

CHAPTER 10

OBSERVATIONS ON THE BRUIN BAY FAULT SYSTEM BETWEEN CHINITNA AND TUXEDNI BAYS, COOK INLET, ALASKAPaul M. Betka^{1,2} and Robert J. Gillis²**INTRODUCTION**

The Alaska Division of Geological & Geophysical Surveys (DGGS) is conducting an ongoing study to understand the structural geology and deformational history of western Cook Inlet. The Bruin Bay fault (BBF) system defines a structural boundary between Mesozoic–Cenozoic sediments of the Cook Inlet forearc basin and the Mesozoic–Cenozoic Talkeetna–Aleutian arc for most of its exposed length between the upper Alaska Peninsula near Becharof Lake northeastward to upper Cook Inlet (fig. 10-1). Recent work conducted along the BBF on the Iniskin Peninsula and at Ursus Head (fig. 10-1A) indicates that the fault system experienced a polyphase slip history characterized by both strike-slip and reverse fault-slip kinematics (Gillis and others, 2013; Betka and Gillis, 2014a, 2014b, 2015). This report presents new field observations made along the BBF near Johnson River, Red Glacier, and Open Creek pass between Chinitna and Tuxedni bays of western Cook Inlet to evaluate along-strike change in the structure of the BBF system (fig. 10-1).

FIELD OBSERVATIONS

The BBF is well exposed immediately south of the Johnson River (fig. 10-2A; location on fig. 10-1B). Here, the fault strikes north and branches to form two thrust splay faults that dip moderately to the west. The lower (easterly in map view) splay uplifts lavas and volcanic breccia of the lower informal member of the Talkeetna Formation (Jtkl; Bull, 2014, 2015) above the well-bedded lavas and volcanoclastic deposits that define the upper informal member of the Talkeetna Formation (Jtku; Bull, 2014, 2015). In the footwall, Jtku strata are folded into a top-easterly-verging, gently inclined, overturned syncline (fig. 10-2A). The upper splay (westerly in map view) juxtaposes Jurassic quartz diorite (Jqd) in the hanging wall above Jtkl in the footwall (fig. 10-2A); this splay forms an ~5-m-thick fault zone that contains cataclasite and forms a distinct red–orange-weathering band, probably resulting from oxidation of iron-sulfide minerals (figs. 10-2A and 10-2B). The stratigraphic separation across both splays of the fault zone indicates a component of top-to-the east reverse motion. However, minor fault-slip surfaces preserved in the fault zone cataclasite (fig. 10-2C; example shown in fig. 10-2B) preserve slickenlines with moderate to shallow rakes on the fault surface and indicate that the sense of slip was oblique, left-reverse. Several minor, dextral-slip surfaces strike northwest and are antithetic to the strike of the fault zone cataclasite (fig. 10-2D; example shown in fig. 10-2B). The upper fault splay was observed at a second location down-dip from the cataclasite (location E shown in fig. 10-2A). Here, the fault zone also contains cataclasite and several northeast-striking slip surfaces that record sinistral-reverse motion (fig. 10-2E; location shown in fig. 10-2A); northwest-striking right-lateral slip surfaces also occur at this outcrop (fig. 10-2E).

The BBF is also well exposed near Red Glacier, approximately 10 km south of the Johnson River locality (fig. 10-3A; location in fig. 10-1B). Here, the fault strikes north–northwest and uplifts Jtkl in the hanging wall above Jtku. Jtku strata are folded into an east-vergent footwall syncline, similar to the syncline preserved near Johnson River, but at this locality the fold is not overturned. In the hanging wall, the strata of Jtkl are also folded and form an east-vergent hanging wall anticline. The stratigraphic separation across the BBF and geometry of the footwall and hanging wall folds suggest a component of top-to-the east reverse motion. However, similar to our observations of the fault near the Johnson River, fault striations preserved on minor fault surfaces in the immediate footwall of the fault (location B in fig. 10-3A) have shallow plunges and suggest the sense of slip was oblique left-lateral (fig. 10-3B). One minor northwest-striking dextral fault also occurs at this location.

