RECONNAISSANCE INVESTIGATIONS OF THE BRUIN BAY FAULT SYSTEM ALONG THE WESTERN MARGIN OF LOWER COOK INLET AND UPPER ALASKA PENINSULA, ALASKA

by
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The Bruin Bay fault is discontinuously exposed for about 400 km from Becharof Lake on the upper Alaska Peninsula northeastward to near the east flank of Redoubt Volcano on the west side of upper Cook Inlet (fig. 1). The fault separates the roots of an Early–Middle Jurassic magmatic arc to the northwest, including parts of its volcanic edifice and Triassic-age metamorphic country rocks(Detterman and Hartsock, 1966; Detterman and Reed, 1980; Riehle and others, 1993; Iliamna subterrane of Wilson and others, 1999), from Middle and Upper Jurassic forearc basin strata (Detterman and Reed, 1980; Trop and others, 2005) to the southeast that were derived from the arc complex (Detterman and Hartsock, 1966; Detterman and others, 1996; Trop and others, 2005; Chignik subterrane of Wilson and others, 1999). The Bruin Bay fault was likely a principal control of exhumation of the Jurassic arc and sediment accommodation for the Mesozoic forearc basin (for example, Trop and others, 2005), and is thought to have been active until as recently as late Oligocene time (Detterman and Reed, 1980). However, little work has focused on understanding the fault's geometry, kinematics, and slip history.

Most of what has been published about the Bruin Bay fault is the result of work performed by the U.S. Geological Survey spanning the 1960s to early 1980s, which continues to be recycled through subsequent literature. Detterman and Reed (1980) recognized that the Bruin Bay fault is not defined by a single plane, but rather is a system of steeply dipping faults up to 6–8 km wide. Motion along the fault system is inferred to be mostly strike-slip and sinistral, with perhaps 19 km (Detterman and Hartsock, 1966) to as much as 65 km (Detterman and Reed 1980) of left-lateral separation from equivocal offset stratigraphic markers, yet only about 3.5–4 km of stratigraphic separation is estimated from units juxtaposed across the fault system (Detterman and Hartsock, 1966).

Reconnaissance investigations by DGGS in 2007, 2009, 2010, and 2012 at several locations along the fault system (fig. 1) were aimed at developing a better understanding of the fault geometry, sense of motion from observations of meso- and macro-scale structures associated with the fault, and kinematic indicators in fault zones. New geochronology of cross-cutting igneous features and thermochronology of hangingwall and footwall blocks are helping to constrain the timing of deformation and exhumation associated with fault slip. Preliminary field observations indicate that the frontal fault plane separating Jurassic forearc deposits from the arc complex dips moderately northwestward at approximately 45°–50° where measured, with proximal hangingwall and footwall deformation characterized by decimeter- to hectometer-scale contractile folds (figs. 31–35) indicative of primarily dip-slip, reverse motion. Hangingwall rocks are intensely brittlely deformed in zones up to approximately 1 km wide, especially in Triassic Kamishak Formation limestones and locally in Early Jurassic Talkeetna Formation volcanic and volcaniclastic rocks. Conversely, deformation of Tuxedni Group and Naknek Formation footwall strata is most often expressed as large-scale folds sometimes restricted to within a few hundred meters of the fault. Faults arc-ward of the main strand tend to dip steeply and might cut lower angle contractile structures. Bi-, and uni-directional slip indicators on surfaces of more steeply dipping faults indicate mostly oblique slip, however the slip sense often varies between components of reverse, normal, dextral, and sinistral motion, suggesting the fault system has evolved over time within different states of stress, accommodated space problems in a complex manner, or both. Anticipated work at key locations along the fault in 2013 and 2014 and geochronologic and thermochronologic analyses in progress should provide a clearer picture of the role of the Bruin Bay fault in the development of the Mesozoic and modern Cook Inlet forearc basin.

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Figure 31. Bruin Bay fault contact at Ursus Head on the northeastern shore of Ursus Cove (see fig. 1 for location). Highly deformed Triassic carbonate strata (Trk) placed over Late Jurassic forearc basin strata (Jn) along a moderately northwest-dipping plane. Jn deformed by a footwall syncline with overturned forelimb. Arcward-dipping backlimb suggests the existence of an additional basinward structure. Trk = Kamishak Formation; Jn = Naknek Formation. Faults shown as red lines; selected marker beds by yellow lines; fold axis by white line.

