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ORIENTATION OF PLANAR DEFORMATION FEATURES (PDFs) IN QUARTZ; F. Langenhorst and A. Deutsch; Institut für Planetologie, Wilhelm-Klemm-Str. 10, D-4400 Münster, Germany

Differently oriented single crystal quartz was shocked experimentally at pressures of 20 to 32 GPa and pre-shock temperatures up to 630°C. Based on this systematic investigation we can demonstrate that the orientation of planar deformation features in quartz is not only dependent on shock pressure but also on pre-shock temperature and shock direction. Moreover, the orientation of PDFs is strongly influenced by the set-up in recovery experiments.

PDFs in quartz are defined as optically recognizable, planar microstructures diagnostically produced by shock compression [1]. PDFs differ from all kind of microstructures found in volcanic environment [2] and therefore, their presence is a primary criterion for recognizing impact craters and ejecta layers such as the K/T boundary [3]. Because experiments have shown a pressure dependence of the orientation of PDFs (e.g. [4, 5]), this property is used extensively for shock wave barometry in natural impact sites. However, the unreflected application of experimental results neglects that parameters such as pre-shock temperature, shock direction, or the experimental arrangement may influence the spatial distribution of PDFs.

In order to test this assumption we performed in cooperation with Dr. U. Hornemann (Ernst-Mach-Institut, Weil am Rhein) shock experiments on single crystal quartz at pre-shock temperatures of 20°, 275°, 540°, and 630°C [7], and with shock directions $[10\bar{1}0]$ and [0001]. Most of the recovery experiments were carried out by using a reverberation technique, whereas in only one experiment a single shock was produced (impedance method). In the former case 0.5 mm thin discs of single crystal quartz were used, in the latter a 15 mm thick cylinder. The orientation of PDFs was measured by means of a conventional universal stage and the results are given in Fig. 1.

Generally, in experimentally shocked quartz the four major orientations of PDFs $\{10\bar{1}3\}$, $\{10\bar{1}2\}$, $\{10\bar{1}1\}$, and $\{1122\}$ can be indexed unequivocally in a stereoplot while some orientations claimed to occur subordinate in nature have never been detected in experiments (e.g. $\{11\bar{2}2\}$, [6]). Fig. 1a illustrates the frequency of PDFs in quartz for the pressure range from 20 to 32 GPa. Clear trends are discernible with increasing pressure: *(i)* $\{10\bar{1}3\}$ decreases till it disappears totally at 32 GPa. *(ii)* $\{10\bar{1}2\}$ occuring for the first time at 25 GPa increases distinctly until it is the only orientation at 32 GPa. *(iii)* $\{10\bar{1}1\}$ and $\{11\bar{2}2\}$ are absent above 25 GPa.

Compared to the unheated reference sample shocked at 20 GPa, pre-heating causes a broader distribution of PDFs but $\{10\bar{1}3\}$ and $\{10\bar{1}1\}$ still represent the prevailing orientations up to 540° C (Fig. 1b). In constrast, quartz pre-heated at 630° C and therefore shocked in the ß-structure totally lacks $\{10\bar{1}3\}$ and the forms $\{10\bar{1}2\}$ and $\{11\bar{2}1\}$ occur frequently.

The shock direction affects the development of PDFs quite drastically as visible by comparing Figs. 1a, c, and d. For example, quartz shocked at 26 to 27.5 GPa parallel to the (0001)-face exhibits predominantly the form $\{10\bar{1}3\}$ at all pre-shock temperatures. A shock front travelling parallel to $(10\bar{1}0)$ however, results at identical pressures in PDFs with an orientation of $\{10\bar{1}2\}$.

Effects of the experimentation technique can be derived from Fig. 1d showing the orientation of PDFs in quartz shocked at 27.5 GPa. In comparison to the well defined peaks at $\{10\bar{1}2\}$ found in samples from reverberation experiments, the impedance matching technique causes PDFs with a broad distribution pattern and indistinct maxima.

Our results have serious implications for shock-wave barometry in nature: the existing classification scheme [6] which relates PDF orientation exclusively to shock pressure is no longer applicable. In consequence we need more experimental data!

