STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

Tony Knowles, *Governor*

John T. Shively, *Commissioner*

Milton A. Wiltse, *Acting Director and State Geologist*

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TRIAL MAGNETOMETER PROFILES ACROSS THE CASTLE MOUNTAIN FAULT, SOUTHCENTRAL ALASKA

By

R.A. Combellick, G.R. Cruse, and W.R. Hammond

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[in envelope]

TRIAL MAGNETOMETER PROFILES ACROSS THE CASTLE MOUNTAIN FAULT, SOUTHCENTRAL ALASKA

by
R.A. Combellick,[1] G.R. Cruse,[1] and W.R. Hammond[2]

INTRODUCTION

This report describes experimental ground-magnetometer profiling that we performed in June 1994 to determine if the method would be useful for locating the active Castle Mountain fault between Wasilla and Houston, Alaska. The profiles were made as part of a project to prepare 1:25,000-scale geologic and construction-materials maps in the Anchorage C-7 NE, C-7 NW, C-8 NE, and C-8 NW Quadrangles (Reger, Combellick, and Pinney, 1994a-c; Reger, Pinney, and Combellick, 1994) (fig. 1). This report is intended primarily as a data release to evaluate the usefulness of this approach. Limitations in the magnetometer data, as described herein, preclude conventional interpretation and development of detailed geological models.

BACKGROUND

The Castle Mountain fault extends at least 300 km from the Copper River Basin west-southwestward to the Matanuska-Susitna lowland, where it crosses the study area and passes within 40 km of Anchorage. Its western extent and, therefore, its total length, are unknown. Limited age control indicates that the most recent surface rupture in the Susitna segment southwest of Houston (fig. 1) occurred between 225 and 1,700 years ago (Detterman and others, 1974). A magnitude 5.7 earthquake in 1984 near Sutton, 18 km east of the study area, was attributed to subsurface displacement on the Talkeetna segment of the fault (Lahr and others, 1986). The age of most recent activity of the intervening segment (here termed the Wasilla segment) is unknown.

Surface expression of the Castle Mountain fault is highly variable. Southwest of Houston, the Susitna segment is visible from the air in many places where a low (1-3 m) scarp mantled with windblown sand disrupts the drainage pattern. In this area the fault appears as a linear boundary between birch-spruce woodlands on the higher, better drained north side, and treeless or sparsely forested marshes on the lower, poorly drained south side (Detterman and others, 1974; Reger, 1981a, b). Surface expression of the Wasilla segment between Houston and the eastern boundary of the Anchorage C-7 NE Quadrangle, a distance of about 30 km, is largely obscured by flood-plain deposits of the Little Susitna River and forested late-Wisconsin glacial drift (Reger, Combellick, and Pinney, 1994a-c). Although several photogeologic lineaments are visible near the projected fault trace in this segment, none can yet be confidently identified as traces of the Castle Mountain fault. East of the Anchorage C-7 NE Quadrangle, the fault is visible in bedrock outcrops and is mapped as one (Barnes, 1962; Clardy, 1974) or two (Detterman and others, 1976; Winkler, 1992) strands that extend eastward into the southern Talkeetna Mountains and bifurcate into numerous subsidiary strands including the Caribou fault system before terminating near the head of Matanuska valley.

Aeromagnetic data show distinctly different magnetic character between the Peninsular terrane northwest of the Border Ranges fault and the Chugach terrane to the southeast (Burns and Winkler, 1994). There is a strong corresponding aeromagnetic gradient along the Border Ranges fault. In contrast, the Castle Mountain fault traverses highly variable and weakly to moderately magnetic rocks of the Peninsular terrane, resulting in an indistinct aeromagnetic signature along the fault. The lack of aeromagnetic evidence for the Castle Mountain fault may be due to the relatively high altitude (300 m above ground level) of surveys that were flown for the maps described by Burns and Winkler (1994). Magnetic variations over the short distances profiled in our study may not be measurable at that elevation.

Although the inferred Wasilla segment of the Castle Mountain fault largely traverses unconsolidated alluvial and glacial deposits, its magnetic signature is likely dominated by underlying bedrock. Bedrock outcrops along the fault trend in the Wasilla segment expose Tertiary sedimentary rocks of the Arkose Ridge and Tyonek formations (Reger, Combellick, and Pinney, 1994a-c), which are likely to be magnetically very weak. In three boreholes drilled 2-3 km NE of Houston for investigation of subsurface coal beds, maximum thickness of glacial deposits was 13.3 m (May and Warfield, 1957). South of the fault zone, bedrock is deeper; a coalbed-methane exploration borehole drilled in the northern part of the Anchorage C-7 SW Quadrangle showed 94.5 m of glacial deposits overlying Tyonek formation (T.J. Ryherd, Alaska Division of Oil

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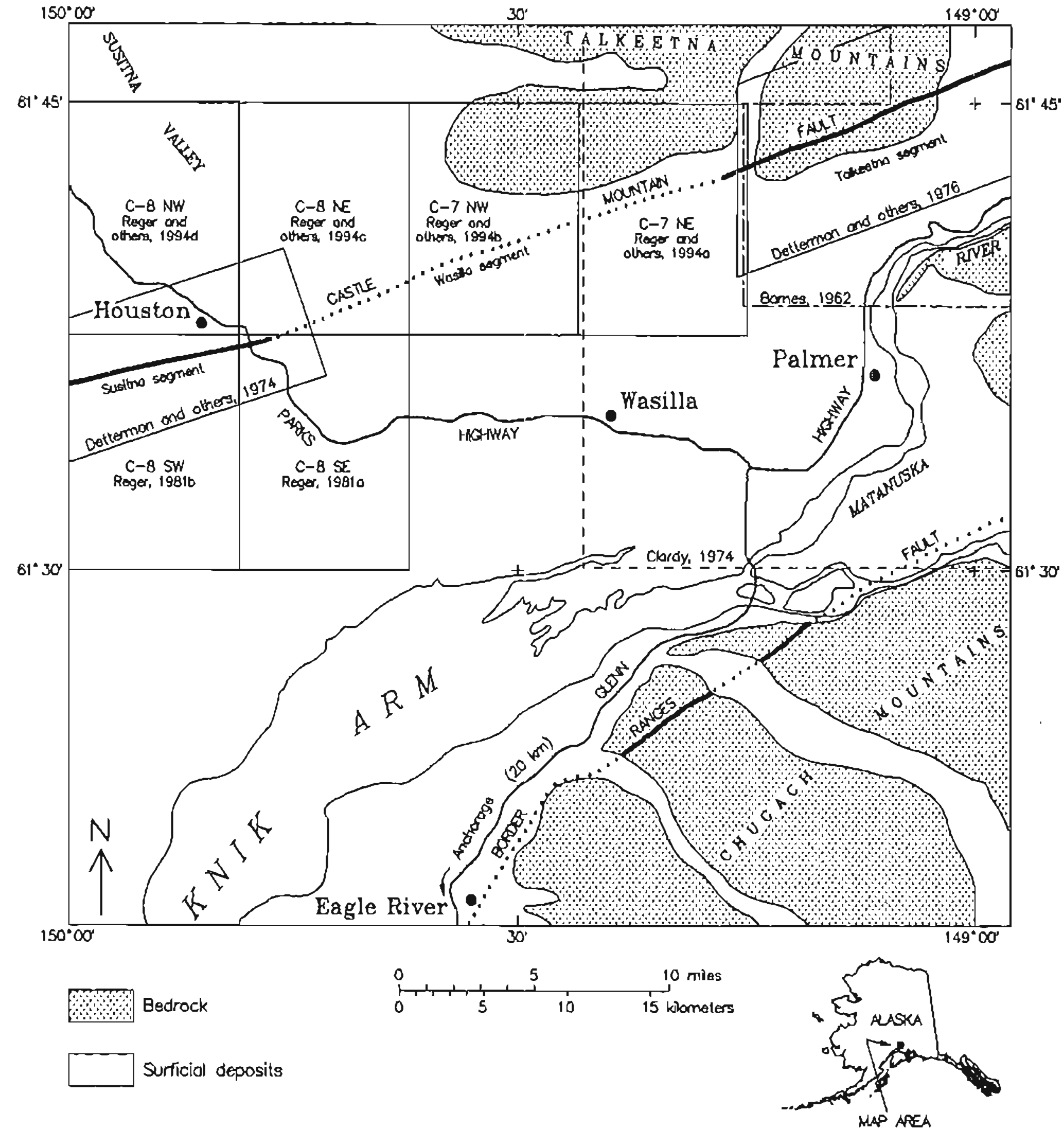