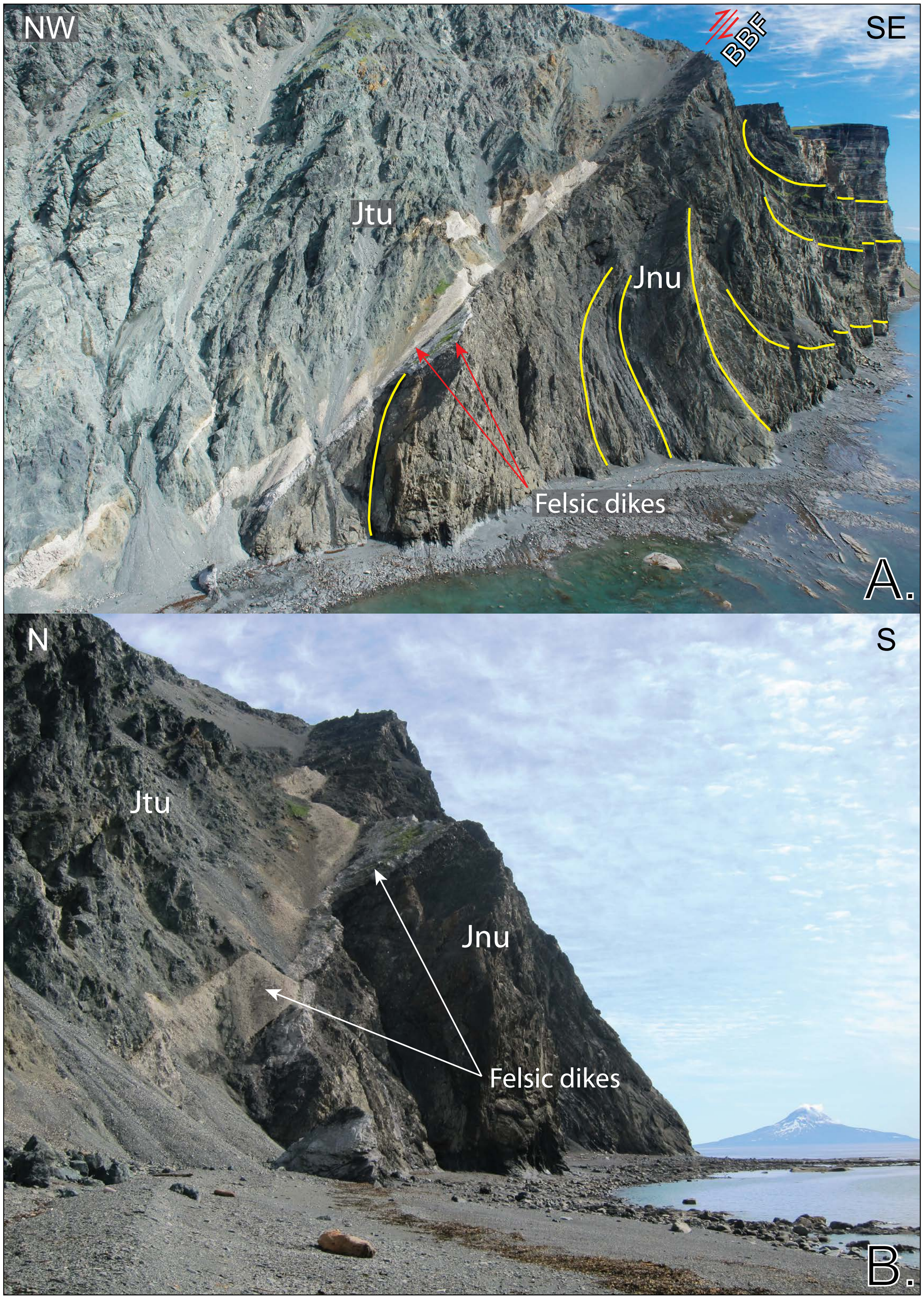

Figure 32. Bruin Bay fault contact southwest of Contact Point (see fig. 1 for location). Highly deformed mafic volcanic rocks of the Jurassic arc edifice placed over Late Jurassic forearc basin strata (Jnu) along a moderately northwest-dipping plane. (A) Jnu deformed by a footwall syncline with an overturned forelimb, similar to the geometry observed at Ursus Head. Two felsic dikes of different composition intruded along fault plane are virtually undeformed, and thus suture the hangingwall to the footwall. (B) Same exposure looking eastward. Differential weathering of hangingwall and footwall rocks exposes the Bruin Bay fault plane and felsic dikes intruded along the plane. Both dikes were sampled for age dating (in progress), and the results should provide a minimum age before which significant motion along the fault ceased. Selected marker beds shown with yellow lines. Jtu = Early Jurassic Talkeetna Formation; Jnu = Late Jurassic Naknek Formation; BBF = Bruin Bay fault.

