THE TREYSA QUINTET OF ANOMALOUS IIIAB IRONS, THE MAIN-GROUP PALLASITES AND ALFRED WEGENER. John T. Wasson. Department of Earth, Planetary and Space Sciences, University of California, Los Angeles, CA 90095-1567, USA. (jtwasson@ucla.edu)

Introduction. This is the 100^{th} anniversary of the fall of the 63-kg Treysa iron meteorite. It fell in Germany at 1525 on 3 Apr 1916; there were many witnesses. A. Wegener [e.g., i] used recorded observations to calculate where the meteorite came down. A year later it was extracted from an impact pit ~1 km from the site.

The iron meteorites Treysa and Delegate have compositions closely similar to those of IIIAB irons but plot above the IIIAB field on an Ir-Au diagram; for this reason they are commonly designated anomalous members of IIIAB (the largest group of iron meteorites). To variable degrees, all refractory siderophiles share this anomaly with Ir. Wasson [2] interpreted the large spread on IIIAB Ir-Au diagrams to be the result of melt-trapping and generated solid and liquid fractional-crystallization tracks for IIIAB; all but a handful of IIIAB irons fall between the tracks and most are closer to the solid track. In contrast, Treysa and Delegate and a new iron, Yarovoye, plot outside the liquid tracks. Ilinskaya Stanitsa and Palmas de Monte Alto plot on or just above the liquid track near Treysa. Their positions are shown in Fig. 1. I call this set the Treysa Quintet. Members of the quintet plot within IIIAB scatter fields on other element-Au diagrams including those for Co, Ni, Ga and As.

Ideal fractional crystallization involves equilibrium between the crystallizing solid and the magma, and thus cannot explain compositions that plot outside the region between the two tracks. Two possible explanations for the anomalous compositions of the Treysa trio are: a) that these meteorites did not form in the IIIAB magma; or b) that they formed by the mixing of early crystallized solids with a late liquid. In the latter case, the 2 μg/g Ir content of Delegate requires the final melt to include ≥10% early IIIAB metal.

Formation models for the Treysa Quintet and the PMG. There are two main reasons why formation on another asteroid seems unlikely: 1) the common taxonomic elements Co, Ni, Ga and Ge for the quintet irons plot within the IIIAB scatter fields; and 2) cosmic-ray ages for Treysa and Delegate fall within the IIIAB 670 Ma cluster [3]. It therefore seems best to examine processes that would need to occur to produce the quintet's observed high contents of refractory siderophiles on the IIIAB asteroid.

Main-group pallasites (PMG) have metal that is closely related to IIIAB metal but, like Treysa, most plot to the right of the IIIAB liquid track, i.e., in the region that cannot be reached by equilibrium crystallization (Fig. 1). Scott [4] noted that it is possible to account for such compositions by mixing early IIIAB metal with late liquids. Wasson and Choi [5] used diagrams to show how this process could expand the compositional space beyond the IIIAB liquid track to include PMG irons. I have therefore explored this as a possible model to explain the position of Treysa, etc. on the Ir-Au and W-Au diagrams. I chose as representative of the early solid the equilibrium composition after FC3% (3% crystallization of the initial magma) crystallization, i. e., a rough average of the first 6% of crystallized solids. Curves on Figs. 2a and 2b show two alternative mixing trajectories: early solids with evolved liquids a) FC45% and b) FC80%. The former can account for the Treysa set but not the PMG on the Ir-Au diagram but cannot account for the quintet on the W-Au diagram.

Showing that the compositional envelope can be expanded by mixing early solids and late (80%) melts is necessary but not sufficient. One must also assess the mechanical and thermal aspects of mixing these two materials that originated at locations that were initially separated from each other. In particular, it is important that the evolved melts were relatively close to the early solids and one must provide a mechanism for crystallizing the melt rapidly to prevent fractional crystallization. As argued in Wasson et al. [2006], the low (0.5 K) temperature drop across the core [6] makes it probable that most (ca. 99%) of the crystallization occurred from center outwards and the remainder from the outer edge of the core downwards. Under such circumstances, in a core with radius 100 km, one can find solids from 0 to 80% crystallization in a 267 m layer just above the remaining magma.

It seems quite plausible that a major impact could have mixed blocks of this solid layer with the underlying melt and at the same time deposited enough heat to melt some of the blocks. It is then necessary to cool the melt rapidly to prevent large scale fractional crystalliation; gradients produced by meter-scale fractional crystallization would have been leveled by solid state diffusions as the asteroid cooled. The best way to achieve rapid cooling is to inject the melt into cooler solids and cool it by heat exchange.

Metal analyses of PMG mostly plot beyond the liquid track and thus require a similar explanation if they formed in the IIIAB asteroid [5]. Here the prevention of large-scale fractional crystallization is easy; the melt mixed with cooler (because of lower thermal conductivity) olivine on a scale of centimeters. This may be the reason that the PMG preserve an appreciably larger compositional spread than the Treysa Quintet.

