Preliminary geologic interpretation of aeromagnetic data in the Yakutat district, Alaska

by

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Abstract

An aeromagnetic survey covering portions of the Yakutat Foreland region in south-central Alaska was made to delineate concentrations of magnetic minerals possibly associated with heavy mineral placers in beach sands and raised beach ridges. However, the larger magnetic anomalies do not correlate with the beach placers in the surveyed area. The dominant magnetic feature, a strong linear positive anomaly almost parallel to the coastline, is thought to reflect a bedrock feature, probably a mafic igneous body enclosed within nonmagnetic rocks of the Yakutat group.

Introduction

As part of the Heavy Metals program of the U. S. Geological Survey, an aeromagnetic survey was made of part of the coastal plain region, or Yakutat Foreland, in the vicinity of Yakutat, Alaska (fig. 1). The survey was made by Lockwood, Kessler, and Bartlett, Inc., under contract to the Geological Survey. The purpose of the investigation was to determine if magnetic mineral concentrations are associated with the beach sands and raised beaches that exist on the Yakutat coastal plain.

Beach sand deposits along the Gulf of Alaska coast have been worked intermittently for their gold content during the last 100 years. A minor gold rush reportedly developed in the Yakutat area after discovery of gold-bearing black beach sands in several places along the shores of Yakutat Bay (Tarr and Butler, 1909, p. 165-168). The richest placers were in the "ruby" sands where garnets and magnetite, along with some gold, were concentrated at high tides by waves. Similarly, Blackwelder (1907, p. 86-87) reported gold-bearing black sands on Black Sand Island south of Yakutat; however, no significant amount of gold has been recovered from the Yakutat district. Some gold mining has been reported on the coastal plain region at Lituya Bay (Wright, 1907, p. 64), which is about 40 miles southeast of the Yakutat district. Here, as at Yakutat Bay, the gold is found in black sands which seem to have been concentrated by waves in layers high on the beaches.

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Geologic setting

The general geology of the Yakutat area, based on brief reconnaissance investigations, has been outlined in reports by Blackwelder (1907), Tarr and Butler (1909), Miller (1961), and Stoneley (1967) and in a compilation map by Plafker (1967). More detailed geologic mapping of the Yakutat quadrangle during 1967 and 1968 under the U. S. Geological Survey's Heavy Metals program has provided additional pertinent data on the stratigraphic and structural relationship of the rock units that underlie the Yakutat Foreland and the adjacent foothills belt of the Saint Elias Mountains.

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The foothills belt and Yakutat Foreland in the area of interest are underlain mainly by the Yakutat Group of Jurassic(?) and Cretaceous age. This unit was also penetrated by the Yakutat 2, Yakutat 3, and Dangerous River 1 exploratory wells, which were drilled on the Yakutat Foreland by the Colorado Oil and Gas Company (Plafker, 1967). The Yakutat Group is an extremely thick eugeosynclinal sequence of bedded sedimentary rocks that is characterized by chaotic structure and zones of tectonically intermixed fragments or blocks of competent rocks, as much as several miles long, in a pervasively sheared matrix of pelite or tuffaceous pelite. The blocks include disrupted beds of wacke sandstone and conglomerate that were originally interbedded with the siltstone, as well as "exotic" greenstone, marble, diorite, volcanic graywacke, chert, and oolitic limestone of widely diverse origins and ages. Isolated outcrops on the Yakutat Foreland and along the margin of the foothills, that were previously differentiated as the "Volcanic unit" (Miller, 1961; Plafker, 1967), appear to be portions of the Yakutat Group in which the resistant greenstone exotics are especially abundant. Outcrops of probable exotic volcanic blocks within the surveyed area are here delineated as "Jurassic(?) and Cretaceous rocks" (sheet 4). The distribution of these greenstone blocks in the outcrop adjacent to the surveyed area and the available well data suggest that comparable rocks occur within the Yakutat Group beneath all of the Yakutat Foreland within the surveyed area. To the east and southeast of the survey area the bedrock outcrops include low-grade metamorphic rocks of the greenschist facies and granitic plutons, in addition to the Yakutat Group.

