PRELIMINARY STRATIGRAPHIC INTERPRETATION OF THE NAKNEK FORMATION: EVIDENCE FOR LATE JURASSIC ACTIVITY ON THE BRUIN BAY FAULT, INISKIN PENINSULA, LOWER COOK INLET

by
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The northeast-trending Bruin Bay fault is a major structure bounding the western side of Cook Inlet where it generally separates Early Jurassic plutonic and volcanic rocks of the Talkeetna arc on the northwest side from Middle and Late Jurassic forearc sedimentary rocks on the southeast side (Detterman and Reed, 1980). Despite the significance and size of this fault system, which can be traced for >400 km, its history remains poorly understood (fig. 1, see Bruin Bay fault section, this paper). To evaluate the possibility of Jurassic activity on the fault, we conducted stratigraphic studies of the Middle and Upper Jurassic units exposed on the southwestern Iniskin Peninsula, nearest the mapped trace of the fault system (fig. 36). LePain and others (2011) reported stratigraphic evidence from the upper Tuxedni Group that suggested that activity on the Bruin Bay fault was likely initiated by late Middle Jurassic time. The following discussion focuses on our observations from the Upper Jurassic Naknek Formation (fig. 37).

We measured detailed stratigraphic sections along the shores of Iniskin and Oil bays (fig. 36), focusing specifically on the Chisik Conglomerate Member and the Northeast Creek Sandstone Member (formerly called the "lower sandstone member"; Detterman and Hartsock, 1966; Detterman and others, 1996). This work has led to an improved understanding of the map-scale distribution of the coarse-grained Chisik, restricting the unit to exposures along Iniskin Bay (fig. 36) where it is dominated by approximately 100 m of poorly organized pebble, cobble, and boulder conglomerate (fig. 38), interpreted as fan delta deposits. In sharp contrast, this conglomeratic package is not present just 7 km to the east in Oil Bay (fig. 36). Instead, the Chisik transitions into >230 m of the age-equivalent Northeast Creek Sandstone Member (fig. 37), which is characterized by bioturbated siltstone and arkosic fine-grained sandstone (fig. 39) interpreted as a storm-influenced shelfal assemblage. The eastward thickening and marked fining of the Chisik–Northeast Creek stratigraphic interval reflects the eastward paleoslope of this part of the basin margin and strongly suggests deposition was driven by activity on the nearby Bruin Bay fault.

The Snug Harbor Siltstone Member occupies a generally recessive zone overlying the Chisik–Northeast Creek interval (fig. 37; Detterman and Hartsock, 1966). Reconnaissance examination indicates Snug Harbor is dominated by tabular, thin bedded, fossiliferous very-fine-grained sandstone and siltstone (fig. 40). Although the depositional environment is poorly constrained, interpretations of the bounding units above and below supports an outer shelf to slope depositional setting. If correct, this would suggest the unit records an important transgressive episode of abrupt deepening along the basin margin. The increase in accommodation may be related to ongoing activity along the Bruin Bay Fault, although the lack of coarse-grained detritus suggests limited exhumation from the nearby hangingwall.

In the Iniskin Peninsula area, the Pomeroy Arkose Member is the youngest preserved member of the Naknek Formation (fig. 37; Detterman and Hartsock, 1966) and typically forms resistant cuestas with southeastward-dipping flat-irons. Similar to the Chisik Conglomerate, our measured sections (fig. 36) and supplementary reconnaissance observations indicate the Pomeroy is considerably coarser grained in the Iniskin Bay area, nearest the Bruin Bay fault. In this area, clast sizes exceeding 2 m in diameter were observed (fig. 41), indicating substantial flow competence and gradient. In contrast, the Pomeroy exposures to the east in Oil Bay (basinward) host almost no conglomerate and are dominated by siltstone and very-fine- to fine-grained sandstone (fig. 42). The facies in Oil Bay include abundant indications of sediment gravity-flow deposition, including sole marks, mudstone intraclasts, and graded beds with rippled tops (fig. 42). Bedding is typically very tabular, although local lenticular channel geometries were also observed. Unlike the underlying Chisik facies, the Pomeroy is nearly devoid of any bioturbation. The balance of observations from Oil Bay support an interpretation of lower slope to basin floor deposition for the Pomeroy, which indicates a marked deepening relative to the Northeast Creek Sandstone Member, further supporting the inference that the intervening Snug Harbor interval records a significant transgression. The very-coarse-grained proximal facies of Pomeroy in Iniskin Bay, near the Bruin Bay fault, suggest basin margin deposition continued to be influenced by activity along this structure into the latest Jurassic.

