CHAPTER 5

STRATIGRAPHIC RECONNAISSANCE OF THE MIDDLE JURASSIC RED GLACIER FORMATION, TUXEDNI GROUP, AT RED GLACIER, COOK INLET, ALASKA

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INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) and U.S. Geological Survey (USGS) are implementing ongoing programs to characterize the petroleum potential of Cook Inlet basin. Since 2009 this program has included work on the Mesozoic stratigraphy of lower Cook Inlet, including the Middle Jurassic Tuxedni Group between Tuxedni and Iniskin bays (LePain and others, 2013; Stanley and others, 2013; fig. 5-1). The basal unit in the group, the Red Glacier Formation (fig. 5-2), is thought to be the principal source rock for oil produced in upper Cook Inlet, and available geochemical data support this contention (Magoon and Anders, 1992; Magoon, 1994). Despite its economic significance very little has been published on the formation since Detterman and Hartsock's (1966) seminal contribution on the geology of the Iniskin–Tuxedni area nearly 50 years ago. Consequently its stratigraphy, contact relations with bounding formations, and source rock characteristics are poorly known. During the 2014 field season, a nearly continuous stratigraphic section through the Red Glacier Formation in its type area at Red Glacier was located and measured to characterize sedimentary facies and to collect a suite of samples for analyses of biostratigraphy, Rock-Eval pyrolysis, vitrinite reflectance, and sandstone composition (fig. 5-3).

The poorly known nature of the Red Glacier Formation is likely due to its remote location, steep terrain, and the fact that the type section is split into two segments that are more than 3 km apart. The lower 375 m segment of the formation is on the ridge between Red Glacier and Lateral Glacier and the upper 1,009 m segment is on the ridge between Red Glacier and Boulder Creek (fig. 5-3). Structural complications in the area add to the difficulty in understanding how these two segments fit together.

STRATIGRAPHIC RECONNAISSANCE OF THE RED GLACIER FORMATION

Our section, on the ridge between Red and Lateral glaciers, includes part of the lower 375 m of Detterman and Hartsock's (1966) type section, and continues southeast along this same ridge to the contact with the overlying Gaikema Sandstone, for a total measured Red Glacier thickness of 681 m (fig. 5-3). The lower 150 to 200 m of Red Glacier is not accessible for measurement due to the steep terrain. Assuming the true thickness of this inaccessible part lies in this range, the total thickness of the formation is between 831 and 881 m. Many faults with minor offsets (few decimeters to a meter) cut the section but do not complicate measurement, as marker beds can be traced with high confidence across these structures.

The lower part of our measured section includes a 178-m-thick lower succession that consists of two thick packages (each 20–40 m thick) of amalgamated, fine- to very-coarse-grained sandstone separated by recessive-weathering mudstone with many interbeds of fine- to very-coarse-grained sandstone (figs. 5-4A and B). Only the upper 20 m or so of the lower amalgamated package was accessible. Sandstones in the amalgamated packages consist of a variety of volcanolithic grains, including dark-colored volcanic rock fragments and abundant light gray and white plagioclase grains. Most sandstones are medium to very thick bedded and appear internally massive, but crudely developed horizontal stratification and well-developed plane-parallel lamination are locally common as is ripple cross-lamination in fine-grained sandstones; graded bedding is not common and, where present, is limited to the upper few centimeters of beds. Mudstone rip-ups are locally prominent as well-defined clast-rich layers, but they also occur widely scattered throughout many sandstone beds. Most sandstone beds lack trace fossils but a few include possible *Phycosiphon* and/or *Helminthopsis*. Belemnites are rare. Recessive-weathering mudstone with many individual beds of sandstone separates the amalgamated sandstone packages. Mudstone consists largely of argillaceous siltstone with undisturbed plane-parallel lamination. Some mudstones are bioturbated and have a mottled appearance and either lack lamination or include disrupted lamina. Mudstone successions include decimeter- to multi-meter-thick beds of coarse-grained sandstone similar to the sandstones in the amalgamated sandstone packages. Massive sandstones and crudely laminated sandstones record deposition from high-density flows, whereas sandstones with well-developed traction structures record deposition from lower-density flows (Lowe, 1982; Mulder and Alexander, 2001; Talling and others, 2012). Mudstones record deposition from dilute, low-density flows (Potter and others, 2005; Talling and others, 2012). Bioturbated mudstones and rare body fossils indicate deposition in a marine setting. The entire package is inferred to have been deposited below maximum storm wave-base.

