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Separation of PET and PVC by Flotation Technique Without Using Alkaline Treatment

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PET and PVC cannot be separated by gravity separation techniques due to their close density. For this reason, plastic recycling needs other separation techniques. Froth flotation, which is used in mineral processing, could be useful because of its low cost and simplicity. The main objective of this research is to investigate the flotation characteristic of PET and PVC and determine the effects of plasticizers on plastic separation without any alkali pre-treatment. In selective flotation experiments, water bottles and waste water pipes were used for this purpose, and Triton XL-100N and diethylene glycol dibenzoate were used as plasticizers. Various parameters such as pH, plasticizer concentration, conditioning time, and flotation time were investigated. According to the results, PET particles were floated with 100% purity, and the product remaining in flotation cell (PVC particles) was obtained with 86.1% purity. 10.1080/08827508.2012.702705

From Science Direct

A. Vidyadhar, A. Das, Enrichment implication of froth flotation kinetics in the separation and recovery of metal values from printed circuit boards, Separation and Purification Technology, Volume 118, 30 October 2013, Pages 305-312, ISSN 1383-5866, http://dx.doi.org/10.1016/j.seppur.2013.07.027.

(http://www.sciencedirect.com/science/article/pii/S1383586613004504)

Abstract: The e-waste printed circuit boards (PCBs) are rich in metal content and processing these wastes for extracting the metal values and removing the non-metallic constituents is a prospective proposition. Froth flotation methodology was observed to be a promising technique for rejecting plastics from the comminution product. It has been shown that nearly reagent-free flotation of relatively coarse size (−1.0 mm) pulverized e-waste is feasible with a reasonably good product at a high yield and excellent recovery. In the present research work, enrichment of ground

1.0 mm PCB powder was investigated through flotation route by varying the operating variables such as frother dosage, pulp density, air flow rate and rotational speed of impeller. The liberation studies accomplish that liberation of metal value from non-metallic constituents at −1.0 mm size is excellent and the particulate system is significantly rich in metal value, containing around 23% metal. In-depth study of froth flotation kinetics is primarily focused on high rejection of plastics and also identification of optimum operating conditions for the same. Single-stage flotation enhances metal content from 23% to over 37%, contributing a mass yield of around 75% with recovery of nearly 95% metal values, suffering nominal loss of around 4% metal value only, while effectively rejecting 32% of the materials in feed through float fraction. The interdependence of kinetics and process variables has been discussed and it has been concluded that a high rotor speed aids efficient rejection of the plastics. However, addition of frother is essential to help stabilize the froth and enhance the kinetics, while efficient pre-concentration is facilitated through a combination of moderate air flow with low pulp density. Generation of pre-concentration through flotation route from the entire −1.0 mm comminution product stands accomplished.

Keywords: Printed circuit boards; Recycling; Froth flotation; Kinetics; Metal recovery

Jennifer M.K. O'Keefe, Achim Bechtel, Kimon Christanis, Shifeng Dai, William A. DiMichele, Cortland F. Eble, Joan S. Esterle, Maria Mastalerz, Anne L. Raymond, Bruno V. Valentim, Nicola J. Wagner, Colin R. Ward, James C. Hower, On the fundamental difference between coal rank and coal type, International Journal of Coal Geology, Volume 118, 1 October 2013, Pages 58-87, ISSN 0166-5162, http://dx.doi.org/10.1016/j.coal.2013.08.007.

(http://www.sciencedirect.com/science/article/pii/S0166516213001912)

Abstract: This article addresses the fundamental difference between coal rank and coal type. While theoretically settled long ago as being different aspects of coal systems science, the two concepts are still often confounded. In recent years, this has resulted in the publication of several works stating that coal type changes with coal rank. Coal type refers solely to coals' depositional origin and the maceral–mineral admixture resulting from that origin. Coal types typically fall in to two categories: humic coals, developed from peat, and sapropelic coals, developed from organic mud. Either type may be allocthonous or autochthonous, and within types, further refinement of depositional environment can be made. Coal rank refers to the changes in geochemistry and resultant changes in reflectance caused by increasing thermal maturity of the coal. Thus, it provides an overprint of maturity on existing coal types. With proper techniques, such as use of crossed polars and etching, maceral forms can be differentiated even at high ranks, and the original coal type determined.

Keywords: Rank; Type; Maceral; Coalification; Geochemistry

B.J. Youlton, J.A. Kinnaird, Gangue–reagent interactions during acid leaching of uranium, Minerals Engineering, Volume 52, October 2013, Pages 62-73, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.03.030.

(http://www.sciencedirect.com/science/article/pii/S0892687513001040)

Abstract: During the acid leaching of uranium, gangue–reagent interactions have both negative and positive consequences. Gangue dissolution increases reagent costs, and in some cases can prevent the economic acid leaching of an ore, but can also increase uranium mineral exposure and improve recoveries. Due to rapid dissolution kinetics, the acid consumption characteristics of the various carbonate species are readily predicted, however the same is not true of silicate gangue. Due to factors including slower leach rates, incongruent dissolution, parabolic kinetics, and surface area, pH and temperature dependence, the gangue acid consumption characteristics of silicate minerals are significantly more complex. A detailed mineralogical investigation and acid leach tests were conducted on sandstone-hosted uranium ore samples. The dissolution characteristics of the more common gangue phases were determined. The study demonstrated that gangue–reagent interactions can be predicted from mineralogical data, thus reducing technical risk during processing.

Keywords: Ore mineralogy; Leaching; Reaction kinetics; Hydrometallurgy

Yousef Ghorbani, Megan Becker, Jochen Petersen, Aubrey N. Mainza, Jean-Paul Franzidis, Investigation of the effect of mineralogy as rate-limiting factors in large particle leaching, Minerals Engineering, Volume 52, October 2013, Pages 38-51, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.03.006.

(http://www.sciencedirect.com/science/article/pii/S0892687513000800)

Abstract: Although heap leaching is by now well established in the mining industry, the process remains limited by low recoveries with different rate-limiting factors that are not clearly understood. In this study, three large particle size classes (+19/−25, +9.5/−16, +4.75/−5 mm) were prepared from a sphalerite ore by two different methods of comminution (HPGR and cone crusher). The particles were then packed into leach reactors that were operated continuously for 11 months with well-mixed internal circulation of the leach solution. Characterization of the residue of the leach reactors indicated that there are areas within the ore particles where although sphalerite grains are accessible to the solution, they remain unreacted. X-ray tomography and QEMSCAN® analysis of the selected samples before, during and after leaching, showed increased leaching of sphalerite grains associated with pyrite due to galvanic interactions. Mineral chemistry (Fe, Mn content of sphalerite) and jarosite precipitation were also investigated as factors influencing sphalerite leaching.

Keywords: Mineral composition; Sphalerite; X-ray tomography; Heap leaching

E.L. Thyse, G. Akdogan, E.J. Olivier, J.H. O'Connell, J.H. Neethling, P. Taskinen, J.J. Eksteen, 3D insights into nickel converter matte phases: Direct observations via TEM and FIB SEM tomography, Minerals Engineering, Vol. 52, October 2013, Pages 2-7, http://dx.doi.org/10.1016/j.mineng.2013.02.013.

(http://www.sciencedirect.com/science/article/pii/S0892687513000708)

Abstract: A prior application of mineralogy to the analysis of nickel converter matte was based on two dimensional in-plane projections of three dimensional phase structures. Recent developments in electron microscopy have established suitable techniques to base further analysis on actual three dimensional projections. Focused ion beam scanning electron microscopy tomography in arrangement with transmission electron microscopy was considered suitable in acquiring three dimensional projections of nickel converter matte phase structures at the mesoscale with subsequent reconstruction for 3D visualization and analysis. Transmission electron microscopic section analysis was particularly useful in signifying that phase structures were geometrically arranged within an underlying nickel-sulfide microtexture. Tomography reconstruction and rendering of a rectangular particle volume allowed for color and grayscale based 3D visualization of the nickel-sulfide microtexture, copper-sulfide and NiCu-alloy phase structures. Color based 3D visualization was specifically effective in assigning a cubic morphology to smaller alloy phase structures. Grayscale based 3D visualization of alloy phase structures illustrated compositional zones correlating to the presence of bright Pt-dominant cores and darker Ni-dominant rims. High-fidelity reconstruction of developed Pt-dominant lobes was produced illustrating insightful morphological detail. It would be important to consider the three dimensional insights gained to the downstream metallurgy of nickel converter matte.

Keywords: Ore mineralogy; Sulfide ores; Precious metal ores

Sima Mohammadnejad, John L. Provis, Jannie S.J. van Deventer, Effects of grinding on the preg-robbing potential of quartz in an acidic chloride medium, Minerals Engineering, Volume 52, October 2013, Pages 31-37, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.03.003.

(http://www.sciencedirect.com/science/article/pii/S0892687513000770)

Abstract: The effect of high-energy milling on the surface properties of quartz is examined with regard to its preg-robbing behavior towards gold. A standard ring mill is used to process dry quartz samples, and the changes in the morphology of the particles, structural deformations and surface chemistry are investigated to explain the increased preg-robbing ability of quartz in acidic chloride solutions. The transition from fine grinding to mechanochemical activation of quartz can be observed from changes in the morphology of the particles, as well as the types of structural deformations. The transition occurs between 1 and 5 min of

grinding in the mill used, corresponding to particle sizes around 0.55 μm. Structural studies differentiate two stages of fine grinding: particle breakage with limited structural disruption, and structural disturbance by mechanochemical alteration, which occurs after particles reach their grinding limits. Quartz keeps its structural order to some degree even after 30 min of aggressive grinding. The surface chemistry of ground quartz demonstrates generation of point defects including low valence silicon and non-bridging oxygen centers. These defect sites play an important role in the surface reactivity of the quartz, and influence the extent of gold loss during preg-robbing.

Keywords: Grinding; Quartz; Leaching; Surface modification

Anita Parbhakar-Fox, Bernd Lottermoser, Dee Bradshaw, Evaluating waste rock mineralogy and microtexture during kinetic testing for improved acid rock drainage prediction, Minerals Engineering, Volume 52, October 2013, Pages 111-124, http://dx.doi.org/10.1016/j.mineng.2013.04.022.

(http://www.sciencedirect.com/science/article/pii/S0892687513001362)

Abstract: This study integrates detailed mineralogical and microtextural analyses of waste rock with the results of standard kinetic test procedures to identify the mineralogical changes that influence leachate chemistry over time. The integration of mineralogy and texture provides the opportunity for improved mine waste management strategies and acid rock drainage (ARD) prediction. Waste rock material from an abandoned gold mine in northern Queensland, Australia, was subjected to column leach kinetic testing over a 30 week period. The column feed comprised of a range of waste rock lithologies (porphyritic rhyolite, massive arsenopyrite, massive pyrite ± galena, and semi-massive polysulphide). In total, 12 individual columns were established to represent six lithologies prepared to two different size fractions (−10 mm and −4 mm). The mineralogy and microtextural characteristics of the column feed material was defined using quantitative X-ray diffractometry (QXRD), scanning electron microscopy and laser ablation (LA-ICPMS) at the start of kinetic tests, and at 5 week intervals during the length of the tests. These data were directly correlated with leachate chemistry (i.e., pH, SO_4 and select elements). Results of this study indicated that sulphide oxidation was strongly influenced by the morphology of sulphide minerals, their trace element contents, the presence of mineral micro-inclusions and galvanic interactions with other sulphide minerals. Waste rock with abundant arsenopyrite was consistently the most acid forming, and oxidised to scorodite (enriched in Zn, Pb and Cu). Pyrite was commonly As-rich as indicated by LA-ICPMS mapping. QXRD results indicated that the abundance of rhomboclase, jarosite, alunite and hydrous ferric oxides increased over time. Galena weathered rapidly to porous anglesite, particularly when in direct physical contact with pyrite. Sphalerite contents decreased consistently over the 30 weeks implying its oxidation, however few reaction products were directly observed. By week 30, the −4 mm fraction material generated lower pH leachate,

higher mass release of elements and sulphate for the majority of samples. This indicates that the particle size used in kinetic tests can exert a significant control on leachate chemistry, especially in the absence of abundant neutralising minerals. This contribution demonstrates the value of integrating mineralogy and microtextural analyses during kinetic testwork to improve the interpretation of sulphide oxidation for better prediction of ARD.

Keywords: Acid rock drainage; Prediction; Mineralogy; LA-ICPMS; Kinetic testing

Melissa Kistner, Gorden T. Jemwa, Chris Aldrich, Monitoring of mineral processing systems by using textural image analysis, Minerals Engineering, Volume 52, October 2013, Pages 169-177, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.05.022.

(http://www.sciencedirect.com/science/article/pii/S0892687513001830)

Abstract: In the last few decades, developments in machine vision technology have led to innovative approaches to the control and monitoring of mineral processing systems. Image representation plays an important role in the performance of the recognition systems used in these approaches, where the use of feature representations based on second-order statistics of the image pixels have predominated. However, these representations may not adequately capture or express the visual textural structure associated with the observed patterns in images. In this study, the use of texton and complex multiscale wavelet representations (steerable pyramids) that exploit higher-order statistical regularities, is investigated. These techniques are applied to two image data sets: industrial platinum group metals froth flotation, and coal particles on a conveyor belt. Compared to grey level co-occurrence matrix and classical wavelet representations, these are observed to improve performance when used as input in the pattern recognition phase.

Keywords: Process control; Froth flotation; Ore handling; Coal

Carlo Philander, Abraham Rozendaal, The application of a novel geometallurgical template model to characterise the Namakwa Sands heavy mineral deposit, West Coast of South Africa, Minerals Engineering, Volume 52, October 2013, Pages 82-94, http://dx.doi.org/10.1016/j.mineng.2013.04.011.

(http://www.sciencedirect.com/science/article/pii/S0892687513001167)

Abstract: Geometallurgy offers significant value to the minerals industry and as a result, Namakwa Sands, a South African heavy mineral sands operation, has implemented a systematic geometallurgical strategy that is integrated with its existing mineral resource management processes. This paper reports on the advanced ore characterisation of the Namakwa Sands deposit, and aims to define the

constituent ore types in terms of bulk geochemistry and mineralogy, including the mineral characteristics that could possibly affect recovery. A novel geometallurgical template model was developed at Namakwa Sands to study and quantify the penalties that deleterious mineral characteristics could potentially impose on the recovery of the ore minerals. In addition to enhanced mineral resource definition, this geometallurgical template model allows mineral resource scoring and ranking based on potential mineral recoveries. The generic structure of the geometallurgical template model makes it potentially viable for general application in the mineral sands industry.

Keywords: Heavy minerals; Geometallurgy; Ore characterisation; Quantitative mineralogy; Mineral processing

Jennifer M.K. O'Keefe, Achim Bechtel, Kimon Christanis, Shifeng Dai, William A. DiMichele, Cortland F. Eble, Joan S. Esterle, Maria Mastalerz, Anne L. Raymond, Bruno V. Valentim, Nicola J. Wagner, Colin R. Ward, James C. Hower, On the fundamental difference between coal rank and coal type, International Journal of Coal Geology, Volume 118, 1 October 2013, Pages 58-87, ISSN 0166-5162, http://dx.doi.org/10.1016/j.coal.2013.08.007.

(http://www.sciencedirect.com/science/article/pii/S0166516213001912)

Abstract: This article addresses the fundamental difference between coal rank and coal type. While theoretically settled long ago as being different aspects of coal systems science, the two concepts are still often confounded. In recent years, this has resulted in the publication of several works stating that coal type changes with coal rank. Coal type refers solely to coals' depositional origin and the maceral–mineral admixture resulting from that origin. Coal types typically fall in to two categories: humic coals, developed from peat, and sapropelic coals, developed from organic mud. Either type may be allocthonous or autochthonous, and within types, further refinement of depositional environment can be made. Coal rank refers to the changes in geochemistry and resultant changes in reflectance caused by increasing thermal maturity of the coal. Thus, it provides an overprint of maturity on existing coal types. With proper techniques, such as use of crossed polars and etching, maceral forms can be differentiated even at high ranks, and the original coal type determined.

Keywords: Rank; Type; Maceral; Depositional environment; Coalification; Geochemistry

Stephen F. Greb, Coal more than a resource: Critical data for understanding a variety of earth-science concepts, International Journal of Coal Geology, Vol. 118, 1 October 2013, Pages 15-32, http://dx.doi.org/10.1016/j.coal.2013.08.003.

