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GEOECOLOGY. A CHALLENGE FOR NEW BOREHOLE GEOPHYSICAL APPLICATIONS

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ABSTRACT

Environmental projects are subject, in an increasing degree, to geoecological research. Geophysical methods are widely involved in data acquisition. Borehole logging methods have also a big potential, but due to methodological, technological and technical problems and limitations their applications meets certain difficulties.

Modifying standard methods first results show the possibility for a widespread practical use.

Very useful geophysical techniques, in addition to the traditional stantard methods, appears to the performance of wideband fullwave form sonic, spectral pulse neutron log and vacuum sampling. A quick look on-site interpretation with an express analysis of gas and fluid samples allow to select intervals of detailed investigations, in the case of pollution evidence, and therefore to plan the necessary steps for geoecological studies and pollution liquidation.

INTRODUCTION

During the last ten years ecological problems have obtained growing importance for the industrialized countries and tremendous financial means have been dedicated to improve the status of the environment in order to allow to the mankind a normal human life.

Besides the problem of avoiding new pollution it is required to establish the degree of ecological damage for selecting suitable methods for its liquidation. A new science is involved in the solution of that global task. This applied science is usually called geoecology.

In the framework of geoecological studies increasingly geophysical methods are used but well logging methods are not yet given the "due attention" because its adaptation to environmental problems creates technical and logistical problems, like:

1. Standard logging methods are not sufficiently sensitive for environmental studies.
2. Flat wells up to 100 metres depth are cheaply drilled mainly for taking soil or fluid samples to perform chemical analyses.
3. For small diameter wells, slim-hole tools with high efficiency are requested.
4. Complicated geological, technological and technical conditions cause difficulties, not typical for logging operations.
5. Rapidly changing logging conditions request a very individual approach

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for each logging operation, for log analysis, also.

To find a solution and to introduce well logging into these specific problems it is a subject of research work towards the demand of such developing direction.

The application of well logging, in the framework of ecological research and studies, may be enforced, by the following measures:

1. Definition of applicability for relevant logging methods.
2. Development of specific tools for environmental studies.
3. On site processing methods for signalization of environmental problems.
4. Development of samplers for fluid and gas analysis of the borehole medium as well as for coring, which will be taken out of the borehole wall.
5. Complex interpretation methods for downhole and surface geophysics.
6. Increasing of sensitivity to the existing methods to suit the needs of environmental studies.

The problems are numerous and as a first step towards the direction to create an "environmetal well logging methodology", we have tried to adapt and modify existing techniques.

TECHNICAL DESCRIPTION OF THE NEW TOOLS

Three tools have been especially developed to meet the challenge of environmetal studies:

a. A pulse neutron-neutron tool.
b. A wideband multielement sonic tool.
c. A vacuum sampler.

These tools have the following characteristics:

a. Pulse Neutron-Neutron Tool (paper output sample in Fig.1.).

This tool is a two channel one with an outer diameter (O.D.) of 42 mm and allows to record pulses in a time period from 0 to 1600 is, and the windows can be selected in 30 is steps.

Other parameters are the following:

Neutron emmission	:	6×10^7 n/s
Working frequencies	:	10 and 20 Hz
Overall length	:	3300 mm

The software package which has been developed by "Der Bohrlochmes-ser" allows to calculate e directly on the well site providing a comparable inde-pendent parameter for further processing.

In a Gamma-Ray version even spectra data may be recorded (Fig.2.).

b. Wideband Sonic (Fig.3.)

The tool works on a transmission frequency of 30 - 45 khz.

The geometrical layout for the 4-element design is the following:

SO,5 or 0.75E1-0.25E2-0.25E

The construction allows the recording of the whole wavetrain for further processing.

Other parameters:

Diapason for travel time	:	125 - 600 is/m
Accuracy of time measurement	:	± 5 is/m
Attenuation limit	:	60 db/m
Outer Diameter (O.D.)	:	48 mm'
Sampling rate	:	2 is
A/D - Transformation	:	12 bit

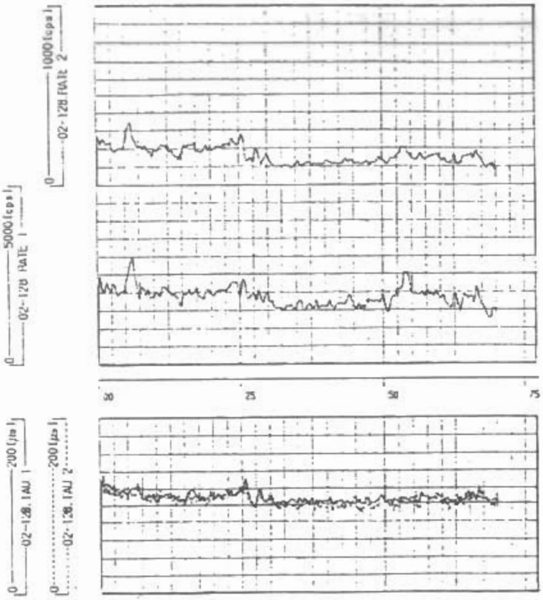

Fig. 1: INN - Record from a flat well.
TAU1 - Calculated from the short spacing.
TAU2 - Calculated from the long spacing.
RATE1 - Pulse rate for the short spacing for the window 2-128.

c. The Vacuum Sampler.

