CHAPTER 8

PRELIMINARY FACIES ANALYSIS OF THE LOWER SANDSTONE MEMBER OF THE UPPER JURASSIC NAKNEK FORMATION, NORTHERN CHINITNA BAY, ALASKA

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INTRODUCTION

Nearly all oil and gas in the Cook Inlet region of southern Alaska is produced from Cenozoic reservoirs (Magoon, 1994). However, a number of plays involving Mesozoic strata are still underexplored and the potential for discovery of new hydrocarbon accumulations remains significant (Stanley and others, 2011). New geologic information is necessary to constrain the nature of the Mesozoic petroleum system. Relatively few wells penetrate below the Cenozoic section; however, excellent exposures of Mesozoic strata are present along the western margin of Cook Inlet and have been the focus of recent stratigraphic and structural studies led by the Alaska Division of Geological & Geophysical Surveys (DGGS; LePain and others, 2013; Gillis, 2013, 2014). New stratigraphic studies of potential Upper Jurassic reservoirs were conducted during the summer of 2014. This brief report summarizes our preliminary observations from one of these units, the lower sandstone member of the Naknek Formation, which is well exposed along the north side of Chinitna Bay (fig. 8-1). This information will lead to an improved depositional model for this formation, and ultimately assist in the assessment of the region's petroleum potential. These data also provide a robust framework for planned geologic mapping in upcoming years, including criteria for map unit identification (Gillis and others, 2014).

LOWER SANDSTONE MEMBER OF THE NAKNEK FORMATION

The presently accepted stratigraphic subdivision of the Upper Jurassic Naknek Formation in the study area was established by Detterman and Hartsock (1966). The Chisik Conglomerate Member marks the base of the formation regionally, but is absent in the Chinitna Bay area (fig. 8-1); instead the basal position is occupied by the laterally equivalent lower sandstone member. The lower sandstone member remains an informal designation; our recent stratigraphic studies (Wartes and others, 2013) and geologic mapping (Herriott and Wartes, 2014) suggest that the unit is widespread in the region and likely warrants formal member status. Robust collections of ammonite and bivalve fossils from the lower sandstone indicate the unit is entirely Oxfordian in age (Detterman and Hartsock, 1966; Imlay, 1981) and likely equivalent in part to the Northeast Creek Sandstone Member of the lower Naknek Formation exposed farther south, along the Alaska Peninsula (Detterman and others, 1996).

CHINITNA BAY SECTION

The lower sandstone member was examined along the north shore of Chinitna Bay, where it forms light gray weathering coastal cliffs (fig. 8-2). The southern part of the exposure lies in the footwall of the Bruin Bay fault, where the unit is subhorizontally dipping and exposed high on the cliff face. Dips increase eastward, rolling over to ~30 degree east dips, bringing the unit down to more accessible exposures at beach level (figs. 8-1, 8-2, 8-3). A detailed measured section indicates the lower sandstone member is approximately 317 m thick at this location.

The base of the lower sandstone member was chosen at a notable change in weathering style, marked principally by an increase in grain size from the underlying Paveloff Siltstone Member of the Chinitna Formation. Similarly, the top of the lower sandstone was picked at a mappable change in outcrop resistance from the cliff-forming sandstone bodies upward into the more recessive, finer-grained facies of the overlying Snug Harbor Siltstone Member of the Naknek Formation. The criteria for formation designation used in this measured section followed the lithostratigraphic characteristics outlined by Herriott and Wartes (2014) for the Iniskin Peninsula region immediately south of Chinitna Bay.

The grain size of the lower sandstone member is dominantly upper very fine to lower fine. Two principal lithofacies are observed: (1) light gray to white weathering arkose, and (2) olive-gray to gray-brown weathering argillaceous sandstone (fig. 8-3). These two facies are interbedded at a variety of scales, often giving the outcrop a banded appearance (fig. 8-4A); where they are finely interbedded, they occasionally preserve partial Bouma sequences dominated by plane-parallel lamination grading up into rippled facies with silty caps.

