UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

DESCRIPTION AND PRELIMINARY MAP OF AIRBORNE ELECTROMAGNETIC SURVEY OF PARTS OF IRON, BARAGA, AND DICKINSON COUNTIES, MICHIGAN

By

William D. Heran and Bruce D. Smith

Open-File Report 80-297

Contents

Page

Figures

Introduction

The data presented herein is from an airborne electromagnetic INPUT* survey conducted by Geoterrex Limited of Canada for the U.S. Geological Survey. The survey area is located in the central part of the Upper Peninsula of Michigan, within parts of Iron, Baraga, and Dickinson Counties. The general area covered is between 46°00′ and 46°30′ latitude and 88°00′ and 88°30′ longitude (fig. 1).

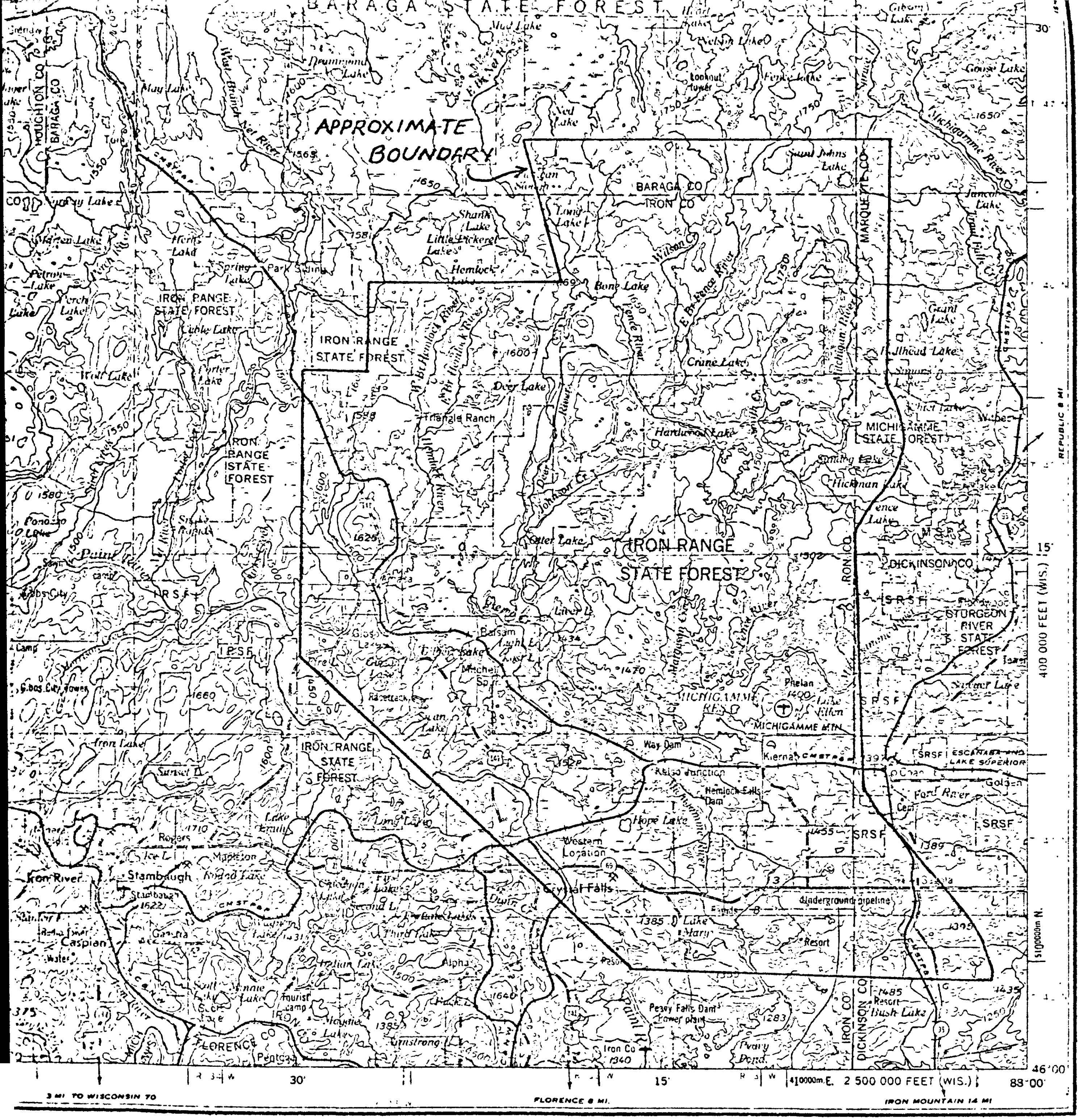
Figure 1.--NEAR HERE

The INPUT survey was flown as part of a U.S. Geological Survey CUSMAP (Conterminous United States Mineral Appraisal Program) project focusing on the Iron River 2° quadrangle. The survey was flown in order to provide geophysical information which will aid in an integrated geological assessment of mineral potentials of this part of the Iron River 2° quadrangle. The flight-line spacing was chosen to maximize the aerial coverage without a loss of resolution of major lithologic and structural features.

