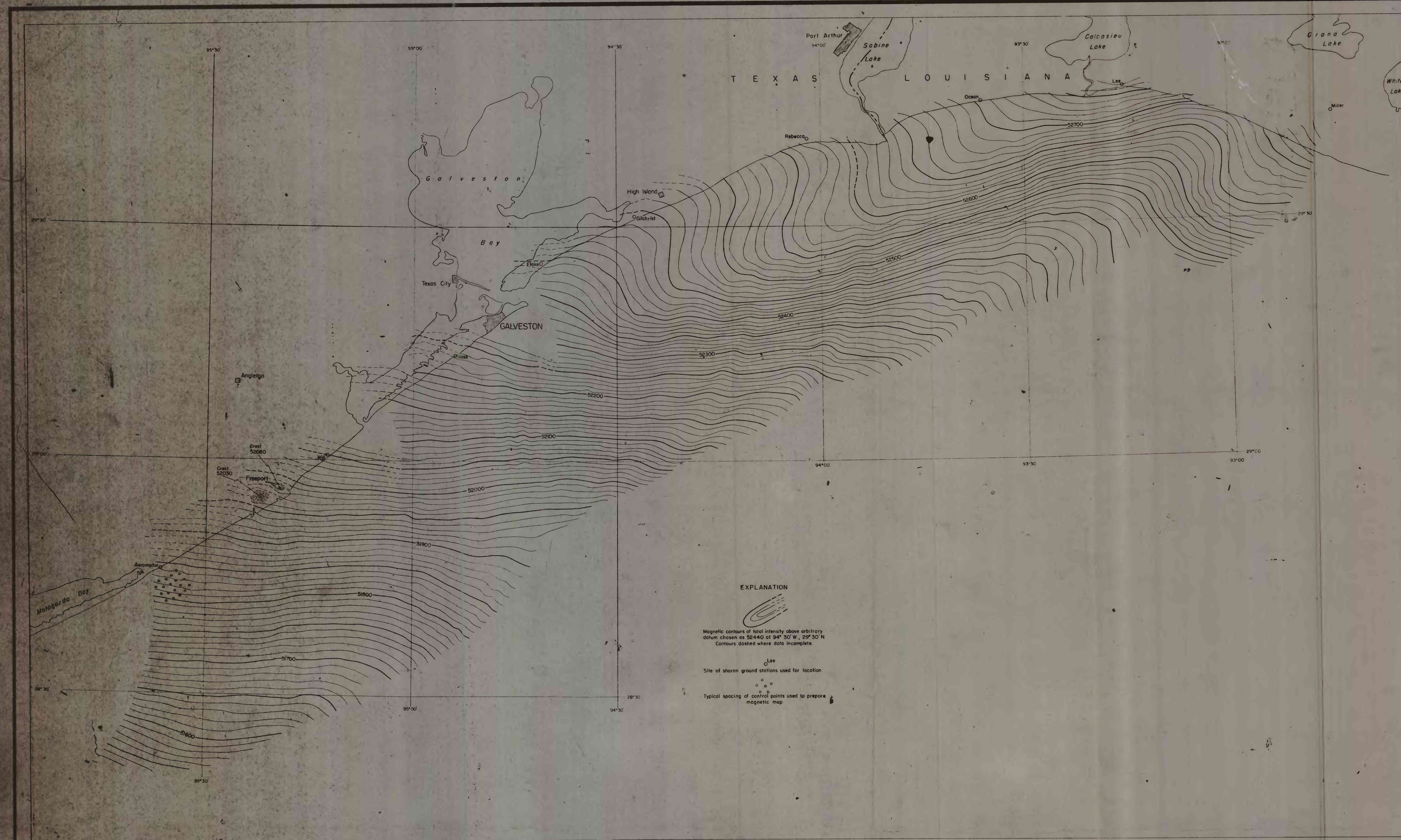
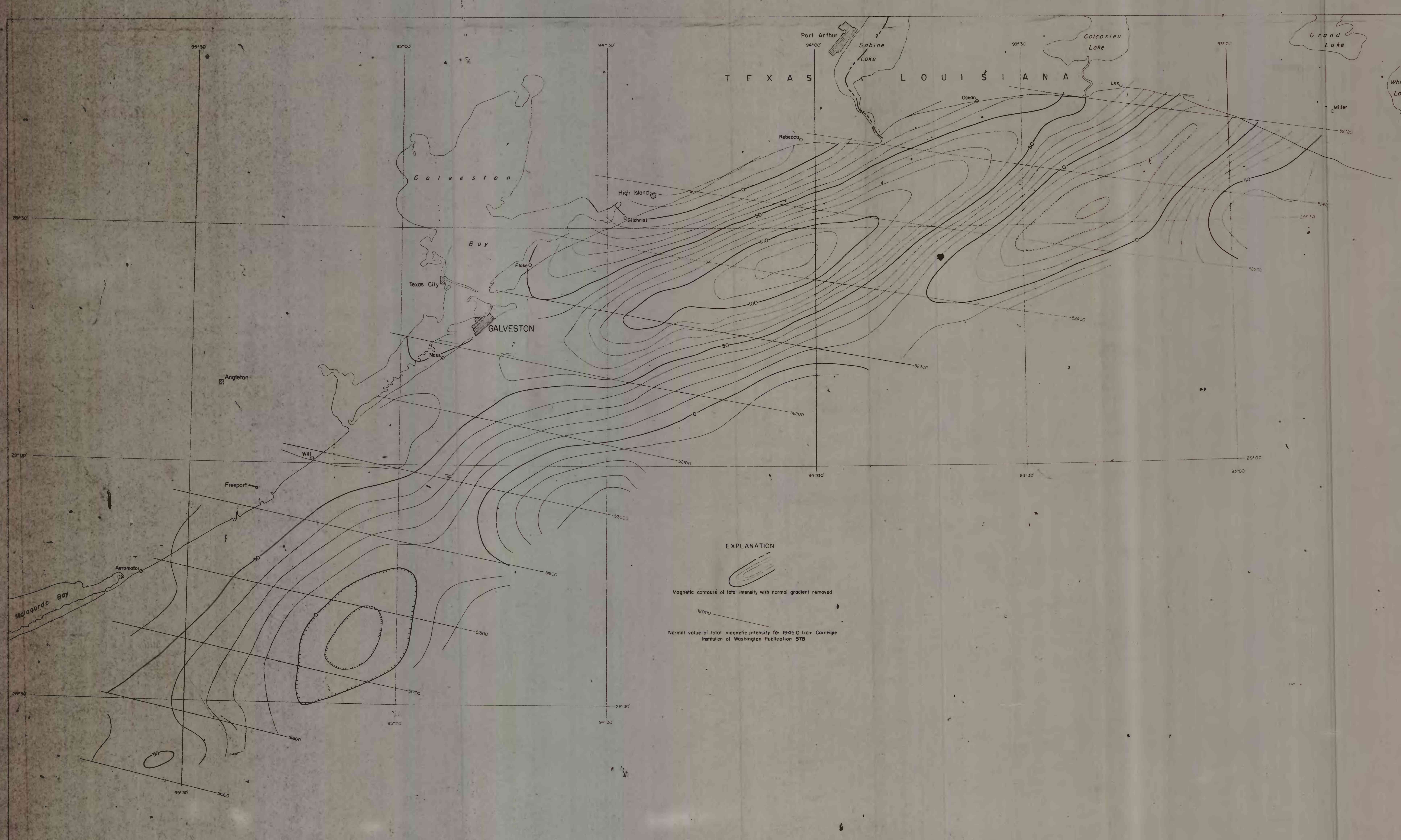
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE OFFICE OF
NAVAL PETROLEUM AND OIL SHALE RESERVES

