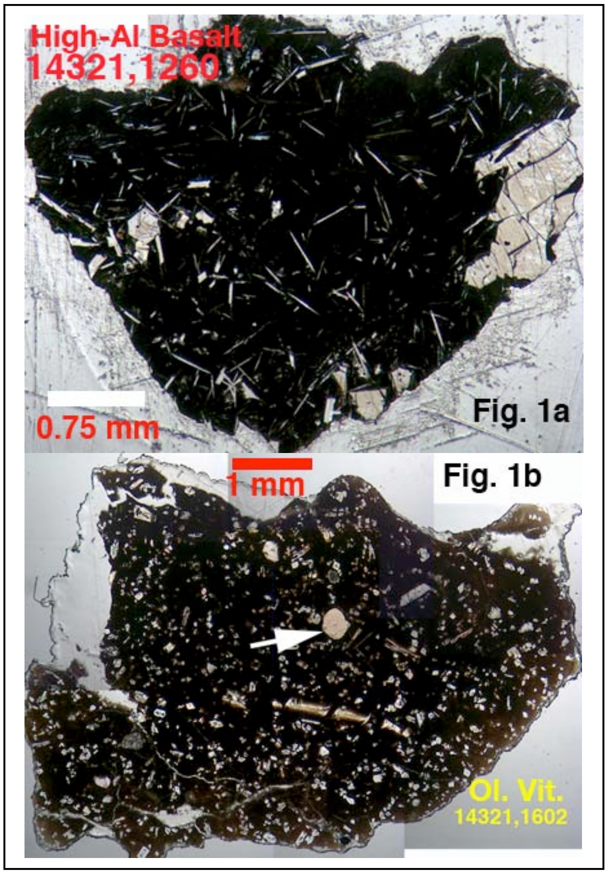
ARE THE APOLLO 14 HIGH-Al BASALTS REALLY IMPACT MELTS? C. R. Neal[1], C. K. Shearer[2], and G.Y. Kramer[1] [1]Dept. Civil Eng. & Geo. Sci., University of Notre Dame, Notre Dame, IN 46556 (neal.1@nd.edu); [2]Institute of Meteoritics, Dept. of Earth & Planetary Sci., Univ. of New Mexico, Albuquerque, NM 87131.

Introduction: Olivine vitrophyres returned by the Apollo 14 mission from the Fra Mauro region are KREEP-rich, high-Mg impact melts composed primarily of euhedral olivines in an opaque glass (e.g., 1-3]). These are petrographically similar to some vitrophyric Apollo 14 high-Al basalts, which are found as clasts in impact breccias (Fig. 1 a,b).



