STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

Walter J. Hickel, *Governor*

Harry A. Noah, *Commissioner*

Thomas E. Smith, *State Geologist*

August 1994

.

Report of Investigations 94-5
INTERPRETATION OF THE AEROMAGNETIC MAP
OF THE ANCHORAGE QUADRANGLE, ALASKA

By
L.E. Burns and G.R. Winkler
In cooperation with U.S. Geological Survey

STATE OF ALASKA
Walter J. Hickel, *Governor*

DEPARTMENT OF NATURAL RESOURCES
Harry A. Noah, *Commissioner*

DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
Thomas E. Smith, *State Geologist*

Division of Geological & Geophysical Surveys publications can be inspected at the following locations. Address mail orders to the Fairbanks office.

Alaska Division of Geological
& Geophysical Surveys
794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

University of Alaska Anchorage Library
3211 Providence Drive
Anchorage, Alaska 99508

Elmer E. Rasmuson Library
University of Alaska Fairbanks
Fairbanks, Alaska 99775-1005

Alaska Resource Library
222 W. 7th Avenue
Anchorage, Alaska 99513-7589

Alaska State Library
State Office Building, 8th Floor
333 Willoughby Avenue
Juneau, Alaska 99811-0571

CONTENTS

FIGURES

SHEETS

INTERPRETATION OF THE AEROMAGNETIC MAP
OF THE ANCHORAGE QUADRANGLE, ALASKA

by
L.E. Burns,[1] and G.R. Winkler[2]

INTRODUCTION

This aeromagnetic interpretation of the Anchorage Quadrangle is part of a joint project of the U.S. Geological Survey (USGS) and the Alaska Division of Geological & Geophysical Surveys (DGGS). USGS studies were conducted under the auspices of the Alaska Mineral Resource Assessment Program (AMRAP). The aeromagnetic map and interpretation presented here are intended as a companion to the geologic map of the Anchorage Quadrangle compiled by Winkler (1992).

Three separate aeromagnetic surveys have been combined for this interpretation. In 1972 DGGS flew an aeromagnetic survey of the north part of the quadrangle (DGGS, 1973). In 1979 the southeast part of the quadrangle was surveyed for the USGS mineral-resource investigations of the Chugach National Forest (USGS, 1980). In 1982 the AMRAP project surveyed the large intervening part of the quadrangle (USGS, 1984). For this report, the three aeromagnetic maps have been patched together to form sheet 1. An interpretation of the magnetic data has been combined with topographic and simplified geologic bases to form sheet 2. The geologic base was simplified from Winkler (1992), with some modifications in the northcentral Chugach Mountains based on the report of Burns and others (1991). Although many map units are displayed on sheet 2 as on the earlier maps, some units from the earlier maps have been combined on sheet 2.

All three surveys were flown at a barometric elevation of about 300 m above ground level, except locally where topography required higher flight elevations. Flight lines for the central and southeastern sections were spaced about 1.6 km apart and for the northern section about 0.8 km apart. Data for all three sections were corrected for a regional magnetic field based on International Geomagnetic Reference Field (IGRF), 1975 or 1978. All data were computer contoured, but the grid sizes for each of the three sections were different (sheet 1).

[1]Division of Geological & Geophysical Surveys, 794 University Avenue, Suite 200, Fairbanks, Alaska 99709-3645.
[2]U.S. Geological Survey - MS 905, Federal Center, Box 25046, Denver, Colorado 80225-0046.

LKB Resources gathered and compiled data for the northern and southeastern sections using a modified fluxgate magnetometer for the southeastern portion, and probably for the northern portion as well. Diversified Technical Services, Inc. flew the survey flights for the central section. The company recorded continuous total-intensity magnetic data along flight traverses with a proton-precession magnetometer having a sensitivity of 0.25 gammas.

In this report we interpret the aeromagnetic map in reference to the main rock units causing the magnetic anomalies. Magnetic susceptibilities of various rock units in the adjacent Valdez Quadrangle were measured and reported by Burns (1982) and Case and others (1986). These rock units continue into the Anchorage Quadrangle and, therefore, the magnetic susceptibilities should be similar. Time did not permit measurements of susceptibilities of the many samples collected from the Anchorage Quadrangle. Earlier aeromagnetic interpretations that aided this study are by Grantz and others (1963) for the western Anchorage Quadrangle, Csejtey and Griscom (1978) for the Talkeetna Mountains Quadrangle, Griscom (1979) for the Talkeetna Quadrangle, Case and others (1979) for the Seward and Blying Sound Quadrangles, and Burns (1982) and Case and others (1986) for the Valdez Quadrangle.

Igneous rock terminology used in this report is from Streckeisen (1976). All ages of plutonic rocks mentioned were determined by the K-Ar method and are summarized in either Burns and others (1991) or Winkler (1992).

SUMMARY OF GEOLOGY AND ROCK MAGNETIC PROPERTIES

The Anchorage Quadrangle is divided into three major tectonostratigraphic terranes (fig. 1), which differ in lithostratigraphy and structural style (Jones and Silberling, 1979). The Peninsular terrane on the north is composed predominantly of volcanic, plutonic, and sedimentary rocks of Jurassic, Cretaceous, and Tertiary age; minor amounts of metamorphic rocks with a probable pre-Jurassic protolith age also are present in the Peninsular terrane. The terrane is separated from the Chugach terrane on the south by the Border Ranges fault (MacKevett and Plafker, 1974; fig. 1, sheet 2). The Chugach terrane is a thick, complexly deformed
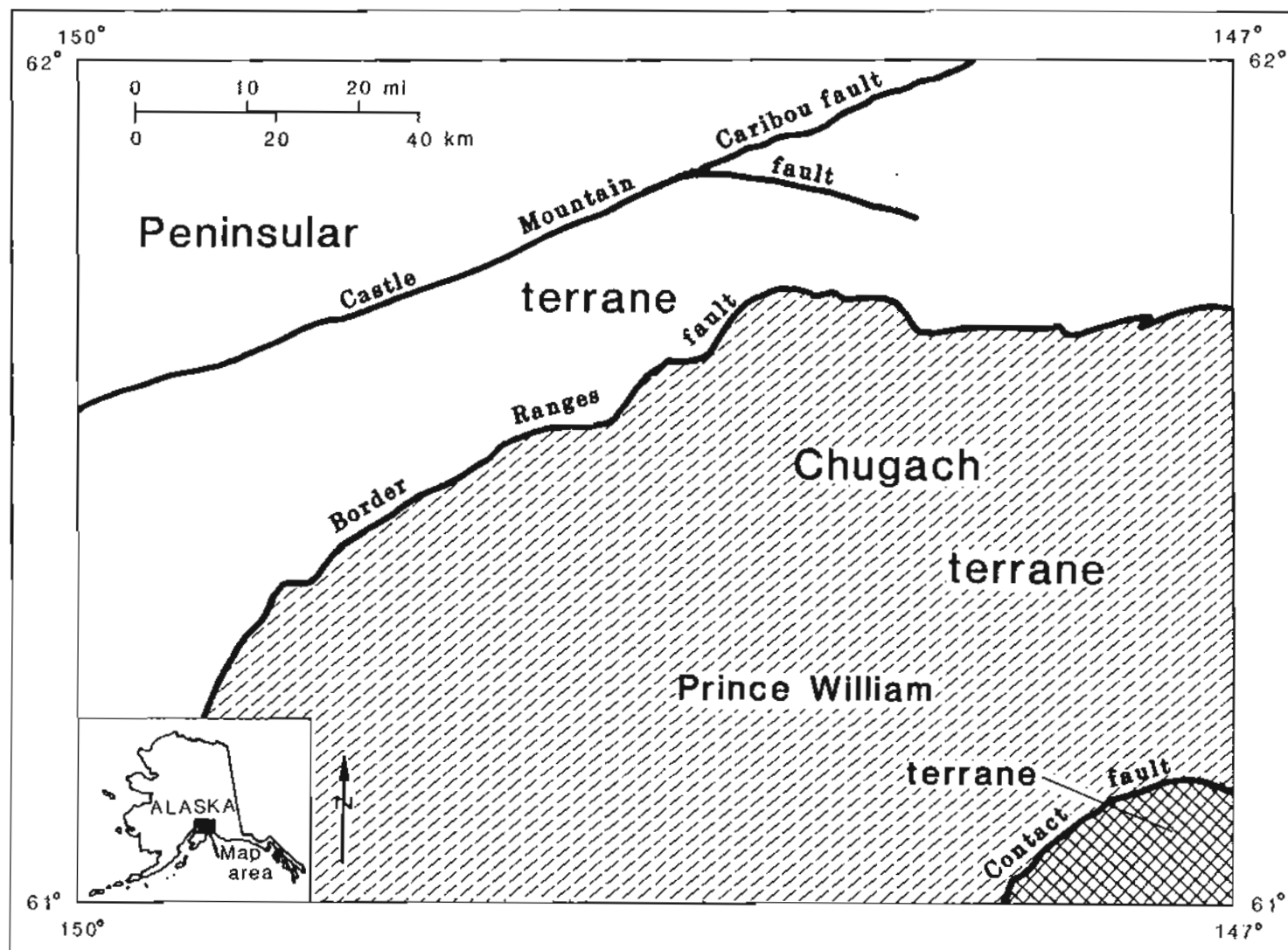
Figure 1. *Anchorage Quadrangle showing major faults and tectonostratigraphic terrane boundaries. Peninsular, Chugach, and Prince William terranes are modified from Jones and Silberling (1979).*

subduction assemblage of flysch, which is mainly of Cretaceous age. The melange is polygenetic and may have been accreted in several successive Mesozoic events. The Prince William terrane crops out in the southeast part of the Anchorage Quadrangle and is separated from the Chugach terrane by the Contact fault (fig. 1). The Prince William terrane is a thick sequence of flysch and minor mafic volcanic rocks of Paleocene and Eocene age, which locally is intruded by plutons of Eocene(?) and Oligocene ages.

PENINSULAR TERRANE

INTRODUCTION

The Peninsular terrane crops out in the northern and northwestern part of the quadrangle and is composed largely of the volcanic and plutonic rocks of a Jurassic island arc with associated minor Jurassic sedimentary rocks (Detterman and Hartsock, 1966; Barker and Grantz, 1982; Burns, 1985). Very thick sequences of sedimentary rocks of Cretaceous and Tertiary age and volcanic rocks of Tertiary age have been deposited on top of and adjacent to the Jurassic arc rocks. Plutonic rocks of Cretaceous and early Tertiary age intrude the Jurassic island arc rocks.

The Border Ranges fault denotes the location of the southern boundary of the Peninsular terrane and is part of the Border Ranges fault system. This fault system forms a zone up to about 12 km wide, which is typically centered around the Border Ranges fault and is composed of many closely spaced, high-angle faults. In the Anchorage Quadrangle, the Border Ranges fault system has a composite history. It formed as a subduction thrust with underthrusting from the south in Cretaceous time (Pavlis, 1982). In Paleogene time, the Border Ranges fault system was reactivated as an oblique-slip boundary with an aggregate dextral offset of several tens of kilometers (Little and Naeser, 1989; Little, 1990).

The Peninsular terrane is subdivided by the Castle Mountain and Caribou fault systems in the Anchorage Quadrangle (fig. 1). Movement along these fault systems has been oblique, the strike-slip motion being right-lateral, and the dip-slip component being up on the north side (Grantz, 1966; Fuchs, 1980).

ROCKS BETWEEN THE BORDER RANGES AND CASTLE MOUNTAIN FAULTS

The oldest rocks of the Peninsular terrane crop out between the Castle Mountain and the Border Ranges faults. Five main belts of rock of Jurassic or older age crop out between the Border Ranges and the Castle

Mountain faults (sheet 2). The trend of the belts follows the oroclinal bend of the Chugach Mountains. Although extensive faulting during Cretaceous and Tertiary time complicated the plan map, a crude stratigraphy of the magmatic arc is preserved. This stratigraphy, viewed from south to north, reflects the sequential formation of a Jurassic magmatic arc and its sedimentary cover. The most southerly and oldest belt is composed of diverse metasedimentary and metavolcanic rocks and includes marble of Permian age (Clark, 1972). These metamorphic rocks crop out in discontinuous fault-bounded slices near the Border Ranges fault and form the basement for the arc (Pavlis, 1983). The rocks are intruded almost everywhere they are exposed by trondhjemite dikes and plutons of Cretaceous age. Ultramafic and mafic plutons of Jurassic age, which compose the plutonic core of the arc, form the second belt and also locally intrude these metamorphic rocks (Burns and others, 1991). This second belt includes the Nelchina River Gabbronorite and the Wolverine and Eklutna bodies (sheet 2). To the north, structurally fragmented plutons of diorite, quartz diorite, and tonalite of Jurassic age (the third belt) locally intrude volcanic rocks of the Talkeetna Formation (the fourth belt), which are in turn overlain by sedimentary and volcanic rocks of Jurassic, Cretaceous, and Tertiary age (the fifth belt).

Metasedimentary and metavolcanic rocks (Jurassic metamorphic age) intruded by trondhjemites (Cretaceous)

A discontinuous belt of metamorphic rock, dominantly schist and amphibolite, crops out near the Border Ranges fault and is intruded by dikes and plutons of trondhjemite, tonalite, and minor diorite of Cretaceous age. The metamorphic and intrusive rocks are combined as unit KJtm on sheet 2. The metasedimentary and metavolcanic rocks are in the greenschist to amphibolite facies and consist largely of siliceous, pelitic, and mafic schist, amphibolite, and minor marble. Carden and Decker (1977) named the metamorphic rocks near the Eklutna body the "Knik River schist terrane" and reported a Jurassic K-Ar date (173 ± 7 Ma) on metamorphic actinolite. The protolith age is considered to be pre-Jurassic; the rocks will be referred to herein as Jurassic metamorphic rocks. This belt of rocks can be traced discontinuously eastward across the Anchorage Quadrangle to the Nelchina Glacier. The metamorphic rocks may correlate with the Haley Creek metamorphic assemblage of the eastern Valdez Quadrangle (Winkler and others, 1981; Plafker and others, 1989). In the Anchorage Quadrangle the metamorphic rocks are intruded by gabbroic rocks and quartz diorites of Jurassic age.