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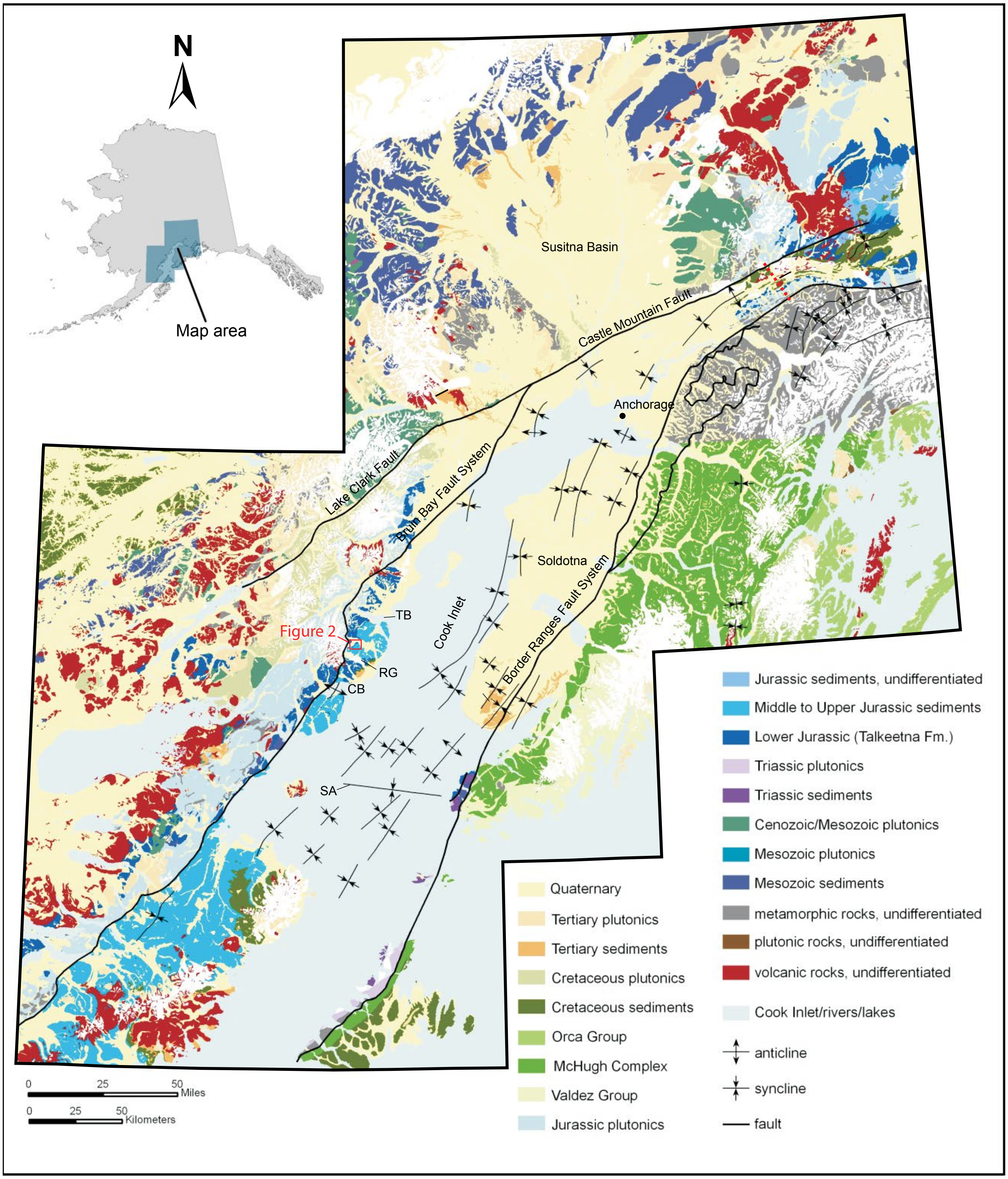


Figure 5-1. Bedrock geologic map of the Cook Inlet region. CB = Chinitna Bay; SA = Seldovia arch; RG = Red Glacier; TB = Tuxedni Bay. Modified from Wilson and others (2009).

