IMP@CT Stakeholder Meeting
28 March 2017

The Polish Club, 55 Prince's Gate, Exhibition Road, London SW7 2PG

Technical engineering and plant operation

Programme

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STAKEHOLDER MEETING 01

Tuesday 28 March 2017

Technical Engineering & Plant Operation

"Challenges associated with Small-Scale plant design and operation"

"Opportunities to apply innovative technologies at the Small-Scale"

Time	Speaker	Title
08.30	Registration	Tea & coffee available
09.00	Tim Sambrook	Welcome and overview of the IMP@CT technical concept
09.10	Colin Collino	Design/build considerations with small-scale plants
09.40	Ludo de Ferranti	Operational obstacles and solutions when processing at the small scale
10.10	Gregor Borg/ Felix Scharfe	The VeRo Liberator technology and how it might be applicable to the small-scale mining and minreal processing field
10.40	Refreshment break	
11.10	Mike Battersby	A technological blueprint for state of the art minerals processing within the European Union
11.40	Paul Ainsworth	Technology options for thickening, tailings disposal and design considerations for slurry transport at the pilot-scale
12.10	LUNCH	
13.15	Gawen Jenkin	By-product recovery of gold and critical elements from ores and concentrates using deep eutectic solvent ionic liquids: BRIO
13.45	Andrew Batchelor	Copper NuWave^{tm} and Microhammer^{tm} overview and lessons learned from working in multi-disciplinary technology teams
14.15	Workshop session	4 round-table discussion to focus on technical challenges
15.20	Refreshment break	
15.30	Note takers	4x5 minute synopses of key points
15.50	Kate Moore	Wrap up comments
16.00	Depart	

Colin Collino

Dr Colin Collino is the chief executive of Gravity Mining Ltd, a Cornish based engineering company specialising in design and manufacture of gravity separation equipment. Gravity mining's engineers have worked for the past 20 years with Richard Mozley's, multi gravity separator and now the company continues to develop a new generation of enhanced gravity separators. Over the last 12 months the company has worked with Minsur, Wolf Minerals, Power Resource Group, Exeter University, SGS and Traxys. Gravity mining also works on projects supporting artisanal and small-scale mining where mobility and multi location deployment is often a primary design feature. Colin has 29 years experience of leading and building start up businesses. The consistent theme of these companies has been the re-engineering of traditional revenue generating businesses with emerging technology. His business experience has mainly involved engineering, mining, media and software development.

Colin trained as a medical doctor at St Thomas's Hospital London and pursued a medical career mainly at the Royal London Hospital to consultant level. Whilst studying for a PhD in lung developmental biomechanics he developed his fascination for technology seeing the huge advantage to be gained from its early adoption.

Design / build considerations with small-scale plants

Dr Colin Collino, CEO Gravity Mining Ltd

A change in the mining model from high capital, long lead time fixed installations for world class deposits to a more flexible smaller scale equipment requirement that may be used in multiple locations creates bespoke design and build challenges. A SOSO mining model offers a new approach to equipment design and build. We will discuss the design requirements informed by mineralogy, operating environment, owner or community input, social license to operate, service life, maintenance, budget, time to deployment, mobility and infrastructure, safety, waste, water, energy and economic use.

We will also discuss the build options for this new generation of equipment, including build location, build materials, proprietary parts, quality control, testing and local and remote monitoring.

The above criteria will be illustrated with practical examples of Gravity Mining projects and with special reference to advances in gravity separation.

Ludo de Ferranti

Ludo is the founder and CEO of Ferranti Processing (FP) a gold producing company focused on tailings re-treatment and brownfield development in Tanzania.
Ludo's work involves finding feasible and safe routes into production from an early stage by initiating the correct project approach and plant design primarily for utilising old stockpiles, tailings or shallow near surface reserves in order to get the production to fund further development.
Aside from FP's larger and well established projects, Ludo has designed and built a movable and modular gold processing plant consisting of crushing, milling, gravity concentration, intensive leach, and agitated leach to take advantage of projects that currently have small reserves and standard practice would be unjustifiable. This readily moveable plant and business strategy has demonstrated good results at early stage or higher risk projects into economically extracting gold.
Ludo consults on design, construction and risk optimisation management for projects across East and Southern Africa ranging from small start-ups to mid-tier miners and exploration companies.

