



SUSITNA-WATANA HYDRO

*Clean, reliable energy for the next 100 years.*

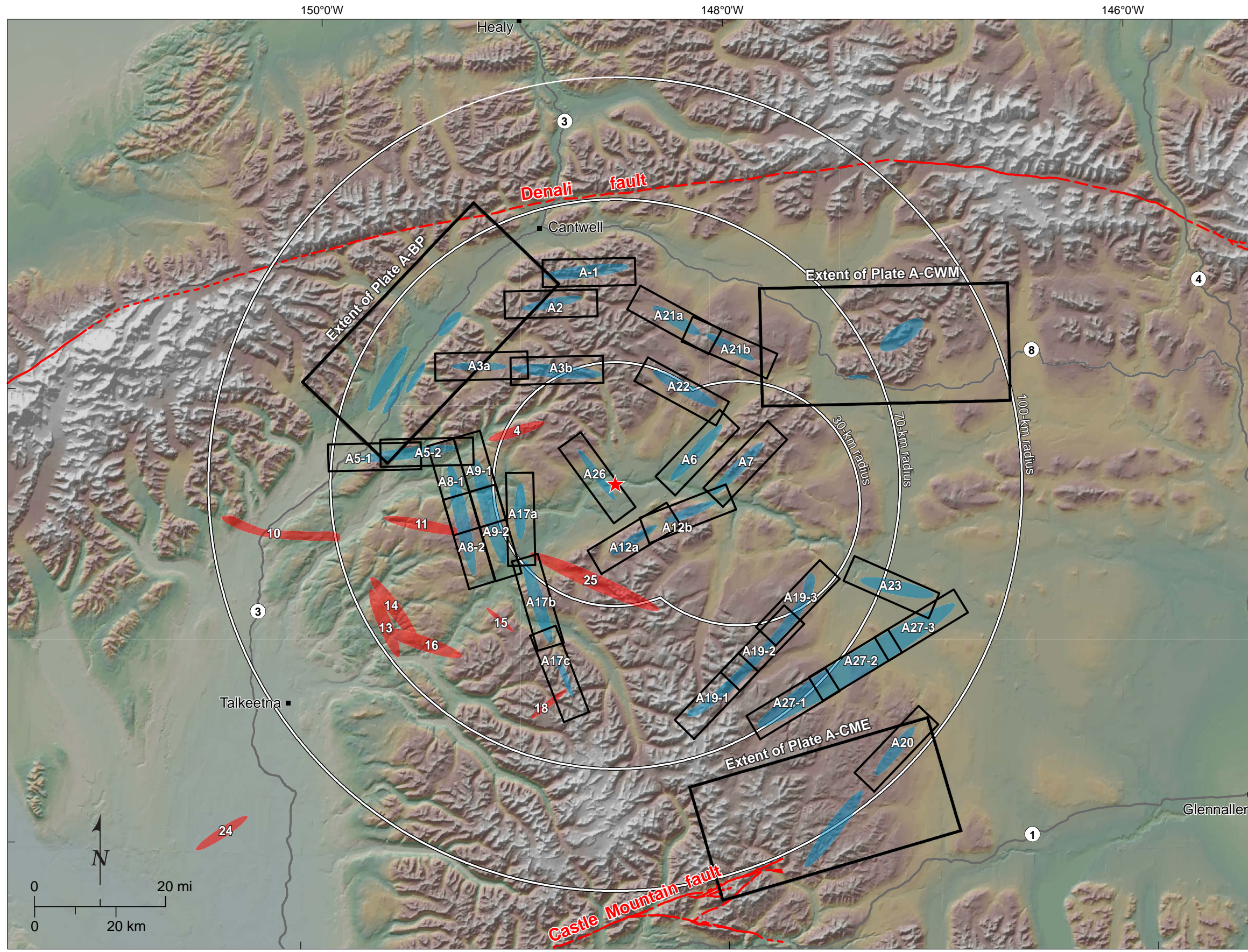
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ALASKA ENERGY AUTHORITY

AEA11-022

16-1401-TM-012014

**Appendix A:  
Strip Maps and Photographic Documentation  
of Lineament Data Presented in FCL (2013)**



**Explanation**

- - - Quaternary fault, solid where well constrained, long dash where moderately constrained, short dash where inferred (Koehler et al., 2012)
- A5-1 Extent of stripmap tile; figure number indicated
- Field work planned in 2013 based on results of TM-8 (FCL, 2013)
- No field work planned in 2013 based on results of TM-8 (FCL, 2013)
- ★ Proposed Watana site






















**Lineament Groups and Corresponding Figures**

Lineament Group	Appendix A Figure Number
1	A1.1, A1.2
2	A2.1, A2.2
3a	A3a.1, A3a.2
3b	A3b.1, A3b.2
4	None, see TM-8 (FCL, 2013)
5	A5-1.1, A5-2.1, A5-2.2
6	A6.1, A6.2, A6.3, A6.4
7	A7.1, A7.2
8	A8-1.1, A8-2.1, A8-2.2, A8-2.3
9	A9-1.1, A9-2.1, A9-2.2, A9-2.3, A9-2.4
10	None, see TM-8 (FCL, 2013)
11	None, see TM-8 (FCL, 2013)
12a	A12a.1, 12a.2
12b	A12b.1, 12b.2
13	None, see TM-8 (FCL, 2013)
14	None, see TM-8 (FCL, 2013)
15	None, see TM-8 (FCL, 2013)
16	None, see TM-8 (FCL, 2013)
17a	A17a.1, A17a.2
17b	A17b.1, A17b.2, A17b.3
17c	A17c.1, A17c.2
18	None, see TM-8 (FCL, 2013)
19	A19-1.1, A19-1.2, A19-1.3, A19-2.1, A19-2.2, A19-3.1, A19-3.2
20	A20.1, A20.2, A20.3, A20.4, A20.5, A20.6
21a	A21a.1, A21a.2
21b	A21b.1, A21b.2, A21b.3
22	A22.1, A22.2
23	A23.1
24	None, see TM-8 (FCL, 2013)
25	None, see TM-8 (FCL, 2013)
26	A26.1, A26.2
27	A27-1.1, A27-2.1, A27-3.1, A27-3.2
Broad Pass area	Plate A-BP, A-BP.1, A-BP.2, A-BP.3
Castle Mtn. fault extension	Plate A-CME, A-CME.1, A-CME.2
Clearwater Mtns. area	Plate A-CWM, A-CWM.1, A-CWM.2, A-CWM.3


























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This explanation applies to all figures and plates in Appendix A.













**Geologic Units from OFR 09-1108 (Wilson et al., 2009)**

-  Water, ice field, or glacier
- Unconsolidated Deposits**
-  Qs Surficial deposits, undivided
-  Qat Alluvium along major rivers and in terraces
-  Qlc Landslide and colluvial deposits
-  Qm Glacial deposits, undivided
-  Qhg Young moraine deposits
-  Qg Major moraine and kame deposits
-  Qgc Glacioalluvium
-  Qgo Outwash in plains, valley train, and fans
-  Qge Glacioestuarine deposits
- Sedimentary Rocks**
-  Tsu Sedimentary rocks, undivided
-  Tkn Kenai Group, undivided
-  Tts Tsadaka Formation
-  Tch Chickaloon formation
-  Km Matanuska formation
-  KJs Turbiditic sedimentary rocks of the Kahiltna flysch sequence
-  Jtxc Undivided Chinitna and Tuxedni formations
-  Jn Naknek Formation, undivided
-  Jtk Talkeetna Formation, undivided
-  JTrlm Limestone and Marble
-  Pe Eagle Creek Formation, marine argillite and limestone



**Igneous Rocks**

- Volcanic and Hypabyssal Rocks**
-  Tvu Tertiary volcanic rocks, undivided
-  Tfv Felsic volcanic and sub-volcanic rocks
-  Tem Mafic volcanic rocks
-  TKd Dikes and sills
-  Trn Nikolai Greenstone and related rocks
-  Pzv Slana Spur Formation, volcanoclastic rocks
-  Pat Station Creek Formation andesitic volcanic rocks
- Plutonic Rocks**
-  Ti Intrusive rocks, undivided
-  Toegr Granitic rocks
-  Tpgr Granitic rocks of Paleocene age
-  Tgd Biotite-hornblende-granodiorite
-  TKg Granitic rocks, undivided
-  TKgd Granodioritic rocks
-  Kgd Granodiorite
-  Jtr Trondhemite
-  JPaur Diorite, gabbro, picrite, and pyroxenite sill and dike swarm complex
-  Jqd Quartz diorite, tonalite, and diorite formations
-  Jqm Granodiorite and quartz monzonite
- Melange and Metamorphic Rocks**
-  TKgg Gneiss
-  Jpmu Plutonic and metamorphic rocks, undifferentiated
-  JPam Amphibolite
-  JPmb Marble
-  Trnm Metabasalt and slate
-  TrPavs Basaltic to andesitic metavolcanic rocks
-  PPast Metamorphosed Skolai Group


**Geologic Units from OFR 98-133 (Wilson et al., 1998)**

-  g Ice fields or glaciers
-  Water
-  Qs Surficial deposits, undifferentiated
-  Tvu Tertiary volcanic rocks, undivided
-  Thf Hypoabyssal felsic and intermediate intrusions
-  Tiv Granitic and volcanic rocks, undivided
-  Tegr Granite and granodiorite
-  Mzpca Phyllite, pelitic schist, calc-schist, and amphibolite of the MacLaren metamorphic belt
-  Kgu Granitic rocks
-  KJf Kahiltna flysch sequence
-  Trcs Calcareous sedimentary rocks
-  Trnm Metavolcanic and associated metasedimentary rocks













**Tectonic Features from WCC report (WCC, 1982)**

-  Detailed feature, from site-specific maps
-  Regional feature, from small-scale maps



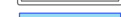
For completeness, features from both regional and detailed scale figures have been included. The location of regional features may not always be accurate and the detailed features may be limited to the extent shown on original figures.

