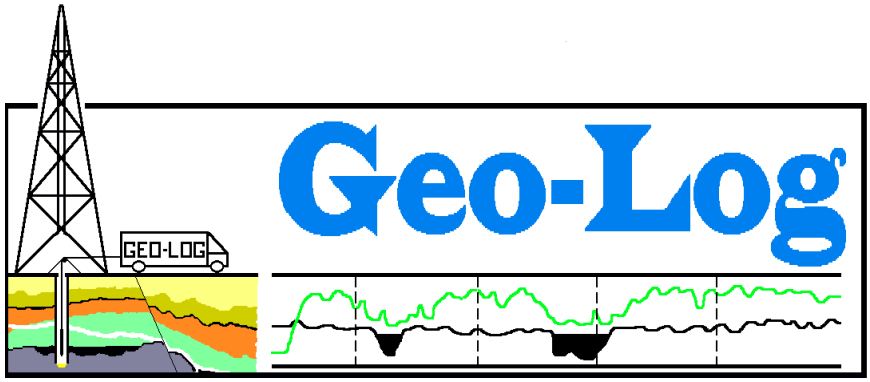

Report on geophysical logs in the MEL-5 borehole (Lipnice nad Sazavou, Czech Republic)

Requested by Aquatest a. s. divize karotaž

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List of annexes

Introduction

The explanatory borehole, MEL-5 has been drilled into granitoid rocks near to the location Lipnice nad Sazavou. Aquatest carried out the geophysical logging, than Geo-Log was requested for few complementary logs. The set of the performed additional logs includes Acoustic Borehole Image log (ABI), Optical Borehole Image log (OBI), standard two-channel (1.0 and 1.5 m) Full Wave Sonic log (FWS), Deviation log (inclination and azimuth) and Temperature/Differential Temperature log. This later was not requested, Geo-Log performed it without charging an extra fee to the Client. The above logs were recorded on 10 November 2005.

The flange level was taken as reference for measuring the depth. The static water level was found at the depth of 22.1 m, so all the logs could be recorded below this level except the OBI log, which does not require the presence of water or any fluid. The depth of the casing shoe is at 16.7 m according to the logs. The borehole was not disturbed at least for one and half month before the operation, thus it could reach a thermal and pressure equilibrium.

Deviation log

The Deviaton log shows almost constant values (Annex Ia.) The borehole dips to 221° direction with 21,5° inclination. From the surface origo the horizontal distance of the bottom is 54.4 m at 139.8 m vertical depth. (Annex Ib.)

Temperature log

From the bottom to the depth of 85 m the Temperature log shows linearity, which means that the thermal gradient is practically constant (1.59 C°/100 m), except a small anomaly at the depth of 105 m. That anomaly can be explained by a weak horizontal flow. Between 85 and 75 m the gradient of the temperature gradually decreases and becomes constant in the 75 – 55 m interval. Between 55 m to 40 m the temperature gradient returns to the normal value, i.e. which is observed in the lower part of the hole. These anomalies are explained by the inflow of water into the hole above 85 m (there are few open fractures at that depth according to the FWS and OBI logs), which moves upward, until it flows out through the fractured zone around the depth of 50 meters. From 30 m up the water gets gradually warmer. (Annex II.)

FWS log

The transit times of the longitudinal and transversal waves have been derived from both channels of the FWS log, than the velocity of longitudinal waves was calculated for the penetrated rocks. Based on the calculated velocity, the borehole can be divided in two sections. From the surface to the depth of 56.5 m, the sonic velocity is 4850 m/sec at the most. Below that depth it is quite constantly 5000 m/sec. On the basis of the FWS log the fractured zones were marked. These intervals are in good accordance with those derived from the ABI log, but the later is able to distinguish the fractures individually. (Annex III.)

ABI log

Altogether 377 fractures were identified from the ABI log, 273 of them is closed, while 104 is open to a certain degree (Annex IV). Individual fractures are represented by tadpole diagram (Annex V.). The clearly identifiable fractures are symbolized by dots (filled circles). Small squares represent fractures, which do not show a full sinusoidal shape. When the small bar attached to the dot is wavy, it means that the sinusoidal shape is distorted. The color of the

symbols characterizes the opening of the fractures: red-open, white-mostly open, gray-partially open, black-closed.

The distribution of the fractures by their azimuth was also analyzed and the results are presented on rose diagrams. On the diagrams the azimuth is divided into 10º wide segments and the outer circle represents 12% relative abundance. The rose diagrams were created from the data of a certain depth interval. The diagrams in the first column on the left were created from uniformly 10m long intervals regardless to any geological boundaries. In the third column the distribution of the all fractures is shown, while in the fourth column the intervals, where the data for the diagrams was taken from, were broken down according to the fractured zones.