Over most of the Foreland, the Yakutat Group is mantled by a sequence of Cenozoic sedimentary rocks and unconsolidated Holocene deposits. These units thicken from the outcrop towards the coast where they attain an aggregate thickness in excess of 5,000 feet. The Cenozoic sequence is exposed west of Yakutat Bay in the Malaspina Glacier area, and its correlatives have been penetrated in all the exploratory wells drilled for oil on the Yakutat Foreland. It consists of continental and marine clastic sedimentary rocks of probable Eocene through Pleistocene age.

The Holocene surficial deposits over most of the foreland include unconsolidated glacial, alluvial, and marine deposits as much as several hundred feet thick. Rapid post-glacial uplift of the Foreland relative to sea level has resulted in formation of a series of elevated beach ridges that are subparallel to the present beaches along the Gulf of Alaska coast. These beach deposits, which are delineated on the maps (sheets 1-4), are known to have local concentrations of gold-bearing black sands.

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Aeromagnetic survey

The aeromagnetic survey was made of the Foreland region between Yakutat Bay and the Alsek River (fig. 1). Two areas, the northern about 30 square miles and the southern about 100 square miles, were flown at about 200 feet above the terrain using northwest-southeast traverses spaced a quarter of a mile apart. Two 18-mile-long reconnaissance traverses were also flown over the region connecting the two detailed surveys.

A Gulf fluxgate magnetometer was used to obtain total intensity magnetic profiles along each traverse. Aeromagnetic maps were compiled on 5-and 10-gamma contour intervals as shown on sheets 1-4. Profiles obtained along the reconnaissance lines are also shown on sheets 2 and 3. The Mesozoic bedrock outcrops and the distribution of both modern and older raised beaches are shown superimposed on the contoured magnetic data. The effect of the Earth's normal total magnetic field intensity, which increases by approximately 5 gammas per mile in a northeasterly direction, has not been removed from the aeromagnetic map.

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Discussion of aeromagnetic data

The dominant magnetic feature of the Yakutat Foreland region is a linear magnetic anomaly which follows the length of the foreland in the southeast section (sheets 3 and 4) and possibly extends into the southern part of the northwest section (sheets 1 and 2), as shown in a comparison of control lines 4 and 5 (fig. 2). In the northwest section this linear magnetic anomaly seems to either terminate or extend toward the ocean. The anomaly is largest (about 200 gammas) and most complex in the eastern edge of the southeast area and gradually decreases in magnitude toward the northwest. The strong linear anomaly does not correlate with the raised beaches, as is clearly seen in sheets 1-4. Indeed, there appears to be no definite correlation between any magnetic anomalies and the raised or present beaches. Apparently the older raised beaches do not contain enough magnetic minerals to allow detection from the elevation at which the survey was flown. Also it is possible that the undulating nature of the magnetic bedrock source masks any magnetic effect of the placer minerals. There are two small anomalies, however, where reconnaissance line B intersects the Dangerous River (sheet 2), and these anomalies may be produced by concentrations of magnetic minerals associated with placers at this location.

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Depth estimates by the slope distance rule (Riddell, 1966) for the geologic feature responsible for the strong linear anomaly were computed from the observed profiles obtained along control lines CL-1, 4, and 5 (sheets 1, 2, 3). The depth to the feature below the ground surface from south to north was determined to be approximately 400 feet at control line 1, 240 feet at control line 4, and 130 feet at control line 5. These estimates are considered to be maximum depths of burial to the top of the magnetic feature which, in actuality, could be much closer to the ground surface.

The strong character of the anomaly and its estimated depth and general correlation to the north-northwest trend of the bedrock outcrops in the vicinity suggest that the magnetic feature is in the Yakutat Group below unconsolidated foreland deposits and possibly Cenozoic sedimentary rocks.

An attempt was made to determine the geologic nature of the magnetic feature by constructing a theoretical magnetic body using a two-dimensional magnetic computer program to simulate a profile plotted from the contoured data. A model which would produce a profile similar to the constructed profile (A-B, sheet 4) is shown in figure 3. The theoretical body is tabular and flat lying, varying in thickness from approximately 800 feet to 200 feet in a southwest direction towards the coastline, and is approximately 500 feet below the ground surface. The magnetic susceptibility contrast was chosen to be 0.9×10^{-3} cgs. The geometry and the magnetic susceptibility

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of the model indicate its physical counterpart is mafic in composition, probably volcanic rocks or hypabyssal intrusives embedded in less magnetic rocks. The magnetic body is abruptly truncated on the northeastern side and perhaps stepped down towards the coast as indicated on figure 3.