GEOPHYSICAL INVESTIGATION
PRELIMINARY MAP



TOTAL INTENSITY AEROMAGNETIC MAP RELATIVE TO ARBITRARY DATUM



TOTAL INTENSITY AEROMAGNETIC MAP WITH NORMAL GRADIENT REMOVED

Total-Intensity Aeromagnetic Survey of Part of the Gulf of Mexico

by James R. Balsley

Introduction

The accompanying maps are the result of an experimental overwater aeromagnetic survey over a part of the Gulf of Mexico conducted during March and April 1946. This survey was the first to use Shoran, a radio navigational aid, as a means of directing and locating the overwater traverses, and was undertaken to determine the usefulness of this method. The Gulf Coast area was chosen because of its physical suitability for this type of survey and because of the active interest in the possibilities of petroleum accumulations in the region.

The project was arranged by the Director, Naval Petroleum and Oil Shale Reserves, who supplied the airplane and magnetic equipment. The Shoran equipment and its operating personnel were supplied by the Air Technical Services Command, Army Air Force. U. S. Geological Survey personnel directed the survey, including the location of the Shoran ground stations, and compiled the results. The Naval Ordnance Laboratory modified and maintained the magnetometer equipment.

Field Procedure

The magnetic measurements were made with the continuous-recording AN/ASQ-3A airborne magnetometer installed in a PBY-5A Catalina amphibian aircraft which had been previously used to survey the Naval Petroleum Reserve No. 4, Alaska. The detecting element of the magnetometer was installed in a plywood housing extending about three feet beyond the tail of the aircraft.

The flight of the aircraft was determined by Shoran, an accurate short-range radio navigation aid. The survey was made by flying a series of circular arcs at exact mile distances from a Shoran ground station designated the drift station. The pilot was directed on this path by a Pilot Direction Indicator. The deviation of the plane's actual path from this predetermined course was continuously recorded. On the same chart and on the magnetic record a mark was made automatically at each exact mile distance from the other ground station designated the rate station. Over land areas the position of the plane was also recorded by a gyro-stabilized Sonne continuous-strip camera. No significant difference of position could be found between the two methods. The Shoran positions are accurate to ± 100 feet.

The positions of the Shoran ground stations were determined by a transit traverse survey from the nearest U. S. Coast and Geodetic Survey triangulation stations. The positions of the stations were plotted on a Lambert Conformal Conic Projection, Standard Parallels 33° and 45°, scale 1:250,000.

The area of the survey was thus covered by a series of concentric circular traverses one mile apart and 1,500 feet above the land and water surface. The outermost arc of each group was flown consecutively in two directions to determine the correction for diurnal variation and instrument drift. Similar double or "base" lines were flown along the coast and all lines were combined to form a network to which the traverses were adjusted. The maximum error of magnetic closure in any cell was 9 gammas; the average of all, 6 gammas.

Magnetic Map

The magnetic map was prepared by plotting the value read on the continuous magnetic record of each traverse at the exact mile distances from the Shoran rate station. These values were then corrected for the heading effect (explained below) and for the combined effect of diurnal variation and instrument drift.

The heading effect is the magnetic field of the airplane at the position of the magnetic detecting element in the tail. The magnitude of the heading effect depends upon the direction of the longitudinal axis of the aircraft with respect to the earth's magnetic field. Consequently, depending upon the altitude of the aircraft, the heading effect adds to or subtracts from the value of the earth's magnetic field that is to be measured. With curved traverses, this effect cannot be removed by a linear adjustment of the whole profile to base lines but must be removed by determining the actual heading of the aircraft at each point of measurement. From the Shoran record of the flight path it is possible to determine easily the direction the airplane was travelling at a particular point, but the actual heading must be computed from the direction and velocity of the wind as well as the air speed and direction of travel of the aircraft. These computations were made using the hourly wind records of the U. S. Weather Bureau stations at New Orleans, La., Galveston and Corpus Christi, Tex. The maximum heading effect in this installation was 18 gammas and the maximum rate of change of heading effect was about 1/4 gamma per degree of heading.

The combined effect of diurnal variation and instrument drift was removed by making a linear adjustment of each profile to fit the baseline network. The maximum correction for instrument drift and diurnal variation applied throughout the length of any traverse was 13 gammas and the average, 4 gammas.

It is apparent in the final map that these adjustments were not always accurate. Unknown changes in the direction of velocity of the wind have introduced errors into the heading correction and probable deviations from linearity of the combined diurnal variation and instrument drift have raised or lowered the magnetic values at the central part of profiles. These errors give rise to the "herringbone" or "chevron" pattern encountered in aeromagnetic maps.

It was hoped that this magnetic survey might indicate negative anomalies sometimes associated with salt domes. It was soon apparent that the combination of an 18-gamma heading effect, gusty winds, and a slow aircraft could cause magnetic effects of the same size and shape as those caused by salt domes. The survey was obviously of little use for locating salt domes. It was continued because broad magnetic features were encountered. It was hoped that these might have some relationship to the structures in the sedimentary rocks and would serve as a guide to other geophysical and geological studies in the region.

