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SOME RESULTS OF HORIZONTAL STRESS MEASUREMENTS BY HYDROFRACTURING METHOD IN UNDERGROUND MINES OF KARVINÁ PART OF "OKR" COALFIELD

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ABSTRACT. Actual knowledge of stress in rock mass is one of basic prerequisites of successful solving of a number of research tasks within the area of sciences dealing with stress conditions and stress phenomena in Earth crust. One of the few methods enabling direct stress measuring in the areas accessible only by boreholes is hydrofracturing method. The following paper describes the application of such a method in the Institute of Geonics, it gives a short characteristics of the apparatus applied evaluating existing results of horizontal stress measurement in locations of Ostrava–Karviná coalfield.

KEYWORDS: hydrofracturing method, horizontal stress, stress measurement, Ostrava–Karviná Coalfield

INTRODUCTION

Determination of stress in rock massif is a basic prerequisite of solving a number of research tasks of scientific disciplines dealing with stress conditions and stress events in Earth crust.

Calculations of stress field based only on theory of elasticity and vertical geostatic stress in a given depth can be considerably contorted particularly in tectonically failured areas, in zones affected by mining activity as well as on contacts of different geological structures. Knowledge of their actual stress values, therefore, is very important for solving various problems in areas of mining activity and underground construction and it is interesting also from the point of view of purely geological and geophysical research.

The method of hydrofracturing of borehole walls is one of the few methods enabling direct measuring of stress in zones accessible only by boreholes. Its basic stages may be characterized as firstly creation of fracture, secondly detection of normal stress component in generated fracture and thirdly detection of spatial orientation of fracture. Provided measurings were made in cracks variously oriented in the same location it is then possible to calculate the magnitude and direction of main stress components in the given area by current mathematical methods which could agree at the best with measuring results.

PRINCIPLE OF MEASUREMENT

Rock mass stress measurement by this method is based on the assumption that at a certain moment of experiment an equilibrium is reached between the pressure of medium opening the fracture and the stress of rock mass trying to close the fracture. This pressure (called psi) is considered [Staš et al. 1994a; Staš et al. 1994b; Guo et al. 1993; Baumgärtner, Rummel 1989] then to be equal to stress acting in normal to created fracture plane. In favourable conditions (isotropic homogeneous rock environment, one of the main stress components is parallel to borehole axis and it is not the minimum one) it is possible to derive according to several measurements on variously oriented fractures in the same geomechanical zone components of main stress perpendicular to borehole axis.

The application of this method is conditioned, however, by sufficient impermeability of rock and its ability of brittle fracture enabling creation of individual fracture.

MEASURING APPARATUS

The apparatus HYDROFRAC–PERFRAC which is applied by our institute was purchased at MESSY Co in Germany. Technical description of this equipment was already published in [Staš et al. 1994a]. It is used for measuring in boreholes of 60 mm diameter, it requires connection to water and compressed–air supplies. Handling length of probes ranges between 2.5 and 3 m (according to type) their external diameter amounts to 54 mm. The high pressure pump enables to apply on borehole wall water pressures amounting up to 45 MPa. Actual range of application of apparatus is limited by length of high pressure hoses which is at maximum about 40 m in downward boreholes.

The equipment consists of a control panel with valve system, of controllable high pressure pump, recorder of pressure development depending on time, of high pressure connection appliances and particularly of two application probes (Fig. 1).

A probe for creation of fracture is inserted into a borehole on a predetermined place. Its working part is an injection interval which is connected by high pressure hoses and pipes with valves and manometers of the control panel. The interval is sealed on its both sides by rubber packers with separate hydraulic system within borehole. A sealed borehole interval can then be loaded by high pressure medium(water)until a fracture occurs. The record of course of experiment is in form of pressure on time dependence. After completing several loading and standstill cycles, required characteristic pressure values (Psi) can be read out of characteristic shape of record (or eventually P_c – pressure necessary for fracture creation, P_r – pressure necessary for opening of existing fracture) which are applicable as input for further calculations.

