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New Insights into the Bruin Bay Fault-Moquawkie Structural Trend, Northwestern Cook Inlet Basin, Alaska, from Subsurface Constraints and Bedrock Geologic Mapping

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ABSTRACT

We integrate recent bedrock geologic mapping with new interpretations of privately- and publically-held subsurface data (including 445 line miles of onshore 2D seismic data, and 115 line miles from a recently-released 2D seismic dataset) to more completely understand the framework of producing structures near the northwestern margin of Cook Inlet basin, a major Alaska oil and gas province. Our studies help to delineate, for the first time in the public domain, details related to position, geometry, and linkages of hydrocarbon-trapping structures in the area. Due to predominately offshore occurrences and poor onshore expression of the basin structures, public knowledge of their framework has been based chiefly on derivative proprietary products, limited publically-released industry data, interpretation of gravity and magnetic anomalies, and surface distribution of wells. The new seismic interpretations constrained by wells reveal a complex array of NNE-striking discontinuous contractional faults and folds that decrease in throw and amplitude along strike as a system, potentially partitioning shortening outside of the study area between the Beluga River and Granite Point structures to the NE and SSW, respectively. Two principal faults, the Bruin Bay and the Moquawkie faults, are sub-parallel, closely spaced, and dip steeply away from each other to the WNW and ESE. The faults share a narrow footwall syncline that is best expressed midway along their respective traces, where their fault throws are greatest. Their hanging-wall anticlines decay in amplitude and change in character to the NNE and SSW, tracking fault slip and producing locally complex geometries. Strata adjacent to the Bruin Bay fault may record an early episode of deformation that is not expressed by the Moquawkie structure. Seismic sections constrained by well control (e.g. Stedatna Creek #1 and Chuit River #1) indicate that locally thick (>4,900 ft), Eocene West Foreland and Paleocene? strata occur in the hanging-wall anticline of the Bruin Bay fault, and are thinner (<1,000 ft) in its footwall, consistent with contractional inversion of a Paleogene extensional feature. This interpretation is supported by new bedrock geologic mapping to the NW in the Capps Glacier area, which clearly indicates that ongoing transtension was the principle mechanism for subsidence at the proximal basin margin during West Foreland deposition. For decades, the Bruin Bay fault has been interpreted as a NE-striking regional transpressional structure continuous for approximately 450 km from the upper Alaska Peninsula to this location, where it either splays into, or is truncated by, the dextral Castle Mountain fault. However subsurface constraints and new bedrock geologic mapping indicate it is neither continuous, of sufficient magnitude to juxtapose Cenozoic units as traditionally mapped, nor connected to the Castle Mountain fault above Jurassic basement. The NNE-striking Bruin Bay-Moquawkie structural complex deviates from the regional trend of the Bruin Bay fault that is well-constrained to the SW. Yet, it is nearly co-axial to the NNE-striking Granite Point and Middle Ground Shoal structures, suggesting that it is not genetically related to the Bruin Bay fault, but rather part of a system of NNE-trending prospective fault-cored anticlines concentrated along the western margin of the basin, which also includes the Trading Bay, McArthur River, Three-Mile Creek, and Beluga River structures.