AN UNUSUAL TYPE B2 CAI AND a P-Ca-RICH CLAST FROM KAIDUN. M. A. Ivanova[1,2], A. V. Ivanov[1], C. A. Lorenz[1] and G. J. MacPherson[2], [1]Vernadsky Institute, Kosygin St. 19, Moscow 119991, Russia. [2]Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC. 20560, USA. E-mail: ivanova-ma@si.edu.

Introduction: Kaidun is a unique heterogeneous polymict breccia [1-6]. Bulk Kaidun samples closely resemble CR chondrites, with the CI-like matrix. Kaidun contains components with different compositions and history: clasts of C, E, R3 and O chondrite material, and achondrite clasts that in some cases are unusual and highly differentiated lithologies [1-6]. Most clasts resemble a known meteorite group, yet all deviate in some respect from the norms for those groups. Some Kaidun materials are not yet represented in the world meteorite collections. Here we report results on petrology, mineral chemistry and bulk composition of one Kaidun sample, #A3-9, a rare CAI that encloses an unusual P,Ca-rich object.

Results: Sample #A3-9 was identified as a white clast in bulk Kaidun and was isolated for study. During this process it broke into two portions, each of which was mounted into a section (Figs. 1, 2). Fragment 1 is a coarse-grained Type B CAI, a rarity because Type B CAIs are confined almost exclusively to CV3 chondrites. The CAI consists of melilite, pyroxene, anorthite grains, and spinel crystals that are distributed very unevenly within the CAI. One concentration of spinel, intergrown with anorthite and melilite (accordingly labeled "SAM"), may represent a xenolith within the CAI. No traces of a Wark-Lovering rim remain on this CAI fragment, although meteorite matrix and locally a partial rim of carbonate adhere to the CAI edge. Melilite in the main part of the CAI is magnesium-rich (Ak_{64-72}) (Fig. 3) although rare more Al-rich (Ak_{52}) grains and more magnesium-rich (Ak_{75}) do occur. Melilite in the SAM aggregate is distinctly more aluminum-rich (Ak_{10-37}). Pyroxene ("fassaite") contains up to ~21 wt.% Al_2O_3 and 6 wt%. TiO_2. Spinel is almost FeO-free but contains up to 0.5 wt% of V_2O_3. Most of this fragment is unaltered, the main secondary mineral being nearly pure calcite that occurs in veins and around the fragment's periphery. However, near the edge of the fragment that adjoins the meteorite matrix the CAI is far more altered, and heterogeneous phyllosilicate is very abundant (the latter phase contains up to ~10 wt.% FeO and gives low analytical sums in microprobe analyses, which together with the textures in b.s.e. images leads us to identify it as phyllosilicate.)

Fragment 2 (Fig. 2) is a part of the same coarse-grained CAI, but is overall resembles the most altered portion of Fragment 1. Mineral compositions are similar, but phyllosilicate is abundant throughout. The most remarkable feature of Fragment 2 is the occurrence of a large clast consisting mostly of phosphate, carbonate, sulfide, and phyllosilicate. At the boundary between this clast and the host CAI is a discontinuous rim of spinel. The carbonates and phosphates are concentrated in the outer regions of clast. The carbonate varies in composition from calcite to dolomite, with several grains being enriched in MnO. Phosphates are enriched in Na_2O and FeO. The carbonate-phosphate-rich clast contains within it several globules, up to 0.12 mm in size, that have concentrically zoned texture. One globule (Fig. 4) has Ti-magnetite in the core with a tiny grain of Fe,Ni-metal inside Ti-magnetite. The core is surrounded by a layer of altered silicate, then a layer of phosphate containing tiny grains of sulfides, and the outer irregular rim contains Ni-rich sulfide in assemblage of chromite.

Discussion: Like other CR chondrites, Kaidun contains only rare small CAIs that are broadly similar to those in CO3 chondrites [7,8]. However, the texture, mineral and bulk chemical compositions of Kaidun CAI #A3-9 are in most ways consistent with it being a Type B2 inclusion. The principal difference is that the melilite in this case is much more magnesium-rich than is typical for Type B2s. The SAM aggregate within the CAI has relatively aluminum-rich melilite, and its bulk chemistry is unlike that of the host CAI, and therefore is may be a trapped xenolith. The phosphate- and carbonate clast in Fragment 2 presents a problem. It appears to have a tight contact with the enclosing CAI, yet if in fact it originated as a xenolith trapped by the molten CAI it should have been severely recrystallized and even partially melted during that event. There is no sign of such intense modification. Therefore we think it likely that the clast is only physically juxtaposed against the CAI within the meteorite matrix, and not genetically related. Regardless, the clast itself is remarkable as a separate lithology. It has no analogues among known Kaidun materials or any known meteorite. Thus, this object may represent a completely new type of meteorite material. Its origin is unclear. Both the clast itself and the globules within it are concentrically zoned, suggestive (in such low-temperature materials) of diffusion-controlled metasomatic alteration. The occurrence of tiny Fe-Ni metal grains within the nodules suggests that metal must have formed at least part of the progenitor material. As carbonate (at least) is unlikely to be a nebular product, we suggest that an aggregate of primary nebular grains experienced the metasomatism within an asteroidal parent body, in the presence of unusual P- and Ca-enriched fluids.

