UNUSUAL REFRACTORY INCLUSIONS FROM A CV3 CHONDRITE FOUND NEAR AXTELL, TEXAS; S.B. Simon[1], L. Grossman[1,2], and J.F. Wacker[3], [1]Department of the Geophysical Sciences, [2]The Enrico Fermi Institute, University of Chicago, Chicago, IL 60637, [3]Battelle, Pacific Northwest Laboratories, Richland, WA 99352

Abstract. A CV3 chondrite reportedly found in Texas in 1943 has recently become available for study. It resembles Allende in texture but is heavily weathered, and its ^{60}Co activity (<1 decay per minute/kg) is lower than that of Allende (1-7 dpm/kg). Six of eight CAIs studied are unusual in some way compared to those in Allende, including: a CTA with a spinel-perovskite core; a CTA with a rare, unnamed Ca-, Ti-rich silicate; a B1 with melilite sprays in the mantle; and a fluffy Type A containing abundant palisade bodies.

A CV3 chondrite reportedly found near Axtell, Texas (31°42'N, 96°49'W) in 1943 has recently become available for study. From the original mass of 6.2 kg, five slabs were cut. Its texture resembles that of Allende, but the meteorite is heavily weathered and most of the chondrules exhibit iron oxide staining. Refractory inclusions, amoeboid olivine aggregates, and dark inclusions are also exposed on the slab surfaces. The oxygen isotopic composition of Axtell, $\delta^{18}O = +1.61$, $\delta^{17}O = -2.54$ (R.N. Clayton, pers. comm.), is identical to that of Allende. Cosmogenic ^{26}Al and ^{60}Co activities were determined by counting a 101 g sample of the Axtell specimen and a piece of Allende for 7000 min. The ^{26}Al activities of both specimens are typical of chondrites, 50 ± 6 dpm/kg for Axtell and 54 ± 4 dpm/kg for Allende. The Axtell sample, however, had <1 dpm/kg ^{60}Co while Allende had measurable ^{60}Co. When Allende fell in 1969, its ^{60}Co activity ranged from 23-180 dpm/kg, with most values > 100 dpm/kg [1]. The current-day activity of ^{60}Co is only ~4 % of that in 1969, i.e. 1-7 dpm/kg, with most values >4 dpm/kg. The ^{60}Co results thus suggest that Axtell is not a piece of Allende. On the basis of these data, however, we cannot rule out the possibility that Axtell is a fragment from near the surface of the pre-atmospheric mass of Allende.

After examination of ten slab surfaces, we selected eight coarse-grained refractory inclusions for study. Although all can be classified as either Type A or B, six are unusual in some way, compared to those we have seen in Allende.

The most unusual inclusion in our suite is AX-4, a 4 × 3.5 mm compact Type A (CTA) with a remarkable spinel-perovskite core, in which spinel is so abundant that many grains are intergrown with one another, forming large, nearly monomineralic regions. In some parts of the core, spinel grains are enclosed in perovskite or interstitial melilite. With increasing distance from the core, the melilite/spinel ratio increases, and the core grades into an outer zone dominated by melilite laths that are typically 50-100 µm wide and 200-400 µm long. The texture of this zone also contrasts with that of typical CTAs, which generally have blocky, more equant melilite crystals. The laths are unzoned, and generally range from $Åk_{22}$ to $Åk_{29}$ except at the rim, where the melilite is more aluminous ($Åk_{13}$). This zone also contains sparsely distributed grains of perovskite, 10-70 µm across, and euhedral spinel crystals, mostly 10-30 µm across. Except for several large (up to 300 µm across) patches of fine-grained anorthite, alteration products (mostly grossular) are restricted to melilite grain boundaries. Although Allende CTA TS12 has a spinel-, perovskite-rich area which resembles the outer part of the core of AX-4 in that melilite encloses abundant spinel, an inclusion with a melilite mantle and a spinel-perovskite core has not been previously reported.

AX-1 is an irregularly shaped, 3.3 × 1.8 mm CTA which is dominated by anhedral to blocky melilite and its alteration products. The inclusion also contains heterogeneously distributed spinel crystals, fine-grained (5-10 µm) except for those in a large palisade body [2] in which they are up to ~50 µm across. In the palisade body and elsewhere in the inclusion, spinel contains ~ 1.2 wt % V_2O_3. Perovskite occurs as blebs in symplectite, and as coarser anhedral to subhedral grains up to 120 µm across. Some of the latter have inclusions of melilite. What is unusual about this inclusion is the presence of a rare, unnamed Ca-, Ti-rich silicate that has only one other reported occurrence [3], in an Allende Type A inclusion. Here, as in Allende, the phase is associated with perovskite. It occurs as anhedral grains, 10-50 µm across, some with perovskite cores or enclosing multiple grains of perovskite. The phase contains ~ 1 wt % MgO, 4 % Al_2O_3, 29 % SiO_2 and 33 % CaO, all within the ranges reported for the Allende material [3], and up to 1 wt % ZrO_2. TiO_2 contents are more variable; they range from 21.6 to 31.2 wt % and are anticorrelated with Sc_2O_3 (0.41-3.8 wt %) and V_2O_3 (0.82-4.3 %), suggesting that these cations compete for the same crystallographic site. This phase may also be present in Allende CTA TS19, where it occurs with fassaite between perovskite and a Fremdling. In this case, however, the phase is very rich in V_2O_3 (~ 6.9-10 wt %), which was probably supplied by the Fremdling. It is not clear that this phase is simply a product of alteration of perovskite, however, because in at least one place in AX-1, a perovskite-free grain occurs adjacent to unaltered perovskite. Also, it is strongly enriched in Sc_2O_3 relative to perovskite, its TiO_2/Sc_2O_3 ratio being <100, and that in perovskite is >900. On the other hand, if it is primary, it is curious that fassaite did not form instead. Perhaps there was insufficient Al_2O_3 and/or Ti_2O_3 available or the f_{O_2} was too high to allow fassaite formation.

