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Metallurgical Testwork Relating to the Development of the Blötberget Iron Ore Deposit, Sweden

Phase 1 – Bench scale testing of Flygruvan composite sample originating from BB12015-MET003

Markku Kuusisto

Assisted by:
Robert Milne (Tata Steel Consulting)
Matthias Reisinger (Tata Steel Consulting)

GTK Mintec
Tutkijankatu 1
83500 OUTOKUMPU
Faksi (013) 557 557

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Authors Markku Kuusisto, GTK Mintec Robert Milne, Tata Steel Consulting (TSC) Matthias Reisinger, Tata Steel Consulting (TSC)	Type of report Research Report Commissioned by Nordic Iron Ore AB / Paul Marsden
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EXECUTIVE SUMMARY

Nordic Iron Ore AB (NIO) are aiming to redevelop the Blötberget iron ore deposit in Ludvika, Central Sweden, which was the site of a historical underground iron ore mining operation.

NIO provided a metallurgical sample to GTK Mintec from a single drill hole with reference ‘BB12015-MET003’. From this drill hole material a composite sample was generated from intersects 370.25m to 398.60m (approximately 140kg) to match the expected Fe grade, magnetite:hematite ratio and phosphorous content of the ore body.

A programme of mineralogical testwork was devised and overseen by Tata Steel UK Consulting Ltd (TSC) acting on behalf of NIO, with the aim of creating a product suitable for sale to steel producers. The main penalty element of concern was phosphorus which was measured at 0.65wt% P_2O_5 in the composite. The sample also contained 34.5wt% Fe and 39.0wt%, SiO_2 and approximately 30% magnetite as determined by Satmagan.

An initial revenue stream for NIO could be the production of a ‘heavy aggregate’ which would only require basic processing by dry low intensity magnetic separation (LIMS) as specific gravity is the main figure of interest. Two 40kg samples were separated from the main metallurgical sample and tested using LIMS on two differed crushed ore sizes; <20mm and <6.7mm. The following two products were produced which met the required S.G. criteria as set out by NIO:

- Test #1: 53.2% Fe, specific gravity (S.G.) 4.24g/cm3, top size 10mm (<20mm magnetic concentrate crushed to <10mm), 41wt% recovery
- Test #2: 54.7% Fe, S.G. 4.34g/cm3, top size 6.7mm, 41wt% recovery

Physical competency testing was undertaken to gain an understanding of the physical properties of the ore. 20 pieces of >50mm (non-crushed) core were taken from the metallurgical sample at random and sent to Sandvik for Crushability Work Index (CWi = 3.8 +/- 0.8) and Abrasion Index (Ai = 0.30) determination. The results suggest that Blötberget “can be considered a typical iron ore, which is crushed easily but very abrasive”. It is therefore considered that attention must be paid to the generation of large amounts of fines during crushing.

The Bond Rod Mill Work Index was determined by GTK Mintec to be 10.4 kWh/t. This value is at the lower end of the range typically observed for iron ores but in relatively good agreement with the energy consumption data reported for the historical processing plant at Blötberget. A Bond Ball Mill Work Index of 18.8 kWh/t (using a 0.100mm closing screen) was reported. It must be noted that the Bond Work Index (BWi) testwork was conducted with raw composite samples of the feed. Once a flowsheet has been defined, it is important that additional comminution data is generated from samples of the actual material to be ground.

A mineralogical study was undertaken to determine the mineral hosts for iron (Fe) and phosphorus (P) and understand the association and state of liberation of minerals hosting these elements.

The principal iron oxide minerals identified were magnetite (as expected and a primary iron mineral) and hematite (some primary hematite but also secondary martite). A considerable proportion of Fe-oxides appears sufficiently liberated from the gangue at relatively coarse size (~1mm). Electron Microprobe Analysis (EPMA) suggested that both hematite and magnetite are 'pure' in that they carry relatively low levels of impurities and in particular phosphorus in the mineral lattice.

Apatite was identified as the principal carrier of phosphorus. Monazite, a rare earth element (REE) phosphate principally containing cerium (Ce) and lanthanum (La) was also identified. Whilst generally well liberated at particle sizes <250µm, phosphate minerals appear to be more intimately associated with hematite (martite) than with magnetite. One important consequence of this is that hematite will likely require finer grinding to achieve liberation from phosphate minerals.

The distributions of the REE between the minerals were reported as follows: monazite (86%), allanite (8%), synchysite (3%) and xenotime (3%). Whilst the overall content of REE was very small (the feed, for example, contains only 0.03wt%), REE did become concentrated in the phosphate-rich froth removed during the batch flotation tests. It is known that, historically, Grangesberg produced a phosphate concentrate containing 17% P for manufacture of 'superphosphate' (fertiliser) which also contained 0.7% REE.

Davis Tube recovery (DTR) tests were undertaken to investigate the release of magnetite at different grind sizes. Subsequent wet LIMS using a drum-type separator failed to produce a satisfactory concentrate from the ground feed at <0.63mm (9.8% SiO_2, >0.3% Na_2O+K_2O). LIMS at <0.315 mm produced a concentrate with 68.9% Fe and satisfactory phosphorus content (<0.03% P), however the content of SiO_2 was slightly elevated (4.2%). LIMS at <0.075 mm produced a high-grade concentrate with ~72% Fe, 0.52% SiO_2 and very low phosphorus content (<0.01% P).

Shaking table tests (used to anticipate the behaviour on spirals) resulted in concentrates with satisfactory %Fe and %SiO_2 being obtained from both the <0.63 mm LIMS tailings (66.6% Fe, 1.9% SiO_2) as well as the <1.18mm feed material (69.3% Fe, 1.7% SiO_2). The levels of phosphorus in the products of gravity concentration, however, exceeded the typically acceptable limit (<0.065% P) by a large margin and would require further processing in the form of magnetic separation (MIMS/WHIMS) and/or flotation.

The combination of gravity concentration and low intensity magnetic separation produced a coarse magnetite concentrate grading 70.6% Fe, 1.6% SiO_2 and 0.07% P with a top size of 1.18mm which was deemed an acceptable product. A hematite concentrate grading 66.3% Fe and 2.4% SiO_2 but containing a very high content of phosphorus (0.37% P) was also produced. Regrinding of the hematite concentrate to <0.315mm followed by wet MIMS/HIMS (HGMS) proved unsuccessful in that it failed to reduce the phosphorus to a level which would be considered acceptable by steel mills. To improve the product grade reverse flotation was investigated for phosphate removal.

Regrinding of the hematite concentrate to <100µm, followed by flotation of the phosphate minerals (apatite, monazite) with a fatty acid based collector (Atrac 1563 from Akzo) and sodium silicate (500g/t) at slightly alkaline pH (~9.5) produced a concentrate grading 67.8% Fe, 2.2% SiO_2 and 0.026% P. The employed collector exhibited excellent flotation kinetics (3min flotation time), and high selectivity was achieved with low reagent additions (50g/t collector) at moderately alkaline pH. Hematite was depressed effectively at pH 9-9.5 resulting in a high flotation yield of 91wt%. Neither of the collectors tested showed any affinity towards quartz or (alumino-)silicates.

Selective flocculation carried out on a sub-sample of the flotation concentrate (<100µm in size) was largely unsuccessful in that it proved to have little effect on the levels of acid gangue (0.2%-pts reduction of SiO2, 0.05%-pts reduction of Al2O3).

Overall, the results are very encouraging in that high quality products with low phosphorus levels can be obtained from Flygruvan ore horizon. Grades of iron in the concentrates exceeded 66% Fe and 70% for the hematite and magnetite products, respectively. The products were generally low on impurities commonly found in iron ores such as alumina, sulphur, and alkalis. The hematite concentrate contained slightly elevated levels of titanium (0.3-0.35 % TiO_2).

The testwork suggests that there may be potential to recover a relatively coarse grained concentrate (top size of 1.0-1.2mm) by a combination of gravity separation (spirals) and wet LIMS.

A flowsheet along the following lines is proposed:

- The option of recovering a heavy aggregate product using dry LIMS after crushing;
- An spiral circuit to recover coarse magnetite and hematite;
- LIMS of the spiral concentrate to produce a coarse magnetite concentrate (low phosphorus) and a hematite “tailing” (high phosphorus);
- Regrinding of the hematite stream followed by phosphate removal by fatty acid flotation, producing a fine hematite concentrate; and
- Stage-wise grinding and LIMS of the spiral tailings, producing a fine magnetite concentrate.

The overall recovery of weight and Fe is estimated to exceed 45% and 85%, respectively.

It must be appreciated, however, that the laboratory-scale work carried out to date has used a single ore sample from the Flygruvan horizon only. Additional testing will need to be undertaken a series of additional bench-scale tests to confirm the validity of the proposed flowsheet for a range of different ore types.

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1 INTRODUCTION

GTK Mintec was appointed by Nordic Iron Ore AB (NIO) to carry out a programme of mineral processing testwork relating to the development of the Blötberget iron ore deposit in Ludvika, Central Sweden.

The GTK Mineral Processing Laboratory (GTK Mintec) located in Outokumpu, Finland, is a renowned test centre specialised in the characterisation and processing of mineral ores. It offers a wide range of services including mineralogical studies, bench scale beneficiation testwork and pilot testing for a wide range of minerals, including iron ores.

The Blötberget deposit is of magmatic origin and known to contain magnetite and hematite as Fe-oxide minerals and quartz, silicates and phosphates as gangue. GTK Mintec understands that the Run-of-mine (RoM) is estimated to contain around 35% Fe and 0.3% P, with an average magnetite:hematite ratio of ~ 60%:40%.

GTK Mintec had already been engaged in an earlier phase of testing on samples from Blötberget in 2013. The main purpose of the testwork discussed in this Report was to develop a processing flowsheet to produce a suitable iron ore concentrate with low levels of phosphorous predominantly for use in the European Steel Industry. Other avenues of revenue such as REE contents and a heavy aggregate for non-metallurgical applications were also to be explored.

The programme of metallurgical testing commenced in early February 2014 and was completed in May 2014. The testwork was overseen by Tata Steel UK Consulting Ltd (TSC) acting on behalf of NIO.

2 SAMPLES FOR TESTING

2.1 Sample Origin

In late January/early February 2013, NIO had provided approximately 466kg of HQ half core to GTK Mintec for metallurgical testing. The cores were obtained from a single drill hole with the reference ‘BB12015-MET003’. According to information provided by the Client, the hole intercepted both Flygruvan and Kalvgruvan at an angle of ~45 degrees so as to produce as much core as possible for metallurgical testwork.

The initial development work, which is the subject of this Report, was carried out on a composite sample made up from drill core sections taken from Flygruvan only.

Intersects 370.25m to 398.60m were combined and homogenized to form a composite matching the expected orebody average in terms of:

- Fe grade
- Ratio of magnetite to hematite
- Phosphorus grade

The total amount of sample available for testing was approximately 140 kg.

Photographs of the core boxes of drill intersects 370.25m to 398.60m as received by GTK Mintec are provided in Appendix A.

2.2 Chemical Assaying of Feed Sample

The head assay was determined as follows:

Table 1: Head feed assay

Element/ Compound	Contents (%)		
	Sample 1 L14012899	Sample 2 L14012900	**Test Feed Avg.**
SiO2	39.3000	38.7000	**39.00**
TiO2	0.1350	0.1270	**0.13**
Al2O3	6.1500	6.0100	**6.08**
Cr2O3	0.0010	0.0031	**0.00**
V2O3	0.0280	0.0290	**0.03**
MnO	0.0340	0.0370	**0.04**
MgO	1.7800	1.7300	**1.76**
CaO	1.1300	1.1600	**1.15**
Rb2O	0.0100	0.0110	**0.01**
SrO	0.0000	0.0000	**0.00**
BaO	0.0450	0.0440	**0.04**
Na2O	2.4400	2.3500	**2.40**
K2O	0.8100	0.8100	**0.81**
ZrO2	0.0130	0.0130	**0.01**
P2O5	0.6300	0.6600	**0.65**
Cu	0.0010	0.0000	**0.00**
Ni	0.0040	0.0030	**0.00**
Co	0.0180	0.0170	**0.02**
Zn	0.0070	0.0060	**0.01**
Pb	0.0020	0.0010	**0.00**
Ag	0.0020	0.0010	**0.00**
S	0.0070	0.0050	**0.01**
As	0.0000	0.0000	**0.00**
Sb	0.0110	0.0080	**0.01**
Bi	0.0020	0.0020	**0.00**
Te	0.0000	0.0000	**0.00**
Y	0.0034	0.0029	**0.00**
Nb	0.0000	0.0000	**0.00**
Mo	0.0000	0.0000	**0.00**
Sn	0.0050	0.0050	**0.01**
W	0.0000	0.0010	**0.00**
Cl	0.0090	0.0100	**0.01**
Th	0.0027	0.0028	**0.00**
U	0.0041	0.0042	**0.00**
Cs	0.0010	0.0010	**0.00**
La	0.0130	0.0120	**0.01**
Ce	0.0180	0.0180	**0.02**
Ta	0.0020	0.0030	**0.00**
Ga	0.0017	0.0009	**0.00**
Fe	34.2000	34.8000	**34.50**
Satmagan	29.4600	29.3600	**29.41**
Eltra S	0.0280	0.0220	**0.03**

3 SCOPE OF WORK

The bench-scale test programme comprised of the following elements:

1. Sample preparation and head assays
2. Coarse product evaluation ('Early Revenue' Phase)
    a) Dry low intensity magnetic separation (LIMS) at <20mm and <6.7mm to produce an 'aggregate' product for non-metallurgical applications
3. Main process development:
    a) Bond Crushability Work Index (CWi) and Abrasion Index (Ai) [carried out by Sandvik]
    b) Bond Rod Mill Work Index testing
    c) Bond Ball Mill Work Index testing
    d) Mineralogical examination of RoM ground to <1.18mm by a combination of optical microscopy, Mineral Liberation Analyzer (MLA), and electron microprobe analysis (EMPA).
    e) Davis Tube Testing at six (6) different grinds to evaluate the effect of grind size on magnetite concentrate grade and recovery
    f) Wet low intensity magnetic separation (LIMS) of ground RoM using drum-type separator at <0.63mm, <0.315mm and <0.075mm
    g) Gravity separation, using Wilfley-type shaking table, of <1.18mm RoM as well as selected intermediate products obtained in f)
    h) Wet LIMS using drum-type separator on products of gravity separation (reground where necessary)
    i) Wet medium intensity (MIMS) and high intensity (or high gradient: WHIMS/WHGMS) magnetic separation on selected products of gravity separation
    j) Reverse laboratory batch flotation for removal of phosphate minerals from hematite concentrate
    k) Selective flocculation testwork on hematite concentrate to remove total acid gangue (TAG) inc. silica and silicates

A visualisation of the work flow is shown in Figure 1 and Figure 2 overleaf.

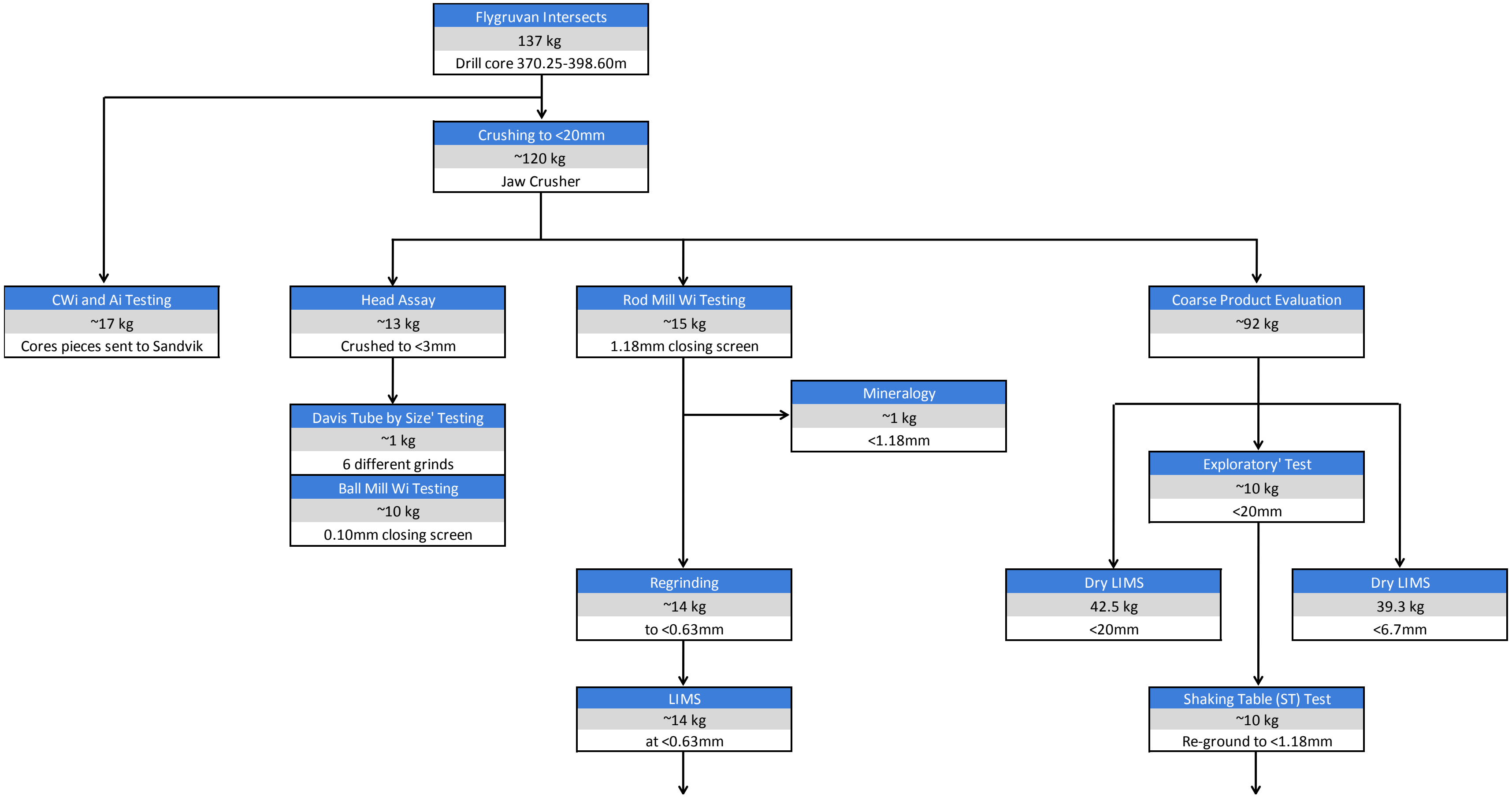

Figure 1: *Work flow diagram of undertaken testing (pt1)*

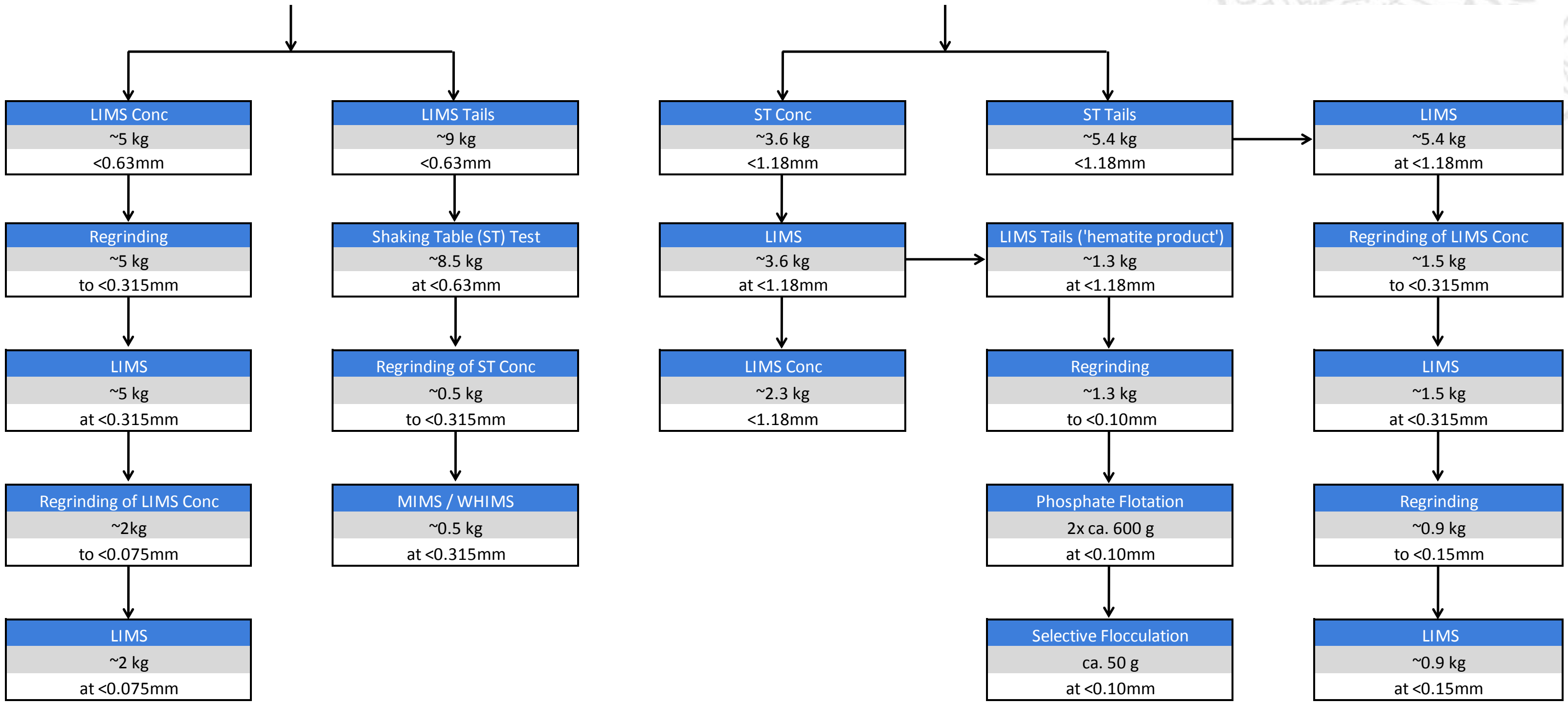

Figure 2: *Work flow diagram of undertaken testing (pt2)*

4 TEST METHODOLOGY AND EQUIPMENT

4.1 Analytical Methods

The following analytical methods were employed during this programme of work:

- XRF – Multi-element analysis by XRF from pressed pellets (Labtium method 180X) for main elements, particularly Fe, SiO_2, Al_2O_3, CaO, MgO, P, Na, K, Mn, TiO_2, V
- ICP – Total dissolution (Labtium method 309) followed by multi-element analysis by ICP-OES (Labtium method 000P) or ICP-MS (Labtium method 000M), for minor elements, particularly Co, Ni, Cu, Zn, Pb, As, REE
- Eltra S – Sulphur analysis by pyrolytical method (Labtium method 810L)
- Satmagan – Saturation magnetisation ('magnetite equivalents' content) by Satmagan (Labtium method 891G)

All chemical analyses were performed by Labtium Oy at their laboratories in Outokumpu (XRF, Eltra S, Satmagan) or Espoo (ICP). Chemical analysis certificates are presented in Appendix B. Copies of Labtium's sampling and assaying procedures are provided in Appendix J.

In addition to the above, polished sections prepared as part of the mineralogical study were submitted for Electron Microprobe (EMPA) analysis to determine impurity levels in the minerals of interest.

4.2 Sample Preparation

The sample was separated from the received drill cores according to the depth reference information provided by the client. Drill core sections from 370.25 m to 398.60 m were combined and homogenized to form approximately 140kg of test feed. After removing a subsample for CWi and AI determinations, the sample was crushed stage-wise to <20mm using a jaw crusher (Figure 3 a)) and pre-screening/intermediate screening to minimize amount of fines and sub-sampled for head assays.

Subsequent crushing to finer sizes was undertaken on a Humboldt-Wedag HW 934-2 roll crusher (Figure 3 b, c)) operated in closed circuit with a vibrating screen.

Grinding was carried out using the following equipment:

- Ball/Rod Mill with changeable ball or rod media
    - Lab mill with stainless steel chamber and media (batches of 0.3-1.5kg with approx 6kg media per 0.5kg feed) , see Figure 3 d)

- Mergan mill with mild steel chamber and media (in batches of up to 5kg with approx 22kg media per 5kg feed), see Figure 3 e)
- Vibratory disc mill (for quantities <100g), see Figure 3 f)

Figure 3: *a) Jaw crusher, b) Rolls crusher, c) rolls crusher internal workings, d) Laboratory batch ball/rod mill, e) Mergan rod/ball mill for larger-scale grinding, f) Vibratory disc mill attachment (not attached to machine)*

4.3 Mineralogical Examination

4.3.1 Introduction

A subsample of the product obtained from the Bond Rod Mill Work Index (Wi) test (<1.18mm top size) was submitted for mineralogical investigation with the aim of:

- Determining mineral hosts for Fe
- Determining minerals hosts for P
- Assessing association of minerals and state of liberation of minerals hosting these elements
- Identifying main gangue minerals
- Determining elemental contamination of minerals hosting Fe

The <1.18mm sample was screened to produce the following fractions:

- 710-1180µm
- 500-710µm
- 250-500µm
- 125-250µm
- 45-125µm

4.3.2 Research Methods

Opical Microscopy

A single polished section was made for each of the five size fractions by individually mounting them in resin and polishing using standard methods. The polished sections were investigated with a reflective light microscope to assess the liberation of the hematite and magnetite in each size fraction.

