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Magnetic Susceptibility Measurements on Concrete Samples

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REPORT

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Magnetic Susceptibility Measurements on Concrete Samples

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Summary:
Multiple magnetic susceptibility measurements were made on five concrete samples for SINTEF. The samples were paramagnetic or ferromagnetic. Susceptibility values ranged from 155 to 10219 $x10^{-5}$ (SI). The two magnetic samples had high susceptibility values with averages of 4773 $x10^{-5}$ (SI) for sample B, and 3735 $x10^{-5}$ (SI) for sample C. In contrast the three weakly magnetic samples have low susceptibility values that ranged from 155 to 211$x10^{-5}$ (SI). Based on the susceptibility values, the calculated magnetic permeability values of the samples are: 1.00162 for sample A, 1.04773 for sample B, 1.03735 for sample C, 1.00202 for sample D, and 1.00162 for sample E.
Multiple susceptibility measurements were made on a large concrete block. These measurements had susceptibility values that ranged from 105 to 198 $x10^{-5}$ (SI). The average susceptibility value is 130 $x10^{-5}$. The calculated magnetic permeability of the concrete block is 1.0013.

	Petrofysikk	Magnetometer
		Fagrapport

CONTENTS

TABLES

1. INTRODUCTION

Core samples, 50cm in diameter by 51cm long, were measured using an MS2C Bartington magnetic susceptibility bridge. Samples were measured in twenty steps, with a background measurement made before and after each set of measurements on individual cores. In addition multiple measurements were made on a large concrete block, 20x20x15 cm using a hand held susceptibility meter (Geofyzik, Brno, KT-5). The susceptibility data is reported in Table 1.

2. METHODS

MS2 Magnetic Susceptibility System

The MS2 Magnetic Susceptibility System (Bartington Instruments Ltd) comprises a portable measuring instrument, the MS2 meter, which displays the magnetic susceptibility value of materials when these are brought within the influence of the MS2C sensor. The MS2C sensor is designed for the volume susceptibility measurements of continuous sections of core. The core is passed through the sensor and measurements are taken at different intervals. A minimum of 20 measurements per sample were made on different locations on the sample.

The sensor is connected to the MS2 meter via a simple coaxial cable. An RS232 serial interface allows the instrument to operate in conjunction with custom IBM compatible software running on a portable PC. The circuitry within the MS2 meter powers the sensor and processes the measurement information produced by it. The measurements are obtained digitally using a time-dependent method. This results in precise and repeatable measurements.

The MS2C sensor operates on the principle of A.C. induction. Power is supplied to the oscillator circuit within the sensor generating a low-intensity alternating magnetic field. Material brought within the influence of this field results in changes in oscillator frequency. The frequency information is returned in pulse form to the MS2 meter where it is converted into a value of magnetic susceptibility. The sensor is particularly insensitive to sample conductivity. The sensor subjects the sample to a non-saturating field which has the advantage of measuring initial susceptibility without destroying any sample magnetic

remanence. We used a coil-diameter of 60mm core-dimensions for measuring the samples. Samples were measured using both the 0.1 and 1.0 sensitivity range. This 0.1 range provides a ten-fold increase in measuring time as compared to the 1 sensitivity range, and provides for additional noise filtering necessary in weakly magnetic samples. The magnetic susceptibility sensor was directly calibrated to the diamagnetism of water (-8.6×10^{-6} SI). Ultra-pure water with a measured value of 18.2 ohmsxmeter was used for the calibration of the MS2C sensor. The theoretical value of 'pure water' is 18.4 ohmsxmeter. The calibration of the water sample was

-8.8×10^{-6} SI.

The accuracy of the MS2C sensor is 2×10^{-6} SI.

Microkappa (Model KT-5), Geofyzika a.s., Brno

The KT-5 is a hand-held magnetic susceptibility meter based on electromagnetic induction using an air-cored coil with a diameter of 55mm. The instrument was used to measure the large concrete block which is to large too fit into the 60 mm Bartington MS2 coil. The instrument has digital reading.

The accuracy of the MS2C field sensor is 2×10^{-5} SI.

3. RESULTS

Cores Samples

All samples were paramagnetic or ferromagnetic with low to relatively high susceptibility values. Two samples (samples B and C) were relatively strongly magnetic and three (samples A, D, E) were relatively weakly magnetic. The 3 weakly magnetic samples had an average susceptibility value of 175×10^{-5} (SI). The susceptibility values ranged from 155 to 164×10^{-5} (SI) for sample A (see Table 1), 176 to 211×10^{-5} for sample D, and from 158 to 164×10^{-5} for sample E. Magnetic permeability values were calculated on the average susceptibility value of each sample. The magnetic permeability values of samples A, D and E are as follows: 1.00162 (A), 1.00202 (D) and 1.00162 (E).

The remaining two samples, B and C had significantly higher susceptibility values with an average of 4254×10^{-5}. Susceptibility values ranged from 1561×10^{-5} to 8468×10^{-5} for

sample B and from 571 $x10^{-5}$ to 10219 $x10^{-5}$ for sample C. The calculated magnetic permeability values are 1.04773 for sample B and 1.03735 for sample C.

Large Concrete Block

A total of 96 measurements were made over the six surfaces of the concrete block. The measurements are listed by surface, labeled A - F, in Table 1. Susceptibility values range from 105 $x10^{-5}$ to 198 $x10^{-5}$. The calculated average susceptibility value is 130 $x10^{-5}$. The calculated magnetic permeability of the concrete block is 1.0013.

4. REFERENCES

Dearing, J., 1994: Environmental Magnetic Susceptibility. Bartington Users Manuel, Bartington Instrument Ltd., Oxford, 102pp.

Table 1: Magnetic Susceptibility Measurements

	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)
Sample A	162	161	161
	157	158	164
	167	162	167
	168	160	162
	159	162	160
	164	162	164
	155	161	162
Sample B	5411	5208	4859
	4950	2673	3799
	5086	4913	3637
	2708	3531	4692
	8468	5057	5233
	5142	5235	7003
	1577	1561	6987
	5844	6561	4425
Sample C	571	1179	4593
	9701	1993	7822
	6031	1101	2118
	8122	530	1276
	1816	5937	2185
	730	3310	10219
	1993	1604	5493
	1681	931	8206
	1718	9197	782
Sample D	207	210	199
	195	210	202
	206	206	201
	211	210	196
	210	203	176
	210	199	206
	208	195	183

	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)
Sample E	163	162	164
	164	161	162
	163	162	164
	161	165	162
	161	163	164
	160	163	161
	160	161	158
Large Concrete Block	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)
Surface A	116	157	108
	134	119	162
	112	165	129
	171	198	110
Surface B	131	114	124
	128	114	131
	112	131	114
	124	117	129
Surface C	111	106	188
	147	106	108
	108	117	122
	121	110	143
Surface D	127	111	109
	114	121	111
	115	128	129
	121	107	131

	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)	Magnetic Susceptibility 10^{-5} (SI)
Surface E	187	142	166
	134	131	135
	142	166	132
	116	121	133
	166	130	178
	155	122	126
	120	128	146
	142	125	158
Surface F	112	111	145
	117	105	106
	103	113	117
	105	117	170
	112	145	111
	117	147	145
	111	147	112
	163	105	123