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The only known mafic igneous rocks in the region are the greenstones within the Yakutat Group, but no good magnetic correlation with the few outcrops of these rocks is evident (sheet 4). Eight samples of the greenstone were found to be only slightly magnetic with an average susceptibility measured in the laboratory of 0.05×10^{-3} cgs. It is possible, however, that relatively unaltered mafic bodies, such as feeder dikes, sills, and related hypabyssal intrusives, occur sporadically within the greenstone masses at depth, and these rocks could account for the strong magnetic anomaly described above. Relatively fresh basalt was encountered in the Colorado Gas and Oil Company's Dangerous River 1 well, probably within the Yakutat Group. Except for the volcanic rocks of the Yakutat Group, there are no known lithologies, either in outcrop or in well sections, that are likely to be sufficiently magnetic to produce the observed anomalies. Alternatively, the anomaly may be caused by some unknown unit that has not been encountered in the outcrop or in the wells.

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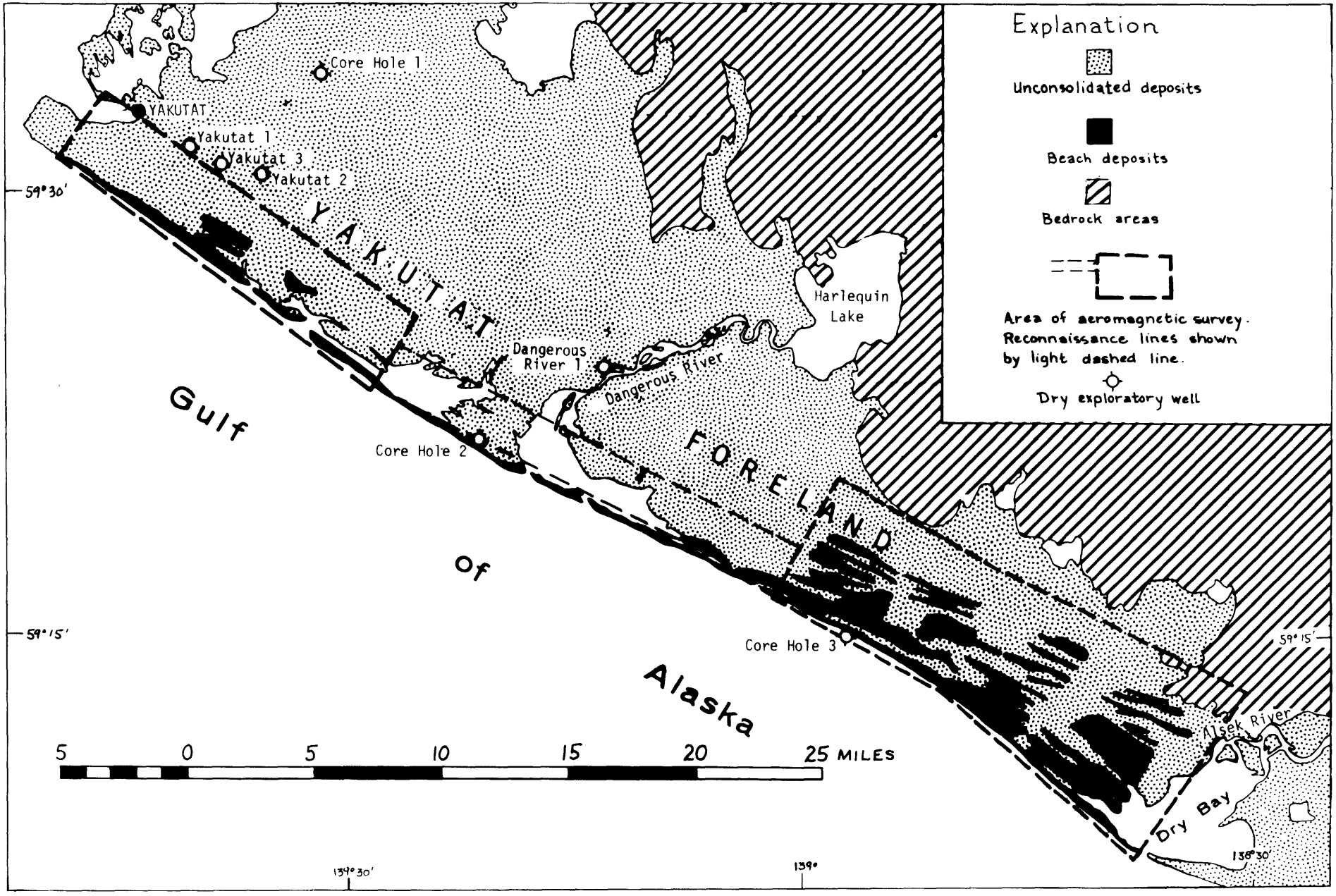

Figure 1. Geologic map of part of the Yakutat district showing the areas covered by aeromagnetic surveys.