The typical dip direction is Eastern in the borehole, it is in the overwhelming majority in case of the open fractures. Based on the image and other logs the entire length of the borehole is divided into seven intervals regarding the abundance and orientation of the fractures. (The topmost zone is marked with 1, the second one with 2 and so forth.) The second, the fourth and the seventh ones are fractured. The intervals are characterized as follows:

- Zone 1. (*16.7 m*) – 21.5 m The lower boundary of this interval is determined only from the OBI log, since other logs are not available. The casing covers the top of the zone, thus it could not be determined. There are few fracture with Northeastern dip directions.
- Zone 2. 21.5 m – 24.2 m This zone is characterized by with varying dip values and high abundance of the fractures, but only 27 pcs are seen in ABI. Eastern and eastern-northeastern dip directions are typical in this interval.
- Zone 3. 24.2 m – 47.0 m The abundance of the fractures is medium.
- Zone 4. 47.0 m – 56.5 m The dominant dip direction is Eastern and the third of the total number of fractures (134 pcs.) is concentrating here.
- Zone 5. 56.5 m – 71.0 m Only few fractures can be found.
- Zone 6. 71.0 m – 96.8 m There are fewer fractures in this interval than in the previous one and their orientation is also different.
- Zone 7. 96.8 m – 106.0 m Altogether 55 fractures can be observed, with dominantly eastern-southeastern dip direction. Opposite to the other two intervals only steep fractures of 60-80º dip can be found.
- Zone 8. 106.0 m – 151.0 m Only few fractures can be found, without characteristic orientation.

Based on the orientation of the fractures the zones form two groups. In the upper four intervals (down to 56.5 m) the typical orientation of the fractures is eastern and eastern-northeastern, while in the lower four zones it is eastern-southeastern. Another difference between the two groups is that the lower group is significantly less fractured. These findings are in accordance with the result of the FWS log.

OBI log

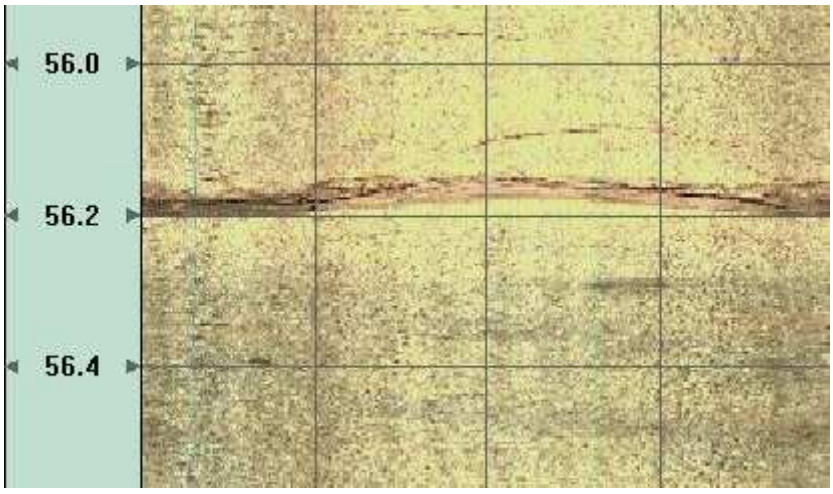
The OBI could be performed along the entire length of the borehole (Annex VI.). The measured azimuth is affected by the steel casing and therefore incorrect from the top to 16.7m, where the bottom of conductor casing was found. The water level is clearly seen at 22.1 m. In general, the recorded optical image confirms the existence of the fractures determined from the ABI log, but in some cases it provides further information as well. For example white features can be observed at depths of 19.8 and 62.4 m, which look as filled veins. In case of the lower one even a small piece of the host rock was also observed in the white mass, which might have broken off from the

side of the fracture (Pic. 1.) The filling material is likely to be some white mineral (or minerals), which, regarding its physical properties, does not differ from the host rock, because the ABI log does not indicate it. It is supposed that it is quartz or feldspar, originated in a later phase of the magma cooling.

Picture 1.: The white feature with the host rock fragments

The center of open fractures is generally dark or even black, because no light is reflected. This is best seen in case of a major fracture at 98.2 m. A part of the fractures shows a slightly reddish color around the fracture itself, which may be the sign of oxidation. Except the above mention two veins no minerals can be recognized in the fractures.

In accordance with the ABI log the OBI log shows well the fractured intervals, which fit well to those determined by Aquatest with injection method. Clearly observable open fractures are found at 35.0 m, 48.2 m, 48.8 m, 56.2 m, and 98.2 m. However at 106.6 m only a minor fracture can be observed. According to the OBI log, the most likely position of the inflow indicated by the Temperature log around the depth of 80 m, is a thin fracture at 79.2 m. The color of the rock (which is not indicated by other methods) changes at 56.2 m (Pic. 2.) Below that level the rock has a darker tone. The difference in color may indicate a slight change either in the composition or the weathering character of the rock. The slower sonic velocity, measured in the upper interval, is basically explained with the large number of the fractures, but this slight lithological change may also be a factor.



Picture 2.: The different colors mean other rock composition

Conclusion

The performed image logs, together with the FWS and Temperature logs, helped to establish the mechanical condition of penetrated rocks, determine the exact location, orientation and character of the fractures and to reveal naturally occurring water movements.