Figure 1. *Index map of study region showing locations of geologic maps with 1:96,000 or greater scale along the Castle Mountain fault. Heavy lines indicate locations of major faults discussed in the text (dotted where concealed by surficial deposits).*

and Gas, written commun., 1994). In the nearby Talkeetna Mountains, exposed bedrock units include amphibolite, schist, volcanics, and volcaniclastic sedimentary rocks of Jurassic age that were intruded by numerous plutons of Cretaceous and Tertiary age (Winkler, 1992). These plutons range from very weakly magnetic felsic rocks to moderately magnetic mafic rocks; similar plutons may be buried and perhaps offset along the Wasilla segment of the Castle Mountain fault. Because bedrock lithologies on both sides of the fault are highly variable, magnetometer profiles across the fault may show different magnetic character even where the profiles are closely spaced.

OBJECTIVE AND APPROACH

The objective of this study was to assess the potential for using ground-magnetometer profiling to locate possible strands of the Castle Mountain fault in the Wasilla segment. We first obtained five profiles across visible scarps of the Susitna segment and one profile across the west end of the mapped Talkeetna segment to determine if a magnetic anomaly exists across known fault segments. After finding apparent anomalies associated with the fault at several locations, we then obtained three profiles at accessible locations in the Wasilla segment either across photogeologic lineaments or projections of lineaments to determine whether significant anomalies exist that could indicate the presence of the fault.

FIELD METHODS

We collected total-field magnetometer readings by using a Gem Systems model GSM-19 portable magnetometer equipped with an Overhauser proton-precession sensor. Published specifications of this unit include a resolution of 0.01 nT (nanoteslas, equivalent to gammas), 0.02 nT relative sensitivity, and 0.2 nT absolute accuracy. For this trial study, we did not install a magnetometer base station. Therefore, variations in our readings that are due to diurnal magnetic variations and short-period phenomena are not taken into account. Although most of the profiles span less than 3 hr (table 1), spurious effects such as solar-magnetic storms and micropulsations could have caused short-term variations of unknown magnitude.

Magnetometer data were digitally logged in the field instrument and later downloaded into a computer for processing and plotting (sheet 1; appendix).

For positioning we used a Trimble Pathfinder Global Positioning System (GPS) receiver, recording 50 or 60 satellite fixes over a 2-to 3-min period for each magnetometer reading. Position data were digitally logged in the receiver unit and later downloaded into a computer for differential correction. We obtained commercial GPS base-station data for a survey marker in southeast Anchorage, 56-76 km from the profile locations. With Trimble processing software we used the base-station data to differentially correct all individual fixes, then determined the average of the 50-60 corrected fixes for each magnetometer station. With differential correction, the standard deviation of fixes at each location ranges from 2 to 8 m in both north-south and east-west directions.

Using the GPS data in conjunction with a Geographic Information System (GIS), we plotted all profile locations along with digitized fault and photolineament locations from Detterman and others (1976), Reger (1981a, b), and Reger, Combellick, and Pinney (1994a-c) on sheet 1.

RESULTS

Magnetometer readings, locations, and times are presented in the appendix, along with plotted profiles. The profiles and their locations in relation to mapped segments of the Castle Mountain fault and other photolineaments also appear on sheet 1. The plotted magnetometer profiles include a moving average to smooth out short-period variations.

Lines 1-4 and 9 cross known locations of the Castle Mountain fault southeast of Houston. Lines 1-4 cross the low scarp of the fault, where it is visible as a linear boundary between birch-spruce woodlands and sparsely forested marshes. The location of this scarp is noted on each profile. Lines 1-4 show a relatively sharp, asymmetrical magnetic anomaly at the scarp, ranging in amplitude from about 50 to 140 nT over a distance of 50-100 m and sloping to the north. The shapes of these anomalies are consistent with those obtained from E-W oriented vertical sheets or dikes in polar regions

Table 1. *Summary of magnetometer profiles performed during this study. See sheet 1 for profile locations and the appendix for magnetometer data*

Profile	Date (1994)	Begin time (ADT)	End time (ADT)	Elapsed time (hr:min)	Length (m)	Traverse direction (° true)
1	2 June	12:12 pm	2:38 pm	2:26	486	345
2	3 June	10:17 am	11:49 am	1:32	483	350
3	3 June	1:23 pm	2:49 pm	1:26	455	340
4	3 June	3:54 pm	4:47 pm	0:53	477	340
5	4 June	1:00 pm	2:04 pm	1:04	424	355
6	4 June	3:04 pm	4:23 pm	1:19	638	355
7	6 June	3:04 pm	5:27 pm	2:23	1,206	170
8	7 June	11:19 am	5:40 pm	6:21	3,550	360
9	8 June	8:57 am	9:52 am	0:55	773	360

when using a N-S traverse direction (Breiner, 1973, fig. 26).

