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The effect of a secondary gas-distribution layer on the fluidization characteristics of a fluidized bed used for dry coal beneficiation

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INTERNATIONAL JOURNAL OF MINERAL PROCESSING, Jan, 2013, Vol. 118, pp. 28-33

During dry beneficiation of coal using a gas-solid fluidized bed a secondary gas-distribution layer forms at the bottom of the bed. The effect of the particle size and depth of this secondary layer on the fluidization characteristics of the bed was investigated in this work. The experimental results show that the variance in both the bed pressure-drop and the bed density decreased with a decrease in the mean particle size of the secondary layer. This reduced variance indicates an improvement in the fluidization quality. Increasing the depth of the secondary layer causes both of these variances to decrease through a minimum and to then increase. The optimum depth of the secondary layer was determined to be 30 mm. The reason for these experimental results is discussed based on the effect the secondary layer has on the gas distribution region of a bubbling bed. It is pointed out that the secondary layer can divide large bubbles passing through the region into small bubbles and can increase the pressure drop of the gas distributor compared to a normal bubbling bed. Furthermore, the actual gas velocity is decreased by the secondary layer, which leads to a moderated shock from the gas to the bed. The secondary layer is, therefore, beneficial for increasing the bed stability. Mathematical models describing the relationship between the standard deviation in the bed density and the experimental factors are proposed. This work provides a foundation for the design of the discharge structure of the bed and for calculating the capacity of the bed. (C) 2012 Elsevier B.V. All rights reserved.

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Air Dense Medium Fluidized Bed for Dry Beneficiation of Coal: Technological Challenges for Future

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PARTICULATE SCIENCE AND TECHNOLOGY, Jan, 2013, Vol. 31(1), pp. 16-27

Air dense medium fluidized bed (ADMFB) offers a better alternative approach for dry coal beneficiation. In recent years, there has been a rapid advancement in the

understanding of fluidized bed behavior and a great deal of work has been done to make this process competitive with conventional wet beneficiation processes. At the same time, much information is available in the general technical literature concerning various aspects of ADMFB; however, this is often uncoordinated information and widely dispersed. So, it is necessary to provide the adequate information systematically, which offers researchers an effective and easy way to obtain specific details. This review critically evaluates the understanding of different operating parameters that affect the cleaning performance of this equipment. Then, following the discussion of different operating parameters, we describe three recent practical developments in ADMFB: the dual-density fluidized bed, vibrated fluidized bed, and magnetically stabilized fluidized bed. Finally, some challenging issues that need special attention are suggested in the conclusion for further improvement of this process. 10.1080/02726351.2011.629285

Investigation of Using Table Type Air Separators for Coal Cleaning

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INTERNATIONAL JOURNAL OF COAL PREPARATION AND UTILIZATION, Jan, 2013, Vol. 33(1), pp. 1-11

In the present study, the application of table type air separators was investigated on three lignite samples and a hard coal sample collected from several regions in Turkey. The Yenikoy lignite sample was used to determine optimum test conditions. These test conditions were used to study Soma, Corum lignite, and Zonguldak hard coal samples with reference to feed rate, riffle height, table frequency, and table slope. Results were analyzed to determine calorific values and ash contents of clean coal and tailing samples. It is concluded from the study that the table-type air separator can be used for the Turkish coal with high-separation efficiency.

10.1080/19392699.2012.717566

Proposal for resources, utilization and processes of red mud in India — A review

Sneha Samal, Ajoy K. Ray, Amitava Bandopadhyay

International Journal of Mineral Processing, Vol. 118, 30 Jan 2013, pp. 43-55

Red mud is a solid waste produced in the process of alumina production from bauxite following the Bayer process. More than 4 million tons of red mud is generated annually in India only. Presently, it is stored or dumped on land, or in the oceans near alumina refineries. However, its high alkalinity is a potential pollution to threat water, land and air. While high costs are associated with the large area of land required for storage of the residue. India is amongst the major producers of alumina in the world. There are some differences in mineralogical composition between the residues from India and other countries due to the difference in the ore type in its production processes. Significant achievements in treatment and utilization of red

mud have been obtained in India in the last decade. In this paper, the various proposals for the utilization of red mud generated in India are presented. Similarly, the drawbacks associated with these potential commercial applications of red mud are discussed.

Recycling of rare earths: a critical review

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Journal of Cleaner Production, **In Press, Corrected Proof**, Available online 5 Jan 2013

The rare-earth elements (REEs) are becoming increasingly important in the transition to a green economy, due to their essential role in permanent magnets, lamp phosphors, catalysts, rechargeable batteries etc. With China presently producing more than 90% of the global REE output and its increasingly tight export quota, the rest of the world is confronted with a REE supply risk. Mining companies are now actively seeking new exploitable REE deposits while some old mines are being reopened. Because of the absence of economical and/or operational primary deposits on their territory, many countries will have to rely on recycling of REEs from pre-consumer scrap, industrial residues and REE-containing End-of-Life products. REE recycling is also recommended in view of the so-called “balance problem”. For instance, primary mining of REE ores for neodymium generates an excess of the more abundant elements, lanthanum and cerium. Therefore, recycling of neodymium can reduce the total amount of REE ores that need to be extracted. Despite a vast, mostly lab-scale research effort on REE recycling, up to 2011 less than 1% of the REEs were actually recycled. This is mainly due to inefficient collection, technological problems and, especially, a lack of incentives. A drastic improvement in the recycling of REEs is, therefore, an absolute necessity. This can only be realized by developing efficient, fully integrated recycling routes, which can take advantage of the rich REE recycling literature. This paper provides an overview of this literature, with emphasis on three main applications: permanent magnets, nickel metal hydride batteries and lamp phosphors. The state of the art in preprocessing of End-of-Life materials containing REEs and the final REE recovery is discussed in detail. Both pyrometallurgical and hydrometallurgical routes for REE separation from non-REE elements in the recycled fractions are reviewed. The relevance of Life Cycle Assessment (LCA) for REE recycling is emphasized. The review corroborates that, in addition to mitigating the supply risk, REE recycling can reduce the environmental challenges associated with REE mining and processing.

Improvement of copper–molybdenum ore beneficiation using a combined flotation and biohydrometallurgy method

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International Journal of Mining Science & Technology, Vol. 23(1), Jan, 2013, pp. 41-46

The authors present the results of analysis of material composition and experimental investigations of acid and biohydrometallurgical leaching of middlings on grain size, pH level, leaching process duration, temperature and slurry density. The rational parameters of flotation and acid-bacterial leaching of middlings providing an efficient release of valuable components from mineral complexes and recovery to flotation concentrate and leaching solution have been determined. A combined flowsheet and a beneficiation process for bulk flotation middlings of copper–molybdenum ore have been suggested, which include middlings grinding, sulfide minerals flotation, bacterial leaching of sulfide flotation tailings, liquid-phase extraction of dissolved copper and electrolysis of re-extraction eluates. The suggested combined method of cleaning of middlings of copper–molybdenum ores beneficiation provides the total copper recovery increase by 0.8% with a reduction of the cost price of saleable material by 0.5%.

A comparison between Miscanthus and bioethanol waste pellets and their performance in a downdraft gasifier

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APPLIED ENERGY, Jan, 2013, Vol. 101, pp. 333-340

Pelletised biomass has been found to have excellent potential for their utilisation in small to medium sized energy systems because of its advantages over loose feedstock. The energy density is increased and so the space occupied in transportation is decreased and the amount of problematic dust or fines is also decreased. Furthermore, pellets provide a more uniform fuel, allowing easier feeding and improved performance in thermal conversion processes. The pellet manufacturing process, or pelletisation process, plays a major role on the quality of pellets produced. Changes to pelletisation parameters such as feedstock moisture content, die diameter, particle size (or screen size), addition of lubricants or binders can significantly alter the quality of the pellets and therefore the ease with which the pellets can be gasified in a downdraft gasification process. One important quality parameter that greatly affects the downdraft gasification process is the strength or durability of pellets. Durability can be defined as the ability of pellets to resist mechanical breakdown during transport or during feeding into an energy plant. Other important parameters that affect downdraft gasification are the ash content and composition of the pellets. The ash is derived from the minerals in the feedstock,

the addition of binders or lubricants and also the pellet production method. Furthermore, gasification efficiency can be also affected by the process parameters such as air-to-fuel ratio, air or biomass feed rate and operating temperature. The current article compares the properties of three different types of pellets and their gasification performance. Two types of Miscanthus and a bioethanol production residue (distiller's dried grains with solubles (DDGS)) were used to make the pellets. The pellets made were of similar size (6-8 mm) and ultimate analysis, so the paper focuses on the most important differences; these were durability, ash content and gasification parameters, expressed through the equivalence ratio which relates the actual air-to-fuel ratio with the calculated stoichiometric value. A series of experiments were conducted in a 50 kW(th) pilot scale downdraft gasifier with the equivalence ratio varied in the range 0.2-0.3. The quality of the gas produced and the gasifier performance were assessed in terms of the gas composition, yield, heating value, cold gas efficiency and carbon conversion efficiency. (C) 2012 Elsevier Ltd. All rights reserved.
10.1016/j.apenergy.2012.01.037

Beneficiation of arsenic bearing complex sulphide ore by flotation

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PHYSICOCHEMICAL PROBLEMS OF MINERAL PROCESSING, 2013, Vol. 49(1), pp. 203-212

In this study beneficiation of a sulphide ore from the Gumushane-Black Sea Region of Turkey was investigated. Detailed flotation studies were carried out with the ore sample which contained 2.95% Pb, 6.72% Zn and 0.32% Cu. Mineralogical analyses showed that the sample includes pyrite, galena, sphalerite, chalcopyrite, tennantite, cerussite, anglesite and smithsonite. On the other hand, hematite, goethite, limonite, calcite and quartz were determined as gangue minerals. Selective sulphide concentrates with low arsenic content were tried to be produced by froth flotation. Individual concentrates of Pb, Zn and Cu assayed 67.54% Pb, and 61.49% Zn and 23.31% Cu where corresponding recoveries were 73.0% and 77.1% and 38.7%, respectively. Arsenic contents were less than 2000 ppm in the lead and zinc concentrates. Copper concentrate assayed 5.03% As since the major copper minerals were in tennantite form (copper arsenic sulphide mineral). In flotation tests, non-toxic reagents such as metabisulphite, caustified starch, and activated carbon were used to depress minerals in relevant circuits.

10.5277/ppmp130118

Computational Modeling of Sand Cementation by Bio-mineral CaCO₃

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MATERIALS PERFORMANCE, MODELING AND SIMULATION

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An innovative sand cementation method of bio-mineral carbonate formation in sand spacing through urea hydrolysis inspired by microbial urease was introduced in the present investigation. A sand column prepared for experimental data and a set of engineering equations for 1-D numerical modeling data of the sand cementation process were adopted. Important characteristic of CaCO₃ weight vertically along the sand column and the urea concentration variation under the effect of microbial urease was investigated based on the experiment and the modeling. Future study was suggested to focus on the model's parameters modification in order to construct an applicable model for industrial up-scaling application in sand or soil strengthening.

10.4028/www.scientific.net/MSF.749.535

Magnetic separation studies for a low grade siliceous iron ore sample

International Journal of Mining Science and Technology, Vol.23(1), Jan, 2013, pp. 1-5

Ranjan Kumar Dwari, Danda Srinivas Rao, Palli Sita Ram Reddy

Investigations were carried out, on a low grade siliceous iron ore sample by magnetic separation, to establish its amenability for physical beneficiation. Mineralogical studies revealed that the sample consists of magnetite, hematite and goethite as major opaque oxide minerals where as silicates as well as carbonates form the gangue minerals in the sample. Processes involving combination of classification, dry magnetic separation and wet magnetic separation were carried out to upgrade the low grade siliceous iron ore sample to make it suitable as a marketable product. The sample was first ground and each closed size sieve fractions were subjected to dry magnetic separation and it was observed that limited upgradation is possible. The ground sample was subjected to different finer sizes and separated by wet low intensity magnetic separator. It was possible to obtain a magnetic concentrate of 67% Fe by recovering 90% of iron values at below 200 µm size.

Characterization and iodide adsorption behaviour of HDPY+ modified bentonite

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ENVIRONMENTAL EARTH SCIENCES, Jan, 2013, Vol. 68(2), pp. 559-566

Owing to its favourable physical, chemical and rheological properties, densely compacted bentonite or bentonite-sand mix is considered as a suitable buffer material in deep geological repositories to store high level nuclear waste. Iodine-

129 is one of the significant nuclides in the high level waste owing to its long half life and poor sorption onto most geologic media. Bentonite by virtue of negatively charged surface has negligible affinity to retain iodide ions. As organo-bentonites are known to retain iodide ions, the present study characterizes hexadecylpyridinium chloride (HDPyCl.H₂O) treated bentonite from Barmer India (referred as HDPy+B) for physico-chemical properties, engineering properties and the iodide adsorption behavior of the organo clay. Batch experiments revealed that HDPy⁺ ions are largely retained (94 % retention) via cation exchange; the ion-exchange process neutralizes the negative surface charge and bridges clay particles leading to reduction in Atterberg limits, clay content and sediment volume. The organo clay retains iodide by Coulombic attraction (at primary sites) and anion exchange (at secondary sites). The free-energy change (ΔG°) = -25.5 kJ/mol value indicated that iodide retention by organo clay is favored physical adsorption process. Iodide adsorption capacity of organo clay decreased significantly (85-100 %) on dilution with 50-80 % bentonite. On the other hand, dilution of bentonite with 50 % organo clay caused 58 % reduction in swell potential and 21 % reduction in swell pressure.

10.1007/s12665-012-1759-z

Flash heat processing of brown coals and hard-coal preparation products prior to their use for energy production

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SOLID FUEL CHEMISTRY, Jan, 2013, Vol. 47(1), pp. 64-69

The principles of calculation of vortex chambers, in which flash heat processing of brown coal or a hard-coal beneficiation product with an ash content of 25-40% produced along can be run, are shown. Fast heat treatment of this type makes it possible to reduce the initial moisture content of brown coal from 35-40 to 2-12% and of coal preparation products, from 20-25 to 10-12%. In the basic parameters (fuel consumption, specific amount of metal, etc.), this method of reducing the moisture content is superior to traditional methods for drying coals and their preparation products (in drum, pipe, fluid-bed, or pneumatic dryers). After decreasing the moisture content of brown coals to a value of a parts per thousand currency sign3%, their bertinization, i.e., preparing a product with properties close to that of grade D coals, is also performed.

10.3103/S0361521912060079

Oxidation and sintering characteristics of magnetite iron ore pellets balled with a novel complex binder

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MINERAL PROCESSING AND EXTRACTIVE METALLURGY REVIEW, 2013, Vol. 34(1), pp. 42-56

Additives can give rise to obvious, step-wise changes both in the oxidation process and in the sintering process. Therefore, the oxidation and sintering characteristics measured in dried pellets prepared from pure magnetite concentrates can not be representative for those characteristics in dried pellets containing additives. The oxidation and sintering characteristics of magnetite iron ore pellets balled with a novel complex binder (namely MHA) were mainly investigated by batch isothermal oxidation measurements in this research. Combined results reveal that the thermal decomposition of MHA binder influences the oxidation and sintering processes of dried pellets. Oxidation rate of pellets increases obviously with increasing the oxidation temperature in the range from 800 degrees C to 1000 degrees C. And the remaining FeO content declines gradually when separately heated for 10 min at low temperature (<1000 degrees C). However, the oxidation rate of pellets decreases distinctly when oxidation temperature is higher than 1000 degrees C. In addition, when oxidation temperature increases from 1000 degrees C to 1250 degrees C, the FeO content of pellets goes up obviously, particularly at 1250 degrees C. The FeO content in the core of sintered pellets heated at 1250 degrees C can even reach 29.68%. SEM spectrum analysis demonstrate that some iron appears in forms of wustite in sintered pellets, which indicates that the reduction reaction of iron oxide occurs during the high temperature sintering process. This is explained by the occurrence of reducing atmospheres because of the pyrogenic decomposition of MHA binder.

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Surface-modified talc particles by acetoxy groups grafting: Effects on mechanical properties of polypropylene/talc composites

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POLYMER ENGINEERING AND SCIENCE, Jan, 2013, Vol. 53(1), pp. 89-95

This article deals with the effects of surface-modified talc particles on mechanical properties of polypropylene (PP)/talc composites. These materials were prepared by injection molding of PP blended with different concentrations of nontreated and treated talc, under the same processing conditions. Differential thermal calorimetry and scanning electron microscopy were used to assess thermal properties and morphology of the final composites. The reinforcing effect of talc, either treated or nontreated surface, on PP is analyzed through the tensile properties as a function of the mineral content (0-10 wt%). Morphological structure of composites revealed that the talc treatment improved the particle dispersion and distribution within the PP matrix and enhanced the interfacial PP-talc adhesion. The mechanical properties of these composites, especially the Young modulus, tensile strength and elongation at break, were found to be improved respect to PP-untreated talc ones. POLYM. ENG. SCI., 2013. (c) 2012 Society of Plastics Engineers

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The control of mineral constituents and textural characteristics on the petrophysical & mechanical (PM) properties of different rocks of the Himalaya

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ENGINEERING GEOLOGY, Feb, 2013, Vol. 153, pp. 125-143

Petrophysical and mechanical (PM) properties of a rock are primarily controlled by its mineral constituents and various textural parameters. Similar rock types in different tectonic setups may be characterized by different mineralogical compositions and textural properties because they might have suffered different deformational processes. This paper presents a study on the mineralogical and textural control on various PM properties in quartzites, granitoids, gneisses, metabasics and dolomite collected from different tectonic set ups. The inter relationships among mineral constituents, various textural parameters, Unconfined Compressive Strength (UCS), Schmidt hammer rebound (R-) value, seismic wave (both P- and S-waves) velocity and their attenuation characteristics were obtained using regression analyses. It has been concluded that there exists no relation between UCS and seismic wave velocity in quartzite, granitoids and gneisses, moderate positive relationship in metabasics and strong negative relationship in dolomite. It has further been noted that in quartzite and dolomite (monominerelic rocks), grain size dominantly control the seismic wave velocity as the relatively coarser grained samples have higher seismic wave velocity, whereas UCS is strongly controlled by grain size as well as the quantity and the orientation of the weak minerals like muscovite, biotite, calcite etc. In gneisses and granitic gneisses, preferred orientation of minerals especially the mica minerals, although in present small quantity is the main factor controlling UCS and seismic velocity. Both these properties increase with the increase in intensity of preferred alignment of minerals, whereas in metabasics it is the presence of amphibole + pyroxene minerals/feldspar that dominantly controls the seismic wave velocity. (C) 2012 Elsevier B.V. All rights reserved.

