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Results of 1:63,360-scale Geologic Mapping and Related Field Studies in the South-Central Tyonek Quadrangle, Alaska: Late Paleocene?-Middle Eocene Transtension and Post-Oligocene Inversion on the Northwest Periphery of the Cook Inlet Forearc Basin

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ABSTRACT

Cenozoic nonmarine strata in upper Cook Inlet are up to 25,000 feet (7,620 m) thick and host significant commercial accumulations of oil and gas. These strata are discontinuously exposed around the basin margins, but the largest area with the most complete exposures of the Cenozoic succession occurs between the mouth of the Beluga River and Mount Spurr Volcano. However, difficult access and often sparsely-distributed outcrops in this area of the northwest basin margin have hindered understanding of the margin-proximal stratigraphy and structures that deform it. New inch-to-mile geologic mapping of approximately 875 sq. mi. along this extent of the basin margin includes parts of the exhumed Late Cretaceous and Paleocene magmatic arcs and the principal structures that define the Cenozoic arc-forearc basin boundary, providing new insights into subsidence mechanisms during Paleogene deposition. Major results include division of the earliest exposed Cenozoic basin strata (West Foreland Formation) into three mappable subunits based on distinct lithofacies, identification of stratigraphic units previously thought to be absent from the area (Hemlock and Sterling formations), and corroboration of a largely overlooked extensional structural model for the northwest basin margin proposed in the mid-1970s. A more nuanced depositional model and better constraints on the timing of arc magmatism and deformation were guided by 37 detailed measured stratigraphic sections, 102 U-Pb and 40Ar/39Ar geochronologic analyses of intrusive, extrusive, and sedimentary rocks, and 143 palynologic analyses from throughout the Cenozoic succession. Often well-expressed meso- to macro-scale cross-cutting relations and over 1000 shear plane measurements constrain the structural style, sense of fault slip, and relative timing of deformation during early basin formation. Stratal thickening and a prominent overlap succession associated with structures within the West Foreland Formation indicate syntectonic deposition during middle Eocene time. In regions approaching the Cook Inlet coast where outcrops are relatively rare due to a glacial deposits and dense vegetation, publicly- and privately-held subsurface data informed the mapping of stratigraphic contacts and major structures. These subsurface data also permit redefining what has classically been called the Bruin Bay fault as a complex system of en echelon faults referred to here as the Beluga River-Moquawkie fault system (BR-MFS). Collectively, the new mapping, field observations, and supplemental data define the northwestern margin of the Cook Inlet forearc basin as a dextral, right-stepping transtensional pull-apart system that initiated as early as 57 Ma, linking the Capps Glacier fault to the northwest with the Castle Mountain fault to the southeast. Deposition of proximal West Foreland Formation strata was syntectonic from <47.9 to <38.7 Ma during margin-oblique, northeast-directed extension. Seismic and well log interpretations suggest initial normal slip locally along the BR-MFS during Paleocene(?) through Eocene time prior to regional structural inversion that likely began after the Oligocene. However, dextral transtension after middle

Miocene time might have occurred locally in the Chuitna River area and certainly occurred on a Lake Clark fault splay, which places Tyonek Formation strata against Late Cretaceous granodiorite along a well-exposed south-dipping plane.