Shape and fracture analysis on cuttings - KTB Hauptbohrung

Susanne Lich & Johannes Duyster
KTB-Feldlabor, Postfach 67, 92667Windischeschenbach

Macroscopic observations on cuttings show, that at certain depth intervals flat or block-shaped cuttings predominate. Flat shaped cuttings show open, unmineralized, fractures, which are oriented parallel to the outer edges (fig. 1). Thinsections reveal that open microcracks often ignore and cross-cut existing structures like foliation (fig. 2), distinct mineral-cleavage (e.g: biotite, hornblende), grain- and phaseboundaries, older generations of closed microcracks (fig. 3) or mineralized fractures. The macroscopic and microscopic fractures show no indication of shearing - they are merely extensional cracks. The shape of flat cuttings is controlled by open, parallel microcracks. Since the open cracks are not mineralized they must be young- we interprete them as drilling-induced. Therefore, cutting-shapes provide information about the breakout behaviour of the borehole.

We developed a method for cutting-shape measurements that can be applied quickly and routinely using digital image-analysis. Besides two-dimensional shape parameters, the three-dimensional parameter *flatness* is determined in the following way:

About 300 cuttings per sample are distributed in such a way, that the cuttings do not touch each other. An image (2400 x 3400 pixels) of the cuttings is scanned using an overhead scanner. The sample is then weighed. For each cutting:

- the equal area diameter is computed from its area in the two dimensional image
- the volume of a sphere of the equal area diameter is determined. Rock-densities are routinely measured in the field laboratory for each cuttings sample, so for each sphere a "weight" can be computed.

$$\textit{Flatness} \text{ is defined as } \frac{\sum \textit{sphere weights}}{\textit{sample weight}}$$

Flatness measures the three dimensional deviation from sphere shape.

Cutting-shapes were measured in the depth interval from 6700 m to 7220 m. Down to 6900 m correlation of the shape-parameter *flatness* with lithology is weak (fig. 4). Possibly this is caused by a change in the drilling parameters.

From 6900 m to 7220 m a good correlation of the cutting-shapes with the content of cataclastic deformed material in the samples can be observed (fig. 4). The more cataclastic the rock is, the more block-shaped the cuttings are. In more stiff rocks (fresh, not altered and not cataclastic material), higher *flatness* values were measured. No correlation of the cutting-shapes is found with different drilling-tools or the caliper-measurements.

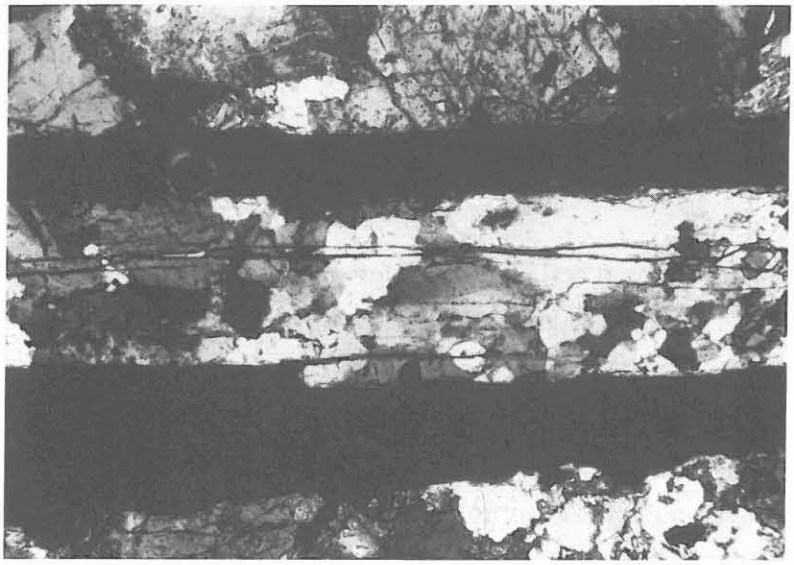

Fig. 1: dense, parallel microcracks cross-cut phase- and grainboundaries of quartz und plagioclase (HC-K7130, 7130 m, mobilisate in amphibolite, thinsection is normal to the flat shape of the cutting , X nic., width of view 2,3 mm)