(http://www.sciencedirect.com/science/article/pii/S0166516213001870)

Abstract: Coal is one of the world's primary energy sources and it is critical for making coke, used in steel making; and is used for a multitude of chemical products. Aside from its significance as a fuel or product, however, coal and data derived from the exploration or mining of coal have also provided the foundation and testing ground for diverse geologic concepts. Because of coal's economic importance, and common variability in thickness, distribution, and quality, it has been critical to collect and correlate a wide variety of surface and subsurface data sets at relatively high-spatial frequency, which varies from the mine to basinal scale. Also, because many coal beds occur in most coal basins, the collection of coal data from multiple beds creates relatively high-temporal frequency data sets at scales from laminae to bed to larger unit scale. These data have been important for the development and expansion of many earth science concepts including aspects of basin analyses, paleogeography, paleoclimatology, paleontology, stratigraphy, sedimentology, structural geology, and tectonics.

Keywords: Coal; Historical geology; Appalachian Basin; Illinois Basin; Pennsylvanian; Carboniferous

Ellen S. Gilliland, Nino Ripepi, Matthew Conrad, Michael J. Miller, Michael Karmis, Selection of monitoring techniques for a carbon storage and enhanced coalbed methane recovery pilot test in the Central Appalachian Basin, International Journal of Coal Geology, Volume 118, 1 October 2013, Pages 105-112, ISSN 0166-5162, http://dx.doi.org/10.1016/j.coal.2013.07.007.

(http://www.sciencedirect.com/science/article/pii/S0166516213001663)

Abstract: The goals of monitoring, verification, and accounting (MVA) for carbon capture, utilization, and storage (CCUS) studies include improved understanding of injection and storage processes, evaluation of interactions among carbon dioxide (CO_2), reservoir fluids, and formation solids, and assessment and minimization of environmental impacts (DOE and NETL, 2009). Site-specific selection of tools for a well-rounded MVA program may include technologies for atmospheric, near-surface, and subsurface monitoring.

An upcoming small-scale CCUS study in an active coalbed methane field in Buchanan County, Virginia, presents a unique application for several established, effective MVA methods. The study will involve injecting up to 20,000 tonnes of CO_2 into three injection wells over a one-year period in order to test the injection and storage potential of the coal seams and to assess the potential for enhanced coalbed methane (ECBM) recovery at offset production wells. The reservoir consists of approximately 15 to 20 coal seams, averaging 0.3 m (1.0 ft) in thickness and distributed over 300 m (1000 ft) of vertical section. This reservoir geometry creates an unusual target for CO_2 injection and also a challenging one for many monitoring and imaging techniques. MVA for the Buchanan County test will include gas content measurements at offset wells, groundwater monitoring, injectate tracer analysis, well logging, surface deformation measurement, passive microseismic monitoring, and

tomographic fracture imaging. Multiple monitoring wells will be drilled in order to facilitate the MVA efforts. Surface deformation measurement, microseismic monitoring, and tomographic fracture imaging are state-of-the art tools that have potential to define the subsurface CO_2 plume beyond the borehole scale. The results of the MVA program for the Buchanan County injection demonstration can be used to improve design for potential future studies of CCUS in thin coals.

Keywords: Carbon sequestration; Enhanced coalbed methane; Monitoring; Geophysics; Microseismic; Characterization

Allan Costine, Aleksandar N. Nikoloski, Micheal Da Costa, Kok Fung Chong, Ralph Hackl, Uranium extraction from a pure natural brannerite mineral by acidic ferric sulphate leaching, Minerals Engineering, Volume 53, November 2013, Pages 84-90, http://dx.doi.org/10.1016/j.mineng.2013.07.010.

(http://www.sciencedirect.com/science/article/pii/S0892687513002288)

Abstract: Brannerite is a refractory uranium mineral from which it is very difficult to liberate the uranium. Hence in commercial mineral processing operations, brannerite often reports to the residue. This paper will show that for a pure form of natural brannerite nearly complete extraction of uranium (~99%) is achievable under practical conditions. The efficient extraction of uranium from ores containing brannerite requires a detailed understanding of the fundamental mechanisms governing the rate and extent of dissolution. These mechanisms are often complicated by the presence of gangue minerals which consume reagents and impact on the solution chemistry. In this study, the acidic ferric sulphate leaching of an exceptionally pure, natural brannerite mineral (35.8% U, 20.1% Ti) was investigated under atmospheric conditions. Hence the variation in mineral composition was not present as a complicating factor and the results were able to identify some of the inhibiting mechanisms, and also the preferred conditions for the leaching of brannerite in an acidic ferric sulphate system. The effects of temperature (40–80 °C), ferric ion concentration (0–100 g/L), H_2SO_4 concentration (10–200 g/L), redox potential (424–752 mV vs. Ag/AgCl), and particle size on uranium and titanium extractions were studied for leach times up to 48 h. Under relatively mild conditions (40 °C, 24 h leach time, 40 g/L H_2SO_4), the extent of uranium extraction was 94.4%. The extractions improved with the use of a higher temperature, a finer particle size, and a longer leach time. The presence of ferric iron was essential for enhanced dissolution rates, but had only a minor effect on the final uranium extractions, particularly at 60 °C and 80 °C. All of the leach residues studied had some crystalline anatase (TiO_2) and lead sulphate (anglesite) present. A strong correlation was found between the concentrations of unleached uranium and the amount of titanium precipitated in the residues, which could be explained by the observation of a Ti-enriched diffusion layer on the surface of the dissolving grains of brannerite, which hindered the extraction process. These findings further the

current understanding of the extraction process and lead a step closer to elucidation of the mechanism of the extraction process.

Keywords: Brannerite; Leaching; Uranium; Refractory; Mechanism

Yong Ke, Li-Yuan Chai, Yan-Jie Liang, Xiao-Bo Min, Zhi-Hui Yang, Jie Chen, Sheng Yuan, Sulfidation of heavy-metal-containing metallurgical residue in wet-milling processing, Minerals Engineering, Volume 53, November 2013, Pages 136-143, http://dx.doi.org/10.1016/j.mineng.2013.07.013.

(http://www.sciencedirect.com/science/article/pii/S0892687513002318)

Abstract: This paper describes the application of wet-milling sulfidation to achieve an efficient conversion of heavy metals (mainly Pb) in metallurgical residues to metal sulfide (MeS) for subsequent metal recovery through floatation. The effects of Na_2S-to-Pb ratio (Na_2S:Pb), ball-to-material mass ratio (B/M), and milling time on the extent of sulfidation were investigated under laboratory conditions. Under the optimal conditions, 73.2% of Pb in sludge can be converted to PbS within 1 h. The comparison of wet-milling sulfidation and contacting sulfidation was performed to test the efficiency of two sulfidation methods and the selective floatabilty of the synthetic sulfides. The results show that wet-milling efficiently improved the sulfidation extent as well as the floatation recovery. Compared with $MeS_{(C)}$ (sulfide formed by contacting sulfidation), $MeS_{(M)}$ (sulfide formed by milling sulfidation) had a smaller particle size, which was not beneficial for its floatability. However the improved sulfidation extent and dispersity can help to increase $PbS_{(M)}$ recovery.

Keywords: Wet-milling sulfidation; Leaching residue; Lead sulfide; Floatation

Zhongwei Zhao, Wenjuan Shuai, Jialiang Zhang, Xingyu Chen, Sn(IV) anions adsorption onto ferric hydroxide: A speciation-based model, Hydrometallurgy, Vol. 140, Nov 2013, pp.135-143, http://dx.doi.org/10.1016/j.hydromet.2013.09.010.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001941)

Abstract: Sn is a detrimental impurity in tungsten hydrometallurgy which should be strictly controlled. Using the freshly precipitated ferric hydroxide to remove Sn impurity from tungstate solution exhibits satisfactory effects. The goal of the present research is to provide further understanding of the adsorption mechanism. The work indicates that the surface of ferric hydroxide consists of three types of surface acid sites denoted as S_1, S_2, and S_3, each of which has a surface density (Γ_i) of 1.0×10^{-3}, 3.1×10^{-3}, and 9.6×10^{-3} $mol \cdot g^{-1}$ and acid constant (pK_H) of 3.6, 5.7, and 10.8 respectively. The pH_{zpc} of 7.9 for the ferric hydroxide is obtained. Since Sn exists in alkaline solution as $Sn(OH)_5^-$ and $Sn(OH)_6^{2-}$, a speciation-based model is developed and data fitting to the model gives six adsorption equilibrium constants which are 26.2, 1.2×10^{-11} and 1.5 for $Sn(OH)_5^-$, and 4.3, 1.6×10^{-15} and 2.2×10^{-3} for $Sn(OH)_6^{2-}$ onto S_1, S_2, and S_3 respectively. The average absolute error of the predicting results and experimental data is 5.3%. The speciation-based model can

successfully describe the Sn adsorption ratio at different pH values and predict the Sn adsorption ratio with different initial Sn concentrations.

Julian M. Steer, Anthony J. Griffiths, Investigation of carboxylic acids and non-aqueous solvents for the selective leaching of zinc from blast furnace dust slurry, Hydrometallurgy, Volume 140, November 2013, Pages 34-41, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.08.011.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001722)

Abstract: The recycling of iron bearing dusts produced during iron and steel manufacturing processes is vital to the sustainability of these processes; however, contamination of these dusts with zinc increases the difficulty to do this. Blast furnace dust, collected by a wet scrubber system, was sampled and characterised to investigate the removal of zinc to produce a treated residue with low zinc content suitable for recycling through the blast furnace. This paper examines a leaching process for the dust using different organic carboxylic acids, to establish if they were capable of extracting high levels of zinc and low levels of iron. Prop-2-enoic acid was found to be particularly effective, extracting high levels of zinc up to 85.7% and low levels of iron, 8.5%. The paper also discusses the mechanisms of extraction more specifically for organic carboxylic acids and found that the iron extraction was well explained by the variation in pH and the Bronsted–Lowry theory; whereas zinc extraction was well explained by substituent group effects and the Lewis acid/base theory. The novel use of a non-aqueous solvent with prop-2-enoic acid, to minimise the ion solvating ability and proton dissociation, was found to reduce the level of iron extraction from 8.5% to 0.1% without detrimental effect on zinc extraction when leaching. A range of mineral and carboxylic acids were also tested to investigate and compare the effect of pH and chemical structure on the leaching efficacy.

Keywords: Blast furnace dust; Carboxylic acid; Leaching; Zinc extraction; Hydrometallurgical

Shaotao Cao, Haijun Ma, Yi Zhang, Xiaofan Chen, Yifei Zhang, Yi Zhang, The phase transition in Bayer red mud from China in high caustic sodium aluminate solutions, Hydrometallurgy, Volume 140, November 2013, Pages 111-119, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.09.009.

(http://www.sciencedirect.com/science/article/pii/S0304386X1300193X)

Abstract: The phase transitions of the main substances in Bayer red mud in high caustic sodium aluminate solutions were studied. Without addition of lime, cancrinite was not found to transform to $CaNaHSiO_4$ even with 16 wt.% CaO present in the original residue up to 270 °C. However, this transition was verified to be a fast reaction which was completed in just 10 min with the temperature higher than 240 °C after adding lime, thus enabling the extraction of Al_2O_3 from the red mud. Whether

additional CaO was supplemented or not, the isomorphous substitution of Fe to Al atoms occurred in hydrated andradite as long as the temperature was more than 240 °C, providing another way to extract Al_2O_3 from Bayer red mud. Accordingly the A/S (weight ratio of solid Al_2O_3 to SiO_2) of red mud would reduce to 0.134 after the complete transition from $Ca_{2.93}Al_{1.97}Si_{0.64}O_{2.56}(OH)_{9.44}$ to $Ca_3(Fe_{0.87}Al_{0.13})_2(SiO_4)_{1.65}(OH)_{5.4}$ in our study, assuming no other Al or Si containing phases. Furthermore, the addition of $CaNaHSiO_4$ seed was confirmed to accelerate both the transition of cancrinite to $CaNaHSiO_4$ and the reaction of isomorphous substitution in the andradite.

Keywords: Bayer red mud; Phase transition; Cancrinite; CaNaHSiO4; Hydrated andradite

Zhongwei Zhao, Jialiang Zhang, Xingyu Chen, Xuheng Liu, Jiangtao Li, Weiguang Zhang, Separation of tungsten and molybdenum using macroporous resin: Equilibrium adsorption for single and binary systems, Hydrometallurgy, Vol. 140, November 2013, Pages 120-127,

(http://www.sciencedirect.com/science/article/pii/S0304386X13002016)

Abstract: Tungsten and molybdenum are widely used in many hi-tech industrial products, but it is a challenge to separate them from the resources containing high contents of the two metals. Based on the difference in tendency to polymerize between W and Mo, a new method using macroporous weak base resin was developed to separate W and Mo. The feasibility of this method was evaluated in this work, particularly. The effect of pH and contact time was studied on the adsorption of W and Mo using macroporous weak base resin D301. In addition, the equilibrium adsorption of W and Mo was investigated at the optimal pH-value in both individual and binary systems. Several single-component and multi-component isotherm models were used to analyze the experimental adsorption data, with which the values of parameters were obtained accordingly. The Freundlich model and the extended Freundlich model were successfully applied to describe the adsorptive behavior of W and Mo in the single and binary system, respectively. Tungsten and molybdenum in the binary adsorption system are interacting with each other in an antagonistic manner and the former exhibits stronger competitive ability. As a result, the equilibrium adsorption amount of W is much higher than that of Mo in the mixed solution. Obviously, the proposed method can effectively separate W and Mo from the mixed solution, and it may have a very promising future in industry.

Keywords: Tungsten; Molybdenum; Macroporous resin; Competitive adsorption; Multi-component adsorption models

Richard Lupia, John L. Armitage, Late Pennsylvanian–Early Permian vegetational transition in Oklahoma: Palynological record, International Journal of Coal Geology, Volume 119, 1 November 2013, Pages 165-176, ISSN 0166-5162, http://dx.doi.org/10.1016/j.coal.2013.06.003.

(http://www.sciencedirect.com/science/article/pii/S0166516213001419)

Abstract: The Wabunsee (Carboniferous: Virgilian) through Sumner (Permian: Leonardian) Groups of Oklahoma preserve a record of terrestrial and nearshore marine environments during glacio-eustatic fluctuations caused by southern hemisphere glaciation. This section, with the Pennsylvanian–Permian Boundary firmly established in the Red Eagle Formation on the basis of conodonts, permitted study of vegetational change across the boundary interval. The palynology of 43 productive samples from five cores in Kay and Osage counties in Oklahoma was investigated. Palynomorphs were assigned to eight morphologic groups that also reflect climate preferences. Four distinct palynofloras are recognized. The three transitions between them—in the lower Council Grove, middle Chase and lower Sumner groups—are abrupt and, in succession, consistent with an interpretation of increasing seasonality/aridity from latest Pennsylvanian into the Early Permian. None of these floristic transitions align with the conodont-based boundary, or with any lithostratigraphic "group" boundary. These palynological data from Oklahoma are in accord with previous data from Kansas that also demonstrated no palynological shift at the boundary and increased seasonality/aridity through this period. Comparison of the palynofloras from Oklahoma, Kansas, and the boundary interval of the Pennsylvanian–Permian Boundary type section in Aidaralash Creek in Kazakhstan reveals differences in composition that suggest local to regional, including climatically induced, heterogeneities that may present an obstacle to confident palynologically based, global correlations in fully terrestrial sections.

Keywords: Palynology; Oklahoma; Kansas; Pennsylvanian; Permian

N.B. du Preez, F.K. Crundwell, B.D.H. Knights, Flotation of PGM-containing minerals: Plant-wide regression and prediction of circuit performance, Minerals Engineering, Volume 54, December 2013, Pages 116-123, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.06.008.