East-west flight lines were flown 400 feet above ground at 1/2-mile intervals. Aerial photos were used for navigation and the flight path was recorded on continuous-strip film. A continuously recording total field ground magnetic station was used to monitor variations in the Earth′s magnetic field. One north-south line was flown to provide a tie for the magnetic data which was recorded simultaneously with the electromagnetic

---

*Registered trademark of Barringer Ltd. Use of trade names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.



● INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1974

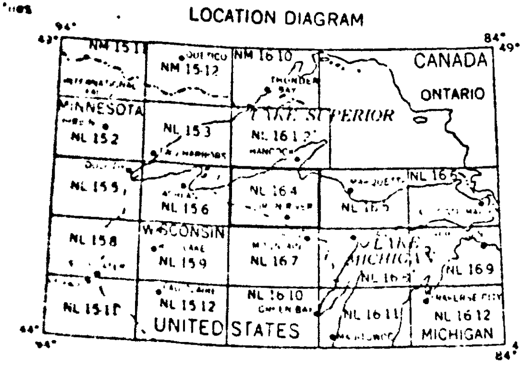


FIGURE 1
LOCATION OF AIRBORNE SURVEY

TOWNSHIP OR RANGE LINE ————

LAND GRANT BOUNDARY —··—··—

SECTIONIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

IRON RIVER, MICHIGAN; WISCONSIN

1958

LIMITED REVISION 1967

data by a sensor mounted in the tail of the aircraft.

This report is one of two open-file reports. The map in the present report contains locations of the fiducial points, the flight lines, and preliminary locations of anomalies and conductive zones, all plotted on an air photomosaic. The latitude and longitude ticks marked on this map are only approximate due to distortion in air photos used to recover the flight line position. This map is preliminary and is not to be considered a final interpretation. The other report (Heran and Smith, 1980) contains a description of the instrument specifications, a copy of the ground station magnetic data, and a microfilm record of the electromagnetic and magnetic data, with reference to the digital data of the flight records. The purpose of two reports is to make the analog and digital records available separate from the anomaly map.

The following sections on the general description of the INPUT system are abridged from a typical interpretation report prepared by Geoterrex Limited of Ottawa, Canada for the U.S. Geological Survey.

General description of INPUT system

The INPUT (Induced Pulse Transient) method (Barringer, 1965), is based upon the study of the decay of secondary electromagnetic fields created in the ground by short pulses generated from an aircraft. The time-varying characteristics of the decay curve are analyzed and interpreted in terms of information concerning the conductivity characteristics of the Earth's surface.

At a normal survey altitude of 400 feet (120 meters) above terrain, the typical effective depth penetration is estimated at about 400 feet (120 meters) below surface, depending upon the conductivity of the conductive body and of the surrounding rocks, the size and attitude of the conductor, and the presence or lack of conductive overburden. In optimum conditions a penetration of 600 feet (185 meters) subsurface may be achieved. One aspect of the INPUT method is that flat-lying surface conductors may produce a different response than bedrock conductors, so that the latter may be distinguished even under a relatively thick overburden such as glacial or pedological formations (laterite, weathered zone, etc.).

The transmitted primary field is discontinuous in nature (fig. 2A) with each pulse lasting one millisecond; the pulse repetition rate is 288 per second. The electromagnetic pulses are created by means of electrical pulses fed into a 3-turn shielded transmitting loop surrounding the survey aircraft and fixed to the nose, tail, and the wing tips.

The secondary field reception is made by means of a receiving coil wound on a ferrite rod and mounted in a "bird" towed behind the airplane on a 500-foot (150-meter) coaxial cable. The axis of the pickup coil is horizontal and parallel to the flight direction. Gaps of two and a half milliseconds between successive primary pulses (fig. 2B) are used for detecting the INPUT voltage, which is a transient voltage (fig. 2C) corresponding in time to the decay of the eddy currents in the ground.

