COMPOSITIONAL ANALYSIS OF THE VERY-LOW-TI MARE BASALT COMPONENT OF NWA 773 AND COMPARISON WITH LOW-TI BASALTS, LAP 03632 & 02436: L.H. Hallis[1,4] K.H. Joy[1,2,3] M.Anand[1,4], and S. S. Russell[1] l.hallis@nhm.ac.uk. [1]The Natural History Museum, Cromwell Rd, London, SW7 5BD, UK. [2]UCL/Birkbeck Research School of Earth Sciences, UCL, Gower Street, London, WC1E 6BT, UK. [3]RAL, CCLRC, Didcot, Oxon, OX11 0QX, UK. [4]Dept. of Earth Science, The Open University, Milton Keynes MK7 6AA, UK.

Introduction: LAP 03632, LAP 02436 and NWA 773 are classified as lunar mare basaltic meteorites. The two LAP samples were discovered on the LaPaz Ice Field in Antarctica in 2002 and 2004. They are paired, low-Ti, unbrecciated holocrystalline mare basalts [1,5]. Altogether, they are part of a group of six paired meteorites (the others are LAP 02205, 02224, 02226 and 04841), with a total mass of ~1.93kg. All of the LAP meteorites have a similar texture, mineral assemblage and bulk composition [1,2,6,7].

NWA 773 is a basaltic regolith breccia containing a large olivine cumulate clast with a modal mineralogy (in vol%) of 48% olivine (Fo_{64-70}); 11% augite ($En_{47-50}Wo_{33-40}$); 27% pigeonite (En_{60-67},Wo_{6-16}); 2% Opx ($En_{70}Wo_{4}$); 11% plagioclase (An_{80-94}) and other minor constituents such as phosphate, troilite, and spinel. The brecciated portion contains lithic and mineral clasts of basaltic composition set in a fine-grained matrix [3].

NWA 773 and the LAP meteorites have been radiometrically dated to be some of the youngest samples in the lunar rock collection. NWA 773 has an age of 2.86-2.91 Ga [8] and the LAP meteorites have been dated at 2.9 -3.1 Ga [5, and references therein]. They therefore provide an important insight into young, low- to very-low-Ti mare basalt petrogenesis.

We present here a study of petrological and mineralogical similarities of specific mare-basalt clasts within the regolith breccia portion of NWA 773 and the above-mentioned LAP samples. The aim is to investigate the relationship between these young lunar basalts.

Methods: All X-ray maps were collected using Oxford Instruments INCA software, on the Natural History Museum's JEOL 5900LV SEM. A Cameca SX50A Wavelength Dispersive electron microprobe was used in the collection of all mineral compositional data.

Results: X-ray mapping (Fig.1) of the three meteorite sections helped identify basaltic lithic clasts and monomict mineral fragments in NWA 773 that have a similar texture and mineral assembledge to the LAP samples.

Pyroxenes (Fig. 2) in both meteorites show a wide range in composition from magnesian subcalcic-augite to pyroxferroite-ferrosilite to hedenbergite. NWA 773 also contains magnesium pigeonite suggesting that the

