A Pyroxene-Enriched Shock Melt Dike In The Buck Mountains 005 (L6) Chondrite.

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Introduction: The Buck Mountains 005 (L6 S4 W2) chondrite contains a ~3-mm-wide complexly-zoned dike that was produced by shock [1]. The dike is dominantly fine-grained (grains <10-15 µm across) and has a core-rim structure (Fig. 1). The inner dike contains large clasts (~50-400 µm across) of olivine and pyroxene that sometimes are recrystallized, whereas the outer dike is fine-grained with grain size decreasing towards the host. Clasts occupy ~25% of the inner dike and ~6% of the outer dike. Feldspar is notably depleted in the dike, comprising only ~ 1.9 area % of the inner dike and <0.1 area % of the outer dike.

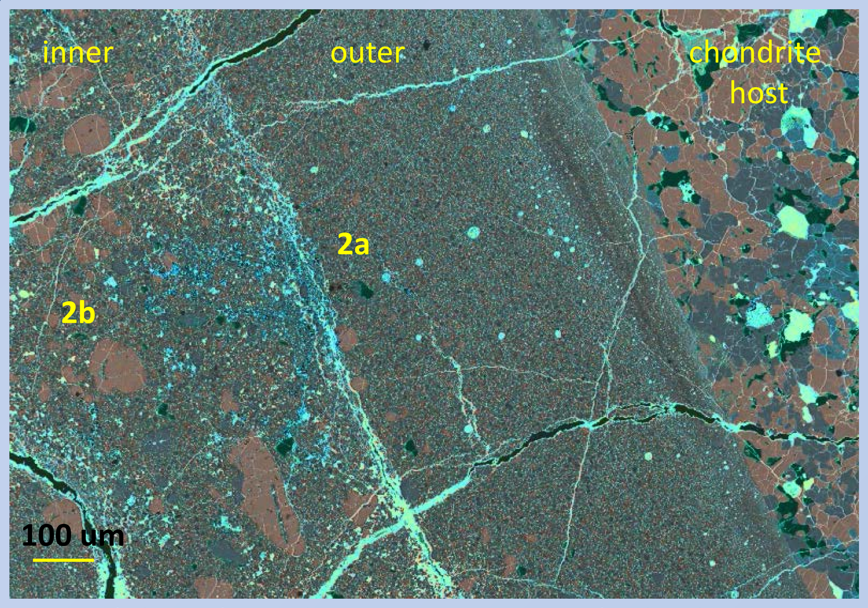


Fig 2 (above) - Colorized BSE image (color key on extreme right) showing the mineralogy and texture of the dike. A sulfide-rich layer separates the inner and outer regions. The outer dike contains rounded metal/sulfide globules not present in the inner dike. The globules are concentrated near the contact with the host meteorite. 2a and 2b refer to the locations of enlargements to the right.

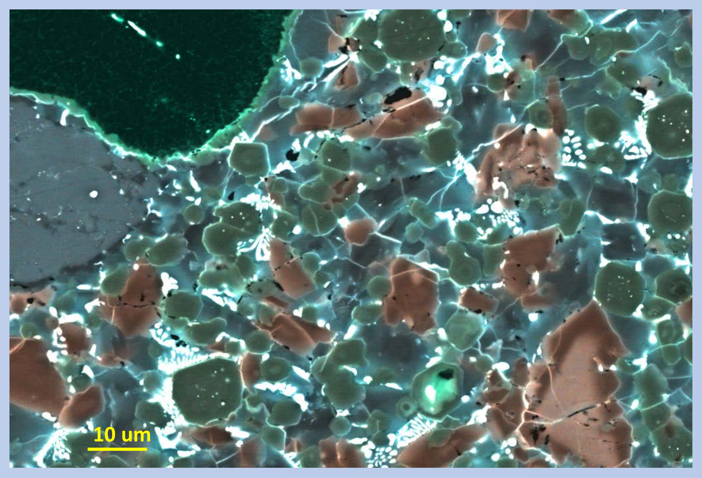


Fig 2a-The dike is holocrystalline, dominated by a groundmass composed of olivine, Al-opx, Mg-pyx with core-rim zoning and metal symplectites. The euhedral shapes of the olivine and Al-opx grains suggests they crystallized from the melt first, followed by the formation of interstitial zoned Mg-pyx.

