Seismic Interpretation and Structural Evaluation of the Hope Basin, Alaska

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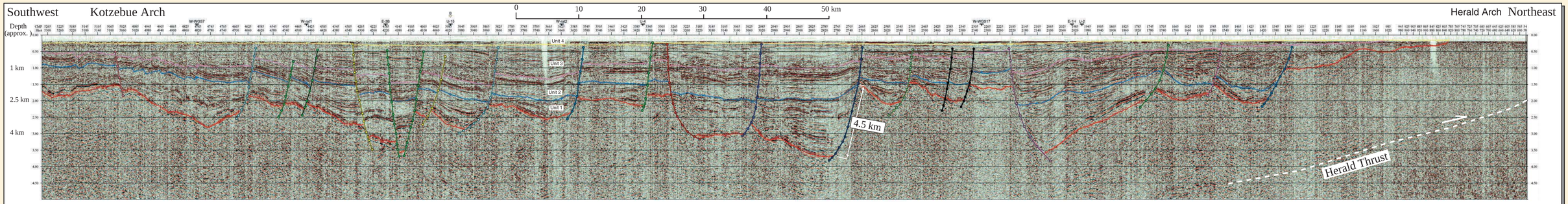
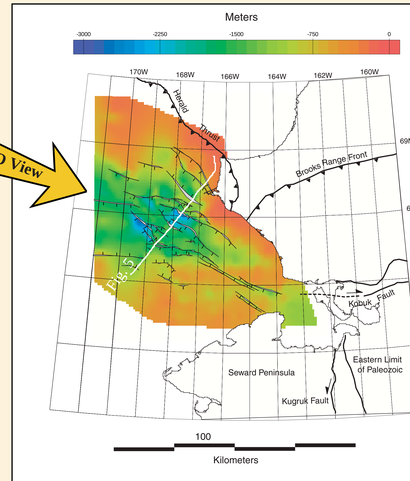


Figure 5: Seismic Line USGS- 18: This line is typical of the deep part of the Hope Basin. See Figure 3 for location. In our interpretation we neglected faults with throws of less than 0.20 sec, because we could not correlated them across multiple lines due to the wide spacing of the surveys. The structure is characterized by numerous listric normal faults bounding rotated half-grabens. The spacing between major faults ranges between 10 and 25 km. The largest faults have throws of up to 4.5 kilometers. Both southwest and northeast vergent faults are present, although southwest vergence predominates. Restoring the fault offsets of the basement yields 28 km of horizontal extension or 14%. The geometry of the fault system appears to be that of a classic extensional belt. There is no a priori evidence of transcurrent deformation. The high at the southwestern end of the line is the continuation of the Kotzebue Arch. The faults at the northeastern end of the basin are on the flank of the Herald Arch. Strong, discontinuous reflectors at ~3.5 sec. at the northeastern end of the line probably represent the Herald Thrust. This fault, of mostly Albian age, is related to the Brooks Range thrust belt and is exposed on land in the Lisburne Peninsula.



Basement Structure

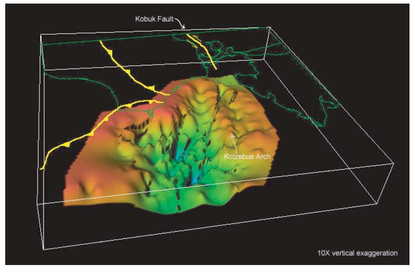
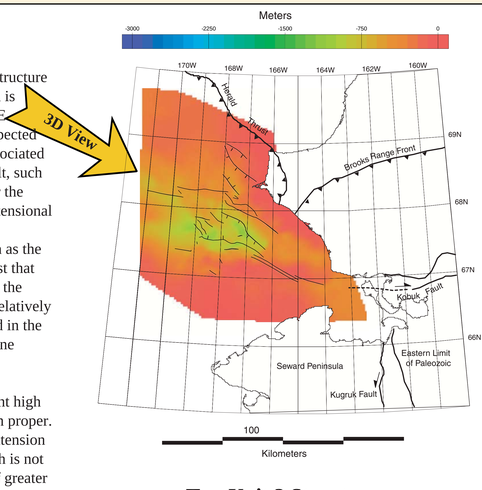


