UNITED STATES
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AEROMAGNETIC INTERPRETATION MAPS OF THE AMBLER RIVER QUADRANGLE, ALASKA

(Discussion to accompany sheets 1, 2 and 3)

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This report is preliminary and has
not been reviewed for conformity
with Geological Survey editorial
standards and stratigraphic nomenclature

INTRODUCTION

A 1:250,000-scale total-intensity magnetic anomaly map (sheet 1) of the Ambler River quadrangle was compiled from regional aeromagnetic surveys flown in 1974 and 1975 on contract for the State of Alaska Department of Natural Resources (DNR). The magnetic data were released by the Alaska Division of Geological and Geophysical Surveys (ADGGS) in 1:63,360-scale aeromagnetic maps during 1975 (western half) and 1976 (eastern half).

The airborne surveys were flown at 300 m (1,000 ft) above ground level (AGL) along north-south flight paths spaced about 1.6 km (1.0 mi) apart in the west and 1.2 km (0.75 mi) apart in the east. Flightline navigation and position, which were controlled by preliminary 1:63,360 topographic mapping, may contain some errors that affect the magnetic anomalies. Altimetry data were continuously recorded for each flight path. A regional magnetic trend of 3.45 gammas/mile north and 2.25 gammas/mile east (a negative southwestward gradient of about 4 gammas/mile) was removed by using the 1965 International Geomagnetic Reference Field updated to the time of the 1974 and 1975 aeromagnetic surveys. The magnetic data were processed and contoured on 1:63,360-scale maps and subsequently compiled (Hackett, 1977) to form the 1:250,000-scale aeromagnetic map. Contour intervals and labels are at 10, 50, and 100 gammas.

To obtain a constant mean terrain clearance the aeromagnetic survey was flown by a "drape flying" technique, i.e., at a nominal 300 m above the ground surface. This procedure minimizes the loss of resolution and attenuation of anomalies that might have occurred with an increased flying height at a constant barometric altitude, i.e., a constant height above sea level rather than a common height above ground level. Rugged topography and marginal weather conditions in the Brooks Range caused the aircraft to diverge in some instances from nominal AGL height. A review of selected altimeter data and comparison of the topographic and aeromagnetic maps shows that some anomaly components are related to topography. Anomalies that have some appreciable or suspected topographic expression are noted on sheet 2.

The aeromagnetic anomalies and patterns (sheet 1) and the resulting magnetic lineaments and trends (sheet 2) are caused mainly by variations in the magnetic mineral content of the bedrock geologic units. This report only qualitatively summarizes the aeromagnetic patterns and trends, and makes some interpretations of the major geologic features. Many oriented samples from various representative rock units would be necessary to determine natural remanent magnetism (NRM) and induced magnetization (IM) as well as assist in modeling the depth, width, and dip of the magnetic units. Detailed geologic and geophysical interpretation of the major anomalies within the Ambler River quadrangle will require more data regarding physical rock properties and geologic setting than are currently available.

Sheet 2 was derived from the aeromagnetic map and prepared to assist in geologic interpretation of the magnetic patterns. The lineaments (O'Leary and others, 1976) are boundaries, trends, and truncation lines of the regional magnetic pattern. The criteria used for identifying major lineaments were: a) change in magnetic gradient, b) termination or truncation of magnetic highs and lows, c) linear pattern of magnetic contours, and d) selected alignments of magnetic highs and lows. Some magnetic boundaries are related to mapped geologic contacts, and these are outlined on the map. The steepest gradients in this region occur over the approximate boundaries between rock units that have differing magnetic properties, where the current total magnetic field is steeply inclined at approximately 77^{o}. Normal magnetic polarization, geometry of the magnetic masses, and possibly reverse remanent magnetism can cause, or in part accentuate, the magnetic lows in some regions.