The analysis of the signal is made in the INPUT receiver by sampling the decay curve at several points or gates, the center and width of which have a fixed relationship with respect to time zero (t_o) corresponding to the termination of the pulses. The INPUT system has six sampling gates, the centers of which are commonly at a mean delay of 300, 500, 700, 1100, 1500, and 1900 microseconds after time zero (fig. 2D). For the Iron River survey, gate centers were set at 420, 620, 820, 1120, 1520, and 2020 microseconds with a primary pulse of 900 microseconds.

Figures 2A-2D.--NEAR HERE

INPUT SIGNAL

(Idealized)

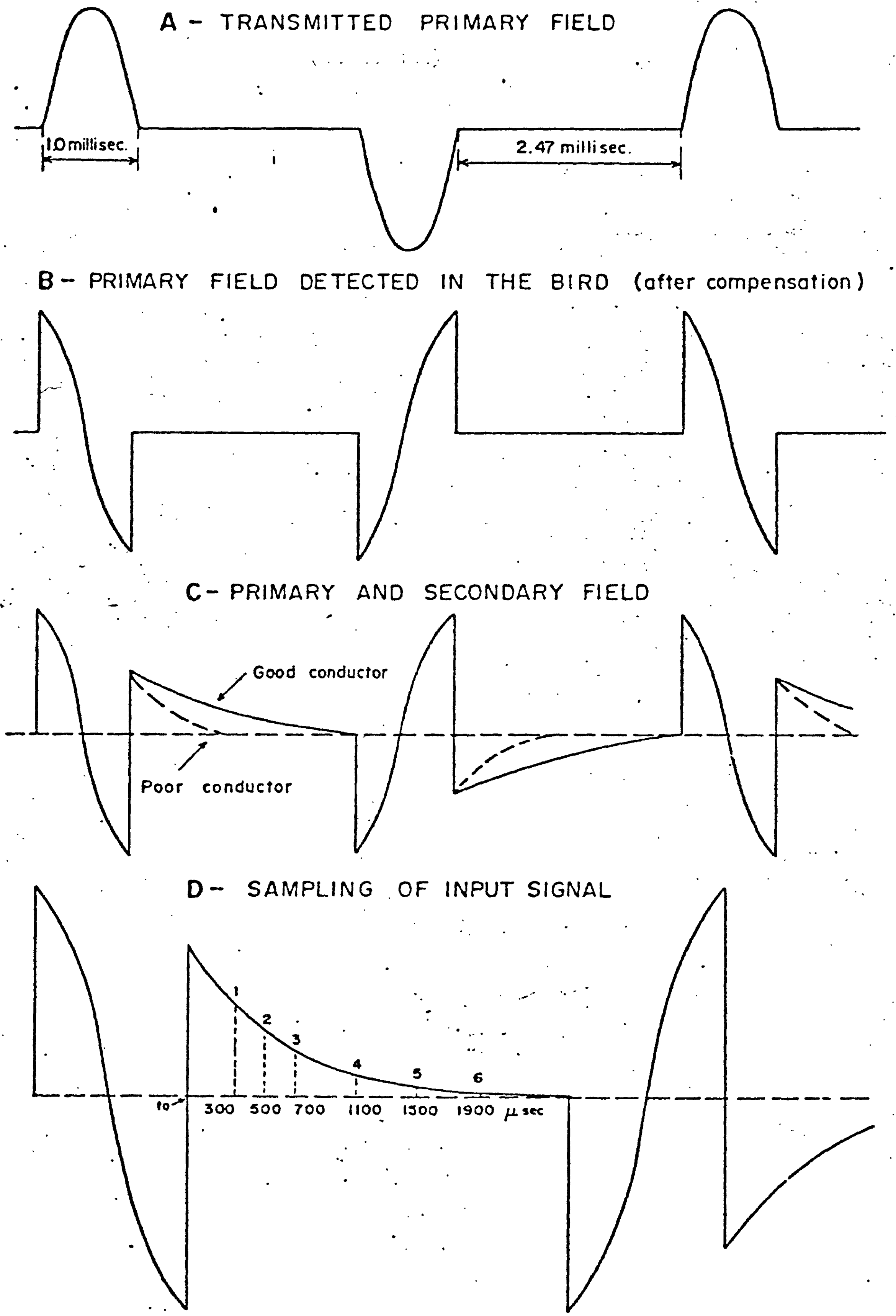


Figure 2

The signals received at each sampling gate are processed in a multichannel receiver to give six analog voltages recorded as six continuous analog traces. Each trace represents the coherent integration of the transient sample, the time constant of integration being about three seconds on the Mark V INPUT system. One channel is sometimes operated at a time constant of approximately 1.0 second in addition to the normal time constant. This integration delay, plus the separation between the receiving bird and tracking camera installed in the aircraft, introduces a delay which has to be taken into consideration and corrected prior to correlating the electromagnetic data with the other simultaneously recorded data which include:

- fiducial marks,
- altimeter trace,
- Earth's total magnetic field,
- 60 Hertz cultural noise monitor (Hz monitor),
- radiometric levels (optional).

