Oxidative and reductive bioprocessing of cobalt-containing ores and biomineralisation of cobaltiferous leachates

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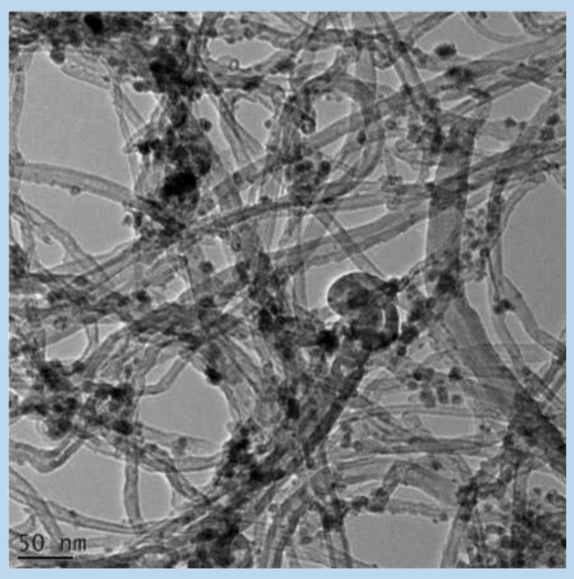
Background

Cobalt is a silver-coloured transition metal which has seen greatly increased global demand in recent decades. Its use in various manufacturing and technological industries, including as a component of rechargeable batteries, super-alloys and catalysts has contributed notably towards this. With a global market value of ~ US$2.1 billion (2013), and limited suitable alternatives, finding new sources of cobalt and developing novel and environmentally-benign (bio)processing technologies to extract and recover this metal are high priorities.



Example of a cobalt catalyst supported on Carbon Nanotubes (Rose *et al*., 2014)

The COG³ Consortium Project

The COG³ (the Geology, Geometallurgy and Geomicrobiology of Cobalt resources leading to new product streams) consortium project is funded by the *Natural Environment Research Council* (UK).

It aims to provide new insights and understanding of how cobalt behaves in geological systems and how cobalt-bearing minerals form in natural environments. The project will also focus on the biogeochemistry of cobalt and optimise protocols for both bioleaching cobalt mineral ores and targeted biomineralization of cobalt-containing leach liquors (PLS), both to recover the metal and to generate technologically functional nano-particles with tailored magnetic and pharmaceutical properties.

Project Partners

Cobalt-bearing ores, and current extraction technologies

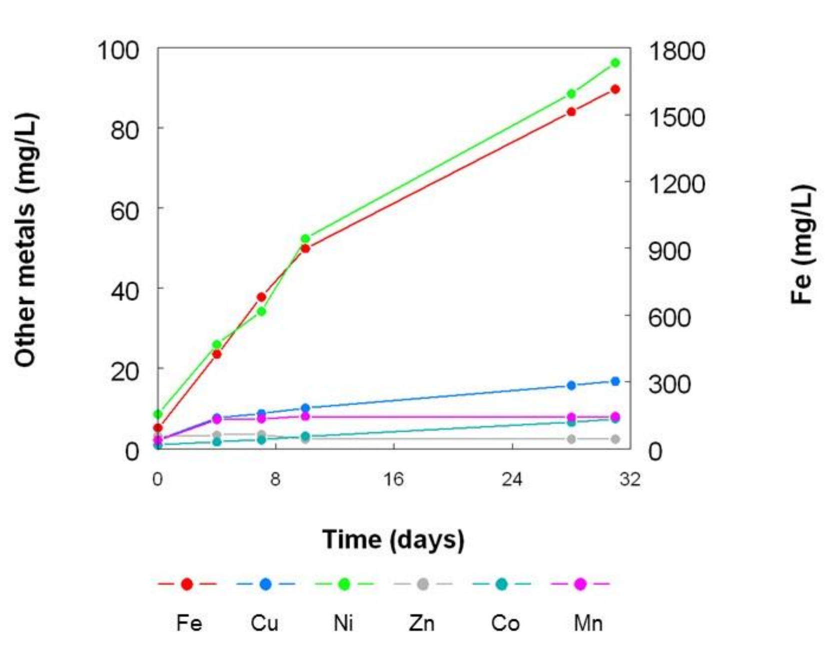
Cobalt is found in a number of different types of (potential) ore reserves, including reduced magmatic sulfide deposits, and oxidized laterite deposits, manganese nodules and "cobalt crusts" (BGS, 2009).