(http://www.sciencedirect.com/science/article/pii/S0892687513001969)

Abstract: A crucial step in the processing of PGM-bearing reefs in South Africa is the flotation of the sulfidic minerals from the host rock. Flotation plays a crucial role in reducing the mass of material to be processed further downstream by smelting, converting and hydrometallurgical refining. However, flotation has the lowest recovery of valuable metals along the processing chain. As a result, small improvements in efficiency in flotation have an enormous benefit to the company's performance. Modelling and simulation play an important role in circuit optimisation, due to the ability to test and examine multiple options in a small amount of time without affecting the operational circuit. Unfortunately flotation is extremely difficult to model and simulate due to the complexity of the mechanism and the large number of variables involved. Whole circuit modelling is even more difficult, for the reasons already mentioned as well as maintaining a consistent mass

balance in the face of multiple recycle streams. The purpose of this work is to construct a whole-circuit model of a flotation circuit, and use the model to predict the effect of changes to the flotation circuit. A goal in the construction of the model was to use as few parameters as possible. The work presented in this paper is focused on the regression of the parameters of a first-order kinetic flotation model to actual pilot plant data. The performance of the model was then validated by predicting the behaviour of a modified flotation circuit. The regression showed excellent correlation with actual plant data on a bank by bank basis. Using the regressed parameters directly on a modified circuit configuration, the model was able to predict the circuit behaviour when compared to plant data.

Keywords: Plant-wide regression; Recycle streams; Flotation kinetics; Mass balance smoothing

G. Mishra, K.S. Viljoen, H. Mouri, Influence of mineralogy and ore texture on pentlandite flotation at the Nkomati nickel mine, South Africa, Minerals Engineering, Volume 54, December 2013, Pages 63-78, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.04.009.

(http://www.sciencedirect.com/science/article/pii/S0892687513001143)

Abstract: The influence of ore mineralogy and ore texture on flotation response was studied for 29 samples from the main mineralised zone at Pit 3 of the Nkomati Ni mine, through laboratory scale flotation testing, laboratory assay, and mineral liberation analyser examination of the ore and the concentrates. The individual sample flotation responses vary widely in terms of Ni grade, and cumulative Ni recovery. It is demonstrated that this is a complex function of ore mineralogy and ore texture. Chalcopyrite is the first sulphide to float, followed by pentlandite and finally pyrrhotite, in ore samples with dominant chalcopyrite, or where pentlandite, pyrrhotite and chalcopyrite occur in equal abundance. However in samples with a high ratio of pyrrhotite to pentlandite and chalcopyrite, pyrrhotite floats earlier than expected, reports to concentrate over the entire flotation period, and depress and extend the flotation of pentlandite over the flotation interval with no clear peak of Ni recovery during flotation. Primary silicates (e.g. olivine and pyroxene) and alteration-related minerals (talc, tremolite and chlorite) are naturally floating, and hence affect the flotation of pentlandite in a similar manner to that of pyrrhotite. The most problematic ore at Nkomati in terms of Ni recovery is characterised by fine disseminated and fine bleb- or net-texture sulphides, contain abundant olivine, pyroxene, amphibole, talc and tremolite, and include abundant metamorphism-related country rock xenoliths (with calc-silicate minerals such as diopside and tremolite).

Keywords: Sulphide ore; Froth flotation; Mineral processing; Mineral liberation analyser; Extractive metallurgy

L. Pérez-Barnuevo, E. Pirard, R. Castroviejo, Automated characterisation of intergrowth textures in mineral particles. A case study, Minerals Engineering, Volume 52, October 2013, Pages 136-142, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.05.001.

(http://www.sciencedirect.com/science/article/pii/S0892687513001428)

Abstract: The characterisation of mineral texture has been a major concern for process mineralogists, as liberation characteristics of the ores are intimately related to the mineralogical texture. While a great effort has been done to automatically characterise texture in unbroken ores, the characterisation of textural attributes in mineral particles is usually descriptive. However, the quantitative characterisation of texture in mineral particles is essential to improve and predict the performance of minerallurgical processes (i.e. all the processes involved in the liberation and separation of the mineral of interest) and to achieve a more accurate geometallurgical model. Driven by this necessity of achieving a more complete characterisation of textural attributes in mineral particles, a methodology has been recently developed to automatically characterise the type of intergrowth between mineral phases within particles by means of digital image analysis. In this methodology, a set of minerallurgical indices has been developed to quantify different mineralogical features and to identify the intergrowth pattern by discriminant analysis. The paper shows the application of the methodology to the textural characterisation of chalcopyrite in the rougher concentrate of the Kansanshi copper mine (Zambia). In this sample, the variety of intergrowth patterns of chalcopyrite with the other minerals has been used to illustrate the methodology. The results obtained show that the method identifies the intergrowth type and provides quantitative information to achieve a complete and detailed mineralogical characterisation. Therefore, the use of this methodology as a routinely tool in automated mineralogy would contribute to a better understanding of the ore behaviour during liberation and separation processes.

Keywords: Geometallurgy; Liberation analysis; Particle mineral texture characterisation; Digital image analysis

K.H. Hestnes, K. Aasly, R. Sandøy, B.E. Sørensen, Occurrence of iron in industrial granitic pegmatite, Minerals Engineering, Volume 52, October 2013, Pages 21-30, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.03.004.

(http://www.sciencedirect.com/science/article/pii/S0892687513000782)

Abstract: Granitic pegmatite is used as raw material for industrial minerals in the production of feldspar and quartz for glass, ceramic and porcelain. One of the most important quality parameters in the feldspar is the content of iron (Fe). At the Lillesand plant, Norway, pegmatite is floated to produce quartz, albite and microcline products. Fe is mostly removed through flotation and magnetic separation, but some Fe is still present in the final products, the amount depending

on the raw material source. Rietveld X-ray Diffraction (XRD), Point counting by optical microscopy, and Electron Microprobe Analysis (EPMA) combined with image analysis of Back-Scatter Electron (BSE) images was used to quantify the mineralogy and to map the distribution Fe in the pegmatites. The study showed that Fe is present as mineral inclusions in feldspar, in addition to its occurrence in minor mineral components such as mica and chlorite. The frequency of Fe-mineral inclusions was higher in albite than in microcline, and they were often associated with micro-fractures and areas of alteration. These findings reveal a potential for reducing total Fe2O3 in the microcline products.

Keywords: Industrial minerals; Mineral quantification; Quality control management

Friederike Minz, Nils-Johan Bolin, Pertti Lamberg, Christina Wanhainen, Detailed characterisation of antimony mineralogy in a geometallurgical context at the Rockliden ore deposit, North-Central Sweden, Minerals Engineering, Volume 52, October 2013, Pages 95-103, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.04.017.

(http://www.sciencedirect.com/science/article/pii/S0892687513001222)

Abstract: The antimony (Sb) content of the Rockliden complex Zn–Cu massive sulphide ore lowers the quality of the Cu–Pb concentrate. The purpose of this study is to characterise the Sb mineralogy of the deposit. The Sb-bearing minerals include tetrahedrite (Cu,Fe,Ag,Zn)12Sb4S13, bournonite PbCuSbS3, gudmundite FeSbS and other sulphosalts. On a microscopic scale these minerals are complexly intergrown with base-metal sulphides in the ore. Based on these observations mineralogical controls on the distribution of Sb-bearing minerals in a standard flotation test are illustrated. Deposit-scale and rock-related variation in the Sb-content and distribution of Sb-bearing minerals were found. This underlines the importance in understanding the geological background as a basis of a 3D geometallurgical model for Rockliden. Such a model is expected to predict the Sb content of the Cu–Pb concentrate, among other process-relevant factors, and helps to forecast when the Cu–Pb concentrate has to be treated by alternative processes, such as alkaline sulphide leaching, before it is sold to the smelter.

Keywords: Sulphide ores; Ore mineralogy; Antimony; Mineral processing; North-Central Sweden

A.J.B. Smith, K.S. Viljoen, R. Schouwstra, J. Roberts, C. Schalkwyk, J. Gutzmer, Geological variations in the Merensky Reef at Bafokeng Rasimone Platinum Mine and its influence on flotation performance, Minerals Engineering, Volume 52, October 2013, Pages 155-168, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.05.015.

(http://www.sciencedirect.com/science/article/pii/S0892687513001659)

Abstract: The Merensky Reef of the Bushveld Complex of South Africa is marked by prominent lateral and vertical variations in its geology, platinum group element grade distribution and platinum group mineralogy. At Bafokeng Rasimone Platinum Mine on the western limb of the complex eleven distinct Merensky Reef facies have been identified. The reef facies show different mineral processing behaviour. Detailed geometallurgical characterisation of three reef facies (FW 1A contact, FW 3 pothole and pothole edge reef facies) at Bafokeng Rasimone Platinum Mine has been carried out in an attempt to understand differences in flotation performance. Results illustrate that the FW 1A contact facies has the best Pt and Pd grades and recoveries in the flotation concentrates and the pothole edge facies has the worst. The differences are related not only to mineralogical and textural characteristics of the platinum group minerals and base metal sulphides in the different facies, but also pertain to the geological position and the mineralogy of the host rocks that are introduced as dilution to achieve a realistic mining cut.

Keywords: Precious metal ores; Froth flotation; Liberation analysis; Ore mineralogy

T. Dzvinamurungu, K.S. Viljoen, M.W. Knoper, A. Mulaba-Bafubiandi, Geometallurgical characterisation of Merensky Reef and UG2 at the Marikana Mine, Bushveld Complex, South Africa, Minerals Engineering, Volume 52, October 2013, Pages 74-81, http://dx.doi.org/10.1016/j.mineng.2013.04.010.

(http://www.sciencedirect.com/science/article/pii/S0892687513001155)

Abstract: The influence of mineralogy on the milling performance and the flotation-based recovery of Au, the platinum group elements (PGE), Co, Cr, Cu, Ni and S was investigated for three samples of the Merensky Reef (BK, RPM and WP facies types) and one sample of the UG2 at the Marikana mine, using a mineral liberation analyser (MLA). The samples differ in their milling behaviour in that a range of milling times are required in order to produce a grind of 60% passing 75 μm. This is primarily controlled by the abundance of plagioclase, orthopyroxene and chromite.

The size distribution of the base metal sulfides (BMS; pyrrhotite, pentlandite and chalcopyrite) is similar for the three samples of Merensky Reef, and is significantly coarser than for BMS in the sample of the UG2. Upon milling to 60% passing 75 μm, the best BMS liberation is achieved for the BK facies type of Merensky Reef, relative to RPM and WP. The degree of BMS liberation in the sample of UG2 is lower than that for samples of the Merensky Reef. Cumulative mass pull during flotation is higher for the sample of the WP facies of Merensky Reef than for the rest of the samples examined. This is due to the higher abundance of orthopyroxene in this sample, which is known to be naturally floating, and which reports to concentrate. A high flotation-based recovery of PGE, Cu and S is observed for all four samples, with the highest recovery associated with the sample of the BK facies type of Merensky Reef. Ni recoveries are generally poor, suggesting that Ni is associated with gangue minerals, in addition to that in pentlandite. Of the three facies types of Merensky Reef examined, the overall characteristics of the BK facies type i.e. a high PGE

grade, low abundance of orthopyroxene, a high abundance of BMS, and a higher degree of liberation of the BMS on milling of the ore, represent the most favourable set of characteristics for the efficient recovery of PGE. It is therefore the best quality ore of the three samples of Merensky Reef examined.

Keywords: Precious metal ores; Grinding; Extractive metallurgy; Froth flotation; Liberation analysis

Duncan M. Smythe, Annegret Lombard, Louis L. Coetzee, Rare Earth Element deportment studies utilising QEMSCAN technology, Minerals Engineering, Vol. 52, Oct 2013, pp. 52-61, http://dx.doi.org/10.1016/j.mineng.2013.03.010.

(http://www.sciencedirect.com/science/article/pii/S0892687513000848)

Abstract: Due to the variability and complex nature of REE-containing ores, it is vital to understand the mineralogical characteristics, before embarking on any metallurgical testwork campaign. REE's are present in a variety of phases/minerals, all of which may react differently during processing. It is therefore important to identify and quantify all the REE-phases present in the ore, their mineral associations, grain size distributions as well as their liberation characteristics. In order to quantify the elemental deportment of the different REE's into the different REE-bearing phases, it is necessary to determine the mineral chemical compositions by Electron Microprobe. By assigning the average measured REE-elemental compositions to the different REE-phases, it becomes possible to determine the amount of each REE per REE-phase. Predictions about the best theoretically achievable grades and recoveries can be made. The data obtained are used to design a metallurgical testwork program suitable for the specific ore-type.

Keywords: Precious metal ores; Liberation analysis; (REE)-Ore mineralogy

Ingjerd Bunkholt, Rolf Arne Kleiv, The colouring effect of pyrrhotite and pyrite on micronised calcium carbonate slurries for the paper industry, Minerals Engineering, Volume 52, October 2013, Pages 104-110, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.04.020.

(http://www.sciencedirect.com/science/article/pii/S0892687513001349)

Abstract: Brightness (R457) is the main quality parameter in the production of ground calcium carbonate (GCC) slurries for the paper industry. In order to study how the presence of trace amounts of pyrrhotite ($Fe_{(1-x)}S$) and pyrite (FeS_2) affect the brightness of GCC slurries, experiments were performed in which a high quality calcite concentrate was spiked with these sulphides prior to micronisation and subsequent spectrophotometric measurements. The results show that even very small additions (<0.05 wt%) have a significant detrimental effect on the brightness of the product. Pyrrhotite reduces the brightness of the product more than pyrite, probably as an effect of differences in inherent optical reflectivity, specific surface

area after micronisation and smearing. In addition, the experiment shows that when brightness is presented as a function of iron concentration, magnetite (Fe_3O_4) produces a different result compared to the sulphides. This indicates that a simple iron analysis is not sufficient to predict brightness of the GCC slurry when several iron-bearing minerals are present. The particle size distribution of the contaminant phase has proven to have a significant effect, as brightness is reduced when the contamination becomes more finely distributed.

Keywords: Mineral processing; Ground calcium carbonate; Brightness; Pyrrhotite; Pyrite

Byron Benvie, Nicole M. Chapman, David J. Robinson, Laura L. Kuhar, A robust statistical method for mineralogical analysis in geometallurgical diagnostic leaching, Minerals Engineering, Volume 52, October 2013, Pages 178-183, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.06.010.

(http://www.sciencedirect.com/science/article/pii/S0892687513002070)

Abstract: CSIRO researchers have been involved in the development of predictive metallurgical indices as a tool in the hydro- and geometallurgy fields. Rapid, small-scale, cost effective tests and protocols have been developed for comparative ranking of attributes relevant to leach performance, e.g. leach index (relative indication of leach performance), recovery, impurity deportment, reagent consumption and mineralogy of samples for their relative ranking. Results from these tests can be used for plant design or process optimisation to maximise the commercial value of an ore body and to minimise the social and environmental impact of mining operations. The motivation for development of these tests includes the reduction in use of traditional mineralogical tools, be they for reasons of accessibility, cost, speed or scale-up for processing of large sample numbers. Mineralogical analysis remains essential for validating leach results in the development of test protocols and as a means of quality control. This paper presents an accurate, robust statistical method for QEMSCAN data analysis that has been developed for use in conjunction with the geometallurgical leach tests.

Keywords: Hydrometallurgy; Mineral processing; Ore mineralogy

Wenying Liu, C.J. Moran, Sue Vink, A review of the effect of water quality on flotation, Minerals Engineering, Volume 53, November 2013, Pages 91-100, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.07.011.

(http://www.sciencedirect.com/science/article/pii/S089268751300229X)

Abstract: As water resources become scarcer and society's demands to reduce freshwater extraction have increased, mine sites have been increasing water reuse and accessing multiple water sources for mineral processing to save freshwater, particularly in froth flotation. Implementation of either strategy may lead to water

quality variation that may impact flotation efficiency. A large number of studies have been carried out to enhance the understanding of water quality variation in flotation. However, these studies tend to be performed on a case by case basis. There is a lack of a framework to put together these existing studies, which makes it difficult to understand the topic comprehensively and therefore difficult to identify gaps and directions for future research. This would eventually hinder the ongoing implementation of water conservation practices and thus lead to more pressure being placed on freshwater. In this paper, a review of the existing studies on water quality variation in flotation is given in three aspects: causes of water quality variation, consequences of water quality variation and solutions for problems caused by water quality variation. Based on the three aspects, a framework was developed, with which these studies were categorized and structured. Organizing literature in this way makes it possible to identify gaps in current research and future research directions.

Hazel M.A. Hunter, Richard J. Herrington, E. Anne Oxley, Examining Ni-laterite leach mineralogy & chemistry – a holistic multi-scale approach, Minerals Engineering, Volume 54, December 2013, Pages 100-109, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.05.002.