Magnetic susceptibility of the metamorphic rocks in the Anchorage Quadrangle has not been determined. The amphibolites may have moderate magnetic susceptibility, although no specific positive anomalies correlate with the metamorphic rocks. Magnetic susceptibility was determined for two samples of the Skolai Group (similar to the Haley Creek terrane) from the Valdez Quadrangle, and relatively high values were measured (0.004 and 0.007 cgs units; Case and others, 1986).

Most of the trondhjemite plutons crop out near the Wolverine body; however, dikes of trondhjemite are common almost everywhere the metamorphic rocks are present. Near the Wolverine body the trondhjemite is thought to intrude rocks of the Chugach and Peninsular terranes. These plutons have been dated at 103-135 Ma (Pavlis, 1982; 1983; Winkler, 1992). The trondhjemite-tonalite plutons contain some minor hornblende diorite near pluton margins (Monteverde, 1984). Most of the rocks are hornblende-biotite tonalite and biotite trondhjemite (Monteverde, 1984). The plutons are non-magnetic.

Ultramafic and mafic plutonic rocks (Jurassic)

A discontinuous belt of ultramafic and mafic plutonic rocks of Jurassic age crosses the Anchorage Quadrangle (Burns, 1985) and includes the Eklutna and Wolverine bodies, the Nelchina River Gabbronorite, and several small unnamed bodies in fault slivers (units Jum and Jg, sheet 2).

The Eklutna and Wolverine bodies are composed dominantly of ultramafic rocks, including dunite, chromititic dunite, clinopyroxenite, and minor websterite, harzburgite, and gabbronorite (Rose, 1966; Clark, 1972; Burns, 1985; Newberry, 1986). The exposed Eklutna body is about 15 km long and 2-3 km wide; analysis of the aeromagnetic data in this report suggests that the Eklutna body continues about 15 km farther to the northeast under the alluvial deposits of the Knik River Valley. Road cuts made in the late 1980s indicate gabbroic rocks crop out northwest of the Eklutna body. The Wolverine body is about 11 km long, 3 km wide, and contains interlayered (intrusive?) gabbroic rocks among the ultramafic rocks. No magnetic susceptibility measurements have been made on the rocks from either body; associated magnetic anomalies do indicate that the rocks are relatively magnetic.

The Nelchina River Gabbronorite (Burns, in press) crops out in the eastern part of the Anchorage Quadrangle and continues eastward into the Valdez Quadrangle where it was referred to as the Tazlina complex by

Winkler and others (1981). Total length of the body is at least 180 km. This unit (Jg) causes the highest amplitude magnetic and gravity anomalies in the Anchorage and Valdez Quadrangles. Although the eastern third of the body (located in the Valdez Quadrangle) is not exposed, aeromagnetic data suggest the body in that area is overlain by only a very thin cover (Winkler and others, 1981; Case and others, 1986).

The Nelchina River Gabbronorite varies in outcrop width from 2 to 10 km, and consists dominantly of gabbronorite, leucogabbronorite, and magnetite gabbronorite, but contains minor dioritic, tonalitic, and ultramafic rocks. Six K-Ar isotopic ages for these rocks from the Anchorage and Valdez Quadrangles are Jurassic (Winkler and others, 1981; Plafker and others, 1989; Winkler, 1992). Gabbroic rock, peridotite, dunite, and diorite of this complex have susceptibilities that are as much as 0.0174 cgs units. Magnetic susceptibilities of 53 out of 59 samples had values greater than 0.001 cgs units (fig. 2) (Case and others, 1986).

Other fault-bounded bodies composed of gabbroic with lesser dioritic and(or) quartz dioritic rocks crop out between the Nelchina River Gabbronorite and the Wolverine body. These bodies are shown on sheet 2 also as unit Jg.

Plutonic rocks of intermediate composition (Jurassic)

Discontinuous outcrops of intermediate plutonic rocks occur in the northern Chugach Mountains and consist of quartz diorite and tonalite with lesser gabbroic rocks, diorite, granodiorite, and trondhjemite (combined as unit Jqd). Many of the bodies are composed of complexly intermixed rocks of various types. Other plutons consist of quartz diorite and tonalite which are densely laced with mafic dikes of unknown age; the dikes are up to 1.5 m wide. When the dikes form from one-fourth to one-half the exposed body, the unit is shown as Jqdd. More than 20 K-Ar dates of the quartz diorite and tonalite from this Chugach belt in the Anchorage Quadrangle have Jurassic ages (Hudson, 1979; Winkler and others, 1981; Burns and others, 1991; Winkler, 1992). The quartz diorite and tonalite intrude the Jurassic metamorphic rocks, Jurassic gabbroic rocks, and the Talkeetna Formation.

No susceptibilities have been measured for quartz diorite-tonalite (Jqd) or the dike rocks from unit Jqdd. Some of the quartz diorite (unit Jqd) is associated with moderate to high positive aeromagnetic anomalies. It is Burns's opinion that the intermediate plutonic rocks are only weakly magnetic and that the magnetic signature is coming from either (1) abundant gabbroic rocks within
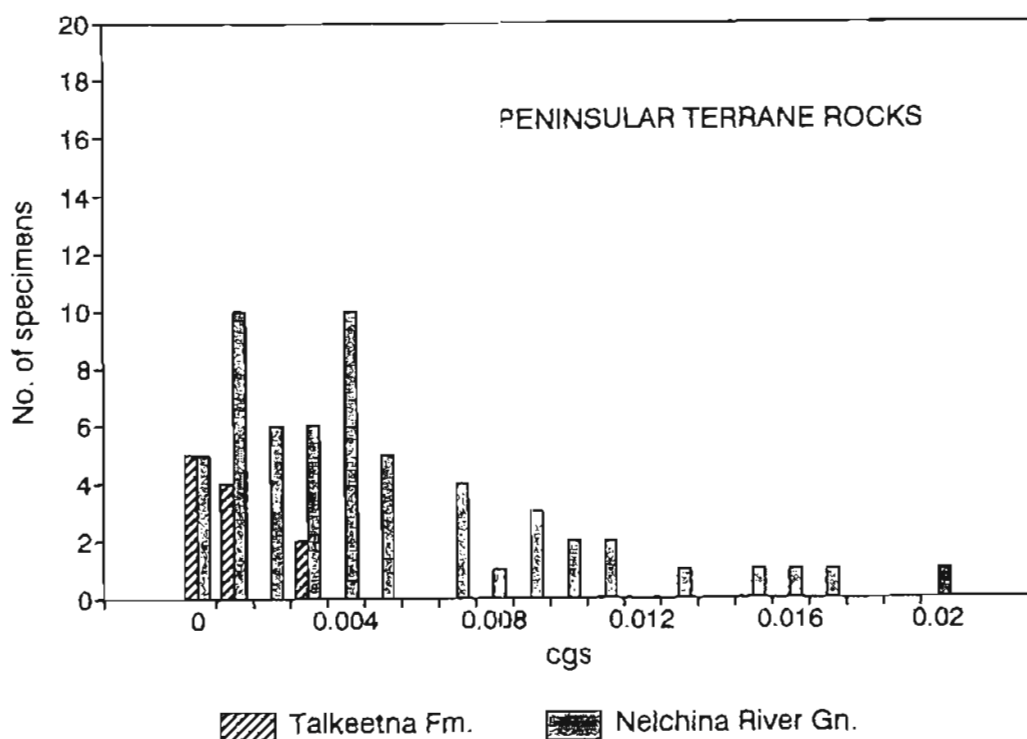
Figure 2. *Magnetic susceptibilities of volcanic rocks in the Talkeetna Formation and Jurassic gabbroic rocks from the Peninsular terrane (modified from Case and others, 1986).*

the quartz diorite, (2) gabbroic rocks at the base of the quartz diorite as noted in the field, or (3) the dense network of mafic dikes. Petrographic study of more than 350 thin sections indicates that little to no iron-oxide minerals are present in the quartz diorites and tonalites, and much magnetite is present in the gabbroic rocks. Additionally, extreme topography, complex intrusive relationships, poor exposure, and extreme deformation make identification of rock type very difficult in the intrusive rocks. It is possible that much of the rock mapped as quartz diorite could be mismapped. Alternatively, but less favored by Burns, the quartz diorite could be magnetic.

Volcanic rocks (Jurassic and Triassic?)

The Talkeetna Formation of mainly Early Jurassic age is a thick sequence of basaltic, andesitic, and dacitic flows and tuffs, and minor volcanogenic, marine sedimentary rocks. The formation (unit JTv) crops out in the northern part of the Chugach Mountains and in the southern Talkeetna Mountains (Csejtey and others, 1978; Winkler, 1992) and extends eastward into the Valdez Quadrangle as far as the Richardson Highway (Winkler and others, 1981).

The magnetic signature of the Talkeetna Formation

is extremely variable. Case and others (1986) reported magnetic susceptibilities from 11 samples of the Talkeetna Formation. The susceptibilities ranged from nearly zero to 0.0054 cgs units, with six samples having values greater than 0.001 cgs units (fig. 2).

Sedimentary rocks (Jurassic, Cretaceous, and Tertiary)

Sedimentary rocks of early Tertiary, Cretaceous, and Jurassic ages generally crop out in and on both sides of the Matanuska Valley. The Eocene and Paleocene Chickaloon and the Cretaceous Matanuska Formations are the most widespread sedimentary units; other Tertiary and Jurassic units are present also (Winkler, 1992). These sedimentary rocks consist dominantly of conglomerate, sandstone, siltstone, and shale, and are basically nonmagnetic. Hence, these units are undifferentiated on the map and are treated as a single unit (TJs).

Hypabyssal intrusive rocks (Jurassic(?) - Tertiary)

Hypabyssal dikes and plugs of basaltic to dacitic composition (unit Ti) intruded both the Chugach and Peninsular terrane rocks in Eocene time (Winkler and

others, 1981; Silberman and Grantz, 1984) and represent one of the last intrusive episodes in the northcentral Chugach Mountains. A few small dikes of lamprophyric composition cut across the structure and stratigraphic units of the map area. These dikes are probably related to extensive Tertiary volcanism in the Talkeetna Mountains to the north (Csejtey and others, 1978). The dikes also yield Eocene ages (Silberman and Grantz, 1984).

Some of the more mafic plugs, the basaltic and gabbroic rocks, are moderately magnetic and form small positive anomalies (unit TJds). Because of the map scale, few of the mafic plugs and dikes are shown on sheet 2; more are shown by Winkler (1992). Age of this unit is uncertain (Winkler, 1992). Profile C-C' (sheet 2) crosses a small anomaly (area 7A) which is probably caused by a moderate sized (5 km^2) plug of this basalt or gabbro. A small body of unit TJds and five or six smaller bodies of unit Ti (not shown on sheet 2) are present within this anomaly (Winkler, 1992). Similar anomalies in and near the Matanuska Valley are probably caused by similar mafic intrusions.

ROCKS NORTH OF THE CASTLE MOUNTAIN-CARIBOU FAULTS

Jurassic plutonic and amphibolite-grade metamorphic rocks are widespread north of the Castle Mountain fault in the Talkeetna Mountains, but they differ in lithology from correlative rocks of the Jurassic arc in the northern Chugach Mountains. The plutonic rocks in the southern Talkeetna Mountains are intermediate-to-silicic composition, and the amphibolite is relatively uniform, weakly foliated, and intricately intermixed with quartz diorite and trondhjemite. Locally, coarsely-crystalline marble and biotite-quartz-feldspar gneiss are intercalated with the amphibolite and plutonic rocks. Pelitic schist (unit Jps), of probable Jurassic age and unknown correlation, is present in the southwestern Talkeetna Mountains and is considered to be nonmagnetic. Volcanic and sedimentary rocks of the Talkeetna Formation are common in the eastern area, and are overlain by Middle and Upper Jurassic, and Cretaceous marine sedimentary rocks, particularly between the Castle Mountain and Caribou faults. The Mesozoic sequences are intruded by Late Cretaceous or early Tertiary plutons and are overlain unconformably by 2,000 m or more of nonmarine sedimentary and volcanic rocks of Tertiary age.

Plutonic rocks (Jurassic, Cretaceous, and Tertiary)

Three different types of intermediate-to-silicic plutons of Jurassic age are present in the Talkeetna Mountains in the Anchorage Quadrangle (Winkler, 1992), including quartz diorite (Jqd), granodiorite (Jgd), and trondhjemite (Jt). Of the three types, trondhjemite (Jt) is the least magnetic; the quartz diorite is moderately magnetic. The granodiorite is presumably weakly to moderately magnetic; the aeromagnetic pattern of the granodiorite is indistinguishable from that formed over the adjacent moderately magnetic Talkeetna Formation volcanic rocks.

An additional Jurassic unit containing intimately mixed amphibolite, quartz diorite, and trondhjemite has been mapped separately (Jma) between the Little Susitna and Kings Rivers. Magnetization in these rocks is variable, but generally weak.

A few small serpentinized ultramafic bodies (Kum) are present in the pelitic schist unit (Jps) in the southwest part of the Talkeetna Mountains. No attributable magnetic anomaly is present over any exposed ultramafic bodies. Two small positive anomalies in the area may, however, suggest buried ultramafic bodies or may be caused instead by Tertiary hypabyssal intrusives discussed above (unit Ti).

Three large, intermediate-to-silicic composition plutons of Late Cretaceous and Early Tertiary age are present in the southwestern part of the Talkeetna Mountains. The aeromagnetic signature over this area indicates the plutons differ in composition; independent geologic mapping in the Willow Creek area and compositional data also indicate that plutons of very different compositions are present (R.J. Newberry, unpub. data, 1989). According to Newberry, the pluton on the east is a quartz diorite-tonalite (unit TKt), and the central pluton is a quartz monzonite (unit Kw), a relatively low-silica rock type (Streckeisen, 1976). The westernmost of the three plutons is a granite (unit TKg) (Csejtey and others, 1978).

