BIO SHALE

Search for sustainable way of exploiting black shale ores using biotechnologies

BIOSHALE PARTNERS

BRGM - Geosciences for a sustainable Earth
BRGM - Project & WP5 leader - France

KGHM Cuprum Ltd. CBR
CBR - WP2/topic leader, technique - Poland

Wroclaw University of Technology
PWR - Poland

University of Opole
UO - Poland

University of Warsaw, Faculty of Biology
UW-FB - Topic leader, Environment - Poland

Geological Survey of Finland
GTK - WP1/6 leader - Finland

Helsinki University of Technology
TKK - Finland

Tecnicas Reunidas
TR - WP4 leader - Spain

University of Wales, Bangor
UWB - WP3 leader - UK

Warwick University, Biological Science
WU-BS - Topic leader, Biology - UK

G.E.O.S. Freiberg, Ingenieurgesellschaft mbH - GEOS - Germany

University of Mining and Geology “Saint Ivan Rilski” - Sofia
UMGS - Bulgaria

Czech Geological Survey
CGS - Czech Republic

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With the kind collaboration of:
- KGHM Polska Miedź S.A. (Poland)
- TVK (Talvivaara Company, Finland)

GENERAL INFORMATION

- Duration:
  3 years (start date 1st October 2004)
- Total budget:
  3.4 M€ (EC 2.3 M€)
- Partnership:
  13 Partners/8 European countries
- Project efforts:
  553 MM (+226 MM Universities Own resources)
- Reporting:
  22 Deliverables

CONTACT/ PROJECT COORDINATION

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**WORK PROGRAMME**

European deposits of black shale ores, in particular, the “Kupferschiefer”, contain considerable reserves of base, heavy, rare and precious metals (Cu, Ni, Zn, Pb, Ag, Zn, Co, Mo, Re, V, Se, Sn, Bi, Au, Pt, Pd, etc.) of which Europe is the main consumer. The black shale ores are typically poly-metallic ores with a variable proportion of sulphidic components. In black shale ores, metal-bearing compounds are dispersed as small-size particles and the valuable metals may be trapped in organic matter in the ore or in slimes.

Two major difficulties restrict the exploitation of such abundant resources: Low efficiency of the conventional techniques from mining extraction to metallurgical processing; Environmental impact of the application of the conventional techniques.

**BIOSHALE project aims at developing Biotechnology for a safe, clean and viable exploitation of black shale ores for metal production and at designing an innovative model of development of mining activities.**

The main milestones of the project are the following:
- Evaluation of the geological resources (geological modelling);
- Selection of metal-bearing components & biological consortia to be tested;
- Assessment of bioprocessing methods and determination of complementary hydrometallurgical processing routes for metals recovery;
- Risk assessment relative to wastes management of the new processing routes;
- Techno-economic evaluation of new processes from mining to metal recovery including social and environmental impacts.

The innovations should have a long-term impact on the mining industry with regard to the challenge of creating knowledge-based industries.

Three Black shale deposits, under natural conditions (Talvivaara), during mining (Lubin) and after mining (Mansfeld) have been chosen as targets of the project R&D actions. The social and economic benefits of this project would be the extension of the exploitation life of European mining sites in operation (Lubin) and to allow exploitation of new resources with considerable reserves (Talvivaara).

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**Project Organisation WP**

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**MULTIDISCIPLINARY PROJECT**

- Geology,
- Mineralogy,
- Mining,
- Microbiology,
- Molecular Biology,
- Biotechnology,
- Mineral processing,
- Hydrometallurgy,
- Process simulation,
- Environmental Assessment,
- Ecology,
- Socio-economic evaluation.

Integrated approach with technical, environmental and biological aspects treated in each work package.
DELIVERABLES - BIOSHALE 1st Year

WP1 (Geology) - Characteristics of the black shale deposits and ores samples

The objectives of the work in the first deliverable of WP1 were:
- to compile reviews of published and unpublished data on Lubin, Talvivaara and Mansfeld deposits,
- to compile an overview of geological characteristics of black shale deposits in the world,
- and to select ore samples for chemical, petrographical, mineralogical and processing studies for WP2, WP3 and WP5 of the Bioshale project.

Sampling campaigns were carried out in 2005: in Lubin mine in Poland in January, in the Mansfeld area in Germany in April, and in Talvivaara in Finland in May. In addition, a sample of the Talvivaara ore was provided for processing tests in December 2004.

WP1 - WP2 Selection of efficient bioleaching microorganisms

“Bioprospecting of black shale ores, mine spoils and tailings, and selection of efficient bioleaching microbial systems”

The objectives of the work were:
- to undertake bioprospecting of black shale ores, shale spoil and tailings in the Lubin, Talvivaara and Mansfeld deposits,
- to isolate and cultivate microorganisms that have potential for enhancing the release of base and noble metals from black shales.
- to screen pure cultures and consortia for their abilities to enhance the oxidative dissolution of sulfide minerals and the degradation of organic matter in black shale deposits.

Microorganisms were collected from each of the sites (Lubin, Mansfeld, Talvivaara) during the field trips. Both water samples and rock samples were taken for cultivation process & direct identification by molecular biology.

WP2 – Black shale samples preparation

The main activities in WP2 were dedicated to:
- Review of the processing history of the Mansfeld black shale ores during the 800 years mining
- Preparation of Lubin black shale and Talvivaara ore samples for purposes of research
- Evaluation of the existing and development of new mining and mineral processing methods for obtaining concentrated shale samples.

WP5- Characterisation

Some work was started in WP5 in order to characterise the mineralogical association (including organic matter) of each type of ores (defined in the WP1) and evaluate possible optimisation during selective exploitation (WP2) and process (WP3, WP4).
WP3 Selection of bacterial consortia for process scale-up tests bacterial cultures & study on the applicability of bioflotation

Preliminary research activities focused on isolating and identifying novel microorganisms (and those available in personal culture collections) that have potential for (a) extracting metals from ores, by accelerating the oxidative dissolution of minerals (metal sulfides); (b) facilitating metal extraction from black shales, by metabolising organic materials.

One of the targets of Bioshale project (Talvivaara Deposit) belongs to a company that carries out extensive R&D studies to demonstrate that “Bio-Heap leaching” might be used in order to recover Ni, Zn and Cu from the ore.

In the frame of Bioshale, a large ore sample of 200 tons was extracted from the Talvivaara deposit and delivered to GTK in February 2005. The sample was prepared for a pilot scale “bio-heap leaching” column that started at GTK in March 2005.

Research carried out in parallel examines and develops biomolecular and cultivation techniques for monitoring these microorganisms.

A number of groups have been involved in investigating whether biological agents can be used to improve the efficiency of mineral flotation, with particular regard to black shales.

WP4 - Definition: Process variant selection options and test work programme

The preliminary work in WP4 was mainly focused on preliminary “process design” in order to develop new bio-hydrometallurgical process for the recovery of valuable metal from black shale ores and concentrates.

More precisely, reasonable process unit operations were described and commented based on the state of the art knowledge and on former experience of the project research teams.