Volcanic and plutonic clast composition and preliminary detrital zircon age data indicate that the sediment source region on the hangingwall block of the Bruin Bay fault was principally composed of the Jurassic Talkeetna arc, although occasional

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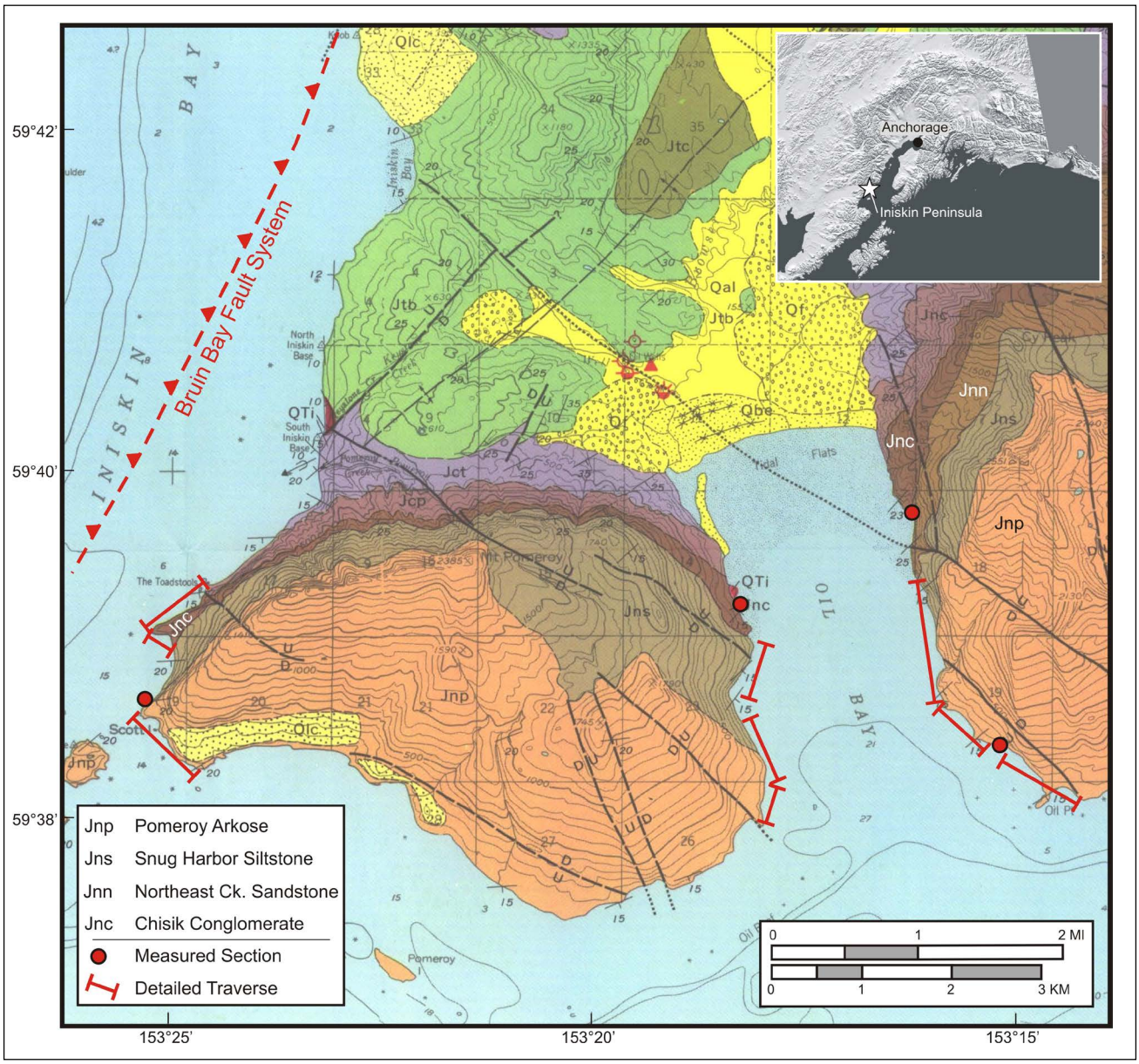

