CHAPTER 1

OVERVIEW OF NEW 1:63,360-SCALE GEOLOGIC MAPPING OF THE INISKIN PENINSULA, LOWER COOK INLET, ALASKA

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The Alaska Division of Geological & Geophysical Surveys (DGGS) and the Alaska Division of Oil and Gas conducted new inch-to-mile (1:63,360-scale) geologic mapping of approximately 235 square miles on the Iniskin Peninsula and adjacent area in summer 2013 (fig. 1-1). The project was part of DGGS's Cook Inlet basin analysis program that has focused on geologic components of Cook Inlet petroleum systems since 2006, initially in the producing Cenozoic stratigraphy.

In 2009, our field investigations transitioned toward the less-well-understood Mesozoic strata, which features oil seeps in several locations and contains the source interval for the trapped oil that is being extracted from the Cook Inlet basin today. The map area straddles the margin of the Early to Late Jurassic Talkeetna arc–forearc basin system and encompasses a relatively complete, but structurally dissected, crustal section from the arc roots upward through the arc edifice into the clastic basin fill. The arc complex has been exhumed against the forearc basin in the hanging wall of the regional-scale, northwest-dipping Bruin Bay fault system and consists mainly of Early to early Middle Jurassic granitoids and Lower Jurassic volcanic and volcaniclastic rocks. The footwall of the fault system bounding the forearc basin is composed of a > 4,800-m-thick succession of Middle to Upper Jurassic marine strata that are folded by a large syncline–anticline pair. Thus the map area provides opportunities to understand changes in the Jurassic stratigraphy through time, relations between hydrocarbon migration and structural trap formation, and more generally, the geologic evolution of the basin.

The most current understanding of the geology of the Iniskin Peninsula area and Cook Inlet Mesozoic stratigraphy comes principally from studies by the U.S. Geological Survey from 1944 to 1958 that were published in a series of reports and maps (for example, Kellum, 1945; Kirschner and Minard, 1949; Hartsock, 1954; Juhle, 1955; Grantz, 1956) and culminated in the seminal 1:63,360-scale compilation geologic map and accompanying report (Detterman and Hartsock, 1966). Whereas this body of work is extensive in both breadth and detail, our work on the peninsula and surrounding areas since 2009 has highlighted the need to revise the mapping to (1) document more accurately how stratigraphic units laterally wedge out across the map area (chapter 2, this volume), (2) provide a simplified Lower Jurassic volcanic arc stratigraphy based on lithofacies associations (chapter 3, this volume), (3) establish new age assignments for several igneous units, (4) constrain the distribution and type of structures associated with the Bruin Bay fault system (chapter 4, this volume), and (5) record the distribution and density of cross-faults cutting the forearc strata.

Figures 1-2A–B compare the most current published map of Detterman and Hartsock (1966) and a simplified, preliminary version of new mapping conducted in 2013. Notable differences in map interpretations include:

- Northeastward pinch-out of the Chisik Conglomerate Member of the Naknek Formation clearly is present west of Oil Bay, ~ 7 miles (~11.5 km) southwest of where it was formerly mapped (chapter 2, this volume).
- Marsh Creek Breccia and Portage Creek Agglomerate members of the Talkeetna Formation exhibit indistinguishable lithofacies associations and are tentatively combined into the Marsh–Portage Creek member (Jtkl of fig. 1-2a), whereas the Horn Mountain Tuff Member has been retained (Jtku of fig. 1-2A) (chapter 3, this volume).
- The areal extent of the unnamed Triassic metamorphic unit from Detterman and Hartsock (1966) has been greatly reduced, and work is ongoing to determine its age in the map area.
- Ages of several igneous exposures have been reassigned based on new $^{40}Ar/^{39}Ar$ geochronologic results. For example, a Tertiary lava (Tf) mapped to the northwest of the Bruin Bay fault has been identified to be Jurassic in age and is now interpreted as a hypabyssal intrusive. The areal extent of this unit has also been significantly reduced.
- The Bruin Bay fault is tentatively interpreted as a right-stepping transpressional system with two overlapping strands that breach the surface. This interpretation is in contrast to the single fault mapped by Detterman and Hartsock (1966) that exhibits a sharp right jog at Chinitna Bay. The new interpretation is largely consistent with an earlier interpretation of the structure by Hartsock (1954).