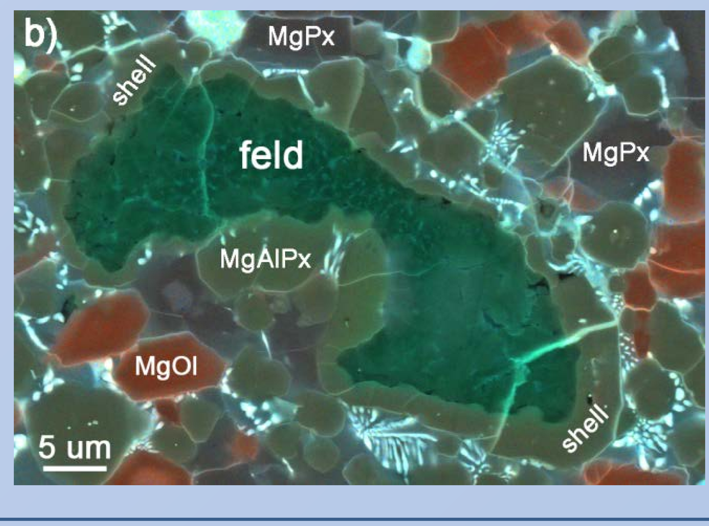


Fig 2b-Rare feldspar occurs as somewhat irregular patches with a composition ($Ab_{84\pm3}$ $Or_{5\pm3}$) similar to that of the host ($Ab_{83\pm2}$ $Or_{6\pm1}$). Observations suggest that this feldspar was incorporated as clasts. Feldspar is always surrounded by shells of Mg-Al-pyroxene with the highest Al_2O_3, up to 14 wt%.

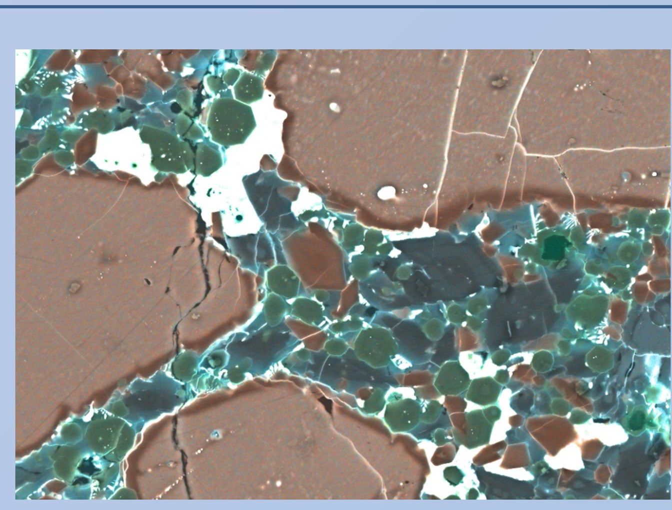
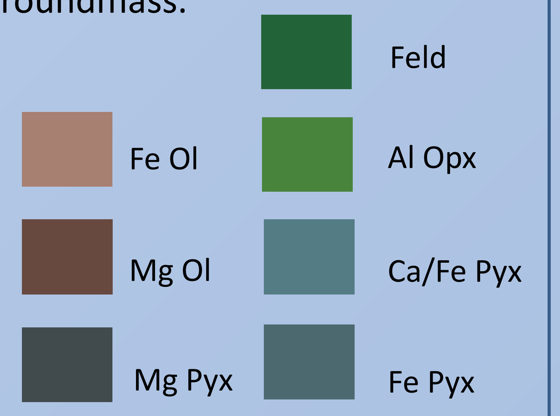


Fig 3a- A false color image showing olivine clasts set in an orthopyroxene-rich groundmass.