The major geologic features in the Ambler River quadrangle generally correlate with the magnetic trends at a 1:250,000 scale, even though some discrepencies are evident between the regionally mapped surface geology and the 1:63,360-scale (ADDGS, 1974, 1975) aeromagnetic data. The geologic mapping within areas of the quadrangle is probably not detailed enough to explain some of the subtle and correlatable trends indicated on the magnetic lineament and anomaly trend map (sheet 2). However, the aeromagnetic data probably define some of the bedrock geology at depth. They may also identify unmapped structural features and should aid in testing suspected geologic trends.

Sheet 3, the geological interpretation map of the aeromagnetic data, shows the major magnetic-lithologic units and their boundaries. The boundaries were identified and integrated from a spectrally colored copy of the aeromagnetic map (sheet 1) and from the lineament and anomaly trend map (sheet 2). The units were cross-correlated with generalized geologic maps (Brosgé and Pessel, 1977; Mayfield and Tailleur, 1978), detailed geologic maps (Fritts, 1969, unpub. data; Pessel and others, 1973) and observations by the author during the 1975, 1976, 1977 field seasons. Identification of major types of geologic trends has been attempted by using the relative magnetite content of the lithologic units and the characteristic magnetic anomaly patterns and amplitudes of 1:63,360-scale aeromagnetic maps. Relative magnetizations and implied lithology of the magnetic anomalies are assigned to prominent areas. Some large asymmetric magnetic lows are thought to be caused by natural reversed remanent magnetism (indicated by the letter "R"). Other negative anomalies adjacent to positive anomalies are probably caused by normal magnetic polarization effects. Relatively persistent zones of steepened magnetic gradients, and abrupt truncation of magnetic anomalies and trends are interpreted as major discontinuities (faults, unconformities, or facies changes) that may have a surface expression.

A geologic terrane was correlated with each magnetic anomaly to indicate the most probable lithologic cause of the magnetic feature. Magnetic-lithologic units were assigned to magnetic anomaly trends to assist in the geologic interpretation of the aeromagnetic data. Local magnetic anomalies are caused by near-surface exposures of relatively high-intensity magnetic rock units. These bedrock units are commonly underlain by larger magnetic bodies and are appreciably influenced by the magnetism of adjacent terranes. The aeromagnetic anomalies in the Ambler River quadrangle represent composite sets of juxtaposed magnetic boundaries, which further complicate geologic interpretation. The interpretive explanation (sheet 3) outlines: 1) the assigned geophysical-geological units, 2) their relative strength of magnetization, 3) implied lithology as derived from the generalized geologic map (Brosgé and Pessel, 1977; Mayfield and Tailleur, 1978), and 4) field observations from 1975 to 1978 (Hackett, unpub. data). Principal magnetic-lithologic boundaries, geophysical faults, and selected structural features have been keyed for reference (see explanation). The major magnetic terranes are outlined according to characteristic regional anomaly patterns, and important magnetic lineaments are identified (fig. 1).

