Geochemistry of Mine water and Tailing at Malanjkhand Copper deposit

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Abstract

The Malanjkhand porphyry copper deposit, located in Madhya Pradesh, is the largest copper mine in Asia. The detailed hydrogeochemical study indicates that mine discharges are highly acidic (3.4–4.4) with very high concentration of Cu (9.2–60.8 mg/L). The pH value of the tailing pond 2.39–2.48 and concentration of Cu 15.6–65.2 mg/L were measured. Groundwater is not polluted while the river downstream of mine is influenced by mine discharges. The water quality of the mine discharges and tailing is mainly affected by the oxidation of chalcopyrite, which present abundantly in the host rock along with minor amount of pyrite. Alpersite, gypsum, epsomite and hexahydrite occur as efflorescent salts during the summer time, and store very high concentration of metals. Alpersite contains Zn (285-391 mg/kg), Ni (62-78 mg/kg) and Cu (7.8-10.9%) whereas epsomite contains Zn (132-160 mg/kg), Ni (35-43 mg/kg) and Cu (3465-4184 mg/kg). Among trace elements in tailing Cu has the highest concentration range (98.2–4492 mg/kg) followed by Mn (131.4–760 mg/kg), Zn (54.3–241 mg/kg), Ni (25.7–170.3 mg/kg) and Pb (12.5–46.4 mg/kg). Tailing rich with efflorescent salt has maximum concentration of metals as well as maximum potential for releasing metals into the aqueous system.
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Introduction

• Mining activities at copper deposit leads to the generation of acid mine drainage
• AMD is characterized by low pH, high concentration of $SO_4^{2-}$ and metals.
• The AMD is caused by oxidation of the sulphide minerals, mostly pyrite and chalcopyrite, occurs in the host rock of copper mineralization
• Surface water and ground water are contaminated near
\[
\begin{align*}
\text{CuFeS}_2(s) + 4.25\text{O}_2(g) + 2.5\text{H}_2\text{O} &= \text{Fe(OH)}_3(s) + \text{Cu}^{2+} + 2\text{SO}_4^{2-} + 2\text{H}^+ \\
\text{FeS}_2(s) + 3.75\text{O}_2(g) + 3.75\text{H}_2\text{O} &= \text{Fe(OH)}_3(s) + 2\text{SO}_4^{2-}(s) + 4\text{H}^+
\end{align*}
\]
Geological Setting

• Malanjkhand copper deposit, located in Madhya Pradesh, Central India, is phophory in nature and the largest one in Asia.
• Total reserve of 331 million tons and annual production of nearly 2 million tons with average grade 1.05% Cu.
• The mining activities started in the year 1982 by Hindustan Copper Limited.
• A concentration plant of 2 MT capacity is located where Cu is extracted through heap leaching process.
Mineralization at Malanjkhand is caused by the hydrothermal fluid and mostly confined to an arc-shaped quartz reef striking for a length of 2.6 km-long along N-S direction, which contains chalcopyrite-pyrite mineralization.

The average width of the quartz reef is around 75 m.

The pink granitoid is more enriched with Cu-mineralization in comparison to grey granitoid of the rest of the pluton.
• Fresh tailings consist mostly of quartz followed by moderate quantity of muscovite, chlorite, orthoclase and plagioclase along with minor amounts of hornblende, pyrite and chalcopyrite.

• Efflorescent salt precipitates over the old tailing during summer time consist of alpersite, hexahydrite, gypsum, anhydrite and epsomite.