K-Ar ages of 79-72 Ma for the quartz monzonite pluton (unit Kw) indicate that it is older than the adjacent plutonic units (TKt and TKg), which have K-Ar ages of 67-65 Ma (Csejtey and others, 1978; Winkler, 1992). The quartz monzonite is host to most of the lode gold mines of the Willow Creek mining district, the most significant mining district in the Anchorage Quadrangle (Ray, 1954; Madden-McGuire and others, 1988).

Magnetic susceptibilities from these plutonic units have not been measured. Based on the aeromagnetic map, the magnetic susceptibility of both the granite and the tonalite-quartz diorite is low, and the magnetitic susceptibility of the quartz monzonite (the central pluton) is moderate.

Sedimentary rocks (Jurassic, Cretaceous, and Tertiary)

Tertiary, Cretaceous, and Jurassic sedimentary rocks also are present north of the Castle Mountain fault, but are all nonmagnetic, and are combined on the geologic base map as unit TJs.

Volcanic rocks (Tertiary)

Tertiary volcanic rocks (unit Tv) of Miocene(?) to Paleocene age (Csejtey and others, 1978) are present in the Talkeetna Mountains and consist of flows, domes, dikes, and pyroclastic rocks of dominantly basaltic and rhyolitic composition. Minor andesite and dacite also are present. The magnetic susceptibility of these rocks has not been measured, but is probably moderately high in the basaltic rocks and low in the rhyolitic rocks.

CHUGACH TERRANE

The Chugach terrane is composed of the McHugh Complex (unit Mzm) (Clark, 1973) and the Valdez Group (unit Kv). These units are separated by the Eagle River thrust fault, which placed the Valdez Group relatively northward beneath the McHugh Complex. In the Anchorage Quadrangle, the McHugh Complex is composed of argillite, gray-green metatuff, marble, graywacke, conglomerate, chert, pillow basalt, and thinly interlaminated gray and green phyllite. Commonly these lithologies are juxtaposed within a melange fabric. The McHugh Complex probably formed in Jurassic and Cretaceous time (for example, Burns and others, 1991; Winkler, 1992). In the Anchorage Quadrangle, the Valdez Group consists predominantly of low-grade metagraywacke, argillite, phyllite, and very minor mafic metatuff. The Valdez Group is interpreted to be Cretaceous in age (for example, Winkler, 1992).

Typical sedimentary and metasedimentary rocks of the McHugh Complex and Valdez Group have very low magnetic susceptibilities. Figure 3, modified from Case and others (1986), shows the susceptibilities of 31 typical metasedimentary rocks in the Chugach terrane from the Valdez Quadrangle. Similar low values, typically less than 0.0001 cgs units, were reported from correlative rocks in the Seward and Blying Sound Quadrangles by Case and others (1979). Their low magnetization is reflected by the near absence of magnetic anomalies. The metavolcanic rocks of the McHugh Complex and Valdez Group are moderately magnetic; susceptibilities of mafic rocks from the Seward and Blying Sound Quadrangles are as much as 0.004 cgs units (Case and others, 1979).

However, metavolcanic rocks within the McHugh Complex and Valdez Group in the Anchorage Quadrangle have virtually no magnetic expression.

The Miners Bay pluton, which consists of an older mafic phase (Tm) intruded by granite (Tg) intrudes the Valdez Group immediately north of the Contact fault. Despite the presence of pyrrhotite in the mafic phase, it has no magnetic signature.

PRINCE WILLIAM TERRANE

The Prince William terrane is composed of the Orca Group (unit To), a thick, complexly deformed sequence of ensimatic flysch of Eocene and Paleocene age. The Prince William terrane is in fault contact with the Valdez Group of the Chugach terrane along the Contact fault. The rocks are dominantly monotonous sequences of sandstone, siltstone, and mudstone, but near Miners Bay, massive conglomerate about 1,000 m thick crops out, and basaltic flows, pillow breccia, and tuff are interbedded with flysch (Nelson and others, 1985). Rocks of the Prince William terrane in the Anchorage Quadrangle are dominantly nonmagnetic. The Orca Group is intruded by small biotite granite and granodiorite plutons of probable Oligocene age. These plutons appear to be nonmagnetic.

INTERPRETATION OF THE AEROMAGNETIC MAP

The surveys were flown using "drape flying" at an attempted constant altitude of 1,000 ft above the topographic surface. Actual flight elevations were approximately 1,000 ft over ridge crests and lakes, but over the narrow, deep glacial valleys in the central and southern parts of the quadrangle, the aircraft flew at a height greater than 1,000 ft. No large anomalies appear to have resulted from the variation in elevation. However, magnetic lows and highs should be checked for possible topographic effects. Detailed discussions of apparent anomalies produced from variations in elevation have been presented by Griscom (1975) and Case and others (1979).

We prepared a generalized interpretive map (sheet 2) from analysis of the aeromagnetic map (sheet 1) in combination with geologic maps (Burns and others, 1991; Winkler, 1992). Subjective boundaries have been drawn around most of the major magnetic anomalies or groups of anomalies, generally along steepened magnetic gradients. These areas are interpreted in terms of the associated rocks that probably cause the anomalies.
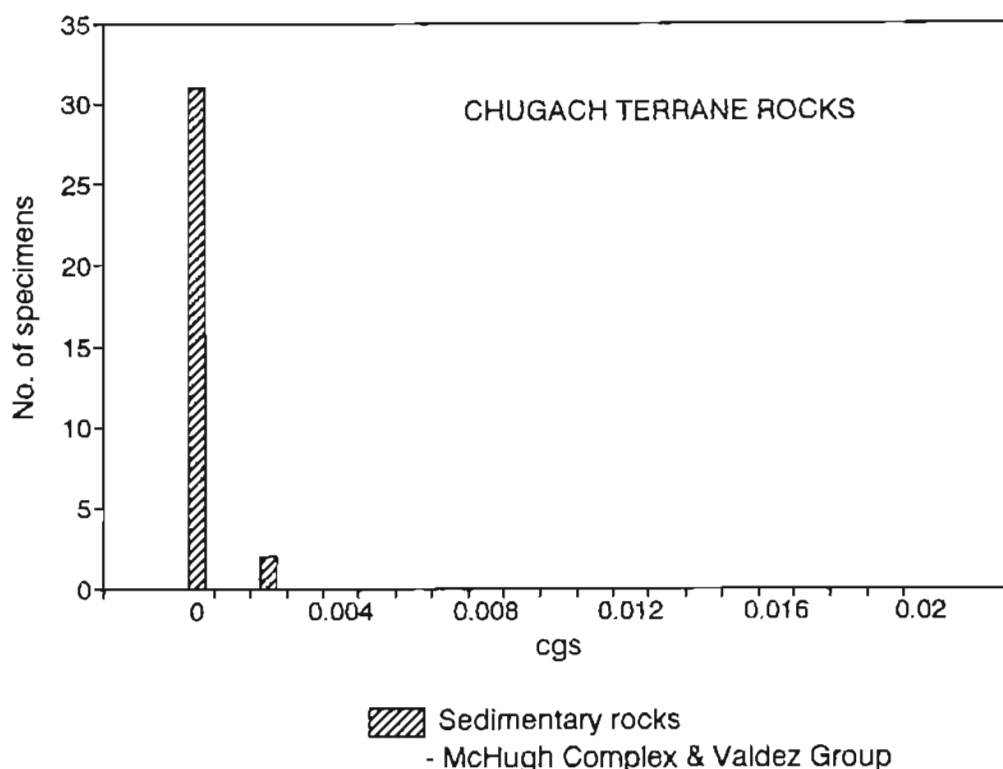
Figure 3. *Magnetic susceptibilities of metasedimentary rocks from the Chugach terrane from the Valdez Quadrangle (modified from Case and others, 1986).*

ANOMALIES OF THE PENINSULAR TERRANE

ANOMALIES BETWEEN THE BORDER RANGES FAULT AND THE CASTLE MOUNTAIN-CARIBOU FAULTS

Areas 1A-B, 1C and 2A-D, 2M

The aeromagnetic signature between the Border Ranges and the Castle Mountain-Caribou faults is dominated by positive anomalies formed by ultramafic and mafic plutonic rocks (areas 1A-B, 2A-D, and 2M). The anomalies follow the oriclinal bend of the northern Chugach Mountains and are immediately north of or within about 2 km of the Border Ranges fault for a distance of over 1,000 km (Fisher, 1981). Where large bodies of the ultramafic and gabbroic rocks are present along this belt, the anomalies are typically smaller (about 500-1,000 gammas in amplitude) near the Border Ranges fault, increase to a larger anomaly (about 1,500 gammas in amplitude) toward the north and northwest, and then gradually drop to the north and northwest. In this case, the lower amplitude anomalies near the Border Ranges fault correspond to ultramafic rocks (the Eklutna body, area 1A), small bodies of gabbroic rock adjacent to an ultramafic body (the Wolverine body, area 1B), or very sheared gabbroic rocks (areas 4E and F). The large positive values to the north are probably due to gabbroic rocks with lesser quartz diorites and possibly some ultramafic rocks (areas 2A-D and 2M). The asymmetry and gradual decrease in values to the north and northwest of these anomalies suggests, as does modeling discussed below, that the upper surface of the gabbroic rocks dips shallowly to the north and northwest.

The aeromagnetic anomaly shows that the Eklutna body trends to the northeast under the Knik River Valley 15 km farther than the body is exposed (area 1A). This extended anomaly suggests that more dunite, wehrlite, and clinopyroxenite exists in the area than was previously known. The Eklutna body may even have originally connected with the Wolverine body (near area 1B), but is now separated by the Jurassic metamorphic rocks and nonmagnetic trondhjemites of Cretaceous age (area 4B) and by Tertiary faults. A small positive anomaly (area 1C) may be caused by a small westward extension of the Eklutna body.

Gabbroic rocks are exposed in the southern and eastern portions of area 2C and are exposed extensively in area 2D. The positive aeromagnetic anomaly (area 2C), about 8 km northwest of the Wolverine body, is caused by gabbroic rocks with intermixed quartz

diorites. The anomaly of area 2M is probably formed from gabbroic rocks (with some intermixed quartz diorites) that are deeper than those in areas 2B-2D. The aeromagnetic high under Duck Flats (area 2B) northwest of the Eklutna body is also interpreted here to be formed by gabbroic rocks with lesser intermixed quartz diorites (see profile B-B' discussion). Grantz and others (1963) referred to the positive anomaly over Duck Flats as the Knik Arm anomaly and concluded it was caused by unexposed plutons.

Area 3

A small aeromagnetic trough (area 3) traceable for at least 65 km occurs between anomalies 1A-B (Eklutna-Wolverine) and 2B-C (Duck Flat-King Mountain area). The rocks in this area are a faulted sequence of plutonic rock of Jurassic age (units Jqd and Jg) and a mixed unit of metamorphic rock and trondhjemite of Jurassic and Cretaceous ages respectively (unit KJtm). In this area, the gabbroic rock is intruded by many dikes of quartz diorite, which might produce a low magnetic signature. Magnetization of the rocks associated with this anomaly is low to moderate and probably varies along its length; the magnetic signature is mainly the result of the two bordering highs formed by the belts of ultramafic and mafic plutonic rock. The geologic units under the aeromagnetic trough could continue at the southwest end under eastern Anchorage.

Area 4A-4F

A steep aeromagnetic gradient that increases to the north or northwest typically occurs immediately north of the Border Ranges fault (Fisher, 1981). Locally, the steepened gradient is absent or displaced farther to the north. In the Anchorage Quadrangle the rocks underlying these relatively magnetically subdued areas just north of the fault trace vary along the length of the fault; in general, the rocks causing this signature appear to be weakly to nonmagnetic. Anomaly 4A is largely covered by alluvium, but a few outcrops of Jurassic metamorphic rock (unit KJtm) are exposed. The geophysical signature of area 4B, caused by the same unit of metamorphic rock and trondhjemite dikes (unit KJtm), is similar to that of area 4A. Western extrapolation of the geology of area 4B suggests that anomaly 4A is caused by the metamorphic rocks, which may also be intruded by trondhjemites in the Anchorage area.

A small aeromagnetic low (area 4C), that is farther from the fault trace than the other anomalies included with area 4, is included here because of its location and the fact that its source could be from a small nonmagnetic

pluton (such as trondhjemite). However, a more likely explanation is that there is a topographic effect because the anomaly is centered over a small, steep-walled cirque valley. A reversely magnetized pluton of probable Tertiary age could also cause the anomaly (Andrew Griscom, written commun., 1992).

Area 4D is underlain by Talkeetna Formation, Tertiary sedimentary rocks, and sheared Jurassic plutonic rocks. The Tertiary sedimentary cover is probably not thick.

Area 4E is sedimentary rocks (TJs) that are probably underlain by sheared gabbroic rocks (Pessel and others, 1981; Burns and others, 1991).

Area 4F is underlain by sheared gabbroic rocks and the same Jurassic metamorphic rock unit (KJtm) that is present in areas 4A and 4B. In area 4F, trondhjemite dikes are also present with the metamorphic rocks.

Areas 5 and 6A-D

Other regions of positive anomalies in the northern Chugach Mountains and vicinity are caused by a fault-bounded pluton of quartz diorite with a particularly dense network of mafic dikes (unit Jqdd; area 5) and the Talkeetna Formation (areas 6A-D). The pluton has a high positive anomaly (almost 1,000 gammas total amplitude), which may be caused by the mafic dikes. The anomaly may also be due in part to (1) topographic effects, (2) being underlain at very shallow depths by more mafic plutonic rock (which was observed in the field), and (3) the contrast in susceptibility with surrounding rocks. The southwestern edge of the pluton is a high-angle fault that is reflected by a very steep aeromagnetic gradient.

The Talkeetna Formation crops out both in the northern Chugach Mountains and in the southern Talkeetna Mountains. The aeromagnetic signature of the exposed Talkeetna Formation in these areas is composed of small, irregularly-shaped, positive anomalies of 500 to 700 gammas amplitude (areas 6A, 6B, and 6C). A quartz diorite containing many mafic dikes, similar to the pluton causing anomaly 5, is also present in area 6A. Lesser positive anomalies in the eastern half of area 6A may be caused by small, shallow mafic intrusions of probable Tertiary age, as described for area 7 below. Although sedimentary rocks are mainly exposed in area 6D, the aeromagnetic signature is similar to that formed over the Talkeetna Formation volcanic rocks and suggests that Talkeetna Formation probably underlies the sedimentary rocks at shallow depths.

