RSG 135

CORE MAGNETICS

Paleomagnetic Services

CORE MAGNETICS

Services in rock magnetic measurements and analyses for the Oil and Engineering Geology Industries

RSG Project 00/3. Rock magnetic parameters and *in-situ* magnetic vectors determined from core samples from the Rockall area.

Report for Rockall Studies Group,
Dublin

by

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Summary

The magnetic susceptibility and remanent magnetic properties of samples from four core pieces from wells in the Rockall area have been determined, to provide information for use in interpreting aeromagnetic survey data from this region. Principal results of the study are:

- Koenigsberger (Qn) ratios for three of the four samples analysed in this study are close to, or significantly greater than, unity. This indicates that the remanent magnetism of these rock units is at least as strong as the induced magnetism. Consequently, it is important that the remanent magnetic properties of the formation are properly quantified and fully utilised in the interpretation of aeromagnetic survey data from this region.

- The polarity of the characteristic high temperature remanent magnetisation is reverse in two of the samples and normal in the other two. The magnetic polarity will have a major effect on the form of magnetic anomalies.

- The direction and intensity of the *in-situ* remanent magnetic vector in each sample has been reconstructed, using the relative proportions of the low- and high-temperature components determined from unblocking temperature spectra. The direction of the low-temperature component is taken to be that of the Recent geomagnetic field in the survey region. The high temperature component is assumed to be the primary magnetisation, whose direction was predicted from published apparent polar wander data for the NW European plate (taking due account of the magnetic polarity). Results are listed in Table 5.

- The number of samples in this study is very small and consequently the remanent magnetic parameters listed in Table 5 must be considered as only rough approximations. A larger number of samples, spanning significantly greater intervals of core (at least several tens of metres) is required to confirm that the magnetic polarity of these samples is representative of the whole formation and to properly average out geomagnetic secular variation, so as to determine the *in-situ* remanent magnetic vectors with appropriate precision.

Contents

1. Objectives:

- To measure the magnetic susceptibility and remanent magnetic properties of a set of four core samples from wells in the Rockall area
- To establish the relative magnitudes of the induced and remanent components of magnetism in the samples, as represented by the Koenigsberger ratio Qn
- To determine the relative strengths of high- and low-temperature components of remanent magnetism and to use these data to predict the total *in-situ* magnetic vector of the formation, for use in interpreting aeromagnetic data.

2. Samples:

- The four wells from which the samples were taken all lie to the North of Rockall Island, in water depths of 1000 to 1600m. Relevant information is summarized in Table 1. The four core pieces were given laboratory reference codes RKA1, 2, 3 and 4 for use in this study.
- All four wells are near vertical and structural dips in their vicinities do not exceed a few degrees (P. Haughton, *pers comm.* to M, Davis, 5/5/01). Consequently, magnetic inclinations specified in borehole co-ordinates will be essentially the same as those specified relative to the horizontal at the drill site.

Table 1. Sample information

Core piece No	Well No	Lat (°N)	Long (°E)	Probable age
RKA1	11/20-sb01	55.42	349.98	Eocene? (~45Ma)
RKA2	16/28-sb01	54.02	346.49	Unknown
RKA3	83/20-sb01	52.44	344.89	Albian-Cenomanian (~100Ma)
RKA4	83/24-sb02	52.25	344.71	Mid-Late Cretaceous (~90Ma)

3. Methododology:

- A total of nine one-inch diameter plug samples were drilled from the four core pieces, using a non-magnetic plugging bit (See Table 2). The samples were trimmed to length using a rock saw with a non-ferrous blade.
- The magnetic susceptibility of each plug sample was measured with a Kappabridge KLY3-S susceptibility meter.
- The natural remanent magnetisation (NRM) was measured using an Agico JR5A automated spinner magnetometer, and the Koenigsberger Ratio, Qn, was calculated, to determine the relative magnitudes of the remanent and induced components of magnetisation in the formation.
- Each plug sample was then subjected to incremental thermal demagnetisation analysis, to remove spurious components of remanent magnetisation associated with drilling and core handling and to isolate the geologically significant components that might contribute to magnetic anomalies observed at the sea surface.

- The thermal demagnetisation data allowed the unblocking temperature spectra of the samples to be established. specifically the relative magnitudes of the low-temperature and high- temperature components of remanent magnetism. Assuming that the *in-situ* low temperature component is a viscous remanent magnetism (VRM) acquired in the Recent geomagnetic field at the drill site and that the high temperature component represents the primary magnetism of the formation, the resultant remanent magnetic vector can then be computed.

4. Results:

4.1 Magnitude parameters.

- Mean values of relevant rock magnetic *magnitude* parameters are given in Table 2. The number of plugs analysed from each piece is listed in column 4. Log mean magnetic susceptibility and NRM (natural remanent magnetisation) intensity values are given in columns 5 and 6 and the Koenigsberger ratio. Q_r, in column 7.

