PRELIMINARY EXAMINATION OF SAHARA 99555: MINERALOGY AND EXPERIMENTAL STUDIES OF A NEW ANGRITE. T. Mikouchi[1,2], G. McKay[1], L. Le[3], D. W. Mittlefehldt[3], [1]Mail Code SN2, NASA Johnson Space Center, Houston, TX77058, USA, [2]Mineralogical Inst., Graduate School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, JAPAN, [3]Lockheed Martin, 2400 NASA Road 1, Houston, TX77058, USA (E-mail: TMikochi@ems.jsc.nasa.gov or mikouchi@min.s.u-tokyo.ac.jp).

Introduction: A 2710 g meteorite, Sahara 99555 (Sah99), was recently recovered from the Sahara and reported to be the 5th angrite. It is the largest angrite ever found and may offer useful information to better understand the unusual petrogeneses of this rare achondrite group [e.g., 1-4]. It may also allow us to examine the chronological record of igneous activity in the very early solar system [e.g., 5]. We obtained a 2.6 g chip of Sah99 and here present a preliminary report of its petrology and mineralogy in conjunction with a crystallization experiment on an analogue composition.

Petrology and Mineralogy: Sah99 is a fine-grained igneous rock mainly composed of olivine (including kirschsteinite), fassaitic clinopyroxene, and anorthitic plagioclase as is typical for angrites. Minor phases include titano-magnetite, troilite, and an unknown silicophosphate phase. The modal abundances of minerals are 33% anorthite, 24% fassaite, 23% Mg-rich olivine, 19% Fe-rich olivine (including kirschsteinite), and 1% others, that are similar to those of LEW87051 (LEW87) and Asuka 881371 (Asu88) [2,6]. The igneous texture is also similar to those of LEW87 and Asu88, but is different from Angra dos Reis (ADOR) and LEW86010 (LEW86). The cut surface of the Sah99 main mass shows millimeter-size spherical vesicles, showing an affinity to Asu88 [6,7].

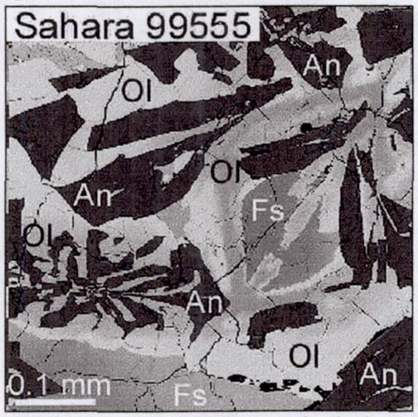

Fig. 1. BSE image of Sahara 99555. Note the complex intergrowth texture of anorthite (An) and olivine (Ol). Olivine shows a skeletal crystal growth surrounding fassaite (Fs) and anorthite.

Olivine in Sah99 is euhedral or skeletal (usually 500 μm) (Fig. 1). Olivine is zoned from Fo_{63} cores to very Fe-Ca-rich rims (Fig. 2) and there is a sharp contact between inner Mg-rich areas and outer Ca-Fe-rich rims. Zoning patterns are very similar to those of LEW87 and Asu88 (Fig. 2) although they contain forsteritic olivine xenocrysts (up to Fo_{90}) which we did not find in Sah99. Olivine rims are complex mixtures of Ca-rich fayalite and Ca-poor kirschsteinite, suggesting an exsolution relationship. These textures are also observed in olivines of LEW87 and Asu88.

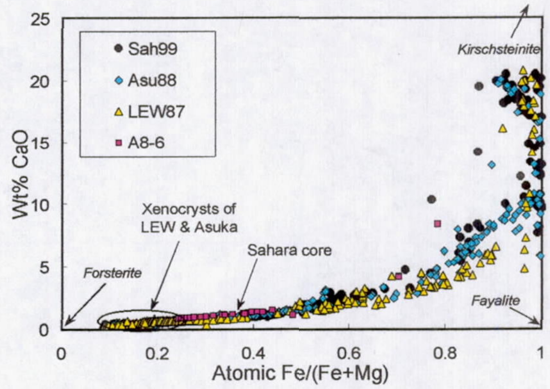

Fig. 2. Atomic Fe/(Fe+Mg) vs Wt% CaO contents of olivine from three angrites and Run A8-6.