Area 7A-J

Small intrusions, probably of moderately magnetic

Tertiary basalt or gabbro (unit TJds), are present in and near the Matanuska Valley and form small positive anomalies (up to 600 gammas; areas 7A-J) in an otherwise smooth aeromagnetic pattern. These are most common in the eastern part of the Anchorage map (areas 7A-F); one of the anomalies is crossed by profile C-C', discussed below, and was modeled as a small magnetic body. Similar anomalies (areas 7G-J) suggest that slightly deeper, but equivalent intrusions may occur discontinuously across the Anchorage Quadrangle at about the same latitude. Anomaly 7J differs from the others because it forms a linear anomaly instead of a bull's-eye shape; alternatively, the anomaly from 7J could form from older magnetic plutonic or volcanic rocks at depth.

Areas 8A-C and 9A-D

The aeromagnetic signature of the Matanuska Valley and Cook Inlet is due to a nonmagnetic sedimentary cover which is underlain by the variably magnetized Talkeetna Formation. The Talkeetna Formation is probably underlain by gabbroic and other plutonic rocks. This moderate-to-deep magnetic basement forms a relatively smooth aeromagnetic pattern. The aeromagnetic pattern suggests that the sedimentary cover ranges from thin (about 2 km; areas 8A-C) to thicker sequences (areas 9A-D). The aeromagnetic signature of areas 8A-C and 8B is generally 100 to 200 gammas higher than the signature of area 9 and is also composed of shorter wavelength anomalies, suggesting the depth to the magnetic basement is less in areas 8A-C and 8B than in areas 9A-D.

Areas 10A, B

Two negative aeromagnetic anomalies (areas 10A, B) are present just south of the northeastern trace of the Caribou fault. These irregularities suggest either shearing and alteration of the rocks surrounding the fault zone, and(or) thick sedimentary rocks in this area.

ANOMALIES NORTH OF THE CASTLE MOUNTAIN-CARIBOU FAULTS

Area 11

Positive and negative "bird's-eye" aeromagnetic anomalies (up to 700 gammas) are caused by Tertiary volcanic rocks (unit Tv) over area 11. These anomalies cover small areas (typically 3 km^2) and are spaced 2 to 3 km apart. The high variability in magnetic signature is typical of volcanic rocks. The variations may be accentuated here because of the bimodal basalt-rhyolite nature of this rock suite and the probability of reversed

remnant magnetization in the sequence. Anomaly 11 and the Tertiary volcanic rocks extend northward into the Talkeetna Mountains Quadrangle (Csejtey and Griscom, 1978).

Area 12

Although positive anomaly 12 is underlain by a variety of rock types, the aeromagnetic signature is probably dominated by the Talkeetna Formation volcanic rocks (unit JTkv). Many of the rocks in the area are also intruded with numerous mafic dikes, which may contribute much of the anomaly. Tertiary sedimentary rocks (unit TJs) crop out in two large areas within anomaly 12. Here the aeromagnetic anomaly is subdued slightly, which coupled with the geologic map (Winkler, 1992) suggests that the Talkeetna Formation is probably present at shallow depths beneath the Arkose Ridge Formation in this area. The Jurassic granodiorite in the northern part of area 12 produces an aeromagnetic signature that is not easily discernible from the signature of the adjacent Talkeetna Formation, and hence is not distinguished on sheet 2. The granodiorite is more extensive to the north, in the Talkeetna Mountain Quadrangle. There the anomaly is more distinct than the anomaly produced by the Talkeetna Formation in area 12. Csejtey and Griscom (1978) interpreted the anomaly over the granodiorite as the result of the moderately magnetic plutonic rock.

Area 13

The Jurassic quartz diorite exposed in the Talkeetna Mountains, like that present in the Chugach Mountains, is weakly magnetic. The aeromagnetic pattern formed from most of the Jurassic quartz diorite around area 13 is almost featureless but contains small amplitude (typically < 70 gammas), positive and negative anomalies that are spaced about 5 km apart. Topographic valleys show up clearly as lows within the anomaly.

Area 14

A slightly negative aeromagnetic anomaly with a very flat gradient (area 14) overlies two Jurassic plutons. The plutons are composed of trondhjemite (unit Jt), and a mixture of amphibolite, quartz diorite, and trondhjemite (Jma). The total anomaly has less than 50 gammas relief. The anomaly extends to the north, where it was interpreted as an expression of trondhjemite by Csejtey and Griscom (1978). Magnetic susceptibility of the trondhjemite unit is probably extremely low; the magnetic susceptibility of the amphibolite-quartz diorite-trondhjemite unit is unknown and probably variable. The

aeromagnetic anomaly suggests either that the amphibolite-quartz diorite-trondhjemite unit is a thin cap which overlies a large trondhjemite body or the magnetization of this unit is also very low in this area.

Area 15

The aeromagnetic anomaly over area 15 is formed from a weakly-to-moderately magnetic tonalite-quartz diorite of Early Paleocene and Late Cretaceous age (unit TKt). The pattern is similar to the pattern caused by the Jurassic quartz diorite of area 13.

Area 16A, B

Two areas with similar positive anomalies (500 to 700 gammas) which largely follow ridgelines lie over different rock types; area 16A lies over quartz monzodiorite (Kw) and area 16B lies over amphibolite and quartz diorite (unit Jma). The pattern is suggestive of moderate magnetization. Both areas are surrounded by areas of low-to-moderate magnetization. The anomaly for area 16B suggests that part of the Willow Creek pluton (Kw) may either underlie (intrude) the amphibolite/plutonic unit at a shallow depth, or may form part of the amphibolite/plutonic unit as mapped. Importantly, these anomalies also overlie the locations of the gold prospects and small-scale lode mines of the Willow Creek mining district (Ray, 1954). Inasmuch as the Willow Creek pluton is associated with the gold deposits, its distinctive aeromagnetic signature may aid in outlining possible extensions to the district that merit exploration.

Areas 17A, B

Two very small aeromagnetic lows (areas 17A and 17B) are present along a fault southwest of the moderate positive anomalies of areas 16A and 16B, and probably represent sheared rock.

Area 18

Anomaly 18 is composed of moderate highs over the ridges (typically 150 gammas amplitude), and lows over the valleys. The bedrock is granite of Early Paleocene or Late Cretaceous age (unit TKg) and is non-to-weakly magnetic. The aeromagnetic pattern caused by the body contrasts sharply with the anomalies to the east and west caused by more magnetic rocks. The low values extend a short distance northward into the Talkeetna Mountains Quadrangle, where Csejtey and Griscom (1978) interpreted the source as granite.

Areas 19A, B

A large area in the northwest corner of the Anchorage Quadrangle forms an aeromagnetic plateau of about 750 gammas amplitude (areas 19A,B). Small peaks of an additional 750 gammas amplitude are present on the plateau. The high is probably formed by Tertiary volcanic rocks, that are covered within the anomalous area. The high continues to the northwest into the Talkeetna Quadrangle, where Griscom (1979) has interpreted the anomaly as forming from covered Tertiary volcanic rocks, which he thought to be almost lying flat.

Areas 20A-C

A linear aeromagnetic low (750 gammas in amplitude; area 20A) trends west-northwest across the presumed Tertiary volcanic rocks. The low is probably caused by a large dike or series of plutons, possibly formed along an old block-faulted surface or by reversely magnetized volcanic rocks. Three circular aeromagnetic lows are present in the southeastern corner of the Talkeetna Quadrangle to the northwest and are presumably related to area 20. Griscom (1979) interpreted these anomalies as produced by reversely magnetized volcanic rocks.

Small lows shown as areas 20B and 20C are present southwest of area 20A. These lows are surrounded by the positive magnetic high discussed above as area 19B. Although the lows of 20B and 20C could form from variability in the rocks forming anomaly 19B, the lows probably formed by reversely magnetized plutonic or volcanic rocks.

Area 21

The edge of a moderately large aeromagnetic high (area 21) with steep gradients is shown on the northern edge of the map. Most of the anomaly is present in the Talkeetna Mountains Quadrangle, and has been interpreted by Csejtey and Griscom (1978) as probably representing an unexposed pluton, possibly a hornblende-rich granodiorite.

ANOMALIES OF THE CHUGACH AND PRINCE WILLIAM TERRANES

Areas 22 and 23A-D

Aeromagnetic anomalies in the Chugach terrane are rare. The map suggests a deep magnetic basement overlain by a thick cover of dominantly nonmagnetic rock (area 22). The three main units present—the McHugh Complex

(unit Mzm), the Valdez Group (unit Kv), and the Orca Group (unit To)—all are non-to-weakly magnetic.

A small positive anomaly (area 23A) at the southern border of the map connects with a similar sized anomaly on the Seward Quadrangle. Case and others (1979) have attributed that anomaly to a deeply buried mafic-ultramafic body. Three other small positive anomalies (areas 23B-D) in the same general area are probably caused from similar bodies; the aeromagnetic gradients of anomaly 23C suggest the body is shallower than the body causing anomaly 23A. The composite pluton of Miners Bay, composed of gabbroic (Tm) and lesser granitic rocks (Tg) (Nelson and others, 1985), crops out on the east side of Unakwik Inlet and has no expression on the aeromagnetic map.

AEROMAGNETIC MODELS THROUGH THE NORTHERN CHUGACH MOUNTAINS

Three cross-sections of aeromagnetic data through the northern Chugach Mountains were modeled by Saki, a 2-1/2 dimensional modeling program (figs. 4, 5, and 6; Webring, 1985). All the profiles show the relatively shallow northward or northwestward dipping faults (or, less likely, intrusive contacts) bordering the northern edge of the Jurassic mafic and ultramafic rocks. The southern or southeastern edge is typically steeper and locally may dip to the south. Previous aeromagnetic and gravity models on the Anchorage and Valdez Quadrangles show similar cross-sections (Burns, 1982; Case and others, 1986). The significant features about the present set of profiles and aeromagnetic models will be discussed individually below.

PROFILE A-A'

A profile trending east-west across the city of Anchorage (figs. 4a-c) and extending west into the Tyonek Quadrangle was constructed using the current aeromagnetic map supplemented by east-west profiles across Cook Inlet that were interpreted by Grantz and others (1963). The composite profile shows two positive aeromagnetic anomalies west of the Border Ranges fault similar to those in the Eklutna-Duck Flats area (anomalies 1A-2B) and the Wolverine-King Mountain area (anomalies 1B-2C). The only difference is that the anomaly farthest away from the Border Ranges fault has a lower amplitude in the Anchorage area than the anomaly closest to the fault; the opposite is seen in the other two areas modeled.

All results of all models attempted suggest that the magnetic rocks underneath Anchorage and Cook Inlet appear to be present at shallow depths (for example, fig. 4). The upper westward surface of the magnetic rocks dips to the west at about 5 to 10°. In the models, the depth to the magnetic rocks underneath Cook Inlet generally agrees with the thicknesses of nonmagnetic Cretaceous and Tertiary sedimentary rocks estimated from drill holes (Hartman and others, 1972). The eastern border is more complex and may reflect thrust fault surfaces, dipping both to the west (the bottom) and to the east (the top), that have been cut by later high angle faults. Alternatively, the bottom and eastern boundaries could represent one curved, thrust fault.

The only rocks exposed west of the Border Ranges fault in the area of profile A-A' are a few small outcrops of deformed metamorphic rock (unit KJtm, sheet 2). Inference about other rock types can be made only by the inferred susceptibilities used with good results in modeling, rock types exposed on trend to the northeast, and aeromagnetic models for nearby profiles, such as for profile B-B' (discussed later). Three models that fit the profile best will be discussed here; each contains three or four blocks of different susceptibilities (figs. 4a-c).

In figure 4a, the eastern anomaly is modeled with a susceptibility of 0.0032 cgs, the middle block with 0.0016 cgs, and the western block with a susceptibility of 0.0039 cgs. The upper surface dips about 10° to the west. In figure 4b, the main differences are that the western block had a susceptibility of 0.0025 cgs, and the dip of the upper surface is 5° to the west. The eastern anomaly is probably formed from gabbroic rocks (or possibly ultramafic rocks). The susceptibility of 0.003 cgs agrees with the susceptibility measurements by Case and others (1986) on gabbroic rocks from the Nelchina River Gabbronorite; we would interpret gabbroic rocks under the city of Anchorage as similar and related to the gabbroic rocks of the Nelchina River Gabbronorite.

Both models of figure 4a and 4b suggest that the middle block is relatively nonmagnetic. Similar susceptibilities were used in models for profile B-B' for a mixture of Cretaceous trondhjemite and metasedimentary and volcanic rocks of Jurassic metamorphic age (KJtm). This mixture of rocks crop out to the northeast of Anchorage and may very well be present to the west of Anchorage. In profile B-B' this relatively nonmagnetic block is present between ultramafic rocks to the southeast and probable mafic plutonic rocks to the northwest.