Line 9, along a north-south road about 2 km southeast of Houston, shows a sharp negative anomaly with a 300 nT amplitude near the fault. On the basis of the horizontal extent of the steep part of the anomaly on each of these profiles (lines 1-4 and 9), the source is within several tens of meters of the surface (Breiner, 1973, p. 31). The anomaly is asymmetrical and, as with lines 1-4, is consistent with an E-W-oriented vertical sheet or dike. It is also consistent with typical anomalies across an E-W-oriented horizontal cylinder (Breiner, 1973, fig. 26), which raises the possibility that the anomaly is caused by a steel culvert buried in the roadbed (see line 9 profile on sheet 1). However, a similar culvert farther north along the profile does not produce a similar anomaly. We checked with local-government officials and utility companies to confirm that there are no buried or overhead utilities near line 9 that would cause anomalous magnetometer readings; this does not rule out the possibility that there is metallic debris buried in the roadbed. Although a fault scarp is not visible on the ground along line 9, the location of the fault is known to within about 50 m by projecting between two photolineaments a short distance east and west of the line. The fault may be the source of the anomaly but this must be confirmed by performing additional parallel profiles away from the road.

Line 7 crosses the western end of the mapped Talkeetna segment of the Castle Mountain fault (Barnes, 1962; Clardy, 1974; Detterman and others, 1976). The westernmost exposure of the northern fault strand is in highly sheared sedimentary rocks of the Tertiary Arkose Ridge formation in a steep cliff along the Little Susitna River, about 500 m east of line 7. The southern strand is not exposed along the river. Additionally, there is no surface expression of either fault strand along line 7, which traverses glacial deposits; the locations of the mapped strands are approximated on the magnetometer profile by extending the mapped trends southwestward from the riverbank exposure. A positive anomaly of about 300 nT appears north of these projected strands; part of another strong positive anomaly appears south of the strands. Both longer, multiple parallel magnetometer lines near this profile and corrections for time variation are necessary to determine if the observed variations correlate with the projected fault strands.

Magnetic profiles along lines 5, 6, and 8 cross lineaments in the Wasilla segment where the location of the Castle Mountain fault is unknown. Lines 5 and 6 cross a scarp that is part of an east-west photolineament several km long and north of the projected trend of the fault in the Anchorage C-7 NW Quadrangle (see also Reger, Combellick, and Pinney, 1994b). The position of the scarp crest, up to 5 m high and facing south, is noted on the profiles. Lines 5 and 6 cross a prominent scarp but show different profile character at the scarp crossing. Line 6 shows a significant level shift across the scarp; line 5 does not.

Line 8 is a long north-south profile along a road 0.7 km east of line 6. The profile crosses the eastward projection of the scarp visible along lines 5 and 6. This scarp is not visible on the ground along line 8, which occupies a debris-flow channel (Reger, Combellick, and Pinney, 1994b). However, its approximate extension is noted on the magnetometer profile, as are approximate extensions of other nearby lineaments. Although the profile shows higher relief in the magnetic field north of the scarp extension and lower relief to the south, there is no other clear indication of a possible fault-related magnetic signature at the projected scarp extension. However, a level shift of more than 150 nT at 500-700 m and a comparably large positive anomaly at 2,800-3,400 m along the profile may correlate with other lineaments (sheet 1). These variations along line 8 may reflect three subsurface rock types with different magnetic signatures, possibly juxtaposed along faults at about the 700-m and 2,800-m positions.

CONCLUSIONS

Magnetometer profiles across the Susitna segment of the Castle Mountain fault southwest of Houston (lines 1-4 and 9) appear to show a consistent, north-sloping anomaly at the fault scarp. This anomaly may relate to drainage-related differences in magnetic susceptibility in near-surface sediments or to differences in subsurface bedrock composition across the fault. If the conditions responsible for this anomaly were similar along the Wasilla segment east of Houston, the method may have high potential for locating the fault in this segment where its surface expression is poor. However, a magnetometer profile (line 7) across projected fault strands at the west end of the Talkeetna segment shows no apparent fault signature at the fault crossings. Although lines 5 and 6 are only about 150 m apart across a prominent scarp, their character near the scarp is very different. Together, the profiles are ambiguous as an indication of a possible fault-related anomaly. Multiple parallel profiles with correction for diurnal and spurious magnetic variation are needed to determine if magnetometer profiling can help locate the Castle Mountain fault and other possible faults in the Wasilla segment. Aeromagnetic survey at very low altitude may be an alternative to ground profiles in this heavily forested area and could reveal fault-related anomalies that are not apparent from higher-altitude surveys.

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REFERENCES CITED

Barnes, F.F., 1962, Geologic map of lower Matanuska Valley, Alaska: U.S. Geological Survey Miscellaneous Geological Investigations Map I-359, scale 1:63,360.

Breiner, Sheldon, 1973, Applications manual for portable magnetometers: Sunnyvale, California, GeoMetrics, 58 p.

Burns, L.E., and Winkler, G.R., 1994, Interpretation of the aeromagnetic map of the Anchorage Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 94-5, 25 p. 2 sheets, scale 1:250,000.

Clardy, B.I., 1974, Bedrock geologic map of the Matanuska Valley, Alaska, *in* Clardy, B.I., Hanley, P.T., Hawley, C.C., and LaBelle, J.C., eds., Guide to the bedrock and glacial geology of the Glenn Highway, Anchorage to the Matanuska Glacier and the Matanuska coal mining district: Anchorage, Alaska Geological Society, 1 sheet, scale 1:96,000.

Detterman, R.L., Plafker, George, Hudson, Travis, Tysdal, R.G., and Pavoni, Nazario, 1974, Surface geology and Holocene breaks along the Susitna segment of the Castle Mountain fault, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-618, scale 1:24,000.

Detterman, R.L., Plafker, George, Tysdal, R.G., and Hudson, Travis, 1976, Geology and surface features along part of the Talkeetna segment of the Castle Mountain - Caribou fault system, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-738, scale 1:63,360.

Lahr, J.C., Page, R.A., Stephens, C.D., and Fogleman, K.A., 1986, Sutton, Alaska, earthquake of 1984: Evidence for activity on the Talkeetna segment of the Castle Mountain fault system: Bulletin of the Seismological Society of America, v. 76, no. 4, p. 967-983.

May, R.R., and Warfield, R.S., 1957, Investigation of subbituminous-coal beds near Houston, westward extremity of Matanuska coalfield, Alaska: U.S. Bureau of Mines Report of Investigations 5350, 20 p.

Reger, R.D., 1981a, Geology and geologic-materials maps of the Anchorage C-8 SE Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Geologic Report 65, 2 sheets, scale 1:25,000.

__________1981b, Geology and geologic-materials maps of the Anchorage C-8 SW Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Geologic Report 68, 2 sheets, scale 1:25,000.

Reger, R.D., Combellick, R.A., and Pinney, D.S., 1994a, Geologic and derivative materials maps of the Anchorage C-7 NE Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 94-24, scale 1:25,000.

__________1994b, Geologic and derivative materials maps of the Anchorage C-7 NW Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 94-25, scale 1:25,000.

__________1994c, Geologic and derivative materials maps of the Anchorage C-8 NE Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 94-26, scale 1:25,000.