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PDFs IN QUARTZ: LANGENHORST F. and DEUTSCH A.

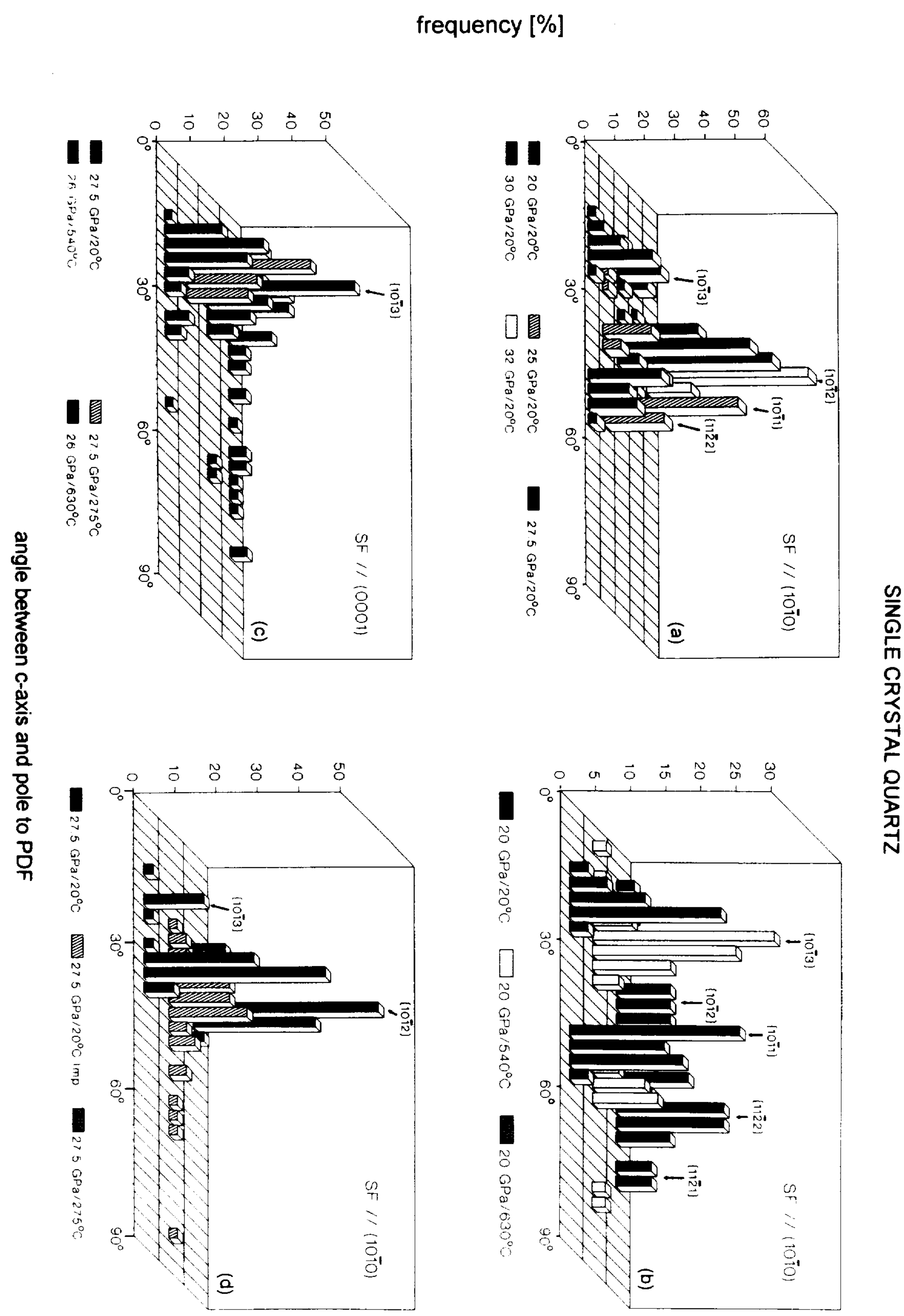

Fig. 1: Frequency distribution of PDFs in experimentally shocked single crystal quartz (a) - (c) reverberation technique (d) comparison reverberation - impedance matching (imp) technique; SF = shockfront