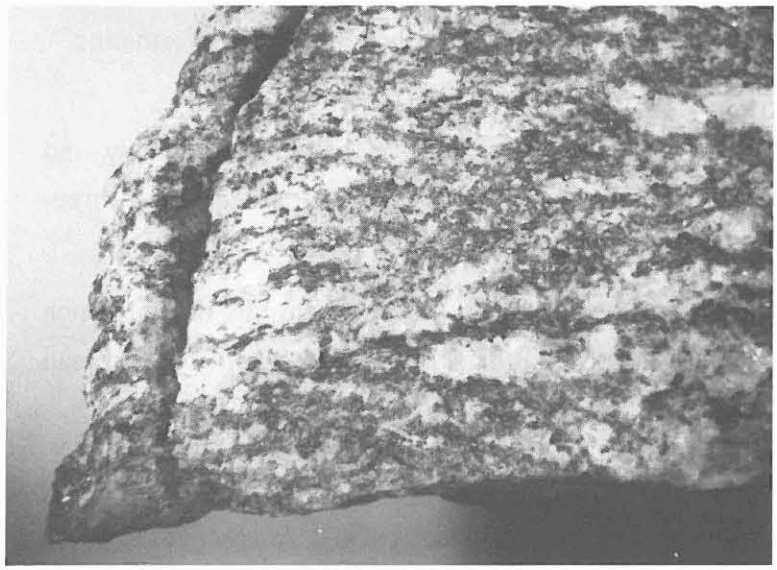

Fig. 2: parallel, open cracks normal to the foliation in a sample of the cuttingsampler (HCS-5697, 5697 - 5705 m, muscovite-biotite-gneiss, width of view 4,2 cm)

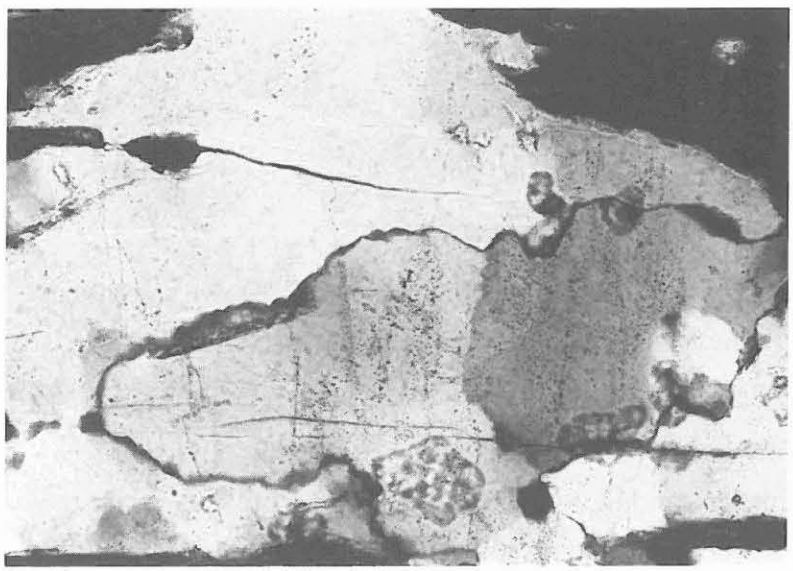

Fig. 3: Subvertical oriented, closed microcracks in quartz are cross-cut by open, nearly horizontal oriented cracks (HC-K7130, 7130 m, mobilisate in amphibolite, thinsection is normal to the flat shape of the cutting, X nic., width of view 1,2 mm)

