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Iron-oxide apatite deposits in eastern China formed by accumulation of magmatic hydrosaline chloride liquids

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Formation of iron-oxide apatite (IOA or Kiruna-type) deposits has been ascribed to either an immiscible iron phosphate melt separated from silicic melt or products from magmatic-hydrothermal fluids. The Ningwu volcanic basin in the Middle-Lower Yangtze River Valley metallogenic belt, Eastern China, hosts tens of Mesozoic IOA deposits. These deposits have mineral assemblages typical of actinolite (diopside)-apatite-magnetite. The orebodies are mainly hosted within the apical zones of the shoshonitic dioritic intrusions and/or at the contacts between the intrusions and overlying country rocks. The intrusions commonly have porphyritic textures and are compositionally similar to the overlying andesitic volcanic rocks suggesting they were formed at a shallow subvolcanic setting.

The orebodies have disseminated, net-textured, and massive magnetite commonly associated with extensive breccia rocks and wall-rock replacement. Magnetite mineralization was closely associated with extensive hydrothermal alteration zone of several km in diameter. The inner alteration zone within the intrusion is characterized by extensive albitization of albite and scapolite. It was gradually transitioned to an intermediate zone dominated by diopside/actinolite, epidote, apatite, and chlorite. The outer zone has extensive carbonate veins with possible abundant pyrite. Precipitation of magnetite was slightly later than albitization and was likely coeval with apatite and actinolite suggesting they are formed by hydrothermal replacement.

Coarse-grained to pegmatitic actionlite-apatite-magnetite veins commonly crosscut the main (disseminated to massive) iron orebody. Magnetite from both main orebody and ore veins have very high TiO_2 (up to 5 wt.%) and V_2O_3 (up to 0.6 wt%) compared to normal hydrothermal magnetite. Fluid inclusions of apatite may have multiple solid minerals and have homogenization temperature up to ~800℃. Apatite from ore assemblages is compositionally distinct from igneous apatite, whereas ore magnetite has elemental compositions similar to igneous magnetite but distinct from hydrothermal magnetite. Textural evidences suggest that the ore assemblages formed from volatile-rich breccia system with extensive alteration. We thus propose a new genetic model that IOA ores were formed by accumulation of high temperature (~800℃) volatile-rich hydrosaline liquids (a highly chlorine concentrated brine) in shallow subvolcanic settings. The hydrosaline liquids were likely immiscible fluid phases in equilibrium with silicate melts during the magmatic-hydrothermal transition. Fluid expansion

and evolution of such unusual hydrosaline system is responsible for the extensive Na-Fe alteration and brecciation, which is characterized in IOA deposits.