As the psi pressure according to theory is equal to normal stress component of rock mass in relation to fracture plane it is therefore necessary to know equally the spatial orientation of created fracture. For this measurement phase another probe is applied, the so–called "impression–packer". It is a rubber packer fitted on its surface by a layer of partially plastic rubber. After installing to the place of

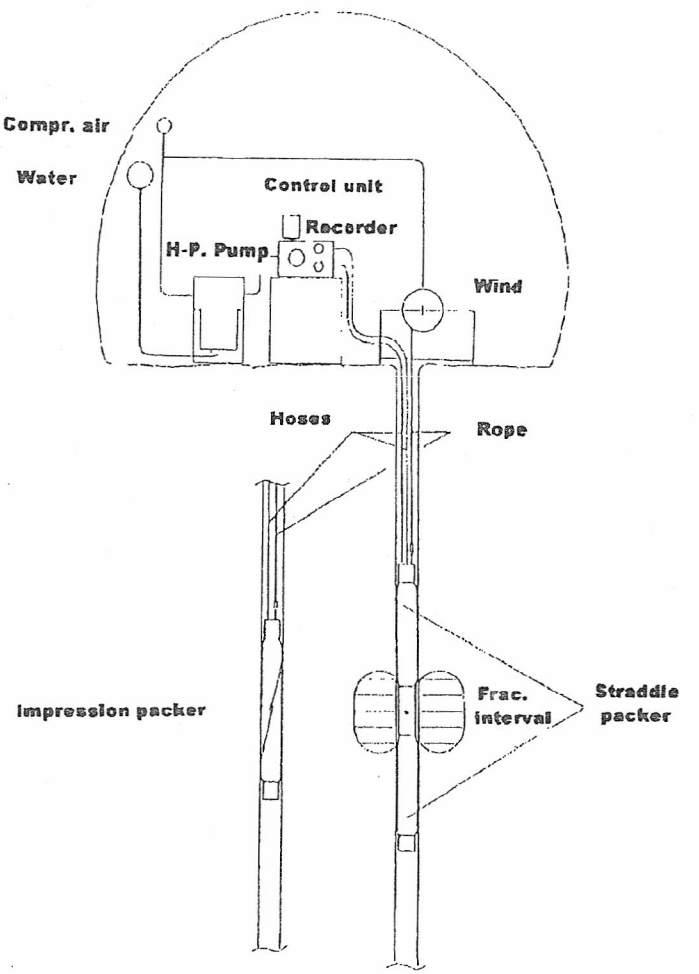

FIG. 1. Schematic illustration of the used equipment HYDROFRAC–PERFRAC

fracture and pressure loading up to a value exceeding the opening pressure a gradual plastic deformation of surface layer of packer occurs. In the area of contact with reopened fracture a relief trace image of fracture occurs on packer surface which still remains to be visible long time after the withdrawal of probe from borehole. For connection with coordinate system the impression–packer is linked by a non-magnetic set of rods with orienting equipment of Pajari company which is able – based on interlocking of special compass units after a predetermined time to fix the direction and incline of borehole as well as the angle of rotation of probe in the borehole.

RESULTS OF MEASUREMENT

Measurings were carried out on several sites. They are part of grant project 205/93/2089 of Grant Agency of Czech Republic. Some horizontal stress measurings

in the area of OKR coalfield are presented in this paper. The measuring results are explicable in general and correspond well with geomechanical situation of given place. These measuring results at the same time are applied also in practice in operational conditions (for instance for designing roof bolt support for coal winning by CONTINUOUS MINER method at ČSM Colliery).

As an example of the effect of actual geomechanical situation on rock mass stress values certain measurements realized on mines of Karviná part of OKR coalfield will be mentioned.

A high anisotropy of stress was recorded during measurings at ČSM Colliery in an area which was relatively less affected by mining activity and it is located between the two Stonava and Albrechtice tectonic faults ($SH = 20.4\,\mathrm{MPa}$, $Sh = 12.7\,\mathrm{MPa}$). Vertical downward boreholes were advanced from the drift No 3404 and the near mine roadway No 292492 advanced in parallel with the drift. The schematic map in Fig. 2 shows mutual orientation of tectonic faults and detected main horizontal stresses in this area. It is obvious that the higher horizontal stress is oriented approximately north–southwards, in parallel with the course of main faults. A similar anisotropy (in size as well as direction) was detected also on the right side of Albrechtice fault by in–hole measurements from crosscuts No 3500 and 3509 equally in an area less affected by mining.

The results of measurements in two localities not very distant one from another (roadway No 36229 × 248 m and roadway No 36232 × 403 m) but with relatively different levels of mining effect in 9.KVĚTEN Colliery were interesting. The geomechanical situation is shown by Fig. 2, 3. The measurings demonstrated high anisotropy of horizontal stresses in case of borehole Bl located below coal working edge in roof strata(lower bench of seam No 35) at the periphery of an area less affected by human activity ($SH = 9-13.3\,\mathrm{MPa}$, $Sh = 2.2-4.4\,\mathrm{MPa}$). On the contrary, in the surroundings of the borehole B2 further below worked–out areas below 35th and 36th seams in an area more affected by mining activity the anisotropy is rather reduced ($SH = 7.7\,\mathrm{MPa}$, $Sh = 6.4\,\mathrm{MPa}$).

