Miller Range 07273: An Unusual Chondritic Melt Breccia

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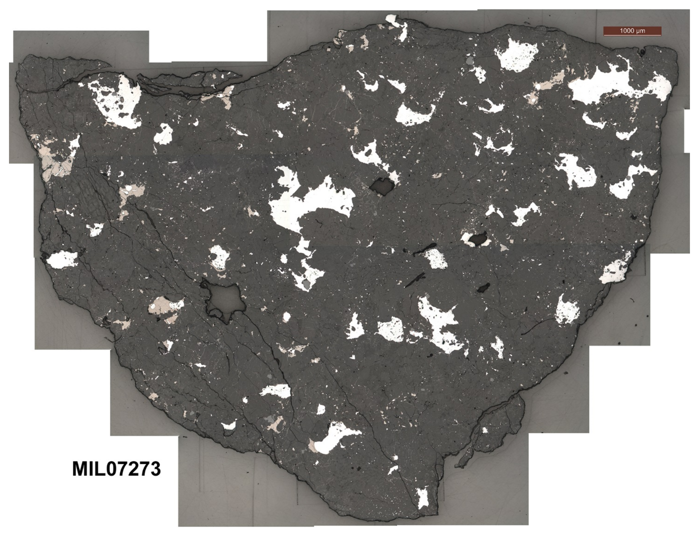
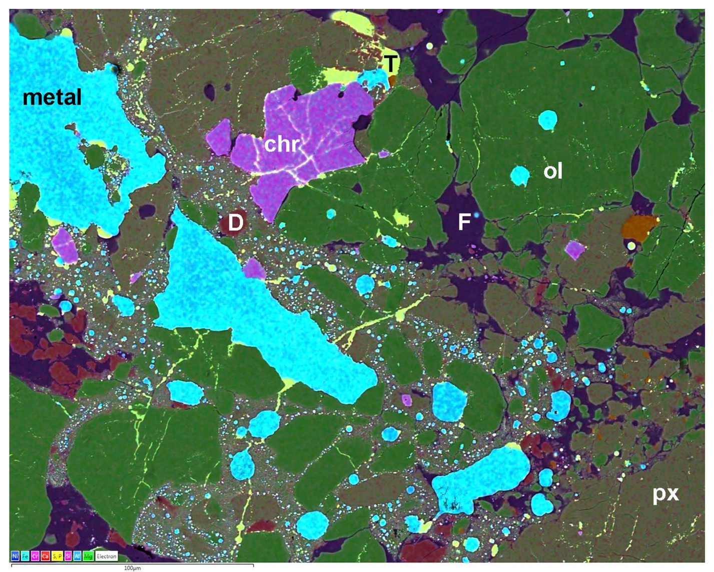
MIL 07273 is a melt breccia containing clasts of equilibrated H-chondrite set in a fine-grained (silicates <5µm across), largely crystalline igneous matrix. Chondrule clasts and fragments are "blackened" due to extensive veining (mainly by troilite), and coarse metal grains appear "fluidized", with scalloped edges around adjacent silicates. Below: transmitted (left) and reflected (right) light images of thin section.

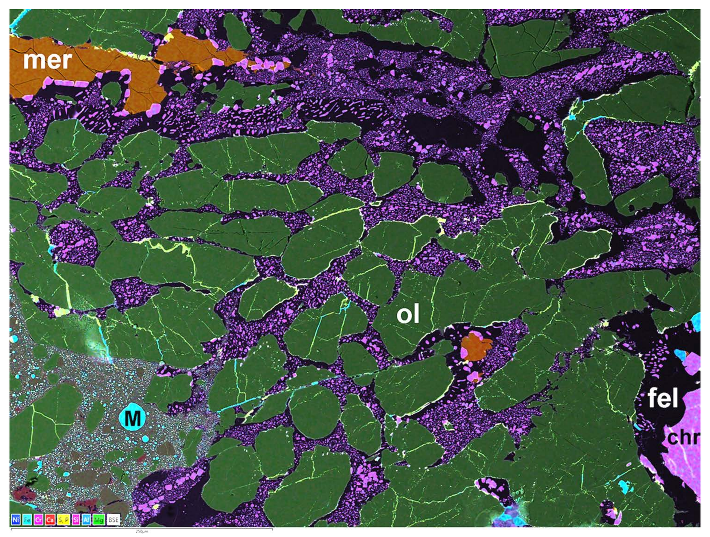


Melting:



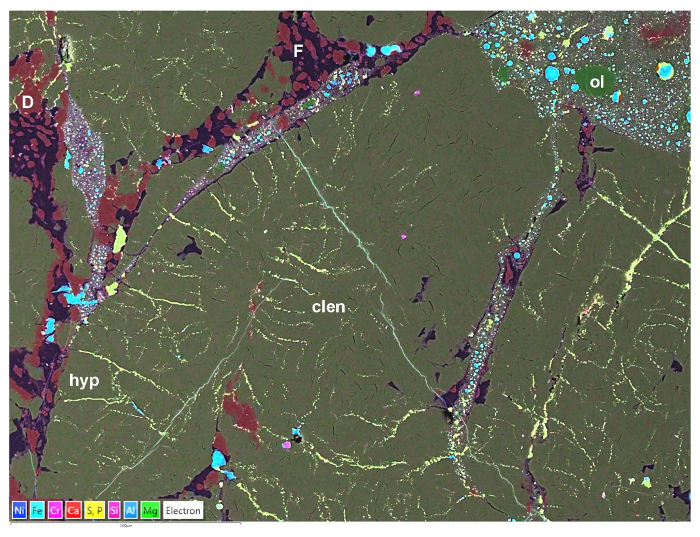
Left: Map of phase chemistry. T = troilite; chr = chromite; ol = olivine; D = diopside; F/fel = feldspathic phase, px = pyroxene. Trolite/metal mix was early melt. Trolite was highly mobile; moving from rims on both large metal grains and metal droplets to form extensive veins cutting across existing silicates.

Two silicate melts stay separate:

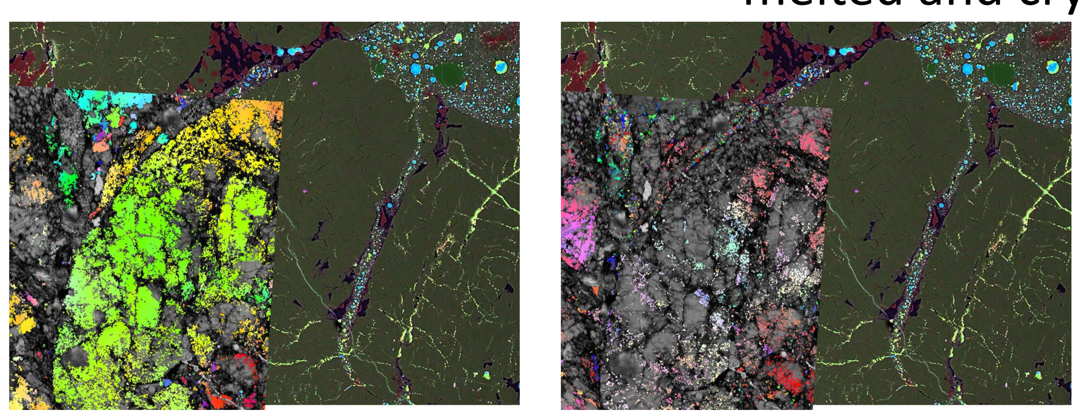


Left: merr=merrillite; M = metal. Olivine-rich chondrule broken apart along troilite veins, with mesostasis melting. Mesostasis melts are rich in feldspar ± chromite (left) and/or diopside (below). These remain distinct from the matrix melt (lower left corner).

