CHAPTER 4

SEDIMENTARY PETROLOGY AND RESERVOIR QUALITY OF THE MIDDLE JURASSIC RED GLACIER FORMATION, COOK INLET FOREARC BASIN: INITIAL IMPRESSIONS

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INTRODUCTION

The Division of Geological & Geophysical Surveys and Division of Oil & Gas are currently conducting a study of the hydrocarbon potential of Cook Inlet forearc basin (Gillis, 2013, 2014; LePain and others, 2013; Wartes, 2015; Herriott, 2016 [this volume]). The Middle Jurassic Tuxedni Group is recognized as a major source of oil in Tertiary reservoirs (Magoon, 1994), although the potential for Tuxedni reservoirs remains largely unknown. As part of this program, five days of the 2015 field season were spent examining outcrops, largely sandstones, of the Middle Jurassic Red Glacier Formation (Tuxedni Group) approximately 6.4 km northeast of Johnson Glacier on the western side of Cook Inlet (fig. 4-1). Three stratigraphic sections (fig. 4-2) totaling approximately 307 m in thickness were measured and described in detail (LePain and others, 2016 [this volume]). Samples were collected for a variety of analyses including palynology, Rock-Eval pyrolysis, vitrinite reflectance, detrital zircon geochronology, and petrology. This report summarizes our initial impressions of the petrology and reservoir quality of sandstones encountered in these measured sections. Interpretations are based largely on hand-lens observations of hand specimens and are augmented by stereomicroscope observations. Detailed petrographic (point-count) analyses and measurement of petrophysical properties (porosity, permeability, and grain density) are currently in progress.

FRAMEWORK MINERALOGY AND PROVENANCE

Red Glacier sandstones are almost exclusively volcanic litharenites that are very-fine- to coarse-grained and moderately to poorly sorted. The rock framework typically consists of 60–80 percent dark grains (figs. 4-3A and 4-B) interpreted to be largely volcanic rock fragments (VRFs). Amphiboles and/or pyroxenes constitute a minor portion of the dark grains. Light-colored grains comprise 20–40 percent of the framework and consist largely of plagioclase as suggested by occasional tabular, lath-shaped crystals. Most of the sandstones contain very little, if any, detrital quartz. The prevalence of VRFs, amphiboles/pyroxenes, and plagioclase suggests the sandstones are volcanogenic and were probably derived from an undissected volcanic arc terrane (Dickinson and Suczek, 1979; Dickinson, 1985). It is hypothesized that the detritus was derived almost exclusively from the erosion of pre-existing volcanic rocks, likely including lava flows, ignimbrites, and tuffs, in close proximity to the depocenter. The source terrane for the Red Glacier sandstones was probably a region of uplifted Lower Jurassic Talkeetna Formation (Bull, 2014; Bull, 2015) west of the Bruin Bay fault (Detterman and Hartsock, 1966).

Sandstones in the lower portion of section 1 (30.4–33.2 m in section) are notably different from the sandstones described above in that they contain a much higher proportion of light-colored grains, largely plagioclase (figs. 4-3C and 4-D). Minor K-feldspar may be present, but it is difficult to distinguish between the two feldspars in hand specimen. Detrital quartz also appears to be present in minor amounts. One possible explanation for the different mineralogy in these samples is that they contain syndepositionally erupted silicic tephra from an active volcanic center in addition to detritus derived from pre-existing volcanic rocks. A more thorough examination of these samples, including the petrographic evaluation of thin sections, should be able to confirm or refute this hypothesis.

RESERVOIR QUALITY

The mixture of abundant VRFs, amphibole/pyroxene, and plagioclase results in a labile framework mineralogy that is highly susceptible to chemical diagenetic alteration. In addition, experimental studies have shown that weathered basaltic detritus becomes extremely ductile and highly susceptible to grain deformation upon even moderate burial (Pittman and Larese, 1991). Due to the high VRF content, authigenic clays (probably chlorite), and zeolites (probably heulandite) are anticipated to be common cements that occlude the primary pore system and result in poor reservoir quality. Examination of hand specimens reveals very little, if any, intergranular porosity and the sporadic occurrence of a white, non-calcareous cement, probably a zeolite (figs. 4-3E and 4-F). Given the Middle Jurassic age of the sandstones (~170 m. y.) and the combination of a chemically and mechanically unstable framework, it is unlikely that significant conventional reservoirs exist in the Red Glacier Formation. However, due to the possibility of extensive authigenic clay cement, the Red Glacier sandstones could

