PLANAR DEFORMATION FEATURES IN QUARTZ GRAINS FROM MIXED BRECCIA OF THE AVAK STRUCTURE, ALASKA; A.M. Therriault[1] and A. Grantz[2]; [1]Geological Survey of Canada, Ottawa, Ontario, K1A 0Y3, Canada; [2]U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025.

Introduction. The Avak structure (Fig. 1), centered 12 km southeast of Barrow village, Alaska, at N71°15' and W156°36', has a subcircular form with a diameter of about 12 km (*1*). Strongly to intensely deformed and uplifted low-grade metamorphic basement rocks and regionally flat-lying to gently dipping sedimentary strata occur in the area (*1*). The deformed rocks are Ordovician and Silurian argillite, Upper Triassic to Lower Jurassic clastic shelf strata, and Lower Cretaceous organic shale and prodelta shale with thin turbidite sandstone interbeds. Permanently frozen Pliocene and Pleistocene marine and nonmarine sand and gravel of the Gubik Formation overlay the deformed rocks. The South Barrow, East Barrow and Sikulik gas fields occur outside the structure and are due to listric faults in the crater rim area, which have truncated the Lower Jurassic Barrow Sand and placed Lower Cretaceous Torok shales against the sand, creating an effective gas trap (*2,3*), with an estimated primary recovery ~37 bcf.

Gravity and seismic data and the core from U.S. Navy Avak 1 well (which was drilled close to the center of the structure and penetrated pervasively deformed rocks from the base of surface casing at about 38 m to total depth at 1226 m) have served to define an uplifted core in the center of the Avak structure. This central uplift, in which Lower Cretaceous rocks have been uplifted more than 500 m above their regional structural position, is about 4 km in diameter. An annular syncline, about 1.6 km wide in which the top of Franklinian argillite lies as much as 300 m below its regional structural position, surrounds this core and is defined in seismic and gravity data. A structurally high rim, or discontinuous "rim anticline," is defined in seismic and gravity data and by the gas fields (*1,2*). Other evidence consistent with an origin by impact cratering is: (1) circumferential, centripetally directed, listric faults that define the rim of the Avak structure and are downdropped toward its center, (2) parts of shatter cones, up to 10 cm high and best developed in cataclastically deformed quartz sandstone of the Lower Jurassic Barrow sand, observed in Avak 1 well, (3) reports of planar deformation features (PDFs) in shocked quartz grains, and (4) mixed breccias (*1*). No optical measurements of the proposed shocked quartz, however, were made. Accordingly, we have undertaken a preliminary study of the "shocked quartz" to confirm or deny the occurrence of shock features.

Results. Three thin-sections (50 2286-92, Avak-51A 2292-99 and Avak-51-B 2292-99) from samples of the mixed breccia lens occurring between 697 and 700 m depth in Avak 1 well were examined. These samples consist of Franklinian argillite fragments (Ordovician and Silurian) in a matrix of Kingak Shale (Jurassic), Barrow Sand (Jurassic), and pebble shale (Lower Cretaceous).

The development of microscopic PDFs is a characteristic feature of quartz grains found at impact sites (*e.g., 4,5,6,7,8,9*). In the samples studied, single quartz grains, <0.45 mm in size, contained from one to six sets of PDFs (Fig. 2). Virtually all sets of PDFs measured showed more than 50 planes within a set. Individual PDFs are usually decorated with <1-3 μm isotropic inclusions and have a spacing of 1 to 5 μm between individual planes. In general, the lamellae sets are sharp to moderately sharp, moderately continuous, straight to slightly curved, and cover more than half the length of the grains. In 70 grains of quartz, the orientations of 203 poles of lamellae planes relative to the optical axis were determined using a universal stage. As the quartz is weakly biaxial and the grains are rarely weakly recovered, *i.e.*, show wavy extinction and rare mosaicism, the precision of measurement did not exceed 5°.

The measurements were plotted on a stereonet (Wulff net projection) following the treatment of Engelhardt and Bertsch (*5*). Overlaying a template of all rational crystallographic orientations into a c-axis vertical projection, the data for each quartz grain was rotated to a best fit. Our results are shown in Figure 3. The dominant orientation corresponds to the ξ $\{11\bar{2}2\}$ crystallographic plane of quartz with 13.8% of the measured orientations falling within ±5° of 47°43' (Fig. 3). Of all the PDFs measured, 26.6% did not correspond to rationale crystallographic planes for PDFs in quartz (Fig. 3).

Conclusion. The PDFs found in the Avak structure fulfill the general criteria defined by Alexopoulos *et al.* (*8*) that must be met for microscopic lamellar features in shock-metamorphosed quartz, *i.e.*, features are well defined and sharp, relatively straight, parallel, and continuous, cover more than 50% of the grain, occur in multiple sets, and have a spacing between features of <5 μm. The distribution of the orientation of the lamellae sets and their crystallographic arrangement correspond well with the distributions of PDF in shocked quartz from impact sites

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with sedimentary targets, such as, the B.P. and Oasis structures (10), and Gosses Bluff (11), and as discussed by (*12*). Our results confirm the previous suggestion by Kirschner *et al.* (*1*) that the Avak structure is a complex impact crater. Given the economic interest at Avak, there is abundant structural data from both geophysics and drilling. These data have considerable potential to constrain the 3-D character of complex impact structures.