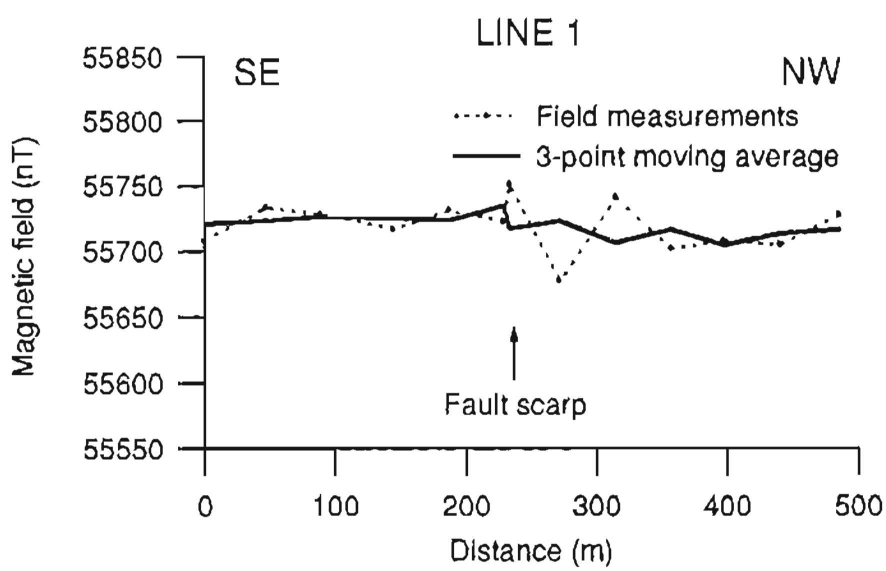
Reger, R.D., Pinney, D.S., and Combellick, R.A., 1994, Geologic and derivative materials maps of the Anchorage C-8 NW Quadrangle, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 94-27, scale 1:25,000.

Winkler, G.R., 1992, Geologic map and summary geochronology of the Anchorage 1° x 3° Quadrangle, southern Alaska: U.S. Geological Survey Miscellaneous Investigation Map I-2283, 1 sheet, scale 1:250,000.

APPENDIX

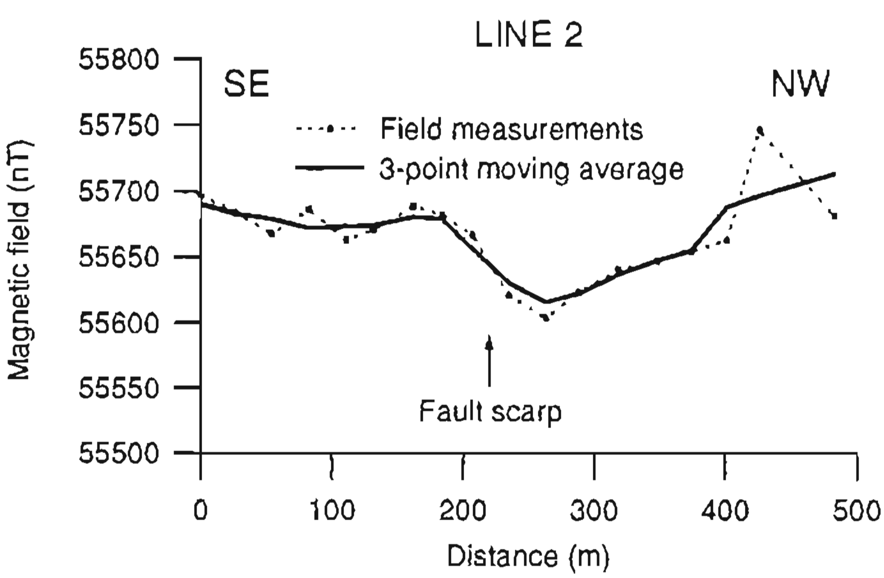
LINE 1 Date: 6/2/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°35'15.2"N	149°59'08.9"W	0.0	55,708.5	2012
2	61°35'16.6"N	149°59'10.0"W	47.3	55,733.4	2024
3	61°35'17.9"N	149°59'10.4"W	89.1	55,728.4	2034
4	61°35'19.6"N	149°59'11.8"W	145.2	55,717.0	2050
5	61°35'20.8"N	149°59'13.0"W	187.5	55,731.3	2058
6	61°35'22.2"N	149°59'13.4"W	229.5	55,723.0	2110
7	61°35'22.3"N	149°59'13.7"W	234.1	55,751.1	2152
8	61°35'23.5"N	149°59'13.9"W	272.6	55,677.6	2158
9	61°35'24.9"N	149°59'14.2"W	315.5	55,741.1	2207
10	61°35'26.2"N	149°59'14.2"W	357.6	55,701.8	2215
11	61°35'27.5"N	149°59'14.8"W	398.1	55,708.1	2224
12	61°35'28.9"N	149°59'15.1"W	440.5	55,704.7	2233
13	61°35'30.3"N	149°59'15.5"W	486.0	55,727.9	2237



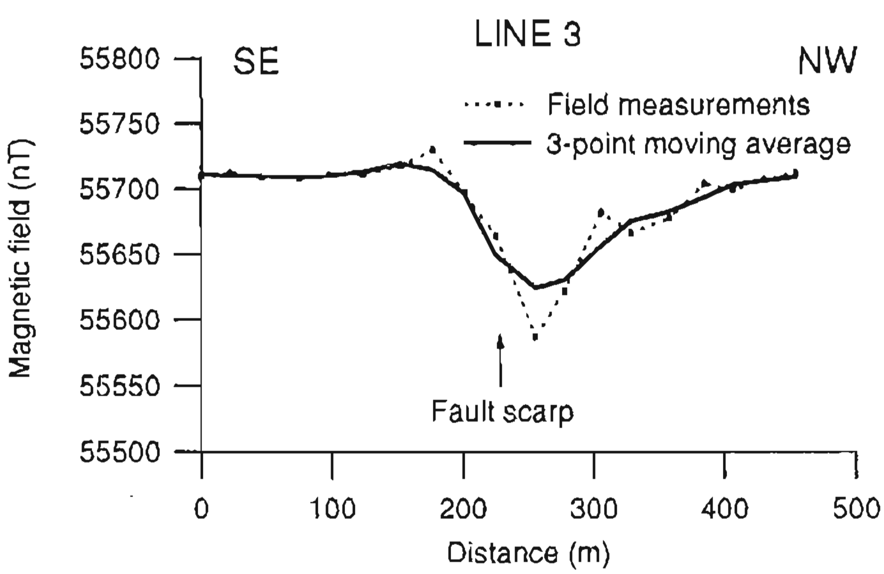
LINE 2 Date: 6/3/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°35'46.9"N	149°56'42.8"W	0.0	55,696.9	1817
2	61°35'47.8"N	149°56'43.2"W	27.6	55,683.1	1822
3	61°35'48.6"N	149°56'43.9"W	54.2	55,667.5	1827
4	61°35'49.5"N	149°56'44.4"W	82.5	55,685.6	1832
5	61°35'50.4"N	149°56'44.8"W	111.1	55,662.8	1837
6	61°35'51.0"N	149°56'45.2"W	131.5	55,670.6	1841
7	61°35'52.0"N	149°56'45.8"W	162.2	55,688.2	1850
8	61°35'52.6"N	149°56'46.2"W	184.0	55,681.9	1855
9	61°35'53.4"N	149°56'46.6"W	207.5	55,666.6	1859
10	61°35'54.2"N	149°56'47.3"W	235.3	55,620.4	1907
11	61°35'55.1"N	149°56'47.8"W	263.3	55,603.3	1913
12	61°35'55.9"N	149°56'47.8"W	288.0	55,623.1	1918
13	61°35'56.9"N	149°56'47.9"W	318.6	55,640.1	1924
14	61°35'57.8"N	149°56'48.4"W	347.3	55,646.2	1929
15	61°35'58.6"N	149°56'48.3"W	373.4	55,653.6	1935
16	61°35'59.5"N	149°56'48.3"W	400.9	55,662.5	1938
17	61°36'00.3"N	149°56'48.7"W	425.7	55,746.0	1944
18	61°36'02.1"N	149°56'49.3"W	483.0	55,680.4	1949