Fassaite is subhedral to euhedral (usually 500 μm) and shows extensive chemical zoning in major and minor elements (though CaO is constant at 22-23 wt%). Asu88 fassaite shows a similar size and texture, but LEW87 fassaite is much smaller. The atomic Fe/(Fe+Mg) of Sah99 fassaite ranges 0.5-1.0. The core of Sah99 fassaite is slightly more Fe-rich than those of LEW87 and Asu88. Minor elements patterns are similar to LEW87 and Asu88 though Cr is lower in Sah99. Al_2O_3 is 5-10 wt% though some fassaite inclusions in olivine reach 18 wt% Al_2O_3. TiO_2 increases 1-5 wt% from core to rim while Cr_2O_3 drops from 0.4 wt% to nearly zero (Fig. 3).

Plagioclase is usually intergrown with olivine of Fo_{50-40} and has an almost Na-free anorthite composition. The complex intergrowth texture was not seen in the previous angrites. Skeletal anorthite crystals are sometimes observed. Anorthite contains high amounts of FeO and MgO, each usually 1.5 wt% and 0.4 wt% or more, respectively. These amounts are comparable to those of the other angrites.

Titano-magnetite contains about 25-27 wt% TiO_2 and 1.5-2 wt% Al_2O_3. Some troilite grains contain 2 wt% of Ni. A Ca-rich silicophosphate phase (up to 45 wt% CaO and 37 wt% P_2O_5) was found in Sah99. A similar phase is known in Asu88 [7,8]. The silicophosphate in Sah99 appears to have a composition ranging from Ca-P-rich, Si-Fe-poor to vice versa.

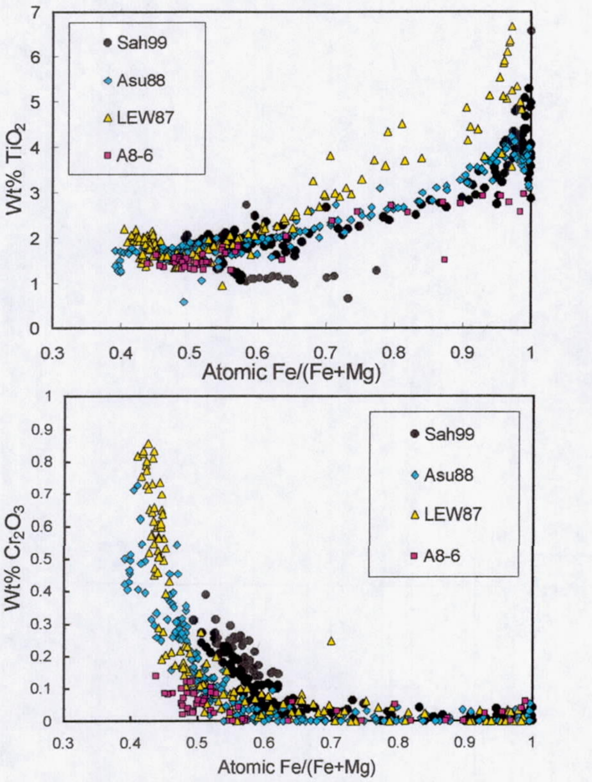

Fig. 3. Atomic Fe/(Fe+Mg) vs minor element contents of fassaite from three angrites and Run A8-6.

