TISHOMINGO IRON METEORITE: A UNIQUE MICROSTRUCTURE AND THERMAL HISTORY.

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Introduction: Most metal in irons, stony irons and chondrites contains a region of martensite (α_2) at <~28 wt% Ni and a cloudy zone (spinodal) microstructure at >~28 wt% Ni in the "M" shaped Ni profile in taenite [1]. The cooling rates of these meteorites are from ~1 to 10,000 ^{0}C/Myr. Tishomingo contains 32.5 wt% Ni and is composed of 80 vol.% martensite and 20 vol.% taenite [2, 3]. The presence of martensite and the lack of a spinodal structure make Tishomingo unique. In order to understand how this unique meteorite formed we determined its microstructure and chemistry using SEM, AEM and EBSD, and its cosmic ray exposure (CRE) age by measuring the noble gases.

Results: SEM and EBSD data show that residual taenite is single crystal fcc, but martensite is composed of both fcc and bcc phases which have a Kurdzumov-Sachs (K-S) or Nishiyama-Wasserman (N-W) orientation relationship. Some of the fcc phases in martensite have a similar crystallographic orientation to the residual - original fcc taenite, but some do not. Some of the bcc phases in martensite have K-S or N-W orientation relationship with residual - original fcc taenite. However, some bcc phases are not directly associated to the original taenite. AEM results from TEM thin foils obtained by focused ion beam (FIB) shows that in the martensite region the Ni content changes from ~4 wt. % to ~55 wt.%. The AEM data confirm that martensite contains bcc α and fcc γ phases [2, 3].

Noble gas measurements show that Tishomingo was exposed to space as a meteoroid with a pre-atmospheric radius of 20-40 cm for a remarkably short time of about ~30-70 Myr.

Discussion: Tishomingo is a large taenite single crystal. To produce such a structure, the cooling rate during solidification at around 1450 ^{0}C was slow. The solidification process would require that the meteorite was buried deeply inside its parent body. The fact that martensite forms rather than a spinodal structure indicates that Tishomingo cooled so fast at 250 ^{0}C that spinodal decomposition did not take place. Therefore, it is probable that after solidification, the parent body broke up before the temperature reached ~250 ^{0}C. This break up may have happened as early as a few hundreds to a few millions of years after solidification. Tishomingo relocated very close to the surface of a second generation parent body, but farther than 1 meter below the body's surface. A recent break-up event took place at least ~30-70 Myr ago (no information about the terrestrial age) and Tishomingo became a meter-sized meteoroid.

The EBSD and AEM data suggest that, after martensite formed, Tishomingo experienced a rapid reheating probably by impact which converted some of the newly formed bcc martensite to fcc. Subsequent cooling/annealing results in the formation of bcc α and fcc γ in residual martensite.

References: [1] Zhang J. et al. 1991. *Geochimica et Cosmochimica Acta* 57:3725-3735. [2] Buchwald V. F. 1975. *Handbook of Iron Meteorites*, UC press. [3] Ives L. K. et al. 1978. *Geochimica et Cosmochimica Acta* 42:1051-1066.