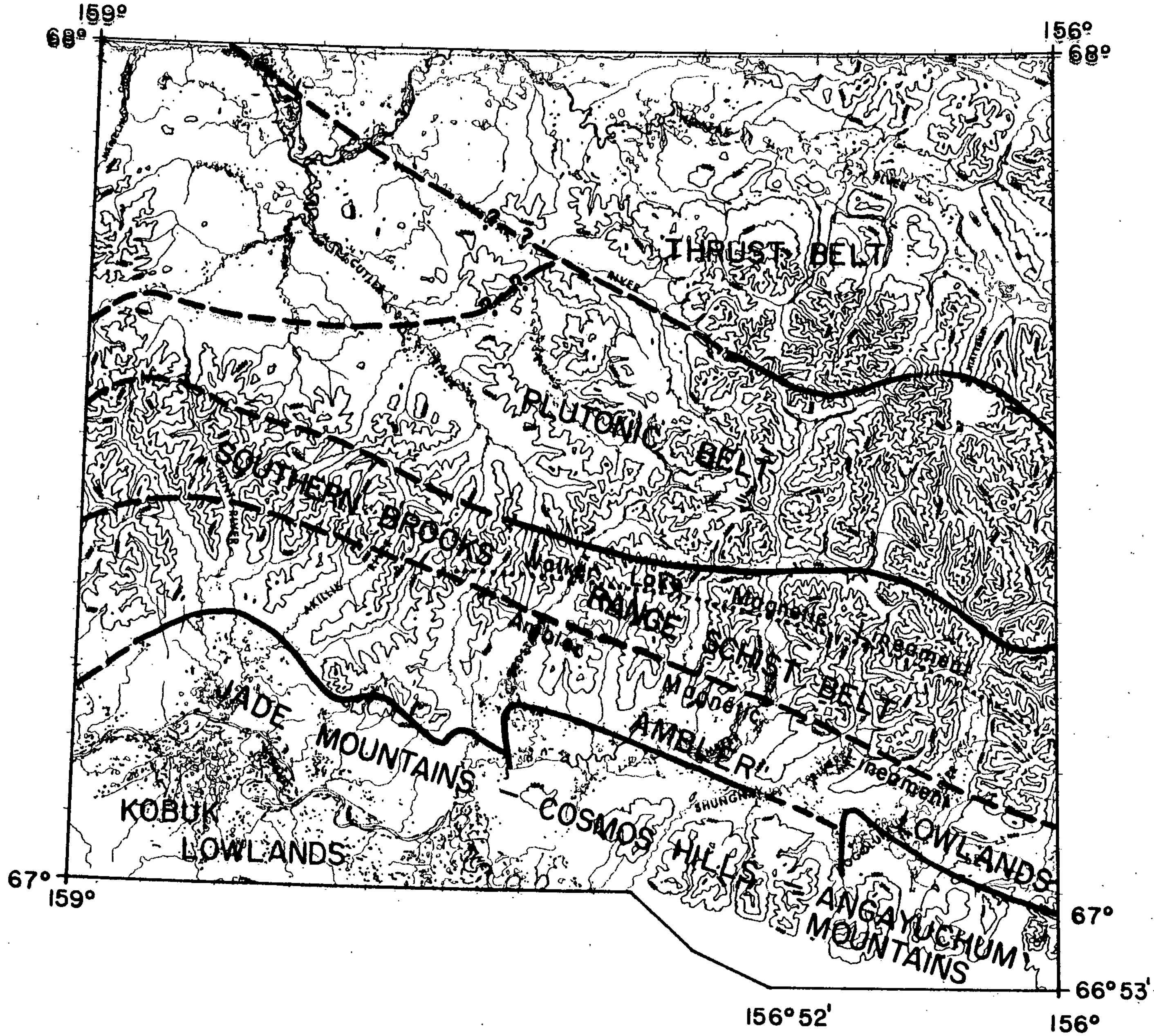

Figure 1.--Aeromagnetic terranes of the Ambler River quadrangle.

GEOLOGICAL INTERPRETATION--DESCRIPTION OF MAGNETIC ANOMALIES, LINEAMENTS AND TERRANES

Ambler Lowlands

The Ambler Lowlands terrane (fig. 1), a linear east-west topographic low in the south-central and southeastern part of the Ambler River quadrangle, parallels the Kobuk fault zone (Grantz, 1966; Patton, 1973) and is approximately coincident with the northern boundary of that fault zone. The fault system is thought to be a crustal break within the basement rocks and may have been subject to repeated movement over a long period of geologic time (Gilbert and others, 1977). Two major changes in the magnetic trends are associated with and parallel to this zone (fig. 1):

a) the northernmost change in magnetic character, a few kilometers north of the lowlands in the southern part of the Brooks Range schist belt, is identified by a regionally persistent step in gradient and has been designated the Ambler Magnetic lineament, and

b) the southern break in magnetic character, the boundary with the Jade Mountains-Cosmos Hills-Angayuchum Mountains terrane, lies at the southern edge of the lowlands and is somewhat broken, wedge-shaped, and irregular.