Mineral Liberation Analyzer (MLA)

All 5 vertical polished sections were analyzed with a mineral liberation analyzer (MLA), which in essence is a scanning electron microscope fitted with two energy-dispersive spectrometers for rapid elemental analysis and special software to automatically perform a range of quantitative mineralogical measurements and calculations. The MLA system provides accurate statistical data on modal mineralogy, grain sizes and liberation of particles. Three separate measurements were performed on all samples in order to obtain accurate and reliable results.

The modal mineralogical contents were measured using the XMOD measurement mode (a modern version of the classical point-counting analysis). The entire sample is divided into a grid of points and an EDS-spectrum is gathered from each point. These EDS spectra are compared to a spectrum library and a mineral name is assigned to each spectrum gathered from the sample. Finally, the relative numbers of each mineral's spectra are converted into percentages.

Liberation of apatite was measured using the XBSE measurement mode where the instrument scans the sample or a section of it and measures and analyses all particles it recognizes. This recognition is based on particles (usually minerals) having a higher grey-scale value than the epoxy mount, which is set as background. This measurement will yield liberation data for the desired mineral phases.

As the XBSE measurement only scans a part of the sample mount (the measurement ends after a satisfactory level of statistical confidence has been reached, which is usually somewhere between 10,000 and 20,000 particles) a third measurement for locating all REE-bearing minerals was necessary. For this task the SPL_XBSE measurement mode was used. It undertakes all the same measurements and analyses as the XBSE, but only to the particles that meet a special operator defined grey level trigger. In other words, in this measurement mode the entire sample is scanned but only the particles that include grains which meet a predefined minimum grey level will be measured and analysed.

Electron Microprobe Analysis (EMPA)

Electron microprobe analyses were needed in order to determine whether the iron-oxides carry any phosphorus. The detection limit of the EDS detectors of the MLA system is about 0.1 w%. A microprobe can detect significantly lower concentrations with much better precision. All EDS analyses showed the P content of the iron-oxides to be below the detection limit. The detection limit of the microprobe was 205 ppm for the analytical conditions used for these analyses.

4.4 Physical Competency

4.4.1 The Bond Rod Mill Work Index

The standard Bond Rod Mill grindability test is a locked-cycle dry grinding procedure which determines a material's resistance to grinding. The mill charge consists of two different sizes of rods weighing 33,380g.

The initial ore charge was 3,040g which contained 19.8 % of <1,180µm material. The equilibrium state was reached after 8 cycles. The detailed Rod Mill Work Index test Report is attached in Appendix C.

4.4.2 The Bond Ball Mill Work Index

The Bond Ball Mill measures 305x305 mm with rounded corners and smooth lining. The ball charge consists of five different sizes of balls weighing about 20,125g.

The initial ore charge was 1,672g which contained 6.9 % <100µm material. The equilibrium state was reached after 5 cycles. The detailed Rod Mill Work Index test Report is attached in Appendix C.

4.5 Bond Crushability Work Index and Abrasion Index (Sandvik)

20 rock pieces of >50mm in size (~17kg in total) were removed from the drill cores at random for crushing characteristics (CWi) determination.

The AI test work requires a minimum of 1.6kg of -19mm +12.7mm material. A 5kg sub-sample was therefore removed from the <20 mm crushed material and screened at 12.7 mm.

The crushing characteristics and abrasion testwork was carried out in cooperation with Sandvik. The full test report is included in Appendix D.

The cores samples sent for crushability testing are displayed in Figure 4.

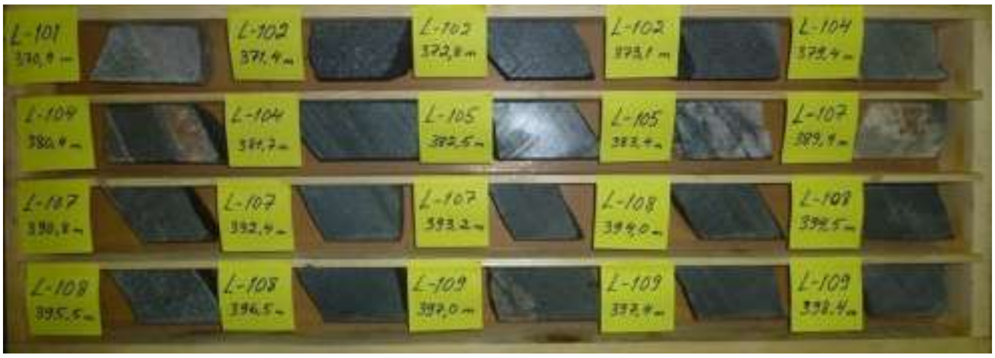

Figure 4: Rock Pieces sent to Sandvik Test and Research Centre, Svedala

4.6 Dry LIMS

Two sub-samples of 40kg of <20mm crushed material were split out for dry low intensity magnetic separation (LIMS) testing. One batch was processed at <20mm whilst the other was crushed to <6.7mm prior to magnetic separation to enhance liberation.

The tests were conducted on an Eriez multi-pole dry LIMS drum separator of 0.9m diameter. The crushed feed material was fed on to the drum via a vibratory feeder and separated at a permanent magnetic field of 1,600 Gauss with a 130mm pole gap. The magnetic portion of the sample was put to one side whilst the non-magnetic portion was reintroduced several additional times at increased drum speeds until a final product was obtained.

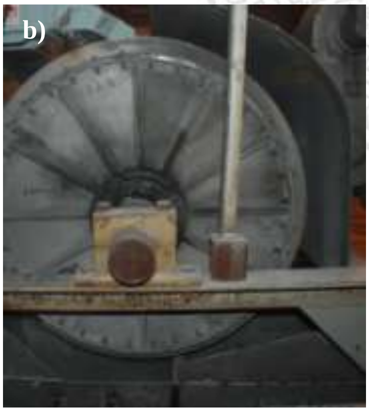

Figure 5: *a) Eriez dry LIMS drum showing vibrating feeder, b) Side view showing product collection bins*

4.7 Wet LIMS

Wet LIMS tests were carried out using a Sala "Blue Ribbon" permanent ferrite magnet drum (200mm diameter) with a nominal magnetic field strength of ~0.07 Tesla (700 Gauss) at the drum surface. Magnetic material adheres to the drum and is separated from the slurry. The magnetic fraction was reintroduced until practically no more material reported to the tailings.

Magnetic and non-magnetic fractions were dried, weighed and assayed separately.

Figure 6: *Sala Blue Ribbon LIMS machine*

4.8 Davis Tube Recovery (DTR) Testwork

Six (6) tests were carried out on subsamples of feed material after grinding to <1 mm, <0.85 mm, <0.63 mm, <0.315 mm, <0.1 mm and <0.063 mm. Two additional tests investigated the effect of magnetic induction on product grade and recovery of the <0.063mm feed material.

On one occasion, LIMS feed material was subjected to DTR testing for the purpose of 'benchmarking' the separation performance observed on the larger (LIMS) drum-type separator.

In each test, representative batches of 20-25g of dry material were mixed with water and dispersed in an ultrasonic bath for about 1 minute prior to the test run. The feed was then introduced into an inclined, rotating (approx.125rpm) glass tube placed between pole-tips of an electromagnet.

In the Davis tube, the strongly magnetic material contained in a sample adheres to the tube around the magnetic poles whilst the weakly magnetic and non-magnetic content is flushed down the tube and collected separately.

In the present programme, both the magnetic and non-magnetic fractions were dried, weighed and assayed separately.
Three different magnetic inductions (as measured in the centre of the tube) were investigated: 1,500 Gauss ("default" or "standard" setting), 1,000 Gauss and 2,500 Gauss. The equipment was set-up as shown in Figure 7. Tilt angle (45 degrees), water flow rate (approx. 1.0 litre/min) and test run duration (15 minutes) remained constant.

Figure 7: *Set-up of Davis Tube equipment*

4.9 Shaking Table

The feed material was mixed with water and fed onto a Deister SD Diagonal Deck No. 15-S shaking table (1.2mx0.56m), see Figure 8. The feed rate was controlled with the aid of a vibratory feeder.

The material was split into a concentrate, a middling and two tailings products. The feed rate utilised was approx. 25-30kg/hour of dry feed.

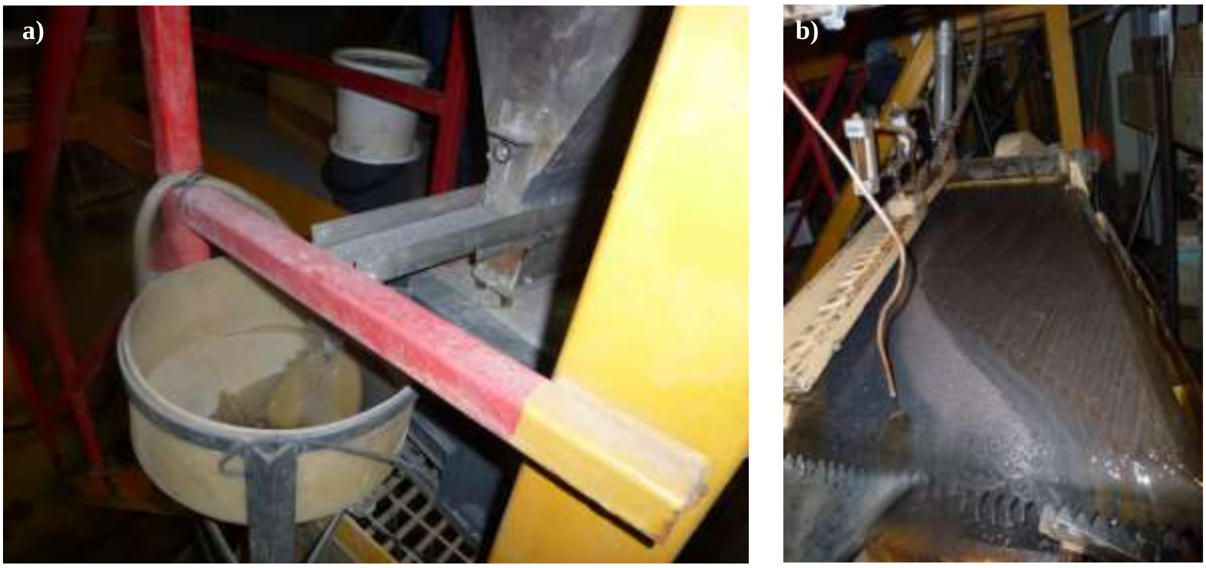

Figure 8: *a) Shaking table feed system b) Shaking table*

4.10 Wet MIMS and HIMS (HGMS)

A representative sub-sample of LIMS tailings material (‘hematite pre-concentrate’) was reground to <0.3mm and subjected to wet medium intensity (MIMS) and high intensity (HIMS, or HGMS for high gradient) magnetic separation to investigate the possibility of phosphorus reduction.

MIMS was carried out using a drum-type rare earth (NdFeB) separator with a magnetic field of ~0.3T (3,000Gaus, on the drum surface) and ~15% solids w/w in the feed (Figure 9 a)).

Wet HIMS (HGMS) was performed using a Sala matrix-type magnetic separator with a 'background field' of ~0.3T (3,000Gauss) (Figure 9 b)). A representative sub-sample was made into a slurry containing 15% material and passed through the high intensity magnetic separation (HIMS) matrix. This is done as a batch process with magnetic material accumulating in the matrix and non-magnetic material flowing through it. Periodically the matrix is flushed with clean water with the magnetic field off and the magnetic material is collected separately.

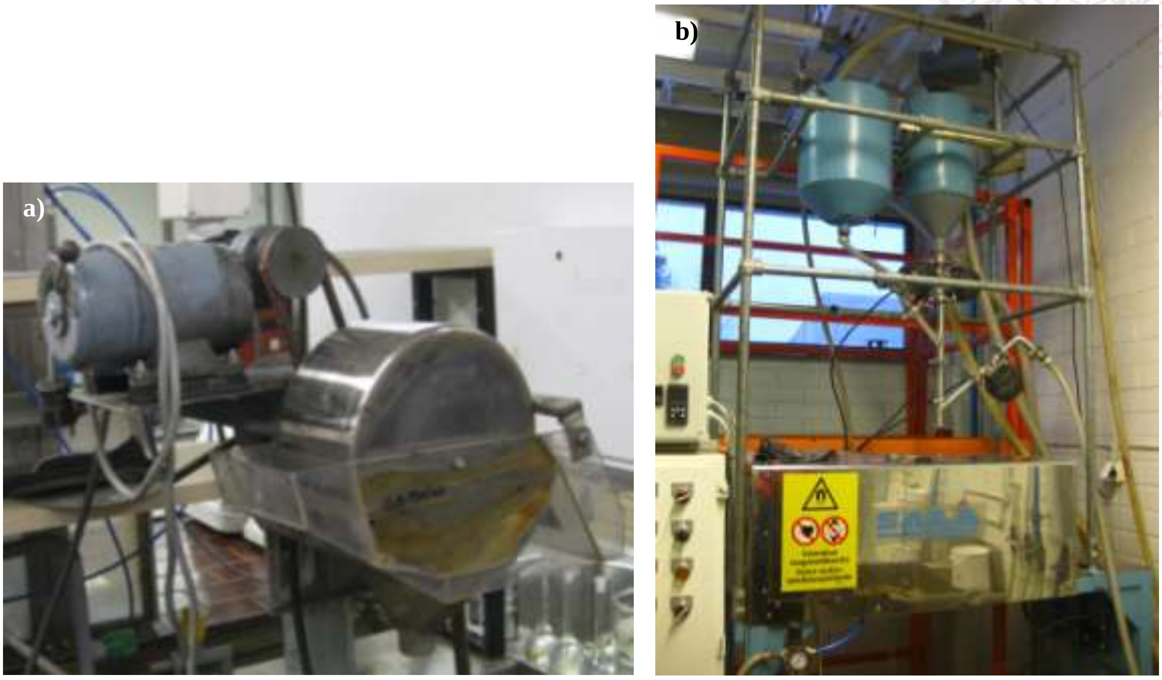

Figure 9: *a) MIMS drum separator, b) WHIMS (HGMS) unit*

It is important to note that the magnetic field strength for a WHIMS (HGMS) unit normally refers to the magnetic induction in the empty separation space ('background field'). The magnitude of the magnetic force, which is proportional to the product of the magnetic flux density, B, and its gradient (B x gradB), is then increased by several orders of magnitude with the insertion of a magnetised (expanded metal sheet or steel wool) matrix. As such, the field strength values of a WMIMS drum and a WHIMS unit are by no means comparable.

4.11 Flotation

Owing to the failure of magnetic separation (WMIMS, WHIMS) to produce a hematite product with satisfactory phosphorus content, the material was reground (stage-wise, i.e. with intermediate wet screening) to <100µm and subjected to two (2) reverse flotation tests.

Phosphate minerals were floated with the aid of fatty acid based collectors at slightly alkaline pH (~9.5) and sodium silicate (water glass – 500g/t) as dispersant:

- Test F1 used a collector mix of Aero 704 (150g/t) and Aero 845 (30g/t) from Cytec.
- Test F2 used a mix of Atrac 1563 from Akzo (150g/t – collector currently used at LKAB to float apatite from magnetite) and Aero 845 (30g/t) from Cytec

The flotation tests were performed using a bench top flotation unit (Figure 10), at 1,100rpm and 1.5litre/min of air. Dry feed was mixed with local tap water and conditioned at ~45wt% solids. The slurry was then diluted and flotation performed at ~40wt% solids. No desliming was carried out prior to flotation.

Where required, a few drops of frother (methyl isobutyl carbinol, MIBC) were added to modify the froth and limit bubble size. During flotation, the pulp level was controlled manually by the addition of local tap water.

For each test, the individually-timed froth samples and the material remaining in the cell were dried and weighed. Chemical analysis was performed using X-ray fluorescence spectroscopy (for Fe, Si, Al, Mg, Ca, Mn, Ti, P) and Eltra combustion analyser (for S).

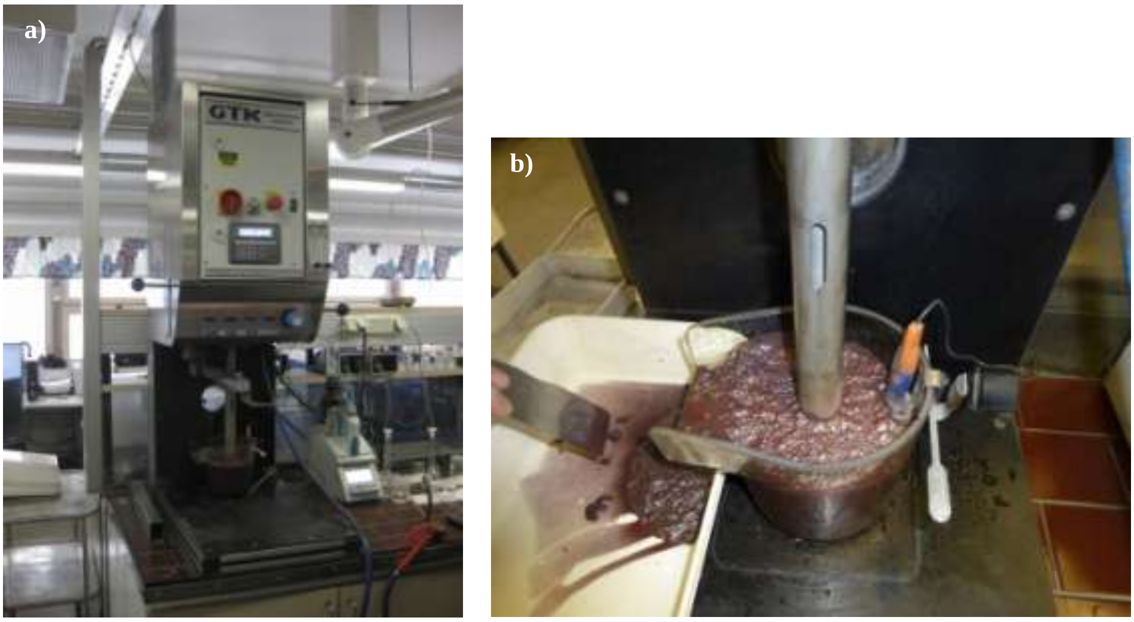

Figure 10: *a) Bench-top flotation unit, b) froth collecting during flotation*

4.12 Selective Flocculation

The aim of the selective flocculation test was to identify if a suitable flocculent (typically starch) would cause the selective formation of aggregates comprised of iron minerals. The lighter, dispersed gangue should report to the supernatant suspension (overflow) whilst the more dense and flocculated iron minerals should report to the sediment (underflow). For each of the tests the following procedure was used:

Step 1. The first step in selective flocculation was to obtain a 'semi-stable' dispersion. The definition of 'dispersed' is not easy to define but, after agitation, the suspended solids should not settle rapidly and certainly no distinct mud line should form that would indicate coagulation. The addition of water glass (500g/t) in combination with the alkaline pH should provide for a sufficiently dispersed suspension.

i. Fill 55g feed sample into 500ml graduated cylinder
ii. Add ~450g of tap water
iii. Add 500g/t of water glass (sodium silicate)
iv. Fill up to 500ml with tap water
v. Mix properly and record pH

Step 2. In the next step, the effectiveness of starch as a selective flocculent needs to be assessed by starting with a dosage of 1,000g/t of cooked starch and then increasing to 1,500g/t if necessary. (Note: The starch has to be solubilised either by cooking or by the addition of caustic soda NaOH). The suspension should be gently, but not violently, agitated during starch addition to aid mixing and formation of large flocculants.

The total dose should be added as two separate dosages (e.g. 2x3ml) up-ending the cylinder 1-3 times after each addition.

Step 3. Flocculation should be very obvious with visible agglomerates that rapidly settle to create a mud line. Recording of the position (height) of the mud line vs. time is used to obtain a settling curve (mm/sec).

The supernatant suspension can then be separated from the sediment flocculants using a rubber tube as a siphon; the resultant products (sediment; supernatant suspension) are dried, weighed and submitted for chemical analysis. Normally the supernatant suspension is removed after 5-8min.

Figure 11: *Equipment used for selective flocculation testing*

5 TEST RESULTS AND DISCUSSION

5.1 Mineralogy

5.1.1 Modal mineralogy

Table 2 presents the results of the calculated bulk modal mineralogy of the sample. Hematite and magnetite were collectively reported as “Magnetite” since, with present methods, it is impossible to reliably differentiate between the different iron oxide minerals. Hence the term “Magnetite” in this table and associated figures refers to iron oxides, essentially magnetite+hematite. Similar tables by sieve fraction are included in appendix E. Figure 12 provides column charts to illustrate the modal mineralogical variations between the sieve fractions and compares them to the calculated bulk.

Table 2: *Modal mineralogy of the calculated bulk sample.*

NIO_XMOD_Calculated_bulk			
Mineral	Wt%	Area%	Analysis Point Count
Quartz	20.45	28.23	32134
Plagioclase	15.33	20.82	23208
K_feldspar	2.52	3.58	4080
Hedenbergite	0.00	0.00	3
Epidote	0.02	0.03	23
Allanite	0.02	0.02	25
Titanite	0.00	0.00	2
Zircon	0.00	0.00	1
Chlorite	0.97	1.20	1410
Biotite	0.68	0.80	865
Phlogopite	3.26	4.25	4786
Muscovite	0.19	0.24	279
Berthierine	0.00	0.00	4
Fluorite	0.02	0.02	30
Calcite	0.03	0.04	63
Synchysite	0.00	0.00	1
Apatite	1.26	1.43	1808
Monazite	0.03	0.02	31
Xenotime	0.00	0.00	0
Anatase	0.00	0.00	0
Magnetite	55.12	39.20	43803
Fe_hydroxide	0.04	0.04	52
Pyrite	0.00	0.00	2
Pyrrhotite	0.00	0.00	1
Chalcopyrite	0.00	0.00	0
Sphalerite	0.00	0.00	3
Galena	0.00	0.00	0
Unclassified	0.06	0.09	134
Total	100.00	100.00	112748

5.1.2 Phosphates and REE-bearing minerals

The main phosphate mineral in the sample is apatite ($Ca_5(PO_4)_3(OH,F,Cl)$). Monazite ($REE(PO_4)$) and xenotime ($Y(PO_4)$) were also encountered, but apatite is by far the main carrier of phoshorus in the sample. Along with monazite and xenotime, also allanite ($(Ce,Ca,Y)_2(Al,Fe)_3(SiO_4)_3(OH)$) and synchysite carry rare earth elements. Based on the MLA data the total REE distribution between these minerals was estimated to be as follows:

- Monazite ~ 86%
- Allanite ~ 8%
- Synchysite ~ 3%
- Xenotime ~ 3%

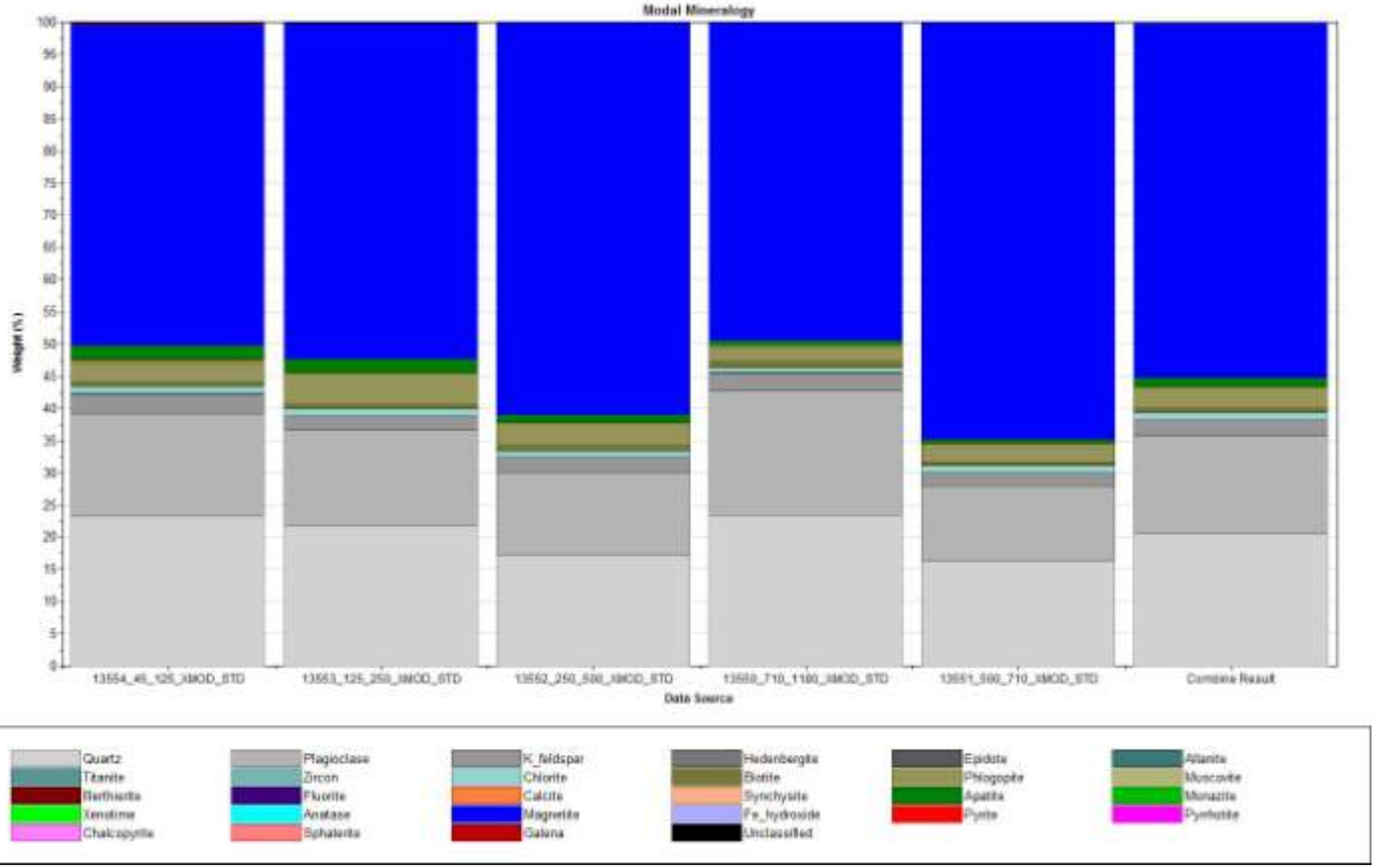

Figure 12: *Modal mineralogy graphs of the sample by sieve fractions and calculated bulk.*

5.1.3 Liberation of apatite

Figure 14 presents the liberation graphs of apatite for each sieve fraction and the calculated bulk. False-colored grain image lists of apatite for each sieve fraction are included in appendix F (see also appendix G for legend of the colors). These graphs and lists tell quite clearly that apatite is rather well liberated in the two finest fractions, 45-125µm and 125-250µm, and poorly liberated in the coarser fractions. The two finer fractions, however, account for only about one third of the bulk, so in order to liberated apatite properly the grinding should undertaken down to <150µm.

