UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

INSTRUMENT SPECIFICATIONS AND GEOPHYSICAL RECORDS FOR AIRBORNE ELECTROMAGNETIC SURVEY OF PARTS OF IRON, BARAGA, AND DICKINSON COUNTIES, MICHIGAN

By

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Open-File Report 80-296

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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 areal coverage without a loss of resolution of major lithologic and structural features.

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

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

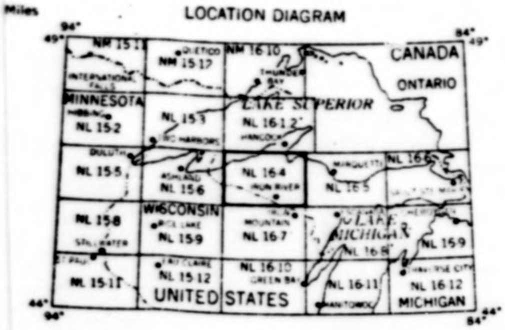

FIGURE 1
LOCATION OF AIRBORNE SURVEY

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

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

This report is one of two open-file reports. The map in the other report Heran and Smith (1980) shows locations of the fiducial points, the flight lines, 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 present report contains a description of the instrument specifications, a copy of the ground station magnetic data, and a 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 magnetic 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.).

Equipment

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 and tail of the fuselage and to the wing tips.

Figure 2.--NEAR HERE

The secondary field reception is made by means of a receiving coil wound on ferrite rod and mounted in a "bird" towed behind the airplane on a 500-foot (150-meter) coaxial cable (fig. 3). The axis of the pickup

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Figure 3.--NEAR HERE

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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.

INPUT SIGNAL

(Idealized)