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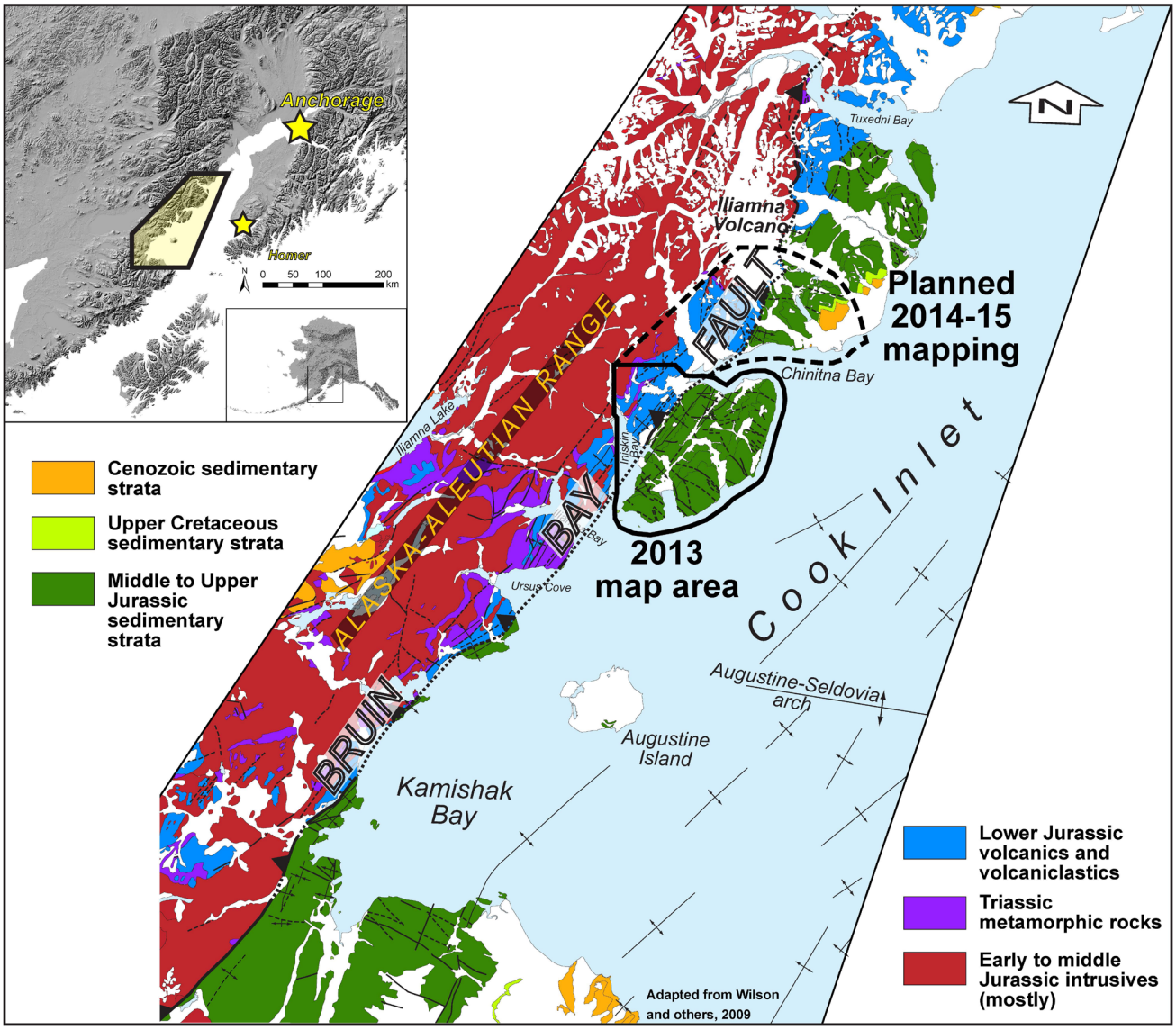

Figure 1-1. Generalized geologic map of lower western Cook Inlet, showing the location of 1:63,360-scale geologic mapping of the Iniskin Peninsula (solid outline) in 2013, and planned geologic mapping in 2014–2015 (dashed outline). Adapted from Wilson and others (2009). Inset shows location of map area in southern Alaska.

- The number of faults that were mapped by Detterman and Hartsock (1966) in the hanging wall of the Bruin Bay fault system has been reduced. Detailed kinematic analyses of one steeply northwest-dipping fault indicates predominantly dextral motion (chapter 4, this volume), in contrast to the several kilometers of sinistral reverse motion interpreted for the fault system in earlier studies (for example, Detterman and Hartsock, 1966; Detterman and Reed, 1980).
- The density and extent of numerous previously-mapped, northwest-striking cross-faults cutting footwall strata has been greatly reduced. Many of these formerly recognized faults have distinct topographic expression, but no observed stratigraphic separation. Most of these features are reassigned as fracture lineaments, or omitted altogether.