5.1.4 Liberation of iron oxides

Iron oxides in the sample include both hematite and magnetite. With current procedures they cannot be reliably separated with the MLA for quantitative purposes, so the liberation graphs of Figure 15 present the liberation of iron oxes as a whole. Photomicrograps taken from all sieve fractions with an ore microscope are provided in appendix H. From these pictures one can get a reasonable idea of the occurrence of hematite-magnetite composite grains, as they show that starting from the coarsest fraction they gradually become more scarse towards the finer fractions. The light microscope photos (Figure 13) illustrate quite clearly that in 250µm and coarser fractions there are a lot of hematite-magnetite composite grains, There are still a few of them in the 125-250µm fraction, but in the finest 45-125µm fraction they become practically extinct and thus both oxides are well-liberated. These observations are also in a good agreement with the cumulative iron oxide liberation graphs of Figure 15.

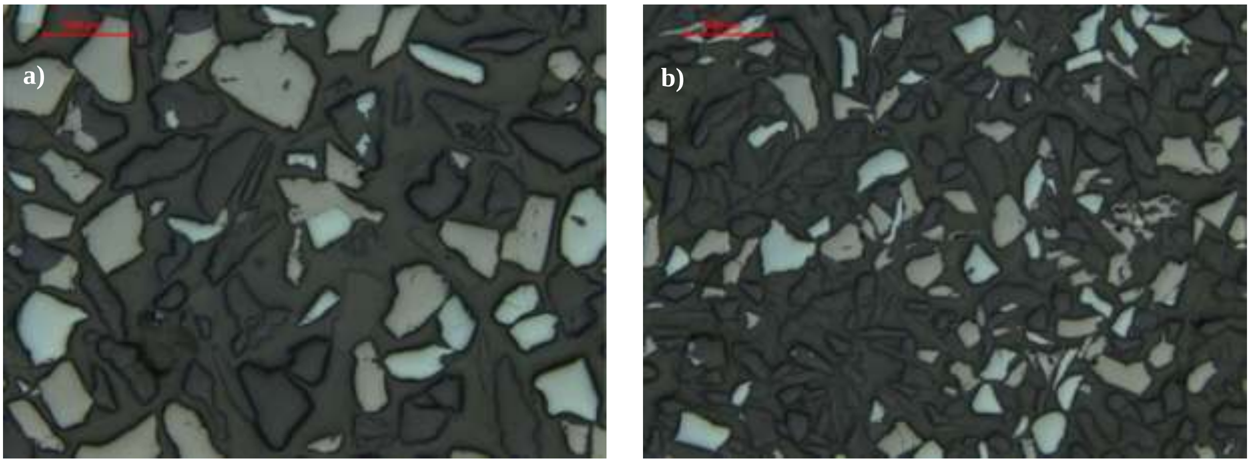

Figure 13: *a) A photomicrograph of the >250µm section showing that composite hematite-magnetite grains still exist in this fraction. b) In the 45-125µm fraction hematite-magnetite composite grains are very rare and both of these iron-oxides are well liberated.*

5.1.5 Microprobe analyses of iron oxides

Some hematite and magnetite grains were analyzed with an electron probe microanalyzer (EPMA) in order to determine whether they contain any phosphorus. The EPMA results are presented in appendix I. In general terms the hematite and magnetite are rather “clean” in the sense that they contain relatively little any unexpected minor or trace elements, such as phosphorus. Hematite does, however, contain some aluminium as the EPMA results indicate, roughly 0.5wt% Al_2O_3. The magnetite contains some aluminium, although significantly less than hematite. Both minerals also contain some vanadium with V_2O_3 contents averaging around 0.1wt%. Magnetite also contains a little bit of manganese with MnO concentrations ranging from 0.05 to 0.14wt%.

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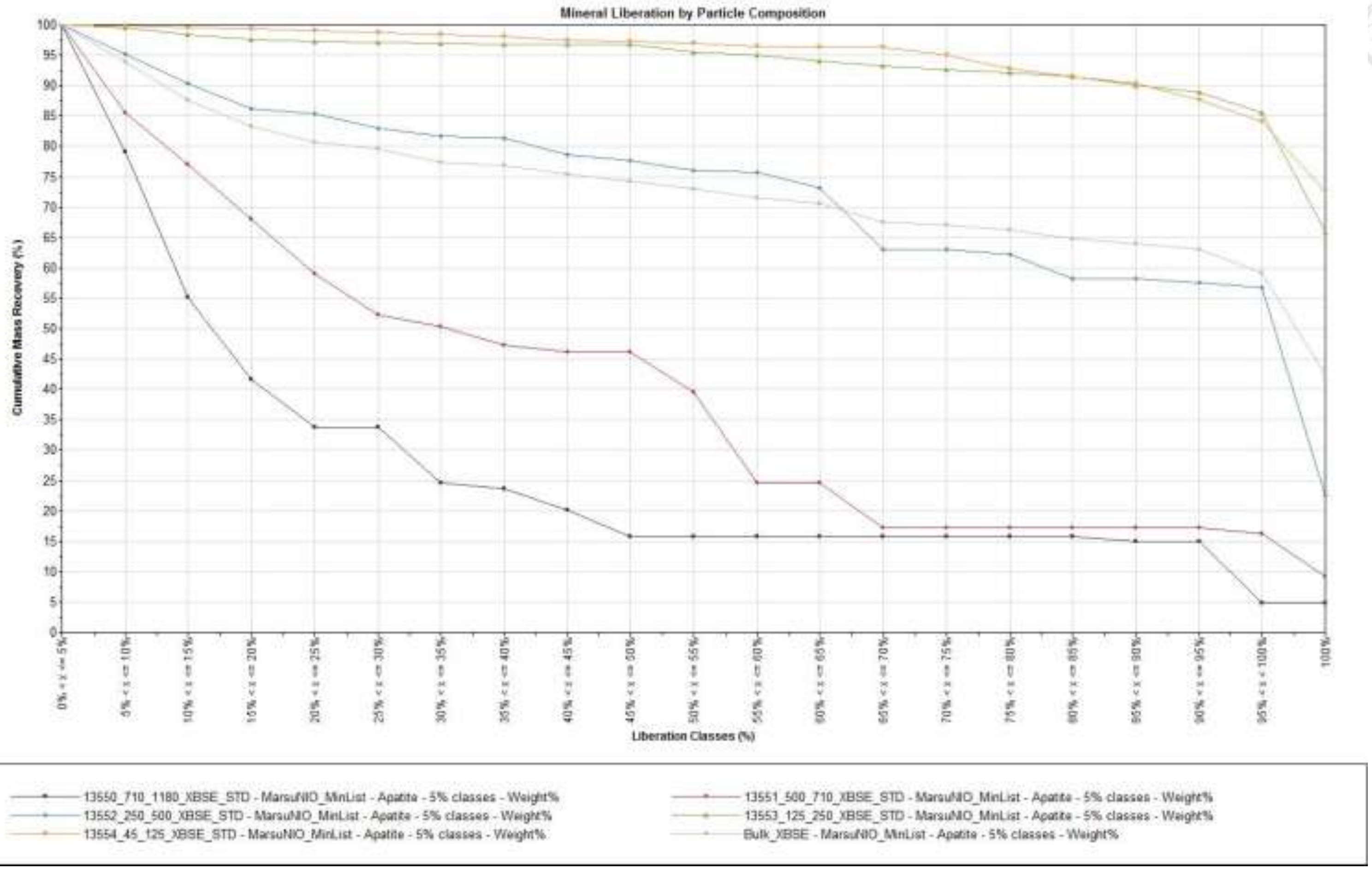

Figure 14: *Liberation graphs of apatite for each sieve fraction and calculated bulk. Only in the two finest fractions apatite is well liberated.*

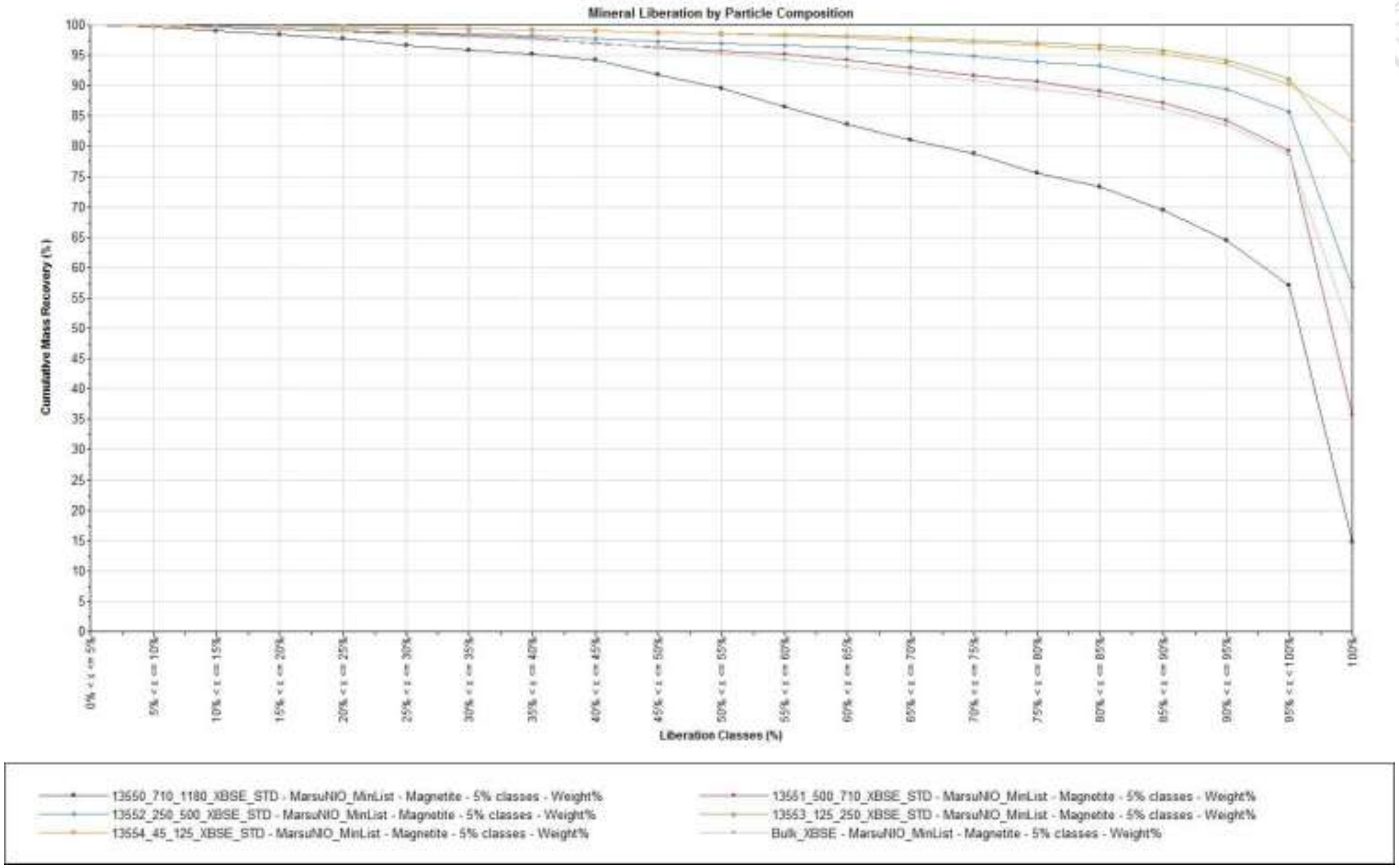

Figure 15: *Liberation graphs of cumulative iron oxides (i.e. magnetite+hematite) by sieve fraction.*

5.1.6 Titanium-bearing mineral phases

The following Ti-bearing minerals were identified in the Flugruvan sample: titanite, biotite, phlogopite, anatase, and Ti-bearing Fe-oxide (Table 3). The concentrations of titanite and anatase were negligible in the calculated bulk sample. Biotite and phlogopite, whilst representing a few percent of the minerals in the bulk sample, did not contribute greatly to the Ti distribution given their low contents of TiO_2 (<0.5%). EMPA analysis revealed that hematite contained only trace levels of TiO_2, whilst magnetite was virtually free of Ti (below detection limit). A small portion of the total iron oxides (0.56% of the total calculated bulk; approximately 1% of the total Fe-oxides), however, did contain between 2-10 wt% TiO_2.

Table 3: *Modal mineralogy of the calculated bulk sample before grouping of phases. Ti-bearing minerals are highlighted with yellow.*

Data Source: Bulk_XMOD					
Mineral Groupings: Ungrouped					
Mineral	Wt%	Area%	Area (micron)	Particle Count	Grain Count
Unknow n	0.01	0.01	0.00	19	19
Low_Counts	0.00	0.00	0.00	1	1
No_XRay	0.00	0.00	0.00	0	0
Quartz	20.45	28.23	0.00	32134	32134
Plagioclase	10.91	14.70	0.00	16480	16480
Albite	4.42	6.12	0.00	6728	6728
K_feldspar	2.48	3.52	0.00	4023	4023
Hyalophane	0.04	0.05	0.00	57	57
Hedenbergite	0.00	0.00	0.00	3	3
Epidote	0.02	0.03	0.00	23	23
Allanite	0.02	0.02	0.00	25	25
Titanite	0.00	0.00	0.00	2	2
Zircon	0.00	0.00	0.00	1	1
Chlorite	0.97	1.20	0.00	1410	1410
Biotite	0.68	0.80	0.00	865	865
Phlogopite	3.26	4.25	0.00	4786	4786
Muscovite	0.19	0.24	0.00	279	279
Berthierite	0.00	0.00	0.00	4	4
Fluorite	0.02	0.02	0.00	30	30
Calcite	0.03	0.04	0.00	63	63
Synchysite	0.00	0.00	0.00	1	1
Apatite	1.26	1.43	0.00	1808	1808
Monazite-(Ce)	0.03	0.02	0.00	31	31
Xenotime-(Y)	0.00	0.00	0.00	0	0
Anatase	0.00	0.00	0.00	0	0
Fe_oxides	54.56	38.81	0.00	43283	43283
Ti-bearing Fe-oxides	0.56	0.40	0.00	520	520
Fe_hydroxide	0.04	0.04	0.00	52	52
Pyrite	0.00	0.00	0.00	2	2
Pyrrhotite	0.00	0.00	0.00	1	1
Chalcopyrite	0.00	0.00	0.00	0	0
Sphalerite w ith hiFe	0.00	0.00	0.00	3	3
Galena	0.00	0.00	0.00	0	0
Iron	0.02	0.01	0.00	19	19
Iron_quartz_mix	0.00	0.00	0.00	1	1
Cr_Steel	0.00	0.00	0.00	2	2
Mn_Steel	0.00	0.00	0.00	2	2
Epoxy_mix	0.02	0.06	0.00	90	90
Total	100.00	100.00	0.00	112748	112748

5.2 Physical Competency

5.2.1 The Bond Rod Mill Work Index

The Bond Rod Mill Work Index value of Blötberget, Upper Level Ore sample was 10.4 kWh/t.

The average of the last three net grams per mill revolution (G_{rp}) was 14.231g. The F_{80} of the sample was 10,042µm and the P_{80} was 836µm. The detailed findings for the Bond Rod Mill Work index are presented in appendix C.

5.2.2 The Bond Ball Mill Work Index

The Bond Ball Mill Work Index value of the Blötberget Upper Level ore sample was 18.8 kWh/t.

The average of the last three net grams per mill revolution (Gbp) was 0.994g. The F_{80} of the sample was 2,355µm and the P_{80} was 80µm. The detailed findings for the Bond Ball Mill Work Index are presented in appendix C.

5.3 Bond Crushability Work Index and Abrasion Index (Sandvik)

Test Results	
Specific gravity (g/cm³):	3.27
Abrasion Index (AI):	0.2959
Work Index (WI):	3.8 +/- 0.8

The detailed results on the Bond Crushability Work Index and Abrasion Index are presented in appendix D.

5.4 Coarse Product Recovery

Table 1: *Dry LIMS <20mm material, 3 passes*

Test product(s)		XRF MP-10 and Satmagan analyses														SG
		Fe		SiO_2		P_2O_5		MgO	Al_2O_3	CaO	Na_2O	K_2O	S	Satmagan		
	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	%	%	%	%	%	%	Rec-%	g/cc
Mag # 3	**41.3**	**53.2**	**61.3**	20.8	22.4	0.66	44.7	1.59	1.95	0.81	0.42	0.27	0.00	**59.0**	**80.5**	4.24
Non-Mag # 3	16.1	45.4	20.4	27.5	11.6	0.83	21.9	2.23	3.27	1.09	0.96	0.50	0.01	30.7	16.4	4.01
(Mag # 2)	57.4	51.0	81.7	22.7	34.0	0.71	66.6	1.77	2.32	0.89	0.57	0.34	0.00	51.0	96.9	4.17
Non-Mag # 2	3.2	46.8	4.2	24.4	2.0	1.15	6.0	1.72	3.32	1.50	1.11	0.44	0.01	14.2	1.5	4.07
(Mag # 1)	60.6	50.8	85.9	22.8	36.0	0.73	72.6	1.77	2.37	0.92	0.60	0.34	0.00	49.1	98.4	4.16
Non-Mag # 1	39.4	12.8	14.1	62.2	64.0	0.42	27.4	1.71	10.20	1.35	4.00	1.48	0.01	1.3	1.6	2.91
Calc'd Feed	*100.0*	*35.8*	*100.0*	*38.3*	*100.0*	*0.61*	*100.0*	*1.74*	*5.46*	*1.09*	*1.94*	*0.79*	*0.01*	*30.3*	*100.0*	*3.56*

Test Conditions		
Material:	42.5kg of <20mm jaw crushed material	
Equipment:	Eriez Dry LIMS machine	
Feed rate:	27-33 tons/hour/m width	
Drum Speed (m/s):	1.5	Roughing
	2.5	Cleaning of Mag # 1
	5.0	Recleaning of Mag # 2

Table 4: Dry LIMS <6.7mm material, 4 passes

Test product(s)		XRF MP-10 and Satmagan analyses														SG
		Fe		SiO_2		P_2O_5		MgO	Al_2O_3	CaO	Na_2O	K_2O	S	Satmagan		
	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	%	%	%	%	%	%	Rec-%	g/cc
Mag # 4	**41.5**	**54.7**	**62.4**	19.0	21.1	0.58	35.7	1.59	1.90	0.73	0.42	0.25	0.02	**62.6**	**86.4**	4.34
Non-Mag # 4	4.7	46.9	6.1	26.7	3.4	0.74	5.2	2.08	2.85	0.99	0.77	0.43	0.01	38.5	6.0	4.03
(Mag # 3)	46.2	53.9	68.5	19.8	24.5	0.60	40.8	1.64	2.00	0.76	0.46	0.27	0.02	60.2	92.4	4.30
Non-Mag # 3	6.5	42.8	7.6	30.3	5.3	0.85	8.2	2.29	3.49	1.19	1.02	0.54	0.01	22.8	4.9	3.89
(Mag # 2)	52.7	52.5	76.2	21.1	29.8	0.63	49.0	1.72	2.18	0.81	0.53	0.30	0.01	55.6	97.3	4.25
Non-Mag # 2	2.7	38.4	2.8	33.4	2.4	1.18	4.7	2.66	4.48	1.61	1.39	0.65	0.02	10.2	0.9	3.77
(Mag # 1)	55.3	51.9	79.0	21.7	32.1	0.65	53.7	1.77	2.29	0.85	0.57	0.32	0.01	53.4	98.2	4.22
Non-Mag # 1	44.7	17.1	21.0	56.7	67.9	0.70	46.3	1.93	9.45	1.530	3.75	1.32	0.01	1.2	1.80	3.09
Calc'd Feed	100.0	36.3	100.0	37.3	100.0	0.67	100.0	1.84	5.49	1.15	1.99	0.77	0.01	30.1	100.0	3.63

Test Conditions		
Material:	39.5kg of <6.7mm jaw and roller crushed material	
Equipment:	Eriez Dry LIMS machine	
Feed rate:	22-28 tons/hour/m width	
Drum Speed (m/s):	1.5	Roughing
	2.5	Cleaning of Mag # 1
	5.0	Stages 3 and 4

5.5 Davis Tube Recovery

Table 5: *PSD of Davis Tube samples after grinding*

Screen opening (µm)	DTR Test Feed Top size 1.0 mm			DTR Test Feed Top size 0.8 mm			DTR Test Feed Top size 0.63 mm			DTR Test Feed Top size 0.315 mm			DTR Test Feed Top size 0.112 mm			DTR Test Feed Top size 0.063 mm		
	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)
1000	0.0	100.0	0.0															
800	9.4	89.6	10.4	0.0	100.0	0.0												
710	4.4	84.7	4.9	3.5	94.8	5.2												
630	4.5	79.8	5.0	4.3	88.4	6.4	0.0	100.0	0.0									
500	7.7	71.2	8.5	7.4	77.5	11.0	1.9	97.2	2.8									
315							13.1	78.0	19.2	0.0	100.0	0.0						
250	23.9	44.8	26.4	22.8	43.7	33.8	9.9	63.4	14.5	7.2	84.3	15.7						
180										8.4	66.1	18.3						
112				17.0	18.5	25.2	24.1	28.0	35.4	10.8	42.6	23.5	0.0	100.0	0.0			
90										5.0	31.7	10.9	7.5	83.4	16.6			
75	28.1	13.7	31.1	5.2	10.8	7.7							6.1	70.0	13.5			
63							9.8	13.7	14.4	5.3	20.2	11.5	6.0	56.7	13.2	0.0	100.0	0.0
45													7.6	40.0	16.8	11.7	74.1	25.9
32							4.8	6.6	7.0	4.7	10.0	10.2	4.8	29.4	10.6	8.3	55.8	18.4
20													5.0	18.3	11.0	4.0	46.9	8.8
U/S	12.4		13.7	7.3		10.8	4.5		6.6	4.6		10.0	8.3		18.3	21.2		46.9
Total	90.4		100.0	67.5		100.0	68.1		100.0	46.0		100.0	45.3		100.0	45.2		100.0
Calc'd P 80 (µm)		633.9			529.9			334.5			233.3			86.2			49.1	

5.5.1 Effect of Grind Size on Recovery

Table 6: *Davis Tube tests at 1500 Gauss to investigate the effect of grind size*