We also examined a well-preserved exposure of the BBF at a high pass above the headwaters of Open Creek, approximately 8 km north of the Johnson River locality (fig. 10-4A; location on fig. 10-1B). The fault zone separates Jurassic quartz diorite to the west from Jtkl exposed to the east for much of its length. However, granitic rocks occur in hanging wall and footwall settings north of the pass (fig. 10-4A). Here, the fault zone is subvertical, more than 100 m wide, and composed principally of intensely deformed Jtkl strata. Also found in the fault zone are common lenses of limestone that were interpreted by Determan and Hartsock (1966) to be part of the Late Triassic(?) Kamishak Formation that are tectonically interleaved with volcanic and volcanoclastic rocks of Jtkl, suggesting the fault cuts the contact between Late Triassic carbonate rocks and overlying volcanic deposits. Cataclasite and tectonic breccia are pervasive throughout the fault zone and contain numerous subvertical slipsurfaces (for example, figs. 10-4B and 10-4C). Minor slip surfaces record predominantly strike-slip fault

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Figure 10-1 (left). **A.** Simplified geologic map of western Cook Inlet modified from compilation by Wilson and others (2012). **B.** Simplified geologic map of the study area modified after Detterman and Hartssock (1966), Detterman and Reed (1980), Wilson and others (2012), and new mapping by the Alaska Division of Geological & Geophysical Surveys. Location is shown in figure 10-1A. Locations of figures 10-2A, 10-3A, and 10-4A and field localities discussed in this report are shown. BL—Becharof Lake.

