MINERAL CHEMISTRY AND MICROSTRUCTURES IN ALH84001; F. Langenhorst[1], C.S.J. Shaw[1], K. Metzler[2]; [1]Bayerisches Geoinstitut, University of Bayreuth, D-95440 Bayreuth, Germany (Falko.Langenhorst@uni-bayreuth.de; Cliff.Shaw@uni-bayreuth.de), [2]Ziegelhof 13, D-48157 Münster, Germany (Knut.Metzler@t-online.de)

Introduction. The ALH84001 meteorite is an orthopyroxenite that was previously misclassified as diogenite. A thorough evaluation of the geochemical and isotopic signature led to reclassification and identification of ALH84001 as a member of the SNC meteorite group [1]. Important mineral phases, other than the predominant orthopyroxene, are chromite, carbonates, and plagioclase. The fabric of ALH84001 reflects igneous and impact-metamorphic processes. Orthopyroxene and chromite crystallization and accumulation in the magma chamber was followed by crystallization of intercumulus plagioclase and later monomict brecciation by impact(s) on Mars. The carbonate formation is interpreted to result from alteration on Mars [2].

Methods and samples. In this study, we have used optical, microprobe, SEM, and TEM techniques to analyse mineral compositions, petrography and microstructures in ALH84001. Samples available were several single grains ca. 1-2 mm in size.

Results. The fabric of our samples consists of large (mean grain size ~ 1 mm), internally fragmented orthopyroxenes that are embedded in a fine-grained, granular matrix composed of orthopyroxene, plagioclase, and carbonates (Fig.1). Texturally, ALH84001 can thus be regarded as a monomict impact breccia, whereas, petrographically, it represents an orthopyroxenite. The compositions of plagioclase, and carbonate vary between $Ab_{54}An_{42}Or_4$ and $Ab_{65}An_{26}Or_9$, and $Mg_{0.41}Ca_{0.15}Fe_{0.44}CO_3$ and $Mg_{0.54}Ca_{0.10}Fe_{0.36}CO_3$, respectively (Fig. 2). We noted also the presence of one interstitial amorphous silica grain that shows apophyses along fractures in orthopyroxene. The carbonates in our samples are unzoned and do not show the ovoid structures that have been interpreted as indication of martian life [3]. As previously noted [1], the carbonate compositions fall along the trend of the 700°C solvus.

The minerals in ALH84001 show many signs of strong shock metamorphism. At the optical scale, orthopyroxene shows distinct mosaicism and fracturing. Grains with plagioclase composition are completely converted to the amorphous state and, similar to the silica grain, show apophyses, i.e., they can be regarded as shock-fused glasses. Carbonates occur as polycrystalline aggregates up to 100 µm in size. Individual grains within the aggregates are on the order of 10 µm in size. Individual grains do not appear to be zoned; however, there is compositional variation from grain to grain in the aggregates (Fig. 2).

TEM analysis reveals the ortho/clino-inversion in orthopyroxene. The monoclinic lamellae are only a few lattice repeats wide (< 50 nm) and are decorated with partial dislocations. This martensitic-type transformation is known to result from shock deformation. TEM furthermore confirms the amorphous nature of grains with plagioclase composition. Carbonates are defect-free but contain bubbles or channels (Fig. 3).

Discussion. Altogether these results indicate a complex multi-stage history with a minimum of two impact events. After crystallization and accumulation in the magma chamber the first impact on Mars might have led to uplift to near-surface regions and monomict brecciation. At this stage, alteration involving the formation of carbonates could have occurred assisted by the high post-shock temperatures in the brecciated rocks. The impact event that later ejected ALH84001 from Mars was the strongest and is reflected in shock melting of feldspar, silica, and the carbonates (cf. also [4]). The latter seems also to have crystallized at this time in the form of fine-grained aggregates. Carbonates show also indications of partial degassing. Using experimental data [5], all of these observations point to very high shock pressures on the order of 50 - 60 GPa.