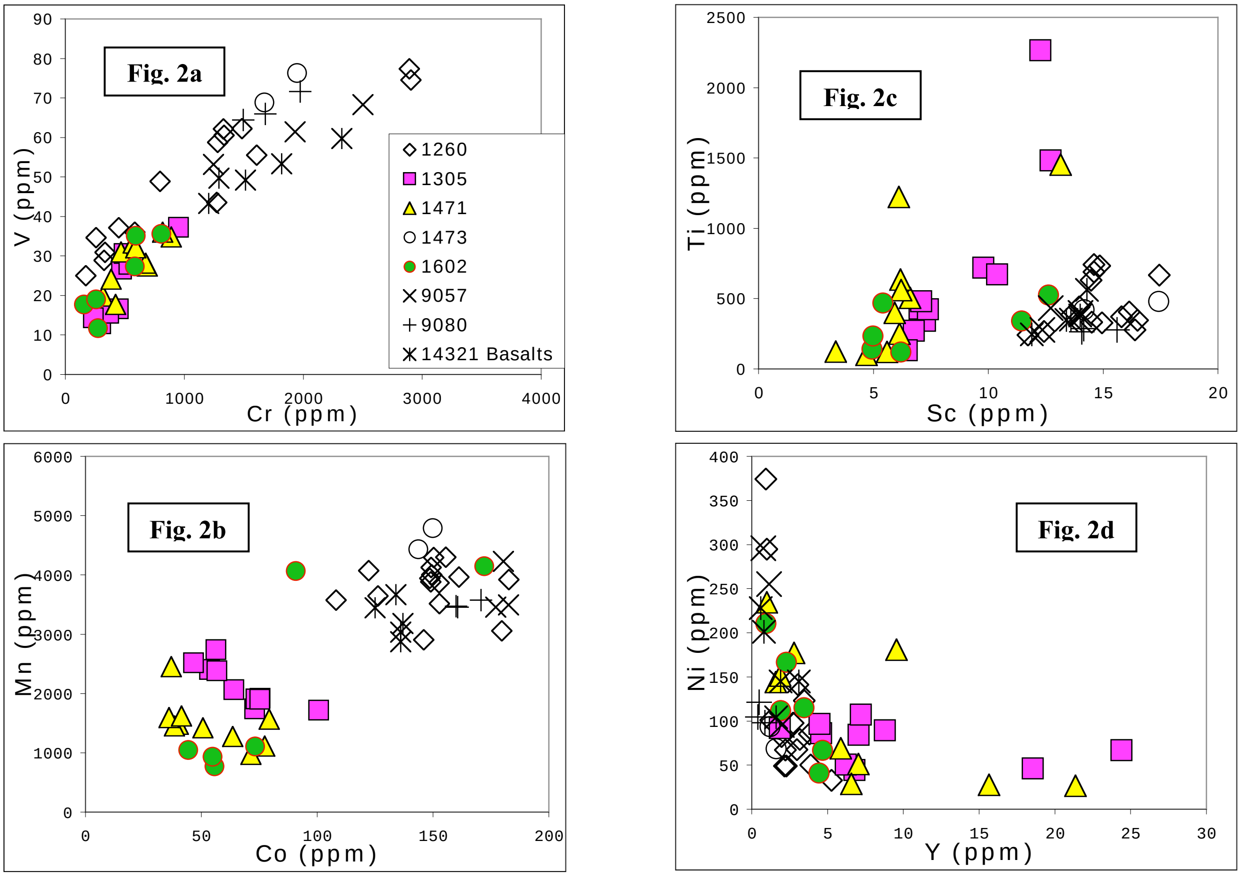
The high-Al basalt clasts have been interpreted as being pristine basalts [4-7] or as impact melts [8,9]. It has been shown, through SIMS analyses of olivine phenocrysts, that the whole-rock compositions of the high-Al basalts are not a product of short-range unmixing [10-12]. These studies also suggested that multiple sources and KREEP assimilation were involved, but could not rule out an impact origin for the Apollo 14 high-Al basalt clasts. The purpose of this study is to compare the compositions of olivine phenocrysts in the high-Al basalts with those in known impact melts, the olivine vitrophyres. If the trace element signatures are similar, it would be reasonable to assume that the Apollo 14 high-Al basalts are, in fact, impact melts.

Samples: Samples of the olivine vitrophyres and high-Al basalts examined in this study were all taken from breccia 14321. Bulk rock and mineralogical data have been reported previously [2-6]. Three olivine vitrophyes, (,1305; ,1471; ,1602) and four high-Al basalts (,1473;, 9080; ,1260; ,9057. These represent Groups 5, 4, 2, and 1, respectively, of [4]).