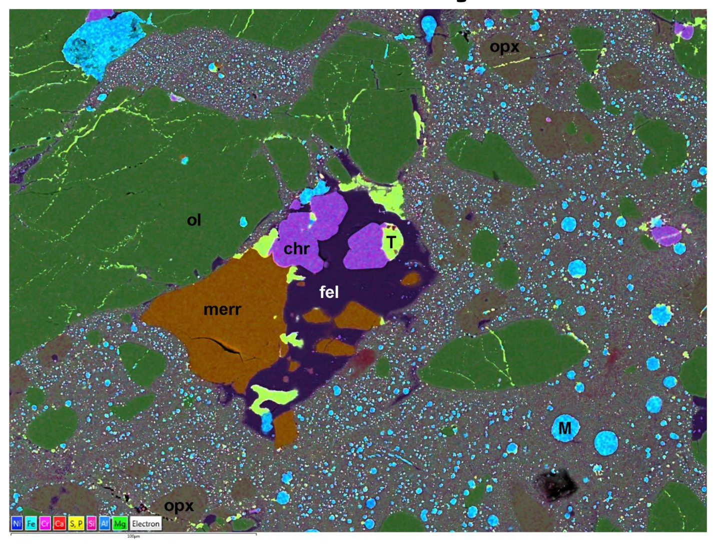
Pyroxene partially melts:



Left: clen = clinoenstatite; hyp = hypersthene. Pyroxene clast containing truncated troilite veins. Feldspathic and main melt components remain separate. Below: IPFx + band contrast maps for hypersthene/ opx (left) and clen (right) super-posed on chemical map. Patches of opx appear to have melted and crystallized as clen quickly, without any change in chemical composition.

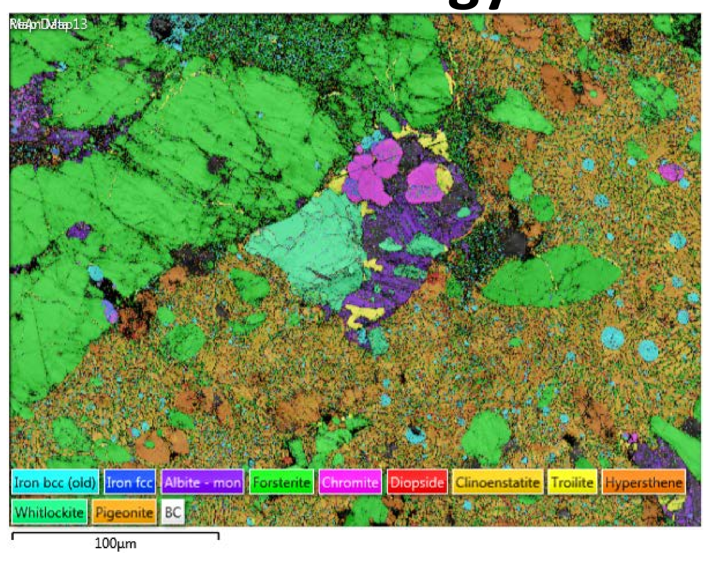


Phase Chemistry:



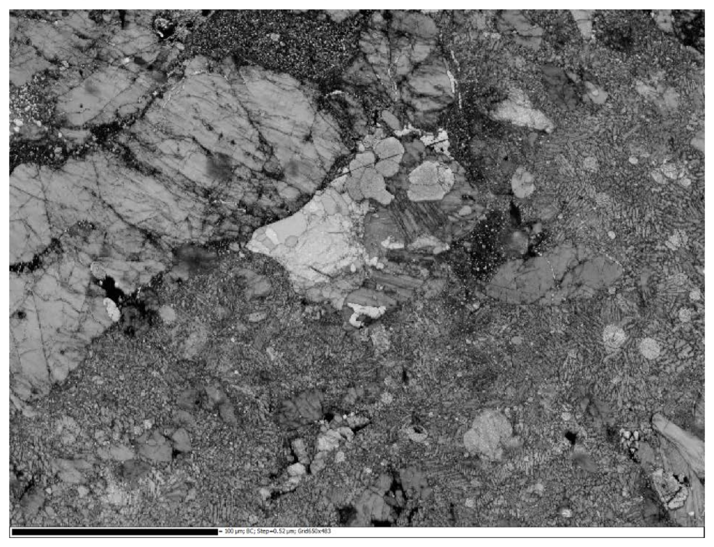
Left: Phase map of matrix-rich area with clasts, created from element maps obtained via SEM/EDS mapping. ol = olivine, opx = low-calcium pyroxene; merr = merrillite; chr = chromite; fel = feldspar; T = troilite, and M =metal.

