# NORTHWEST AFRICA 7533, AN IMPACT BRECCIA FROM MARS.

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**Introduction:** NWA 7533 consists of crystal and lithic clasts, mainly pyroxene and feldspar, in clast-laden impact melt bodies and fine-grained (~1µm) matrix (Fig. 1). It is paired with the NWA 7034 martian breccia on the basis of similar mineral and oxygen isotopic compositions, and magnetic properties [1-3].

**Clast-laden Impact Melt Rock:** The largest objects (~1 cm) in NWA 7533 are flat, oval or aerodynamically sculpted melt bodies containing lithic and crystal fragments, often with melt mantles or coatings. They have a fine-grained subophitic to fasciculate texture (grain size 2-5 µm) and are characterized by clots of pyroxene dendrites (+ magnetite, chromite or ilmenite) embedded in aureoles of plagioclase.

**Matrix:** The fine-grained interclast matrix that occurs between melt bodies has lithic clasts, and crystal clasts with sizes down to ~5 µm. It consists of anhedral micron-sized plagioclase with sub-micron pyroxene (Fig. 1b) surrounding and embedded in it, plus magnetite, often symplectitic or lacy.

**Melt Spherules:** These are ~100 µm to >3mm in diameter (grain size 1-5µm except for long dendrites). Olivine ($Fo_{74-65}$) occurs as chain dendrites in one melt sphere and tiny Fe oxides decorate the surface of another.

**Coarse Grained Clasts:** Clasts (up to ~2 mm) are dominantly crystal clasts (pyroxenes and feldspars, as well as magnetite and chlorapatite), and coarse-grained noritic-monzonitic fragments (>1mm grains) made up of several of these phases. In Fig. 1a, we show a clast with augite, perthite and chlorapatite. Minerals found in clasts (Fig. 2a) include orthopyroxene $En_{76-\sim60}$, inverted pigeonite $En_{58-46}$, augite $En_{44-30}Wo_{\sim40}$, plus chlorapatite and Fe oxides. Inverted pigeonite $En_{58-46}$ (Fig. 2b) contains $En_{41-32}Wo_{41-46}$ 10 µm lamellae (Fig. 3) without diffusion gradients. Feldspars include plagioclase $An_{54-31}$, anorthoclase, K feldspar, plus perthite and antiperthite (Fig. 4).

**Fine Grained Clasts:** There are clasts of microbasalts with subophitic to granoblastic textures, grain size ~50µm, with orthopyroxene $En_{73-63}$ or pigeonite $En_{63-49}$ and with augite $En_{46-29}$, plagioclase $An_{66-30}$ and Fe-rich spinel.

**Alteration:** Calcite, probably terrestrial [2], occurs filling fractures. Rare pyrite is replaced mainly by Si-bearing Fe hydroxide (goethite?), and one melt sphere is crosscut by veins with Ba-rich feldspar.

**Discussion:** The NWA7533 and 7034 breccias offer us a new way to study the geology of Mars. In particular, the abundance of alkali feldspars in these breccias suggests a connection with orthoclase-rich rocks analyzed by Curiosity at Bathurst Inlet [4]. The fine pyroxene in their matrix suggests an origin as wind-blown dust.

These breccias are polymict with clasts from different rock types and with different thermal histories.The diversity of pyroxene compositions is like that of howardite breccias and, like them, they lack maskelynite. However, their geochemistry is different [2,5,6].

The noritic–monzonitic rocks may be related by crystal fractionation, as there are correlations between pyroxene, plagioclase and spinel compositions. They are more evolved than the microbasalts. The most magnesian orthopyroxene has not been found attached to plagioclase and probably represents orthopyroxenites like ALH 84001.

The exsolution in inverted pigeonite, augite and perthite indicates a deep-seated origin for these clasts. The presence of rocks with either hypersolvus or subsolvus alkali feldspars suggests a range of water pressures. The lack of M-shaped diffusion profiles [7] in inverted pigeonite after exsolution indicates quenching by excavation from considerable depth. Moreover, all clasts show enrichment in HSE [5,6] with an enrichment in Ir of 20-120x SNC at the same MgO and excess Ni equivalent to ~4-5% CI chondrite. This supports an impact rather than a volcanic origin for this breccia, and suggests impact recycling of a very thick impact melt sheet.

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**References:** [1] Met. Bull. [2] Agee C. B. et al. (2013) *Science Express*, DOI:10.1126/ science .1228858. [3] Rochette P. et al. (2013) *LPS XVIV.* [4] Sautter V. et al. (2013) *LPS XVIV.* [5] Humayun M. et al. (2013) *LPS XVIV,* Abstract #1429. [6] Yang S. et al. (2013) (1996) *LPS XVIV.* [7] Hewins, R.H (1976) *Trans Amer Geophys Union (EOS)* 57, p 356.

