of extensional structural concepts.

2.) Subsidence Phase - Subsistence follows extension owing to cooling of the stretched lithosphere. During subsidence, displacement are essentially vertical, smoothly varying, and relatively small, giving rise to the closely spaced steep faults with less than 1 km displacement that are typical of so many basins. These faults will generally be down-to-basin and irrotational. They tend to be uniformly distributed throughout the basin, but reactivation of the extensional structures during subsidence may control their distribution in detail.

3.) Later Reactivation - At any stage in the basin history, a change in tectonic setting may superimpose structures on an extensional basin. Most importantly, the major normal and transfer faults developed during extension provide zones of weakness through much of the crust. Reactivation of these zones of weakness controls the style, orientation, and location of a wide variety of later structures. For example, early normal faults may be reactivated as reverse faults, and subsequent strike-slip movement on transfer faults may produce a range of wrench-style structures in the overlying sequence.