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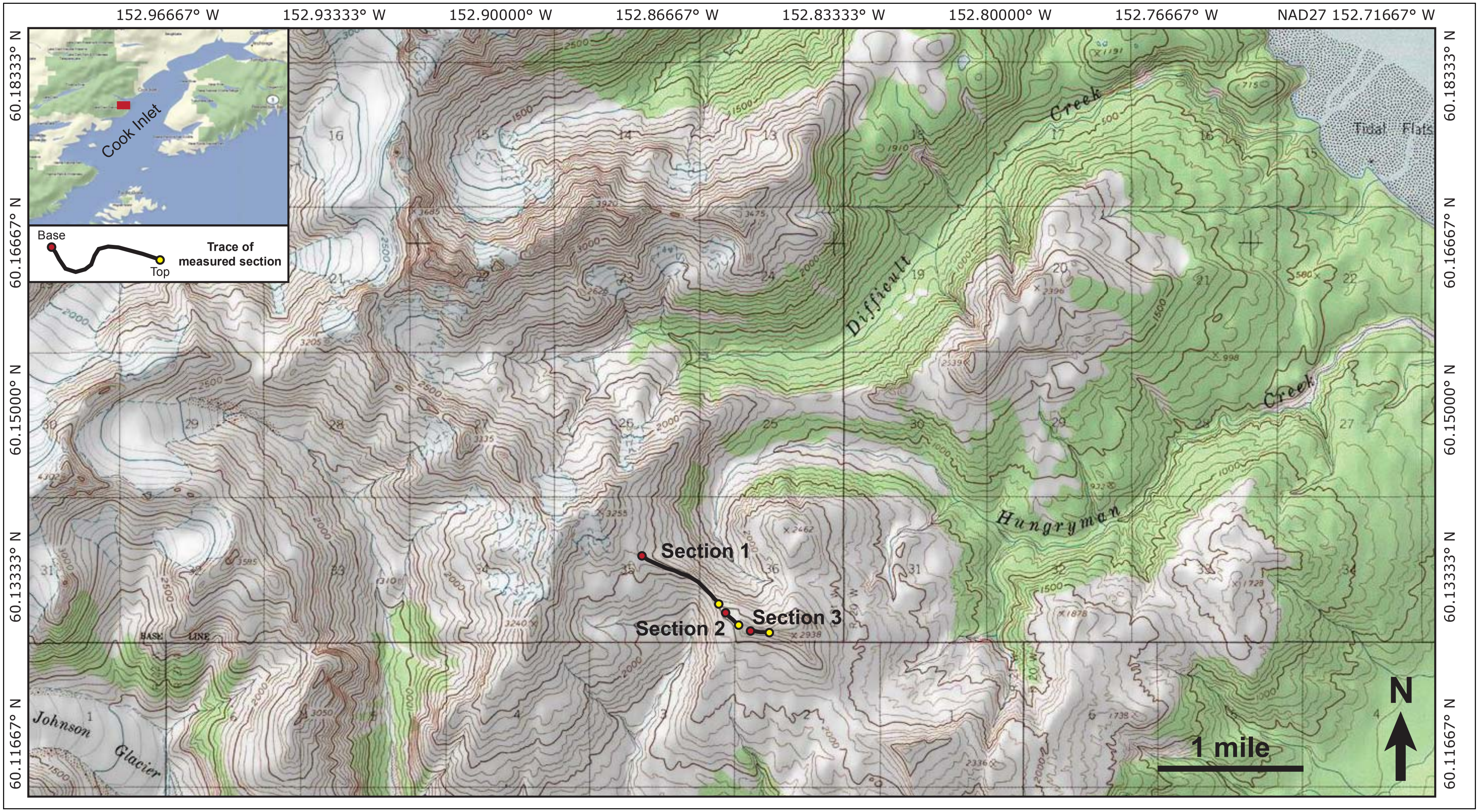

Figure 4-1. Topographic map showing location of measured sections of Red Glacier Formation northeast of Johnson Glacier on the west side of Cook Inlet. Inset is index map with red box showing location of topographic map in Cook Inlet basin.