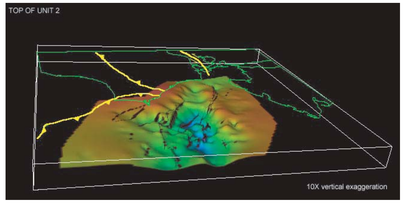
Figure 6. Structural Maps: The basement structure map (left) shows that these portion of the Hope Basin is wedge-shaped, wit the largest normal faults on the NE side. The strike of the faults is within the range of expected normal-fault orientation for a transtensional basin associated with an east-west trending right-lateral strike slip fault, such as the Kobuk fault (Basile and Brun, 1999). However the geometry of the faults is not. Analog models of transtensional basins (McClay an Dooley, 1995), as well as the characteristics of well known pull-appart basins such as the Dead Sea (ten Brink and Ben-Avraham, 1989) suggest that steep master faults should be present on both sides of the basin. In the Hope basin most of the large faults are relatively gently dipping listric faults, and they are concentrated in the central part of the study area, southwest of the Lisburne Peninsula.

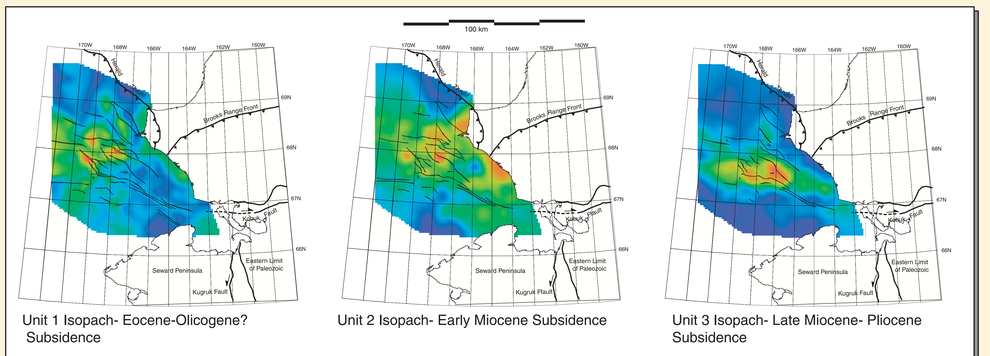
The Kotzebue Arch is an East-West trending basement high that separates the Selawick basin from the Hope basin proper. It has been proposed that the Kotzebue Arch is the extension of the Kobuk Fault, but for most of its length the Arch is not bounded by faults, but rather it separates two areas of greater subsidence.

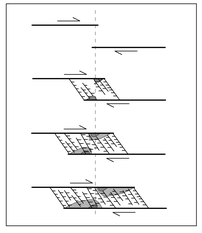
The structure of Unit 2 (right), shows that by Miocene time faulting was concentrated along a narrower north-west trending graben. The relief on the Kotzebue Arch was also small by that time, although the large normal faults southwest of the Lisburne Peninsula remained active.



Top Unit 2 Structure







Depocenter migration. The light gray area is the basin depression while the dark gray is the depocenter. Note that the area of subsidence elongates and migrates in the direction opposite of strike-slip movement. Modified from Golke et al., 1994.

Figure 7. Subsidence Patterns: Deposition of Unit 1 during the Early Tertiary was strongly controlled by faulting. The areas of greatest sedimentary thickness were isolated half grabens bound by listric normal faults. The depocenter was located southwest of the Lisburne Peninsula. Subsidence during the Early Miocene was distributed over a broader area, probably driven by thermal reequilibration followed Early Tertiary extension. However, the depocenter remained in the same area and the large normal faults remained active. During deposition of Unit 3 in the Late Miocene-Pliocene, subsidence was concentrated along a narrow band parallel to the Kotzebue Arch. The depocenter migrated to the southeast. This is opposite to the pattern of depocenter migration expected for a pull-appart basin formed by a right lateral fault (see left, Golke et al., 1994). Seismic data from the Russian portion of the Hope basin would be key in determining if these patterns hold up over entire basin.

Conclusions: There are multiple problems with the link of Hope Basin formation to the strike-slip along the Kobuk fault. These include: 1) the large size of the basin relative to the fault and its magnitude of slip, 2) the lack of evidence for strike-slip deformation within the basin, 3) the geometry of the normal fault systems, and 4) the peculiar pattern of depocenter migration relative to the theoretical models. Other process may have played a role in the evolution of the basin. One possibility is that Early Tertiary extension in the Hope Basin was driven by gravitational collapse of the Herald-Lisburne fold-and-thrust belt. Lines of evidence that support this hypothesis are: 1) the fact that the extent of the basin closely matches the dimensions of the thrust belt, 2) extension is limited to the hanging wall of the Herald thrust, 3) the vergence of the faults is predominantly down to the southwest, as would be expected if extension were driven by gravitational gradient, and 4) the normal faults are roughly parallel to the Herald Thrust.

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