NORTHWEST AFRICA 5492: AN EXTREMELY REDUCED CHONDRITIC METEORITE WITH LOW VOLATILE ELEMENT CONTENTS. P. Friend[1], J. Zipfel[2], M. Gellissen[1,2], R. Kleinschrodt[1], C. Muenker[1], A. Pack[3], T. Schulz[1], A. Stracke[4] and H. Palme[2]. [1]Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicherstraße 49b, 50674 Köln. [2]Senckenberg Forschungsinstitut und Naturmuseum, Senckenberganlage 25, D-60325 Frankfurt am Main, jzipfel@senckenberg.de, [2]Geowissenschaftliches Zentrum, Georg-August-Universität Göttingen, D-37077 Göttingen, [4]Institut für Mineralogie, Universität Münster, D-48149 Münster.

Introduction: We report on the petrology, mineral chemistry, major and trace element and O- and W-isotope composition of Northwest Africa (NWA) 5492. The meteorite has a chondritic texture, enstatite-rich mineralogy and bulk chemistry reflecting FeNi-excess and volatile depletion. This meteorite does not fit any present classification.

Petrography and Mineral Chemisty: NWA 5492 has a brecciated, chondritic texture with well delineated chondrules (PP, RP, POP and rare BO), chondrule fragments and various clasts. Among the latter are impact melt clasts, chondrule-rich clasts and abundant granular fine-grained clasts consisting of silicates, metal and sulfide (Fig. 1). Ca,Al-rich inclusions or AOAs were not observed. Large FeNi and sulfide grains are irregularly shaped and occur in chondrule interstitials often forming elongated aggregates. A fine-grained matrix is virtually absent. No fresh chondrule glass was observed. Shock features in larger olivines are minor. The weathering grade is moderate with <20% of FeNi being replaced by Fe-oxides.

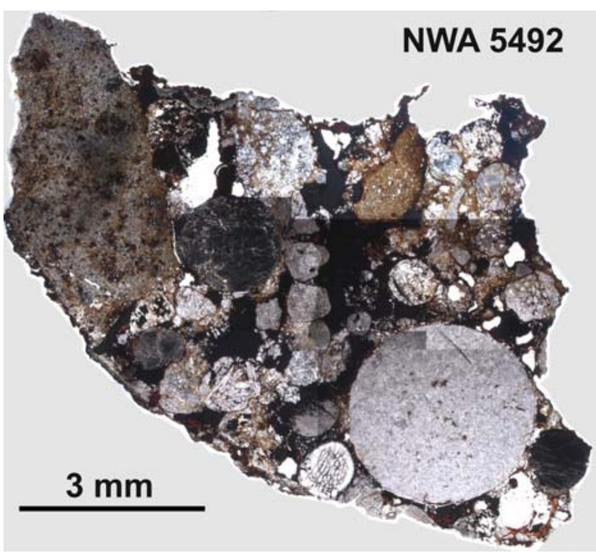

Fig. 1. Transmitted light photomicrograph of a thin section of NWA 5492. Chondrules, chondrule fragments and granular fine-grained clasts (left) are easily recognizable.

Mineral chemistry was determined with EMP. The dominant mineral is almost pure enstatite (Fs <0.5 %) with low CaO (<0.5 wt. %). Rare olivine is forsteritic (Fa <0.3%) with very low contents CaO (<0.02 wt.%) and Cr_2O_3 (<0.3 wt.%). Clinopyroxene ($En_{49}Fs_{0.4}Wo_{51}$) and plagioclase (An = 35%) are present. FeNi is kamacite with Ni contents of ~5.5 wt.%. Sulfide is mostly troilite (FeS), subordinate daubreelite ($FeCr_2S_4$) and minor alabandite (MnS). Mineral chemistry is consistent with low temperature equilibration. Some enstatite crystals are speckled with abundant tiny Ni-free Fe metal grains associated with SiO_2, indicating secondary reduction affecting all ypes of chondrules and clasts.

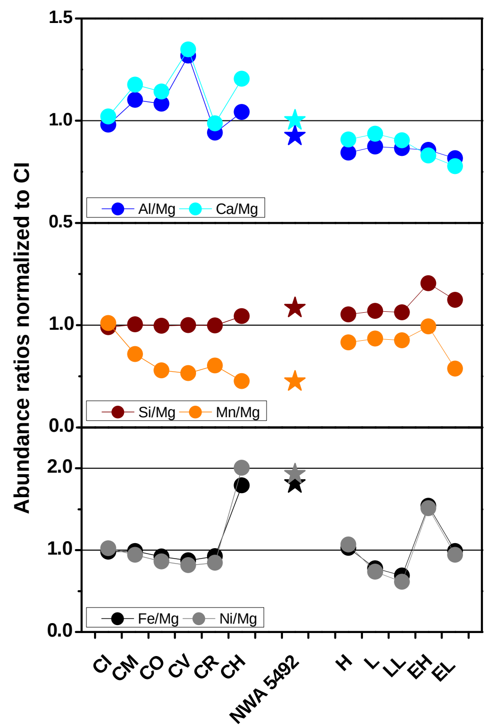

Fig. 2: Major element trends in chondritic meteorites and NWA 5492. This meteorite does not fit into any of the presently known chondrite groups. Data CI [1], CC [2], CR [3, 4], CH [5,6], OC [7].