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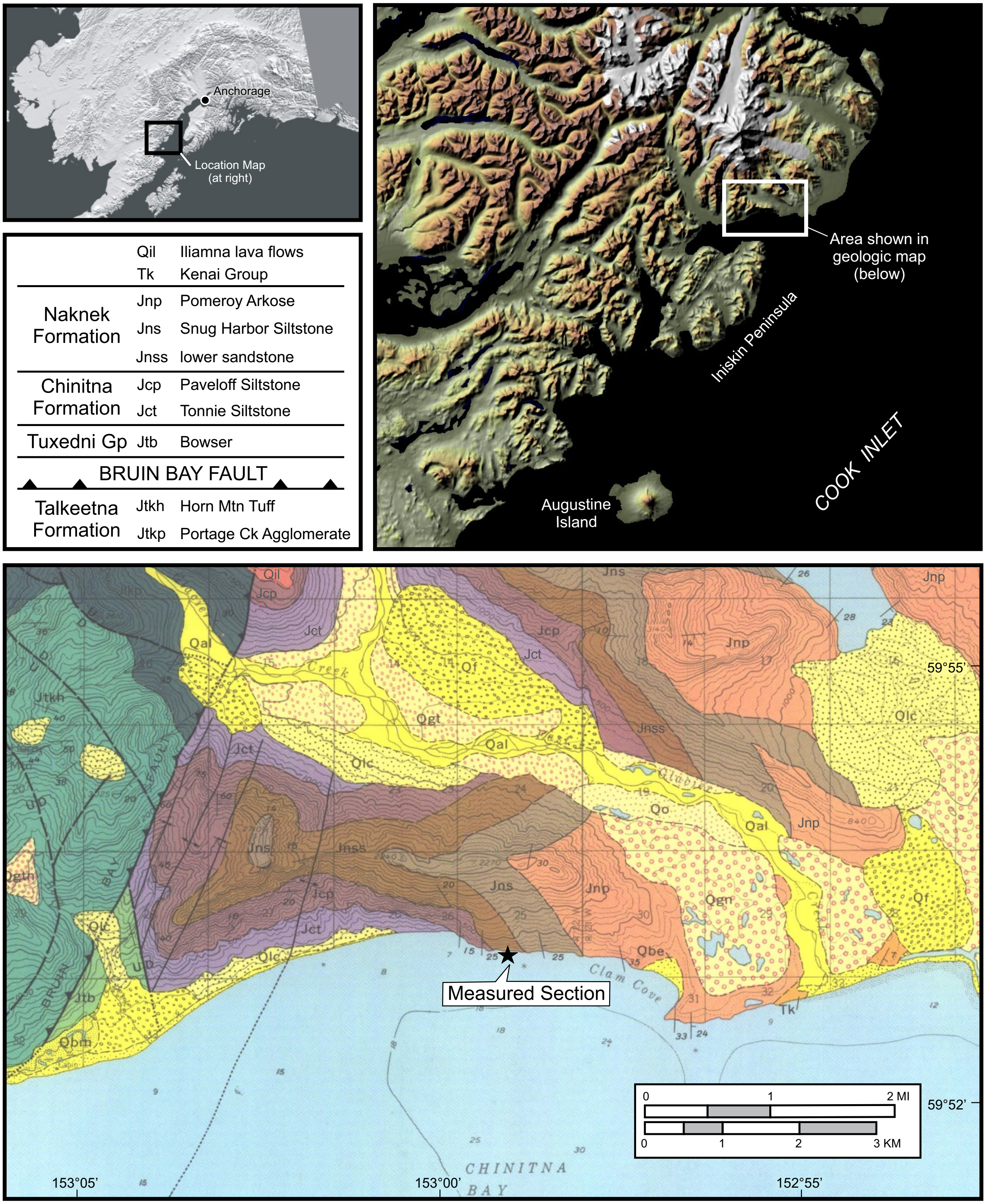

Figure 8-1. Geologic map of the area north of Chinitna Bay (Detterman and Hartsock, 1966), showing the location of detailed measured section.