(http://www.sciencedirect.com/science/article/pii/S089268751300143X)

Abstract: Ambient acid leach extraction of Ni-laterites is being heralded as a breakthrough in environmentally conscious mining, however to be successfully exploited they require comprehensive characterisation of their mineralogy and chemistry. This industry-academia collaborative research uses XRD, EPMA and ICPAES techniques to examine the acid leaching characteristics of Turkish Çaldağ ore. Mineral scale and small column scale leach experiments were carried out with material examined over various lengths of time at ambient conditions. The characterised residues and solution leach inter-relationships and selectivities are compared to bottle roll and heap leach results, demonstrating where true correlations exist and where differences exist as a result of the experimental scale limitations.

Keywords: Nickel; Laterite; Sulphuric acid; Ambient leaching; Hydrometallurgy; Leach behaviour

T.D.H. McGrath, W.P. Staunton, J.J. Eksteen, Development of a laboratory test to characterise the behaviour of free gold for use in a combined flash flotation and gravity concentrator model, Minerals Engineering, Volume 53, November 2013, Pages 276-285, http://dx.doi.org/10.1016/j.mineng.2013.08.004.

(http://www.sciencedirect.com/science/article/pii/S0892687513002549)

Abstract: Currently there is no process model which simulates the behaviour of gravity recoverable gold (GRG) in flash flotation unit operation. Once developed,

such a flash float model could be incorporated into an existing model for gravity concentration. Together, the integrated gravity recovery-flash float model will provide a tool for predicting the recovery of GRG in a closed milling circuit using both batch centrifugal concentration and flash flotation. In order to design a flash flotation model, a reliable laboratory method to characterise the response of GRG when subjected to flash flotation conditions has been developed. This paper details the evaluation of the effects of various chemical (reagent concentrations, sulfide presence, etc.) and operational (airflow, agitation, etc.) parameters on the overall GRG recovery by lab scale flash flotation. Of the factors evaluated, free gold flotation was found to be most impacted by potassium amyl xanthate (PAX) and copper sulfate reagent levels, as well as agitation speed and sulfide mineral additions.

Keywords: Mineral processing; Gold ores; Froth flotation; Gravity concentration

J. Yianatos, L. Bergh, L. Vinnett, F. Díaz, Modeling of residence time distribution in regrinding Vertimill, Minerals Engineering, Volume 53, Nov. 2013, Pages 174-180, http://dx.doi.org/10.1016/j.mineng.2013.08.006.

(http://www.sciencedirect.com/science/article/pii/S0892687513002562)

Abstract: The regrinding stage is necessary to achieve the particle size (liberation) for the final upgrade in the cleaning flotation process. At present, vertical stirred mills are increasingly employed at industrial scale. The regrinding process characterization requires mixing regime knowledge along with the mean residence time of the liquid and solid phases. In this work, residence time distribution (RTD) measurements were performed in two different industrial flotation plants. Both plants operate with Vertimills of 1000–1500 HP in the regrinding process with different circuit arrangements according to the plant treatment capacity. The RTD was measured using the radioactive tracer technique, which allows for non-invasive tracer detection in real time. It was found that mixing was not perfect in agitated Vertimills and consequently the RTD was better modeled by the more flexible Large and Small Tanks in Series (LSTS) model which allowed the characterization of the different mixing regimes for both liquid and solids in the regrinding mills. Effective mean residence times in the range of 1.7–12.5 min were obtained with RTD shapes similar to those obtained in tumbling ball mills. It was found that residence times of liquid and solid particles were similar. RTD estimations are useful for better understanding the Vertimill behavior and to identify the actual breakage rates, as well as for improving Vertimill modeling and simulation.

Keywords: Vertical mill; Residence time distribution; Particle size; Modeling

E.L. Thyse, G. Akdogan, P. Taskinen, K.S. Viljoen, J.J. Eksteen, Towards understanding nickel converter matte solidification, Minerals Engineering, Vol 54, Dec 2013, pp 39-51, http://dx.doi.org/10.1016/j.mineng.2013.03.023.

(http://www.sciencedirect.com/science/article/pii/S0892687513000976)

Abstract: Nickel converter mattes are complex metallurgical solutions of Ni, Cu, S, Fe and O along with low concentrations of many other elements including Co, Pb and PGEs. Studies on how such complex mixed solutions evolve upon cooling may contribute towards an improved understanding of matte solidification. Liquidus and primary phase equilibria were calculated for Cu–Ni–S ternaries including fixed iron and cobalt concentrations. True liquid matte starting compositions and calculated assays were subsequently superimposed on relevant Cu–Ni–S_FeCo ternary systems. Multiphase cooling equilibria were also calculated for variable Cu–Ni–S–Fe–Co–O matte systems. In addition, actual industrial mattes were analysed using automated mineralogy, electron probe microanalysis and field emission scanning electron microscopy. The effect of the end composition of the ternary systems at fixed iron and cobalt concentrations on the liquidus temperature range has been quantified. The liquidus temperature range is lowered when the fixed iron and cobalt concentration decreases. The solidification pathway of oxygen-free liquid matte has been estimated. Moreover, it has been shown that variations in the starting composition of oxygen-free matte alter the path of solidification towards the eutectic. The examination of multiphase cooling equilibria for variable Cu–Ni–S–Fe–Co–O liquid phase systems provided a quantitative understanding of solidification processes to within ±2.5 °C. The analysed nickel and copper-sulphide phase structures have shown to exhibit chemical non-equilibrium within high and low iron matte. It can be concluded that the present study has provided a coherent insight into nickel converter matte solidification processes.

Keywords: Pyrometallurgy; Sulphide ores; Precious metal ores

C.W. Steyn, C. Sandrock, Benefits of optimisation and model predictive control on a fully autogenous mill with variable speed, Minerals Engineering, Volume 53, November 2013, Pages 113-123, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.07.012.

(http://www.sciencedirect.com/science/article/pii/S0892687513002306)

Abstract: Autogenous (AG) milling is utilised around the world for particle size reduction. The system exhibits highly non-linear behaviour in addition to being subject to unmeasured variability associated with most ore bodies. Anglo American Platinum aimed at improving online optimisation of the circuit by implementing industrial model predictive control (MPC) to reduce system variability and continuously drive towards the optimal operating point within system constraints. The industrial dynamic matrix controller commissioned on the AG mill with a variable speed drive resulted in a 66% reduction in power and a 40% reduction in load standard deviation. These are the main controlled variables of the mill. The controller also improved the objective function, effective power utilisation, by 11%. This reduction in operated variable variability enabled a test campaign where the mill was controlled at various operating regions in order to establish the conditions conducive to the finest product size at a given mill feed rate. Moving the mill operating region from the benchmarked plant to the optimal grind environment and

stabilising the mill at this point with the model predictive controller provided an estimated potential recovery increase of 0.32% (absolute) due to better liberation.

Keywords: Autogenous; Milling; Optimisation; Response surface analysis; Model based control; Benefit analysis

Reza M. Rahman, Seher Ata, Graeme J. Jameson, Froth recovery measurements in an industrial flotation cell, Minerals Engineering, Volume 53, Nov. 2013, Pages 193-202, http://dx.doi.org/10.1016/j.mineng.2013.08.003.

(http://www.sciencedirect.com/science/article/pii/S0892687513002537)

Abstract: The froth phase serves an important role in upgrading the final concentrate in flotation. At present, the techniques that are used in the mineral industry to determine the effect of froth phase on the metallurgical performance of plant scale flotation cells have limitations. The aim of this paper is to investigate the performance of the froth in an industrial flotation cell. A unique device has been developed which is able to decouple the froth zone from the pulp zone. The device consists of two concentric tubes. The inner tube acts as a dropback collection chamber or catcher. The particles that return from the froth phase fall directly into the catcher and are collected as froth dropback. This technique is capable of measuring plant scale flotation cell froth recovery as well as providing valuable information on froth dropback particles. The froth recovery measurements were carried out in a rougher bank of a copper concentrator treating sulphide minerals. The dropback device is designed so that it can be immersed into an industrial size flotation cell and plant froth recovery measurements can be taken at any given location. During the experiments, the bubbles laden with valuable mineral particles entered the device from the flotation cell, subsequently rising to form a froth layer at the top of the device. The particles that detached or drained from the froth zone were collected in the dropback collection chamber whereas the concentrate sample was collected through a launder. By sizing and chemical analysis of the concentrate and dropback samples, the froth recovery was estimated on the basis of the valuable component. The effect of air rate on the froth recovery was also investigated. Metallurgical grades of the froth dropback device samples for different particle size ranges were compared to those of the concentrator to better understand the froth dropback mechanism.

Keywords: Flotation; Froth; Froth dropback; Froth recovery

A. Yap, F. Saconi, M. Nehring, F. Arteaga, P. Pinto, M.W.A. Asad, S. Ozhigin, S. Ozhigina, D. Mozer, A. Nagibin, E. Pul, D. Shvedov, D. Ozhigin, D. Gorokhov, V. Karatayeva, Exploiting the metallurgical throughput–recovery relationship to optimise resource value as part of the production scheduling process, Minerals Engineering, Volume 53, November 2013, Pages 74-83, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.06.005.

(http://www.sciencedirect.com/science/article/pii/S0892687513001933)

Abstract: A single process plant throughput rate to achieve a certain recovery at a certain cost is often assumed over the life of a resource project for strategic planning purposes. The process plant throughput–recovery relationship that exists for each ore type can and should be exploited for the purpose of creating additional economic value within the resource plan. This paper investigates the impact on Net Present Value (NPV) of strategic resource plans when allowing a fluctuating process plant throughput rate over the life of a base metals operation in comparison to only considering a single fixed throughput rate for a given plant size configuration. The metallurgical throughput–recovery relationship is confirmed as being an important factor in planning the extraction of the resource to feed a given process plant of fixed size since this impacts heavily upon the production schedule and therefore the NPV of the project. Mathematical programming to better aid the decision making process is investigated in comparison to traditional manual approaches to thus help determine the best throughput rate to use in each period. Results suggest that it would seem reasonable to expect an increase of around 4.0% in NPV when allowing a fluctuating process plant throughput rate over a single fixed throughput rate over the life of a midsize underground operation when using a mathematical programming approach.

Keywords: Metallurgical recovery; Plant throughput; Resource planning; Optimisation

V. Martínez-Gómez, R. Pérez-Garibay, J. Rubio, Factors involving the solids-carrying flotation capacity of micro bubbles, Minerals Engineering, Volume 53, Nov. 2013, Pages 160-166, http://dx.doi.org/10.1016/j.mineng.2013.07.016.

(http://www.sciencedirect.com/science/article/pii/S0892687513002343)

Abstract: Dissolved air flotation (DAF) is a technique used extensively for separating fine particles in water and wastewater treatment, but, unfortunately, its use is still limited for froth flotation of minerals. This appear to be due to the very low lifting power of the microbubbles (40–70 μm) and low airflow rate because of the low solubility of air in water. Thus, the efficiency of DAF in treating mineral particles has shown to be poor and as a solid/liquid separation technology is limited to slurries with no more than 3% solids. This work presents results showing (measuring) the limits of DAF as a function of particle size distribution, solids content and air superficial velocity. Interestingly, the microbubbles were found to be not selective with respect to particle size, floating both fine and coarse particles, which is most likely due to the existence of several mechanisms acting on the flotation of particles by these minute bubbles.

Binfang Cao, Yongfang Xie, Weihua Gui, Lijun Wei, Chunhua Yang, Integrated prediction model of bauxite concentrate grade based on distributed machine vision, Minerals Engineering, Volume 53, November 2013, Pages 31-38, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.07.003.

(http://www.sciencedirect.com/science/article/pii/S0892687513002215)

Abstract: Concentrate grade of bauxite flotation is an important technology indicator, which has a direct effect on aluminum quality. Considering the unity, locality and inaccuracy of existing prediction methods of concentrate grade based on machine vision, a distributed machine vision system of bauxite flotation process is built in this paper, from which an integrated prediction model of concentrate grade is presented. At first, we use experimental methods to analyse image data from different flotation stages, as well as comment on the relationship between its global trends and local trends. Then taking advantage of the multiple kernels least squares support vector machine and wavelet extreme learning machine, models for prediction of concentrate grade and its residual compensation are established respectively to predict the concentrate grade through integration. Finally, validation and industrial applications show that the integrated prediction model based on distributed machine vision has a good generalization capability, which can achieve a good prediction accuracy of concentrate grade, with a relative error of less than 6%, thus laying a foundation for optimal control based on mineral grade in flotation process.

XingQing Zhao, RuCheng Wang, XianCai Lu, JianJun Lu, ChengXiang Li, Juan Li, Bioleaching of chalcopyrite by Acidithiobacillus ferrooxidans, Minerals Engineering, Volume 53, November 2013, Pages 184-192, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.08.008.

(http://www.sciencedirect.com/science/article/pii/S0892687513002586)

Abstract: Acidithiobacillus ferrooxidans (A. ferrooxidans) was selected to experimentally study the effects of bacteria on the oxidation of chalcopyrite. The results indicated that A. ferrooxidans remarkably promoted the oxidation of chalcopyrite. The pH of the cell broth medium was observed to increase and then decrease during the bioleaching experiment. The number of suspended bacteria in the bio-oxidation process could be divided into three stages: the initial 4 days, in which the bacteria attached to the chalcopyrite surface and the number of suspended bacteria slightly decreased; day 5 to day 52, in which the suspended bacteria clearly increased with time and reached a maximum of 3.58 × 107 cells/L on day 52; and day 53 to day 80, in which the number of suspended bacteria decreased. Other parameters such as redox potential (Eh) and iron ion concentrations increased with time. SEM micrographs showed that the cells were directly attached to the erosion pits on the smooth surfaces of the chalcopyrite. The erosion pits were similar to the bacteria in shape and size, and thus, the pits were likely products of dissolution by organic acids secreted by the attached cells. Compared to the unoxidized chalcopyrite, the elemental sulfur of the eroded chalcopyrite was clearly reduced, and the elemental oxygen was slightly increased. Moreover, a biofilm was present on the surfaces of the chalcopyrite particles. Therefore, the adherence of the cells to the mineral surfaces played a

predominant role in altering the mineral appearance, which is important during the leaching of chalcopyrite.

Keywords: Chalcopyrite; Bioleaching; Acidithiobacillus ferrooxidans; Attachment

Jun Yang, Guangqing Zhang, Oleg Ostrovski, Sharif Jahanshahi, Changes in an Australian laterite ore in the process of heat treatment, Minerals Engineering, Volume 54, December 2013, Pages 110-115, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.05.009.

(http://www.sciencedirect.com/science/article/pii/S0892687513001593)

Abstract: This paper examines an Australian garnieritic-type ore and changes in phase composition and morphology caused by heating in argon at 400–1000 °C using XRF, XRD, DTA/TG, SEM/EDS and BET analyses. The mineral phases detected by XRD in the original ore include chlorite, talc, hematite and quartz. Traces of iron silicate, Fe–Cr spinel and monoxide phase (predominantly manganese oxide) were observed by EDS. Nickel was detected in chlorite, talc, iron silicate and monoxide phase. Heat treatment at 400–500 °C did not change XRD patterns. At 600 °C, dehydroxylation of the brucitic phase of chlorite occurred. Chlorite was converted into olivine (forsterite) and enstatite at 600–800 °C. Upon heating to 900–1000 °C, talc was also converted into olivine and enstatite. Ni-bearing phases after heat treatment at 800–850 °C were forsterite, enstatite, talc, iron silicate and monoxide.

Keywords: Garnierite; Pre-treatment; Dehydration; Mineralogical change

Farzaneh Ahmadzadeh, Jan Lundberg, Remaining useful life prediction of grinding mill liners using an artificial neural network, Minerals Engineering, Vol. 53, Nov. 2013, Pages 1-8, http://dx.doi.org/10.1016/j.mineng.2013.05.026.