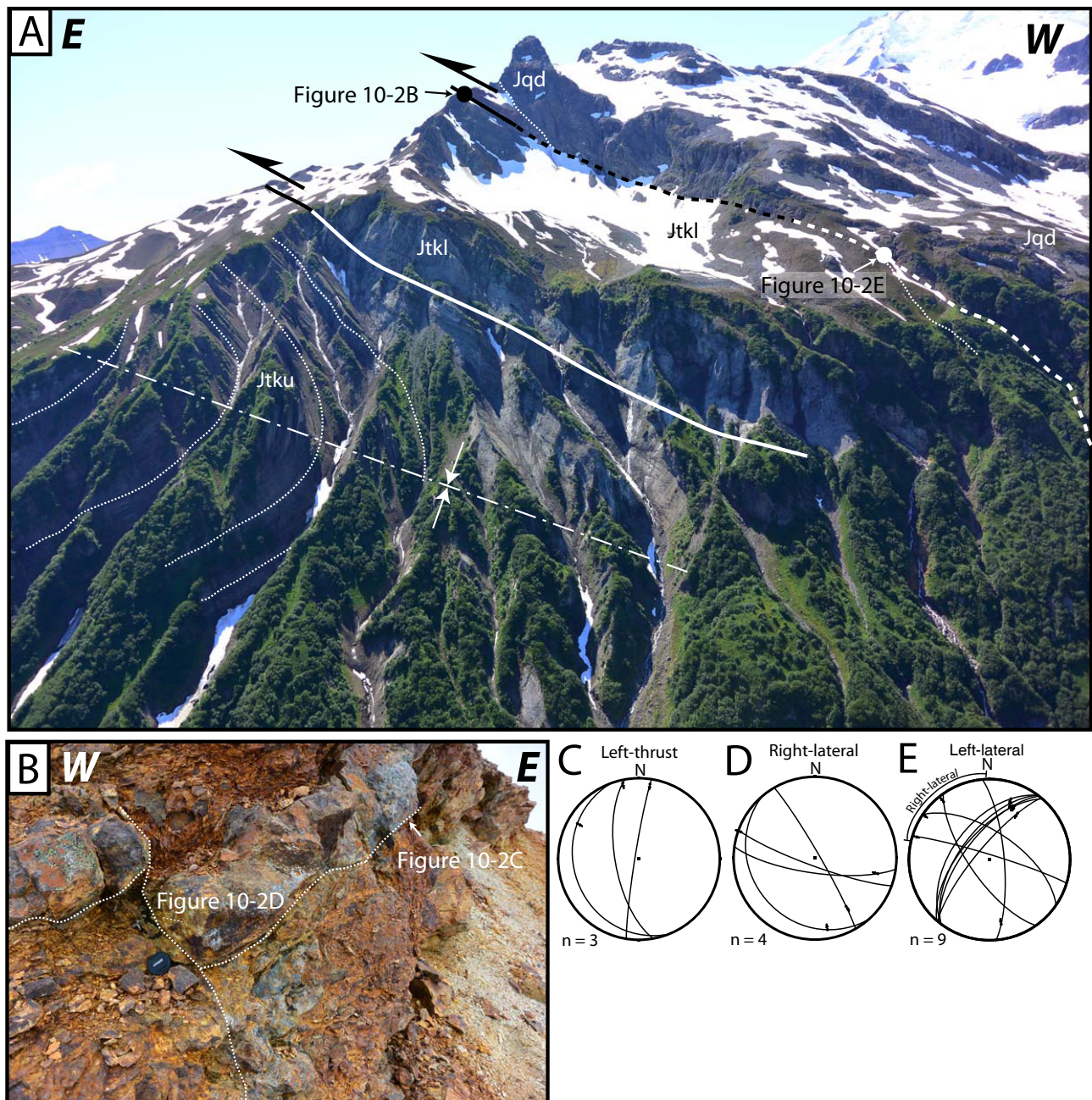


Figure 10-2 (above). Field photographs and stereograms of the Johnson River and Red Glacier localities. **A.** Aerial photograph, viewed toward the south, of the Bruin Bay fault south of the Johnson Glacier (location on fig. 10-1B; locations of figs. 10-2B and 10-2E are shown); field of view is approximately 1 mile. The fault (thick white/black line, dashed where inferred) uplifts the lower member of the Talkeetna Formation (Jtkl) above the upper member (Jtku) of the Talkeetna Formation; trace of bedding shown with thin dotted lines (see Bull, 2014, 2015, for informal member designations). Note strata of Jtku are folded into an overturned-to-the-east footwall syncline. Jqd—Jurassic quartz diorite. **B.** Photograph of oxidized fault zone cataclasite contained in the upper ramp (location shown in A); field of view is ~3 m. A competent sandy, volcanoclastic layer preserves minor slip surfaces (locations B and D) that indicate both thrust and strike-slip sense of shear. Fault-slip data from locations C and D are shown in figures 10-2C and 10-2D. Lens cap in lower left of photo for sense of scale. **C–E.** Stereograms showing fault slip data from minor fault surfaces in the fault zone cataclasite (C, D) and in the immediate footwall of the Bruin Bay fault (E); data locations shown in A and B. Arrows show attitude of striations and motion of the hanging wall; see text for discussion of fault-slip kinematics.