Superimposed on these regional magnetic features is the Ambler Lowland terrane, a linear zone of nearly flat magnetic field that reflects the major structurally controlled topographic depression of the Ambler Lowlands. The Kobuk fault zone, which occurs at the southern edge of the Ambler Lowlands terrane, defines a significant change in rock types (Tailleur, 1970; Patton, 1973) and is outlined by magnetic anomaly patterns and trends. Two different crustal complexes have been suggested to be in contact in this root zone (the Kobuk suture) along the southern flank of the Brooks Range (Tailleur, 1973;

Roeder and Mull, 1978). This regionally identified geologic and geophysical feature is interpreted to represent a major boundary between oceanic and continental crust that was juxtaposed possibly in Late Jurassic and Early Cretaceous time during the Brooks Range orogeny. Structural mixing of rocks from both sources has probably occurred over a wide area associated with this geologically and geophysically outlined boundary. This major magnetic feature suggests a south-dipping boundary that, although locally broken, extends many kilometers both within and east of the Ambler River quadrangle along the southern margin of the Brooks Range (Hackett, 1977, 1980 in press).

Jade Mountains-Cosmos Hills-Angayuchum Mountains

Within the Jade Mountains-Cosmos Hills-Angayuchum Mountains terrane (fig. 1), the magnetic signature is characterized by sharp, high-amplitude anomalies that are related to exposures and subcrops of mafic and ultramafic igneous rocks. Large, high-amplitude anomalies reflect the exposed serpentinite bodies, and adjacent magnetic patterns indicate additional ultramafic bodies beneath the alluvium or Cretaceous sedimentary rocks. Some moderate and broad magnetic lows are associated with the phyllites, carbonates, and related rocks in the area. In the Jade Mountains, anomaly patterns suggest south-southwestward-dipping, layered slabs of volcanic and ultramafic rocks. The large asymmetric negative anomalies associated with the mafic and ultramafic rocks indicate that reversed remanent magnetization might be present in addition to normal polarization effects of these southward-dipping magnetic bodies. Because magnetic property measurements (NRM may be present) from outcrops are not available, the dip of these magnetic layers with depth is not quantitatively documented. However, geologic attitudes taken from selected outcrops (Patton and others, 1968; and Fritts, 1969, 1970, and 1971; Pessel and Brosgé, 1977; and Hackett, unpub. data, 1975, 1977) indicate a regionally south to southwestward dip at the surface. In the Cosmos Hills, the mafic and ultramafic rocks and the overlying clastic rocks have been tectonically emplaced and were subsequently arched over schist and carbonate rocks (Fritts, 1969), which may correlate with some schist terranes in the belt just north of the Ambler Lowlands (fig. 1). The magnetic patterns over and adjacent to the Cosmos Hills show the arch in the rocks expressed at the surface.

Kobuk Lowlands

The Kobuk lowlands (fig. 1), in the southwest corner of the Ambler River quadrangle, contains poorly drained tundra-covered marshes, ponds, and lakes through which the Kobuk River meanders. Extensive alluvium and fluvioglacial, lacustrine, and eolian deposits blanket the area. Broad asymmetric magnetic anomaly patterns indicate considerable and varied depth to magnetic basement throughout the lowlands. However, tilted grabens or yoked basins as interpreted from magnetic patterns may be present under the surficial deposits. These basins probably contain considerable thicknesses of Cretaceous or younger(?) clastic sedimentary rocks. Relatively high-intensity magnetic anomalies over the Waring Mountains at the extreme southern edge of the quadrangle may be in part caused by tilted east-west-trending mafic and ultramafic rock units (Ju, Js) that are overlain by Cretaceous clastic rocks (Kc). These magnetic anomalies are probably the segmented westward extension of a prominent magnetic trend along the Shungnak-Kobuk lowlands to the east (Hackett, 1977, 1980 in press). Clastic rocks with significant percentages of mafic rock fragments may also contribute to the relatively narrow and high-intensity magnetic anomalies in the area.