Example of a cobalt-containing limonitic laterite ore

Current methods of cobalt extraction and processing are energy-intensive, with large carbon footprints. Depending on the ore type, the extraction methods involve leaching, froth flotation, or the production of a matte. Copper (often the major metal in magmatic ores) is then recovered and impurities (including cobalt) are removed. Cobalt is then recovered by precipitating as cobalt hydroxide or cobalt sulfide, after which the pure metal can be recovered (Roberts and Gunn, 2013).

Preliminary data

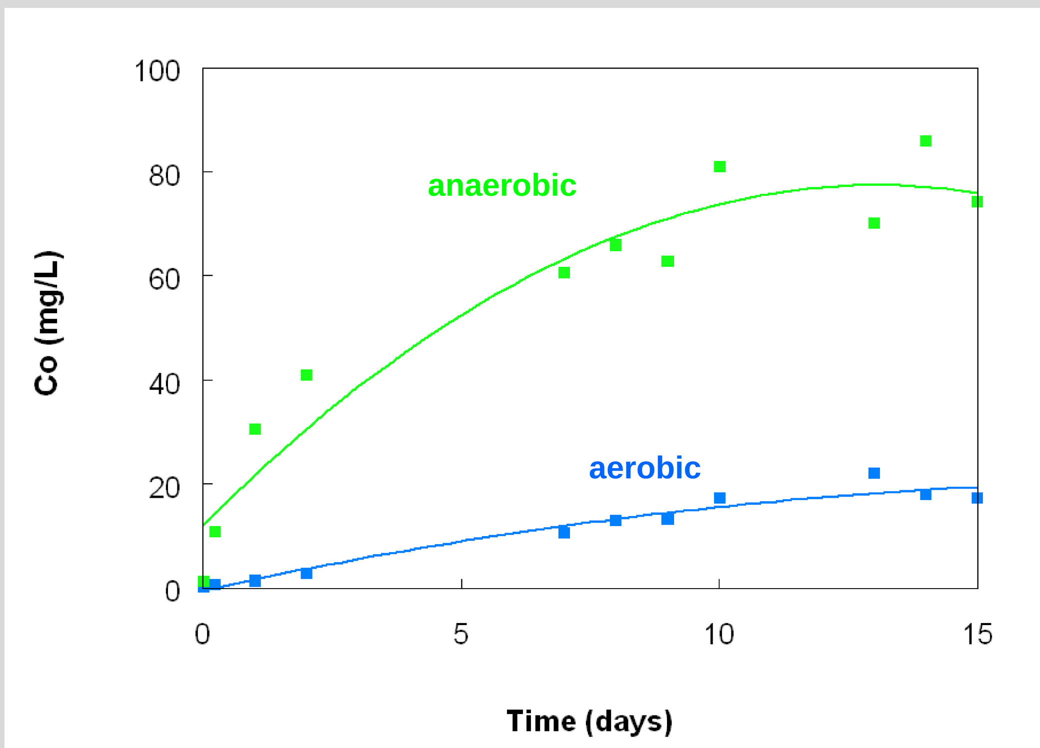
Initial laboratory experiments have confirmed that cobalt can be successfully bioleached from both oxidised and reduced deposits at 35ºC and pH1.8.



	Amount extracted (mg/100g)
Fe	3,200
Ni	200
Cu	35
Mn	18
Co	17
Zn	5

Oxidative bioleaching of a cobaltiferous pyrite ore (from Sakatti, Finland) by a consortium of mesophilic iron- and sulfur-oxidising acidophilic bacteria.

Anaerobic bioleaching of Co from a limonitic laterite ore



Comparison of aerobic and anaerobic bioleaching of cobalt from a laterite ore (Shevchenko, Kazakhstan) by a consortium of mesophilic iron-oxidising and iron-reducing acidophilic bacteria.

Bioprocessing cobalt-bearing ores

Two bioleaching options are available for processing cobalt-bearing ores:

- Oxidative bioleaching of reduced (e.g. sulfidic) ores;
- Reductive bioleaching of oxidised ores (e.g. laterites, or Mn nodules).

The first of these has been successfully demonstrated at a full-scale operation at Kasese (Uganda) where cobalt was extracted in stirred tanks from Co-rich pyritic tailings produced from copper mining, and recovered from PLS using solvent extraction and electrowinning (SX-EW; Morin and d'Hugues, 2007).

Cobalt associated with manganese(IV) minerals (e.g. asbolane) has also been bioleached successfully (lab scale) from lateritic ores, via reductive mineral dissolution (Johnson *et al*., 2013).

Future work

Future work will involve screening a large range and number of cobalt ores from different global locations for oxidative and reductive bioleaching, selective recovery of Co from PLS via biosulfidogenesis and liaising with partners in the consortium to synthesise specific Co mineral end products.

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Cobalt
Geology, Geomicrobiology, Geometallurgy