BASE FROM U.S. GEOLOGICAL SURVEY, 1953

EXPLANATION FOR MAP SYMBOLS

Approximate boundary of anomaly area--

Approximate axis of magnetic high

Approximate axis of magnetic low

Area of apparent reversed magnetization-

Polarization low -- Queried where uncertain

Anomaly caused by topographic effect--

Area inferred to be underlain by mafic-

----- Contact--Dashed where approximately located; dotted where concealed

Thrust fault--Dotted where concealed. Sawteeth on upper plate

Queried where uncertain

----- High-angle fault--Dotted where concealed

ultramafic rocks Paleomagnetic sample site

Oueried where uncertain

□□□□□□□ Zone of steepened magnetic gradient

lumber is keyed to discussion in text

Over the southern half of Knight Island, in anomaly area 49, magnetic highs of 200-400 gammas overlie terranes of pillow basalt and sheeted dikes in the western and central parts of the island. In the eastern part, however, between Snug Harbor and the Bay of Isles, magnetic anomalies (area 50) are much subdued over sheeted dikes, sills, and pillow basalt. This area is characterized by considerable alteration, shear zones, and belts of greenschist metamorphic rocks. At the extreme southeast end of the island, a magnetic low (anomaly 69, number out of sequence) over flysch appears to have an inverse correlation with topography and may be caused by reversed magnetization of the mafic rocks at depth, although effects of drape-flying may ant increase in the Earth's field intensity (Cady, 1978).

A conspicuous negative anomaly (area 51) occurs over Knight Island Passage between Chenega and Knight Islands. Because water depths in Knight Island Passage are locally as great as 300-400 m, part of the low may be the effect of topography of the top of the magnetic basement. Although a slab of mafic rocks may underlie the entire area at depth, the configuration of the shallower mafic surface is of concern in resource appraisals. In order to determine if shallow magnetic rocks are continuous at depth beneath the passage, a generalized two-dimensional model along profile B-B' was prepared (fig. 2). Because of the geologic complexity along the line of the profile and undoubted wide range in magnetization of the mafic rocks, no attempt was made to obtain an exact fit between the observed and computed profiles. Moreover, the profile is nearly perpendicular to the direction of flight lines, and the gradients between flight lines are interpolations. A mean magnetization of 1.65x10-3 emu/cm³ was assumed. This value is somewhat greater than most of the mean magnetizations measured at the six paleomagnetic sites in the vicinity of the island but is less than that of the more strongly magnetized dikes (see table 1).

The computed profile of the model shown in figure 2 approximately matches the observed profile. An exact fit could be obtained by adding or subtracting small blocks of magnetic material, either by changing body configuration or by changing values of the magnetization. We do not believe that obtaining an exact fit is warranted because of the many unknowns. For example, the sharp computed low near the east end of Knight Island is an edge effect of the assumed anomalous mass. If the magnetic rocks extended eastward, knight Island is an edge effect of the assumed anomalous mass. If the mighted to the section to the low would simply shift eastward, still diverging from the observed anomaly. Several conclusions can be drawn from the model, however. First, the observed anomaly can be matched by a body having a depth extent of 1 to 2 km, for the assumed value of magnetization. If the magnetization is less than 1.65x10⁻³ emu/cm³, the body could extend to depths greater than 2 km. Second, mafic rocks at the east end of the profile, near the head of Drier Bay and the Bay of Isles, are conspicuously less magnetic than those to the west. This difference may result from alteration or metamorphism in the zone of considerable shearing, from low original magnetite content, or from fortuitous orientation of the remanent and induced magnetic fields that produces a low resultant inclination of magnetization. The last possibility is suggested by the magnetization at site 401 (see table 1). A third result is that magnetic mafic rocks at shallow depth beneath Knight Island Passage are not required in the model, even though they may be present at great depth beneath the passage. Either the shallower mafic rocks at Chenega Island had separate vents from those at Knight Island or the mafic rocks between Chenega and Knight Island have been faulted out or downfolded to depth beneath the passage.

Although the magnetic anomalies across Knight Island can be accounted for by a mafic block only 1-2 km thick, the enormous gravity anomaly over the islands requires that the mafic mass extend to at least 5 km and possibly as much as 10 km below sea level (Case and others, 1979).

The large ovoid anomaly (area 52) over the northern part of Knight Island and over Ingot, Disk, and Sphinx Islands includes positive anomalies of 300-400 gammas as well as several relative negative anomalies. Two of the negative anomalies are over topographically low areas and may be caused by the greater depth to the mafic rocks beneath the aircraft. It is possible that the ovoid anomaly represents a volcanic center, perhaps a local seamount, although no geologic evidence supports this interpretation. Small positive anomalies in area 53 occur over the pillow basalt of Eleanor Island.

A north-trending belt of magnetic highs (anomaly area 54) overlies Knight Island Passage near Crafton Island, where pillow basalt and flysch are exposed, and extends across Lone Island, where pillow basalt is exposed. Mafic rocks probably extend northward at depth beneath the Dutch Group, Axel Lind, and Little Axel Lind Islands (anomaly area 55), although only flysch has been found on these islands.

basalt exposed on Glacier Island, and the high-amplitude anomalies offshore to the southwest almost certainly reflect subsurface continuation of the mafic rocks toward Little Axel Lind Island. In the extreme northeast corner of the map area, small anomalies occur over a flysch terrane that includes thin belts of pillow basalt (anomaly area 57). Pillow basalt and greenstone crop out in the Cordova quadrangle immediately to the east.