Phase Mineralogy:



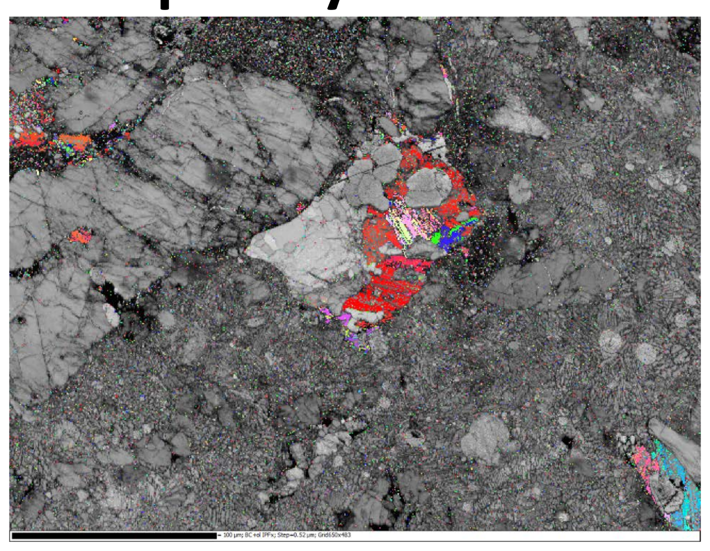
Left: Phase map created using EBSD. Phases are identified by matching to a reference crystal structure. Matrix areas are dominantly composed of low- Ca pyroxenes that index as clinoenstatite or pigeonite.

Crystallinity:



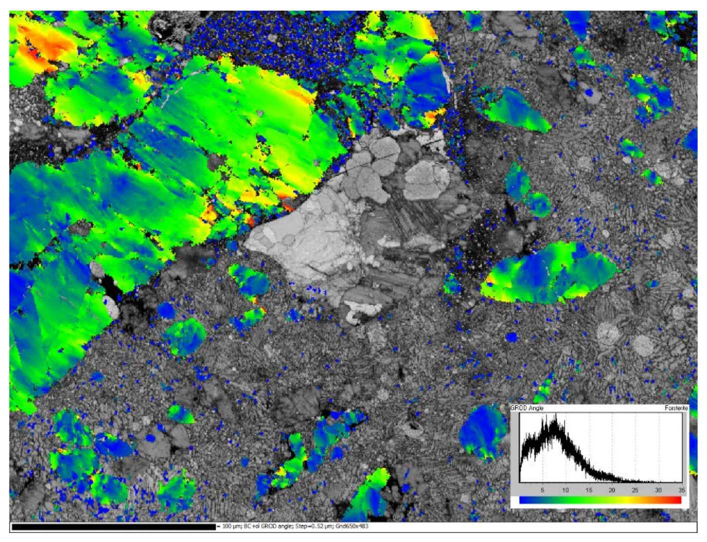
Left: Band contrast map obtained with EBSD. Brighter phases have better crystallinity. Black indicates non-crystalline areas (glass, holes, cracks). There is little glass in MIL 07273, all of it is feldspathic.