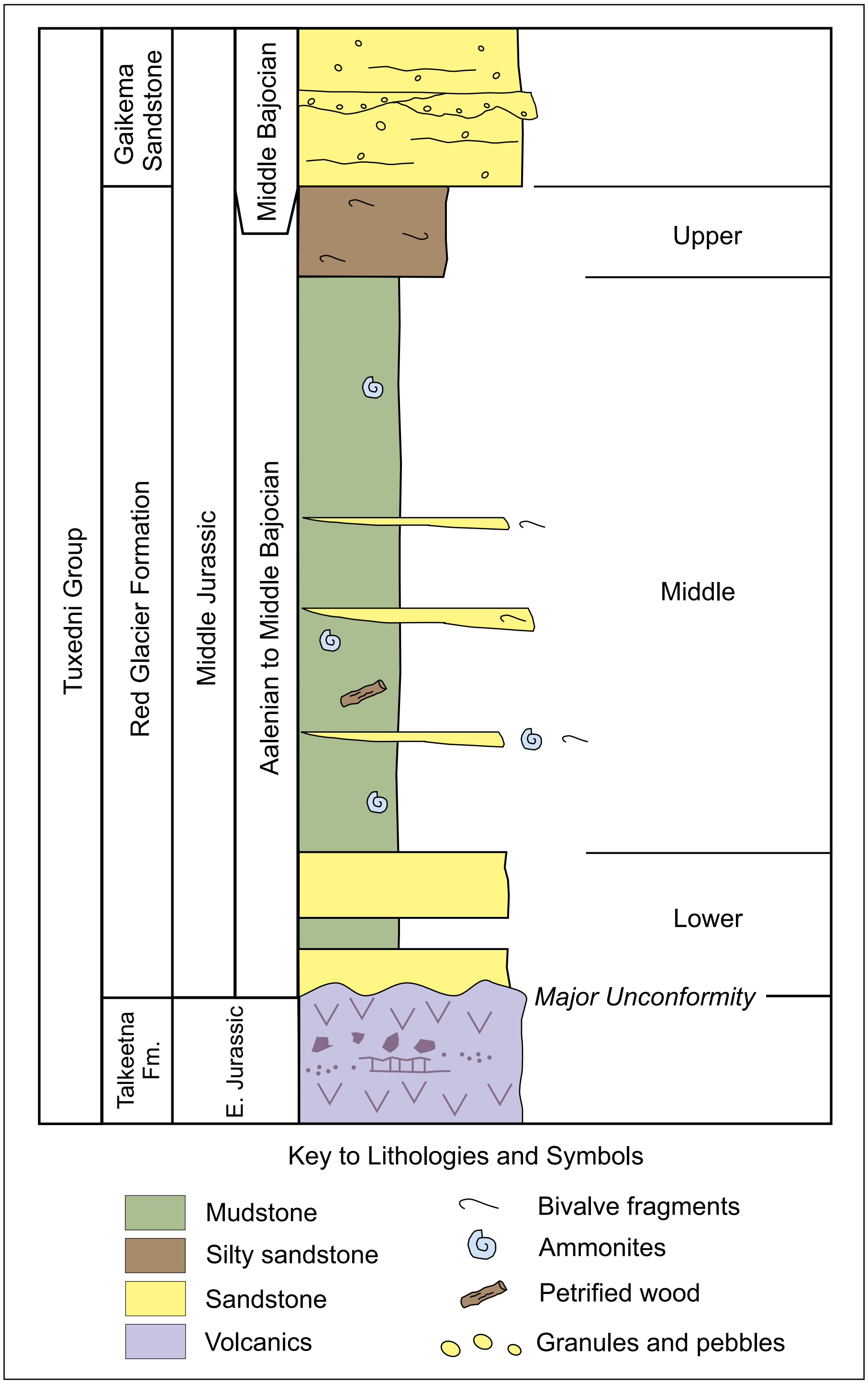


Figure 5-2. Generalized stratigraphic column showing the Red Glacier Formation and Gaikema Sandstone. Compiled from Detterman and Hartsock (1966) and modified based on the author's experience.