A similar low anisotropy of stress distribution was recorded by measurings in Lazy Colliery in a vertical borehole drilled from the roadway No 39509 × 17 m in the vicinity of shaft pillar. Equally an area is concerned which is rather affected by mining activity particularly by numerous worked out areas in overlying strata. Similarly as measurings in the area of 9.KVĚTEN Colliery which is heavily disturbed by mining activity these measurings indicate an almost isotropic distribution of horizontal stresses ($SH = 7.6-8.3\,\mathrm{MPa}$, $Sh = 5.3-6.7\,\mathrm{MPa}$).

CONCLUSIONS

It is obvious that even such measuring values could be and actually are affected by local geomechanical and geological situation, by advancing orientation of borehole etc. But it can be presumed that the results of such measurings are substantially more acceptable for practical applications than an assumption based only on elastic model of environment and geostatic loading. As expected, the measurings have proved that horizontal stresses in areas where such measurements had

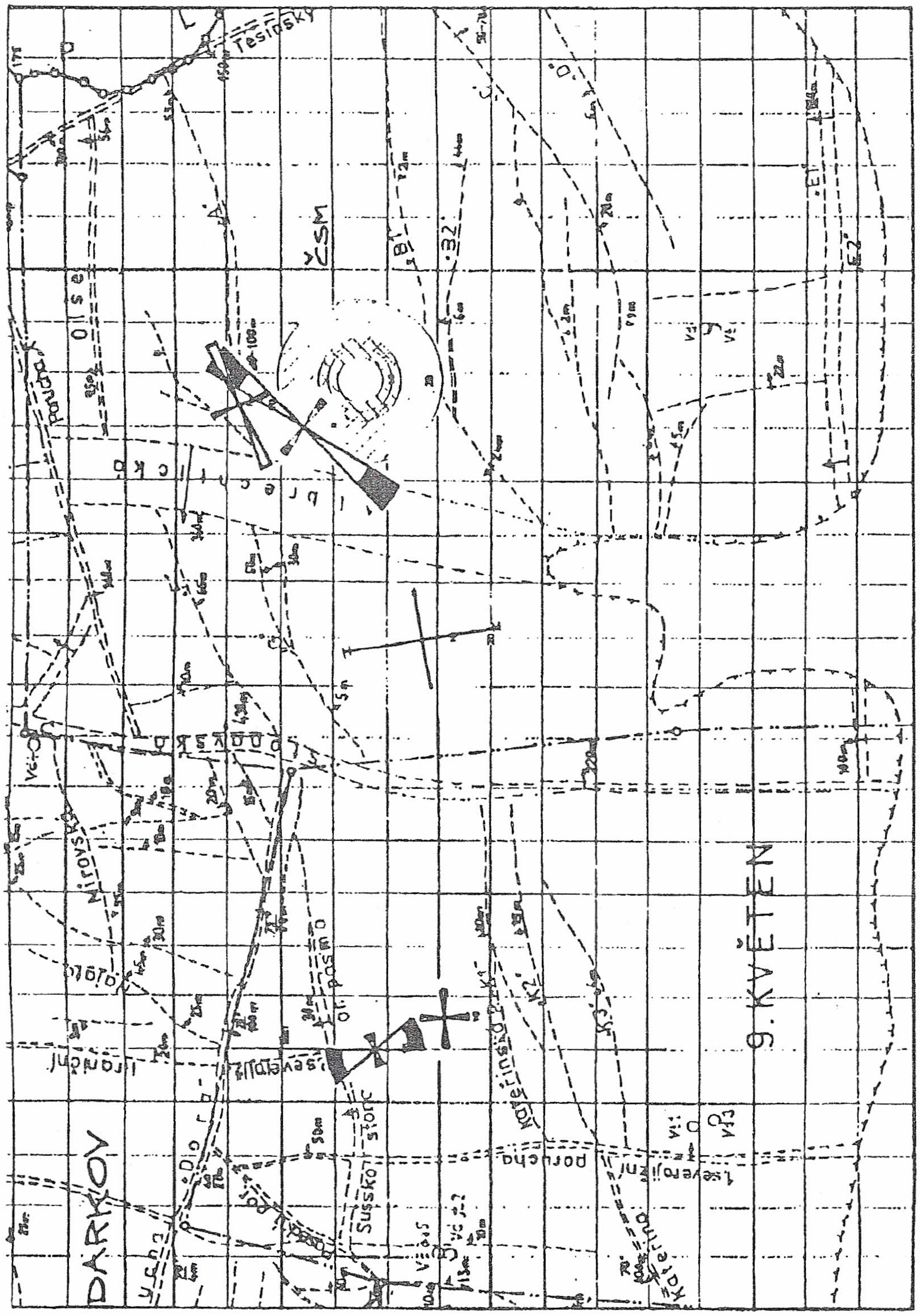

FIG. 2. The results of measurements in the ČSM and 9.KVĚTEN Colliery.