 T-2 Location of trench T-2 (shown on Figures A14 and A16)




**Faults Compiled by FCL (Wilson et al., 1998; Wilson et al., 2009; Williams and Galloway, 1986; Clautice, 1990; Clautice, 2001; Csejtey, 1978; Kachadoorian, 1979; Smith, 1988)**

-  Fault, approximate
-  Fault, inferred or queried
-  Fault, certain
-  Fault, concealed
-  High-angle reverse fault, approximate
-  High-angle reverse fault, certain
-  High-angle reverse fault, concealed
-  High-angle reverse fault, inferred or queried
-  Thrust fault, approximate
-  Thrust fault, certain
-  Thrust fault, concealed
-  Lineament

**Hydrographic Features from National Hydrography Dataset, 2000, 1:24,000 scale**

-  Stream
-  Ice mass
-  Lake or pond

**Other Items**

-  Location of photograph taken during 2013 field reconnaissance, labeled with photo ID and showing view direction
-  GPS waypoint
-  GPS track line, July 2013

Note: For full explanation of geologic units see USGS OFR 09-1108 and USGS OFR 98-133.

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Attributes of lineaments mapped by FCL (2013) that apply to all figures and plates in Appendix A

Reconnaissance (INSAR)

- 1-5
- - - 10
- 77
- - - 88

Detail (LiDAR)


- 1-5
- - - 10
- 77
- - - 88


Lineament Groups


- 17a** Lineament group mapped for this study coinciding with previously mapped fault or lineament
- 25** No previously mapped fault or lineament coincides with lineament group

Explanation for relevant geologic units of Williams and Galloway (1986) shown on Figure A20.5 and A23.1











Geologic Units

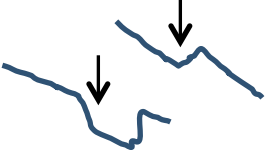
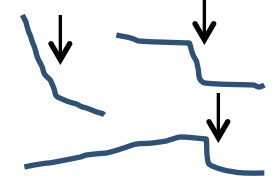
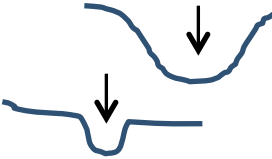

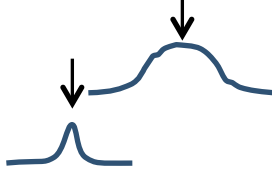
 **Bottom deposits of 914 - 975 m lake**  
 Overprint denoting glacial drift that is mantled by bottom sediments of glacial lake that extended to 914 - 975 m above modern sea level, largely confined to middle Susitna valley, above ice dam below Fog Lake (off map) and apparently bounded on east and south side by glacier ice. Does not cover late(st) Wisconsin (last major) morainal systems. No shoreline features are mapped.

 **Bottom deposits intermediate (777 - 747) lake**  
 Overprint denoting bottom deposits of a local lake that covered melting glacier ice between Tyone Lake and Lake Louise, apparently behind Tyone Spillway, and drained as the elevation of the spillway was cut down from 777 m to 747 m above sea level while stagnant ice was still in valley bottom.

 **Bottom deposits of last regional lake**  
 Overprint denoting drape of bottom deposits over drift and thick lake sediments that persisted in Copper River drainage basin from just before deposition of Old Man moraines to a time when glaciers had retreated to within 16 to 24 km of present glaciers: older than 13,000 years.

Symbols

-  AA Location and letter designation of radiocarbon-dated stratigraphic section in accompanying text.
-  Ice boundary, morainal ridge, kame terrace, delta, or other ice contact feature marking edge of glacier: hachures toward glacier.
-  Shoreline of regional lake: mapped for the lake in Copper River basin where at 747 m (maximum elevation); the elevation to which Tyone Spillway was eroded, and successively lower levels in the northern part of area between 747 m and 701 m above sea level. Lesser recessional shorelines mapped by Nichols and Yehle (1969) not shown.
-  Upper limit of post-glacial (Holocene, in part) shoreline of Tazlina Lake from elevation 564 m down to present lake level 544 m caused by lowering of lake as Tazlina River has deepened its canyon.
-  Delta of glacial lake, including those of modern glacial lakes such as Tazlina Lake.
-  Linear or drumlinoid feature, due to ice scour, direction of ice movement indicated by arrow.
-  Spillway for glacial meltwater, including that stored in large glacial lakes.
-  Contact between map units where not glacial boundary, most commonly between different levels of lake deposits.
-  Active (?) fault, lower Sonona Creek, offsetting unconsolidated deposits.
-  \* Location of selected erratic boulders, mountain top erratic stones transported by glaciers, e.g. Sheep Mountain; many occurrences on mountains lower than 1829 m not shown.

Attribute	Cross Section Morphology*	Description	Examples
1		Linear break-in-slope bisecting a planar surface	Uphill- or downhill-facing scarps, ateral moraines or kame deposits along lateral margins of valley glaciers
2		Abrupt changes in slope adjacent to otherwise relatively horizontal (and planar) surfaces	Linear range fronts, faceted ridges, terrace risers, steep downstream faces of roushe mountonees
3		Linear U-shaped trough	Glacial valleys, ice-scoured flutes, flood-scoured flutes,
4		Linear V-shaped trough	Active stream channels
5		Linear ridges	Drumlins, water-scoured terrain, eskers
6 (also 77)	n/a	A series of aligned features	Could include attributes #1 -5 above and/or aligned saddles, tonal lineaments, etc.
66	n/a	Data artifacts	Linear seams between data sets collected on different dates
88	n/a	A series of aligned features, which are too small to individually map at the given scale	Could include features with attributes #1-5 above and/or aligned saddles, tonal lineaments, etc.
99	n/a	A line which encloses a broad expanse of features all having the same orientation	An area of jointing or of glacial striae all having the same, parallel orientation
10	n/a	Anthropogenic lineaments	Roads, rail roads, power lines and other linear clearings, etc.

Notes: \*Arrow points to location of the mapped feature.

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UNCONSOLIDATED DEPOSITS

Alluvial deposits

**Qa** FLOODPLAIN ALLUVIUM - Unconsolidated deposits in modern stream drainages. Material ranges from coarse, unsorted gravel in highland valleys to finely bedded silt in large river drainages.

Glacial deposits

**Qdt<sub>3</sub>** TILL OF LATE WISCONSIN AGE - 11,800 to 25,000 yr B.P.


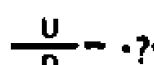


**Qdt<sub>2</sub>** TILL OF EARLY WISCONSIN AGE - 40,000 to 75,000 yr B.P.

**Ks** SCHIST - Medium- to coarse-grained biotite-plagioclase-quartz schist with local garnet and feldspar porphyroblasts to 0.5 mm. Dominantly gray or brown weathering. Includes local horizons that contain randomly oriented hornblende on foliation surfaces. Stippled pattern near intrusive contacts indicates hornfelsed zone in schist. K-Ar age of 57.2 m.y. was obtained from biotite in this unit in the adjacent Healy A-1 Quadrangle (Smith, 1981).





**Kp** PHYLLITE - Silver-gray, biotite-bearing phyllite with biotite porphyroblasts to 2mm long; locally calcareous. Minor compositional banding with more quartzose layers parallel to foliation. Biotite yielded K-Ar age of 53 ± 1.6 m.y. (loc. 3 on map; Turner and Smith, 1974). Grades into amphibole-bearing phyllite (Khp) unit.

**Khp** AMPHIBOLE-BEARING PHYLLITE - Medium to dark gray spotted phyllite with planar laminations. Spotted with porphyroblastic biotite. Interlayered with beds that contain randomly oriented amphibole on foliation surfaces. Amphibole prisms commonly 0.5 to 3 mm long. K-Ar age of actinolitic hornblende from this unit in Healy A-1 Quadrangle is 64.1 m.y. (Smith, 1981).