References. (*1*) Kirschner C.E. *et al.* (1992) *Am. Ass. Petrol. Geol. Bull. 76*, 651-679. (*2*) Lantz R.J. (1981) *Oil & Gas Journal 79*, 197-200. (*3*) Grieve R.A.F and Masaitis V.L. (1994) *Intern. Geol. Review 36*, 105-151. (*4*) Hörz F. (1968) *Shock Metam. Nat. Materials (eds. B.M. French and N.M. Short)*, 243-254. (*5*) Engelhardt W.V. and Bertsch W. (1969) *Contr. Mineral. Petrol. 20*, 203-234. (*6*) Stöffler D. (1972) *Fortschr. Mineral. 49*, 50-113. (*7*) Walzebuck J.P. and Von Engelhardt W. (1979) *Contr. Mineral. Pertol. 70*, 267-271. (*8*) Alexopoulos J. *et al.* (1988) *Geology 16*, 796-799. (*9*) Grieve R.A.F. *et al.* (1990) *Eos 71*, p. 1792. (*10*) French B.M. *et al.* (1974) *Geol. Soc. Am. Bull. 85*, 1425-1428. (*11*) Crook K.A.W and Cook P.J. (1966) *J. Geol. Soc. Australia 13*, 495-516. (*12*) Therriault A.M. and Grieve R.A.F. (1995) *LPSC XXVI*, (this volume).

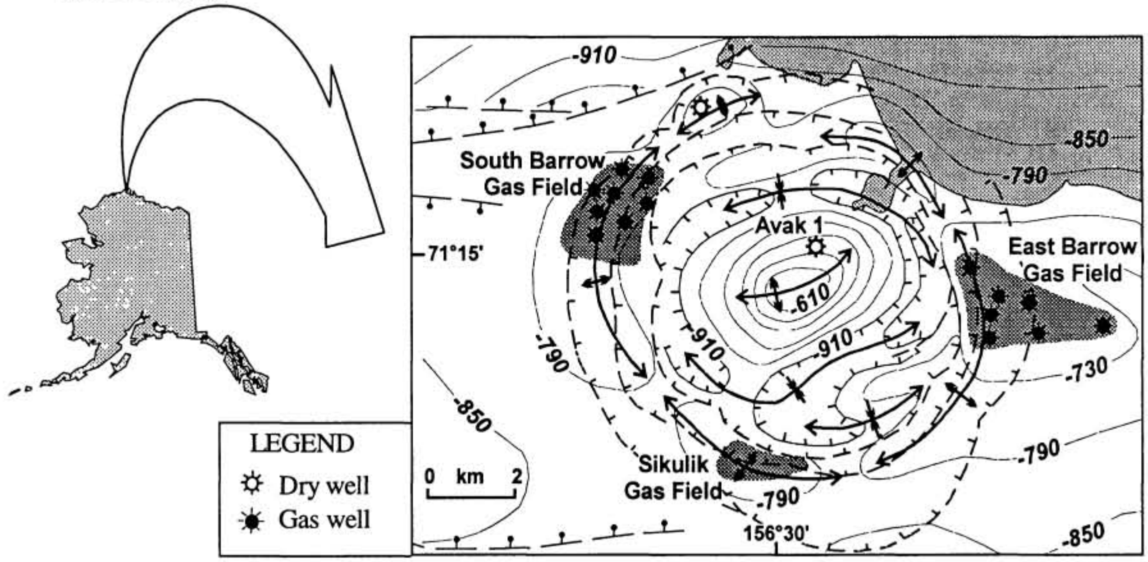

Figure 1: Location of the Avak structure, Alaska, and structure contour map on top of Franklinian argillite (Ordovician-Silurian). Contour interval 60 m. Gas fields are indicated. [After (*1*)]

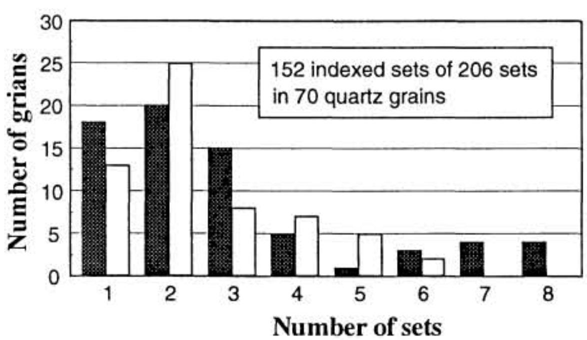

Figure 2: Number of sets of planar deformation features per individual quartz grains from the studied samples of mixed breccia from Avak, Alaska.

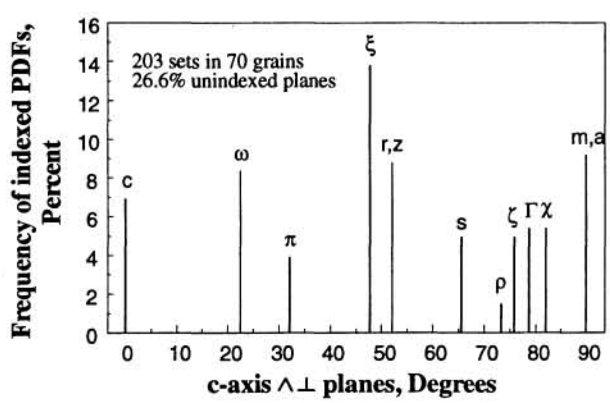

Figure 3: Indexed planar deformation features of quartz grains in relation to quartz crystallographic indices for the studied samples of mixed breccia from Avak, Alaska.