Lake Clark fault, assessment of tectonic activity based on reconnaissance mapping of glacial deposits, northwestern Cook Inlet Alaska.

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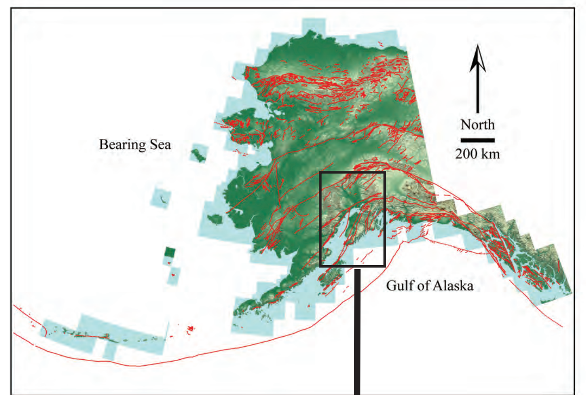
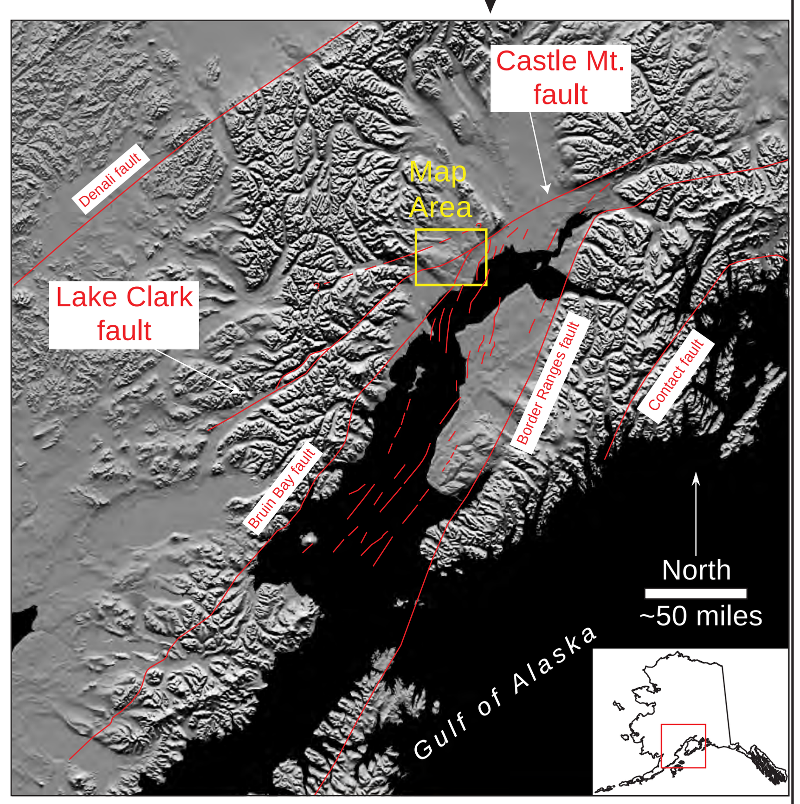
1 Background



The Lake Clark fault is a right oblique reverse fault extending northeast from Lake Clark in the western Alaska Range to the northern Cook Inlet forearc basin. Right transpressional deformation in the region is driven by collision of the Yakutat Microplate (4.9 cm/yr) and Pacific Plate (5.3 cm/yr) into North America. Previous studies on the Lake Clark fault have shown post-Eocene displacements of 26 km right lateral and 500-1000 m northwest-side-up vertical (Haeussler and Saltus, 2004; Detterman et al., 1976b). Quaternary deformation was noted by some earlier mapping efforts however, data on the timing of deformation was lacking.

The Castle Mountain fault extends northeast of the Lake Clark fault, and has the same strike and sense of motion. Paleoseismic investigations have been conducted on the Castle Mountain fault, however, similar data for the Lake Clark fault does not exist. Thus, questions remain regarding the role of the Lake Clark fault in accommodating right oblique strain along northwestern Cook Inlet west of the Castle Mountain fault.



Prior mapping of glacial and glacioestuarine deposits along the coastal lowlands of northwestern Cook Inlet used local moraine names, preventing regional correlation with the accepted Cook Inlet glacial chronology. Information on the relative age of surficial deposits is a critical first step in evaluating the history of the Lake Clark fault.