Table 2. Rock magnetic magnitude parameters

Sample #	Well #	Sample Depth (m)	No of plug samples	Mean susceptibility* (x 10-6 SI)	Mean NRM intensity* (mA/m)	Mean Q_r^+
RKA1	11/20-sb01	15.92-16.10	2	1291.2	423.3	8.4
RKA2	16/28-sb01	147.8-147.92	3	24454.1	975.9	1.0
RKA3	83/20-sb01	131.45-131.5	1	104.13	2.814	0.69
RKA4	83/24-sb02	38.72-38.79	2	511.0	19.36	0.97

*These values are given as log means
+ Computed using a value of 49,201 nT for the present-day mean geomagnetic field intensity in the survey area (based on the 1990 IGRF)

- The Qn value is much greater than unity in sample RKA1. so that the remanent magnetism of this rock unit predominates over the induced magnetism. Qn values are close to unity in samples RKA2 and RKA4 so that their remanent and induced magnetisations have equal importance. Sample RKA3 is the only one in which the Qn ratio is significantly less than unity, so that the induced component exceeds the remanent component. These results underline the potential contribution of the remanent magnetism of the formation to observed magnetic anomalies in this region and the need to properly quantify the remanent magnetic properties of the formation. for use in interpreting aeromagnetic survey data.

4.2 Directional parameters.

- Since the cores were not oriented during drilling, the magnetic declinations are referred simply to the flat half-core surface (rather than geographic North). The number of samples measured was too small to define a statistically valid mean low temperature direction suitable for paleomagnetic re-orientation. Consequently. magnetic declination values in these samples have only limited value and are not considered further.

- The inclination of the high temperature magnetic component in each sample, defined by Principal Component Analysis of the thermal demagnetisation data, is listed in Table 3. Predicted inclination values for the Rockall area in the Cretaceous and Early Tertiary are listed in Table 4. These were calculated from the paleomagnetic apparent polar wander (apw) curve for the NW European plate compiled by Van der Voo (1993), using an axial dipole geomagnetic field model.

Table 3. High temperature magnetic inclination values

Sample #	Well #	Plug #	High T component				
			Inc	95% confid angle	Mean Inc (without sign)	95% confid angle*	Notes
RKA1	11/20-sb01	RKA1-1	-46.4	6.7			Excl anom.
		RKA1-2	10.7	2.4	43.8		sample
		RKA1-3	-41.3	1.5			RKA1-2
RKA2	16/28-sb-1	RKA2-1	44.8	2.4			
		RKA2-2	42	3.5	41.6	9.2	
		RKA2-3	37.5	5.1			
RKA3	83/20-sb01	RKA3-1	-54.5	2.6	54.5		
RKA4	83/24-sb02	RKA4-1	63.9	4.3	63.9		
		RKA4-2	63.9	2.7			

* Valid only for N>=3

Table 4. Predicted axial geomagnetic dipole inclination values for the Rockall area

Age	Inclination (°)
Lower Tertiary (37-66 Ma)	61
Upper Cretaceous (67-97 Ma)	55.5
Lower Cretaceous (98-144 Ma)	55

- The high temperature inclination for sample RKA3 (54.5°) is similar to the predicted axial dipole field (adf) value for the Early Cetaceous age of this sample (55°). However, the mean value for sample RKA1 (43.8°) is significantly less than the predicted adf value of 61° and that for sample RKA4 (63.9°) is greater than the predicted value of 55.5°. The differences probably reflect the fact that the measured magnetic vectors effectively represent "spot" readings of the geomagnetic field defined in single samples, in which geomagnetic secular variation and other sources of local directional variability (e.g. local tectonic movements) have not been averaged out. Consequently, the measured directions do not conform well to the adf model. Measurements on sets of samples spanning greater thicknesses of core are required to properly average out this natural variability.

- Although the number of samples from each core is too small for the adf model to be applicable to the remanent magnetic directions, nonetheless, the measured unblocking temperature spectra for each sample should permit the relative proportions of the low and high temperature remanent magnetic components of the formation to be established with reasonable certainty. Table 5 lists the polarity of the remanent magnetism and the direction and strength of the mean *in-situ* remanent magnetic vector for each sample, reconstructed from the unblocking temperature spectra data using the procedure outlined in Section 2.

Table 5. Remanent magnetism parameters

Sample #	Well #	Magnetic polarity	*In-situ* remanent magnetic field vector of rock		
			Dec (°)	Inc (°)	Intensity (mA/m)
RKA1	11/20-sb01	R	184	-54	255.0
RKA2	16/28-sb-1	N	2	63	970.7
RKA3	83/20-sb01	R	184	-54	1.68
RKA4	83/24-sb02	N	3	59	19.34

5. Conclusions

- Qn values for three of the four samples analysed in this study are close to, or significantly greater than, unity so that the remanent magnetism of these rock units is at least as strong as the induced magnetism. Consequently, it is important that the remanent magnetic properties of the formation are properly quantified and fully utilised in the interpretation of aeromagnetic survey data over this region.

- The polarity of the characteristic high temperature remanent magnetisation is reverse in two of the samples and normal in the other two. The magnetic polarity will have a major effect on the form of magnetic anomalies.

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6. References.

Van der Voo, R. 1993. Paleomagnetism of the Atlantic, Tethys and Iapetus Oceans. Cambridge University Press. 411pp.