(http://www.sciencedirect.com/science/article/pii/S0892687513001878)

Abstract: Knowing the remaining useful life of grinding mill liners would greatly facilitate maintenance decisions. Now, a mill must be stopped periodically so that the maintenance engineer can enter, measure the liners' wear, and make the appropriate maintenance decision. As mill stoppage leads to heavy production losses, the main aim of this study is to develop a method which predicts the remaining useful life of the liners, without needing to stop the mill. Because of the proven ability of artificial neural networks (ANNs) to recognize complex relationships between input and output variables, as well as its adaptive and parallel information-processing structure, an ANN has been designed based on the various process parameters which influence wear of the liners. The process parameters were considered as inputs while remaining height and remaining life of the liners were outputs. The results show remarkably high degree of correlation between the input and output variables. The performance of the neural network model is very consistent for data used for training (seen) and testing (unseen).

Keywords: Remaining useful life; Artificial neural network; Principal component analysis; Wear prediction; Maintenance scheduling; Mill liners

Anne Oxley, Nic Barcza, Hydro–pyro integration in the processing of nickel laterites, Minerals Engineering, Volume 54, December 2013, Pages 2-13, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.02.012.

(http://www.sciencedirect.com/science/article/pii/S0892687513000691)

Abstract: Hydrometallurgical process routes are seen to be the future of treatment of the lower grade nickel laterites ores. Hydrometallurgical projects of recent years have focused on HPAL and have been largely unsuccessful economically so far, with huge capital cost overruns. The simplest and least capital intensive of the possible alternatives to HPAL is atmospheric heap leaching. Development work is also underway by several companies into atmospheric tank leaching which is also a potentially viable alternative. The natural product for a leaching process is a high grade nickel intermediate either from a direct precipitation process (containing approx. 36% Ni) or via ion exchange (>50% Ni). There are many existing pyrometallurgical facilities which could easily be adapted to take this nickel intermediate giving them significant potential benefits especially as nickel laterite ore grades diminish. The nickel production from these plants could also be increased and for new plants large capital and operating cost savings achieved by using suitable intermediates. There are also potential environmental benefits with much less energy consumed and lower greenhouse gases emitted per tonne of nickel produced. In the future an integrated hydrometallurgical plant with attached existing smelter or a more advanced pyrometallurgical smelting process (e.g. a DC arc furnace) could well be the way forward for new projects.

Keywords: Nickel laterites; Hydrometallurgical pyrometallurgical integration; Heap leaching; Nickel and cobalt

Bianca Newcombe, E. Wightman, D. Bradshaw, The role of a flash flotation circuit in an industrial refractory gold concentrator, Minerals Engineering, Vol 53, Nov 2013, Pages 57-73, http://dx.doi.org/10.1016/j.mineng.2013.06.016.

(http://www.sciencedirect.com/science/article/pii/S0892687513002136)

Abstract: In order to determine the contribution of the flash flotation circuit to the overall plant performance of the Kanowna Belle concentrator, two survey campaigns both with and without the flash circuit in operation have been conducted on two distinctly different ore types: a very high grade ore, and a very low grade ore of higher hardness. Using two different ores with the same target valuable mineral species (gold and pyrite) through the same treatment route allows any trends in performance to be more easily identified. As both survey campaigns involved running the plant with and without the flash flotation circuit in operation, the significant contribution of the flash flotation cell to overall plant recovery and final concentrate grade is highlighted. The flash circuit on this plant may be considered

as the primary rougher, contributing in excess of 42% of the valuable material that is recovered to the final concentrate stream, at a grade of approximately 35% sulphur; and in-so-doing reducing the overall plant footprint that would otherwise be required to achieve the same recoveries at the target concentrate grade. Mineralogical analysis of survey samples shows that the feed to the flash flotation cell (cyclone underflow) is of a much higher grade and contains a higher proportion of well liberated valuable material as compared to the conventional flotation circuit feed (cyclone overflow). Maximising the recovery of this material before it re-enters the milling circuit should be of paramount importance to optimising overall plant performance. When the flash flotation circuit is taken off-line the recovery of sulphur (and hence pyrite) is observed to decrease dramatically, and whilst the recovery of gold also decreases, it is to a much lesser extent. The difference in the recoveries of gold and pyrite that is observed without the flash flotation circuit in operation is most likely attributable to a change in the way the gold is being liberated as a function of the change in grinding circuit operation that is required when the flash circuit is taken off-line. The distribution of valuable material in the cyclone overflow stream (conventional flotation feed) undergoes a step change when the flash circuit is taken off-line with an increase in the amount of valuable fines being generated, which is further reflected in the flotation tails with a higher proportion of both pyrite and gold being present in the intermediate and fine size classes. This increase in the amount of pyrite fines in particular may have contributed to the loss in recovery that was observed when the flash flotation circuit was taken off-line. Pulp chemistry data from various points around the flotation circuit highlight the different processing conditions in the flash cell, compared to the conventional circuit, which will impact on the type of minerals able to be recovered by flotation, as well as reagent selection for this type of processing application.

Keywords: Froth flotation; Sulphide ores; Gold ores; Ore mineralogy; Flotation machines; Particle size

N.O. Lotter, J.F. Oliveira, A.L. Hannaford, S.R. Amos, Flowsheet development for the Kamoa project – A case study, Minerals Engineering, Volume 52, October 2013, Pages 8-20, http://dx.doi.org/10.1016/j.mineng.2013.02.014.

(http://www.sciencedirect.com/science/article/pii/S089268751300071X)

Abstract: Ivanplats Ltd. appointed Xstrata Process Support to perform the flowsheeting development work for their hypogene and supergene geomet units of the Kamoa Copper deposit, located west of Kolwezi in the Democratic Republic of the Congo. Through appropriate use of Gy's sampling and subsampling models, and systematic flowsheet development using modern Process Mineralogy, an optimised Milestone Flowsheet was developed, delivering a final concentrate grade of 32.8% Cu at 85.4% recovery with hypogene ore, and 45.1% Cu grade at a recovery of 83.4% for supergene ore. These results were obtained from representative samples of drill-core, quantitative mineralogy and high-confidence flotation testing. The significant value of this development is that a single flowsheet will treat both

hypogene and supergene ores and produce treatable concentrates. Further work to advance the flowsheet performance beyond this milestone benchmark, and to perform variability testing for this resource, has been identified for investigation in the near future.

Keywords: Hypogene; Supergene; Process mineralogy; Sampling; Flotation testing

Walter Amos Ngobeni, Gregory Hangone, The effect of using sodium dimethyl-dithiocarbamate as a co-collector with xanthates in the froth flotation of pentlandite containing ore from Nkomati mine in South Africa, Minerals Engineering, Volume 54, December 2013, Pages 94-99, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.04.027.

(http://www.sciencedirect.com/science/article/pii/S0892687513001416)

Abstract: Sodium ethyl and potassium amyl xanthates are commonly used in bulk and selective froth flotation of pentlandite ores respectively. Pulp pH plays a significant role in pentlandite flotation and xanthates are sensitive to pH. Consequently, more stable collectors have to be used in the froth flotation of pentlandite ores. The dithiocarbamates are possible replacement as they are believed to be stable in a wider range of pH and their use yields a faster flotation rates than xanthates. However, it may be uneconomical to use dithiocarbamates as pure collectors due to their cost. The present study explored feasibility of using di-C1-DTC to replace or partially replace PAX and SEX in nickel flotation. The tested molar ratios were 90:10 and 70:30; with xanthates as the abundant constituent in all the mixtures. This study showed that the using di-C1-DTC as co-collector was beneficial as the mixtures 30di-C1-DTC:70SEX and 10di-C1-DTC:90PAX improved nickel recovery and grade respectively. Furthermore, there were no significant differences in cumulative mass and water recoveries obtained with all the mixtures therefore differences in nickel recoveries were due to the differences in the selectivity properties of the collectors and not physical processes viz. physical entrapment and hydraulic entrainment.

Keywords: Collector mixtures; Pentlandite; Thiol collectors

Bo Feng, Xian-ping Luo, The solution chemistry of carbonate and implications for pyrite flotation, Minerals Engineering, Volume 53, November 2013, Pages 181-183, ISSN 0892-6875, http://dx.doi.org/10.1016/j.mineng.2013.08.007.

(http://www.sciencedirect.com/science/article/pii/S0892687513002574)

Abstract: The solution chemistry of carbonate and implications for pyrite flotation in the presence of lizardite have been investigated. The results show that lizardite causes problems in the flotation of pyrite, by adhering to the pyrite particles. Addition of various reagents which can produce carbonate has been found to improve pyrite recovery during flotation. The solution chemistry of carbonate indicated that carbonate mainly exists in the form of CO 3 2 - ions in the pH range

that carbonate can restore pyrite flotation recovery. When the reagent producing the carbonate ion is able to provide it at a higher concentration, the pyrite flotation performance is improved.

Keywords: Lizardite; Pyrite; Slime coatings; Carbonate; Solution chemistry

C.P. Brough, R. Warrender, R.J. Bowell, A. Barnes, A. Parbhakar-Fox, The process mineralogy of mine wastes, Minerals Engineering, Volume 52, October 2013, Pages 125-135, http://dx.doi.org/10.1016/j.mineng.2013.05.003.

(http://www.sciencedirect.com/science/article/pii/S0892687513001441)

Abstract: The discipline of process mineralogy developed through the recognition that metallurgical flowsheets could be optimised by thorough characterisation of the precursor ore mineralogy, mineral associations, grain size and textures. In a procedure analogous to process mineralogy it is shown here that effective characterisation of mine wastes for Acid Rock Drainage and Metal(loid) Leaching (ARDML) potential must follow a similar set of robust practices which include: (i) representative sampling; (ii) static/screening level geochemical tests and qualitative mineralogical assessment; (iii) longer-term kinetic geochemical tests and quantitative mineralogical assessment; and (iv) quantitative numerical modelling to assess source term chemistry associated with the mine facilities and thereby determine potential impacts to receptors. This process is dependent on a sufficiently robust drill core database and a detailed mine plan through which an assessment of mine wastes is possible. Such detailed characterisation may be limited by insufficient budgets, however omission of a thorough mineralogical investigation may lead to a lack of understanding of the primary geochemical controls on mine waste behaviour. In turn, this can lead to over- or under-engineering of mine facilities, which can have financial and/or environmental implications. Several case studies are presented to illustrate how mineralogy can be applied to solve problems in ARDML prediction and mitigation, specifically within waste rock assessment.

Keywords: Process mineralogy; ARDML; Mineralogy; Mine waste

Mike D. Adams, Impact of recycling cyanide and its reaction products on upstream unit operations, Minerals Engineering, Volume 53, November 2013, Pages 241-255, http://dx.doi.org/10.1016/j.mineng.2013.04.012.

(http://www.sciencedirect.com/science/article/pii/S0892687513001179)

Abstract: A typical operations outcome to dealing with the environmental and economic issues associated with cyanide in gold plant tailings streams involves the recycle of cyanide and its associated reaction products. This recycle stream may take the form of return dam water or tailings thickener overflow to the mill, or a cyanide recovery stream to the leach from a SART (sulphidization–acidification–recycling–thickening) or AVR (acidification–volatilization–reneutralization) circuit. The chemical composition and cyanide speciation of these solutions may be

relatively complex, containing various metal cyanide species, thiocyanate, cyanate and other breakdown products. Several of these species are reported to have a deleterious effect on upstream unit operations. For example, while cyanide is in common use as a depressant for pyrite in mineral flotation, ferrocyanide and thiocyanate ions have also been shown to exhibit a depressant action in some cases. Primary flotation recovery of gold can thus be compromised and may be responsible for significant lost revenue, particularly from high-grade refractory gold operations. Bioleaching plants tend to separate cyanide circuits to an independent water balance to ensure that no cyanide or thiocyanate returns to inflict dire consequences on the bacterial population. Tolerable levels of these ions are exceedingly low, creating a risk factor and constraining water balance flexibility. Milling-in-cyanide has been periodically mooted as a beneficial circuit modification, particularly in operations that have tailings thickening, SART or dolomitic ore from which significant levels of free and complexed cyanides and thiocyanates are present. Potential consequences include unwanted side reactions with freshly activated mineral surfaces within mills operating at elevated temperatures and significant cyanide losses under these conditions. The evidence for the effects of recycled cyanides and associated species on upstream gold processing circuits have to date not been assessed in a systematic fashion. This paper presents a review of the available literature and analysis of associated data in these areas. Common arguments from operators justifying certain process plant configurations, modifications and operating setpoints around recycle streams are examined. Impacts of cyanide recycle on milling, flotation and bioleaching are quantified in the context of exemplary case studies. The various literature and case study flowsheets provide a useful analysis of the application of recycle streams to operating plant flowsheets, often requiring creative or inelegant solutions. In the current work, plant operating data is analyzed to quantify some of these effects; moreover, a simulation model has been developed to further quantify and explain some of these effects and provide insight into the decision-making process for plant designers and operators alike. Recycles without water treatment or other means may raise thiocyanate and cyanide levels above site-specific tolerances for operability.

Keywords: Cyanidation; Recycling; Tailings disposal; Milling; Flotation; Bioleaching

Bulelwa Ndlovu, Saeed Farrokhpay, Dee Bradshaw, The effect of phyllosilicate minerals on mineral processing industry, International Journal of Mineral Processing, Volume 125, 10 December 2013, Pages 149-156, ISSN 0301-7516, http://dx.doi.org/10.1016/j.minpro.2013.09.011.

(http://www.sciencedirect.com/science/article/pii/S0301751613001968)

Abstract: The increased exposure to low grade ores has highlighted the importance of understanding phyllosilicate gangue mineralogy. These minerals exist as common gangue minerals and have been shown to present challenges during ore beneficiation, with issues arising throughout the processing circuit. Nonetheless, the industry's understanding of the issues and solutions related to these minerals

remains poor; a likely result of the gap between mineral processing and mineralogy. This paper gives a comprehensive description of the phyllosilicate group; classifying the minerals according to variations in structure. The typical problems encountered with these minerals are discussed, with specific reference to industrial operations. The current practices being used to mitigate the effects of phyllosilicate minerals are also reviewed. This paper provides a better understanding of the effect of phyllosilicate minerals on mineral processing.

Keywords: Clays; Phyllosilicate; Mineral processing; Flotation; Rheology

T.E. Amer, W.M. Abdella, G.M. Abdel Wahab, E.M. El-Sheikh, A suggested alternative procedure for processing of monazite mineral concentrate, International Journal of Mineral Processing, Volume 125, 10 December 2013, Pages 106-111, http://dx.doi.org/10.1016/j.minpro.2013.10.004.

(http://www.sciencedirect.com/science/article/pii/S0301751613002007)

Abstract: An alternative procedure for the processing of monazite mineral concentrate has been suggested. This procedure is based on a prior separation of the REEs and Th oxalates from the sulfate liquor of the hydrous oxide cake obtained after alkali breakdown of monazite concentrate. From the mixed oxalate precipitate, it was possible to optimize the selective alkali dissolution of Th using a mixed Na2CO3/NaHCO3 solution. Highly pure oxide products of the three interesting metal values; viz REEs, Th and U have properly been prepared.

Keywords: Hydrous oxide cake; REEs; Thorium; Uranium; Breakdown of monazite

Sydney Sabedot, Carlos Otávio Petter, Carlos Hoffmann Sampaio, Spectrophotometric characterization of iron and titanium minerals in sedimentary kaolin deposit, International Journal of Mineral Processing, Vol. 124, 14 Nov. 2013, Pp. 35-41, http://dx.doi.org/10.1016/j.minpro.2013.07.003.

(http://www.sciencedirect.com/science/article/pii/S0301751613001476)

Abstract: The northern region of Brazil produces kaolin for paper industry. Ipixuna Mine, located in the Pará State, exploits important sedimentary kaolin deposits, which are extracted ROM material blocks that vary in color depending on both the paragenesis and concentration of mineral contaminants. Samples were collected from different mining fronts, which represented the different varieties of ore. Samples were processed in a pilot plant. Both products and tailings were analyzed to define the mineral paragenesis and color data. Specific studies on the iron and titanium minerals and spectrophotometry were performed on the samples. The results indicated that the proportion of goethite, hematite and anatase and the particle size of the last two minerals in the blocks of ore affect their color and mineral processing efficiency. This study defined seven spectral groups of kaolin ore, the relationship of the groups with the paragenesis of mineral contaminants, varieties of

ore that can be economically processed and the best blending options between ore varieties to improve the processing operations.