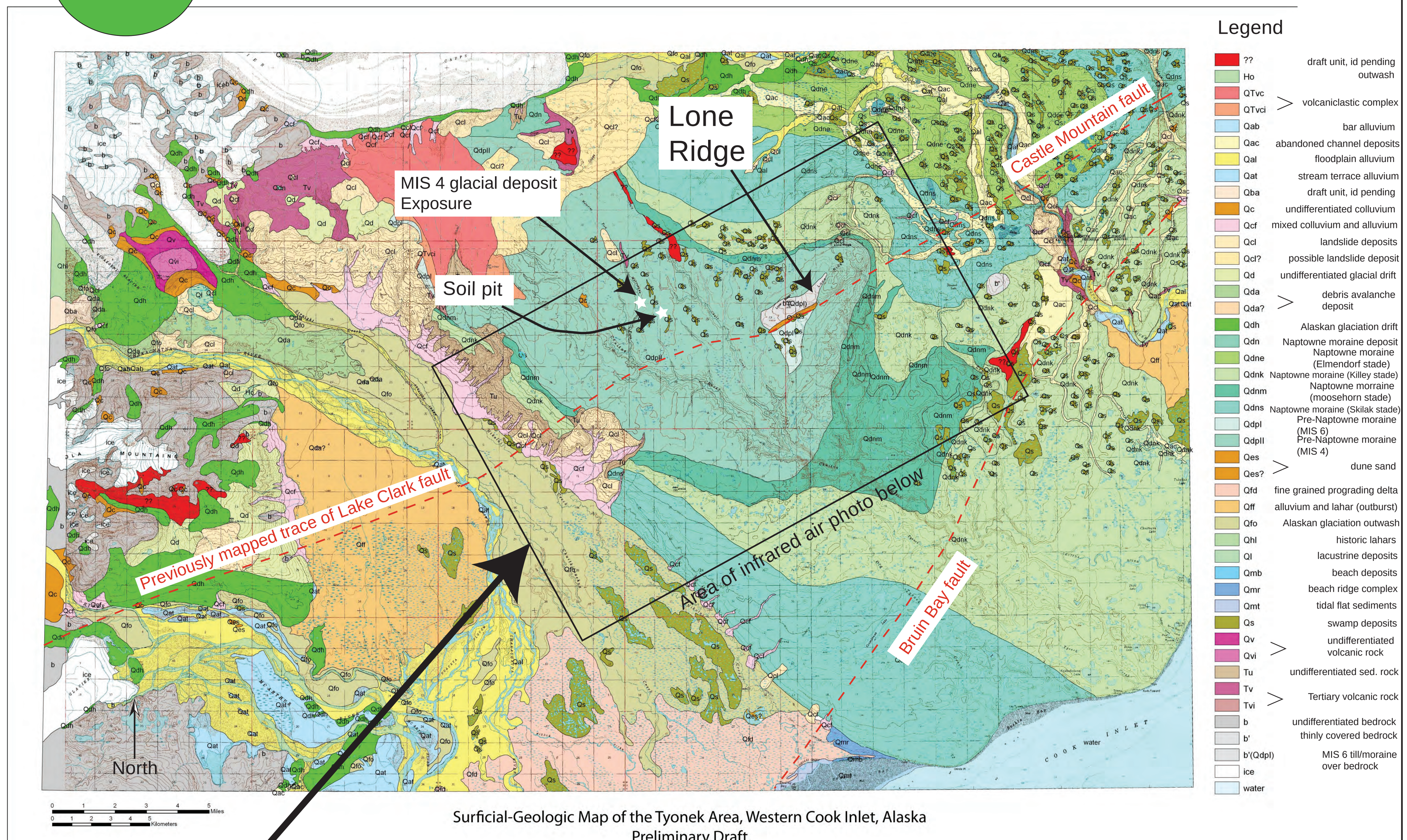
Therefore, the focus of this study is to:

1) Perform surficial geologic mapping in the Tyonek-Capps glacier area, northwestern Cook Inlet, as part of the State of Alaska (DGGS) STATEMAP program.

2) Perform field reconnaissance along the Lake Clark fault to document the presence or absence of Quaternary tectonic features and evaluate the timing of deformation.