As noted above, broader positive anomaly areas 58-60 are probably underlain by deep-seated mafic rocks. A broad northwest-trending magnetic high near Port Wells and Esther Passage (anomaly area 61) may likewise be caused by deeply concealed mafic rocks, but we have no geologic evidence for this

A broad ovoid magnetic high (anomaly 62) occurs over and east of Peak and Naked Islands. This

The northeastern part of anomaly area 56 coincides closely with the sheeted dike complex and pillow

broad high has very gentle magnetic gradients whose breadth suggests that the depth to the anomaly is about 10 km or more. A similar anomaly, more elongate north-south, occurs near Seal and Green Islands (anomaly 63). Again, depths of the sources of this anomaly could be 10 km or more, as judged from the gentle gradients. Both anomalies are in areas of apparent relative gravity lows, hence dense mafic procks are not the cause of the anomalies. Two possible magnetic sources are deeply buried serpentinite or granite of low density. Because most of the granite bodies of the area are nonmagnetic or weakly magnetic, we favor serpentinite as a source.

In the southeastern part of the area several high-amplitude short-wavelength anomalies (anomaly areas 64-67) lie in the vicinity of Montague Island. Anomaly areas 64, 65, and 67 are offshore, southeast of Montague Island, and anomaly area 66 is over the island. Although geologic mapping on Montague Island is incomplete, no mafic or granitic rocks have yet been found there. The sequence appears to be exclusively flysch of the Orca Group. A helicopter landing was made at the site of anomaly 66, but only lysch was found at the landing site. These anomalies are probably produced by shallow concealed mafic flows or plutons within the Orca Group.

One of the most significant magnetic anomalies of the Gulf of Alaska region is the great magnetic high (anomaly 68) that trends northwest in the southeastern part of the area. This high is the northwest end of large magnetic high that extends southeast of Montague Island and possibly farther (Taylor and O'Neill, 774, p. 722). It appears to truncate magnetic stripes that have been identified north and east of the Aleutian trench. Taylor and O'Neill referred to the anomaly as the "continental margin" anomaly, and postulated that it "* * results from an oceanward extension of the volcanic rocks to the southeast described by Souther [1972] and found along the Alaskan continental margin. * * * This anomaly might indicate a ormer obduction zone [Coleman, 1971] where an ophiolite sequence was scraped off against the continental plate as the oceanic plate descended under the continental. This process would elevate the more magnetic ophiolite sequence." Their favored interpretation was that the anomaly is caused by a belt of volcanic rocks.

Within the area covered by this report, the anomaly indicates that the magnetic body extends northwest nearly to the Sargent lineament. The body, causing a relative high of 200-400 gammas, is about 30 km wide and is probably buried 10 km or more. Offshore gravity data south of Montague Island indicate a broad high of 10-20 mgal over the southeastern part of the magnetic high; however, the northwestern part of the magnetic anomaly occurs over a relative gravity low. One interpretation of these relations is that the main mass producing the anomalies is ultramafic in composition and that it has a variable degree of serpentinization along strike. Where magnetic and gravity highs coincide, as south of Montague Island, the mass is probably relatively unserpentinized. Where no special gravity highs are present, as west of Montague Island, the serpentinization is probably greater and the mass is less dense.

MAGNETIC ANOMALIES AND MINERAL RESOURCES Gold. -- Most of the economic gold deposits, both placer and vein deposits, are in the northwestern part of the Seward quadrangle. Lode deposits in the Hope district occur in quartz veins. Magnetic anomalies indicate that the magnetic basement is very deep in this area, and therefore the flysch sequence is thick, perhaps as much as 10 km. Magnetic lineaments trend roughly north-south in the area, as do many of the veins. Whether there is a genetic relation between gold deposits, thick flysch, the magnetic lineaments, and the north-trending veins remains to be determined; if there is one, then virtually all of the western third of the area might constitute a minor gold province. (Whether gold deposits might be associated with the maficultramafic complex of the Resurrection Peninsula remains to be determined.)

Copper-bearing massive sulfides.--Because the massive sulfide deposits appear to be genetically related to tholeitic rocks, the magnetic data provide a means for tracing shallow segments of the tholeitic belts beneath flysch, water, or glaciers. As noted above, high-amplitude short-wavelength anomalies along these belts are strong indications of mafic rocks, but absence of this type of anomaly does not necessarily imply absence of mafic rocks. Some mafic rocks do not have good magnetic expression because of effects of alteration, metamorphism, or the orientation of the total magnetization vector. Thus, two main areas of potential copper massive sulfide deposits, judging from magnetic data, are the Resurrection Peninsula and areas to the north and south (anomaly areas 18-27), and the Knight Island belt (anomaly areas 46-58).

Nickel-chromite.--The main area where nickel (geochemical anomalies) and chromite (small stringers in serpentinite) have been found is the Resurrection Peninsula. Because the most favorable rocks for these commodities are ultramafic, the major area of potential significance is the area underlain by known or inferred ultramafic rocks, specifically anomaly area 25. The other area where relatively shallow ultramafic rocks are suspected is in the extreme northwest corner of the area, where shallow mafic-ultramafic rocks probably lie just northwest of the Border Ranges fault.