The two Type B1 inclusions in the suite, AX-5 and AX-7, cannot be considered typical of this type of inclusion. AX-5, 3.2 × 2.5 mm, has a melilite-rich mantle with coarse, euhedral, radially oriented laths up to 640 µm long, and most are 50-100 µm wide. In a rather striking departure from the normal B1 structure, in which the mantle is a solid, continuous shell of melilite, the mantle in AX-5 is only ~70 % melilite, and many laths diverge inward from the rim, forming sprays, with fassaite (4.6-8.1 wt % TiO_2^{tot}) and anorthite between the laths. In the interior, melilite is interstitial to fassaite and anorthite, and is generally more Mg-rich ($Åk_{40-50}$) than in the mantle ($Åk_{14-42}$). Small, rounded grains of spinel are poikilitically enclosed in all phases, but it is much more abundant in the interior than in the outer part of the inclusion. Also abundant in the interior are small (~5-10 µm) grains of NiFe metal and pentlandite, and at least one grain of an Fe-free Ni-sulfide, perhaps heazlewoodite, is present.

AX-7, 6.4 × 5.3 mm on the slab surface, has a continuous, 500 µm-wide melilite mantle ($Åk_{20-40}$) and is extremely spinel-rich. Fassaite is mostly subhedral, 300-500 µm across, and is much more abundant than melilite in the interior of the inclusion. Opaque assemblages are generally ~10 µm across, rounded, enclosed in fassaite, and made of magnetite + NiFe metal. The largest assemblage, 80 µm across, contains magnetite and FeS. Unlike most B1s, which have spinel-poor mantles, spinel in AX-7 is uniformly distributed and very abundant, dominating the entire inclusion except for the outermost 100 µm and one spinel-poor island. The spinel grains are small (mostly 5-20 µm). Although experiments show that, for most Type B compositions, spinel should be the first phase to crystallize [4,5], most B1s have spinel-poor mantles and spinel-rich cores, suggesting that spinel crystals were pushed inward, rather than incorporated, by melilite crystals as they grew. For some reason, this did not occur in AX-7, perhaps due to an unusual cooling history, bulk composition or both. The great abundance of tiny spinel crystals may be due to an unusually high bulk Al_2O_3 content, giving AX-7 a higher liquidus temperature and allowing it to retain more crystal nuclei.

Two inclusions are notable for the abundances of palisade bodies in them, especially AX-2, a 5.3 × 2.7 mm, irregularly-shaped, heavily altered "fluffy" Type A inclusion [6]. Melilite is fine-grained (5-70 µm) with much subgrain development, indicating recrystallization. Except for a few spinel-rich areas, the melilite generally encloses little spinel. Wark and Lovering [2] found no palisade bodies in any of the Allende Type A inclusions they studied, but in AX-2, most of the spinel is present in palisade bodies, which range from about 50 to 300 µm across. Most are round, but several are oval or flattened, as if they were deformed. They consist of rings of spinel grains enclosing melilite and spinel ± fassaite ± perovskite. In the largest one, melilite ranges from $Åk_{12}$ to $Åk_{40}$ and fassaite has ~10 wt % TiO_2^{tot}. AX-9, 4.6 × 3.7 mm on the slab surface, is a heavily altered, possibly brecciated Type B2 with abundant palisade bodies. Some are large (>250 µm across) and contain anorthite, in addition to the usual melilite and spinel. Some have thick spinel shells, whereas others have incomplete rings that appear to have been frozen in the act of formation. Also consistent with *in situ* formation is the fact that their rims are jagged, not smooth as would be expected if the spinel crystals had nucleated on the edges of liquid droplets that were later incorporated as solids into the host CAIs [2]. They may instead be chains of crystals brought together by surface tension during crystallization of their liquid hosts.

Spinel is very heterogeneously distributed in AX-9. The interior is fairly rich in coarse spinel (up to ~40 µm). Most of the rest of the inclusion is virtually spinel-free except for the palisades and the outermost ~200 µm along part of the rim, where melilite and fassaite enclose numerous, small (~5 µm) spinel grains. Fassaite and anorthite are anhedral and as large as 500 µm across. Much of the melilite exhibits wavy extinction and development of subgrains (~10 µm across), indicating that the inclusion has been shocked. There are also patches where fassaite or anorthite poikilitically enclose subhedral melilite grains 10-20 µm across, a texture observed in some Leoville [7] and Vigarano inclusions (but rare in Allende) and attributed to remelting of the inclusions.

Comment: We have been unable to substantiate the claim that this meteorite was found in 1943, but of eight CAIs we studied, six are unusual in some way when compared to analogous Allende inclusions. The likelihood of this occurring during an investigation of a similar amount of Allende is low. In light of this and the ^{60}Co results, we believe that the Axtell specimen is a new, previously undescribed CV3 chondrite.

References. [1] Evans J.C. *et al. JGR 87*, 5577-5591. [2] Wark D.A. & Lovering J.F. (1982) *GCA 46*, 2595-2607. [3] Floss C. *et al.* (1992) *Meteoritics 27*, 220. [4] Stolper E. (1982) *GCA 46*, 2159-2180. [5] Stolper E. & Paque J.M. (1986) *GCA 50*, 1785-1806. [6] MacPherson G.J. & Grossman L. (1984) *GCA 48*, 29-46. [7] Simon S.B. & Grossman L. (1991) *LPS XXII*, 1261-1262.