Keywords: Kaolin ore; Spectrophotometry; Kaolin spectral groups; Kaolin processing

Baozhong Ma, Chengyan Wang, Weijiao Yang, Yongqiang Chen, Bo Yang, Comprehensive utilization of Philippine laterite ore, part 1: Design of technical route and classification of the initial ore based on mineralogical analysis, International Journal of Mineral Processing, Volume 124, 14 November 2013, Pages 42-49, ISSN 0301-7516, http://dx.doi.org/10.1016/j.minpro.2013.08.003.

(http://www.sciencedirect.com/science/article/pii/S0301751613001701)

Abstract: Nickel, cobalt, iron, and chromium are potentially valuable metals contained in laterite ores. Mineralogical analysis results revealed that the laterite from the Philippines contained predominantly fine iron oxide/oxyhydroxide, as well as a small amount of slightly coarse chromite and gangue mineral aggregates. Additionally, the coarse cores of minerals were closely surrounded and adhered by a matrix of fine minerals. The chemical components were closely related to the particle sizes of constituent minerals. Based on these findings, a classification method was devised and three samples with different components were obtained under the proposed optimal scheme. About 50% of Mg and Si were removed from the fine fraction (S1) and more than 85% of Fe and Ni distributed in it. The other two samples are Co-riched and the content in the intermediate fraction (S2) and the coarse fraction (S3) was 0.22% and 0.28%, respectively. Cr in S2 was as high as 6.75%. A technical route was designed for processing these three samples and the preliminary tests indicate that the recoveries of Fe, Ni, Co and Cr can reach about 94%, 85%, 70% and 30%, respectively; Fe content in the prepared iron concentrate is over 61% and Cr content in the obtained Cr-riched residue is above 12%. Consequently, comprehensive utilization of Philippine laterite ore can be realized following the proposed route.

Keywords: Laterite ore; Mineralogical analysis; Classification; Design of technical route; Comprehensive utilization

Guanghui Li, Shuhui Zhang, Mingjun Rao, Yuanbo Zhang, Tao Jiang, Effects of sodium salts on reduction roasting and Fe–P separation of high-phosphorus oolitic hematite ore, International Journal of Mineral Processing, Volume 124, 14 Nov. 2013, Pages 26-34, http://dx.doi.org/10.1016/j.minpro.2013.07.006.

(http://www.sciencedirect.com/science/article/pii/S0301751613001634)

Abstract: Effects of sodium salts on reduction roasting and Fe–P separation of high-phosphorus oolitic hematite ore were studied in the process of coal-based direct reduction followed by wet magnetic separation. Various parameters, including reducing temperature and time, type and dosage of sodium salts, grinding fineness of magnetic separation feed and magnetic field intensity were investigated. The

results of reduction and Fe–P magnetic separation are significantly improved by the addition of sodium sulfate and borax, in comparison with those in the absence of additives. A magnetic concentrate with total iron grade of 92.7% and phosphorus content of 0.09% was obtained from an oolitic hematite ore containing 48.96% iron and 1.61% phosphorus when reduced in the presence of 7.5% sodium sulfate and 1.5% borax and wet magnetic separated under the proper conditions. The results of optical microscopy and X-ray diffraction (XRD) analyses of reduced pellet reveal that metallic iron grains exist in sizes of 10–20 μm and are associated with gangue minerals closely when reduced in the absence of sodium salts. By contrast, the oolitic structure is destroyed and metallic iron grains grow markedly to the mean size of 50 μm when reduced in the presence of sodium sulfate and borax. Sodium salts are capable of destroying the oolitic structure via reacting with gangues, enhancing the reduction of iron oxide and promoting the growth of metallic iron grains during reduction, which is beneficial for Fe–P separation of the oolitic hematite ore.

Keywords: Oolitic hematite; Reduction roasting; Magnetic separation; Sodium salts; Dephosphorization

A.F. Grabsch, P.D. Fawell, S.J. Adkins, A. Beveridge, The impact of achieving a higher aggregate density on polymer-bridging flocculation, International Journal of Mineral Processing, Volume 124, 14 November 2013, Pages 83-94, ISSN 0301-7516, http://dx.doi.org/10.1016/j.minpro.2013.04.011.

(http://www.sciencedirect.com/science/article/pii/S0301751613001051)

Abstract: The polymer-bridging flocculation processes that take place in hydrometallurgical thickening are very much affected by the solid concentration at the point of flocculant dosing, with the optimum concentrations maximising settling flux often well below that of the thickener feed. This is a consequence of the open, low density aggregate structures formed by flocculation. Achieving adequate solids dilution in full-scale applications can be problematic, and a flocculant that can produce a denser aggregate and thereby reduce the extent of solids dilution required may offer practical advantages. There is evidence that Rheomax® DR 1050 (BASF) has such potential, although detailed quantification of this has not been previously published. The kinetics of flocculation of fine calcite slurries in turbulent pipe flow by Rheomax DR 1050 was contrasted against a conventional acrylamide/acrylate copolymer over a range of solid concentrations and dosages. Focused beam reflectance measurement (FBRM) was used to provide in-line monitoring of aggregate size as a function of reaction time, with batch sampling also producing corresponding settling rates. These reaction profiles confirmed distinct responses to solid concentration for the two flocculants; the conventional flocculant was superior in the range 20–40 kg m^{-3}, while the optimum for Rheomax DR 1050 was near 60 kg m^{-3}. Fitting of a population balance model to this kinetic data indicated that this behaviour primarily reflected a higher fractal dimension from flocculation with Rheomax DR 1050. The experimental results and model predictions

are used to explore the practical scenarios under which Rheomax DR 1050 would be expected to perform best, showing that even at high solids, the benefit may only be realised in applications requiring higher dosages and mass throughputs. The practical limitations of the experimental approach used here to measure flocculation kinetics are also discussed.

Keywords: Acrylamide/acrylate; Flocculant; Kinetics; Fractal; Settling

R. Sommerville, R. Blissett, N. Rowson, S. Blackburn, Producing a synthetic zeolite from improved fly ash residue, International Journal of Mineral Processing, Volume 124, 14 November 2013, Pages 20-25, ISSN 0301-7516, http://dx.doi.org/10.1016/j.minpro.2013.07.005.

(http://www.sciencedirect.com/science/article/pii/S0301751613001622)

Abstract: Fly ash, if not utilised, is considered a waste product. Zeolitisation of coal fly ash offers the opportunity to create an added value product from a waste stream. Using a two-step zeolitisation process, Si is leached from improved fly ash residue — a previously untested feedstock for this process. Optimisation of the conditions of crystallisation of synthetic zeolite are discussed in this paper. The type of synthetic zeolites produced was found to be highly dependent on the conditions of the crystallisation process. Zeolites formed include zeolite Na-P1, sodalite, zeolite Na-A, zeolite K-A, and others. Crystallisation parameters explored in this paper include sodium aluminate addition, duration of crystallisation period, temperature, and the type of fly ash (improved fly ash residue vs. untreated fly ash). Yields of up to 250 g/kg of ash of high purity zeolite Na-P1 were produced from improved fly ash residue. Although this is an improvement on yields in literature, tentative profitability calculations on a full scale plant require a yield of 286 g/kg ash in order to achieve a return on investment within 4 years.

Keywords: Fly ash; Zeolitisation; Improved ash residue; Synthetic zeolite

Amir Rahimi, Arezou Niksiar, A general model for moving-bed reactors with multiple chemical reactions part I: Model formulation, International Journal of Mineral Processing, Volume 124, 14 November 2013, Pages 58-66, ISSN 0301-7516, http://dx.doi.org/10.1016/j.minpro.2013.02.015.

(http://www.sciencedirect.com/science/article/pii/S0301751613000628)

Abstract: A general model is developed for moving-bed reactors where multiple non-catalytic gas–solid reactions and multiple gas-phase reactions take place. The grain model is adopted and modified as the kinetics model for multiple non-catalytic gas–solid reactions case. The proposed model covers the modified grain model and provides the local degree knowledge of the origin solid reactant along with the intermediate solids within the porous pellets. The heat transfer by convection, conduction and radiation in the gas bulk and the radial temperature distribution of the pellet are considered. The model predictions for solid conversion, gas

temperature, and gas concentrations are obtained for an industrial moving-bed reactor for Fe2O3 pellets reduction. This proposed model well simulates the experimental data with an average 1.2% error.

Keywords: Moving-bed; Gas–solid reactions; Multiple reactions; Hematite; Kinetics

Amir Rahimi, Arezou Niksiar, A general model for moving-bed reactors with multiple chemical reactions, Part II: Effect of kinetic model, International Journal of Mineral Processing, Volume 124, 14 November 2013, Pages 67-74, ISSN 0301-7516, http://dx.doi.org/10.1016/j.minpro.2013.06.003.

(http://www.sciencedirect.com/science/article/pii/S0301751613001397)

Abstract: The general model developed in the first part of this study is based on the grain model. In order to determine the overlapping range of this kinetic model and the unreacted shrinking core model the attempt is made in this part of the article to identify the simplest and most accurate model. Although under certain circumstances the found results in both the models are almost similar, the developed model based on grain model predicts the experimental data much better than the shrinking core model. The simplicity of the model's results in the outcome is due the predominant diffusional regime. This regime is revealed where the pellet size is big; nevertheless, the results of two models are not similar even in small values of pellet porosity. Two correlations for determining effective diffusivity are tested and it shows a direct effect on the overlapping range of both the models.

Keywords: Moving bed; Gas–solid reactions; Shrinking core model; Grain model; Multiple reactions

Shane Donatello, Christopher R. Cheeseman, Recycling and recovery routes for incinerated sewage sludge ash (ISSA): A review, Waste Management, Volume 33, Issue 11, November 2013, Pages 2328-2340, ISSN 0956-053X, http://dx.doi.org/10.1016/j.wasman.2013.05.024.

(http://www.sciencedirect.com/science/article/pii/S0956053X13002559)

Abstract: The drivers for increasing incineration of sewage sludge and the characteristics of the resulting incinerated sewage sludge ash (ISSA) are reviewed. It is estimated that approximately 1.7 million tonnes of ISSA are produced annually world-wide and is likely to increase in the future. Although most ISSA is currently landfilled, various options have been investigated that allow recycling and beneficial resource recovery. These include the use of ISSA as a substitute for clay in sintered bricks, tiles and pavers, and as a raw material for the manufacture of lightweight aggregate. ISSA has also been used to form high density glass–ceramics. Significant research has investigated the potential use of ISSA in blended cements for use in mortars and concrete, and as a raw material for the production of Portland cement. However, all these applications represent a loss of the valuable phosphate

content in ISSA, which is typically comparable to that of a low grade phosphate ore. ISSA has significant potential to be used as a secondary source of phosphate for the production of fertilisers and phosphoric acid. Resource efficient approaches to recycling will increasingly require phosphate recovery from ISSA, with the remaining residual fraction also considered a useful material, and therefore further research is required in this area.

Keywords: Sewage sludge incineration; Ash characteristics; Pozzolanic cements; Phosphate recovery; Ceramics; Sintered brick and tile

Juan Hao, Haifeng Wang, Shuhe Chen, Bin Cai, Linhan Ge, Wencheng Xia, Pyrolysis characteristics of the mixture of printed circuit board scraps and coal powder, Waste Management, Available online 21 November 2013, ISSN 0956-053X, http://dx.doi.org/10.1016/j.wasman.2013.10.043.

(http://www.sciencedirect.com/science/article/pii/S0956053X13005291)

Abstract: Thermogravimetric (TG) analysis and infrared spectroscopy were used to analyze the pyrolysis characteristics of printed circuit board scraps (PCBs), coal powder and their mixtures under nitrogen atmosphere. The experimental results show that there is a large difference between waste PCBs and coal powder in pyrolysis processing. The pyrolysis properties of the mixing samples are the result of interaction of the PCBs and coal powder, which is influenced by the content of mixture. The degree of pyrolysis and pyrolysis properties of the mixture are much better than that of the single component. The TG and the differential thermogravimetric (DTG) curves of the PCBs mixed with coal powder move towards the high-temperature zone with increasing amount of coal powder and subsequently the DTG peak also becomes wider. The Coats–Redfern integral method was used to determine the kinetic parameters of pyrolysis reaction mechanism with the different proportion of mixture. The gas of pyrolysis mainly composes of CO2, CO, H2O and some hydrocarbon. The bromide characteristic absorption peak has been detected obviously in the pyrolysis gas of PCBs. On the contrary, the absorption peak of the bromide is not obvious in pyrolysis gas of the PCBs samples adding 40% coal powder.

Keywords: Pyrolysis; Printed circuit board scraps; Coal powder; Kinetic

B. Acevedo, C. Barriocanal, R. Alvarez, Pyrolysis of blends of coal and tyre wastes in a fixed bed reactor and a rotary oven, Fuel, Volume 113, November 2013, Pages 817-825, http://dx.doi.org/10.1016/j.fuel.2012.12.077.

(http://www.sciencedirect.com/science/article/pii/S0016236112011015)

Abstract: The pyrolysis of blends of two wastes from scrap tyres with a coal of 36 wt.% db volatile matter content was carried out in two ovens of different configuration in order to compare the characteristics of the products obtained. The rotary oven was expected to improve the blending of the raw materials and to

promote a synergistic effect. Mass balances were performed with gas and oil yields showing the greatest differences. The chars obtained were studied on the basis of their true and apparent densities, Hg porosimetry and by determining their surface area under N_2 at 77 K and under CO_2 at 273 K. The chars were also examined by scanning electron microscopy (SEM). The oils were subjected to Fourier spectroscopy (FTIR). It was observed that the oils obtained in the rotary oven were more aromatic and contained smaller amounts of oxygenated functional groups due to their higher residence time in the hot zone of the reactor.

Keywords: Coal; Scrap tyres; Carbonization; Chars; Pyrolysis oil

H.R. Watling, Chalcopyrite hydrometallurgy at atmospheric pressure: 1. Review of acidic sulfate, sulfate–chloride and sulfate–nitrate process options, Hydrometallurgy, Volume 140, November 2013, Pages 163-180, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.09.013.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001989)

Abstract: The need to process low-grade and/or complex chalcopyrite-containing ores that cannot be concentrated is the main driver for the development of hydrometallurgical processes. The ferric sulfate–sulfuric acid system, with or without the assistance of microorganisms, has been studied extensively because it comprises the most promising, low-cost process route. Alternative oxidants to ferric ion are known but, as yet, their superior oxidation strengths have not been exploited other than at laboratory scale, probably due to their higher costs. Hybrid sulfate–chloride and sulfate–nitrate systems were included because they may offer specific advantages in some instances. The aims of this review were to summarise current knowledge in respect of these systems and highlight potentially rewarding areas for future research.

Keywords: Chalcopyrite; Leaching; Dissolution; Passivation; Sulfides

Sami Virolainen, Riina Salmimies, Mehdi Hasan, Antti Häkkinen, Tuomo Sainio, Recovery of valuable metals from argon oxygen decarburization (AOD) dusts by leaching, filtration and solvent extraction, Hydrometallurgy, Volume 140, Nov 2013, PP. 181-189, http://dx.doi.org/10.1016/j.hydromet.2013.10.002.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001990)

Abstract: For each ton of steel produced from a typical steelmaking plant, up to several tens of kilograms of dust, containing significant amounts of valuable and/or environmentally harmful metals, are also produced. A hydrometallurgical route for the recovery of these metals from argon oxygen decarburization (AOD) dusts, with selective leaching, filtration and solvent extraction was studied experimentally. Batch leaching of dusts with concentrated H2SO4 was found to be difficult to optimize for yields for the target metals (Zn and Mo), while keeping Fe in the solid phase. Zn and Mo could be recovered with comparable yields, while keeping Fe totally

undissolved, by controlled leaching at pH above 3. Water was successfully used to leach Mo with 45% yield, while Ca, K, Cr, Mg, Pb, and Mn were leached as impurities. It was found that solid/liquid separation of the undissolved solids by pressure filtration was challenging and it was further observed that the properties of the initial dusts have a strong influence on this process step. D2EHPA was found to provide good extraction selectivity for Zn from acidic leaching solutions, except over Fe. A pure Mo/Cr mixture was extracted with hydroxyoxime LIX 84-I, trioctylamine TOA and quaternary ammonium salt Aliquat 336. The best Mo/Cr selectivity was achieved with Aliquat 336.

