

**PRIMITIVE SNC PARENT MAGMAS AND CRYSTALLIZATION: LOW  $P_{H_2O}$  EXPERIMENTS.** D.J. Ford and M.J. Rutherford, Department of Geological Sciences, Brown University, Providence, Rhode Island 02912.

**INTRODUCTION.** SNC meteorites are generally believed to present one of the best opportunities to study the composition and petrogenesis of Mars magmas. The crystallization ages, noble gas content, oxygen isotopic composition, and shocked minerals of the meteorites are consistent with a Martian origin [1,2]. The samples range from dunite to clinopyroxenite to microgabbro. Efforts by researchers to determine parental magmas for the more primitive SNC meteorites have been complicated by crystal accumulation and possible melt segregation and removal. This has resulted in a range of parent magma estimates [3-6], although all appear to be Fe-rich and Al-poor. One major objective of this project is to refine the Chassigny parent magma estimate [5] by forcing olivine + clinopyroxene saturation upon the proposed melt composition. EETA 79001 magma compositions are also being investigated to determine the parent magma and the origin of the coarse-grained olivine and orthopyroxene megacrysts. Low pressure experiments with small but finite  $P_{H_2O}$  are being utilized to facilitate equilibrium, and to simulate the  $H_2O$  indicated for these magmas [4,6,7].

The presence of small (0.5-1.0 wt %) amounts of  $H_2O$  in SNC magmas appears to be required by the occurrence of hydrous minerals and textures [6,7] in melts trapped by growing phenocrysts. This evidence for hydrous melts occurs in all SNC's except EETA 79001 and ALHA 77005, where the inclusion textures have been obscured by shock effects. The lack of hydrous minerals or low temperature melts in the intercumulus regions of these rocks suggests that final emplacement was sufficiently close to the surface to allow degassing as the magma equilibrated with the low P atmosphere. Any  $H_2O$  left in intercumulus phases would also tend to be lost during impact heating. Thus, although the bulk  $H_2O$  of SNC's is very low [8], we believe this is explained by the near Mars surface emplacement of SNC magmas and by shock effects. Magmatic processes involving  $H_2O$  need to be examined in order to characterize SNC magmas immediately prior to their final emplacement.

**PROCEDURE.** Two series of experiments have been performed to refine SNC parent magma estimates, obtain crystallization paths, and explore the role of  $H_2O$  in SNC petrogenesis. Series I used small fragments of EETA 79001. Series II starting materials consisted of synthetic Chassigny A\* composition [6] contained within excess Fo<sub>68</sub> olivine and 1-5% clinopyroxene (Mg# 76). Samples were placed in AgPd tubing ( $T \leq 1060^\circ\text{C}$ ) or Pt tubing pre-saturated with Fo<sub>68</sub> olivine ( $T > 1060^\circ\text{C}$ ) and run at temperatures of 950 to 1150°C in TZM or HfC pressure vessels. A small excess of  $H_2O$  and pressures of 0 to 150 bars were used to obtain melts with up to 1.5 wt % dissolved  $H_2O$ . Another set of A\* experiments was carried out under water saturated conditions at 1 kilobar. All experiments were buffered with a QFM assemblage in a separate tube.

**EXPERIMENTAL RESULTS.** Results of the series I experiments on EETA 79001 are plotted in Figure 1, a projection from olivine onto the Wo-Opx-Plag normative diagram (after [3]). Small degrees of dry melting of this rock produced a melt essentially at the previously determined four-phase reaction point. Increasing the  $P_{H_2O}$  from 0 to 10 to 100 bars yields increasingly plagioclase normative melts as predicted by [6]. These melts have low  $K_2O$  values and contain 1-3 wt %  $P_2O_5$ .

