6.3. Physical Properties of the Sediments

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Introduction

During the cruise of Boris Petrov 2001 the physical properties of 82 sediment cores with a total length of 240 m were logged with a MultiSensorCoreLogger. Density, p-wave velocity and magnetic susceptibility of the cores were measured.

Logging of these properties allows a first interpretation of sediment properties of unopened cores. Variation in the parameters reflect changes in sediment composition and porosity, so an indication for the lithology of the cores can be given (Thomson and Oldfield 1986, Weber et al. 1997). For example, a diamicton layer will show higher density, lower p-wave amplitude, higher p-wave velocity and - depending from the magnetisation of the accumulated grains- higher or lower magnetic susceptibility than the surrounding pelitic sediment.

Magnetic susceptibility is defined as the dimensionless proportional factor of an applied magnetic field in relation to the magnetization in the sample (expressed in SI units). Variations in magnetic susceptibility in sediments of the Eurasian part of the Arctic Ocean correlate with the content of ferrimagnetic grains (magnetite, titanomagnetite or maghemite; Thompson and Oldfield 1986). These minerals are more abundant in volcanic and metamorphic rocks (e.g. Putoran Plateau Basalts). Thus susceptibility acts as a good indicator for terrestrial derived material. Furthermore the Ob and Yenisei river signals can be differentiated, because of their very different geologies of the catchment areas. The Ob drains great parts of the West Sibirian lowlands consisting of sedimentary rocks with low values in magnetic susceptibility. In contrast the Yenisei has a hinterland geology with source rocks of higher magnetic susceptibility, such as the volcanites of the Putoran Plateau.

Method

The Geotek **M**ulti**S**ensor**C**ore**L**ogger (MSCL14) allows the logging of core thickness, p-wave travel time, attenuated gamma counts, magnetic susceptibility and temperature. For determining densities, gamma rays of a 137 Cs-source are used. Magnetic susceptibility is measured with a BARTINGTON MS2C coil sensor the volume susceptibility (dimensionless, all values presented here are in 10^{-5} in the SI-System). Dense material absorbs more gamma-radiation than light material, so this inverse relation can be used to correlate gamma—ray-absorption withdensity. Magnetic susceptibility is commonly used as an indicator for the mineralogical composition of the sediments and for lateral core correlation (e.g., Kleiber and Niessen 2000). It is defined as the dimensionless proportional factor of an applied magnetic field in relation to the magnetisation in the sample.
Technical details of the Multi Sensor Core Logger and the set up are given in Tab. 6.4. The logger was calibrated according to the method of Best et al. (1999).

After data processing, p-wave amplitude, p-wave velocity (normalized for 20¡C), gamma density, magnetic susceptibility, acoustic impedance and fractional porosity can be computed.
In addition to normal p-wave measurnents transmission seismograms were recorded (Breitzke et al. 1996, Breitzke 2000) which reveal grain size information.

Prior to logging the cores were stored in the laboratory for at least 24 hours to equilibrate with room temperature (mean temperature: 20¡C). All cores were logged in 1 cm intervals. High-resolution logging was performed for Holocene key cores in increments of 0.5 cm. After each gravity core, a calibration liner filled with water and a stepped aluminium insert was logged (Best et al. 1999). This method serves to simulate different porosities and logging environments because aluminium as the solid componenthas a density and y-ray absorption coefficent close to natural dry grain density (2,7 g/cm^2) (see Weber et al. 1997).

Settings

Sensor offsets from the reference point:

γ-sensor	22 cm
p-wave-sensor	36 cm
susceptibility loop:	80 cm

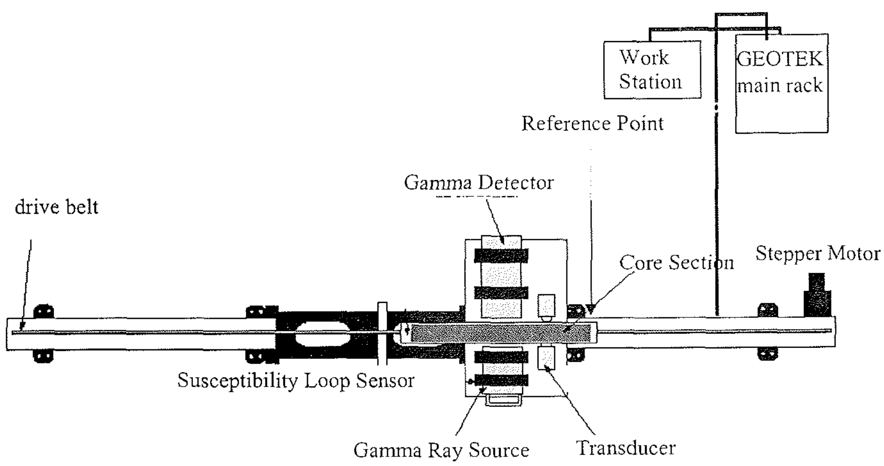


Fig. 6.11: Top view of set up of the **M**ulti**S**ensor**C**ore**L**ogger

Sensors:

a) Ultrasonic Transducers to measure the travel time of compressional p-waves through the core. 250 kHz piezo-electric ceramic transducers, spring-loaded against the sample. Accurate to about 0.2%, depending on core condition.