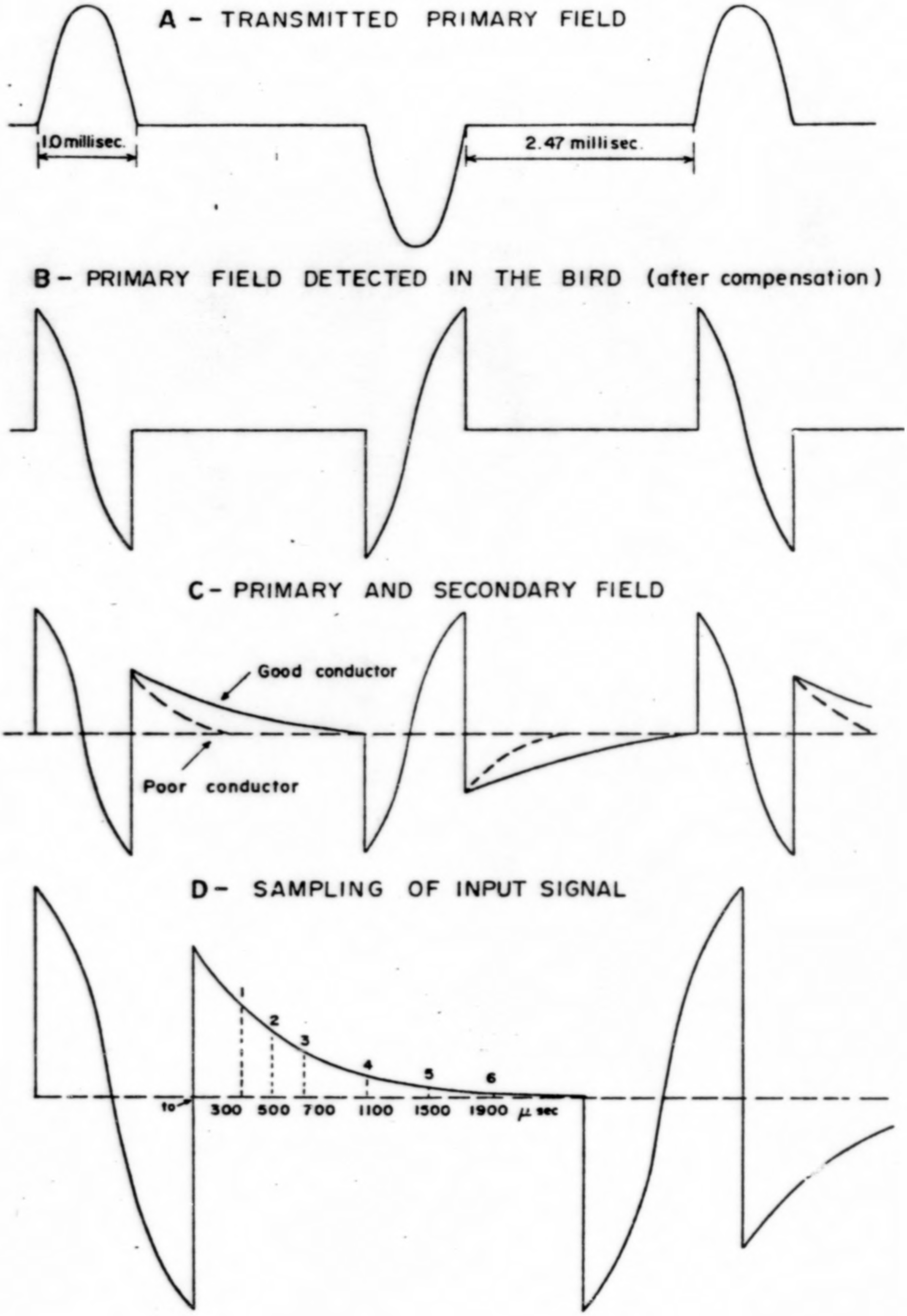