The middle part of our section includes 573 m of dark gray, dark brown, and black mudstone with thin laminae up to 1 mm thick of siltstone and very-fine-grained sandstone (fig. 5-4C). Beds of fine- to coarse-grained sandstone up to 0.5 m thick punctuate this part of the section but are not abundant (fig. 5-4D). Dark brown mudstone is commonly soft and fissile. Dark gray mudstone appears moderately bioturbated in the lower 100 m of the package, and bioturbation fabrics are not apparent in the upper part. Ammonites, belemnites, and bivalves are scattered throughout and are most conspicuous when incorporated in beds of coarser material (silt and fine sand; fig. 5-4E). Several discrete horizons include pieces of petrified logs up to 30 cm long and 20 cm diameter (fig. 5-4F). Well-developed quartz crystals up to 5 cm long are scattered along the ground surface at several locations. Thin sheet-like accumulations of a fibrous zeolite(?) mineral are present as dike-like features that cut across stratigraphy and as sill-like features that are concordant with stratigraphy. Prominent clastic dikes filled with fine-grained sandstone are common and are oriented at high angles to bedding. Sandstone composition is similar to sandstones in the lower part of the section, and most beds are massive or normally graded; mudstone rip-up clasts are present locally but are not abundant. Mudstone records deposition in relatively deep water from suspension and from low-energy, dilute muddy flows (Potter and others, 2005; Talling and others, 2012). These conditions were interrupted occasionally by more energetic low- and high-density sediment gravity flows that transported fine- to coarse-grained sand. The appearance of the dark gray and brown mudstones suggests that marine organic material was an abundant component in sediment at the time of deposition. Rock-Eval pyrolysis results, underway at the time of this writing, will test this supposition and add to a limited dataset collected in 2009 (LePain and others, 2013).

The upper part of our section is 41 m thick and consists of light-brown-weathering sandy siltstone and silty sandstone (figs. 5-4G and H). Although not perfectly exposed, the contact between the middle and upper parts of the section appears to