In profile A-A' the far western block is most likely composed of plutonic rock; the composition could be quartz diorite, gabbroic, or a mixture of the two. Susceptibilities for this block vary with the dip of the surface. The shallower dips required lower susceptibilities. The rocks could be quartz diorite with a dip
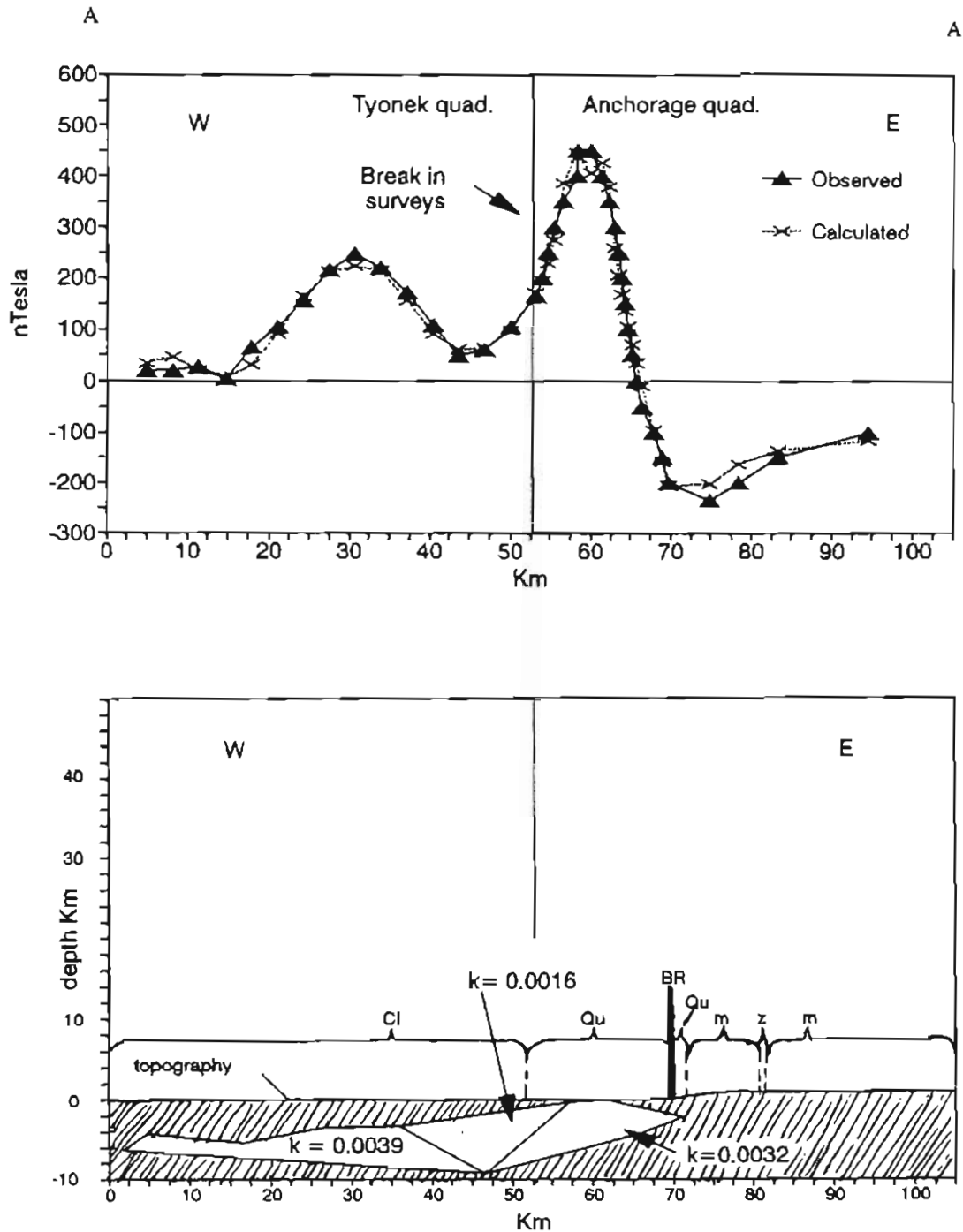
Figures. 4a-c: *Profile A-A' across the city of Anchorage. The top part of the diagrams show observed and calculated magnetic profiles. The bottom part of diagrams are cross-sections which show topography, geologic contacts, and the model which produces the calculated profile. Flight altitude was 1,000 ft above ground level. The western part of the profile was taken from Grantz and others (1963). A constant of 440 gammas was added to Grantz's data to enable joining profiles; a constant of 400 gammas was then subtracted from every point in the profile from the aeromagnetic map for modeling purposes. Geologic designators used: CI - Cook Inlet; Qu - Quaternary deposits; BR - Border Ranges fault; m - McHugh Complex; and z - Valdez Group. Each body in the model has a magnetic susceptibility, k, in cgs units. No vertical exaggeration.*
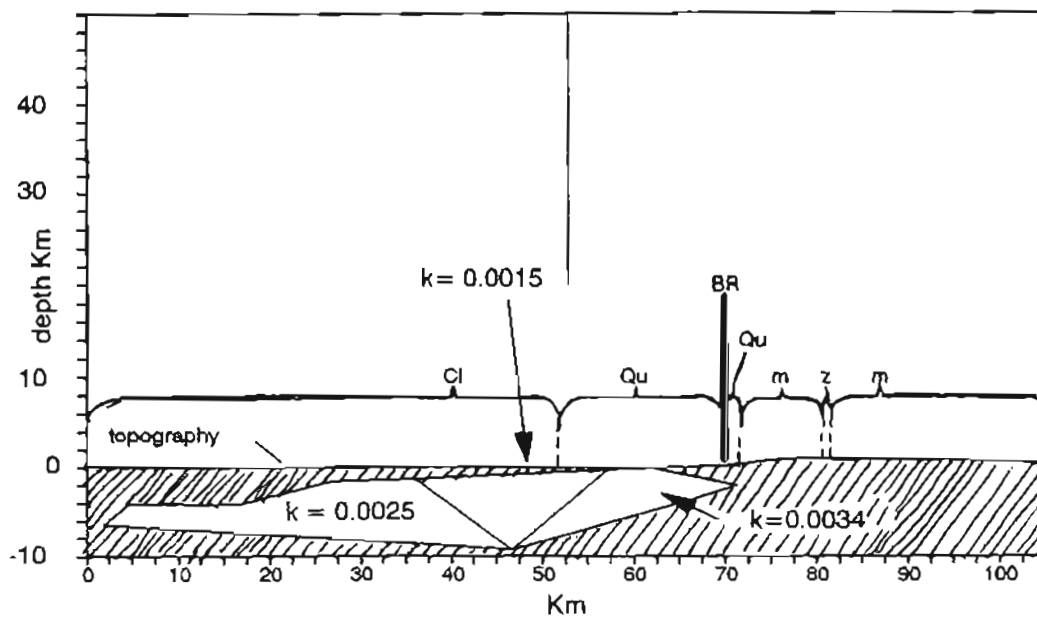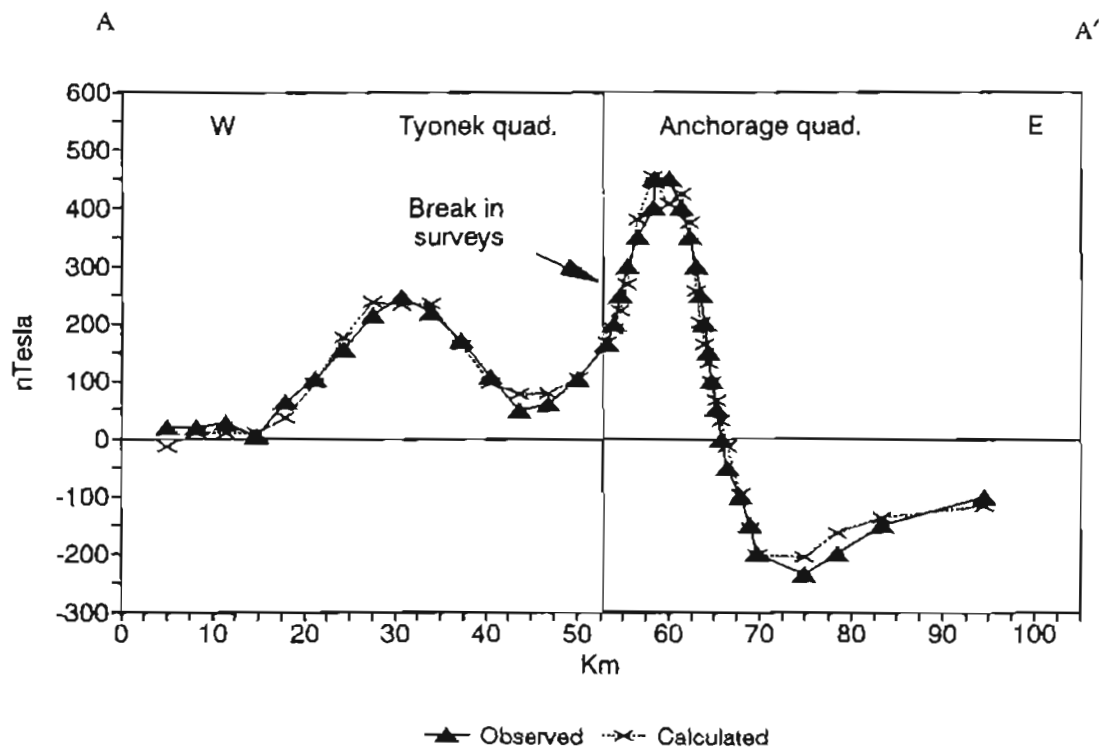
A   A′

Figure 4b.

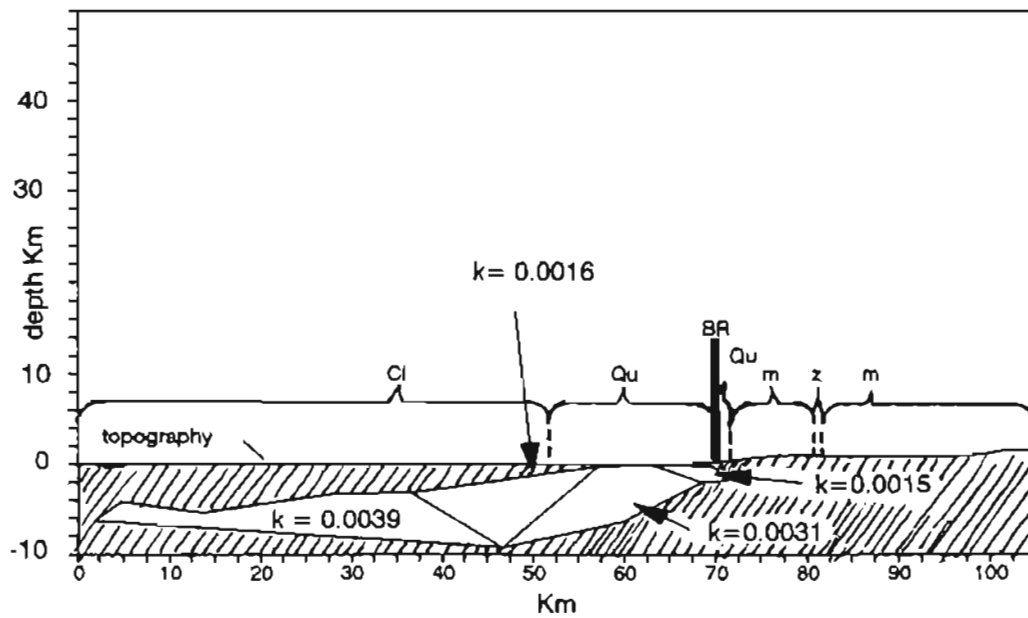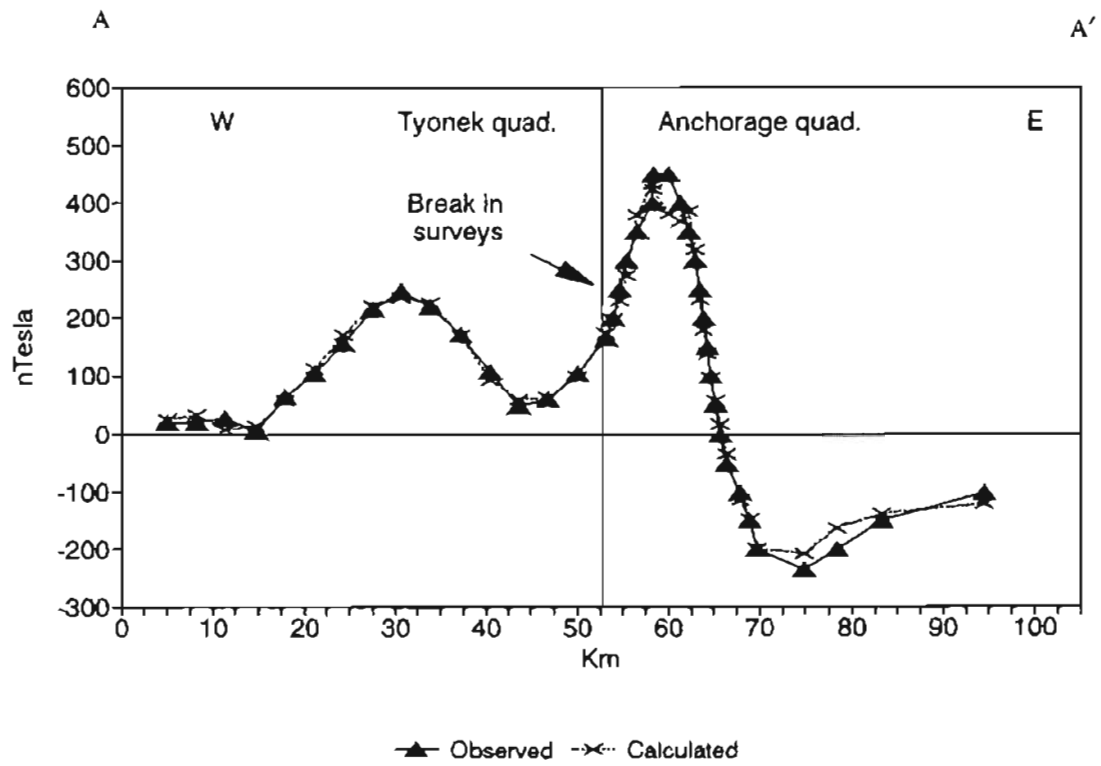A   A′

Figure 4c.

of about 5°, or could be gabbroic with a steeper dip and a higher susceptibility.

Figure 4c is an example of a model which includes a susceptibility (0.0015 cgs units) for unit KJtm east of the large positive anomaly. Adding this additional unit did not require that other blocks in the model be changed dramatically for the calculated profile to still resemble the observed profile. Various other similar geometries and susceptibilities could of course model the profile as well.

PROFILE B-B'

The profile and models (B-B'; figs. 5a-c) across Duck Flats and the Eklutna ultramafic body suggest that a large mass of magnetic rock is present under Duck Flats. The largest anomaly in the profile is formed from the body under Duck Flats, not from the Eklutna body. Various magnetizations and geometries were used in the models. In all the models the upper surface of this magnetic body dips about 13 to 15° to the northwest toward Wasilla. The models indicate that the magnetic body does not have to continue across the Castle Mountain fault. Likely sources for this anomaly are either gabbroic rocks, quartz diorite, or a complex mixture of these intrusive rocks.