Figure 36. Geologic map of the southwestern Iniskin Peninsula, modified from Detterman and Hartsock (1966) to illustrate approximate trace of the Bruin Bay fault system and the location of Naknek Formation outcrops investigated in this study. Notably, Detterman and Hartsock (1966) recognized that the Chisik Conglomerate (Jnc) and Northeast Creek Sandstone (Jnn) members were lateral equivalents, but in their mapping shown here, they incorrectly depict the Chisik as present along both sides of Oil bay. Our work indicates that only the Northeast Creek Sandstone is present at this stratigraphic position in Oil Bay and the actual pinch-out of Chisik facies must occur in the uplands between Iniskin and Oil bays. See text for additional discussion of stratigraphic changes in the Naknek Formation.

sedimentary clasts suggest that rocks of the Middle Jurassic Chinitna Formation and/or Tuxedni Group were also unroofed (fig. 37). The observed relationship between the Naknek Formation and the Bruin Bay fault is remarkably similar to that described along the Little Oshetna fault in the Talkeetna Mountains (fig. 36; Trop and others, 2005), likely indicating syn-depositional tectonism controlled the evolution of much of the Late Jurassic forearc basin margin.

Future stratigraphic studies and detailed geologic mapping will aim to further document these facies changes in the Iniskin Peninsula area. These data will allow for an improved model for development of the basin margin and provide new constraints on the broader evolution of the Jurassic forearc basin. Furthermore, this stratigraphic work will be combined with detailed analysis of reservoir quality in the Naknek Formation, which remains a viable, albeit poorly tested, target for conventional and unconventional hydrocarbon exploration (Stanley and others, 2011).

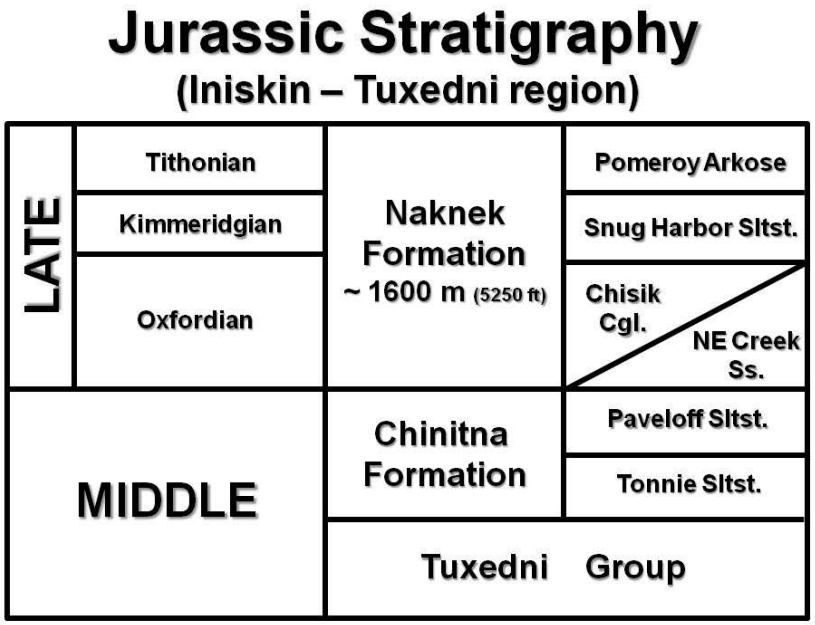

Figure 37. Simplified stratigraphic chart of Jurassic forearc basin units in the Iniskin Bay area, based on Detterman and Hartsock (1966) and Detterman and others (1996).

Figure 38. Representative photographs of the Chisik Conglomerate Member of the Naknek Formation along Iniskin Bay. The coarse-grained facies observed here are interpreted to reflect activity along the nearby Bruin Bay fault system. (A) Poorly sorted pebble and cobble conglomerate and discontinuous sandstone; (B) clast-supported conglomerate; (C) pebble and cobble conglomerate illustrating mix of volcanic and plutonic clast types; (D) example of largest observed clast (2.8 × 1.9 m).