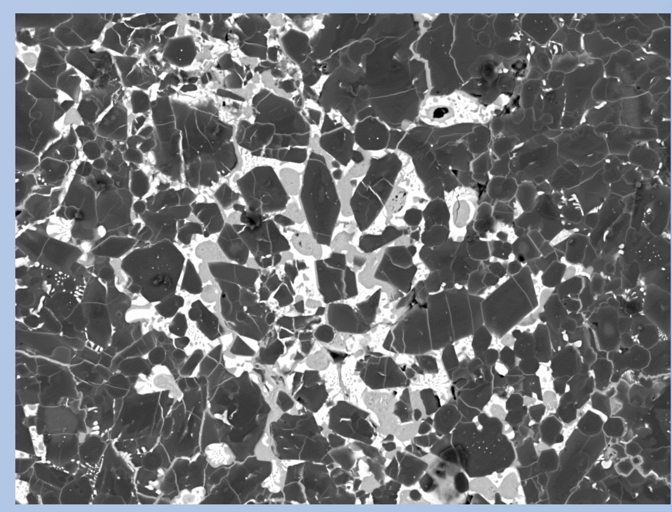


Fig 3b-A band of troilite and cellular metal (largely but not completely altered by terrestrial weathering) entraining angular silicate clasts and crystals is concentrated at the edges of the inner dike.