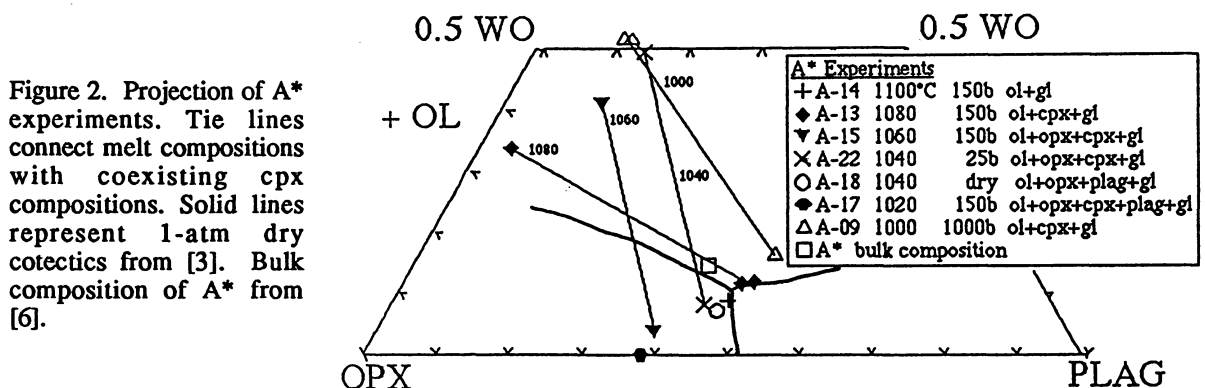
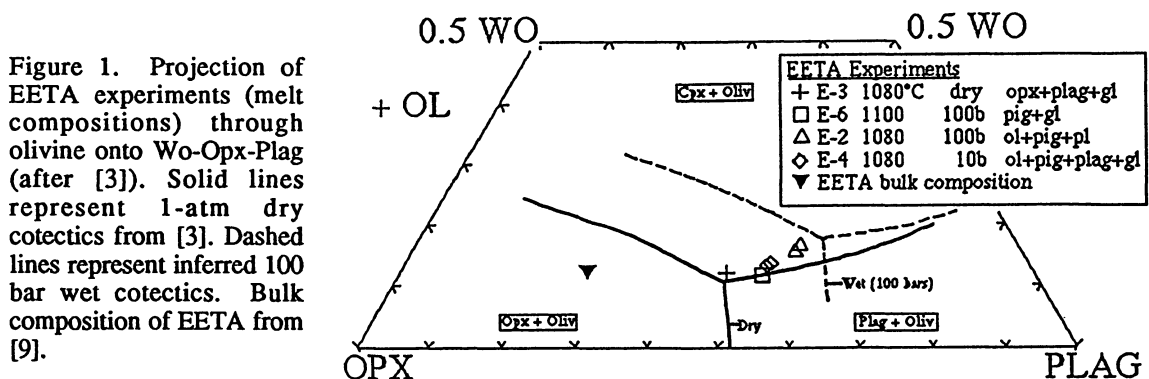
The results of the series II experiments on the A\* composition with excess Fo<sub>68</sub> and seeds of clinopyroxene are plotted in Figure 2. Experiment A-18 (dry) yields a melt essentially at the four-phase reaction point. In this experiment, calcium-rich pyroxene is present in euhedral crystals but is surrounded by a low-calcium pyroxene. The other A\* experiments illustrate how the olivine (Fo<sub>68</sub>) saturated phase boundaries move with decreasing temperature and with the addition of  $H_2O$ . Ultimately, at low T and large degrees of crystallization (A-17), the melt becomes relatively Wo and Plag depleted in contrast to crystallization at higher water pressures.

**DISCUSSION.** The experiments on EETA 79001 recreate a series of possible low pressure crystallization conditions. Comparison of the natural and experimental assemblages places limits on the crystallization history of EETA 79001. Experiments at 1080°C show the increase of

## SNC PARENT MAGMAS AND CRYSTALLIZATION: Ford D.J. and Rutherford M.J.

normative plagioclase in cotectic melts with H<sub>2</sub>O increasing from 0 to 1 wt %. Under "dry" conditions, a Mg# 46 melt coexists with two pyroxenes similar to groundmass pyroxenes in EETA 79001 [9], suggesting the final crystallization was under low pressure dry conditions. After more than 40% melting under low pressure wet conditions (1 wt% H<sub>2</sub>O), orthopyroxene is the sole EETA 79001 liquidus phase. This suggests that under no low pressure conditions could the orthopyroxene-olivine megacrysts of EETA 79001 lithology A be derived from the magma that produced EETA 79001 groundmass. The experiments also emphasize the P<sub>2</sub>O<sub>5</sub>/K<sub>2</sub>O dichotomy in EETA 79001; partial melts contain 2-3 wt% P<sub>2</sub>O<sub>5</sub> but only 0.05-0.2 wt% K<sub>2</sub>O, suggesting cumulate phosphates in the rock, and a SNC magma source with a high P/K ratio.

The experiments on the early Chassigny composition, A\*, show how H<sub>2</sub>O and temperature affect olivine (Fo<sub>68</sub>) and clinopyroxene saturated melts. As predicted by [3], clinopyroxene composition is particularly sensitive to T and X<sub>H<sub>2</sub>O</sub>. Figure 2 shows that the four-phase saturation point evolves to lower Wo with increasing crystallization at low pressure wet conditions (1 wt% H<sub>2</sub>O). Therefore it is impossible to derive the high Al<sub>2</sub>O<sub>3</sub> melts required to crystallize the kaersutites found in SNC melt inclusions except at high water contents. Given the low T (<1000°C) and high H<sub>2</sub>O required for kaersutite stability, we favor entrapment of a low (<1 wt %) H<sub>2</sub>O melt followed by buildup during cooling and crystallization.



References: [1] H.Y. McSween (1985) *Rev. Geophys.*(23), pp.391-416. [2] J.H. Jones (1989) *Proc. 19th Lunar Planet. Sci. Conf.*, pp.465-474. [3] J. Longhi & V. Pan (1989) *Proc. 21st Lunar Planet. Sci. Conf.*, pp.695-709. [4] R.P. Harvey & H.Y. McSween (1992) *Earth Planet. Sci. Lett.* (111), pp. 467-482. [5] A.H. Treiman (1992) *XXIII Lunar Planet. Sci. Conf. (abstr.)*, pp.1447-1448. [6] M.C. Johnson, M.J. Rutherford & P.C. Hess (1991) *Geochim. Cosmochim. Acta* (55), pp.349-366. [7] R.J. Floran, M. Prinz, P.F. Hilava, K. Keil, C.E. Nehru and J.R. Hinthorne (1978) *Geochim. Cosmochim. Acta* (42), pp. 1213-1219. [8] M. Carr and H. Wänke (1991) *XXII Lunar Planet. Sci. Conf. (abstr.)*, pp. 181-182. [9] H.Y. McSween & E. Jarosewich (1983) *Geochim. Cosmochim. Acta* (47), pp. 1501-1513.