Southern Brooks Range Schist Belt

Metamorphic rocks in the southern Brooks Range schist belt (fig. 1) have subtle and variable magnetic responses but show strongly developed regional magnetic anomalies and gradients subparallel to structural and stratigraphic trends. Some magnetic anomalies are locally associated with a chloritic schist unit (Pzcq, sheet 2) in the central and northern part of the schist belt. Relatively high susceptibility contrasts are in part associated with a magnetite-rich quartzite unit (Pzmq, sheet 2). The regional aeromagnetic data indicate that magnetic anomalies greater than 40 gammas are absent over most of the known zinc, copper, lead, gold, and silver deposits within the schist belt. This important metallogenic trend, the southern Ambler District mineral belt, can be magnetically characterized only in terms of its association with other regional geologic features on the 1:250,000-scale aeromagnetic map. Truncation of magnetic anomalies suggests basement faults or near-vertical contacts at depth between the schist-belt rocks, the Ambler Lowlands, and the rocks in the Cosmos Hills-Angayuchum Mountains trend.

Variable and inconsistent anomalies occur over felsic intrusive rocks that are also numerous in the south and central parts of the Ambler River quadrangle (Mayfield and Tailleur, 1978). Small granitic bodies have been mapped near the Walker Lake fault (Pessel and others, 1975) and within the schist belt (Pessel and Brosgé, 1977). A small stock crops out in the core of the arch of the Cosmos Hills, just south of the quadrangle boundary (Fritts, 1970, 1971). A small skarn that may have resulted from granitic intrusion at depth or localized thermal metamorphism crops out near the core of the Kalurivik Arch in the schist belt (Wiltse, 1975; Tailleur and Pessel, oral commun.). Some mafic lenses (mi) within the schist belt (Pessel and Brosgé, 1977) that have important structural significance cause localized positive magnetic anomalies which produce irregularities in the regional magnetic pattern.

The absence of any strong magnetic boundaries along the southern portions of the Brooks Range schist belt may be due to a northerly change in metamorphic grade (Mayfield, 1975) and repeated thermodynamic metamorphism associated with mid-Paleozoic and probable Jurassic-Cretaceous orogenic events (Gilbert and others, 1977). Magnetite formed in the ferruginous sediments at very low metamorphic grades may selectively recrystallize into other minerals (such as iron-titanium oxides and ferromagnetic sulfides) at increased pressures and temperatures, which may result in different magnetic susceptibilities in different places over a metasedimentary rock unit.

Walker Lake Magnetic Lineament

A narrow, high-relief magnetic zone is associated in part with the Walker Lake fault first described by Fritts and others (1972). The Walker Lake magnetic lineament (fig. 1) is associated with an important lithologic boundary that trends across many tens of kilometers in the southern Brooks Range. This geological and geophysical feature appears to be a stratigraphic boundary (possibly a regional unconformity or megafacies change), but structural dislocation of units on both sides of the lineament occurs in some areas. Fritts thought this geologic boundary, which separates a northern carbonate-calc schist terrane from the southern mica quartz-rich schist belt, was a major thrust fault. The Walker Lake magnetic lineament, which is in part correlative with this geologic boundary, trends from Walker Lake east of the Ambler River quadrangle into the study area, where it seemingly broadens and then disappears westward near the Redstone River. The magnetic gradient associated with this lineament also diverges and dies out near the west-central part of the Ambler River quadrangle (Gilbert and others, 1977) and may be truncated by the Ambler magnetic lineament. The Kalurivik Arch, a major antiformal structure that extends for at least 62 km along and within the southern Brooks Range schist belt (Pessel and others, 1973) occurs between the Walker Lake and Ambler magnetic lineaments. The convergence of these lineaments outlines the western boundary of this important anticlinal trend. Other reconnaissance-mapped bedrock units appear to have subtle convergent structural trends in the central and western part of the quadrangle. The southern and westward termination of magnetic features associated with geologic trends may reflect a southwesterly convergent structural style for the western Brooks Range schist belt.