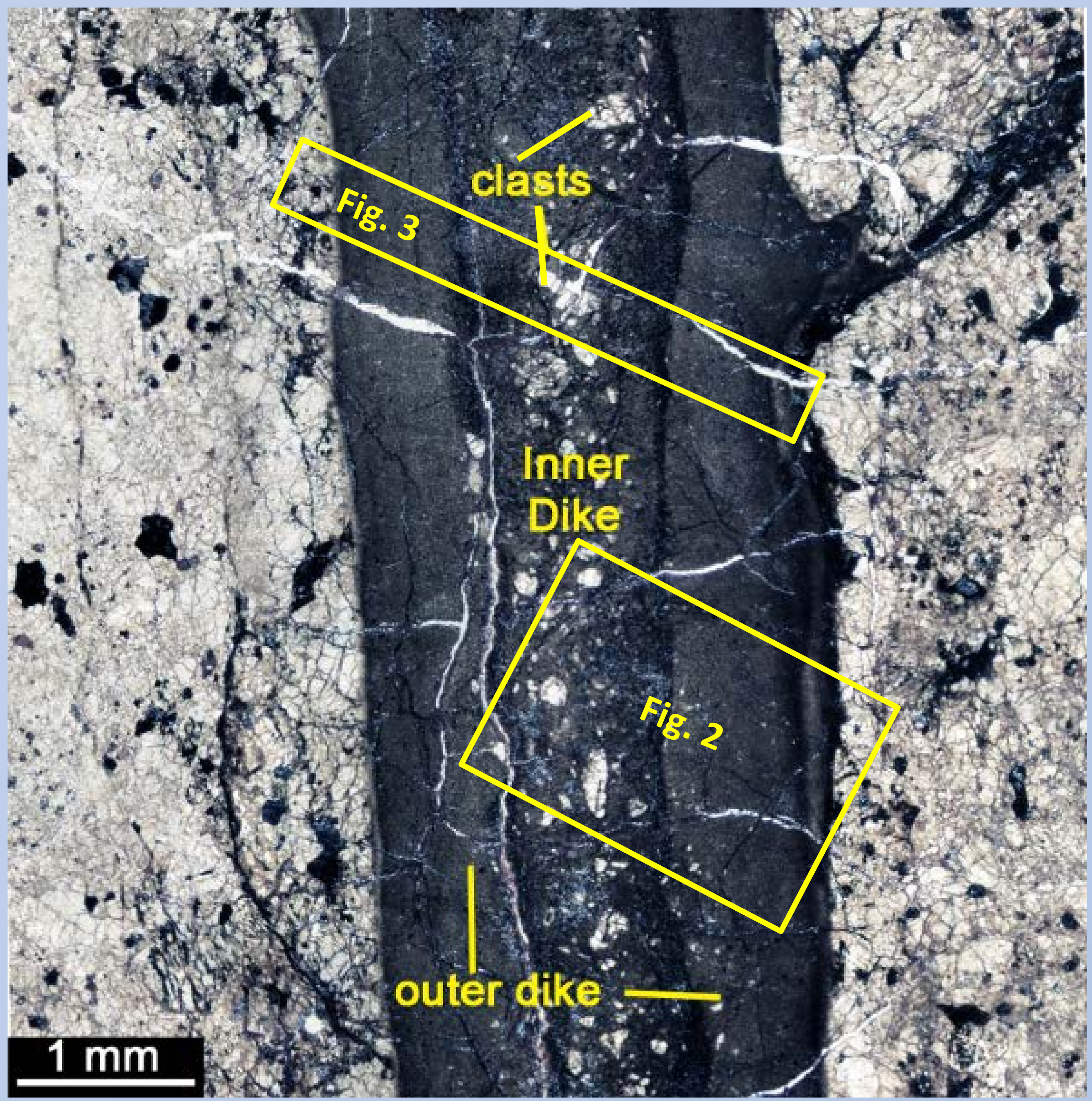
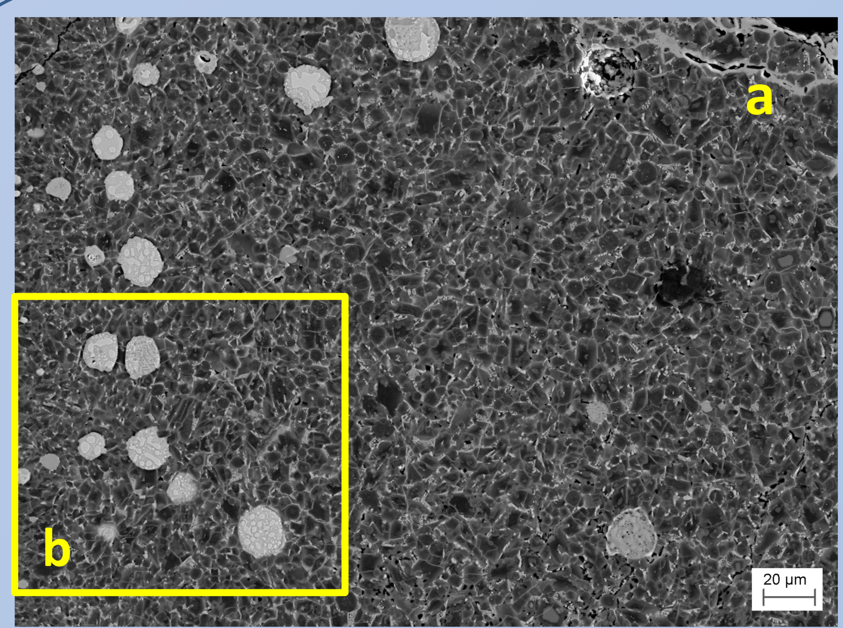
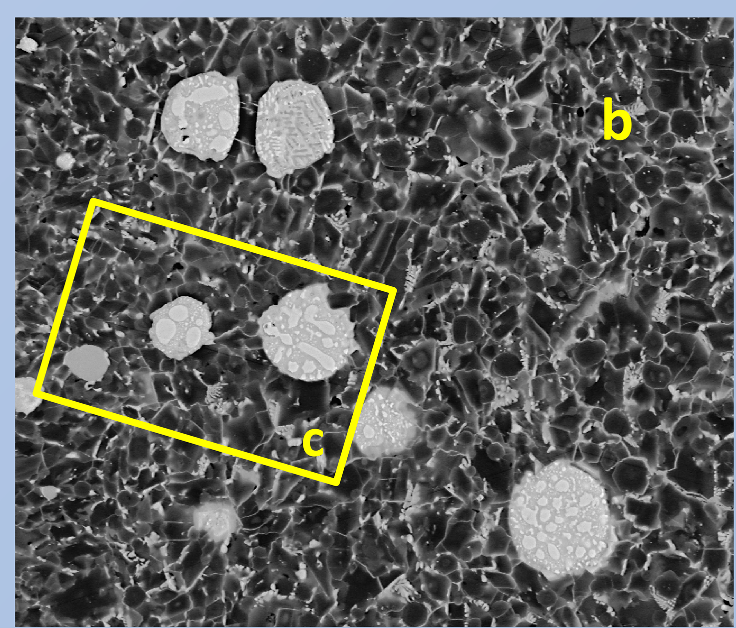