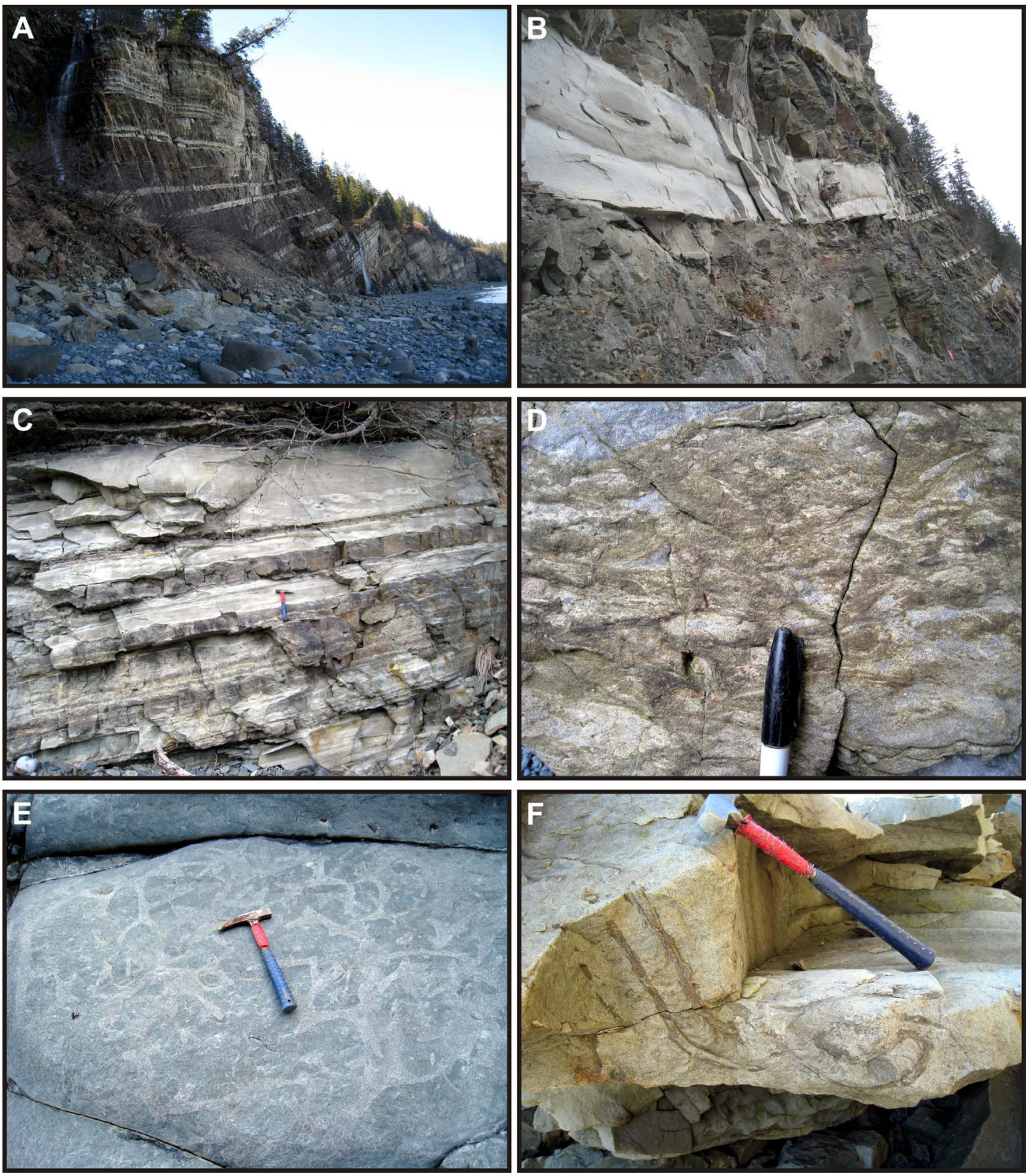

Figure 39. Representative photographs of the Northeast Creek Sandstone Member of the Naknek Formation in Oil Bay. This interval is interpreted as the basinward equivalent of the Chisik Conglomerate. (A) Banded appearance typical of this unit aids differentiation from bounding units above and below, which lack this characteristic; (B) light-colored, arkosic, tabular-bedded, very-fine- to fine-grained, laumontite-cemented sandstone interbedded with brown-colored, hackly weathering, very-fine-grained, bioturbated sandstone; (C) cyclic stacking of laminated, rippled sandstone interbedded with bioturbated siltstone interval is interpreted as stacked tempestites; (D) moderate bioturbation fabric where original lamination is still partly preserved; (E) robust Thalassinoides burrows filled with coarse-grained sand; (F) nested Rhizocorallium trace fossils.

