MÖSSBAUER SPECTROSCOPIC INVESTIGATION OF THE METALLIC PHASES IN THE ALMAHATA SITTA METEORITE (FRAGMENT#051).

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Introduction: The Almahata Sitta meteorite fall was unique because asteroid 2008 TC_3, the parent body of the Almahata Sitta meteorites, was the first asteroid to be detected and tracked in space before impacting earth and fell in Sudan in 2008 [1]. In a previous work, we studied the whole-rock sample of the Almahata Sitta fragment #051, hereafter referred to as AS#051, and classified it as a magnesian ureilite [2]. Ureilites are carbon-bearing achondritic meteorites, and their origin and formation history remain enigmatic [3]. The study of metallic phases in ureilites is important for understanding the petrogenesis of ureilites, as well as redox conditions under which they have formed. Here we report on the Mössbauer spectroscopic results of the metallic phases from the AS#051 ureilite in an attempt to contribute to the understanding of their possible origin.

Experimental: The metal particles of the AS#051 ureilite were extracted from the bulk powdered sample by a hand magnet in acetone [4,5]. The extracted metal particles vary in size from submillimeter to very fine grains, and they appear black, indicating their association with carbon. Mössbauer spectra were collected at room temperature (RT) using a ^{57}Co(Rh) source. The spectrometer was calibrated using the spectrum of α-Fe at RT. Spectra were analyzed using a Voigt-based hyperfine-field distribution (HFD) for magnetic Fe sites and quadrupole-splitting distribution (QSD) for non-magnetic Fe sites.

Results and Discussion: The Mössbauer spectrum of the metal particles of AS#051 ureilite is dominated by a strong magnetic sextet (relative absorption area = 77%) with a magnetic hyperfine field of 33.4 T and near-zero isomer shift and quadrupole splitting, characteristic of kamacite. In addition, the spectrum shows absorption peaks that can be assigned to taenite, 13%; cohenite [$(Fe,Ni)_3C$], 4%; schreibersite [$(Fe,Ni)_3P$], 4%; and a Fe-oxide/hydroxide phase (2%). No silicates or troilite were detected. The most abundant type of metal in ureilites is grain-boundary metal (mostly kamacite), where both metal and carbon occur along silicate boundaries, and is believed to have been formed by carbon-induced reduction of silicate rims [6]. Cohenite and schreibersite are very common in iron meteorites, but their occurrence is rare in ureilites where they have generally been observed, along with FeNi metal and sulfides, in the metallic spherules (10-50 micron) within silicates [3]. We have detected very small amounts of cohenite (2%) and taenite (3%) in the Mössbauer spectrum of the whole-rock powdered sample of the AS#051 [2], however, schreibersite has only been detected in the spectrum of the AS#051 metal particles. In the Mössbauer spectrum of the AS#051 metal particles, the sextet assigned to taenite has a relative area of 13%, and will therefore give more reliable Mössbauer parameters. The refined hyperfine parameters (magnetic hyperfine field = 30.8 T, isomer shift = 0.06 mm/s and near-zero quadrupole splitting) are typical of taenite/disordered γ-FeNi [4]. Direct observation of taenite in the metal of ureilites has not been reported before; however its existence was inferred indirectly, e.g., from the high Ni contents displayed by micron-sized metal grains in the carbonaceous-matrix of the Kenna ureilite [6]. Furthermore, Mössbauer spectroscopy of some weathered ureilites indicated the presence of goethite [FeO(OH)] which seems to have formed by oxidation of high-Ni metal [7]. We did not observe taenite in the AS#051 metal grains that we studied by optical microscopy and electron microprobe analysis [2]. However, the taenite phase may occur on a very fine scale (submicrometer/nanometer), possibly in the submicron metal inclusions (within silicates) responsible for the dark appearance of some silicate grains in transmitted light [2]. Further work, including, e.g., electron microscopy and microXRD, is needed to better characterize the metallic phases in the Almahata Sitta fragment#051.

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