Tectonic Implications of New Geological and Geophysical Results from the Susitna Basin, South-Central Alaska*

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Abstract

Exploratory wells, seismic reflection, gravity, and aeromagnetic data provide new insights into the tectonic history of the Susitna basin, about 80 km NW of Anchorage. Seven exploratory wells drilled in the Susitna basin from 1964 to 2005 found no commercial quantities of oil or gas, but at least one company has announced plans to drill more wells in the near future. Three wells in the Susitna basin bottomed in a package of Paleogene volcanic and sedimentary rocks. The ages of these rocks are based on Paleocene palynomorphs and five $^{40}$Ar/$^{39}$Ar step-heating ages on whole-rock samples, as follows: 57.3 ± 0.2 Ma on basalt from the Trail Ridge Unit 1 well; 54.3 ± 0.4 on andesite (?) and 56.9 ± 0.4 Ma on basalt from the Pure Kahiltna Unit 1 well; and 56.4 ± 0.8 and 56.7 ± 1.1 Ma on basalt from the Sheep Creek 1 well. This package is about the same age as the Arkose Ridge Formation in the nearby Talkeetna Mountains. The volcanic package is overlain by a nonmarine sequence of sandstone, siltstone, and coal that contains Eocene palynomorphs and is more than 1,300 m thick in the Trail Ridge and Pure Kahiltna wells. The Eocene strata, in turn, are unconformably overlain by Miocene and younger strata. In the western part of the Susitna
basin, seismic reflection and aeromagnetic data reveal the presence of a prominent syncline flanked by N-striking reverse faults. The Trail Ridge well is located on the western limb of this syncline and penetrated a sequence of conglomerate and sandstone, about 2,500 m thick, that contains early Miocene to Quaternary palynomorphs. We hypothesize that Miocene and younger folding and faulting created a synclinal depocenter that accommodated the thick sedimentary pile at the Trail Ridge well. In the eastern part of the basin, seismic profiles show that Tertiary strata are deformed into open folds and cut by reverse faults. Subtle NE-striking aeromagnetic lineations are coincident with anticlinal crests in the Paleogene volcanic package. Gravity modeling indicates that the southwestern margin of the basin is the Beluga Mountain fault, a NW-striking, SW-dipping thrust fault. We suggest that Paleogene strata in the Susitna basin record volcanism, subsidence, and sedimentation that accompanied eastward passage of a slab window related to subduction of the Resurrection-Kula spreading ridge. The Miocene-on-Paleogene unconformity is not precisely dated but may record uplift and erosion that accompanied the initiation of Yakutat microplate subduction beneath south-central Alaska. Compressional deformation associated with microplate subduction resulted in folding, faulting, and subsidence of at least one synclinal depocenter during the Neogene and Quaternary.
Tectonic implications of new geological and geophysical results from the Susitna basin, south-central Alaska


Summary

Exploratory wells, seismic reflection, gravity, and aeromagnetic data provide new insights into the tectonic history of the Susitna basin, located about 80 km NW of Anchorage, Alaska. Seven exploratory wells drilled in the Susitna basin from 1984 to 2005 found no commercial quantities of oil or gas. However, at least one company has announced plans to drill more wells in the near future.

Three wells in the Susitna basin bottomed in a package of Paleogene volcanic and sedimentary rocks. The ages of these rocks are based on Paleocene planktonic forams and new “Ar-Ar” step-heating ages on whole-rock samples, as follows: 57.3 ± 0.2 Ma on basalt from the Trail Ridge Unit 1 well; 54.3 ± 0.4 Ma on andesite (Kyk); and 59.9 ± 0.4 Ma on basalt from the Pure Kahitna Unit 1 well; and 56.4 ± 0.8 Ma on basalt from the Sheep Creek 1 well. This package is about the same age as the Akolu Ridge Formation in the nearby Talkeetna Mountains. Olivine- and plagioclase-phyric basalt from core in unit F in the Sheep Creek 1 well at 1,307 ft (398 m) depth, dated at 56.4 ± 0.8 Ma.

In the eastern part of the Susitna basin, seismic reflection and aeromagnetic data reveal the presence of a prominent syncline flanked by thrusting marine faults. The Trail Ridge well is a topographic high where a Pleistocene fluvial channel, about 600 ft (180 m) wide, crosses the syncline and is flanked by a 0.500 mi (0.80 km) wide reverse-slip tear fault. The fluvial channel is filled with fine sandy, allitic, and clayey sediments that contain Eocene palynofossils and has an apparent thickness of more than 1,300 ft (398 m) in the Trail Ridge and Pure Kahitna wells. The Eocene strata, in turn, are unconformably overlain by Miocene and younger marine strata. Eocene marine deposition is indicated by the presence of coal and terrestrial palynofossils and the absence of marine fossils.

In the western part of the Susitna basin, seismic profiles show that Tertiary strata are deformed into open folds and cut by reverse and thrust faults. Subtle NE striking aeromagnetic lineaments are coincident with anticlinal crests in the Paleogene volcanic package. Gravity modeling indicates that the southwestern margin of the Susitna basin is the Castle Mountain fault, a NW-striking, SW-dipping normal fault.

We suggest that Paleogene strata in the Susitna basin record volcanism, subsidence, and sedimentation that accompanied southwest passage of a slab window related to subduction of the Reunion-Kula spreading ridge. The Miocene-on-Paleogene unconformity is not precisely dated but may record uplift and erosion that accompanied the inflation of Yakutat microplate subduction beneath south-central Alaska. Compressional deformation associated with microplate subduction resulted in folding, healing, and subsidence of at least one synclinal depocenter during the Neogene and Quaternary.

SUSITNA BASIN

Correlation and volcanic geochronology of wells

Preliminary cross section of Peters Hills and Susitna basins (location shown on geologic map)

Seismic line A (location shown on geologic map)

Seismic line B (location shown on geologic map)