Ultramafic rocks are inferred under anomaly area 68, in the southeastern part of the area but at such great depth, probably 10 km or more, that area is not prospective. REFERENCES CITED

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The axis of a large transverse positive anomaly (17) of about 10-20 gammas in the northwestern part of the area coincides with the valley of Turnagain Arm. Inasmuch as the flysch terrane north and south of the valley is relatively nonmagnetic, we envision two possible sources for the anomaly. First, concentrations of magnetite could occur in the young sediments of the valley which reach a thickness of at least 300 m. However, magnetite amounts to less than 0.8 percent by weight in 10 samples collected from a 100-m drill hole at the head of Turnagain Arm, according to Susan Bartsch-Winkler (oral commun., 1978). Because the aircraft was flying at an elevation of at least 1.5 km north and south of Turnagain Arm but as low as 0.3 km over the water itself, the high of 20 gammas may result simply from closeness to a buried magnetic basement or to the center of the main dipole field and attend-

One of the geologically most significant groups of anomalies in the area is the major belt of largeamplitude highs and lows associated with the Resurrection Peninsula mafic-ultramafic complex. The complex is exposed in a north-plunging anticline whose east flank is cut by the Placer River fault, and it is represented by at least three distinct groups of anomalies.

The first group (anomaly area 18) includes anomalies of high amplitude, steepened gradient, and short wavelength that correlate with the exposed sheeted dike complex and pillow basalt sequence on the main peninsula. This pattern of shallow high-amplitude anomalies continues offshore, south-southwest of the south end of the peninsula, for at least 25-30 km. Although most of the anomalies within this belt are positive, several prominent local negative anomalies, 19 and 20, occur in part over topographically high areas and are clearly caused by reversed remanent magnetization, even though the mean vector sum of the remanent and induced magnetization at paleomagnetic site 311 (anomaly area 20) has a positive inclination Sheeted dikes and pillow basalts at three sites on the southern part of the Resurrection Peninsula have reversed remanent magnetization of variable inclination (Hillhouse and Grommé, 1977), but only one site is over a negative anomaly. It seems clear that the Q-values are locally greater than 1 (to yield negative aeromagnetic anomalies) or the inclinations of the mean vector sums are low. In one area of positive anomalies, paleomagnetic site 201, the inclination of the mean vector sum of induced and remanent magnetization is positive, but of low inclination. Where Q is less than 1, the induced component of magnet ization is dominant, leading to positive anomalies over topographic highs. Other examples of anomalies due to reversed remanent magnetization may occur offshore to the south of the Resurrection Peninsula (anomalies 21 and 22), although these negative anomalies could be normal polarization lows.

A second type of anomaly over the mafic-ultramafic complex is defined by the zone of steepened gradient (anomaly area 23) that occurs west of the belt of high-amplitude anomalies. This west-sloping gradient indicates that mafic-ultramafic rocks extend at least 5 km and as much as 10 km west of the exposed complex. The anomalies are partly produced by the westward dip of the west limb of the anticline Offshore magnetic highs (anomaly 24) near lat 59°45' N., long 149°15' W., could be caused by either shallow or deeper mafic-ultramafic rocks, but because the coverage is incomplete, depth estimates are not possible. No attempt was made to model magnetic anomalies of the Resurrection Peninsula because the anomalies are three-dimensional rather than two-dimensional features.

The third major anomaly related to the mafic-ultramafic complex is the large magnetic high (anomaly areas 25 and 26), more than 300 gammas in amplitude, at the north end of the Resurrection Peninsula. Although sheeted dikes and pillow basalt underlie part of the anomaly, the high also overlies a terrane that contains a large gabbro body and several small serpentinite bodies. This large anomaly is very similar to anomalies over serpentinite masses in California and elsewhere, and it may represent a largely concealed ultramafic body--possibly serpentinized dunite. It should be pointed out that a large positive gravity anomaly of as much as 40 mgal occurs over the sheeted dike-pillow basalt terrane (Case and others, 979), but the large magnetic anomaly is on the northeast flank of the gravity high rather than beneath t. Less dense serpentinite might occur at depth beneath the magnetic anomaly. Its northerly extent i uncertain: the main deeper anomaly (anomaly 26) extends to at least lat 60°15' N., but a small shallow high (anomaly 27) near the south end of Kenai Lake may be related to the same mafic-ultramafic body. It is possible that the broad high (anomaly 28) in T. 4 N., R. 1 W. and 1 E., near Trail Lake, is produced by the same body.

In order to define limiting depths and dimensions of the rock mass causing the anomaly north of the Resurrection Peninsula, magnetic effects of a simplified model were calculated along profile A-A' (fig. 1 If the mean susceptibility of the body is 0.003 cgs unit, equivalent to an apparent induced magnetization of 0.00165 emu/cm³, magnetized in the Earth's present field (inclination 73°, declination 26°), a body of trapezoidal cross section with an upper breadth of 2 km, lower breadth of about 8 km, and average thickness of about 0.5 km, yields a computed anomaly that crudely approximates the observed anomaly in amplitude and shape. If the inclination is steeper (85°), the fit of computed and observed anomalies is slightly better. Of course, a thicker body having a lower magnetization can also account for the observed anomaly.