Sample ID	Product	Weight		Element & Oxide Contents, plus Satmagan values (%)												
		grams	wt.-%	Fe	P_2O_5	SiO_2	Al_2O_3	CaO	MgO	MnO	Na_2O	K_2O	V	TiO_2	S	Satmagan
				XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	Eltra	
- 1.0 mm	Feed (Assays)	**23.1**		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
	BackCalc Feed	*22.44*	*100.00*	***37.39***	***0.605***	*36.30*	*5.31*	*1.17*	*1.47*	*0.035*	*1.94*	*0.795*	*0.020*	*0.136*	*0.015*	***32.22***
	Tailing	**14.31**	63.77	21.30	0.85	52.50	7.86	1.69	2.00	0.018	2.97	1.19	0.017	0.202	0.023	1.16
	Concentrate	**8.13**	**36.23**	**65.70**	**0.174**	**7.78**	0.82	0.253	0.54	0.064	0.13	0.101	0.024	0.020	0.002	**86.90**
- 0.8 mm	Feed (Assays)	**23.0**		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
	BackCalc Feed	*22.34*	*100.00*	***37.59***	***0.602***	*36.12*	*5.34*	*1.15*	*1.46*	*0.036*	*1.97*	*0.798*	*0.019*	*0.140*	*0.016*	***31.75***
	Tailing	**14.39**	64.41	21.50	0.85	52.40	7.87	1.65	2.01	0.020	2.99	1.19	0.017	0.206	0.020	0.96
	Concentrate	**7.95**	**35.59**	**66.70**	**0.152**	**6.66**	0.75	0.232	0.46	0.064	0.11	0.089	0.024	0.020	0.008	**87.49**
- 0.63 mm	Feed (Assays)	**23.1**		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
	BackCalc Feed	*22.24*	*100.00*	***37.82***	***0.615***	*35.85*	*5.24*	*1.16*	*1.40*	*0.035*	*1.94*	*0.776*	*0.019*	*0.140*	*0.015*	***31.74***
	Tailing	**15.05**	67.67	22.30	0.88	51.70	7.54	1.67	1.96	0.020	2.85	1.13	0.018	0.202	0.018	0.94
	Concentrate	**7.19**	**32.33**	**70.30**	**0.059**	**2.68**	0.44	0.104	0.23	0.065	0.03	0.035	0.022	0.009	0.009	**96.22**
- 0.315 mm	Feed (Assays)	**23.6**		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
	BackCalc Feed	*22.88*	*100.00*	***35.80***	***0.629***	*37.76*	*5.74*	*1.15*	*1.66*	*0.033*	*2.11*	*0.838*	*0.019*	*0.134*	*0.017*	***31.17***
	Tailing	**15.69**	68.58	19.80	0.89	54.10	8.18	1.63	2.31	0.020	3.06	1.21	0.017	0.192	0.018	0.85
	Concentrate	**7.19**	**31.42**	**70.70**	**0.061**	**2.09**	0.43	0.091	0.25	0.062	0.03	0.027	0.022	0.008	0.016	**97.34**
- 0.112 mm	Feed (Assays)	**23.4**		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
	BackCalc Feed	*22.32*	*100.00*	***36.74***	***0.640***	*36.73*	*5.54*	*1.15*	*1.55*	*0.038*	*2.05*	*0.797*	*0.020*	*0.140*	*0.022*	***31.65***
	Tailing	**15.43**	69.13	20.90	0.91	52.90	7.90	1.64	2.19	0.023	2.96	1.15	0.018	0.201	0.025	1.13
	Concentrate	**6.89**	**30.87**	**72.20**	**0.034**	**0.53**	0.26	0.046	0.11	0.070	0.00	0.007	0.023	0.005	0.015	**100.00**
- 0.063 mm	Feed (Assays)	**23.6**		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
	BackCalc Feed	*22.52*	*100.00*	***36.72***	***0.633***	*36.78*	*5.48*	*1.14*	*1.54*	*0.042*	*2.01*	*0.797*	*0.019*	*0.136*	*0.023*	***31.11***
	Tailing	**15.73**	69.85	21.40	0.90	52.50	7.75	1.62	2.18	0.028	2.88	1.14	0.018	0.194	0.027	1.72
	Concentrate	**6.79**	**30.15**	**72.20**	**0.016**	**0.35**	0.21	0.023	0.05	0.075	0.00	0.003	0.020	0.003	0.014	**99.19**

5.5.2 Effect of Field Strength on Recovery

Table 7: *Effect of altering the field strength on <0.063mm Davis Tube samples*

Sample ID	Product	Weight		Element & Oxide Contents, plus Satmagan values (%)												
		grams	wt.-%	Fe	P_2O_5	SiO_2	Al_2O_3	CaO	MgO	MnO	Na_2O	K_2O	V	TiO_2	S	Satmagan
				XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	Eltra	
- 0.063 mm	Feed (Assays)	**23.4**		**34.50**	**0.645**	**39.00**	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
"A"	*BackCalc Feed*	*22.19*	*100.00*	***36.71***	***0.646***	***36.70***	*5.54*	*1.13*	*1.54*	*0.040*	*2.06*	*0.780*	*0.019*	*0.135*	*0.026*	***31.15***
1,000 Gauss	Tailing	**15.58**	70.21	21.70	0.91	52.10	7.80	1.59	2.17	0.027	2.93	1.11	0.018	0.192	0.028	2.38
	Concentrate	**6.61**	**29.79**	**72.10**	**0.025**	**0.40**	0.22	0.031	0.07	0.072	0.00	0.003	0.023	0.001	0.022	**98.97**
- 0.063 mm	Feed (Assays)	**23.3**		**34.50**	**0.645**	**39.00**	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
"B"	*BackCalc Feed*	*22.10*	*100.00*	***36.27***	***0.680***	***37.14***	*5.64*	*1.15*	*1.59*	*0.041*	*2.09*	*0.797*	*0.019*	*0.133*	*0.028*	***31.05***
2,500 Gauss	Tailing	**15.30**	69.23	20.30	0.97	53.50	8.06	1.64	2.28	0.027	3.02	1.15	0.018	0.191	0.032	0.96
	Concentrate	**6.80**	**30.77**	**72.20**	**0.028**	**0.34**	0.21	0.037	0.05	0.073	0.00	0.003	0.022	0.002	0.020	**98.74**

5.5.3 LIMS Feed Check

Table 8: *Davis Tube test on the LIMS feed material for comparison*

Sample ID	Product	Weight		Element & Oxide Contents, plus Satmagan values (%)												
		grams	wt.-%	Fe	P_2O_5	SiO_2	Al_2O_3	CaO	MgO	MnO	Na_2O	K_2O	V	TiO_2	S	Satmagan
				XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	Eltra	
- 0.63 mm	Feed (Assays)	22.2		**34.50**	**0.645**	39.00	6.08	1.15	1.76	0.036	2.40	0.810	0.019	0.131	0.025	**29.41**
Prepared	*Back Calc Feed*	*21.47*	*100.00*	***37.43***	***0.629***	*36.22*	*5.34*	*1.15*	*1.52*	*0.034*	*1.98*	*0.750*	*0.019*	*0.140*	*0.037*	***32.29***
LIMS Feed	Tailing	**14.05**	65.44	21.50	0.89	52.40	7.79	1.65	2.09	0.017	2.97	1.11	0.018	0.205	0.044	0.91
	Concentrate	**7.42**	**34.56**	**67.60**	**0.134**	**5.59**	0.69	0.198	0.45	0.065	0.11	0.069	0.022	0.016	0.023	**91.70**

5.6 LIMS

Table 9: *LIMS feed check*

Screen opening (µm)	LIMS Test Feed Top size 0.63 mm		
	Weight (g)	Pass. (%)	Frac. (%)
630	0.00	**100.0**	0.0
500	4.06	**91.0**	9.0
355	9.12	**70.7**	20.3
250	8.20	**52.4**	18.2
125	11.94	**25.9**	26.6
75	5.28	**14.1**	11.7
32	3.95	**5.4**	8.8
- 32	2.41		5.4
Total	**44.96**		100.0

Calc'd P 80 (µm) **421.6**

5.6.1 100% <0.63mm LIMS

Table 10: *<0.63mm LIMS Test*

Test product(s)	Weight		XRF MP-10, Eltra S and Satmagan analyses																					
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	grams	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
Mags 4	5060.4	36.03	63.90	64.7	9.80	9.2	0.178	9.7	0.64	14.1	0.065	65.4	1.01	6.5	0.247	7.5	0.22	3.8	0.110	5.0	0.026	37.5	80.63	98.5
Non-Mags 4	51.3	0.37	28.20	0.3	45.20	0.4	1.27	0.7	4.03	0.9	0.050	0.5	5.13	0.3	1.76	0.5	1.24	0.2	0.90	0.4	0.041	0.6	4.46	0.1
(Mags 3)	5111.7	36.39	63.54	64.9	10.16	9.7	0.19	10.4	0.67	15.0	0.065	65.9	1.05	6.8	0.26	8.0	0.23	4.0	0.118	5.4	0.027	38.1	79.87	98.6
Non-Mags 3	77.9	0.55	34.10	0.5	38.80	0.6	1.10	0.9	3.27	1.1	0.041	0.6	4.51	0.4	1.51	0.7	1.17	0.3	0.73	0.5	0.035	0.8	3.65	0.1
(Mags 2)	5189.6	36.95	63.10	65.5	10.59	10.2	0.20	11.3	0.71	16.1	0.064	66.5	1.10	7.3	0.28	8.7	0.24	4.3	0.127	5.9	0.027	38.9	78.72	98.7
Non-Mags 1+2	8855.6	63.05	19.50	34.5	54.40	89.8	0.93	88.7	2.18	83.9	0.019	33.5	8.25	92.7	1.72	91.3	3.15	95.7	1.19	94.1	0.025	61.1	0.63	1.3
Calc'd Feed	*14045.2*	*100.00*	*35.61*	*100.0*	*38.21*	*100.0*	*0.66*	*100.0*	*1.64*	*100.0*	*0.036*	*100.0*	*5.61*	*100.0*	*1.19*	*100.0*	*2.08*	*100.0*	*0.80*	*100.0*	*0.025*	*100.0*	*29.48*	*100.0*
Feed Assays			34.50		39.00		0.65		1.76		0.036		6.08		1.15		2.40		0.81		0.025		29.41	

Test Conditions		
Test Material:	14.1 kg	Screened & roller crushed material
Magnetic field :	700	Gauss (average)
Flow restrictor dia. :	4.0	mm (at the basin bottom)
Feed solids :	20.0	wt%
	12.0	wt%
Feed pump speed :	1.2	litre/min of feed slurry
Preparations for Mags 3 re-cleaning :		Demagnetizing, pH raising from 7 to 11 with caustic soda, and diluting the feed pulp

5.6.2 100% <0.315mm LIMS

- <0.63mm LIMS concentrate (combined 'Mags 3+4') reground to < 0.315mm followed by LIMS
- LIMS 'Mags 5' magnetite product at 100% <0.315 mm.

Table 11: *<0.315mm LIMS Test*

Test product(s)	Weight		XRF MP-10, Eltra S and Satmagan analyses																					
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	grams	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
Mags 5	4496.9	32.02	68.90	61.7	4.18	3.5	0.062	3.0	0.36	7.0	0.064	59.8	0.60	3.4	0.088	2.4	0.09	1.4	0.044	1.8	0.014	20.5	91.53	98.5
Non-Mags 4+5	614.8	4.38	27.30	3.3	48.80	5.6	1.21	8.0	3.00	8.0	0.036	4.6	4.29	3.3	1.61	5.9	1.10	2.3	0.68	3.7	0.024	5.0	0.91	0.1
(Mags 3)	5111.7	36.39	63.90	65.1	9.55	9.1	0.20	10.9	0.68	15.0	0.061	64.4	1.04	6.8	0.27	8.3	0.21	3.7	0.120	5.5	0.015	25.5	80.63	98.6
Non-Mags 3	77.9	0.55	34.10	0.5	38.80	0.6	1.10	0.9	3.27	1.1	0.041	0.7	4.51	0.4	1.51	0.7	1.17	0.3	0.73	0.5	0.035	0.9	3.65	0.1
(Mags 2)	5189.6	36.95	63.45	65.6	9.99	9.7	0.21	11.9	0.72	16.1	0.060	65.0	1.10	7.2	0.29	9.0	0.23	4.0	0.130	6.0	0.015	26.4	79.47	98.7
Non-Mags 1+2	8855.6	63.05	19.50	34.4	54.40	90.3	0.93	88.1	2.18	83.9	0.019	35.0	8.25	92.8	1.72	91.0	3.15	96.0	1.19	94.0	0.025	73.6	0.63	1.3
Calc'd Feed	*14045.2*	*100.00*	*35.74*	*100.0*	*37.99*	*100.0*	*0.67*	*100.0*	*1.64*	*100.0*	*0.034*	*100.0*	*5.61*	*100.0*	*1.19*	*100.0*	*2.07*	*100.0*	*0.80*	*100.0*	*0.021*	*100.0*	*29.76*	*100.0*
Feed Assays			34.50		39.00		0.65		1.76		0.036		6.08		1.15		2.40		0.81		0.025		29.41	

Test Conditions		
Test Material:	14.1 kg	Screened & roller crushed material
Material processing:		Pre-screening and SS Rod Mill regrinding to 100% minus 0.315 mm
Magnetic field :	700	Gauss (average)
Flow restrictor dia. :	4.0	mm (at the basin bottom)
Feed solids :	20.0	wt% (Roughing)
Feed pump speed :	1.2	litre/min of feed slurry

5.6.3 100% <0.075mm LIMS

Table 12: *<0.075mm LIMS Test*

Test Product(s)	Weight		XRF MP10, Eltra S and Satmagan analyses																					
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	grams	Wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
Mags 7	1878.6	93.81	72.20	97.8	0.52	13.2	0.009	13.2	0.12	34.9	0.065	94.1	0.27	45.3	0.013	13.1	0.00	1.3	0.009	17.4	0.013	88.7	99.33	99.9
Non-Mags 6-7	123.9	6.19	24.70	2.2	52.00	86.8	0.90	86.8	3.39	65.1	0.062	5.9	4.95	54.7	1.31	86.9	1.12	98.7	0.65	82.6	0.025	11.3	0.87	0.1
[Calc.Feed]	2002.5	100.00	69.26	100.0	3.71	100.0	0.064	100.0	0.32	100.0	0.065	100.0	0.56	100.0	0.093	100.0	0.07	100.0	0.049	100.0	0.014	100.0	93.24	100.0
Feed Assay [i.e. 'Mags 5']			68.90		4.18		0.062		0.36		0.064		0.60		0.088		0.09		0.044		0.014		91.53	

Test Conditions		
Test Material:	14.1 kg	Screened & roller crushed material
Material processing:		Pre-screening and SS Ball Mill regrinding to 100% minus 0.075 mm Two-stage WLIMS re-cleaning, using as low feed solids as possible
Magnetic field :	700	Gauss (average)
Flow restrictor dia. :	4.0	mm (at the basin bottom)
Feed solids :	20.0	wt% (Roughing)
Feed pump speed :	1.2	litre/min of feed slurry

5.7 Shaking Table

5.7.1 Test 1 Non-magnetic LIMS Tailing

The non-magnetic portion of the LIMS feed (<0.63mm) was tested using a shaking table and formed 4 products.

Table 13: *Shaking table test on <0.63mm non-magnetic LIMS tailings*

Test product(s)	Weight		XRF MP-10, Eltra S and Satmagan analyses																					
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	grams	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
Concentrate	2103.8	25.11	66.60	79.5	1.94	0.9	0.87	24.9	0.08	1.0	0.005	6.7	0.50	1.6	1.01	14.8	0.08	0.7	0.018	0.4	0.023	31.1	0.91	36.6
Middling	5003.2	59.72	5.31	15.1	71.40	80.3	0.87	59.2	2.30	68.4	0.019	60.3	10.20	77.5	1.91	66.5	3.75	80.9	1.56	74.9	0.016	51.5	0.53	50.7
(Conc + Middling)	7107.0	84.84	23.45	94.6	50.84	81.3	0.87	84.2	1.64	69.4	0.015	66.9	7.33	79.1	1.64	81.2	2.66	81.7	1.10	75.3	0.018	82.6	0.64	87.4
Tailing 1	1127.0	13.45	7.11	4.5	66.10	16.8	0.85	13.0	4.14	27.8	0.039	27.9	10.90	18.6	2.02	15.8	3.35	16.3	2.07	22.4	0.020	14.5	0.50	10.8
(Conc + Middl. + Tails 1)	8234.0	98.29	21.22	99.2	52.93	98.0	0.87	97.2	1.98	97.2	0.018	94.8	7.82	97.7	1.70	97.1	2.76	97.9	1.24	97.6	0.018	97.1	0.62	98.2
Tailing 2	143.4	1.71	10.20	0.8	61.80	2.0	1.44	2.8	3.28	2.8	0.057	5.2	10.50	2.3	2.93	2.9	3.32	2.1	1.71	2.4	0.031	2.9	0.67	1.8
Calc'd Feed	*8377.4*	*100.00*	*21.03*	*100.0*	*53.08*	*100.0*	*0.88*	*100.0*	*2.01*	*100.0*	*0.019*	*100.0*	*7.86*	*100.0*	*1.72*	*100.0*	*2.77*	*100.0*	*1.24*	*100.0*	*0.019*	*100.0*	*0.62*	*100.0*
Feed Assays			19.55		54.35		0.93		2.18		0.020		8.24		1.72		3.14		1.19		0.027		0.65	

Test Material: 8.8 kg; combined WLIMS Test 1 Non-Magnetic Tails 1-3.

5.7.2 Test 2 RoM Material

RoM material of <1.18mm was tested to be used as a comparison to the LIMS route.

Table 14: *Shaking table test on <1.18mm RoM material*

Test product(s)	Weight		XRF MP-10, Eltra S and Satmagan analyses																			
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	grams	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
Concentrate	3653.3	**40.28**	**69.3**	**75.2**	1.73	1.9	0.37	23.2	0.20	5.0	0.04	46.9	0.47	3.5	0.43	15.1	0.04	0.9	0.025	1.2	0.013	35.3	**54.1**	**72.7**
Middling	4606.5	50.79	15.8	21.6	60.5	83.8	0.81	64.0	2.15	68.3	0.03	39.0	8.42	79.6	1.59	70.6	3.18	85.3	1.24	76.8	0.014	48.0	14.2	24.0
(Conc + Middling)	8259.8	91.06	39.5	96.9	34.5	85.7	0.62	87.2	1.29	73.3	0.03	85.9	4.90	83.1	1.08	85.6	1.79	86.1	0.70	78.1	0.014	83.3	31.8	96.7
Tailing 1	736.8	8.12	12.6	2.8	59.4	13.2	0.83	10.5	4.85	24.6	0.05	12.2	10.2	15.4	1.72	12.2	2.95	12.7	2.05	20.3	0.028	15.4	10.7	2.9
(Conc + Middl. + Tails 1)	8996.6	99.19	37.3	99.6	36.5	98.8	0.63	97.7	1.58	97.9	0.03	98.2	5.34	98.6	1.13	97.8	1.89	98.8	0.81	98.4	0.015	98.7	30.1	99.6
Tailing 2	73.9	0.81	17.4	0.4	52.3	1.2	1.84	2.3	4.03	2.1	0.08	1.8	9.54	1.4	3.02	2.2	2.83	1.2	1.63	1.6	0.024	1.3	13.6	0.4
Calc'd Feed	*9070.5*	*100.00*	*37.1*	*100.0*	*36.7*	*100.0*	*0.64*	*100.0*	*1.60*	*100.0*	*0.04*	*100.0*	*5.37*	*100.0*	*1.14*	*100.0*	*1.89*	*100.0*	*0.82*	*100.0*	*0.015*	*100.0*	*30.0*	*100.0*
Feed Assays			**34.5**		**39.0**		**0.65**		**1.76**		**0.04**		**6.08**		**1.15**		**2.40**		**0.81**		**0.025**		**29.4**	

Test Material: 9.2 kg; screened & roller crushed RoM material.

5.8 LIMS on <1.18mm Shaking Table Concentrate

An initial test to check parameters was carried out and then subsequently the remainder of the material was processed. Both tests showed a good correlation of test results.

Table 15: *Test 1 - LIMS on <1.18mm Shaking Table Test*

Product	Weight		XRF MP10, Eltra S and Satmagan analyses																					
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		TiO_2		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	g	Wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
WLIMS Mags	883.1	65.05	**70.60**	**66.4**	**1.55**	**55.0**	**0.153**	**25.3**	0.27	84.8	0.056	94.6	0.45	61.2	0.027	12.7	0.174	25.0	0.02	31.8	0.024	68.0	0.013	61.0	**83.91**	**99.3**
WLIMS NM	474.5	34.95	66.40	33.6	2.36	45.0	0.84	74.7	0.09	15.2	0.006	5.4	0.53	38.8	0.345	87.3	0.97	75.0	0.08	68.2	0.021	32.0	0.016	39.0	1.03	0.7
[Calc.Feed]	**1357.6**	100.00	**69.13**	100.0	**1.83**	100.0	**0.393**	100.0	**0.21**	100.0	**0.039**	100.0	**0.48**	100.0	**0.138**	100.0	**0.452**	100.0	**0.04**	100.0	**0.023**	100.0	**0.014**	100.0	**54.94**	100.0
Feed Assay [ST Conc.]			69.30		1.73		0.370		0.20		0.041		0.47		0.130		0.428		0.04		0.025		0.013		54.10	

Test Conditions	
Test Material:	1.36 kg; combined shaking table concentrate product, 100% <1.18 mm
Process:	One-stage WLIMS re-treatment using feed solids roughly at 10 wt%
Nominal magnetic field strength:	~ 0.07 Tesla
Basin bottom flow restrictor dia.:	5 mm
Volumetric slurry feed rate:	~ 1.3 litre/min

***Table 16:** Test 2: LIMS on <1.18mm Shaking Table Test*

Product	Weight		XRF MP10, Eltra S and Satmagan analyses																							
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		TiO_2		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	g	Wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
WLIMS Mags	1466.0	64.8	**70.50**	**66.1**	1.64	**56.7**	**0.164**	**25.5**	0.29	79.2	0.060	92.5	0.45	59.6	0.028	13.5	0.262	31.0	0.01	18.7	0.026	69.5	0.011	60.9	**84.43**	**99.3**
WLIMS NM	797.8	35.2	66.30	33.9	2.30	43.3	0.88	74.5	0.14	20.8	0.009	7.5	0.56	40.4	0.330	86.5	1.07	69.0	0.08	81.3	0.021	30.5	0.013	39.1	1.16	0.7
[Calc.Feed]	**2263.8**	100.0	**69.02**	100.0	**1.87**	100.0	**0.416**	100.0	**0.24**	100.0	**0.042**	100.0	**0.49**	100.0	**0.134**	100.0	**0.547**	100.0	**0.03**	100.0	**0.024**	100.0	**0.012**	100.0	**55.08**	100.0
Feed Assay [ST Conc.]			69.30		1.73		0.370		0.20		0.041		0.47		0.130		0.428		0.04		0.025		0.013		54.10	

Test Conditions	
Test Material:	2.26 kg; combined shaking table concentrate product, 100% <1.18 mm
Process:	One-stage WLIMS re-treatment using feed solids roughly at 10 wt%
Nominal magnetic field strength:	~ 0.07 Tesla
Basin bottom flow restrictor dia.:	5 mm
Volumetric slurry feed rate:	~ 1.3 litre/min

5.9 LIMS on Shaking Table Tailing (‘Scavenger’ LIMS)

***Table 17:** LIMS conducted on <1.18mm shaking table tailings*

Test product(s)	Weight		XRF MP-10 and Satmagan analyses																					
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		TiO_2		Satmagan	
	grams	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
Mags 5 magnetite con.	781.3	**14.75**	**69.80**	**63.6**	**2.84**	**0.7**	**0.042**	**0.7**	0.46	2.7	0.073	33.3	0.63	1.1	0.064	0.5	0.08	0.4	0.048	0.5	0.005	0.6	**95.46**	**96.7**
Non-Mags 4+5	146.2	2.76	9.00	1.5	72.80	3.4	1.06	3.3	3.12	3.4	0.046	3.9	5.63	1.8	1.65	2.7	1.53	1.5	0.850	1.7	0.078	1.7	1.02	0.2
(Mags 3)	927.5	17.51	60.22	65.1	13.87	4.1	0.202	4.0	0.88	6.2	0.069	37.3	1.42	2.9	0.314	3.2	0.31	1.9	0.174	2.2	0.017	2.3	80.57	96.9
Non-Mags 2+3	617.8	11.66	15.80	11.4	62.70	12.3	1.18	15.5	3.47	16.2	0.034	12.3	5.58	7.7	1.67	11.3	1.54	6.2	0.94	7.9	0.132	12.2	0.62	0.5
(Mags 1)	1545.3	29.17	42.46	76.5	33.39	16.4	0.59	19.5	1.92	22.3	0.055	49.5	3.08	10.6	0.86	14.6	0.80	8.1	0.480	10.1	0.063	14.5	48.61	97.4
Non-Mags 1	3753.0	70.83	5.36	23.5	69.90	83.6	1.01	80.5	2.74	77.7	0.023	50.5	10.70	89.4	2.07	85.4	3.73	91.9	1.77	89.9	0.152	85.5	0.54	2.6
Calc'd Feed	*5298.3*	*100.00*	*16.18*	*100.0*	*59.25*	*100.0*	*0.89*	*100.0*	*2.50*	*100.0*	*0.032*	*100.0*	*8.48*	*100.0*	*1.72*	*100.0*	*2.88*	*100.0*	*1.39*	*100.0*	*0.126*	*100.0*	*14.56*	*100.0*
Feed Assays **(Shaking table rejects)**			**15.40**		**60.28**		**0.82**		**2.52**		**0.031**		**8.66**		**1.62**		**3.15**		**1.35**		**0.122**		**13.73**	

Test Conditions	
Test Material:	5.30 kg; combined shaking table Midds + Tails 1-2
Size:	1.18 mm in one-stage Roughing, 0.315 mm in two-stage Cleaning (steps 2 and 3) 0.150 mm in two-stage Recleaning (steps 4 and 5)
Nominal magnetic field strength:	~ 0.07 Tesla
Basin bottom flow restrictor dia.:	4 mm
Volumetric slurry feed rate:	~ 1.3 litre/min

5.10 WHIMS/WMIMS

Table 18: *WMIMS/WHIMS on <0.315 reground shaking table concentrate*

Test product(s)	Weight		XRF MP-10, Eltra S and Satmagan analyses																			
			Fe		SiO_2		P_2O_5		MgO		MnO		Al_2O_3		CaO		Na_2O		K_2O		Eltra S		Satmagan	
	grams	wt.-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%	%	Rec-%
WMIMS Mags Conc.	64.25	**13.18**	**67.20**	**13.3**	**1.36**	**9.5**	**0.54**	**8.0**	0.10	17.4	0.029	32.2	0.45	12.1	0.61	7.5	0.02	4.3	0.013	10.2	0.029	23.4	**4.55**	**55.8**
WMIMS Non-Mags	419.60	86.11	66.70	86.4	1.69	77.1	0.90	86.6	0.07	79.5	0.009	65.4	0.48	84.4	1.07	86.4	0.06	84.0	0.016	81.8	0.014	73.7	0.55	44.0
(HGMS Mags)	483.85	99.29	66.77	99.7	1.65	86.6	0.85	94.6	0.07	96.9	0.012	97.6	0.48	96.5	1.01	93.9	0.05	88.3	0.016	92.0	0.016	97.1	1.08	99.8
HGMS Non-Mags	3.45	0.71	30.50	0.3	35.70	13.4	6.86	5.4	0.33	3.1	0.040	2.4	2.42	3.5	9.15	6.1	1.02	11.7	0.190	8.0	0.068	2.9	0.29	0.2
Calc'd Feed	*487.30*	*100.00*	*66.51*	*100.0*	*1.89*	*100.0*	*0.89*	*100.0*	*0.08*	*100.0*	*0.012*	*100.0*	*0.49*	*100.0*	*1.07*	*100.0*	*0.06*	*100.0*	*0.017*	*100.0*	*0.016*	*100.0*	*1.08*	*100.0*
Feed Assays			**66.60**		**1.94**		**0.87**		**0.08**		**0.005**		**0.50**		**1.01**		**0.08**		**0.018**		**0.023**		**0.91**	
(Shaking table Conc.)																								