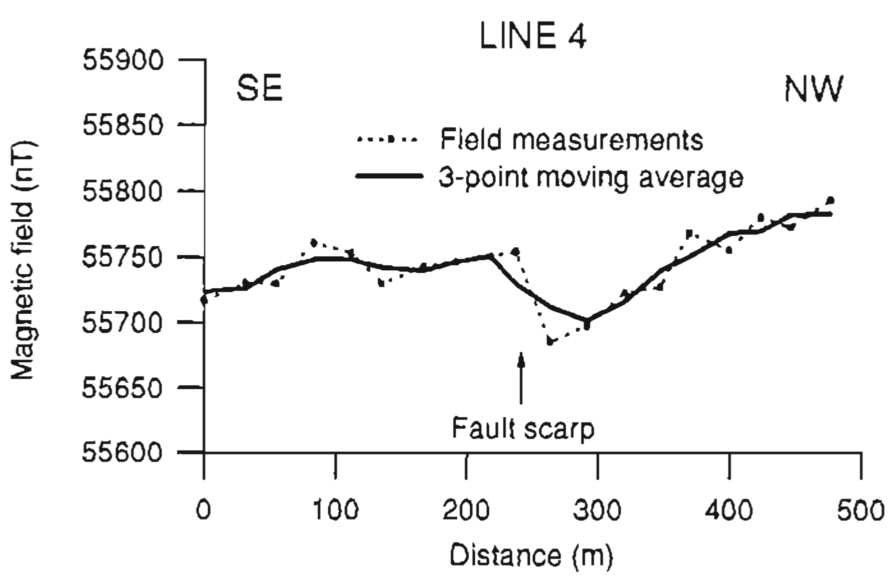
LINE 3 Date: 6/3/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°35'48.2"N	149°56'35.3"W	0.0	55,709.4	2123
2	61°35'48.8"N	149°56'35.7"W	22.0	55,712.0	2126
3	61°35'49.6"N	149°56'36.4"W	46.5	55,708.9	2131
4	61°35'50.4"N	149°56'37.0"W	74.9	55,707.9	2136
5	61°35'51.1"N	149°56'37.6"W	97.6	55,710.3	2141
6	61°35'51.9"N	149°56'38.4"W	123.8	55,710.8	2145
7	61°35'52.7"N	149°56'39.3"W	152.5	55,717.1	2150
8	61°35'53.5"N	149°56'39.8"W	177.3	55,729.4	2155
9	61°35'54.2"N	149°56'40.5"W	201.2	55,697.2	2159
10	61°35'54.9"N	149°56'41.0"W	225.5	55,663.9	2205
11	61°35'55.9"N	149°56'41.6"W	255.9	55,586.9	2211
12	61°35'56.5"N	149°56'42.1"W	277.8	55,622.2	2215
13	61°35'57.3"N	149°56'42.9"W	306.1	55,682.1	2220
14	61°35'58.0"N	149°56'43.3"W	328.5	55,666.3	2225
15	61°35'59.0"N	149°56'43.8"W	358.2	55,677.6	2230
16	61°35'59.6"N	149°56'44.9"W	384.3	55,703.8	2234
17	61°36'00.3"N	149°56'45.5"W	406.8	55,699.0	2239
18	61°36'01.0"N	149°56'46.1"W	430.3	55,706.5	2244
19	61°36'01.7"N	149°56'46.8"W	454.7	55,711.8	2249



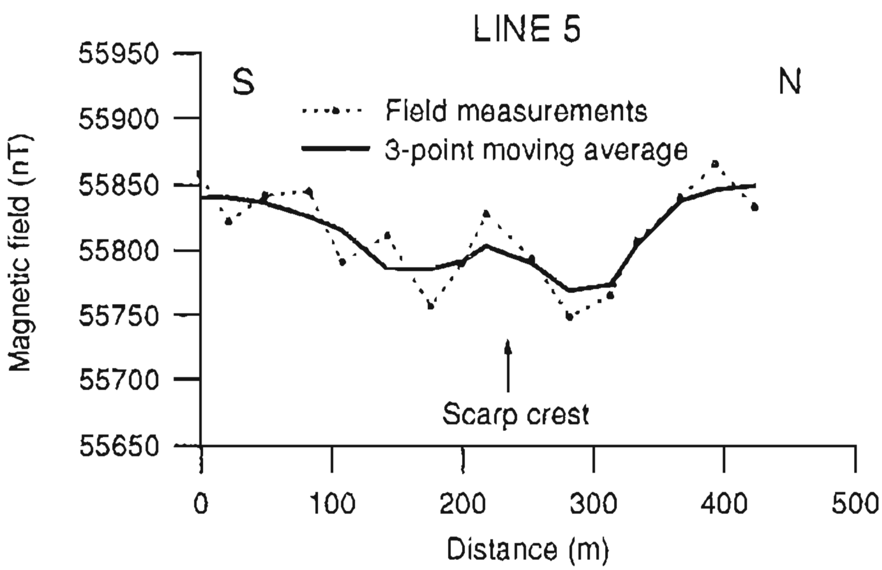
LINE 4 Date: 6/3/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°35'49.1"N	149°56'27.7"W	0.0	55,716.8	2354
2	61°35'50.0"N	149°56'28.7"W	31.5	55,730.4	2357
3	61°35'50.7"N	149°56'29.3"W	54.7	55,729.8	0000
4	61°35'51.6"N	149°56'30.2"W	83.7	55,760.5	0002
5	61°35'52.4"N	149°56'30.9"W	111.9	55,752.9	0005
6	61°35'53.0"N	149°56'31.8"W	135.2	55,729.9	0007
7	61°35'54.0"N	149°56'32.7"W	166.8	55,742.6	0010
8	61°35'54.7"N	149°56'33.2"W	191.8	55,746.5	0014
9	61°35'55.6"N	149°56'33.6"W	218.6	55,750.3	0016
10	61°35'56.1"N	149°56'34.4"W	237.6	55,753.9	0019
11	61°35'56.9"N	149°56'34.5"W	263.4	55,685.7	0023
12	61°35'57.7"N	149°56'35.4"W	291.2	55,697.7	0026
13	61°35'58.6"N	149°56'36.1"W	320.5	55,723.0	0028
14	61°35'59.4"N	149°56'36.8"W	347.2	55,727.5	0032
15	61°36'00.0"N	149°56'37.6"W	369.6	55,768.3	0037
16	61°36'00.9"N	149°56'38.2"W	399.6	55,755.1	0039
17	61°36'01.6"N	149°56'39.0"W	423.5	55,780.3	0041
18	61°36'02.3"N	149°56'39.6"W	446.5	55,772.7	0044
19	61°36'03.2"N	149°56'40.3"W	476.9	55,793.0	0047