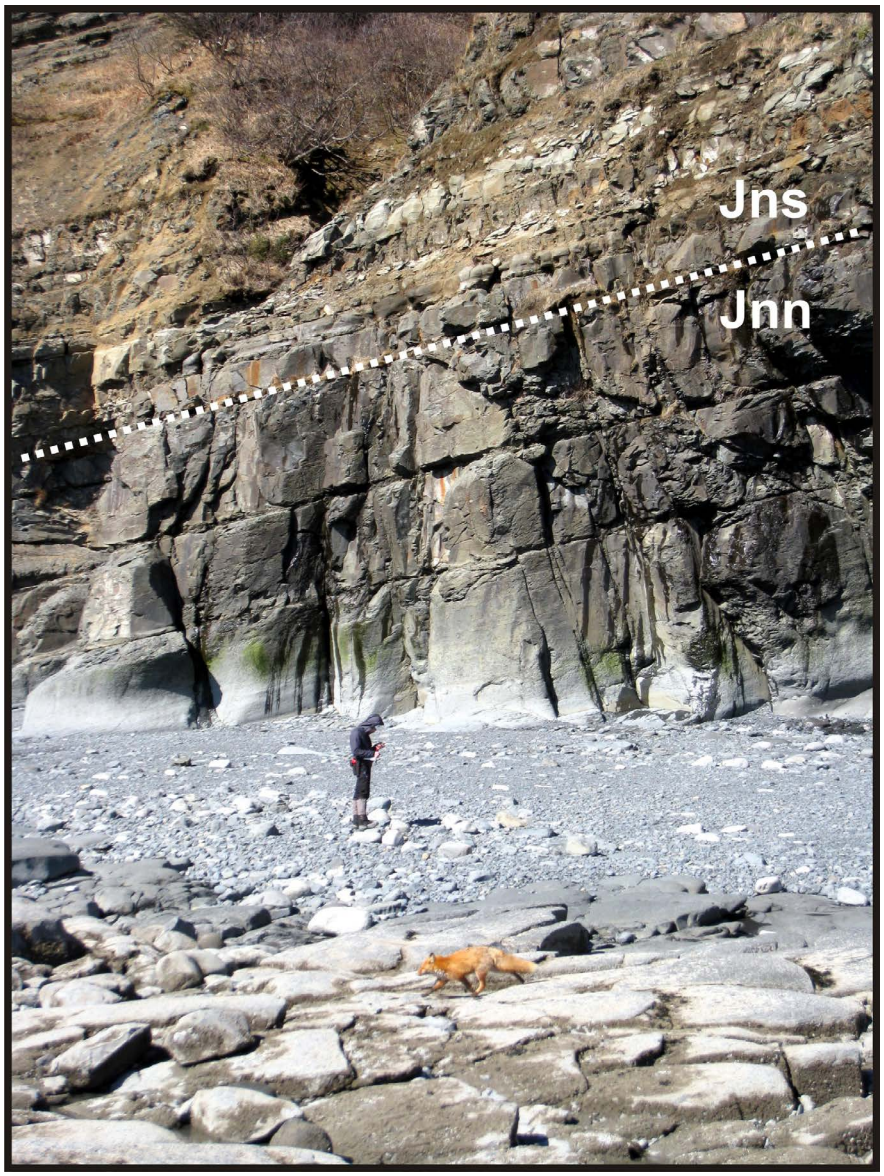

Figure 40. Annotated photograph of the interpreted contact between the Northeast Creek Sandstone Member (Jnn) and the Snug Harbor Siltstone Member (Jns) of the Naknek Formation, western Oil Bay. Note the transition upward to the more recessive Snug Harbor, here interpreted as a significant transgressive unit.

