ODP

Processing Notes:

Magnetic Data

OCEAN
DRILLING
PROGRAM

3/2004

Processing Notes: Magnetics Data

First leg logged: Leg 134
Last leg logged: Leg 189

Tools Used

Two types of magnetic data were collected during the ODP: magnetic remanence and susceptibility data. Two tools were developed jointly by the oil industry (TOTAL and Schlumberger) and the French government research institutions (CNRS-ENS). The tools were constructed by CEA-LETI, a branch of the French Atomic Energy Commission, which also developed the technical solutions (see Bibliography). The tools were run separately during Legs 134 (1 hole) and 145 (2 holes), but were subsequently refined and combined into a tool string, which also included the Natural Gamma Ray Spectrometry Tool (NGT). The magnetic tool became known as the Geologic High Resolution Magnetic Tool (GHMT). A total of forty holes were logged with the GHMT.

GHMT Measurement

The GHMT consists of two sondes: SUMS (Susceptibility Magnetic Tool) and NMRS (Nuclear Resonance Magnetometer Tool). The former makes an induction-type measurement that records a signal related to formation susceptibility, while the latter is a high-precision nuclear magnetic resonance device that measures the total magnetic field.

The magnetic induction (B) measured by the NMRS in a borehole is a function of location (p) and time (t) and can be expressed as a sum of different components (Pozzi et al., 1993):

$$B(p,t) = B_r(p) + B_a(p) + B_t(p,t) + B_f(p)$$

where:

- $B_r(p)$: dipolar Earth's magnetic field
- $B_a(p)$: anomaly field related to large scale heterogeneities
- $B_t(p,t)$: transient variations of the magnetic field, of external origin
- $B_f(p)$: field due to the magnetization (induced and remanent) of the sediment surrounding the borehole.
- $B(p,t)$ generally presents a shift towards high values at the top of the logged section; this effect is caused by the highly magnetized bottom hole assembly (pipe effect) and can be removed by modeling the pipe as a magnetic dipole.

Data Processing

Techniques

The goal of GHMT data processing is to obtain a magnetic reversal sequence that allows one to determine the magnetostratigraphy of a logged interval.

After removal of the first three components and correction for pipe effect, the field due to the local magnetization ($B_f(p)$) is obtained. The susceptibility effect on the scalar total field magnetometer is calculated from the susceptibility tool (SUMS) and a transfer coefficient which depends on the geomagnetic location of the hole, the hole diameter, and a calibration ratio. To obtain the magnetostratigraphy from $B_f(p)$, the susceptibility and total field measurements are combined to discriminate between induced and remanent magnetization. To obtain comparable data, the susceptibility effect and the remanent component are smoothed using Hanning filtering.

As the zero reference is not well defined and the volumes of investigation of the magnetometer and the susceptibility sonde are different, the polarity cannot be determined directly from the remanent component. The Koenigsberger coefficient, however, is supposed to be approximately constant for a given lithology. Then the slope of the mean square fit in a crossplot of the remanent versus the induced component may indicate the polarity of the paleomagnetic field (Barthès, 1991; Thibal, 1995). The correlation (positive slope) or anti-correlation (negative slope) between these two curves indicates respectively a normal or reverse polarity. The study of the correlation is performed in a sliding window versus depth. The length of a reversal and the time between two reversals is close to being random and the distance between them varies greatly. Therefore, the computation is performed several times by varying window heights and the results can be combined afterwards.

The number of window necessary for the interpretation is different for each hole and is chosen by the log analyst. A synthesis of the polarity sequence could be established considering that, for a given depth:

- if the slope is positive in every window, the final polarity is normal
- if the slope is negative in every window, the final polarity is inverse
- if the slope is either positive or negative, the final polarity is undetermined.

The higher the amplitude of the slope, the stronger the correlation or anti-correlation between the curves.

This synthesis can be compared to a standard geomagnetic time scale to determine the magnetostratigraphy of the logged sediment.