Test Conditions - HIMS	
Test Material:	0.5kg; reground Shaking table Concentrate <0.315(The feed to Shaking table was combined tailings (NM1-3) from the WLIMS test at < 0.63 mm size)
Equipment:	Sala HIMS 10-15-20 SCR with 3.5 XMO expanded metal matrix
Feed solids:	~ 15 wt%
Nominal magnetic field strength:	~ 0.3 Tesla
Basin bottom flow restrictor dia.:	6.8 mm (slurry flow velocity ~ 35 mm/sec)
Test Conditions - MIMS	
Test Material:	HIMS magnetic product
Equipment:	Sala NdFeB permanent magnet WMIMS drum
Feed solids:	~ 10 wt%
Nominal magnetic field strength:	~ 0.3 Tesla
Basin bottom flow restrictor dia.:	4 mm

30.9.2014

5.11 Phosphate Reverse Flotation

Table 19: *Flotation Test 1*

FLOTATION TEST REPORT

Mintec

Sample :	ST-WLIMS Hematitic Conc. < 1.18 mm	**Grinding :**	Mill : St. Steel Ball Mill & Swing Mill
Project :	1281262 / 2402		Charge : 8 kg St. Steel balls
Date :	28/04/2014		Water : n.m.
Done by :	MPK, MEK	**Sieving :**	P100 = 100 µm
Test No. :	1		

Remarks : Flotation feed ca. 600 g (on dry basis)
Pre-screening, SS ball mill & swing mill grindings, plus re-screening down to 100 micron top size

Apatite removal by reverse flotation

Feed size	Grind-ings	Condit. min	Reagents (g/t) NaOH (5-%)	H_2SO_4 (20-%)	Water glass	Aero 704	Aero 845	MIBC	Cell l	Air l/min	Rotor rpm	pH	Flot'n min	Product	Weight g	Weight wt.-%
< 100 µm	(stage-															
	wise)								1.5		1100	7.9	natural			
		10			500							9.7	due to water glass			
		5				50	10					9.6				
												9.5				
										1.5		9.5	1	RF1	3.8	0.64
												9.4		(RT1)	586.9	99.36
										1.5		9.4	2	RF2	4.9	0.83
														(RF1+2)	8.7	1.47
												9.4		(RT2)	582.0	98.53
		5				50	10									
										1.5		9.3	1	RF3	11.2	1.90
														(RF1...3)	19.9	3.37
												9.2		(RT3)	570.8	96.63
		1						10								
										1.5		9.2	2	RF4	8.8	1.49
														(RF1...4)	28.7	4.86
												9.1		(RT4)	562.0	95.14
				0.2 ml							*	7.3				
		5				50	10									
										1.5		7.8	2	RF5	10.2	1.73
														(RF1...5)	38.9	6.59
												7.9		(RT5)	551.8	93.41
			0.8 ml								**	9.5				
										1.5		9.5	2	RF6	5.5	0.93
														(RF1...6)	44.4	7.52
												9.4		Cell Conc.	546.3	92.48
Totals		26			500	150	30	10				Total	10	Calc'd Head	590.7	100.00
														Assayed Head		

Grades and Recoveries (by XRF)

Product	Fe %	Fe Rec%	SiO_2 %	SiO_2 Rec%	P_2O_5 %	P_2O_5 Rec%	MgO %	MgO Rec%	MnO %	MnO Rec%	Al_2O_3 %	Al_2O_3 Rec%	CaO %	CaO Rec%	Na_2O %	Na_2O Rec%	K_2O %	K_2O Rec%
RF1	27.90	0.3	1.04	0.3	24.60	18.0	0.37	3.2	0.123	9.3	0.42	0.5	30.80	19.4	0.10	0.7	0.025	0.9
(RT1)	66.85	99.7	2.08	99.7	0.72	82.0	0.07	96.8	0.008	90.7	0.51	99.5	0.83	80.6	0.09	99.3	0.018	99.1
RF2	47.40	0.6	2.35	0.9	12.40	11.7	0.41	4.5	0.074	7.2	0.67	1.1	15.20	12.4	0.13	1.2	0.044	2.1
(RF1+2)	38.88	0.9	1.78	1.3	17.73	29.7	0.39	7.7	0.095	16.5	0.56	1.6	22.01	31.8	0.12	1.9	0.036	3.0
(RT2)	67.01	99.1	2.07	98.7	0.63	70.3	0.07	92.3	0.007	83.5	0.51	98.4	0.71	68.2	0.09	98.1	0.018	97.0
RF3	56.40	1.6	1.13	1.0	7.89	17.0	0.16	4.0	0.038	8.5	0.44	1.6	8.94	16.6	0.06	1.3	0.017	1.8
(RF1...3)	48.74	2.5	1.41	2.3	12.19	46.8	0.26	11.7	0.063	25.0	0.49	3.2	14.66	48.4	0.08	3.2	0.025	4.8
(RT3)	67.22	97.5	2.09	97.7	0.484	53.2	0.07	88.3	0.007	75.0	0.51	96.8	0.55	51.6	0.09	96.8	0.018	95.2
RF4	51.10	1.1	2.58	1.9	10.30	17.5	0.44	8.7	0.060	10.5	0.73	2.1	11.80	17.2	0.13	2.2	0.044	3.7
(RF1...4)	49.46	3.6	1.77	4.2	11.61	64.2	0.32	20.4	0.062	35.5	0.57	5.4	13.78	65.6	0.10	5.3	0.031	8.4
(RT4)	67.47	96.4	2.08	95.8	0.330	35.8	0.06	79.6	0.006	64.5	0.51	94.6	0.369	34.4	0.09	94.7	0.017	91.6
RF5	57.30	1.5	1.22	1.0	7.13	14.0	0.14	3.2	0.037	7.5	0.46	1.5	8.06	13.6	0.06	1.2	0.015	1.5
(RF1...5)	51.52	5.1	1.63	5.2	10.44	78.3	0.27	23.6	0.056	43.1	0.54	6.9	12.28	79.2	0.09	6.5	0.027	9.9
(RT5)	67.66	94.9	2.10	94.8	0.204	21.7	0.06	76.4	0.005	56.9	0.51	93.1	0.227	20.8	0.09	93.5	0.017	90.1
RF6	63.90	0.9	2.07	0.9	2.24	2.4	0.24	3.0	0.023	2.5	0.63	1.1	2.69	2.5	0.10	1.0	0.034	1.8
(RF1...6)	53.05	6.0	1.68	6.1	9.42	80.6	0.27	26.5	0.052	45.6	0.55	8.0	11.09	81.7	0.09	7.5	0.028	11.7
Cell Conc.	67.70	94.0	2.10	93.9	0.184	19.4	0.06	73.5	0.005	54.4	0.51	92.0	0.202	18.3	0.09	92.5	0.017	88.3
Calc'd Head	66.60	100.0	2.07	100.0	0.88	100.0	0.08	100.0	0.008	100.0	0.51	100.0	1.02	100.0	0.09	100.0	0.018	100.0
Assayed Head	66.34		2.32		0.87		0.12		0.008		0.55		1.03		0.08		0.021	

* Checking the flotation response to lowered pH

** Returning the pH back to the level used at the start

30.9.2014

Table 20: *Flotation Test 2*

FLOTATION TEST REPORT

Mintec

Sample :	ST-WLIMS Hematitic Conc. < 1.18 mm	**Grinding :**	Mill : St. Steel Ball Mill & Swing Mill
Project :	1281262 / 2402		Charge : 8 kg St. Steel balls
Date :	05/05/2014		Water : n.m.
Done by :	MPK, MEK	**Sieving :**	P100 = 100 µm
Test No. :	2		

Remarks : Flotation feed ca. 600 g (on dry basis)
Pre-screening, SS ball mill & swing mill grindings, plus re-screening down to 100 micron top size

Apatite removal by reverse flotation

Feed size	Grind-ings	Condit. min	Reagents (g/t) NaOH (5-%)	H_2SO_4 (20-%)	Water glass	Atrac 1563	Aero 845	MIBC	Cell l	Air l/min	Rotor rpm	pH	Flot'n min	Product	Weight g	wt.-%	Fe %	Fe Rec%	SiO_2 %	SiO_2 Rec%	P_2O_5 %	P_2O_5 Rec%	MgO %	MgO Rec%	MnO %	MnO Rec%	Al_2O_3 %	Al_2O_3 Rec%	CaO %	CaO Rec%	Na_2O %	Na_2O Rec%	K_2O %	K_2O Rec%
< 100 µm	(stage-																																	
	wise)								1.5		1100	7.7	natural																					
		10			500							9.4	due to water glass																					
		5				50	10					9.3																						
												9.2																						
										1.5		9.1	1	RF1	29.2	5.19	44.90	3.5	0.89	2.2	15.30	83.1	0.18	9.7	0.077	31.5	0.37	3.9	17.10	82.0	0.05	3.7	0.007	1.9
												9.1		(RT1)	533.6	94.81	67.63	96.5	2.15	97.8	0.171	16.9	0.09	90.3	0.009	68.5	0.49	96.1	0.21	18.0	0.07	96.3	0.020	98.1
										1.5		9.1	2	RF2	20.0	3.55	62.90	3.4	1.53	2.6	3.05	11.3	0.26	9.6	0.036	10.1	0.58	4.2	3.44	11.3	0.05	2.5	0.021	3.8
														(RF1+2)	49.2	8.74	52.22	6.9	1.15	4.8	10.32	94.4	0.21	19.4	0.060	41.6	0.46	8.2	11.55	93.3	0.05	6.3	0.013	5.7
												9.0		**(RT2)**	513.6	**91.26**	**67.81**	**93.1**	2.17	95.2	**0.058**	**5.6**	0.08	80.6	0.008	58.4	0.49	91.8	**0.080**	**6.7**	0.07	93.7	0.020	94.3
		5				50	10																											
										1.5		9.0	1	RF3	38.4	6.82	68.60	7.0	0.61	2.0	0.303	2.2	0.03	2.1	0.012	6.5	0.36	5.0	0.330	2.1	0.01	1.0	0.004	1.4
														(RF1...3)	87.6	15.57	59.40	13.9	0.91	6.8	5.93	96.6	0.13	21.5	0.039	48.1	0.41	13.2	6.63	95.3	0.03	7.2	0.009	7.1
												9.0		(RT3)	475.2	84.43	67.75	86.1	2.30	93.2	0.039	3.4	0.09	78.5	0.008	51.9	0.50	86.8	0.060	4.7	0.08	92.8	0.021	92.9
		1						—																										
										1.5		9.0	2	RF4	30.9	5.49	68.20	5.6	1.12	3.0	0.221	1.3	0.11	6.3	0.018	7.8	0.44	5.0	0.253	1.3	0.02	1.6	0.012	3.4
														(RF1...4)	118.5	21.06	61.69	19.5	0.97	9.8	4.44	97.9	0.13	27.8	0.034	55.9	0.42	18.2	4.97	96.6	0.03	8.8	0.010	10.5
												9.0		(RT4)	444.3	78.94	67.71	80.5	2.38	90.2	0.026	2.1	0.09	72.2	0.007	44.1	0.51	81.8	0.046	3.4	0.08	91.2	0.022	89.5
				0.2 ml							*	7.3																						
		5				50	10																											
										1.5		7.2	2	RF5	235.0	41.76	69.40	43.6	0.59	11.8	0.017	0.7	0.00	0.4	0.003	9.9	0.30	25.7	0.022	0.8	0.00	0.6	0.001	2.1
														(RF1...5)	353.5	62.81	66.82	63.2	0.72	21.6	1.50	98.6	0.04	28.3	0.013	65.8	0.34	43.9	1.68	97.5	0.01	9.4	0.004	12.6
												7.4		(RT5)	209.3	37.19	65.82	36.8	4.39	78.4	0.036	1.4	0.18	71.7	0.012	34.2	0.74	56.1	0.074	2.5	0.17	90.6	0.046	87.4
			0.5 ml								**	9.2																						
										1.5		9.1	2	RF6	150.0	26.65	68.20	27.4	1.81	23.2	0.020	0.6	0.00	0.3	0.006	12.6	0.41	22.4	0.037	0.9	0.04	15.2	0.008	11.0
														(RF1...6)	503.5	89.46	67.23	90.5	1.04	44.8	1.06	99.2	0.03	28.5	0.011	78.4	0.36	66.3	1.19	98.4	0.02	24.6	0.005	23.6
												9.1		Cell Conc.	59.3	10.54	59.80	9.5	10.90	55.2	0.077	0.8	0.65	71.5	0.026	21.6	1.56	33.7	0.167	1.6	0.50	75.4	0.141	76.4
Totals		**26**			**500**	**150**	**30**					**Total**	**10**	**Calc'd Head**	**562.8**	**100.00**	**66.45**	**100.0**	**2.08**	**100.0**	**0.96**	**100.0**	**0.10**	**100.0**	**0.013**	**100.0**	**0.49**	**100.0**	**1.08**	**100.0**	**0.07**	**100.0**	**0.019**	**100.0**
														Assayed Head			**66.34**		**2.32**		**0.87**		**0.12**		**0.008**		**0.55**		**1.03**		**0.08**		**0.021**	

* Checking the flotation response to lowered pH

** Returning the pH back to the level used at the start

5.12 Selective Flocculation

Selective flocculation was conducted in the manner as described in Section 5. Two tests were conducted using cooked starch as the flocculent and with an addition of water glass.

5.12.1 Selective Flocculation Test 1

Test Products	Weight (g)	XRF analysis			
		%Fe	%P2O5	%Al2O3	%SiO2
O/F Tails	0.09	N/A	N/A	N/A	N/A
U/F Product	54.2	67.8	0.173	0.48	1.97
Feed	55.0	67.7	0.184	0.51	2.1

N.B. There was insufficient material for analysis of the tailings

Test Conditions:	
Feed:	Concentrate from Flotation Test 1, 67.7% Fe
Sample Weight:	55.0g
Natural pH check:	~ 7.85 after mixing
Reagents:	0.55 ml (5-% solution) water glass added
pH after reagents:	~ 9.25
pH check after 1,500 g/t starch added:	~ 9.15

5.12.2 Selective Flocculation Test 2

Test Products	Weight (g)	XRF analysis			
		%Fe	%P2O5	%Al2O3	%SiO2
O/F Tails	1.24	N/A	N/A	N/A	N/A
U/F Product	53.0	67.8	0.181	0.46	1.92
Feed	55.0	67.7	0.184	0.51	2.1

N.B. There was insufficient material for analysis of the tailings

Test Conditions:	
Feed:	Concentrate from Flotation Test 1, 67.7% Fe
Sample Weight:	55.0g
Natural pH check:	~ 7.55 after mixing
Reagents:	0.55 ml (5-% solution) water glass added
pH after reagents:	~ 8.95
pH check after 1,500 g/t starch added:	~ 8.75

5.13 Product Screen Analyses

5.13.1 <1.18mm Magnetic Concentrate

SCREEN ANALYSIS TABLE

Eastern Finland office
Mintec

Project name : "MarsuNIO"
Code : 1281262 / 2402

Date : 22.4.2014
By : MEK

Note : Combination of elutriation screening and Ro-Tap dry screening for 10 min

Sample data : NIO BB12015 / 'Upper Level' ore - Gravity_WLIMS test, magnetite conc. < 1.18 mm screen check

Screen opening (µm)	Gravity (ST) - WLIMS test Magnetitic concentrate Top size 1.18 mm					
	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)
	Magnetite Conc.					
1180	0.00	100.0	0.0			
1000	3.35	96.9	3.1			
710	10.20	87.3	9.6			
500	15.15	73.1	14.2			
250	37.80	37.7	35.4			
125	26.70	12.7	25.0			
75	9.85	3.5	9.2			
- 75	3.70		3.5			
Total	106.75		100.0			

Calc'd P 80 (µm): 601.9

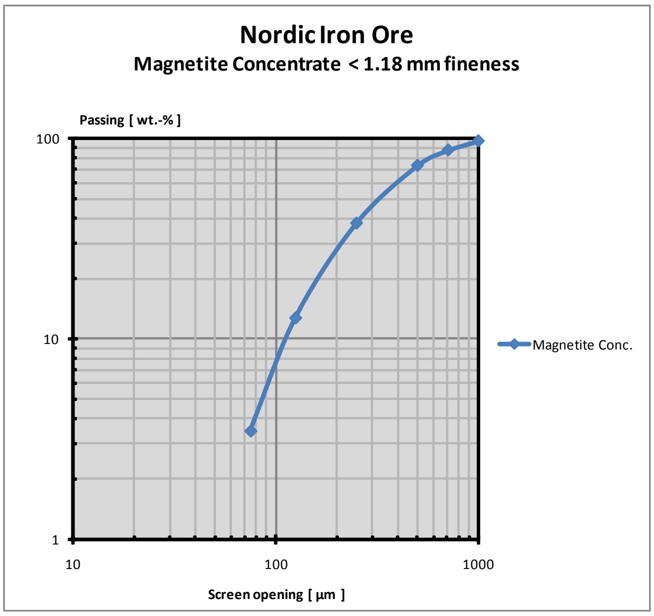

Figure 16: *Screen analysis of <1.18mm LIMS magnetic concentrate*

5.13.2 Fine Magnetite Concentrate

SCREEN ANALYSIS TABLE

Eastern Finland office
Mintec

Project name : "MarsuNIO"
Code : 1281262 / 2402

Date : 12.5.2014
By : JTP

Note : Combination of elutriation screening and Ro-Tap dry screening for 10 min

Sample data : Fine magnetite concentrate product (< 150 microns)

Screen opening (µm)	Fine magnetite End concentrate product Top size 150 µm																		
	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)
150	0.2	99.5	0.5															
125	2.3	94.3	5.2															
90	5.7	81.4	13.0															
75	4.3	71.6	9.8															
63	5.2	59.8	11.8															
32	12.5	31.4	28.4															
U/S	13.8		31.4															
Total	44.0		100.0															

Calc'd
P 80
(µm) 87.9

Figure 17: *Fine magnetic concentrate from LIMS*

5.13.3 Flotation Feed/Products

SCREEN ANALYSIS TABLE

Eastern Finland office Project name : **"MarsuNIO"** Date : 5.5.2014

Mintec Code : **1281262 / 2402** By : MPK

Note : Combination of elutriation screening and Ro-Tap dry screening for 10 min

Sample data : **Apatite removal flotation, Test 2 feed (< 100 microns)**

Screen opening (µm)	Apatite removal flotation Test 2 Feed Top size 100 µm																	
	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)	Weight (g)	Pass. (%)	Frac. (%)
100	0.0	**100.0**	0.0															
90	1.7	**93.5**	6.5															
75	3.4	**80.5**	13.0															
63	2.8	**69.7**	10.7															
45	5.4	**49.0**	20.7															
20	6.3	**24.9**	24.1															
U/S	6.5		24.9															
Total	**26.1**		100.0															

Calc'd
P 80
(µm) **74.5**

Figure 18: *Flotation feed screen analysis (due to the high yield of the flotation tests, the products will have a similar size analysis)*

6 SUMMARY AND DISCUSSION OF RESULTS

6.1 Recovery of Products for non-metallurgical Applications

- Dry low intensity magnetic separation yielded the following 'heavy aggregate' products for customer testing:
    - Test #1: 53.2% Fe, specific gravity (S.G.) 4.24g/cm3, top size 10mm (<20mm magnetic concentrate crushed to <10mm), 41wt% recovery
    - Test #2: 54.7% Fe, S.G. 4.34g/cm3, top size 6.7mm, 41wt% recovery

6.2 Physical Competency Testing

- Crushability Work Index (CWi = 3.8 +/- 0.8) and Abrasion Index (Ai = 0.30) data, determined by Sandvik, suggests that Blötberget "can be considered a typical iron ore, which is crushed easily but very abrasive". Attention must be paid to the generation of large amounts of fines during crushing.
- The Bond Rod Mill Work Index was determined by GTK Mintec to be 10.4 kWh/t. This value is at the lower end of the range typically observed for iron ores but in relatively good agreement with the energy consumption data reported for the historical processing plant at Blötberget.
- A Bond Ball Mill Work Index of 18.8 kWh/t (using a 0.100mm closing screen) was reported.
- It must be noted that the Bond Work Index (BWi) testwork was conducted with raw composite samples of the feed. Once a flowsheet has been defined, it is important that additional comminution data is generated from samples of the actual material to be ground.

6.3 Mineralogy

The findings of the mineralogical study can be summarised as follows:

- Liberation of iron oxides: Both hematite (partly martite-altered) and magnetite occur in the sample. The 'liberation graph' indicates that a considerable proportion of Fe-oxides are sufficiently liberated from the gangue at relatively coarse size (~1mm).
- Electron Microprobe Analysis (EPMA) suggests that hematite and magnetite are generally 'pure' in that they carry relatively low levels of impurities and in particular phosphorus.
- Apatite, which is the principal carrier of phosphorus, are well liberated at particle sizes <250µm. However, phosphates appear to be more intimately associated with hematite (martite) than with magnetite. One important consequence of this is that hematite will require finer grinding to achieve liberation from phosphate minerals.

6.4 LIMS

- No satisfactory LIMS concentrate could be recovered (9.8% SiO_2, >0.3% Na_2O+K_2O) from the ground feed at <0.63mm.
- LIMS at <0.315 mm produced a concentrate with 68.9% Fe and satisfactory phosphorus content (<0.03% P). The content of SiO_2 was slightly elevated (4.2%).
- LIMS at <0.075 mm produced a concentrate with ~72% Fe, 0.52% SiO_2 and very low phosphorus content (<0.01% P).

6.5 Gravity Concentration

- Concentrates with satisfactory %Fe and %SiO_2 could be obtained from both the <0.63 mm LIMS tailings (66.6% Fe, 1.9% SiO_2) as well as the <1.18mm feed material (69.3% Fe, 1.7% SiO_2). The levels of phosphorus in the products of gravity concentration, however, exceeded the typically acceptable limit (<0.065% P) by a large margin.

6.6 Combination of Gravity Concentration, LIMS and MIMS/WHIMS

- The combination of gravity concentration and low intensity magnetic separation produced :
  - a coarse magnetite concentrate grading 70.6% Fe, 1.6% SiO_2 and 0.07% P with a top size of 1.18mm; and
  - A hematite concentrate grading 66.3% Fe and 2.4% SiO_2 but containing a very high content of phosphorus (0.37% P).
- Regrinding of the hematite concentrate to <0.315mm followed by wet MIMS/HIMS (HGMS) proved unsuccessful in that it failed to reduce the phosphorus to a level which would be considered acceptable by steel mills.

