MANGANESE (SEDIMENTARY, HYPOGENE AND SUPERGENE)

	Source	Trap	Modification	Preservation
Critical Process	Addition and concentration of dissolved Mn to anoxic seawater	Addition of oxygen to anoxic seawater and precipitation of Mn oxides	Post-depositional modification of stratiform Mn in rocks	Exhumation and preservation of Mn oxide ores
Constituent Process: What are the processes that control the critical process?	Sustained presence of anoxic seawater Venting of Mn-bearing hydrothermal fluids into seawater Terrestrial erosion and transport of Mn-bearing materials to seawater Volcanic eruption and addition of Mn-bearing materials to seawater	Spurts of oxygen prior to 2.45 Ga–related to cyanobacterial activity Great Oxidation Event (2.45–2.1 Ga) – related to cyanobacterial activity Neoproterozoic Oxidation Event (~800–600 Ma) – end of stratified oxic-anoxic ocean Local enviornmental conditions promoting mixing of shallow oxidized and deeper anoxic, Mn-rich seawater	Burial and diagenesis, resulting in conversion of Mn oxides to Mn carbonates Supergene alteration of stratiform Mn carbonates to form massive Mn oxide layers Hypogene alteration of stratiform Mn carbonates, resulting in Mn oxide-rich veins and fault zones Structural pathways promoting fluid transport and alteration	Protection of Mn oxide ores from erosion Stable plateaus with slow rates of erosion
Targeting: How can we target each constituent process?	Basins Iron-formations Exhalative deposits (e.g. VMS)	Oxidized intervals in sedimentary rocks Stratiform Mn oxides Iron-formations Margins of basins	Mn-carbonates in sedimentary rocks Supergene Mn oxide zones Hypogene Mn oxide zones Pathways for Mn-bearing fluids	Hard caps on top of sedimentary carbonate rocks Plateaus and areas with abundant relict regolith
Mappable Proxies: Which layers are needed and how are they created?	Basins (m+tectonic) Iron-formations (m+WAROX) VMS occurrences (MINEDEX) Carbonate rocks (m+WAROX) Black (sulfidic) shales (m+WAROX) Clastic rocks (m+WAROX) Sedimentary rocks older than 2.45–2.1 Ga (m)	Red beds (m+WAROX) High MnO wt% content of rocks (c) Iron-formations (m+WAROX) Proximity to basin edges (m+tectonic) Barite (WAROX) Mn indicator minerals (WAROX) Gradients in basin thickness (m+tectonic) Mn oxide indicator minerals (WAROX)	Mn-carbonates, with microspheres (mc+WAROX) Supergene Mn oxide minerals (WAROX) Hypogene Mn oxide minerals (WAROX) 1:100 000 and 1:500 000 linear structures layers (m+g) Mn-rich pisolite and oolite accumulations (MINEDEX) Fault intersections with Mn-carbonate sedimentary rocks (m+g) High MnO/ Al_2O_3 (c) Syn-depositional faults in basins (m+g) High MnO/ (CaO + MgO(c) High MnO/ SiO_2 (c) High MnO/ Fe_2O_3T (c) High MnO Wt% (c)	Hard caps (m) Stable plateaus (m)

Data Sources

m = mapping
g = geophysical interpretation
i = isotopic ratios (e.g. Nd-Sm)
c = geochemistry
chron = geochronology
mc = mineral chemistry
s = reflectance spectroscopy
WAMEX = WAMEX database /reports
WAROX = WAROX database
rad = radiometric data

Blue text = geological proxy layer available in the Atlas [hyperlinked]
Scale of use: Terrane vs District
PD236

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