AN EXPERIMENTAL INVESTIGATION OF THE SHERGOTTITE NWA 6162. R. Gaylen Barnett[1] , John H. Jones[2], David S. Draper[2] , and Loan H. Le[3] ,[1]University of New Mexico MSC04 2545, [1]University of New Mexico, Albuquerque, NM, [2]Mail Code KR, NASA, Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058, [3]Jacobs Sverdrup Co., Houston, TX 77058.

Introduction: The Martian meteorite North West Africa 6162 (NWA 6162) is a shergottite found in Morocco in 2010. The meteorite has large olivine crystals with Mg-depleted rims as low as Fo_{65} and Mg-rich cores of up to Fo_{74} [1]. It is similar both in appearance and compositon to another shergottite, SaU 005.

Statement of the Problem: Our objective is to determine if NWA 6162 represents a liquid or if it is a product of olivine accumulation. Olivine accumulation would leave the parent melt Mg-depleted and the complementary olivine cumulates would be Mg-enriched. Therefore, if NWA 6162 is a partial cumulate we would expect that liquidus olivines grown from this bulk composition would be more magnesian than olivines in the natural sample.

Approach: Experiments were conducted at JSC at one bar using gas-mixing furnaces over a range of temperatures with a controlled oxygen fugacity of IW+1 (one log unit above the iron-wüstite buffer). The experiments were run at 50°C increments from 1550°C to 1150°C . Durations ranged from one hour to 168 hours with longer durations at lower temperatures.

Our starting material was a mixture of oxides and carbonates that was melted at 1450°C, quenched into water, and then ground to a fine powder. Individual charges were suspended at temperature on Re loops to minimize iron loss. Charges were quenched in water (excluding NWA 5) at the end of the run. They were then cast in epoxy, cut and polished. Experiments were then analyzed with a Cameca SX-100 electron microprobe at JSC at 15kV and 20nA. A 1μm focused electron beam was used for crystalline phases, and either a 3μm or 5μm beam for glasses. Baskscattered electron (BSE) images were obtained for most charges (Figure 1). Matrix corrections were performed using standard ZAF techniques.

We assessed our approach to equilibrium using four different methods. First, we evaluated zoning of mineral phases. Significant zoning was present only in two charges (NWA-3 and NWA-10). Second, we measured the olivine/liquid K_D value defined as $(Fe/Mg)_{ol}/(Fe/Mg)_{liq}$ and compared it to the accepted value of 0.35±0.01 [2,3]. Olivine/liquid K_D's ranged from 0.31 to 0.36. Third, we performed least-squares mass balance mode calculations. In all cases we obtained successful mass balance modes. The sums of squares of residuals (Σr^2) ranged from 0.004 to 0.079, with one exception — NWA-9 had an Σr^2 of 0.275 (see below). Fourth, we plotted MgO vs. Al_2O_3 of experimental glasses and observed smooth trends, suggesting systematic behavior for these elements (Fig. 2). It can therefore be concluded that these experiments were acceptably close to equilibrium.

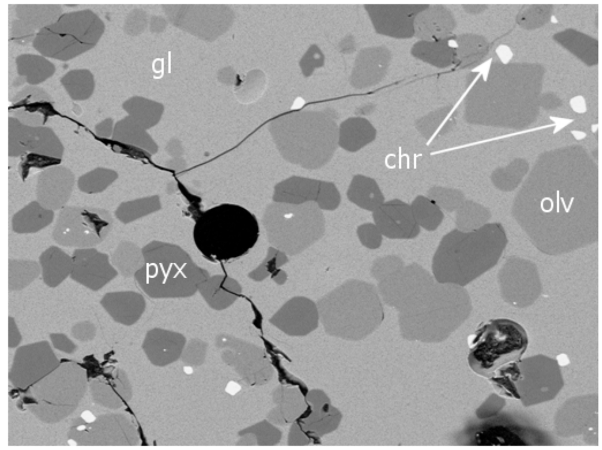

Figure 1. NWA-9. No zoning is observed in any of the silicate phases. Labels refer to: glass (gl), olivine (olv), low-Ca pyroxene (pyx), and chromite (chr).

Results: Experimental results are summarized in Table 1 and Figure 2. No crystals were present at 1550 or 1500°C. At 1450°C, chromite and zoned olivines appear. These olivines had cores of ~Fo_{88}-Fo_{96} and rims of ~Fo_{85}-Fo_{88}. It was the only charge in which zoned olivines were present. Every subsequent charge at lower temperatures also contained olivine. At 1300°C low-Ca pyroxene appeared and was present in every charge run below this temperature.