Figure 1 (above) –A transmitted light image showing a portion of the dike and adjacent L6 chondrite host. The inner dike contains silicate clasts that were clearly once part of the chondrite. The outer dike is dominantly fine-grained, with grain size decreasing towards the host. Thin shock veins in the host are subparallel to the dike, and one thicker vein branches from the dike into the host.

Fig.3- A BSE mosaic showing a section across the entire dike. 3a and 3b refer to the locations of enlargements in the images above. The bright material in and along the edges of the inner dike is dominantly troilite containing cellular metal (mostly converted to iron oxide as a result of weathering).





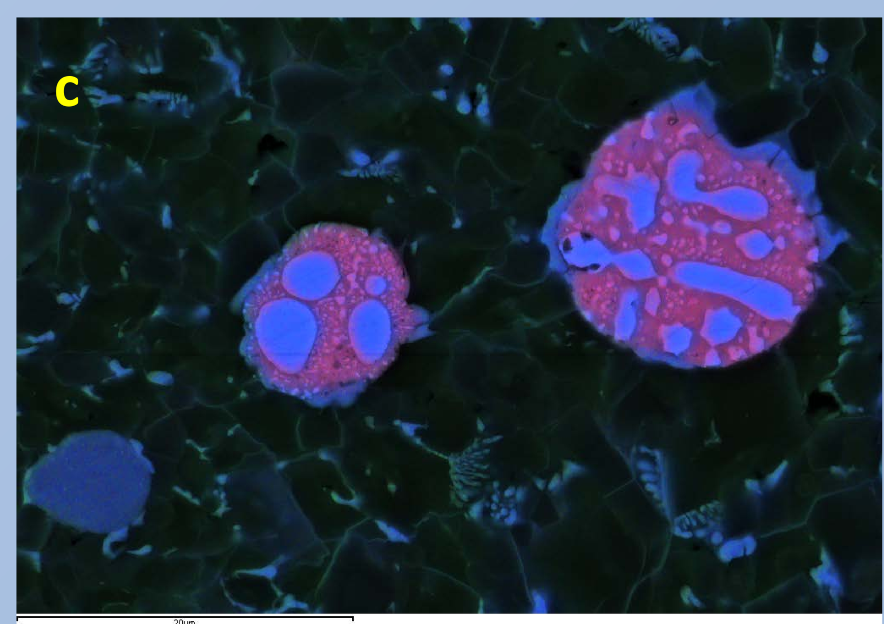


Fig. 4- a) BSE image showing globules with cellular-dendritic texture present within the outer dike structure. The globules are composed of intergrowths of sulfide with metal (much of which has been replaced by iron oxides as a result of weathering). The textures of these intergrowths indicate rapid cooling of the melt. Such globules are predominantly concentrated towards the host chondrite and range from ~5-40 µm across. b) Higher magnification BSE image of globules. c) Colorized BSE image displays the chemical characteristics of symplectites and three metal globules. The smallest has been entirely replaced by weathering product. The non-oxidized metal from the globules has Ni/(Ni+Fe) = 0.08-0.09 by weight (N= 6), similar to that of the host chondrite. The symplectites were formed from FeO reduction and are essentially Ni free, with Ni/(Ni+Fe) = 0.00±0.01 by weight (N=9).