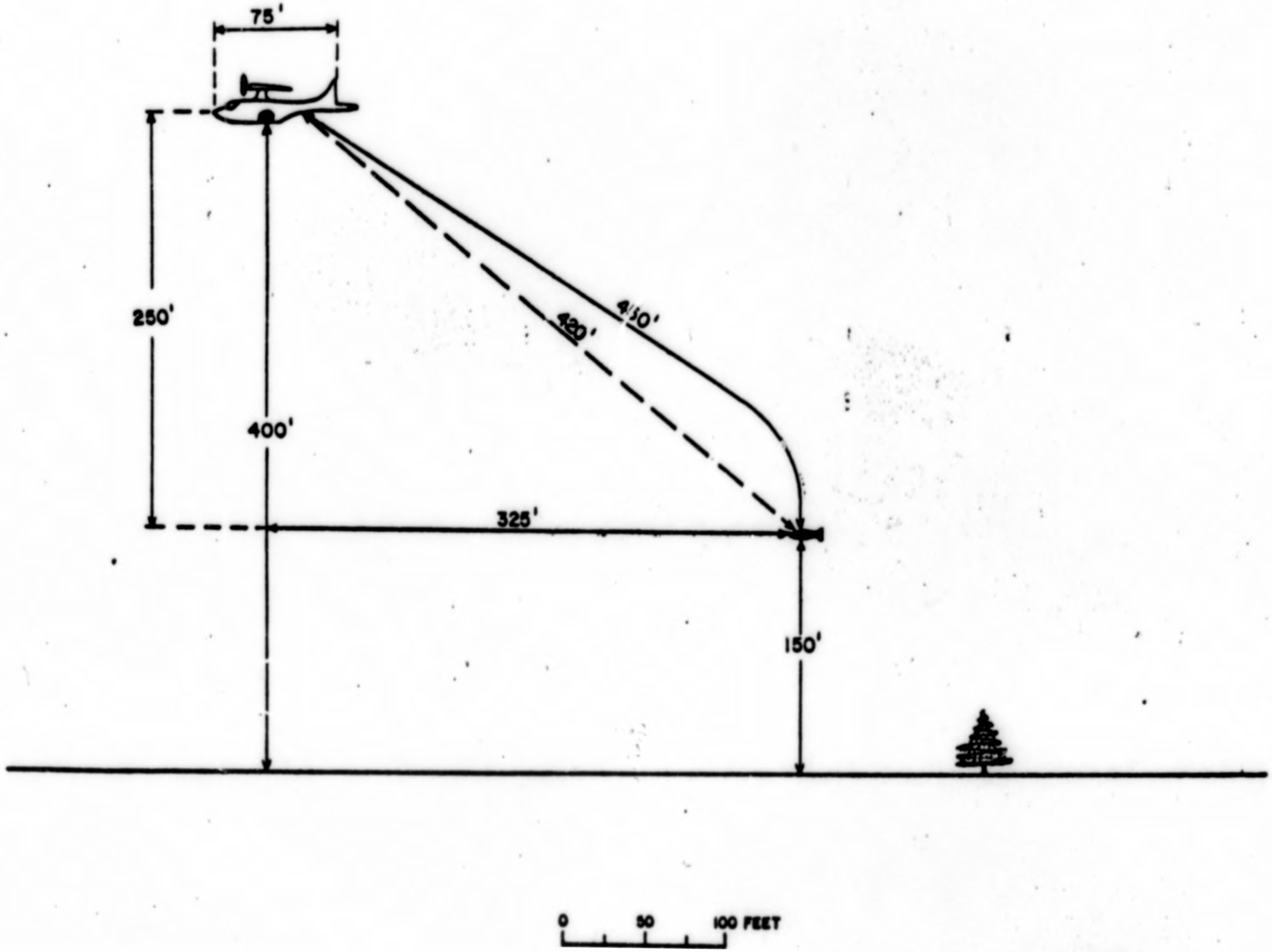