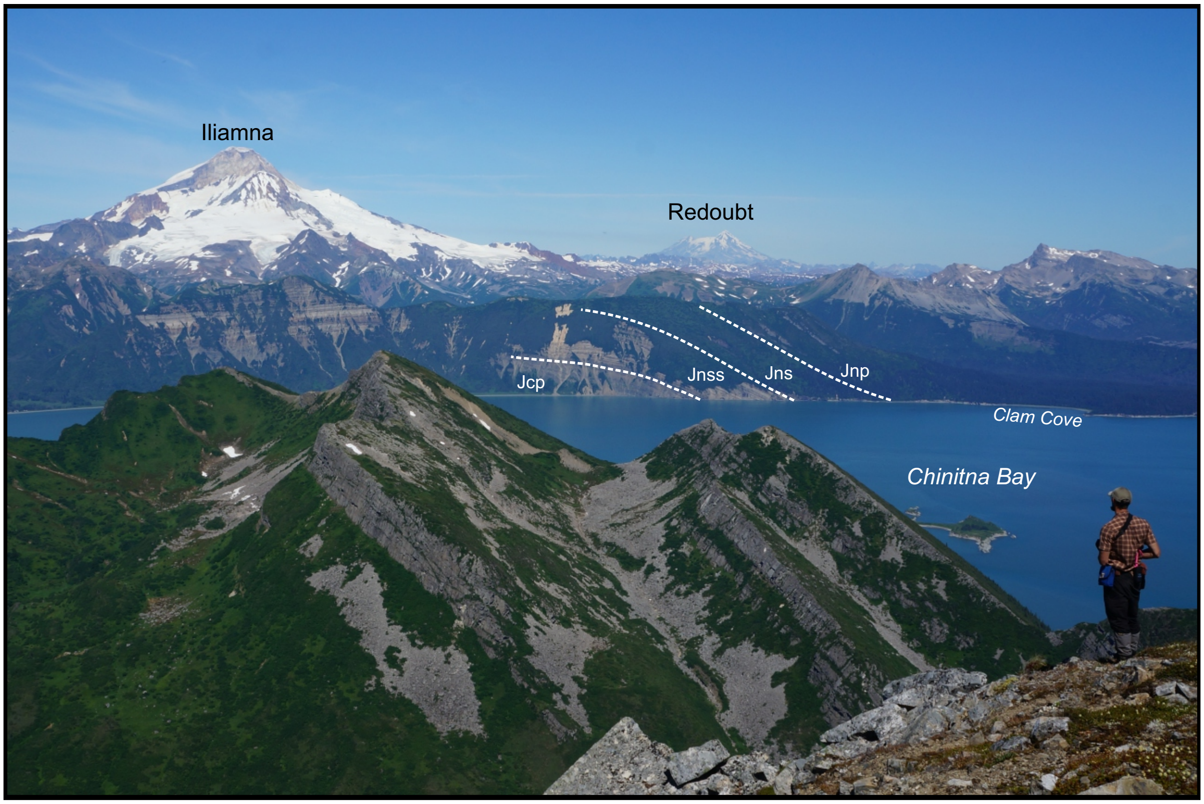

Figure 8-2. View to the north, looking across Chinitna Bay. Jcp = Paveloff Siltstone of the Chinitna Formation; Jnss = lower sandstone member of the Naknek Formation; Jns = Snug Harbor Siltstone of the Naknek Formation; Jnp = Pomeroy Arkose of the Naknek Formation.

Figure 8-3. Representative view of exposure quality along the north shore of Chinitna Bay. The banded appearance of parts of the outcrop is a common feature of the lower sandstone member in this region.

