USGS-OFR-95-XXX-A 07/06/95 Version

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

# AEROMAGNETIC SURVEYS ACROSS CRATER FLAT AND PARTS OF YUCCA MOUNTAIN, NEVADA

By

R.F. Sikora[1], D.L. Campbell[2] and R.P. Kucks[2]

1995

95-XXX-A Report documentation
95-XXX-B Airborne magnetic data on diskette

Open-File Report 95-XXX-A

Prepared in cooperation with the
Nevada Operations Office
U.S. Department of Energy
(Interagency Agreement DE-AI08-92NV10874)

This report is preliminary and has not been reviewed for conformity with U.S.Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade, firm or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Menlo Park, California
1995

[1]Menlo Park, CA [2]Denver, CO

"PRELIMINARY DRAFT"

# Aeromagnetic Surveys Across Crater Flat And Parts Of Yucca Mountain, Nevada

by

R. F. Sikora, D. L. Campbell, and R. P. Kucks

## Abstract

As part of the a study to characterize a potential nuclear waste repository at Yucca Mountain, aeromagnetic surveys were conducted in April 1993 along the trace of a planned seismic profile across Crater Flat and parts of Yucca Mountain. This report includes a presentation and preliminary interpretation of the data. The profiles are at scales of 1:100,000 and 1:48,000. Also included is a grided color contour map of the newly acquired data and a discussion of the likely applicability of very-low-frequency (VLF) electromagnetic surveys to other Yucca Mountain project objectives.

## Introduction

Aeromagnetic surveys were flown by the United States Geological Survey (USGS) over Crater Flat and part of Yucca Mountain, Nevada, to help in the interpretation of the subsurface geologic structure at the potential location of a nuclear waste repository. This report briefly discusses features seen on the aeromagnetic profiles and their possible sources. These data will eventually be used along with results from other studies, including proposed seismic surveys, to make the final interpretations of geologic structure.

## Acknowledgments

Thanks to D. A. Ponce who initiated the study, assisted with programs, and provided a helpful technical review. Thanks also to R.J. Bisdorf for his constructive review of the manuscript and to T.G. Hildenbrand for his help in data format conversions.

## Magnetic Surveys



Magnetic surveys are used to help locate and identify the sources of anomalies in the Earth's magnetic field. Magnetic anomalies may be related to near-surface geology or to geologic structural features within the Earth's crust. Magnetic data may reveal the existence of faults, distribution of stratigraphic units, the presence of intrusive bodies, the thickness and shape of sedimentary basins, and depth to the bottom of magnetic sources. Magnetic anomalies will tend to form along boundaries where there is a vertical offset of beds (Bath and others, 1982)

## Specifications of Survey

On April 26, 1993, 106.2 miles of aeromagnetic profile data were obtained during flights over the study area. The profiles were flown at 300 feet above ground level (radar controlled) and are at 1/4 mile spacing. The average speed of the aircraft was 90 nautical miles per hour. The flight lines were flown in groups of three, with the center line following the proposed seismic profiles, and with an additional line out to each side (fig. 1). The aeromagnetic data were measured using a Geometrics model G813 proton-precession airborne magnetometer mounted on the wing-tip or tail stinger of the aircraft and recorded on a GR33 chart recorder (recording pitch, roll, radalt, heading, VLF and mag), digital tape, and video backup for flightline recovery. The sensitivity was 0.5 nanoTeslas, and the cycle time was 0.5 seconds. Global Positioning System (GPS) was used as the primary navigation system.

## Calibration of Instrument

A calibration check of the airborne magnetometer was conducted using a certified Geometrics G856 base-station magnetometer, which was calibrated following USGS and U.S. Department of Energy guideline specifications. The purpose of calibration is to assure the accuracy, validity, and applicability of the methods used to collect, process and interpret magnetic data.

## Profiles

The profile data are displayed in figures 3-1 through 3-15 at a scale of 1:100,000. Plates 1 and 2 display the profiles at a scale of 1:48,000. All profiles are displayed with west to the left on the illustration. The actual direction of flight for each of the lines is indicated on the index map on plate 2.