b) A gamma ray source and detector for measuring the attenuation of gamma rays through the core. 137-Cs gamma source in a lead shield with 5 mm collimator. Density resolution of better than 1% depending upon count time.

c) A magnetic susceptibility sensor to determine the amount of magnetically susceptible material present in the sediments. Bartington loop sensor with 140 mm coil diameter.

d) Core diameter: The diameter of the core, including the liner, is measured using a pair of displacement transducers connected to the spring loaded compressional wave transducers. This enables the compressional wave velocity and density (from the gamma ray attenuation measurements) to be corrected for changes in core diameter.

e) Temperature: An IR thermal sensor is employed 10 cm above the core. Surface core temperatures are logged and can be used to correct p-wave velocities for temperature changes that may occur during the logging process.

Table 6.4.: Sensor specifications

P-wave Velocity and Core diameter Plate Transducer diameter: 5 cm Transmitter pulse frequency: 250 kHz Transmitted pulse repetition rate: 1 kHz Received pulse resolution: 50 ns
Density Gamma ray source: Cs-137 Source activity: 356 MBq Source energy: 0.662 MeV Collimator diameter: 5.0 mm (SL), 2.5 mm (KAL) Gamma detector: Gammasearch2, model SD302D, ser. no. 3019 , John Caunt Scientific Ltd., 15 sec counting time; 1 sec for quickies
Magnetic Susceptibility Loop sensor type: BARTINGTON MS-2C, ser. no. 130 Loop sensor diameter: 14 cm Alternating field frequency: 565 Hz, counting time 10 s, precision 0.1 * 10^-5 SI Magnetic field intensity: about 80 A/m RMS

The following figure (Fig. 6.12) shows an example of typical onboard measurements. In this case two parallel cores of one station were logged before one of the cores was opened on board. We used a special setup, which allowed logging of the cores very quickly (about 5 minutes per core meter, quicky -mode).
The physical properties are a useful tool for core correlation as well as sediment sampling of the opened cores. In combination with sediment echosoundung (Niessen and Dittmers this volume) they are a useful tool far a acoustic stratigraphy. Magnetic susceptibility proved to be an excellent tool for core correlation. In Fig. 6.13 the physical properties of all opened cores are listed. You find this data set on the Pangaea web site: www.pangaea.de.

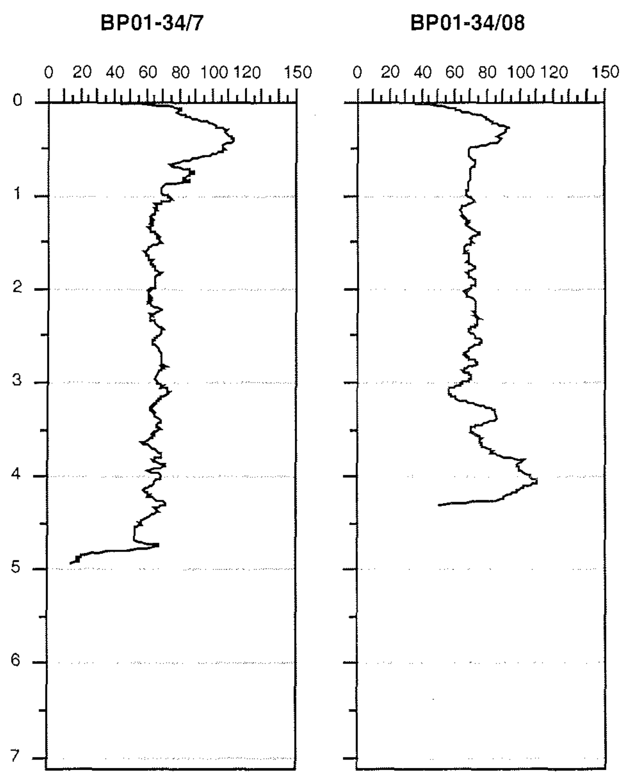


Fig. 6.12: Magnetic susceptebility of cores BP01-34/07 and BP01-34/08 wich are situated in the north eastern corner of the working area. Although the cores have differrent lenghts they include the same time interval. According to the curve the shorter core BP01-34/8 seems to penetrate older sediments than BP01-34/07.