6.7 Reverse Flotation for Phosphate Removal

- Regrinding of the hematite concentrate to <100µm and followed by flotation of the phosphate minerals (apatite, monazite) with a fatty acid based collectors (Atrac 1563 from Akzo) and sodium silicate (500g/t) at slightly alkaline pH (~9.5) produced a concentrate grading 67.8% Fe, 2.2% SiO_2 and 0.026% P, a flotation yield of 91wt%.
- The employed collector exhibited excellent flotation kinetics (3min flotation time), and high selectivity was achieved with low reagent additions (50g/t collector) at moderately alkaline pH.
- Hematite was depressed effectively pH 9-9.5 but not in the neutral pH. Neither of the collectors tested showed any affinity towards quartz or (alumino-)silicates.

6.8 Selective Flocculation for Removal of Acid Gangue (SiO_2, Al_2O_3)

- Selective flocculation carried out on a sub-sample of the flotation concentrate (<100µm in size) proved little effective (0.2%-pts reduction of SiO_2, 0.05%-pts reduction of Al_2O_3).

7 CONCLUSIONS

Overall, the results are very encouraging in that high quality products with low phosphorus levels can be obtained from Flygruvan ore horizon. Grades of iron in the concentrates exceeded 66% Fe and 70% for the hematite and magnetite products, respectively.

The testwork suggests that there may be potential to recover a relatively coarse grained concentrate (top size of 1.0-1.2mm) by a combination of gravity separation (spirals) and wet LIMS.

A flowsheet along the following lines is proposed:

- The option of recovering a heavy aggregate product using dry LIMS after crushing;
- An spiral circuit to recover coarse magnetite and hematite;
- LIMS of the spiral concentrate to produce a coarse magnetite concentrate (low phosphorus) and a hematite “tailing” (high phosphorus);
- Regrinding of the hematite stream followed by phosphate removal by fatty acid flotation, producing a fine hematite concentrate; and
- Stage-wise grinding and LIMS of the spiral tailings, producing a fine magnetite concentrate.

A Simple mass balance created using data from the undertaken testwork is presented in Figure 19, below.

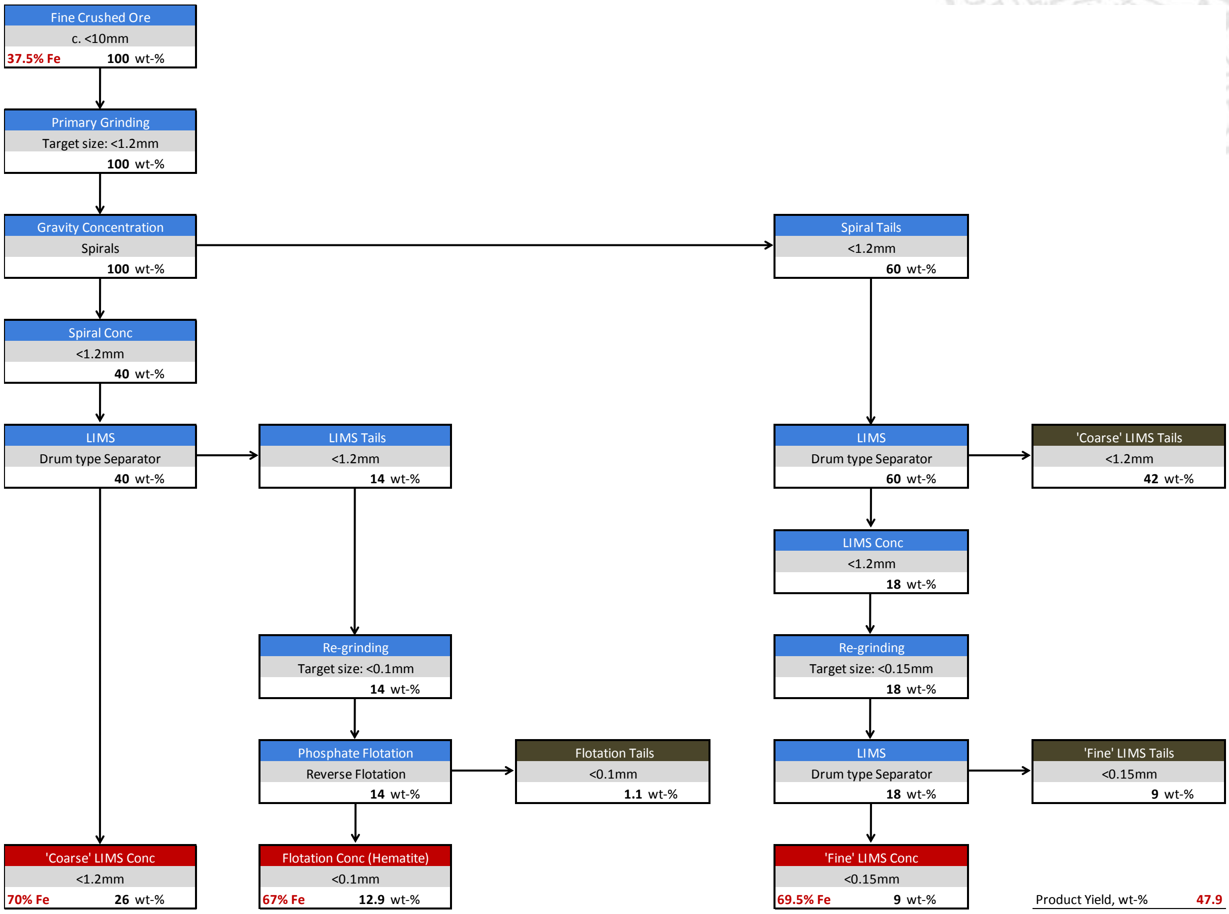

Figure 19: *Simple Mass Balance*

The overall recovery of weight and Fe is estimated to exceed 45% and 85%, respectively.

It must be appreciated, however, that the laboratory-scale work carried out to date has used a single ore sample from the Flygruvan horizon only. Additional testing will need to be undertaken a series of additional bench-scale tests to confirm the validity of the proposed flowsheet for a range of different ore types.

8 APPENDIX A – CORE SECTIONS AS DELIVERED

Figure 20: *Core as delivered; 370.25-370.92m (4.5kg)*

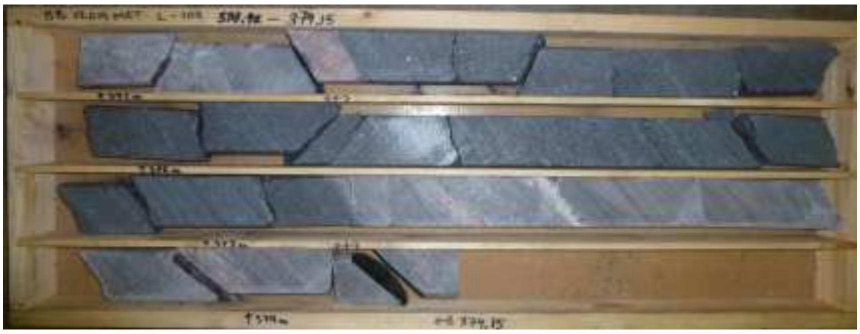

Figure 21: *Core as delivered; 370.92-374.15m (27.8kg)*

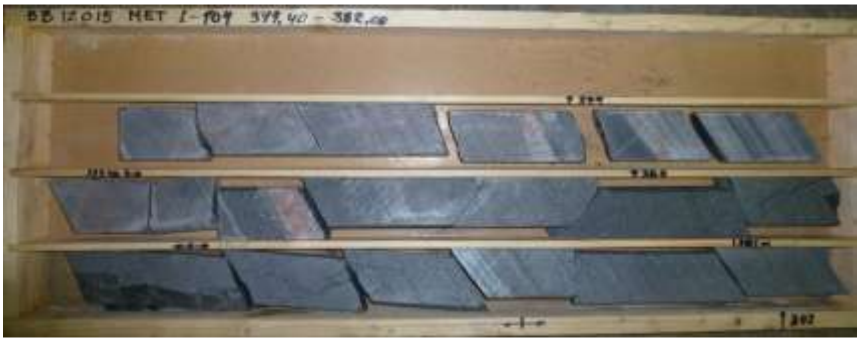

Figure 22: *Core as delivered; 379.40-382.08m (24.9kg)*

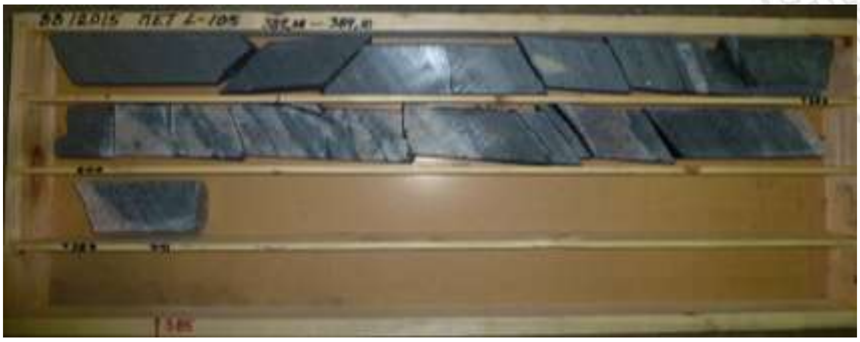

Figure 23: *Cores as delivered; 382.08-384.10m (17.9kg)*

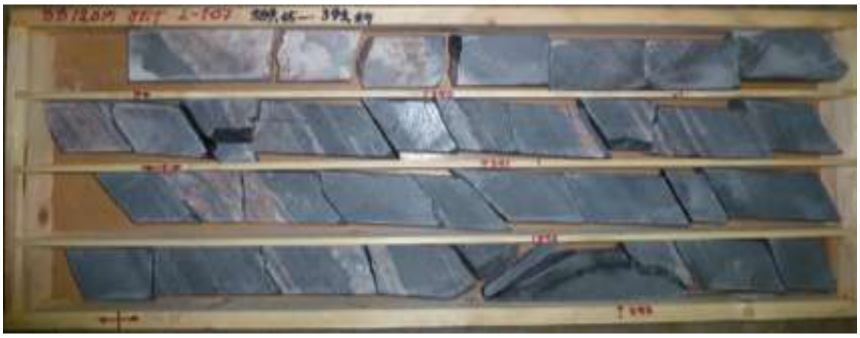

Figure 24: *Cores as delivered; 389.65-393.24m (26.6kg)*

Figure 25: *Core as delivered; 393.24-396.90m (30.3kg)*

Figure 26: *Core as delivered; 393.24-398.60m (12.2kg)*

9 APPENDIX B – ASSAY CERTIFICATES

9.1 Head Assay

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 11.2.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 118904
Method : 180X-O
Date : 11.2.2014
Comment : Nordic Iron Ore - Blötberget 'Upper Level' / Bench Test Feed, analysis request 11.2.2014

Contents (%)

	Sample 1 L14012899	Sample 2 L14012900	Test Feed Avg.
SiO2	39.3000	38.7000	**39.00**
TiO2	0.1350	0.1270	**0.13**
Al2O3	6.1500	6.0100	**6.08**
Cr2O3	0.0010	0.0031	**0.00**
V2O3	0.0280	0.0290	**0.03**
MnO	0.0340	0.0370	**0.04**
MgO	1.7800	1.7300	**1.76**
CaO	1.1300	1.1600	**1.15**
Rb2O	0.0100	0.0110	**0.01**
SrO	0.0000	0.0000	**0.00**
BaO	0.0450	0.0440	**0.04**
Na2O	2.4400	2.3500	**2.40**
K2O	0.8100	0.8100	**0.81**
ZrO2	0.0130	0.0130	**0.01**
P2O5	0.6300	0.6600	**0.65**
OxSumm	96.6000	96.5000	**96.55**
Cu	0.0010	0.0000	**0.00**
Ni	0.0040	0.0030	**0.00**
Co	0.0180	0.0170	**0.02**
Zn	0.0070	0.0060	**0.01**
Pb	0.0020	0.0010	**0.00**
Ag	0.0020	0.0010	**0.00**
S	0.0070	0.0050	**0.01**
As	0.0000	0.0000	**0.00**
Sb	0.0110	0.0080	**0.01**
Bi	0.0020	0.0020	**0.00**
Te	0.0000	0.0000	**0.00**
Y	0.0034	0.0029	**0.00**
Nb	0.0000	0.0000	**0.00**
Mo	0.0000	0.0000	**0.00**
Sn	0.0050	0.0050	**0.01**
W	0.0000	0.0010	**0.00**
Cl	0.0090	0.0100	**0.01**
Th	0.0027	0.0028	**0.00**
U	0.0041	0.0042	**0.00**
Cs	0.0010	0.0010	**0.00**
La	0.0130	0.0120	**0.01**
Ce	0.0180	0.0180	**0.02**
Ta	0.0020	0.0030	**0.00**
LOI	0.0000	0.0000	**0.00**
Ga	0.0017	0.0009	**0.00**
Si	18.4000	18.1000	**18.25**
Ti	0.0810	0.0760	**0.08**
Cr	0.0007	0.0021	**0.00**
V	0.0190	0.0190	**0.02**
Fe	34.2000	34.8000	**34.50**
Mn	0.0260	0.0290	**0.03**
Mg	1.0800	1.0400	**1.06**
Ca	0.8100	0.8300	**0.82**
Ba	0.0410	0.0400	**0.04**
Satmagan	29.4600	29.3600	**29.41**
Eltra S	0.0280	0.0220	**0.03**

9.2 Assay of returned crushability test material (from Sandvik)

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 5.3.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 119093
Method : 180X-O
Date : 5.3.2014
Comment **: Nordic Iron Ore - Blötberget 'Upper Level' ore feed / Sandvik test material returned, analysis request 05.03.2014**

Contents (%)

	Sample 1 L14018817	Sample 2 L14018818	Sandvik Avg.	vs.	Test Feed Avg. (11.02.2014)
SiO2	40.9000	41.3000	**41.10**		**39.00**
TiO2	0.1480	0.1470	**0.15**		**0.13**
Al2O3	5.6400	5.7900	**5.72**		**6.08**
Cr2O3	0.0051	0.0048	**0.00**		**0.00**
V2O3	0.0250	0.0250	**0.03**		**0.03**
MnO	0.0350	0.0330	**0.03**		**0.04**
MgO	1.6100	1.6100	**1.61**		**1.76**
CaO	0.9500	0.9500	**0.95**		**1.15**
Rb2O	0.0088	0.0096	**0.01**		**0.01**
SrO	0.0004	0.0000	**0.00**		**0.00**
BaO	0.0460	0.0460	**0.05**		**0.04**
Na2O	2.3400	2.4200	**2.38**		**2.40**
K2O	0.6200	0.6300	**0.63**		**0.81**
ZrO2	0.0120	0.0110	**0.01**		**0.01**
P2O5	0.5000	0.4970	**0.50**		**0.65**
OxSumm	96.6000	96.8000	**96.70**		**96.55**
Cu	0.0010	0.0010	**0.00**		**0.00**
Ni	0.0040	0.0040	**0.00**		**0.00**
Co	0.0020	0.0010	**0.00**		**0.02**
Zn	0.0060	0.0050	**0.01**		**0.01**
Pb	0.0000	0.0000	**0.00**		**0.00**
Ag	0.0010	0.0020	**0.00**		**0.00**
S	0.0030	0.0030	**0.00**		**0.01**
As	0.0000	0.0000	**0.00**		**0.00**
Sb	0.0120	0.0100	**0.01**		**0.01**
Bi	0.0020	0.0020	**0.00**		**0.00**
Te	0.0000	0.0000	**0.00**		**0.00**
Y	0.0025	0.0024	**0.00**		**0.00**
Nb	0.0000	0.0000	**0.00**		**0.00**
Mo	0.0000	0.0000	**0.00**		**0.00**
Sn	0.0060	0.0060	**0.01**		**0.01**
W	0.0000	0.0000	**0.00**		**0.00**
Cl	0.0060	0.0070	**0.01**		**0.01**
Th	0.0037	0.0028	**0.00**		**0.00**
U	0.0037	0.0037	**0.00**		**0.00**
Cs	0.0020	0.0020	**0.00**		**0.00**
La	0.0110	0.0110	**0.01**		**0.01**
Ce	0.0160	0.0150	**0.02**		**0.02**
Ta	0.0040	0.0000	**0.00**		**0.00**
LOI	0.0000	0.0000	**0.00**		**0.00**
Ga	0.0021	0.0026	**0.00**		**0.00**
Si	19.1000	19.3000	**19.20**		**18.25**
Ti	0.0890	0.0880	**0.09**		**0.08**
Cr	0.0035	0.0033	**0.00**		**0.00**
V	0.0170	0.0170	**0.02**		**0.02**
Fe	34.0000	33.6000	**33.80**		**34.50**
Mn	0.0270	0.0260	**0.03**		**0.03**
Mg	0.9700	0.9700	**0.97**		**1.06**
Ca	0.6800	0.6800	**0.68**		**0.82**
Ba	0.0410	0.0410	**0.04**		**0.04**
Eltra S	0.0176	0.0230	**0.020**		**0.025**
Satmagan	29.14	31.75	**30.45**		**29.41**

9.3 Dry LIMS – Coarse Product

Labtium Oy
REPORT OF XRF ANALYSIS 20.2.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 18966
Method : 180X-O
Date : 20.2.2014
Comment : Nordic Iron Ore - Blötberget 'Upper Level' / Eriez DLIMS Tests 1 & 2, analysis request 19.2.2014

Contents (%)

	Test1/NM1 L14015013	Test1/NM2 L14015014	Test1/NM3 L14015015	Test1/FM3 L14015016	Test2/NM1 L14015017	Test2/NM2 L14015018	Test2/NM3 L14015019	Test2/NM4 L14015020	Test2/FM4 L14015021
SiO2	62.2000	24.4000	27.5000	20.8000	56.7000	33.4000	30.3000	26.7000	19.0000
TiO2	0.2430	0.0890	0.0870	0.0550	0.2030	0.1500	0.1010	0.0820	0.0490
Al2O3	10.2000	3.3200	3.2700	1.9500	9.4500	4.4800	3.4900	2.8500	1.9000
Cr2O3	0.0086	0.0086	0.0082	0.0067	0.0088	0.0092	0.0091	0.0079	0.0063
V2O3	0.0150	0.0440	0.0340	0.0350	0.0200	0.0380	0.0360	0.0340	0.0340
MnO	0.0130	0.0290	0.0370	0.0570	0.0170	0.0410	0.0430	0.0530	0.0690
MgO	1.7100	1.7200	2.2300	1.5900	1.9300	2.6600	2.2900	2.0800	1.5900
CaO	1.3500	1.5000	1.0900	0.8100	1.5300	1.6100	1.1900	0.9900	0.7300
Rb2O	0.0094	0.0110	0.0120	0.0120	0.0088	0.0110	0.0110	0.0110	0.0110
SrO	0.0043	0.0000	0.0000	0.0000	0.0034	0.0000	0.0000	0.0000	0.0000
BaO	0.0650	0.0370	0.0570	0.0290	0.0620	0.0600	0.0620	0.0480	0.0300
Na2O	4.0000	1.1100	0.9600	0.4200	3.7500	1.3900	1.0200	0.7700	0.4200
K2O	1.4800	0.4350	0.5000	0.2740	1.3200	0.6500	0.5400	0.4290	0.2490
ZrO2	0.0260	0.0060	0.0070	0.0050	0.0210	0.0090	0.0070	0.0060	0.0040
P2O5	0.4240	1.1500	0.8300	0.6600	0.7000	1.1800	0.8500	0.7400	0.5800
OxSumm	98.3000	94.2000	95.1000	95.2000	97.8000	95.2000	95.1000	95.2000	95.1000
Cu	0.0010	0.0010	0.0010	0.0000	0.0010	0.0030	0.0020	0.0020	0.0020
Ni	0.0020	0.0050	0.0040	0.0050	0.0030	0.0060	0.0060	0.0060	0.0050
Co	0.0130	0.0090	0.0070	0.0070	0.0070	0.0100	0.0090	0.0090	0.0060
Zn	0.0030	0.0040	0.0070	0.0090	0.0030	0.0070	0.0040	0.0060	0.0140
Pb	0.0050	0.0000	0.0000	0.0000	0.0040	0.0010	0.0010	0.0000	0.0000
Ag	0.0020	0.0010	0.0020	0.0020	0.0010	0.0020	0.0030	0.0020	0.0030
S	0.0100	0.0050	0.0060	0.0040	0.0070	0.0190	0.0100	0.0090	0.0160
As	0.0000	0.0010	0.0020	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000
Sb	0.0130	0.0090	0.0090	0.0090	0.0130	0.0100	0.0120	0.0090	0.0090
Bi	0.0020	0.0020	0.0030	0.0020	0.0020	0.0030	0.0030	0.0020	0.0020
Te	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000
Y	0.0034	0.0033	0.0020	0.0015	0.0044	0.0032	0.0028	0.0034	0.0016
Nb	0.0019	0.0015	0.0000	0.0000	0.0013	0.0005	0.0000	0.0000	0.0000
Mo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sn	0.0060	0.0070	0.0050	0.0050	0.0060	0.0090	0.0060	0.0060	0.0040
W	0.0000	0.0010	0.0010	0.0010	0.0000	0.0010	0.0010	0.0010	0.0000
Cl	0.0110	0.0060	0.0060	0.0050	0.0120	0.0090	0.0070	0.0070	0.0040
Th	0.0022	0.0042	0.0027	0.0044	0.0023	0.0034	0.0039	0.0034	0.0043
U	0.0000	0.0056	0.0062	0.0067	0.0005	0.0055	0.0057	0.0063	0.0067
Cs	0.0000	0.0020	0.0010	0.0030	0.0020	0.0010	0.0030	0.0020	0.0020
La	0.0090	0.0180	0.0120	0.0140	0.0140	0.0200	0.0180	0.0170	0.0110
Ce	0.0160	0.0240	0.0210	0.0160	0.0180	0.0310	0.0240	0.0190	0.0150
Ta	0.0020	0.0030	0.0040	0.0000	0.0010	0.0030	0.0020	0.0050	0.0030
LOI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ga	0.0016	0.0039	0.0019	0.0028	0.0023	0.0002	0.0016	0.0046	0.0015
Si	29.1000	11.4000	12.9000	9.7200	26.5000	15.6000	14.2000	12.5000	8.8700
Ti	0.1450	0.0540	0.0520	0.0330	0.1220	0.0900	0.0610	0.0490	0.0300
Cr	0.0059	0.0059	0.0056	0.0046	0.0060	0.0063	0.0062	0.0054	0.0043
V	0.0100	0.0300	0.0230	0.0240	0.0140	0.0260	0.0240	0.0230	0.0230
Fe	12.8000	46.8000	45.4000	53.2000	17.1000	38.4000	42.8000	46.9000	54.7000
Mn	0.0100	0.0230	0.0290	0.0440	0.0140	0.0320	0.0330	0.0410	0.0540
Mg	1.0300	1.0400	1.3400	0.9600	1.1600	1.6000	1.3800	1.2600	0.9600
Ca	0.9600	1.0700	0.7800	0.5800	1.0900	1.1500	0.8500	0.7100	0.5200
Ba	0.0580	0.0330	0.0510	0.0260	0.0560	0.0540	0.0560	0.0430	0.0260
Satmagan	1.2600	14.1700	30.7300	58.9800	1.2100	10.1500	22.7500	38.4500	62.6400

9.4 Davis Tube Assay Results

9.4.1 Effects of grind size on recovery

Labtium Oy
REPORT OF XRF ANALYSIS 27.2.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 119046
Method : 180X-O
Date : 27.2.2014
Comment **: Nordic Iron Ore - Blötberget 'Upper Level' ore feed / DTR basic test series - 1,500 Gauss, analysis request 27.2.2014**

Contents (%)