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A review of the beneficiation of rare earth element bearing minerals

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MINERALS ENGINEERING, Feb, 2013, Vol. 41, pp. 97-114

Rare earth elements (REEs) comprise the fifteen elements of the lanthanide series as well as yttrium, and may be found in over 250 different minerals. These elements are required for many different applications such as high-strength permanent magnets, catalysts for petroleum refining, metal and glass additives and phosphors used in electronic displays. The only REE bearing minerals that have been extracted on a commercial scale are bastnasite, monazite, and xenotime. These minerals may be beneficiated using gravity, magnetic, electrostatic and flotation separation techniques. Increased demand for the different products manufactured from REE has

resulted in a constriction of supply from China, which currently produces 97% of the world's rare earths, via export quotas. Many new rare earth deposits are currently being developed to help meet the demand void created by the Chinese export quotas, however most of these developing deposits include rare earth minerals for which there is limited processing knowledge. This paper examines the separation techniques that are currently employed for rare earth mineral beneficiation and identifies areas in need of further research. (C) 2012 Elsevier Ltd. All rights reserved. 10.1016/j.mineng.2012.10.017

Recovery of gold and silver from spent mobile phones by means of acidothiourea leaching followed by adsorption using biosorbent prepared from persimmon tannin

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Hydrometallurgy, Volume 133, February 2013, Pages 84-93

A new approach of recovering precious metals from printed circuit boards (PCBs) of mobile waste by acidothiourea leaching followed by selective adsorption on low-cost and environmentally benign biomass sorbent prepared from easily available agricultural waste is suggested. The influence of various parameters like thiourea (TU) concentration, acid concentration, pulp density, temperature, and contact time were studied for gold and silver leaching using a batchwise method. It was found that the PCB sample with smaller particle size distribution (53 to 75 μm) yielded higher amounts of gold and silver being leached into the solution. The optimum conditions for the leaching of gold were found to be 0.5 M TU in 0.05 M H_2SO_4 at 45 °C, while that of silver were 0.5 M TU in 0.01 M H_2SO_4 at 60 °C. Under the optimum leaching conditions, an average of 3.2 mg/g of gold and 6.8 mg/g of silver were extracted from incinerated sample of PCBs of mobile waste. Kinetic studies revealed that the complete leaching of silver was achieved in less than 2 h, while it took approximately 6 h at ambient temperature in the case of gold. Presence of 0.01 M ferric ions facilitated the gold dissolution rate and complete leaching was achieved within 2 h. Conventional copper cementation for recovery of gold and silver from pregnant leached liquor was not so effective. Adsorptive recovery of dissolved gold and silver using activated carbon as well as crosslinked persimmon tannin gel was also examined. Low-cost persimmon tannin extract crosslinked with sulfuric acid was found to be a promising material for the complete recovery of gold and silver from the leached liquor. This adsorbent not only adsorbed the dissolved precious metals selectively but also reduced the adsorbed cationic species of gold to the elemental gold.

Manganese extraction by sulfur-based reduction roasting–acid leaching from low-grade manganese oxide ores

Yuanbo Zhang, Zhixiong You, Guanghui Li, Tao Jiang

Hydrometallurgy, Volume 133, Feb, 2013, Pages 126-132

In recent years, the comprehensive utilization of low-grade manganese oxide ores has received much attention due to the shortage of high-grade manganese ore resources. In this study, low-grade manganese oxide ores were treated by reduction roasting using chemically pure sulfur as a reductant. Then, the roasted samples were subjected to sulfuric acid leaching to extract manganese (Mn). The effects of roasting temperature, roasting time, S/Mn mole ratio, sulfuric acid concentration, leaching temperature, stirring rate, leaching time and liquid-to-solid ratio on the Mn and Fe leaching were discussed. The leaching efficiencies of 95.6% for Mn and 14.5% for Fe were obtained under the following optimized conditions: 550 °C of roasting temperature, 10 min of roasting time, 0.50 of S/Mn, 1.0 mol/L of sulfuric acid concentration, 25 °C of leaching temperature, 200 r/min of stirring rate, 5 min of leaching time and 5:1 of liquid-to-solid ratio.

Hydrometallurgical recovery/recycling of platinum by the leaching of spent catalysts: A review

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Hydrometallurgy, Vol.133, Feb, 2013, pp. 23-32

Platinum is one of the precious metals with many applications, including in catalysis, electronic devices and jewelry. However, its limited resources are becoming depleted. To meet the future demand and conserve resources, it is necessary to process spent platinum-containing materials, such as catalysts, electronic scraps and used equipment. These materials are usually processed by pyro/hydrometallurgical processes consisting of thermal treatment followed by leaching, precipitation or solvent extraction. This paper reviews platinum leaching from such resources using acidic and alkaline solutions in the presence of oxidizing agents, such as nitric acid and hydrogen peroxide, sodium cyanide and iodide solutions. The results of the study are described with respect to the recovery of platinum and other metals under the optimized conditions of leaching with lixiviants. Previous studies have achieved platinum recovery using aqua regia and acidic solution in the presence of chlorine to produce platinum from spent catalysts on a commercial scale; however, the process generates toxic nitrogen oxide and chlorine gases. This paper reports the salient findings of efforts to replace the aqua regia with hydrogen peroxide in acidic solution, chloride salts, sodium cyanide and iodide solution to improve the economics of the existing processes and reduce the environmental pollution.

An overview of solid-liquid separation of residues from coal liquefaction processes

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CANADIAN JOURNAL OF CHEMICAL ENGINEERING, Feb, 2013, Vol. 91(2), pp. 324-331.

Direct coal liquefaction process typically produces mixed oils (60%) and gases (15%). The remainder is a high-boiling viscous residue that contains oils, asphaltenes, unreacted coal, mineral matter and potentially valuable liquefaction catalyst. Effective separation of the components of the residue stream is important to the economic and environmental performance of the process. Solidliquid separation technologies, such as filtration, hydrocyclones, centrifugation, critical solvent deashing and distillation have been reviewed in relation to their use in coal liquefaction processes. Individual operations used have not been completely satisfactory, and a better overall result is obtained when they are used in combination. (c) 2012 Canadian Society for Chemical Engineering
10.1002/cjce.21647

Sticking of iron ore pellets during reduction with hydrogen and carbon monoxide mixtures: Behavior and mechanism

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Powder Technology, Vol. 235, Feb 2013, pp. 1001-1007

Hydrogen and carbon monoxide mixtures are reducing agents for main direct reduction (DR) processes. However, sticking of iron ore pellets during reduction always leads to discontinuous operation. In order to evaluate the effects of the temperature, syngas constituents and reduction degree on sticking properties, reduction of iron ore pellets in the presence of H₂-CO mixtures was conducted at 800–1000 °C. The experimental results indicated that fibrous iron on the sticking interface hooked the pellets together at lower temperatures, while sintering of fresh iron with high activity led to the rise of sticking index (SI) at high temperature. SI decreased with the addition of H₂ in reducing gas for the porous iron precipitation on the interface. Sticking firstly occurred on edge angles and then developed connection in large area as reduction degree increased. Bonding of wustite phase could be attributed to the sticking at lower reduction degree. Additionally, crystallization of iron phase and formation of low melting eutectic phase became the dominant factor as reduction degree increased.

Fine coal dry cleaning using a vibrated gas-fluidized bed

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FUEL PROCESSING TECHNOLOGY, Feb, 2013, Vol. 106, pp. 338-343

Fine coal (-6 mm) cleaning in a dry way becomes more important with the extensive deployment of the mechanized mining and progressively serious water shortage, especially in North-West China. In this paper, we attempted to use the segregation in a vibrated gas-fluidized bed of dissimilar particles to provide a solution to this problem. The effects of several factors including the superficial air velocity, bed height, vibration intensity and fluidizing time on the segregation performance were experimentally studied. The bubble-driven jiggling mechanism was proposed to explain the separation process. The results show that the probable error E values of the separation of -6+3 mm and -3+1 mm size fraction of feed coal samples are 0.19 and 0.175 respectively, which indicates that fine coal separation using a vibrated gas-fluidized bed can provide a simple and efficient way for coal cleaning in dry and cold regions in North-West China. (C) 2012 Elsevier B.V. All rights reserved. 10.1016/j.fuproc.2012.08.019

Fungal degradation of coal as a pretreatment for methane production

Haider, R; Ghauri, MA; SanFilipo, JR; Jones, EJ; Orem, WH; Tatu, CA; Alchtar, K; Akhtar, N
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Coal conversion technologies can help in taking advantage of huge low rank coal reserves by converting those into alternative fuels like methane. In this regard, fungal degradation of coal can serve as a pretreatment step in order to make coal a suitable substrate for biological beneficiation. A fungal isolate MW1, identified as *Penicillium chrysogenum* on the basis of fungal ITS sequences, was isolated from a core sample of coal, taken from a well drilled by the US. Geological Survey in Montana, USA. The low rank coal samples, from major coal fields of Pakistan, were treated with MW1 for 7 days in the presence of 0.1% ammonium sulfate as nitrogen source and 0.1% glucose as a supplemental carbon source. Liquid extracts were analyzed through Excitation-Emission Matrix Spectroscopy (EEMS) to obtain qualitative estimates of solubilized coal; these analyses indicated the release of complex organic functionalities. In addition, GC-MS analysis of these extracts confirmed the presence of single ring aromatics, polyaromatic hydrocarbons (PAHs), aromatic nitrogen compounds and aliphatics. Subsequently, the released organics were subjected to a bioassay for the generation of methane which conferred the potential application of fungal degradation as pretreatment. Additionally, fungal-mediated degradation was also prospected for extracting some other chemical entities like humic acids from brown coals with high huminite content especially from Thar, the largest lignite reserve of Pakistan. (C) 2012 Elsevier Ltd. All rights reserved. 10.1016/j.fuel.2012.05.015

Mineral matter and the nature of pyrite in some high-sulfur tertiary coals of Meghalaya, northeast India

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Coal samples collected from four different sources in the Jaintia Hills of Meghalaya, northeast India, have been investigated for their sulfur content, mineral matter, and to assess their potential behavior upon beneficiation. These coals contain high sulfur which occurs both in organic and inorganic forms. The organic sulfur content is much higher than the inorganic sulfur. Studies on different size and gravity fractions indicated that the mineral phases are concentrated in higher density fractions ($d > 1.8$) and in general are fine grained ($< 50 \mu m$). Data of reflected-light optical microscope and electron probe micro-analysis (EPMA) revealed that minerals in these coals are sulfides-pyrite, marcasite, sphalerite, pentlandite; sulfates-barite, jarosite; oxides-hematite, rutile; hydroxides-gibbsite, goethite; phosphate-monazite; carbonate-calcite, siderite and silicates-quartz, mica, chlorite, and kaolinitic clay. The disulfides of iron occur in two modes - mainly pyrite and occasionally marcasite with wide size ranges and in various forms, such as: framboid, colloidal precipitate, colloform-banded, fine disseminations, discrete grains, dendritic (feathery), recrystallized, nuggets, discoidal, massive, cavity-fracture- and cleat-fillings. Framboidal pyrite has formed primarily due to biological activities of sulfur reducing bacteria in the early stages of coalification. Massive and other varieties have formed at later stages due to coalescence and recrystallization of the earlier formed pyrites. Sulfur isotopic values indicate a biogenic origin for the pyrites. Association of trace metals, such as Ni, and Zn has been recorded in these pyrites. Given the large fractions of organic sulfur present, these coals can be upgraded only partially to reduce the sulfur content by beneficiation. 10.1007/s12594-013-0023-9

Shake flask and column bioleaching of a pyritic porphyry copper sulphide ore

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International Journal of Mineral Processing, Mar, 2013, Vol. 119, pp. 16-20

The purpose of this study was to test the feasibility of using bacterial leaching to solubilize copper from a porphyry sulphide ore, a part of the Sarcheshmeh Copper Complex. The bulk ore sample contained 18% pyrite and 0.8% Cu mostly as secondary chalcocite and Cu oxides. Mineral microscopy showed that pyrite grains in this porphyry ore were coated by chalcocite. Conventional flotation could not be used for ore beneficiation because Cu-sulphide could not be selectively separated from pyrite and consequently the flotation concentrate contained too much Fe and less Cu. Hence bioleaching was tested as an alternative process for this ore. The bioleaching was tested with a consortium of mesophilic acidophiles comprising *Leptospirillum* and *Acidithiobacillus* spp., originally enriched from the Sarcheshmeh site. Several mineral salt formulations were tested in shake flask bioleaching experiments. These experiments resulted in 89-92% Cu yields with no discernible differences between the different formulations. Sterile controls representing chemical acid leaching resulted in about 60% Cu solubilization. For column bioleaching experiments, ore samples (similar to 40 kg each; 75% - 12 mm) were agglomerated and treated with a schedule of 4 days of irrigation and 4 days of rest

period. The column bioleaching tests yielded Cu recoveries of about 90%. The abiotic control had 50% Cu recovery. Thus the test results were favorable for using the bioleaching approach for this Cu-ore material. (C) 2013 Elsevier B.V. All rights reserved. 10.1016/j.minpro.2012.12.010

The greenhouse gas impact of IPCC and ore-sorting technologies

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Minerals Engineering, Mar, 2013, Vol. 42, pp. 13-21

In-pit crushing and conveying (IPCC) and ore sorting are two developing technologies that, in addition to providing likely economic benefits, also have the potential to reduce the greenhouse gas footprint of mining and mineral processing operations. A life cycle assessment study was carried out to provide estimates of the likely greenhouse gas reductions from the implementation of IPCC and ore sorting technologies in a hypothetical copper mining and mineral processing operation. Based on the assumed configurations and operating characteristics of the two systems, the results indicated that IPCC had 4% less (i.e. 3 kg CO₂e/t ore or 0.16 kg CO₂e/t ore.km) greenhouse gas emissions than truck haulage for the base case configuration. Using electricity generated from natural gas rather than black coal increased the greenhouse gas advantage of IPCC over truck haulage from 4% to about 22% (i.e. 14 kg CO₂e/t ore or 0.74 kg CO₂e/t ore.km). However, transport distance and annual plant feedrate affect the magnitude of these greenhouse gas reductions. A potential reduction of about 13 kg CO₂e/t ore in greenhouse gas emissions was estimated from the use of ore sorting technology based on black coal generated electricity, while with natural gas-based electricity the reduction was only 8 kg CO₂e/t ore. The mass rejection rate of the ore sorting device was the main operational variable affecting the magnitude of this reduction, although it is also affected by the specific comminution and concentration energy requirements of the ore. While the results indicate that ore sorting offers nearly four times the potential reduction in greenhouse gas emissions than IPCC did at the same annual plant feedrate for the base case configuration with black coal-based electricity, the situation was reversed with natural gas-based electricity, with IPCC offering nearly double the potential reduction in greenhouse gas emissions than ore sorting. However, it should be appreciated that due to the limited amount of publicly available data on these technologies at the present time, the results of this study should be viewed as first estimates only. Crown Copyright (c) 2012 Published by Elsevier Ltd. All rights reserved. 10.1016/j.mineng.2012.11.012

Unlocking possibility of blasting near residential structure using electronic detonators

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Ever since development of human civilization, mining and agriculture has been the backbone of growth. Today the most developed countries of the world are the ones

focused on core economical development, be it power generation, steel making, oil and gas production, or agriculture. Mining has been gaining importance over the years both from the economic perspective and as an area of sustained research. With the advent of globalization, things have changed very fast and today it is an industry that is driving the economies of several nations. Global competition has propelled countries to reach higher production levels through better techniques of drilling and blasting, excavation and mineral processing. We now have bigger and faster drill machines and excavators. In Explosives technology too significant progress has been made towards having safer explosives and accurate initiating systems that have increased overall control over blasting in terms of vibration, fragmentation, throw, fly rock and overall blast economics. Explosives and Rock Blasting Technology has advanced so much in the last few decades that blasting can now be precisely performed, controlled and predicted. Development of new tools like electronic blasting systems and advanced simulation software has made it possible to customize blasting results as per requirement. These developments have helped mining engineer worldwide in reaping huge productivity benefits besides making it possible to meet the environmental norms even in most demanding conditions. Inability to blast large size shots on account of proximity of mines to human habitation have always constrained mine management in fully leveraging the strength of large size production equipments. Mine managers have been forced to conduct small blasts on increased frequency to provide feed to large capacity shovels while compromising on Shovel productivity on account of undesirable movement of shovels during blasting. This paper deals with a case study at SEB quarry of Tata Steel wherein it was difficult to fire a big blast due to existing nearby structures. A critical scientific study was conducted before successfully firing of one of the biggest shot of 83 tonnes in the history of quarry. The paper discusses the issues being faced, alternate solutions opted and the final outcome.

High intensity magnetic separation for the clean-up of a site polluted by lead metallurgy

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Journal of Hazardous Materials, Volumes 248–249, 15 March 2013, Pages 194-201

The industrial history in the district of Linares (Spain) has had a severe impact on soil quality. Here we examined soil contaminated by lead and other heavy metals in “La Cruz” site, a brownfield affected by metallurgical residues. Initially, the presence of contaminants mainly associated with the presence of lead slag fragments mixed with the soil was evaluated. The subsequent analysis showed a quasi-uniform distribution of the pollution irrespective of the grain-size fractions. This study was accompanied by a characterization of the lead slag behavior under the presence of a magnetic field. Two main magnetic components were detected: first a ferromagnetic and/or ferrimagnetic contribution, second a paramagnetic and/or antiferromagnetic one. It was also established that the slag was composed mainly of lead spherules and iron oxides embedded in a silicate matrix. Under these conditions, the capacity of

magnetic separation to remove pollutants was examined. Therefore, two high intensity magnetic separators (dry and wet devices, respectively) were used. Dry separation proved to be successful at decontaminating soil in the first stages of a soil washing plant. In contrast, wet separation was found effective as a post-process for the finer fractions.