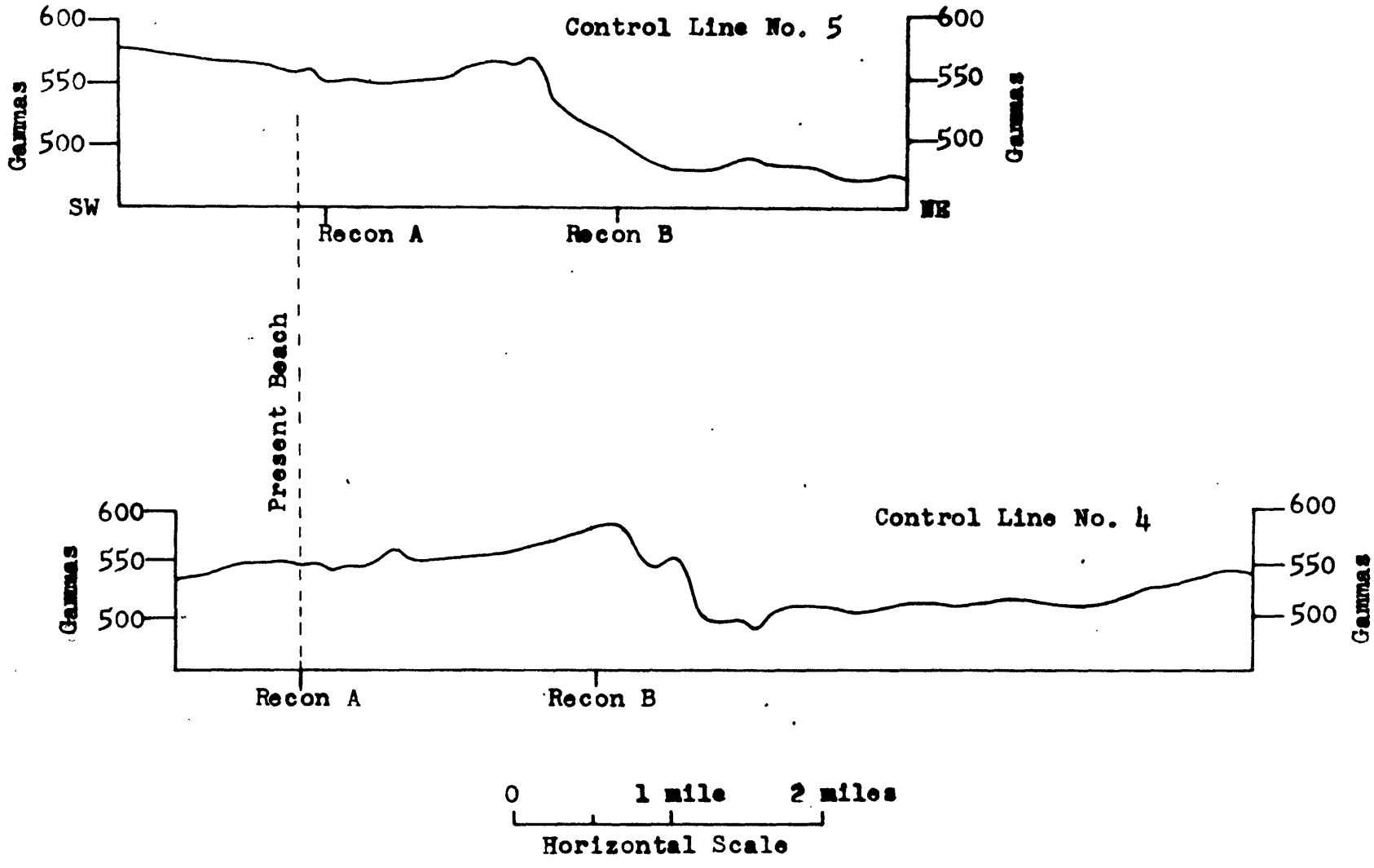

Figure 2.--Comparison of northeast-southwest magnetic profiles across the Yakutat Foreland, Alaska.