Plutonic Belt

North of the Walker Lake magnetic lineament, a belt of plutonic rocks (fig. 1) intruding schists and carbonates is characterized by low-amplitude magnetic anomalies. There are large, asymmetric negative anomalies associated with the mid-Paleozoic and younger(?) intrusive rocks along this belt. The younger granitic rocks appear to have intruded a complexly folded and faulted series of metamorphic rocks and massive carbonates that show structural evidence of extensive thrust faulting. Rock alteration, which includes increased metamorphic grades (Mayfield, 1975), probably outlines contact metamorphic aureoles associated with and bordering some of the plutonic bodies which may be reflected by relatively high-intensity magnetic zones near the plutons. Many of the magnetic boundaries, which are associated with the contacts between the plutons and the country rock, are roughly concentric and elongate. These magnetic patterns suggest pretectonic emplacement and later tectonic infolding within the metamorphic (metasedimentary) basement.

A negative and low-amplitude magnetic anomaly is associated with the Shishakshinovik pluton (T. 23 N, Rs. 10 and 11 E.) that suggests a batholithic complex with vertical or northward dipping contacts. Local positive magnetic anomalies reflect the thermally metamorphosed roof pendants (Pessel and others, 1973) over this pluton. The magnetic configurations and patterns suggest that the Redstone (T. 25 N., R. 8 E.) and Kaluich (T. 25 N., Rs. 2 and 3 E.) plutons dip to the south at depth. The asymmetric low and high magnetic patterns associated with these plutonic bodies imply that normal magnetic polarization effects are present over these large intrusive complexes.

Within the plutonic belt the dominant west-northwest magnetic trends associated with chlorite schists (unit Pzuc, sheet 2) are locally deflected by northwest-southeast lineaments that suggest horizontal separation and block movements in the area. Regional bedrock mapping by various workers throughout the plutonic belt does not indicate that significant faulting is associated with the lineaments. However, some minor north-south and northwest-southwest block faults have been documented by detailed mapping in parts of the quadrangle (Gilbert and others, 1977). In the adjoining Survey Pass quadrangle to the east (Pessel and Brosgė, 1977; D. Grybeck and S. W. Nelson, written commun.), similar block faults have been observed and noted by the author during the 1975-78 field seasons.

Widespread effects of Cretaceous tectonism and plutonism, which may have affected a considerable part of the western and central Brooks Range (Tailleur and Brosgė, 1970; Tailleur, 1970; Newman and others, 1977), are believed to be outlined in part by the regional aeromagnetic anomaly patterns within the Ambler River quadrangle. The complex alteration of the metamorphic grade of the various rocks units associated with plutonism has undoubtedly contributed to the complex aeromagnetic patterns and susceptibility contrasts within the quadrangle. Areas of intrusive rocks within the plutonic belt are outlined on the geologic interpretation map as curvilinear zones of steepened magnetic gradients and sharp magnetic discontinuities that persist for many kilometers in the central part of the quadrangle. These magnetic patterns and lineaments reflect major magnetic discontinuities within the basement rocks and probably indicate a fundamental tectonic pattern that is related to the emplacement of the plutons. The intense magnetic relief associated with magnetite-rich metamorphic and igneous terranes dominates the east-central and central parts in the Ambler River quadrangle. A subtle regional break in magnetic gradient in the northern parts of the plutonic belt outlines the possible westward extension of a south-vergent thrust belt (Mull, 1977). North of the axis of the regional intrusive rock belt a relatively thick sequence of Paleozoic carbonate clastic and pelitic rocks overlies deep magnetic basement.