A review of zinc oxide mineral beneficiation using flotation method

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Advances in Colloid and Interface Science, **In Press, Corrected Proof**, Available online 13 March 2013

In recent years, extraction of zinc from low-grade mining tailings of oxidized zinc has been a matter of discussion. This is a material which can be processed by flotation and acid-leaching methods. Owing to the similarities in the physicochemical and surface chemistry of the constituent minerals, separation of zinc oxide minerals from their gangues by flotation is an extremely complex process. It appears that selective leaching is a promising method for the beneficiation of this type of ore. However, with the high consumption of leaching acid, the treatment of low-grade oxidized zinc ores by hydrometallurgical methods is expensive and complex. Hence, it is best to pre-concentrate low-grade oxidized zinc by flotation and then to employ hydrometallurgical methods. This paper presents a critical review on the zinc oxide mineral flotation technique. In this paper, the various flotation methods of zinc oxide minerals which have been proposed in the literature have been detailed with the aim of identifying the important factors involved in the flotation process. The various aspects of recovery of zinc from these minerals are also dealt with here. The literature indicates that the collector type, sulfidizing agent, pH regulator, depressants and dispersants types, temperature, solid pulp concentration, and desliming are important parameters in the process. The range and optimum values of these parameters, as also the adsorption mechanism, together with the resultant flotation of the zinc oxide minerals reported in the literature are summarized and highlighted in the paper. This review presents a comprehensive scientific guide to the effectiveness of flotation strategy.

From Science Direct

Scott Middlemas, Z. Zak Fang, Peng Fan, A new method for production of titanium dioxide pigment, Hydrometallurgy, Volumes 131–132, January 2013, Pages 107-113, <http://dx.doi.org/10.1016/j.hydromet.2012.11.002>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002423>)

Abstract: Titanium dioxide (TiO₂) has been widely used as pigment in paints, paper and cosmetic products, as well as high-tech applications such as solar cells, semiconductors, biomedical devices and air purification. TiO₂ pigment is primarily produced by a high temperature chloride process, which forms CO₂ as a reaction byproduct. A novel hydrometallurgical process for making TiO₂ pigment without direct CO₂ emission is investigated. The novel process involves alkaline roasting of titania slag, with subsequent washing, leaching, solvent extraction, hydrolysis, and calcination stages, resulting in high-purity anatase or rutile pigments. Experimental validation for each of the processing steps is demonstrated. Pigment whiteness is critically sensitive to trace amounts of discoloring impurities such as iron. The use of solvent extraction proved to be highly effective in reducing the concentration of discoloring impurities in the final pigment to commercially acceptable levels.

Keywords: Titanium dioxide; Slag roasting; Energy reduction; Solvent extraction

Laura Castro, Camino García-Balboa, Felisa González, Antonio Ballester, M. Luisa Blázquez, Jesús A. Muñoz, Effectiveness of anaerobic iron bio-reduction of jarosite and the influence of humic substances, Hydrometallurgy, Vol.131–132, Jan. 2013, Pages 29-33, <http://dx.doi.org/10.1016/j.hydromet.2012.10.005>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002228>)

Abstract: Nowadays there is a growing interest in developing clean mining processes free of toxic chemicals. Biotechnology could be a cost-effective and environmentally friendly alternative to traditional leaching methods. Jarosite is an important sulfate mineral that occurs naturally and also can be produced as a waste in industrial processes. In this work, bioreduction of jarosite using *Shewanella putrefaciens* and a natural consortium under anaerobic conditions is presented as an acceptable bioleaching method. Moreover, the influence of humic substances that appear in natural environments acting as electron shuttles between microorganisms and insoluble oxides has been investigated. One key factor for the industrial implementation of anaerobic bioleaching is the metal recovery from minerals. The precipitates formed as products of dissimilatory iron reduction, the bacterial ability to obtain ferrous ions in solution and the stimulation of insoluble Fe(III) ores reduction by electron shuttles have been examined in this research.

Keywords: Iron-reducing bacteria; Jarosite; Anaerobic Fe(III) reduction; Bioleaching; Humic substances

A.N. Zagorodnyaya, Z.S. Abisheva, A.S. Sharipova, S.E. Sadykanova, Ye.G. Bochevskaya, O.V. Atanova, Sorption of rhenium and uranium by strong base anion exchange resin from solutions with different anion compositions, Hydrometallurgy, Volumes 131–132, January 2013, Pages 127-132, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.11.003>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002435>)

Abstract: The results of joint uranium and rhenium sorptions from the solutions with strong base anion exchange resin Ambersep A920U (herein after A920), are presented in the paper. Effect of salt form (sulfate, chloride, nitrate, hydroxide), nature of sulfate, nitrate, and chloride containing compounds (acids, their sodium and zinc salts), sodium carbonate and ammonium hydrocarbonate and their concentration in the solutions (1–1000 mol/m³) to sorption ability of the metals were studied in static conditions. It was found that A920 anionite sorb the metals from the solutions differently. Rhenium is sorbed with the anion exchange resin of all salt forms and from the solutions of any composition. The nature of sulfates (acid, salts) has different effects: sulfuric acid better suppresses rhenium sorption as compared to that for zinc and sodium sulfates. The increase of sulfate concentration from 1 to 1000 mol/m³ reduces sorption of rhenium gradually and steeply. The nature of nitrates and chlorides does not affect sorption ability of rhenium but high concentration of the compounds depresses its sorption. Rhenium sorption from carbonate and hydrocarbonate solutions proceeds similarly to that for sulfate solutions. Rhenium is sorbed better from sodium carbonate solutions than from ammonium hydrocarbonate solutions. Uranium is well sorbed with the anion exchange resin in sulfate form and badly with the anionite in nitrate and chloride forms. Uranium is sorbed only from sulfate, carbonate and hydrocarbonate solutions in contrary to rhenium. Sorption ability of uranium at concentrations from 1 to 1000 mol/m³ is growing in contrary to rhenium, however at higher concentrations sorption ability is declining similarly to that for rhenium.

Keywords: Sorption; Rhenium; Uranium; Mineral acids; Sodium and zinc salts; Carbonates and hydrocarbonates

Anna D'Aloya, Aleksandar N. Nikoloski, An electrochemical investigation of the formation of CoSx and its effect on the anodic dissolution of iron in ammoniacal-carbonate solutions, Hydrometallurgy, Vol. 131–132, January 2013, Pages 99-106, <http://dx.doi.org/10.1016/j.hydromet.2012.10.010>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002393>)

Abstract: It has been found that the co-presence of cobalt (II) and thiosulphate ions in ammoniacal-carbonate solutions promotes the passivation of iron, under conditions in which it would otherwise continue to dissolve anodically. Electrochemical experiments have shown a relationship between the immersion

time required for passivation and the formation of a solid species on the iron surface, which is thought to be implicated in the mechanism of passivation, whilst not being itself the protective species. Based on a combination of electrochemical, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX) and grazing incidence X-ray diffraction (GIXRD) characterisation techniques, the said species has been identified as CoS_x, resulting from the interaction of cobalt (II) and thiosulphate ions. It is thought to form as a product of the cathodic reactions taking place on the iron surface during its active dissolution. These findings are particularly relevant to the Caron process, in which the ammoniacal-carbonate solutions containing dissolved cobalt and thiosulphate ions are used to leach nickel and cobalt from pre-reduced laterite ores rich in metallic iron. Both the loss of cobalt into the CoS_x layer and the passivation of iron and of its alloys with nickel and cobalt, are potential contributing factors to the low cobalt and nickel recoveries, which are typical of the Caron process. This study provides a better understanding of the conditions under which the CoS_x layer forms and promotes the passivation of iron, and may therefore provide useful information to help minimise the effect this may have on the extraction efficiency of the process. In particular, at the cobalt and thiosulphate ion concentrations usually encountered at a Caron plant, the passivation of iron was found to be prevented by maintaining a high enough concentration of ammonia.

Keywords: Caron process; Cobalt sulphide; Ammonia; Leaching; Iron passivation

Debabrata Pradhan, Ajit Kumar Patra, Dong-Jin Kim, Hun-Saeng Chung, Seung-Won Lee, A novel sequential process of bioleaching and chemical leaching for dissolving Ni, V, and Mo from spent petroleum refinery catalyst, Hydrometallurgy, Volumes 131–132, January 2013, Pages 114-119, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.11.004>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002447>)

Abstract: Two step leaching experiments were carried out to extract nickel, vanadium, and molybdenum present in spent refinery catalyst. A bioleaching process was applied in the first step. Pulp density, initial Fe(II) concentration, initial pH, particle size, and temperature were varied to optimize the bioleaching process. Ni, V, and Mo were leached out with maximum recoveries of 97%, 92% and 53%, respectively, at an optimized bioleaching condition of initial ferrous ion of 2 g/L, initial pH of 2, pulp density of 10% (w/v), particle size of (- 106 + 45) μm, and a temperature of 35 °C. As the Mo leaching rate was very low, a second leaching step for the bioleached residue was applied with different concentrations of (NH₄)₂CO₃, Na₂CO₃, or H₂SO₄. The second step leaching was optimum at a concentration of 30 g/L (NH₄)₂CO₃ with respect to Mo extraction. The rate of Mo dissolution with respect to concentration of lixiviant in the second leaching step was evaluated. The percentages of Ni, V, and Mo leached were 97%, 97% and 99%, respectively, by

combining the first step under optimized conditions and the second step with 30 g/L $(\text{NH}_4)_2\text{CO}_3$.

Keywords: Bioleaching; Acid leaching; Alkali leaching; Spent catalyst; Reaction order

Gordana J. Dević, Zoran V. Popović, Biomarker and micropetrographic investigations of coal from the Krepoljin Brown Coal Basin Serbia, International Journal of Coal Geology, Volume 105, January 2013, Pages 48-59, ISSN 0166-5162, <http://dx.doi.org/10.1016/j.coal.2012.11.010>.

(<http://www.sciencedirect.com/science/article/pii/S0166516212002741>)

Abstract: We investigated early diagenetic processes of the extractable organic matter from the Miocene freshwater sequence, which consists of coal fragments in clays, sandstones and shales alternating with continuous brown coal layers. We examined eight coals, thirteen sediments and three non-coaly underground layers. The molecular assemblages of the identified aliphatic hydrocarbons in the Krepoljin Basin reflect the abundance of plant taxa as precursors or participants in the early diagenetic stage. The data provide insight into the conditions prevailing in the lakes and bogs during early diagenesis. The dominance of diterpanes indicates that the prevalent of the organic matter was of gymnosperous origin. The hopanoid contents are considered to reflect microbial activity. That the organic matter in the Miocene Krepoljin Coal Basin is immature was confirmed by the presence of biolipids such as $\beta\beta$ -hopanes, C₂₇ 17 β (H)-trisnorhopane. Saturated and aromatized abietanes, pimaranes and phyllocladananes, the most abundant compounds in all samples, indicate a predominantly higher plant input related to the Coniferous group, but identification of the individual plant families was not possible. β -Amyrin and other triterpenoid-derived triaromatic and triaromatic C-ring cleaved hydrocarbons with triterpenoid structures are thought to be characteristic for angiosperms. Unsaturated compounds, Δ^2 -triterpanes, early intermediaries in the diagenetic transformation of angiosperms also indicate a low degree of sediment maturity.

Keywords: Miocene freshwater environment; Maceral composition; Alkanes; Diterpanes; Triterpanes; Steranes; Coal biomarkers

Łukasz Kruszewski, Supergene sulphate minerals from the burning coal mining dumps in the Upper Silesian Coal Basin, South Poland, International Journal of Coal Geology, Volume 105, January 2013, Pages 91-109, ISSN 0166-5162, <http://dx.doi.org/10.1016/j.coal.2012.12.007>.

(<http://www.sciencedirect.com/science/article/pii/S0166516212002881>)

Abstract: Sulphate minerals of various chemical compositions form subtle mixtures of small aggregated crystals on some burning coal-mining dumps in the Upper Silesian Coal Basin, Poland. They include Na and Mg sulphates — blödite and konyaite. Magnesium sulphates belong to the second group and hexahydrate is its most common representative. Aluminium sulphates include tamarugite, pickeringite, and alunogen. Iron sulphates are copiapite-group minerals, metavoltine, butlerite, and voltaite-group minerals. Calcium sulphates are almost exclusively represented by gypsum. EDS proved to be, in general, a better tool than WDS for the chemical analysis of the sulphates. Both the Rietveld and Pawley methods were found to be useful in the calculation of unit cell parameters. The analysed sulphates contain some rare and interesting elements, the most important being Tl, Ga, In, Cd, Se, and As. The sulphates formed as a result of the mutual action of various supergene processes, including the oxidation of S-rich coal-fire gases, metal leaching from waste-rocks by H₂SO₄ solutions and evaporation. The complexity of the sulphate efflorescence composition is explained by the chaotic nature of settings involving a variety of waste rocks, hydration–dehydration reactions, and access of both ground and rain water- and atmospheric oxygen.

Shifeng Dai, Weiguo Zhang, Colin R. Ward, Vladimir V. Seredin, James C. Hower, Xiao Li, Weijiao Song, Xibo Wang, Huan Kang, Licai Zheng, Peipei Wang, Dao Zhou, Mineralogical and geochemical anomalies of late Permian coals from the Fusui Coalfield, Guangxi Province, southern China: Influences of terrigenous materials and hydrothermal fluids, International Journal of Coal Geology, Volume 105, January 2013, Pages 60-84, ISSN 0166-5162, <http://dx.doi.org/10.1016/j.coal.2012.12.003>.

Abstract: The Late Permian coal in the Fusui Coalfield of southern China is characterized by high Fe-sulfide and organic sulfur contents (2.60 and 2.94%, respectively). Trace elements including Zr (354 µg/g on average), Hf (9.18 µg/g), Y and rare earth elements (REY, 302 µg/g), Li (97.9 µg/g), and Cs (7.02 µg/g) are significantly enriched in these coals. In addition to Hg and Se enrichment in the roof and floor of the coal, fluorine, Mo, and U are enriched in the roof; the floor is rich in Cl, S, Fe, Pb, and Cd. Compared to the upper continental crust, REY in the parting and coal bench samples are characterized by heavy-REY and light-REY enrichment, respectively; the coals, partings, and host rocks (roof and floor) have negative Eu anomalies. The coal benches have higher ratios of U/Th, Yb/La, Nb/Ta, and Zr/Hf, and more abundant heavy rare earth elements than their adjacent partings. These geochemical anomalies are attributed to the composition of terrigenous materials derived from the Yunkai Upland, multi-stage (syngenetic and epigenetic) hydrothermal fluid activities, and intensive leaching and re-distribution of lithophile elements from partings to the underlying coal benches. Both the organic and sulfide sulfur are also derived mainly from the hydrothermal fluids rather than the marine influence. The minerals in the samples studied, including kaolinite, quartz, and REE-bearing minerals, are of both terrigenous and hydrothermal origin. Al-oxyhydroxides, crystalline FeSO₄(OH), water-bearing Fe-oxysulfate, and goyazite were derived from the hydrothermal activity. Kaolinite, quartz, REE-bearing

minerals, and apatite from the sediment source region were also subjected to destruction by hydrothermal fluid leaching.

Georgiana A. Moldoveanu, Vladimiro G. Papangelakis, Recovery of rare earth elements adsorbed on clay minerals: II. Leaching with ammonium sulfate, Hydrometallurgy, Volumes 131–132, January 2013, Pages 158-166, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.10.011>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X1200240X>)

Abstract: The present study investigates the use of ammonium sulfate as a lixiviant in the recovery of rare earth elements (REE) from clays. Rare earth ions are physically adsorbed on clay minerals, with concentrations ranging from 0.05 to 0.5 wt.%. It was previously shown that they could be easily recovered via an ion exchange mechanism during leaching with inorganic monovalent salt solutions (such as ammonium sulfate). A standardized desorption procedure was established to systematically investigate the influence of leaching conditions such as lixiviant concentration, temperature, pH and agitation rate on desorption kinetics and REE extraction levels. It was determined that the optimum leaching conditions, leading to 80–90% total REE extraction, required pH values in the range 3–4 and moderate temperatures (< 50 °C) in order to avoid lanthanide precipitation/loss via hydrolysis. Various lixiviant concentrations above a certain “cut-off” level (about 6 times the stoichiometric requirement) did not affect extraction levels, while the agitation speed was irrelevant with regards to leaching efficiency, requiring only sufficient stirring to ensure complete slurry suspension for effective mass-transfer. Extraction kinetics were found to be very fast, with less than 5 min to reach terminal extraction, and independent of lixiviant concentration, pH, temperature and agitation speed.

Raju Banda, Thi Hong Nguyen, Seong Ho Sohn, Man Seung Lee, Recovery of valuable metals and regeneration of acid from the leaching solution of spent HDS catalysts by solvent extraction, Hydrometallurgy, Volume 133, February 2013, Pages 161-167, <http://dx.doi.org/10.1016/j.hydromet.2013.01.006>.

Abstract: Leaching and solvent extraction experiments have been performed to recover Mo and Co from spent HDS catalysts. The dissolution behavior of metals in spent catalysts was investigated with respect to HCl concentration, time and S/L ratio. Particle size had negligible effect, whereas reaction temperature had created a great effect. Under the optimum leaching condition viz: 3 mol/L HCl, 90 °C, 250 µm particle size, 5% (w/v) solid to liquid ratio and 60 min reaction time, it was possible to dissolve 97% and 94% of Mo and Co, respectively. Solvent extraction was conducted for recovery of Mo using TBP and Mo was stripped from the loaded TBP with dilute HCl solution. The Mo free raffinate was processed for the recovery of Co by Alamine 308 in three counter current extraction stages and Co was quantitatively stripped with acidified distilled water. Furthermore, a complete extraction and stripping of HCl was achieved with TEHA in counter current extraction and stripping experiments. Using the process developed in this study, it was possible to recover

99% of Mo and Co and 90% of HCl with their purity higher than 99%. Finally, a conceptual process flow sheet was presented.