The southern boundary of the bodies is more uncertain. Various geometries produce values which roughly fit the observed profile. However, none of these bodies produce a profile which fits the data 20 to 30 km to the southeast of the anomaly. This suggests the geometry and susceptibilities are not quite correct in the models shown.

Without susceptibility data, no one model can be favored; however, the susceptibilities used in figures 5a and 5b are probably more realistic geologically than the high susceptibilities used in the thin body model (fig. 5c). In figures 5a and 5b, the Eklutna body appears to be quite small. The models suggest that the Border Ranges fault dips 50-60° to the north, and that it may be cut by younger high angle faults.

The body in the northwest part of profile B-B' is probably Tertiary volcanic rocks or an intrusion. The shape of the body in figures 5a-5c is influenced by edge effects, and could be considerably thinner.

PROFILE C-C'

Two models are shown for profile C-C' (figs. 6a-6b); the large anomaly in the profile is formed from the Nelchina River Gabbronorite. Figure 6a shows a simple one-body model for the big anomaly, and figure 6b shows a multiple-body model. The models show the common general shape for aeromagnetic and gravity models which have been calculated for the area previously (Burns, 1982; Case and others, 1986). All modeling suggests that the northern boundary of the gabbroic body dips about 10-20° to the north. The body is bounded on the south by a fault which dips more steeply, varying in the models from about 60° to the south to 60° to the north. Commonly, the southern part of the Nelchina River Gabbronorite consists of cataclastically deformed and very altered gabbroic rocks (Pessel and others, 1981). The extreme deformation and alteration may be the reason that the apparent width of the gabbroic body at the surface is much smaller in one model (fig. 6a) than what is actually exposed. Alternatively, the modeling may just indicate that a simple one body model does not fit the exposed geology very well. Also, errors associated with subjectively joining the two surveys near the northern border of the gabbroic body may also be the reason the geometry of the model in figure 6a is not correct at the surface.

A model with a wider gabbroic body at the surface (fig. 6b) required a small area of very high susceptibility. The susceptibility value used, k=0.0077 cgs units, is not impossible for a magnetite-rich gabbroic rock. Geologic mapping indicated that the Nelchina River Gabbronorite has local areas where much magnetite is present in the gabbroic rocks (for example, Burns, in press). Various geometries and susceptibilities could be produced which would fit the observed aeromagnetic profile fairly well.

In profile C-C' a positive anomaly of 600 gammas amplitude reflects anomaly 7c on sheet 2 (fig. 6a). This anomaly is present over the Talkeetna Formation just north of the gabbroic body and is probably caused by a magnetic pluton, about 5 km², which is not exposed. The anomaly has very steep gradients, suggesting a very shallow source. Many dikes of Tertiary andesite are present in the area, which suggests that the intrusion is Tertiary andesite or basalt (unit Ti). A model using a small intrusion of fairly magnetic rock, such as basalt, produces a profile which reasonably fits the observed profile.

MAGNETIC ANOMALIES AND MINERAL RESOURCES

PENINSULAR TERRANE

ROCKS BETWEEN THE CASTLE MOUNTAIN - CARIBOU FAULTS AND THE BORDER RANGES FAULT

Small prospects of chromite have been located in the Eklutna and Wolverine ultramafic bodies (Rose,
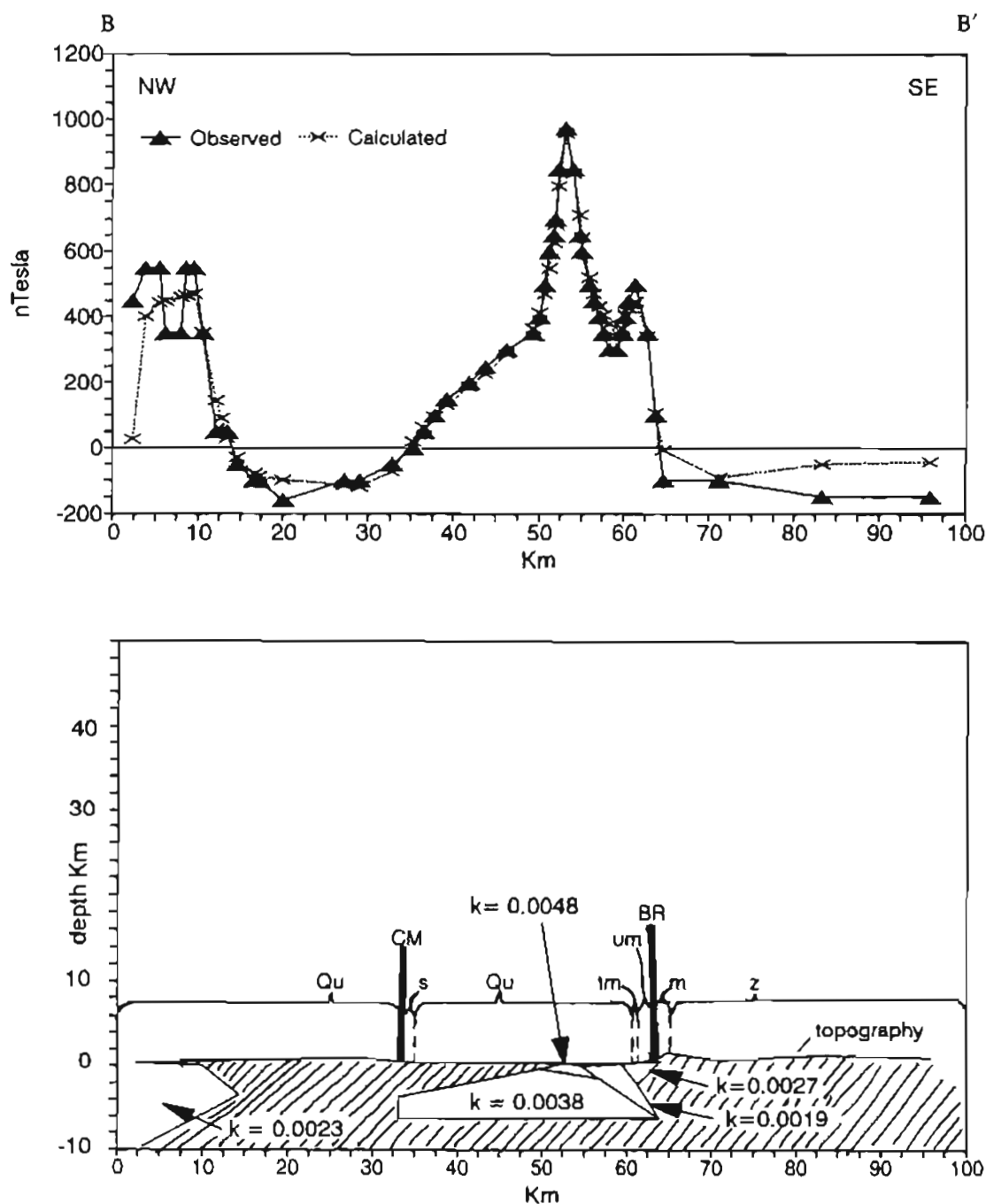
Figure 5a-c. *Profile B-B' across Duck Flats and the Eklutna ultramafic body. The top part of the diagrams show the observed and calculated magnetic—profiles. The bottom part of the diagrams are cross-sections which show topography, geologic contacts, and the model which produced the calculated profile. Flight altitude was 1,000 ft above ground level. A constant of 400 gammas was subtracted from every point in the profile from the aeromagnetic map for modeling purposes. Geologic designators used: Qu - Quaternary deposits; CM - Castle Mountain fault; s - Ternary-Jurassic sedimentary rocks; tm - Cretaceous trondhjemite and Jurassic metamorphic rocks; um - Eklutna ultramafic body; BR - Border Ranges fault; m - McHugh Complex; and z - Valdez Group. Each body in the model has a magnetic susceptibility, k, in cgs units. No vertical exaggeration.*
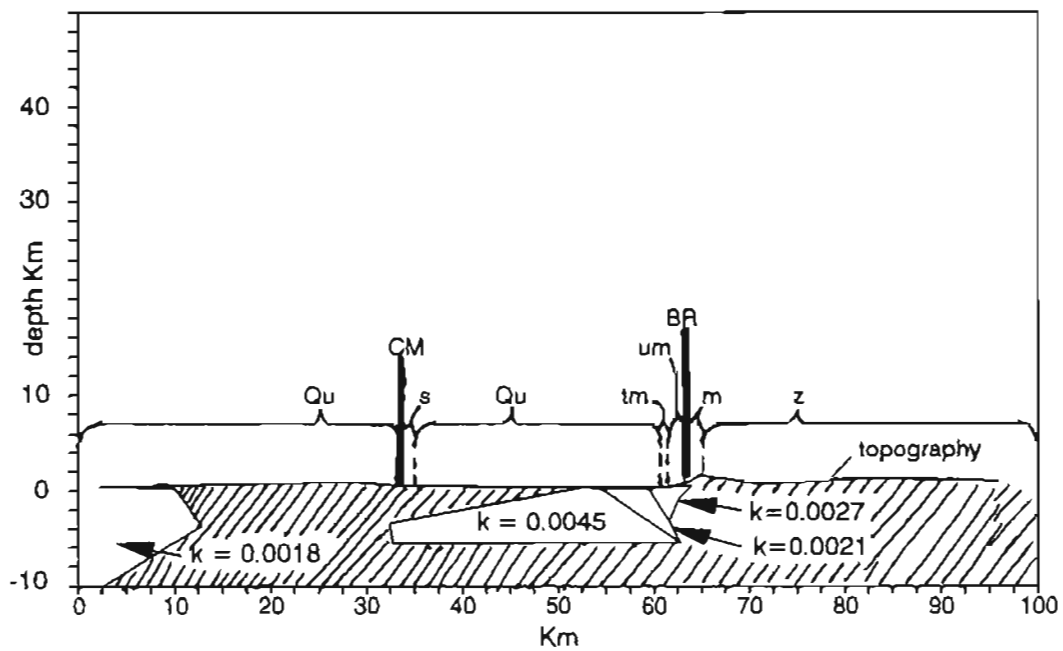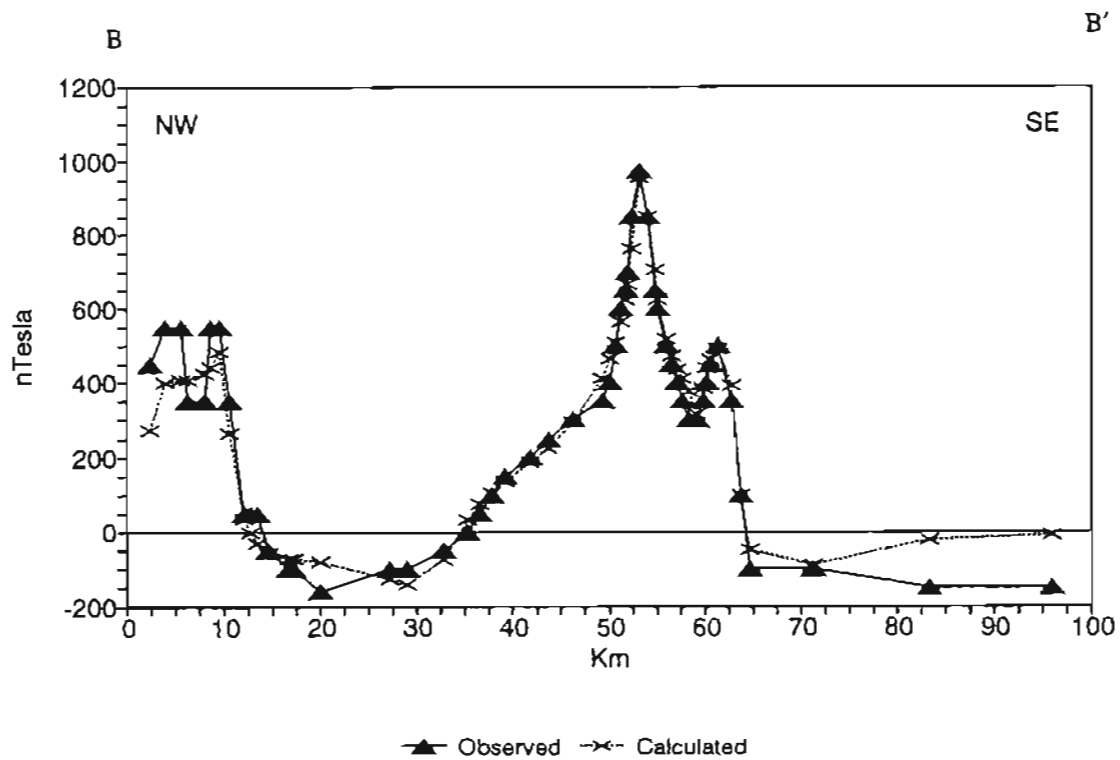
B
B'

Figure 5b.

