The Effect of Pressure on the Electrical Conductivity of KTB Rocks

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1. Introduction

This project summarizes lithological rock parameters like porosity, permeability, density, rock fabric analysis, inner surface area and pressure dependent complex electrical resistivity. An unusual pressure effect was detected. This observation will be discussed in more detail because of its principle interest for highly conducting zones in the earth crust.

2. Experimental and Results

11 representative samples (22 plugs; diameter 30 mm, 20 mm high) were selected for this study. They include:

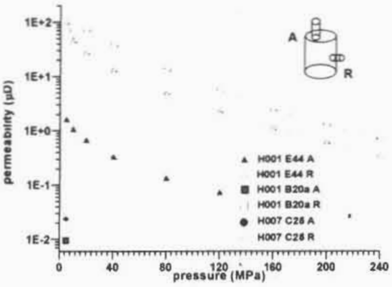
- the three main lithological units
- foliation ranging from horizontal to vertical
- ore content from 0 to 7%

3. Porosity and Permeability

Porosities:
- 0.4 to 2.0 vol %.

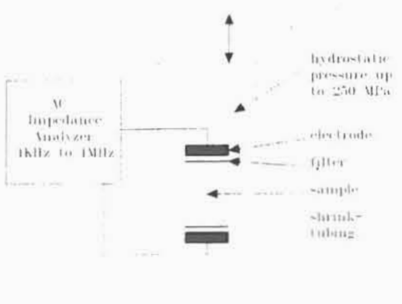
Pore radii distribution:
- maximum in the range of 20-50 µm.

The permeability was measured in an autoclave using a pressure transient method and Argon gas as the flow medium. Hydrostatic pressures (Pmantle) were increased up to 240 MPa.

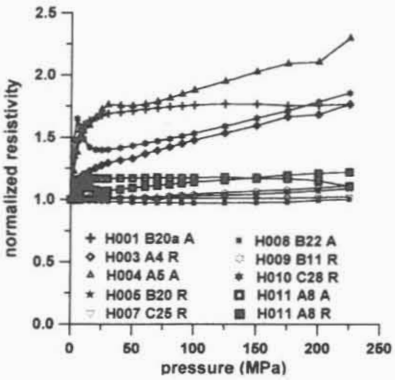


4. Complex electrical resistivity as a function of pressure

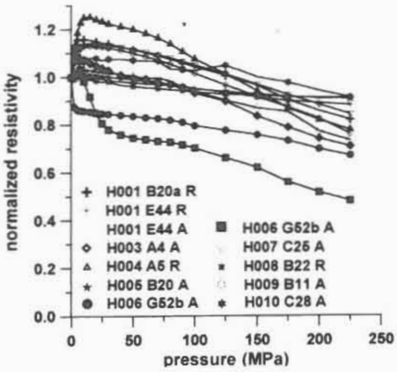
The autoclave used allowed an increase of the hydrostatic fluid pressure up to 250 MPa. The sample was evacuated and back-saturated with a 1 molar NaCl solution (7.8 S/m) to reduce the contribution of surface conductivity that was determined to be in the range of about 5 x 10-5 S/m.



A "normal" pressure dependence of the volume resistivity was detected in most of the samples. The normalized volume resistivity increases as a function of pressure.

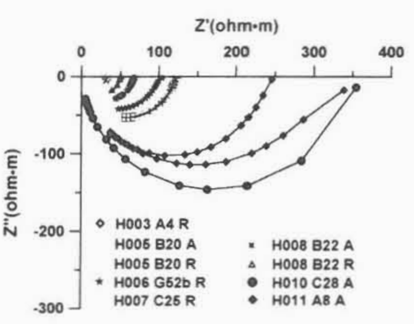


The "unusual" pressure effect was measured on some samples and is characterized by a normal pressure dependence in the low pressure region and a reversed effect at high pressures.

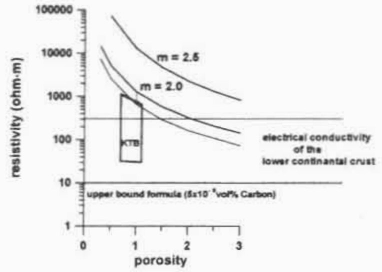


5. Frequency dependent complex resistivity

The frequency dispersion was measured at different levels in pressure in the frequency range 1 kHz up to 1 MHz. Data are given as Cole-Cole diagrams: the real part of the resistivity is plotted versus the imaginary part. The Figure shows data measured at a pressure of 200 MPa.



Neither the Archie model nor the UBF (Duba& Shankland) model alone can explain the observed high conductivities in the KTB rocks. Calculations based on the Archie model result in higher resistivities than measured (cementation exponent m=2, 2.5 resp.), while the UBF gives too low values. But the amount of ilmenite in the KTB cores is more than sufficient to produce the observed high conductivity if interconnected.



6. Conclusion

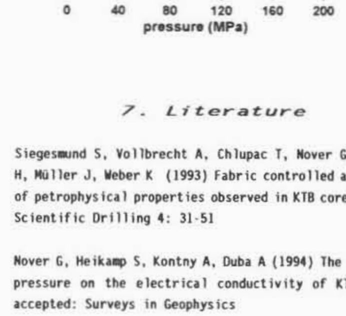
The frequency dependence of the complex resistivity was interpreted using modified Cole-Cole models.

These models exhibite the general features:

- The complex response of the sample is controlled by polarizations that are due to fluid solid interactions.

- The unusual pressure effect can be considered using an additional model parameter that describes the presence of highly conducting and interconnected phases in rock samples. It is based on a reconnection of ore minerals.

- The time development of the volume resitivity indicates that electrolytic conduction dominates in most of the KTB rock samples.



7. Literature

Siegesmund S, Vollbrecht A, Chlupac T, Nover G, Dürrast H, Müller J, Weber K (1993) Fabric controlled anisotropy of petrophysical properties observed in KTB core samples. Scientific Drilling 4: 31-51

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