Keywords: Spent catalyst; HCl leaching; Separation; Recovery

Manju Gurung, Birendra Babu Adhikari, Hidetaka Kawakita, Keisuke Ohto, Katsutoshi Inoue, Shafiq Alam, Recovery of gold and silver from spent mobile phones by means of acidothiourea leaching followed by adsorption using biosorbent prepared from persimmon tannin, Hydrometallurgy, Volume 133, February 2013, Pages 84-93, <http://dx.doi.org/10.1016/j.hydromet.2012.12.003>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002691>)

Abstract: A new approach of recovering precious metals from printed circuit boards (PCBs) of mobile waste by acidothiourea leaching followed by selective adsorption on low-cost and environmentally benign biomass sorbent prepared from easily available agricultural waste is suggested. The influence of various parameters like thiourea (TU) concentration, acid concentration, pulp density, temperature, and contact time were studied for gold and silver leaching using a batchwise method. It was found that the PCB sample with smaller particle size distribution (53 to 75 μm) yielded higher amounts of gold and silver being leached into the solution. The optimum conditions for the leaching of gold were found to be 0.5 M TU in 0.05 M H_2SO_4 at 45 $^\circ\text{C}$, while that of silver were 0.5 M TU in 0.01 M H_2SO_4 at 60 $^\circ\text{C}$. Under the optimum leaching conditions, an average of 3.2 mg/g of gold and 6.8 mg/g of silver were extracted from incinerated sample of PCBs of mobile waste. Kinetic studies revealed that the complete leaching of silver was achieved in less than 2 h, while it took approximately 6 h at ambient temperature in the case of gold. Presence of 0.01 M ferric ions facilitated the gold dissolution rate and complete leaching was achieved within 2 h. Conventional copper cementation for recovery of gold and silver from pregnant leached liquor was not so effective. Adsorptive recovery of dissolved gold and silver using activated carbon as well as crosslinked persimmon tannin gel was also examined. Low-cost persimmon tannin extract crosslinked with sulfuric acid was found to be a promising material for the complete recovery of gold and silver from the leached liquor. This adsorbent not only adsorbed the dissolved precious metals selectively but also reduced the adsorbed cationic species of gold to the elemental gold.

Keywords: Spent mobile phones; Precious metals; Acidothiourea leaching; Adsorption; Persimmon extract

M.A. Torres, G.E. Meruane, T.A. Graber, P.C. Gutiérrez, M.E. Taboada, Recovery of nitrates from leaching solutions using seawater, Hydrometallurgy, Vol.133, Feb 2013, pp100-105, <http://dx.doi.org/10.1016/j.hydromet.2012.12.008>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002745>)

Abstract: The objective of this work is to investigate the use of seawater to recover potassium and nitrate from the waste tails of SQM operations. The use of seawater as an alternative to fresh water is an attractive option for the resource-rich northern Chilean mines, especially for those operating in the Salar de Atacama Desert where fresh water is scarce. In this study, the performance of four leaching agents was evaluated for recovering potassium and nitrate from discarded salts: 1) freshwater; 2) seawater; 3) seawater saturated with chloride ions; and 4) seawater saturated with chloride, sulfate and magnesium ions. The tests were performed in columns loaded with the same quantity of salt and irrigated at the same rate for a period of 152 hours. These tests showed that leaching with seawater provides nearly the same potassium and nitrate leaching efficiency as when fresh water is used. However, leaching with seawater saturated with chloride, sulfate and magnesium ions yielded approximately 10% lower potassium and nitrate recoveries compared with the tests when seawater was used alone. In contrast, the use of saturated seawater is expected to yield a geomechanically more stable heap because most of the chloride-, sulfate- and magnesium-containing salts will remain unleached.

Keywords: Leaching of nitrates; Seawater; Recovery of salts; Sodium nitrate; Brine

Debabrata Pradhan, Ajit Kumar Patra, Dong-Jin Kim, Hun-Saeng Chung, Seoung-Won Lee, A novel sequential process of bioleaching and chemical leaching for dissolving Ni, V, and Mo from spent petroleum refinery catalyst, Hydrometallurgy, Volumes 131–132, January 2013, Pages 114-119, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.11.004>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002447>)

Abstract: Two step leaching experiments were carried out to extract nickel, vanadium, and molybdenum present in spent refinery catalyst. A bioleaching process was applied in the first step. Pulp density, initial Fe(II) concentration, initial pH, particle size, and temperature were varied to optimize the bioleaching process. Ni, V, and Mo were leached out with maximum recoveries of 97%, 92% and 53%, respectively, at an optimized bioleaching condition of initial ferrous ion of 2 g/L, initial pH of 2, pulp density of 10% (w/v), particle size of (- 106 + 45) μm , and a temperature of 35 °C. As the Mo leaching rate was very low, a second leaching step for the bioleached residue was applied with different concentrations of $(\text{NH}_4)_2\text{CO}_3$, Na_2CO_3 , or H_2SO_4 . The second step leaching was optimum at a concentration of 30 g/L $(\text{NH}_4)_2\text{CO}_3$ with respect to Mo extraction. The rate of Mo dissolution with respect to concentration of lixiviant in the second leaching step was evaluated. The percentages of Ni, V, and Mo leached were 97%, 97% and 99%, respectively, by combining the first step under optimized conditions and the second step with 30 g/L $(\text{NH}_4)_2\text{CO}_3$.

Keywords: Bioleaching; Acid leaching; Alkali leaching; Spent catalyst; Reaction order

Zhenlei Cai, Yali Feng, Haoran Li, Zhuwei Du, Xinwei Liu, Co-recovery of manganese from low-grade pyrolusite and vanadium from stone coal using fluidized roasting coupling technology, Hydrometallurgy, Volumes 131–132, January 2013, Pages 40-45, <http://dx.doi.org/10.1016/j.hydromet.2012.10.002>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002198>)

Abstract: Based on the novel technology of Co-recovery of manganese from low-grade pyrolusite and vanadium from stone coal using fluidized roasting coupling technology, the leaching effect of manganese and vanadium has been investigated and many technical conditions have also been optimized. The results indicated that the optimum leaching efficiency of 99.25% for manganese and 91.84% for vanadium could be attained under the conditions that the mass ratio of stone coal to pyrolusite was 3:1, the roasting temperature of stone coal was 1000 °C, the roasting temperature of pyrolusite was 800 °C, the roasting time was 2 h, the sulphuric acid concentration was 2 mol/L, the leaching temperature was 75 °C, and the leaching time was 2 h.

Keywords: Co-recovery; Fluidized roasting; Coupling technology; Low-grade pyrolusite; Stone coal

K.C. Nathsarma, P.C. Rout, K. Sarangi, Manganese precipitation kinetics and cobalt adsorption on MnO₂ from the ammoniacal ammonium sulfate leach liquor of Indian Ocean manganese nodule, Hydrometallurgy, Volume 133, Feb. 2013, Pages 133-138, <http://dx.doi.org/10.1016/j.hydromet.2012.12.009>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000029>)

Abstract: Precipitation of manganese from the SO₂-roast leach ammoniacal ammonium sulfate solution bearing both high and low concentrations of manganese in the presence of copper, cobalt and nickel ions was carried out in a stainless steel reactor fitted with a turbo grid. Air/O₂ was used to precipitate Mn as MnO₂ from the solution. There was adsorption loss of cobalt from the solution. Precipitation of manganese from the solution was 57.2–99.9%. The maximum adsorption loss of Co was 22.1%. The precipitation of Mn and adsorption loss of cobalt from the solution followed the first order kinetics. The rate constants for the precipitation of manganese and loss of cobalt were evaluated and the experimental data were fitted to Freundlich and Langmuir adsorption isotherms.

Keywords: Manganese nodule; Precipitation; Manganese; Cobalt; Adsorption

K.C. Nathsarma, P.C. Rout, K. Sarangi, Manganese precipitation kinetics and cobalt adsorption on MnO₂ from the ammoniacal ammonium sulfate leach liquor of Indian Ocean manganese nodule, Hydrometallurgy, Volume 133, Feb. 2013, Pages 133-138, <http://dx.doi.org/10.1016/j.hydromet.2012.12.009>.

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Keywords: Manganese nodule; Precipitation; Manganese; Cobalt; Adsorption

Yuanbo Zhang, Zhixiong You, Guanghui Li, Tao Jiang, Manganese extraction by sulfur-based reduction roasting–acid leaching from low-grade manganese oxide ores, Hydrometallurgy, Volume 133, February 2013, Pages 126-132, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.01.003>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000054>)

Abstract: In recent years, the comprehensive utilization of low-grade manganese oxide ores has received much attention due to the shortage of high-grade manganese ore resources. In this study, low-grade manganese oxide ores were treated by reduction roasting using chemically pure sulfur as a reductant. Then, the roasted samples were subjected to sulfuric acid leaching to extract manganese (Mn). The effects of roasting temperature, roasting time, S/Mn mole ratio, sulfuric acid concentration, leaching temperature, stirring rate, leaching time and liquid-to-solid ratio on the Mn and Fe leaching were discussed. The leaching efficiencies of 95.6% for Mn and 14.5% for Fe were obtained under the following optimized conditions: 550 °C of roasting temperature, 10 min of roasting time, 0.50 of S/Mn, 1.0 mol/L of sulfuric acid concentration, 25 °C of leaching temperature, 200 r/min of stirring rate, 5 min of leaching time and 5:1 of liquid-to-solid ratio.

Keywords: Manganese oxide ores; Sulfur; Reduction roasting; Leaching

M.A. Torres, G.E. Meruane, T.A. Graber, P.C. Gutiérrez, M.E. Taboada, Recovery of nitrates from leaching solutions using seawater, Hydrometallurgy, Volume 133, February 2013, Pages 100-105, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.12.008>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002745>)

Abstract: The objective of this work is to investigate the use of seawater to recover potassium and nitrate from the waste tails of SQM operations. The use of seawater as an alternative to fresh water is an attractive option for the resource-rich northern Chilean mines, especially for those operating in the Salar de Atacama Desert where fresh water is scarce.

In this study, the performance of four leaching agents was evaluated for recovering potassium and nitrate from discarded salts: 1) freshwater; 2) seawater; 3) seawater saturated with chloride ions; and 4) seawater saturated with chloride, sulfate and magnesium ions. The tests were performed in columns loaded with the same quantity of salt and irrigated at the same rate for a period of 152 hours. These tests showed that leaching with seawater provides nearly the same potassium and nitrate leaching efficiency as when fresh water is used. However, leaching with seawater saturated with chloride, sulfate and magnesium ions yielded approximately 10% lower potassium and nitrate recoveries compared with the tests when seawater was used alone. In contrast, the use of saturated seawater is expected to yield a geomechanically more stable heap because most of the chloride-, sulfate- and magnesium-containing salts will remain unleached.

Keywords: Leaching of nitrates; Seawater; Recovery of salts; Sodium nitrate; Brine

G.K. Das, Y. Pranolo, Z. Zhu, C.Y. Cheng, Leaching of ilmenite ores by acidic chloride solutions, Hydrometallurgy, Volume 133, February 2013, Pages 94-99, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.12.006>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002721>)

Abstract: The direct leaching of Australian ilmenite ore samples with HCl was found to be much more effective with high chloride (Cl⁻) concentration (~ 500 g/L) in the feed solution. The presence of CaCl₂ was more effective for leaching than that of MgCl₂ and NaCl due to its higher solubility. The effects of pulp density, retention time, HCl concentration, CaCl₂ concentration and temperature were examined to optimise the leaching conditions. The optimum conditions for leaching ilmenite in this study were found to be 5–7.5 M HCl solution with a total Cl⁻ concentration of ~ 500 g/L, 3.3% (w/w) pulp density, 70–80 °C and 4–6 h of retention time. Under these conditions, the optimum leaching efficiencies were ~ 98–99% Ti and 96% Fe for ilmenite ore A and 94% Ti and 93% Fe for ilmenite ore B. One of the advantages of the HCl–CaCl₂ direct leach process is that the HCl–CaCl₂ solution can be recycled back to leaching after Ti recovery. The leach residue containing mainly unleached rutile and pseudorutile can be used as a feed for synthetic rutile production.

Keywords: Ilmenite ore; Chloride leaching; Titanium extraction

Manis Kumar Jha, Jae-chun Lee, Min-seuk Kim, Jinki Jeong, Byung-Su Kim, Vinay Kumar, Hydrometallurgical recovery/recycling of platinum by the leaching of spent catalysts: A review, Hydrometallurgy, Volume 133, February 2013, Pages 23-32, <http://dx.doi.org/10.1016/j.hydromet.2012.11.012>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002526>)

Abstract: Platinum is one of the precious metals with many applications, including in catalysis, electronic devices and jewelry. However, its limited resources are becoming depleted. To meet the future demand and conserve resources, it is necessary to process spent platinum-containing materials, such as catalysts, electronic scraps and used equipment. These materials are usually processed by pyro/hydrometallurgical processes consisting of thermal treatment followed by leaching, precipitation or solvent extraction. This paper reviews platinum leaching from such resources using acidic and alkaline solutions in the presence of oxidizing agents, such as nitric acid and hydrogen peroxide, sodium cyanide and iodide solutions. The results of the study are described with respect to the recovery of platinum and other metals under the optimized conditions of leaching with lixiviants. Previous studies have achieved platinum recovery using aqua regia and acidic solution in the presence of chlorine to produce platinum from spent catalysts on a commercial scale; however, the process generates toxic nitrogen oxide and chlorine gases. This paper reports the salient findings of efforts to replace the aqua regia with hydrogen peroxide in acidic solution, chloride salts, sodium cyanide and iodide solution to improve the economics of the existing processes and reduce the environmental pollution.

Keywords: Spent catalyst; Platinum; Leaching; Recycling; Hydrometallurgy

Michael J. Nicol, Hajime Miki, Suchun Zhang, Petrus Basson, The effects of sulphate ions and temperature on the leaching of pyrite. 1. Electrochemistry, Hydrometallurgy, Volume 133, February 2013, Pages 188-196, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.01.010>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000133>)

Abstract: A detailed study of the electrochemical behavior of pyrite under typical bio-leaching conditions has been carried out with the focus on the effect of the concentration of sulphate ions on the mixed potential, cyclic voltammetric and potentiostatic measurements. The mixed potential decreases with increasing sulphate ion concentration and the addition of iron(II) and increases as expected with increasing iron(III) concentration and agitation at constant pH. Temperature, pH and the concentration of dissolved oxygen have minimal effects on the mixed potential in the presence of iron(III). Cyclic voltammetric and potentiostatic data confirm that the rate of anodic oxidation of pyrite decreases with increasing sulphate ion concentration and increases with increasing temperature. The pH and dissolved

oxygen concentration have little effect while addition of chloride ions inhibits the anodic oxidation of pyrite. Studies of the cathodic reduction of iron(III) and dissolved oxygen have shown that the rate of the former is several orders of magnitude more reversible (rapid) than that of dissolved oxygen which only exhibits measurable reactivity at potentials well below the mixed potentials in the presence of iron(III). The reduction of iron(III) is inhibited by sulphate ions due to the formation of electrochemically less reactive sulphate complexes.

Keywords: Pyrite; Dissolution; Voltammetry; Potentiostatic; Sulphate ion

Sadia Ilyas, Jae-chun Lee, Ru-an Chi, Bioleaching of metals from electronic scrap and its potential for commercial exploitation, Hydrometallurgy, Vol 131–132, Jan 2013, pp 138-143, <http://dx.doi.org/10.1016/j.hydromet.2012.11.010>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002502>)

Abstract: In this study, ability of moderately thermophilic bacterial consortium to extract metals from electronic scrap was evaluated using shake flasks and lab-scale column reactor. We investigated the effects of having additional energy source (FeS_2 , S^0 , $\text{FeS}_2 + \text{S}^0$), using different consortia of moderately thermophilic bacteria and washing charge material as a pretreatment. At scrap concentrations of 10%, an adapted consortium of *Sulfobacillus thermosulfidooxidans* and *Thermoplasma acidophilum* extracted approximately 85% of Cu, 75% of Al, 80% of Ni and 80% of Zn from pretreated electronic scrap with $\text{FeS}_2 + \text{S}^0$ (1%). However, a consortium of *S. thermosulfidooxidans* and *Sulfobacillus acidophilus*, containing $\text{FeS}_2 + \text{S}^0$, extracted 90% of Cu, 80% of Al, 82% of Ni and 85% of Zn. During column bioleaching studies of 165 days, approximately 74% Zn, 68% Al, 85% Cu, 78% Ni was leached out. The results of the leaching process are significant for understanding how to implement these processes on an industrial scale.

Keywords: Column bioleaching; Electronic scrap; Moderate thermophiles

Łukasz Kruszewski, Supergene sulphate minerals from the burning coal mining dumps in the Upper Silesian Coal Basin, South Poland, International Journal of Coal Geology, Volume 105, January 2013, Pages 91-109, ISSN 0166-5162, <http://dx.doi.org/10.1016/j.coal.2012.12.007>.

(<http://www.sciencedirect.com/science/article/pii/S0166516212002881>)

Abstract: Sulphate minerals of various chemical compositions form subtle mixtures of small aggregated crystals on some burning coal-mining dumps in the Upper Silesian Coal Basin, Poland. They include Na and Mg sulphates — blödite and konyaite. Magnesium sulphates belong to the second group and hexahydrate is its most common representative. Aluminium sulphates include tamarugite,

pickeringite, and alunogen. Iron sulphates are copiapite-group minerals, metavoltine, butlerite, and voltaite-group minerals. Calcium sulphates are almost exclusively represented by gypsum. EDS proved to be, in general, a better tool than WDS for the chemical analysis of the sulphates. Both the Rietveld and Pawley methods were found to be useful in the calculation of unit cell parameters. The analysed sulphates contain some rare and interesting elements, the most important being Tl, Ga, In, Cd, Se, and As. The sulphates formed as a result of the mutual action of various supergene processes, including the oxidation of S-rich coal-fire gases, metal leaching from waste-rocks by H₂SO₄ solutions and evaporation. The complexity of the sulphate efflorescence composition is explained by the chaotic nature of settings involving a variety of waste rocks, hydration–dehydration reactions, and access of both ground and rain water- and atmospheric oxygen.

