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In situ stress measurements in highly fractured rock at Hüttenberg, Austria

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With 3 Figures and 4 Tables

Summary

In situ stress measurements have been carried out in the mine of Hüttenberg in highly fractured rock having an average joint spacing of 9 cm. The doorstopper method was used. The absolute values of the calculated stresses were highly influenced by the joints whereas the direction of the principal stresses appeared to be independent thereof. The greatest principal stress was directed WNW and was in good agreement with the tectonic stress field of Central Europe.

Zusammenfassung

Im Bergbaugebiet von Hüttenberg wurden in situ Spannungsmessungen nach der doorstopper-Methode durchgeführt. Die Messungen erfolgten in stark geklüftetem Fels mit einem mittleren Kluftabstand von 9 cm. Die Berechnung der absoluten Spannungswerte wurde durch die Klüftung stark beeinträchtigt, während die ermittelten Richtungen zuverlässig erschienen. Die größte Hauptnormalspannung ist WNW gerichtet und in guter Übereinstimmung mit dem tektonischen Spannungsfeld in Mitteleuropa.

Introduction

In situ stress measurements are being carried out all over the world in order to determine the tectonic field. The most important method for obtaining information on the complete stress tensor is the stress relief technique which measures the expansion of the rock during unloading by overcoring. There exist several variations of this technique, but all demand long pieces of sound rock to be available. For the use of triaxial cells, the average fracture spacing must be larger than 80 cm; this provides a 50 % chance for 60 cm of unfractured core to be obtained which is required by this method

(Ribacchi, 1977). The application of the doorstopper method of Leeman (1969) can do with the lowest fracture spacings of all stress relief techniques. The reported values of mean fracture spacing are in this case normally greater than 20 cm. The present report describes the application of the doorstopper method in highly fractured rock with an average joint spacing of 9 cm.

Site description

The location of the measurements was at longitude 14°34'E and latitude 46°56'N in Hüttenberg/Austria within the Eastern Alps. A drive striking ENE leads from the valley floor of Görschitz to the point of measurement at a level of 800 m. The vertical overburden was about 120 m and the distance from the valley axis was more than 800 m. The valley strikes N-S and follows the great Görschitztal fault. This major fault is split