B   B′
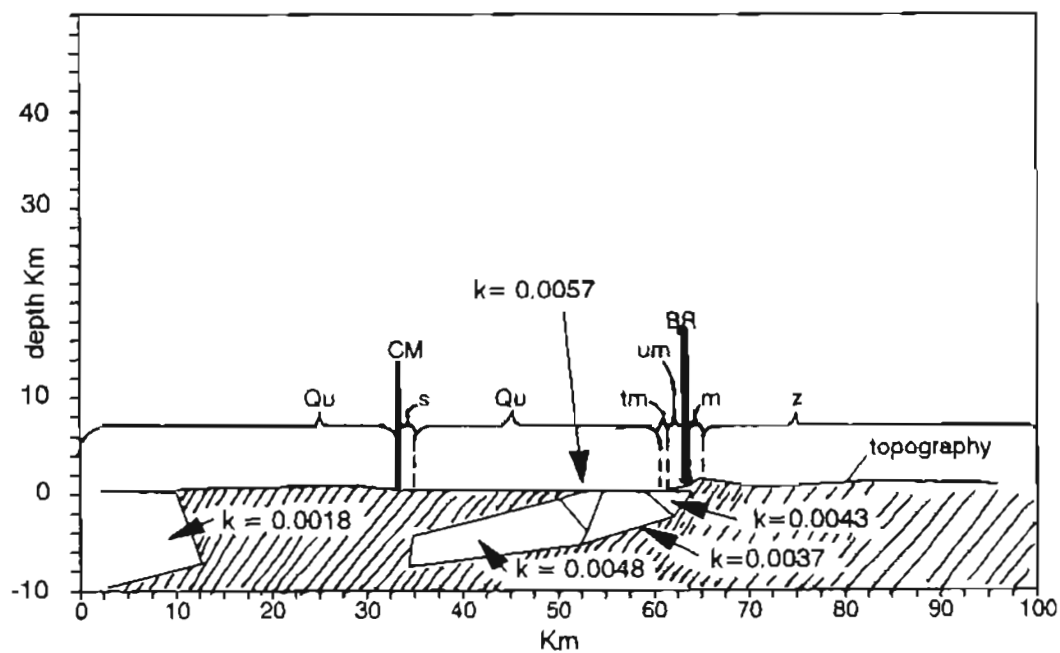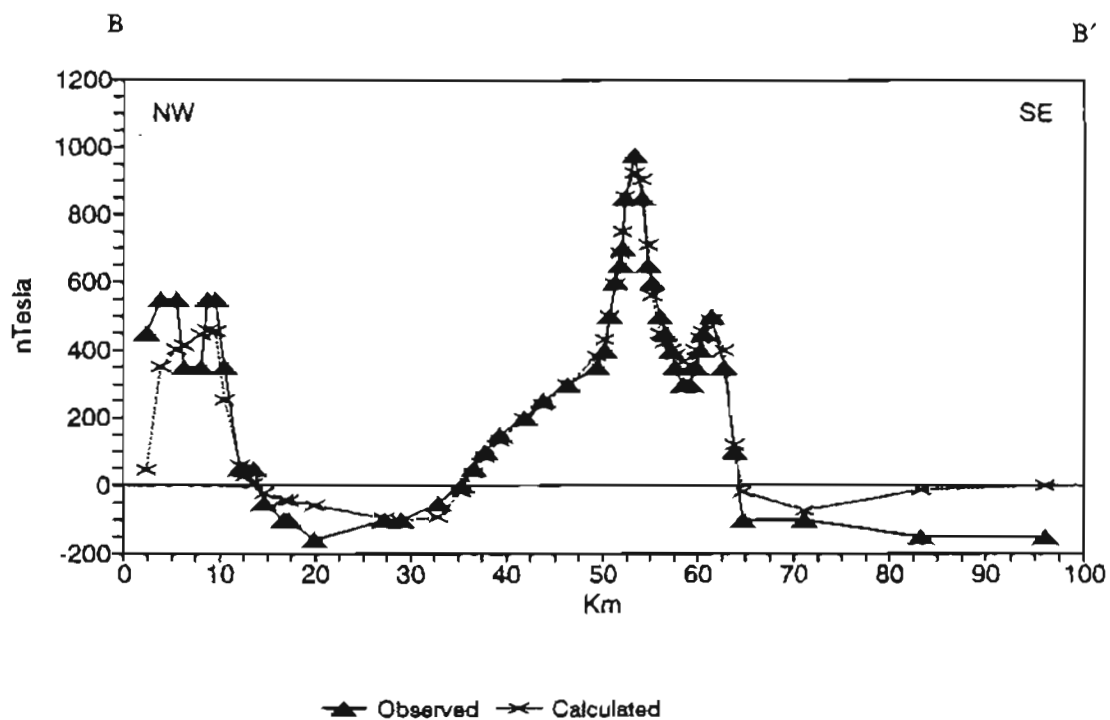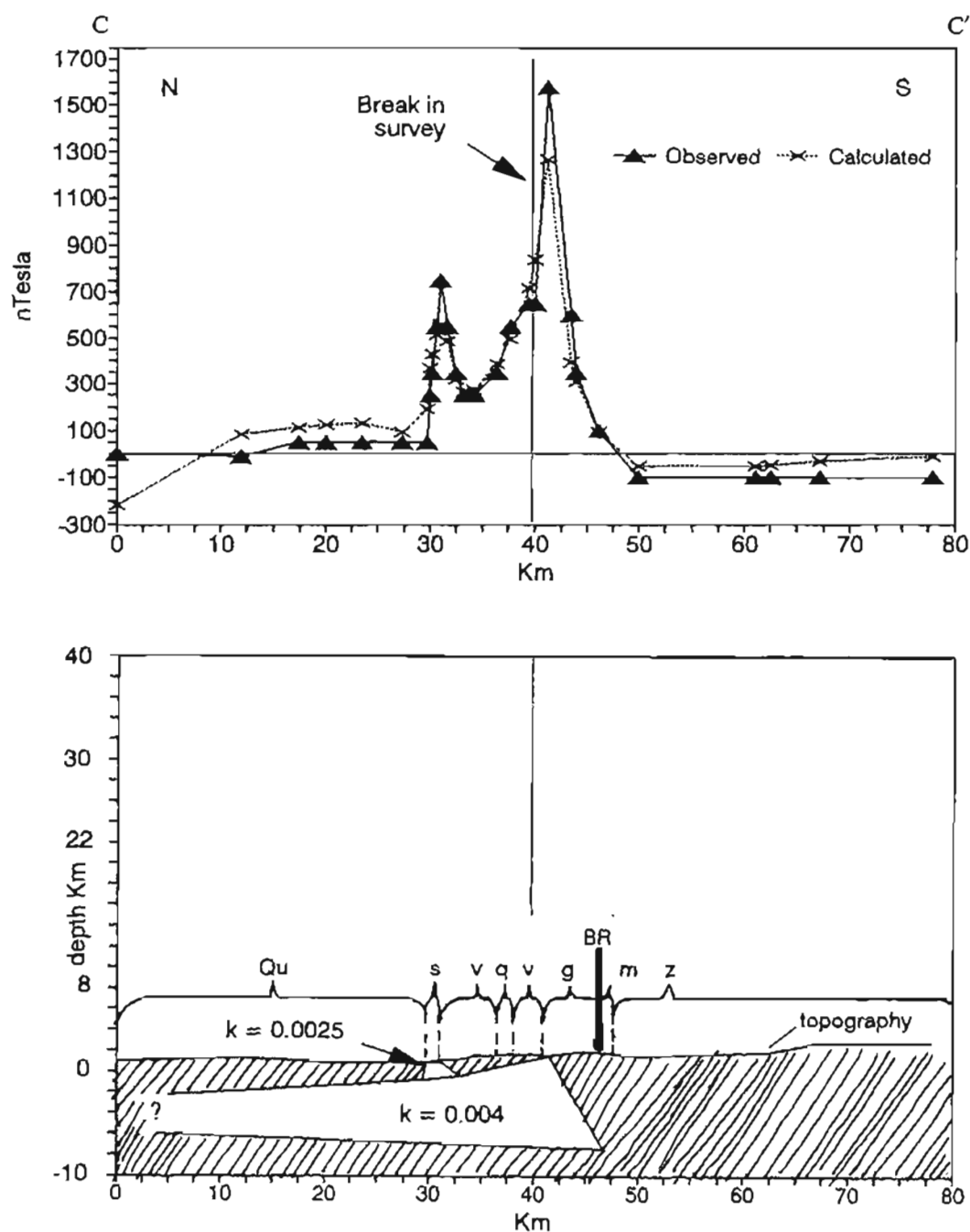

Figure 5c.

Figure 6a-b. *Profile C-C' across the Nelchina River Gabbronorite. The top part of the diagram shows the observed and calculated magnetic profiles. The bottom part of the diagrams are cross-sections which show topography, geologic contacts, and the model which produces the calculated profile. Flight altitude was 1,000 ft above ground level. A constant of 4,750 gammas was subtracted from points on the northern survey to enable joining. Then a constant of 400 gammas was subtracted from every point in the profile from the aeromagnetic map for modeling purposes. Geologic designators used: Qu - Quaternary deposits; s - Tertiary-Jurassic sedimentary rocks; v - Talkeetna Formation volcanic rocks; q - quartz diorite; g - Nelchina River Gabbronorite; BR - Border Ranges fault; m - McHugh Complex; and z - Valdez Group. Each body in the model has a magnetic susceptibility, k, in cgs units. No vertical exaggeration.*
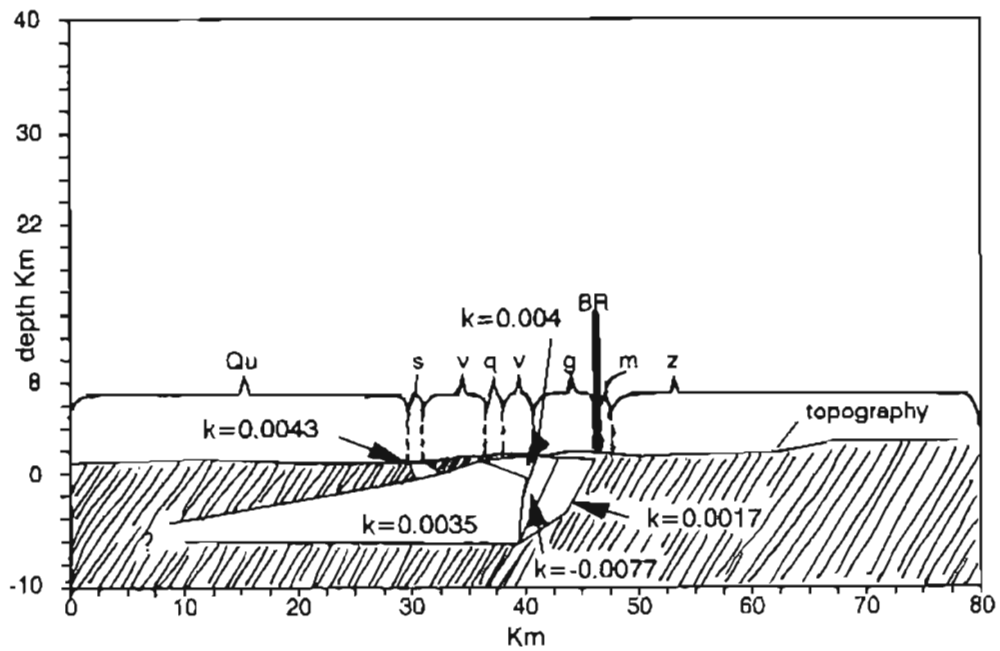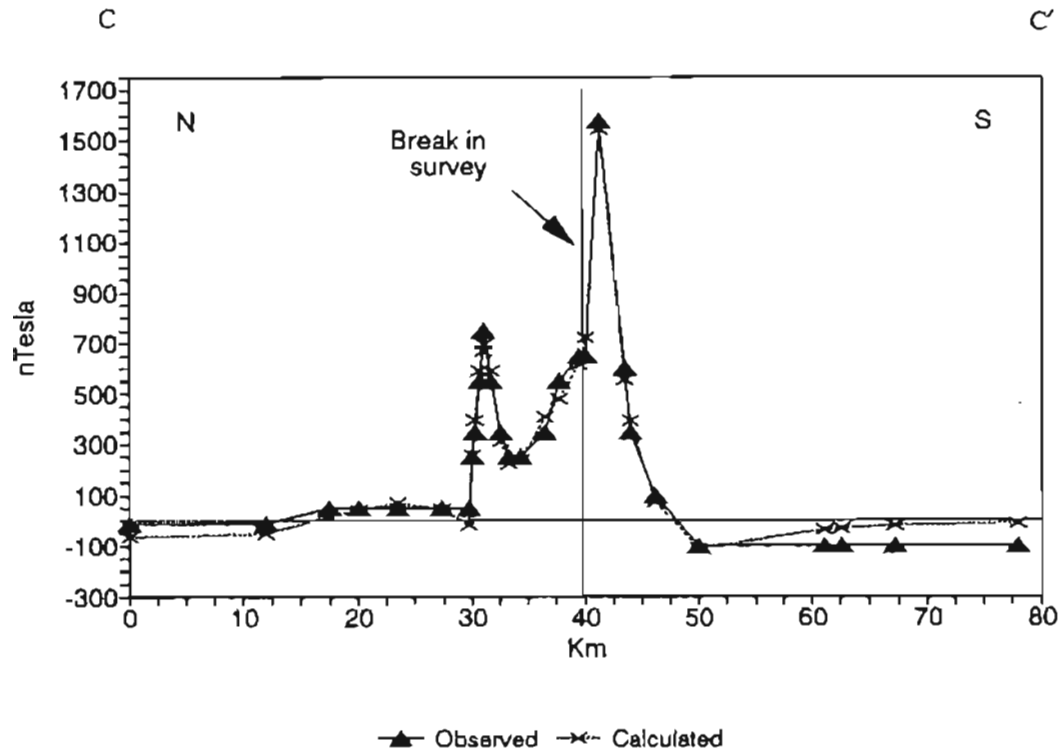
Figure 6b.

1966) and were discussed in detail by Foley and Barker (1985) and Newberry (1986). None of the chromite prospects found to date are large enough to be economic in 1991 market conditions and no significant platinum group element (PGE) values have been noted (for example, Clark, 1972; Clark and Greenwood, 1972). None of the prospects cause anomalies on the aeromagnetic map, because chromite is only weakly magnetic.

Some gabbroic rocks, particularly in the eastern part of the quadrangle, contain 5 - 15 percent modal magnetite (Burns and others, 1983; Burns, in press). Many of the larger aeromagnetic anomalies in the eastern part of the quadrangle are probably formed by these magnetite gabbronorites. Newberry (1986) examined these rocks for vanadium and titanium contents and found all areas to be subeconomic.

Small prospects are located in stratiform to stratabound, slightly argentiferous, pyrite-rich zones and rare copper-sulfide-bearing quartz veinlets in the Talkeetna Formation in the Anchorage Quadrangle (Grantz, 1961; McMillin, 1984; Newberry, 1986). Low assay values for the pyrite-rich zones and the small size of copper veins indicate poor economic potential (Newberry, 1986). No particular aeromagnetic anomalies are associated with these zones.