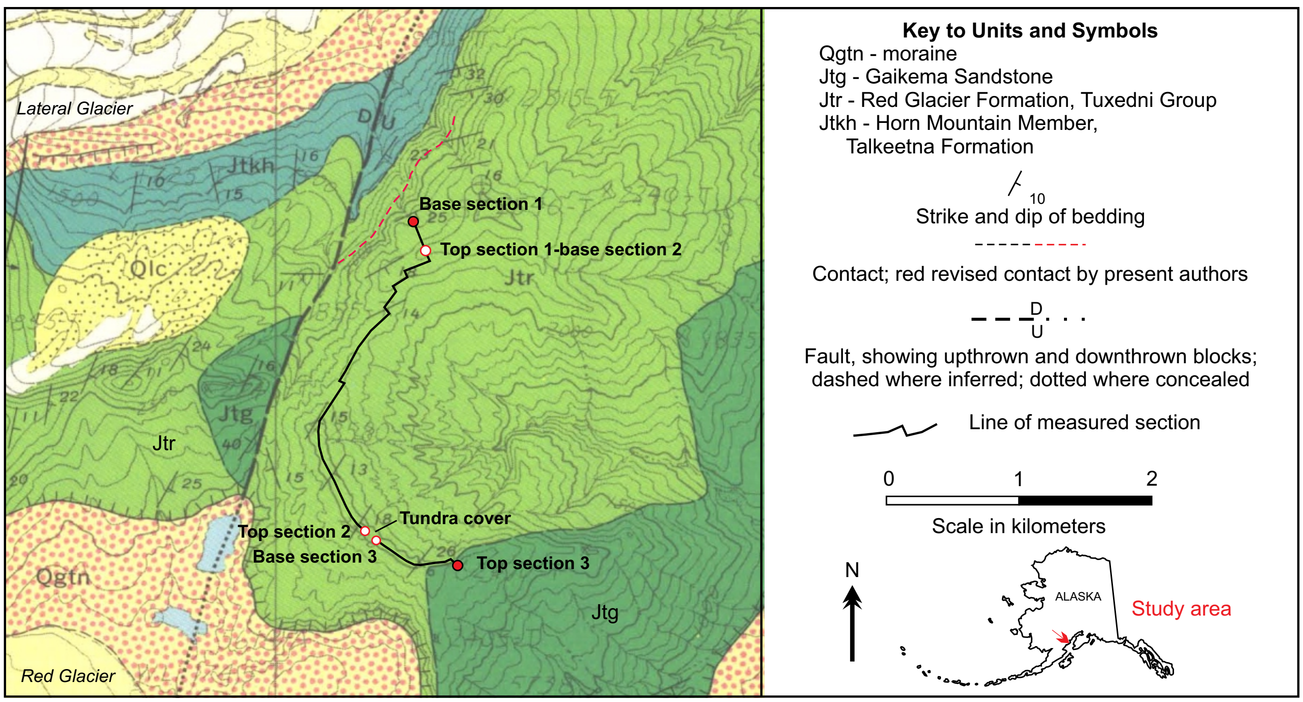
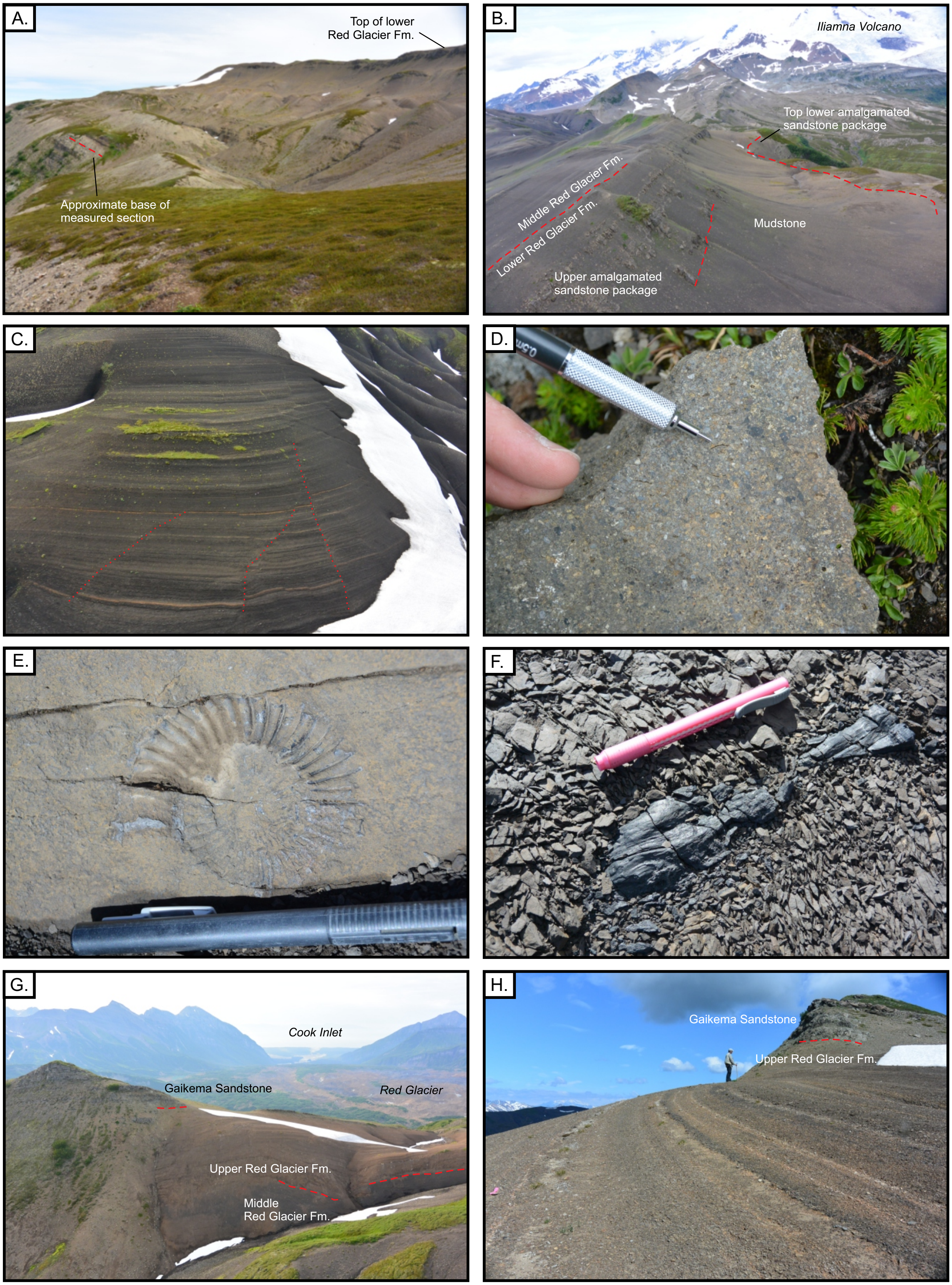