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References. [1] D.W. Mittlefeldt (1994) Meteoritics 29, 214-221; [2] A.H. Treiman (1995) Meteoritics 30, 294-302; [3] D.S. McKay (1996) Science 273, 924-930; [4] E.R.D. Scott, A. Yamaguchi, and A.N. Krot (1997) Nature 387, 377-379; [5] F. Langenhorst, A. Deutsch, B.A. Ivanov, and U. Hornemann (2000) this volume.

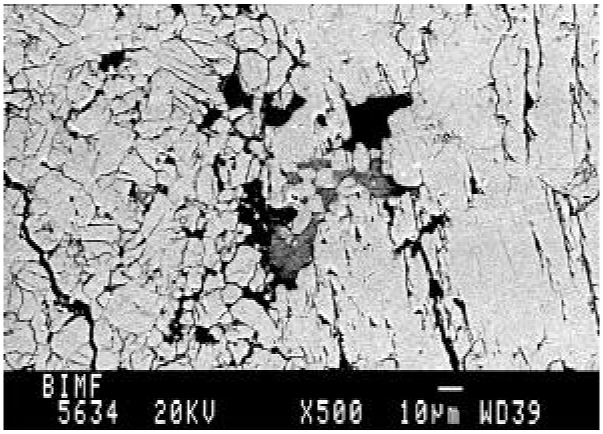

Fig. 1. Backscattered SEM image of ALH84001 showing fractured orthopyroxene (light-grey) with plagioclase (black) and (dark-grey) carbonate inclusions.

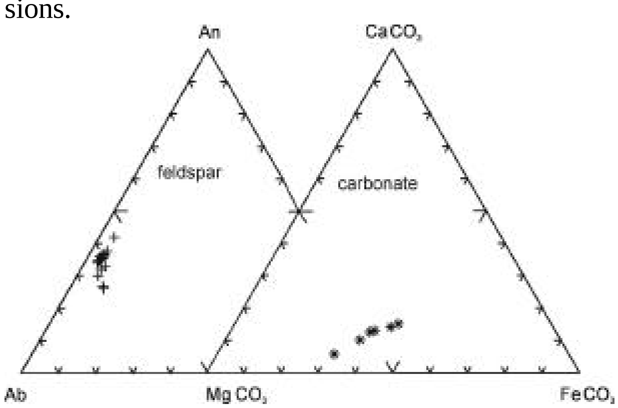

Fig. 2 Chemical compositions of feldspars and carbonates in ALH84001.

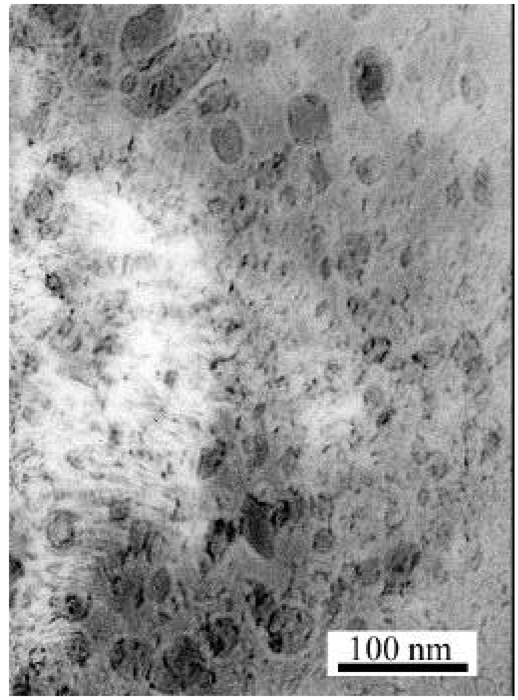

Fig. 3 Dark-field TEM image of a carbonate showing bubbles or channels that are interpreted to represent shock-induced degassing structures.