The lighter colored arkose is typically more resistant, with tabular bedding ranging from thin and flaggy to massive. The arkose often preserves sedimentary structures, including trough and low-angle cross-stratification, and locally hummocky and swaley bedforms (fig. 8-4B). Trains of mudstone intraformational rip-up clasts are common, particularly above through-going scour surfaces. Evidence for soft-sediment deformation ranges from diffuse zones of dewatering (fig. 8-4C) to meter-scale disrupted beds with ball and pillow structures.

The argillaceous sandstone is often structureless, although remnant textures (fig. 8-4D) indicate the unit has been disrupted by burrowing organisms. A variety of bioturbation was observed, ranging from cryptic and wispy fabrics to zones with well-expressed, complexly churned facies (fig. 8-4E). Discrete trace fossils recognized include *helminthopsis*(?), *phycosiphon, thalassinoides, paleophycus, diplocraterion, fugichnia*(?), *teichichnus*, and *rhizocorralium*.

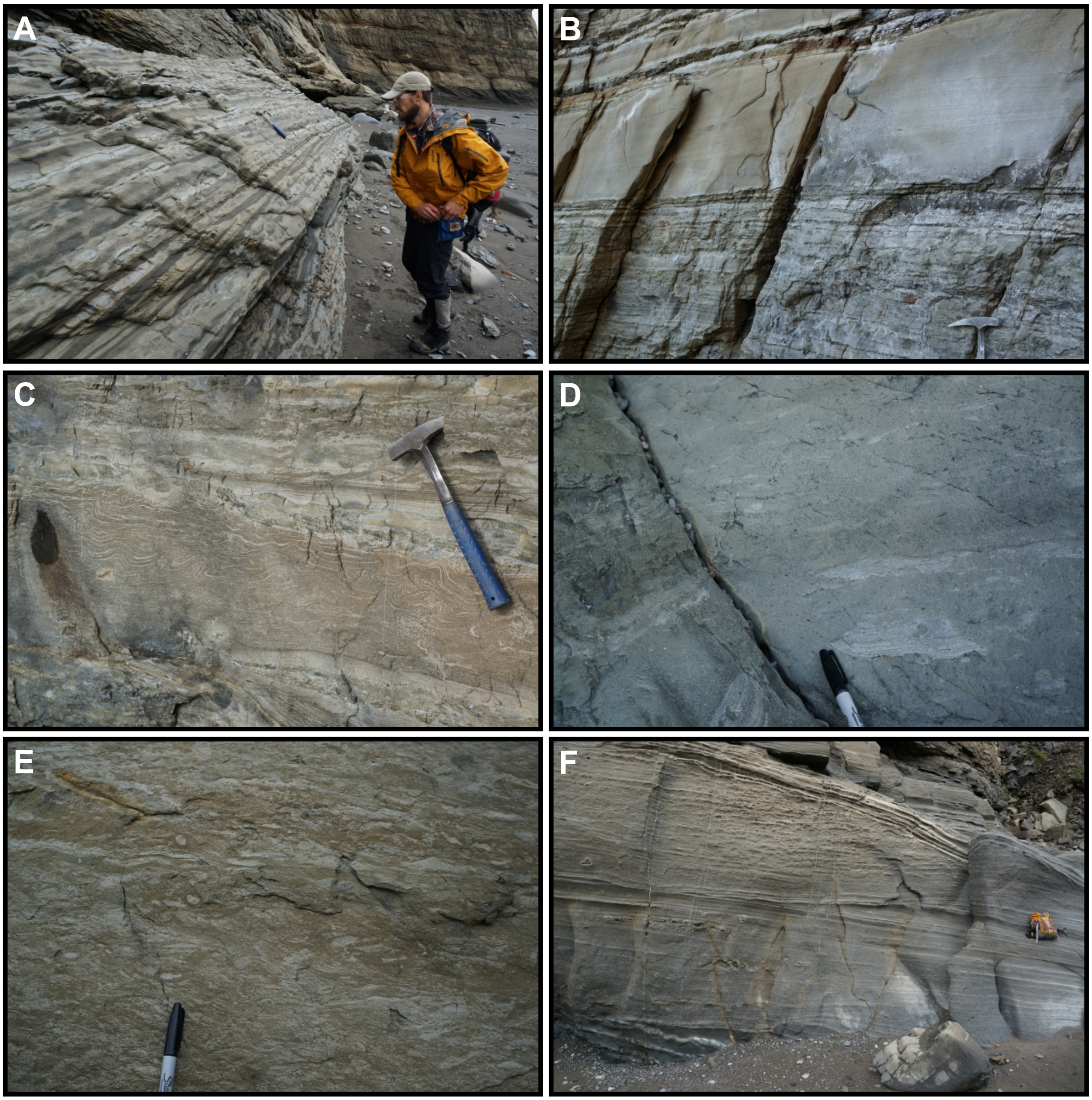

Figure 8-4. Representative photographs of the lower sandstone member along the north side of Chinitna Bay. **A.** View of rhythmically interbedded argillaceous sandstone and arkose; B. Hummocky cross-stratification; **C.** Convolute bedding; **D.** Example of locally intense bioturbation, with only wispy remnants of less disturbed zones; **E.** Bioturbation fabric; **F.** Coarse-grained sandstone with mud rip-up clasts and internal truncation surface.

A less common lithofacies is medium gray to reddish brown, medium- to very-coarse-grained sandstone (fig. 8-4F). This facies typically exhibits a sharp, erosive base with up to 2 m of relief. Internally, these coarser zones are moderately to poorly sorted and locally include thin gravel stringers, carbonaceous and woody debris, and belemnite and bivalve fossils (figs. 8-4F and 8-5).

Figure 8-5. Photographs of angular unconformity in the lower sandstone member along northern Chinitna Bay. **A.** Annotated view of angular unconformity, illustrating the westward (toward the upper left) increase in the amount of section removed beneath the surface. **B.** Close-up view of the unconformity, including the conglomeratic base of the reddish-brown weathering bed.