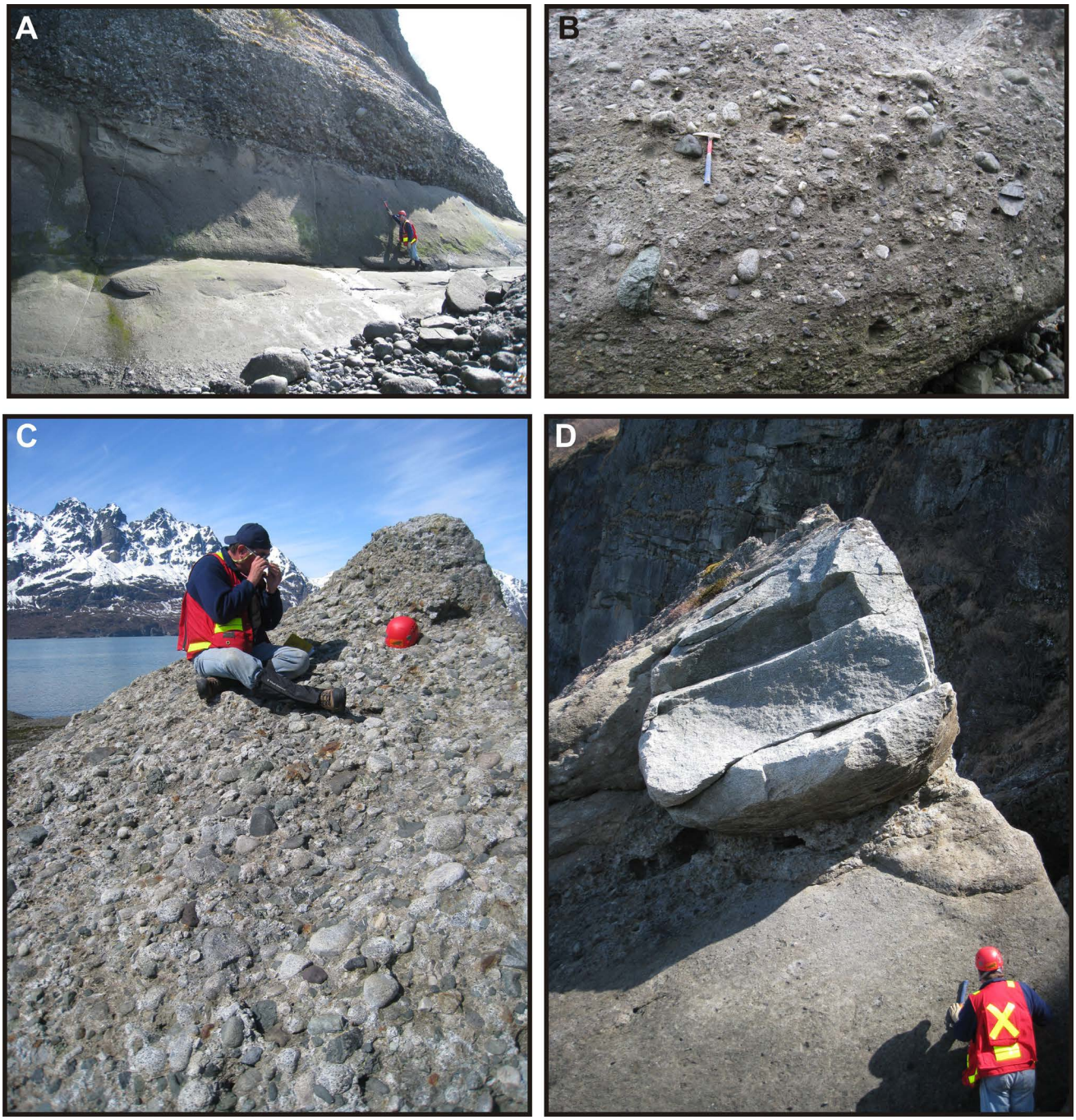

Figure 41. Representative photographs of the Pomeroy Arkose Member of the Naknek Formation along Iniskin Bay. Similar to the Chisik Conglomerate, the coarse-grained facies observed here are interpreted to reflect activity along the nearby Bruin Bay fault system. (A) Thick, amalgamated beds of medium- to coarse-grained sandstone and moderately sorted pebble conglomerate; (B) poorly sorted conglomerate; (C) clast-supported conglomerate illustrating the abundance of diorite pebbles and cobbles derived from the unroofing Talkeetna arc; (D) example of largest observed clast (~3 m diameter).