The belt of schist (in part metavolcanic rocks) that trends north from near the mafic-ultramafic complex nearly to Turnagain Arm is apparently expressed by a series of magnetic highs of very low amplitude (anomaly area 29) and by two small highs of higher amplitude (anomalies 30 and 31). If the schist were not a recognizable mappable geologic unit, the belt of small highs would not have been especially noteworthy. Anomaly 31 overlies an area where the metamorphic rocks may reach amphibolite grade. From these relationships, we cannot discount the possibility that many of the low-amplitude anomalies to the west, in area 4 and elsewhere, could be caused by metamorphic rocks at depth rather than small plutons. Further more, it is possible that the magnetic "steps" to the west, such as lineaments 6-16, could reflect metamorphic features of the flysch sequence or the basement rather than actual vertical displacements of the

A broad magnetic low (anomaly 32) east of the Placer River fault occurs above a thick section of flysch overlain by glaciers and probably indicates great depth to magnetic basement. It is possible that part of the low is due to drape-flying over high peaks of the area. To the south, another major low (anomaly 33) likewise occurs over thick flysch, but it probably is partly a polarization low related to the major magnetic high (anomalies 25 and 26) to the west-southwest.

A prominent regional magnetic gradient (the Sargent lineament, anomaly 34) trends north-northeast across the area. The level of the magnetic field is consistently higher to the east than to the west, although the difference in level is only 20-50 gammas. From the breadth of the gradient, its source lies at great depth, 5 km or more. This lineament may indicate that magnetic basement is shallower or slightly more magnetic to the east than to the west. In the southern part of the area, the lineament is the northwest flank of a broad magnetic high, anomaly 35. Flysch is mainly exposed along the trend of the magnetic high, but small exposures of greenstone occur at Whidbey Bay, T. 2 S., R. 3 E. Thus it is possible that the high is caused by largely concealed mafic rocks. The flysch terrane between the Placer River fault and the Sargent lineament is characterized by very flat magnetic gradients. Magnetic basement must lie at great depth, 5-10 km, in this region. It is difficult to

detect any magnetic expression of the Placer River fault. An area of small magnetic lows and highs (anomaly area 36) of moderately steep gradient occurs on the trend of anomaly 35. The correlation of the lows with high topography suggests that the sources have local reversed remanent magnetization. Because some of the granitic bodies farther north are weakly magnetic, we might speculate that the small anomalies are caused by a concealed granit's pluton, but mafic rocks are an The granitic body near Derickson and Deep Water Bays, T. 4 and 5 N., R. 5 and 6 E., does not appear to have substantial magnetic expression, but a negative flexure (anomaly 37) in the contours defining the

Sargent lineament suggests to us that the granite is less magnetic or reversely magnetized with respect

A group of small magnetic highs occurs over the Eshamy Granite (anomaly 38); the granite is near a belt of mafic rocks, and some of the anomalies may reflect mafic rocks rather than the main granite body. A prominent negative anomaly (area 70, number out of sequence) over Main Bay and Falls Bay is in part a topographic effect but locally may indicate reversed magnetization. Another group of small magnetic lows and highs (anomaly areas 39 and 40) overlies the granitic pluton and adjacent sedimentary rocks at Culross Island and the mainland to the west. This anomaly area probably has composite sources caused by both granitic and mafic rocks, and possibly metasedimentary rocks. Most of the exposed granitic body has little magnetic expression, but a prominent high (anomaly 40) occurs near its southwes margin. Moreover, considerable contact metamorphism of sedimentary rocks on Culross Island may indicate covered granite at depth. This anomaly, however, may be produced by mafic masses near Culross Passage mentioned by Grant and Higgins (1909). Some of the negative anomaly areas correlate inversely with opography, so reversed magnetization is suspected. In the Talkeetna area, Griscom (in press) has found that contact-metamorphosed sedimentary rocks adjacent to granitic plutons are reversely magnetized.

To the east, the well-exposed granitic body at Perry Island has the most prominent magnetic expression (anomaly area 41)of any granite in the region. Some steep gradients coincide closely with mapped contacts of the granite near both north and south ends of the island. Why this granite should be more magnetic than others is not clear. Perhaps it was emplaced through a considerable thickness of mafic rocks and was contaminated by magnetic materials from the mafic rocks. However, gabbro and diorite are locally associated with granitic bodies of this part of the quadrangle, and the Perry Island anomalies might be caused by such mafic or intermediate rocks at shallow depth.

At Esther Island the main granitic body appears to cause a residual negative indentation in the regional magnetic contours (anomaly 42), hence it may be less magnetic or reversely magnetized with respect to adjacent rocks. This granite, however, has an associated body of gabbro near the southeast end of the island which produces a prominent magnetic high (anomaly 43). A small negative anomaly (44) occurs over flysch in T. 10 N., R. 8 E. The anomaly is over a topographic

high and presumably is the expression of a small concealed reversely magnetized pluton.

A granite body in T. 10 N., R. 11 and 12 E. is associated with very low amplitude negative anomalies The most prominent and extensive belt of mafic rocks in the Prince William Sound region is exposed along the trend of Elrington, Knight, and Glacier Islands. The same belt probably extends east to the Ellamar Peninsula in the Cordova quadrangle. This is the most economically significant belt in the region because of the presence of copper-bearing massive and disseminated sulfides at Latouche and Knight Islands. Magnetic

This belt includes well-developed sheeted dike complexes on Knight and Glacier Islands, thick sequences of pillow basalt and pillow breccia, numerous mafic sills in the flysch, and small gabbroic bodies. Although no ultramafic bodies have been mapped, ultramafic inclusions and float have been found on Knight Island (Richter, 1965). The general structure is that of a doubly plunging anticline from Elrington Island to northern Knight Island, and another doubly plunging anticline is inferred near Glacier Island. A structural

anomalies associated with the belt turn sharply to the northeast, north of Lone Island, reflecting the

saddle of unknown trend is inferred between Knight Island and Glacier Island. As on the Resurrection Peninsula, at least two groups of anomalies are associated with the Knight Island belt: a group of high-amplitude, relatively short wavelength anomalies over exposed or shallow segments of he complex (anomaly areas 46-57) and broader long-wavelength anomalies over deeper segments of the complex (anomalies 58-60). Extensions of the mafic rocks beneath water-covered areas are strikingly shown by anomalies between Lone Island and Ingot Island (anomaly 54) and southwest of Glacier Island (anomaly 56).