Our mapping of the Iniskin Peninsula area benefitted from helicopter access to rugged, higher-elevation regions that were either inaccessible or impractical to visit by previous workers. Conversely, the limited distribution of outcrops in the lower-elevation interior regions of the map area hampered mapping stratigraphic and structural relations exposed during previous field studies. As a result, the new map is thought to be greatly improved over earlier efforts in the high country of the Tilted Hills and region northwest of the Bruin Bay fault where stratigraphic and structural relations are well expressed. Perhaps the most significant limitation to mapping was what we speculate to be a substantial encroachment of dense vegetation over the past 50 years that has rendered subtle, yet important, geologic relations unverifiable for parts of the Tonnie syncline and Fitz Creek anticline. Additionally, access to land in part of the core of the Fitz Creek anticline, including many of the

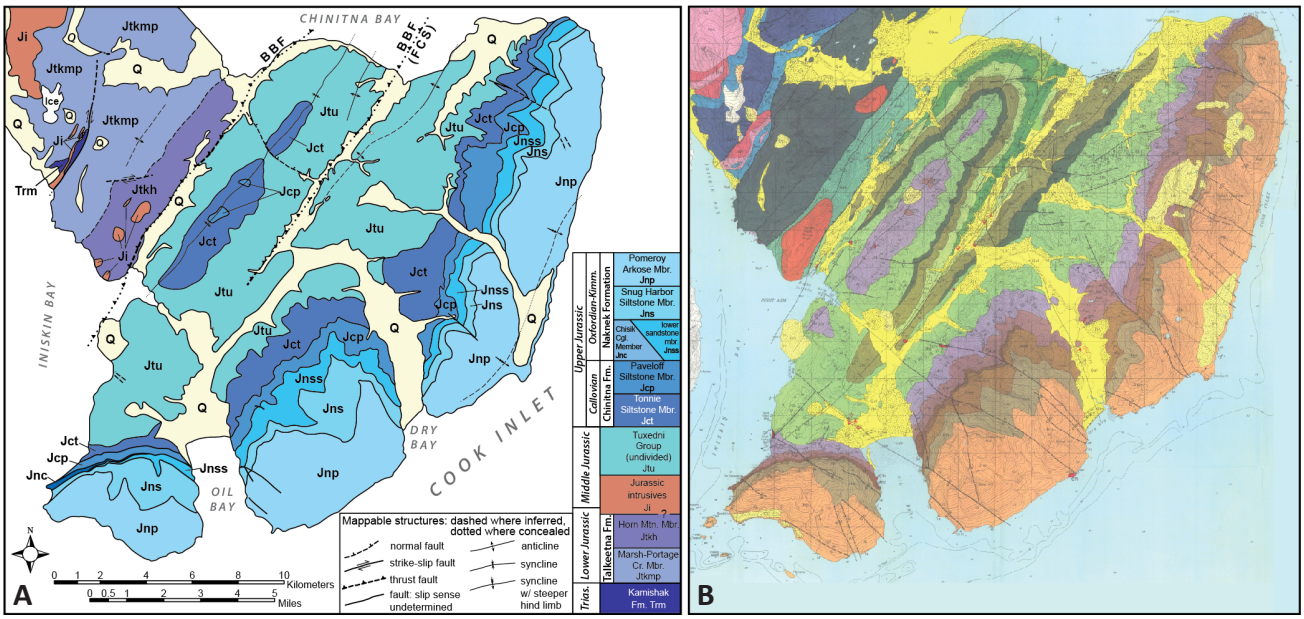

Figure 1-2. Comparison of (A) simplified preliminary inch-to-mile geologic map of the Iniskin Peninsula constructed from data collected during the 2013 DGGS mapping campaign, and (B) excerpt of the inch-to-mile geologic map of Detterman and Hartsock (1966) for same area. Major differences include significant revision of contact locations and position of stratigraphic wedging for the Naknek Formation, simplification of Talkeetna Formation stratigraphy, reinterpretation of Bruin Bay fault as a right-stepping transpressional fault system, simplification of Bruin Bay fault hanging-wall structure, age reassignment and major revision of distribution of hanging-wall intrusive rocks, and delineation of footwall cross-faults from fracture sets. A. Tuxedni Group (Jtu) was mapped in the field, but presented as undivided until completion of aerial photographs and satellite imagery interpretation of lowlands near Iniskin Bay. Stratigraphic contacts defining the Fitz Creek anticline and Tonnie syncline will appear on future versions of the map. Quaternary unit provisionally adapted from Detterman and Hartsock (1966). BBF = Bruin Bay fault; FCS = Fitz Creek strand of BBF.