## Major Anomalies

The gridded and contoured aeromagnetic survey data (fig. 1) show a number of magnetic features that can also be seen on a detailed aeromagnetic map (fig.2) of the Timber Mountain area (U.S. Geological Survey, 1979). A broad magnetic low in the western third of profiles 1, 2, and 3 may be due to reversely magnetized tuffs (Kane and Bracken, 1983). These tuffs are Miocene in age and consist of quartz and hornblende-bearing rhyolite ash-flows (Carr and others, 1986). However, Langenheim (1994) suggests that this anomaly may be related to a reversely magnetized basalt flow that was identified in drill-hole USW VH-2 (Carr and Parrish, 1985).

A broad magnetic high occurs just south of Black Cone, on profiles 1, 2, and 3 and 4, 5, and 6. The source of this high is unknown but may be due to buried normally-magnetized volcanic rocks if they thicken towards the center of the anomaly ( Kane and Bracken, 1983). A drill hole over this anomaly revealed about 300 m of Topopah Spring Member of the Paintbrush Tuff and over 140 m of densely-welded Bullfrog Member of the Crater Flat Tuff (Carr, 1985). Kane and Bracken (1983) suggest that both of these units have magnetic properties that could cause the anomaly. Physical property measurements by Rosenbaum and Snyder (1984) show that both these units are normally magnetized. However, Langenheim (1994) suggests that this magnetic anomaly may be caused by a buried basalt or an intrusion at depth.

A deep north-south trending low in the middle of lines 4, 5, 6 is ascribed by Kane and Bracken (1983) to a possible offset in underlying horizontal tuffs. Magnetic highs over Yucca Mountain, at the northeast end of lines 10,11,12 and the northwest two-thirds of lines 13, 14, 15, generally correlate with exposures of the Topopah Spring Member of the Paintbrush Tuff. Kane and Bracken (1983) speculate that linear magnetic features in this area may reflect offsets in flat-lying volcanic units. Such offsets may only represent lithologic causes, such as variations in thickness or magnetic properties of the volcanic units, or they could be due to tectonic elements, such as faults (Bath and others, 1982). Joint interpretation of these data, together with seismic and other data still to come, should help resolve the nature of these possible offsets.

## Applicability of VLF Surveys

The USGS airplane that flew the Crater Flat aeromagnetic lines was equipped with a Very Low Frequency (VLF) electromagnetic-wave receiver. This VLF receiver was developed by Branch of Geophysics for making maps of the electrical resistivity of surficial units (Flanigan and others, 1986).

VLF electromagnetic waves are broadcast by Navy navigation stations located along both coasts in the United States. Commonly used stations in the conterminous United States are located in Cutler ME (24.4 kHz) and Seattle WA

(24.0 kHz). As the VLF waves propagate, they are effected by electrical resistivities of the near-surface geologic units. These effects are detected by the airborne receiver and are then inverted to infer a VLF resistivity value, a weighted average of true rock resistivities between the surface and a depth of about 100 ft.



One objective of the Crater Flat airborne work was to determine whether airborne VLF resistivity data might be useful for Yucca Mountain investigations. Unfortunately, the VLF equipment was not functional on the day the Crater Flat lines were flown, so no VLF data were obtained along those particular lines. However, good VLF data were acquired over the nearby Beatty block of ground. From the Beatty survey results, we can confidently report that airborne VLF data, if acquired at Yucca Mountain, would likely be useful for certain Yucca Mountain site-characterization purposes.

Measured VLF resistivity values for the Beatty survey range from 45 ohm-m to 1,000 ohm-m. Generally, the high resistivities (>500 ohm-m) reflect outcrops of crystalline rocks; low resistivities (<500 ohm-m) reflect soils and surficial materials; and the lowest resistivities (<100 ohm-m) reflect wet ground with seeps and springs. It doesn't seem possible to distinguish particular geological formations using only resistivity values. Locally, high resistivity zones extend from crystalline rock outcrops out into the valleys; presumably, the VLF is mainly seeing crystalline rock there, under a thin cover of valley fill material. If VLF data were available from the Crater Flat area, a similar effect might be observed along the west side of Crater Flat, where the graben edge is likely covered by sediments.

Springs may not necessarily show up as lows on the VLF resistivity map. A possibility, not verified, is that springs along vertical faults result in resistivity lows while seeps along outcropping confining units do not. This is plausible from a theoretical standpoint since a saturated fault zone might extend deep, so that the weighted average VLF resistivity from it would be lower than that due to a thin saturated zone with resistive rocks above and below it. Early electrical work done on the surface at Yucca Mountain showed certain fault zones to be resistivity lows (Klein, 1990).