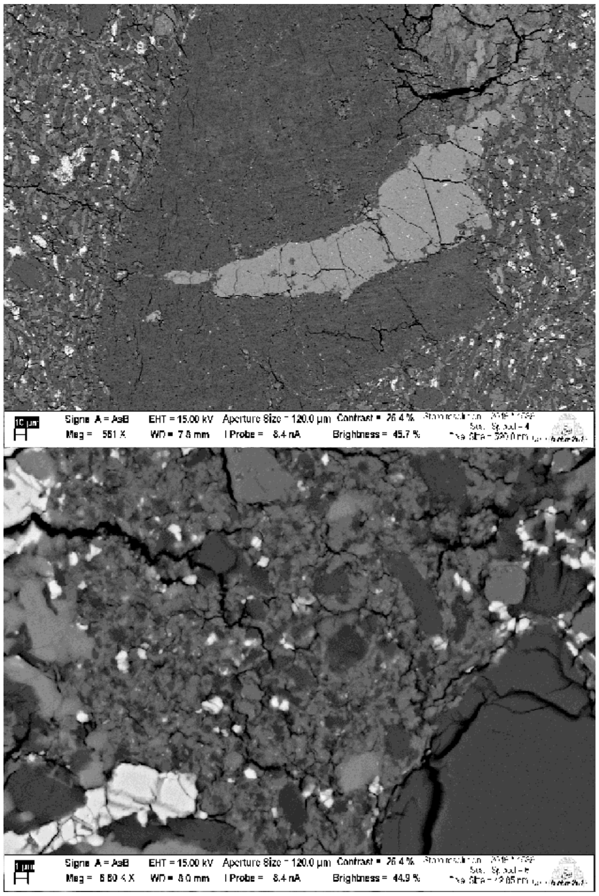

Fig. 1 (a) perthite in clast in melt rock. (b) matrix.

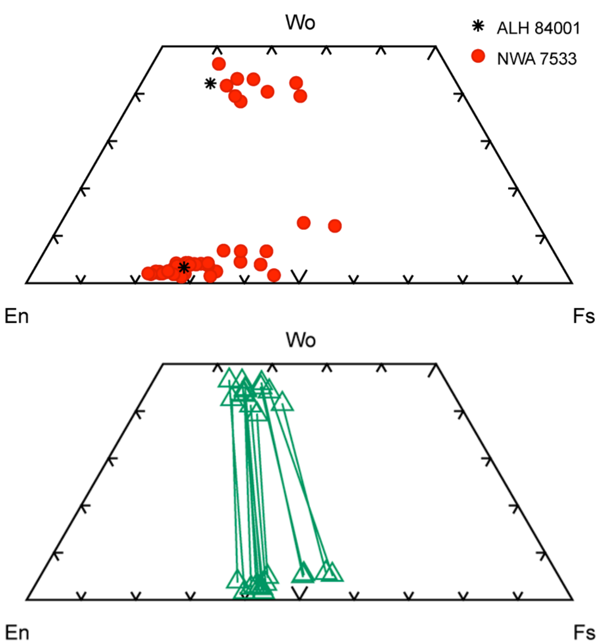


Fig. 2 (a) Opx/pig and augite clasts. (b) Opx-augite pairs for inverted pigeonite.

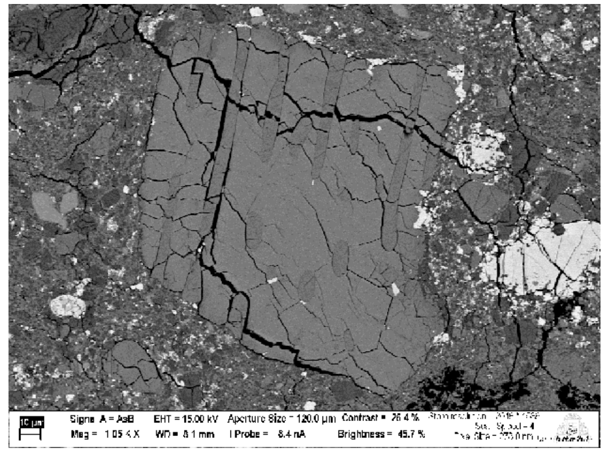

Fig. 3 200μm clast of inverted pigeonite.

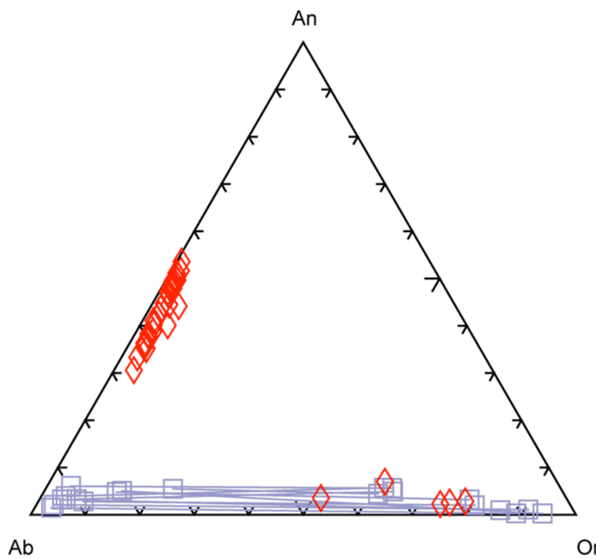


Fig. 4 Plagioclase and bulk perthite, plus tielines for perthite phases.