Operational obstacles and solutions when processing at the small-scale

Ludo de Ferranti, Ferranti Processing

The most important question to consider before going any further with plant/project design on this scale is, why are you doing it?

Now considering your available capital, process flow sheet and cash flow there are many variations. Now what I see people doing when running the 'modular plant model' is to add in process by process as cash is generated. However I would say that a single downstream process is often the same price and has far greater extraction efficiency overall. So, no need for the expensive previous up stream processes. By falling in this trap you cut a huge piece from your revenue, coupled with doubling your processing cost when having to re-process it again later. This end of the industry has to run by slightly different rules.

If more people/ consultants could successfully design in house and dodge the salesman, the number and viability of projects would increase drastically. However, I have found that finding someone with real in-depth knowledge of a mine site from bottom to top is a very rare person.

None of this involves cutting on plant quality. There is no substitute to the best plant equipment only. Why? Because the plant itself is a very small percentage of the project and not where you should be looking to make savings.

Gregor Borg

Gregor Borg is a German economic geologist by training and has worked in academia, geological surveys, and industry alike for over 30 years. He studied geology in Germany and South Africa and holds the position of Professor of Economic Geology and Petrology at the Martin Luther University Halle-Wittenberg in Germany. He is deputy chairperson of the advisory board of two public companies, Deutsche Rohstoff AG and Ceritech AG. Additionally, he is a consultant to international exploration and mining companies and – lately - to the mineral processing industry. He is author or coauthor of more than 65 full scientific papers and a large number of confidential internal consultancy reports. He has practically explored for and academically studied various types of precious and base metal deposits on several continents. He can claim the discovery of two gold mines in Tanzania (Buzwagi and Golden Ridge) with over 3 Moz Au contained. His particular expertise is in the field of Archean gold, sediment- hosted lead-zinc, stratabound copper, supergene non-sulphide zinc, and rare earth element deposits. Together with his team, he has specialized in the mineralogical and geochemical characterization of ores and slag (feed and product materials) in the mineral processing of primary and secondary mineral resources.

Felix Scharfe

Felix Scharfe is a German business man and one of the two individual owners of PMS Handelskontor GmbH, based in Hamburg, Germany, who have invented and now manufacture the patented VeRo Liberator®. PMS is a highly innovative engineering start-up company with its offices in Hamburg and engineering and production facilities just outside of Hamburg. Mr. Scharfe has studied international business and has managed the family office in Hamburg since 2002. His background has been in national and international business investments and trade, and he is now also responsible for the international marketing of the VeRo Liberator® to the mining, mineral processing-, smelting-, and recycling industry.

The VeRo Liberator® technique for energy-efficient comminution and improved particle liberation

Gregor Borg & Felix Scharfe, PMS GmbH, Abteistr. 1, D-20149 Hamburg, Germany E-Mails: gregor.borg@geo.uni-halle.de; felix.scharfe@pms-hh.de

The VeRo Liberator® is a new, highly efficient comminution system for all types of ores, metallurgical slags, and solid recycling materials. It has a highly reduced energy consumption, breakage predominantly along particle boundaries, and extremely high degree of particle liberation. Additional features are: water-free operation, low noise level, small physical footprint, and easy maintenance. Throughput is in the range of 60 to 100 t/h and energy consumption between 3 and 12 kWh/t – depending on the materials' properties, i.e. hardness, toughness, (in-)homogeneity, and texture of intergrowth. The machine features a unique vertical, fourfold axle-in-axle system, with steel hammer tools, rotating on three levels clockwise and anticlockwise against each other at very high variable speeds. This results in highly turbulent particle flow, angular particle shapes, and extreme particle size reduction ratios of up to 1.000 for massive sulphide ore and even 6.250 for an industrial mineral composite - all in a single, quick pass of around 20 seconds. It has been five years only from invention, to engineering, accompanying university research with bulk sample testing, and public presentation to market entry, which recently has been achieved with a major global mining house having purchased a first unit.