Coring is for deep drilling the most informative source. For ecological drilling that role is carried out by sampling.

Chemical analysis of water samples are very expensive. Therefore it is recommended to use a vacuum sampler, provided that on the well site the possibility of a rough estimation of the presence of polluted material by means of a gas-chromatograph.

The sampler is vacuumised on the requested depth where it will be opened to receive the fluid. Due to the vacuum the gas dissolves and a gas sample can be taken and chromatographied.

The outer diameter (O.D.) of the sampler is 50 mm. Doubling or triplicating the number of diameters it allows to increase the statistics.

Besides the standard logging complex techniques, based on such methods as Gamma-Ray, Caliper, Resistivity, etc. the new tools provide the possibility for a new approach to environmental wells.

We have applied at Loutraki area, Greece and at Thuringia, Germany the above mentioned methodology to inspect the availability of such technique to investigate fully or even partly polluted areas. It seems that even in compli- cated, geological, areas the outcome is very promising. This is enabling us to apply the same technique in areas of complicated geological factors. Even in the simple case of qualitative information the high data density gives the opportunity for an introductory processing procedure.

WELL LOGGING FOR THE ENVIRONMENT

To define a role for well logging methods in the wide area of the environmental problems the following basic tasks must be solved.

Fig. 2: Print spectrum for the record of Fig. 1

1. Lithological estimation with a high degree of resolution.
2. Saturation changings along the borehole.
3. Presence of polluting components.
4. Sampling procedure.
5. Quick borehole elemental analysis.

The dominating method is, presently, the chemical analysis, providing that we can ensure the necessary accuracy. Sampling is therefore carried out mechanically on a predecided rate. This procedure makes environmental studies extremely expensive and the results cannot be available before a certain time delay.

Here is the chance for Well Logging Methodology. Running a Sonic and a Pulse-neutron probe, in a borehole, irregularities may be found, taking a sample out of the interoal of suspiction thr gas phase may be fast chromatographical and in the case of confirmation off the fluid phase may be procceed (preserved) for the chemical analysis or additional samples can be taken for double checking the result. Well logs can cut the cost substantially and may be included in the technological line of environmental status research. Also, there a-re some problems where borehole logging methods play an independent role for environmental studies:

- Locating metallic substances in the environment of a borehole (Fig. 4.).
- Porosity calculations for different conditions (Fig. 5.).
- Correlating surface anomalies downhole (Fig. 6).
- Status estimation in hydrological wells (Fig. 7.).
- and even regeneration jobs in hydrological wells.

In Fig. 4. is shown the case of locating metallic objects with the help of a 3D Magnetic tool (probe). The log was run in a borehole of 15.0 metres deep, drilled at a distance of 2.0 metres away from a metallic plate. the magnetic anomaly allows to fix the existence of the metallic object at a

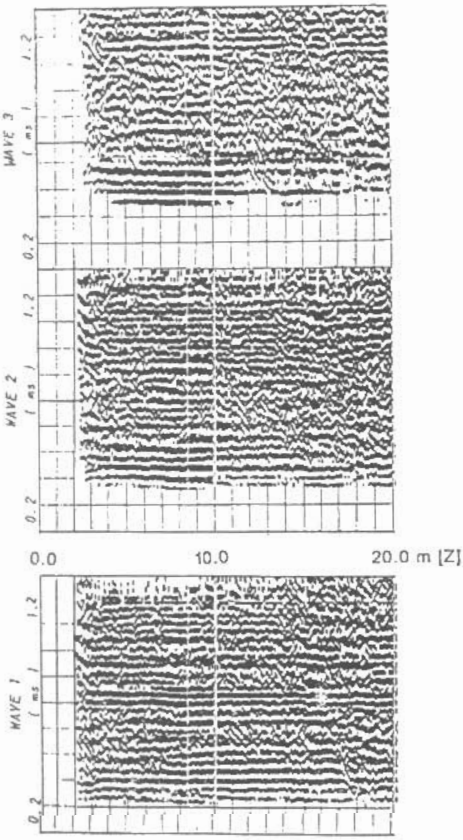

Fig. 3: Full wave train record for the Multielement Sonic Log.

