Petrological and mineralogical study of the Sahara99555 angrite meteorite

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The recently discovered angrite Sahara99555 is a basaltic achondrite consisting of fassaite, anorthite and Ca-rich olivine. This meteorite contains characteristic textures and chemical compositions typical for quenched magma, suggesting the formation near the surface of the parent body. Because Sahara99555 does not contain any xenocrysts and is enriched in Fe, it is likely that its bulk composition represents an evolved parent magma composition. The crystallization experiment using the angrite analogue starting composition shows that 50 degrees/hour cooling from 1300 to 900 degrees well reproduced textures and chemical zoning of Sahara99555, supporting its rapid crystallization.

Angrite meteorite is a group of basaltic achondrites having 4.56 b.y. crystallization ages. Because angrites are enriched in refractory elements (Ca, Al, Ti) and poor in volatile elements (Na, K), they show characteristic mineral assemblages consisting of fassaite, Ca-rich olivine and anorthite. So far only four angrites (Angra dos Reis, LEW860101, LEW87051 and Asuka881371) have been found and they were all small. Recently 2.6kg angrite (Sahara99555) was recovered from the Sahara and this discovery can give us better understandings of this unique meteorite group and igneous activities in the early solar system. Here we report the results of its mineralogy and crystallization experiments.

The modal abundances of Sahara99555 are 33anorthite, 24 0.000000assaite, 23Mg-rich olivine, 19 2.062716e-307-rich olivine, and 1414thers. Though anorthite is homogeneous and nearly free from Na and K, olivine (Fe#=0.35-1.0, CaO=1-20 wt) and fassaite (Fe#=0.5-1.0, Al2O3=5-10 wt, TiO2=1-5 wt, Cr2O3=0.4-0 wt) show extensive chemical zoning both in major and minor elements. They are zoned to the composition nearly free from Mg. Anorthite and olivines are euhedral to subhedral (some show skeletal growth textures) and show complex intergrowth textures. Fassaites are subhedral to anhedral and some exceed 1mm in size. Although the overall texture and chemical compositions of Sahara99555 are generally similar to those of LEW87051 and Asuka881371, the intergrowth of olivine and anorthite has not been reported in the previous angrites and Sahara99555 does not contain xenocrysts unlike LEW87051 and Asuka881371. Fassaites and olivines in Sahara99555 are more Fe-rich than those in LEW87051 and Asuka881371,suggesting crystallization of Sahara99555 from more evolved magma. The texture and chemical zoning of Sahara99555 imply the formation from the quenched magma near the surface of the angrite parent body, probably the most rapidly crystallized samples among the known angrites.

In order to further understand Sahara99555 petrogeneses, we performed crystallization experiments using the analogue angrite starting composition. We cooled the charges at 100 degrees and 50 degrees per hour from 1300 to 900 degrees. The oxygen fugacity was controlled at logfO2=IW+2 by the zirconia sensors. The run product of 100 degree/hour cooling contains only olivine and fassaite, and anorthite failed to crystallize. However, the run product of 50 degree/hour cooling contains olivine, fassaite, and anorthite, having similar textures (presence of skeletal olivine and anorthite, large fassaite grains) and chemical zoning to those of Sahara99555. The experiments slower than 50 degrees per hour cooling are still in progress, but these crystallization experiments support the idea that Sahara99555 crystallized from the magma near the surface (probably, the burial depth less than 1 m). Furthermore, the similarities of textures and chemical compositions between Sahara99555 and LEW87051/Asuka881371 suggest that they are petrogenetically related and the Sahara99555 magma was derived from slightly evolved LEW87051 and/or Asuka881371 magma(s).