Keywords: Steelmaking dust; Zinc; Molybdenum; Leaching; Solvent extraction

Xiaodong Wang, Robbie G. McDonald, Robert D. Hart, Jian Li, Arie van Riessen, Acid resistance of goethite in nickel laterite ore from Western Australia. Part I. The relationship between goethite morphologies and acid leaching performance, Hydrometallurgy, Volume 140, November 2013, Pages 48-58, http://dx.doi.org/10.1016/j.hydromet.2013.09.005.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001771)

Abstract: Nickel containing goethite in laterite ores shows extreme variability in heap leaching performance. This has been difficult to characterise making utilisation of these ores for heap leaching problematic. The variability of the leaching performance is demonstrated for selected samples using atmospheric pressure leaching. Quantitative mineralogical analysis based on X-ray diffraction, crystallite morphology from transmission electron microscopy imaging and the chemical composition measured by energy dispersive X-ray spectrometry of the pre- and post-leached laterite ore samples suggests acid resistant (slow leaching) goethite is paragenetically interlaced with silica or kaolinite. Caustic digestion is shown to be effective in breaking up cementation frameworks and liberating the goethite interlaced by silica or kaolinite. Large single domain goethite and high chromium substituted goethite are also identified in the slow leaching samples. A better understanding of the microstructure of the acid resistant laterite ores is expected to lead to improvement in the hydrometallurgical processing for these ores.

Keywords: Laterite; Acid leaching; Caustic digest; Goethite; Morphology

Avijit Biswal, Barsha Dash, B.C. Tripathy, T. Subbaiah, Shun Myung Shin, Kali Sanjay, B.K. Mishra, Influence of alternative alkali reagents on Fe removal during recovery of Mn as Electrolytic Manganese Dioxide (EMD) from Mn sludge, Hydrometallurgy, Volume 140, November 2013, Pages 151-162, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.10.001.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001965)

Abstract: Flow sheet for recovery of Mn values from Mn sludge, a by-product obtained during processing of the Mn nodules through ammonia–ammonium

sulphate–sulphur dioxide leaching process route as Electrolytic Manganese Dioxide (EMD) was developed. The unit operations include dissolution of Mn sludge with sulphuric acid in presence of activated charcoal, purification of liquor in two stages—removal of Fe by adjusting pH to ~ 4 followed by precipitation of other impurities as sulphides by addition of Na2S. The purified liquor was electrowinned for producing EMD. During first stage purification, Fe precipitation was carried out with CaO that resulted in loss of Mn due to its entrapment in the gypsum. The paper discusses use of alternative alkali reagents MgO and NaOH to minimise the Mn loss. Physico-electrochemical characteristics of the EMD produced from the purified MnSO4 solutions obtained by using CaO, MgO and NaOH for Fe removal during stage I purification and subsequent stage II purification of other impurities as sulphides was investigated and the discharge capacities of the EMD samples were found to be 267, 260 and 250 mAhg− 1 respectively.

Keywords: Mn sludge; Electrolytic Manganese Dioxide; Iron precipitation; Solid–liquid separation; Discharge capacity

Julian M. Steer, Anthony J. Griffiths, Investigation of carboxylic acids and non-aqueous solvents for the selective leaching of zinc from blast furnace dust slurry, Hydrometallurgy, Volume 140, November 2013, Pages 34-41, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.08.011.

(http://www.sciencedirect.com/science/article/pii/S0304386X13001722)

Abstract: The recycling of iron bearing dusts produced during iron and steel manufacturing processes is vital to the sustainability of these processes; however, contamination of these dusts with zinc increases the difficulty to do this. Blast furnace dust, collected by a wet scrubber system, was sampled and characterised to investigate the removal of zinc to produce a treated residue with low zinc content suitable for recycling through the blast furnace. This paper examines a leaching process for the dust using different organic carboxylic acids, to establish if they were capable of extracting high levels of zinc and low levels of iron. Prop-2-enoic acid was found to be particularly effective, extracting high levels of zinc up to 85.7% and low levels of iron, 8.5%. The paper also discusses the mechanisms of extraction more specifically for organic carboxylic acids and found that the iron extraction was well explained by the variation in pH and the Bronsted–Lowry theory; whereas zinc extraction was well explained by substituent group effects and the Lewis acid/base theory. The novel use of a non-aqueous solvent with prop-2-enoic acid, to minimise the ion solvating ability and proton dissociation, was found to reduce the level of iron extraction from 8.5% to 0.1% without detrimental effect on zinc extraction when leaching. A range of mineral and carboxylic acids were also tested to investigate and compare the effect of pH and chemical structure on the leaching efficacy.

Keywords: Blast furnace dust; Carboxylic acid; Leaching; Zinc extraction; Hydrometallurgical

Shaotao Cao, Haijun Ma, Yi Zhang, Xiaofan Chen, Yifei Zhang, Yi Zhang, The phase transition in Bayer red mud from China in high caustic sodium aluminate solutions, Hydrometallurgy, Volume 140, November 2013, Pages 111-119, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.09.009.

(http://www.sciencedirect.com/science/article/pii/S0304386X1300193X)

Abstract: The phase transitions of the main substances in Bayer red mud in high caustic sodium aluminate solutions were studied. Without addition of lime, cancrinite was not found to transform to $CaNaHSiO_4$ even with 16 wt.% CaO present in the original residue up to 270 °C. However, this transition was verified to be a fast reaction which was completed in just 10 min with the temperature higher than 240 °C after adding lime, thus enabling the extraction of Al_2O_3 from the red mud. Whether additional CaO was supplemented or not, the isomorphous substitution of Fe to Al atoms occurred in hydrated andradite as long as the temperature was more than 240 °C, providing another way to extract Al_2O_3 from Bayer red mud. Accordingly the A/S (weight ratio of solid Al_2O_3 to SiO_2) of red mud would reduce to 0.134 after the complete transition from $Ca_{2.93}Al_{1.97}Si_{0.64}O_{2.56}(OH)_{9.44}$ to $Ca_3(Fe_{0.87}Al_{0.13})_2(SiO_4)_{1.65}(OH)_{5.4}$ in our study, assuming no other Al or Si containing phases. Furthermore, the addition of $CaNaHSiO_4$ seed was confirmed to accelerate both the transition of cancrinite to $CaNaHSiO_4$ and the reaction of isomorphous substitution in the andradite.

Keywords: Bayer red mud; Phase transition; Cancrinite; CaNaHSiO4; Hydrated andradite

Zhongwei Zhao, Jialiang Zhang, Xingyu Chen, Xuheng Liu, Jiangtao Li, Weiguang Zhang, Separation of tungsten and molybdenum using macroporous resin: Equilibrium adsorption for single and binary systems, Hydrometallurgy, Vol. 140, November 2013, Pages 120-127,

(http://www.sciencedirect.com/science/article/pii/S0304386X13002016)

Abstract: Tungsten and molybdenum are widely used in many hi-tech industrial products, but it is a challenge to separate them from the resources containing high contents of the two metals. Based on the difference in tendency to polymerize between W and Mo, a new method using macroporous weak base resin was developed to separate W and Mo. The feasibility of this method was evaluated in this work, particularly. The effect of pH and contact time was studied on the adsorption of W and Mo using macroporous weak base resin D301. In addition, the equilibrium adsorption of W and Mo was investigated at the optimal pH-value in both individual and binary systems. Several single-component and multi-component isotherm models were used to analyze the experimental adsorption data, with which the values of parameters were obtained accordingly. The Freundlich model and the extended Freundlich model were successfully applied to describe the adsorptive behavior of W and Mo in the single and binary system, respectively. Tungsten and molybdenum in the binary adsorption system are interacting with each other in an

antagonistic manner and the former exhibits stronger competitive ability. As a result, the equilibrium adsorption amount of W is much higher than that of Mo in the mixed solution. Obviously, the proposed method can effectively separate W and Mo from the mixed solution, and it may have a very promising future in industry.

Keywords: Tungsten; Molybdenum; Macroporous resin; Competitive adsorption; Multi-component adsorption models

R.P. Girón, B. Ruiz, E. Fuente, R.R. Gil, I. Suárez-Ruiz, Properties of fly ash from forest biomass combustion, Fuel, Volume 114, December 2013, Pages 71-77, ISSN 0016-2361, http://dx.doi.org/10.1016/j.fuel.2012.04.042.

(http://www.sciencedirect.com/science/article/pii/S0016236112003249)

Abstract: Nowadays forest biomass is increasingly being used as a renewable energy source. This application, however, has the disadvantage that it produces large quantities of fly ash. The characteristics of the fly ashes produced differ depending on the source of the biomass and the combustion conditions; and these characteristics determine its eventual application (in cement, nutrient soil, etc.). In addition the absence of heavy metals in the fly ashes makes them very useful as a means of obtaining activated carbon, zeolite or belite cement. In this work fly ashes from the combustion of forest biomass (Eucalyptus globulus bark) in a pulp mill in Northern Spain were investigated. The ashes were produced by two types of combustion systems: grate furnace and fluidized bed combustion. Close examination of the raw fly ashes and their corresponding sieved fractions of different grain size led to the following conclusions: (i) fluidized bed combustion of forest biomass is more efficient than grate furnace combustion; (ii) unburned carbons tend to be concentrated in the granulometric fractions of higher grain size, particularly in the fly ash from grate furnace combustion; (iii) the higher grain size fraction shows good textural properties that make it a potential precursor for activated carbons, (iv) the largest concentrations of mineral matter occur in the finest granulometric fractions which could be used as fertilizers or as raw material to obtain zeolites or belite cement, and (v) the intermediate granulometric fraction from fluidized bed combustion, due to its high concentration of SiO2 originating from the combustor bed, could be used again to make up the combustor bed.

Keywords: Eucalyptus globulus; Fly ash; Grate furnace combustion; Fluidized bed combustion; Unburned carbons

Ashu Rani, Chitralekha Khatri, Renu Hada, Fly ash supported scandium triflate as an active recyclable solid acid catalyst for Friedel–Crafts acylation reaction, Fuel Processing Technology, Volume 116, December 2013, Pages 366-373, ISSN 0378-3820, http://dx.doi.org/10.1016/j.fuproc.2013.08.003.

(http://www.sciencedirect.com/science/article/pii/S0378382013002634)

Abstract: Coal generated fly ash is converted into an efficient solid Lewis acid catalyst by loading scandium triflate on thermally and chemically activated fly ash. The activation of fly ash increased the surface silanol groups responsible for loading of scandium triflate species on fly ash surface. The physico-chemical properties of prepared fly ash supported scandium triflate (FST) catalyst were examined by XRD, FTIR, TEM and TGA analysis. The proposed model structure of FST shows that the triflate species withdraws the electron density from the scandium resulting in generating electron deficient Lewis acid sites on fly ash surface as confirmed by NH3 adsorbed FT-IR spectrum of FST catalyst. The catalyst showed higher activity for solvent free single pot Friedel–Crafts acylation of 2-methoxynaphthalene (2-MN) using acetic anhydride as an acylating agent achieving conversion up to 84% and selectivity of the desired product, 2-acetyle-6-methoxynaphthalene (6-AMN) up to 73%. 6-AMN is a precursor for anti-inflammatory drug, (S)-(+)-6-mathoxy-α-methyl-2-naphthaleneacetic acid, known as Naproxen. The stability of the catalyst was confirmed by hot filtration test. The catalyst could be easily regenerated and reused giving similar conversion up to three reaction cycles under similar experimental conditions. The work reports an alternative pathway for utilization of waste fly ash by using it in developing novel and cost effective, recyclable catalyst system for industrially important acylation reactions.

Keywords: Fly ash; Solid Lewis acid; Scandium triflate; Acylation

Olga V. Tupikina, Susanna H. Minnaar, George F. Rautenbach, David W. Dew, Susan T.L. Harrison, Effect of inoculum size on the rates of whole ore colonisation of mesophilic, moderate thermophilic and thermophilic acidophiles, Hydrometallurgy, Available online 19 December 2013, ISSN 0304-386X, http://dx.doi.org/10.1016/j.hydromet.2013.10.010.

(http://www.sciencedirect.com/science/article/pii/S0304386X13002107)

Abstract: Bioheap leaching of low grade copper sulphides has been applied successfully at the commercial scale for the extraction of copper from secondary sulphide minerals. It is important to optimise the inoculation of heaps in order to minimise the residence time required for the heap and to maximise extraction. Thermophilic bioleaching of the primary sulphide chalcopyrite poses an additional challenge of rising temperatures inside the heap demanding microbial succession. After heap start up, rising heap core temperatures make conditions less favourable for mesophilic microbial species, and the moderately thermophilic community succeeds them in the consortium. In turn, thermophilic microorganisms succeed the moderately thermophilic microbes as the higher temperatures are reached. A detailed understanding of the microbial colonisation of whole ore is necessary to optimise microbial succession during thermophilic bioleaching, as is that of microbial growth kinetics on whole ore. Most published research is focused on microbial growth rates of bioleaching organisms in liquid cultures; little work is reported on microbial colonisation of whole ore and subsequent microbial activity. To extend the information available on the microbial diversity and succession in a

bioleaching habitat, a study of bioleaching microbes colonising the ore body is required.

Keywords: Bioleaching; Chalcopyrite; Mesophilic; Moderate thermophilic and thermophilic chemolithotrophic micro-organisms; Microbial colonisation; Heap inoculation.

S. Poorni, K.A. Natarajan, Microbially induced selective flocculation of hematite from kaolinite, International Journal of Mineral Processing, Volume 125, 10 Dec. 2013, Pp. 92-100, http://dx.doi.org/10.1016/j.minpro.2013.10.002.

(http://www.sciencedirect.com/science/article/pii/S0301751613001981)

Abstract: Microbially induced selective flocculation of hematite from kaolinite has been demonstrated using Bacillus subtilis. Growth of bacterial cells in the presence of kaolinite resulted in enhanced production of extracellular proteins while that of hematite promoted significant secretion of exopolysaccharides. Bacterial cells were adapted to grow in the presence of the minerals and use of hematite-grown and kaolinite-grown cells and their metabolic products in the selective flocculation of hematite and dispersion of kaolinite illustrated. Bacterial cells and extracellular polysaccharides exhibited higher surface affinity towards hematite, rendering it hydrophilic; while significant protein adsorption enhanced surface hydrophobicity of kaolinite. Bacterial interaction with hematite and kaolinite resulted in significant surface chemical changes on the minerals. Due to higher surface affinity towards extracellular proteins, zeta potentials of kaolinite shifted in the positive direction, while those of hematite shifted in the negative direction due to higher adsorption of extracellular polysaccharides. Bacterial interaction promoted selective flocculation of only hematite, while kaolinite was efficiently dispersed. Mineral-specific stress proteins were generated on growing B. subtilis in the presence of kaolinite. Interfacial aspects of microbe–mineral interactions are illustrated to explain microbially-induced selective flocculation of hematite from kaolinite with relevance to clay and iron ore beneficiation.

Zhiming Sun, Xiaoping Yang, Guangxin Zhang, Shuilin Zheng, Ray L. Frost, A novel method for purification of low grade diatomite powders in centrifugal fields, International Journal of Mineral Processing, Volume 125, 10 December 2013, Pages 18-26, http://dx.doi.org/10.1016/j.minpro.2013.09.005.

(http://www.sciencedirect.com/science/article/pii/S0301751613001907)

Abstract: This study presented a novel method for purification of three different grades of diatomite from China by scrubbing technique using sodium hexametaphosphate (SHMP) as dispersant combined with centrifugation. Effects of pH value and dispersant amount on the grade of purified diatomite were studied and the optimum experimental conditions were obtained. The characterizations of original diatomite and derived products after purification were determined by scanning electron microscopy (SEM), X-ray diffraction (XRD), infrared spectroscopy

(IR) and specific surface area analyzer (BET). The results indicated that the pore size distribution, impurity content and bulk density of purified diatomite were improved significantly. The dispersive effect of pH and SHMP on the separation of diatomite from clay minerals was discussed systematically through zeta potential test. Additionally, a possible purification mechanism was proposed in the light of the obtained experimental results.