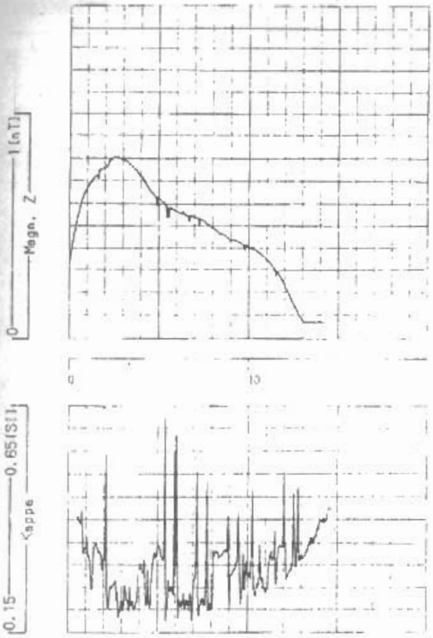

Fig. 4: Application of Magnetic Log for Remote Detection of Metallic Substances.

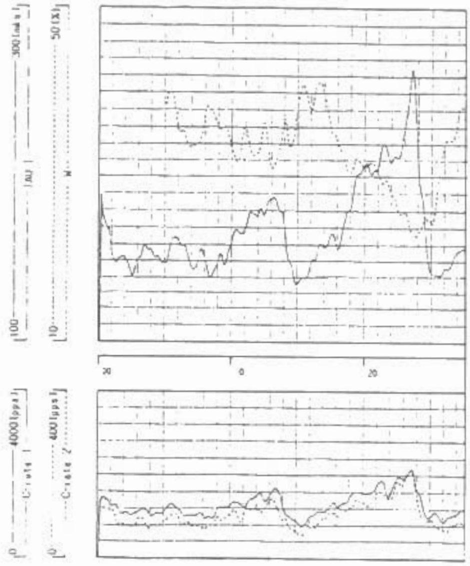

Fig. 5: Porisity calculation for an INN-record in a sandy-shale environment.

depth from 2.5 down to 12.9 metres.

Fig. 5. shows a sample of porosity calculation from Pulse-Neutron measurements. The environment was not especially defined, therefore the porosity values are only a rough estimate.

Fig. 6. is a sample of a magnetic log under a surface magnetic anomaly.

Locating a magnetic body at 1000 m depth it was clarified that the surface anomaly is caused by that body. For hydrological wells it is importand to know from where water is flowing into the well. In Fig. 7 a flowmeter job was run to establish the actual situation of the well, after a regeneration job by help of an acoustic generator was carried out. The flow was increased by more than 50%.

There are more possibilities for applications on logging methods, a decision must be taken according to the specific problem that each time has to be sol-ved.

CONCLUSION

Borehole logging methods may be quite helpful for the study of environmental problems. Neither standard nor new methods are able to deliver informations that allow us to cut the costs of the expensive chemical analyses.

Even in the case of low accuracy a qualitative approach can assist to find polluted materials.

Three new tools are especially designed to promote this idea. Pre-

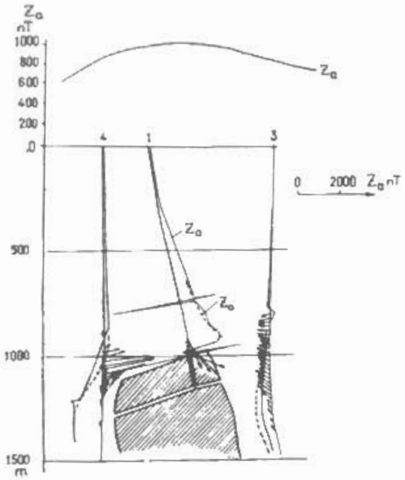

Fig. 6: Magnetic Log for the correlation of surface anomalies with downhole events.

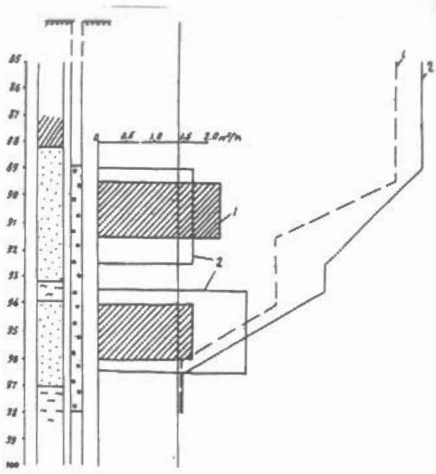

Fig. 7: Flowmeter results in a Hyrological well before and after regeneration by an acoustic generator.
1. Before regeneration.
2. After regeneration.

liminary results, in Germany and Greece confirm the advantage of a wider use of borehole logging methods for environmental studies and/or applications.

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