Keywords: Sulphate minerals; Konyaite; Hexahydrite; Unit-cell parameters; Burning coal-mining dumps; Upper Silesian Coal Basin; X-ray diffraction

C.L. Lin, Ching-Hao Hsieh, Tsend-Ayush Tserendagva, J.D. Miller, Dual energy rapid scan radiography for geometallurgy evaluation and isolation of trace mineral particles, Minerals Engineering, Volume 40, January 2013, Pages 30-37, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.09.001>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512002956>)

Abstract: Procedures are described for the evaluation and isolation of trace mineral particles from sample populations at the ppm level by dual energy rapid scan radiography using an X-ray microtomography instrument (XMT). After calibration of the XMT, the samples are split into narrow size fractions, each size fraction distributed/assembled on projection plates, and then the plates placed in the sample holder of the XMT for irradiation at two energy levels (dual energy analysis). In this way, for example, more than 200,000 particles of 250 × 150 μm in size can be interrogated in less than 1 h and the composition of particles containing high density mineral phases estimated. These trace particles can be isolated for 3D analysis by high resolution X-ray microtomography and/or selected for surface characterization using XPS, TOF/SIMS, or other analytical instruments. Rapid scan radiography can be used for the examination of drill core samples, tailings samples, or any other particulate sample containing trace mineral particles.

Keywords: Trace mineral particles; Dual energy radiography; Geometallurgy; Tailings analysis; Drill core analysis; X-ray microtomography

F. Engström, D. Adolfsson, C. Samuelsson, Å. Sandström, B. Björkman, A study of the solubility of pure slag minerals, Minerals Engineering, Volume 41, February 2013, Pages 46-52, <http://dx.doi.org/10.1016/j.mineng.2012.10.004>.

(<http://www.sciencedirect.com/science/article/pii/S089268751200341X>)

Abstract: Large amounts of oxidic by-product are annually produced by the steel industry worldwide. By far the largest in volume is slag, generated from different stages of steel production. In order to avoid landfilling, steelmakers usually try to process the slag into useful resources that can be used externally. However, leaching of different metals can sometimes be a problem. Since steel slags are a mixture of numerous types of minerals, the solubility of each mineral will affect the outcome of the leachability. The aim of this study was to investigate how six common slag minerals behave during dissolution. Mayenite ($\text{Ca}_{12}\text{Al}_{14}\text{O}_{33}$), merwinite ($\text{Ca}_3\text{MgSi}_2\text{O}_8$), akermanite ($\text{Ca}_2\text{MgSi}_2\text{O}_7$), gehlenite ($\text{Ca}_2\text{Al}_2\text{SiO}_7$), γ -dicalcium silicate ($\gamma\text{-Ca}_2\text{SiO}_4$) and tricalcium aluminate ($\text{Ca}_3\text{Al}_2\text{O}_6$) were synthesized and their dissolution was evaluated through titration using HNO_3 at constant pH. Acidic to alkaline pHs (4, 7 and 10) were selected to investigate the solubility of the minerals under conditions comparable to those prevailing in newly produced slags, and one pH value, representing acid conditions. It can be concluded that all six minerals behave differently when dissolving and that the rate of dissolution is generally slower at higher pH values, which are normal in the case of steelmaking slags. At pH 10, the solubility of merwinite, akermanite and gehlenite is considered low. The dissolution of $\gamma\text{-Ca}_2\text{SiO}_4$ is not affected in the same way as the other minerals when the pH is changed.

Keywords: Slag; Mineral; Solubility; Leaching

Nikhil Dhawan, M. Sadegh Safarzadeh, Jan D. Miller, Michael S. Moats, Raj K. Rajamani, Crushed ore agglomeration and its control for heap leach operations, Minerals Engineering, Volume 41, February 2013, Pages 53-70, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.08.013>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003287>)

Abstract: Based on the extensive experience of heap leaching operations, crushed ore agglomeration can be successfully considered and utilized as a pretreatment step for the heap leaching of ores containing significant amounts of fines and clay minerals. The drum agglomeration is considered as a pretreatment step for the heap leaching of copper and gold ores whereas the agglomeration of uranium and nickel ores has received less attention over the past years. The acceptance of binder application for acidic leaching systems is limited primarily due to the lack of acid-tolerant binders. The use of binder depends mainly upon the cost considerations, impact on recovery and safe practice. Of equal importance are the quality control and characterization tools for the agglomerates to ensure better heap performance. This paper attempts to provide a concise overview of available quality control and characterization tools for crushed ore agglomeration with industrial examples from the gold, copper, nickel and uranium operations. Consequently, different agglomeration-heap leaching systems and their differences are summarized. The requirements for effective agglomeration, characteristics for an ideal agglomerate

and integrated flowsheet of crushed ore agglomeration-heap leaching system are discussed.

Keywords: Heap leach; Agglomeration; Binder; Quality control tools; Characterization

Xiao-Bo Min, Cui-Yu Yuan, Li-Yuan Chai, Yan-Jie Liang, Hai-Jing Zhang, Xian-de Xie, Yong Ke, Hydrothermal modification to improve the floatability of ZnS crystals, Minerals Engineering, Volume 40, January 2013, Pages 16-23, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.09.012>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003202>)

Abstract: Crystalline structure and surface properties significantly affect the floatability of metal sulphides. In this study, a novel methodology to modify zinc sulphide (ZnS) crystals was proposed to improve the floatability of the crystals. Initially, ZnS crystals, synthesised from zinc hydroxide (Zn(OH)₂) and sulphur (S) under hydrothermal conditions, were used to assess the floatability. X-ray diffraction (XRD) and transmission electron microscopy (TEM) were employed to analyse the crystalline structure and surface properties of the sulphides. Conventional flotation tests were performed to evaluate the floatability. The effects of mineraliser (KOH) concentration, precursor (Zn(OH)₂) concentration, hydrothermal temperature and holding time on the floatability of the ZnS crystals were investigated. The optimal flotation recovery of ZnS (82.53%) was obtained with a KOH concentration of 5 mol/L, a Zn(OH)₂ concentration of 10%, a holding time of 4 h and a hydrothermal temperature of 260 °C. Then, sludge containing fine and amorphous zinc compounds, which was generated during the disposal of metallurgical waste water, was employed to test the recovery of valuable metals using modified hydrothermal sulphidation. The results show that the recovery of Zn in the sludge can reach 66.3% under the optimal conditions.

Keywords: Hydrothermal modification; Floatability; Grain size; Heavy metal; ZnS

Qing Shi, Guofan Zhang, Qiming Feng, Leming Ou, Yiping Lu, Effect of the lattice ions on the calcite flotation in presence of Zn(II), Minerals Engineering, Volume 40, January 2013, Pages 24-29, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.09.016>.

(<http://www.sciencedirect.com/science/article/pii/S089268751200324X>)

Abstract: The effect of Zn²⁺ on calcite flotation and the effect of lattice ions on calcite flotation in presence of Zn²⁺ were investigated through microflotation tests, zeta potential measurements, and surface analysis. The results show that Zn species inhibit the interaction between the reagents and calcite through the formation of surface precipitation coating on the calcite surface, when the concentration of Zn²⁺ is

higher than 10^{-5} mol/L. The effect of Zn species on calcite flotation can be decreased with the increase of Ca^{2+} , instead of CO_3^{2-} . In presence of Ca^{2+} and CO_3^{2-} , the change of floatability suggests that Zn species can be desorbed with an optimum ratio of $\text{Ca}^{2+}/\text{CO}_3^{2-}$. The zeta potential measurements and surface analysis show the existence of a mixture of hydrozincite and zinc hydroxide products on mineral surface, and zinc surface coating can be desorbed due to the strong chemical adsorption of Ca^{2+} and the formation of hydrozincite in the bulk solution.

Keywords: Calcite; Flotation; Zinc(II); Lattice ions

F. Contreras, J. Yianatos, L. Vinnett, On the froth transport modelling in industrial flotation cells, Minerals Engineering, Volume 41, February 2013, Pages 17-24, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.10.016>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003585>)

Abstract: A froth transport model for industrial flotation cells characterisation has been developed in terms of operating variables for a three-phase system (i.e., gas, liquid and valuable/non-valuable solid). The new approach, based on previous literature, involves three transport mechanisms: a vertical transport zone, a combined vertical and horizontal transport zone that allows the liquid and solid phases to be carried to the concentrate stream, and a mechanism in which the gas phase is gradually removed from the top of the froth (bubble collapse). To develop and evaluate the model, non-conventional measurements were conducted in a 130 m³ flotation cell in the Cu/Mo rougher circuit at Division El Teniente, Codelco-Chile. The solid axial profile in the froth, the froth recovery and the froth transport times for the three phases (measured by radioactive tracers), are among the most important measured variables. The mean froth residence times and froth recovery estimations were used as boundary conditions in the proposed model. The aim of the froth transport model was to provide a simple and practical understanding of the froth performance in the flotation equipment. A practical description of the froth zone behaviour will allow new designs and configurations to be evaluated for the radial and peripheral launders in mechanical cells, improve the recovery of valuable minerals and decrease the gangue entrainment into the concentrate stream.

Keywords: Froth flotation; Froth modelling; Froth transport; Froth recovery; Froth residence time

Otávia Martins Silva Rodrigues, Antônio Eduardo Clark Peres, Afonso Henriques Martins, Carlos Alberto Pereira, Kaolinite and hematite flotation separation using etheramine and ammonium quaternary salts, Minerals Engineering, Volume 40, January 2013, Pages 12-15, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.09.019>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003275>)

Abstract: Clay minerals are widespread in various types of mineral deposits. When present, they contribute to the high content of certain parameters such as silica, aluminium, and magnesium. This study aimed to find selectivity windows to separate hematite from a clay mineral (kaolinite) to allow reduction of the levels of silica and alumina in iron ore. The collectors used were: etheramine Flotigam EDA (EDA) and the ammonium quaternary salts: dodecyltrimethylammonium bromide (DTAB) and Tomamine Q-14-2 PG (AQ142). The depressant used was corn starch. The separation selectivity was achieved using DTAB in the pH range between 4 and 10. Using the collectors EDA and AQ142, the selectivity was obtained only in the presence of starch, at pH 10. Laboratory scale tests showed that as far as the particles size is concerned, better selectivity was achieved with finer particles. Circuit configurations including cleaner and scavenger stages, and pilot scale tests, will be required prior to a possible industrial implementation of the separation.

Keywords: Flotation collectors; Froth flotation; Kaolinite; Hematite

M.S. Manono, K.C. Corin, J.G. Wiese, The effect of ionic strength of plant water on foam stability: A 2-phase flotation study, Minerals Engineering, Volume 40, January 2013, Pages 42-47, <http://dx.doi.org/10.1016/j.mineng.2012.09.009>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003172>)

Abstract: Water recycling poses a challenge to mineral concentrators. The quality of process water is often uncontrollable and varies across operations due to changes in the amount of total dissolved solids, the ionic strength and pH. A change in ionic strength could affect the flotation process by affecting the surface reactions occurring at the mineral surface and also the stability of the froth. This study investigated the effect of ionic strength on the water recovery, bubble size, foam height and foam collapse time in a 2-phase flotation system in an attempt to predict the overall foam stability behaviour which is believed to be directly proportional to froth stability. Batch flotation results showed a tremendous increase in water recovery with increasing ionic strength. The bubble size decreased quite significantly with an increase in ionic strength. Foam height and collapse time increased with increasing ionic strength. These findings suggest that the ionic strength of plant water plays an important role in froth stability.

Keywords: Bubble size; Foam stability; Foam height; Ionic strength; Water recovery

Roman Weber, Marco Mancini, Natalia Schaffel-Mancini, Tomasz Kupka, On predicting the ash behaviour using Computational Fluid Dynamics, Fuel Processing Technology, Volume 105, January 2013, Pages 113-128, ISSN 0378-3820, <http://dx.doi.org/10.1016/j.fuproc.2011.09.008>.

(<http://www.sciencedirect.com/science/article/pii/S0378382011003225>)

Abstract: The objective of this paper is to examine several approaches for predicting the ash behaviour using Computational Fluid Dynamics (CFD). The emphasis is placed on details of the sub-models used. In models that aim at predicting the temperature–time history of fuel particles, from the injection position to the deposit surface, the information about the char combustion rate is essential. Of particular importance is determination (through measurements) of the rate of char oxidation for the last 20% of burnout. Predictions of the size distribution of fly-ash particles near the deposition surface seem to be unreliable and measured data are needed for deriving appropriate corrections. Fragmentation of fuel particles is perhaps one of the unresolved issues which require an urgent attention. The current CFD-predictions of slagging and fouling in industrial boilers are indicative, at their best. This is certainly the case when numerous parameters, including these describing the particle sticking propensity, are taken from the literature. It is relatively easy to tune the model predictions to the expected (measured) results by changing a few key parameters. There is, however, a much more reliable way to proceed. By combining CFD-predictions with an advanced fuel characterization, with the latter being application dependent and fuel dependent, the deposition problems at hand can be tackled. What is to be determined experimentally and under what conditions, requires a consensus of an experienced fuel engineer/mineralogist and a CFD-expert.

Keywords: Ash deposition; Boilers; CFD

S.J. Mangena, J.R. Bunt, F.B. Waanders, Mineralogical behaviour of North Dakota lignite in an oxygen/steam blown moving bed reactor, Fuel Processing Technology, Volume 106, February 2013, Pages 474-482, ISSN 0378-3820, <http://dx.doi.org/10.1016/j.fuproc.2012.09.015>.

(<http://www.sciencedirect.com/science/article/pii/S0378382012003311>)

Abstract: In this study, lignite from North Dakota (USA) was thermally treated in a commercial-scale oxygen/steam blown moving bed reactor at the Dakota Gasification Company (DGC) in order to identify mineralogical changes that occur during the conversion process. After reaction, the solid particulate remnants were extracted from the reactor reaction zones and characterised using XRD, CCSEM and SEMPC techniques. It was found that the feed coal mineralization was mainly dominated by organically bound calcium. On the other hand, the crystalline phases present in the hottest regions of the reactor were governed by gehlenite and bredigite which may have formed from the transformation, (at higher temperatures), of the organically bound Ca and Mg to form CaO and MgO and subsequent interaction with the reactive silica and transformation products of the clays. A significant amount of calcite was found to develop at the start of the reduction zone; it is suggested that the calcite was synthesised from the reaction of CaO (formed from the transformation of the organically bound Ca) with the CO₂ from the product gas

in the reactor, in agreement with the literature. The glass phase was found to constitute the major part of the ash mineral assemblage in the reduction and combustion zones of the reactor. This phase was composed mainly of the Ca, Mg, Na aluminosilicates with some Fe. There was therefore a significant amount of melting that occurred in the hotter reaction zones (i.e. reduction and combustion zones) of the reactor. The organically bound Ca, Mg and Na seemed to have played a significant role in the formation of this glass phase.

Keywords: Moving-bed gasification; Coal; Mineralogy; XRD; CCSEM; SEMPC

S.J. Mangena, J.R. Bunt, F.B. Waanders, Physical property behaviour of North Dakota lignite in an oxygen/steam blown moving bed gasifier, Fuel Processing Technology, Volume 106, February 2013, Pages 326-331, ISSN 0378-3820, <http://dx.doi.org/10.1016/j.fuproc.2012.08.016>.

(<http://www.sciencedirect.com/science/article/pii/S0378382012003098>)

Abstract: In this study lignite originating from North Dakota (USA) was thermally treated in an oxygen/steam blown commercial-scale moving bed gasifier operating on lump coal at the Dakota Gasification Company (DGC) in order to identify the physical property changes that occur during heating. After reaction, the solid particulate remnants were extracted from the reactor and characterised using standard techniques. Thermal fragmentation was found to be severe with the coal tested, i.e. the lump coal was found to decrease in size to about 90% $6.3\ \mu\text{m}$ particles in the drying and de-volatilisation zones of the reactor. The particle size (mean Sauter diameter) however increased slightly in the reduction and combustion zones due to ash melting and subsequent agglomeration. The particle as well as the bulk density residual profiles of the fuel bed samples in the reactor was found to be in alignment with the residual ash content profile. The ash fusion temperature (AFT) of the feed coal to the commercial-scale moving-bed gasifier was found to be higher as compared to the ash bed. Fluxing elements in the dominating glass phase determined in the reduction and combustion zones are most probably the reason behind this phenomenon.

Keywords: Coal; Lignite; Particle size distribution; Density; Ergun index; Ash fusion temperature

Facun Jiao, Yoshihiko Ninomiya, Lian Zhang, Naomo Yamada, Atsushi Sato, Zhongbing Dong, Effect of coal blending on the leaching characteristics of arsenic in fly ash from fluidized bed coal combustion, Fuel Processing Technology, Volume 106, February 2013, Pages 769-775, ISSN 0378-3820, <http://dx.doi.org/10.1016/j.fuproc.2012.10.015>.

(<http://www.sciencedirect.com/science/article/pii/S0378382012004043>)

Abstract: The leaching characteristics of arsenic (As) in fly ash collected from lab-scale fluidized bed reactor have been systematically investigated through the combustion of two bituminous coals (A and B) and their mixture with different blending ratio. Leaching tests were conducted according to Japanese Industrial Standard (JIS). The results indicate that, the fly ash derived from the combustion of coal B, which contains abundant calcium, shows a larger capture ability for arsenic vapor than that from coal A, due to the chemical reaction of arsenic with CaO. This reaction is however competed by the sulfation of CaO at coal combustion temperature, therefore, a nonlinear increase was observed with increasing the blending ratios of high-calcium coal B with coal A. Leaching performance of arsenic from fly ash is largely dependent on the finally pH of the leachate. CaO in fly ash preferentially generates a high-pH leachate during leaching test and subsequently promotes the combination of calcium with arsenic to form precipitate. Improving Ca/S ratio through the combustion of blending coal is a promising method to prevent the emission of arsenic into ambient and reduce its leachability from fly ash.

Keywords: Arsenic; Leaching behavior; Coal blending; Fluidized bed

Virginie Derycke, Mukendi Kongolo, Mostafa Benzaazoua, Martine Mallet, Odile Barrès, Philippe De Donato, Bruno Bussière, Raphaël Mermillod-Blondin, Surface chemical characterization of different pyrite size fractions for flotation purposes, International Journal of Mineral Processing, Volume 118, 30 January 2013, Pages 1-14, <http://dx.doi.org/10.1016/j.minpro.2012.10.004>.

(<http://www.sciencedirect.com/science/article/pii/S0301751612001172>)

Abstract: A surface chemical approach of different pyrite size fraction is developed in this paper in the prospect of addressing the well-known coarse pyrite flotation challenge for environmental purposes. This work aims at exploring the effect of particle size on pyrite surface chemistry through the study of three pyrite size fractions up to 425 μm . Pyrite surface evolution was investigated through dry crushing, air oxidation and aqueous conditioning using X-ray photoelectron spectroscopy (XPS) and diffuse reflectance infrared spectroscopy (DRIFT) as complementary surface characterization tools. XPS, which characterized the outmost surface (about 40 \AA depth), indicated that pyrite size fraction did not impact its surface chemistry after crushing. However, DRIFT which characterizes the whole oxidation layer, led to the conclusion that ferric sulfate was more abundant in the finer fraction than in the two coarser fractions. Those two surface characterization tools allowed a thorough insight into the three-dimensional oxidation product structures of pyrite from different size fractions. The surface evolution of coarse fractions had the same surface evolution trend when submitted to aging and conditioning processes than the fine pyrite size fraction, studied in previous works, in terms of surface species speciation and their relative proportion. Those results led to a better understanding of particle size impacts on pyrite surface chemistry.

Sneha Samal, Ajoy K. Ray, Amitava Bandopadhyay, Proposal for resources, utilization and processes of red mud in India — A review, International Journal of Mineral Processing, Volume 118, 30 January 2013, Pages 43-55, ISSN 0301-7516, <http://dx.doi.org/10.1016/j.minpro.2012.11.001>.

(<http://www.sciencedirect.com/science/article/pii/S0301751612001214>)

Abstract: Red mud is a solid waste produced in the process of alumina production from bauxite following the Bayer process. More than 4 million tons of red mud is generated annually in India only. Presently, it is stored or dumped on land, or in the oceans near alumina refineries. However, its high alkalinity is a potential pollution to threat water, land and air. While high costs are associated with the large area of land required for storage of the residue. India is amongst the major producers of alumina in the world. There are some differences in mineralogical composition between the residues from India and other countries due to the difference in the ore type in its production processes. Significant achievements in treatment and utilization of red mud have been obtained in India in the last decade. In this paper, the various proposals for the utilization of red mud generated in India are presented. Similarly, the drawbacks associated with these potential commercial applications of red mud are discussed.

Keywords: Red mud; Review; Utilization; India; Proposal

Agnieszka Mierczynska-Vasilev, David A. Beattie, The effect of impurities and cleavage characteristics on talc hydrophobicity and polymer adsorption, International Journal of Mineral Processing, Volume 118, 30 January 2013, Pages 34-42, ISSN 0301-7516, <http://dx.doi.org/10.1016/j.minpro.2012.11.003>.

(<http://www.sciencedirect.com/science/article/pii/S0301751612001342>)

Abstract: We have investigated three natural talc samples from different geographical locations (Rhode Island (USA), Delaware (USA), and Flinders Range (Australia)) to determine the effect of impurities and cleavage characteristics on hydrophobicity and polymer adsorption. Bulk (electron microprobe) and surface (X-ray photoelectron spectroscopy) composition measurements have indicated that the Rhode Island and Delaware talcs have the lowest level of Al atoms substituted within the talc structure (0.008%), and detectable at the cleaved basal plane surface (1.5 and 1.7%), and that the Flinders Range talc has the highest level of Al atoms (8.5% bulk; 8.2% surface). Contact angle measurements have highlighted the role of Al atom substitution and step-edge density (as revealed by AFM imaging) on the measured hydrophobicity of the cleaved surfaces, with the Flinders Range talc and the Rhode Island talc having significantly lower contact angles than the Delaware talc (65° and 83°, respectively, versus 90° for the Delaware). In addition, we have characterised the adsorption of two polysaccharide polymers on the three talc samples (CMC and Dextrin TY) using in situ tapping mode AFM. CMC adsorbs with

the same morphology on all three talc samples, whereas Dextrin TY presents three different morphologies on the talc surfaces. The potential implications of the observed variation in adsorption behaviour on mineral flotation are discussed.

Keywords: Talc; Dextrin; CMC; Atomic force microscope; Contact angle

Hangqiao Liu, Guoxia Wei, Rui Zhang, Removal of carbon constituents from hospital solid waste incinerator fly ash by column flotation, Waste Management, Volume 33, Issue 1, January 2013, Pages 168-174, ISSN 0956-053X, <http://dx.doi.org/10.1016/j.wasman.2012.08.019>.

(<http://www.sciencedirect.com/science/article/pii/S0956053X12004096>)

Abstract: Hospital solid waste incinerator (HSWI) fly ash contains a large number of carbon constituents including powder activated carbon and unburned carbon, which are the major source of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in fly ash. Therefore, the removal of carbon constituents could reduce PCDD/Fs in fly ash greatly. In this study, the effects of the main flotation parameters on the removal of carbon constituents were investigated, and the characteristics of the final product were evaluated. The results showed that loss on ignition (LOI) of fly ash increased from 11.1% to 31.6% during conditioning process. By optimizing the flotation parameters at slurry concentration 0.05 kg/l, kerosene dosage 12 kg/t, frother dosage 3 kg/t and air flow rate 0.06 m³/h, 92.7% of the carbon constituents were removed from the raw fly ash. Under these conditions, the froth product has LOI of 56.35% and calorific values of 12.5 MJ/kg, LOI in the tailings was below 5%, and the total toxic equivalent (TEQ) of PCDD/Fs decreased from 5.61 ng-TEQ/g in the raw fly ash to 1.47 ng-TEQ/g in the tailings. The results show that column flotation is a potential technology for simultaneous separation of carbon constituents and PCDD/Fs from HSWI fly ash.

Keywords: Hospital solid waste; Fly ash; Flotation; Carbon constituents; PCDD/Fs

D. Majuste, V.S.T. Ciminelli, P.J. Eng, K. Osseo-Asare, Applications of in situ synchrotron XRD in hydrometallurgy: Literature review and investigation of chalcopirite dissolution, Hydrometallurgy, Volumes 131-132, January 2013, Pages 54-66, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2012.10.001>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002186>)

Abstract: *In situ* synchrotron X-ray diffraction (S-XRD) techniques are potentially versatile research tools for advancing the current understanding on dissolution reactions of commercially important minerals. The paper presents a review on the applications of S-XRD to investigate solid phase transformations in aqueous media, with emphasis on reactions relevant to hydrometallurgy, including the dissolution of nickel laterite ores and metal sulfides, such as pyrite (FeS₂), bornite (Cu₅FeS₄) and

chalcocite (Cu_2S). The results of an *in situ* synchrotron time-resolved X-ray diffraction (S-TRXRD) study of the dissolution of chalcopyrite (CuFeS_2) are also reported. The S-TRXRD measurements were carried out in capillary-based cells containing fine particles by using two different experimental approaches — flow method (FM) and non-flow method (NFM). At 25 °C (FM), no transformation of the crystal structure was observed, in agreement with the well-known slow dissolution rate of the mineral. In the temperature range 100–200 °C (NFM), the formation of covellite (CuS), elemental sulfur (S_8), and metal sulfates (ferrous or cupric sulfates) was detected on CuFeS_2 particles. Our results demonstrate that the mineral conversion to such product phases commenced about 10 min after the start of measurements, and suggested that the formation of elemental sulfur is possibly related to an initial oxidation of CuFeS_2 by Fe^{3+} ions, followed by CuS oxidation by the same oxidants. The new results in combination with the previous reports demonstrate that the S-XRD techniques can be used to improve our knowledge on key hydrometallurgical processes. This work highlights the features of different experimental set-ups and the possibilities to be explored by applying *in situ* methods, alone or in combination with other analytical tools.

O.J. Solis-Marcía, G.T. Lapidus, Improvement of chalcopyrite dissolution in acid media using polar organic solvents, *Hydrometallurgy*, Volumes 131–132, Jan 2013, Pages 120-126, <http://dx.doi.org/10.1016/j.hydromet.2012.11.006>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X12002460>)

Abstract: The proposal of hydrometallurgical routes for treating chalcopyrite has increased due to the environmental problems caused by pyrometallurgical processing. However, hydrometallurgical methods have not found widespread acceptance for chalcopyrite because the refractory nature of this mineral phase does not permit leaching under ambient conditions. Moderately high temperatures and pressures are required to break a protective passivation layer formed by intermediate oxidation products. As an alternative, the addition of catalysts, such as pyrite and/or silver ions, to the leach has shown some promise to modify this passivating film. However, the improvements have not been economically attractive, still requiring long processing times. On the other hand, the use of polar organic solvents, as part of the acid leaching solution, has been shown to offer a solution to the formation of the protective layer. In the present investigation, chalcopyrite leaching in mixed polar organic/aqueous acid media is studied, varying the concentration and type of solvent, as well as the oxidant. The results show a beneficial effect of the solvents on copper and iron extractions, using different oxidants at relatively low temperatures, achieving high conversions in only 5 h at 50 °C.

A. Berton, M. Jubinville, D. Hodouin, C.G. Prévost, P. Navarra, Ore storage simulation for planning a concentrator expansion, *Minerals Engineering*, Vol. 40, January 2013, Pages 56-66, <http://dx.doi.org/10.1016/j.mineng.2012.10.001>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003299>)

Abstract: Stockpiling ore within a storage facility located between the mine and the concentrator can help damp production fluctuations originating from either the mining operation or the ore processing operation. To increase ore production rates, additional equipment is often installed within concentrators and mines. However, ore storage facilities may create bottlenecks in the production chain, if they are not properly redesigned. This paper proposes a mine-to-mill simulation method to determine the limitations of existing ore storage facilities and help their resizing in a context of production expansion. The modeling method combines three simulators to evaluate the production losses attributed to ore storage facilities: (1) a dynamic simulator of the 2D distribution of a storage facility filling profile, (2) a dynamic logistic model to simulate mine production and (3) a Monte Carlo simulator to emulate mine and concentrator equipment downtimes. The resulting overall simulator is able to provide answers to a very practical and critical industrial question: is an existing ore storage facility capable of handling increases in the production rate? Results of an application of this simulation technique to an iron ore processing plant helped reorient the plant expansion prefeasibility studies.

J. Li, K. Bunney, H.R. Watling, D.J. Robinson, Thermal pre-treatment of refractory limonite ores to enhance the extraction of nickel and cobalt under heap leaching conditions, Minerals Engineering, Volume 41, February 2013, Pages 71-78, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.11.002>.

(<http://www.sciencedirect.com/science/article/pii/S089268751200355X>)

Abstract: A low grade Western Australian slow-leaching limonite ore (Ore G) was selected to investigate the effect of thermal pre-treatment (roasting) upon the extraction kinetics of nickel and cobalt. The optimised thermal treatment conditions were established using batch roasting and bottle roll leaching tests to determine the effectiveness of each treatment relative to the leach performance of the untreated Ore G. The optimum treatment conditions were then applied to Ore G on a larger scale to provide a bulk sample for subsequent column leach tests. The faster leaching kinetics of both nickel and cobalt of the roasted ore were believed to be partially due to extra surface area created through water escape from goethite during the dehydroxylation process. Interestingly, however, the roasted ore consumes essentially the same amount of acid compared to untreated ore per unit of nickel extracted. Thus roasting of selected ores prior to heap leaching is a pre-treatment that could be applied to the vast WA resource of refractory goethitic ores which are currently not economic to process. The economics, however, would need to be assessed on a case by case basis with the additional processing costs needing to be at least off-set by the value of the recovered value metals.

Xuan Qu, Liguang Wang, Anh V. Nguyen, Correlation of air recovery with froth

stability and separation efficiency in coal flotation, Minerals Engineering, Vol. 41, Feb. 2013, Pages 25-30, <http://dx.doi.org/10.1016/j.mineng.2012.10.013>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003500>)

Abstract: Recent research progress in hard rock mineral flotation shows that froth stability can be represented by air recovery, which is defined as the fraction of air entering a flotation cell that overflows the weir in unburst bubbles, and that air recovery has strong correlation with the separation performance of mineral flotation. Yet no experimental work on air recovery has been devoted to coal flotation. This paper studies air recovery in coal flotation and examines the links between air recovery, froth stability and coal flotation performance. A series of experiments were conducted using a laboratory-scale mechanical flotation cell at various methyl isobutyl carbinol (MIBC) concentrations and aeration rates. It was found that air recovery has a strong correlation with dynamic froth stability determined by measuring the maximum froth height in a non-overflowing froth column. At a fixed aeration rate (hydrodynamic condition) and various MIBC concentrations, a strong correlation between air recovery and coal flotation performance was also observed.

Cristian S. Santarosa, Dustin Crandall, Igor V. Haljasmaa, Tae-Bong Hur, James J. Fazio, Robert P. Warzinski, Roberto Heemann, J. Marcelo M. Ketzer, Vyacheslav N. Romanov, CO₂ sequestration potential of Charqueadas coal field in Brazil, International Journal of Coal Geology, Volume 106, 1 February 2013, Pages 25-34, <http://dx.doi.org/10.1016/j.coal.2013.01.005>.

(<http://www.sciencedirect.com/science/article/pii/S0166516213000086>)

Abstract: Although coal is not the primary source of energy in Brazil there is growing interest to evaluate the potential of coal from the south of the country for various activities. The I2B coal seam in the Charqueadas coal field has been considered a target for enhanced coal bed methane production and CO₂ sequestration. A detailed experimental study of the samples from this seam was conducted at the NETL with assistance from the Pontificia Universidade Católica Do Rio Grande Do Sul. Such properties as sorption capacity, internal structure of the samples, porosity and permeability were of primary interest in this characterization study. The samples used were low rank coals (high volatile bituminous and sub-bituminous) obtained from the I2B seam. It was observed that the temperature effect on adsorption capacity correlates negatively with as-received water and mineral content. Langmuir CO₂ adsorption capacity of the coal samples ranged 0.61–2.09 mmol/g. The upper I2B seam appears to be overall more heterogeneous and less permeable than the lower I2B seam. The lower seam coal appears to have a large amount of micro-fractures that do not close even at 11 MPa of confining pressure.

A. Tuncuk, S. Ciftlik, A. Akcil, Factorial experiments for iron removal from kaolin by using single and two-step leaching with sulfuric acid,

Hydrometallurgy, Volumes 134–135, March 2013, Pages 80-86, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.02.006>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000339>)

Abstract: In the present study, to investigate the effects of acidic leaching on the iron removal from kaolin clay supplied by Cam-Ser Madencilik A.S., the 2⁴ full factorial design of experiments and analysis of variance (ANOVA) were performed. The aim of the initial phase of research was to determine the effects of the main and interaction factors which can potentially influence the iron removal process. The factors were; pulp density, sulfuric acid concentration, temperature, leaching duration and reducing agent (oxalic acid, citric acid and hydrogen peroxide) concentration. The highest iron extraction yield (IEY) (26.3%) was obtained after 120 min of treatment at 90 °C, 20% pulp density, 3 M H₂SO₄ and with 0.50 M H₂O₂ as a reducing agent. For the purpose of increasing the IEY, in the second phase of research, initially the particle size of the kaolin sample was decreased to – 106 µm providing the liberation of iron oxides. Then, two-step leaching experiments were carried out with the optimum leaching conditions of full factorial design tests. The maximum IEY was 37.0% after two-step leaching with the optimum conditions of H₂SO₄ and H₂SO₄ with oxalic acid leaching. Iron oxide content of kaolin clay was decreased from 2.40% to 1.51%.

Ozge Gok, Corby G. Anderson, Dissolution of low-grade chalcopyrite concentrate in acidified nitrite electrolyte, Hydrometallurgy, Volumes 134–135, March 2013, Pages 40-46, <http://dx.doi.org/10.1016/j.hydromet.2013.01.021>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X1300025X>)

Abstract: Copper sulfides are generally treated by flotation followed by smelting. However, concerns over air pollution have made governments tighten their regulations regarding the emission of sulfur dioxide. Thus, hydrometallurgical techniques seem to be the most convenient methods to selectively extract non-ferrous metals. In this study, the leaching kinetics of copper from low-grade concentrate by nitrite salt was investigated. The probabilities of several chemical reactions and the products formed were explained based on literature data and thermodynamic analysis. The copper concentrate was obtained from a flotation plant in the Kastamonu region of Turkey. Leaching experiments were conducted in sulfuric acid electrolyte (0.5 M–2.0 M) containing nitrite compounds (0.025 M–0.15 M) at a moderate temperature (80–120 °C). A high level of copper recovery (96%) from low-grade chalcopyrite concentrate was obtained under a total pressure of 6 atm at 120 °C within 2 h when using small amounts of nitrite species due to their autocatalytic behavior in acidic solutions. Elemental sulfur was the primary leaching product on the mineral surface, as confirmed using XRD and SEM/EDX analysis, and the formation of the sulfur layer inhibited leaching rate at later stage of dissolution process.

D.M. Puente-Siller, J.C. Fuentes-Aceituno, F. Nava-Alonso, A kinetic-thermodynamic study of silver leaching in thiosulfate-copper-ammonia-EDTA solutions, Hydrometallurgy, Volumes 134-135, March 2013, Pages 124-131, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.02.010>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000509>)

Abstract: In this research, an analysis of the effect of ethylenediaminetetraacetic acid (EDTA), thiosulfate and cupric ions on the silver leaching kinetics was performed. For that purpose leaching experiments with pure metallic silver were carried out at different concentrations of these reagents at room temperature. The results of this study showed that small amounts of EDTA accelerate the leaching of silver more efficiently than higher concentrations due to an increase in the oxidation potential of the leaching solution. These results were in accord with Pourbaix diagrams and redox potential measurements. A synergistic effect was found in the silver leaching kinetics when the thiosulfate and EDTA concentrations were both decreased. On the other hand, the silver leaching kinetics was reduced at low Cu(II) concentrations due to the decrease in the oxidizing ability of the leaching solution. Characterization by SEM and EDXS of the silver in the first minutes of leaching revealed that the silver particles were coated by a layer of copper sulfides and copper oxides. Furthermore, characterization of the solid residue during the precipitation of silver in the leaching experiment was performed by the same analytical techniques, showing the presence of silver sulfide on the unreacted silver surface. The mechanism by which the silver sulfide is precipitated was found to be related to the copper sulfide formation. It was also observed that an increase in the concentration of EDTA promotes the silver dissolution avoiding the formation of copper sulfides or oxides; in these cases the process is controlled by the chemical reaction. These observations were also supported with Pourbaix and species distribution diagrams.

Agnieszka Furmann, Maria Mastalerz, Simon C. Brassell, Arndt Schimmelmann, Flynn Picardal, Extractability of biomarkers from high- and low-vitrinite coals and its effect on the porosity of coal, International Journal of Coal Geology, Volume 107, 1 March 2013, Pages 141-151, ISSN 0166-5162, <http://dx.doi.org/10.1016/j.coal.2012.09.010>.

(<http://www.sciencedirect.com/science/article/pii/S0166516212002224>)

Abstract: The influence of two solvents on the degree of bitumen extractability and the porosity of the extracted coals was investigated using two high-volatile bituminous coals with different petrographic composition. The Springfield Coal (vitrinite-rich) and the Lower Block Coal (vitrinite-poor) from the Illinois Basin were Soxhlet-extracted with methanol (CH₃OH) and dichloromethane (CH₂Cl₂). The abundances of three selected groups of biomarkers extracted from both coals were compared: (1) n-alkanes plus pristane and phytane; (2) hopanes; and (3) 3- and 4-ring aromatic hydrocarbons (phenanthrene, anthracene, fluoranthene, and pyrene).

Overall, the extracts of the vitrinite-poor Lower Block Coal contained greater amounts of n-alkanes and hopanes, whereas aromatic hydrocarbons were extracted in greater quantities from the vitrinite-rich Springfield Coal. Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography/Mass Spectrometry (GC/MS) confirmed that the average lengths of aliphatic chains were greater in CH₂Cl₂ extracts from both coals. For the Lower Block Coal, the aromaticity of extracted organic matter was greater in the CH₂Cl₂ extract than in the CH₃OH extract. Both coals showed an increase in microporosity ($2\text{--}50\text{ nm}$ measured by CO₂ adsorption) after solvent treatments. In addition, the mesopore surface area (2–50 nm, measured by N₂ adsorption) was reduced likely because of a shift in the size distribution of mesopore diameters towards those of macropores (i.e. >math>50\text{ nm}</math>). Our analyses of compound classes present in the extracts and resultant porosity changes in the extracted coals provide useful insights into the structural and molecular differences in two bituminous coals of different maceral compositions.

Astrid Blandón, Georges Gorin, Combining palynofacies and petrography in the study of sub-bituminous tropical coals: A case history from Lower Tertiary coals in Colombia, *International Journal of Coal Geology*, Volume 108, 30 March 2013, Pages 65-82, <http://dx.doi.org/10.1016/j.coal.2012.07.002>.

(<http://www.sciencedirect.com/science/article/pii/S0166516212001759>)

Abstract: Colombia contains large coal reserves of Late Cretaceous to Cenozoic age in various sedimentary basins, but little is known about their potential to generate hydrocarbons. In Western Venezuela, coals are known to be potential source rocks for oil and the vicinity of these coals with coal-bearing basins in Colombia has prompted new studies in Colombian tropical coals to develop concepts about their hydrocarbon generating potential. The Paleogene Amagá Formation studied here, although of limited geographical extension, is an ideal field laboratory which contains low-rank coal seams, in which the transformation and preservation state of organic matter permits the assessment of environment and vegetation types existing at the time of peat formation. Several seams up to 1 m thick have been analyzed using both bulk seam samples and ply (or lithotype) samples. It is demonstrated that bulk seam samples are not representative for a proper evaluation of the hydrocarbon generation potential of seams. One needs to evaluate all lithotype assemblages within a seam. Proximate analysis and Rock-Eval pyrolysis provide a rapid and cheap way to assess the generation potential of each lithotype. The potentially interesting lithotypes can be further analyzed through the combination of petrographic and palynological observations. These methods permit the comparison of coal macerals with the equivalent palynofacies constituents, provided that a preparation technique especially designed for tropical, sub-bituminous, Tertiary coals is used. The palynofacies technique has proved to be more accurate than petrography in determining the relative proportion of the potentially oil-prone constituents/macerals, which can be hidden or difficult to identify in petrographic polished section. Moreover, the comparison between

resinite oil observed in petrography and resins identified in palynofacies may yield indications of early hydrocarbon generation. This methodology provides a fully detailed inventory of coal properties with respect to hydrocarbon generation potential. The use of palynofacies is an additional tool to apprehend the floral composition and paleoenvironment of coals, thereby increasing the geological and geochemical database needed to evaluate their potential. Such a methodology may prove very important to assess the petroleum potential of thicker coal deposits in prospective petroleum provinces, such as the Cerrejon coals in Northern Colombia.

Zofia Stępniewska, Anna Pytlak, Agnieszka Kuźniar, Methanotrophic activity in Carboniferous coalbed rocks, International Journal of Coal Geology, Volume 106, 1 February 2013, Pages 1-10, <http://dx.doi.org/10.1016/j.coal.2013.01.003>.

(<http://www.sciencedirect.com/science/article/pii/S0166516213000062>)

Abstract: Carboniferous coalbed rocks originating from the Lublin Coal Basin (South-East Poland) were investigated for the presence and activity of aerobic methanotrophic bacteria. Laboratory studies of samples collected from 914 to 1004 m below earth's surface and performed at 30 °C, 100% water capacity (WHC) and 10% v/v headspace CH₄ revealed microbial methane oxidation which ranged from 0.13 to 0.75 μM CH₄ g⁻¹ day⁻¹. Methanotrophic activity (MA) was also investigated as a function of temperature (5–30 °C), moisture content (25–200% WHC) and substrate concentration (1–30% v/v CH₄). The highest MA was recorded at 30 °C, 100% WHC and 20% CH₄ v/v, indicating the mesophilic and microaerophilic character of methanotrophic bacteria (MB) present in the coalbed. Lack of detectable MA at 5 and 10 °C shows narrow temperature tolerance of MB, which may result from a long-term isolation of the bacterial habitat and stability of thermal conditions in the coalbed. Cryo-SEM revealed presence in the investigated rocks of bacteria (c.a. 2–2.5 μm long and 0.5–1 μm wide) and spore-like structures (0.5–1 μm in diameter). These observations were confirmed by fluorescence in situ hybridization with probes Mg705 (5'fluoresceine), Mg84 (5'Cy3) and Ma450 (5'Cy5), which showed that enrichments in NMS medium contain types I and II MB of similar size. Identification performed with the use of DNA amplification of 16S rRNA targeted group specific primers confirmed the presence of bacteria belonging to *Methylosinus*, *Methylomicrobium*, *Methylocystis* and *Methylocaldum*. Here we show that coalbed rocks constitute a habitat for diverse MB.

Adam Jordens, Ying Ping Cheng, Kristian E. Waters, A review of the beneficiation of rare earth element bearing minerals, Minerals Engineering, Volume 41, February 2013, Pages 97-114, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.10.017>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003597>)

Abstract: Rare earth elements (REEs) comprise the fifteen elements of the lanthanide series as well as yttrium, and may be found in over 250 different minerals. These

elements are required for many different applications such as high-strength permanent magnets, catalysts for petroleum refining, metal and glass additives and phosphors used in electronic displays. The only REE bearing minerals that have been extracted on a commercial scale are bastnäsite, monazite, and xenotime. These minerals may be beneficiated using gravity, magnetic, electrostatic and flotation separation techniques. Increased demand for the different products manufactured from REE has resulted in a constriction of supply from China, which currently produces 97% of the world's rare earths, via export quotas. Many new rare earth deposits are currently being developed to help meet the demand void created by the Chinese export quotas, however most of these developing deposits include rare earth minerals for which there is limited processing knowledge. This paper examines the separation techniques that are currently employed for rare earth mineral beneficiation and identifies areas in need of further research.

Terry Norgate, Nawshad Haque, The greenhouse gas impact of IPCC and ore-sorting technologies, Minerals Engineering, Volume 42, March 2013, Pages 13-21, ISSN 0892-6875, <http://dx.doi.org/10.1016/j.mineng.2012.11.012>.

(<http://www.sciencedirect.com/science/article/pii/S0892687512003810>)

Abstract: In-pit crushing and conveying (IPCC) and ore sorting are two developing technologies that, in addition to providing likely economic benefits, also have the potential to reduce the greenhouse gas footprint of mining and mineral processing operations. A life cycle assessment study was carried out to provide estimates of the likely greenhouse gas reductions from the implementation of IPCC and ore sorting technologies in a hypothetical copper mining and mineral processing operation. Based on the assumed configurations and operating characteristics of the two systems, the results indicated that IPCC had 4% less (i.e. 3 kg CO₂e/t ore or 0.16 kg CO₂e/t ore.km) greenhouse gas emissions than truck haulage for the base case configuration. Using electricity generated from natural gas rather than black coal increased the greenhouse gas advantage of IPCC over truck haulage from 4% to about 22% (i.e. 14 kg CO₂e/t ore or 0.74 kg CO₂e/t ore.km). However, transport distance and annual plant feedrate affect the magnitude of these greenhouse gas reductions. A potential reduction of about 13 kg CO₂e/t ore in greenhouse gas emissions was estimated from the use of ore sorting technology based on black coal generated electricity, while with natural gas-based electricity the reduction was only 8 kg CO₂e/t ore. The mass rejection rate of the ore sorting device was the main operational variable affecting the magnitude of this reduction, although it is also affected by the specific comminution and concentration energy requirements of the ore. While the results indicate that ore sorting offers nearly four times the potential reduction in greenhouse gas emissions than IPCC did at the same annual plant feedrate for the base case configuration with black coal-based electricity, the situation was reversed with natural gas-based electricity, with IPCC offering nearly double the potential reduction in greenhouse gas emissions than ore sorting. However, it should be appreciated that due to the limited amount of publicly

available data on these technologies at the present time, the results of this study should be viewed as first estimates only.

Sanghyuk Lim, Kyung Hyun Ahn, Seung Jong Lee, Ashish Kumar, Nicky Duan, Xiaodan Sun, Shane P. Usher, Peter J. Scales, Yield and flow measurement of fine and coarse binary particulate mineral slurries, International Journal of Mineral Processing, Volume 119, 6 March 2013, Pages 6-15, ISSN 0301-7516, <http://dx.doi.org/10.1016/j.minpro.2012.12.009>.

(<http://www.sciencedirect.com/science/article/pii/S0301751612001457>)

Abstract: The presence of coarse particulate components in tailings streams poses significant challenges to the mineral processing industry. Suspensions with fast-settling coarse fractions make traditional rheological measurements tedious and inaccurate. These measurements are critical to the design and operation of mixing, dewatering, pumping and tailings equipment and operations. A methodology for predicting the gel point, close packing fraction and shear rheology of particulate slurries containing a binary mixture of fine and coarse material is presented. The model has validity subject to the constraint that the particle size of the coarse material is sufficiently distinct from that of the fine material. The model enables calculation of the gel point and close packing fraction of the mixture based on the gel points and close packing fractions of the pure fine and coarse materials in the suspension. The model predicts that the gel point (and close packing fraction) of the fine material increases with increasing coarse fraction until a maximum value is attained before decreasing to the gel point (or close packing fraction) of the coarse material. This relationship provides a subsequent basis for a yield stress model to accurately predict the yielding behaviour of binary mixtures of fine and coarse material. The model is useful in determining whether a sample exhibits yield stress behaviour through knowledge of the gel point and close packing fraction of the constitutive fine and coarse components. The model is exemplified using particulate mixtures containing coagulated aluminium oxide, calcium carbonate and coarse sand.

Muddasar Habib, Nicholas J. Miles, Philip Hall, Recovering metallic fractions from waste electrical and electronic equipment by a novel vibration system, Waste Management, Volume 33, Issue 3, March 2013, Pages 722-729, ISSN 0956-053X, <http://dx.doi.org/10.1016/j.wasman.2012.11.017>.

(<http://www.sciencedirect.com/science/article/pii/S0956053X12005405>)

Abstract: The need to recover and recycle valuable resources from Waste Electrical and Electronic Equipment (WEEE) is of growing importance as increasing amounts are generated due to shorter product life cycles, market expansions, new product developments and, higher consumption and production rates. The European Commission (EC) directive, 2002/96/EC, on WEEE became law in UK in January 2007 setting targets to recover up to 80% of all WEEE generated. Printed Wire Board

(PWB) and/or Printed Circuit Board (PCB) is an important component of WEEE with an ever increasing tonnage being generated. However, the lack of an accurate estimate for PCB production, future supply and uncertain demands of its recycled materials in international markets has provided the motivation to explore different approaches to recycle PCBs. The work contained in this paper focuses on a novel, dry separation methodology in which vertical vibration is used to separate the metallic and non-metallic fractions of PCBs. When PCBs were comminuted to less than 1 mm in size, metallic grades as high as 95% (measured by heavy liquid analysis) could be achieved in the recovered products.

Keith Quast, Danfeng Xu, William Skinner, Ataollah Nosrati, Tom Hilder, David J. Robinson, Jonas Addai-Mensah, Column leaching of nickel laterite agglomerates: Effect of feed size, Hydrometallurgy, Volumes 134–135, March 2013, Pages 144-149, <http://dx.doi.org/10.1016/j.hydromet.2013.02.001>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000285>)

Abstract: Heap leaching is a promising, less costly, alternative technology for processing low grade nickel (Ni) laterite ores compared with traditional, energy intensive processes (e.g. autoclave/tank leaching). However, significant technical challenges remain with Ni laterite heap leaching, preventing its general adoption. This paper presents some highlights of laboratory column leaching studies undertaken to characterise, evaluate and optimise sulphuric acid leaching behaviour of Ni laterite agglomerates. The main focus of the paper is to assess the effect of the initial feed ore particle size to the agglomeration stage on the leaching behaviour of the resulting agglomerates. This type of investigation provides basic but valuable information regarding Ni laterite agglomerate robustness and leaching performance under industrially-relevant, continuous acid irrigation conditions. In particular, Ni, cobalt (Co) and other key metals' (e.g. Fe, Mg, Al and Mn) extraction rates, acid consumption and bed slump were determined at a given acid percolation rate as a function of time > 100 days. The findings show that the particle size of the agglomerate feed ore has a significant impact on the subsequent column leaching performance. Ni and Co recoveries of 90% and 80%, respectively, were achieved over 100 days for – 38 µm size feed, 5–40 mm agglomerates, but these decreased by 10% for the agglomerates made from coarser feed particles (i.e., 2–15 mm). Potential implications of the findings for devising strategies for improved Ni laterite plant heap leach operations are discussed.

Rong Fan, Andrea R. Gerson, Mineralogical characterisation of Indonesian laterites prior to and post atmospheric leaching, Hydrometallurgy, Vol.134–135, Mar 2013, pp. 102-109, <http://dx.doi.org/10.1016/j.hydromet.2013.02.004>.

Abstract: Nickel laterite is of increasing importance as an economically viable source of Ni. However, practical strategies for low cost atmospheric leaching of laterites have been hampered in part by poor recovery and the formation of potentially environmentally harmful residues, for instance jarosite. It is important

therefore to define the mineralogical forms of nickel present, using readily accessible laboratory-based approaches, in the ores and residues, and the form of secondary precipitates in the residues, as a means for future optimisation of leach parameters. To this end a detailed mineralogical study of an Indonesian laterite and residues resulting from atmospheric acid leaching has been undertaken. The leach process involved the sequential reactions of first, limonite (3 h) and then saprolite (11 h) in sulphuric acid leach liquor. The acid, dry limonite and saprolite ores were added in the weight ratio of 1.4:1:1. At 100 °C, over 80% of the total Ni was extracted into solution during the whole leach process. The limonite ore was found to contain Ni (1.2 wt.%) predominantly within Fe oxy/hydroxides, serpentine and phylломanganate whilst in the residue Ni (0.4 wt.%) is present in highly crystalline leach resistant minerals, such as spinels. The majority of the Ni (1.6 wt.%) in the saprolite ore was present in serpentine with a small fraction also present in phylломanganate. This association is further confirmed by the similar saprolite leach extraction curves of Ni and Mg. Goethite and jarosite are both found to be concentrated in the saprolite residue, as is consistent with the decrease in Fe extraction during the saprolite leach. For the final 11 h residue of the saprolite leach, the Ni (0.3 wt.%) is mainly present in undissolved lizardite and leach resistant pyroxene and spinel minerals.

Weimin Zeng, Guanzhou Qiu, Miao Chen, Investigation of Cu–S intermediate species during electrochemical dissolution and bioleaching of chalcopyrite concentrate, Hydrometallurgy, Volumes 134–135, March 2013, Pages 158-165, <http://dx.doi.org/10.1016/j.hydromet.2013.02.009>.

Abstract: The electrochemistry behaviour of chalcopyrite electrodes was investigated by cyclic voltammetry. The results showed that the Cu–S intermediate species during electrochemical dissolution of chalcopyrite was mainly as Cu_2S , Cu_xS ($1 < x < 2$) and CuS . The formation process of these species was analysed. It was shown that the oxidation of chalcopyrite can only produce CuS , but Cu_xS and Cu_2S were mainly formed due to the reduction reaction of copper ion and sulphur. Furthermore, it was found that the addition of copper ion could greatly affect the formation of Cu–S intermediate species. Therefore, during bioleaching of chalcopyrite, the effect of different concentrations of copper ion on the bioleaching process was investigated. The results revealed that when the copper concentration was low, it was hard to form Cu–S species in the ore residue. However, as copper concentration increased, the formation of Cu–S intermediate species also increased and could be detected by X-ray diffraction.

Ataollah Nosrati, David J. Robinson, Jonas Addai-Mensah, Establishing nickel laterite agglomerate structure and properties for enhanced heap leaching, Hydrometallurgy, Volumes 134–135, March 2013, Pages 66-73, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.01.019>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000236>)

Abstract: Producing robust agglomerates with desirable structural properties is key to the success of the heap leaching of complex, low-grade nickel (Ni) laterite ores. The agglomerate microstructure characterization is essential for greater understanding and correlation with its key properties (e.g., porosity, permeability, strength) and performance during heap leaching. In this study, computed X-ray tomography and scanning electron microscopy are used with compressive strength and re-wetting integrity/stability analyses to establish links between Ni laterite agglomerate strength/stability, microstructure (e.g., porosity, inter-particle bridges), formulation of agglomeration medium and granule drying/curing condition. It is shown that both the agglomeration medium (e.g., tap water vs. 30% w/w H₂SO₄) and agglomerate drying/curing play pivotal roles in structural changes within the agglomerates and hence significantly impact on the agglomerate's physicochemical and microstructural properties. Acidic medium, in contrast to tap water, leads to significant leaching of Ni, Co and gangue from the ore during mixing. Upon agglomerate drying, solidified/crystallized leached species form strong intra-granular solid bridges which lead to greater agglomerate compressive strength. The strength of dry agglomerate is markedly greater for acid- than for water-bound agglomerates at equivalent residual moisture content. Structural stability/integrity of cured agglomerates upon contact with acidic solution, however, decreases dramatically due to greater internal pore volumes and the acid solubility of solid bridges. These findings are useful in shedding more light on agglomerate structure.

A. Tuncuk, S. Ciftlik, A. Akcil, Factorial experiments for iron removal from kaolin by using single and two-step leaching with sulfuric acid, Hydrometallurgy, Volumes 134–135, March 2013, Pages 80-86, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.02.006>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000339>)

Abstract: In the present study, to investigate the effects of acidic leaching on the iron removal from kaolin clay supplied by Cam-Ser Madencilik A.S., the 2⁴ full factorial design of experiments and analysis of variance (ANOVA) were performed. The aim of the initial phase of research was to determine the effects of the main and interaction factors which can potentially influence the iron removal process. The factors were; pulp density, sulfuric acid concentration, temperature, leaching duration and reducing agent (oxalic acid, citric acid and hydrogen peroxide) concentration. The highest iron extraction yield (IEY) (26.3%) was obtained after 120 min of treatment at 90 °C, 20% pulp density, 3 M H₂SO₄ and with 0.50 M H₂O₂ as a reducing agent. For the purpose of increasing the IEY, in the second phase of research, initially the particle size of the kaolin sample was decreased to – 106 µm providing the liberation of iron oxides. Then, two-step leaching experiments were carried out with the optimum leaching conditions of full factorial design tests. The maximum IEY was 37.0% after two-step leaching with the optimum conditions of H₂SO₄ and H₂SO₄ with oxalic acid leaching. Iron oxide content of kaolin clay was decreased from 2.40% to 1.51%.

Ozge Gok, Corby G. Anderson, Dissolution of low-grade chalcopyrite concentrate in acidified nitrite electrolyte, Hydrometallurgy, Volumes 134–135, March 2013, Pages 40-46, <http://dx.doi.org/10.1016/j.hydromet.2013.01.021>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X1300025X>)

Abstract: Copper sulfides are generally treated by flotation followed by smelting. However, concerns over air pollution have made governments tighten their regulations regarding the emission of sulfur dioxide. Thus, hydrometallurgical techniques seem to be the most convenient methods to selectively extract non-ferrous metals. In this study, the leaching kinetics of copper from low-grade concentrate by nitrite salt was investigated. The probabilities of several chemical reactions and the products formed were explained based on literature data and thermodynamic analysis. The copper concentrate was obtained from a flotation plant in the Kastamonu region of Turkey. Leaching experiments were conducted in sulfuric acid electrolyte (0.5 M–2.0 M) containing nitrite compounds (0.025 M–0.15 M) at a moderate temperature (80–120 °C). A high level of copper recovery (96%) from low-grade chalcopyrite concentrate was obtained under a total pressure of 6 atm at 120 °C within 2 h when using small amounts of nitrite species due to their autocatalytic behavior in acidic solutions. Elemental sulfur was the primary leaching product on the mineral surface, as confirmed using XRD and SEM/EDX analysis, and the formation of the sulfur layer inhibited leaching rate at later stage of dissolution process.

Diego F. Lisbona, Christopher Somerfield, Karen M. Steel, Leaching of spent pot-lining with aluminium nitrate and nitric acid: Effect of reaction conditions and thermodynamic modelling of solution speciation, Hydrometallurgy, Volumes 134–135, March 2013, Pages 132-143, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.02.011>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000510>)

Abstract: A study of the leaching behaviour of spent pot-lining (SPL), a hazardous waste generated at the end-of-life of aluminium smelting cells, has been carried out using $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ and HNO_3 solutions. Following an initial water wash, a single leaching step using 0.5 M HNO_3 and 0.36 M $\text{Al}(\text{NO}_3)_3$ at 60 °C extracted a total of 96.3 wt.% of the remaining fluoride, complete extraction of magnesium and 90% of the calcium content, originally in the form of MgF_2 and CaF_2 . In the absence of $\text{Al}(\text{NO}_3)_3$, iron extraction is almost complete when SPL is treated with 0.5 M HNO_3 solution at 60 °C. CN^- was selectively extracted when 0.2 M HNO_3 at 60 °C was used, and could be selectively precipitated from the scrubbing solution in the form of salts of transition metals for catalytic applications. Experimental observations have been correlated with a mathematical model of the solution equilibria, which identified AlF_2^{2+} and AlF_2^+ as the main species responsible for fluoride extraction from Na_3AlF_6 and CaF_2 . Selective precipitation by pH adjustment is proposed as a means to

recover fluoride and metal values. Aluminium and fluoride can be selectively precipitated as $\text{AlF}_2\text{OH}\cdot 1.4\text{H}_2\text{O}$ for conversion into smelter grade (SG) AlF_3 .

D.M. Puente-Siller, J.C. Fuentes-Aceituno, F. Nava-Alonso, A kinetic-thermodynamic study of silver leaching in thiosulfate-copper-ammonia-EDTA solutions, Hydrometallurgy, Volumes 134-135, March 2013, Pages 124-131, ISSN 0304-386X, <http://dx.doi.org/10.1016/j.hydromet.2013.02.010>.

(<http://www.sciencedirect.com/science/article/pii/S0304386X13000509>)

Abstract: In this research, an analysis of the effect of ethylenediaminetetraacetic acid (EDTA), thiosulfate and cupric ions on the silver leaching kinetics was performed. For that purpose leaching experiments with pure metallic silver were carried out at different concentrations of these reagents at room temperature. The results of this study showed that small amounts of EDTA accelerate the leaching of silver more efficiently than higher concentrations due to an increase in the oxidation potential of the leaching solution. These results were in accord with Pourbaix diagrams and redox potential measurements. A synergistic effect was found in the silver leaching kinetics when the thiosulfate and EDTA concentrations were both decreased. On the other hand, the silver leaching kinetics was reduced at low Cu(II) concentrations due to the decrease in the oxidizing ability of the leaching solution. Characterization by SEM and EDXS of the silver in the first minutes of leaching revealed that the silver particles were coated by a layer of copper sulfides and copper oxides. Furthermore, characterization of the solid residue during the precipitation of silver in the leaching experiment was performed by the same analytical techniques, showing the presence of silver sulfide on the unreacted silver surface. The mechanism by which the silver sulfide is precipitated was found to be related to the copper sulfide formation. It was also observed that an increase in the concentration of EDTA promotes the silver dissolution avoiding the formation of copper sulfides or oxides; in these cases the process is controlled by the chemical reaction. These observations were also supported with Pourbaix and species distribution diagrams.

SELECTIVE ABSTRACTS

Full-text Papers available in NML Eprints
(<http://eprints.nmlindia.org>)

Abhilash, and Pandey, B D and Singh, A K (2013) *Comparative Performance of Uranium Bioleaching from Low Grade Indian Apatite Rock in Column and Bioreactor. Energy Procedia, 39 . pp. 20-32.*

Uranium ore from the Narwapahar mines, Jharkhand, India (~0.047% U₃O₈), rich in apatite content (5%) was investigated for bio-processing in lab-scale columns and bioreactor. With a load of 2.0 kg ore in column at pH 1.7 using *A. ferrooxidans* and *L. ferrooxidans*, uranium recovery of 57% and 66% was achieved, respectively in 40 days in comparison to 39% in chemical leaching. Bio-leaching studies with the Narwapahar ore carried out in a 2L bioreactor at 10% (w/v) pulp density at pH 2.0, rpm 150 and 35oC yielded 57% and 63% uranium recovery by 10% (v/v) enriched culture of *A. ferrooxidans* and *L. ferrooxidans*, respectively in 5 days. In another set of experiments, biogenic ferric sulfate generated in the bioreactor was mixed with the ore slurry and 90.3% uranium biorecovery was achieved in 10 h at pH 2.0, 20% (w/v) pulp density of <45 μm particles and 40oC with *L. ferrooxidans* as against 87% leaching at 35oC with *A. ferrooxidans*. <http://eprints.nmlindia.org/6723/>

Alex, T C and Kalinkin, A M and Nath, S K and Gurevich , B I and Kalinkina, E V and Tyukavkina, W and Kumar, Sanjay (2013) *Utilization of zinc slag through geopolymerization: Influence of milling atmosphere. International Journal of Mineral Processing, 123 (IF-1.378). pp. 102-107.*

Having no major application, zinc slag generated during imperial smelting process (ISP) all over the world is simply dumped. Some occasional research attempts, seen in the literature, are limited to its use as a replacement for aggregates in construction related applications. This study is a part of our activities towards complete utilization of slag for building material applications using geopolymerization process, which involves formation of a new rock like species from various aluminosilicate minerals under strong alkaline environment. This slag has been subjected to short grinding in a high-energy AGO-2 mill to enhance its reactivity. The paper particularly focuses on the influence of the grinding atmosphere, viz. air or CO₂ on the geopolymers prepared from milled slag. Studies have shown that the particulate characteristics mostly remain unaffected by the milling atmosphere. However, conduction calorimetric experiments have shown that the milling atmosphere has a bearing on the reactivity of slag despite their similarity in particulate characteristics; CO₂-milled slag has been found to be more reactive than the air-milled slag. Both air and CO₂-milled slag has been found good geopolymerization behavior leading to high compressive strength of the

geopolymer products; higher compressive strength values for the geopolymer prepared from the latter further shows its enhanced reactivity over the former. TCLP tests of the prepared samples confirm that the release of toxic metals is within USEPA limits and hence the process is an environment friendly way of utilizing the zinc slag. <http://eprints.nmlindia.org/6719/>

Vidyadhar, A and D, Renuka and Sharma, Mamta and Das, Avimanyu (2013) *Beneficiation of High Ash Non-Coking Coal from Vasundhra Mines, Odisha*. In: Twenty-sixth National convention of Metallurgical and Materials Engineers & National seminar on "Exploitation of Lean Grade Ore, Ore Fines and Urban Ores: Challenges, Problems and Solutions, 22-23 January, 2013, CSIR - National Metallurgical Laboratory.

Coal is the vital energy fuel world-over, statistically contributing to 55% of installed energy generation capacity during the calendar year 2011 and it plays a pivotal role in the macro- economic development of the country. India has definitive coal reserves estimated by the Ministry of Coal at 93 billion tonnes, which is estimated to suffice and cater to energy generation requirement of the country, spanning over 30 to 60 years with proper scientific exploitation. However, Indian coal has been observed to be of low quality on account of its high ash content attribute and the high ash non-coking category coal constitutes sizeable quantity of near-gravity materials (NGM), which entails beneficiation to suit end-user or application specific qualitative level. The present manuscript demonstrates the beneficiation of high ash non-coking coal from Vasundhara mines, with 57% ash content intended for scaling down the ash content to 25% in obtaining clean coal at a reasonable yield, deploying physical beneficiation techniques. The coal was characterised thoroughly in terms of petrographic characteristics, size analysis, washability and chemical composition and the gross calorific value of the coal was observed to be 3221 Kcal/kg. The processing was initiated at a top size of 6.3 mm after initial deshaling of the ROM coal on account of its high ash content. Tactical combination of gravity separation and flotation techniques yielded clean coal with 25% ash at 40% yield and an intermediate clean product with 49% ash at 12% yield. The low ash content in the final clean coal is possibly achievable from the combined clean coal with 25% ash content adopting chemical beneficiation route. <http://eprints.nmlindia.org/6420/>

Dey, Shobhana and Paul, Gyan Manjari and Pani, Santosh (2013) *Effective flotation of weathered coal using frother blend*. In: National Seminar On Coal Preparation Technology, CPT-2013 , 22-23 February 2013, CIMFR, Dhanbad.

Froth flotation of weathered coal is a challenging task in a conventional flotation cell using commonly used collector and frother. Generally weathered coal shows the erratic flotation behaviour due to the surface oxidation as it makes the coal surface

hydrophilic. When the surface gets oxidized, surface modifier is employed to float the clean coal. Frothers play significant role in stabilizing the mineralized bubble. It reduces the bubble size by reducing the interfacial tension at the air water interface. During this investigation, the flotation was carried out with two types of frothers namely; methyl isobutyl carbinol (MIBC), a weak frother and a strong polyglycol type. The Factorial design matrix was used for carrying out the experiments with the different ratio of frother blend, collector and promoter dosage. The high concentration of MIBC is found to be not effective for recovering the significant amount of carbon value as it causes less reduction of the interfacial tension at the air-water interface. The presence of a correct dosage of strong frother with weak one dramatically improves the flotation behaviour as it stabilizes the air-water interface and also reduces the consumption of the frothers.

<http://eprints.nmlindia.org/6551/>

Vasumathi, N and Vijaya Kumar, T V and Subba Rao, S and Prabhakar, S and Bhaskar Raju, G (2013) *Column flotation technology for the beneficiation of coking and non-coking coal fines*. In: National seminar on Coal Preparation Technology, CPT-2013, CSIR-CIMFR, Dhanbad, 22 -23 Feb 2013, CSIR-CIMFR, Dhanbad.

The importance of coal is bound to increase for the coming years with the growth of coal consuming industries. Power sector is the most potential consumer of the non-coking coal and for coking coal iron & steel sector remains the major consumer. In future, coal gasification which is successfully adopted in China, an advanced coal-based power generation technology has the potential to provide higher generating efficiency and can be adopted to efficiently burn India's high-ash coals. In the present study investigations are carried out on coal fines for both coking and non coking coals by conventional and column flotation techniques to suit industrial applications. Coking coal sample is taken from Jamadoba area in Jharkhand and non-coking coal is drawn from coal belt in Central Coal Fields, Jharkhand. For both the coals detailed studies are in progress for optimizing the reagent consumption and to establish the feasibility of column flotation technology for producing low ash concentrates with reasonably high recoveries. <http://eprints.nmlindia.org/6567/>

Vidyadhar, A and Kumari, Neha and Sharma, Mamta and Singh, Ratnakar and Das, Avimanyu (2013) *Beneficiation of Non-Coking Coal for Generating Low Ash Clean Coal*. In: Recent Trends & Future Needs in Coal Preparation (CPT - 2013), 22-23 February, 2013, CSIR-CIMFR, Digwadih campus, Dhanbad.

The rapid upsurge in India's electricity demand with passage of time is consensual perception among energy planners and coal certainly will occupy the centre stage in driving the growth momentum of the country's economy at macro-economic level.

80% Consumption of non-coking coal is attributable to power sector and India's definitive coal reserves is estimated to be around 93 billion tonnes (source: Ministry of Coal), and with focussed scientific exploitation of the same, it is adept in catering to energy generation requirement of the country, spanning over next 5-6 decades. However, Indian coal has been observed to be of low quality on account of its high ash content attribute and non-coking category coal constitutes sizeable quantity of near-gravity materials (NGM), which entails beneficiation to suit end-user. The beneficiated coal has immense potential for being used as a blendable mix for metallurgical applications and such blend formulation of clean coal facilitates maximising the infusion of non-coking coal with scarce coking coal for catering to metallurgical industries, enabling lesser dependence on import of high-rank low ash content coke. The present manuscript is aimed at generating low ash (10%) clean coal from high ash (28.88%) non coking coal. The coal was characterised thoroughly in terms of petrography characteristics, size analysis, washability and chemical composition and the gross calorific value of the coal was observed to be 5327 Kcal/kg. The processing was initiated at a top size of 12.5 mm and efforts were made to achieve the objective of 10% ash level in the clean coal at the coarsest possible size adopting advanced gravity based techniques. Tactical combination of gravity separation and flotation techniques yielded clean coal (10% ash content) with maximum possible produce and results were discussed in light of experimental details. <http://eprints.nmlindia.org/6421/>

Vasumathi, N and Vijaya Kumar, T V and Subba Rao, S and Prabhakar, S and Bhaskar Raju, G and Shivakumar, S and Raman, Uma (2013) *Single reagent for coal flotation*. In: National Conference on Coal Preparation Technology 2013, 22-23 Feb 2013, CSIR-CIMFR, Dhanbad.

Froth flotation is widely used for the beneficiation of fine coal and collectors are important for the effective separation in flotation. Conventionally, diesel in combination with a commercial frother is used in most of the coal washeries. With the escalating costs of petroleum products and their negative impact on environment, attempts were made to formulate an eco-friendly single reagent to replace diesel-frother system without hindering the flotation process performance. NML-Madras Centre in collaboration with M/s Somu Organo Chem Pvt Ltd, has been working on the formulation and evaluation of flotation reagents. Laboratory flotation tests were carried out using series of single reagents on a coking coal sample from Jharia region in the eastern part of India with an ash content of 24.9%. The best among the single reagents, Sokem 590C, yielded a float of 56.57% at 13.97% ash in the bench scale laboratory test. Based on encouraging results of flotation tests and kinetics studies, plant trials were conducted at a coal preparation plant in eastern India. The results of plant trials using this single reagent, Sokem 590C, are highly encouraging and economical as compared to diesel-frother system and this single reagent is non-petroleum based & biodegradable. <http://eprints.nmlindia.org/6439>