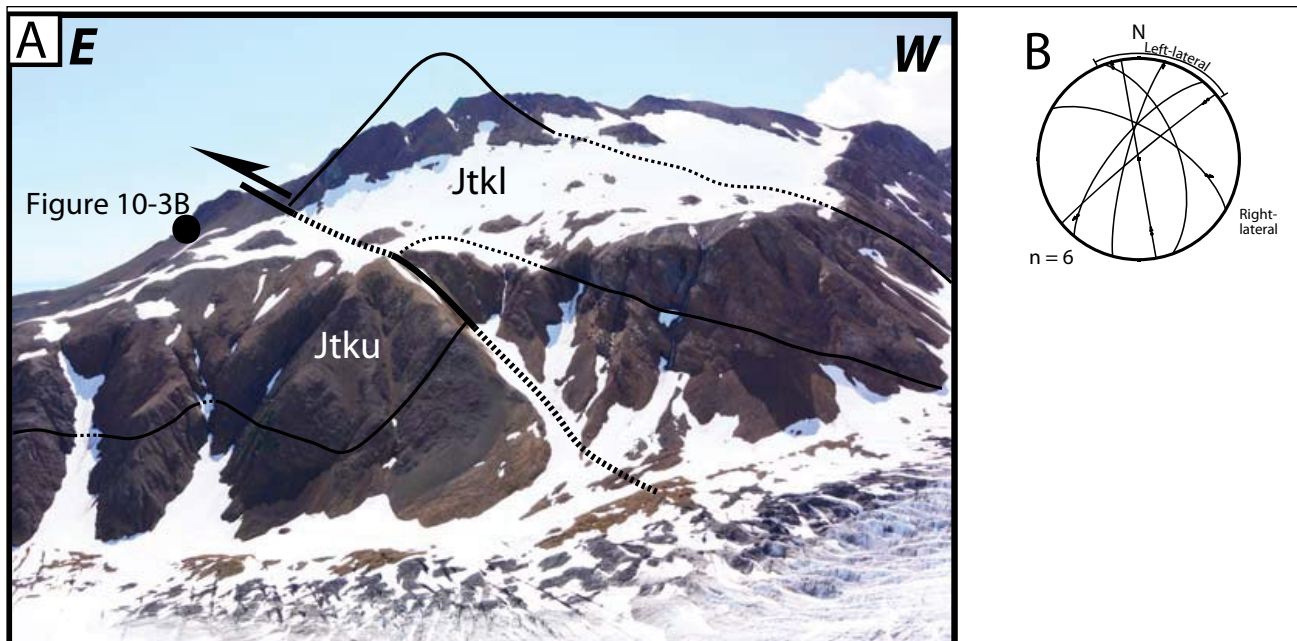


Figure 10-3. **A.** Aerial view, looking toward the south, of the Bruin Bay fault south of Red Glacier (location on fig. 10-1); field of view is approximately 1 mile. The fault uplifts Jtkl above Jtku along a thrust ramp that dips moderately to the west. Thick dashed lines show trace of fault; thinner dashed lines show trace of bedding; dashed where inferred. **B.** Stereogram showing fault slip data from minor fault surfaces in the fault zone; location of figure 10-3B is shown in figure 10-3A. Arrows show attitude of striations and motion of the hanging wall; see text for discussion of fault-slip kinematics.

kinematics. Sinistral faults strike dominantly northeast and have subhorizontal striations. A set of north–northwest-striking sinistral faults have an orientation that is consistent with synthetic Riedel shears (fig. 10-4D). Right-lateral faults strike northwest or west and are interpreted to be antithetic to the north–northeast strike of the fault zone (fig. 10-4D).

CONCLUSIONS

Observations along the BBF system between Chinitna and Tuxedni bays indicate that the fault kinematics record left-transpressional movement. Near the Johnson River and Red Glacier the fault strikes northeast and dips moderately to steeply northwest; at these localities, the BBF accommodates oblique, left-reverse slip. Fault-slip kinematics preserved to the north at Open Creek are dominated by sinistral strike-slip deformation along a subvertical fault zone, contrasting somewhat with the sinistral-reverse fault-slip kinematics observed at the two localities to the south. The change of fault-slip kinematics probably reflects the change in strike of the BBF zone from north–northeast near Chinitna Bay and Red Glacier to a more northerly strike north of the Johnson River. Fault-slip kinematics of the BBF reported in this study are consistent with thrust and left-reverse sense of slip previously reported south of the study area on the Iniskin Peninsula and at Ursus Head (fig. 10-1; Betka and Gillis, 2014a, 2014b, 2015). Altogether, new data collected by DGGs from 2013 through 2015 suggest that the BBF dominantly accommodated sinistral transpression. Ongoing work and companion studies will attempt to resolve the timing and tectonic setting of deformation along the BBF system.