Outputs

For each hole logged with the GHMT, raw and processed GHMT data are displayed in an ASCII file. This file contains the following data from left to right:

- DEPTH (mbsf): sub-bottom depth
- MAGS (ppm SI): magnetic susceptibility, corrected for hole diameter
- BFI (nT): susceptibility effect
- BFIF (nT): filtered BFI
- MAGB (nT): raw total magnetic field
- BTCOR (nT): total magnetic field, corrected for pipe effect and present Earth's magnetic field
- BTCORF (nT): filtered BTCOR
- REMA (nT): remanent component
- SLOPE (1-10): slope determined in the first to tenth window

Size of each window:

1 → 11 samples = 1.52 m
2 → 13 samples = 1.82 m
3 → 17 samples = 2.43 m
4 → 23 samples = 3.35 m
5 → 31 samples = 4.57 m
6 → 41 samples = 6.09 m
7 → 53 samples = 7.92 m
8 → 67 samples = 10.05 m
9 → 88 samples = 13.25 m
10 → 101 samples = 15.24 m

Processing History

All of the GHMT data from Leg 145 to Leg 184 were processed at the log analysis center in Aix en Provence (France). Legs 188 and 189 were processed at the Borehole Research Group at the Lamont-Doherty Earth Observatory. A summary of the available data and the holes processed is provided in the GHMT Summary Table.

Data storage

The GHMT proprietary data are saved on CD-ROM, along with other logging data recorded during each leg, and in the archive directory on the LDEO-BRG file server. Processed magnetic data are available through the online database, along with any related documentation.

Bibliography

- Barthès V, 1991. Traitement et interprétation des données GHMT. Rapport interne CEA/LETI/DSYS/SESA.

- Pozzi J-P, Barthès V. Thibal J, Pocachard J, Lim M, Thomas T, and Pagès G, 1993. Downhole magnetostratigraphy in sediments: comparison with the paleomagnetism of a core. J. Geophys. Res., 98, 7939-7957.

- Thibal J, 1995. Analyse de l'aimantation des sédiments par diagraphies magnétiques. PhD thesis, Univ. of Paris XI Orsay.

MAGNETIC DATA SUMMARY TABLE

Logging Date	Leg	Hole	Tool Type	Processed	Depth Shifted	Remarks
1990	134	831B	NMRT/SUMB	N	N	No NGT run
1992	145	883F	NMRT/SUMB	Y	Y	No NGT run
1992	145	884E	NMRT/SUMB	Y	Y	No NGT run
1994	154	925C	GHMT	Y	Y	No NGT run No MAGB data available
1994	154	926B	GHMT	Y	Y	No NGT run No MAGB data available
1994	155	931B	GHMT	Y	Y	
1994	155	933A	GHMT	Y	Y	
1995	160	966F	GHMT	Y	Y	
1995	160	967E	GHMT	Y	Y	
1995	162	984B	GHMT	Y	Y	No MAGB data available
1995	162	986C	GHMT	Y	Y	
1995	162	987E	GHMT	Y	Y	
1996	165	998B	GHMT	Y	Y	
1996	165	1000B	GHMT	Y	Y	No MAGB data available
1996	165	1001A	GHMT	N	N	Bad data
1996	167	1014A	GHMT	Y	Y	No MAGB data available
1996	167	1016A	GHMT	Y	Y	No MAGB data available
1996	167	1019C	GHMT	Y	Y	No MAGB data available
1996	167	1020B	GHMT	Y	Y	No MAGB data available
1996	167	1022C	GHMT	Y	Y	No MAGB data available
1997	171B	1050C	GHMT	Y	Y	
1997	171B	1051A	GHMT	Y	Y	
1997	171B	1052E	GHMT	Y	Y	
1997	175	1081A	GHMT	Y	Y	
1997	175	1082A	GHMT	Y	Y	
1997	175	1084A	GHMT	Y	Y	
1997	175	1085A	GHMT	Y	Y	No MAGB data available
1998	177	1093D	GHMT	Y	Y	No MAGB data available
1998	178	1095B	GHMT	Y	Y	
1998	178	1096C	GHMT	Y	Y	
1998	178	1103A	GHMT	Y	Y	
1998	181	1119C	GHMT	Y	Y	No MAGB data available

Logging Date	Leg	Hole	Tool Type	Processed	Depth Shifted	Remarks
1998	181	1123B	GHMT	Y	Y	No MAGB data available
1998	181	1124C	GHMT	Y	Y	No MAGB data available
1998	182	1126D	GHMT	Y	Y	No MAGB data available
1998	182	1127B	GHMT	Y	Y	
1999	184	1144A	GHMT	Y	Y	
1999	184	1146A	GHMT	Y	Y	
1999	184	1148A	GHMT	Y	Y	
2000	188	1166A	GHMT	Y	Y	
2000	189	1168A	GHMT	Y	Y	
2000	189	1170D	GHMT	Y	Y	
2000	189	1172D	GHMT	Y	Y	