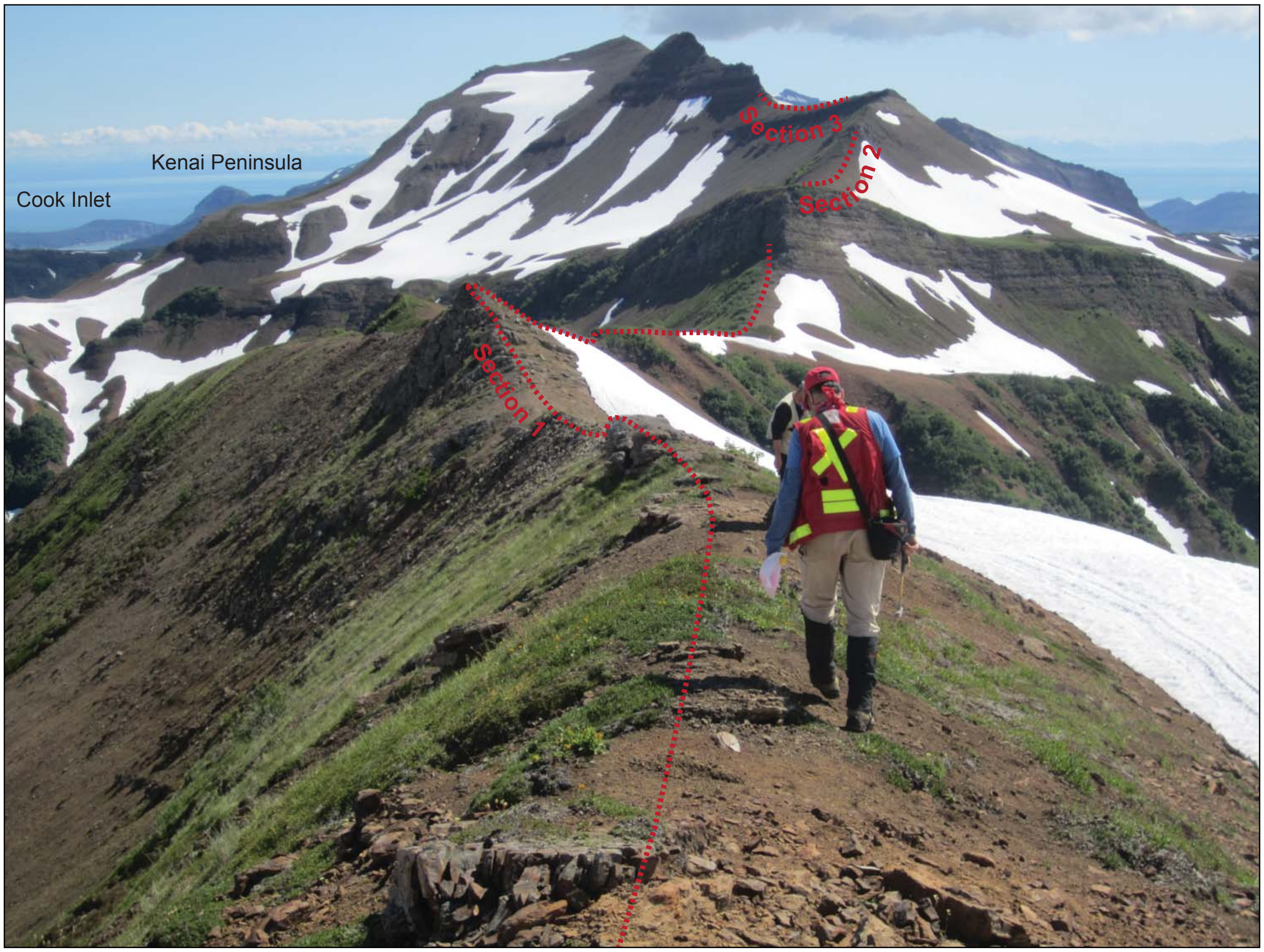

Figure 4-2. View southeastward of the three measured sections of Red Glacier Formation along ridge crest. Lithologies consist largely of fine- to coarse-grained sandstone with minor interbedded siltstone. Geologists for scale.

have potential as tight-gas reservoirs. The interfingering of tight sandstones and potential source rocks of the Red Glacier Formation (LePain and Stanley, 2015) also suggests the possibility of this formation to host continuous oil accumulations, perhaps analogous to those in the Late Devonian and Early Mississippian Bakken Formation of North Dakota (Nordeng, 2009). A similar possibility has been suggested for the overlying Gaikema Sandstone (Helmold and Stanley, 2015). Additional analyses from a larger geographic area are needed before making sweeping conclusions regarding the regional reservoir potential of the Red Glacier Formation.

