# Manganese source and mineralization in the Permian ocean in South China: the role of volcanism, submarine hydrothermal process and oxidation state of the ocean

HAO YAN[1], DAO-HUI PI[1*], SHAO-YONG JIANG[1, 2*]

[1]State Key Laboratory of Geological Processes and Mineral Resources, Collaborative Innovation Center for Exploration of Strategic Mineral Resources, Faculty of Earth Resources, China University of Geosciences, Wuhan 430074, China. Email: 18630112659@163.com, daohuipi@cug.edu.cn

[2] State Key Laboratory for Mineral Deposits Research, Department of Earth Sciences, Nanjing University, Nanjing 210093, China. Email: shyjiang@nju.edu.cn

Large amounts of manganeses accumulated in the Permain ocean in South China, such as the Zunyi Mn-carbonate ore deposit from Guizhou Province, southwestern China, which is hosted within the volcanic tuffs and limestones of Permian Longtan Formation of shallow marine facies. The ages of tuffs were determined at 259.4 Ma to 260.3 Ma by precise zircon U-Pb dating, indicating a close temporal relationship between Mn mineralization and the Emeishan LIP volcanism (ca. 259 Ma) [1].

Pisolitic, oolitic and clastic Mn-carbonate ores were cemented by tuffs, and displayed a causal linkage to the Emeishan large igneous event with high Al, Ti, Th, Sc contents, low initial $^{87}Sr/^{86}Sr$ ratios, trace elment compositions, REE patterns and Pb isotopic compositions. The negative values of both pyrite $\delta^{34}S$ and Mn-carbonate $\delta^{13}C$ in ores suggest that the ocean was redox stratified. Combined with previous studies [2], we suggest that both the volcanism, submarine hydrothermal process and redox condition of the ocean played a significant role for the Mn mineralization in the Permian ocean of South China. Large amounts of $Mn^{2+}$ was first released to the ocean through either submarine hydrothermal activity or water-rock interaction of volcanic tuffs that erupted contemporaneously to the Emeishan LIPs at Zunyi. Then, $Mn^{2+}$ was oxidized to form insoluble Mn-oxyhydroxide in surface ocean oxic condition. These Mn-oxyhydroxides precipitated and later on they were reduced to form Mn-carbonates at the redox interface during diagenesis, possibly dirved by organic matter decomposition. These Mn-carbonates were finally preserved as pisolite, oolite and clast ores in the sedimentary columns.

[1] Shellnutt et al. (2012) *Gondwana Research*. **22**, 118-126. [2] Wei et al. (2016) *Chemical Geology*. **440**, 1-14.