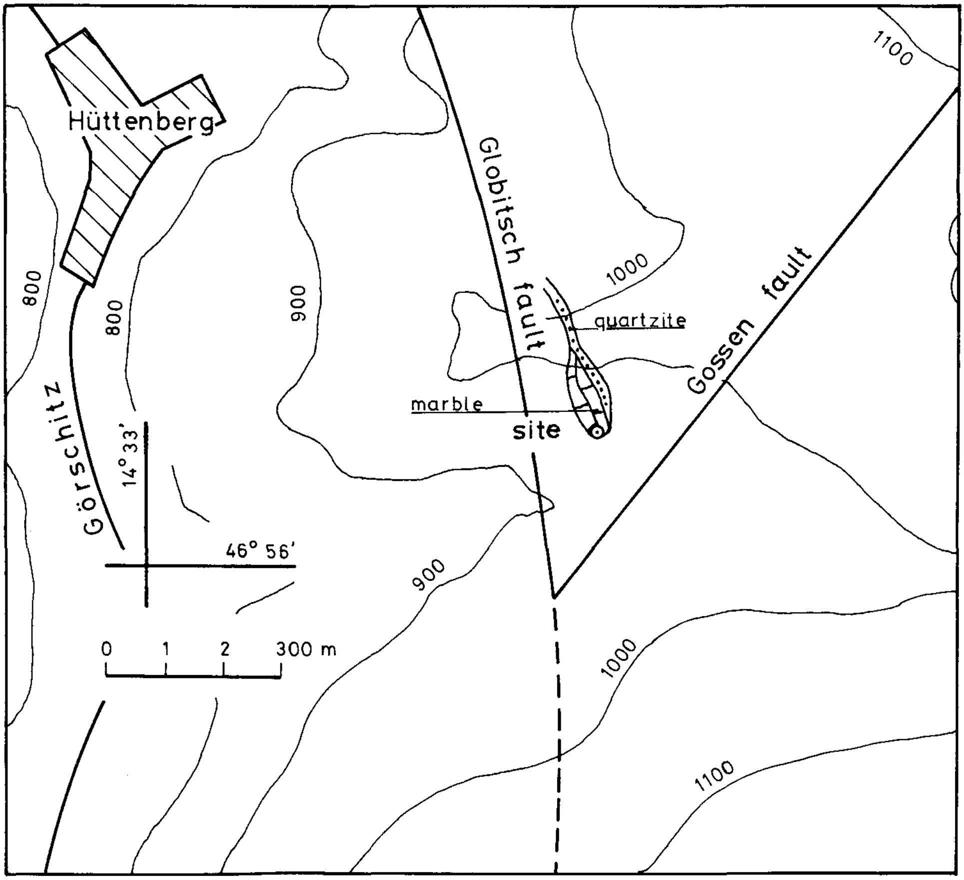

Fig. 1: Location of measurement and main rock material after Clar et al. (1953) and Weissenbach et al. (1978).

into several minor faults. Two of them pass the site at a distance of less than 150 m (see Fig. 1). It has been established that these faults were active until the Miocene time (CLAR et al., 1953); most probably they caused the high degree of fracturing of the rock found at the site. The rock material is marble, which forms a small SSW dipping lens embedded within garnet mica schist of Cambrian age.

Measurements

The measurements were taken in three boreholes. Holes 1 and 2 have been drilled horizontally with double-tube core barrels of 76 mm outer diameter, hole 3 with a single tube barrel of 66 mm diameter inclined at 32 degrees upwards, normal to a predominant joint. To get a real chance at setting the doorstopper on a sound unfractured rock face, the ground of the hole had to be inspected carefully. Closed cracks cannot normally be seen at all. Therefore the polished face of the bore was dried a short time (about 2 minutes) until it gave a clear reflection of the light. At this stage of drying, joints are seen as dark lines. Further drying removes the water from the joints and they cannot be recognized any longer. If the borehole was found to be whole, a doorstopper was glued on, a zero measurement was taken and overcoring was undertaken. As soon as the core with the glued-on strain cell had been brought out of the borehole and the readings had been completed, the modulus of elasticity and Poisson's ratio was determined by means of radial pressure equipment similar to that discribed by LEEMAN (1971). This procedure requires a minimum core length of 4 cm which was reached in 9 samples. Applying this procedure we also tested the adhesive properties of the glue; it was found that they were quite good. Each doorstopper measures 4 strains, but only 3 strains are necessary to determine a plane stress state. Therefore one strain measurement can always be used to check the validity of the remaining ones. The influence of temperature changes (mostly caused by the drilling) was very low. The temperature difference between the bottom of the hole and the air outside was measured to be less than 22°C.

Results

The rock properties are collected in table 1. This table gives rock-quality designator (RQD) values, the medium joint spacing, the deformation modulus, Poisson's ratio, the density and the strength of the cores. The measured strains showed a large scatter within each hole. Table 2 shows the strains, their standard deviations and the calculated stresses on the polished ground of each hole. The mean of the vertical component of the stress vector acting in the ground surface vanishes, but the standard deviation is 9 MPa. A straightforward calculation of the in situ stresses with a computer program described by KOHLBECK et al. (1980) using least square estimation has been carried out. The stress tensor is given in table 3, the principal stresses are given in table 4. It can be seen that the greatest principal stress acts predominantly horizontally in a WNW direction. A comparison between the vertical stress and the expected stress resulting from the overburden can be made. An overburden of 120 m (see Figs. 2 and 3) with the density of 2.7/g/cm^3 of marble gives 3.2 MPa. This value may rise up to 5 or 6 MPa because of the

