# The geology, geometallurgy and geomicrobiology of cobalt resources leading to new product streams

**Cobalt is recognised as an important technology enabling metal and classified as a critical material by the European Union.**

The CoG$^3$ project will:

- understand the natural behaviour and biogeochemistry of cobalt.
- develop and apply novel bioprocessing strategies for cobalt extraction, recovery and synthesis of targeted products.

Co-rich arsenide ore, Bou Azzer

This project will deliver:


Test pit at Piauí Ni-Co laterite, Brazil

- New knowledge about cobalt residence and cycling in natural systems.
- New bioprocessing strategies for cobalt ores and the development of bioengineered and biomineral products.
- ‘Mine to product’ concept for cobalt.
- Increased public understanding of cobalt and its place in modern society.

## Work Package 1 - The New Sources of Cobalt

The aim of this work package is to provide detailed mineralogical, chemical and atomistic-scale characterization of natural Co-bearing materials that represent potential new sources of the element. This comprehensive characterization program will underpin the proposed research of work packages 2-4. Cobalt-containing materials from four contrasting reserves will be studied:

- **Cobalt-rich laterites**: Shevchenko, Acoje, Çaldağ, Piauí
- **Seafloor Fe-Mn crusts and nodules**
- **Reduced sediment-hosted Co ores:** Central African Copperbelt, Kupferschiefer
- **Chalcogenide** mineralogy of Bou Azzer, Morocco.


## Work Package 2 - Natural Biogeochemistry of Cobalt: Biotic and Abiotic Constraints on Cobalt Mineral Formation and Transformation

This work package will unravel the natural biogeochemistry of cobalt in aerobic and anaerobic environments, studying potential interactions with microbiota and their effects on cobalt speciation and mobility using field samples and extant microbial communities.

**The work will:**

- **Increase our knowledge of trace element cycling and the formation of Co-rich ores.**
- **Increase information on options for bioprocessing of such ores.**

- One focus is to investigate key Fe(III) host mineral phases using a combination of characterization techniques, including synchrotron methods.
- Geochemical, microbiological and mineralogical analyses will give a unique dataset illustrating the phase associations of Fe, Mn, and Co during microbial redox experiments.
- High density pure cultures of the well-studied model laboratory Fe(III)- and Mn(VI)-reducing bacteria will be used for bioprocessing in WP3.

Diamond Light Source, the UK synchrotron facility

## Work package 3 - Bioprocessing of Cobalt: Abiotic and Biotic Leaching and Production of New Biomineral Products

This work package focuses on:

- Environmentally-benign bioprocessing for extracting cobalt from primary ores.
- Recovering cobalt from the process liquors.
- Biomineralization of cobalt to synthesize targeted products.

These biological strategies for metal recovery will be compared with existing technologies which to date have focused on abiotic leaching for recovery of metals of interest.

Experimental reductive bioleaching

**Bioprocessing** will use microorganisms (bacteria, archaea and fungi) to bioleach Co-containing ores and mineral concentrates and to selectively remove Co from leach solutions. By combining these two components, novel integrated approaches will be devised to facilitate the recovery of Co from primary ores.

**Biomineralization** will be used to selectively precipitate Co from the leach solutions in the form of sulfides, oxalates, carbonates and phosphates depending on the microorganism used.

## Work package 4 - Improving the Supply Chain of Cobalt

Here the focus is:

- improving the cobalt supply chain through research into the geometallurgy of cobalt with direct engagement of industry.
- organization of a major industry-science technology forum, brokered by the Cobalt Development Institute, aiming to drive technology transfer, increase stakeholder engagement and promote awareness of security of supply.

Research will focus on the geometallurgy of cobalt-bearing sulfide ores in order to develop environmentally-friendly extraction of cobalt from these sources.

Experimental laboratory work will be conducted to develop a geometallurgical model which integrates the effect of mineralogical and geotechnical properties of characteristic ore types, flowsheet design, process variables such as grind size and reagent type and dosage.

The CoG$^3$ project is led by Professor Richard Herrington at the Natural History Museum, London.

The consortium comprises 8 UK academic institutions and 7 industry partners, training 7 PhD students and 6 post-doctoral researchers to become the next generation of multidisciplinary mineral resource scientists.

It has £2.5 million NERC funding and in excess of £250k direct industry support.

**www.nhm.ac.uk/cog3-project**

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