MAP SYMBOLS

-  Contact - dashed where approximately located ; dotted where concealed; queried where inferred
-  High-angle fault - dashed where approximately located; dotted where concealed; queried where inferred. D, downthrown side; U, upthrown side
-  Thrust fault - dashed where approximately located. Sawteeth on upper plate. Arrow indicates dip of fault
-  Lineament - inferred from aerial photographs, may represent fault




GLACIAL LIMITS

-  Glaciation of unassigned age, dashed where discontinuously mapped
-  Glaciation of Illinoian age, dashed where discontinuously mapped
-  Glaciation of late Wisconsin age, dashed where discontinuously mapped
-  Glaciation of Holocene age, dashed where discontinuously mapped




OTHER FEATURES




-  Prominent meltwater drainage channel
-  Radiocarbon sample locality

PROMINENT WAVE-CUT SCARPS

-  3,700-ft (1,120-m) lake, dashed where discontinuously mapped, dots on descending scarp
-  3,650-ft (1,110-m) lake, dashed where discontinuously mapped, open triangles point down descending scarp
-  3,400-ft (1,030-m) lake, dashed where discontinuously mapped, solid triangles point down descending scarp

AREAS INUNDATED BY GLACIER-DAMMED LAKES

-  3,700-ft (1,120-m) lake
-  3,650-ft (1,110-m) lake
-  3,400-ft (1,030-m) lake

-  Contact
-  Thrust fault
-  Shear

QUATERNARY

- Qa** Alluvium, alluvial terraces and fans
- Qid** Ice disintegration deposits
- Qt** Till
- Qo** Outwash

TERTIARY

- Tsu** Conglomerate, sandstone and claystone

MESOZOIC

TRIASSIC

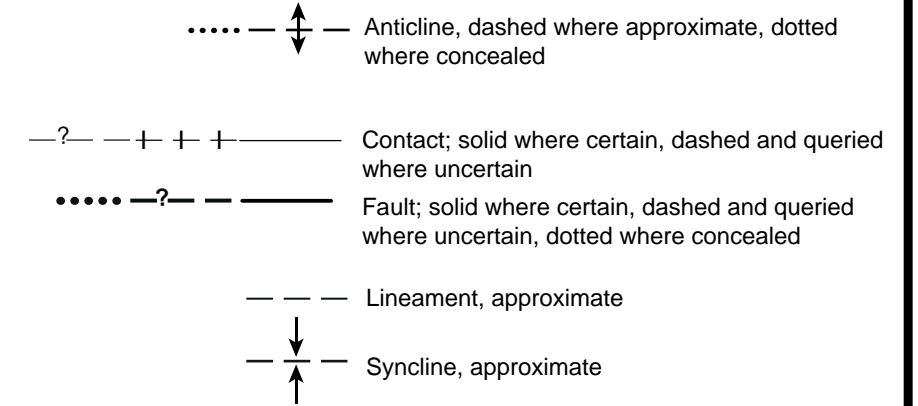
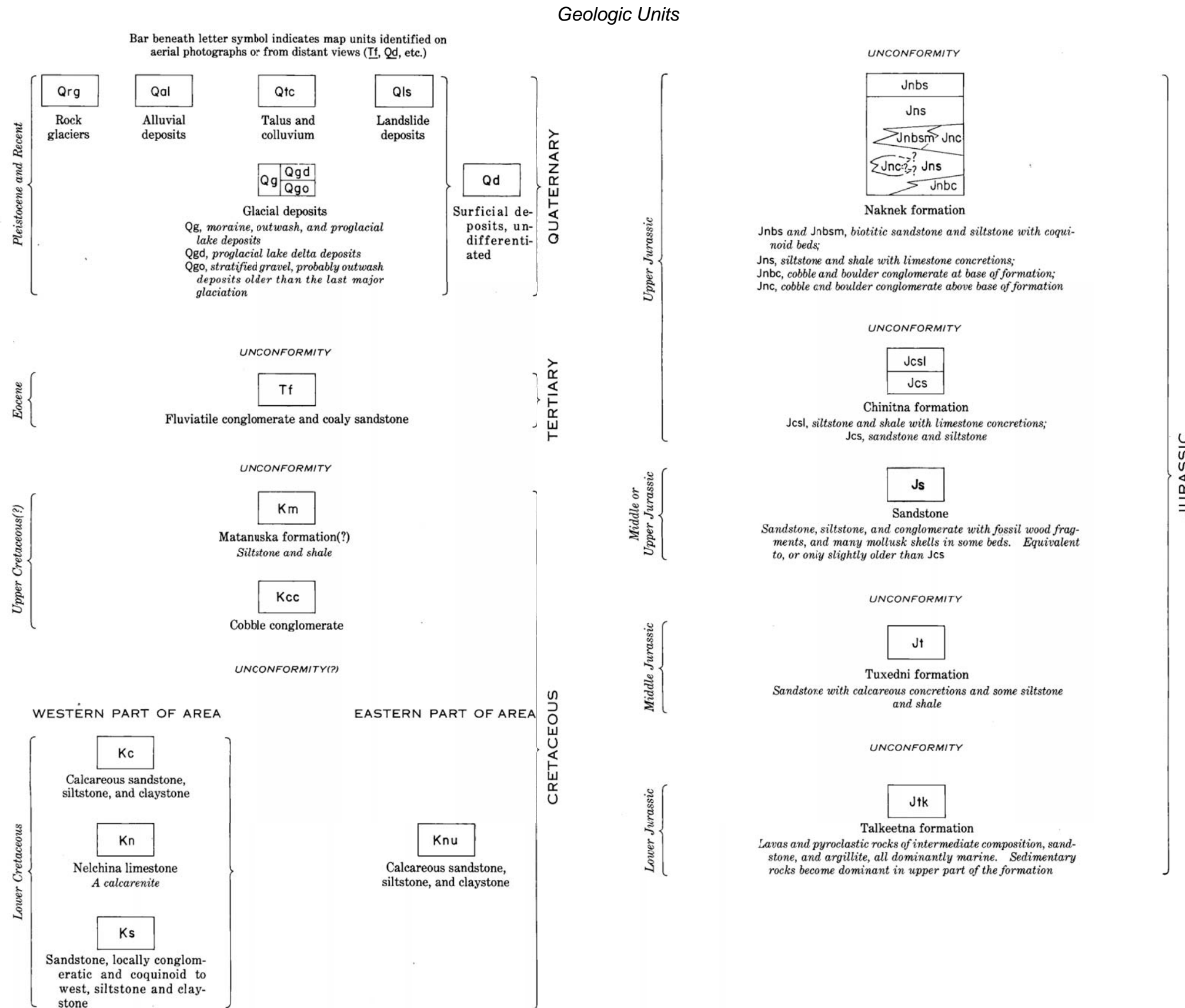
- TRvs** Basaltic metavolcanic rocks, metabasalt and slate

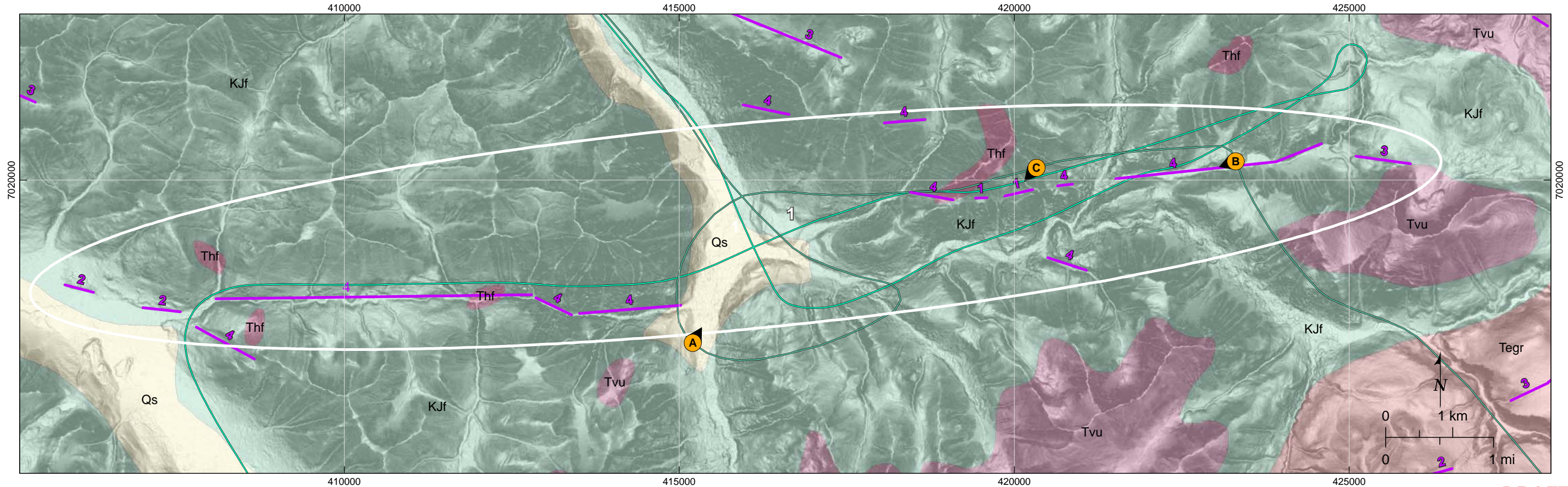
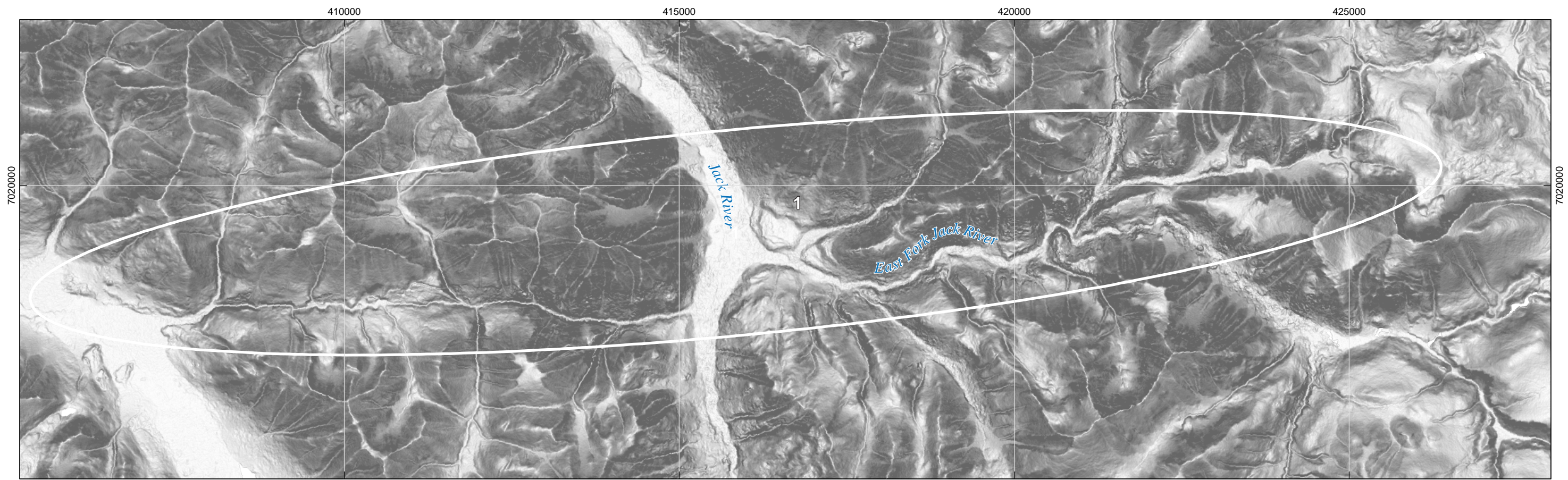
Modified from selected portion of Smith et al. (1988) explanation