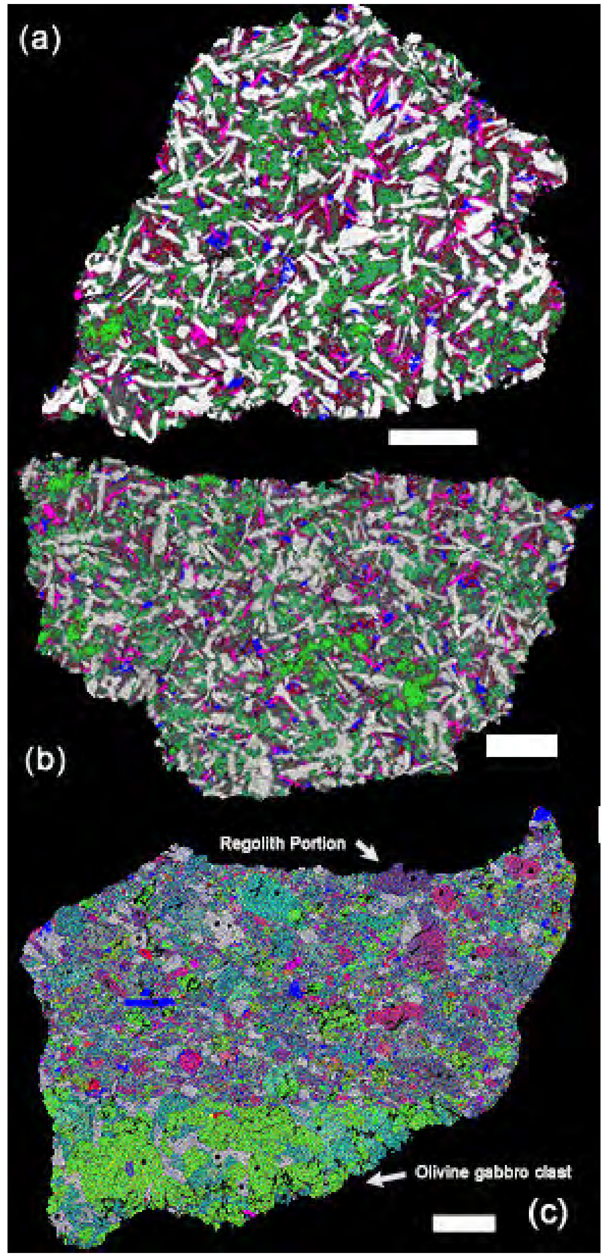

Fig. 1. False colour X-ray maps of sections of (a) LAP 03632, 19, and (b) LAP 02436,27 and NWA 773 (BM 2001, M23) where white represents Al (plagioclases), yellow represents Ca (phosphates), red represents Fe (pyroxene rims and fayalitic areas), green represents Mg (pyroxene cores and forsteritic olivines), blue represents Si (cristobalite grains), and pink represents Ti (ilmenite and spinel) enriched areas. This technique particularly highlights the location of forsteritic olivine (bright green areas), fayalite (brightest red areas), ilmenite (pink), silica (blue) and plagioclase (white phases). Scale bar in all images = 1mm.

original regolith environment contained a diverse mixture of lithologies: including those with compositions more typical of the non-mare, high-Mg suite of rocks.

Two populations of *olivines* occur within the lithic and monomict clast component of NWA 773 and in the LAP groundmass: early stage forsteritic olivines (LAP:Fo_{65-68}; NWA 773: Fo_{66-71}) and later stage fayalites (LAP: Fa_{95-98}, NWA 773:Fa_{87-94}).

Plagioclases within NWA 773 have marginally more anorthite content (An_{85-96}) than LAP (An_{82-91}). Within the LAP sections the plagioclase mostly exhibits simple or multiple twinning but some crystals have experienced partial conversion to 'maskelynite' glass. The plagioclase of NWA 773 shows little evidence of relict twinning and it has been entirely maskelynised.

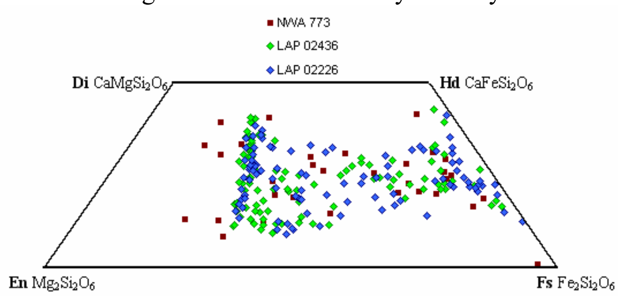

Fig. 2: Pyroxene compositions showing a spread from subcalcic augite to hedenbergite-ferrosilite. NWA 773 also contains magnesium pigeonite.

Spinels are slightly larger in NWA 773 (up to 200 µm) than those identified in the LAP stones (<60 µm). In NWA 773 these phases are normally in the form of chromite with a smaller population of ulvöspinels (Fig. 3). The LAP spinel element compositions span the subsolidus reaction series between the two end-member species, but typically contain less Cr than those in NWA 773.

