COOLING RATE ESTIMATES OF QUENCHED ANGRITES: APPROACHES BY CRYSTALLIZATION EXPERIMENTS AND COOLING RATE CALCULATIONS OF OLIVINE XENOCRYSTS. T. Mikouchi1,2, M. Miyamoto3, G. McKay2, L. Le3, 1Dept. of Earth and Planetary Science, University of Tokyo, Hongo, Tokyo 113-0033, Japan, 2SN2, NASA Johnson Space Center, Houston, TX 77058, USA, 3Lockheed Martin, Houston, TX 77058, USA (mikouchi@eps.s.u-tokyo.ac.jp).

Introduction: Recent discovery of angrites Sahara99555 and D’Orbigny provides a good opportunity to re-evaluate angrite origins. Common characteristics of these angrites plus two previous angrites (LEW87051 and Asuka881371) include quenched melt textures and lack of evidence for shock and thermal metamorphism. These angrites probably formed near their parent body(s) surface somehow surviving subsequent impact events. All of them but Sahara99555 contain magnesian olivine xenocrysts reaching several millimeters across. In this abstract we used two independent approaches to estimate cooling rates of these “quenched” angrites: (1) crystallization experiments and (2) cooling rate calculations of olivine xenocrysts. We then discuss petrogenesis and formation history of the quenched angrites.

Crystallization Experiments: We performed crystallization experiments using Asuka881371 groundmass composition [1]. Runs were from 1300 °C to 900 °C at 50 °C/hour (@log fO2=IW+2). ~1mm fragments of San Carlos olivine (Fo89) were added to the starting material as an analogue of olivine xenocrysts. Quenched runs consist mainly of Ca-, Fe-rich olivine, fassaite, anorthite, and spinel. San Carlos olivines show extensive (~50 µm) zoning at the rim due to interaction with the surrounding melt. The texture is closest to those of olivine xenocrysts in Asuka881371 and D’Orbigny. Olivine phenocrysts are zoned from Fo75Fa24La1 cores to nearly Mg-free, Ca-rich rims. Skeletal olivine is common. In contrast, fassaites usually grew to exceed 1 mm with no skeletal growth. Fassaite ranges from mg#=0.55 cores to almost Mg-free rims. Despite minor differences in the core compositions, zoning patterns of olivine and fassaites from these experiments agree well with those of the quenched angrites in both major and minor elements [1,2].

Cooling Rates of Olivine Xenocrysts: We calculated cooling rates of olivine xenocrysts in LEW87051, Asuka881371, and D’Orbigny by fitting calculated Fa and Ca zoning profiles at the rims to the observed ones by numerically solving atomic diffusion equations. We presumed that the original compositions were homogeneous because of internally homogeneous nature of the megacrysts. We then calculated zoning profiles produced by interaction with the surrounding melts as the sample cooled from 1300 to 1000 °C at various rates (@log fO2=IW+2). The best fitting cooling rates for all three meteorites are 7-13 °C/hour. These cooling rates correspond to burial depths of less than 0.5 m.

Discussion and Conclusion: Our 50 °C/hour cooling run closely reproduced mineralogical and petrological properties of the quenched angrites [1,2], although this rate appears slightly faster than natural angrites because of the presence of abundant skeletal crystals. Experiments at slower cooling rates (1~10 °C/hr) are in progress. It is remarkable that our cooling rate calculations gave nearly identical results (7-13 °C/hour) for LEW87051, Asuka881371 and D’Orbigny, and are consistent with the crystallization experiment. Thus, there is no doubt that the quenched angrites formed by rapid cooling of magmas entraining magnesian olivine xenocrysts of locally different abundances. Minor differences in groundmass compositions may be attributed to locally different melt compositions in the same magma due to different degrees of dissolved olivine xenocryst component. Impact melting is a plausible heat source to explain such a shallow setting of the magma with relict olivines. However, the magma might be produced by endogenous melting and trapped olivine xenocrysts during eruption onto the surface. The origin of the olivine xenocryst is unclear, but the quenched angrites appear to have experienced complex histories prior to incorporation of xenocrysts into the groundmass melt and subsequent rapid crystallization. Furthermore, the formation of the glassy and porous portion of D’Orbigny [3] makes its history more complicated.