Chemical Composition: Major and minor elements were determined with XRF and trace elements with ICP-MS on aliquots of a 830 mg homogenized sample. Results in wt. % are: Si 14.31, Ti 0.048, Al 0.92, Fe_{total} 38.44, Mg 11.15, Mn 0.097, Ca 1.07, Na 0.20, P 0.44, Cr 0.27, Ni 2.7. Abundances of Mg and CI-normalized refractory, common, moderately volatile and siderophile elements in NWA 5492 are compared to other chondrite groups in Fig. 1. The refractory elements Al, Ca, Ti in NWA 5492 are at about the same level as in CI-chondrites similar to CR-chondrites. The Si/Mg ratio is slightly enhanced, but still significantly below EH-chondrites. The moderately volatile Mn is severely depleted in NWA 5492 comparable only to CH-chondrites. Excess metal is reflected in high Fe/Mg and Ni/Mg ratios, again similar to CH-chondrites; P and Mo are also enhanced. REE patterns are flat except for some enrichment in LREE, which may be ascribed to terrestrial alteration. Similar effects are found for Ba, Th, U and Rb. The highly volatile elements Cs and Pb are depleted by factors of 5 and 10, respectively.

Oxygen Isotopes: Oxygen isotope ratios were determined by means of laser fluorination. Two powdered samples were reacted with purified F_2 and O_2 was analyzed using a THERMO MAT253 multicollector gas mass spectrometer in continuous flow mode. Interfering NF_3 was separated using a 5A molecular sieve GC column. The results are: $\delta^{18}O$ = +5.09, +5.26 (± 0.2) and $\delta^{17}O$ = +2.95, +3.19 (±0.15) with $\Delta^{17}O$ = +0.59, +0.60 (±0.05), different from any other type of chondritic meteorite (Fig. 3).

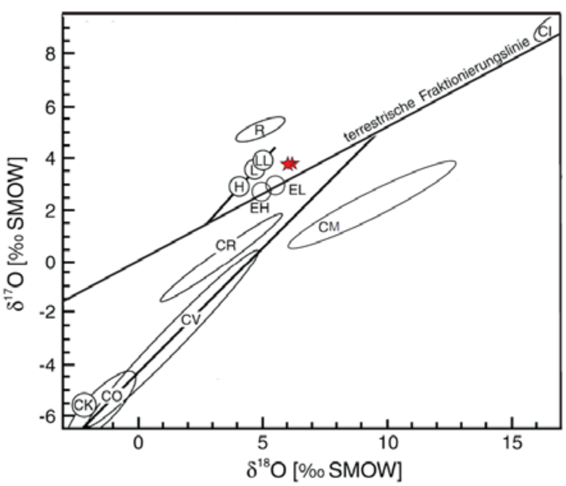

Fig. 3: Oxygen isotopic composition of NWA 5492.

W-isotopes: A bulk sample, a metal-rich and a metal–poor separate were analyzed for W-isotopes using the Neptune MC ICP-MS following the analytical protocol by [8]. Three meteorite splits define an isochron with an initial $^{182}W/^{184}W$ ratio of $\varepsilon^{182}W$ = -3.30 ± 0.20. This low initial overlaps with the CAI initial of $\varepsilon^{182}W$ = -3.28 ± 0.12 [9] and the initial of an internal isochron for the H4 chondrite Ste. Marguerite ($\varepsilon^{182}W$ = -3.22 ± 0.12 [10]), but is significantly below the initials defined by internal isochrons of CB and CH chondrites [11], attesting to the primitive nature of NWA 5492.

Discussion: The reduced mineralogy of NWA 5492 resembles E-chondrites, but the refractory elements, the Mg/Si ratio and the depleted volatile elements are very different from E-chondrites. The almost constant Fa and Fs contents of olivine and low Ca-pyroxene are even lower than in type 4 E-chondrites. Metal is free of Si and Cr (below 200 ppm), unlike metal in E-chondrites.

The chemical composition of NWA 5492 (Fig. 1), and the excess of metal as well as the absence of matrix in this meteorite may suggest some relationship to CH chondrites. But there are important differences. NWA 5492 is not enriched in refractory elements, apparently contains no CAIs and is more reduced than CH-chondrites. Also CH-chondrites have different oxygen isotope composition. Compared to other chondrites, the ^{182}Hf-^{182}W model age for NWA 5492 is very old, postdating CAI formation by not more than 0.7 Ma. This age may date primary metal-silicate condensation in the early solar nebula.

Cosmochemical Implications: NWA 5492 is extremely reduced, but low in volatile elements. The Fa contents of the olivines are within the range of forsteritic olivines in chondritic meteorites, recording the oxygen fugacity of the H_2-dominated solar nebula [12]. The bulk composition and oxygen fugacity of this meteorite are consistent with a nebular condensate after condensation of Si. Such material has been postulated as the initial accretionary component for the Earth [13]. Recent detailed modeling of Earth accretion [14] confirmed the early accretion of volatile poor reduced material. Thus NWA 5492 may represent a cosmochemically important component.

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