	-1.0 mm M	**-1.0 mm NM**	**-0.8 mm M**	**-0.8 mm NM**	**-0.63 mm M**	**-0.63 mm NM**	**-0.315 mm M**	**-0.315 mm NM**	**-0.112 mm M**	**-0.112 mm NM**	**-0.063 mm M**	**-0.063 mm NM**
	L14017448	**L14017449**	**L14017450**	**L14017451**	**L14017452**	**L14017453**	**L14017454**	**L14017455**	**L14017456**	**L14017457**	**L14017458**	**L14017459**
SiO2	7.7800	52.5000	6.6600	52.4000	2.6800	51.7000	2.0900	54.1000	0.5300	52.9000	0.3500	52.5000
TiO2	0.0200	0.2020	0.0200	0.2060	0.0090	0.2020	0.0080	0.1920	0.0050	0.2010	0.0030	0.1940
Al2O3	0.8200	7.8600	0.7500	7.8700	0.4400	7.5400	0.4300	8.1800	0.2600	7.9000	0.2100	7.7500
Cr2O3	0.0035	0.0026	0.0044	0.0076	0.0091	0.0096	0.0150	0.0180	0.0790	0.0420	0.1670	0.0790
V2O3	0.0350	0.0250	0.0350	0.0250	0.0330	0.0260	0.0330	0.0250	0.0340	0.0260	0.0330	0.0260
MnO	0.0640	0.0180	0.0640	0.0200	0.0650	0.0200	0.0620	0.0200	0.0700	0.0230	0.0750	0.0280
MgO	0.5400	2.0000	0.4600	2.0100	0.2300	1.9600	0.2500	2.3100	0.1100	2.1900	0.0500	2.1800
CaO	0.2530	1.6900	0.2320	1.6500	0.1040	1.6700	0.0910	1.6300	0.0460	1.6400	0.0230	1.6200
Rb2O	0.0120	0.0094	0.0091	0.0100	0.0120	0.0100	0.0120	0.0098	0.0088	0.0091	0.0100	0.0096
SrO	0.0000	0.0027	0.0000	0.0026	0.0000	0.0026	0.0000	0.0024	0.0000	0.0026	0.0000	0.0025
BaO	0.0170	0.0610	0.0110	0.0640	0.0070	0.0650	0.0070	0.0660	0.0030	0.0620	0.0060	0.0600
Na2O	0.1300	2.9700	0.1100	2.9900	0.0300	2.8500	0.0300	3.0600	0.0000	2.9600	0.0000	2.8800
K2O	0.1010	1.1900	0.0890	1.1900	0.0350	1.1300	0.0270	1.2100	0.0070	1.1500	0.0030	1.1400
ZrO2	0.0020	0.0210	0.0030	0.0200	0.0020	0.0190	0.0030	0.0190	0.0020	0.0200	0.0010	0.0190
P2O5	0.1740	0.8500	0.1520	0.8500	0.0590	0.8800	0.0610	0.8900	0.0340	0.9100	0.0160	0.9000
OxSumm	94.6000	97.0000	94.4000	97.0000	94.2000	96.9000	94.2000	97.3000	94.1000	97.2000	94.0000	97.1000
Cu	0.0030	0.0000	0.0000	0.0000	0.0000	0.0010	0.0020	0.0010	0.0020	0.0020	0.0030	0.0010
Ni	0.0030	0.0030	0.0120	0.0050	0.0090	0.0060	0.0160	0.0100	0.0430	0.0220	0.0900	0.0350
Co	0.0000	0.0030	0.0000	0.0040	0.0020	0.0030	0.0110	0.0230	0.0030	0.0080	0.0070	0.0200
Zn	0.0120	0.0060	0.0110	0.0030	0.0120	0.0040	0.0100	0.0050	0.0100	0.0050	0.0130	0.0050
Pb	0.0000	0.0070	0.0000	0.0030	0.0000	0.0030	0.0000	0.0030	0.0000	0.0040	0.0000	0.0050
Ag	0.0040	0.0020	0.0040	0.0020	0.0030	0.0020	0.0020	0.0010	0.0040	0.0010	0.0030	0.0020
S	0.0030	0.0140	0.0020	0.0050	0.0020	0.0040	0.0020	0.0060	0.0020	0.0110	0.0020	0.0150
As	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000	0.0010	0.0000
Sb	0.0120	0.0170	0.0150	0.0150	0.0100	0.0140	0.0090	0.0140	0.0090	0.0140	0.0080	0.0140
Bi	0.0030	0.0020	0.0020	0.0020	0.0030	0.0020	0.0030	0.0020	0.0020	0.0020	0.0010	0.0020
Te	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Y	0.0017	0.0045	0.0000	0.0048	0.0007	0.0043	0.0001	0.0047	0.0001	0.0043	0.0003	0.0047
Nb	0.0000	0.0020	0.0000	0.0016	0.0000	0.0018	0.0000	0.0021	0.0000	0.0019	0.0000	0.0018
Mo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0025	0.0023	0.0120	0.0066
Sn	0.0050	0.0090	0.0050	0.0090	0.0020	0.0080	0.0000	0.0080	0.0010	0.0080	0.0010	0.0080
W	0.0090	0.0010	0.0040	0.0000	0.0010	0.0000	0.0010	0.0000	0.0000	0.0010	0.0010	0.0010
Cl	0.0030	0.0110	0.0030	0.0100	0.0020	0.0090	0.0020	0.0100	0.0000	0.0080	0.0030	0.0090
Th	0.0041	0.0024	0.0039	0.0031	0.0045	0.0024	0.0045	0.0026	0.0040	0.0030	0.0040	0.0024
U	0.0078	0.0009	0.0082	0.0013	0.0093	0.0014	0.0088	0.0016	0.0084	0.0007	0.0089	0.0015
Cs	0.0000	0.0030	0.0030	0.0020	0.0030	0.0030	0.0030	0.0030	0.0020	0.0030	0.0030	0.0000
La	0.0070	0.0160	0.0070	0.0200	0.0040	0.0190	0.0050	0.0180	0.0030	0.0200	0.0030	0.0180
Ce	0.0070	0.0270	0.0060	0.0250	0.0040	0.0240	0.0040	0.0250	0.0020	0.0280	0.0020	0.0250
Ta	0.0050	0.0030	0.0050	0.0030	0.0000	0.0000	0.0000	0.0020	0.0000	0.0040	0.0020	0.0000
LOI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ga	0.0020	0.0012	0.0011	0.0012	0.0040	0.0005	0.0015	0.0008	0.0031	0.0014	0.0023	0.0017
Si	3.6400	24.6000	3.1200	24.5000	1.2500	24.2000	0.9800	25.3000	0.2500	24.7000	0.1600	24.5000
Ti	0.0120	0.1210	0.0120	0.1240	0.0050	0.1210	0.0050	0.1150	0.0030	0.1200	0.0020	0.1160
Cr	0.0024	0.0018	0.0030	0.0052	0.0062	0.0066	0.0100	0.0120	0.0540	0.0290	0.1140	0.0540
V	0.0240	0.0170	0.0240	0.0170	0.0220	0.0180	0.0220	0.0170	0.0230	0.0180	0.0220	0.0180
Fe	65.7000	21.3000	66.7000	21.5000	70.3000	22.3000	70.7000	19.8000	72.2000	20.9000	72.2000	21.4000
Mn	0.0500	0.0140	0.0500	0.0160	0.0500	0.0160	0.0480	0.0150	0.0540	0.0180	0.0580	0.0210
Mg	0.3200	1.2100	0.2800	1.2100	0.1400	1.1800	0.1500	1.3900	0.0700	1.3200	0.0300	1.3200
Ca	0.1800	1.2100	0.1660	1.1800	0.0740	1.1900	0.0650	1.1700	0.0330	1.1700	0.0160	1.1600
Ba	0.0150	0.0550	0.0090	0.0570	0.0060	0.0590	0.0060	0.0590	0.0030	0.0560	0.0050	0.0540
Eltra S	0.002	0.023	0.008	0.020	0.009	0.018	0.016	0.018	0.015	0.025	0.014	0.027
Satmagan	86.90	1.16	87.49	0.96	96.22	0.94	97.34	0.85	100.00	1.13	99.19	1.72

9.4.2 Effect of field strength on recovery

Labtium Oy
REPORT OF XRF ANALYSIS 28.2.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 119065
Method : 180X-O
Date : 28.02.2014
Comment **: Nordic Iron Ore - Blötberget 'Upper Level' ore feed / Additional DTR tests - 1,000 vs. 2,500 Gauss, analysis request 28.2.2014**

Contents (%)

	A-63µm M L14018410	A-63µm NM L14018411	B-63µm M L14018412	B-63µm NM L14018413
	Field 1,000 Gauss		Field 2,500 Gauss	
SiO2	0.4000	52.1000	0.3400	53.5000
TiO2	0.0010	0.1920	0.0020	0.1910
Al2O3	0.2200	7.8000	0.2100	8.0600
Cr2O3	0.1740	0.0740	0.1710	0.0670
V2O3	0.0340	0.0260	0.0330	0.0260
MnO	0.0720	0.0270	0.0730	0.0270
MgO	0.0700	2.1700	0.0500	2.2800
CaO	0.0310	1.5900	0.0370	1.6400
Rb2O	0.0120	0.0100	0.0100	0.0095
SrO	0.0000	0.0024	0.0000	0.0028
BaO	0.0060	0.0600	0.0050	0.0590
Na2O	0.0000	2.9300	0.0000	3.0200
K2O	0.0030	1.1100	0.0030	1.1500
ZrO2	0.0010	0.0190	0.0000	0.0190
P2O5	0.0250	0.9100	0.0280	0.9700
OxSumm	94.0000	97.1000	94.0000	97.3000
Cu	0.0030	0.0020	0.0040	0.0020
Ni	0.0870	0.0320	0.0880	0.0310
Co	0.0090	0.0190	0.0190	0.0040
Zn	0.0150	0.0060	0.0110	0.0050
Pb	0.0000	0.0040	0.0000	0.0040
Ag	0.0050	0.0010	0.0010	0.0010
S	0.0030	0.0150	0.0030	0.0140
As	0.0000	0.0000	0.0000	0.0000
Sb	0.0090	0.0090	0.0080	0.0100
Bi	0.0030	0.0020	0.0040	0.0020
Te	0.0000	0.0000	0.0000	0.0000
Y	0.0000	0.0042	0.0003	0.0042
Nb	0.0000	0.0011	0.0000	0.0013
Mo	0.0150	0.0062	0.0140	0.0055
Sn	0.0020	0.0070	0.0020	0.0070
W	0.0010	0.0000	0.0010	0.0000
Cl	0.0020	0.0090	0.0020	0.0070
Th	0.0041	0.0026	0.0043	0.0023
U	0.0091	0.0017	0.0080	0.0017
Cs	0.0020	0.0040	0.0020	0.0000
La	0.0030	0.0170	0.0030	0.0170
Ce	0.0020	0.0260	0.0000	0.0270
Ta	0.0060	0.0000	0.0050	0.0030
LOI	0.0000	0.0000	0.0000	0.0000
Ga	0.0044	0.0004	0.0012	0.0019
Si	0.1900	24.4000	0.1600	25.0000
Ti	0.0010	0.1150	0.0010	0.1150
Cr	0.1190	0.0510	0.1170	0.0460
V	0.0230	0.0180	0.0220	0.0180
Fe	72.1000	21.7000	72.2000	20.3000
Mn	0.0560	0.0210	0.0560	0.0210
Mg	0.0400	1.3100	0.0300	1.3800
Ca	0.0220	1.1300	0.0260	1.1700
Ba	0.0050	0.0540	0.0040	0.0530
Eltra S	0.0218	0.0284	0.0198	0.0318
Satmagan	98.97	2.38	98.74	0.96

30.9.2014

9.4.3 Davis Tube test on LIMS feed

LABTIUM

Labtium Oy
REPORT OF XRF-ANALYSIS 13.3.2014

Customer	: Markku Kuusisto, GTK Mintec
Order	: 119187
Method	: 180X-O
Date	: 12.3.2014
Comment	: Nordic Iron Ore Blötberget Upper Level / DTR Test, LIMS Feed < 0.63mm

Contents (%)

	DTR Mags L14019919 Corrected	DTR NMags L14019920
SiO2	5.59	52.4
TiO2	0.016	0.205
Al2O3	0.69	7.79
Cr2O3	0.0045	0.0035
V2O3	0.032	0.026
MnO	0.065	0.017
MgO	0.45	2.09
CaO	0.198	1.65
Rb2O	0.011	0.010
SrO	0.0000	0.0019
BaO	0.012	0.064
Na2O	0.11	2.97
K2O	0.069	1.11
ZrO2	0.002	0.018
P2O5	0.134	0.89
OxSumm	94.40	97.10
Cu	0.001	0.001
Ni	0.009	0.004
Co	0.006	0.003
Zn	0.011	0.002
Pb	0.000	0.004
Ag	0.002	0.001
S	0.002	0.005
As	0.000	0.000
Sb	0.007	0.011
Bi	0.004	0.002
Te	0.001	0.000
Y	0.0008	0.0045
Nb	0.0000	0.0016
Mo	0.0000	0.0000
Sn	0.001	0.007
W	0.000	0.000
Cl	0.002	0.007
Th	0.0028	0.0027
U	0.0085	0.0013
Cs	0.002	0.003
La	0.007	0.017
Ce	0.007	0.025
Ta	0.007	0.001
LOI	0.0000	0.0000
Ga	0.0009	0.0011
Si	2.61	24.5
Ti	0.009	0.123
Cr	0.0031	0.0024
V	0.022	0.018
Fe	67.6	21.5
Mn	0.051	0.013
Mg	0.27	1.26
Ca	0.141	1.18
Ba	0.010	0.058
Eltra S	0.023	0.044
Satmagan	91.70	0.91

9.5 LIMS

9.5.1 <0.63mm

LABTIUM

Labtium Oy
REPORT OF XRF-ANALYSIS 17.3.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 119234
Method : 180X-O
Date : 17.03.2014
Comment : Nordic Iron Ore
Blötberget Upper Level / LIMS Feed < 0.63mm, LIMS test products

Contents (%)

Test product weight, g			5111.7	77.9
	Mags 3 A L14021735	Mags 3 B L14021736	Mags 3 Avg.	Non-Mags 3 L14021737
SiO2	10.2000	10.3000	10.2500	38.8000
TiO2	0.0240	0.0220	0.0230	0.2090
Al2O3	1.1000	1.1000	1.1000	4.5100
Cr2O3	0.0047	0.0031	0.0039	0.0037
V2O3	0.0330	0.0320	0.0325	0.0370
MnO	0.0660	0.0640	0.0650	0.0410
MgO	0.7200	0.7000	0.7100	3.2700
CaO	0.4020	0.2940	0.3480	1.5100
Rb2O	0.0110	0.0100	0.0105	0.0130
SrO	0.0000	0.0000	0.0000	0.0000
BaO	0.0150	0.0150	0.0150	0.0780
Na2O	0.2400	0.2500	0.2450	1.1700
K2O	0.1140	0.1170	0.1155	0.7300
ZrO2	0.0040	0.0030	0.0035	0.0140
P2O5	0.2630	0.2050	0.2340	1.1000
OxSumm	94.6000	94.6000	94.6000	95.5000
Cu	0.0000	0.0000	0.0000	0.0040
Ni	0.0090	0.0060	0.0075	0.0040
Co	0.0040	0.0040	0.0040	0.0030
Zn	0.0120	0.0110	0.0115	0.0070
Pb	0.0000	0.0000	0.0000	0.0010
Ag	0.0020	0.0020	0.0020	0.0010
S	0.0030	0.0020	0.0025	0.0110
As	0.0000	0.0000	0.0000	0.0010
Sb	0.0080	0.0090	0.0085	0.0070
Bi	0.0030	0.0030	0.0030	0.0020
Te	0.0000	0.0000	0.0000	0.0000
Y	0.0000	0.0017	0.0009	0.0031
Nb	0.0000	0.0000	0.0000	0.0008
Mo	0.0000	0.0000	0.0000	0.0000
Sn	0.0030	0.0020	0.0025	0.0100
W	0.0010	0.0000	0.0005	0.0000
Cl	0.0030	0.0040	0.0035	0.0090
Th	0.0047	0.0042	0.0045	0.0034
U	0.0087	0.0083	0.0085	0.0046
Cs	0.0020	0.0020	0.0020	0.0030
La	0.0070	0.0080	0.0075	0.0270
Ce	0.0080	0.0090	0.0085	0.0320
Ta	0.0040	0.0060	0.0050	0.0010
LOI	0.0000	0.0000	0.0000	0.0000
Ga	0.0015	0.0008	0.0012	0.0025
Si	4.7900	4.8100	4.8000	18.1000
Ti	0.0140	0.0130	0.0135	0.1250
Cr	0.0032	0.0021	0.0027	0.0025
V	0.0220	0.0220	0.0220	0.0250
Fe	63.2000	63.3000	63.2500	34.1000
Mn	0.0510	0.0500	0.0505	0.0320
Mg	0.4400	0.4200	0.4300	1.9700
Ca	0.2870	0.2100	0.2485	1.0800
Ba	0.0140	0.0130	0.0135	0.0690
Eltra S	0.0346	0.0294	0.032	0.0352
Satmagan	80.65	80.81	**80.73**	3.65

9.5.2 <0.315mm

LABTIUM

Labtium Oy
REPORT OF XRF-ANALYSIS 17.-25.3.2014

Customer	: Markku Kuusisto, GTK Mintec
Orders	: 119234, 119263, 119321
Method	: 180X-O
Date	: 17.-25.3.2014
Comment	: Nordic Iron Ore Blötberget Upper Level / LIMS Feed < 0.63 mm & < 0.315 mm, LIMS test products

Contents (%)

Test product weight, g	8855.6	77.9	614.8	4496.9	Calc. Test Feed weight 14045.2
	Fineness < 0.63 mm		Reground down to < 0.315 mm prior to re-cleanings		
	Non-Mags 1+2 L14022309	Non-Mags 3 L14021737	Non-Mags 4+5 L14024110	Mags 5 L14024109	
SiO2	54.4000	38.8000	48.8000	4.1800	
TiO2	0.1970	0.2090	0.1320	0.0080	
Al2O3	8.2500	4.5100	4.2900	0.6000	
Cr2O3	0.0025	0.0037	0.0100	0.0077	
V2O3	0.0230	0.0370	0.0310	0.0310	
MnO	0.0190	0.0410	0.0360	0.0640	
MgO	2.1800	3.2700	3.0000	0.3600	
CaO	1.7200	1.5100	1.6100	0.0880	
Rb2O	0.0100	0.0130	0.0098	0.0110	
SrO	0.0019	0.0000	0.0005	0.0000	
BaO	0.0670	0.0780	0.0680	0.0060	
Na2O	3.1500	1.1700	1.1000	0.0900	
K2O	1.1900	0.7300	0.6800	0.0440	
ZrO2	0.0190	0.0140	0.0100	0.0030	
P2O5	0.9300	1.1000	1.2100	0.0620	
OxSumm	97.3000	95.5000	96.3000	94.2000	
Cu	0.0020	0.0040	0.0000	0.0010	
Ni	0.0040	0.0040	0.0070	0.0110	
Co	0.0060	0.0030	0.0000	0.0000	
Zn	0.0030	0.0070	0.0050	0.0120	
Pb	0.0030	0.0010	0.0030	0.0000	
Ag	0.0010	0.0010	0.0030	0.0030	
S	0.0050	0.0110	0.0090	0.0020	
As	0.0000	0.0010	0.0010	0.0020	
Sb	0.0120	0.0070	0.0140	0.0060	
Bi	0.0020	0.0020	0.0020	0.0030	
Te	0.0000	0.0000	0.0000	0.0000	
Y	0.0047	0.0031	0.0045	0.0000	
Nb	0.0017	0.0008	0.0009	0.0000	
Mo	0.0000	0.0000	0.0000	0.0000	
Sn	0.0070	0.0100	0.0110	0.0010	
W	0.0000	0.0000	0.0060	0.0030	
Cl	0.0100	0.0090	0.0060	0.0020	
Th	0.0026	0.0034	0.0029	0.0046	
U	0.0016	0.0046	0.0034	0.0079	
Cs	0.0000	0.0030	0.0040	0.0020	
La	0.0180	0.0270	0.0260	0.0040	
Ce	0.0260	0.0320	0.0380	0.0030	
Ta	0.0010	0.0010	0.0040	0.0000	
LOI	0.0000	0.0000	0.0000	0.0000	
Ga	0.0019	0.0025	0.0016	0.0032	
Si	25.4000	18.1000	22.8000	1.9500	
Ti	0.1180	0.1250	0.0790	0.0050	
Cr	0.0017	0.0025	0.0069	0.0053	
V	0.0160	0.0250	0.0210	0.0210	
Fe	19.5000	34.1000	27.3000	68.9000	
Mn	0.0150	0.0320	0.0280	0.0500	
Mg	1.3100	1.9700	1.8100	0.2200	
Ca	1.2300	1.0800	1.1500	0.0630	
Ba	0.0600	0.0690	0.0610	0.0060	
Eltra S	0.0246	0.0352	0.0241	0.0135	
Satmagan	0.63	3.65	0.91	**91.53**	

30.9.2014

9.5.3 <0.075mm

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 3.4.2014

Customer	: Markku Kuusisto, GTK mintec
Order	: 119431
Method	: 180X-O
Date	: 3.4.2014
Comment	: Nordic Iron Ore, Blötberget Upper Level LIMS Test 1 / Re-cleaning of "Mags 5" after regrinding down to minus 0.075 mm

Contents (%)

	Mags 7 L14025778	Non-Mags 6-7 L14025779
SiO2	0.5200	52.0000
TiO2	0.0020	0.1430
Al2O3	0.2700	4.9500
Cr2O3	0.0550	0.0530
V2O3	0.0310	0.0250
MnO	0.0650	0.0620
MgO	0.1200	3.3900
CaO	0.0130	1.3100
Rb2O	0.0100	0.0081
SrO	0.0000	0.0000
BaO	0.0040	0.0630
Na2O	0.0000	1.1200
K2O	0.0090	0.6500
ZrO2	0.0020	0.0190
P2O5	0.0090	0.9000
OxSumm	94.0000	96.7000
Cu	0.0020	0.0040
Ni	0.0320	0.0280
Co	0.0020	0.0010
Zn	0.0120	0.0060
Pb	0.0000	0.0030
Ag	0.0020	0.0020
S	0.0020	0.0170
As	0.0020	0.0010
Sb	0.0050	0.0150
Bi	0.0020	0.0020
Te	0.0000	0.0000
Y	0.0000	0.0046
Nb	0.0000	0.0014
Mo	0.0000	0.0034
Sn	0.0000	0.0110
W	0.0000	0.0000
Cl	0.0020	0.0060
Th	0.0036	0.0025
U	0.0092	0.0046
Cs	0.0030	0.0000
La	0.0030	0.0360
Ce	0.0020	0.0480
Ta	0.0050	0.0050
LOI	0.0000	0.0000
Ga	0.0005	0.0021
Si	0.2400	24.3000
Ti	0.0010	0.0860
Cr	0.0370	0.0360
V	0.0210	0.0170
Fe	72.2000	24.7000
Mn	0.0500	0.0480
Mg	0.0700	2.0500
Ca	0.0090	0.9300
Ba	0.0040	0.0560
Eltra S	0.0131	0.0254
Satmagan	**99.33**	**0.87**

9.5.4 <1.18mm RoM shaking table concentrate

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 16.4.2014

Customer	: Markku Kuusisto, GTK Mintec
Order	: 119556
Method	: 180X-O
Date	: 16.04.2014
Comment	: Nordic Iron Ore, Blötberget Upper Level Feed fineness < 1.18mm (Ore ==> Shaking table Conc.) - WLIMS testing; analysis request 15.4.2014

Contents (%)

	WLIMS Mags L14028370	WLIMS NM L14028371
SiO2	1.5500	2.3600
TiO2	0.0270	0.3450
Al2O3	0.4500	0.5300
Cr2O3	0.0032	0.0047
V2O3	0.0380	0.0660
MnO	0.0560	0.0060
MgO	0.2700	0.0900
CaO	0.1740	0.9700
Rb2O	0.0110	0.0110
SrO	0.0000	0.0000
BaO	0.0050	0.0050
Na2O	0.0200	0.0800
K2O	0.0240	0.0210
ZrO2	0.0020	0.0090
P2O5	0.1530	0.8400
OxSumm	93.7000	90.9000
Cu	0.0010	0.0030
Ni	0.0060	0.0020
Co	0.0110	0.0000
Zn	0.0100	0.0040
Pb	0.0000	0.0000
Ag	0.0030	0.0030
S	0.0010	0.0040
As	0.0010	0.0020
Sb	0.0070	0.0140
Bi	0.0020	0.0030
Te	0.0000	0.0000
Y	0.0012	0.0026
Nb	0.0000	0.0016
Mo	0.0000	0.0000
Sn	0.0030	0.0150
W	0.0000	0.0400
Cl	0.0020	0.0030
Th	0.0046	0.0054
U	0.0089	0.0093
Cs	0.0000	0.0020
La	0.0040	0.0250
Ce	0.0090	0.0380
Ta	0.0000	0.0040
LOI	0.0000	0.0000
Ga	0.0035	0.0025
Si	0.7300	1.1000
Ti	0.0160	0.2070
Cr	0.0022	0.0032
V	0.0250	0.0450
Fe	70.6000	66.4000
Mn	0.0430	0.0040
Mg	0.1600	0.0500
Ca	0.1240	0.6900
Ba	0.0040	0.0050
Satmagan	**83.91**	1.03
Eltra S	0.0133	0.0158

30.9.2014

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 22.4.2014

Customer	: Markku Kuusisto, GTK Mintec
Order	: 119594
Method	: 180X-O
Date	: 22.04.2014
Comment	: Nordic Iron Ore, Blötberget Upper Level Feed fineness < 1.18mm (Ore ==> Shaking table Conc.) - WLIMS testing; analysis request 22.4.2014

Contents (%)