Interpretation

Since the analysis of magnetic data does not produce a unique result, other geophysical or geological information is required for a conclusive interpretation. Because in this region little of such information has been published, it is possible to present only tentative geological explanations of the magnetic features. Precise interpretation of the magnetic map must be delayed until other data are available.

However, at west longitudes 93° 00', 93° 15', and 93° 45' there are available underwater gravity profiles 1/ that aid in the analysis of the magnetic data. The gravity contours constructed from these profiles show a striking parallelism to the magnetic contours, and the positive gravity feature at 29° 30' N. and 93° 00' W. can be closely correlated with a similar magnetic feature. Unfortunately, this magnetic survey does not include the area where the main positive gravity feature is indicated. Nevertheless, four 300-mile magnetic traverses flown recently at west longitudes 93° 15', 93° 25', 93° 35', and 93° 50' verify the existence of a magnetic feature corresponding to the large gravity anomaly.

The size and shape of the magnetic anomalies indicate that the basement rocks contain either significant compositional differences or broad surface warps. The observed magnetic anomalies can be duplicated by anomalies computed from masses of various shapes and composition and at various depths. In order to limit the number of possible explanations of the magnetic features, preliminary computations were made from the gravity information to determine an explanation that fits both sets of data. These computations show that both the magnetic and gravity anomalies can be duplicated by assuming a mass of basement rock of composition between granite and diabase with a relief of 10,000 feet above a general level 35,000 feet below sea level. This seems to be a geologically reasonable interpretation but it should be noted that both the gravity and magnetic anomalies can also be duplicated by compositional differences in the basement rocks. Whether or not these features have any counterpart in overlying near-surface sedimentary structures will have to be determined by the geophysical investigations and drilling now being done in the region.

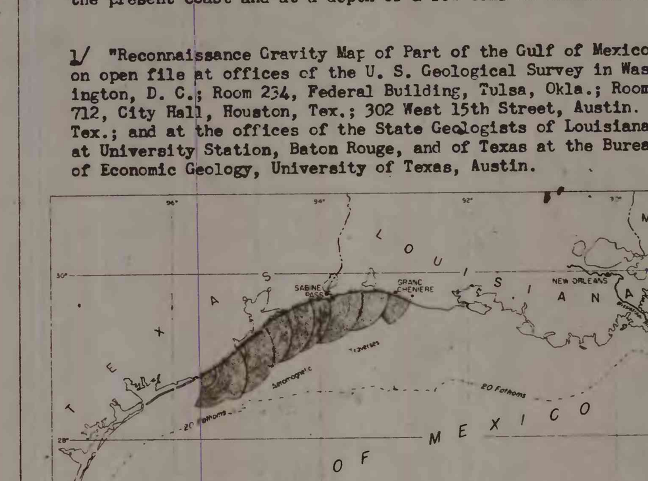
Conclusions

1. An accurate and reliable aeromagnetic map can be made in unmapped areas by using Shoran to direct and locate the flight of the survey plane.

2. An inboard installation is not practical for most surveys in which it is desired to map magnetic features of small magnitude and areal extent. A towed bird installation such as that now used by the U. S. Geological Survey is in general preferable.

3. The magnetic features shown on this map are probably caused by structures in the basement rocks roughly parallel to the present coast and at a depth of a few tens of thousand feet.

1/ "Reconnaissance Gravity Map of Part of the Gulf of Mexico" on open file at offices of the U. S. Geological Survey in Washington, D. C., Room 234, Federal Building, Tulsa, Okla.; Room 712, City Hall, Houston, Tex.; 302 West 15th Street, Austin, Tex.; and at the offices of the State Geologists of Louisiana at University Station, Baton Rouge, and of Texas at the Bureau of Economic Geology, University of Texas, Austin.



INDEX MAP
SHOWING AREA SURVEYED

Shore positions and grid from Aeronautical Sectional Chart, Scale 1:500,000 Lambert Conformal Conic Projection

TOTAL INTENSITY AEROMAGNETIC MAP OF PART OF THE GULF OF MEXICO

RELATIVE TO ARBITRARY DATUM

10 0 10 20 30 40 Statute Miles

Flown 1500 feet above sea level

1949

Prepared by Geological Survey, US Department of the Interior, from data collected from aerial survey conducted jointly by the Geological Survey, Naval Ordnance Laboratory, and Army Air Technical Services Command for the Director of Naval Petroleum Reserves