MINERALOGY AND PETROGRAPHY OF A STRANGE ACHONDRITE GRA06129. Y. Liu[1], L.A. Taylor[1], R.D. Ash[2], and J.M.D. Day[2]. [1]Planetary Geosciences Institute, Dept. of Earth & Planetary Sciences, Univ. of Tennessee, Knoxville, TN 37996. (yangl@utk.edu); [2] Dept. Geology, Univ. Maryland, College Park, MD 20740.

Introduction: GRA06128 (447.6 g) and GRA06129 (196.45 g) were found on the Graves Nunataks Ice Field, Antarctica, during the 2006 meteorite season and are considered to be paired. Preliminary examination of this achondrite shows that it is unlike any pervious achondrites, including those with known, planetary origins [1]. Here, the mineralogy and petrography of GRA06129 are presented. A companion abstract by Ash et al. [2] reports trace-elements in minerals. In almost every aspect, this achondrite is distinctly different from all other achondrites in that it contains high abundances of alkalis and is relatively evolved.

Methods: Two sections (,22 and ,25) from GRA06129, with areas of ~1.6 cm^2 and ~0.9 cm^2, were studied. Mineral modes were obtained using the *Feature Scan Phase Distribution* software package of an Oxford instrument energy dispersive spectrometer interfaced to an electron microprobe at Tennessee, as well as mineral major-element chemistry. Trace elements in minerals were analyzed at Maryland [2].

Petrography: GRA06129 has a crystalline, granoblastic texture with extensive fractures. Weathering and alteration occur along all fractures. No FeNi metals were found in either section. The rock consists of plagioclase (75 vol%), olivine (9 %), orthopyroxene (5 %), augite (5 %), phosphates (1.9 % chlorapatite + 0.7 % merrillite), sulfides (2.4 % troilite + 0.2 % pentlandite), and oxides (<0.2 %).

Silicate phases display a wide range in grain size. Plagioclase has typical polysynthetic twinning, but also shows transformation twinning (cf., microcline). Most plagioclase grains show granoblatic textures, and no apparent chemical zonations was observed. Small olivines (<100 µm) are enclosed in plagioclase or occur mostly in restricted areas. Orthopyroxenes are commonly intergrown with augite, with irregular boundaries. Augite typically contains exsolution orthopyroxene lamella (up to 5 µm in width). Merrillite commonly occurs along with phosphates of 0.1-0.6 mm in size (Fig. 1). Almost all large sulfide grains (10-60 µm) consist of intergrowths of pentlandite and troilite. Smaller pentlandite droplets (2-3 µm) are ubiquitously enclosed in all silicate phases. Anhedral ilmenite and Cr-ulvöspinel are the oxide phases.

Mineral Chemistry: Compositions of silicate minerals are extremely uniform (Fig. 2) – i.e., inter- and intra-grain homogeneity: oligoclase plagioclase ($Ab_{14.6\ \pm0.4}An_{83.6\ \pm0.4}$); olivines with $Fo_{39.9\ \pm0.4}$; orthopyroxene

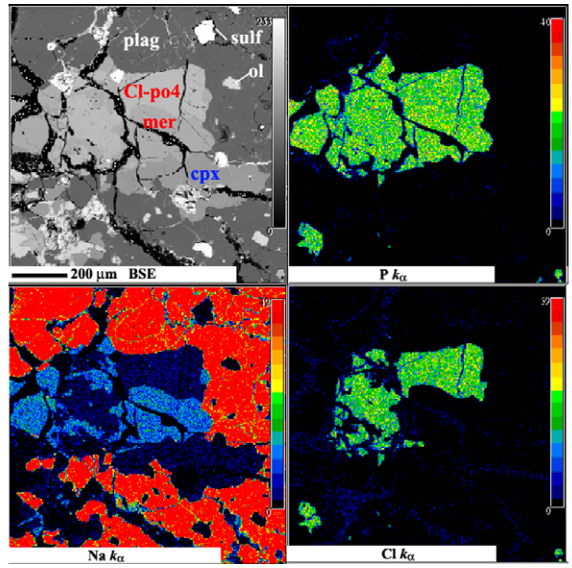

Fig. 1. Two phosphates intergrown Cl-apatite + Na-merrillite.