The results presented here provide a comprehensive map of surficial deposits in the Tyonek-Capps glacier area using regionally accepted Quaternary nomenclature. The map results place broad constraints on the recency of activity along this part of the Lake Clark fault and are important for seismic hazards assessments related to petroleum production infrastructure, as well as the greater Anchorage metropolitan area.

3 Surficial Geologic Map



Surficial-Geologic Map of the Tyonek Area, Western Cook Inlet, Alaska
Preliminary Draft

4 Mapping Results and Relative Age of Glacial Deposits

We mapped three ages of glacial deposits in the Tyonek map area based on stratigraphic position, surface morphology of glacial erratics, and cross cutting relations.

The map units include from youngest to oldest:

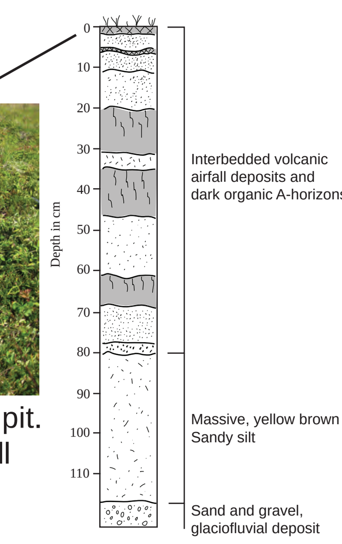
Marine Isotope Stage (MIS) 2, late Wisconsin Naptowne glacial deposits (~25 ka and younger), characterized by sharp crested moraine morphology and fresh well-preserved erratics.

Marine Isotope Stage (MIS) 4, early Wisconsin glacial deposits (~60-75 ka) characterized by well-preserved, smooth-surfaced erratics and stratigraphic position above the Naptowne limit.

Marine Isotope Stage (MIS) 6, early penultimate glacial deposits (~130-180 ka), characterized by pitted, poorly preserved erratics.

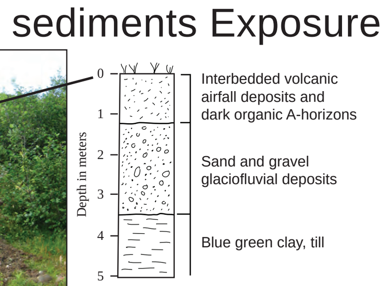
North-northeast-trending moraines east of Lone Ridge sourced from the Susitna River valley to the northeast indicate that ice from western sources joined with ice from the northeast during both the Naptowne and penultimate glaciations.

Soil stratigraphy



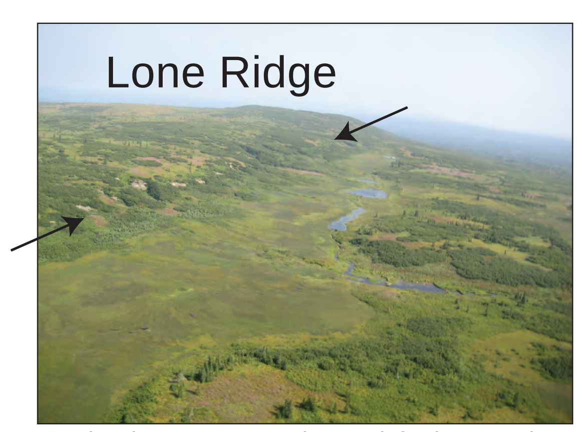
See map for location of soil pit. ~80 cm of interbedded airfall deposits overlie MIS 4-age glaciofluvial deposits.

Glacial sediments Exposure



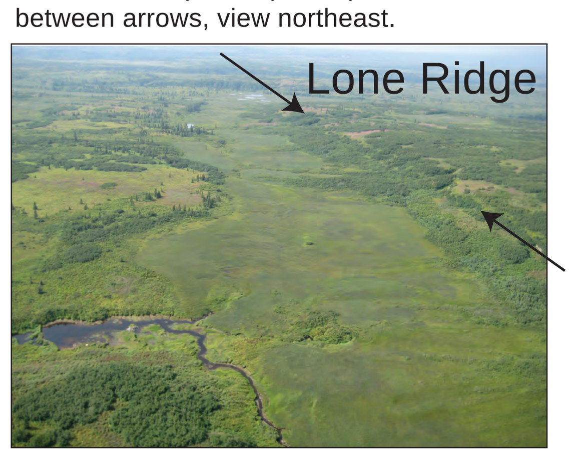
See map for location of exposure. Cleaned off exposure shows presence of MIS-4 age glaciofluvial deposits and glacial till.