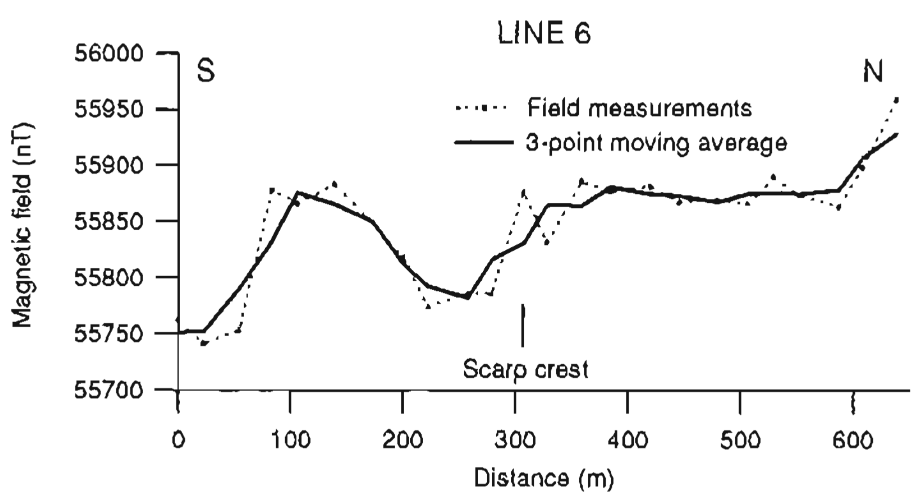
LINE 5 Date: 6/4/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°40'16.3"N	149°31'26.9"W	0.0	55,857.2	2100
2	61°40'17.0"N	149°31'26.8"W	21.8	55,822.0	2104
3	61°40'17.8"N	149°31'27.5"W	49.4	55,841.2	2111
4	61°40'18.9"N	149°31'27.6"W	83.3	55,844.8	2115
5	61°40'19.7"N	149°31'27.8"W	108.3	55,791.0	2119
6	61°40'20.8"N	149°31'28.3"W	142.9	55,811.2	2123
7	61°40'21.9"N	149°31'27.9"W	176.0	55,756.8	2127
8	61°40'22.5"N	149°31'28.9"W	199.7	55,789.5	2129
9	61°40'23.1"N	149°31'29.0"W	218.7	55,827.5	2134
10	61°40'24.2"N	149°31'29.5"W	253.8	55,793.6	2137
11	61°40'25.1"N	149°31'30.1"W	282.3	55,748.3	2142
12	61°40'26.1"N	149°31'30.6"W	313.6	55,765.3	2146
13	61°40'26.7"N	149°31'30.7"W	333.8	55,807.0	2151
14	61°40'27.7"N	149°31'31.3"W	367.0	55,839.8	2154
15	61°40'28.6"N	149°31'31.7"W	393.8	55,865.1	2160
16	61°40'29.5"N	149°31'32.0"W	423.7	55,832.8	2204



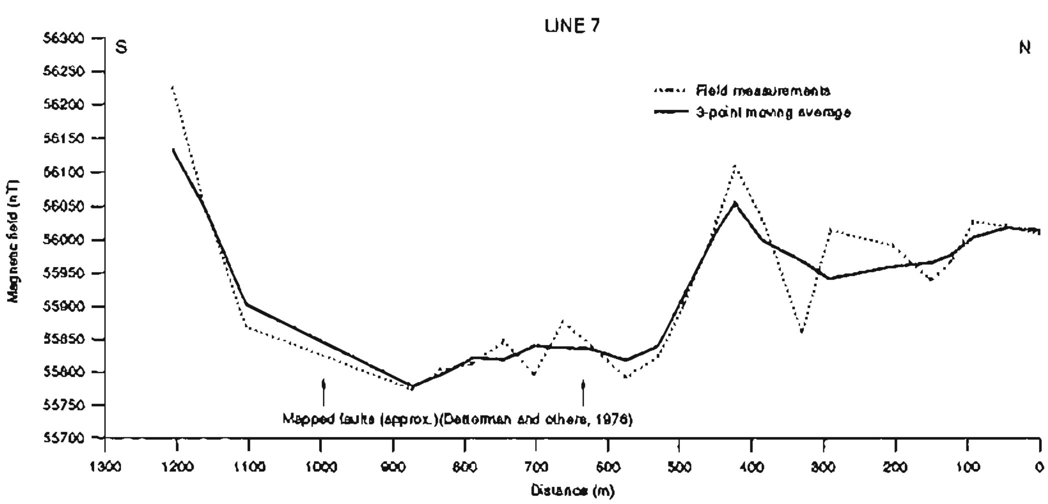
LINE 6 Date: 6/4/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°40'15.1"N	149°31'16.0"W	0.0	55,762.0	2304
2	61°40'15.9"N	149°31'16.4"W	22.7	55,740.8	2308
3	61°40'16.9"N	149°31'16.3"W	54.1	55,752.8	2310
4	61°40'17.8"N	149°31'16.5"W	83.3	55,878.1	2314
5	61°40'18.5"N	149°31'16.8"W	105.9	55,866.2	2318
6	61°40'19.5"N	149°31'17.7"W	138.9	55,883.4	2322
7	61°40'20.6"N	149°31'17.6"W	173.4	55,848.0	2325
8	61°40'21.5"N	149°31'17.9"W	200.1	55,817.7	2328
9	61°40'22.2"N	149°31'17.9"W	222.4	55,774.0	2332
10	61°40'23.3"N	149°31'18.1"W	257.5	55,786.8	2334
11	61°40'23.9"N	149°31'18.6"W	278.7	55,786.2	2337
12	61°40'24.8"N	149°31'19.2"W	307.3	55,876.8	2339
13	61°40'25.5"N	149°31'19.4"W	328.0	55,830.8	2343
14	61°40'26.5"N	149°31'19.3"W	358.2	55,886.0	2348
15	61°40'27.3"N	149°31'19.5"W	384.4	55,876.6	2351
16	61°40'28.4"N	149°31'19.7"W	419.8	55,881.8	2356
17	61°40'29.3"N	149°31'19.4"W	445.3	55,867.2	0001
18	61°40'30.2"N	149°31'20.5"W	478.8	55,869.4	0004
19	61°40'31.1"N	149°31'20.7"W	506.6	55,865.8	0007
20	61°40'31.8"N	149°31'21.0"W	529.0	55,889.2	0010
21	61°40'32.5"N	149°31'20.5"W	552.4	55,873.2	0013
22	61°40'33.6"N	149°31'21.3"W	587.1	55,863.1	0016
23	61°40'34.2"N	149°31'21.2"W	608.1	55,898.2	0019
24	61°40'35.2"N	149°31'21.7"W	638.0	55,958.8	0023



