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# Occurrence patterns and enrichment mechanism of Co in the world-class Panzhihua Fe-Ti oxide deposit, SW China

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Co is a crucial strategic and critical metal mineral. The Panzhihua deposit is the largest Fe-Ti oxide deposit in the world and holds 10,000 to 20,000 tons of Co resource with grades varying from 0.01% to 0.02%. The Panzhihua gabbroic intrusion can be divided into 6 phase zones: Upper zone, Middle zone(b), Middle zone(a), Lower zone, Bottom zone and Marginal zone. The oxide ores are concentrated in the Middle zone(a) and Lower zone. Detailed field geological investigations, major and trace element analysis, mineralogical analysis including EMPA, LA-ICP-MS and mineral mapping have been conducted to study the occurrence patterns and distribution of Co-Ni, identify Co independent minerals, and discuss the controlling factors for Co enrichment mechanism. Co, Ni are predominantly enriched in the massive magnetite (average 277.06 ppm Co, 281.09 ppm Ni) of the Lower zone. Co occurs as three types:(1) independent minerals such as cobalt pentlandite ($Co_{3.96-6.98}Ni_{0.85-2.62}Fe_{1.36-2.53}S_8$), linnaeite ($Co_{1.65-1.88}Ni_{0.99-1.05}Fe_{0.15-0.37}S_4$), Co-bearing pyrite ($Co_{0.09-0.12}Fe_{0.89-0.93}S_2$), pentlandite($Co_{0.53-0.55}Ni_{4.57-4.65}Fe_{3.80-3.83}S_8$) and siegenite ($Co_{1.22-1.25}Ni_{1.28-1.30}Fe_{0.55-0.58}S_4$); (2) isomorphic state substituting for Fe and/or Mg in pyrrhotite (111.23-1964.32 ppm), olivine (160.74-184.14 ppm), pyrite (2.95-272.14 ppm), titanomagnetite (57.11-180.86 ppm), ilmenite (56.55-110.38 ppm), pyroxene (33.84-39.63 ppm); (3) microscopic inclusions in chalcopyrite. Magmatism, including mantle partial melting, fractional crystallization, sulfide segregation and crystallization, and hydrothermal activities are controlling factors for Co enrichment. Partial melting controls the initial Co, Ni content of the primary magma. Early crystallization of olivine at depth removes Co, Ni and result in Co, Ni depletion in the parental magma of the Panzhihua intrusion. Co, Ni strongly partitions into the sulfide melt during sulfide segregation. Crystallization of sulfide melts results in the formation of Co, Ni independent minerals (such as cobalt pentlandite) extremely enriched in Co, Ni. In the residual silicate melt, fractional crystallization results in the Co, Ni enrichment in earlier crystallized olivine, titanomagnetite and the Ni depletion in later crystallised pyroxene, ilmenite. Hydrothermal activities contribute to the successive activation and replacement of Co in magmatic sulfide minerals, leading to the formation of hydrothermal Co-rich minerals (such as linnaeite). The research will offer valuable insights into understanding the Co mineralization, resource assessment and comprehensive utilization in magmatic Fe-Ti oxide deposits.

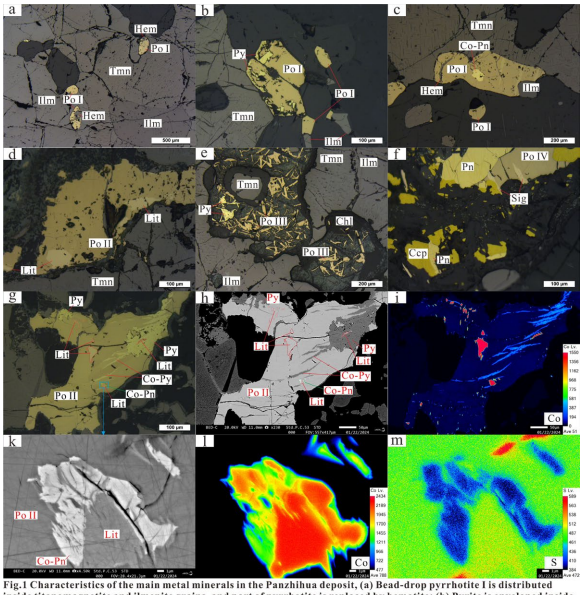


Fig.1 Characteristics of the main metal minerals in the Panzhihua deposit, (a) Bead-drop pyrrhotite I is distributed inside titanomagnetite and ilmenite grains, and part of pyrrhotite is replaced by hematite; (b) Pyrite is enveloped inside flaky pyrrhotite I; (c) Cobalt pentlandite is enveloped inside flaky pyrrhotite I; (d) Linnaeite is enveloped inside flaky pyrrhotite II; (e) Fibrous pyrrhotite III is coexist with pyrite and chlorite; (f) Pyrrhotite IV is coexist with pentlandite, chalcopyrite, siegenite; (g, h, i) Pyrrhotite II is coexist with linnaeite, which were replaced by the pyrite and the vein-like Co-bearing pyrite, g-microscopic image, h-back-scattered electron image, i-mapping image of Co elemental; (k, l, m) Cobalt pentlandite is replaced by pyrrhotite II and linnaeite, k-back-scattered electron image, l-mapping image of Co elemental; m-mapping image of S elemental; Tmn-titanomagnetite; Ilm-ilmenite; Po-pyrrhotite; Hem-hematite; Py-pyrite; Co-Pn-Cobalt pentlandite; Lit-linnaeite; Chl-chlorite; Sig-siegenite; Ccp-chalcopyrite; Pn-pentlandite.

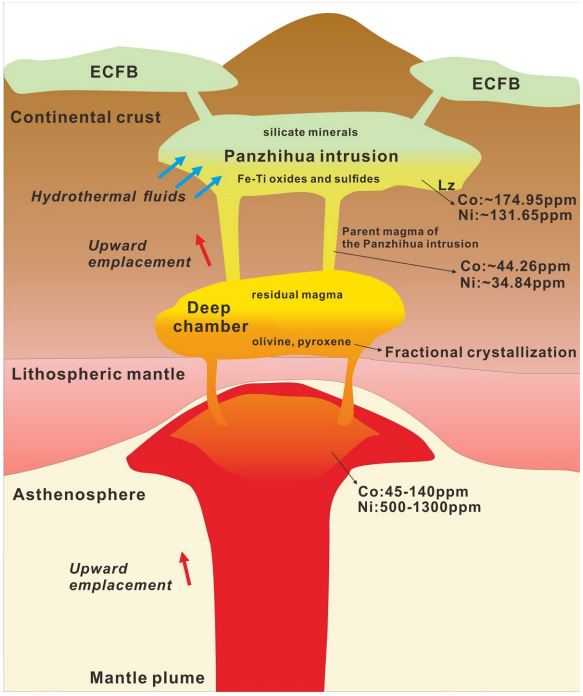


Fig.2 Cartoon diagram showing the enrichment process of Co, Ni