Uplift, Subsidence, and Reactivation of the Sabine Uplift Due to Changes in Flexural Compensation Between Different Crustal Blocks: Implications for the Burial and Thermal History of the Haynesville Shale

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Flexural isostasy between crustal blocks of different buoyancy can explain changes in freeboard of the Sabine Uplift relative to the adjacent East Texas Basin and North Louisiana Salt Basin during the Jurassic and Cretaceous. The model correctly predicts the thickness of Lou Ann salt deposits and disappearance of the Sabine Uplift as a structural high in the Late Jurassic. Early uplift of the Sabine region is caused by underlying buoyant (thick) crust compensated at short wavelengths by Airy isostasy or flexure of a weak lithosphere. As the lithosphere cools and strengths following formation of the Gulf margin, buoyancy differences between adjacent crustal blocks are compensated at longer wavelengths and the Sabine Uplift is dragged down by less buoyant (thinner) crustal blocks. Reactivation of the Sabine Uplift in the mid-Cretaceous is consistent with partial relaxation of accumulated stress which allows lateral buoyancy differences to compensate at shorter wavelengths. Thus buoyant crustal blocks are uplifted and less buoyant blocks experience subsidence. Flexural model results are consistent with the stratigraphy of the East Texas Basin - Sabine Uplift - North Louisiana Salt Basin region during the Cretaceous and Early Tertiary including the amount and areal extent of erosional truncation of Lower Cretaceous units. Possible mechanisms for relaxation of continental lithosphere are thermal rejuvenation, horizontal in-plane stress, viscous relaxation, and extensional faulting. Gravity and total tectonic subsidence interpretations agree that the Sabine Uplift is underlain by thicker crust. Recent heat flow measurements also are consistent with lateral variations in crustal thickness and/or crustal composition. Heat flow values of 82 +/- 6 mW/m2 a few kilometers east of the Texas-Louisiana Border and approximately 40 km south of Shreveport, Louisiana (Negraru et al., 2008) are higher than the surrounding region and much higher than the continental average of 50 mW/m2. Thermal modeling of lateral variations in basal heat flow and burial history due to underlying crustal blocks of different thickness and/or composition have important implications for the timing and degree of thermal maturation. Spatial variations in basal heat flow of 10 mW/m2 can explain differences in the gas maturation of the Barnett Shale (Negraru et al., 2008). Thus underlying basement structure might control gas occurrence in the Late Jurassic Haynesville Shale.