LINE 7 Date: 6/6/94

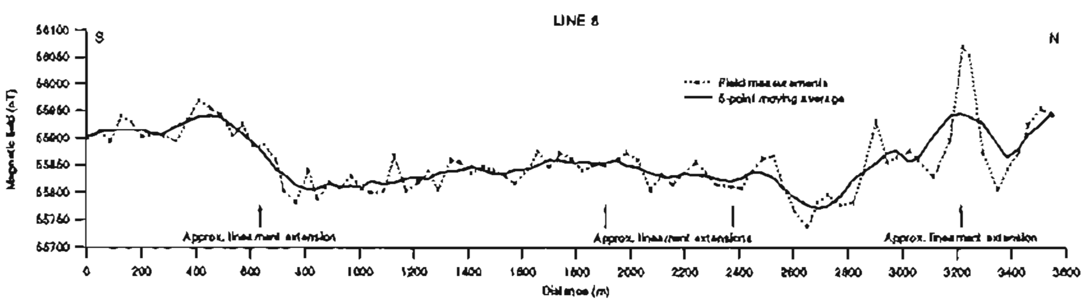
Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
125	61°43'15.7"N	149°14'33.3"W	0.0	56,007.4	2304
124	61°43'14.3"N	149°14'32.1"W	46.5	56,019.7	2309
123	61°43'12.9"N	149°14'31.7"W	91.3	56,026.9	2314
122	61°43'11.9"N	149°14'31.0"W	123.2	55,966.5	2317
121	61°43'11.1"N	149°14'30.3"W	150.1	55,939.4	2320
120	61°43'09.5"N	149°14'29.5"W	202.7	55,990.7	2323
119	No GPS fixes			55,949.2	2327
118	61°43'06.7"N	149°14'28.1"W	290.5	56,014.7	2336
117	61°43'05.5"N	149°14'27.2"W	329.1	55,861.1	2339
116	61°43'03.9"N	149°14'25.8"W	384.1	56,030.0	2343
115	61°43'02.6"N	149°14'25.3"W	422.9	56,108.9	2348
114	61°43'01.8"N	149°14'24.9"W	448.7	56,026.5	2353
113	61°43'00.5"N	149°14'23.9"W	493.2	55,904.0	2359
112	61°42'59.3"N	149°14'23.8"W	529.8	55,823.9	0003
111	61°42'57.9"N	149°14'23.3"W	574.7	55,792.3	0006
110	61°42'56.4"N	149°14'22.6"W	620.6	55,838.4	0012
109	61°42'55.1"N	149°14'21.7"W	662.8	55,876.5	0016
108	61°42'53.9"N	149°14'21.2"W	702.9	55,796.3	0020
107	61°42'52.6"N	149°14'20.5"W	744.7	55,847.2	0024
106	61°42'51.2"N	149°14'19.5"W	789.9	55,811.9	0027
105	61°42'49.8"N	149°14'19.3"W	833.7	55,803.1	0052
104	61°42'48.6"N	149°14'18.4"W	872.9	55,773.2	0056
103	No GPS fixes			55,759.9	0100
102	No GPS fixes			55,799.9	0106
101	61°42'41.1"N	149°14'18.5"W	1,104.2	55,869.4	0113
100	61°42'39.3"N	149°14'17.8"W	1,160.0	56,042.1	0122
99	61°42'38.0"N	149°14'16.5"W	1,205.7	56,223.0	0127



LINE 8 Date: 6/7/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°39'12.2"N	149°30'34.9"W	0.0	55,896.7	1919
2	61°39'13.8"N	149°30'35.0"W	48.4	55,915.1	1959
3	61°39'15.0"N	149°30'35.1"W	85.7	55,893.2	2002
4	61°39'16.3"N	149°30'34.9"W	128.0	55,940.8	2004
5	61°39'17.7"N	149°30'34.9"W	168.5	55,927.3	2007
6	61°39'18.7"N	149°30'35.1"W	202.3	55,902.4	2010
7	61°39'20.3"N	149°30'35.2"W	248.9	55,907.2	2016
8	61°39'21.3"N	149°30'35.5"W	280.4	55,904.4	2019
9	61°39'22.8"N	149°30'35.2"W	328.7	55,894.4	2021
10	61°39'24.2"N	149°30'35.5"W	372.0	55,933.3	2025
11	61°39'25.5"N	149°30'35.6"W	411.0	55,969.5	2027
12	61°39'26.9"N	149°30'35.4"W	454.1	55,953.8	2030
13	61°39'28.1"N	149°30'34.8"W	493.5	55,942.9	2032
14	61°39'29.4"N	149°30'34.7"W	535.3	55,904.9	2035
15	61°39'30.6"N	149°30'34.6"W	572.3	55,925.7	2038
16	61°39'31.9"N	149°30'34.7"W	612.0	55,885.4	2040
17	61°39'33.2"N	149°30'34.7"W	651.0	55,887.0	2057
18	61°39'34.6"N	149°30'34.6"W	694.6	55,860.0	2060
19	61°39'35.5"N	149°30'34.6"W	723.2	55,803.3	2102
20	61°39'36.9"N	149°30'34.4"W	766.5	55,781.2	2107
21	61°39'38.4"N	149°30'34.0"W	813.3	55,840.6	2109
22	61°39'39.5"N	149°30'34.3"W	846.2	55,788.9	2117
23	61°39'41.0"N	149°30'34.8"W	893.3	55,817.8	2121
24	61°39'42.1"N	149°30'34.5"W	927.5	55,809.6	2125
25	61°39'43.5"N	149°30'34.1"W	973.2	55,829.3	2128
26	61°39'44.7"N	149°30'33.9"W	1,008.4	55,807.4	2131
27	61°39'45.8"N	149°30'34.6"W	1,044.8	55,799.7	2136
28	61°39'47.3"N	149°30'34.8"W	1,090.1	55,801.4	2140
29	61°39'48.5"N	149°30'34.6"W	1,128.5	55,867.7	2143
30	61°39'49.9"N	149°30'34.7"W	1,172.0	55,803.5	2146
31	61°39'51.4"N	149°30'34.9"W	1,218.0	55,819.3	2149
32	61°39'52.6"N	149°30'34.6"W	1,255.4	55,839.0	2152
33	61°39'53.7"N	149°30'34.7"W	1,290.9	55,805.1	2154
34	61°39'55.2"N	149°30'35.2"W	1,338.0	55,860.5	2158
35	61°39'56.3"N	149°30'34.8"W	1,371.8	55,855.0	2201
36	61°39'57.7"N	149°30'34.9"W	1,413.7	55,835.6	2204
37	61°39'59.0"N	149°30'35.2"W	1,457.1	55,847.8	2207
38	61°40'00.3"N	149°30'34.8"W	1,497.0	55,840.7	2240
39	61°40'01.7"N	149°30'34.9"W	1,540.4	55,829.8	2243
40	61°40'02.8"N	149°30'34.9"W	1,573.7	55,816.5	2246
41	61°40'04.3"N	149°30'34.5"W	1,621.6	55,843.0	2249
42	61°40'05.5"N	149°30'34.7"W	1,659.1	55,876.5	2252
43	61°40'06.9"N	149°30'34.7"W	1,700.5	55,846.0	2254
44	61°40'08.1"N	149°30'34.7"W	1,739.0	55,872.6	2257
45	61°40'09.6"N	149°30'34.8"W	1,785.3	55,861.6	2300
46	61°40'10.8"N	149°30'34.5"W	1,822.8	55,840.4	2305
47	61°40'12.4"N	149°30'34.9"W	1,871.1	55,851.3	2310
48	61°40'13.5"N	149°30'34.5"W	1,907.0	55,850.3	2315