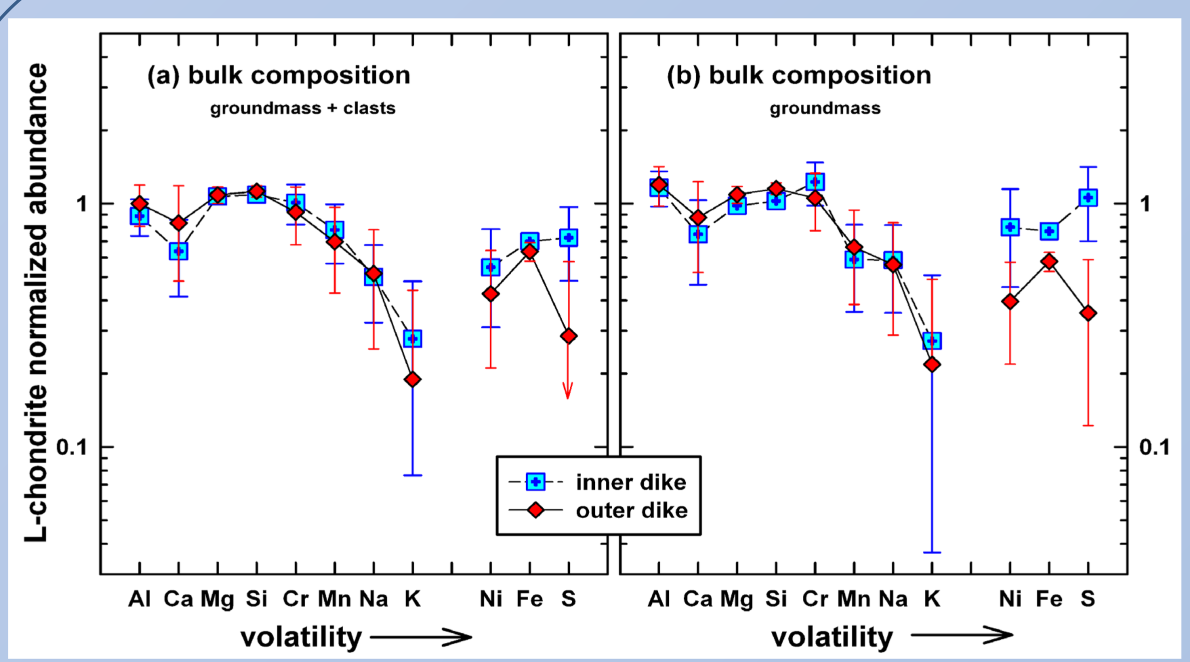


Fig. 5- Modal reconstruction was used to calculate bulk compositions for the inner and outer dike. The figures above compare the dike chemistry to that of the L-chondrite host, with figure b excluding relicts clasts. The dike has L-chondritic abundances of Al, Ca, Mg, Si, and Cr, but is progressively depleted in Mn, Na, and K , consistent with the low abundance of feldspar in the dike, and suggesting loss of volatile elements during vaporization. The inner and outer dikes are depleted in Fe, Ni, and S, suggesting partial loss of a metal-sulfide melt. If relict clasts are excluded, the inner dike appears to have chondritic proportions of metal and sulfide, concentrated along the edges of this region.