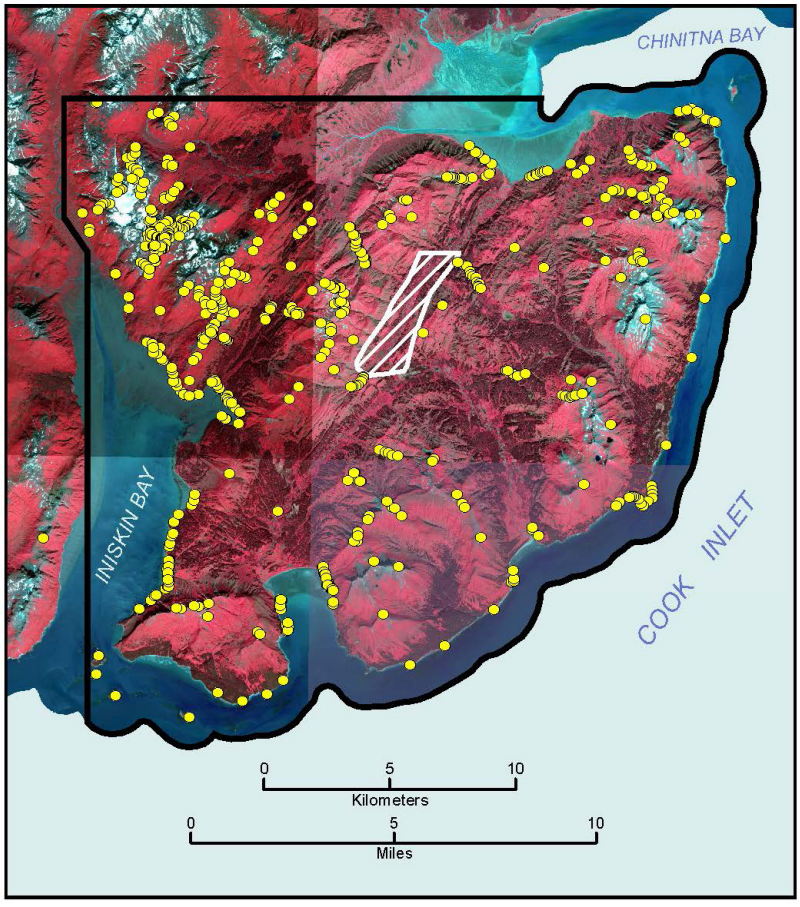

Figure 1-3. SPOT 5 satellite image of the Iniskin Peninsula showing approximate map outline (black polygon), locations of field stations (yellow dots), and zone of exclusion from mapping by the landholders along the hinge of the Fitz Creek anticline (not shown).

hydrocarbon seeps and historic well sites, was not permitted, prohibiting collection of structural data along that part of the fold axis (fig. 1-3). Efforts are ongoing to supplement the field mapping of the interior portions of the peninsula by using satellite imagery and aerial photographs. Map interpretations made on the basis of these methods will be field checked where possible in 2014. Additional geologic mapping northeast of the Iniskin Peninsula is planned for 2014–15 (fig. 1-1) to develop a better understanding of how sedimentary facies and structural style change along strike of the Jurassic forearc basin margin.

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REFERENCES

Detterman, R.L., and Hartsock, J.K., 1966, Geology of the Iniskin–Tuxedni region, Alaska: U.S. Geological Survey Professional Paper 512, 78 p., 6 sheets, scale 1:63,360.

Detterman, R.L., and Reed, B.L., 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368-B, p. B1–B86, 1 sheet, scale 1:250,000.

Grantz, Arthur, 1956, Magnetite deposits at Tuxedni Bay, Alaska: U.S. Geological Survey Bulletin 1024-D, p. 95–106.

Hartsock, J.K., 1954, Geologic map and structure sections of the Iniskin Peninsula and adjacent area of Alaska: U.S. Geological Survey Open-File Report 54-118, 1 p., 3 sheets.

Juhle, R.W., 1955, Iliamna Volcano and its basement: U.S. Geological Survey Open-File Report 55-77, 141 p., scale 1:96,000.

Kellum, L. B., 1945, Jurassic stratigraphy of Alaska and petroleum exploration in northwest America: New York Acad. Sci. Trans., ser. 2, v. 7, no. 8, p. 201–209.

Kirschner, C.E., and Minard, D.L., 1949, Geology of the Iniskin Peninsula, Alaska: U.S. Geological Survey Oil and Gas Investigations Map 95, 1 sheet, scale 1:48,000.

Wilson, F.H., Hults, C.P., Schmoll, H.R., Haeussler, P.J., Schmidt, J.M., Yehle, L.A., Labay, K.A., and Shew, N.B., 2009, Preliminary integrated geologic map databases for the United States: preliminary geologic map of the Cook Inlet region, Alaska: U.S. Geological Survey Open-File Report 2009-1108.