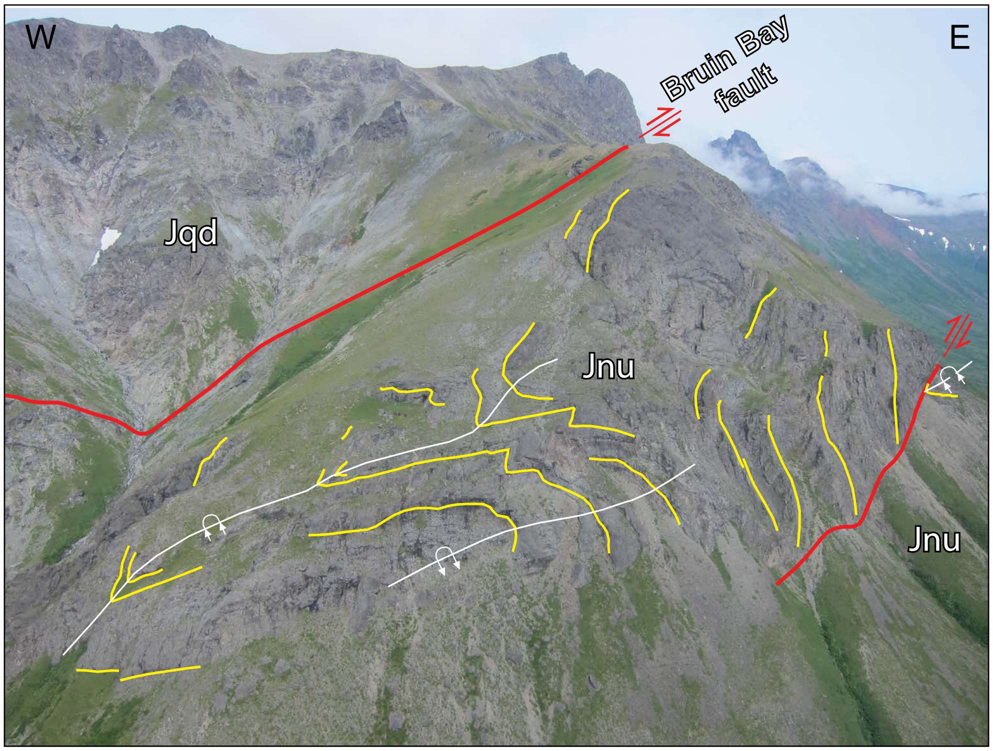

Figure 33. Bruin Bay fault contact northeast of Lake Grosvenor, Katmai National Park and Preserve (see fig. 1 for location). Highly fractured Jurassic arc intrusives placed over Late Jurassic forearc basin strata (Jnu) along a moderately steeply northwest-dipping plane. The larger-scale footwall structure is an overturned syncline with a local breaching fault. Disharmonic folding locally thickens the backlimb of the syncline. Jqd = Middle Jurassic quartz diorite; Jnu = Late Jurassic Naknek Formation. Faults shown as red lines; selected marker beds as yellow lines; fold axes as white lines.