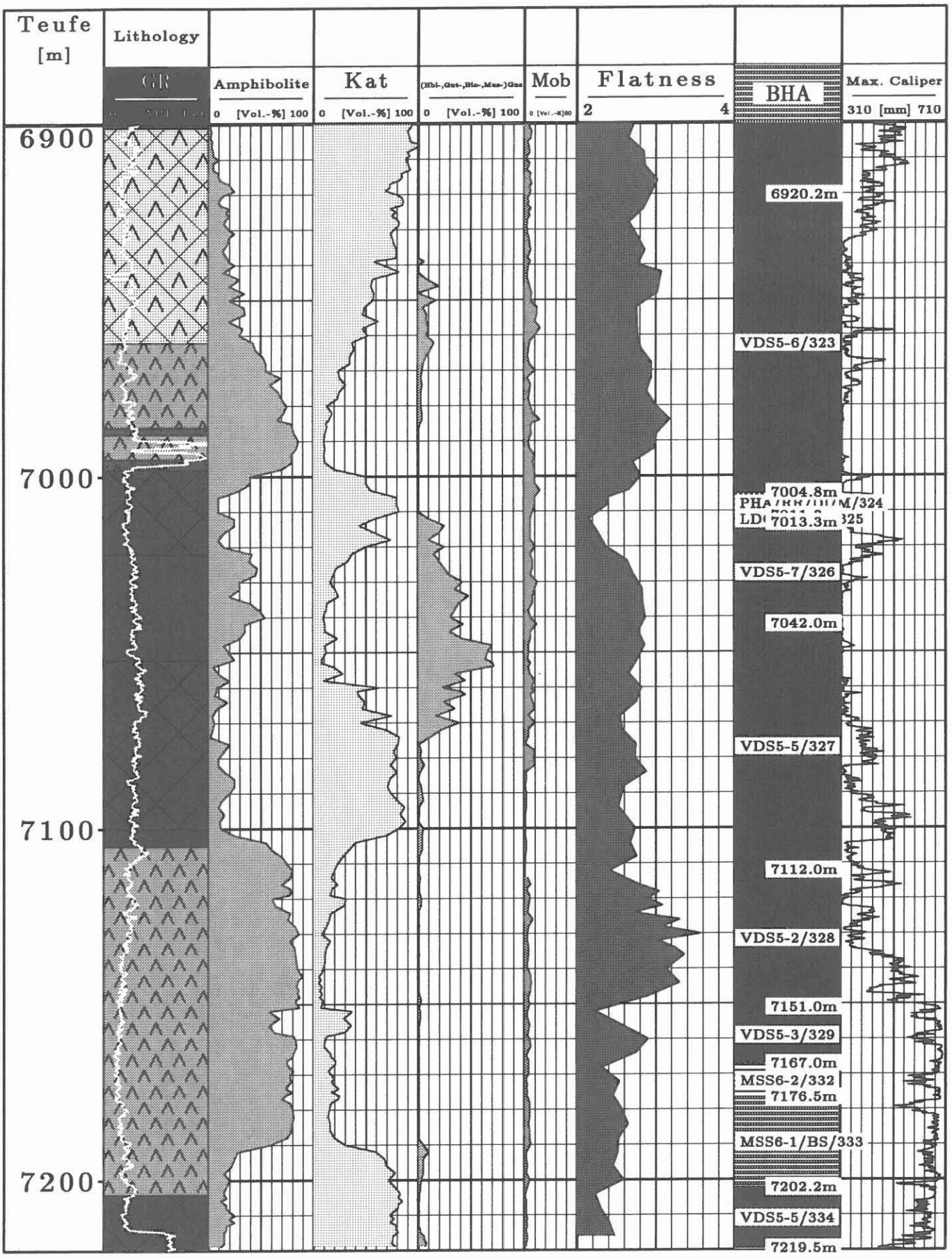

Fig. 4: Correlation of shape-parameter flatness of cuttings with lithology, components of lithology, drilling-tools and caliper-measurements.