Evidence for O_2-rich Environments on Mars from Hydrous Mn(IV)-oxides in Northwest Africa (NWA) 7034 and 7533 Meteorites

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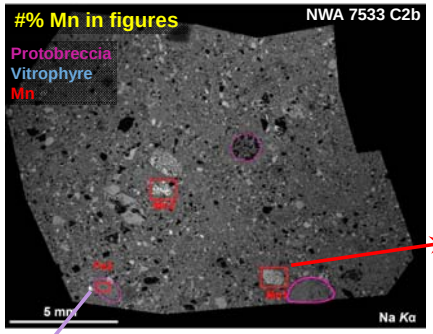
MnO_2 Phases in Black Beauty

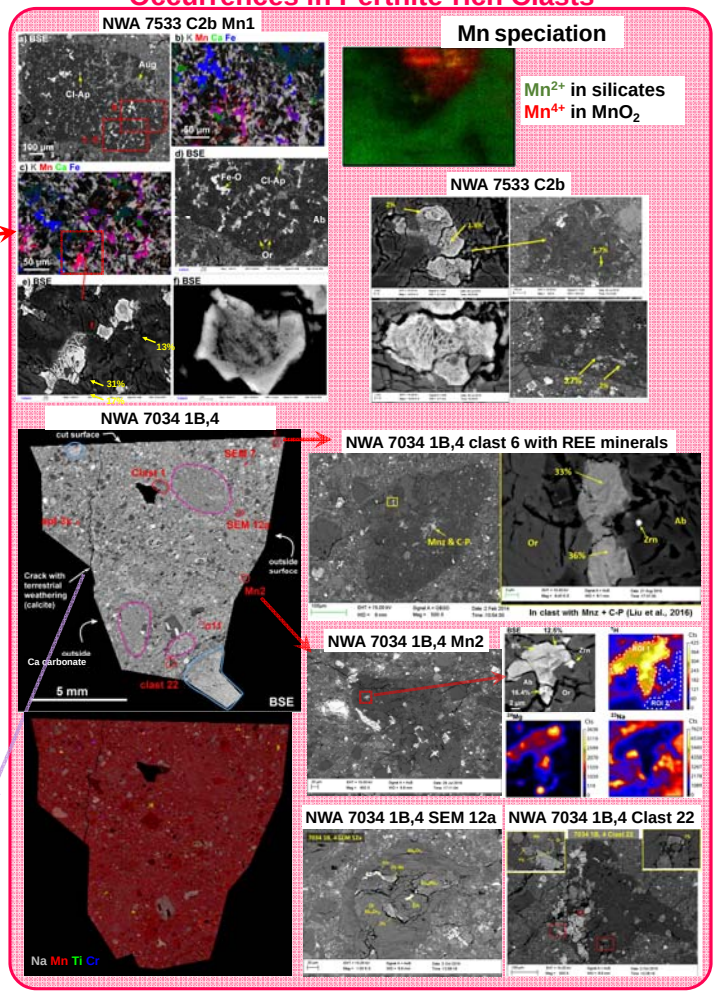
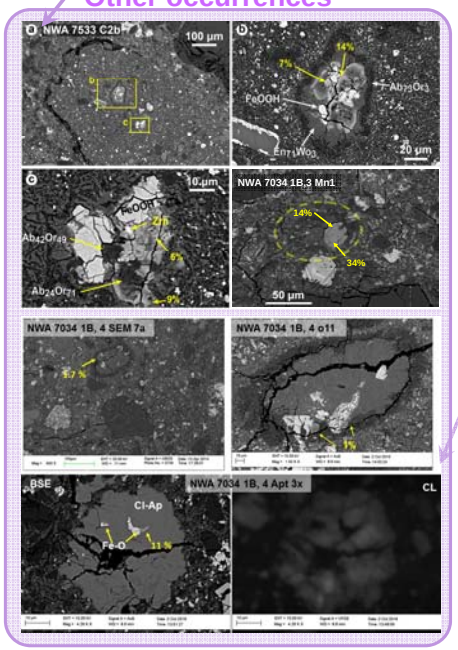
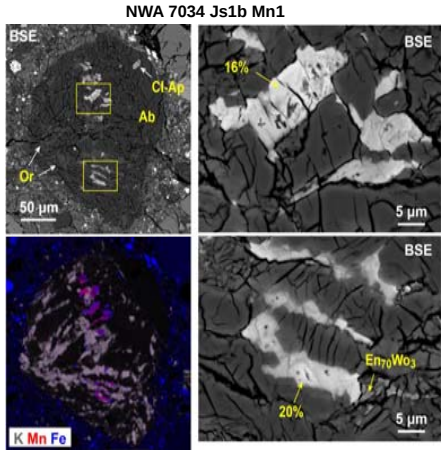
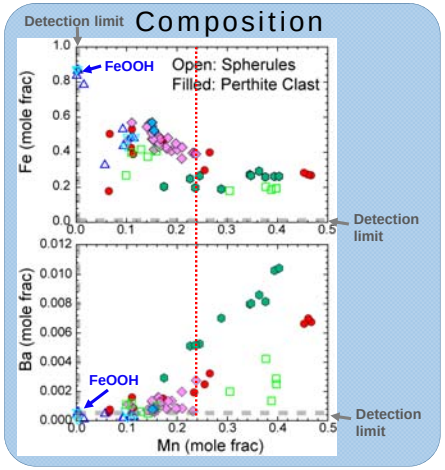
- Birnessite or vernadite as nanocrystalline aggregates in all eight sections of regolith breccias NWA 7034 and 7533
- Most common occurrence is in perthite-rich clasts, with occasional ≤1 μm zircons (Zrn); they also occur in spherules but not in the matrix of the breccias
- Large compositional variation within a clast
- The Mn contents are negatively correlated with Fe when the mole fraction of Mn (X_{Mn}) <0.24
- The Mn contents are positively correlated with Ba when X_{Mn} > 0.24, and those in perthite-rich clasts contain higher Ba

Origin on Mars in O_2-rich environment

- The source of Mn s not terrestrial, because cations in terrestrial weathering products are typically derived from materials inside the meteorites and desert varnish occurs only on the surface
- The source of Mn is not silicates inside NWA 7034 and 7533, as it would require significant alteration to provide enriched Mn
- It is unlikely to be a Martian Mn^{2+} salt (halite, sulfide) that was oxidized by terrestrial weathering, because such a phase is unknown in Martian rocks. A Martian Mn2+-carbonate would be stable on Earth
- The most likely explanation is Mn^{4+}-oxides formed on Mars in an O_2-rich environment
- The agent with high redox potential is likely di-oxygen (O_2) from free O_2, or products of oxychloride compounds or nitrides or hydroxides



Occurrences in Perthite-rich Clasts



Other occurrences