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### Explanation

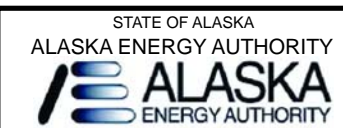
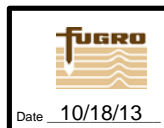
### Lineaments, Faults, Contacts, Synclines, and Anticlines





Notes: 1. See Figures A0.2, A0.3, A0.4, and A0.5 for explanation.  
 2. Geology by Wilson et al., 1998

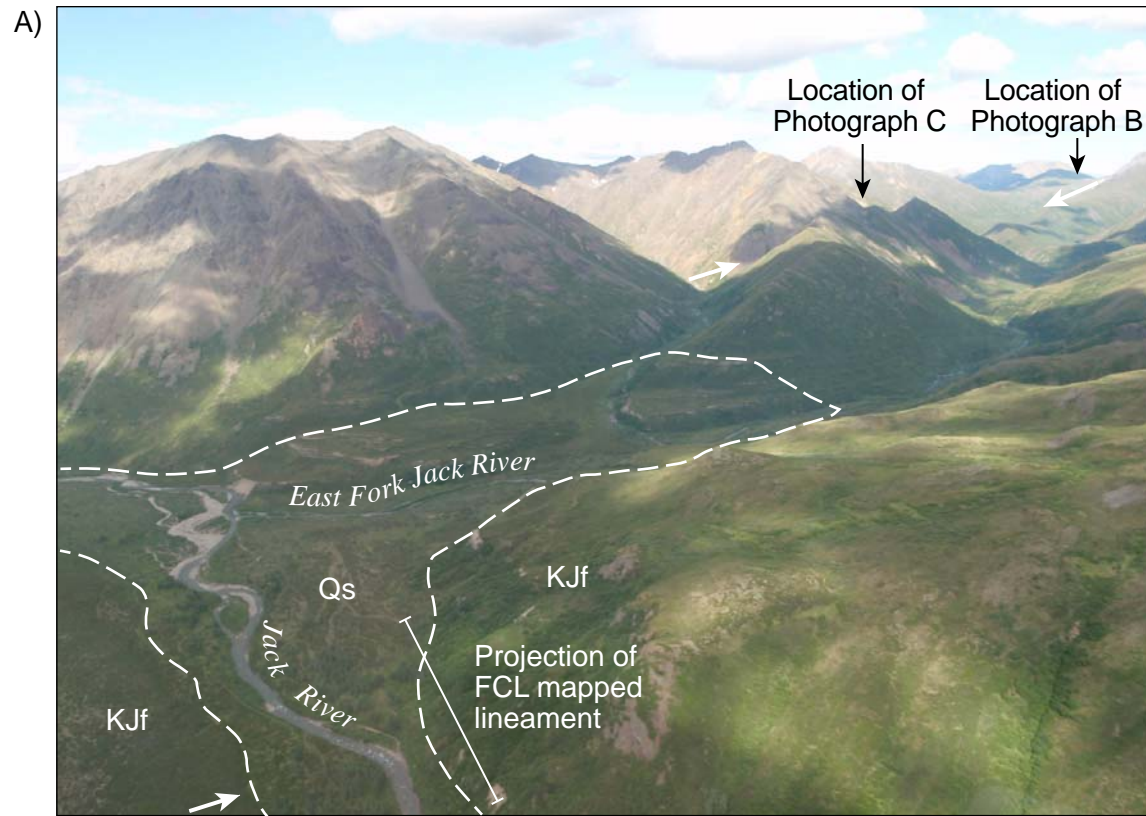
**DRAFT**



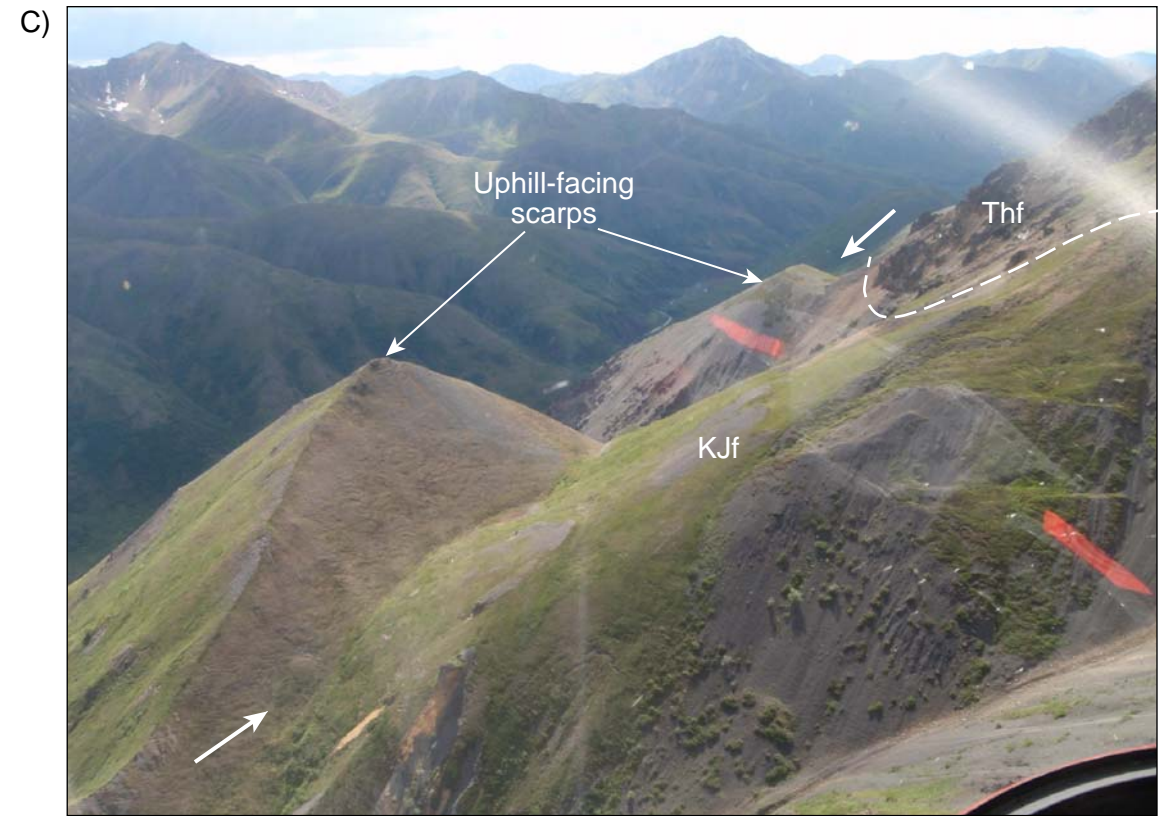
SUSITNA-WATANA HYDROELECTRIC PROJECT  
 LINEAMENT GROUP 1  
 MAP DATA

FIGURE  
 A1.1

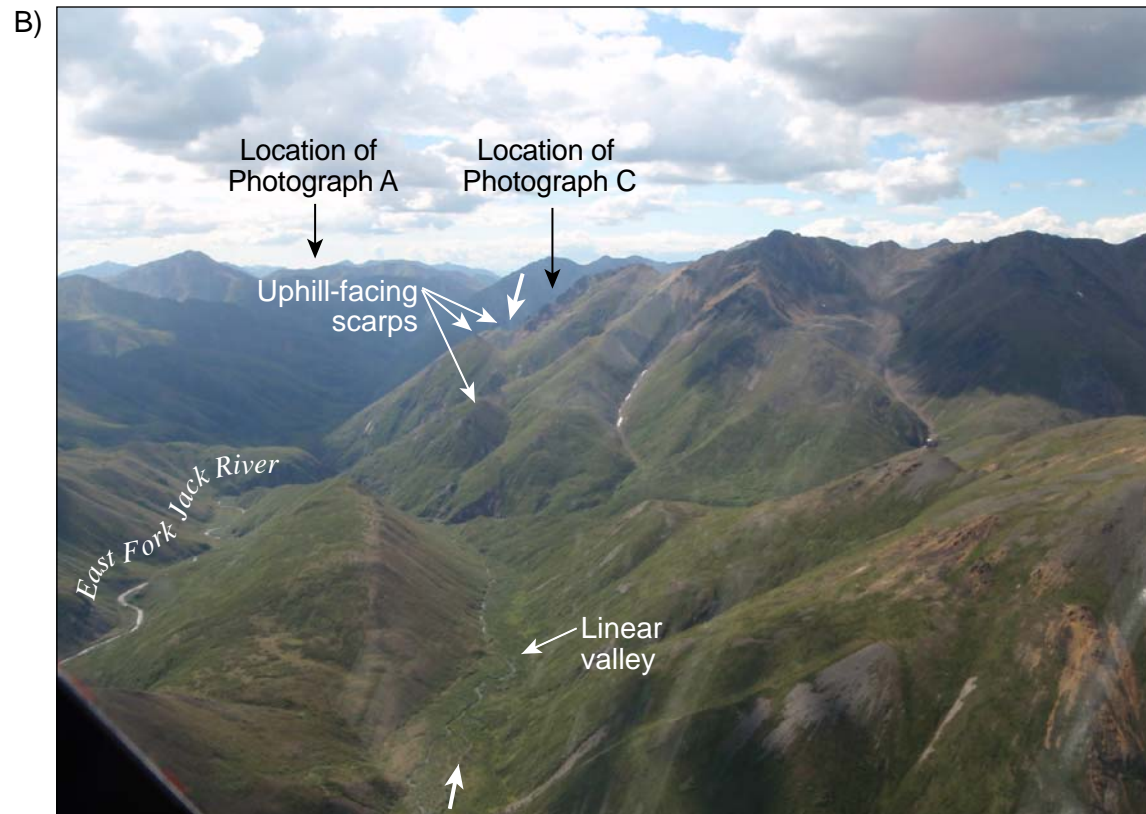
79\_218900\_Alaska\_Railbel/2189\_Lineament Report October 2013, modified 10.18.13



View looking northeast from location A towards the confluence of the Jack River and the East Fork Jack River. Arrows point along the alignment of mapped lineaments. Note absence of linear expression in Quaternary deposits.