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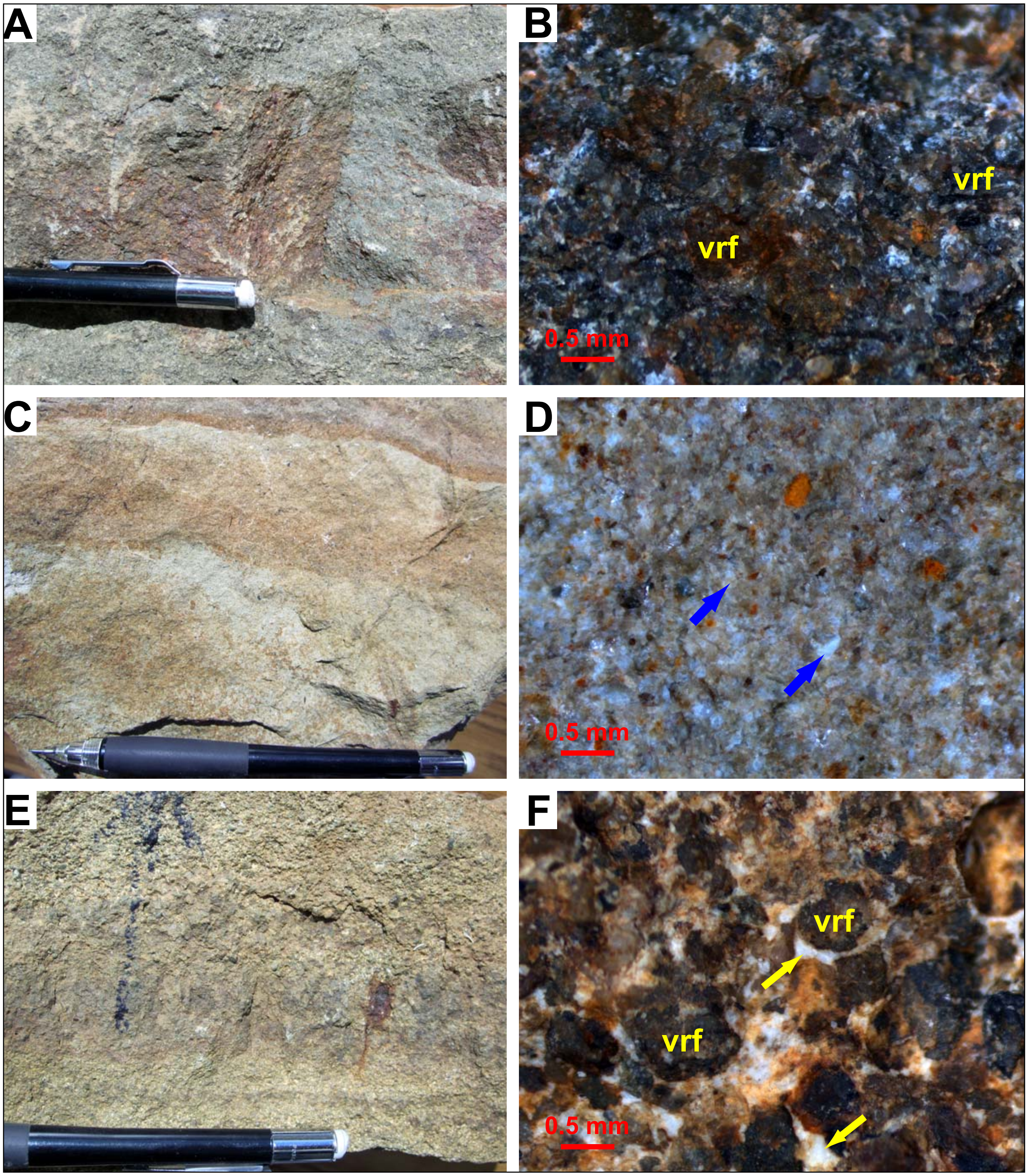

*Figure 4-3. Photographs of Red Glacier sandstones from measured section 1. **A.** Upper fine- to lower medium-grained, poorly-sorted, gray-green-colored sandstone consisting largely of volcanic rock fragments (VRFs). Hand specimen photograph; 187.5 m in section. **B.** Same sample as A, showing rock framework consisting predominantly of dark-colored, subangular to subrounded VRFs. Stereomicrograph; 187.5 m in section. **C.** Upper very-fine-grained, moderately-well-sorted, tan-colored sandstone consisting largely of euhedral to subhedral plagioclase crystals and minor detrital quartz. Hand specimen photograph; 30.4 m in section. **D.** Same sample as C, showing rock framework consisting predominantly of light-colored, angular to subangular, plagioclase grains (arrows). Orange grains are oxidized mafic components. Stereomicrograph; 30.4 m in section. **E.** Lower to upper medium-grained, poorly-sorted, tan-green-colored sandstone consisting largely of VRFs. Hand specimen photograph; 196.6 m in section. **F.** Same sample as E, showing white, non-calcareous, probably zeolite cement (arrows) filling intergranular pores between subrounded VRFs. Stereomicrograph; 196.6 m in section.*

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