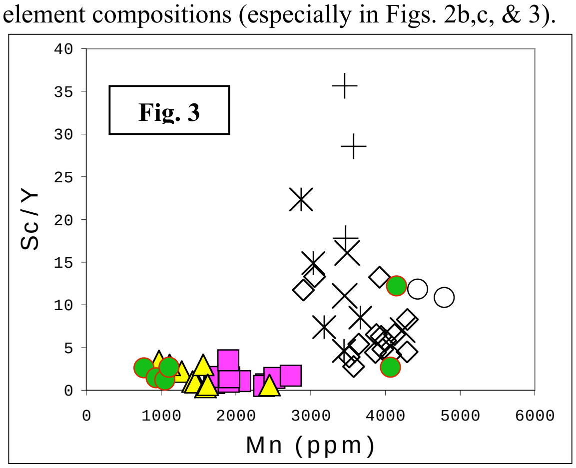
Analytical Methods: Major element data for the olivines were analyzed using a JEOL 8600 Superprobe at the University of Notre Dame using an accelerating voltage of 15 keV and a beam current of 30 nA. Mineral standards were used and all data were reduced online using ZAF corrections. Trace elements (^{45}Sc, ^{48}Ti, ^{51}V, ^{52}Cr, ^{55}Mn, ^{59}Co, ^{60}Ni, ^{89}Y,) were quantified using the Cameca ims 4f at the University of New Mexico campus operated by IOM. Analyses were made using primary O^- ions accelerated through a nominal potential of 10.0 kV. A primary beam current of 20 nA was focused on the sample over a spot diameter of 20 µm. Sputtered secondary ions were energy filtered using a sample offset voltage of 105V and an energy window of ±25 V. Analyses involved repeated cycles of peak counting. Background counting was included to monitor detection noise. Absolute concentrations of each element were calculated using empirical relationships of Trace Element$^+$/^{30}Si$^+$ ratios (normalized to previously measured SiO_2 content) to determine element concentrations as derived from daily calibration. Calibration curves used at least 3 basaltic glass and/or mineral standards for each element, and for each element have correlation coefficients generally > 0.91.

Results: Olivines from olivine vitrophyres are more Fo-rich than those from the high-Al basalts ($Fo_{64.2}$-$Fo_{75.1}$ vs. $Fo_{79.0-91.2}$), except for one large, round olivine in ,1602 (see by the arrow in Fig. 1b), which has a core composition of Fo_{68} and a rim of $Fo_{67.6}$, within the range defined by the high-Al basalts.

Trace element contents show the high-Al basalt olivines analyzed here have similar compositions to those reported by [10-12]. Compositions of olivines from the olivine vitrophyres overlap with those from the high-Al basalts and extend to lower values in abundances of V, Sc, Cr, Ni, Mn, and Co, and overlap and extend to higher values in abundances if Ti and Y (Fig. 2 a-d).



Discussion: The olivines from the high-Al basalts have a distinctly lower Fo content than those from the vitrophyres. Only one large, rounded olivine from vitrophyre 14321,1602 has a Fo content within the range of the high-Al basalts. While olivine trace element abundances overlap between the two rock types, it is evident that the olivine vitrophyres and high-Al basalts contain olivines with distinct trace element compositions (especially in Figs. 2b,c, & 3).



It is important to note that the low-Fo olivine from 14321,1602 plots with those from the high-Al basalts. We interpret this, along with its morphology, to indicate that this particular olivine was inherited from a possible high-Al basalt component involved in the formation of this impact melt. All other analyzed olivines in the vitrophyres crystallized from the impact melt.

Conclusion: The Apollo 14 high-Al basalts are not impact melts. They are crystalline products of a magma generated by partial melting within the Moon. Olivine vitrophyres, however, may contain a high-Al basalt component that was incorporated during the impact melting process.

References: [1] Allen F.M. et al. (1979) *PLPSC 10*, 695-712. [2] Shervais J.W. et al. (1988) *PLPSC 18*, 45-57. [3] Neal C.R. & Taylor L.A. (1989) *GCA 53*, 529-541. [4] Dickinson T. et al. (1985) *JGR 90*, C365-C374. [5] Shervais J.W. et al. (1985) *JGR 90*, C375-C395. [6] Neal C.R. (1988) *PLPSC 18*, 139-153. [7] Kramer G.Y & Neal C.R. (2003) LPSXXXIV, Abs. 2035. [8] Snyder G.A. et al. (2000) *Origin of Earth & Moon*, 361-395. [9] Snyder G.A. & Taylor L.A. (2001) *MaPS 36*, A194. [10] Hagerty J.J. et al. (2001) *LPSXXXII*, Abs. 1235. [11] Hagerty J.J. et al. (2002) *Wksp on Moon Beyond 2002*, Abs. 3041. [12] Hagerty J.J. et al. (2005) *MaPS* (in press).