Because of the geometry of VLF fields, different stations couple more or less well to linear conductors like possible faults. In the Beatty study area, with east-west flight lines, features trending north-south showed up better on the Cutler data than the Seattle data. Ideally, two such VLF stations at azimuths 90-degrees apart should be recorded simultaneously so as to detect features trending in all directions. Although, features trending parallel to flight lines will always be less well resolved than ones that trend perpendicular to flight lines.

References

Bath, G.D., 1968, Aeromagnetic anomalies related to remanent magnetization in volcanic rock, Nevada Test Site, Nevada, in Nevada Test Site, Geological Society of America Memoir 110, p. 135-146.

Bath, G.D., Dixon, G.L., and Rosenbaum, J.G., 1982, Relation of aeromagnetic anomalies to faulted volcanic terrains at the Nevada Test Site (abs.): Geological Society of America, Rocky Mountain Section, 35th Annual Meeting, Abstracts with Program, v. 14, n. 6, p. 302.

Carr, W.J., 1982, Volcano-tectonic history of Crater Flat, southwestern Nevada, as suggested by new evidence from drill hole USW-VH-1 and vicinity: U.S. Geological Survey Open File Report 82-457, 23 p.

Carr, W.J. and Parish, L.D., 1985, Geology of Drill Hole USW VH-2 and structure of Crater Flat, southwestern Nevada: U.S. Geological Survey Open-File Report 84-474, 41 p.

Carr, W.J., Beyers, F.M., Jr., and Orkild, P.P., 1986, Stratigraphic and tectonic relations of Crater Flat Tuff and some older volcanic units, Nye County, Nevada: U.S. Geological Survey Professional Paper 1323, 28 p.

Flanigan, V.J., Long, C.L., Rohret, D.H., and Mohr, P.J., 1986, Apparent resistivity map of the rift systems of Kilauea and Mauna Loa volcanoes, Island of Hawaii, Hawaii: U.S. Geological Survey Map Miscellaneous Field Investigations MF-1845B.

Kane, M.F. and Braken, R.E., 1983, Aeromagnetic map of the Yucca Mountain and surrounding regions, southwest, Nevada: U.S. Geological Survey Open-File Report 83-616, 19 p.

Klein, D.P., 1990, Geoelectric Surveys, Chapter 2.3 in Oliver, H.W., Hardin, E.L., and Nelson, P.H., eds., Status of data, major results, and plans for geophysical activities, Yucca Mountain Project, U.S. Geological Survey for the Department of Energy: Department of Energy Report, Yucca Mountain Project, YMP/90-38, p. 33-46.

Rosenbaum, J.G., and Snyder, R.B., 1985, Preliminary interpretation of paleomagnetic and magnetic property data from drill holes USW G-1, G-2, G-3, and VH-1 and surface localities in the vicinity of Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 85-49, 73 p.

"PRELIMINARY DRAFT"

U.S. Geological Survey, 1979, Aeromagnetic map of the Timber Mountain area, Nevada: U.S. Geological Survey Open-File Report 79-587, 3 sheets, scale 1:62,500.

"PRELIMINARY DRAFT"

Figure 1. Index map and gridded aeromagnetic data along seismic traces across Crater Flat and Yucca Mountain at scale of 1:100,000. Contour interval is 40 nT. Numbers indicate locations of the 15 profiles. All profiles are shown from W to E. USW VH-1 and USW VH-2 are drill holes nearest to the major anomalies. See Carr and Parrish (1985).

Figure 2. Timber Mountain aeromagnetic survey showing locations of the 15 new profiles along the seiemic traces. This survey was flown in 1977 with E-W lines draped at 400 ft with 1/4 mi spacing. IGRF gradient was removed (USGS, 1979).

Plate 1. Aeromagnetic profiles 1-12 following seismic traces across Crater Flat and Yucca Mountain. All profiles read W to E. Profiles are stacked N to S in sets of three.