Feldspar crystal orientation:



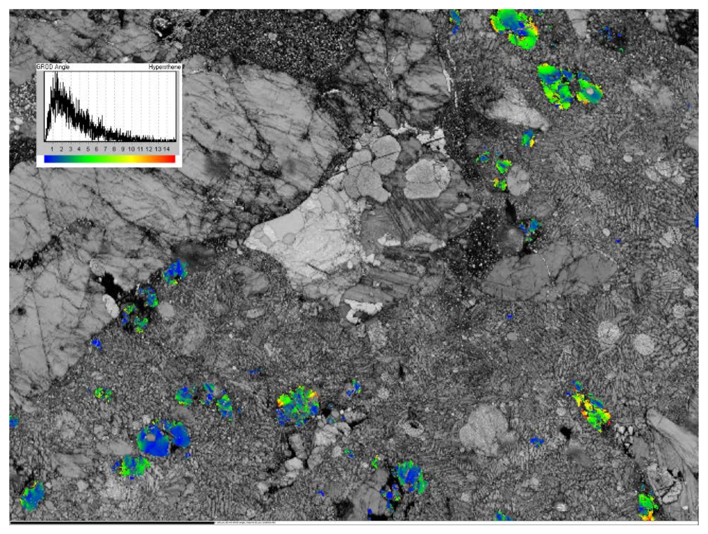
Left: Inverse pole figure x-direction (IPFx) map of feldspar, with different colors representing different crystal orienta-tions. The feldspathic region is comprised of numerous grains, many oriented the same way.

Olivine Deformation:



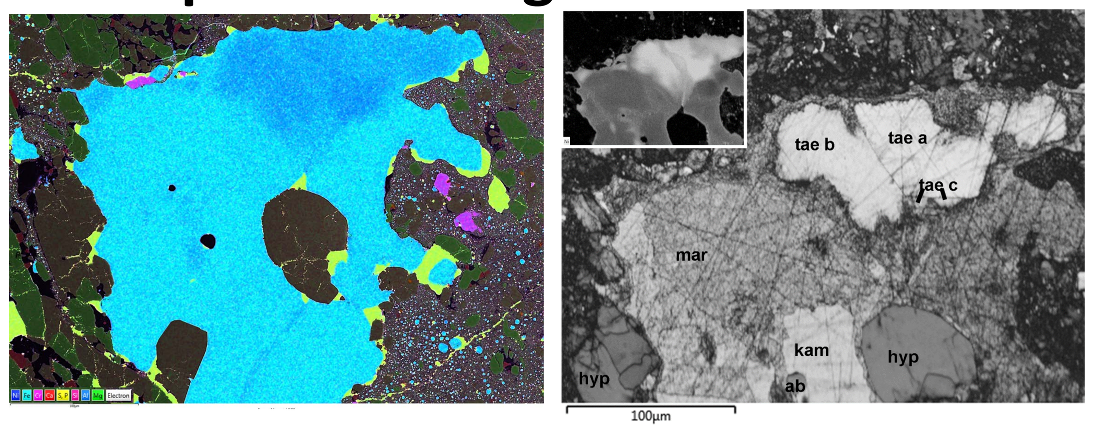
Left: Image showing GROD (grain orientation deviation) angles for olivine. Colors indicate the distortion of crystal lattice from a reference value. Olivine clasts include the most deformed silicates in MIL 07273.

Orthopyroxene Deformation:



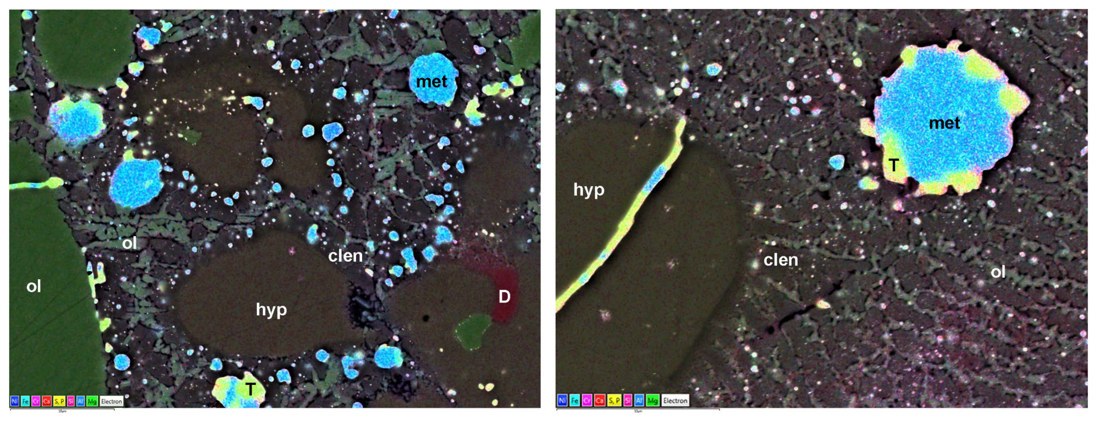
Left: Image showing GROD angles for orthopyroxene. Orthopyroxene clasts are among the most heavily deformed grains in MIL 07273, although not as much as the most deformed olivine grains.

