WATSON: A NEW LINK IN THE IIE IRON CHAIN; E. Olsen[1,2], J. Schwade[3], A. M. Davis[4], R. N. Clayton[2,4], T. K. Mayeda[4], R. S. Clarke Jr.[5], E. Jarosewich[5] and I. M. Steele[2]; [1]Field Museum of Natural History, Chicago, IL 60605, [2]Dept. of the Geophysical Sciences, Univ. of Chicago, Chicago, IL 60637, [3]Olivet Nazarene Univ., Kankakee, IL, [4]Enrico Fermi Inst., Univ. of Chicago, [5]National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560

The Watson iron meteorite was found in 1972 near Watson, South Australia (35 km N of Cook). The original mass was 93 kg. The mass was first cut in 1990. The second slice removed revealed an extraordinarily large mass of silicate rock embedded in the metal: 10×4 cm on one face, and 8×5 cm on the opposite face, approximately 30 cm^3, ≈ 110 g of material. This is the largest single silicate mass known in an iron meteorite. Two chips were removed about 6 cm apart. Optical and backscattered electron examination showed them to be identical; the rock is mineralogically and texturally homogeneous.

The rock has an igneous texture, reminiscent of peridotites. Large orthopyroxene crystals (400 to 1000 μm) contain abundant poikilitic crystals of subhedral to euhedral olivine (10 to 100 μm; majority 50-60 μm). Subhedral and euhedral olivines occur also unenclosed by orthopyroxene. Calcic pyroxene occurs as irregular crystals (200-400 μm in long dimension) interstitial to orthopyroxene. A feldspathic phase is interstitial around both pyroxenes. Also interstitial is troilite. Chromite occurs as euhedral to entirely anhedral grains not enclosed by orthopyroxene, and associated with euhedral and subhedral olivine, and feldspathic material. Chromite does not occur uniformly, but as widely separated large (200-350 μm) grains. Metal occurs sparsely as round beads (<5 to 20 μm). Image analysis [1] (4.5 mm^2) gave the following calculated volumetric percentages: 37% olivine, 35% orthopyroxene, 8% calcic pyroxene, 12% feldspar, 2% chromite, 4% troilite, 0.1% whitlockite, <1% metal. No ilmenite was found.

Olivine, orthopyroxene, and clinopyroxene have uniform, unzoned compositions throughout the mass: Fa$_{20}$, Fs$_{17}$-Wo$_3$ and Fs$_9$-Wo$_{41}$, respectively. The clinopyroxene always contains closely spaced submicron exsolution lamellæ that are too small to analyze. Chromite has 7% Al$_2$O$_3$, 4% MgO, 1.5% MnO, 0.8% TiO$_2$, and 0.03% NiO. Troilite is Ni-free. Analysis of one metal bead gave an average of 8.4% Ni, with a range of 7 to 22% Ni. The Ni distribution appears uneven; backscattered electron images do not reveal a regular Widmanstätten pattern. The feldspathic material is quite variable from spot to spot, An$_{2-5}$–Or$_{6-29}$. The feldspathic masses have zero to low birefringence, usually with wavy extinction; they are either strained glass or maskelynitized plagioclase.

From the modal image analysis and the mineral analyses a bulk analysis can be calculated, which is close to the bulk silicate composition of an H-chondrite. The oxygen isotope composition ($\delta^{17}O$ = +2.84, $\delta^{18}O$ = +4.22) plots close to Netschaëvo, Colomera, and Kodaikanal, all IIE-anomalous irons [2]. The IIE irons have the same oxygen isotopic composition as H chondrites. Of IIE-anomalous irons, only Netschaëvo has similar mineralogy with, however, lower FeO olivine and orthopyroxene compositions. The modal ratio, (olivine)/(olivine+pyroxene) in Netschaëvo is 0.31; in Watson it is 0.47. Watson falls within the range for H-chondrites for this ratio [3]. Netschaëvo is a unique chondrite [4] intermediate between H and E chondrites; Watson has a more normal H-group composition and mineralogy. The texture of Watson silicate is similar to that of ALHA 77005, a shergottite; its crystallization sequence may be similar [6].

The metal surrounding the silicate mass originally consisted of cm-sized polycrystalline taenite with isolated grains and grain clusters of olivine, pyroxene, schreibersite and troilite along the taenite crystal boundaries. During slow cooling to ≈200°C a 0.10±0.05 mm Widmanstätten pattern formed. At the some later time a rapid temperature rise occurred with major plastic deformation of the metal. Taenite lamellae were curved and twisted with much of the deformation taken up along the preexisting taenite crystal boundaries. Troilite and some schreibersite were melted, and some kamacite converted to martensite. During this event the silicate mass was intruded into the metal. Two-pyroxene thermometry [5] gives an equilibration temperature of 1100°C (similar to Netschaëvo and Kodaikanal, 1060° and 1160°C, respectively). Cooling was apparently fairly rapid after this because pyroxene equilibration stopped at 1100°C, and the distorted Widmanstätten pattern was not destroyed.

Trace elements were determined in olivine, orthopyroxene, calcic pyroxene, feldspar and whitlockite by ion microprobe. The REE patterns of all phases except olivine are shown in Fig. 1, along with the bulk REE pattern calculated from the mineral analyses and the modal proportions of phases (calculated on a metal- and sulfide-free basis). The REE patterns appear to be governed by equilibrium partitioning between the constituent phases. The bulk has an average Mg-normalized enrichment factor for refractory elements of 0.70 relative to ordinary chondrites [7]. This value is somewhat uncertain due to the large uncertainty in the modal percentage of REE-rich whitlockite.

We conclude that the silicate is a closed system melted and recrystallized H chondrite intruded into a metal (core?) mass of the enigmatic IIE parent body. The locally high potassium content of the feldspathic material (often found in silicate inclusions in IIE irons) supports this association, as well as the close relationship between the IIE irons and the H-chondrites, established by oxygen isotope compositions [2].

Watson provides a link between the primitive IIE iron, Netschaëvo, with its inclusions of unheated, relatively pristine chondrule-bearing chondrite, and other more highly processed IIEs, such as Weekeroo Station, Colomera and Elga, which are mineralogically highly fractionated, with nonchondritic bulk compositions, rare olivine and abundant K-feldspar.

References: [1] ULTIMAGE™ v 1.3.4 (GRAFTEK, France); [2] R. N. Clayton *et al* (1983) *EPSL* **65**, 229; [3] E. Olsen & E. Jarosewich (1971) *Science* **174**, 583; [4] R. W. Bild and J. T. Wasson (1977) *Science* **197**, 58; [5] D. H. Lindsley (1983) *Am. Mineral.* **68**, 477; [6] L. L. Lundberg *et al* (1990) *GCA* **54**, 2535; [7] Kallemeyn G. W. *et al.* (1989) *GCA* **53**, 2747.

Figure 1. Rare earth elements in silicates and whitlockite in Watson. Bulk composition calculated from modal abundances and mineral analyses. Uncertainties shown are ±1σ.