From gravitational evidence, the main axis of the positive anomaly associated with the Knight Island high extends north between Lone Island and Naked Island to connect with the high over Glacier Island (Case and others, 1979). However, magnetic anomalies characteristic of shallow sources are not developed at the same site as the axis of the gravity high. Water depths in this area exceed 500 m, so magnetic anomalies of short wavelength, if present, would be greatly attenuated as observed at a level 300 m above the surface. It is possible that the offshore gravity data are erroneous in part (the surveys were conducted in 1964 when shipborne gravity meters were in developmental stages), and cross-coupling corrections were not made. More likely, this apparent offset results from the "extra" Bouguer correction made for stations at sea; for example; water depths between Lone Island and Glacier Island are as much as 300-400 m. The Bouguer correction for water depth of 300 m is about 20.6 mgal. This correction could lead to an eastward shift of the apparent gravity axis toward deep-water areas. Resolution of the apparent discrepancy between gravity and magnetic ata will require new gravity surveys with modern shipborne gravimeters of high reliability, and terrain

Throughout the length of the belt of mafic rocks, the magnetic expression is exceedingly variable for several reasons. First, effects of terrain and drape-flying are extreme because the islands are rugged, and of high relief, and water depths change dramatically over short distances. Second, the intrinsic magnetization or original magnetite content of the sills, dikes, and flows may vary from place to place. Third, post-emplacement alteration or metamorphism has locally converted original magnetite to nonmagnetic minerals Finally, the thickness and volume of mafic rocks vary greatly along the belt. We can characterize the belt by noting that where short-wavelength high-amplitude anomalies are present, mafic rocks, exposed or conealed at relatively shallow depth, are the most probable source. But absence of anomalies does not mean

At the south end of the belt (anomaly area 46), mafic rocks are widely exposed on Elrington, Evans, and Flemming Islands and along the east side of Bainbridge Island. Several small magnetic lows within the area are reversed, as indicated by inverse correlation with high topography, but a low in Latouche Passage may be a polarization low or a topographic effect of the passage. The short-wavelength anomalies of this southern belt are superimposed on a great northwest-trending magnetic high (anomaly 68) that will be described below. Magnetic anomalies over Latouche Island indicate that mafic rocks occur in the flysch terrane that under-

ies most of the island, but only a few outcrops of mafic rocks have been mapped. Inasmuch as it has been

thousand gammas in the area during a reconnaissance ground survey in 1975. The few measured samples of exposed mafic rocks, however, have very low susceptibilities. Magnetic rocks that cause the anomaly do not

crop out at the few sites we visited, but the steep magnetic gradients imply that they are only a few hundred

postulated that massive sulfide deposits at Latouche are genetically related to tholeiitic volcanic activity (Winkler and others, 1977, Wiltse, 1973a, 1973b), the aeromagnetic anomalies strengthen the spatial correlation t the south end of Elrington Island, exposed mafic rocks have only slight magnetic expression (anomaly area Farther north, anomaly area 48, over Chenega Island, includes the largest anomaly of the whole region. At the north end of the island, values are as high as 800 gammas. Intermixed flysch and greenstone bodies crop out near the anomaly. Before the aeromagnetic high was known, we found magnetic anomalies of several

An aeromagnetic survey of the Seward and northern part of the Blying Sound quadrangles was flown by Geometrics, Inc., during 1975-77 to provide magnetic data to aid in an appraisal of the mineral resources. Background details of the regional geology and major structures are described in a companion report by ysdal and Case (1979), and interpretations of the gravity data are described in a report by Case and others (1979). Preliminary results of a paleomagnetic investigation have been reported by Hillhouse and Grommé (1977), and a more complete analysis of the results is in preparation. The aeromagnetic survey was flown at a nominal height of 300 m above the surface and flight lines were spaced about 1.7 km apart. otal magnetic field was measured by a proton-precession magnetometer. The International Geomagnetic Reference Field (IGRF), updated to 1976, was removed, and the residual values were computer-contoured to produce the aeromagnetic map (sheet 1). Detailed aeromagnetic maps at scale 1:63,360 and a map at scale 1:250,000 have been released as Open-File Reports 78-1080 through 1083 (U.S. Geological Survey, 1978). Magnetic anomalies in the Seward-Blying Sound region are somewhat less complex than in other parts of south-central Alaska, primarily because of the huge volume of relatively nonmagnetic flysch that constitutes the Valdez and Orca Groups. Several rather isolated groups of mafic-ultramafic rocks are significantly more magnetic than the flysch assemblages, and cause distinctive patterns of magnetic anomalies. A few of the