Figure 2

Figure 3

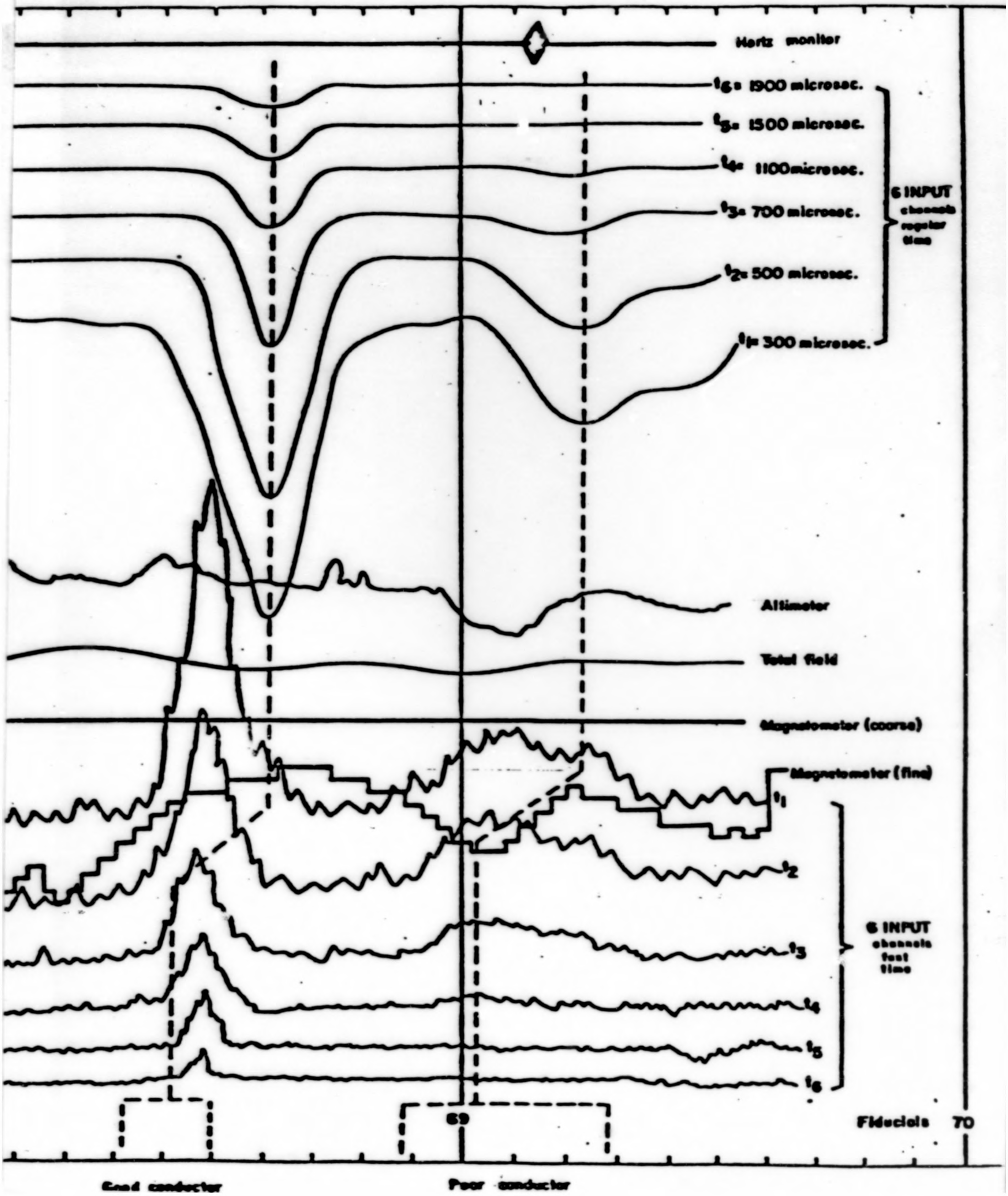
RELATIVE POSITION OF BIRD AND AIRCRAFT

BARRINGER INPUT SYSTEM



TYPICAL INPUT RECORDING

Figure 4



The signals received at each sampling gate are processed in a multi-channel receiver to give six analog voltages recorded as six continuous analog traces (fig. 4). Each trace represents the coherent integration of

Figure 4.--NEAR HERE

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 powerline monitor (Hz monitor),
- radiometric levels (optional).

The analog INPUT and magnetic base station data are available in this report.

Magnetometer

The magnetometer is a Geometrics G-803 nuclear precession unit adapted to operate in conjunction with the INPUT equipment. Readings are taken approximately every second with a sensitivity of plus or minus 2 gammas and recorded at a full scale of 5 inches for 200 gammas. The coarse trace is recorded at a full scale of 5 inches for 20,000 gammas, or at a full scale of 5 inches for 2000 gammas. The sensing head is mounted at the end of a 3-meter stringer, on the tail of the PBY aircraft. The magnetometer record is also shown in figure 4.

Other equipment

The tracking camera is a 35 mm continuous-strip camera equipped with a wide-angle lens. The 35 mm film is synchronized with the geophysical record by means of fiducial marks printed approximately every 20 seconds, the counter of the intervalometer being driven by the clock of the magnetometer.

A radar altimeter is used, and its output is recorded on the chart.

A 60-hertz signal monitor (Hz monitor), tuned to the local domestic power distribution frequency, is commonly used to assist in the detection of power lines.

Procedures

Field operations

The flight-line spacing for INPUT surveys is normally in the range of 1/8 mile (200 meters) to 1/4 mile (400 meters) for mineral exploration. This survey was flown with 1/2-mile (800-meters) line spacing in order to maximize areal coverage without a loss of resolution of major structural and lithologic units. During survey flights the altitude of the aircraft is maintained at approximately 400 feet (120 meters) above the ground with the bird flying about 200 feet (60 meters) below the aircraft.

The heading of the aircraft is such that two adjacent lines are normally flown in opposite directions. Visual navigation is based on airphoto mosaics or in some cases on topographic maps of suitable scale.

Compilation

At the end of each flight, all records and films were developed, edited, and all synchronized fiducial marks were checked. Then, the actual flight-path recovery was made by picking visible marks common to both 35 mm film and photomosaics. Identified points with their fiducial number were plotted on the mosaic. Then, the electromagnetic anomalies were transferred from the records onto the mosaic overlay by interpolation according to their own fiducial number.

The position of the INPUT anomalies must be corrected to take into account the separation between the bird and the aircraft, as well as the delay introduced in the integration circuitry. This offset, or lag, was plotted toward the smaller fiducial numbers (to the left on the record as shown in fig. 4).

The INPUT anomalies are represented on a map by means of symbols that condense the most significant characteristics: the location of the center and half-peak width of the electromagnetic anomaly; the number of INPUT channels affected by a noticeable deflection; the peak amplitudes of the first and fourth channels. Shown also are the altitudes at which the anomalies were recorded, the amplitude of any magnetic features which coincide with INPUT anomalies, and any associated response on the Hz monitor.