2 Surficial Expression of the Lake Clark Fault in the Vicinity of Lone Ridge.



Bedrock escarpment (~20 m) fault extends between arrows, view northeast.

See air photo for Lone Ridge location



View southwest, fault between arrows.

Subtle bench in hillside and knotch in drainage divide, View southwest

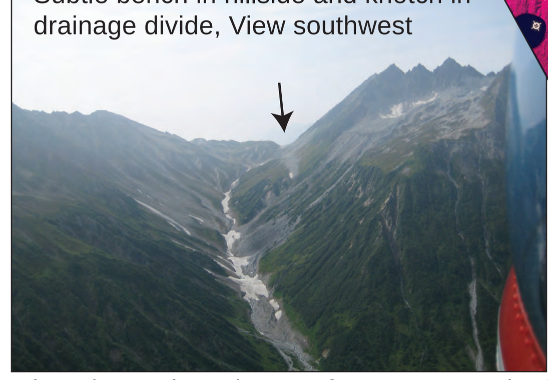
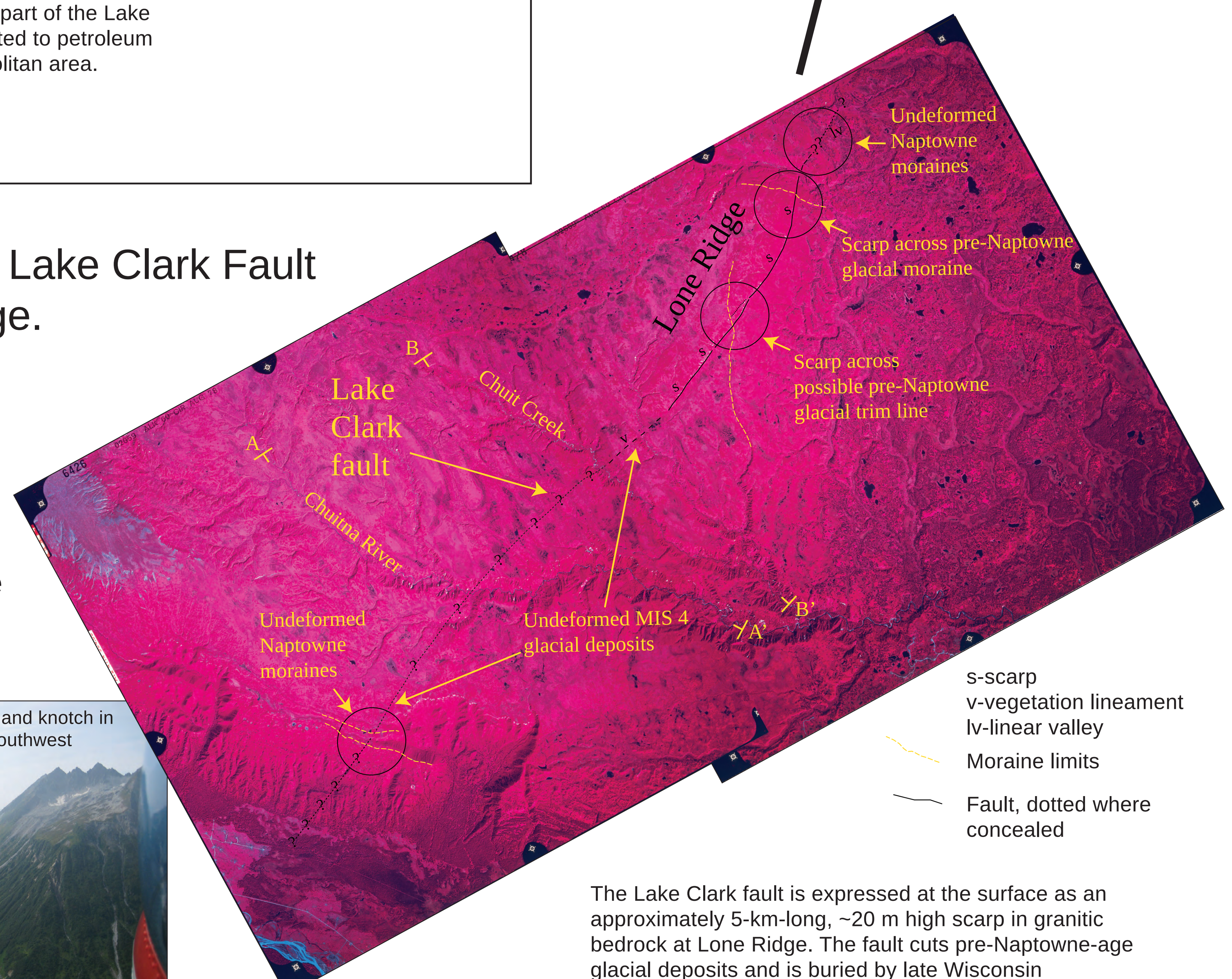