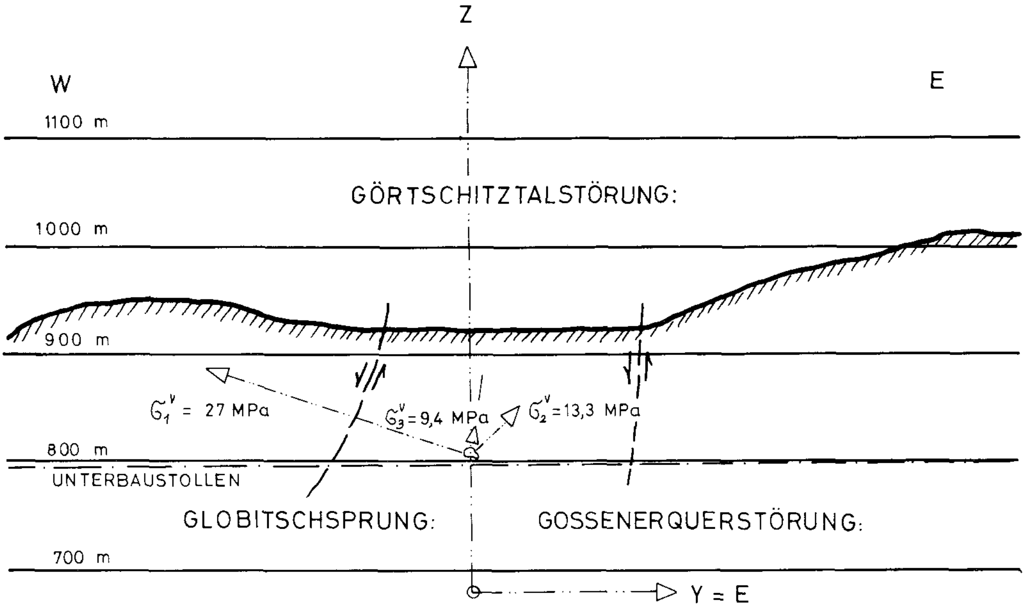

Fig. 2: W-E cross section through measuring point with principal stresses from HERMANN (1981).

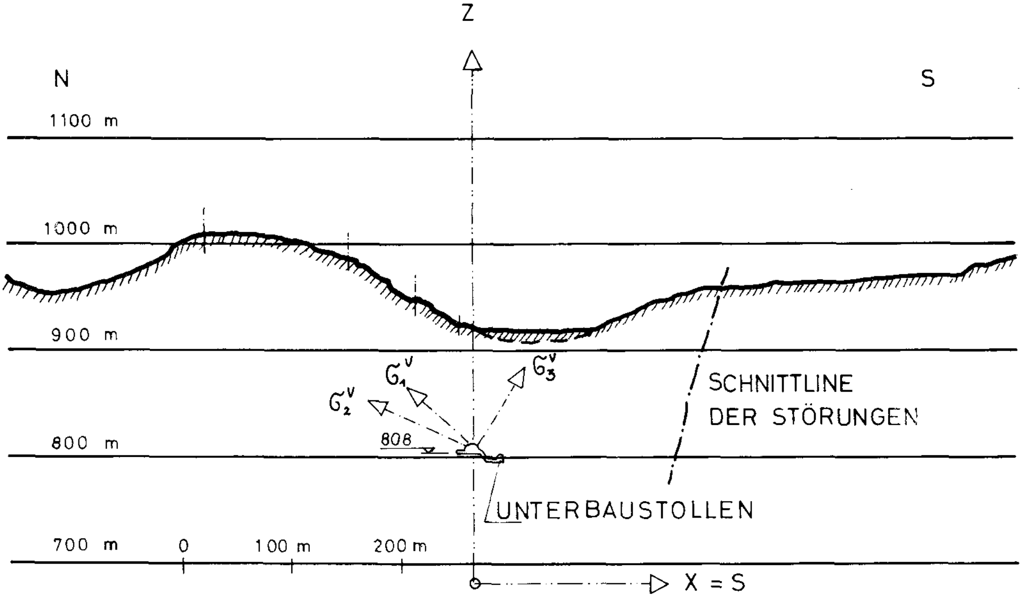

Fig. 3: N-S cross section through measuring point with principal stresses from HERMANN (1981).