Figure 5-3 (above). Geology of the Red Glacier type area modified from Detterman and Hartsock (1966) and showing the line of the measured section from figure 5-2. Red dashed line shows our revised location of the contact between the Talkeetna Formation and Red Glacier Formation.

Figure 5-4 (right). **A.** View to the north, showing the lower Red Glacier Formation. Area shown in photo is immediately north of Lateral Glacier. **B.** View to the south–southwest, showing the contact between the lower and middle Red Glacier Formation. **C.** View from the air toward the east, showing well-stratified mudstones of the middle Red Glacier Formation. Note the minor faults (shown with dotted red lines). **D.** Coarse-grained volcanolithic sandstone from the middle Red Glacier Formation. **E.** Ammonite preserved in a silty sandstone bed in middle Red Glacier Formation. **F.** Fragment of petrified wood in siltstone from the middle Red Glacier Formation. Eraser is 12 cm long. **G.** View to the east–southeast, showing the contact between middle and upper Red Glacier Formation (lower red dashed line) and the upper Red Glacier Formation and Gaikema Sandstone. Note the sharp contact between the middle and upper Red Glacier Formation. **H.** View to the north, showing stratified siltstone and silty sandstone of the upper Red Glacier Formation. The dashed red line marks the contact between the upper Red Glacier Formation and Gaikema Sandstone.


A.
Top of lower
Red Glacier Fm.
Approximate base of
measured section
B.
Iliamna Volcano
Top lower amalgamated
sandstone package
Middle Red Glacier Fm.
Lower Red Glacier Fm.
Mudstone
Upper amalgamated
sandstone package
C.
D.
E.
F.
G.
Cook Inlet
Gaikema Sandstone
Red Glacier
Upper Red Glacier Fm.
Middle
Red Glacier Fm.
H.
Gaikema Sandstone
Upper Red Glacier Fm.

be conformable but sharp, and corresponds to a prominent color change from dark gray and brown mudstones to light brown coarser-grained lithologies (fig. 5-4G). The contact with the overlying Gaikema Sandstone also appears to be conformable and is placed at the base of first thick sandstone succession with abundant trough cross-stratification (fig. 5-4H). Siltstones and silty sandstones include prominent plane-parallel (horizontal) lamination. The upper part of the section is interpreted as a prodeltaic succession transitional to the overlying shallow marine (deltaic) Gaikema Sandstone.

A suite of samples was collected throughout the accessible part of the formation for analyses of Rock-Eval pyrolysis, vitrinite reflectance, palynology, and sandstone composition. These samples will help in evaluating the source rock characteristics and thermal maturity of the formation and assist in correlation to subsurface locations throughout the basin. Analytical results will be summarized in a subsequent report.

ACKNOWLEDGMENTS

DGGS's field work in the Cook Inlet basin was funded by the State of Alaska and Apache Corporation. We thank Jeff Shearer at Lake Clark National Park and Preserve for help with permitting. We are grateful to Merlin "Spanky" Handley of Pathfinder Aviation for getting us into and out of mountainous locations safely, and Mike Fell, also of Pathfinder Aviation, for invaluable assistance getting helicopter fuel to our remote camp. Jim Clough (DGGS) and Marwan Wartes (DGGS) are thanked for reviewing a draft of this manuscript.

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