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AEROMAGNETIC RECONNAISSANCE OF THE EAST-CENTRAL TANANA LOWLAND, ALASKA

By

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INTRODUCTION

In 1954 the U. S. Geological Survey conducted a reconnaissance airborne-magnetometer survey over an area of 900 square miles in east-central Tanana Lowland; the survey extends from the hills north of Fairbanks south across the lowland to the northern foothills of the Alaska Range (see index map). This survey was a part of a program of regional and reconnaissance aeromagnetic evaluation of possible petroleum provinces and was coordinated with other geologic investigations of the U. S. Geological Survey in Alaska. The principal target of the survey was the determination of the thickness of fill, if any, beneath the lowland, based on an analysis of magnetic anomalies produced by the underlying basement rocks.

AEROMAGNETIC SURVEY

Sixteen north-south traverses approximately 60 miles long and spaced one mile apart were flown at an altitude of 2,000 feet above mean sea level (except where local topography required a higher flight altitude). Continuous total-intensity aeromagnetic data were obtained from a modified AN/ASQ-3A airborne magnetometer with a fluxgate detecting element towed about 75 feet below a DC-3 aircraft. Flight lines plotted on topographic maps were used for pilot guidance. The actual flight paths were recorded by a gyrostabilized continuous-strip-film camera. These data were then compiled as a total-intensity magnetic contour map (see transparency). The regional magnetic gradient is about 2.5 gammas per mile, increasing in a northerly direction (U. S. Coast and Geodetic Survey, 1955) and has not been removed from the magnetic map.

GEOLOGY

The known basement rocks of the east-central part of the Tanana Lowland include quartz-sericite schist in the hills on the north side of the Tanana River and in Clear Creek Butte, orthoclase-quartz-sericite schist in the hills at the south side of the map area, and mafic and ultramafic rocks in the Wood River Buttes. Small bodies of granite and granodiorite are intrusive into the schist. A sedimentary sequence consisting of poorly consolidated conglomerate, sandstone, claystone and coal is thrown into broad folds along the south edge of the Lowland, and dips north beneath the Lowland. The lowland is mantled with alluvium and outwash, and the lower parts of the hills north of the Tanana River are mantled with loess. A few patches of basalt occur on the edge of the plain east-northeast of Fairbanks.

Rock units

Birch Creek Schist.--The Birch Creek Schist, of Precambrian age (Mertie, 1937, p. 55), consists of quartz-sericite schist, quartzite, and sericite schist, and includes small bodies of black carbonaceous schist, marble, limy schist, and amphibolite (Mertie, 1937, p. 49; Péwé, 1958). Except for pyrite, opaque minerals are rare or absent. The schistosity, a parallelism of mica plates, is much contorted and tightly folded, and it is cut by a pronounced axial plane fracture cleavage that generally dips less than 45°, and is the most readily observable structure in the exposures.

Totatlanika Schist.--The Totatlanika Schist, of Mississippian(?) age (Wahrhaftig, 1958, p. 12), is feldspar-quartz-sericite schist and gneiss, characterized by potassium feldspar crystals as much as an inch across. Associated with it are layers of black carbonaceous schist. The Totatlanika Schist is exposed in the Japan Hills and along the south border of the mapped area. It probably underlies the Tertiary rocks under the southern part of the mapped area, and extends an unknown distance to the north, buried beneath the Tanana Lowland. Its pronounced foliation is parallel to original bedding and dips 5° to 35° generally to the south.

Mafic and ultramafic rocks.--Fine-grained gabbro, coarse hornblendite, and serpentine crop out in the Wood River Buttes. These may be the westerly extension of a N. 80° E.-trending belt 3-5 miles wide and 45 miles long of magnetite-bearing olivine diabase and serpentine that disappears westward beneath alluvium about 15 miles east of the east edge of the mapped area near lat 64°40' N. (Mertie, 1937, pl. 1, p. 204-205). According to Mertie, these rocks are Devonian (?) in age.

Granitic rocks.--Porphyritic, medium to coarse-grained biotite granite forms the ridge that extends eastward from the head of Engineer Creek, in the northeast corner of the map area (Péwé, 1958). Dark-gray medium-grained quartz diorite forms a small hill at the east end of the Ladd Air Force Base runway (Péwé, 1958). Porphyritic granite may underlie parts of the lowland, because this kind of granite is exposed in the hills along the northeast border of the Tanana Lowland, 15 to 25 miles east of the mapped area, and between lat 64°15' N. and lat 64°24' N.

Basalt.--Three small patches of olivine baslat of Tertiary age crop out at the north edge of the Tanana Lowland about 5 miles east of Fairbanks (Péwé, 1958).