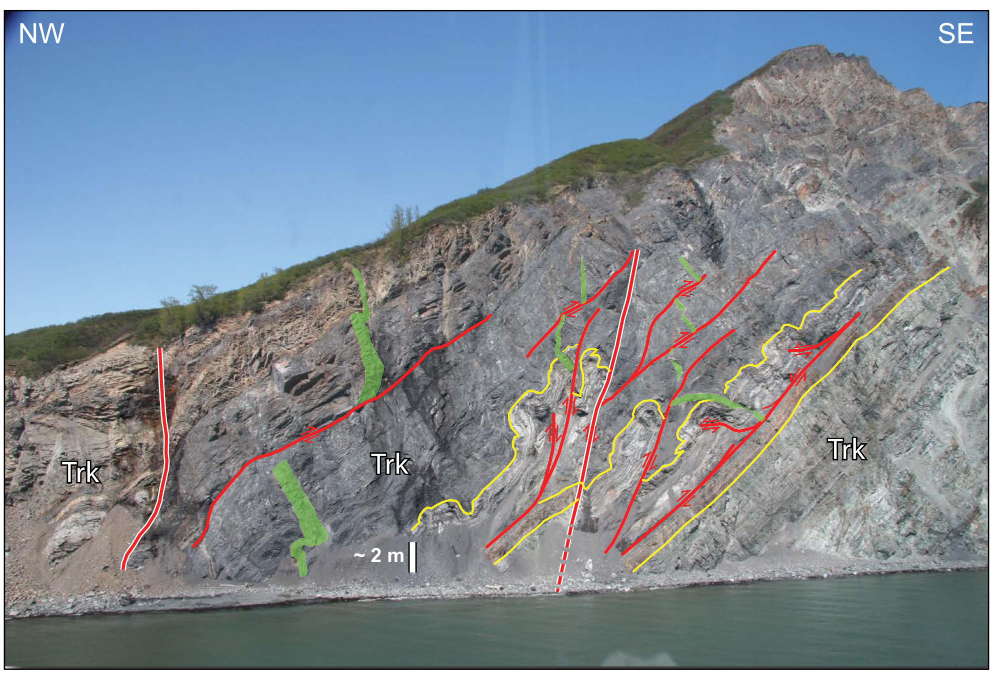

Figure 34. Hinterland-dipping panel in hangingwall of the Bruin Bay fault at Ursus Head (see fig. 1 for location) Triassic carbonate strata (Trk) deformed by an imbricate fan that detaches in a mechanically less competent interval. Imbricate fan later cut by high-angle(?) reverse fault. Trk = Kamishak Formation. Selected marker beds marked with yellow lines; earlier faults with red lines; and later faults as red lines with white outlines. Offset dikes shown with green shading.

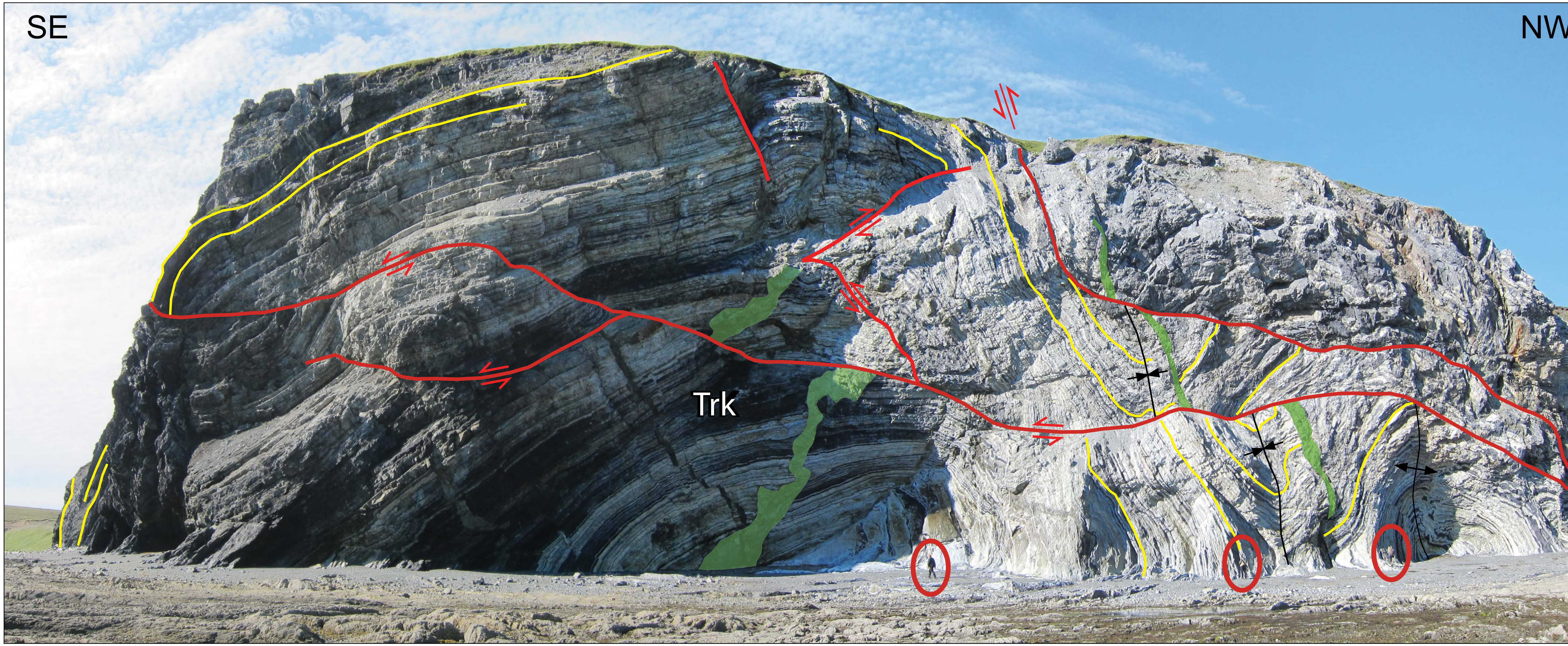

Figure 35. Anticline with overturned forelimb in hangingwall of Bruin Bay fault deforming Kamishak Formation limestone (Trk) near Contact Point (see fig. 1 for location). Tight detachment folds in backlimb of anticline cut by out-of-sequence thrust faults. Trk = Kamishak Formation. Selected marker beds shown by yellow lines; out-of sequence thrust faults shown by red lines; fold axes shown by black lines. Offset dikes shown as green shading. Geologists for scale (red ovals).