"PRELIMINARY DRAFT"

Plate 2. Aeromagnetic profiles 13-15 and index map of profiles across Crater Flat and Yucca Mountain. All profiles read W-E. Profiles are stacked N to S in sets of 3. Scale is 1:48,000. Arrows on the index map indicate original flight direction.

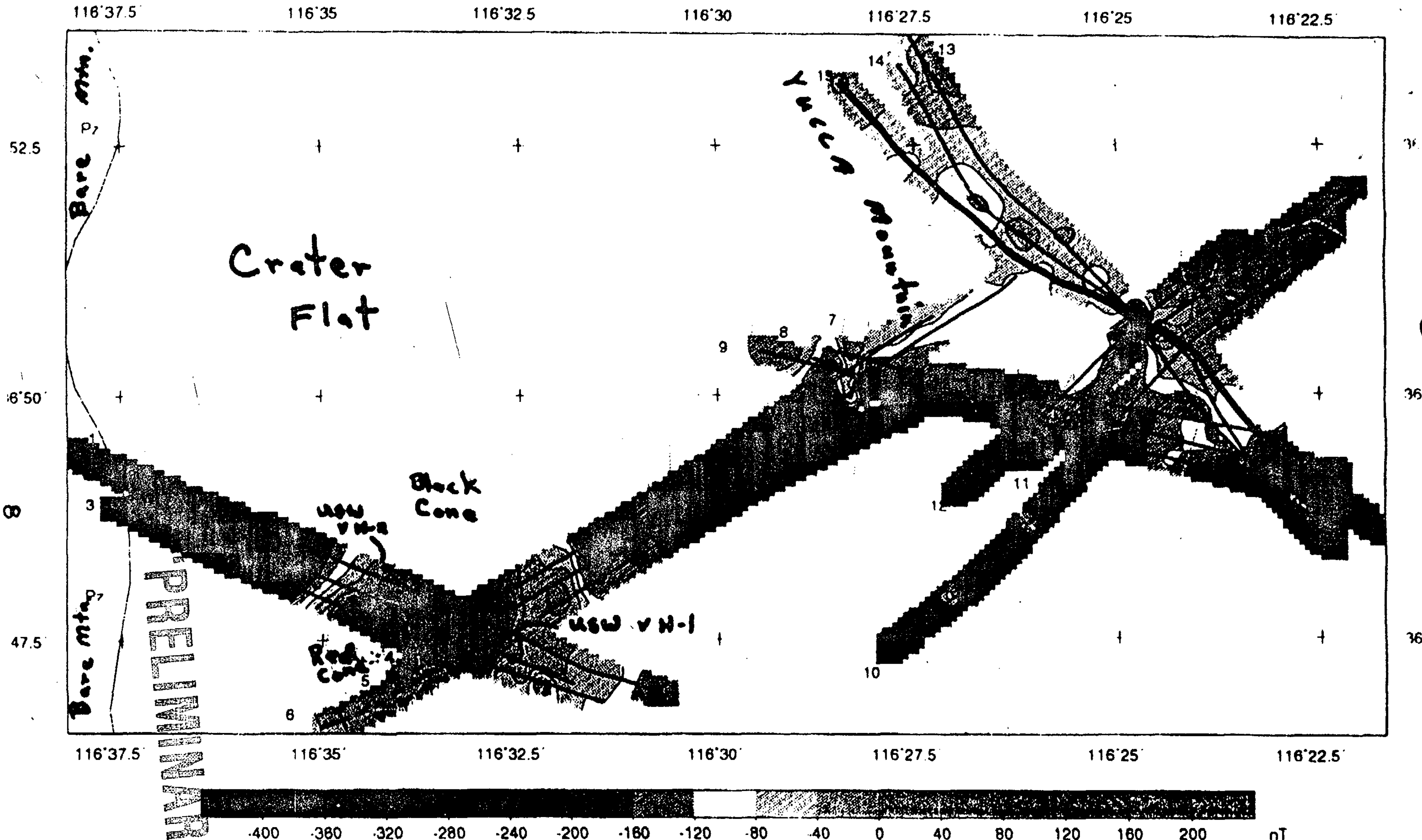



Figure 1. Index map and gridded aeromagnetic data along seismic traces across Crater Flat and Yucca Mountain at scale of 1:100,000. Contour interval is 40 nT.Numbers indicate locations of the 15 profiles. All profiles are shown from W to E. USW VH-1 and USW VH-2 are drill holes nearest to the major anomalies. See Carr and Parrish (1985).