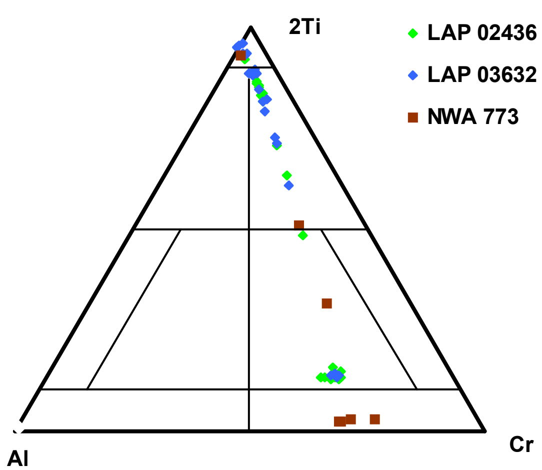

Fig. 3: Spinel trends for LAP 02226, LAP 02436 and NWA 773 highlighting the transition from chromites to ulvöspinel.

Other Basaltic Mineral Assemblages: NWA 773 contains clasts with a mineral assemblage of hedenbergite, fayalite and tridymite, indicating the decomposition of the unstable mineral pyroxferroite under slow cooling in a thick ponded lava flow or hypabyssal condition (Fig. 4). [4]. Nevertheless, this feature highlights the extreme fractional crystallization and Fe-rich nature of NWA 773 basaltic magma.

Aggregates of similar mineral assemblages are found associated with mesostasis areas in the LAP samples, albeit at a much smaller scale. These observations suggest that LAP 03632, LAP 02436 and the specified clasts in NWA 773 crystallised from very late stage melts.

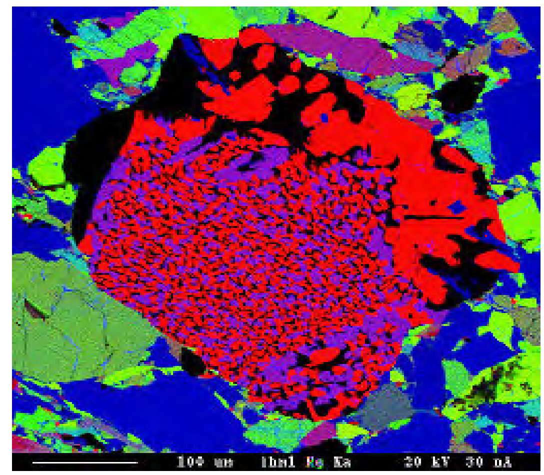

Figure 4: RGB (FeMgCa) false colour x-ray map of a decomposed pyroxferroite clast within NWA 773. The red areas correspond to fayalite, the purple areas to hedenbergite and the black areas to silica and K-rich glass.

Summary: The LAP meteorites investigated in this study are Low-Ti in composition and contain evolved mineral phases, suggesting that the samples were crystallised from a highly fractionated Low-Ti parental melt.

VLT basaltic clasts and mineral phases analysed from the regolith breccia portion of NWA 773 exhibit a similar range of composition, suggesting that there may be a petrological connection between highly-evolved young, Low-Ti and VLT mare basalt volcanism on the Moon.

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References [1] Joy K.H. et al (2006) *Meteorit. Planet. Sci.* 41, 1003–1025 [2] Collins S.J et al. (2005). Lunar and Planetary Science XXXVI. #1147 [3] Jolliff, B. et al 2003. *Geochim. Cosmochim. Acta,* Vol. 67, pp 4857-4879. [4] Heiken G.H, Vaniman D.T. and French B.M (1991): *The Lunar Sourcebook,* pp134. [5] Anand M. et al. 2005. *Geochim. Cosmochim. Acta,* Vol. 70, Issue 1, pp 246-264. [6] Zeigler R. A. et al. 2005. *Meteorit. Planet. Sci.* 40, 1073–1102. [7] Day J. M. D., et al. 2006. *Geochim. et Cosmochim. Acta* 70, 1581–1600. [8] Fernendes. A. et al (2002) *The Moon beyond 2002* p16 #3033. Note: Thin sections LAP 03632,19, LAP 02436,27 were provided by the Meteorite Working Group (MWG) and section NWA 773 (BM 2001, M23) was allocated by the Natural History Museum, London.