GEOLOGIC INTERPRETATION OF AEROMAGNETIC MAP OF THE SEWARD AND BLYING SOUND QUADRANGLES, ALASKA

Five main belts of mafic-ultramafic rocks are distinguished in the area. In the extreme northwest corner of the Seward quadrangle, mafic or ultramafic rocks are inferred to underlie the large magnetic high northwest of the Border Ranges fault, because exposed rocks under the high in the Anchorage quadrangle o the north include peridotite, dunite, clinopyroxenite, and gabbro (Clark, 1972). The second belt is in he McHugh Complex (a melange), between the Border Ranges and Eagle River faults. Small isolated bodies of greenstone, basalt, pillow basalt, gabbro, and serpentinite are scattered through the melange, which is composed dominantly of sedimentary rocks in the Seward quadrangle. The third belt of mafic-ultramafic rock s exposed on the Resurrection Peninsula, in the southwestern part of the area, where pillow basalt, mafic sheeted dikes, gabbro, and serpentinite have been mapped (Tysdal and others, 1977). Isolated patches of reenschist crop out to the north along this trend. The fourth belt, and one of the largest in the area, xtends from Bainbridge, Elrington, and Evans Islands through Knight Island and apparently continues beneath Prince William Sound past Glacier Island to the mainland in the extreme northeast corner of the map area. Mafic sheeted dikes, pillow basalt, massive greenstone, mafic sills, and small isolated bodies of gabbro constitute this belt. All four belts produce magnetic anomalies, including some that can be sed with confidence to trace the belts beneath cover of water, ice, or sedimentary rocks; however, some parts of the mafic belts are nonmagnetic. A fifth belt of mafic-ultramafic rocks is inferred to be deeply buried in the southeastern part of the area beneath a large broad northwest-trending magnetic high.

granitic plutons are magnetic, but most appear to have little or no magnetic expression.

f /45ch(?)

GENERALIZED GEOLOGY MODIFIED FROM TYSDAL AND CASE (1979)

DESCRIPTION OF MAP UNITS

UNCONSOLIDATED SEDIMENTARY DEPOSITS, UNDIVIDED (Holocene)

GRANITE AND GRANODIORITE (Oligocene)--Unfoliated granite and granodiorite

GABBRO (Oligocene(?), Eocene(?), or Paleocene(?))--Olivine-bearing plutonic rocks

GREENSTONE, UNDIVIDED--Basaltic rocks not distinguished as to pillows, dikes, or tuffs

SEDIMENTARY ROCKS, UNDIVIDED--Flysch of sandstone and siltstone, in part metamorphosed to slate and phyllite

SCHIST--Sandstone, siltstone, and some tuffs metamorphosed to biotite grade of greenschist facies

McHUGH COMPLEX--Weakly metamorphosed clastic and volcanic rocks; in large part is a melange

GRANITE (Eocene(?))--Muscovite-bearing granite of Cedar Bay area

GRANITE OF HARDING ICEFIELD REGION (Eocene)--Foliated granite

SEDIMENTARY ROCKS, UNDIVIDED--Flysch of sandstone and siltstone

SHEETED BASALT DIKES--Sequence composed almost wholly of dikes

SHEETED BASALT DIKES--Sequence composed almost wholly of dikes

ULTRAMAFIC ROCKS--Small tabular bodies of serpentinized dunite

GABBRO--Large pluton that intrudes sheeted dikes and flysch

GREENSTONE AND SEDIMENTARY ROCKS--Basalt sills and dikes intruding flysch

PILLOW BASALT AND SEDIMENTARY ROCKS--Interbedded pillow basalt and flysch

ORCA GROUP (lower Eocene(?) and Paleocene)--Divided into:

GABBRO--Small plutons and locally coarse-grained dikes

PILLOW BASALT--Submarine extrusive basalt

VALDEZ GROUP (Upper Cretaceous)--Divided into:

PILLOW BASALT--Submarine extrusive basalt

TUFF--Aquagene tuff interbedded with flysch

McHUGH COMPLEX (Cretaceous and(or) Jurassic)

GLACIER

Several major magnetic lineaments, expressed as zones of steepened magnetic gradient, trend north and northeast through the area. Some of these are believed to represent deep-seated geologic boundaries between blocks having different depths to magnetic basement or different magnetic properties. Acknowledgments. -- We are grateful to many specialists for cooperation throughout this investigation. Invaluable guidance in magnetic modeling was provided by Richard J. Blakely. Robert Sikora measured sus-ceptibilities of many rock specimens and assisted in the magnetic modeling. Gordon Thrupp assisted in he paleomagnetic measurements. Susan Bartsch-Winkler generously provided measurements of the magnetite content of samples from the Portage drill hole and other geologic data from the Turnagain Arm area. We especially wish to thank our colleagues E. M. MacKevett, Jr., George Plafker, Gary Winkler, Travis Hudson

and Andrew Griscom for many helpful suggestions and discussions in the field and office.

MAGNETIC PROPERTIES OF MAJOR ROCK UNITS Determining magnetic properties of rocks is a major problem in quantitative interpretation of aeromagnetic data. Hand specimens collected from outcrops, or drilled specimens obtained from depths of several centimeters or more within the rock, commonly yield values of susceptibility and remanent magnetization that are somewhat too low to account for many of the observed aeromagnetic anomalies in this area. his discrepancy probably results in part from the near-surface weathering of magnetite to less magnetic or nonmagnetic oxides. For example, susceptibilities (all presented as centimeter-gram second (cgs) units) were measured on more than 89 random, unoriented hand specimens from the mafic-ultramafic complexes. Only 19 values are greater than 0.1×10^{-3} . Maximum measured value for basalt is about 3×10^{-3} ; for diabase, about 4×10^{-3} ; for "greenstone," about 3.4×10^{-3} ; for serpentinite, about 1.5×10^{-3} cys units. Many remanent magnetizations determined from drill cores of pillow basalt, dikes, and sills also have low values, less than 1×10^{-3} electromagnetic units (emu) as shown in table 1. Values of Q, the ratio of remanent to induced magnetization, have a wide range, but most values are about 0.5 to 1.0. Thus, the total magnetization, the vector sum of the induced and remanents. the vector sum of the induced and remanent components, as observed at the flight elevation, may be slightly dominated by the remanent component in some areas, but in other areas the induced component is dominant. Where the mean vector sum of the remanent and induced magnetization is steep, especially on Knight Island, we presume that the aeromagnetic anomalies are not offset horizontally very far from the rocks causing them. Remanent magnetizations of rocks from three sites on the Resurrection Peninsula are reversed, and the inclination of the mean vector sum of the remanent and induced magnetization at one of the sites is