Coal-bearing formation.--A coal-bearing formation, of probable Eocene age (Wahrhaftig, 1958, p. 10), rests unconformably on the Totatlanika Schist in the northern foothills of the Alaska Range, and is exposed in the valleys of the Wood River and Tatlanika Creek. It consists of poorly consolidated sandstone with few heavy-mineral grains, and claystone, conglomerate, and subbituminous coal. Along the south border of the mapped area the formation is between 2,000 and 3,000 feet thick and contains many thick beds of coal; it thins abruptly northward, and is only a few hundred feet thick where Tatlanika Creek emerges from the foothills. North of lat 64°07' N. the formation contains no minable coal. It is not present in the Japan Hills, where the overlying Nenana Gravel rests directly on the Totatlanika Schist.

The coal-bearing formation is thrown into broad open folds the axes of which trend roughly east. Dips on the flanks are locally 35°-50°, particularly along the southern edge of the map area; elsewhere the beds are nearly flat.

Nenana Gravel.--The Nenana Gravel, of middle Miocene or younger age (Wahrhaftig, 1958, p. 11-12) is the youngest deformed rock in the Tanana Lowland and is exposed extensively in the hills in the southern part of the mapped area. It is predominantly a coarse, poorly consolidated conglomerate. Pebbles and cobbles of altered gabbro containing 3 to 5 percent of magnetite or ilmenite locally make up 15 to 50 percent of thick layers of the gravel. The gravel is about 2,000 feet thick along the south edge of the Tanana Lowland.

The Nenana Gravel is deformed into two broad structural terraces separated by a north-dipping monocline. The higher terrace underlies the dissected plateau in the south part of the mapped area, and the lower terrace underlies the sloping plain north of it. The monocline is marked by a scarp on the north side of the plateau; the monocline dips 25°-50° N. and is about 1,000-1,500 feet high. A broad anticlinal dome with dip as much as 25° is centered at the Japan Hills.

Alluvium and outwash gravel.--The flat floor of the Tanana Lowland is underlain by variable thickness of alluvium and outwash. The alluvium and outwash south of lat 64°30' N. were deposited by the Wood River, Tatlanika Creek, Dry Creek, and their tributaries, and form a belt of large coalescing fans that slope gently down to the north. They grade from coarse sand and gravel near the mountains to fine sand and silt at the latitude of the Wood River Buttes. The material north of lat 64°30' N. was deposited by the Tanana River and grades from sand and gravel east of Fairbanks to fine sand and silt west of Fairbanks. Its greatest known thickness is about 675 feet at the Tanana River just south of Fairbanks (Péwé, 1958).

Loess and silt.--Loess of Quaternary age mantles the lower slopes of hills north of the Tanana River; the loess was reworked by gullying and landsliding, was mixed with vegetation, and has been deposited as silt in the valley bottoms north of the Tanana River (Péwé, 1958). The maximum thickness of this material is about 300 feet, and it thins to a feather edge on the upper slopes of the hills. The loess consists chiefly of quartz, muscovite, and feldspar, with small amounts of heavy minerals. The silt deposits in the valley bottoms are shown as alluvium on the accompanying map, but the loess-mantled hillsides have not been distinguished from areas of bedrock outcrop.

MAGNETIC INTERPRETATION

The area covered by the aeromagnetic map can be divided into three parts with respect to magnetic patterns. The southern part is a region characterized by low magnetic gradients and low-amplitude anomalies having no well-defined trends. The northern part of the lowland is an area of generally similar low magnetic relief, but steep-gradient anomalies characterize the hilly area north of Fairbanks. Separating these two areas is a prominent two-dimensional anomaly that trends approximately easterly across the survey area at about lat 64°30' N.

Southern area

This area includes the northern edge of the foothills of the Alaska Range and the southern part of the Tanana Lowland. The generally north-trending magnetic contours (north of the Japan Hills) show a gradient of about 10 gammas per mile decreasing to the west and terminating at the magnetic low along the west edge of the survey area. The 300-gamma magnetic high associated with the low trends in a south-southwesterly direction.

The magnetic anomalies over the area of outcrop of the Nenana Gravel and Totatlinika Schist of the Japan Hills parallel the east-west structural grain to some extent. For example, the low positive anomaly along the crest of the fold that brings Totatlanika Schist to the surface in the Japan Hills continues west to the edge of the survey area.

The absence of larger anomalies in the areas of exposure of the Nenana Gravel indicates that the layers of gravel containing the gabbro pebbles probably are too thin to produce anomalies that may be related to the structure of the gravel. The magnetic pattern over the area of outcrop of the Nenana Gravel and the Totatlanika Schist is most probably produced by the Totatlanika Schist. The magnetic pattern over the adjacent southern part of the lowland (exclusive of the 300-gamma anomaly five miles southeast of the Wood River Buttes) may also be produced by the Totatlanika Schist. However, about two miles east of the broad anomaly at the eastern edge of the mapped area between lat 64°20' and 64°25' N. is a group of hills of Birch Creek Schist. The anomaly there may be produced by the westward continuation of the structure that brought Birch Creek Schist to the surface to form the hills.