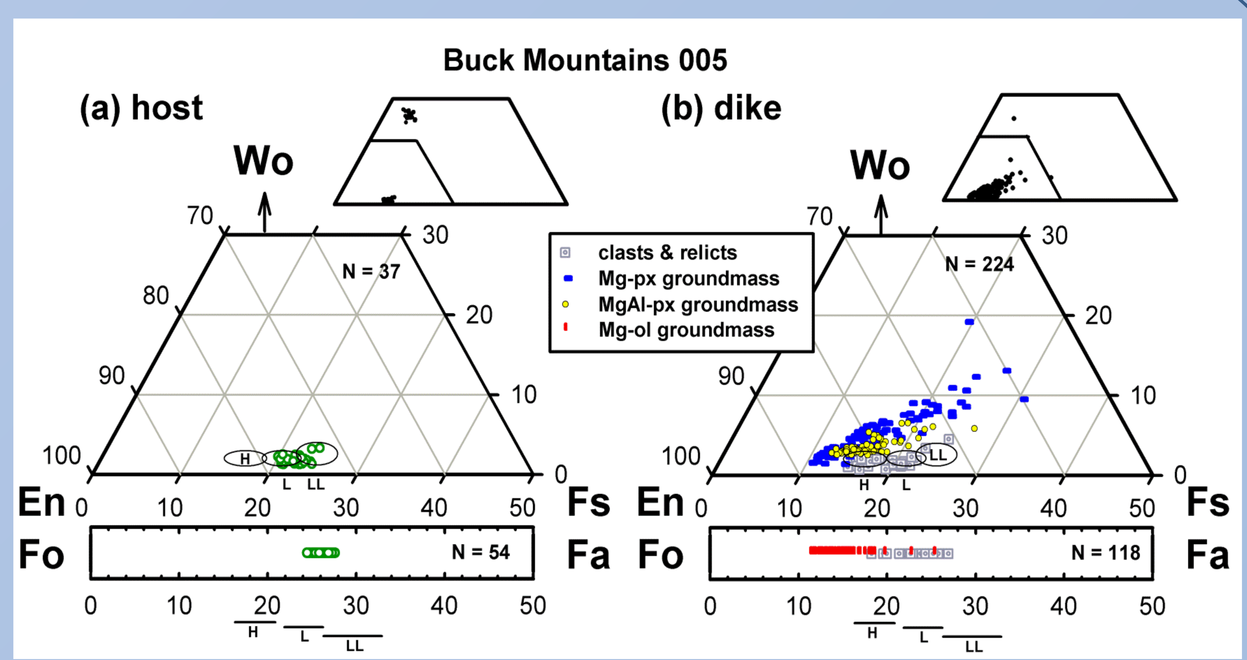


Fig. 6- The dike is dominated by groundmass ferromagnesian minerals that are more magnesian than the host, and which crystallized from melt. Textural relationships indicate that anhedral Mg-pyroxene grains (Wo_{1-19} Fs_{10-31}, mean Fs_{16}, with prominent igneous core-rim zoning) crystallized after euhedral-subhedral olivine (Fa_{11-25}, mean Fa_{15}) and MgAl-pyroxene ($Wo_{2.5-6.6}$ Fs_{12-22}, mean Fs_{13}, typically ~6-9 wt% Al_2O_3) grains. Ferroan olivine and low-Ca pyroxene grains with compositions similar to the host are present as large clasts and formed by cataclasis. Other ferroan grains are more magnesian, some with igneous textures, and are probably relict grains or clasts that melted and resolidified without fully equilibrating with the surrounding melt.

Implications

- Important processes to form the dike include cataclasis accompanied by melting and partial vaporization and FeO-reduction
- Dike differs in bulk composition from L-chondrite in having low metal and sulfide abundances, as well as low feldspar and olivine and excess pyroxene
- Partial vaporization of alkalis destabilized feldspar and left excess Al and Si that was incorporated into Al-pyroxene
- FeO reduction destabilized Fe-bearing olivine and pyroxene and created metal symplectite and Mg-rich rims on clasts
- A low clast content and evidence for alkali vaporization indicates that temperatures in the shock melt were high initially
- Presence of relict grains, narrow Mg rims on grains, and the presence of cellular-dendritic metal-sulfide indicate that cooling must have been rapid
- Despite rapid cooling, texture is holocrystalline, not glassy, probably reflecting the presence of many seed nuclei caused by incomplete melting

References: [1] Hutson M., Ruzicka A., Jull A.J.T., Smaller J.E., and Brown R. (2013) Meteoritics & Planetary Science, In Press.
[2] Brearley A. and Jones R.H. (1998) Reviews in Mineralogy, 36, pp. 3-1 to 3-398.