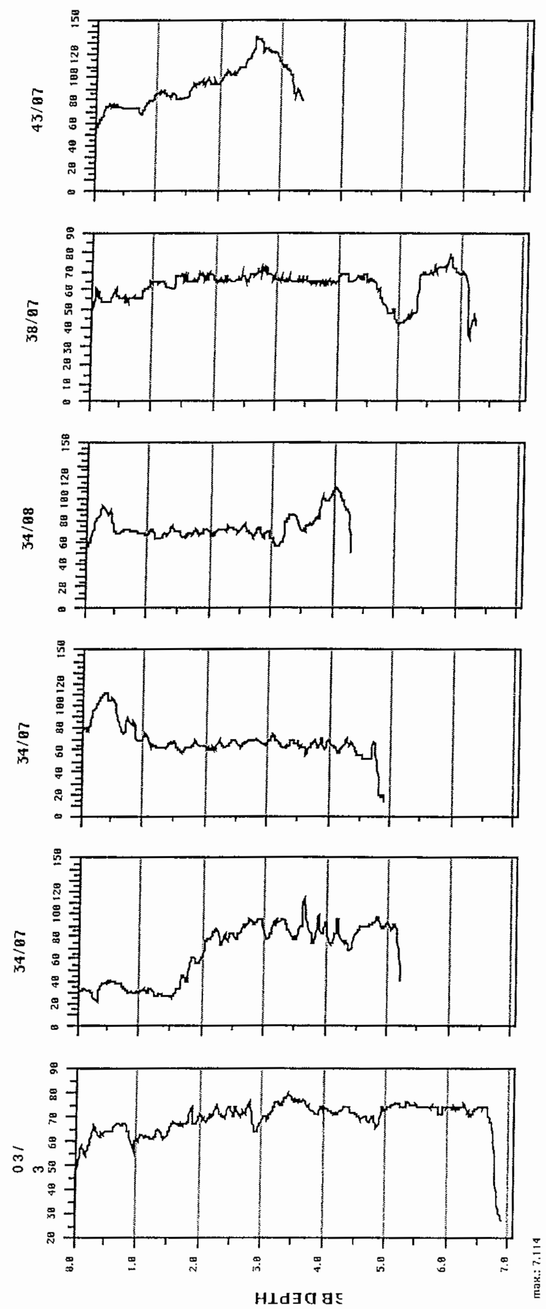
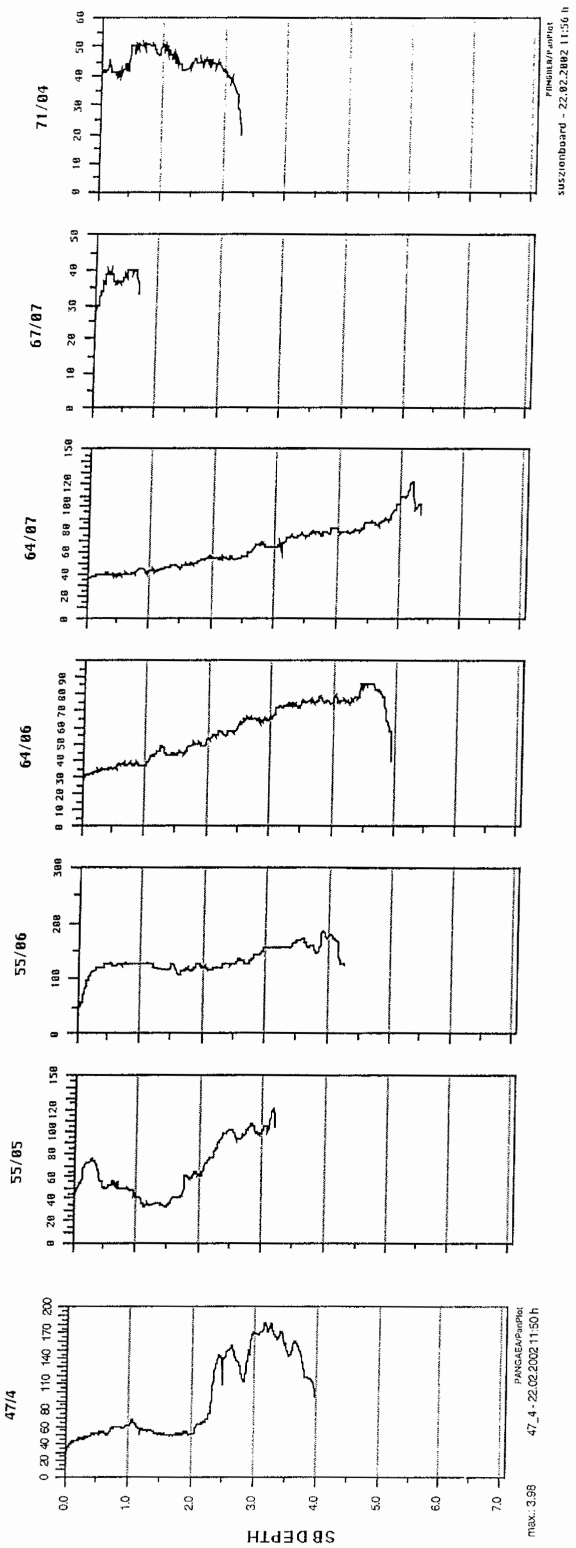


Fig. 6.13: Magnetic susceptebility of cores all measured cores from the 2001 years expeditions.



Continued with Fig. 6.13: