Paul Norris

Honorary Speaker at the 22nd IBS in Freiberg

Paul Norris started his experience in biohydrometallurgy in the year 1972 with his PhD-thesis at the University of London, UK, on the accumulation of metals by microorganisms with Prof. Don Kelly as supervisor. Paul continued in cooperation with Don Kelly his work as Lecturer in Biological Sciences at the University of Warwick in the UK focusing on bioleaching microorganisms. Paul retired from Warwick in 2013.

Paul became aware of iron- and sulfur-oxidizing bacteria principally through Olli Tuovinen's work with *Thiobacillus ferrooxidans* (as it was known in 1972). Paul's first year of PhD-study, where he was dealing with the accumulation of metals by microorganisms, overlapped with Olli's final year. Both were supervised by Don Kelly at the University of London's Queen Elizabeth College. After moving to the University of Warwick with Don Kelly, Paul began working with mineral sulfides during Jim Brierley's visit to the laboratory in 1976 and this led to further bioleaching and other studies with organisms from acidic, mostly thermal environments.

Paul Norris was awarded "The John Phillips Medal (1997)" by the UK Mineral Industry Research Organization (MIRO) for work on biomining. He did consulting for several mining companies between 1982 and 2013 for the application of microorganisms in environmental biotechnology and bioleaching. Paul´s first contribution to an IBS was in 1978. Since then he served as member of the IBS Scientific Committee until 2009.

Paul Norris talking with Jim Brierley…

Some of his most interesting contributions to metal accumulation, extremophile microbiology and biohydrometallurgy include: studies of metal uptake in yeasts (1977) and (possibly) the first publications of *Leptospirillum ferrooxidans* in pure culture on pyrite (1982); of rapid autotrophic growth of moderately thermophilic bacteria and thermophilic archaea on mineral sulfides (1983); of the mechanisms of carbon dioxide fixation (1989) and ferrous iron oxidation (2007) in thermoacidophilic archaea; of bioleaching in high temperature (80°C) reactors (1993); of descriptions of *Sulfobacillus acidophilus* (1996), *Acidimicrobium ferrooxidans* (1996), ferrous iron-oxidizing ferroplasmas (1998), thermotolerant *Acidihalobacter* species (2010) and the moderately thermophilic, bioleaching actinobacterium '*Acidithiomicrobium*' (2007, 2011).

In 2013 Paul Norris was awarded "Honorary University Fellow" visiting the Environment and Sustainability Institute at the University of Exeter's campus at Penryn, Cornwall, UK.

We are looking forward to future readings of many exciting publications summarizing Paul´s experience in the field of biohydrometallurgy!

850 Years of Ore Mining in Saxony - Lessons (to Be) Learned

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Keywords: Variscides, ore veins, greisen, skarn, ore mining, exploration, tin, tungsten, lithium, indium, fluorite, mining data, public acceptance, resource policy, Erzgebirge, Saxony.

Abstract. Geology blesses the Free State of Saxony with a wide variety and wealth of ore and spar deposits. In Saxony the beginning of ore mining dates back to the middle of the 12^{th} century, when silver extraction from veins started in the Freiberg region. During the past 850 years landscape and nature in the mining districts, the society, its history and culture, as well as innovation in science and technology, were driven by mining and processing of metal ores. Over the century's phases of intense mining activity alternated with collapses of the mining industry. After the most intense mining phase during German Democratic Republic (GDR) times the last tin mine was shut down in 1992. Up to now remediation of underground openings, mine dumps and shafts eliminates the massive legacies of extensive state mining. With the global rise of metal prices companies applied for the first new exploration licenses in 2005. Since then 50 applications were issued by the State Mining Authority of Saxony. With the first new underground fluorspar mine (Niederschlag) and several successful exploration projects on poly-metallic deposits Saxony faces the rising of a new era of ore mining. Based on an active resource policy the Free State of Saxony intends to implement a new generation of profitable, safe and environmentally compatible ore mines that meet with acceptance in the society.

Ore Geology

The underground of Saxony is part of the west- and mid-European Variscides [1]. Ore and spar resources are widespread over the state. Recent awareness marks three ore districts in Saxony as most relevant: a) the Kupferschiefer deposits as eastern part of the German Copper Belt with resources especially of Cu, Ag, Pb and Zn [2, 3], b) rare earth element resources in carbonatide complexes near Delitzsch [4] and c) the poly-metallic ore district of the Erzgebirge ("Ore Mountains") with parts of the Vogtland. The Kupferschiefer and the Delitzsch structure were not mined so far in Saxony and can be considered as relevant future resources [5]. In contrast, the Erzgebirge was and is an important ore mining province in Europe, still containing prolific deposits of Ag, Sn, W, Li, In, U, Pb, Zn, Cu, Bi, Co, Ni, Ge and Ga. As an example, the Erzgebirge is suggested to be among the largest In-enriched ore districts known worldwide [6]. Several of the southernmost deposits extend cross-border into the Krušné hory as adjacent part of the mountain range in the Czech Republic.

The geology of the Erzgebirge is built of a large antiformal megastructure with a core of para- and orthogneisses and mica schists, which are tectonically overlain by phyllitic units of low metamorphic rocks [7]. Ore deposits in the Erzgebirge origin form different types of mineralization mainly of late-, and post-Variscian age. Main deposits consist of mineralized veins, skarn and greisen. Specific vein deposits and greisen are associated with granite intrusions. Poly-metallic veins are hosted by gneisses, mica shists, granites or different metamorphic units [7].

Mining History

Recorded history reports that in the year 1168 pure silver was found in the ground of a small settlement (Christiansdorf) located in the vicinity of Freiberg today [8]. Extensive silver mining developed rapidly and spread over the Erzgebirge during the following centuries. With silver as main target of production, other ore metals like Sn, Zn, Ni, Bi, Pb, Co, U or Cu were extracted depending on demand and technical possibilities in mining and processing. Periods of flourishing mines were interrupted by collapses of the mining industry in particular due to wars or basic technological or economic problems. With a more general view, three main phases of historic mining are distinguished for the Erzgebirge, which are referred to as *Berggeschrey (~ mining hype)*. The first *Berggeschrey* developed after mining was initiated in the 12th century. The beginning of the so called second *Berggeschrey* is dated to the late 15th century after rich new silver veins were opened up in Schneeberg and other communities.

The most intense mining phase in the Erzgebirge so far, the third *Berggeschrey*, took place during GDR times. Forced by the will of economic autarky the state mining industry of the GDR explored and exploited its ore deposits over four decades extensively and in a non-sustainable way. As most important and most intense mining activity the Soviet-German mining company SDAG Wismut produced 231 kt of uranium between 1946 and 1990 [9]. With the reunification of Germany all active ore mines in the Erzgebirge were shut down at the beginning of the 1990's due to the economic change.

Since closing of the last tin mines in Altenberg and Ehrenfriedersdorf until 1992, the Erzgebirge faces the consequences of 850 years of ore exploitation. Nowadays the Free State of Saxony spends between 10 to 15 Mio. € annually to remediate suddenly occurring caves to the surface, collapsed mining galleries, instable shafts and mine water outbursts as dangerous legacies of the past. Just on secure closure of the uranium mines and coverage of its waste rock heaps and tailing ponds the Federal State of Germany as new owner of the former GDR mining company Wismut AG expended funds of about 2.7 billion € in Saxony. Today, 25 years after shutdown of the last ore mine, remediation work at most of the mines is almost completed. Only local mining tradition and visitors mines remind tourists of the former mining activity in the Erzgebirge.

New Ore Mining in the 21st Century

With the increase of raw material prices on world's market ore and spar deposits in Saxony attracted companies and investors also from abroad again. Since 2006 about 50 mining licenses (exploration or exploitation) have been granted for ore and spar deposits by the State Mining Authority of Saxony. The close correlation between application activity in Saxony during the past 10 years and world's metal prices illustrates how intense global financial dependences effect investment even in small and specific mining district like the Erzgebirge (Fig. 1).

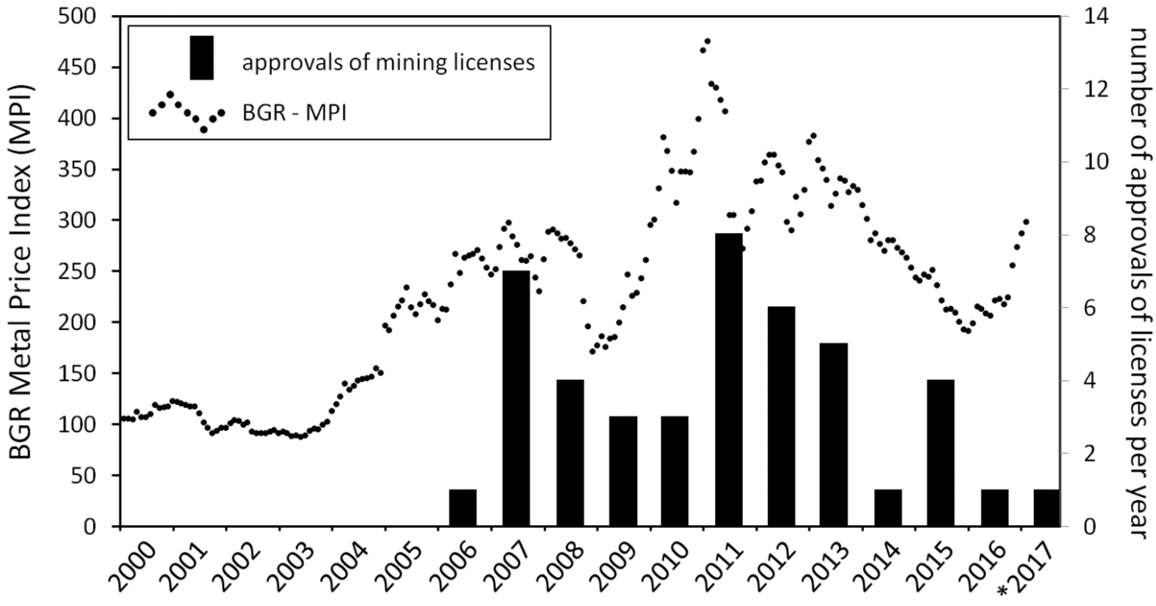

Fig. 1. Annual number of approvals by the State Mining Authority of Saxony for exploration and exploitation licenses on ore and spar deposits compared to the metal price index BGR-MPI [10] as a measure for the world price level of metals (* until April 2017).

Since 2006 almost the entire area of the Erzgebirge in the south of Saxony was covered by mining licenses (Fig. 2). The German Mining Act defines strong restrictions regarding the duration of licenses and the need to return or revoke licenses in case of inactivity and of exploration results that are economically not sufficient for the company. As a result a turnover of projects takes place continuously leading to an average of 15 to 20 active licenses during the last years. Even the slump in metal prices between 2013 and 2016 was successfully bridged (Fig. 1). This fuels the expectation that the new *Berggeschrey* will continue for the next decades.

For most of the new projects the companies applied for exploration licenses. So far economic exploration mainly concentrates on Sn, W, F and Li deposits. For these raw materials total resources still deposited in the Erzgebirge are estimated to about 770 kt Sn, 230 kt W, 6.5 Mt F [5] and 96 kt Li in the German part of the Zinnwald field [11]. The new exploration projects differ in organization, financing and operation. Some projects remain as low budget enterprise, others are well financed. Some projects are restricted to reevaluation of old data and some field work, others consolidate existing geological and mining information with new exploration data from drilling, sampling and analytics to a sound reevaluation of the deposit. Finally exploration ends after a feasibility study or results in an internationally accepted standard resource classification like the JORC Code for the Sn deposits Sadisdorf (JORC resource 15 kt Sn) and Gottesberg (JORC resource 114 kt Sn) [12] or the PERC–Report for the lithium project in Zinnwald [11].

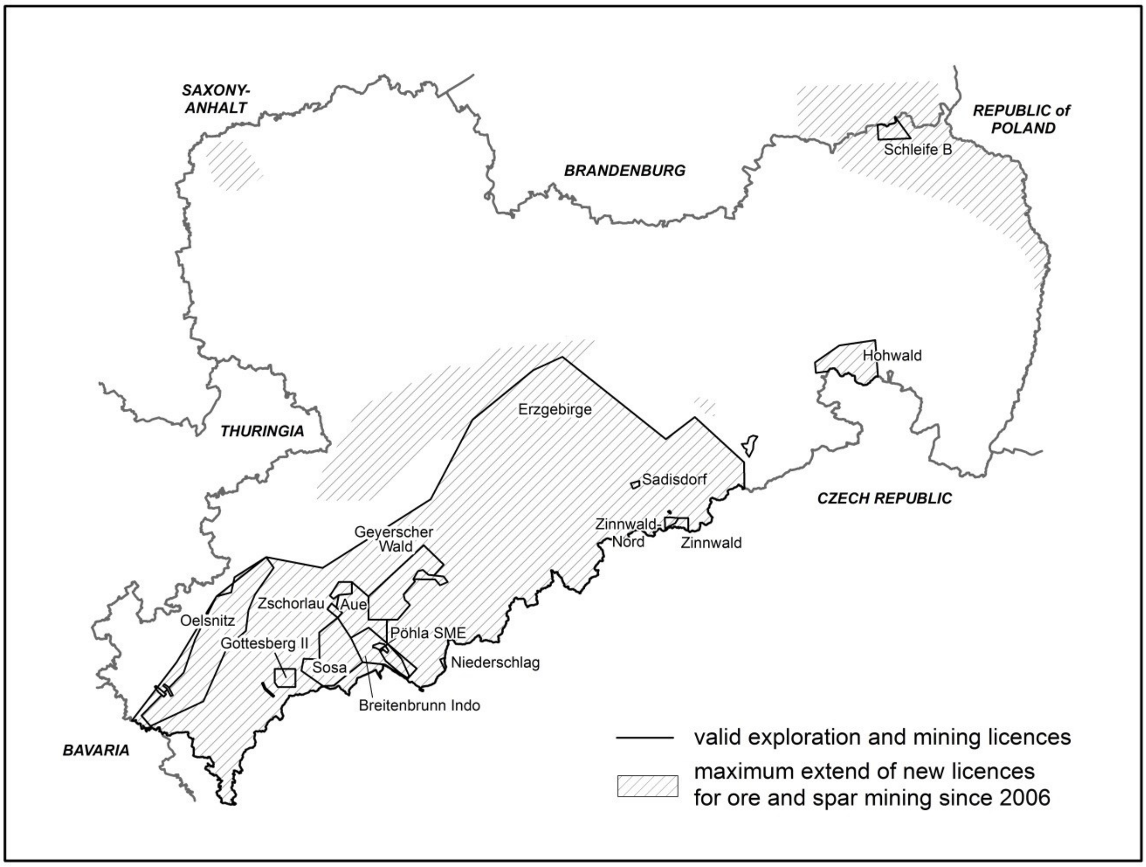

Fig. 2. Areal distribution of new licenses with field names for ore and spar mining in Saxony as of April 2017.

Up to now three new mining projects are already based on licenses for exploitation. The Schleife B license in Saxony is a minor part of the entire project extending into Brandenburg (Fig. 2). It focusses on the copper and silver deposits of the Kupferschiefer and actually carries out a regional planning procedure for the new mine. In the license field of Pöhla (Fig. 2) the company prepares to set up the new mine on the Sn-W-deposit. In Niederschlag the first new underground mine in Germany since four decades was opened up in 2013. The mine ramps up and extracts fluorite from a vein with a regular production of 98.5 kt raw fluorite in 2015 [13].

Resource Policy

Over 850 years mining gave to Saxony raw materials, prosperity, labor, advances in science and technology and cultural identity. Even after more than 20 years without a producing ore mine Saxony retains all structures, networks and regulations needed for a successful re-launch of ore and spar mining. With the Mining Academy as Technical University and the State Mining Authority of Saxony (Oberbergamt) in Freiberg two of the oldest existing mining related organizations support the new *Berggeschrey*. A variety of mining companies, consulting engineers, research institutions and scientists are organized under the umbrella of a geo-mining network (GeoCompetenceCentre Freiberg, GKZ). In addition, up to this day the majority of the population in the old mining districts of the Erzgebirge understands mining still as an opportunity and as a challenge.

Based on this the Free State of Saxony endorses new ore and spar mining. 2012 the government implemented its Raw Materials Strategy [14] which is oriented along concrete guidelines. The principle guideline highlights the common purpose to support new mines that are accepted, well balanced with the environment, realized by applying best practice technologies and economically successful. Other guidelines of the strategy cover aspects and concrete actions on topics like research, networking, administration, know-how, education, international cooperation, secondary raw materials as well as public acceptance.

With the new mining projects the enormous value of old exploration and mine data especially from GDR times became obvious. As an example, SDAG Wismut expended about 5.6 billion Mark (GDR) for the exploration of ore deposits in the GDR [9] leaving Saxony as one of the most intensely prospected regions at least in Europe. In a couple of new exploration projects it was proven, that these old data match well and show good reproducibility compared to recently acquired data. As one main activity of the Raw Materials Strategy the project ROHSA 3 (Raw Material Data of Saxony) was initiated. It is designed to save, to exploit, to digitize and to make available all existing raw material information and data like well data, analysis data, maps and technical reports. By opening this information for the public ROHSA 3 creates high values for the economy, for science and for the technical administration. In December 2016 a web based search engine was launched by the Geological Survey of Saxony in order to give public access to metadata of documents, maps, drilling data, and to technical information on deposits and mining activities [15].

Challenges for New Ore Mining

Saxony is facing the transition from an old towards a new mining era. The specific nature of this new mining can be defined by the geology of the deposits and the environment of the Erzgebirge: With a general view, comparatively small geological structures contain high-quality raw materials of high economic value with a medium- to low- grade ore content. In addition, new mines have to be constructed in a densely populated region, in a sensitive natural environment.

In consequence, new ore mines will be best suited with a minimum impact at the surface, operated with best practice technology in mining and processing and communicated in the region with an honest and responsible dialogue. The history and its remains of old mining teach us, that an economically sound concept for the mining enterprise is the base for a sustainable mining cycle ending with the restoration of the secure usability of the surface.

From the technical and research point of view Saxony has good preconditions with the TU Mining Academy of Freiberg and a variety of research and technical consultants and institutions like the Helmholtz Institute Freiberg for Resource Technology. Relevant technical R&D is needed especially to meet the requirements for sustainable small scale mining and specific challenges in processing the particular ores. On a long scale new geological concepts based on international research with existing and new data should result in new innovative concepts of generation and distribution of ore deposits in Saxony.

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Lecture Programme *)

Sunday, 24th September 2017

Chair W. Sand, Donghua University, Songjiang, Shanghai/CN and TU Freiberg, Freiberg/D

17:30–18:15 **Evening Lecture**
Progress in Biohydrometallurgy over the last thirty years?
P. Norris, University of Exeter/UK

Monday, 25th September 2017

Tank Leaching I

Chairs P. D'Hugues[1]; A. Schippers[2]; [1]Bureau de Recherches Géologiques et Minières (BRGM), Orléans/F; [2]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D

09:00 **Keynote Lecture**
Bioleaching in stirred tank reactor to process Kupferschiefer ore
A. Guezennec[1]; C. Joulian[1]; P. D'Hugues[1]; [1]Bureau de Recherches Géologiques et Minières (BRGM), Orléans/F

The Kupferschiefer deposits host the largest known copper reserve in Europe. These black shale type ores are currently exploited in Poland through pyrometallurgical smelting. In Germany exploration campaigns were recently carried out in order to assess and prepare future exploitation of this ore deposit type. The main copper-bearing minerals are: chalcocite, bornite, chalcopyrite and covellite. This type of ore is also characterized by high amounts of carbonate and organic carbon. They can also potentially present high content of arsenic (volatile in pyrometallurgical processes). During the last years, some mining operations in the area face an increased As and C contents, and a lower Cu contents. This phenomenon leads to a lower quality concentrate as well as operating and environmental issues during smelting.

In this context, several European research projects were dedicated to the development of new bioleaching approaches as alternative and complementary routes to the conventional smelting methods for the processing of the Kupferschiefer ores (BioShale, ProMine, EcoMetals, BIOMORE). By using a multi-scale approach from molecular techniques to bench-scale small pilot continuous tests, Cu recovery from this type of ores using bioleaching was demonstrated as technically feasible and efficient. The stirred tank bio-reactor (STR) was shown as the best process option when compared to heap leaching due to the high content of carbonate in the ore. Efficient Cu leaching was obtained at 25% solid load which is quite high compared to those encountered in most of the commercial bioleaching applications in STR (between 15 and 20%). The selected consortium (mesophile to moderately thermophile) has shown a rare copper tolerance since copper content increased up to more than 40 g L^{-1} without any negative effect on the bacterial community.

This key-note lecture will present an overview of the work performed on this topic in the last decade and will discuss the new insights and future developments for the integration of bioprocess options in the metallurgical treatment of black-shale type ores.

09:30 **Effect of temperature ramping on stirred tank bioleaching of a copper concentrate**
S.Hedrich[1], C. Joulian[2], T. Graupner[1], A. Schippers[1], A.-G. Guézennec[2]; [1]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D; [2]Bureau de Recherches Géologiques et Minières (BRGM), Orleans/F

09:45 **Column bioleaching of a saline, calcareous copper sulfide ore**
E. Pakostova[1]; B. Grail[1]; D. Johnson[1]; [1]Bangor University, Bangor/UK

*) as of 27th July 2017. Subject to alterations. Title and authors information as given by the submitter. No proof by DECHEMA. If not noted otherwise, more information on the presentations can be found in the proceedings.

10:00	**Optimization of copper bio leaching operation by moderately thermophilic consortia in Iranian Babak Copper Company (IBCCO)** A. Naghibzadeh[1]; M. Kargar[2]; Z. Manafi[2]; [1]Iranian Babak Copper Co (IBCCO), Tehran, Iran/IR; [2]Jahrom Branch, Islamic Azad University, Jahrom, Shiraz/IR; Copper Tank bio-leaching from copper concentrate is developing in industrial-scale production (50000 ton copper cathode per year) by Iranian Babak Copper Company (IBCCO). As a first project of copper cathode production in large-scale in the world, bioleaching of the copper concentrate (from Miduk copper complex) by using moderately thermophilic microbes can be an economic alternative for the conventional smelting. It was programmed to operate full-scale production with d80 of 10 µm of the concentrate grain size to obtain more than 95 % copper recovery. In this work, the concentrate (28 % Cu, 28.75 % Fe, 41 % $CuFeS_2$ and 15 % secondary copper minerals, and 30.17 % FeS2 of the concentrate) from one Iranian copper concentrate plant was used to find the optimum conditions in which the maximum copper recovery could be reached. In this regard, as a primary testing program according to the designed experiments for optimizing the process, the bioleaching tests in controlled 5-liter bioreactors showed that it was possible to obtain more than 80 % copper recovery (d80 of the concentrate = 45 µm) during 6 days of bioleaching process. It was determined that pulp density, pH, concentrate type, microbial diversity, and grain size of concentrate particle were the influential parameters in copper extraction from the concentrate. In the future, the large-scale tests will be conducted to approach the requirements of industrial production.
10:15	**Establishment of an iron-oxidizing culture of acidophilic micro-organisms for bioleaching of waste electrical and electronic equipment (WEEE)** A. Hubau[1]; A. Guezennec[1,2]; M. Minier[2]; A. Chagnes[3]; [1]Bureau de Recherches Géologiques et Minières (BRGM), Orléans/F; [2]Chimie Paris Tech –CNRS, Paris/F; [3]GeoResources Lab, Université de Lorraine, CNRS, CREGU, Vandoeuvre-lès-Nancy/F Many studies deal with the possibility of metal recovery from WEEE by bioleaching methods. However, the efficiency of biohydrometallurgical processes strongly depends on the micro-organisms and the design of the reactor since solid-liquid-gas mass transfer plays an important role in bioleaching processes. In the present study, a double-stage continuous bioreactor was designed to bioleach comminuted spent printed circuit boards (PCB) of low and medium grade. In the first stage of the bioreactor, a bubble column inoculated with an acidophilic consortium (BRGM-KCC) mainly composed by *Leptospirillum ferriphilum*, *Sulfobacillus thermosulfidooxidans* and *Sulfobacillus benefaciens* is used to oxidize iron (II) into iron (III). The resulting lixiviant solution is then sent to the second stage of the reactor where bioleaching of PCB occurs under mechanical stirring. The bubble column, in the first stage of the reactor, favors the growth of microorganisms, which may be limited in the second stage due to the presence of inhibitory metals in solution. Such a double-stage reactor is particularly performant to achieve high bioleaching efficiency (Guezennec et al, 2015).The present paper investigates the kinetic of oxidation of ferrous iron and specific growth rate of the consortium. Iron concentration ranging from 1 to 18g.L^{-1}, at around 36°C and pH 1,3 was tested and the influence of the residence time on the final ferric iron concentration was studied. Maximal oxidation rate was determined and used to design the second stage of the reactor.
	Heap Leaching
Chairs	*F. Glombitza[1]; M. Ranjbar[2]; [1]G.E.O.S. Ingenieurgesellschaft mbH, Halsbrücke/D; [2]Shahid Bahonar University of Kerman, Kerman/IR*
11:00	**Keynote Lecture** **Unravelling the complexity of heap bioleaching** J. Petersen[1], [1]University of Cape Town, Rondebosch/ZA

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11:30	**Reduction of iron(III) ions at Elevated Pressure by Acidophilic Microorganisms** R. Zhang[1]; A. Schippers[1]; [1]Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover/D
11:45	**The impact of heap self-heating on microbial activity during the bioleaching of low-grade copper sulfide ores** D. Shiers[1]; D. Collinson[1]; H. Watling[1]; [1]Commonwealth Scientific and Industrial Research Organisation (CSIRO), Perth/AUS
12:00	**Bio-heap Leaching of Primary Copper Sulfide Ore by JOGMEC** T. Shinkawa[1]; T. Kamiya[2]; T. Chida[2]; S. Furukawa[2]; [1]Japan Oil, Gas and Metals National Corporation, Kosaka/J; [2]Japan Oil, Gas and Metals National Corporation, Tokyo/J
12:15	**Nickel bioleaching at elevated pH: research and application** J. Sun, B. Chen, J. Wen, B. Wu; General Research Institute for Nonferrous Metals, Beijing, China
12:30	**Biodesulfurization of a coarse-grained high sulfur coal in a full-scale packed-bed bioreactor** A. Doodkanlou Milan[1]; A. Ahmadi[1]; M. Hosseini[1]; [1]Isfahan University of Technology, Isfahan/IR
	Innovative Methods I
Chairs	*M. Chen[1]; W. Sand[2]; [1]CSIRO Mineral Resources, Clayton/AU; [2]Donghua University, Songjiang, Shanghai/CN and TU Freiberg, Freiberg/D*
14:45	**Keynote Lecture** **Characterization and localized insight into leaching of sulfide minerals** M. Chen[1], Y. Yang[1]; [1]CSIRO Mineral Resources, Clayton/AU
15:15	**Method for the recovery of Indium from diluted bioleaching solutions** V.Radek[1]; U. Šingliar[1]; M. Bertau[1]; [1]TU Bergakademie Freiberg, Institut für Technische Chemie, Freiberg/D
15:30	**Changes in Metal Leachability through Stimulation of Iron Reducing Communities within Waste Sludge** M. Roberts[1]; D. Sapsford[1]; M. Harbottle[1]; A. Weightman[1]; G. Webster[1]; [1]Cardiff University, Cardiff/UK
15:45	**Bioleaching Magnetite and Hematite through Reductive Dissolution in Seawater** B. Dold[1]; J. Palau[2]; J. Cama[2]; C. Ayora[2]; E. Torres[2]; R. Benaiges[3]; J. Urmeneta[3] [1]Luleå University of Technology, Luleå/S; [2]IDAEA-CSIC, Barcelona/E; [3]Universidad de Barcelona, Barcelona/E The objective of this study is i) to evaluate the potential impact on marine environments of submarine tailings disposal from an iron oxide mine and ii) to explore if reductive dissolution in seawater might be a metallurgical process for iron and trace element recovery. Within this context, it is necessary to evaluate the interaction between the iron oxides and the seawater in the presence of microbes capable to reduce ferric iron. In this study, microbial reductive dissolution of magnetite and hematite by *Shewanella loihica* was investigated in the laboratory at 10°C using synthetic seawater and lactate as carbon source. Synthetic hematite, magnetite were used for the experiments. The transformation of lactate to acetate during Fe(III) reduction was monitored as direct indication of microbiological activity. In addition, abiotic experiments were performed at 10 and 20°C using seawater and ultrapure water. The results of biotic experiments clearly showed that the reductive dissolution was catalyzed by the microbial metabolic activity, which was supported by the observed preferential colonization of *Shewanella loihica* on the surfaces of iron oxides. Moreover, in the biotic experiments 1) the redox potential decreases rapidly to reducing conditions (-70 - 100 mV), 2) the concentration of lactate decreases, while acetate increases

as a secondary product of the microbial activity and 3) iron concentrations increase in the solution. Reductive dissolution and Fe release to the aqueous phase was observed in all biotic experiments regardless the type of iron oxides. In contrast, abiotic controls maintained the more oxidizing conditions from the beginning of the experiment (300 - 400 mV) and no iron release to the solution was observed. The kinetics of reductive dissolution was faster for magnetite for hematite. The results of this study suggest that the microbial reductive dissolution of magnetite in seawater has the potential to be an alternative metallurgical process instead of high energy consuming smelting used today, with less CO_2 emissions and fresh water consumption.

16:00	**Mechanism of silver-catalyzed bioleaching of enargite concentrate** K. Oyama[1]; T. Hirajima[1]; K. Sasaki[1]; H. Miki[1]; N. Okibe[1]; [1]Kyushu University, Fukuoka/J
	Innovative Methods II
Chairs	*C. Demergasso[1]; M. Schlömann[2]; [1]Universidad Católica del Norte, Antofagasta/RCH; [2]TU Bergakademie Freiberg, Freiberg/D*
16:45	**Keynote Lecture** **From knowledge to best practices in bioleaching** C. Demergasso[1]; R. Véliz[1]; P. Galleguillos[1]; S. Marín[1]; M. Acosta[1]; J. Bekios[1]; [1]Universidad Católica del Norte, Antofagasta/RCH
17:15	**Investigation of controlled Redox Potential with pyrite during chalcopyrite bioleaching by mixed moderately thermophiles** X. Huang[1]; J. Wang[1]; H. Zhao[1]; R. Liao[1]; X. Wang[1]; M. Hong[1]; G. Qiu[1]; [1]Central South University, Changsha/CN
17:30	**Bioleaching of chalcopyrite with two different metallogenic types: A mineralogical perspective** S. Deng[1]; G. Gu[1]; J. Ji[1]; B. Xu[1]; [1]Central South University, Changsha/CN
17:45	**Microbial community composition in mine waste, comparing sites in Cornwall and Western Devon** T. Sbaffi[1]; A. Buckling[2]; C. Bryan[2]; [1]University of Exeter, Penryn/UK; [2]Environment and Sustainability Institute, University of Exeter, Penryn Campus, Penryn/UK

Tuesday, 26th September 2017

	Molecular Methods / Biofilms I
Chairs	*M. Vera[1]; J. Xia[2]; [1]Pontificia Universidad Católica de Chile, Santiago/RCH; [2]Central South University, Changsha/CN*
09:00	**Keynote Lecture** **In-situ characterization and molecular mechanisms evaluation of interfacial interaction between minerals and bioleaching microorganisms** J. Xia[1]; H. Liu[1]; Z. Nie[1]; L. Liu[1]; H. Zhu[1]; L. Wang[1]; Y. Yang[1]; Y. Ma[1]; X. Pan[1]; Y. Zhao[2]; C. Ma[2]; L. Zheng[2]; X. Zhen[3]; L. Zhang[3]; W. Wen[3]; [1]Central South University, Changsha/CN; [2]Chinese Academy of Sciences, Beijing/CN; [3]Chinese Academy of Sciences, Shanghai/CN
09:30	**Mineralogical Dynamics of Primary Copper Sulfides Mediated by Acidophilic Biofilm Formation** R. Bobadilla-Fazzini[1], [1]Codelco Tec, Santiago de Chile/RCH
09:45	***Acidihalobacter prosperus*, a halophilic acidophile, has unique mechanisms to survive high chloride concentrations at low pH** E. Watkin[1]; D. Holmes[2]; M. Dopson[3]; [1]CHIRI Biosciences, Curtin University, Bentley/AUS; [2]Center for Bioinformatics and Genome Biology, Andres Bello University,

Santiago/RCH; [3]Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar/S

High concentrations of chloride ions inhibit the growth of acidophilic iron and sulfur oxidizing microorganisms used in biomining, a problem particularly relevant to Western Australian and Chilean biomining operations. This growth inhibition is due to the chloride ion disrupting homeostatic mechanisms resulting in acidification of the cytoplasm. *Acidihalobacter prosperus* is an acidophile that has been shown to oxidize iron at levels of NaCl as high as 50 $g.L^{-1}$. However, little is known about the mechanisms this microorganism adopts in order to tolerate such high chloride ion concentrations. This study applied proteomics to elucidate how *A. prosperus* alters its proteome under high chloride concentrations. *A. prosperus* (DSM 5130 ^{T}) was grown in the presence of sub-optimal (3.8 $g.L^{-1}$) and optimal (30 $g.L^{-1}$) NaCl concentrations. Total soluble proteins produced by cells were compared using 2D LC mass spectrometry with iTRAQ. Spectral data were analyzed against a protein sequence database for the whole genome using ProteinPilot™ 4.5 Software.

Analysis of differential expression showed that *A. prosperus* adopted several changes in its proteome in response to increased NaCl levels. These included maintenance of cell wall and outer membrane function and increased abundance of proteins involved in iron and sulfur oxidation. However a reduction in proteins involved in carbon metabolism was noted. One potential adaptation to high chloride in the *Ac. prosperus* Rus protein involved in ferrous iron oxidation was an increase in the negativity of the surface potential of Rus Form I (and Form II) that could help explain how it can be active under elevated chloride concentrations. Gaining an understanding of the range of mechanisms that acidophilic iron oxidizing microorganisms may use to help the cell function in the presence of elevated concentrations of chloride can be applied to the development of saline biomining operations or improve alterative processes.

10:00 **Molecular regulatory network involved in biofilm structure development by *Acidithiobacillus thiooxidans* includes Pel exopolysaccharide machinery**

M. Díaz[1]; N. Guiliani[2]; [1]Department of Biology, Faculty of Sciences, University of Chile, Santiago/RCH; [2]Universidad de Chile - Facultad de Ciencias, Santiago/RCH

10:15 **Genomic Insights into the Evolutionary Mechanisms and Dynamics of Extreme Acidophiles**

C. González[1]; M. Lazcano[1]; P. Tapia[2]; J. Valdés[2]; D. Holmes[1]; [1]Fundacion Ciencia & Vida, Santiago/RCH; [2]Universidad Mayor, Santiago/RCH

Extreme acidophiles thrive at <pH 3 in environments rich in sulfuric acid and high levels of heavy metals. Many are polyextremophilic chemolithoautotrophs, fixing CO_2 from the atmosphere and using hydrogen, sulfur and iron as energy sources. They are important microorganisms used in the commercial recovery of metals (biomining) and recycling of metals and nutrients in naturally occurring acidic conditions such as surface and deep subsurface pyritic environments and acidic hot-springs. Extreme acidophiles have also attracted recent attention because their genomes can be plundered for clues about the early evolution of cellular metabolism and bioenergetic pathways on early earth and their implications for astrobiology.

Extreme acidophiles are found in the Archaeal and Bacterial domains of the tree of life, including members of the Crenarchaeota, Euryarchaeota, Firmicutes, Nitrospirae, Aquificae and Proteobacteria. They have also been detected in the Domain Eukarya. Integrative "omics" analysis of over 170 genomic and metagenomic sequences of extreme acidophiles sheds light on their functional diversification and provides insight into the evolutionary forces that have shaped their genomic structure, linking organismal physiology to biogeochemical processes.

Strikingly, phylogenomic scrutiny suggests that, with a few notable exceptions, acidophiles evolved from ancestral neutrophiles and not the other way around. We will discuss models that examine a "pH-ladder" hypothesis whereby neutrophiles can gain the ability to grow down to about pH 4 in a step-by-step process that mainly involves mutations and duplications of pre-existing genes. However, in order to grow in environments below pH 4, horizontal gene transfer of specific genes and gene cassettes is hypothesized to be the main driving force of adaptive evolution.

10:30 **Computational analysis of chalcopyrite-attached bacteria, automated cell counting, and quantification of biofilm formation**

S. Bellenberg[1]; A. Buetti-Din[2]; M. Vera[3]; O. Ilie[2]; K. Lykov[2]; I. Pivkin[2]; W. Sand[4]; M. Dopson[5]; [1]Universität Duisburg-Essen, Fakultät für Chemie, Essen/D; [2]Institute of Computational Science, Faculty of Informatics, Universita della Svizzera Italiana, Lugano/CH; [3]Pontificia Universidad Católica de Chile, Institute for Biological and Medical Engineering. Department of Hydraulic and Environmental Engineering, School of Engineering, Santiago/RCH; [4]Universität Duisburg-Essen, Fakultät für Chemie, Biofilm Centre, Essen/D; [5]Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar/S

Efficient dissolution of chalcopyrite, the most abundant copper mineral, is challenging for bioleaching under mesophilic and moderately thermophilic conditions in heap leaching operations while stirred-tank bioleaching of chalcopyrite concentrates is efficient, but currently uneconomic. Consequently, it is desirable to improve dissolution kinetics and reduce the lag-time between heap construction and metal recovery during heap bioleaching. The direct inter-action of attached cells and their extracellular polymeric substances (EPS) with metal sulfide mineral surfaces are important for bioleaching as they enhance the rate of metal release. The hereby presented SysMetEx project studies biofilm formation and metal dissolution from chalcopyrite by employing mixed cultures of *Acidithiobacillus caldus, Leptospirillum ferri-philum*, and *Sulfobacillus thermosulfidooxidans*. The project aims at optimizing inoculation strategies of mixed cultures providing quantitative insights into the process. Likewise, inocu-lation and improving initial mineral colonization is tested for its potential to represent a strategy for speeding up commercial bioleaching operations. In order to study different inoculation strategies of bioleaching assays, it is important to efficiently quantify biofilm formation. The large amount of experimental conditions typically assessed in bioleaching studies, together with high cell densities to be quantified per condition, make this task very time consuming. In order to speed up image analysis and to improve quantification by reducing human bias in cell counting, we created a program using the Python programming language. The strength of the program relies on well-established machine learning methods and efficient use of parallel computing. We validated our program using samples from chalcopyrite bioleaching cultures composed of the three above-mentioned species. The application of our computer program helped to follow the time-dependent development of the mineral colonization and to determine the inoculation strategy of mixed microbial cultures that led to efficient bioleaching rates.

Metal Recovery

Chairs *J. Petersen[1]; S. Hedrich[2]; [1]University of Cape Town, Rondebosch/ZA; [2]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D*

11:15 **Keynote Lecture**
Bioelectrochemical Leaching of Copper Sulfide Minerals

M. Ranjbar[1]; [1]Shahid Bahonar University of Kerman, Kerman/IR

11:45 **Microbial Production of Schwertmannite: Development from Microbial Fundamentals to Marketable Products**

S. Reichel[1]; E. Janneck[1]; D. Burghardt[2]; S. Peiffer[3]; M. Schlömann[4]; G. Kießig[5]; T. Koch[6]; I. Arnold[6]; J. Laubrich[7]; [1]G.E.O.S. Ingenieurgesellschaft mbH, Halsbrücke/D;

	[2]TU Dresden, Institut für Grundwassermanagement, Dresden/D; [3]Universität Bayreuth, Lehrstuhl für Hydrologie, Bayreuth/D; [4]TU Freiberg, Institut für Biowissenschaften, Freiberg/D; [5]UBIG mbH, Wünschendorf/D; [6]Lausitz Energie Bergbau AG (LEAG), Cottbus/D; [7]Wismut GmbH, Chemnitz/D
12:00	**Rare Earth Elements recovery and sulphate removal from phosphogypsum waste waters with Sulphate Reducing Bacteria** J. Mäkinen[1]; M. Bomberg[1]; M. Salo[1]; M. Arnold[1]; P. Koukkari[1]; [1]VTT Technical Research Centre of Finland Ltd., Espoo/FIN
12:15	**Diversity of thermophilic iron- pyrite-oxidizing enrichments from solfataric hot springs in the Chilean Altiplano** F. Remonsellez[1], [1]Universidad Católica del Norte, Antofagasta/RCH
12:30	**Comparative Analysis of Functional Gene Diversity of Acid Mine Drainage and Its Sediment by Geochip Technology** L. Tan[1]; H. Yun[2]; X. Xu[1]; J. He[1]; H. Wu[1]; G. Qiu[1]; X. Liu[1]; J. Xie[1]; [1]Central South University, Changsha/CN; [2]Chinese Academy of Sciences, Beijing/CN
12:45	**Bio-oxidation Process for Gold Concentrates with a High Arsenic Content using Thermophilic Bacteria** H. Yang[1]; L. Tong[2]; Z. Jin[2]; Y. Song[2]; W. Sand[3]; [1]Northeastern University, Shenyang/CN; [2]School of Metallurgy, Northeastern University, Shenyang/CN; [3]Aquatische Biotechnologie, Biofilm Centre, Universität Duisburg, Essen/D High-arsenic containing refractory gold ores exist in many areas in China. In all cases, the arsenic is an unwanted impurity and its presence causes great concern due to its potential impact on process chemistry and its potential hazard to the environment. These ores usually require a pretreatment stage, such as roasting or pressure oxidation to render the gold amenable to extraction. Biooxidation is an attractive pretreatment technology because it eliminates toxic gaseous emissions. It utilizes the ability of acidophilic bacteria to oxidize pyrite (FeS_2) and arsenopyrite (FeAsS). Once the sulfides are oxidized, the gold is free to be contacted by the leaching agent, usually cyanide. In industrial applications of bio-metallurgy, cultures of mesophiles or moderate thermophiles are widely used for oxidizing sulfide ores. Such microorganisms include *Acidithiobacillus ferrooxidans, Acidithiobacillus thiooxidans, Acidithiobacillus caldus, Leptospirillum ferrooxidans* and *Leptospirillum ferriphilum* among others. In practice, the biooxidation cultures tend to be dominated by *L. ferriphilum* and *A. caldus* at 40°C~45°C.The mixed bacterial culture HQ0211 was found to be applicable to pre-oxidize the complicated high-arsenic gold ores. It was found that the oxidation process of the arsenic was [AsS]2-→As(Ⅲ+) →As(Ⅴ+). Gold recovery can be significantly increased with the HQ0211 bio-oxidation process compared to the traditional direct cyanidation.
	Biosorption / Bioremediation I
Chairs	*S. Willscher[1]; A. Kaksonen[2], [1]University Halle-Wittenberg, Halle/D; [2]CSIRO, Floreat/AUS*
15:00	**Keynote Lecture** **Recent advances in biomining and microbial characterisation** A. Kaksonen[1]; N. Boxall[1]; T. Bohu[1]; K. Usher[1]; C. Morris[1]; P. Wong[1]; K. Cheng[1]; [1]CSIRO, Floreat/AUS
15:30	**Biogenic iron compounds for hazardous metal remediation** L. Castro[1]; M. Blázquez[1]; F. González[1]; J. Muñoz[1]; A. Ballester[1]; [1]Universidad Complutense de Madrid, Madrid/E
15:45	**Optimization of Bioscorodite Crystallization for Treatment of As(III)-bearing Wastewaters** M. Tanaka[1]; T. Hirajima[1]; K. Sasaki[1]; N. Okibe[1]; [1]Kyushu University, Fukuoka/J

*) as of 27th July 2017. Subject to alterations. Title and authors information as given by the submitter. No proof by DECHEMA. If not noted otherwise, more information on the presentations can be found in the proceedings.

16:00	**Chemical vs. Biological Crystals, all the same?** J. Weijma[1], [1]Wageningen University, Wageningen/NL
16:15	**Microbial Recycling of Precious and Rare Metals Sourced from Post-consumer Products** N. Saitoh[1]; T. Nomura[1]; Y. Konishi[1]; [1]Osaka Prefecture University, Sakai/J
	Innovative Methods III
Chairs	*J. Lloyd[1]; A. Schippers[2]; [1]University of Manchester/ UK; [2]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D*
17:00	**Keynote Lecture** **Putting subsurface microbes to work; metal recovery and biosynthesis of functional metallic nanoparticles** J. Lloyd[1], [1]University of Manchester/ UK *No abstract available*
17:30	**Reductive dissolution of a lateritic ore containing rare earth elements (REE) using *Acidithiobacillus* species** I. Nancucheo[1], [1]Universidad San Sebastián, Concepción/RCH
17:45	**Incorporation of indigenous microorganisms increases leaching rates of Rare Earth Elements from Western Australian Monazite** M. Corbett[1]; J. Eksteen[2]; X. Niu[3]; E. Watkin[4]; [1]CHIRI Biosciences, Curtin University, Perth/AUS; [2]Western Australian School of Mines, Curtin University, Perth/AUS; [3]Curtin Water Quality Research Centre, Curtin University, Perth/AUS; [4]Curtin University, Bentley/AUS
18:00	**The Mechanism of in and Ge Occurrence in Sphalerite Crystal and the Influence on Properties:a DFT (Density Function Theory) Simulation** L. Tong[1]; H. Yang[1]; J. Xu[1]; P. Xu[1]; C. Li[1]; [1]Northeastern University, Shenyang/CN

Wednesday, 27th September 2017

	Tank Leaching II
Chairs	*F. Roberto[1]; S. Hedrich[2]; [1]Newmont Mining Corporation, Englewood/USA; [2]Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover/D*
09:00	**Keynote Lecture** **Copper Heap Bioleach Microbiology – Progress and Challenges** F. Roberto[1]; [1]Newmont Mining Corporation, Englewood/USA
09:30	**Bioleaching of Valuable Components from Pyrometallurgical Final Slags** P. Georgiev[1]; I. Spasova[1]; V. Groudeva[2]; M. Nicolova[1]; A. Lazarova[3]; M. Iliev[3]; R. Ilieva[3]; S. Groudev[1]: [1]University of Mining and Geology "Saint Ivan Rilski", Sofia/BG; [2]University of Sofia, Sofia/BG; [3]University of Mining and Geology, Sofia/BG
09:45	**Bioleaching of supergene porphyry copper ores from Sungai Max Gorontalo of Indonesia by an iron- and sulfur oxidizing mixotrophic bacterium** S. Chaerun[1]; F. Putri[1]; M. Mubarok[1]; W. Minwal[1]; Z. Ichlas[1]; [1]Institut Teknologi Bandung, Bandung/RI
10:00	**Comparison of reductive and oxidative bioleaching of jarosite waste for valuable metals recovery** J. Mäkinen[1]; M. Salo[1]; H. Hassinen[2]; P. Kinnunen[1]; [1]VTT Technical Research Centre of Finland Ltd., Espoo/FIN; [2]Tampere University of Technology, Tampere/FIN

10:15	**Feasibility of metal extraction from waste metallurgical slags in the presence of *Acidithiobacillus thiooxidans*** <u>A. Potysz</u>[1]; P. Lens[2]; J. van de Vossenberg[2]; E. Rene[2]; M. Grybos[3]; G. Guibaud[3]; J. Kierczak[4]; E. van Hullebusch[2]; [1]University of Wroclaw, Wrocław/PL; [2]UNESCO-IHE Institute for Water Education, Delft/NL; [3]University of Limoges, Limoges/F; [4]University of Wroclaw, Wroclaw/PL Pyrometallurgical slags are considered as secondary metal resources in biohyrometallurgical industry. This study has been undertaken to investigate acidic bioleaching of Cu, Zn and Fe from amorphous and crystalline copper slags. Experimental approach included eight treatments to explore the effect of pulp density (1% and 3% *wt./v*) and fraction size (< 0.3 mm and 1-2 mm) on metal extraction profiles throughout 40 days in the presence and absence of *Acidithiobacillus thiooxidans*. The optimal bioleaching conditions for crystalline slags were 1% pulp density and < 0.3 mm particle size during 21 days long treatment. Under these conditions as much as 79%, 76%, and 45% of Cu, Zn and Fe were extracted. On the other hand, the optimal conditions for amorphous slag were 1% pulp density and 1-2 mm particle size, also during 21 days long treatment. Up to 81%, 79% and 22% of Cu, Zn and Fe, were leached respectively at these conditions. The differences in slags behavior under tested conditions are attributed to different chemical and mineralogical properties of studied wastes. The reduction of particle size of crystalline slag created better accessibility to major metal bearing phases (e.g. copper sulfide – bornite). Interestingly, larger size of amorphous slag particles allowed to obtain better extraction yield compared to smaller fraction, due to the lower buffering capacity of the larger slag fraction, which were able to maintain acidic conditions favorable for activity of *A. thiooxidans*. Therefore, this study concludes that *A. thiooxidans* is a suitable catalyst for bioleaching and metallurgical slags from copper processing could be potentially used in biohydrometallurgical industry. The search for optimal reactor design should be further investigated.
10:30	**Production Development of Olimpiadinskoe Gold Processing Plant through BIONORD® Technology Processing** <u>A. Belyi</u>[1]; D. Chernov[1]; N. Solopova[1]; [1]JSC "Polyus", Krasnoyarsk/RUS
	Biosorption / Bioremediation II
Chairs	*K. Pollmann[1]; S. Willscher[2]; [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden/D; [2]University Halle-Wittenberg, Halle/D*
11:15	**Development of Metal Ion Binding Peptides Using Phage Surface Display Technology** <u>S. Matys</u>[1]; F. Lederer[1]; N. Schönberger[2]; R. Braun[1]; F. Lehmann[1]; K. Flemming[1]; S. Bachmann[1]; S. Curtis[3]; R. MacGillivray[4]; K. Pollmann[1]; [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden/D; [2]TU Bergakademie Freiberg, Freiberg/D; [3]University of British Columbia/Norman B. Keevil Institute of Mining Engineering, Vancouver/CDN; [4]University of British Columbia/Centre for Blood Research, Vancouver/CDN
11:30	**Recycling of Florescent Phosphor Powder Y2O3: Eu by Bioleaching by Means of Acidithiobacillus ferrooxidans** <u>R. Auerbach</u>[1]; K. Bokelmann[2]; S. Ratering[3]; R. Stauber[2]; S. Schnell[3]; J. Zimmermann[1]; [1]Fraunhofer Projectgroup IWKS of Fraunhofer ISC, Hanau/D; [2]Fraunhofer Projectgroup IWKS of Fraunhofer ISC, Alzenau/D; [3]Justus-Liebig University Giessen, Giessen/D
11:45	**Integrated Sulfate Reduction and Biosorption Process for the Treatment of Mine Drainages** <u>D. Cotoras</u>[1]; C. Hurtado[1]; P. Viedma[1]; [1]Universidad de Chile, Santiago/RCH
12:00	**The use of algal biomass to sustain sulfidogenic bioreactors for remediating acidic metal-rich waste waters** <u>A. Santos</u>[1]; D. Johnson[1], [1]Bangor University, Bangor/UK

*) as of 27th July 2017. Subject to alterations. Title and authors information as given by the submitter. No proof by DECHEMA. If not noted otherwise, more information on the presentations can be found in the proceedings.

12:15	**Detoxification of Heap after Gold Leaching Using Biodegradation** M. Belykh[1]; S. Petrov[1]; A. Chikin[1]; G. Voiloshnikov[1]; N. Belkova[2] [1]Irkutsk Research Institute of Precious and Rare Metals and Diamonds JSC, Irkutsk/RUS; [2]Limnological Institute SB RAS, Irkutsk/RUS
12:30	**Analysis of Microbial Communities associated with Bioremediation Systems for Thiocyanate-laden Mine Water Effluents** R. Huddy[1]; F. Kadzinga[1]; R. Kantor[2]; S. Rahman[2]; S. Harrison[1]; J. Banfield[2;] [1]University of Cape Town, Cape Town/ZA; [2]University of California, Berkeley/USA
12:45	**pH and Soil Additive-Depending Uptake of Various Metals and Metalloids by *Helianthus tuberosus* from a Uranium Containing Test Field Site** S. Willscher[1]; [1]University Halle-Wittenberg, Halle/D
	Molecular Methods / Biofilms II
Chairs	*M. Dopson[1]; M. Schlömann[2]; [1]Linnaeus University, Kalmar/S; [2]TU Bergakademie Freiberg, Freiberg/D*

15:00 **Keynote Lecture**

Optimizing Acidophile Biofilm Formation for Metal Sulfide Dissolution: The SysMetEx Project

M. Dopson[1]; W. Sand[2]; P. Wilmes[3]; I. Pivkin[4]; A. Poetsch[5]; K. Kubista[6]; [1]Linnaeus University, Kalmar/S; [2]Universität Duisburg Essen, Essen/D; [3]University of Luxembourg, Luxembourg/L; [4]Università della Svizzera italiana, Lugano/CH; [5]Ruhr University Bochum, Bochum/D; [6]TATAA BIOCENTER AB, Gothenburg/S

With global accessible high grade ores starting to become depleted, in recent decades the sustainable technology of biohydrometallurgy has steadily gained interest. A key target sulfide mineral for heap bioleaching is chalcopyrite. However, both the long lag time prior to copper release and poor recovery efficiencies at mesophilic and moderately thermophilic temperatures have so far prevented this technology from widespread implementation. The SysMetEx project uses three acidophile model species (*Acidithiobacillus caldus*, *Leptospirillum ferriphilum*, and *Sulfobacillus thermosulfidooxidans)* to investigate the rate of biofilm formation and subsequent copper recoveries with the ultimate aim of reducing the lag time between heap initiation and the first recovery of copper. The methods used are a combination of bioleaching experiments, microscopic investigation of cell attachment to the mineral surface, and metatranscriptomic plus metaproteomic investigations of cellular activities under different inoculation strategies. To aid in data analysis, a fully closed *Leptospirillum ferriphilum* genome has been obtained and the presence of key genes for cell attachment, metabolism, and stress tolerance identified. In addition, an automated system for investigation of microscopic images of attached cells has been developed. Finally, how alternative inoculation strategies affect both the chalcopyrite leaching conditions and consequently on the metal release rate have been evaluated. All these data are being fed into particle and ODE based models to help in understanding and optimizing chalcopyrite bioleaching.

15:30 ***Leptospirillum ferriphilum* – Genome, Transcriptome, and Proteome of a Biomining Model Species**

M. Herold[1]; S. Christel[2]; S. Bellenberg[3]; A. Poetsch[4]; A. Buetti-Din[5]; I. Pivkin[5]; W. Sand[6]; P. Wilmes[1]; M. Dopson[2]; [1]University of Luxembourg, Esch-sur-Alzette/L; [2]Linnaeus University, Kalmar/S; [3]Universitaet Duisburg-Essen, Essen/D; [4]Ruhr-Universität Bochum, Bochum/D; [5]Institute of Computational Science, Faculty of Informatics, Universita della Svizzera Italiana, Lugano/CH; [6]TU Bergakademie Freiberg, Freiberg/D

The acidophile *Leptospirillum ferriphilum* is one of the key biomining species and has been identified in many industrial heap and tank biomining operations. The *L. ferriphilum* type strain (ATCC 49881 and DSM 14647) is an obligate aerobe that is only capable of

	gaining energy via ferrous iron oxidation and organic carbon via carbon dioxide fixation. While a draft of the *L. ferriphilum*^{T} genome has been previously published (Cárdenas *et al.*, doi:10.1128/genomeA.01153-14), here we report a 2.5 Mb closed genome for the type strain that newly resolves 100 kb of repetitive sequences and identifies an additional 140 genes. Analysis of the genes predicted to code for key biomining processes confirmed electron transport pathways for energy conservation; carbon dioxide fixation for cellular carbon via the reductive tricarboxylic acid (TCA) cycle; *nif* genes for nitrogen fixation; pH (e.g. K^+-transporting ATPase) and metal(oid) homeostasis (e.g. a Cu(I)/Ag(I) efflux complex) mechanisms; oxidative stress response enzymes (e.g. cytochrome *c* peroxidase); and chemosensory, motility, and biofilm formation systems that are important for catalyzing metal sulfide dissolution. In addition, *L. ferriphilum*^{T} was cultured in a ferrous iron limited chemostat and RNA transcripts plus proteins were identified by next generation sequencing and mass spectrometry based proteomics, respectively. The RNA transcripts and protein concentrations were then identified to ascertain which of the key biomining processes were active under the specific culture conditions.
15:45	**Mineral Specific Biofilm Formation of *Acidibacillus ferrooxidans* Hütt2** S. Schopf[1]; [1]TU Bergakademie Freiberg, Freiberg/D
16:00	**Comparative genomics of iron oxidizing acidophiles of the *Acidiferrobacteraceae* family** F. Isotta[1]; P. Covarrubias[1]; A. Moya-Beltrán[2]; S. Bellenberg[3]; C. Thyssen[3]; W. Sand[3]; H. Nuñez[1]; D. Holmes[2]; R. Quatrini[1]; M. Vera[4]: [1]Fundacion Ciencia & Vida, Santiago/RCH; [2]Fundación Ciencia & Vida - Universidad Andres Bello, Santiago/RCH; [3]Universitaet Duisburg-Essen, Essen/D; [4]Pontificia Universidad Católica de Chile, Santiago/RCH
16:15	**Proteins Binding to Immobilized Rusticyanin Detected by Affinity Chromatography** J. Kucera[1]; O. Janiczek[1]; J. Smoldas[1]; M. Mandl[1], [1]Masaryk University, Brno/CZ
	Molecular Methods / Biofilms III
Chairs	*M. Dopson[1]; M. Schlömann[2]; [1]Linnaeus University, Kalmar/S; [2]TU Bergakademie Freiberg, Freiberg/D*
17:00	**Inhibition kinetics of iron oxidation by *Leptospirillum ferriphilum* in the presence of thiocyanate in bioremediated cyanidation tailings waste water** C. Edward[1]; S. Harrison[1], [1]University of Cape Town, Cape Town/ZA
17:15	**The Mondo Minerals Nickel Sulfide Bioleach Project: From Test Work to early Plant Operation** M. Gericke[1]; J. Neale[1]; J. Seppälä[2]; A. Laukka[2]; P. van Aswegen[3]; S. Barnett[4]; [1]Mintek, Randburg/ZA; [2]Mondo Minerals B.V., Kajaani/FIN; [3]P Met. Consulting cc, Johannesburg/ZA; [4]Consultant, Isle of Wight/UK
	Public Evening Lecture
18:00	**850 years of ore mining in Saxony – lessons (to be) learned** B. Cramer, TU Bergakademie Freiberg, Freiberg/D

*) as of 27th July 2017. Subject to alterations. Title and authors information as given by the submitter. No proof by DECHEMA. If not noted otherwise, more information on the presentations can be found in the proceedings.

Poster Presentations

001 **On the immobilization of desferrioxamine like siderophores for selective metal binding**
M. Anke[1]; K. Szymańska[2]; R. Schwabe[1]; O. Wiche[1]; D. Tischler[1]; [1]TU Bergakademie Freiberg, Freiberg/D; [2]Silesian University of Technology, Gliwice/PL

002 **Gallium mobilization in soil by bacterial metallophores**
R. Schwabe[1]; B. Obst[1]; M. Mehnert[1]; D. Tischler[1]; O. Wiche[1]; [1]TU Bergakademie Freiberg, Freiberg/D

003 **Attachment of *Acidithiobacillus ferrooxidans* and bioleaching of chalcopyrite under influence of organic substances associated with copper solvent extraction**
X. Liu[1]; H. Zhang[1]; H. Yu[1]; [1]Shanghai Institute of Technology, Shanghai/CN

004 **A comparison of three bioprocessing approaches applied to a cobalt-containing laterite ore**
S. Smith[1]; B. Grail[1]; D. Johnson[1]; [1]Bangor University, Bangor/UK
Technological applications are causing increasing global demand for cobalt (Co). Oxidized lateritic ores represent previously unexploited Co reserves, although current processing technologies (used to recover nickel from them) are highly energy intensive. Bioprocessing protocols for obtaining Co present an option with significantly decreased environmental impacts. Here we present results from three bioprocessing approaches that were applied to a Co-con-taining limonitic laterite from Shevchenko, Kazakhstan. Firstly, anaerobic reductive bioleaching was carried out in a bioreactor experiment at pH 1.8 and 35°, alongside an aerobic control. This experiment was carried out with a consortium of sulfur (S^0)- and iron-oxidising and iron-redu-cing bacteria; anaerobic bioprocessing resulted in extraction of 88.5% of the Co, compared to 22% under aerobic conditions. As Fe(III) and Mn(IV) reduction is an acid consuming reaction, addition of 1M H_2SO_4 was required to maintain the pH at 1.8. Secondly, an experiment was carried out using *Acidithiobacillus caldus*^{T} to bioleach the limonite aerobically. The culture was grown on S^0 in a bioreactor and ore was added when the experiment had fallen to pH 1.4. The concentration of soluble Fe(II) increased as a result of indirect aerobic reduction of Fe(III), and the pH continued to decrease reaching 0.84 by the end of experiment. During the 33 day experiment, 95% of the Co was extracted from the ore. A third approach, designed to mimic flooded heap rather than stirred tank bioleaching, involved mixing limonitic ore and S^0 (5:1) which was then packed into a column. A layer of S^0 (inoculated with a consortium of Fe(II)/S^0-oxidizers and Fe(III)-reducers) was added to the top of the ore/ sulfur layer, with the objective that acid would be generated in this surface layer and oxygen consumed, promoting suitable conditions for reductive processing of the oxidized ore in the underlying layer. The column was irrigated with pH 1.8 liquor which was re-circulated through the column. Bioleaching of Co was again observed, though rates of extraction were significantly lower than in bioreactors.

005 **Optimization of bioleaching of waste printed circuit boards using *Aspergillus niger***
F. Faraji[1]; R. Golmohammadzadeh[1]; F. Rashchi[1]; [1]University of Tehran, Tehran/IR
In order to reduce energy consumption and achieve environmental assessments, an echo-friendly and cost effective method is suggested for recovery of metal species from electronic wastes such as printed circuit boards (PCBs). Furthermore, it is vital to develop processes to recover valuable metals from PCBs to meet future needs. Fungi are known to be an efficient alternative for this purpose. In this research, Aspergillus niger in sucrose medium was utilized to leach the valuable metals (Ni, Zn and Cu) from PCBs of computers. The effects of two parameters were surveyed which include different conditions (one-step, two-step and spent medium bioleaching) and pulp density. Response surface methodology subdivision of D-optimal was used to optimize bioleaching parameters. In this case, the most effective

parameter for recovery of Ni and Cu was found to be pulp density and for Zn was the method used for bioleaching. The optimized condition was determined to be spent medium and pulp density of 20g/L. The overall recovery obtained was 44.98% of Ni, 98.46% of Zn and 66.22% of Cu.

006 **Optimization of Ni, Cu and Zn Recoveries in Bioleaching of Electronic Scraps**
M. Mostafavi[1]; F. Rashchi[2]; S. Beikzadeh-Noei[2]; N. Mostoufi[2]; [1]University of Tehran, Kish International Campus, Kish/IR; [2]University of Tehran, Tehran/IR

007 **Revisiting the chromeazurol S assay for various metal ions**
M. Mehnert[1]; R. Schwabe[1]; S. Vater[1]; T. Heine[1]; G. Retamal[2]; G. Levicán[2]; M. Schlömann[1]; D. Tischler[1]; [1]TU Bergakademie Freiberg, Freiberg/D; [2]Universidad de Santiago de Chile, Santiago/RCH

008 **Rapid removal of zinc from circum-neutral pH waste waters using a novel low pH biosulfidogenic reactor**
R. Holanda[1]; D. Barrie Johnson[1]; [1]Bangor University, Bangor/UK
In the United Kingdom, as in many post-industrial/mining countries, metal mining has left a legacy of several hundred kilometers of metal-contaminated, circum-neutral pH watercourses (e.g. from areas with hydrothermal base metal sulfide deposits in which pyrite is often absent). These represent a significant pollution hazard into streams and rivers into which they flow.
Application of full-scale neutrophilic biosulfidogenic (sulfate- and sulfur-reducing) reactors both to recover metals from and to remediate mine drainage and process waters has been demonstrated worldwide. Recently, low pH sulfate-reducing bioreactors have been developed to selectively recover metals from acidic waste waters, though these are generally not suitable for mitigating metal-rich, circum-neutral pH mine waters. We have recently adapted the low pH sulfidogenic bioreactors to be suitable for removing chalcophilic transition metals from circum-neutral pH and alkaline waste waters. The major modification is the inclusion of elemental sulfur (S^0) in the bioreactor to act as an alternative electron acceptor to sulfate, generating H_2S, and using glycerol as electron donor. In contrast to sulfate reduction, which consumes protons at low pH, reduction of S^0 is pH-neutral in acidic liquors ($7\ S^0 + C_3H_8O_3 + 3\ H_2O \rightarrow 3\ CO_2 + 7\ H_2S$), while formation of sulfide mineral phases generates protons (e.g. $Zn^{2+} + H_2S \rightarrow ZnS + 2\ H^+$) and the resulting change in pH serves as a simple way of controlling influx of circum-neutral pH waste water into the acidic bioreactor.
Tests carried out with a low pH sulfur-reducing bioreactor using synthetic and actual mine water (pH 7.05; 58 mg/L Zn^{2+}) draining mineral tailings from an abandoned lead/zinc mine in the west of England, confirmed the potential of the system to remediate neutral pH mine waters, and also to recover metals from them, which can at least partly offset operational costs. Over 99% of zinc was removed, at a precipitation rate of approximately 13 mg L^{-1} h^{-1} of ZnS, when operating at a hydraulic retention time of <5 hours. The bicarbonate alkalinity of the mine water also allowed effective (>99%) off-line removal of the zinc, at similar precipitation rate, using biogenic H_2S generated within the bioreactor.

009 **Electrochemical process engineering in biohydrometallurgical metal recovery from mineral sulfides**
C. Tanne[1]; A. Schippers[1]; [1]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D

010 **Adsorption of Chromium (VI) and Desorption as Chromium (III) from the Aqueous Chromium (VI) Solution Using Persimmon Gel**
T. Tsuruta[1]; T. Hatano[1]; [1]Hachinohe Institute of Technology, Hachinohe/J

011 **Siderophore purification via immobilized metal affinity chromatography**
T. Heine[1]; M. Mehnert[1]; R. Schwabe[1]; D. Tischler[1]; [1]TU Bergakademie Freiberg, Freiberg/D

012 **Thermochelin, a hydroxymate siderophore from *Thermocrispum agreste* DSM 44070**
T. Heine[1]; M. Mehnert[1]; R. Schwabe[1]; D. Tischler[1]; [1]TU Bergakademie Freiberg, Freiberg/D

014 **Approaches to eliminate bacteria introduced during active bioleaching from the deep subsurface**
H. Ballerstedt[1]; A. Schippers[1]; E. Pakostova[2]; D. Johnson[2]; [1]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D; [2]University of Bangor, Bangor/UK

015 **Bioleaching of copper slag material**
A. Schippers[1]; [1]Federal Institute for Geosciences and Natural Resources, Hannover/D

016 **Electrochemical impedance spectroscopy studies of chalcopyrite involving iron (II) ions**
D. Bevilaqua[1]; F. Arena-Delfino[1]; A. Benedetti[1]; [1]Institute of Chemistry, Sao Paulo State University, Araraquara/BR

017 **Evaluation of substrate consumption kinetics in different support materials for biotrickling filters aiming biogas desulfurization**
L. Hidalgo[1]; J. Santos[1]; A. Sarti[1]; S. Tayar[1]; M. Palmieri[1]; D. Bevilaqua[1]; [1]Institute of Chemistry, Sao Paulo State University, Araraquara/BR

018 **Biotechnical selenate removal in inverse fluidized bed reactor**
K. Cheng[1]; M. Ginige[1]; A. Kaksonen[1]; [1]CSIRO, Floreat/AUS

019 **Pilot scale bioleaching of metals from pyritic ashes**
E. Vestola[1]; J. Mäkinen[2]; T. Korhonen[3]; R. Neitola[3]; A. Kaksonen[4]; [1]Talis Consultants, Leederville/AUS; [2]VTT Technical Research Centre of Finland, Espoo/FIN; [3]Geological Survey of Finland, Outokumpu/FIN; [4]CSIRO, Floreat/AUS

020 **Monitoring of biofilm development on surfaces using an electrochemical method**
O. Fysun[1]; [1]Robert Bosch GmbH, Waiblingen/D

021 **Screening of important variables of organic acids degradation by *Phanerochaete chrysosporium* using Plackett-Burman design in refractory arsenic-bearing and carbonaceous gold ores**
Q. Liu[1]; H. Yang[2]; L. Tong[2]; J. Peng[2]; [1]Shanghai Polytechnic University, Shanghai/CN; [2]School of Metallurgy, Northeastern University, Shenyang/CN

022 **Bioleaching of chalcopyrite-bornite mixed ores in the presence of mixed culture**
H. Zhao[1]; X. Huang[1]; R. Liao[1]; Y. Zhang[1]; J. Wang[1]; W. Qin[1]; G. Qiu[1]; [1]Central South University, Changsha/CN
In this work, bioleaching of chalcopyrite-bornite mixed ores in the presence of mixed culture consisting of *A.caldus and L.ferriphilum* strains was carried out. Bioleaching results showed that bioleaching behaviors of chalcopyrite-bornite mixed ores in the presence of sole *A.caldus*, *L.ferriphilum* strain and mixed culture were all in accordance with the proposed optimum redox potential theory, and extremely high copper extraction can be obtained. Real-time PCR technique was used to analyze the changes of percentages of *A. caldus* and *L. ferriphilum* during bioleaching. Results showed that the change rules were similar between bioleaching systems of sole chalcopyrite and chalcopyrite-bornite mixed ores, indicating that the chemical factor instead of biological factor should be the main cause for the high copper extraction of chlacopyrite-bornite mixed ores.

023 **Manganese Removal from Metal Refinery Wastewater using Mn(II)-oxidizing Bacteria**
S. Kitjanukit[1]; K. Takeda[2]; S. Asano[2]; N. Okibe[1]; [1]Kyushu University, Fukuoka/J; [2]Sumitomo Metal Mining Co.,Ltd, Ehime/J

024 **Investigating the microbial colonization and leaching of an arsenic mine tailing using a mixed mesophilic culture**
E. Ngoma[1]; K. Shaik[1]; D. Borja[2]; M. Smart[1]; J. Park[3]; H. Kim[2]; J. Petersen[4]; S. Harrison[1]; [1]University of Cape Town, Cape Town/ZA; [2]Chonbuk National University, Jeonju/ROK; [3]Mine Reclamation Corporation, Wonju-si/ROK; [4]University of Cape Town, Rondebosch/ZA

025 **Microbiological As(III) oxidation and immobilization as scorodite at moderate temperatures**

Y. Era[1]; T. Hirajima[1]; K. Sasaki[1]; N. Okibe[1]; [1]Kyushu University, Fukuoka-shi/J

026 **Microbial community analysis inside a biooxidation heap for gold recovery in Equador**

C. Aspiazu[1]; P. Aguirre Chamba[2]; S. Hedrich[3]; A. Schippers[3]; [1]Orenas S.A., Guayaquil/EC; [2]Universidad Técnica Particular de Loja (UTPL), Loja/EC; [3]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D

027 **Screening of important variables of organic acids degradation by *Phanerochaete chrysosporium* using Plackett-Burman design in refractory arsenic-bearing and carbonaceous gold ores**

Q. Liu[1]; H. Yang[2]; L. Tong[2]; J. Peng[2]; [1]Shanghai Polytechnic University, Shanghai, China, Shanghai/CN; [2]School of Metallurgy, Northeastern University, Shenyang/CN

028 **Investigation of the flotation interface with spectroscopic reflection techniques**

T. Firkala[1]; F. Lederer[1]; K. Pollmann[1]; M. Rudolph[1]; [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden/D

029 **The surface chemistry characterization during bioleaching and biooxidation**

S. Ghassa[1]; H. Abdollahi[1]; M. Gharabaghi[2]; S. Chehreh Chelgani[3]; M. Jafari[1]; [1]University of Tehran, Tehran/IR; [2]University of Tehran, Tehran/D; [3]University of Michigan, Michigan/USA

030 **Examining the effects of typical reagents for sulfide flotation on bio-oxidation activity of Ferrooxidans microorganisms**

M. Jafari[1]; S. Shafaei[1]; H. Abdollahi[1]; M. Gharabaghi[1]; S. Chehreh Chelgani[2]; S. Ghassa[1]; [1]University of Tehran, Tehran/IR; [2]University of Michigan, Michigan/USA

031 **The decreasing and whereabouts of iron ions in the pure culture process of extremely acidophilic microorganism**

W. He[1]; J. Wang[1]; L. Wu[1]; C. Fang[1]; Y. Wu[1]; Y. Zi[1]; H. Zhao[1]; W. Qin[1]; G. Qiu[1]; [1]Central South University, Changsha/CN

No abstract available

032 **Fabrication of Magnetic Polymer Composite Sorbents and its Application for Recovery of Platinum from Acidic Solution**

M. Song[1]; D. Reddy[1]; Y. Yun*[1]; [1]Chonbuk National University, Jeonju/ROK

033 **Investigation of Intermediates Evolutions during Bornite Bioleaching by Mesophilic Mixed Bacteria**

X. Wang[1]; J. Wang[1]; H. Zhao[1]; M. Hu[1]; X. Huang[1]; R. Liao[1]; M. Hong[1]; [1]Central South University, Changsha/CN

034 **Molecular response of the acidophilic iron oxidizer "*Ferrovum*" sp. JA12 to the exposure to elevated concentrations of ferrous iron**

S. Ullrich[1]; A. Poehlein[2]; M. Schlömann[1]; M. Mühling[1]; [1]TU Bergakademie Freiberg, Institute of Biological Sciences, Freiberg/D; [2]Georg-August-University Göttingen, Göttingen Genomics Laboratory, Göttingen/D

035 **The responses of microbial community and zinc leaching efficiency to temperature in sphalerite bioleaching system**

Y. Xiao[1], [1]Central South University, Changsha/CN

Temperature plays a key role in driving microbial community and biological processes, including bioleaching processes. In this study, we investigated the effects of temperature (30, 35, 40, 45 and 50℃, respectively) on zinc recovery and the microbial community. 16s rRNA gene sequencing was used to explore the composition, structure and diversity of microbial communities. Although the dominant genera were *Acidithiobacillus* and *Sulfobacillus* at different temperature, detrended correspondence analysis (DCA) showed that structures of microbial communities were significantly different. On day 30, Shannon diversity was 1.480

(30°C), 1.323 (35°C), 0.479 (40°C), 0.545 (45°C) and 0.849 (50°C), respectively, and zinc leaching efficiency was 66.3% (30°C), 72.2% (35°C), 71.2% (40°C), 78.2% (45°C) and 89.1% (50°C), respectively. Physicochemical parameters, e.g., the concentration of ferric iron, also showed differences at different temperatures. In conclusion, to some extent, higher temperature could enhance zinc leaching efficiency, through changing structure and diversity of microbial community and increasing the concentration of ferric iron.

036 **The use of heap bioleaching as a pre-treatment for platinum group metal leaching**

J. Mwase[1]; J. Petersen[2]; [1]Universite de Liege, Liege/B; [2]University of Cape Town, Rondebosch/ZA

037 **Effect of galactose on EPS production and attachment of *Acidithiobacillus thiooxidans* to mineral surfaces**

P. Aguirre[1]; A. Sanchez[2]; J. Gentina[3]; A. Schippers[4]; [1]Universidad Técnica Particular de Loja, Loja/EC; [2]Universidad Tecnica Particular de Loja, Loja/EC; [3]Pontificia Universidad Católica de Valparaiso, Valparaíso/RCH; [4]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D

039 **Addition of surfactant to improve the microbial treatment of a sulfur-spent catalyst**

M. Gomez-Ramirez[1]; A. Rico-Chavez[1]; J. Aburto[2]; R. Garcia de Leon[2]; N. Rojas-Avelizapa[1]; [1]Instituto Politécnico Nacional (IPN), Queretaro/MEX; [2]Instituto Mexicano del Petroleo, Mexico City/MEX

In Mexico, the oil industry generates hazardous wastes such as sulfur containing-spent catalysts, which represent a great problem since sulfur is the main element in highly toxic gases such as hydrogen sulfide and sulfur oxides. Due to the high sulfur content, the Mexican oil industry uses the "Superclaus" process to desulfurize natural gas removing up to 98.5%. Catalysts used are exhausted and then discharged. Previous work showed that *Acidithiobacillus thiooxidans* DSM 26637 is able to remove sulfur from a spent catalyst at a rate of 0.185 mg $S*g*h^{-1}$ after 9 days; however the period of treatment was considered long. The present study evaluated the enhanced effect of three surfactants on sulfur oxidizing activity (SOA) of *A. thiooxidans* DSM 26637 and then sulfur removal by ICP-EOS from spent catalyst. Two nonionic surfactants and an alkylglucosyde nonylphenol surfactant were evaluated. Nonylphenol was evaluated at two different concentrations on SOA and sulfur removal from spent catalyst at 16.5% at pH 3, 30°C and 140 rpm during 7 days.

Results showed that nonylphenol addition has a positive effect on SOA of *A. thiooxidans* DSM 26637. Sulfate production was 7889 mg/L without surfactant while the addition of nonylphenol increases sulfate production up to 10983 mg/L after 7 days. Glucopon 425 and Glucopon 625 had a harmful effect on *A. thiooxidans* DSM 26637 since sulfates were produced within 3168 - 3838 mg/L, respectively. Nonylphenol increased the sulfur oxidation by enhancing the SOA of *A. thioooxidans* DSM 26637 by about 20% respect to non-nonylphenol. For pH, treatment added with nonylphenol decreased from 2.5 to 0.73 and non-nonylphenol from 2.5 to 1.06, respectively. Treatments with Glucopon 425 and Glucopon 625 decrease pH to 1.71 and pH 1.48, respectively. Nonylphenol concentration had a positive effect enhancing SOA of *A. thiooxidans* DSM 26637; at higher surfactant concentration (0.3%) sulfate production was 10695 mg/L after 7 days. Those systems at 0.003%, sulfate production was 7610 mg/L and non-surfactant was 5976 mg/L at the same time. ICP analysis indicated a sulfur reduction of 43.9% in the spent catalyst treated by *A. thiooxidans* DSM 26637 in presence of nonylphenol at 0.3% after 7 days. A similar value was reached without surfactant (42.8%) but after 14 days.

Data suggest the potential application of this bioprocess as an alternative to short the treatment period for sulfur-contaminated catalysts.

041 **Effect of Marmatite on Bioleaching Behaviors of Chalcopyrite**

R. Liao[1]; J. Wang[1]; H. Zhao[1]; X. Wang[1]; X. Huang[1]; M. Hong[1]; [1]Central South University, Changsha/CN

042 **Resistance of Moderately Thermophilic Acidophilic Microorganisms to Ferric Iron Ions**
A. Bulaev[1]; [1]Research Center of Biotechnology of the Russian Academy of Sciences, Moscow/RUS

043 **Pyrite Oxidation by Moderately Thermophilic Microorganisms**
A. Bulaev[1]; M. Labyrich[2]; [1]Research Center of Biotechnology of the Russian Academy of Sciences, Moscow/RUS; [2]Russian State Agrarian University - Moscow Agricultural Academy named after K.A. Timiryazev, Moscow/RUS

044 **Biogenic hydrogen sulphide for cyanide regeneration in solutions during cupriferous gold ore processing**
A. Faiberg[1]; A. Mikhailova[1]; V. Dementiev[1]; S. Gudkov[1]; [1]JSC Irgiredmet, Irkutsk/RUS

045 **Evolution of compositions and contents of capsule and slime EPSs for adaptation to and action on energy substrates and heavy metals by typical bioleaching microorganisms**
Z. Nie[1]; H. Liu[1]; J. Xia[1]; H. Liu[1]; Y. Cui[1]; G. Qiu[1]; [1]Central South University, Changsha/CN

046 **Identification of Sulfur Activation Relevant Protein Genes of Extremely Thermophilic Acidianus manzaensis**
H. Liu[1]; J. Xia[1]; Z. Nie[1]; Y. Ma[1]; Y. Yang[1]; L. Liu[1]; X. Pan[1]; P. Yuan[2]; [1]Central South University, Changsha/CN; [2]Chinese Academy of Sciences, Guangzhou/CN

047 **Effects of air on microbial community and tailing wastewater remediation in reducing bacteria remediation process**
M. Zhang[1]; X. Liu[1]; M. Sun[2]; Y. Li[1]; J. Wen[1]; [1]General Research Institute for Nonferrous Metals, Beijing/CN; [2]China Certification & Accreditation Institute, Beijing/CN
To research the effects of air on tailing wastewater remediation and microbial community, experiments of air utilization in sulfate reducing bacteria remediation process were conducted. The physiochemical properties were determined using inductively coupled plasma atomic emission spectroscopy and X-ray diffraction, and microbial community structure was investigated by MiSeq high throughput sequencing. The results indicated there was no obvious redox potential difference between group Air+ and Air-, however, the differences of pH, dissolved sulfur and dissolved iron were obvious ($p<0.05$). The percentage of acidophilic bacteria and the dissolved metal ion concentration decreased when a small amount of air was present, however, the percentage of sulfate reducing bacteria, the dissolved sulfur concentration and iron sulfide increased obviously when a small amount of air was present.

048 **Bioleaching of Minor Element from European Copper Shale**
S. Hopfe[1]; S. Kutschke[1]; K. Pollmann[1]; [1]Helmholtz-Zentrum Dresden-Rossendorf, Institut für Ressourcentechnologie, Freiberg/D
In most modern technologies such as flat screens, highly effective magnets and lasers, as well as luminescence phosphors, Rare Earth Elements (REE) are used. Unfortunately there is nearly no recycling of REE containing wastes. In literature, some technical approaches are described, using all strong inorganic acids or toxic chemicals. A potential environmentally friendly alternative could be bioleaching.
During recycling of energy-saving bulbs fluorescent phosphor (FP) is collected as a distinct fraction. It contains about 10% REE-oxides bound in the hardly water-soluble triband dyes as oxides, phosphates and aluminates [4]. Previous investigations showed that especially the yeast *Yarrowia lipolytica* is likely eligible for leaching of REE from FP. An industrial application requires an efficient and inexpensive process. Therefore, the influence of different components of the culture medium, of the mixing and of the interaction time on metal release was investigated. Prolonging the leaching time accompanied by an exchange of the leaching solution lead to a considerable increase of the overall leaching rate. Furthermore, alternative substrates in medium were tested. Raw glycerin as well as sunflower oil turned out to be suitable, even though the leaching rate was only half as high as with glucose in medium. Nevertheless, it shows that it is possible to use cheaper substrates for the process. Apart from

this, the leaching of the single fluorescent dyes was investigated. It could be shown, that the leaching is selective regarding to the white halophosphate and red yttrium-europium oxide. The blue and green dyes, like lanthanum phosphate were not solubilized, which is contradictory to some mineralogical studies about leaching of monazite.
In conclusion the results show that bioleaching is a potential alternative to technical leaching approaches, providing the basis for the development of an eco-friendly recycling process.

049 **Potential Bioleaching Effects in In-situ Recovery Applications**
C. Richter[1]; H. Kalka[1]; H. Märten[1,2]; [1]Umwelt- und Ingenieurtechnik GmbH Dresden (UIT), Dresden/D; [2]Heathgate Resources Pty. Ltd. (Heathgate), Adelaide, South Australia/AUS

050 **Comparative Variants of Microbial Pretreatment and Subsequent Chemical Leaching of a Gold-Bearing Sulphide Concentrate**
I. Spasova[1]; M. Nicolova[1]; P. Georgiev[1]; S. Groudev[1]; [1]University of Mining and Geology "Saint Ivan Rilski", Sofia/BG

051 **The effect of co-culture microorganisms with different ferrous- and sulfur-oxidizers on chalcopyrite bioleaching**
X. Feng[1]; L. Ma[1]; J. Tao[1]; X. Liu[1]; G. Qiu[1]; [1]Central South University, Changsha/CN
No abstract available

052 **Effect of Acidithiobacillus ferrooxidans magnetotaxis on bornite bioleaching**
W. He[1]; L. Wu[1]; C. Fang[1]; X. Qiu[1]; H. Zhao[1]; J. Wang[1]; [1]Central South University, Changsha/CN
No abstract available

053 **Investigation of fluoride tolerance in *Acidithiobacillus ferrooxidans***
J.Tao[1,2], L. Ma[1,2], C. Qin[1,2], H. Yin[1,2], Y. Liang[1,2], G. Qiu[1,2], X. Liu[1,2]; [1]School of Minerals Processing and Bioengineering, Central South University, Changsha, China; [2]Key Laboratory of Biometallurgy, Ministry of Education, Changsha, China

054 **Genomic Characterization of the Arsenic-Tolerant Actinobacterium, *Rhodococcus erythropolis* S43**
G. Retamal Morales[1]; M. Mehnert[2]; R. Schwabe[2]; D. Tischler[2]; M. Schlömann[2]; G. Levicán[3]
[1]Universidad de Santiago de Chile, Santiago/RCH; [2]IMFD Technische Universität Freiberg, Freiberg/D; [3]Universidad de Santiago de Compostela, Santiago/D

055 **Fabrication and Application of Polyethylenimine/Ca-Alginate Blended Hydrogel Fibers as High-Capacity Adsorbents for Recovery of Gold from Acidic Solutions**
J. Bediako[1]; Y. Yun[1]; [1]Chonbuk National University, Jeonju/ROK

056 **Biological Mn(II) oxidation as the final stage of an integrated bioremediation process for mitigating acidic, metal-rich mine waters**
A. Santos[1]; D. Johnson[1], [1]Bangor University, Bangor/UK
Waste waters from mining sites vary considerably in their range and content of heavy metals. Manganese (Mn) is one of the metals frequently present in streams draining coal and metal mines, and plays an important role in geochemical cycles in sediments and the water column, in addition to being a fundamental trace nutrient for essentially all organisms. Some microorganisms (bacteria and fungi) can catalyse Mn oxidation and increase the reaction rate by several orders of magnitude compared to abiotic reactions. A biosulfidogenic reactor system was used to recover copper and to remove all other transition metals (Ni, Zn and Co) apart from Mn, using a synthetic liquor based on the chemical composition of a moderately acidic, metal-rich mine water from a copper mine in North Brazil. The solution (adjusted to pH 6.5) generated by this treatment was used as feed liquor for a separate upflow Mn(II) oxidation bioreactor, packed with Mn(IV) biofilm-colonised pebbles obtained from a catchment stream in the Snowdonia, north Wales. The column was filled with the partly-processed mine water containing manganese as the sole residual transition metal, and operated in continuous flow

mode, with hydraulic retention times ranging between 12 and 48 hours. Over 99% of manganese was removed when operated under optimized conditions. Clone libraries based on the 16S rRNA genes for bacteria and archaea as well as 18S rRNA genes for eukaryotes were constructed in indigenous microorganisms. Preliminary results confirmed presence of Mn(II)-oxidizing bacteria closely related to *Pseudomonas* and *Leptothrix* on the colonised pebbles, and a Mn-oxidizing fungus (identified as an ascomycete with 99% gene similarity to *Ulospora bilgramii* and several other species) was isolated from the bioreactor and has been studied further for its ability to remove soluble Mn from moderately acidic and circum-neutral pH liquors.

057 **Oxygen and extraction rate distribution during heap bioleaching of copper sulfides with forced aeration**

M. Huang[1], X. Miao[1]; [1]University of Science and Technology Beijing, School of Civil and Resource Engineering, Beijing/CN

Microbial heap leaching is an effective way to extract metals from copper sulfide ores. The heaps are usually tens of meters high and wide, which causes great difficulty for natural air convection at the middle and bottom parts. The oxygen in the air flow plays a key role in the bio-chemical reaction of minerals and the microbial activities. Leaching processes in low oxygen areas could be retarded or even suspended. Therefore, forced aeration at the heap bottom provides an effective way to optimize the oxygen distribution within the heaps, and then promotes the leaching rates.

Numerical simulation with COMSOL 3.5 was introduced to reveal the air flow rules and copper extraction rate distributions during the heap bioleaching of secondary copper sulfides. A two-dimensional and isosceles trapezoid model was developed (20 m in height, 80 m in bottom width and 40° in slope angle). The leaching process was simulated under the consideration of variable ratios (Q_l/Q_g) of irrigation (Q_l)-aeration (Q_g) rate. The irrigation rate Q_l was 0.036 $m^3/(m^2 \cdot h)$, and the Q_l/Q_g were 1:2.5, 1:10, 1:25, 1:50, respectively. Additionally, the numerical simulation also considered strict fundamental assumptions, governing equations and boundary conditions.

After the conduction of aeration at the heap bottom, stable air flows quickly formed from the bottom up, and the flow rates drastically decreased with the increase of heap height. When Q_l/Q_g <1:10, the horizontal component of the flow velocity was greater than the vertical one at the same height. When Q_l/Q_g >1:25, the diffusion pattern of the air flow turned from a spherical diffusion to an approximately vertical diffusion. In the simulated Q_l/Q_g ranges, the oxygen concentrations at the bottom and surface reached a level close to the atmosphere; low-oxygen concentration areas mainly located at the middle heap, and these areas gradually narrowed down or even disappeared as the aeration rate increased.

After 300-day leaching, taking ventilation site as the center, copper extraction rates extended outward in a concentric ellipticity shape. The link line of same extraction rates was approximately parallel to the heap saturation line. As the aeration rate increased, the areas with high extraction rates (>60%) correspondingly enlarged, while the low-extraction-rate areas gradually diminished.

When Q_l/Q_g=1:2.5, Cu leaching rate at the same height increased from the heap center to the slope. When Q_l/Q_g=1:10, Cu leaching rate at the bottom fisrtly increased then decreased towards the slope, while it trended to decrease towards the slope when the height was greater than 5 m. Moreover, Cu leaching rates and distribution rules were similar when Q_l/Q_g=1:25 and 1:50, i.e. Cu extraction rate at the middle of aeration sites and the heap boundary were higher than other sections below 5 m, while it sequentially decreased outward from the center at 10 m and 15 m height.

The results indicated a close relation between air permeation distance and Cu leaching rate. In natural condition, the oxygen permeated into the heap from the slope, and its concentration quickly dropped to only 50% within 4~6 meters. Thus, the absence of sufficient oxygen resulted in a poor activity for aerobic leaching microorganisms. When the compressed air was injected into the heap, the oxygen supply strongly depended on the aeration rate. Though the air diffusivity improved to a considerable level, the horizontal and vertical diffuse distances were less than 25 m and 15 m when the Q_l/Q_g ratio was 1:2.5~1:50. Interestingly, Cu leaching rate hardly increased when the forced aeration rate > 0.9 $m^3/(m^2 \cdot h)$, which indicated that these aeration rates had met the oxygen requirements of mineral dissolution reactions.

Compared with the natural ventilation, the numerical simulation showed that forced aeration improved the air diffusion and oxygen distribution in the heap, and then improved the leaching rate at differential heap heights. Higher ratio of irrigation to aeration rate leaded to a larger area with high Cu extraction rate (>60%). When the aeration rate was higher than 0.9 $m^3/(m^2 \cdot h)$, oxygen concentration was no longer a rate limiting factor for the bio-chemical dissolution of the secondary copper sulfides.

058 **Simplified Expression and Production of Small Metal Binding Peptides**

R. Braun[1]; F. Lederer[1]; S. Matys[1]; K. Pollmann[1]; [1]Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz-Institut Freiberg für Ressourcentechnologie, Dresden/D

059 **Comparative study on the bioleaching of gold-containing arsenopyrite or arsenopyrite + pyrite minerals**

Y. Song[1]; H. Yang[1]; L. Tong[1]; A. Auwalu[1]; Y. Chen[1]; Y. Chen[1]; [1]School of Metallurgy, Northeastern University, Shenyang/CN

No abstract available

060 **Development of Metal Ion Binding Peptides Using Phage Surface Display Technology**

N. Schönberger[1,2]; K. Pollmann[2]; [1]Helmholtz-Institut Freiberg für Ressourcentechnologie, Dresden/D; [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden/D

061 **The surfactant Tween-80 promotes the biooxidation of arsenopyrite**

H. Yang[1]; Y. Song[2]; L. Tong[2]; A. Auwalu[2]; W. Sand[3]; Y. Chen[2]; Y. Chen[2]; [1]Northeastern University, Shenyang/CN; [2]School of Metallurgy, Northeastern University, Shenyang/CN; [3]Aquatische Biotechnologie, Biofilm Centre, Universität Duisburg, Essen/D

Arsenopyrite is one of main gold-bearing minerals in refractory gold ores. The chemical behavior of the surface of arsenopyrite is very important for the efficiency of the bio-oxidation process. The effect of the surfactant Tween-80 on arsenopyrite biooxidation has been investigated. For the tests a mixed culture was used (HQ0211). The surfactant Tween-80 can promote the dissolution rate of arsenic, if used together with the mixed culture HQ0211. During leaching of pure arsenopyrite, the effects of the surfactant were evaluated by measuring the pH and the redox potential of the solution, the Fe^{2+}-concentration, the bacterial cell concentration and the leaching rate of arsenic. In the biooxidation process, elementary sulfur was detected. The results show that the leaching efficiency of arsenic increased from 52% to 73% by adding 0.1 $g \cdot L^{-1}$ Tween-80. This concentration changed the surface conditions of the mineral and accelerated the formation of elemental sulfur. With Tween-80 the leaching efficiency of arsenic increased by 21%, and the leaching time decreased by 20%. Thus, Tween-80 is an efficient tool to improve arsenopyrite oxidation.

062 **Metagenome-derived draft genome sequence of *Acidithiobacillus ferroxidans* (clone RV1) from an abandoned gold tailing in Neuquén, Argentina**

R. Ulloa[1]; F. Issotta[2]; A. Moya-Beltrán[3]; H. Nuñez[2]; P. Covarrubias[2]; R. Quatrini[2]; A. Giaveno[1]
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063 **EPS Characterization of a Cell Wall-Lacking Archaeon *Ferroplasma Acidiphilum***

R. Zhang[1]; V. Blanchard[2]; T. Neu[3]; M. Vera[4]; W. Sand[5]; [1]Bundesanstalt für Geowissenschaften und Rohstoffe , Hannover/D; [2]Charité Medical University, Berlin/D; [3]Helmholtz Centre for Environmental Research-UFZ, Magdeburg/D; [4]Pontificia Universidad Católica de Chile, Institute for Biological and Medical Engineering. Biological Sciences and Medicine, Department of Hydraulic and Environmental Engineering, School of Engineering, Santiago/RCH; [5]TU Bergakademie Freiberg/Donghua University, Changsha/CN

064 **Immobilization of Arsenic by a thermoacidophilic mixed culture with pyrite as energy source**
S. Vega[1]; J. Weijma[1], [1]Wageningen University, Wageningen/NL;

065 **Bioleaching of a nickel-cobalt sulfide flotation concentrate**
H. Yang[1]; L. Tong[1]; H. Yang[1]; S. Zhao[1]; X. Wang[1]; [1]Northeastern University, Shenyang/CN
No abstract available

066 **pH dictates the relative toxicities of cationic metals and anions (other than sulfate) to acidophilic bacteria**
C. Falagan[1]; D. Johnson[2]; [1]Bangor University, Menai Bridge/UK; [2]Bangor University, Bangor/UK
No abstract available

067 **Biooxidation of a refractory gold ore: implications of whole-ore heap biooxidation**
B. Chen[1]; J. Sun[1]; H. Shang[1]; B. Wu[1]; J. Wen[1]; [1]National Engineering Laboratory of Biohydrometallurgy, General Research Institute for Nonferrous Metals, Beijing/CN

068 **Type IV secretion systems diversity in the *Acidithiobacillus* genus**
R. Flores-Ríos[1]; A. Moya-Beltrán[2]; N. Harold[1]; R. Quatrini[3]; [1]Fundación Ciencia & Vida, Santiago/RCH; [2]Fundación Ciencia & Vida; Universidad Andres Bello, Santiago/RCH; [3]Fundacion Ciencia & Vida, Santiago/RCH

069 **Biological production of copper concentrate from flotation tailings and low grade ore**
I. Nancucheo[1]; [1]Universidad San Sebastián, Concepción/RCH

070 **Abiotic leaching of chalcopyrite in sulfuric acid solution**
S. Joe[1]; C. Inoue[1]; T. Kamiya[2]; T. Chida[2]; [1]Tohoku University, Sendai/J; [2]Japan Oil, Gas and Metals National Corporation, Tokyo/J
The aim of this work is to deepen the understanding on chalcopyrite leaching under aerobic and acidic conditions. To achieve this, we carried out shake flask experiments in sulfuric acid solution (initial pH of 0.7, 1.0 and 2.0) containing 2.5% of chalcopyrite flotation concentrate (provided from Atacama copper mine, Chile) without addition of ferric ion or thermophilic bacteria at 30-60 °C. Although the experimental conditions are very simple, it is expected to obtain important and fundamental information adoptable to understand many other factors affecting bioleaching of chalcopyrite, such as microorganisms and ferric ion. For two weeks leaching at 60 °C, 96% of copper was released at initial pH of 0.7, whereas 38% and 3% of the copper extractions were obtained at initial pHs of 1.0 and 2.0, respectively. Copper leaching was never occurred in an anaerobic condition and not catalyzed by ferrous or ferric ion. Here the main electron acceptor was concluded to be dissolved oxygen. Our findings are believed to be helpful to more clearly evaluate the factors on bioleaching.

071 **Complete genome sequence of *Leptospirillum ferriphilum* YSK, a super ferrous oxidizer with nitrogen fixation ability**
L. Ma[1]; X. Liu[1]; G. Qiu[1]; [1]Central South University, Changsha/CN
No abstract available

072 **Reaction between ferric and fluoride ions and its applied implications for the bioleaching of fluoride containing ore**
X. Wang[1]; W. Qin[1]; G. Qiu[1]; [1]Central South University, Changsha/CN
No abstract available

073 **Analysis of Microbial Community in Heap Bioleaching of Low-grade Copper Sulfide Ores**

H. Shang[1]; J. Wen[1]; B. Wu[1]; B. Chen[1]; [1]National Engineering Laboratory of Biohydrometallurgy, General Research Institute for Nonferrous Metals, Beijing/CN

No abstract available

074 **In-situ bioremediation of a lead-zinc sulfides mine tailings by sulfate reducing bacteria and iron reducing bacteria : Mine Tailings Remediation Experiment of Pilot- and Field-Scale**

X. Liu[1]; M. Zhang[1]; Y. Li[1]; Z. Wang[1]; J. Wen[1]; [1]General Research Institute for Nonferrous Metals, Beijing/CN

075 **The Application of High Throughput Sequencing Techniques in Bioleaching**

S. Zhou[1]; [1]Changsha Medical University, Changsha/CN

076 **Recovery of copper from pyritic copper ores using a biosurfactant-producing mixotrophic bacterium as bioflotation reagent**

E. Sanwani[1]; T. Wahyuningsih[1]; S. Chaerun[1]; [1]Institute of Technology Bandung, Bandung/RI

077 **An Effective Rare Earth Element Bio-Accumulator *Penidiella* sp. Strain T9 for Selective Recovery from Acidic Mine Drainage**

T. Horiike[1]; H. Kiyono[2]; M. Yamashita[2]; [1]Shibaura Institute of Technology, Saitama/J; [2]Shibaura Institute of Technology, Tokyo/J

078 **Bioleaching of Mt.Weld monazite by phosphate solubilisation: Evidences of induced dissolution of rare earth elements**

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Rare earth elements (REEs) are often seen as the prerequisite for the shift from a carbon-based economy to the carbon-free/green economy present in modern technologies, including hybrid vehicles. Furthermore, by considering the fact that current methods for separation of REEs are complex, expensive and potentially uneconomic for low grade mineral ores, application of phosphate solubilising microorganisms (PSMs) for phosphor (P) and REEs bio- solubilisation has been proposed. It has been proposed that solubilisation of the phosphate matrix of monazite (a phosphate REE mineral) by PSMs is mediated via the production of organic acids. In the present work, the requirement for direct contact of microbial isolate with the surface of Mt.Weld monazite concentrate (La 13%, Ce 23%, Pr 2.55%, Nd 8.9%, P 25%, and Y 0.30%) for maximal REEs dissolution was investigated.

Monazite dissolution was observed in the following order: Biotic direct contact>> Biotic indirect contact >> Abiotic. After 48h Ce dissolution was 261% greater after direct contact of the microbe with the mineral surface compared to indirect contact and 382% after 18 d. SEM photomicrographs demonstrated biofilm formation and the breakdown of the mineral surface with direct contact of the microbe while the mineral surface remained intact after indirect contact. This may explain a microbially mediated dissolution on mineral surfaces through direct/indirect mechanisms.

The outcomes from this research could lead to the development of a new, benign, eco-friendly bioleaching process to enhance the monazite and REE minerals dissolution.

080 **Selective chemical and biological metal recovery from Cu-rich bioleaching solutions**

S. Hedrich[1]; R. Kermer[2]; T. Aubel[2]; M. Martin[2]; B. Johnson[3]; A. Schippers[4]; E. Janneck[2]; [1]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D; [2]GEOS Ingenieurgesellschaft mbH, Halsbrücke/D; [3]Bangor University, Bangor/D; [4]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D

081 **Comparative bioleaching and mineralogical characterization of black shale-hosted ores and corresponding flotation concentrates**
A. Kamradt[1]; J. Schaefer[2]; A. Schippers[3]; S. Hedrich[3]; [1]Martin Luther University Halle-Wittenberg, Halle/D; [2]UVR-FIA GmbH, Freiberg/D; [3]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover/D

082 **Construction of a cell surface engineered yeast aims to selectively recover molybdenum, a rare metal**
M. Chien[1]; N. Ikeda[1]; K. Kubota[2]; C. Inoue[1]; [1]Graduate School of Environmental Studies, Tohoku University, Sendai City/J; [2]Department of Civil and Environmental Engineering, Tohoku University, Sendai/J

083 **Identifying the mechanisms of chloride ion tolerance in halotolerant acidophiles**
H. Khaleque[1]; J. Ramsay[1]; A. Kaksonen[2]; N. Boxall[2]; E. Watkin[1]; [1]CHIRI Biosciences, Curtin University, Perth/AUS; [2]CSIRO Land and Water, Perth/AUS
Microorganisms with the ability to oxidise iron/sulfur at low pH in the presence of high levels of chloride ion stress have potential for bioleaching of iron sulfide ores in regions where high salinity exists in groundwater or in the ores. Previous studies confirmed the ability of isolates V6, F5 and V8 to oxidise iron/sulfur efficiently under acidic conditions and high osmotic stress. Isolates V6 and F5 are both strains of *Acidihalobacter prosperus* and have shown higher chloride ion tolerance than the type strain DSM 5130. Isolate V8 is the first identified strain of the species "*Acidihalobacter ferrooxidans*" to be studied. All three isolates are able to tolerate copper, which is rarely seen in halophilic acidophiles. The three strains were further characterized by full genome sequencing. Comparative genome analysis showed differences in the assembly of operons that have key roles in the oxidation of iron/sulfur as well as for those regulating the production of osmoprotectants, which are known to play an important role in the survival of acidophiles under high osmotic stress. Genes related to copper tolerance were also observed in these genomes. Whole proteome analysis of differentially abundant proteins at varying chloride ion concentrations were then compared to those for the salt sensitive strain *Acidithiobacillus ferrooxidans*. The results of this work indicated novel mechanisms of salt tolerance under acidic conditions. The understanding of salt tolerance mechanisms by these acidophiles will help in extending the applicability of these microorganisms in bioleaching applications in regions of high salinity.

084 **A Flocculation Method to Eliminate the Third Phase in the Solvent Extraction Process of a Bioleaching Liquid Containing Cobalt and Copper Ions**
L. Tong[1]; H. Yang[1]; Y. Liu[2]; Z. Jin[1]; G. Chen[1]; [1]Northeastern University, Shenyang/CN; [2]CNMC Luanshya Copper Mines PLC, CNMC Luanshya Copper Mines PLC/Z
No abstract available

085 **In situ characterization of surface organic composition changes of thermoacidophilic archaea *Acidianus manzaensis* YN25 in response to energy substrate**
L. Liu[1]; X. Pan[1]; X. Xia[1]; Y. Zhou[1]; Z. Nie[1]; J. Xia[1]; [1]Central South University, Changsha/CN

086 **Selective bioleaching of cobalt from a Zambian copper and cobalt flotation concentrate**
L. Tong[1]; H. Yang[1]; Y. Liu[2]; Z. Jin[1]; A. Ali[1]; [1]Northeastern University, Shenyang/CN; [2]CNMC Luanshya Copper Mines PLC, CNMC Luanshya Copper Mines PLC/CN
No abstract available

087 **Bioleaching of Low-grade Chalcopyrite Ores by the Thermophilic Archaean *Acidianus brierleyi***
N. Saitoh[1]; T. Nomura[1]; Y. Konishi[1]; [1]Osaka Prefecture University, Sakai/J

088 **Adaptation of the Iron-Oxidizing *Ferrimicrobium acidiphilum* to Chloride and to Oxidative-Stress Conditions Caused by NaCl**

M. Kaszuba[1]; S. Schopf[1]; J. Rivera-Araya[2]; G. Levicán[2]; M. Schlömann[1]; [1]TU Bergakademie Freiberg, Institute of Biological Sciences, Freiberg/D; [2]Universidad de Santiago de Chile, Facultad de Química y Biología, Santiago de Chile/RCH

Acidophilic iron-oxidizing bacteria tend to be very sensitive to increased concentrations of chloride. This is a problem for bioleaching operations, since acidophilic iron oxidizers are of key importance for bioleaching, but simultaneously such increased chloride concentrations may occur in bioleaching operations, for example, due to recycling of the acid solution after solvent extraction, due to the use of sea water, or due to the occurrence of atacamite. Although *Acidihalobacter prosperus*, a *Sulfobacillus* strain and adapted strains of *Acidithiobacillus ferrooxidans* and *Leptospirillum ferriphilum* have been described to tolerate increased chloride levels, little is known about the biochemical mechanisms enabling acidophilic iron oxidizers to tolerate chloride. Therefore, the heterotrophic iron oxidizing bacterium *Ferrimicrobium acidiphilum* T23^T was exposed to different chloride concentrations (from 50 mM to 400 mM NaCl). Bacteria were cultivated in shake flasks with DSMZ medium 1190 and 5 mM citric acid, in weekly cycles at 30°C and 130 rpm. Adaptation was conducted stepwise with increasing concentrations. This strain showed ability to tolerate no more than 200 mM of NaCl. Reproducible subcultivation so far was only achieved in the presence of 100-150 mM NaCl. Measurements of reactive oxygen species (ROS) with dichloro-dihydro-fluorescein diacetate (DCFH-DA) exhibited that addition of > 200 mM of NaCl may cause oxidative stress in bacterial cells. What is more interesting, the addition of a compatible solute, e.g. 1 mM of trehalose, can lower ROS production and thus reduce oxidative stress.

089 **Experimental study on column bioleaching of a refractory copper - cobalt oxide ore in Zambia**

Y. Liu[1]; H. Yang[2]; L. Tong[2]; F. Xiao[2]; G. Chen[2]; Z. Jin[2]; W. Sand[3]; [1]CNMC Luanshya Copper Mines PLC, Luanshya/Z; [2]School of Metallurgy, Northeastern University, Shenyang/CN; [3]Donghua University, College of Environmental Engineering, Freiberg/D

The Zambian low-grade refractory copper - cobalt oxide ore contains Cu 0.56%, Co 0.11%, S 15.20%, Fe 12.8%, Ca 1.38%. In order to investigate bioleaching of copper, a comparative column leaching experiment was carried out. The effective height of the leaching column is 77 cm, the inner diameter is 16 cm, the ore-packing amount is 18 kg with a copper grade of 0.56%. From two columns one was used for acid leaching and another one for bioleaching. The leaching test was divided into two stages: the first stage was acid leaching with a solution spray rate of 5 L x m^{-2} x h^{-1}. This stage lasted 19 d. The leaching rate of copper in the acid leaching test was 76%, whereas that of the microbial leaching test was 68%. After 20 days the experiment entered the second stage. The acid leaching column was maintained with the same spray rate. In the bio-leaching column the spray liquid was replaced by a liquid containing acidophilic bacteria. At the end of the leaching tests, the leaching of copper in the acid leaching test amounted to 85%, while that of microbial leaching test amounted to 91%. The results show that bioleaching of Zambian ores is the preferential technique.

090 **Isolation of specific binding peptides for ionic species of nickel and cobalt using the phage surface display technique**

S. Matys[1]; N. Schönberger[2]; K. Flemming[3]; F. Lehmann[4]; F. Lederer[4]; K. Pollmann[4]; [1]Helmholtz-Zentrum Dresden-Rossendorf/Helmholtz Institute Freiberg for Resource Technology, Freiberg/D; [2]Technische Universität Bergakademie Freiberg, Institute of Non-Metallurgy and Pure Substances, Freiberg/D; [3]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Resource Ecology, Dresden/D; [4]Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz Institute Freiberg for Resource Technology, Freiberg/D

Since several years, the phage surface display technique has been successfully applied for the development of new receptor-ligand pairs for medical purposes, new pharmaceuticals or the elucidation of protein-protein interactions. A comparatively new methodological approach is the use of this technique for bioremediation. In the BMBF-funded German-French project "EcoMetals" we focused on novel innovative biological methods for the extraction of copper and accompanying elements from complex copper-containing ores or tailings. The selective separation of individual industrially relevant chemical elements from complex copper-containing leaching solutions represents a particular challenge. Where established chemical methods do not work due to low concentrations or complex composition of these solutions, selectively binding biological structures could become attractive. Up to now, metal-binding peptides are regarded as particularly promising candidates. We used for the isolation and characterization of nickel- and cobalt-specific peptides a bacteriophage library (Ph.D.C7C Phage Display Peptide Library Kit, New England Biolabs, Inc.) for targeted removal and enrichment of these elements from a complex leaching solution. In this library the minor coat protein pIII is genetically modified leading to the expression of 5 copies phage tail protein containing a foreign heptapeptide loop flanked by a disulfide bridge. From a pool of 10^9 different peptide motifs, 24 peptides for nickel and 19 peptides for cobalt were isolated in an iterative process, the so-called bio-panning. The binding strength of these phages was compared with the wildtype. Cross binding tests revealed for most of the nickel binding phages also binding capacities for cobalt and vice versa.

091 **Phage display – a new tool for the recovery of critical elements from primary and secondary sources**

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The development of effective and ecofriendly processes for the recovery of critical elements poses a challenge for scientists all over the world. Beside the relevance for the environment new products and techniques have to be highly specific for target materials and be economically applicable. Critical elements such as rare earth elements are part of a multitude of modern electronic devices. However, their recycling rate is low partly due to the similar chemical and physical properties of the elements making their separation difficult.

To generate highly specific peptides that bind specifically to individual elements of interest, the phage surface display (PSD) technology was used. PSD technology was originally developed to identify peptides with high binding specificity for biological molecules such as viruses, antibodies or fusion proteins. Later the technology was successfully applied for inorganic targets as well.

In the current project four different fluorescent phosphor components were used to identify a small number of specific binding peptides via PSD. The newly identified peptides differ strongly in their amino acid composition and binding behavior. Binding properties can be improved by substitution of individual amino acids by more effective amino acids.[1] The application of peptides in bioflotation processes is now being tested as an efficient separation process for rare earth minerals.

In summary, phage surface display is a promising tool for the development of highly specific binding peptides. The development of ecofriendly material specific collectors in bioflotation and separation processes has the potential to revolutionize traditional recycling techniques.

092 **Production of Amphiphilic Hydroxamate Siderophores Marinobactins by *Marinobacter* Sp. DS40M6 for Bioflotation Process**

S. Schrader[1]; S. Kutschke[1]; M. Rudolph[1]; K. Pollmann[1]; [1]HZDR, Dresden/D

093 **A New Technology for Bacterial Sulfur Removal from High Sulfur Anode Mud**

Q. Chen[1]; L. Tong[1]; H. Yang[1]; W. Sand[2]; [1]School of Metallurgy, Northeastern University, Shenyang/CN; [2]Aquatische Biotechnologie, Biofilm Centre, Universität Duisburg-Essen, Essen/D

As a by-product of smelting combined with electrolytic processes, anode muds contain gold, silver and platinum group metals. Thus, these muds are important raw materials for a recovery of precious metals. However, a high sulfur content in the anode muds will seriously affect the winning of these precious metals. This paper proposes a new technique for a removal of the elemental sulfur in the anode muds by bioleaching. The effects of particle size, pH, temperature and pulp concentration on bacterial desulfuration were explored in shake flat tests and tank leaching experiments, respectively. The results show that the elemental sulfur in anode muds can be removed effectively by microbial oxidation and the precious metals get enriched efficiently.

094 **Bioleaching Experiments on a low-grade Complex Zinc Ore from Inner Mongolia**

J. Li[1]; L. Tong[1]; Q. Chen[1]; Z. Jin[1]; H. Yang[1]; [1]School of Metallurgy, Northeastern University, Shenyang/CN

095 **The Mechanism of Skutterudite Acid Leaching:a DFT Study of H^+ Effect on CoO(010)surface**

J. Xu[1]; H. Yang[2]; L. Tong[2]; Z. Jin[3]; S. Yan[2]; [1]Northeastern University, ShenYang/CN; [2]School of Metallurgy, Northeastern University, ShenYang/CN; [3]School of Metallurgy, Northeastern University, Shenyang/CN

096 **Insights into Heap Bioleaching at the Agglomerate-Scale**

A. Cox[1]; C. Bryan[1]; [1]University of Exeter, Penryn/UK

097 **Research on bio-leaching of nickel-bearing tailings in Jilin,China**

X. Wang[1]; H. Yang[1]; L. Tong[1]; Z. Jin[1]; S. Zhao[1]; [1]School of Metallurgy, Northeastern University, Shenyang/CN

098 **Analysis for transformation of acid - alkaline system in the process of biooxidation - gold extraction**

Z. Liu[1]; Y. Song[2]; H. Yang[2]; [1]China National Gold Group Corporation, Beijing/CN; [2]School of Metallurgy, Northeastern University, Shenyang/CN

The technology biooxidation - gold extraction to deal with refractory gold ores is more and more popular in worldwide. In this process, oxidation slag from acid system transforming to alkaline system is very important. If not in accordance with the standard operation, on the one hand it would cause the cyanide liquid overflow leading to the balance of production water system being broken, which could make the treatment of cyanide solution more difficult; On the other hand would cause extra oxidation solution entering the cyanide system, which could increase consumption of lime and sodium cyanide, meanwhile, generate a large number of SCN^- impacting gold extraction. Through analysis and calculation for the washing operation, The study optimized the washing process, controlled indicators of washing rate of the element such as element S in the oxidation solution, and ensured the impurity content control within the industry standard in the cyanide system. For reducing production costs, improving the leaching rate of gold, maintaining stability of oxidation cyanidation water system, and reducing the pollution of the environment, the study provided technical support.

099 **A comparison of bioleaching behavior of two different chalcopyrite by moderately thermophiles through investigating the chalcopyrite crystallographic properties**

Y. Zhang[1]; J. Zhang[1]; B. Zhang[1]; W. Qin[1]; K. Chang[1]; G. Qiu[1]; [1]Central South University, Changsha/CN;

100 **Removal of arsenic from aqueous solution by *Aeromonas hydrophila***

L. Castro[1]; M. Blázquez[1]; F. González[1]; J. Muñoz[1]; A. Ballester[1]; [1]Universidad Complutense de Madrid, Madrid/E

101 **Biosynthesis of copper nanoparticles from bioleaching solutions using aqueous extracts of *Aloe vera* and *Geranium***

A. Pawlowska[1]; Z. Sadowski[1]; [1]Wroclaw University of Science and Technology, Wroclaw/PL

102 **Investigation of the Ga complexation behaviour of the siderophore Desferrioxamine B**
R. Jain[1]; K. Pollmann[2]; [1]Helmholtz-Zentrum Dresden - Rossendorf, Dresden/D; [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden/D

103 **The Effect of Initial Solution pH on Surface Properties of Ferric Iron Precipitates Formed during Biooxidation of Ferrous Iron by *Leptospirillum ferriphilum***
B. Mabusela[1]; T. Ojumu[1]; [1]Cape Peninsula University of Technology, Cape Town/ZA

104 **Adhesion Studies of Microorganisms on Natural Ore Material – who are the Key-Players in Bioleaching of Sulfidic Mineral Surfaces**
N. Eisen[1]; S. Schopf[1]; M. Schlömann[1]; [1]TU Bergakademie Freiberg, Institute of Biological Sciences, Freiberg/D

105 **Biochemical Aspects of Energy Metabolism in Thermotolerant Sulfobacillus**
A. Panyushkina[1]; I. Tsaplina[1]; V. Melamud[1]; E. Kostryukova[2]; [1]Federal Research Center of Biotechnology of Russian Academy of Sciences, Winogradsky Institute of Microbiology RAS, Moscow/RUS; [2]Federal Medical and Biological Agency SRI of Physical-Chemical Medicine, Moscow/RUS

106 **Use of specific metal binding of self-assembling S-layer proteins for metal bioremediation and recycling**
M. Vogel[1]; S. Matys[1]; F. Lehmann[1]; B. Drobot[1]; T. Günther[1]; K. Pollmann[1]; J. Raff[1]; [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden/D

107 **Comparative Study of NaCl-tolerance Mechanisms in Acidophilic Iron-oxidizing Bacteria**
J. Rivera-Araya[1]; M. Schlömann[2]; G. Levicán[1]; [1]Universidad de Santiago de Chile, Facultad de Química y Biología, Santiago/RCH; [2]IMFD Technische Universität Freiberg, Freiberg/D

108 **Influence of Citrate on Metal Dissolution and Respiration Rate of Microbial Leaching Cultures**
F. Giebner[1]; J. Rolle[2]; J. Helmich[2]; M. Schlömann[2]; S. Schopf[2]; [1]TU Bergakademie Freiberg, Freiberg/D; [2]TU Bergakademie Freiberg, Institute of Biological Sciences, Freiberg/D

109 **The influence of pyrite on galvanic assisted bioleaching of low grade chalcopyrite ore**
B. Wu[1]; [1]General Research Institute for Nonferrous Metals, BeiJing/CN

110 **Microbial ferrous iron oxidation versus ferric ion precipitation at low temperature conditions**
E. Chukwuchendo[1]; B. Mabusela[1]; T. Ojumu[1]; [1]Cape Peninsula University of Technology, Cape Town South Africa, Cape Town/ZA

111 **Innovative biohydrometallurgical approaches in the EU project FAME**
S. Reichel[1]; M. Martin[1]; C. Bryan[2]; C. Vila[3]; A. Fiuza[4]; W. Reimer[5]; [1]G.E.O.S. Ingenieurgesellschaft mbH, Halsbrücke/D; [2]University of Exeter, Camborne School of Mines, Penryn/UK; [3]University of Porto, Porto/P; [4]University of Porto, Porto/D; [5]Geokompetenzzentrum Freiberg e. V., Freiberg/D

112 **Comparison of chemical and biotic leached mineral ore sections**
J. Heinrich[1]; A. Korda[1]; N. Eisen[1]; G. Heide[1]; [1]TU Bergakademie Freiberg, Freiberg/D
No abstract available

113 **Transcription Dynamics of Calvin-Benson-Bassham (CBB) Pathway Genes in *Acidithiobacillus thiooxidans* Growing under Different Carbon Dioxide Levels**
S. Marín[1]; Y. Villegas[2]; P. Galleguillos[3]; M. Acosta[1]; C. Demergasso[1]; [1]Universidad Católica del Norte, Antofagasta/RCH; [2]Universidad de Antofagasta, Antofagasta/RCH; [3]Centro de Investigación Científico y Tecnológico para la Minería, Antofagasta/RCH

114 **Influence of air flow rate and CO_2 supplementation on the bioleaching of a Cu concentrate from Kupferschiefer ore**
A. Guezennec[1]; C. Joulian[1]; J. Jacob[1]; F. Bodenan[1]; P. D'Hugues[1]; S. Hedrich[2]; [1]Bureau de Recherches Géologiques et Minières (BRGM), Orléans/F; [2]Bundesanstalt für Geowissenschaften und Rohstoffe, Hanover/D

116 **Bioleaching of pyrite by iron-oxidizing acidophiles under the influence of reactive oxygen species**
N. Huynh[1]; S. Bellenberg[2]; M. Vera[3]; P. Ansgar[4]; W. Sand[1]; [1]Insitute of Biosciences, Environmental Microbiology, TU Bergakademie Freiberg, Freiberg/D; [2]Biofilm Centre, Aquatische Biotechnologie, Universität Duisburg-Essen, Essen/D; [3]Institute for Biological and Medical Engineering. Schools of Engineering, Medicine and Biological Scienes, Department of Hydraulic and Environmental Engineering. School of Engineering, Pontificia Universidad Católica de Chile, Santiago/RCH; [4]Ruhr Universität Bochum, Bochum, Germany, Bochum/D

117 **Expression of candidate cold adaption and metabolic related genes in *Acidithiobacillus ferrivorans* PQ33 strain growth at 5°C in ferrous iron**
G. Guerra-Bieberach[1]; R. Ccorahua[1]; A. Eca[1]; J. Bernaldo[1]; C. Rojas-Ayala[1]; P. Ramirez[1]; [1]National University of San Marcos, Lima/PE

118 **Bioleaching for removal of chromium and phosphor from LD slag**
S. Thallner[1]; W. Schnitzhofer[1]; C. Hemmelmair[1]; S. Martinek[1]; [1]ACIB GmbH, Linz/A

122 **Bioleaching of tailings resulting from benefication of polymetallic ores for recovery of valuable metals**
N. Vardanyan[1]; G. Sevoyan[2]; A. Vardanyan[1]; [1]SPC "Armbiotechnology" of NAS of Armenia, Yerevan/ARM; [2]Armenian National Politechnic University, Yerevan/ARM

123 **Biooxidation of a high-grade arsenopyritic gold ore in a stirred tank reactor using a mixed culture of moderate thermophile microorganisms**
H. Abdolahi[1]; A. Ahmadi[1]; H. Zilouei[1]; [1]Isfahan University of Technology, Isfahan/IR

124 **Microorganisms Oxidize Iron (II) Ions in the Presence of High Concentrations of Sodium Chloride – Potentially Useful for Bioleaching**
N. Huynh[1]; S. Kaschabek[1]; W. Sand[1]; M. Schlömann[1]; [1]Institute of Biosciences, Environmental Microbiology, TU Bergakademie Freiberg, Freiberg/D

125 **Effect of X-ray µ-CT scanning on the growth and activity of microorganisms in a heap bioleaching system**
M. Ghadiri[1]; M. Fagan-Endres[1]; S. Harrison[1]; [1]University of Cape Town, Cape Town/ZA

126 **Are there viruses in industrial bioleaching econiches?**
P. Covarrubias[1]; R. Muñoz[2]; R. Bobadilla-Fazzini[3]; P. Martinez[4]; R. Quatrini[5]; [1]Fundación Ciencia & Vida, Santiago/RCH; [2]Anglo American Chile, Santiago/RCH; [3]CodelcoTec SpA, Santiago/D; [4]CodelcoTec SpA, Santiago/RCH; [5]Fundacion Ciencia & Vida, Santiago/RCH

127 **Evaluation of Long-Term Post Process Inactivation of Bioleaching Microorganisms**
M. Bomberg[1]; H. Miettinen[1]; P. Kinnunen[1]; [1]VTT Technical Research Centre of Finland Ltd., Espoo/FIN

128 **Microbial survey on industrial bioleaching heap by high-throughput 16S sequencing and metagenomic analysis**
M. Acosta[1]; P. Galleguillos[2]; C. Demergasso[1]; [1]Universidad Católica del Norte, Antofagasta/RCH; [2]Centro de Investigación Científico y Tecnológico para la Minería, Antofagasta/RCH

129 **Leaching of pyrite by *Acidithiobacillus ferrooxidans* monitored by electrochemical methods**
A. Saavedra[1]; [1]Buenos Aires University, Buenos Aires/RA

130 **FISH Analysis of Mixed Microbial Communities involved in Biological Sulphate Reduction for ARD Bioremediation**

T. Hessler[1]; T. Marais[1]; R. Huddy[1]; R. van Hille[1]; S. Harrison[1]; [1]University of Cape Town, Cape Town/ZA

131 **Genetic basis of metal resistance in *Acidiphilium* sp. DSM 27270 (Yenapatur)**

F. Issotta[1]; R. Bobadilla-Fazzini[2]; A. Moya-Beltran[3]; P. Covarrubias[4]; R. Quatrini[4]; P. Martinez[2]; [1]Fundación Ciencia & Vida, Santiago/RCH; [2]CodelcoTec SpA, Santiago/RCH; [3]Universdad Andres Bello, Santiago/RCH; [4]Fundacion Ciencia & Vida, Santiago/RCH

132 **Numerical Modelling of Copper Bioleaching from Chalcopyrite (SysMetEx)**

O. Ilie[1]; A. Buetti-Dinh[1]; W. Sand[2]; M. Dopson[3]; I. Pivkin[1]; [1]Università della Svizzera Italiana, Lugano/CH; [2]Universität Duisburg-Essen, Essen/D; [3]Centre for Ecology and Evolution in Microbial Model Systems (EEMiS), Linnaeus University, Kalmar/S

Acidophilic bacteria are used in biomining to enhance metal extraction from mining ores and reduce toxic compounds release. The bacteria form thin biofilms on the surface of chalcopyrite particles where they act as biological catalyzers in the process of mineral dissolution, releasing copper together with other demineralization products. Using both numerical and experimental models, the SysMetEx project aims to identify methods of reducing the long lag period typically encountered at the beginning of chalcopyrite heap bioleaching operations.

A mechanistic, time-dependent, numerical model was developed at reactor level to understand the dominating mechanisms in a bioleaching system, to identify and optimize key process parameters and to guide the laboratory experiments. The ODE model integrates a thermodynamically based coupling of microbial anabolism and catabolism, complexation equilibria and chalcopyrite dissolution, while considering the fractal nature of chalcopyrite grain geometry. The mathematical model considers the same consortium of three bacterial species as the one used in the experimental models: *Acidithiobacillus caldus*, *Leptospirillum ferriphilum*, and *Sulfobacillus thermosulfidooxidans*.

133 **Bioleaching of minor element from European copper shale**

S. Kutschke[1]; R. Bertheau[2]; K. Pollmann[2]; [1]HZDR, Freiberg/D; [2]HZDR/ HIF, Freiberg/D

The ore deposit of the European Copper Shale (Kupferschiefer) is large sediment-hosted copper deposits with a high content of base metals, precious metals and PGM. The European Copper Shale ore possesses a large content of carbonate rocks. Therefore heterotrophic microorganisms were examined to leach metals at neutral pH avoiding carbonate dissolution.

The leaching efficiency of Kombucha-culture, *Yarrowia lipolytica, Sporosarcina ureae* and *Bacillus licheniformis* was tested for copper shale ore samples from Mansfeld mining waste dump (Germany), Sangerhausen mine (Germany) and Rudna mine (Poland). The chemical analyses of leaching solutions showed that beside copper up to 12 % of lanthanides as well as 43 % cobalt. On the other hand nearly 70 % of zinc was leached by *S. urea*.

It is possible to recover rare earth metals from copper shale using microbial producers of chelating agents. Further investigation should be focused on optimization of leaching conditions and economical calculations.

134 **Bacterial leaching of minerals using *Streptomyces***

J. Hurtado[1]; [1]Universidad Peruana Cayetano Heredia, Liam/PE

Microorganism play a key role in arsenopyrite oxidation in natural and commercial processes. There are many organisms involved in the bacterial leaching operations.The objective of this study was todemonstrate the use of Streptomyces in the bacterial leaching of arsenopyrite.

Ten isolates of Streptomyces from arsenopiryrite, pyrite, polimetalic sulfides and magnetite from Peruvian mining zones have been characterized and they have been tested by growth on arsenopyrite tailings. Only two isolates were able to develop with this mineral. Streptomyces sp. E1 and Streptomyces variabilis AB5 leached 19.1 % and 15.5 % of arsenic present in tailings while, the control without inocula, only showed 2.5% of leaching.

This study demonstrated that Streptomyces is able to degradate arsenopyrite.

135 **Microbial fuel cell operating with thiosulfate and an acidophilic mixed culture**

J. Hurtado[1]; [1]Universidad Peruana Cayetano Heredia, Lima/PE

Microbial fuel cells (MFC´s) have been demonstrated using a variety of microorganisms including acidophilic microorganisms. Bacterial leaching often realease metlas and and inorganic sulfur compounds as tetrathionate and thiosulfate to the mining process and waste waters. The untreated acidic metal-rich water may harm the environment. It has been reported generation of electricity in microbial fuel cells using tetrathionate, but not using thiosulfate. Here, we investigate the use of thiosulfate in microbial fuel cells using an acidophilic mixed culture.The fuel cell used in this study was a two-chamber camera with anode and cathode chambers separated by a Naflon membrane. The electrodes were Graphite felt. The anolyte was thiosulfate at pH 3.6 and the catholyte was water. A mixed culture of anaerobic bacteria growing in thiosulfate, developed from copper sulfides was used as inoculum. The maximum cell voltage obtained was 18 mV. This study demonstrated that thiosulfate generate electricity using a acidophilic bacterial cell culture.

136 **Possible biooxidation of arsenopyrite from refractory gold ore using the bacteria *Acidithiobacillus ferrivorans* ACH isolated from the Chilean Altiplano**

F. Remonsellez[1]; [1]Universidad Católica del Norte, Antofagasta/RCH

The mineral processing industry has focused his interest in find and use new technologies that have a lower economic and energy cost to recovery of metals with commercial interested such as copper, gold and nickel. Low grade refractory sulphide gold ore is preferentially associated with high amount of pyrite and arsenopyrite. In such ore, gold is dispersed as submicroscopic particles and efficient recovery of this finely dispersed gold is very difficult by conventional method (e.g. cyanidation) without pretreatment. However, microbial activity could be strongly affected by the presence of high concentrations of heavy metals in the process (0.1 - 1M). Therefore, arsenical resistance mechanisms are important to bioleaching of arsenopyrite because arsenic is released in this process.

The principal aim of this work is evaluate the ability to oxidize an arsenopyrite concentrate (34.8% of arsenic) and propose possible mechanisms of arsenic resistance in *Acidithiobacillus ferrivorans* ACH. In a previous work, we isolated and characterized this strain from an acid stream (pH <3) located in the Chilean Altiplano, which was capable of grow in the presence of iron, sulfur pyrite as energy source.

Two concentrations of pulp (1% and 5 %) were tested in erlenmeyer flasks with 30 mL of MAC medium (pH 1.7). The flasks were agitated at 120 rpm with orbital agitation. Microbial growth was determined by cell counting and redox potential measuring. Our results indicate that the strain was able to grow in the presence of the concentrate ore as only energy source, reaching cellular concentrations of 2.2×10^7 cells/mL in both conditions. Moreover, we observed an increase of redox in the cultures at 1% of pulp, with values of 568 mV. However, the redox potential values not showed an considerable increased in the cultures at 5% of pulp. This phenomenon was analyzed by visualizing the concentrate in a scanning electron microscope coupled to X-ray spectroscopy (SEM-EDX), detecting the presence of a large amount of iron precipitate on the surface of the concentrate that possibly would affect the redox potential values in the 5% pulp assay. On the other hand, preliminary genome data of *A. ferrivorans* ACH indicate the presence of putative genes related with arsenic resistant mechanisms such as driving ATPase (*arsA*), arsenical resistant operon trans-acting repressor (*arsD*), arsenate reductase (*arsC*), arsenical resistant operon repressor (*arsR*), and arsenic efflux pump (*arsB*). The presence of these determinants could explain the tolerance and activity of *A. ferrivorans* ACH strain in front to arsenopyrite ores.

Our results are relevant because there is no scientific evidence of tolerance to high concentrations of arsenic in bioleaching strains isolated from natural ecosystems such as the Chilean Altiplano, enhancing his possible use in bioleaching processes in similar conditions.

138 **An XRD, XPS and XANES study on the bioleaching of arsenopyrite with or without pyrite**
Y. Yang[1]; W. Liu[1]; C. Wang[2]; M. Chen[1]; [1]Commonwealth Scientific and Industrial Research Organisation (CSIRO), Clayton/AUS; [2]ZIJIN Mining Group Co. Ltd, Xiamen/CN

139 **Process and cost improved agitator solutions for bioleaching reactors**
J. Jung[1]; [1]EKATO RMT, Schopfheim/D

140 **Preliminary study on in-situ realtime quantitation of target bacteria on the principle of flow cytometry**
Y. Sugai[1]; G. Murakami[1]; K. Sasaki[1]; [1]Kyushu University, Fukuoka/J

141 **Intensification of Arsenic Mobilization by Combination of Bio-chemical Leaching with EDTA in the Soil and Sediment Bioremediation**
I. Štyriaková[1]; D. Štyriaková[1]; A. Bekényiová[1]; I. Styriak[1]; J. Šuba[1]; [1]Institute of Geotechnics SAS, Kosice/SK

142 **Microbial dissolution of iron surface coatings in industrial minerals**
J. Šuba[1]; I. Štyriaková[2]; I. Štyriak[2]; D. Štyriaková[2]; [1]Slovak Academy of Sciences, Institute of Geotechnics, Košice/SK; [2]Institute of Geotechnics, SAS, Košice/SK

143 **Utilizing of bioceramic filters in As removal from bioleachates**
A. Bekényiová[1]; Z. Danková[1]; I. Štyriaková[1]; D. Štyriaková[1]; [1]Slovak Academy of Sciences, Institute of Geotechnics, Košice/SK

144 **Bio Degradation of Thiocyanate and Cyanide in CIL leaching wastes's liquid phase**
A. Belyi[1]; A. Teleutov[1]; A. Revenko[1]; N. Solopova[1]; V. Sekachev[1]; A. Malashonok[1]; G. Krasilnikov[1]; [1]JSC "Polyus", Krasnoyarsk/RUS

145 **Microbial Population of Industrial Bioleach Reactors**
A. Bulaev[1]; A. Belyi[2]; A. Panyushkina[1]; N. Solopova[2]; T. Pivovarova[1]; [1]Winogradsky Institute of Microbiology, Moscow/RUS; [2]JSC "Polyus", Krasnoyarsk/RUS

146 **Heap biooxidation of gold-sulfide and polymetallic ores and tailings**
A. Epiforov[1]; [1]JSC Irgiredmet, Irkutsk/RUS

147 **Processing of complex gold-bearing sulfide raw materials using a biohydrometallurgical method**
A. Seleznev[1]; L. Shketova[1]; [1]JSC Irgiredmet, Irkutsk/RUS
Refractory sulfide gold-bearing ore from a Russian deposit was studied.
The causes for the ore refractoriness are: gold association with sulfides and the ore preg-robbing. In the course of the oxidation of sulfides gold which is finely disseminated in them liberates and is amenable to recovery. The major contributors to this process acceleration are bacteria of genus *A. Thiobacillus*.
A combined product containing 22 g/t Au was generated during gravity concentration and flotation. A feature of the product studied is that it has higher sulfides content (about 50%). The portion of sulfides can be mainly found in the form of pyrite (46.3%). The portion of arsenopyrite is 4.1%. The portion of carbonaceous matter contained in this product is significant and is 3.4%. The carbon is preg-robbing and has an impact on the recovery indices of the ore and the resulting concentration products**.** Diagnostic leaching showed high resistance of this mineral raw materials to cyanidation (45.6% Au is recoverable). Therefore, it has an overall negative impact onto the oxidation of sulfides and requires specific processing methods. In order to evaluate the efficiency of roasting and cyanidation technology for processing these concentrates, test work was carried out. It was found that an oxidative roasting allows the increase in gold recovery from 45-48%, to 72-83% during a subsequent cyanidation. The recovery of gold using cyanidation with carbon from the oxidation products was 93-95% during POX of the concentrates mixture. In the course of biooxidation a significant amount of sulfuric acid and other oxidation products form. The excess of sulfuric acid requires neutralization,

during which a significant amount of gypsum forms. It covers sulfides with the products of oxidation and neutralization. So, the rates of arsenopyrite and pyrite oxidation are 70% and 30%, respectively, when using a conventional biooxidation. This provides only 70% Au recovery during the subsequent cyanidation with carbon.

Positive results were achieved after the two-stage biooxidation combined with an intermediate regrinding of the biooxidation product. This allowed the breakage of gypsym aggregates and the liberation of non-liberated sulfides for the subsequent oxidation.Another option is to remove acidic solutions during biooxidation and their replacement with fresh water. This option provides higher gold recovery during the subsequent cyanidation. Based on the test work on biooxidation of the concentrate conducted, the rates of arsenopyrite and pyrite oxidation achieved were over 95% and, up to 93%, respectively. Gold recovery using cyanidation increased, up to 95%.

Therefore, gold recovery indices using POX and biooxidation options are similar. Considering all the options of the concentrates liberation from this deposit it can be concluded with a high degree of certainty that the preferable option of the ore processing is biooxidation in organizing a full ore processing flow sheet at the site.

148 **Enzymatic pre-treatment of carbonaceous matter in preg-robbing gold ores: Effect of iron additives**

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149 **Biomineralization processes in Río Tinto**

R. Amils[1]; M. Oggerin[1]; N. Rodríguez[2]; [1]Universidad Autónoma de Madrid, Madrid/E; [2]Centro de Astrobiología, Torrejón de Ardoz/E

150 **Changes of cobalt and molybdenum forms from catalyst for hydrodesulfurization of oil in the process of bioremediation of complex pollutants from the oil industry**

M. Vrvic[1]; [1]Faculty of Chemistry, University of Belgrade, Belgrade/SRB

151 **Bioleaching of Cadmium from Contaminated Paddy fields by Consortium of Autotrophic and Indigenous Cadmium-tolerant bacteria**

Y. Deng[1]; X. Liu[1]; [1]Central South University, Changsha/CN

153 **Characterization of a novel psychrotolerant *Acidithiobacillus ferrivorans* strain from metal mine-impacted environment**

A. Chen[1]; Y. Liang[1]; [1]School of Mineral Processing and Bioengineering, Central South University, Changsha, Hunan/CN

No abstract available

154 **Identification and Denitrification Function of a Novel Strain of *Pseudomonas aeruginosa* Isolated from Aquifers of a Sand Stone Uranium Deposit**

Y. Liu[1]; Z. Chen[1]; Z. Li[1]; L. Xu[1]; X. Wang[1]; J. Liu[2]; [1]East China University of Technology, Nanchang/CN; [2]East China University, Shanghai/CN

Acid in-situ leaching has been widely used in sand stone uranium ores for nearly 30 years in China for its low cost and less workforce. But with the uranium mine decommission, the potential acid, heavy metals and radioactive pollution to underground water was paid more attention these years. 512 uranium deposit is located in the northwest of China and have been carried on acid in-situ leaching for about 25 years and now many leaching sections are facing to decommission. The aquifer's characteristics in the in-situ sections are of low pH, high nitrate and sulfate concentration for the use of sulfuric acid as leaching solution and ammonia nitrate as washing solution in the processing. It's necessary to obtain an efficient denitrifier which can denitrify nitrate or nitrite and enhance pH simultaneously in the waste water or the aquifers underground. In 512 Uranium Mine, pH of the aquifers was 4.07-4.49 and nitrate concentration was as high as 397.0-454.0mg/L in the range of 30-60m away from the leaching site[1].

A strain named CX5, which is capable of reducing nitrate to nitrite, nitrogen or the other nitrogen oxygen compounds at pH 4.00 under micro oxygen condition, was isolated and purified from aquifers sample of a sandstone uranium deposit in Xin Jiang, China. CX5 was

characterized by ELx808BLG as *Pseudomonas aeruginosa* with the SIM=0.660>0.5, DIST=4.867<5 after 24h cultivation. In the same time, CX5 was identified by 16SrDNA sequence analysis which resulted that the 16SrDNA sequence similarity of CX5 to *Pseudomonas aeruginosa* was 99%. Results of the denitrification tests showed nitrate removal rate by CX5, after 1 day adaptation by medium with lower pH, was 90.0% in 6 days with 1% inocula in shaking flasks at micro aerobic, 30℃ and the initial pH 4.62±0.03 conditions. In the processing, about 25% of nitrite accumulation was observed in the first 3 days and from the 4th day there was no nitrite accumulation was observed. Further more, effects of pH and temperature to CX5 were studied, results indicated that the adaptive pH of CX5 was 4.00-9.00 (the optimum pH was 6.50-7.80) and the working temperature was 20-45℃ (the optimum temperature was 35 ± 3℃). As a consequences, it will be prospectively that CX5 would be widely used in the acidic or weak acidic environmental bioremediation, especially in 512 uranium mine's underground water's restoration with no neutralization before treatment or remediation.

155 **Uranium Column Bioleaching with Additional Pyrite from Fluoride-Contained Uranium Ore**

Y. Liu[1]; Z. Sun[1]; G. Chen[1]; J. Li[1]; L. Xu[1]; W. Xu[1]; [1]East China University of Technology, Nanchang/CN

With the increasing uzilization of uranium both in nuclear power industry and the generation of electricity has resulted in progressive exhaustion of high-grade uranium reserves worldwide. Bioleaching as a biological oxidation and complexation processe to mobilize metal cations from often almost insoluble ores, is mainly employed
worldwidely in uranium. Pyrite is essential for uranium recovery especially in bioleaching[1]. Unfortunately, most uranium ores has low pyrite in China. In order to decrease cost of uranium extraction and improve uranium recovery, column bioleaching experiments were carried on with additional pyrite in the high fluoride-contained uranium ores.

The average grade of U of samples was 0.1789%, F was 3.36% in weight and particle sizes was -8mm. 0.42 FeS_2 was contained in the additional pyrite(wt%) with size of -3mm. Dominant bacterium in culture for irrigation was *Acidithiobacillus ferrooxidans* and *Leptospirrilum ferrooxidans* was the minor one. 3 columns were established as: minerals(40kg) + pyrite(3.0%(wt)) with culture, minerals(40kg) with culture (control-1)and minerals(40kg) + pyrite(3.0%(wt)) with no culture (control-2), respectively. After 103 days, uranium leaching rates by sludge were 93.77%, 89.93% and 78.17%, acid consumptions were 3.23%, 3.11% and 3.40% for the 3 columns, respectively. The culture's compositions changed with the leaching processes greatly with the dominant bacteria of *At.thiooxidans* and *L. ferrooxidans* at the end of leaching. It confirmed that the given uranium ores with high fluoride and low pyrite could be treated efficiently with the additional pyrite and the adaptive mixed culture.

156 **Microbial community in Chromate slags and isolation of Cr-reducing bacteria**

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Isolation of microbes with high Cr(VI) reduction ability is crucial for remediation of Cr pollution. Inthe present study, we aimed to isolate microbes that were tolerant to Cr and had Cr(VI) reducing ability. According to our 16S rRNAgene sequencing results, bacterial community in slag had 65 unique genera, and it had higher community evenness than soil bacterial community had. Five strainswere isolated from the Chromate slag. Identification of the strains showed that five strains belonged to four different genera and all four genera had higher abundance in slag than in soil. Only two (*Microcell sp.*CSU2 and *Streptomyces sp.*CSU) of the five strains showed Cr reducing ability, while others did not have. Our results also suggested that Cr(VI)reducing ability in *Streptomyces*was a common property of the genus, while in *Microcell*was a species-specific property.

157 **The mud accident in Fundão - after the mud, the dust comes**
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158 **Investigating the microbial metabolic activity on mineral surfaces of pyrite rich waste rocks in an unsaturated heap-simulating column system**
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159 **South African coal tailings bioflotation for desulphurization using *Mycobacterium phlei***
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160 **X-Ray Diffraction of Iron Containing Samples: the Importance of a Suitable Configuration**
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161 **Linking microbial community dynamics in BIOX leaching tanks to process conditions: Integrating lab and commercial experience**
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162 **Growth and activity of mesophilic microorganisms on low-grade ore in a simulated heap bioleaching environment**
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Recent studies of microbial growth within heap leaching systems have found higher microbial populations associated with the mineral (interstitial liquid and ore phases) than in the bulk flowing pregnant leach solution (PLS). However, little information on microbial growth rates on low-grade whole ore during the start-up phase of heap and column leaching is available. In this study, we extend the knowledge base of growth and activity of mesophiles on low-grade ore in a packed ore-bed, as demonstrated previously using the iron and sulphur oxidizing microorganism, Acidithiobacillus ferrooxidans, under various physicochemical conditions.
Microbial growth and colonization of an ore-bed by members of the mixed mesophilic bioleaching culture was investigated. The relative growth rates, oxidizing activities and location of colonization within the ore-bed, of Leptospirillum ferriphilum dominated, At. ferrooxidans dominated, and a mixed mesophilic bioleaching cultures are compared. The impact of iron concentrations at the mineral surface on colonization of the ore-bed by members of the mixed microbial consortium is also considered.

164 **Biosorption of heavy metals through the use of organic waste from the tequila processing process**
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165 **Bioleaching of chalcopyrite with mesophilic bacteria in saline medium**
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Chalcopyrite is the most refractory and abundant mineral of copper sulphides, so the extractive metallurgy of this metal is mainly based on this mineral. Due to this, to allow the continuous use of this mineral, it is necessary to develop technological alternatives for the processing of these sulphides.
There are several studies related to the leaching of this mineral in different media, of which the most common are ammoniacal, nitrated, sulfated, chlorinated and the use of bacteria. At the seminar "Sea Water for Mining" organized at Expomin 2014 was held *"Today there are no bacteria that can be used in bacterial leaching with sea water without desalination"*.
The objective of this work is to demonstrate that there are bacteria able to bioleaching chalcopyrite in saline medium, which are able to grow in natural and salt medium with a significant extraction of copper from the ore.
The bioleaching results of the low grade ore studied were satisfactory. In the stage of bacterial growth in saline medium it is observed that there are fluctuations in the increase of bacteria,

due to the diversity of the chemical compounds present in the synthetic and natural medium, from day 30 the bacteria in all synthetic saline medium and natural systems increase exponential growth that leads to the increase in Cu^{2+} extraction, indicating that they were adapted to the environment. The extraction of Cu^{2+} in the synthetic saline medium is slightly higher than that of the natural saline medium.

166 **Effect of acetate and citrate on chemical and biological leaching of pyrite and chalcopyrite with sulfooxidant and ferrooxidant mesophilic bacteria**

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Mining is considered as one of the most polluting industries since it generates large volumes of waste and some toxic reagents used in the processes, so the use of microorganisms has proved to be an option to carry out friendlier processes to the environment. In addition, although bioleaching is a low-cost extraction process, its application is limited by its slow kinetics. The used microorganisms, aerobic and autotrophic, have the ability to incorporate electrons into iron II and sulfur during their respiratory chain through the Calvin cycle, thus performing an oxidation of iron II to iron III and sulfur to elemental sulfur or even sulfate.

Since the standard normal iron potential is conditioned by pH, and also by those complex ions that may be found in the medium, in this work to obtain higher rate both in the growth of the bacteria and in the bioleaching, it was decided to enrich the nutrient media with an external carbon source and different from CO_2 (acetate and citrate). Mineral cultures containing pyrite or chalcopyrite in MKM medium, inoculated with a bacterial consortium and added with citric acid or ammonium acetate, were maintained in orbital incubator at 38 ° C and 150 rpm for 31 days, periodically monitored the pH, oxidation-reduction potential, bacteria per milliliter and the concentration of iron II, iron III and copper in solution. The results showed a higher rate of leaching with citrate in the case of chalcopyrite, whereas in the presence of acetate was 3 times greater for pyrite.