Photo located southwest of map area north of Blockade Glacier

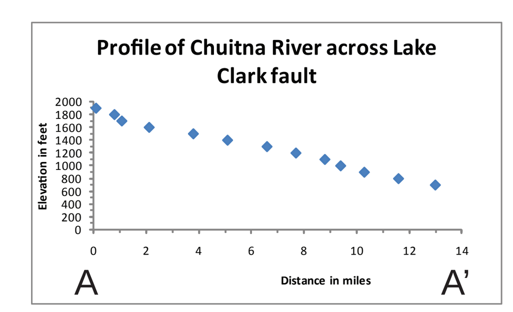


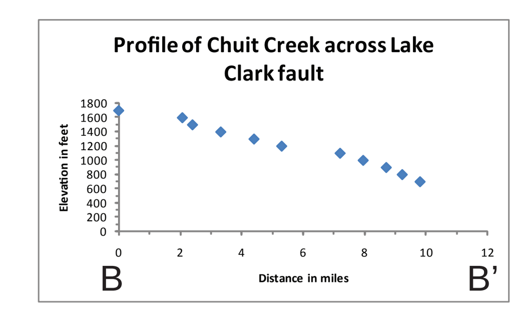
s-scarp
v-vegetation lineament
lv-linear valley
Moraine limits
Fault, dotted where concealed

The Lake Clark fault is expressed at the surface as an approximately 5-km-long, ~20 m high scarp in granitic bedrock at Lone Ridge. The fault cuts pre-Naptowne-age glacial deposits and is buried by late Wisconsin Naptowne ice limit deposits (<25 ka).

5 Stream Profiles Across the Lake Clark Fault

Two profiles normal to the fault show convex up profiles, possibly indicating Quaternary folding.





Profile locations shown on air photo.

6 Implications for Regional Neotectonics

Understanding possible kinematic linkages between the Lake Clark and Castle Mountain faults has important implications for estimating maximum earthquake rupture lengths and magnitudes.

In map view, the Lake Clark fault is the southwestern extension of the Castle Mountain fault. The two faults have similar strike and sense of motion, but are characterized by different Holocene paleoseismic histories. Previous work along the Castle Mountain fault suggests four late Holocene surface ruptures and a late Pleistocene-Holocene slip rate of 2-3 mm/yr Haeussler et al., 2002; Willis et al., 2007). In contrast, our mapping suggests that the Lake Clark fault has not been active in the map area during the Holocene. This apparent discrepancy may be related to:

1) A transition of right lateral slip from the Castle Mountain fault to right transpressional deformation in fault-cored folds in the Cook Inlet Basin, as originally suggested by Haeussler et al. (2000).

2) Large uncertainties in the amount of late Pleistocene lateral offset along the Castle Mountain fault. Estimates range from 7-9.1 m (Detterman et al., 1976) to 36 m (Willis et al., 2007).

3) Tectonic features obscured by dense vegetation along the Lake Clark fault, and/or distributed slip on unrecognized structures.

7 Conclusion

The eastern part of the Lake Clark fault in the study area is characterized by a relatively low rate of activity and has been tectonically quiescent since at least the late Wisconsin (MIS 2) Naptowne glacial ice limit ~25 kya. Tectonic features are not preserved across MIS 4 glacial deposits (~70 ky) due to either lack of preservation or lack of activity. Paleoseismic history of the western part of the Lake Clark fault is unknown.

Much work remains to be done. We are planning further studies along the Lake Clark fault in summer 2010, including mapping refinement, exploring dating options for the glacial chronology, and aerial reconnaissance to the west in the Alaska Range.

The data are important for seismic hazards assessments related to resource infrastructure in the Cook Inlet region and seismic safety of the greater Anchorage metropolitan area.

References Cited

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