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Fold-Nappes and Polyphase Thrusting in North-Central Brooks Range, Alaska

Ongoing study involving inch-to-the-mile mapping of a geologic transect along the Itkillik-Koyukuk Rivers is providing new information on the structural style and kinematic development of the central Brooks Range. The principal structures controlling north-directed structural telescoping are three detachments. These detachments are stratigraphically controlled and occur in: (1) Devonian Hunt Fork Shale, (2) Mississippian Kayak Shale, and (3) Permian and Triassic shale. The detachments and the subsidiary thrusts that branch from them form a thrust complex that developed in two stages. During the first stage, duplexes consisting of horses of Mississippian Lisburne Group platform carbonates formed where the Kayak Shale detachment ramped up to Permian and Triassic beds, imbricating the intervening Lisburne Group. In the second stage, alpine-style fold nappes involving Devonian Kanayut Conglomerate and elements of the underlying Hunt Fork Shale were emplaced sequentially from south to north on thrust faults solely in the Hunt Fork Shale. Thrust faults that emplace the fold nappes merge with the previously formed detachment in the Kayak Shale. Complex deformation associated with both stages include: (1) ramping of duplexes in Lisburne Group rocks over previously imbricated Lisburne Group rocks; (2) regional folding of imbricated Lisburne Group rocks; (3) folded individual subsidiary faults within the duplexes of Lisburne Group rocks; (4) warping, folding, and thrusting of the Kayak Shale detachment associated with generation and emplacement of the underlying fold nappes; and (5) faults that cut through the hinge area of fold nappes and thrust the trailing limbs of the fold nappes over the overturned leading limbs of the fold nappes.

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Detachment Tectonics in Sadlerochit and Shublik Mountains and Applications for Exploration Beneath Coastal Plain, Arctic National Wildlife Range, Alaska

Preliminary field investigations suggest three detachments in the Sadlerochit and Shublik Mountains: (1) the Kingak Shale, (2) along the pre-Mississippian unconformity, and (3) within the pre-Mississippian basement. The Kingak Shale décollement is the sole thrust for divergently branching subsidiary thrusts that repeat the Cretaceous Kemik Sandstone Member and overlying section. Well-exposed footwall and hanging-wall cutoffs together with multiple repetitions of Jurassic and Cretaceous over short distances demonstrate the detachment and provide permissive evidence of large-scale shortening. The detachment along the pre-Mississippian unconformity is not a sole thrust for subsidiary thrust faults. It is marked by cleavage development and folding of the overlying Mississippian and younger rocks in marked disharmony with the underlying homoclinal pre-Mississippian strata. Detachment within the pre-Mississippian basement is not exposed but is interpreted from cumulative shortening across thrust faults observed and inferred in the Sadlerochit and Shublik Mountains. As envisioned, it would be a shallow south-dipping floor thrust for subsidiary faults largely controlled by the basement infrastructure.

Thrust faults that cut the overlying Mississippian and younger section have horizontal displacements of 5-8 km and emplace pre-Mississippian rocks on Cretaceous strata. A large number of smaller thrust faults, responsible for deformation of the pre-Mississippian surface contribute to shortening. Structures involving the pre-Mississippian section trend east-west whereas earlier formed structures related to the Kingak Shale décollement trend east-northeast to west-southwest. Possible exploration leads beneath the coastal plain include: (1) large, broad, basement-involved structural culminations that may have subtle seismic expressions and (2) pre-Mississippian potential reservoirs thrust over Cretaceous source beds. Possible applications for regional seismic interpretation include: (1) a means of discriminating basement-involved structures from preexisting basement-detached structures and (2) suggestion that two broadly different structural patterns exist under the coastal plain.

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Interior Provinces in Alaska

The U.S. Geological Survey is using a multidisciplinary approach to assess the petroleum potential of the interior provinces of Alaska. Geophysical parameters, petroleum geochemistry, thermal maturation, paleontology, and petrography are some of the disciplines being used to evaluate the basins as well as to compare them geologically with other explored basins.

Three types of interior provinces have been tested by exploratory drilling for their petroleum potential: three Tertiary nonmarine basins, two Jurassic and Cretaceous flysch and fold belts, and a Paleozoic thrust belt. Although the presence of hydrocarbons has not yet been demonstrated, the present data base is too limited to make a definitive assessment of hydrocarbon potential.

During the 1983-84 field seasons, we acquired new gravity data and collected rock samples in and adjacent to the Yukon flats and the Nenana basins. These basins contain upper Tertiary, primarily nonmarine, sedimentary rock in extensional graben and half-graben complexes that are superimposed across preexisting terrane boundaries. The location and development of the basins result from strike-slip motion along the Tintina and Denali fault systems. Adjacent to the basins and within the fault systems are thick sections of nonmarine lower Tertiary coal-bearing rocks in deformed basin remnants. If these lower Tertiary rocks are present beneath the upper Tertiary fill, their greater depth and advanced maturation could enhance the hydrocarbon generative potential. Gravity modeling suggests the Tertiary fill is at least 3 km thick in the deeper parts of the basins and may be significantly thicker.

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Rua Cove: Anatomy of Volcanogenic Fe-Cu Sulfide Deposit in Ophiolite on Knight Island, Alaska

Tabular deposits of massive Fe-Cu sulfide and subjacent fracture- and void-controlled sulfide in volcanic breccia represents a sea-floor and subsea-floor hydrothermal system in the Tertiary ophiolitic terrane on Knight Island. The massive sulfide bodies at Rua Cove occur within a sequence of mafic volcanic rocks that include pillow lava, pillow-fragment breccia, mixed volcanic-chert breccia, and hyaloclastite. The principal massive sulfide horizon, composed of pyrrhotite and chalcopyrite with thin partings of talc + chlorite + quartz, is concordant with fine-grained volcaniclastic units altered to an assemblage of chlorite + quartz + sphene + ilmenite.

Discordant, diffuse feeder-zone mineralization below the massive sulfide body includes fracture- and void-filling aggregates of pyrrhotite + chalcopyrite + talc + quartz and late-stage veins of quartz + epidote + chlorite + pyrrhotite + chalcopyrite. The formation of talc appears to postdate pervasive chloritization of mafic breccia and hyaloclastite.

The thick section of mixed volcanic breccia and hyaloclastite suggests a depositional environment near the base of a steep volcanic edifice. Sulfide deposition was contemporaneous with formation of breccia and hyaloclastite. Rapid burial by fine-grained volcaniclastic material and succeeding lava flows inhibited sea-floor weathering of the Fe-rich massive sulfide. The occurrence of additional "nested" massive sulfide bodies, isolated fragments of massive sulfide in the volcanic breccia, and sulfide-rich matrix supporting fragments cut by quartz-sulfide veins suggests recurrent hydrothermal activity and sulfide deposition near an active volcanic center. The spatial association with sheeted dikes at depth and intercalated and overlying flysch-type strata of the Orca Group indicate that mineralization occurred in a rift setting near a continental margin.

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Temperature and Depth of Permafrost on North Slope, Alaska

Analysis of recently measured near-equilibrium temperatures from 24 oil-exploration wells on and near the National Petroleum Reserve in