View looking southwest from location C at a detailed view of aligned uphill-facing scarps. Note Thf contact is up-slope from the scarp in the distance.

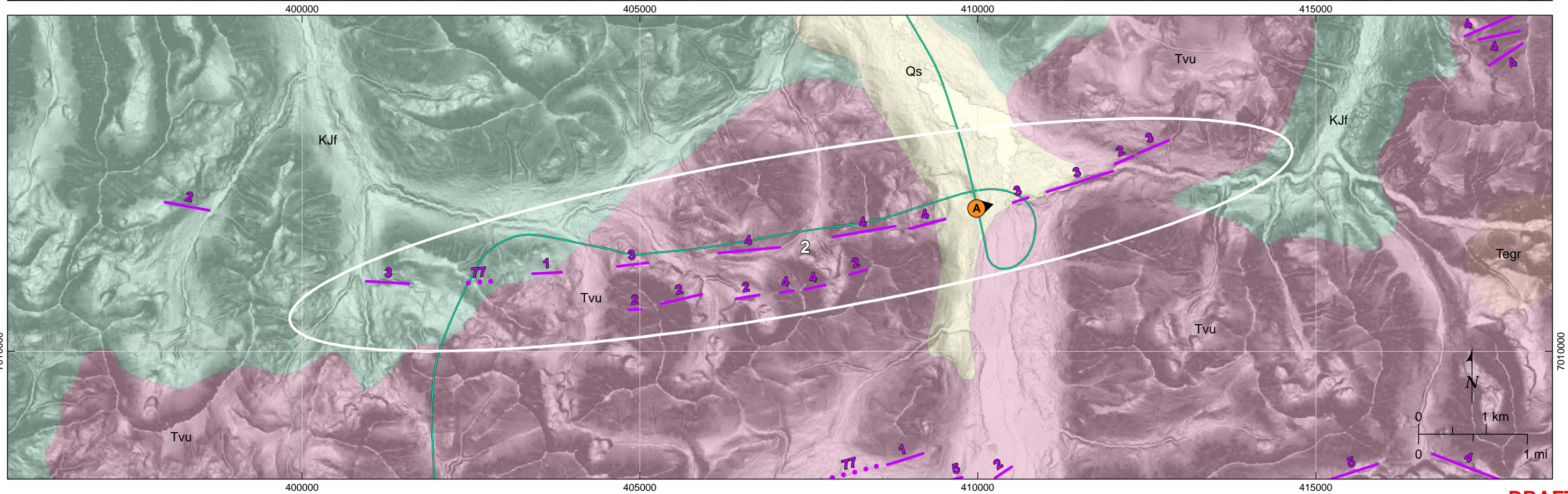
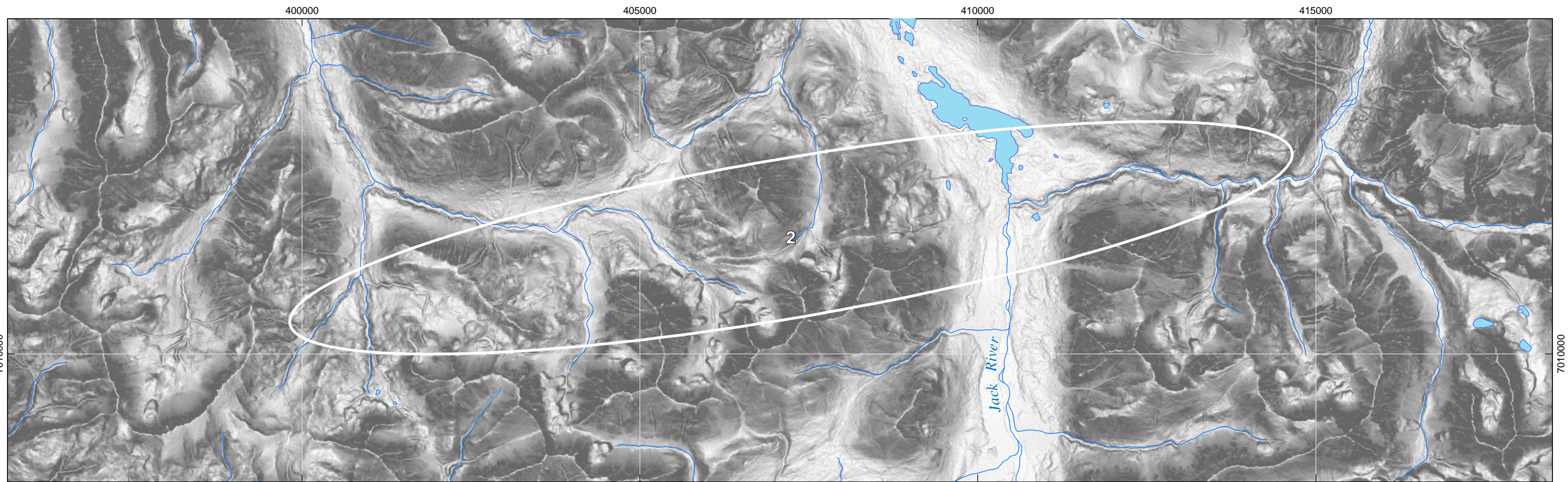


View looking southwest from location B along alignment of linear features. Arrows indicate the alignment of the mapped lineaments.

79\_218900\_Alaska\_Railbelt/2189\_Lineament Report October 2013, modified 10.18.13

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Notes: 1. See Figures A0.2, A0.3, A0.4, and A0.5 for explanation.  
 2. Geology by Wilson et al., 1998.

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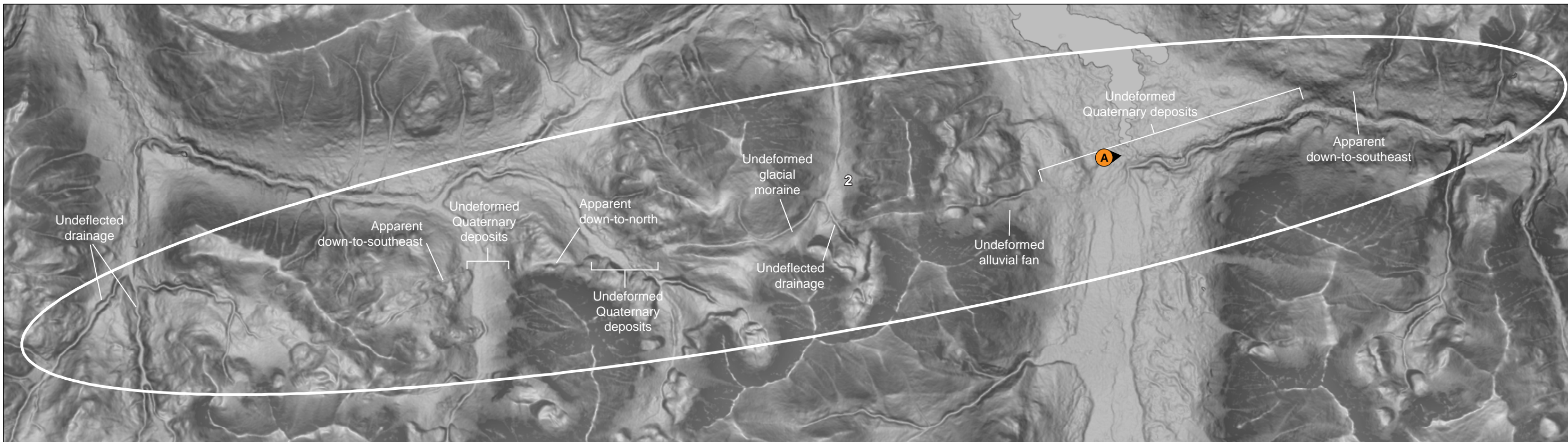
SUSITNA-WATANA HYDROELECTRIC PROJECT  
 LINEAMENT GROUP 2  
 MAP DATA