49	61°40'14.9"N	149°30'34.7"W	1,950.7	55,860.8	2318
50	61°40'16.1"N	149°30'34.5"W	1,986.9	55,873.2	2321
51	61°40'17.4"N	149°30'34.7"W	2,026.5	55,860.3	2323
52	61°40'18.9"N	149°30'34.2"W	2,074.3	55,804.6	2326
53	61°40'20.2"N	149°30'34.2"W	2,115.7	55,833.6	2329
54	61°40'21.5"N	149°30'34.3"W	2,155.9	55,815.1	2331
55	61°40'22.9"N	149°30'34.4"W	2,199.9	55,836.3	2335
56	61°40'24.3"N	149°30'34.1"W	2,240.7	55,856.4	2337
57	61°40'25.5"N	149°30'34.4"W	2,279.8	55,836.1	2339
58	61°40'26.7"N	149°30'34.1"W	2,317.9	55,815.8	2343
59	61°40'28.3"N	149°30'34.1"W	2,365.4	55,811.8	2345
60	61°40'29.7"N	149°30'34.4"W	2,411.2	55,808.3	2347
61	61°40'30.8"N	149°30'34.4"W	2,443.1	55,837.7	0025
62	61°40'32.2"N	149°30'34.3"W	2,486.0	55,863.2	0027
63	61°40'33.4"N	149°30'34.2"W	2,525.6	55,868.4	0030
64	61°40'34.7"N	149°30'34.0"W	2,564.9	55,809.1	0033
65	61°40'36.0"N	149°30'34.2"W	2,606.1	55,765.9	0035
66	61°40'37.5"N	149°30'34.2"W	2,652.0	55,736.9	0037
67	61°40'38.7"N	149°30'34.1"W	2,688.0	55,783.4	0041
68	61°40'39.9"N	149°30'34.2"W	2,725.0	55,797.0	0043
69	61°40'41.4"N	149°30'34.2"W	2,773.5	55,777.2	0046
70	61°40'42.9"N	149°30'34.1"W	2,819.6	55,782.3	0049
71	61°40'44.1"N	149°30'34.1"W	2,854.6	55,835.0	0051
72	61°40'45.6"N	149°30'33.9"W	2,903.0	55,933.3	0054
73	61°40'47.0"N	149°30'34.2"W	2,945.1	55,856.1	0059
74	61°40'48.1"N	149°30'34.0"W	2,978.8	55,865.9	0101
75	61°40'49.6"N	149°30'34.3"W	3,025.3	55,877.4	0104
76	61°40'50.5"N	149°30'33.2"W	3,058.5	55,857.8	0106
77	61°40'52.3"N	149°30'32.9"W	3,114.4	55,828.9	0110
78	61°40'53.7"N	149°30'35.7"W	3,174.5	55,897.7	0116
79	61°40'55.1"N	149°30'35.3"W	3,219.3	56,070.2	0119
80	61°40'55.9"N	149°30'35.8"W	3,244.2	56,054.3	0122
81	61°40'57.2"N	149°30'37.8"W	3,294.4	55,873.9	0124
82	61°40'58.9"N	149°30'38.8"W	3,348.1	55,806.8	0128
83	61°40'59.6"N	149°30'40.7"W	3,384.0	55,843.5	0130
84	61°41'00.6"N	149°30'42.5"W	3,424.8	55,875.4	0132
85	61°41'01.2"N	149°30'44.6"W	3,460.4	55,925.8	0135
86	61°41'02.7"N	149°30'44.6"W	3,505.8	55,954.7	0137
87	61°41'04.1"N	149°30'44.3"W	3,550.5	55,942.4	0140



LINE 9 Date: 6/8/94

Station	Latitude	Longitude	Distance (m)	Magnetic field (nT)	Time(UTC)
1	61°36'53.4"N	149°50'30.5"W	0.0	Bad reading	1657
2	61°36'54.3"N	149°50'30.4"W	25.4	55,780.6	1659
3	61°36'55.8"N	149°50'30.6"W	73.7	55,799.8	1702
4	61°36'57.0"N	149°50'30.4"W	111.9	55,798.7	1705
5	61°36'58.7"N	149°50'31.0"W	164.3	55,813.0	1708
6	61°36'59.5"N	149°50'30.4"W	190.9	55,823.8	1712
7	61°37'00.7"N	149°50'30.5"W	227.8	55,827.9	1714
8	61°37'01.9"N	149°50'30.3"W	264.2	55,504.5	1717
9	61°37'03.1"N	149°50'30.7"W	302.6	55,599.4	1720
10	61°37'04.3"N	149°50'30.8"W	339.7	55,661.6	1723
11	61°37'05.5"N	149°50'30.6"W	377.3	55,688.7	1726
12	61°37'06.8"N	149°50'30.8"W	417.2	55,691.3	1729
13	61°37'08.1"N	149°50'30.6"W	456.2	55,705.3	1731
14	61°37'09.3"N	149°50'30.7"W	495.0	55,703.4	1734
15	61°37'10.4"N	149°50'30.7"W	529.5	55,736.2	1736
16	61°37'11.7"N	149°50'30.6"W	569.7	55,756.5	1739
17	61°37'13.1"N	149°50'30.6"W	611.7	55,741.2	1741
18	61°37'14.4"N	149°50'30.7"W	650.8	55,723.2	1744
19	61°37'15.7"N	149°50'30.6"W	692.2	55,757.3	1747
20	61°37'17.0"N	149°50'30.5"W	732.4	55,792.5	1749
21	61°37'18.3"N	149°50'30.6"W	772.6	55,813.7	1751