The Mg content of the olivine crystals decreased monotonically as run temperature decreased (see Table 1). The closest experimental matches to the core compositions in NWA 6162 were at 1300°C and below, where olivine ranged between Fo_{69}-Fo_{75}.

Discussion: Because the first olivine crystals to form in our experiments (1450°C; ~Fo_{90}) were much more forsteritic than those in the meteorite, we conclude that NWA 6162 is a partial olivine cumulate.

As previously stated, the olivine rims in the meteorite are ~Fo_{65}. None of these experiments produced olivine crystals with this Mg content. The amount of Mg in these crystals decreases with decreasing temperature, however NWA-10 proved difficult to analyze in the electron microprobe because the melt pockets were small, so experiments lower in temperature than 1150°C may not be possible to analyze.

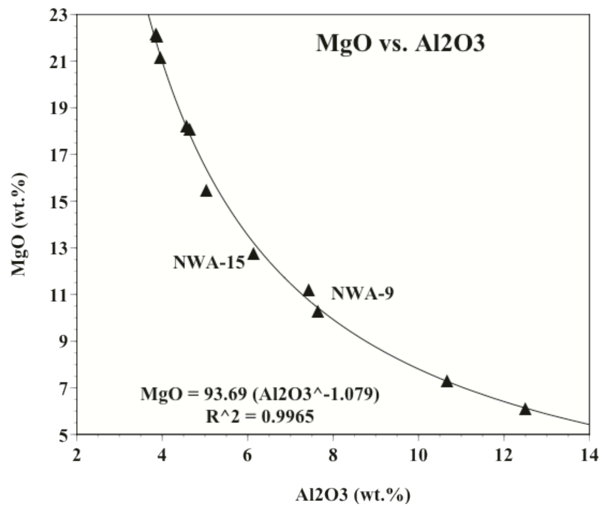

Figure 2. MgO v. Al_2O_3 for NWA 6162 experimental glasses. NWA-9 and NWA-15 were both performed at 1300°C. NWA-9 was at temperature (7 days) for twice as long as NWA-15 and consequently lost ~0.75 wt.% Na_2O. All experiments are excellently fit by a single regression.

Another complication is that one of our 168 hour runs (NWA-9) at 1300°C had a comparatively large Σr^2 of 0.275. On further inspection, it became clear that almost all of this large residual was because of Na loss. We repeated this experiment for a shorter duration (NWA-15), which produced a result much more consistent with the other experiments (Table 1).

Conclusions: Our experimental results provide evidence that NWA 6162 is the product of olivine accumulation. It is significant that none of our experimental olivines were as Fo-poor as are the rims on natural NWA 6162 olivines. But this observation is also in keeping with the interpretation that NWA 6162 is a cumulate.

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References: [1] S. M. Kuehner and A. J. Irving. (2011). *Lunar and Planet. Sci. XLII*. [2] J. Filiberto and R. Dasgupta (2010*). Earth and Planetary Sci. Letters* **304**, 527-537. [3] D. Musselwhite et. Al. (2006) *Meteoritics and Planetary Sci.* **41**, 1271-1290.

Table 1
Summary of Experimental Conditions and Run Products

Experiment	T (°C)	Duration (Hrs)	Phases (Wt.% Mode)	Ol Fo	Px En/Wo
NWA-1	1550	1	Gl		
-2	1500	1	Gl		
-3	1450	1	Gl(97), Ol(3), Chr(tr)	85-96	
-8	1400	4	Gl(84), Ol(16), Chr(1)	83	
-5*	1400	4	Gl(85), Ol(15), Chr(tr)	83	
-14	1350	24	Gl(74), Ol(24), Chr(2)	81	
-15	1300	72	Gl(63), Ol(31), Pyx(6), Chr(tr)	78	78/2.4
-9**	1300	168	Gl(50), Ol(26), Pyx(22), Chr(tr)	75	78/2
-4	1250	48	Gl(48), Ol(28), Pyx(22), Chr(2)	75	75/3.5
-12	1200	56	Gl(35), Ol(32), Pyx(33), Chr(tr)	71	69/7
-10	1150	168	Gl(29), Ol(35), Pyx(36), Chr(tr)	70	63-66/9-14

*Air quenched. **Lost ~0.75 wt.% Na_2O. Glass (Gl), Olivine (Ol), low-Ca Pyroxene (Pyx), Chromite (Chr)