Crystallization Experiment: We performed a crystallization experiment at log*f*O_2 of IW+2 by using a synthetic glass of the Asu88 groundmass composition in order to understand textures, phase relations and mineral compositions of a rapidly cooled angrite magma. The Asu88 groundmass composition was employed because it is similar to that of LEW87 and we consider that this composition is representative of an angritic magma that crystallized near the surface of its parent body (we have not yet obtained the Sah99 bulk composition). Several small grains (~1 mm) of San Carlos olivine (Fo_{89}) were mixed with the starting material as analogue of olivine xenocrysts in LEW87 and Asu88. Charges were cooled from 1300 °C to 900 °C at 100 °C/hr (Run A8-3) and 50 °C/hr (Run A8-6).

Both runs contain large fassaite grains and skeletal olivine laths reaching 1-2 mm. Plagioclase did not crystallize in A8-3. However, anorthite laths crystallized in A8-6 and formed a complex intergrowth with olivine in the groundmass (Fig. 4). Olivine is zoned from Fo_{80} cores to Fe-Ca-enriched rims. Fassaite shows extensive chemical zoning at the edge. Al_2O_3 (14-8 wt%) and Cr_2O_3 (0.15-0 wt%) drop slightly from core to rim, while TiO_2 (1.5-3 wt%) increases. A8-6 is remarkably similar to Sah99 in texture, especially in the presence of skeletal olivine crystals, large fassaite, and intergrowths of olivine and anorthite. Although mineral compositions are slightly different from Sah99 (A8-6 phases are more Mg-rich), general zoning patterns are almost identical.

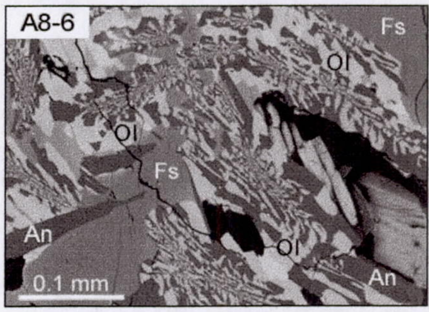

Fig. 4. BSE image of the A8-6 charge. Note a complex anorthite (An) - olivine (Ol) intergrowth similar to Sahara 99555. Fs: Fassaite.

Discussion and Conclusion: Sah99 is a new angrite similar to LEW87 and especially Asu88. Nevertheless, unlike these two previous angrites, Sah99 does not contain any xenocrysts (at least in our sample) and we believe that the bulk composition closely represents a magma composition. In this respect, Sah99 is similar to LEW86. The presence of skeletal olivine and plagioclase crystals suggests that Sah99 crystallized very quickly from the magma. Our experiment supports this scenario and the 50 °C/hr cooling run of the Asu88 groundmass melt successfully reproduced texture, zoning patterns of olivine and fassaite, general mineral abundances, mineral sizes and mineral compositions of Sah99. Thus, we conclude that Sah99 cooled very quickly, probably within 1 m of the surface, from an angritic magma that was slightly more Fe-rich than those of LEW87 and Asu88. The appropriate geological setting would be crystallization in a thin lava flow. The Sah99 magma might be closely related to those of LEW87 and Asu88, and it is possible that the Sah99 magma was derived from slightly evolved LEW87 and/or Asu88 magma(s).

Acknowledgement: We thank Prof. T. Tagai (The University Museum, University of Tokyo, Japan) for supplying a sample of Sahara 99555. This work was supported by the National Academy of Sciences through an NRC associateship at NASA Johnson Space Center (TM).

References: [1] Prinz et al. (1977) *EPSL, 35,* 317-330. [2] Mittlefehldt D. W. and Lindstrom M. M. (1990) *GCA, 54,* 3209-3218. [3] McKay G. et al. (1990) *LPS XXI,* 771-772. [4] Mikouchi T. et al. (1996) *Antarctic Meteorite Res., 9,* 174-188. [5] Nyquist L. E. et al. (1994) *Meteoritics, 29,* 872-885. [6] Yanai K. (1994) *Proc. NIPR Symp. On Antarct. Meteorites, 7,* 30-41. [7] Prinz M. and Weisberg M. K. (1995) *Antarct. Meteorites XX,* 207-210. [8] Warren P. H. and Davis A. M. (1995) *Antarct. Meteorites XX,* 257-260.