Mike Battersby

Mike Battersby has over 35 years experience in the minerals industry. In 1997 he co-founded Maelgwyn Mineral Services Ltd (MMS), based in Cardiff, Wales, where he is currently the Managing Director. MMS provide innovative new technology to the mineral extraction and environmental industries. Prior to this Mike had many years operational experience with AngloGold, DeBeers and Billiton in Africa and Australia. Mike has degrees in Mineral Processing (Cardiff University) and Enterprise & Innovation (Swinburne University of Technology) He is a Chartered Engineer and is a Member of the Institute of Materials, Minerals & Mining (London), the Australasian Institute of Mining & Metallurgy and the Society of Mining Engineers of AIME (USA). Mike is a Director of CEEC - the Coalition for Energy Efficient Comminution – a not for profit global industry organization promoting energy efficiency in mining. Mike is also active in the sporting world of triathlon where he is an international age group competitor and sits on the Board of Directors of both the British Triathlon Federation and Welsh Triathlon.

A Technological Blueprint for State of the Art Minerals Processing within the European Union

Michael Battersby, Maelgwyn Mineral Services Ltd, Cardiff, Wales, UK

The historical development of mining over the last century has moved mining away from the densely populated areas of Europe to new world countries where resources could be exploited on a much larger scale and such economics of scale could be used to greatly improve profitability. However, in recent times the resources of most of these large scale projects have been depleted and identification of new massive orebodies become rare. This has led to renewed interest in the old historical mining areas of Europe where large scale mining is not really possible for social and environmental reasons despite the resources left having somewhat higher values in modern terms. In addition, many of these historical mining sites have left a legacy of tailings and waste where, due to the processing techniques at the time, still have high metal values but are often synonymous with community issues such as water and dust pollution and exposure to many elements now considered toxic.

Reprocessing of waste and the small scale mining of the associated original deposits has become attractive however the processing methods and equipment mainly used on a large scale over the last 100 years are now not fit for purpose for this specialised environment and a new approach is required. Maelgwyn Mineral Services (MMS) has for 20 years been developing state of the art mineral processing technology and innovative concepts that encompasses the requirements for such applications; high unit throughput but with small footprint, high grade/recovery ratios, minimising or neutralising any waste production that could give rise to future issues, lower energy and water requirements and mobility of equipment. The ultimate aim is to develop a mineral processing facility that is fit for the next century.

Paul Ainsworth

Paul is a Process Engineer and has worked on a wide range of international paste and process related projects. His experience focuses on the development of process flow sheets, equipment design, commissioning and trouble shooting. Paul has extensive knowledge of solid/liquid separation test work that has involved many different ore types and applications. His experience has taken projects from initial testing work, design and engineering through to commissioning and completion. Paul joined the UK based Paterson and Cooke Practice in 2014 and travels extensively supporting the Paterson & Cooke group worldwide. Prior to Paterson & Cooke, Paul spent over 8 years with FLSmidth, formerly Dorr Oliver. He join FLSmidth straight after graduating from the Mineral Engineering BEng course at Camborne School of Mines in 2006. During his time with FLSmidth he worked on many different projects across the globe testing, designing and commissioning both pilot plant and full scale operations.

Technolgy options for thickening, tailings disposal and design considerations for slurry transport at the pilot-scale

Paul Ainsworth, Paterson & Cooke (UK) Ltd.

Tailings produced from a small scale plant can create opportunities to explore options that may not be applicable to large scale plants due to the required throughput, cost and technology. This presentation discusses the available equipment options and the advantages that each offer, as well as the key factors when selecting a particular piece of equipment when operating over a range of materials. Additionally, the considerations and pitfalls when handling small scale flows experienced with small scale plants will also be examined. A number of case studies will be presented which will include small scale plants that have been in operation and the options that were considered during their design with the reasons for the exclusion or inclusion of various technologies.

Gawen Jenkin

Gawen Jenkin is Associate Professor in Mineral Resources at the University of Leicester. He has over 30 years experience as a geochemist and mineralogist with an emphasis on mineral exploration and ore genesis, in particular gold, and has published over 50 peer reviewed papers. Recent projects have included the Cononish gold deposit, Scotland, Cyprus VMS and a re-appraisal of Broken Hill mineralisation. Recently he has led a major collaboration with Prof. Andy Abbott in Chemistry at Leicester to develop the application of deep eutectic solvent ionic liquids to mineral processing, working together with mineral companies in the UK, Sweden, Peru and the Philippines. He is co-principal investigator on a current £3.3M NERC SoS consortium project "Tellurium and Selenium Cycling and Supply (TeaSe)" leading the work package on application of deep eutectic solvents to by-product recovery. He is also a co-investigator on the SOCRATES European Training Network for the sustainable, zero-waste valorisation of critical-metal-containing industrial process residues. He was Chair of the UK Mineral Deposits Studies Group 2010-2013. He is a SEG Fellow, Member of the Mineralogical Society and ProfGradIMM.