The analog and magnetic base station data are available in another report (Heran and Smith, 1980).

Description of anomaly map

The normal field procedure during an airborne electromagnetic survey is to recover the flight paths at the end of each day of operations. This recovery consists of using the fiducial marks, synchronized with the 35 mm film strip of the flight recorder, to plot the fight paths on a set of photomosaics. The INPUT anomalies are then located along the appropriate flight path from the analog records given in another report Heran and Smith (1980). The location of INPUT anomalies is corrected to take into account the delay between the recording of the anomaly and its location on the ground. Figure 3 is the anomaly map with a photomosaic background as recovered by the contractor.

Figure 3.--NEAR HERE

The anomaly map presented herein (fig. 3) is <u>not</u> a final interpreted map. The map is being released in order that interested persons may make more immediate use of the information. Normally a geophysical report by a contractor would include a description of the probable source of each anomalous trend and each anomaly. One example of the detailed interpretation of a similar airborne geophysical survey has been given by Mishra, Murthy, and Narain (1978). Palacky and West (1973) give a detailed account of automated interpretation of INPUT data.

The anomaly map condenses the most significant characteristics of the survey with symbols as given on the map index. The only subjective elements introduced are in the identification of groups of anomalies belonging to a conductive zone and the rejection of certain INPUT responses as being due to noise sources.

Previous related work

Geology of parts of the Iron River 2° quadrangle have been mapped at a scale of 1:24,000 by Bayley (1959), Gair and Wier (1956), and Wier (1967). Geology of the Ned Lake quadrangle was mapped by Foose (1978) at a scale of 1:62,500. Cannon and Klasner (1976) published a geologic and geophysical map of the Witch Lake quadrangle at a scale of 1:62,500. Balsley, James, and Wier (1949) conducted an aeromagnetic survey of Baraga, Iron, and Haughton Counties, Michigan.

References

Balsley, J. R., James, H. L., and Wier, K. L., 1949, Aeromagnetic survey of parts of Baraga, Iron, and Haughton Counties, Michigan with preliminary geologic interpretation: U.S. Geological Survey Geophysical Investigations Map, 1 sheet.

Barringer, A. R., 1965, The Barringer INPUT airborne electromagnetic exploration system: Barringer Research Limited, Toronto, Canada.

Bayley, R. W., 1959, Geology of the Lake Mary quadrangle, Iron County, Michigan: U.S. Geological Survey Bulletin 1077, 112.

Cannon, W. F., and Klasner, J. S., 1976, Geology map and geophysical intepretation of the Witch Lake Quadrangle, Marquette, Iron, and Baraga Counties: Michigan U.S. Geological Survey Miscellaneous Investigations Map I-987.

Foose, M. P., 1978, Preliminary geologic map of the Ned Lake quadrangle, Michigan: U.S. Geological Survey Open-file Report 78-386.

Gair, J. E., and Wier, K. L., 1956, Geology of the Kiernan quadrangle, Iron County, Michigan, U.S. Geological Survey Bulletin 1044, 88 p.

Heran, W. D., and Smith, B. D., 1980, Instrument specifications and geophysical records for airborne electromagnetic survey of parts of Iron, Baraga, and Dickinson Counties, Michigan: U.S. Geological Survey Open-file Report 80-296, 15 p.

Mishra, D. C., Murthy, K. S. R., and Narain, H., 1978, Interpretation of time-domain airborne electromagnetic (INPUT) anomalies: Geoexploration, 16, p. 203-222.

Palacky, G. J., and West, G. F., 1973, Quantitative interpretation of INPUT AEM measurements: Geophysics, v. 38, no. 6, (December 1973), p. 1145-1158.

Telford, W. M., Geldart, L. P. and Keys, D. A., 1976, Applied Geophysics: Cambridge University Press, p. 549.

Wier, K. L., 1967, Geology of Kelso Junction quadrangle, Iron County, Michigan: U.S. Geological Survey Bulletin 1226, 47 p.