Incomplete melting of metal:

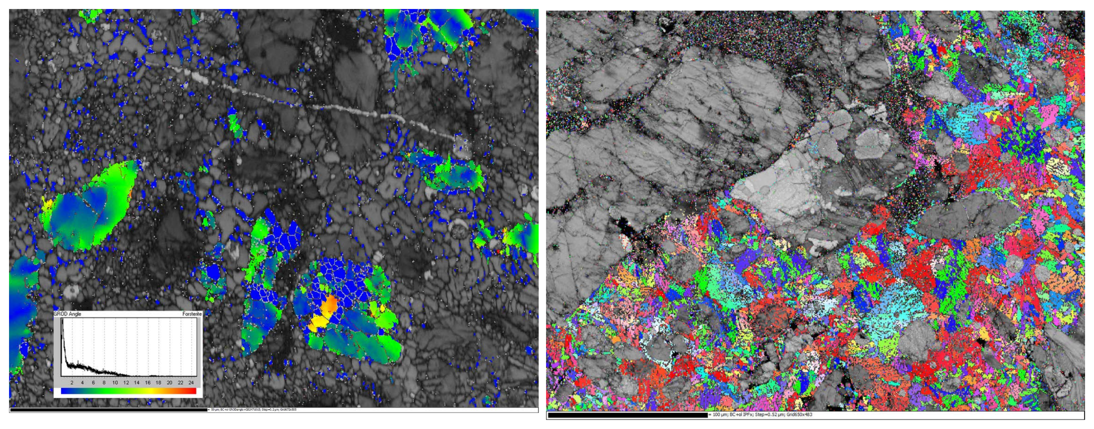


Coarse metal grains are "fluidized", entraining and surrounding silicates. Element maps (upper left) show diffuse variations in nickel. EBSD analysis reveals that coarse metal is dominantly martensite (mar) with remnant grains of kamacite (kam) and taenite (tae), as shown in the band contrast image in the upper right. The inset shows a Ni x-ray map. Martensite surrounding taenite is enriched in Ni. hyp = hypersthene; ab = albite

Matrix Silicates:



Melt matrix in chemical maps (above) and EBSD maps (below – GROD angle left; IPFx right). Matrix surrounds fragments of host ol and opx that are strained and recrystallized (below left) and metal/sulfide droplets. Crystalline matrix is composed of ol and low-Ca pyroxene grains which are undeformed and clearly crystallized from the melt. Matrix pyroxenes index as clinoenstatite and pigeonite, and are enriched in Na and Al, qualifying as omphacite. Clusters of matrix pyroxenes have the same crystal orientation (below right). Relatively iron-rich matrix olivine crystallized after pyroxene (as shown above).



Summary: Features observed in MIL 07273 can be explained by a shock event that pro-duced brief heating at high pressure, a sudden pressure drop, with a slower drop in temperature, producing plastic deformation, brecciation, localized melting and crystalliza-tion. Matrix texture and composition suggests crystallization at high pressure followed by back-reaction of high-P poly-morphs. Up to ~50% of MIL was melted. Yet, this appears to have had little effect on the composition of non-matrix silicates.

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