SELECTIVE ABSTRACTS

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

Anand, Amit and Jha, Manis K and Kumar, Vinay and Sahu, Rina (2013) ***Recycling of Precious Metal Gold from Waste Electrical and Electronic Equipments (WEEE): A review.*** **In: Proceeding of the XIII International Seminar on Mineral Processing Technology, 10/12/2013 To 12/12/2013, CSIR-IMMT, Bhubaneswar.**

Gold finds a wide range of application in electronic devices i.e. in mobile phone PCBs, coated plates, connectors etc. This is because of its high conductivity, ability to carry low ampere current, high sensitivity and resistance to corrosion. Due to the increasing demand of electronic devices conventional reserves of gold are depleting. At the same time life of electronic goods is decreasing because of rapid changes in device features and abilities. This produces a large amount of obsolete electronic gadgets which gradually results into a large amount of electronic waste. Even during production of electronic products, steps involved generate waste water containing gold which can be recycled. In order to meet the increasing demands and conserve resources, it is necessary to recycle the e-waste generated. Gold recovery is also necessary because of its high market value and vast application in different fields such as jewelry, coinage, medical appliances etc. Recovery of gold from e-waste has gained attention because of its concentration in e-waste which is around 100 times more than that is found in gold ores. The present paper gives an idea of the various hydrometallurgical processes such as cementation, adsorption, solvent extraction etc used in the recovery of gold from electronic scrap. The paper also highlights the use of different types of leachants such as Cyanide, Thiourea, Thiosulfate etc. for the recovery of gold. Chemical reactions and the process parameters viz. pH, temperature, concentration of leachant, pulp density, stirring speed etc. involved in different processes are also reported. Based on the review made, some flow sheet and recommendations have been proposed for effective and feasible recovery / recycling of gold from e-waste.http://eprints.nmlindia.org/6797/

Choubey, Pankaj K and Jha, Manis K and Sahu, S K and Kumar, Vinay and Jeong, Jinki and Lee, Jae-chun and Pathak, Devendra Deo (2013) *Solvent extraction (SX) and separation of Sn/ Pb from the leach liquor of waste solder material and effluents.* In: Proceedings of the XIII international Seminar on Mineral Processing Technology (MPT-20I3), 10/12/2013 to 12/12/2013, CSIR-IMMT, Bhubaneswar.

R&D efforts have been made to develop a suitable process for extraction and separation of tin (Sn) and lead (Pb) metals from the chloride leach liquor of waste solder material and effluents using solvent extraction (SX) process. The studies were carried out for the extraction of tin from the leach liquor of solder materials containing 24.71 g/L Sn and 3.54 g/L Pb using tris 2-ethylhexyl amine (TEHA) diluted in kerosene and isodecanol was used as a modifier. The percentage extraction of Sn from leach liquor was found to be increased with increase in the concentration of extractant (TEHA). The 98.58% recovery of Sn was found using 20% TEHA in contact time 15 min and phase ratio (O/A) 1. Mc-Cabe Thiele diagram was also plotted to determine the stage requirement for the selective extraction of Sn using 20% tris 2-ethylhexyl amine and it was found that at O/A 0.5 in 2-stages of counter current extraction, Sn can be completely recovered from the leach liquor. After the stripping of Sn from loaded organic, the pure solution of tin is obtained. The pure lead solution is obtained as raffinate. From the purified solutions, lead and tin the salts/ metals could be obtained using crystallization/ electrolysis.
http://eprints.nmlindia.org/6773/

Dey, Shobhana and Paul, Gyan Manjari and Pani, Santosh (2013) *Flotation behaviour of weathered coal in mechanical and column flotation cell.* Powder Technology, 246 (IF-2.265). pp. 689-694.

The low rank or oxidized coals show unpleasant flotation behaviour. The non-coking coal from Talcher, containing 26.8% ash, 4.9% moisture, 35.7% volatile matter and 1% oxygen was used for the investigation. The flotation performance of the weathered coal in a mechanical and column flotation cell was compared at low ash level of about 12%. The oxidized coals possess negative surface charge due to the surface functional groups like carboxylic (− COOH) and phenolic (− OH). The surface charge could be determined by zeta potential study. The flotation at different pH values and pre-treatment of coal fines using a modifier were studied in a mechanical and column flotation cell. This type of coal is very difficult to float even at higher concentration of collector due to less dispersion of the collector molecules on the coal surface. The surface charge determined by the zeta potential study appears to be negative. It designates the oxidation of the surface and makes the coal hydrophilic in nature. As a result, attachment of air bubbles with the particles gets reduced. Flotation performances, due to the modifier added in grinding mill, give encouraging results as it is inferred from the isoelectric point shifted towards the alkaline regime. Flotation studies carried out with promoter added in the mill followed by diesel oil in mechanical cell show that cleaning of the rougher concentrate is essential to reduce the ash content in the concentrate, whereas the

single-stage flotation in a column is found to be better which yields 49.6% concentrate at 12% ash. http://eprints.nmlindia.org/6671/

Dey, Shobhana and Pani, Santosh and Bhattacharyya, K K (2013) *Effective processing of iron ore slime using column flotation.* In: Flotation-13, 18-22 November 2013, Cape Town, South Africa.

Indian iron ores slimes are generally rich in iron content. The presence of high alumina and silica in the iron ores reduces the grade and poses difficulty in processing. Due to fine granulometry and mineralogical complexity, processing of iron ore slimes by conventional physical separation methods such as gravity and magnetic separation, has limited success. Froth flotation is a versatile method used in mineral processing to remove the impurities from the fine ore. The iron ore slime containing 58.7% Fe, 5% SiO2 and 4.88% Al2O3 was used for this investigation. Column flotation was used as it is a better alternative for processing of iron ore slimes. Tests were conducted at alkaline pH using sodium oleate as a collector and MIBC as frother. A factorial design of experimental approach was followed taking three variables namely froth height, superficial air velocity and collector dosage. The interaction effects of variable parameters on recovery and Fe grade of concentrate were studied. The relationship between residence time of air in froth zone and recovery was also studied. http://eprints.nmlindia.org/6769/

Ghosh, Anirban and Kumari, Sujata and Abhilash, and Pandey, B D (2013) *Microbial upgradation of Meghalaya coal by Rhodococcus rhodochrous and Pseudomonas aeruginosa.* In: Proceedings of XIII international seminar on Mineral Processing Technology, 10-12, December 2013, Bhubaneswar.

Meghalaya Coal contains 1.61 to 8.92 % of sulfur. The sulfur commonly exists as inorganic sulfur Meghalaya found mainly as pyrite and organic sulfur (mainly found as heterocyclic aromatic compounds like thiophene, dibenzothiophene and phenyl disulphide). In this investigation, bacterial strain enriched with L.ferrooxidans isolated from Tirap coal mines, Assam in 9K media at 40oC and pH 1.6-1.8, was able to remove 51.4% pyritic sulfur using 10%(w/v) Meghalaya coal sample of <50μm size in 3 days. Consequently, two different bacteria Rhodococcus rhodochrous and Pseudomonas aeruginosa pre-adapted on 75mM of dibenzothiophene (DBT) and Phenyl disulphide (PDS) respectively resulted in maximum 51% and 52% desulfurization 10 %(w/v) non-depyritised feed coal sample at an optimum pH 6 and 40oC, in 72h. The various parameters governing the process are discussed.
http://eprints.nmlindia.org/6777/

Jha, Amrita Kumari and Jha, Manis K and Kumar, Vinay and Sahu, Rina (2013) *Recovery of neodymium as value added product NdF3 from rare earth magnet.* In: Proceedings of the XIII International Seminar on Mineral Processing Technology (MPT-20 I 3), 10/12/2013 to 12/12/2014, CSIR-IMMT, Bhubaneswar.

Rare earth metals (REMs) have broad applications in the manufacturing of fluorescent materials for lamp, CRT and plasma displays, permanent magnets for hybrid car, hard disk of personal computer etc. These equipments are disposed at the end of their life which cause hazardous to environment and also affect human health as well as aquatic life. In order to conserve the natural resources and reduce the environmental pollution, the hydrometallurgical process has been studied to recover the valuables from magnet of the hard disk of the personal computers. The various process parameters have been studied to leach out the neodymium and other associated metals viz. iron, nickel, boron using sulfuric acid as lixiviant at different pulp density and time. A quantitative dissolution of neodymium and other metals was achieved under the optimized condition. Pure neodymium fluoride salt was produced from the purified solution by the selective precipitation, crystallization/ evaporation processes. http://eprints.nmlindia.org/6772/

Gupta, R C (2013) *The utilisation of iron ore fines : Technical options and challenges.* Journal of Metallurgy and Materials Science, 55(4) (Non-SCI). pp. 235-256.

This paper presents the scenario of its current use by sinter and pellet industry. It also gives the factors which are considered to utilize the ore fines e.g. chemical analysis, energy use, equipment requirement and scope of product use. The R & D work done in India has resulted the development of various products utilizing waste fines from mines and steel plant. These technologies which are under development, eg fluxed pellet, hollow pellet, CPR Pellet, Fluxed DRI, Iron Granules and Iron Cake, are described in this paper. It has been concluded in the paper that India is a leading iron ore producer in the world and has enough potential to use its own resources. The present sinter and pellet plant capacities can be enhanced much further along with assessment for the viability of exploiting the in house emerging technologies. The potential technology may be promoted through pilot trials in India. http://eprints.nmlindia.org/6887/

Kumari, Anjan and Kumar, Vinod and Jha, Manis K and Soni, B K (2013) *Processing of poly-cracked ash of printed circuit boards for recovery of valuable and rare metals.* In: Proceedings of the XIII International Seminar on Mineral Processing Technology (MPT-20I3), 10/12/2013 to 12/12/2013, CSIR-IMMT, Bhubaneswar.

In the present study, recovery of valuable and rare metals from the poly-cracked ash of printed circuit boards obtained from pyrolysis has been incorporated by following physical beneficiation and hydrometallurgical process. The ash is subjected to size reduction for the separation of metallic component from non-metallic fractions by tabling and froth flotation by which 95-97% of metal enrichment in the concentrate was obtained. Subsequently the enriched metal concentrate was subjected to selective metal extraction by hydrometallurgical treatment. Most of the

metals (Cu, Pb, Fe, etc) were leached in HNO3 at elevated temperature and variable time interval using a pulp density of 100 g/L. The characterization of both poly-cracked ash and residues left after leaching were made by XRD, EPMA, EDS, etc. to validate the experimental results. The metals of interest from the leach liquor could be recovered/separated using solvent extraction technique which can further be processed to get pure metal salts/ sheets. http://eprints.nmlindia.org/6774/

Pani, Santosh and Dey, Shobhana and Singh, Ratnakar (2013) *Quantitative Evaluation of Frother Blend Interaction and Its Effect on Coal Flotation.* In: Proceedings of the XIII International Seminar on Mineral Processing Technology (MPT-2013), 10-12 December, 2013, IMMT, Bhubaneswar.

In this investigation the weak and powerful frothers, like methyl isobutyl carbinol (MIBC) and polyethylene glycol-600 (PEG) were used for studying the surface tension of frother blends at various concentrations. The critical micelle concentrations (CMC) were determined using surface tension values at different concentrations. PEG requires very low concentration (100 ppm) to attain the CMC, whereas for MIBC, about ten times more concentration (1000 ppm) is required.The interactions between the different types of frother molecules at different blends were studied through different thermodynamic properties. A more negative value of interaction parameter (â)and heat of adsorption are found at 90:10 ratio of frother blend. Flotation studies of coal fines were studied with above two types of frothers and their blend. It is found that recovery of carbon value increases significantly when a 10% (w/w) of powerful frother was added with MIBC. The recovery of carbon at 90:10 ratio of frother blend is 77.6% at 18% ash. http://eprints.nmlindia.org/6808/

Pramanik, Swati and Purohit, Bijoy Kumar and Meshram, Pratima and Sahu, S K and Pandey, B D (2013) *Chemical Beneficiation of Physically treated Hingula coal on Laboratory scale.* In: Proceedings of the XIII International Seminar on Mineral Processing Technology (MPT-20 I 3), 10/12/2013 to 12/12/2014, CSIR-IMMT, Bhubaneswar.

Crude oil and coal are the backbone of energy chain for industrial growth, but limited production of oil in India makes coal as the only reliable source of energy. Due to non-availability of good quality coal, supply of high ash (15-55%) coal to power sector has increased over the years. Such coals cause erosion, difficulty in pulverization, low flame temperature and affect efficiency of thermal power station. Although coal is mostly beneficiated by physical method, but combining it with chemical method may improve the quality and efficiency of boilers/plant capacity while reducing the greenhouse gas emissions. This study is based on the treatment of Hingula coal (29.6% ash) obtained from Talcher coal field, Odisha. After physical beneficiation (prox. anal.: 13.3% ash, 49.0% FC, 37.7% VM and 11.8% moisture) material was chemically treated with different alkali and acids to further reduce the ash content. Process parameters such as alkali/acid concentration, time,

temperature and pulp density were optimised for de-ashing of coal. Bench scale treatment with Na2CO3 solution for 60 min at 85^{0}C and 60% pulp density followed by acid wash with dil. HCl, reduced ash content to 9.8%. Similar results were obtained when coal was treated with 10% H2SO4 for 60 min at room temperature and 10% pulp density. Coal before and after chemical beneficiation was characterised by XRD and EPMA. Experiments were carried out on kg scale to validate the bench scale data. When physically beneficiated coal (~1.2 kg) was treated with 0.25N Na2CO3 solution for 60 min at 85^{0}C and 60% pulp density followed by acid wash with 1% HCl in an agitated reactor, ash content was reduced to 8.98%. The product is being characterised to ascertaining the properties of the demineralised coal. http://eprints.nmlindia.org/6819/

Vasumathi, N and Vijaya Kumar, T V and Ratchambhigai, S and Subba Rao, S and Prabhakar, S and Bhaskar Raju, G and Shivakumar, S and Uma, Raman (2013) *Single reagent for graphite flotation.* In: XIII International Seminar on Mineral Processing Technology (MPT 2013), 11 to 13 December 2013, CSIR-IMMT, Bhubaneswar.

Generally, diesel and frother are used as reagents in graphite flotation. With the escalating cost of petroleum products and their negative impact on environment, attempts are made to formulate an eco-friendly single reagent to replace the diesel-frother system without affecting the flotation performance. CSIR-NML Madras Centre in collaboration with M/s Somu Organo Chem Pvt Ltd., India, has worked out the formulation and evaluation of single reagent on a low grade graphite ore sourced from eastern India. The petrography studies indicate that the ore primarily consists of quartz and graphite with minor quantity of mica and analyzing 87.85% ash content. The ore is crushed in stages followed by primary coarse wet grinding to 242 µm (d80). Rougher flotation is carried out in Denver flotation cell with a view to eliminate gangue as much as possible in the form of primary tailings with minimal loss of carbon. Regrinding of rougher concentrate to 216 µm (d80) is opted to improve the liberation of graphite values. This approach involving a primary coarse grinding and regrinding of rougher float followed by multi-stage cleaning using this single reagent is found to yield better recovery and grade when compared with that of the dual reagent system. A final concentrate of 12.03% weight recovery with 3.22% ash could be achieved. Based on encouraging laboratory studies using the single reagent, plant trials were carried out. From the cost benefit analysis, this single reagent proves to be an economically viable in place of diesel-frother for processing low grade graphite. http://eprints.nmlindia.org/6815/

Vidyadhar, A and Renuka, D and Sharma, Mamta (2013) *High Ash Non-Coking Coal from India: Beneficiation and Implications.* In: Proceedings of the XIII International Seminar on Mineral Processing Technology (MPT-2013), 10-12 December, 2013, IMMT, Bhubaneswar.

In the entire spectrum of industrialization from global perspective, coal as the primary source of energy is the fulcrum of major developmental factors on which hinges the growth of economy at macro level, supposedly vital for improvement in quality of living conditions, thereby, impacting the lives of millions across the world. The International Energy Agency (IEA) as well as national/regional energy agencies have projected coal to be the key component of energy mix well into the future. The primacy of coal as source of energy is factually expected to surpass the significance of oil as a typical and primary source of energy in next 4-5 years, and this phenomena per se has the potential in accomplishing the much desired cost economy in providing respite from consistent escalation in input cost of energy generation. India by definitive coal reserves estimation undertaken by the Ministry of Coal is pegged at 93 billion tonnes, and with appropriate investigation and advancement in efficacious methodologies for scientific exploitation, the estimated reserve is sufficient to cater to energy generation requirement of the country, spanning over 30 to 60 years. 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, Odhisa, 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, chemical composition and the gross calorific value of the coal was observed to be 3221 Kcal/kg. The beneficiation process was initiated at a top size of 6.3 mm after initial deshaling of the ROM coal. 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. 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/6814/.