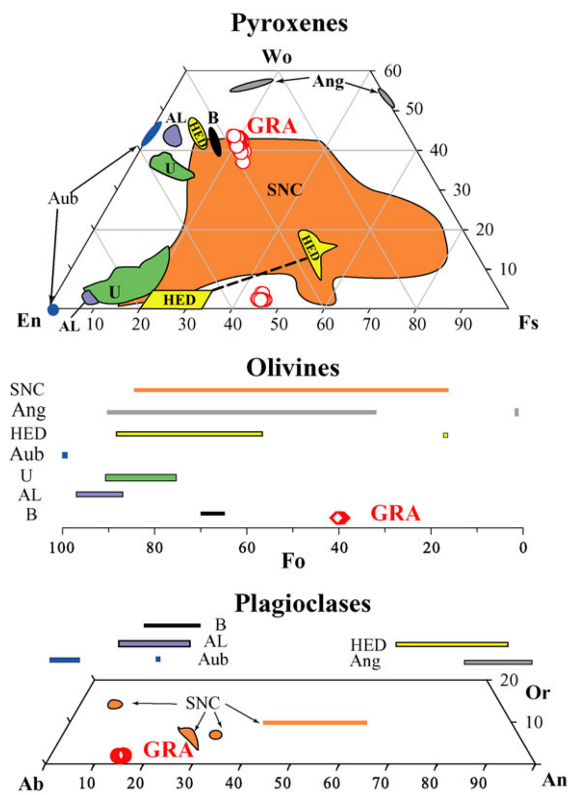

Fig. 2. GRA06129 mineral compositions in comparison to other silicate achondrites. Data are from [7, 8] for B, brachinites; AL, acapulcoites and lodranites; U, ureilites; Aub, aubrites; HED, howardites, eucrites, and diogenites; Ang, angrites; SNC, Martian meteorites.

with $En_{52.9\ \pm0.3}Wo_{2.3\ \pm0.1}$ and Mg# of 54.1 ±0.4; augite with $En_{37.7\ \pm0.4}Wo_{42.4\ \pm0.8}$ and Mg# of 65.5 ±1.1. Trace elements in silicate minerals are also homogeneous in each mineral phases [2]. The coexisting orthopyroxene and augite yield a temperature of 845°C using two pyroxene geothermometer [3] and the QUILF program [4]. The exsolution lamellae of 5 µm in augite suggests slow cooling [5]. Atomic Fe/Mn ratios of pyroxenes and olivines seem to follow the trend defined by terrestrial samples (Fig. 3).

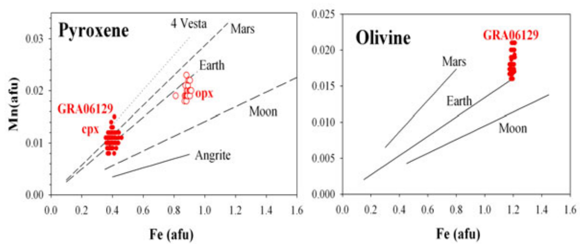

Fig. 3. Mn and Fe plot of pyroxene and olivines. Fe-Mn trends of the planetary bodies are from [6].

