

### Thermometry of the CK4 chondrite Hammadah al Hamra 280, Libya

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Hammadah al Hamra 280 (HaH 280), an assemblage of 20 pieces of a slightly equilibrated carbonaceous chondrite (CK4), was found on March 2000 in the Libyan Sahara desert by a meteorite hunter. The total weight is 26.5 kg. The here presented investigations focussed on the determination of the equilibration temperature.

**Mineralogy:** HaH 280 shows well-developed chondrules in a yellow to grey-green coloured, fine-grained matrix. In two out of four thin sections CAIs were found. All CAIs contain An-rich plagioclase and Ca-rich pyroxene (fassaite with varying Ti-contents and diopsidic cpx). Some CAIs contain green spinel, apatite, Fe-oxides (magnetite, ilmenite), and in one case also little amounts of pentlandite. Only one of the investigated CAIs contains olivine.

**Mineral chemistry:** Matrix and chondrule olivines have Fa contents ranging from Fa31.5 to Fa33.0 with an average of Fa32.3 and a standard deviation (SD) of 0.4 mol% Fa. In contrast olivines in CAI have Fa contents from Fa19.9 to Fa24.7 with an accumulation around Fa20. Clinopyroxenes show an average of Fs9.6 (Fe/(Fe+Mg+Ca)), ranging from Fs8.5 to Fs10.2 with Wo contents ranging from Wo47.2 to Wo48.9 (Ca/(Ca+Fe+Mg)) with a mean of Wo48.0. In accordance with the projection scheme after Lindsley [1] HaH 280 pyroxenes have Fs9.0 – Fs10.8 and Wo43.1 – Wo46.0. CAI spinels coexisting with olivine have Cr/(Cr+Al)-ratios between 0.014 and 0.041. The Fe/(Fe+Mg)-ratios vary slightly from 0.4 to 0.439. Spinel in CAIs not in association with olivine have lower Cr contents (Cr/(Cr+Al) = 0.001 to 0.003) and higher Fe-contents. The Fe/(Fe+Mg)-ratios vary slightly from 0.456 to 0.485.

**Thermometry:** Calculation of the equilibration temperatures was done for HaH 280 by QUILF [2,3,4,5] and by using the ol-spl thermometer of Sack & Ghiorso [6]. Calculations with QUILF for the olivine + cpx pair at P = 1bar yield temperatures between 640 and 709 °C. The mean temperature is 678°C (SD = 27°C). Equilibration temperatures, calculated with the olivine-spinel thermometer after Sack & Ghiorso [6] lead to a range of 619°C and 741 °C for HaH 280. The average temperature is 682°C (SD = 58 °C). Temperatures of both methods are very close to each other (Fig. 1). We therefore estimate a metamorphic

temperature for the CK4 chondrites of about 650°C to 710 °C.

Compared to the results of Geiger & Bischoff [7] our temperatures are insignificantly higher than their estimations for CK4 chondrites (550-650°C, based on determined equilibration temperatures of coexisting pyroxenes) and the metamorphic temperature of the Karoonda meteorite of 580°C [8] based on oxygen isotope thermometry. For Maralinga (CK4-an) Geiger & Bischoff [7] reported an equilibration temperature of 720°C (opx-cpx thermometry). In comparison with the results of Noguchi [9] (750°C-850°C), who examined Maralinga, Y 693, EET 87507 and some fragments in Karoonda, our results are about 100°C to 160°C lower.

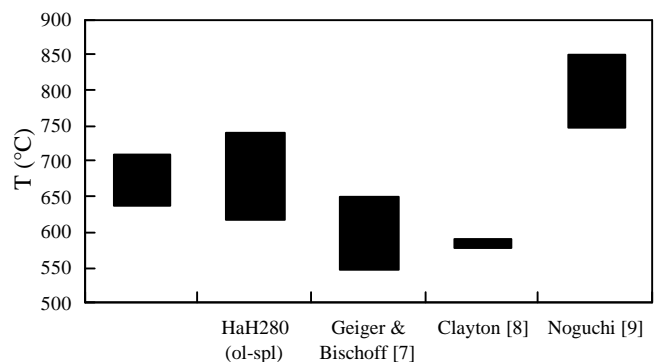


Fig. 1. Equilibration temperatures for CK4 chondrites from this study and from the literature.

References: [1] Lindsley (1983) *Am. Mineralogist* **68**, 477-493. [2] Frost et al. (1988) *Am. Mineralogist* **73**, 727-740. [3] Lindsley & Frost (1992) *Am. Mineralogist* **77**, 987-1003. [4] Frost & Lindsley (1992) *Am. Mineralogist* **77**, 1004-1020. [5] Andersen et al. (1993) *Computers & Geosciences* **19**, 1333-1350. [6] Sack & Ghiorso (1991) *Am. Mineralogist* **76**, 827-847. [7] Geiger & Bischoff (1991) *Meteoritics* **26**, 337. [8] Clayton et al. (1977) *EPSL* **34**, 209-224. [9] Noguchi (1993) *Proc. NIPR Symp. Antarct. Meteorites* **6**, 204-233.