ROCKS NORTH OF THE CASTLE MOUNTAIN - CARIBOU FAULTS

Lode gold mines of the Willow Creek mining district are present in the southwest part of the Talkeetna Mountains. The mines are present in an eastern and western zone (Ray, 1954). Quartz monzonite underlies the western zone, and a mixed unit of amphibolite, quartz diorite, and trondhjemite (unit Jma; Winkler, 1992) underlies the eastern zone. The gold is present in a quartz vein system. Individual lode gold deposits of the Willow Creek mining district are not distinguishable on the aeromagnetic map. However, both of these zones have aeromagnetic signatures composed of many small "bird's-eyes" of limited areal size (commonly less than 2 km^2) which typically have a positive anomaly about 700 gammas amplitude (areas 16A and 16B). The similarity of the aeromagnetic signatures, coupled with the presence of gold prospects and mines in both areas, suggests that (1) quartz monzonite is at least in part the reason for the gold concentration, and (2) quartz monzonite probably occurs at shallow depths under the eastern zone.

Some gold placers have been found in the northcentral part of the quadrangle (Cobb, 1972). These placers have no magnetic expression at 300 m above the surface.

CHUGACH AND PRINCE WILLIAM TERRANES

Small quartz veins containing gold ± silver are present in a few areas in the Chugach terrane, particularly near Crow Creek along the southwest boundary of the map and between Metal Creek and Mount Sargent Robinson north of the Knik Glacier (Cobb, 1972). Generally, the veins occur near felsic dikes and plugs. As these areas and units show no manifestation in the aeromagnetic map, these areas are not shown on the map.

SUMMARY

The two major tectonostratigraphic terranes that form most of the Anchorage Quadrangle have very different aeromagnetic signatures. The aeromagnetic pattern of the Peninsular terrane is characterized by variation, including strong positive anomalies, flat anomalies, and moderately strong, negative anomalies. In contrast, the aeromagnetic signature of the Chugach and Prince William terrane shows little fluctuation, and in general reflects the monotonous sequence of non-to-weakly magnetic flysch.

Jurassic units, including ultramafic and gabbroic rocks, volcanic rocks of the Talkeetna Formation, and various other plutonic rocks, form a magnetic basement in the Peninsular terrane. These rocks are overlain in the Matanuska Valley and Cook Inlet by sedimentary rocks of Jurassic through Tertiary age and are intruded, particularly north of the Castle Mountain fault, by Cretaceous and Tertiary plutonic and hypabyssal rocks.

The largest positive aeromagnetic anomaly in the Anchorage Quadrangle and in southern Alaska is formed by the plutonic rocks of the Peninsular terrane near the Border Ranges fault. The major source of the anomaly is interpreted to be gabbroic rocks, with less input from ultramafic rocks and quartz diorite. The maps and profiles indicate that the upper surface of the gabbroic/plutonic rocks dip steeply on the south and southeast sides and shallowly to the north and northwest.

Many of the plutons in the Talkeetna Mountains, including the quartz monzonite associated with gold mining in the Willow Creek mining district, can be distinguished from adjacent plutons by their aeromagnetic signatures. In addition, the locations of small plugs of probable Tertiary age can also be discerned on the aeromagnetic map in the Chugach and possibly Talkeetna Mountains even though they are not exposed.

The large trough and adjacent highs in the northwest corner of the quadrangle are probably due to reversely and normally magnetized Tertiary volcanic rocks, although the trough could also be formed from a

reversely magnetized pluton.

The aeromagnetic signature of the Chugach and Prince William terranes suggests a relatively deep (deeper than 5 km) magnetic basement covered by a thick cover of nonmagnetic rock. The few small anomalies that are present probably represent small moderately-to-deeply buried mafic-ultramafic bodies.

ACKNOWLEDGMENTS

REFERENCES CITED

Alaska Division of Geological & Geophysical Surveys staff, 1973, Aeromagnetic map, Anchorage Quadrangle: Alaska Division of Geological & Geophysical Surveys Open-File Report AOF-21, 1 sheet, scale 1:250,000.

Barker, Fred, and Grantz, Arthur, 1982, Talkeetna Formation in the southeastern Talkeetna Mountains, southern Alaska: An Early Jurassic intraoceanic island arc, [abs.]: Geological Society of America, Abstracts with Programs, v. 14, no. 4, p. 147.

Burns, L.E., 1982, Analysis of gravity and magnetic anomalies over a layered gabbro complex, Chugach Range, Alaska: U.S. Geological Survey Open-File Report 82-460, 96 p.

_____1985, The Border Ranges ultramafic and mafic complex, south-central Alaska: Cumulate fractionates of island-arc volcanics: Canada Journal of Earth Science, v. 22, p. 1020-1038.

_____in press, Geology of gabbroic rocks near the Nelchina Glacier, south-central Alaska: U.S. Geological Survey Bulletin.

Burns, L.E., Little, T.A., Newberry, R.J., Decker, J.E., and Pessel, G.H., 1983, Preliminary geologic map of parts of the Anchorage (C-2), (C-3), (D-2), and (D-3) Quadrangles, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigation 83-10, 3 sheets, scale 1:25,000.

Burns, L.E., Pessel, G.H., Little, T.A., Pavlis, T.L., Newberry, R.J., Winkler, G.R., and Decker, John, 1991, Geology of the northern Chugach Mountains, southcentral Alaska: Alaska Division of Geological & Geophysical Surveys, Professional Report 94, 63 p., 2 sheets, scale 1:63,360.

Carden, J.R., and Decker, J.E., 1977, Tectonic significance of the Knik River schist terrane, south-central Alaska: Alaska Division of Geological & Geophysical Surveys, Geologic Report No. 55, p. 7-9.

Case, J.E., Tysdal, R.G., Hillhouse, J.W., and Gromme', C.S., 1979, Geologic interpretation of aeromagnetic map, Seward and Blying Sound Quadrangles, Alaska: U.S. Geological Survey Miscellaneous Map 880D, 2 sheets, scale 1:250,000.

Case, J.E., Burns, L.E., and Winkler, G.R., 1986, Maps showing aeromagnetic survey and geologic interpretation of the Valdez Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies, Map MF-1714, 2 sheets, scale 1:250,000.

Clark, A.L., and Greenwood, W.R., 1972, Geochemistry and distribution of platinum-group metals in mafic to ultramafic complexes of southern and southeastern Alaska: U.S. Geological Survey Professional Paper 800-C, p. C157-160.

Clark, S.H.B., 1972, The Wolverine Complex, a newly discovered layered ultramafic body in the western Chugach Mountains, Alaska: U.S. Geological Survey Open File Report 522, 10 p., 1 sheet, scale 1:63,360.

_____1973, The McHugh Complex of southern Alaska: U.S. Geological Survey Bulletin 1372-D, 11 p.

Cobb, E.H., 1972, Metallic mineral resources map of the Anchorage Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF 409, 2 sheets, scale 1:250,000.

Csejtey, Bela, Jr., and Griscom, Andrew, 1978, Text to accompany preliminary aeromagnetic interpretive map of the Talkeetna Mountains Quadrangle, Alaska: U.S. Geological Survey Open-File Report 78-558C, 14 p., 2 sheets, scale 1:250,000.

Csejtey, Bela, Jr., Nelson, W.H., Jones, D.L., Silberling, N.J., Dean, R.M., and Morris, M.S., 1978, Reconnaissance geologic map and geochronology, Talkeetna Mountains Quadrangle, northern part of Anchorage Quadrangle, and southeast corner of Healy Quadrangle, Alaska: U.S. Geological Survey Open File Report OF 78-558A, 2 sheets, scale 1:250,000.

Detterman, R.L., and Hartsock, J.K., 1966, Geology of the Iniskin-Tuxedni region, Alaska: U.S. Geological Survey Professional Paper PP-512, 78 p., 5 sheets, scale 1:63,360.

Fisher, M.A., 1981, Location of the Border Ranges fault southwest of Kodiak Island: Geological Society of America Bulletin, v. 92, p. 19-30.

Foley, J.Y., and Barker, J.C., 1985, Chromite deposits

along the Border Ranges fault, southern Alaska: U.S. Bureau of Mines Information Circular, IC 8990, part 1, 58 p.

Fuchs, W.A., 1980, Tertiary tectonic history of the Castle Mountain - Caribou fault system of the Talkeetna Mountains, Alaska: Salt Lake City, University of Utah, Ph.D. thesis, 162 p.

Grantz, Arthur, 1961, Geologic map and cross sections of the Anchorage D-2 Quadrangle and the northeasternmost part of the Anchorage D-3 Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-342, 1 sheet, scale 1:48,000.

_____1966, Strike-slip faults in Alaska: U.S. Geological Survey Open-file Report 267, 4 sheets, scale 1:96,000.

Grantz, Arthur, Zietz, Isidore, and Andreasen, G.E., 1963, An aeromagnetic reconnaissance of the Cook Inlet area, Alaska: U.S. Geological Survey Professional Paper PP-316-G, p. 117-134.

Griscom, Andrew, 1975, Aeromagnetic map and interpretation of the Nabesna Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-655-H, 2 sheets, scale 1:250,000.

_____1979, Aeromagnetic map and interpretation, Talkeetna Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-870-B, 2 sheets, scale 1:250,000.

Hartman, D.C., Pessel, G.H., and McGee, D.L., 1972, Preliminary report on stratigraphy of Kenai Group, Upper Cook Inlet, Alaska: Alaska Division of Geological Survey, Special Report No. 5, 11 sheets, scale 1:500,000.

Hudson, T.L., 1979, Mesozoic plutonic belts in southern Alaska: Geology, v. 7, p. 230-234.

Jones, D.L., and Silberling, N.J., 1979, Mesozoic stratigraphy - the key to tectonic analysis of southern and central Alaska: U.S. Geological Survey Open File Report 79-1200, 40 p.

MacKevett, E.M., Jr., and Plafker, George, 1974, The Border Ranges fault in south-central Alaska: U.S. Geological Survey Journal of Research, v. 2, no. 3, p. 323-329.

Madden-McGuire, D.J., Silberman, M.L., and Church, S.E., 1988, Geological relationships, K-Ar ages, and isotopic data from the Willow Creek gold mining district, southern Alaska: Bicentennial Gold 88, Melbourne, Australia, May 1988, 3 p.

McMillin, S.L., 1984, Hydrothermal alteration and sulfide mineralization in the Lower Jurassic Talkeetna Formation, Sheep Mountain, south-central Alaska: Fairbanks, University of Alaska unpublished M.S. thesis, 193 p.

Monteverde, D.H., 1984, Tonalite and trondhjemite plutonism in the western Chugach Mountains, southern Alaska: an example of near-trench magmatism [M.S. thesis]: Lehigh University, Bethlehem, Pa., 82 p.

Nelson, S.W., Dumoulin, J.A., and Miller, M.L., 1985, Geologic map of the Chugach National Forest, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1645-B, 16 p., 1 sheet, scale 1:250,000.

Newberry, R.J., 1986, Mineral resources of the northcentral Chugach Mountains, Alaska: Alaska Division of Geological & Geophysical Surveys, Report of Investigations 86-23, 44 p.

Pavlis, T.L., 1982, Origin and age of the Border Ranges fault of southern Alaska and its bearing on the late Mesozoic tectonic development of southern Alaska: Tectonics, v. 1, p. 343-368.

_____1983, Pre-Cretaceous crystalline rocks of the western Chugach Mountains, Alaska: Nature of the basement of the Jurassic Peninsular terrane: Geological Society of America Bulletin, v. 94, p. 1329-1344.

Pessel, G.H., Henning, M.W., and Burns, L.E., 1981, Preliminary geologic map of parts of the Anchorage (C-1), (C-2), (D-1), and (D-2) Quadrangles, Alaska: Alaska Division of Geological & Geophysical Surveys Open-File Report 121, 1 sheet, scale 1:63,360.

Plafker, George, Nokleberg, W.J., and Lull, J.S. 1989, Bedrock geology and tectonic evolution of the Wrangellia, Peninsular, and Chugach terranes along the Trans-Alaskan Crustal Transect in the Chugach Mountains and southern Copper River Basin, Alaska: Journal of Geophysical Research, v. 94, n. B4, p. 4255-4295.

Ray, 1954, Geology and ore deposits of the Willow Creek mining district, Alaska: U.S. Geological Survey Bulletin 1004, 84 p., 8 sheets, scale 1:31,680.

Rose, A.W., 1966, Geology of chromite-bearing ultramafic rocks near Eklutna, Anchorage Quadrangle, Alaska: Alaska Division of Mines and Minerals, Geologic Report 18, 22 p., scale 1:42,000.

Silberman, M.L., and Grantz, Arthur, 1984, Paleogene volcanic rocks of the Matanuska Valley area and the displacement history of the Castle Mountain fault: *in* Coonrad, W.L. and Elliott, R.L., eds., The U.S. Geological Survey in Alaska: Accomplishments during 1981: U.S. Geological Survey Circular 868, p. 82-86.

Streckeisen, A., 1976, To each plutonic rock its proper name: Earth Science Review, v. 12, no. 1, p. 1-35.

U.S. Geological Survey, 1980, Aeromagnetic map of the Chugach area, Alaska: U.S. Geological Survey Open-File Report 80-58, 1 sheet, scale 1:250,000.
_____ 1984, Aeromagnetic map of part of the Anchorage 1° x 3° Quadrangle, Alaska: U.S. Geological Survey Open-File Report 84-352, 1 sheet, scale 1:250,000.

Webring, Mike, 1985: SAKI: A Fortran program for generalized linear inversion of gravity and magnetic profiles: U.S. Geological Survey Open-file Report 85-122, 108 p.

Winkler, G.R., 1978, Framework grain mineralogy and provenance of sandstone from the Arkose Ridge and Chickaloon Formations, Matanuska Valley: *in* Johnson, K.M., ed., The U.S. Geological Survey in Alaska: Accomplishments during 1977: U.S. Geological Survey Circular 772-B, p. B70-B73.

Winkler, G.R., Silberman, M.L., Grantz, Arthur, Miller, R.J., and MacKevett, E.M., Jr., 1981, Geologic map and summary geochronology of the Valdez Quadrangle, southern Alaska: U.S. Geological Survey Open File Report 80-892-A, 2 sheets, scale 1:250,000.

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