Table 1.--Summary of magnetic properties of mafic rocks from the Seward and Blying Sound quadrangles, Alaska [K, Magnetic susceptibility, in cgs units; J, Magnetization, in emu/cm3; Q, Koenigsberger ratio (ratio of remanent to induced magnetization); I, Inclination of magnetization, in degrees;

less than 30°. Thus, some aeromagnetic anomalies may be offset horizontally from the source rocks

Declination of magnetization, in degrees

 $\frac{22}{5}$ amples with K > 0.0002.

from these islands have low susceptibilities.

Rock type	Site number	Number of samples	Average K	Average induced J(10 ⁻³)	Average Q	Average I	remanent D	J(10-3)	(reman	nent + i	induced J(10 ⁻³)
			REST	JRRECTION PENINSUL	<u>A</u>						
Sheeted dikes	201	65	0.00243	1.35	1.02	-60.10	277.48	1.24	18.39	314.11	0.66
do.	311	17	.00123	.682	.531	- 9.37	328.62	.187	61.49	357.76	.70
do.	201, 311	82	.00128	1.21	.959	-59.05	280.78	1.00	28.15	319.11	.62
do.	201, 311	66	.00269	1.49	.959	-59.03	280.62	1.24	28.13	318.95	.76
Pillow basalt	301	10	.0000565	.0313	.0391	-31.18	341.70	.000582	72.23	22,55	.03
			KNIGH	T ISLAND AND VICIN	VITY						
Sheeted dikes	392	9	0.000264	0.147	1.06	74.50	253.77	0.0780	81.64	356.10	0.2
do.	401	10	.0000447	.00249	.899	-29.02	285.67	.0102	61.39	327.64	.02
do.	421	20	.0014	.778	.993	85.52	70.69	.739	79.90	34.35	1.5
do.	502	10	.000314	.175	.509	48.14	296.34	.0136	74.29	15.12	2 .18
do.	All sites, all samples	49	.000692	. 385	.951	86.89	62.06	.316	79.83	30.24	4 .69
do.	392, 421, 502 2/	15	.00210	1.17	.930	86.44	58.77	1.08	80.00	30.92	2 2.2
illow basalt	351	10	.0013	.723	.431	46.11	128.64	.278	74.57	74.90	9.0
do.	371	11	.0000670	.0373	1.91	44.97	69.05	.0707	55.89	61.85	5 .1
do.	3 51, 371	21	.000653	. 364	.510	48.53	116.50	.162	72.62	72.23	3 .4

The sheeted dikes tend to have a slightly larger susceptibility and remanent magnetization than the pillow basalts. This difference may result from alteration of the pillow flows by chemical reactions with seawater or from greater ease of weathering and alteration of pillow flows because they are more porous and All of the sedimentary rocks are essentially nonmagnetic. Susceptibilities of more than 30 specimens of sandstone, argillite, slate, phyllite, and schist are all less than 10-4 cgs unit. Similarly, susceptibilities of 17 samples of granitic rocks are all less than 10^{-4} cgs unit. Although granitic rocks on Perry Island and Culross Island are locally magnetic, as discussed below, the few samples measured

Because of the rugged steep terrain in most of the area, "drape-flying" at a constant elevation of 300 m above the surface was impossible to achieve. Flight elevations were approximately 300 m over ridge crests, lakes, and sea, but over the narrow deep glacial valleys and fiords the aircraft could not safely maintain a constant height above the surface, and therefore some apparent anomalies result from the geometry of the actual survey. For example, numerous apparent magnetic lows may appear over valleys if the topography is carved in a magnetic medium even though magnetic properties do not vary laterally. On the other hand, if the magnetic basement is buried beneath the topographic relief, magnetic highs may occur over valleys because the aircraft is actually closer to the basement than over the ridges, even though the distance above the ground surface may be higher over the valleys. A possible additional effect is that of the earth's main dipole field: an increase in elevation of 1 km above sea level can decrease the main field by about 25 gammas. Griscom (1975) further discussed problems inherent in drape-flying.