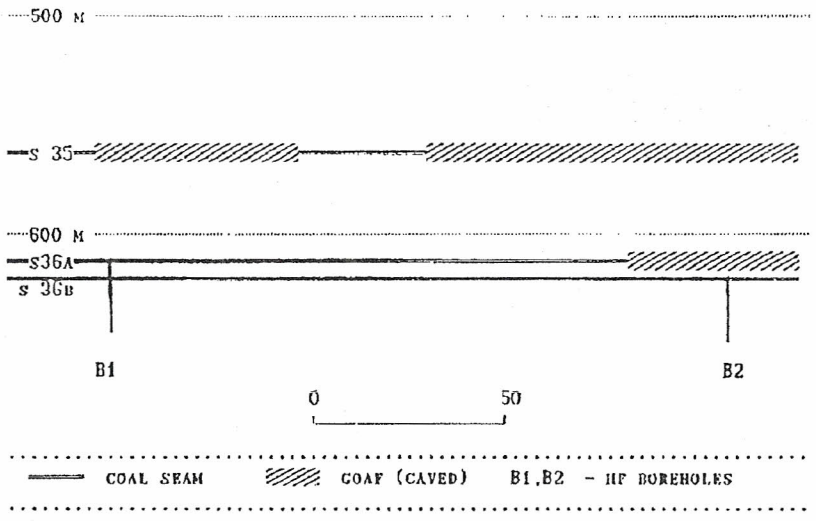

FIG. 3. Schematic vertical cut of the measurement area in 9.KVĚTEN Colliery.

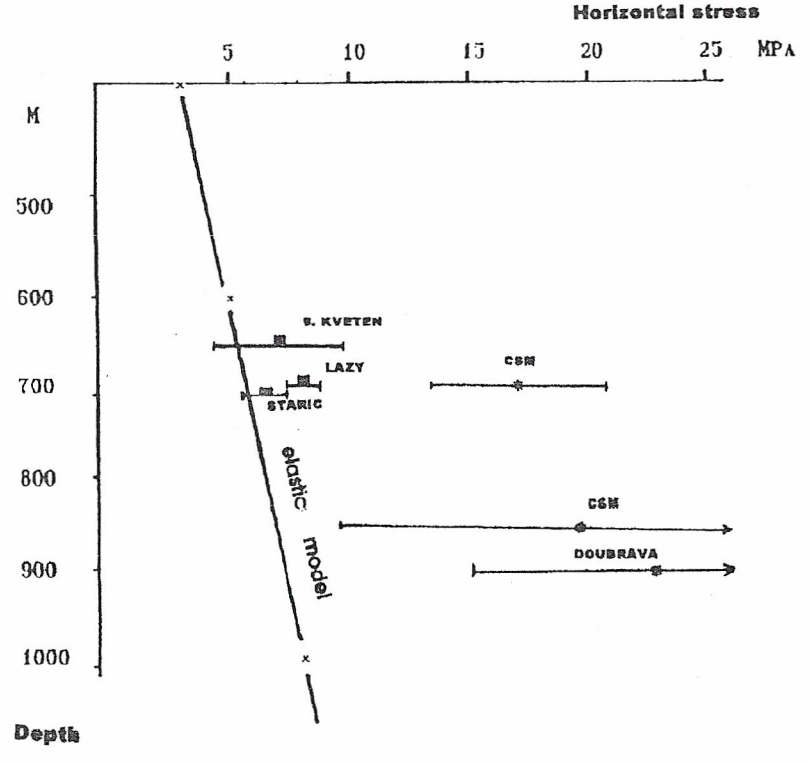

FIG. 4. The comparison of the measurement horizontal stress and the stress values derived from a model of elasticity for the given depth.

been successfully implemented exceed at least stress values derived from a model of elasticity for the given depth (Fig. 4). Moreover, the measured stresses indicate considerable variability of magnitude of anisotropy of horizontal stresses in dependence on geomechanical situation. This can be exemplified by the above-mentioned horizontal stress measurements in two not very distance boreholes on 9.KVĚTEN Colliery.

Based on statistically low number of measurings up to now it is not possible to make any general conclusions at present. Nevertheless, it can be registered that in areas of Karviná part of "OKR" coalfield which globally are less disturbed by mining activities, anisotropy of stresses is substantially less pronounced both when produced by action of isolated inhomogeneities or by original stress distribution of intact rock mass. In areas which are more disturbed or more uniformly affected by mining activities, the tendency of stress distribution approaches to isotropic stress distribution.

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