By-product recovery of gold and critical elements from ores and concentrates using deep eutectic solvent ionic liquids: BRIO

Jenkin, G.R.T.1, Abbott, A.P.2, Smith, D.J.1, Holwell, D.A. 1, Al-Bassam, A.Z.M.2, Bevan, F.2, and Harris, R.C.2

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Ionic liquids are anhydrous salts that are liquid at low temperature. They are powerful solvents and electrolytes with high selectivity in both dissolution and recovery. Deep eutectic solvents (DES) are ionic liquids that are mixtures of salts such as choline chloride with hydrogen-bond donors such as urea. DESs are environmentally benign, yet chemically stable and the components are already cheaply produced in large quantities [1].

Electrum dissolves rapidly with an iodine oxidizing agent in DES at 50°C and gold recovery by electrodeposition has been demonstrated [2]. This is a potential alternative to cyanidation. A large range of Ag, Bi, Te or Sb sulfides and sulfosalts also dissolve rapidly as do native tellurium and bismuth. Base metal sulfides dissolve relatively slowly, but pyrite, sphalerite and all gangue minerals are insoluble. However, pyrite, arsenopyrite and many other sulphides and arsenides, are soluble by electrolysis in DES [3,4]. Thus inclusions of gold and other target minerals locked within pyrite or arsenopyrite could be liberated by electrolysis.

Processing with DES would be well-suited to small-scale operations with limited water availability, since the DES would be recycled in a closed system and only small volumes of aqueous waste produced. High grade and mineralogically complex concentrates represent ideal materials.

References:
[1] Jenkin GRT et al. (2016) Minerals Engineering, 87, 18-24
[2] Abbott AP et al. (2015) Green Chemistry, 17, 2172-2179
[3] Abbott AP et al. (2017) Electrochemistry Communications, 76, 20-23.
[4] Abbott AP et al. submitted to Green Chemistry January 2017.

Andrew Batchelor

Dr Andrew Batchelor (BEng, PhD) completed his undergraduate studies at the University of Queensland in Minerals Processing Engineering and postgraduate studies at the University of Nottingham in Chemical Engineering.
He has worked extensively on microwave-infrared thermal sorting and microwave-induced fracture of ores applications over the past 10 years, including at both laboratory and pilot scale. The pilot scale systems developed have been operated within University laboratories, industrial estates and at an active mine. The development of novel microwave systems has required working closely with stakeholders and multidisciplinary teams on collaborative projects to understand the techno-economic benefits of microwave processes at scale, supported by metallurgical testing, microwave system design and process optimisation.
Other areas of interest include processing of metalliferous, ferrous and industrial minerals, and remediation and recycling of industrial wastes. His research activities involve fundamental investigations of novel separation and recovery techniques with a view to pursuing scale-up of processes to provide a route-to-market for new and innovative technologies to support sustainable production and use of metals and materials.

Copper Nuwave^{tm} and Microhammer^{tm}: overview and lessons learned from working in a multidisciplinary technology group

Dr Andrew R. Batchelor, Microwave Process Engineering, Faculty of Engineering, The University of Nottingham

Pre-concentration, reducing ore competency and liberation of valuable minerals closer to their native grain sizes are three potential avenues for improving mineral processing operations. Laboratory microwave treatments of ores have for a long time shown potential benefits in these areas with metalliferous ore processing, including reduced comminution energy consumption, enhanced liberation, increased recovery and increased throughput. However, until recently, microwave processes have not been demonstrated at a scale in the order of that required by the mining industry.

The last 10 years has seen a rapid increase in the pace of development of microwave processing in the mining industry through collaborative projects between researchers, mining companies, and technology and engineering specialists. Key to the development process was the integration of electromagnetic design and materials handling solutions for transportation and presentation of the ore to microwave irradiation in a safe and reliable manner, identification of hardware suppliers that were able to support scientific investigations in the short term and with the capacity to fulfil supply chain demand in the long term, and strong engagement from both the project sponsors and customers. This multidisciplinary approach by stakeholders has taken microwave treatments from small batch laboratory experiments to continuous pilot scale systems capable of processing up to 150t/h within 5 years, along with conceptual designs for higher throughput systems supported by techno-economic analysis.

NOTES

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