FIGURE  
 A2.1

79\_218900\_Alaska\_Railbelt/2189\_Lineament Report October 2013, modified 10.18.13



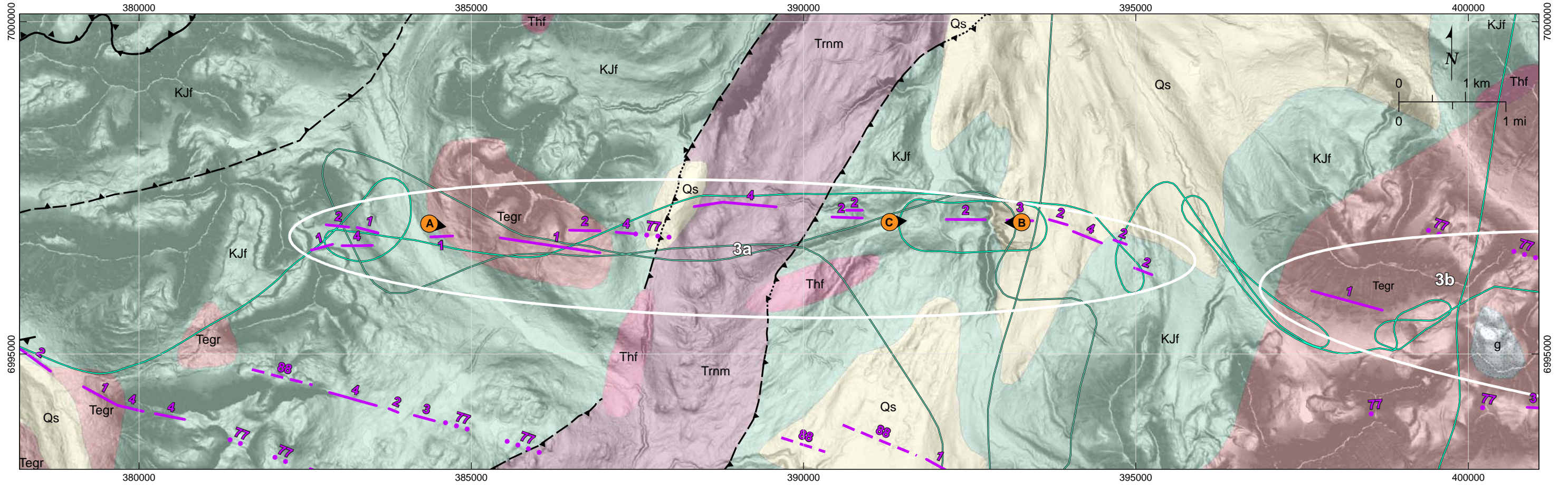
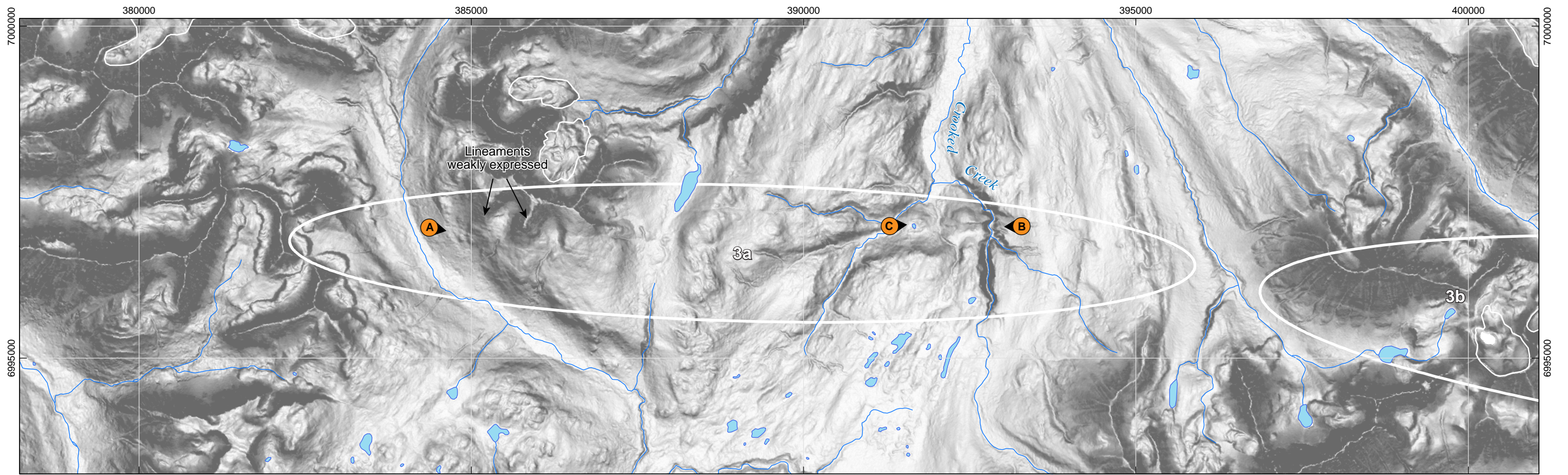
Photograph taken from location A looking east-northeast. Arrows show the alignment of FCL-mapped lineament. Note lack of apparent deformation in bedrock exposure along Jack River.



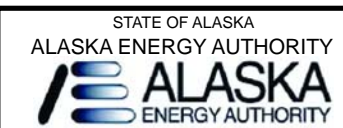
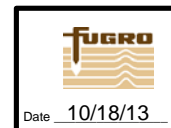
79\_218900\_Alaska\_Railbel/2189\_Lineament Report October 2013, modified 12.16.13

**DRAFT**

<p>Date 12/16/13</p>	<p>STATE OF ALASKA ALASKA ENERGY AUTHORITY</p>	<p>SUSITNA-WATANA HYDROELECTRIC PROJECT LINEAMENT GROUP 2 MAP DATA AND PHOTOGRAPH</p>	<p>FIGURE A2.2</p>
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Notes: 1. See Figures A0.2, A0.3, A0.4, and A0.5 for explanation.  
 2. Geology by Wilson et al., 1998.



SUSITNA-WATANA HYDROELECTRIC PROJECT  
 LINEAMENT GROUP 3a  
 MAP DATA

**DRAFT**

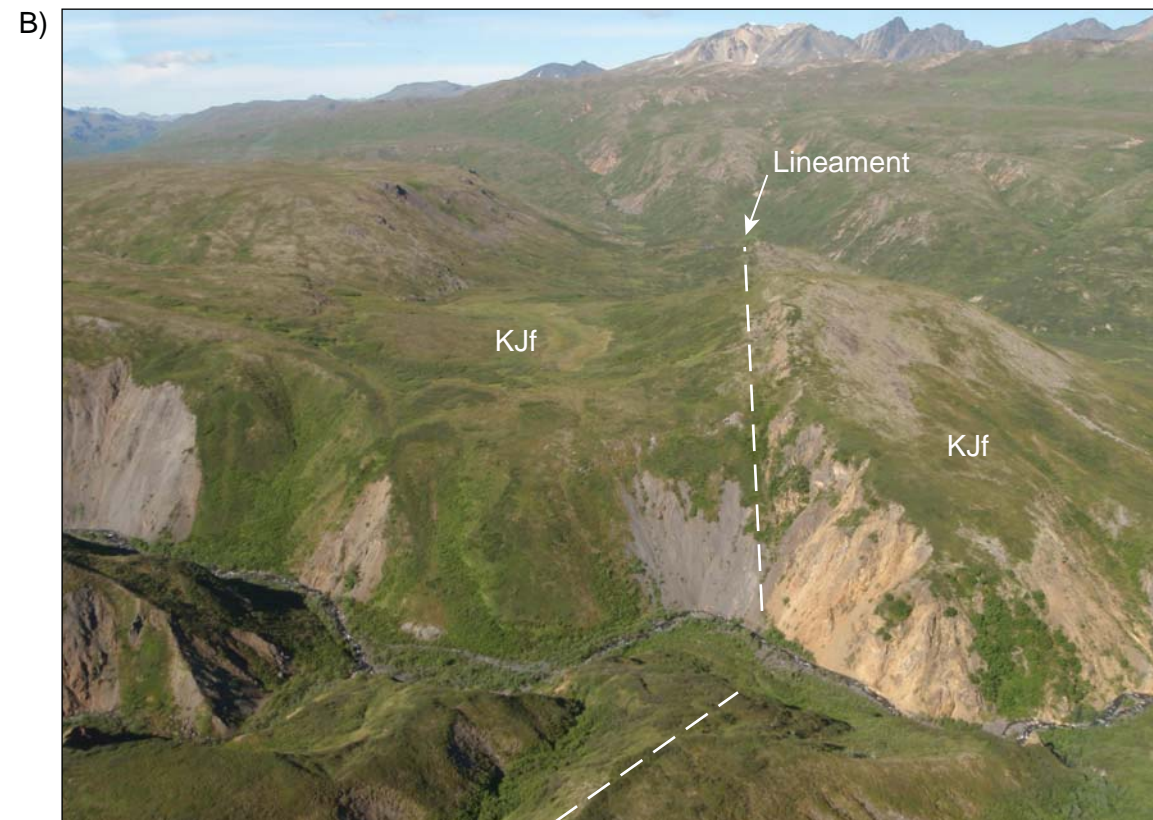
FIGURE  
 A3a.1

79\_218900\_Alaska\_Railbelt/2189\_Lineament Report October 2013, modified 10.18.13

