Sedimentation Aided Salt Flow, Fold Growth, and Faulting: Chinook and Cascade Folds, Deepwater Gulf of Mexico

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High-resolution 3D seismic imaging allows detailed reconstruction of the relationship between fold development, deep salt flow, and crestal faulting of the Chinook and Cascade folds in the deepwater Gulf of Mexico. Using 3-D seismic and biostratigraphic data, we have found the following events: (1) short wavelength (~2300m), small amplitude folds (~540m) within the upper Cretaceous and upper Jurassic stratigraphic sequences develop early, no later than the late Jurassic; (2) longer wavelength and larger amplitude fold growth, starting in the early Cretaceous that accommodated, at most, minor shortening; anticlinal hinges were fixed relative to each other at this time; (3) subsequent periods of increased sedimentation are matched by increased fold growth and fault slip. After the early Cretaceous, the development of the Cascade and Chinook structures was continuous, punctuated by episodes of accelerated growth during the middle Miocene at rates of 337 and 235 m/Ma in the Cascade fold and 203 and 230 m/Ma in the Chinook fold. The last event of accelerated growth occurred during the late Miocene in both the Cascade (1038 m/Ma) and Chinook (1189 m/Ma) folds. Although limb tilt rates varied through fold growth, the highest rates also occurred during the middle Miocene. Crestal faults display maximum slip rates of 88 and 90 m/Ma in the mid Miocene. Although the earliest small-wavelength folds are likely contractional, the amount of shortening was very small during later, longer wavelength fold growth. Fold amplification must have involved movement of salt from the syncline and into the anticlines in excess of what was required for purely contractional folding. Normal faulting is a response to bed-extension accompanying folding and salt movement. A large fault within the Chinook fold that strikes both normal to the fold axis and parallel to the presumed regional shortening direction (NW-SE) has maximum offset deep in the fold diminishing upward - implying the greatest axis parallel (NE-SW) extension in the oldest layers. In contrast, faults that extend the section parallel to the regional shortening direction lose offset both upward and downward from their maximum, implying that shortening parallel extension is small deep in the fold, consistent with outer arc extension during folding.