Thrust Belt

North and northeast of the plutonic belt, the "thrust belt" (Mayfield and Tailleur, 1978) typically has a subdued magnetic signature, indicating that a magnetic basement lies at considerable depth under the carbonates and sediments of the Baird, Lisburne, and Endicott Groups of Paleozoic age. Some positive anomalous areas, such as within the Kavachurak Creek and Tunukuchiak Creek drainages, probably are associated with a shallowing magnetic basement and may reflect tectonic windows within the carbonate and clastic terranes. A broad magnetic high along the northern part of the Ambler River quadrangle indicates some deep and significant regional intrabasement contrasts toward the north. The relatively large positive magnetic anomalies over the Cutler River lowlands are probably associated with mafic rocks or magnetite-rich chloritic schist units (Pscq, sheet 2) at shallow depths. In the northeastern part of the quadrangle, a change in the magnetic grain and steepening of gradient infers a major basement discontinuity at depth in this area. The subtle break in magnetic contours and patterns at the southern edge of the thrust belt probably marks the northern edge of the granitic core of the Brooks Range.

CONCLUSIONS

The aeromagnetic anomalies, trends, and lineaments in the Ambler River quadrangle correlate well with known regional geologic and tectonic trends at a 1:250,000 scale. However, the geological interpretation of the Ambler River quadrangle aeromagnetic data has been generalized from 1:63,360-scale aeromagnetic maps to reduce some of the more obvious ambiguity that occurred when integrating regionally mapped geologic information and geophysical data at different scales.

The southern parts of the aeromagnetic map (sheet 1) are mostly dominated by intense magnetic relief along the Jade Mountains-Cosmos Hills-Angayuchum Mountains terrane. This terrane is associated with exposed metamorphic, mafic, and subordinate ultramafic rocks. Northern truncation of magnetic anomalies within and adjacent to the Ambler River Lowlands suggest, major basement faults or near-vertical lithologic contacts between the Jade Mountains-Cosmos Hills-Angayuchum Mountains terrane and the southern Brooks Range schist belt. In addition, a persistent change in regional magnetic gradient, the Ambler magnetic lineament, indicates a significant change in basement lithology along the southern margin of the Brooks Range. This magnetic gradient provides some geophysical evidence for a possible covered south-dipping boundary between basement rocks of predominately oceanic character to the south and continental rocks to the north. A narrow, composite magnetic high is associated with the Walker Lake fault (Fritts, 1970) and trends as a magnetic lineament from Walker Lake in the Survey Pass quadrangle to where the magnetic high broadens as a gradient westward across the Ambler River quadrangle. This magnetic trend, the Walker Lake magnetic lineament, is truncated by the Ambler magnetic lineament near the Redstone River, where the lineament outlines the western plunge of the Kalurivik Arch. Metamorphic and volcanic rocks of the southern Brooks Range schist belt have a subdued but variable magnetic signature and show strongly developed regional magnetic trends subparallel to geologic strike. Aeromagnetic lineaments and anomaly trends within the plutonic belt outline major magnetic zones within the basement rocks and probably indicate a fundamental tectonic pattern that is interpreted to be related to the emplacement of plutons. The thrust belt, a thick stratigraphic sequence of tectonically emplaced Paleozoic carbonate and clastic rocks, overlies deep magnetic basement in the east-central and northeast parts of the quadrangle.

Oriented rock samples from some of the major magnetic units are needed for a detailed interpretation of the aeromagnetic data. Detailed geological mapping, geophysical surveys, and rock-sampling programs to obtain physical rock properties would provide more definitive data for determining the metamorphic and petrophysical effects of buried plutonic bodies. A quantitative study of detailed aeromagnetic and ground magnetic data would provide additional evidence for the possible size, shape, and depth of burial of the magnetic units and for the configuration of selected metamorphic, igneous, and sedimentary terranes.

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