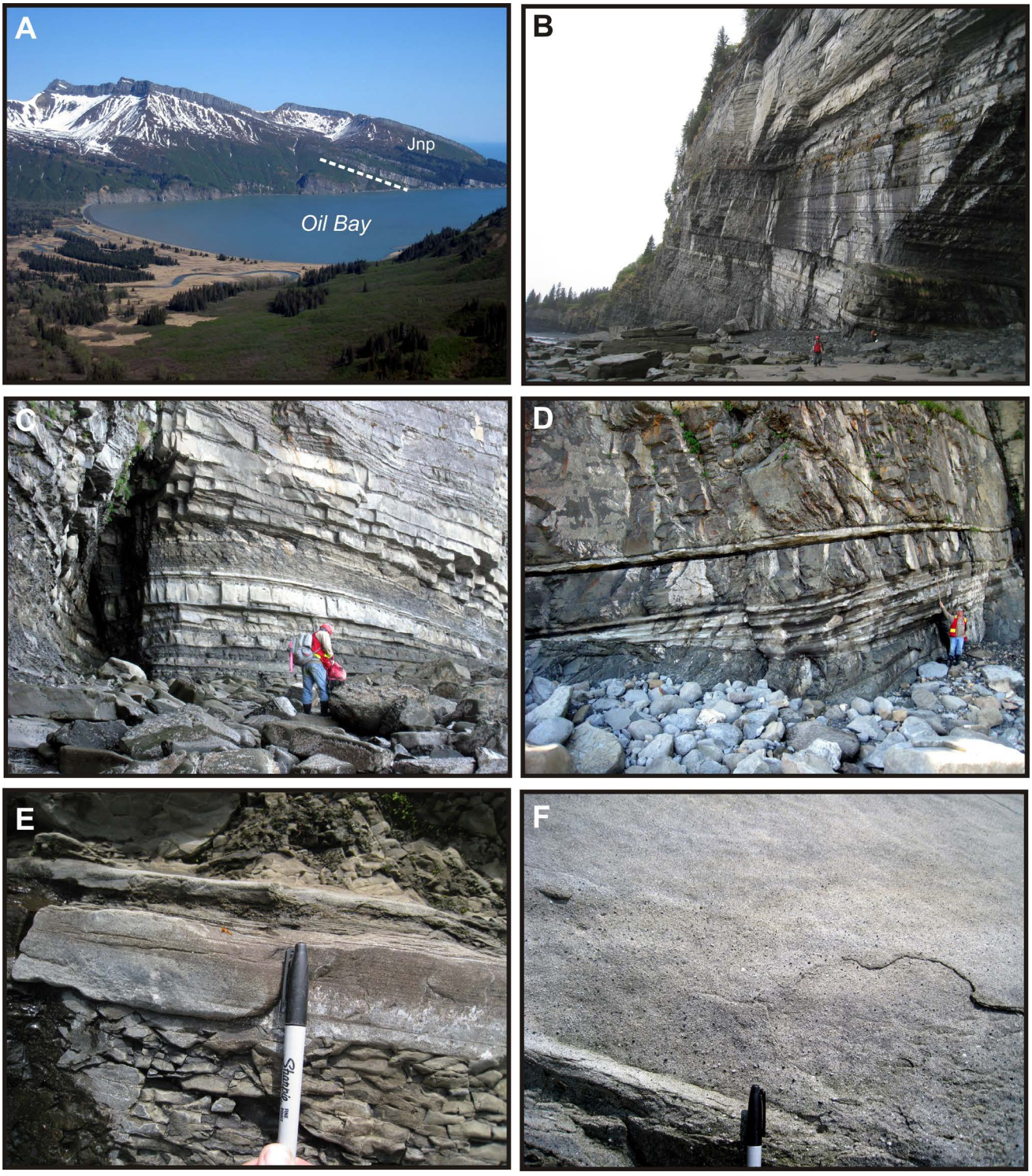

Figure 42. Representative photographs of the Pomeroy Arkose Member of the Naknek Formation along Oil Bay. (A) View to the southeast across Oil Bay showing the resistant Pomeroy (Jnp), which forms prominent cuestas with flat-irons dipping southeastward into Cook Inlet; (B) example of rugged coastal exposures of laterally continuous, tabular-bedded sandstone and siltstone; (C) upward-thickening packages of sandstone and siltstone interpreted as stacked sediment gravity-flow deposits; (D) incision along the margin of a submarine channel; (E) normally graded fine- to very-fine sandstone with massive to laminated internal structure and capped by weakly developed current ripples—interpreted as partial Bouma sequence associated with turbidite deposition; (F) upward-fining, poorly sorted, structureless sandstone interpreted as high concentration mass flow deposit.