lateral pressure of the adjacent mountain, whereas the in situ calculation gave 12 MPa. The low stress values measured at the bottom of the holes indicate that the discrepancy is due to incorrect assumptions in the calculations. There are mainly 2 restrictions: 1st there should be a uniform state of stress over the measuring site, 2nd the stress concentration on the flattened ground of the hole should not be affected by the joints. Obviously neither assumption can be valid in the present case. The deviations gave a systematic error for the absolute values of the stresses which cannot be removed by taking more samples. However, the directions of the principal stresses seem to be firmly established.

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		well No.			
		1	2	2	mean
RQD	%	23	43	21	29
joint spacing	cm	8	12	7	9
density	kg/dm^3	2.7	2.71	2.71	2.71
strength	MPa	78.4	64.4	83.4	75.4
E horiz.	GPa	47	49	54	50
E vert.	GPa	45	65	71	60
υ horiz.		0.134	0.154	0.262	0.183
υ vert.		0.158	0.298	0.372	0.276

Table 1: Rock properties from marble cores

E = Deformation modulus
υ = Poisson's ratio

Hole No.		strains in ppm at angle with horizontal				stresses in MPa (x = horizontal, y = vertical)		
		90°	45°	0°	135°	Sxx	Syy	Sxy
1	value	20	−7	75	136	4	2	−3
	stand. dev.	189	111	226	210	11	9	4
2	value	−99	−20	165	72	9	−5	−2
	stand. dev.	134	154	166	114	10	8	5
3	value	23	82	−53	−102	−3	1	5
	stand. dev.	144	200	138	85	11	11	4

Table 2: Strain and stresses on ground of hole.

Komponents	Sxx	Syy	Szz	Sxy	Syz	Szx
Stresses in MPa	14	24	12	4	—4	—3
Errors	5	10	5	3	1	1

Table 3: Stress tensor from in situ measurements (x directed toward S, y directed toward E, z directed upwards)

Komponents	S_1	S_2	S_3
Stresses	9	13	27
dip.from horiz.	60	24	18
direction from N	346	206	108

Table 4: Principal stresses calculated from values of table 2.

Literature

CLAR, E., & MEIXNER, H. (1953): Die Eisenspatlagerstätte von Hüttenberg und ihrer Umgebung. — Carinthia (II), **63**, H. 1, S. 67—92.

CLAR, E. (1953): Über die Verbiegung von Faltenachsen am Hüttenberger Erzberg. — Der Karinthin, **23**, S. 260—264.

HERMANN, W. (1981): Anwendung des Doorstopperverfahrens zu Spannungsmessungen im Kristallin der Saualpe/Kärnten. — Unveröff. Dipl.-Arbeit, TU Wien.

LEEMAN, E. R. (1971): The CSIR "Doorstopper" and Triaxial Rock Stress Measuring Instruments. — Rock Mech., **3**, S. 25—50.

KOHLBECK, F., RIEHL-HERWISCH, G., ROCH, K.-H., & SCHEIDEGGER, A. E. (1980): In situ Spannungsmessungen an der Periadriatischen Naht in der Ebriachklamm bei Eisenkappel, Kärnten, Österreich. — Mitt. Ges. Geol. Bergbaustud. Österr., **22**, S. 139—153.

RIBACCHI, R. (1977): Rock stress measurements in anisotropic rock masses. — Proc. Int. Symp. "Field measurements in rock mechanics", Zürich, **1**, S. 197—208.

WEISSENBACH, PILGER, A., SCHÖNBERG, R., FRITSCH, W. & MEIXNER, H. (1978): Geolog. Karte der Saualpe, Nord (Kärnten), Geolog. Bundesanstalt, Wien 1978.

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