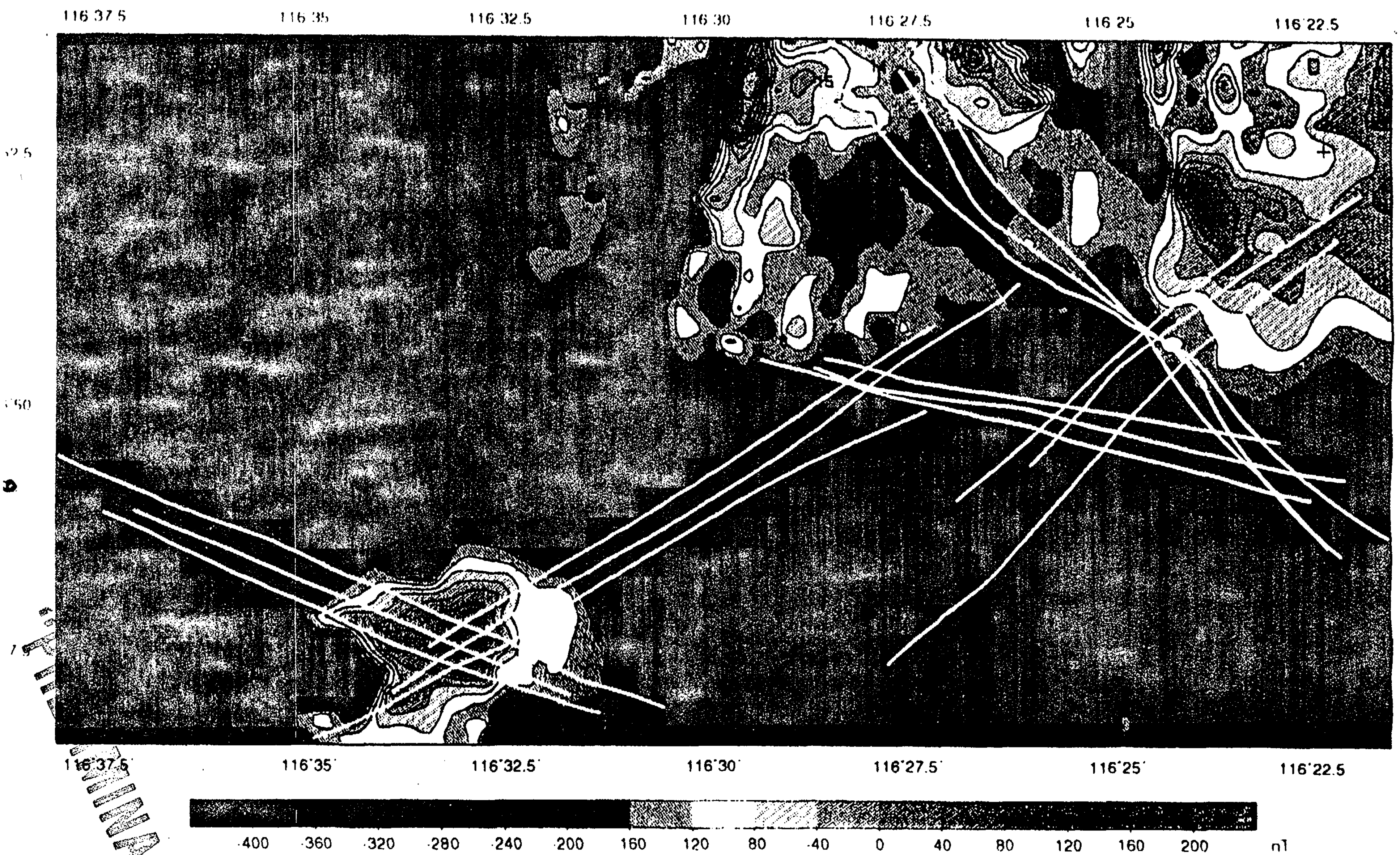




Figure 2. Timber Mountain aeromagnetic survey showing locations of the 15 new profiles along the seismic traces. This survey was flown in 1977 with E-W lines draped at 400 ft with 1/4 mi spacing. IGRF gradient was removed (USGS, 1979).