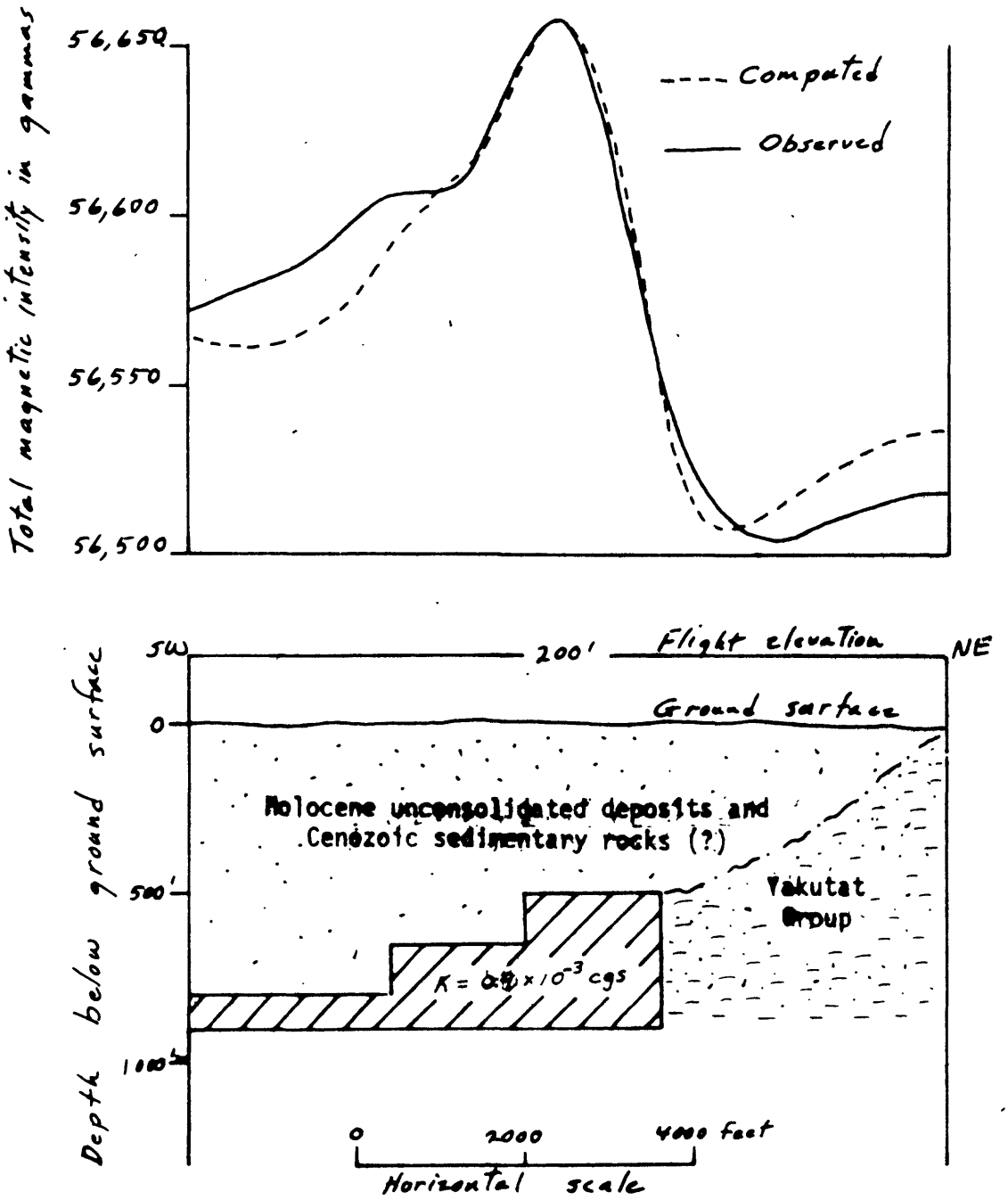

Figure 3.--Comparison of observed total intensity magnetic profile and anomaly computed for a two-dimensional magnetic body.