INTERPRETATION OF THE AEROMAGNETIC MAP

From combined analysis of the aeromagnetic map (sheet 1) and the regional geologic map (Tysdal and Case, 1979), a generalized interpretive map (sheet 2) has been prepared. Subjective boundaries have been drawn around most of the major magnetic anomalies, and these areas are interpreted in terms of the associated rocks One of the largest features of the magnetic map (sheet 1) is a major change in the level of the magnetic

field from east to west. Values of the magnetic field consistently are at least 100 gammas higher in the east

half of the area than in the west half. We do not know whether or not this regional variation is an artifact caused by an error in parameters of the IGRF. It may be that the total thickness of flysch is greater in the In most of the western third of the map, the magnetic trends are about north-south, as is the grain of the regional geology. In the extreme northwest corner of the area, hear Turnagain Arm, a large magnetic high (anomaly , sheet 2), having a relief of more than 500 gammas, forms part of the "Knik Arm anomaly" discussed by Grantz, zietz, and Andreasen (1963). They interpreted the anomaly as being generally related to the Seldovia geanticline: Elongate narrow discontinuous but widely distributed intrusive bodies occur along the axis of the Seldovia geanticline where it is exposed from the Copper River to the northwest side of Kodiak Island. These axial plutons are inferred to produce the Knik Arm anomaly." They did not specify the compositions of the "plutons." Clark

1972) mapped ultramafic bodies near the site of the Knik Arm anomaly, north of Turnagain Arm. MacKevett and Plafker (1974) postulated that the southern extension of the Border Ranges fault lies close to the east edge of

the Knik Arm anomaly. From these considerations, Andrew Griscom (oral commun., 1975) proposed that the Knik Arm

anomaly reflects a belt of mafic-ultramafic rocks along the east margin of the Kenai Lowland.

From the steepness of the magnetic gradients on the east flank of the anomaly, we estimate that the top of the magnetic mass is less than 2 km below the flight elevation, or roughly 1 km or less below the ground surface. Judging from the limited aeromagnetic data, the east flank of the mass is steep and has a fairly straight trace. The east flank of the anomaly is presumably the trace of the Border Ranges fault, hence it appears to be a highangle rather than low-angle fault near Turnagain Arm.

Immediately to the east of the Border Ranges fault, small magnetic highs and lows having amplitudes of a few tens of gammas (anomaly area 2) occur over the McHugh Complex. These anomalies mainly are associated with blocks of mafic and ultramafic rocks of the melange, but some anomalies could be related to small granitic plutons, although none are exposed in the area. Small outcrops of serpentinite, gabbro, and basalt occur under the small highs just west of the Eagle River thrust in T. 8 and 9 N., R. 3 and 4 W. (anomaly 3).

Still farther south (anomaly area 4), small magnetic highs and lows over the Valdez Group flysch could reflect small unexposed granitic plutons or local mafic bodies. At least two of these anomalies (R) appear to be caused by rocks of reversed remanent magnetization because they have an inverse correlation with topography. Farther south, along the west border of the quadrangle, a discontinuous regional magnetic low (anomaly 5) is defined by a series of small closed lows and by several poorly defined zones of steepened magnetic gradient (anomalies 6, 7, and 8). A small high (anomaly 9) over the Harding Icefield probably represents a concealed pluton

The large granitic plutons in the southwestern part of the quadrangle, near the Ailik and Harris Peninsulas, differ little from adjacent sedimentary rocks in magnetization, but negative flexures in the regional contours suggest that they may be slightly less magnetic or reversely magnetized (anomalies 10 and 11). Several zones of steepened magnetic gradient (anomalies 12-16) trend north from the strongly magnetic bodies of the mafic-ultramafic complex exposed on the Resurrection Peninsula (discussed below). These magnetic lineaments are parallel to the regional geologic grain and may represent deeply buried steps in the magnetic basement or slight differences in magnetization of the basement. From analysis of the breadths of these gradients, the magnetic basement could be 5 km or more beneath the flight elevation. The deepest magnetic basement may occur between the Eagle River thrust fault and lineaments 15 and 16. It is possible that some of the gradients may represent slight diurnal variations in the earth's field between adjacent north-south flight lines.

Anomaly computed for inclination 73°, declination 26°, Observed anomaly Anomaly computed for inclination 85° declination 30° Magnetization = 1.65×10-3

GEOLOGIC INTERPRETATION OF AEROMAGNETIC MAP OF THE SEWARD AND BLYING SOUND QUADRANGLES, ALASKA

GEOLOGIC INTERPRETATION

upper Jurassic

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET

CORRELATION OF MAP UNITS

Holocene

01igocene

Qu

Tg

Tgc

Tos Tog Top Tod Togs Tops Togb

Kv Kvs Kvp Kvd Kvt Kvg Kvu

NATIONAL GEODETIC VERTICAL DATUM OF 1929

J. E. CASE, R. G. TYSDAL, J. W. HILLHOUSE, AND C. S. GROMMÉ

1979

Very deep mum-

serpentinital?)

BOUNDARY OF AFROMAGNETIC SURVEY

QUATERNARY

TERTIARY

TYONEK ANCHORAGE VALDEZ

10

00

SELDOVIA BLYING MIDDLETON ISLAND

KENAI SEWARD CORDOVA

Q 2 4 6 KILOMETERS

Figure 1.--Analysis of the magnetic anomaly north of the Resurrection Peninsula along profile A-A'. Datum for computed profile is arbitrary.

Computed anomaly for inclination 73°, declination 25° Mostly pillow basalt Mainly mafic rocks magnetization = 1.85 x 10 emu/cm Mainly flysch Magnetization = 0 Magnetization = 0 Q 3 4 6 KILOMETERS

Figure 2.--Interpretation of magnetic profile B-B' across Chenega and Knight Islands. Datum for computed profile is arbitrary.

THIS MAP IS ONE OF A SERIES, ALL BEARING THE NUMBER MF-880 BACKGROUND INFORMATION RELATING TO THIS MAP IS PUBLISHED AS U.S. GEOLOGICAL SURVEY CIRCULAR 760 , AVAILABLE FREE FROM U.S. GEOLOGICAL SURVEY, RESTON, VA. 22092