The only subjective elements introduced by this processing are in the decision as to whether a deflection corresponds to a genuine anomaly or to a noise source (SFERIC electromagnetic noise, compensation noise, etc.), and in the correlation of the anomalies from line to line to delineate a conductive zone.

MADACS digital acquisition system

The MADACS is a computer-based software system using an Interdata processor, model 6/16 with 32 K memory. This computer is linked with a Digi-Data, model 1600 magnetic-tape drive with a true-read-after-write feature which allows checking of the recording processes as many times as the particular application permits. The checking procedure includes elimination of errors due to bad tape spots. Use of multiple buffers permits recording and processing data simultaneously with acquisition of new data with no resulting dead time.

The system uses an Electrohome TV monitor to display acquired data and operator messages and is fully interactive with a Cybernex alpha-numeric keyboard which can be used remotely for special installations.

MADACS archive tape specifications

The archive magnetic tapes contain only the production data. All calibrations and scrub lines can be found on the field tapes.

Tape density: 9 track, 800 bpi, NRZ 1 compatible

Recording mode: EBCDIC (4 byte words, 32 bits)

Block size: 5000 words

Record length: 50 words (200 bytes)

25I8 Format

Description of one logical record (1 paramter = 8 characters)

PARAMETER	BYTE POSITION	# BYTES	DESCRIPTION
1	1 - 8	8	Identification (flight x 10)
2	9 - 16	8	Fiducial line x 10 + pa(?)
3	17 - 24	8	time in seconds (x 10)
4	25 - 32	8	Magnetometer (x 100)
5	33 - 40	8	nil
6	34 - 48	8	nil
7	49 - 56	8	nil
8	50 - 64	8	nil
9	65 - 72	8	Altimeter in feet
10	73 - 80	8	Channel 1 INPUT
11	81 - 88	8	Channel 2 INPUT
12	82 - 96	8	Channel 3 INPUT
13	83 - 104	8	Channel 4 INPUT
14	105 - 112	8	Channel 5 INPUT
15	113 - 120	8	Channel 5 INPUT
16	121 - 128	8	INPUT total field
17	129 - 136	8	nil
18	137 - 144	8	nil
19	145 - 152	8	nil
20	153 - 160	8	nil
21	161 - 168	8	nil
22	169 - 176	8	nil
23	177 - 184	8	nil
24	185 - 192	8	nil
25	193 - 200	8	nil

Mark V INPUT and magnetic system instrument specifications

Transmitters: Pulse Width 0.90 m sec.

Pulse Separation 2.51 m sec.

Receiver:	GATE CENTRE CHANNEL	GATE WIDTH (μ sec)	(μ sec)
1	420	200	
2	620	200	
3	820	400	
4	1120	400	
5	1520	600	
6	2020	800	

Magnetometer: Geometrics Model G-803

		Sensitivity	Scale
Fine scale:	200 gammas full scale	+ 2	inch = 40 gammas
Coarse scale:	20,000 gammas full scale	+ 200	inch = 4000 gammas

Total field increases downwards.

Magnetometer reads every 1.0 sec.

Other Instrument Specifications

Altimeter: Model Sperry RT220

Approximate scale: 1 inch - 100 feet

Altitude increases downwards

FIDUCIAL SYSTEM

1 FIDUCIAL = 20 seconds = 20 magnetometer readings

INPUT lag = 4.0 seconds = 0.20 fiducials

Ground Station Magnetometer: Geometrics Model G-806

	Sensitivity	Scale
100 gammas full scale	+ 1	inch = 10 gammas

Magnetometer reads approximately every 5 second.

(Paper speed = 0.5 inch/minute)

MADACS Digital Acquisition System: Interdata processsor, Model 6/16

MADACS reads every 0.2 second.

Analog and digital data

Magnetic base station records are given in figure 5. A microfilm copy of the analog airborne data is provided with this report (fig. 6). Inquiries concerning the digital data of the flight records or any aspects of the INPUT survey data can be made by writing to

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Figures 5 and 6.--NEAR HERE

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.

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