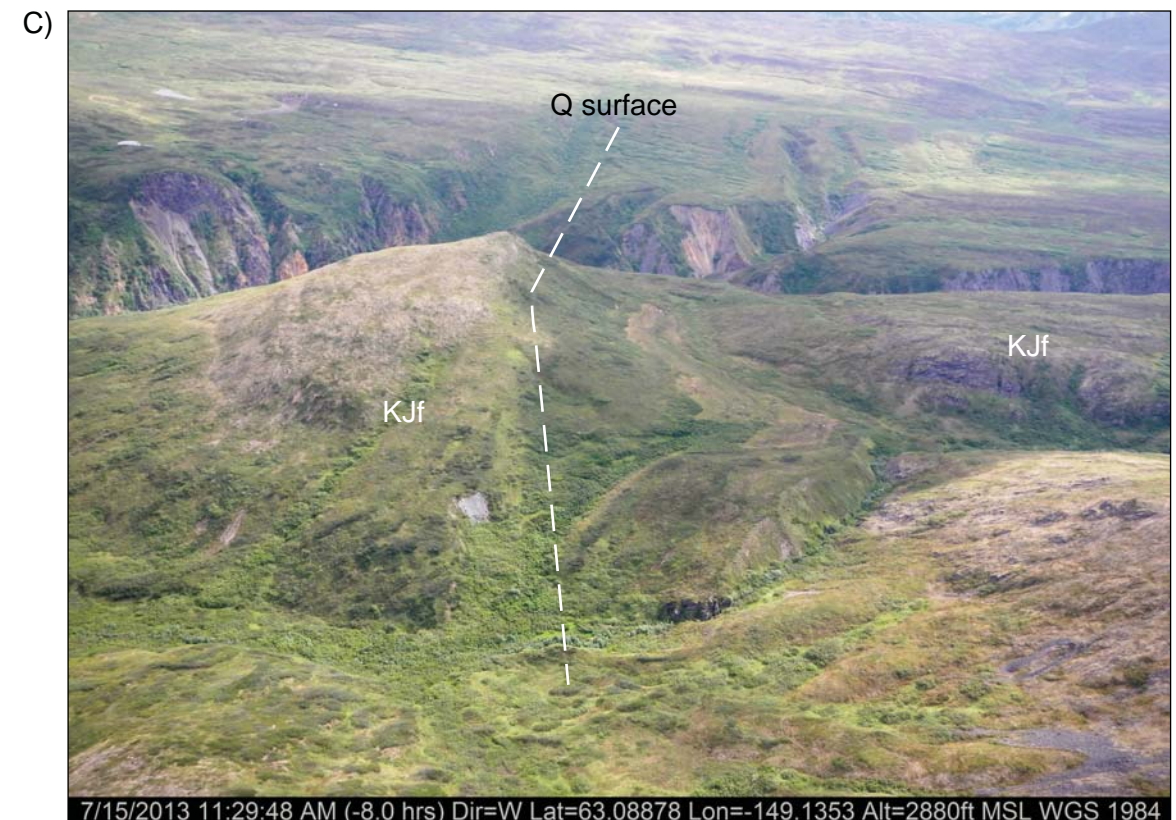
79\_218900\_Alaska\_Railbelt/2189\_Lineament Report October 2013, modified 10.18.13



View looking east at likely solifluction-related scarps on hillside that correspond with mapped lineaments. Large arrows point along lineaments.

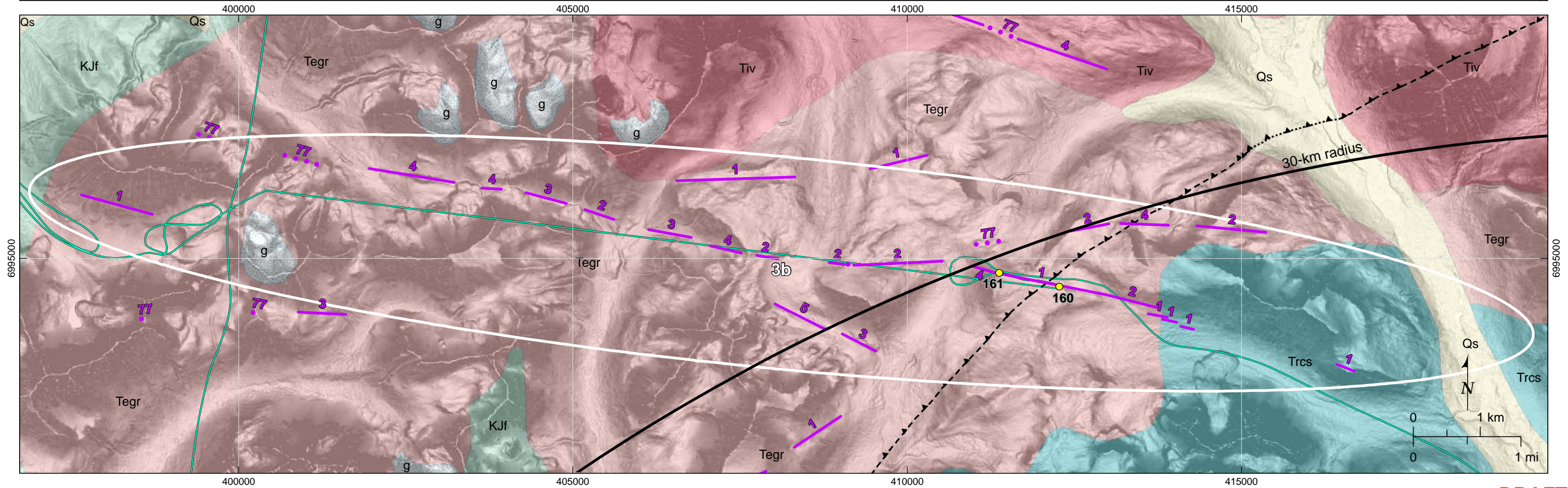
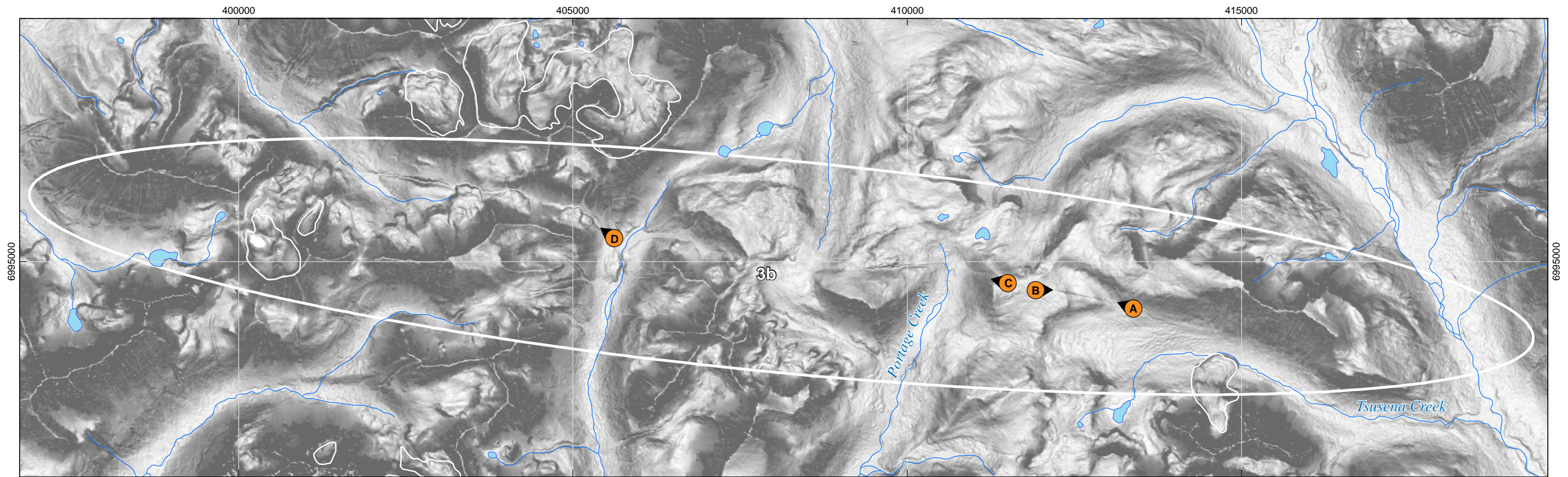


View looking west along 3a lineament expressed as sharp ridge within Kahlitna flysch (KJf). Apparent color change and topographic expression may suggest a geologic structure, however, none were previously mapped. The feature may be a result of weathering because of lithologic change within the flysch.

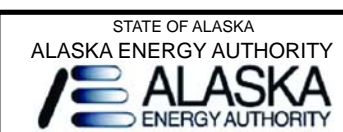
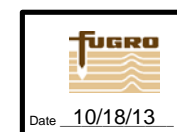


View looking east past ridge, with unfaulted Quaternary sediments in the foreground and far distances.