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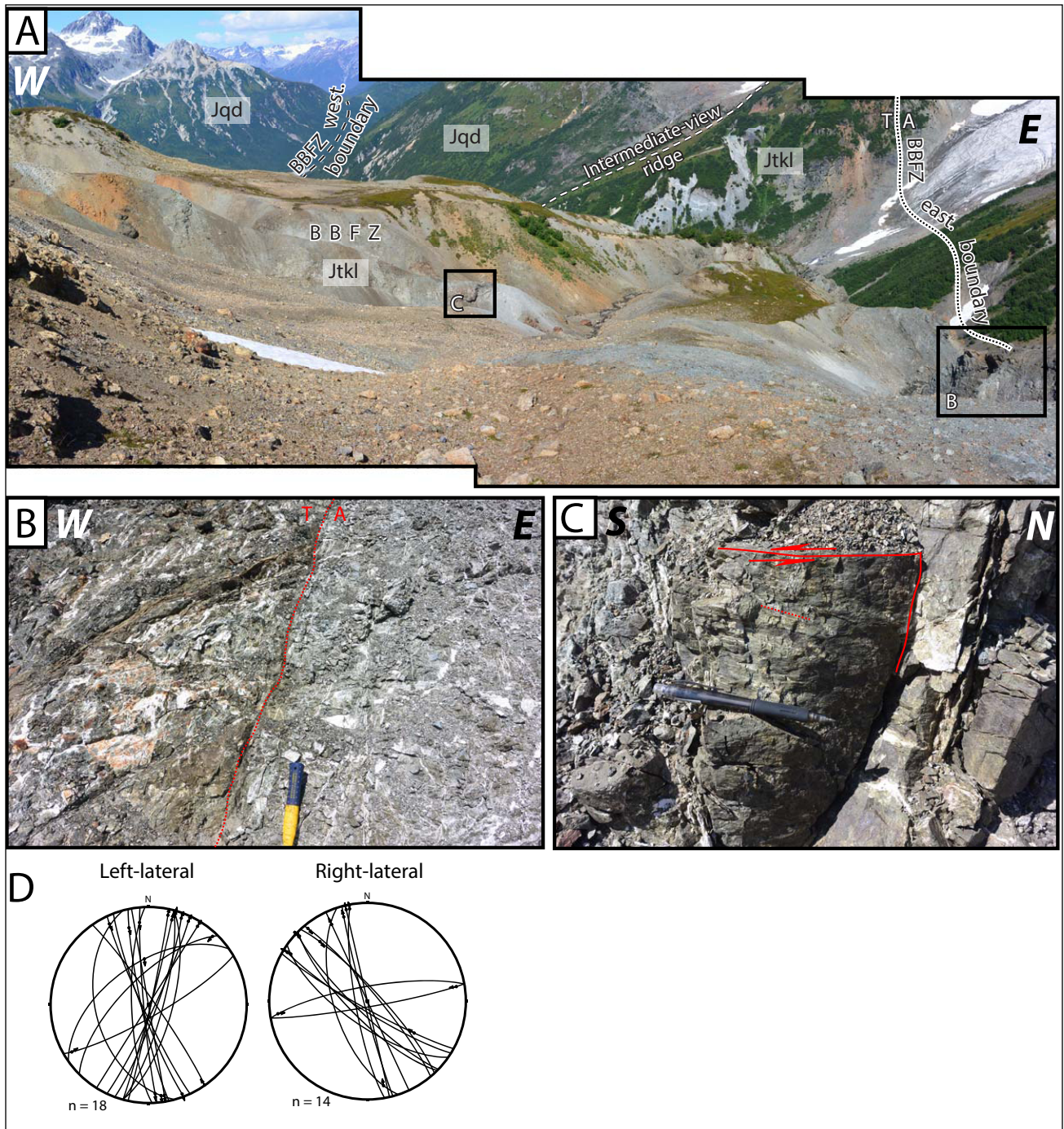


Figure 10-4. Field photographs and stereograms of the Open Creek locality. **A.** Panoramic view toward the north of the Bruin Bay fault zone (BBFZ) at the pass south of the headwaters of Open Creek (location on fig. 10-1A); field of view is approximately 0.5 miles. Here, the fault zone is defined by cataclasite contained dominantly within steeply dipping strata of the Talkeetna Formation (subvertical layering in fig. 10-4A) and is hundreds of meters wide (western boundary of the BBFZ out of view in foreground). Locations of figures 10-4B and 10-4C are shown. T—toward; A—away. **B.** Example of fault zone cataclasite in the Talkeetna Formation; dashed red line shows trace of a fault surface with sinistral sense of slip. Hammer handle for sense of scale. **C.** Example of a minor slip surface, showing quartz slickenfibers and steps indicative of left-lateral slip. Red line shows trace of fault surface and short dashed line shows attitude of the slip lineation. Pencil for sense of scale. **D.** Stereograms showing attitudes of left- and right-lateral faults measured at locations B and C. Arrows show attitude of striations and motion of the hanging wall; see text for discussion of fault-slip kinematics.

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