IIIAB irons plotting to left of the liquid track. At several different degrees of fractional crystallization are mixing curves with plus signs marking 5% increments in the fraction of trapped melt. Based on this modeli there are numerous IIIAB irons that trapped 50% or more of equilibrium melt. However, in contrast to the Cape York suite, we cannot be sure that the melt and solids were in equilibrium; thus some fraction of these may also reflect the mixing of early solids with late melt. This is also suggested by the fact that Ir levels off at 0.15 µg/g at high Au contents.

References: [1] Wegener A. (1918) *Astron. Nachr.* 207, 187. [2] Wasson J (1999) *GCA* 63, 2875. [3] Voshage H. and Feldmann H. *EPSL* 45, 293. [4] Scott E. (1977) *GCA* 41, 349. [5] Wasson J. and Choi B. (2003) *GCA* 67, 3079. [6] Haack H. and Scott E. *JGR* **97**, 14727.

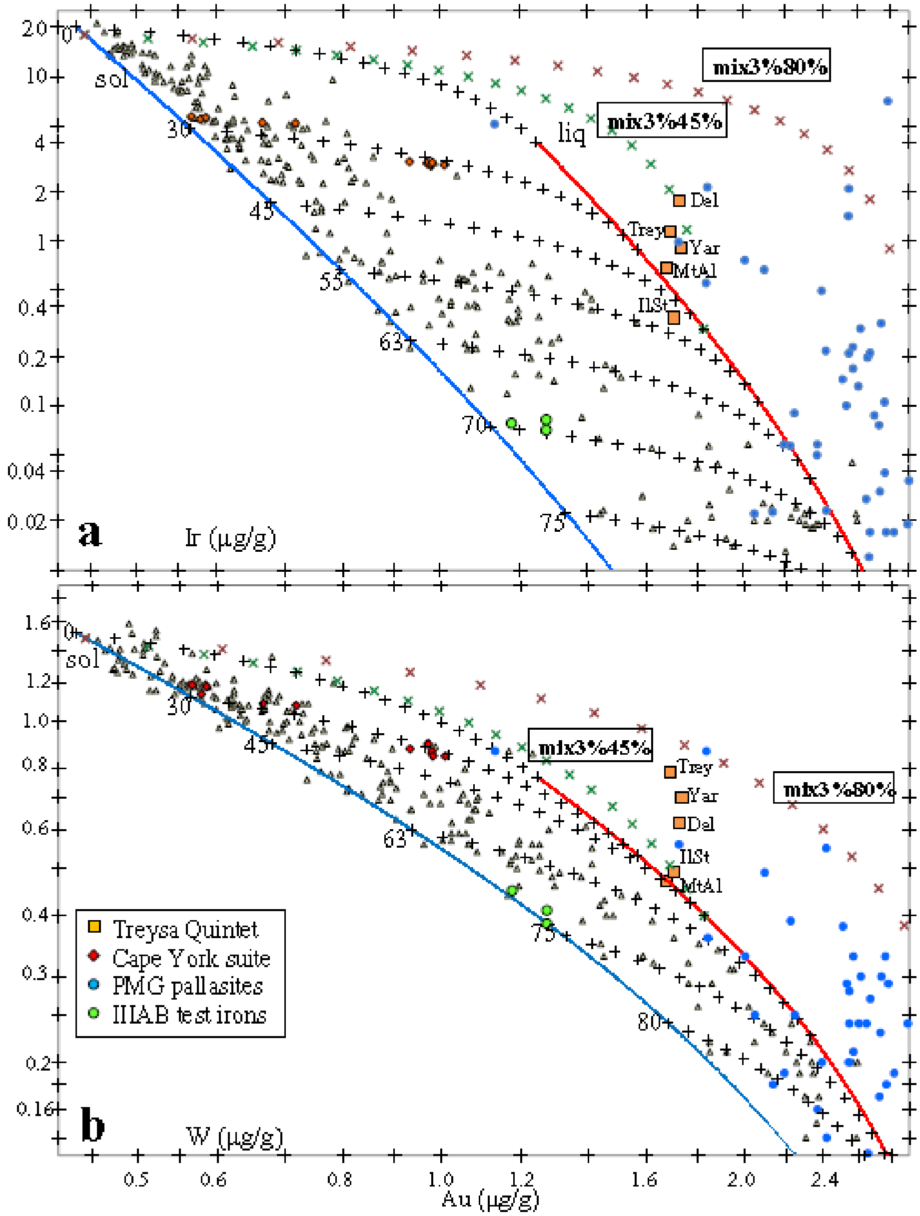

Fig. 1. Ir-Au and W-Au diagrams showing positions of 260 IIIAB irons and model fractional-crystallization solid and liquid tracks. Treysa and four related irons plot above the liquid track, and cannot be explained by mixing equilibrium solids and liquids (as invoked to explain the spread in Cape York values). The positions of the Treysa Quintet and the PMG pallasites can be explained by mixing early solids with residual melt after 80% crystallization, but this requires rapid solidification of the melt to prevent fractional crystallization.