<u>The unique feature of this rock is the presence of unusually large (0.1-0.6 mm) phosphates.</u> The merrillite ($Na_{1.7}Ca_{18.2}(Fe_{0.5}Mg_{1.5})(PO_4)_{14}$) contains 2.3-2.5 wt% Na_2O, which is higher than those in lunar rocks and some Martian meteorites but similar to those in ALH84001 and Pallasite [7]. Merrillites also contain 2.7-3.1 wt% MgO and 1.4-1.9 wt% FeO. Chlor-apatite contains 3.3-5.5 wt% Cl. Compositions of large sulfide grains are close to that of troilite (FeS). The pentlandite lamella, $(FeNi)_9S_8$, contain up to 26 wt% Ni. The coexisting pentlandite and troilite reflect exsolution of

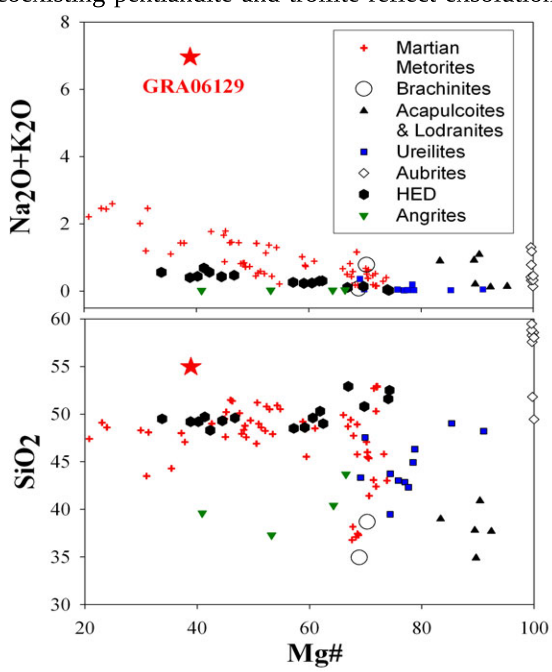

Fig. 4. Comparison of GRA06129 with other non-metal achondrites [8, 10-11].

pentlandite from a monosulfide solid solution at T ≤ 600 C under a slow-cooling condition at a relatively high S fugacity [9]. However, the small sulfide grains trapped in silicate minerals are also dominantly pentlandite, indicative of possible sulfide immiscible melt during most of the crystallization process. Chromium ulvöspinel contains up to 38.5 wt% Cr_2O_3 with Mg# of 4.5-6.5.

Bulk Composition: Given the homogeneous mineral compositions, the bulk composition of the rock was estimated using the modal abundances of minerals, mineral compositions, and their respective densities. The estimated bulk composition is basaltic trachyandesite: 55.0 wt% SiO_2, 0.1 wt% TiO_2, 14.8 wt% Al_2O_3, 0.1 wt% Cr_2O_3, 4.1 wt% MgO, 4.9 wt% CaO, 8.4 wt% FeO, 6.7 wt% Na_2O, 0.2 wt% K_2O, 3.3 wt% FeS, and ~1.2 wt% P_2O_5.

Discussion: Compared to previously documented achondrites, GRA069129 is different in almost every aspect (Figs. 2 and 4): **(1) extreme homogeneous minerals; (2) sodic plagioclase; (3) high abundance of large phosphates; (4) coexisting troilite and pentlandite; (5) relatively Fe-rich and Na-rich bulk-rock compositions; (6) different oxygen isotopes (except for aubrite); (7) very old age (preliminary results show ~4.5 ±0.2 Ga, [2]).**

GRA06129 may also have undergone re-equilibration, as shown by the homogeneous major- and trace-element concentrations in silicate minerals and the granoblastic texture of the plagioclase.

Based on mineralogy, petrography, and geochemistry, we can exclude: (1) terrestrial origin based on the oxygen isotopes and the presence of troilite; (2) lunar origin because of the high Na content; (3) Martian origin based on the oxygen isotopes; (4) aubrites, which consist mainly of enstatite. However, the relatively Fe- and Na-rich bulk-rock composition, and volatile-rich signatures (Na, phosphate, sulfides) suggest this meteorite originated from a differentiated source, which can only be formed on a relatively large planetary body that experienced differentiation, such as crustal formation.

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