No anomalies in the southern part of the Lowland are suitable for depth analyses. The fairly steep gradient about 12 miles north of the Japan Hills, however suggests that the basement rocks are present at shallow depths.

Northern area

The magnetic pattern over the northern part of the lowland is similar to the pattern observed over the southern part, but the magnetic contours trend easterly whereas the trend of the contours in the southern part of the lowland trend northward. This change in trend may indicate a change in lithology of the basement rocks or, possibly, a change in structural trend. North of about lat 64°45' N. the anomalies are characterized by steep gradients and narrow widths, though the amplitudes are less than 100 gammas. The anomalies are elongated in a southwesterly direction which is also the general trend of the hills and valleys. Birch Creek Schist, which is widely exposed in the hilly areas, undoubtedly produces the observed anomalies, though the magnetic anomalies are not generally associated with hills such as Ester Dome or Clear Creek Butte, for example. Many of the anomalies of the area are over low saddles, flat ground, or are on the lower slopes of the hills. This implies that the magnetic susceptibility of the Birch Creek Schist varies laterally over the survey area. From this it may be concluded that magnetic anomalies over sedimentary basis underlain by Birch Creek Schist will not necessarily delineate anticlinal structures that have cores of Birch Creek Schist. In addition, the absence of anomalies over large parts of the Tanana Lowland is no positive indication that the sedimentary fill is thick, for a non-magnetic part of the Birch Creek Schist could be present beneath only a thin cover of sedimentary rocks.

It is assumed that the northern part of the Tanana Lowland is underlain by rocks similar (magnetically) to those exposed in the hills, that is, Birch Creek Schist, it is then possible to estimate the depth of burial even though there are no suitable anomalies for depth analyses. The procedure involves continuing the total-intensity magnetic field over the exposed Birch Creek Schist upward until it resembles the field observed over the covered areas. Profile B-B' was selected to represent the magnetic field produced by the schist while profile A-A' represents the magnetic field over the covered areas (see maps and figure 1).

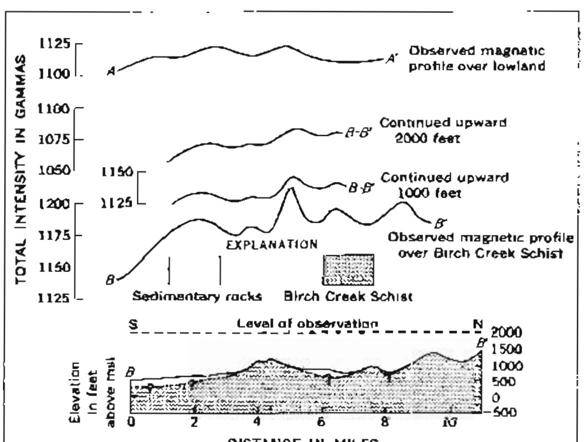

FIGURE 1.— *Upward continuation of the magnetic field observed over outcrops of Precambrian Birch Creek Schist (BB') compared to an observed magnetic profile (AA') where these rocks are at depth*

When profile B-B' is continued upward 2,000 feet by a procedure developed by Henderson and Zietz (1949), the resulting profile (see figure 1) closely resembles profile A-A'. Hence, it is estimated that about 2,000 feet of sedimentary rocks may overlie the Birch Creek Schist.

Central area

Perhaps the most significant magnetic feature in the survey area is the steep-gradient, two-dimensional anomaly that traverses the survey area at about lat 64°30' N. Although there is no surface indication of an intrusive rock, this anomaly is produced by dikelike bodies whose upper surface is covered only by a thin veneer of alluvium and whose near-vertical sides are about 4 miles apart. The axis of this important magnetic anomaly lies along the projection of a belt of mafic and ultramafic rocks mapped by Mertie (1937, pl.1) in the region east of the mapped area and of similar rocks of the Wood River Buttes. It is therefore inferred that the anomaly is produced by mafic and ultramafic rocks and that the belt of these rocks is probably continuous beneath the Tanana Lowland.

A similar anomaly, only a part of which lies within the survey area, is located about five or six miles southeast of the Wood River Buttes. This anomaly appears to trend south-southwest. Additional aeromagnetic traverses to the west may show that the distribution of the rocks of the Wood River Buttes is far greater than area of outcrop would indicate.

CONCLUSIONS

The east-trending anomaly in the central part of the lowland, together with exposures of basement rocks in the Wood River Buttes, Clear Creek Butte, and the hills around Blair Lakes, indicate that the area of possible sedimentary basin beneath the eastern part of the Tanana Lowland is small. The Nenana Gravel probably pinches out northward either by thinning or by erosion between the Japan Hills and lat 64°20' N. Inasmuch as the gravel is a continental formation and rests directly on schist, there is little room for a potentially oil-bearing basin in the Tanana Lowland east of long 148° 15' W. Nothing is known about the possible occurrence of oil in the western part of the lowland, but the conclusions of this reconnaissance survey are not favorable.

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