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Notes: 1. See Figures A0.2, A0.3, A0.4, and A0.5 for explanation.  
 2. Geology by Wilson et al., 1998.



SUSITNA-WATANA HYDROELECTRIC PROJECT  
 LINEAMENT GROUP 3b  
 MAP DATA

**DRAFT**

FIGURE  
 A3b.1

79\_218900\_Alaska\_Railbelt/2189\_Lineament Report October 2013, modified 10.18.13



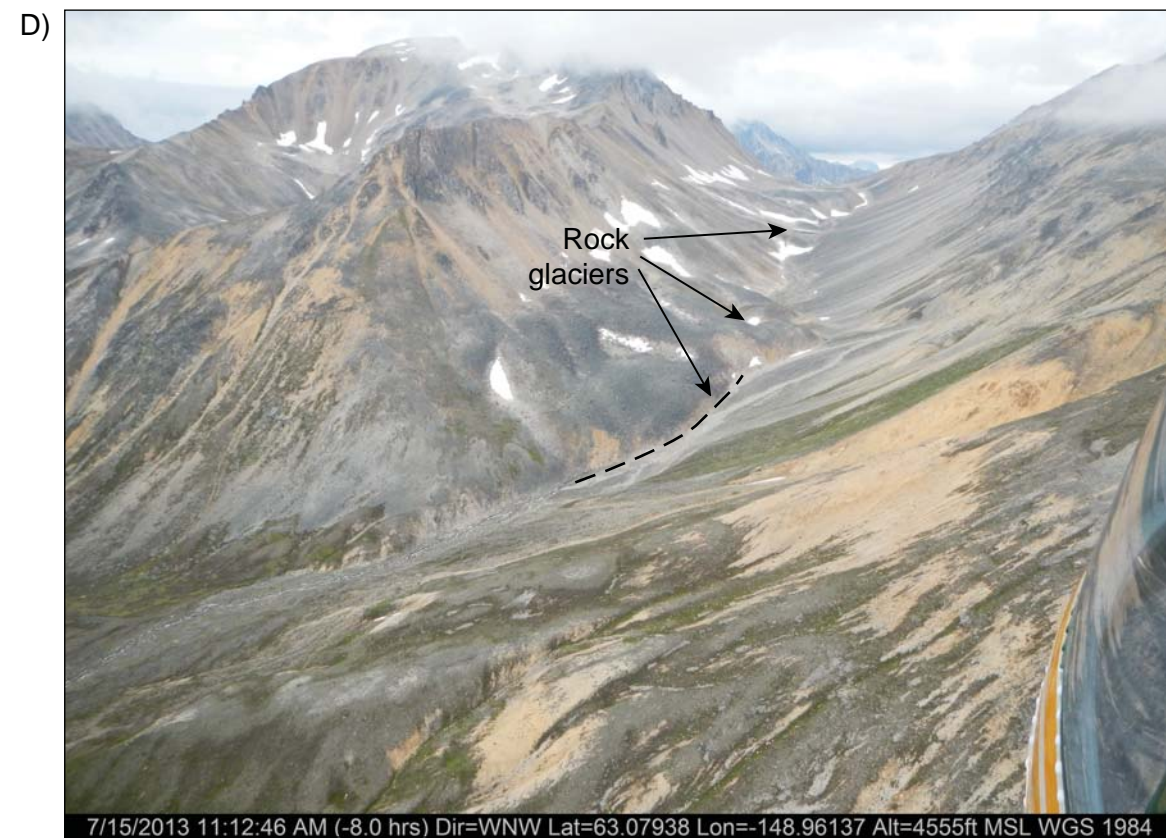
View looking west along north-facing escarpment in Eocene granitics.



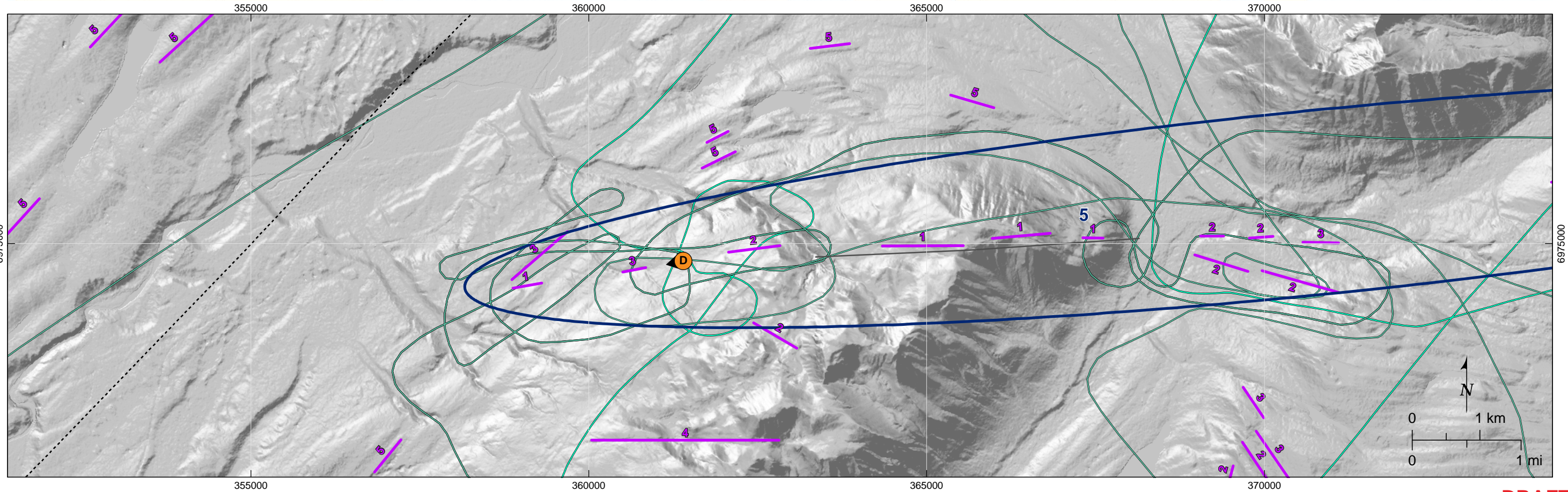
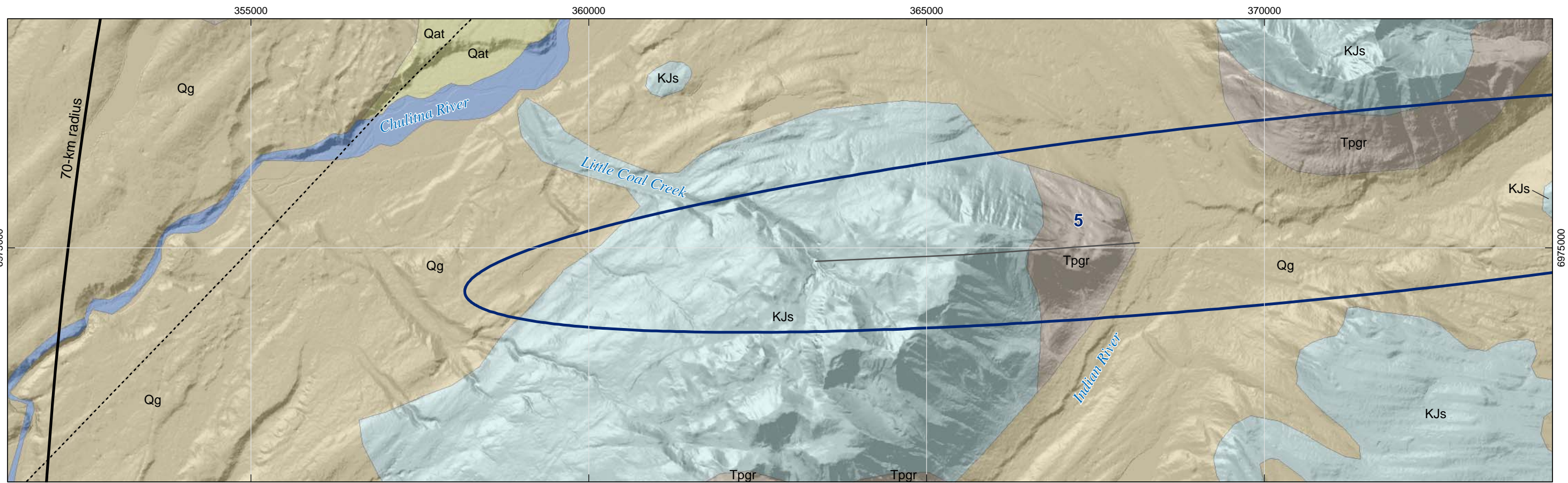
View looking east along lower talus scree field that shows decreasing relief at west end of lineament 3b.



View looking west along lineament 3b projection. South-facing escarpment indicates a reversal in kinematic morphology.

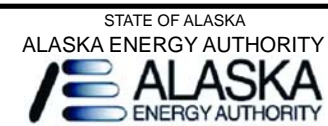
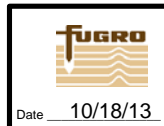


View looking west along lineament 3b projection. Holocene rock glaciers are not offset, and lineament is expressed as a linear valley.



Notes: 1. See Figures A0.2, A0.3, A0.4, and A0.5 for explanation.  
 2. Geology by Wilson et al., 2009.

**DRAFT**



SUSITNA-WATANA HYDROELECTRIC PROJECT  
 LINEAMENT GROUP 5  
 MAP DATA

FIGURE  
 A5-1.1