References: [1] Ivanov (1989) *Geochim. Int*., 26, 84. [2] Ivanov et al. (2003) *Meteorit. Planet. Sci., 32,* 725-737. [3] Zolensky and Ivanov (2003) *Chem. Erd*. 63, 185-246. [4] MacPherson et al. (2009) *Geochim. Cosmochim. Acta* 73, 5493-5511. [5] Ivanov et al. (2007) *Geochem.*

Int. 45, 957-970. [6] Ivanov et al. (2008) *Geochem. Int.* 46, 759-774. [7] MacPherson et al. (1994) *Meteoritics* 29, 494. [8] Ulyanov et al, (1994) *Meteoritics* 29, 542-543.

Fig. 1. Combined elemental map in Mg (red), Ca (green), and Al (blue) of a CAI #A3-9 (fragment 1), and BSE image of SAM aggregate (dark grey-spinel; grey-anorthite; white-melilite).

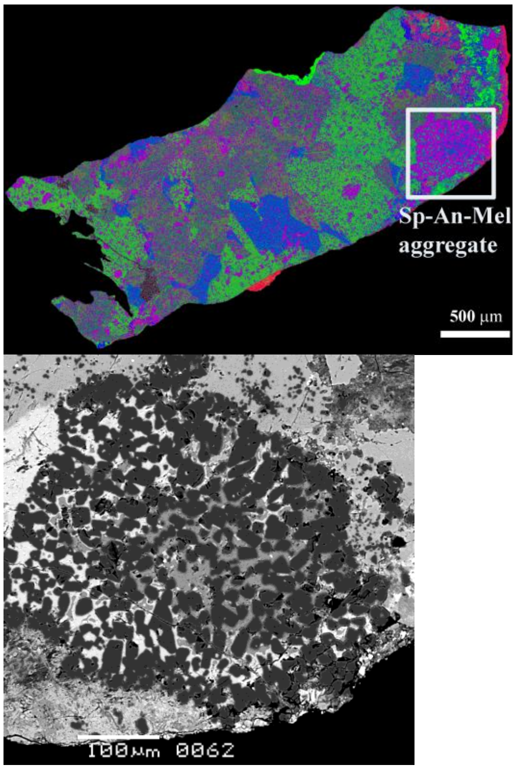
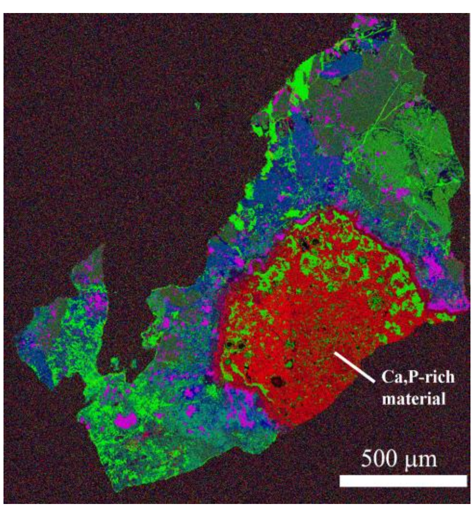


Fig.2. Combined elemental map in Mg (red), Ca (green), and Al (blue) of a CAI #A3-9 (fragment 2), with carbonate-phosphate-rich material.



3. Melilite composition in the CAI and the SAM aggregate.

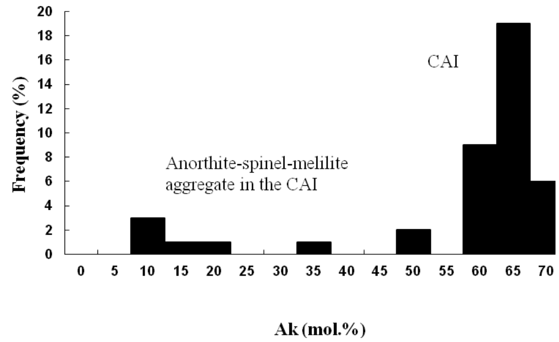


Fig.4. Combined elemental map of a P-rich globule from the fragment 2.