The unit displays occasional upward-coarsening trends, but the vertical stacking of facies is otherwise not organized into a clear repeating pattern or motif. Most bed sets appear generally tabular at the scale of the exposure. However, in at least two positions in the measured sections there are subtle truncations running more than 100 m across the outcrop (fig. 8-5). These local(?) angular unconformities both cut downsection toward the west.

PRELIMINARY INTERPRETATION

Many of the facies observed in the lower sandstone member along northern Chinitna Bay are very similar to those reported from elsewhere on the Iniskin Peninsula to the south (Wartes and others, 2013; Herriott and Wartes, 2014). The evidence for well-developed and locally diverse burrowing infauna is consistent with a shelfal setting. The occasional preservation of hummocky cross-stratification provides further evidence that deposition was influenced by waves, likely in a lower shoreface setting (Dott and Bourgeois, 1982). The relative role of a deltaic influence is unclear, although the weakly-expressed upward-coarsening motif is consistent with progradational character of delta-front settings. In addition, the coarser-grained facies may represent distributary channels and mouth bars. Further assessment of the detailed measured section will seek to refine this interpretation.

Our measured thickness of 317 m is considerably thicker than estimates for the lower sandstone member on the south side of Chinitna Bay (Detterman and Hartsock [1966] reported a thickness of 256 m, while Herriott and Wartes [2014] calculated 253 m). This difference may reflect differing mapping criteria, leading to variable placement of formation contacts. However, our mapping in the Hickerson Lake area (Herriott and others, 2015), only a few miles north of Chinitna Bay, indicated a thickness of 322 m for the lower sandstone member in that area. Thus, we tentatively suggest that the unit thickens markedly northward, perhaps indicating variations in accommodation along the margin.

The angular unconformities in the lower sandstone member suggest possible uplift of more proximal parts of the depositional system. The cause of these intraformational surfaces is unclear, but may be related to syndepositional activity on the nearby Bruin Bay fault (Wartes and others, 2013; Trop and others, 2005). Alternatively, the Late Jurassic growth of the batholith may have promoted magmatic inflation(?) and subtle tilting of the forearc basin.

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