	WLIMS Mags L14029348	**WLIMS NM L14029349**
SiO2	1.6400	2.3000
TiO2	0.0280	0.3300
Al2O3	0.4500	0.5600
Cr2O3	0.0047	0.0100
V2O3	0.0380	0.0650
MnO	0.0600	0.0090
MgO	0.2900	0.1400
CaO	0.2620	1.0700
Rb2O	0.0110	0.0120
SrO	0.0000	0.0000
BaO	0.0040	0.0060
Na2O	0.0100	0.0800
K2O	0.0260	0.0210
ZrO2	0.0040	0.0090
P2O5	0.1640	0.8800
OxSumm	93.7000	91.0000
Cu	0.0010	0.0020
Ni	0.0080	0.0050
Co	0.0030	0.0000
Zn	0.0110	0.0020
Pb	0.0000	0.0000
Ag	0.0050	0.0040
S	0.0030	0.0050
As	0.0010	0.0000
Sb	0.0090	0.0080
Bi	0.0020	0.0030
Te	0.0000	0.0000
Y	0.0003	0.0037
Nb	0.0000	0.0005
Mo	0.0000	0.0000
Sn	0.0040	0.0150
W	0.0000	0.0120
Cl	0.0030	0.0030
Th	0.0042	0.0061
U	0.0080	0.0096
Cs	0.0020	0.0030
La	0.0070	0.0240
Ce	0.0070	0.0340
Ta	0.0010	0.0120
LOI	0.0000	0.0000
Ga	0.0028	0.0034
Si	0.7700	1.0800
Ti	0.0170	0.1980
Cr	0.0032	0.0070
V	0.0260	0.0440
Fe	70.5000	66.3000
Mn	0.0460	0.0070
Mg	0.1800	0.0800
Ca	0.1870	0.7600
Ba	0.0040	0.0060
Satmagan	**84.43**	1.16
Eltra S	0.0110	0.0130

9.5.5 <0.150mm reground shaking table tailings (scavenger)

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 8.5.2014

Customer : Markku Kuusisto, GTK Mintec
Orders : 119725, 119741
Method : 180X-O
Date : 8.5.2014
Comment : Nordic Iron Ore, Blötberget Upper Level
Shaking table Test 2, combined rejects - WLIMS testing; analysis requests 7.-8.5.2014

Contents (%)

	Rgh NM1 L14031116	Cln NM2+3 L14031117	(Cln M3) L14031118	Cln NM4+5 L14031633	Cln M5 L14031634
SiO2	69.9000	62.7000	16.4000	72.8000	2.8400
TiO2	0.1520	0.1320	0.0160	0.0780	0.0050
Al2O3	10.7000	5.5800	1.6800	5.6300	0.6300
Cr2O3	0.0039	0.0120	0.0450	0.0580	0.0850
V2O3	0.0060	0.0160	0.0240	0.0076	0.0260
MnO	0.0230	0.0340	0.0710	0.0460	0.0730
MgO	2.7400	3.4700	1.0800	3.1200	0.4600
CaO	2.0700	1.6700	0.2780	1.6500	0.0640
Rb2O	0.0110	0.0094	0.0100	0.0071	0.0120
SrO	0.0067	0.0017	0.0000	0.0032	0.0000
BaO	0.0920	0.0980	0.0200	0.0880	0.0080
Na2O	3.7300	1.5400	0.4400	1.5300	0.0800
K2O	1.7700	0.9400	0.1680	0.8500	0.0480
ZrO2	0.0260	0.0110	0.0040	0.0120	0.0030
P2O5	1.0100	1.1800	0.1770	1.0600	0.0420
OxSumm	99.2000	97.8000	95.3000	98.7000	94.3000
Cu	0.0010	0.0010	0.0040	0.0030	0.0020
Ni	0.0040	0.0080	0.0250	0.0290	0.0450
Co	0.0100	0.0050	0.0080	0.0220	0.0080
Zn	0.0030	0.0030	0.0090	0.0040	0.0130
Pb	0.0070	0.0040	0.0000	0.0060	0.0000
Ag	0.0000	0.0010	0.0040	0.0010	0.0020
S	0.0040	0.0050	0.0030	0.0090	0.0030
As	0.0000	0.0000	0.0010	0.0000	0.0010
Sb	0.0100	0.0130	0.0120	0.0110	0.0060
Bi	0.0020	0.0020	0.0030	0.0030	0.0040
Te	0.0020	0.0000	0.0000	0.0020	0.0000
Y	0.0053	0.0043	0.0003	0.0039	0.0007
Nb	0.0021	0.0012	0.0000	0.0015	0.0000
Mo	0.0000	0.0000	0.0000	0.0062	0.0015
Sn	0.0030	0.0080	0.0030	0.0050	0.0010
W	0.0010	0.0000	0.0000	0.0010	0.0010
Cl	0.0100	0.0080	0.0020	0.0080	0.0020
Th	0.0015	0.0023	0.0025	0.0016	0.0026
U	0.0000	0.0011	0.0070	0.0001	0.0093
Cs	0.0010	0.0020	0.0020	0.0020	0.0030
La	0.0140	0.0220	0.0070	0.0220	0.0060
Ce	0.0220	0.0340	0.0080	0.0300	0.0030
Ta	0.0020	0.0010	0.0030	0.0010	0.0050
LOI	0.0000	0.0000	0.0000	0.0000	0.0000
Ga	0.0012	0.0005	0.0020	0.0008	0.0036
Si	32.7000	29.3000	7.6800	34.0000	1.3300
Ti	0.0910	0.0790	0.0090	0.0470	0.0030
Cr	0.0027	0.0084	0.0310	0.0400	0.0580
V	0.0041	0.0110	0.0170	0.0052	0.0180
Fe	5.3600	15.8000	58.1000	9.0000	69.8000
Mn	0.0180	0.0270	0.0550	0.0360	0.0570
Mg	1.6500	2.0900	0.6500	1.8800	0.2800
Ca	1.4800	1.2000	0.1990	1.1800	0.0450
Ba	0.0820	0.0880	0.0180	0.0780	0.0070
Satmagan	0.54	0.62	78.25	1.02	**95.46**

9.6 Shaking Table

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 7.4.2014

Customer : Markku Kuusisto, GTK MINTEC
Order : 119460
Method : 180X-O
Date : 7.4.2014
Comment : Nordic Iron Ore, Blötberget Upper Level

Contents (%)

	WLIMS Test 1 Non-Mags 1...3 <0.63mm Shaking Table Test 1				Roller crushed ore <1.18mm Shaking Table Test 2			
	1_Conc	1_Middling	1_Tails-1	1_Tails-2	2_Conc	2_Middling	2_Tails-1	2_Tails-2
	L14026307	L14026308	L14026309	L14026310	L14026311	L14026312	L14026313	L14026314
SiO2	1.9400	71.4000	66.1000	61.8000	1.7300	60.5000	59.4000	52.3000
TiO2	0.3980	0.1230	0.1190	0.1400	0.1300	0.1220	0.1170	0.1470
Al2O3	0.5000	10.2000	10.9000	10.5000	0.4700	8.4200	10.2000	9.5400
Cr2O3	0.0032	0.0025	0.0028	0.0028	0.0048	0.0044	0.0210	0.0430
V2O3	0.0660	0.0071	0.0085	0.0120	0.0480	0.0130	0.0090	0.0130
MnO	0.0050	0.0190	0.0390	0.0570	0.0410	0.0270	0.0530	0.0790
MgO	0.0800	2.3000	4.1400	3.2800	0.2000	2.1500	4.8500	4.0300
CaO	1.0100	1.9100	2.0200	2.9300	0.4280	1.5900	1.7200	3.0200
Rb2O	0.0120	0.0090	0.0140	0.0110	0.0100	0.0093	0.0170	0.0120
SrO	0.0000	0.0060	0.0057	0.0057	0.0000	0.0032	0.0040	0.0040
BaO	0.0080	0.0880	0.1310	0.1130	0.0050	0.0700	0.1310	0.1100
Na2O	0.0800	3.7500	3.3500	3.3200	0.0400	3.1800	2.9500	2.8300
K2O	0.0180	1.5600	2.0700	1.7100	0.0250	1.2400	2.0500	1.6300
ZrO2	0.0110	0.0230	0.0240	0.0280	0.0050	0.0180	0.0220	0.0260
P2O5	0.8700	0.8700	0.8500	1.4400	0.3700	0.8100	0.8300	1.8400
OxSumm	90.9000	99.3000	99.0000	98.6000	92.7000	98.5000	98.8000	98.2000
Cu	0.0010	0.0000	0.0010	0.0050	0.0030	0.0000	0.0010	0.0040
Ni	0.0070	0.0030	0.0050	0.0040	0.0070	0.0050	0.0090	0.0150
Co	0.0010	0.0210	0.0120	0.0050	0.0000	0.0010	0.0030	0.0040
Zn	0.0010	0.0020	0.0050	0.0120	0.0080	0.0030	0.0070	0.0090
Pb	0.0000	0.0050	0.0060	0.0070	0.0000	0.0040	0.0050	0.0070
Ag	0.0050	0.0000	0.0000	0.0000	0.0020	0.0010	0.0000	0.0000
S	0.0040	0.0040	0.0110	0.0230	0.0030	0.0040	0.0070	0.0210
As	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000
Sb	0.0110	0.0090	0.0090	0.0100	0.0090	0.0120	0.0080	0.0090
Bi	0.0030	0.0030	0.0020	0.0030	0.0030	0.0020	0.0020	0.0020
Te	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Y	0.0038	0.0045	0.0054	0.0075	0.0016	0.0040	0.0056	0.0094
Nb	0.0004	0.0021	0.0016	0.0019	0.0000	0.0001	0.0007	0.0004
Mo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sn	0.0140	0.0030	0.0040	0.0050	0.0070	0.0040	0.0030	0.0050
W	0.0000	0.0010	0.0000	0.0000	0.0070	0.0010	0.0010	0.0010
Cl	0.0030	0.0130	0.0110	0.0110	0.0020	0.0110	0.0120	0.0100
Th	0.0057	0.0009	0.0022	0.0029	0.0039	0.0024	0.0019	0.0035
U	0.0095	0.0000	0.0000	0.0002	0.0088	0.0004	0.0005	0.0022
Cs	0.0010	0.0010	0.0030	0.0000	0.0010	0.0020	0.0020	0.0030
La	0.0260	0.0120	0.0180	0.0290	0.0150	0.0130	0.0180	0.0310
Ce	0.0400	0.0170	0.0270	0.0410	0.0160	0.0190	0.0250	0.0440
Ta	0.0000	0.0010	0.0020	0.0000	0.0060	0.0020	0.0010	0.0010
LOI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ga	0.0033	0.0011	0.0011	0.0015	0.0033	0.0010	0.0011	0.0012
Si	0.9100	33.4000	30.9000	28.9000	0.8100	28.3000	27.8000	24.5000
Ti	0.2390	0.0740	0.0710	0.0840	0.0780	0.0730	0.0700	0.0880
Cr	0.0022	0.0017	0.0019	0.0019	0.0033	0.0030	0.0150	0.0290
V	0.0450	0.0048	0.0058	0.0080	0.0330	0.0085	0.0061	0.0086
Fe	66.6000	5.3100	7.1100	10.2000	69.3000	15.8000	12.6000	17.4000
Mn	0.0040	0.0150	0.0300	0.0440	0.0320	0.0210	0.0410	0.0610
Mg	0.0500	1.3900	2.4900	1.9800	0.1200	1.2900	2.9200	2.4300
Ca	0.7200	1.3600	1.4400	2.0900	0.3060	1.1400	1.2300	2.1600
Ba	0.0070	0.0790	0.1170	0.1010	0.0050	0.0620	0.1170	0.0980
Satmagan	**0.91**	0.53	0.50	0.67	**54.10**	14.19	10.69	13.57
Eltra S	0.023	0.016	0.020	0.031	0.013	0.014	0.028	0.024

9.7 WMIMS/WHIMS

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 15.4.2014

Customer	: Markku Kuusisto, GTK Mintec
Order	: 119543
Method	: 180X-O
Date	: 15.4.2014
Comment	: Nordic Iron Ore, Blötberget Upper Level HGMS & WMIMS testing; analysis request 14.4.2014

Contents (%)

	WMIMS M	WMIMS NM	HGMS NM
	L14027872	L14027873	L14027874
SiO2	1.3600	1.6900	35.7000
TiO2	0.5200	0.3860	0.0760
Al2O3	0.4500	0.4800	2.4200
Cr2O3	0.3600	0.0360	0.0200
V2O3	0.0600	0.0670	0.0390
MnO	0.0290	0.0090	0.0400
MgO	0.1000	0.0700	0.3300
CaO	0.6100	1.0700	9.1500
Rb2O	0.0120	0.0110	0.0048
SrO	0.0000	0.0000	0.0019
BaO	0.0070	0.0070	0.1130
Na2O	0.0200	0.0600	1.0200
K2O	0.0130	0.0160	0.1900
ZrO2	0.0070	0.0120	0.0810
P2O5	0.5400	0.9000	6.8600
OxSumm	90.9000	90.8000	95.6000
Cu	0.0060	0.0000	0.0170
Ni	0.1820	0.0230	0.0150
Co	0.0040	0.0000	0.0010
Zn	0.0030	0.0000	0.0100
Pb	0.0000	0.0000	0.0090
Ag	0.0040	0.0050	0.0020
S	0.0190	0.0080	0.0770
As	0.0000	0.0000	0.0090
Sb	0.0100	0.0110	0.0220
Bi	0.0030	0.0020	0.0040
Te	0.0000	0.0000	0.0000
Y	0.0037	0.0016	0.0160
Nb	0.0018	0.0014	0.0030
Mo	0.0350	0.0000	0.0002
Sn	0.0180	0.0160	0.0110
W	0.0000	0.0170	0.0010
Cl	0.0020	0.0030	0.0160
Th	0.0041	0.0064	0.0025
U	0.0093	0.0098	0.0024
Cs	0.0020	0.0030	0.0020
La	0.0230	0.0310	0.0260
Ce	0.0300	0.0430	0.0420
Ta	0.0040	0.0030	0.0030
LOI	0.0000	0.0000	0.0000
Ga	0.0031	0.0023	0.0014
Si	0.6400	0.7900	16.7000
Ti	0.3090	0.2320	0.0460
Cr	0.2460	0.0250	0.0140
V	0.0410	0.0450	0.0260
Fe	67.2000	66.7000	30.5000
Mn	0.0220	0.0070	0.0310
Mg	0.0600	0.0400	0.2000
Ca	0.4390	0.7600	6.5300
Ba	0.0060	0.0060	0.1010
Satmagan	**4.55**	0.55	0.29
Eltra S	0.029	0.014	0.068

9.8 Flotation

9.8.1 Test 1

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 28.-29.4.2014

Customer : Markku Kuusisto, GTK Mintec
Orders : 119653, 119656
Method : 180X-O
Date : 28.-29.4.2014
Comment : Nordic Iron Ore, Blötberget Upper Level
Apatite Reverse Flotation, Test 1 / analysis request 28.4.2014

Contents (%)

	Test1/ F1 L14030100	F2 L14030101	F3 L14030102	F4 L14030103	F5 L14030104	F6 L14030105	Cell Conc. L14030127
SiO2	1.0400	2.3500	1.1300	2.5800	1.2200	2.0700	2.1000
TiO2	0.1290	0.2110	0.2490	0.2290	0.2460	0.2530	0.3330
Al2O3	0.4200	0.6700	0.4400	0.7300	0.4600	0.6300	0.5100
Cr2O3	0.0490	0.0920	0.0430	0.0920	0.0590	0.0960	0.0360
V2O3	0.0330	0.0540	0.0640	0.0580	0.0630	0.0680	0.0650
MnO	0.1230	0.0740	0.0380	0.0600	0.0370	0.0230	0.0050
MgO	0.3700	0.4100	0.1600	0.4400	0.1400	0.2400	0.0600
CaO	30.8000	15.2000	8.9400	11.8000	8.0600	2.6900	0.2020
Rb2O	0.0061	0.0095	0.0100	0.0095	0.0100	0.0110	0.0130
SrO	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BaO	0.0210	0.0090	0.0080	0.0090	0.0060	0.0070	0.0030
Na2O	0.1000	0.1300	0.0600	0.1300	0.0600	0.1000	0.0900
K2O	0.0250	0.0440	0.0170	0.0440	0.0150	0.0340	0.0170
ZrO2	0.0060	0.0110	0.0050	0.0100	0.0060	0.0090	0.0080
P2O5	24.6000	12.4000	7.8900	10.3000	7.1300	2.2400	0.1840
OxSumm	94.4000	93.2000	92.0000	92.7000	91.9000	91.1000	90.8000
Cu	0.0020	0.0040	0.0000	0.0000	0.0000	0.0040	0.0010
Ni	0.0260	0.0510	0.0220	0.0490	0.0310	0.0550	0.0180
Co	0.0160	0.0180	0.0040	0.0080	0.0060	0.0090	0.0080
Zn	0.0060	0.0050	0.0010	0.0030	0.0040	0.0050	0.0020
Pb	0.0070	0.0030	0.0000	0.0050	0.0010	0.0000	0.0000
Ag	0.0080	0.0070	0.0070	0.0070	0.0110	0.0070	0.0020
S	0.0390	0.0230	0.0120	0.0180	0.0130	0.0090	0.0030
As	0.0020	0.0020	0.0020	0.0020	0.0010	0.0010	0.0010
Sb	0.0210	0.0200	0.0100	0.0100	0.0090	0.0120	0.0110
Bi	0.0020	0.0020	0.0030	0.0030	0.0040	0.0040	0.0030
Te	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Y	0.0570	0.0290	0.0180	0.0250	0.0240	0.0094	0.0005
Nb	0.0014	0.0010	0.0015	0.0011	0.0014	0.0005	0.0010
Mo	0.0025	0.0039	0.0000	0.0044	0.0003	0.0043	0.0000
Sn	0.0110	0.0140	0.0130	0.0110	0.0130	0.0140	0.0150
W	0.0010	0.0000	0.0010	0.0000	0.0010	0.0010	0.0000
Cl	0.0520	0.0250	0.0180	0.0220	0.0140	0.0070	0.0030
Th	0.0069	0.0074	0.0080	0.0074	0.0080	0.0069	0.0044
U	0.0042	0.0074	0.0090	0.0082	0.0097	0.0110	0.0100
Cs	0.0040	0.0040	0.0030	0.0030	0.0010	0.0040	0.0020
La	0.1230	0.0800	0.0780	0.0940	0.1560	0.0690	0.0210
Ce	0.1970	0.1260	0.1200	0.1460	0.2300	0.0990	0.0290
Ta	0.0050	0.0000	0.0040	0.0040	0.0020	0.0000	0.0030
LOI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ga	0.0014	0.0019	0.0054	0.0018	0.0003	0.0016	0.0028
Si	0.4900	1.1000	0.5300	1.2100	0.5700	0.9700	0.9800
Ti	0.0770	0.1260	0.1490	0.1380	0.1470	0.1520	0.2000
Cr	0.0340	0.0630	0.0290	0.0630	0.0400	0.0660	0.0250
V	0.0230	0.0360	0.0440	0.0390	0.0430	0.0460	0.0440
Fe	27.9000	47.4000	56.4000	51.1000	57.3000	63.9000	67.7000
Mn	0.0950	0.0570	0.0300	0.0470	0.0280	0.0180	0.0040
Mg	0.2200	0.2500	0.1000	0.2600	0.0800	0.1500	0.0400
Ca	22.0000	10.9000	6.3800	8.4600	5.7600	1.9200	0.1450
Ba	0.0190	0.0080	0.0070	0.0080	0.0050	0.0060	0.0030

9.8.2 Test 2

Labtium Oy
REPORT OF XRF ANALYSIS 5.5.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 119701
Method : 180X-O
Date : 5.5.2014
Comment : Nordic Iron Ore, Blötberget Upper Level
Apatite Reverse Flotation, Test 2 / analysis request 5.5.2014

Contents (%)

	Test2/F1 L14030740	F2 L14030741	F3 L14030742	F4 L14030743	F5 L14030744	F6 L14030745	Cell Conc. L14030746
SiO2	0.8900	1.5300	0.6100	1.1200	0.5900	1.8100	10.9000
TiO2	0.2250	0.2780	0.2870	0.2770	0.3260	0.3650	0.3040
Al2O3	0.3700	0.5800	0.3600	0.4400	0.3000	0.4100	1.5600
Cr2O3	0.1550	0.2800	0.1380	0.2130	0.0410	0.0750	0.2120
V2O3	0.0490	0.0660	0.0660	0.0640	0.0600	0.0630	0.0600
MnO	0.0770	0.0360	0.0120	0.0180	0.0030	0.0060	0.0260
MgO	0.1800	0.2600	0.0300	0.1100	0.0000	0.0000	0.6500
CaO	17.1000	3.4400	0.3300	0.2530	0.0220	0.0370	0.1670
Rb2O	0.0088	0.0098	0.0100	0.0120	0.0100	0.0100	0.0110
SrO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BaO	0.0120	0.0070	0.0040	0.0060	0.0060	0.0040	0.0120
Na2O	0.0500	0.0500	0.0100	0.0200	0.0000	0.0400	0.5000
K2O	0.0070	0.0210	0.0040	0.0120	0.0010	0.0080	0.1410
ZrO2	0.0060	0.0060	0.0070	0.0060	0.0070	0.0090	0.0090
P2O5	15.3000	3.0500	0.3030	0.2210	0.0170	0.0200	0.0770
OxSumm	93.6000	91.2000	90.6000	90.7000	90.7000	90.7000	91.8000
Cu	0.0030	0.0040	0.0040	0.0060	0.0010	0.0020	0.0040
Ni	0.0780	0.1400	0.0730	0.1070	0.0200	0.0360	0.1020
Co	0.0000	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000
Zn	0.0040	0.0040	0.0020	0.0040	0.0020	0.0000	0.0020
Pb	0.0030	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ag	0.0210	0.0070	0.0040	0.0030	0.0030	0.0030	0.0020
S	0.0230	0.0130	0.0050	0.0050	0.0030	0.0030	0.0060
As	0.0030	0.0030	0.0010	0.0020	0.0000	0.0020	0.0000
Sb	0.0130	0.0100	0.0090	0.0090	0.0090	0.0090	0.0110
Bi	0.0020	0.0030	0.0030	0.0010	0.0040	0.0030	0.0040
Te	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Y	0.0510	0.0130	0.0039	0.0002	0.0000	0.0008	0.0014
Nb	0.0010	0.0005	0.0004	0.0007	0.0007	0.0012	0.0014
Mo	0.0150	0.0260	0.0090	0.0180	0.0000	0.0032	0.0190
Sn	0.0120	0.0140	0.0130	0.0150	0.0140	0.0130	0.0140
W	0.0070	0.0000	0.0000	0.0120	0.0010	0.0190	0.0160
Cl	0.0300	0.0090	0.0020	0.0020	0.0020	0.0000	0.0030
Th	0.0190	0.0086	0.0062	0.0047	0.0047	0.0033	0.0032
U	0.0110	0.0100	0.0092	0.0094	0.0085	0.0090	0.0083
Cs	0.0000	0.0000	0.0010	0.0030	0.0020	0.0010	0.0020
La	0.3900	0.1000	0.0250	0.0100	0.0030	0.0040	0.0080
Ce	0.5800	0.1470	0.0330	0.0140	0.0030	0.0050	0.0080
Ta	0.0000	0.0020	0.0020	0.0060	0.0040	0.0010	0.0000
LOI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ga	0.0006	0.0042	0.0009	0.0000	0.0026	0.0023	0.0008
Si	0.4100	0.7200	0.2900	0.5200	0.2700	0.8400	5.1000
Ti	0.1350	0.1670	0.1720	0.1660	0.1960	0.2190	0.1830
Cr	0.1060	0.1910	0.0940	0.1460	0.0280	0.0510	0.1450
V	0.0330	0.0450	0.0450	0.0440	0.0410	0.0430	0.0410
Fe	44.9000	62.9000	**68.6000**	**68.2000**	**69.4000**	**68.2000**	59.8000
Mn	0.0590	0.0280	0.0090	0.0140	0.0020	0.0050	0.0200
Mg	0.1100	0.1600	0.0200	0.0700	0.0000	0.0000	0.3900
Ca	12.2000	2.4600	0.2360	0.1810	0.0150	0.0260	0.1190
Ba	0.0110	0.0060	0.0030	0.0050	0.0050	0.0040	0.0110

9.9 Selective Flocculation

LABTIUM

Labtium Oy
REPORT OF XRF ANALYSIS 13.5.2014

Customer : Markku Kuusisto, GTK Mintec
Order : 119793
Method : 180X-O
Date : 13.5.2014
Comment : Nordic Iron Ore, Blötberget Upper Level

Contents (%)	Selective Flocculation Tests		Apatite Removal Flotation Test 1	Apatite Removal Flotation Test 2	
	Test 1 U/F L14032474	Test 2 U/F L14032475	Flocculation Test Feed Cell Conc. L14030127	Back-combined 'RT2' product L14032476	Back-calculated 'RT2' product in material balance (as reference)
SiO2	1.9700	1.9200	2.1000	2.1100	2.17
TiO2	0.3390	0.3460	0.3330	0.3340	
Al2O3	0.4800	0.4600	0.5100	0.4700	0.49
Cr2O3	0.0320	0.0320	0.0360	0.0900	
V2O3	0.0630	0.0630	0.0650	0.0630	
MnO	0.0050	0.0050	0.0050	0.0080	0.008
MgO	0.0600	0.0600	0.0600	0.0600	0.08
CaO	0.1880	0.1990	0.2020	0.0750	0.080
Rb2O	0.0095	0.0110	0.0130	0.0091	
SrO	0.0000	0.0000	0.0000	0.0000	
BaO	0.0050	0.0040	0.0030	0.0030	
Na2O	0.0700	0.0600	0.0900	0.0700	0.07
K2O	0.0170	0.0160	0.0170	0.0170	0.020
ZrO2	0.0090	0.0090	0.0080	0.0090	
P2O5	0.1730	0.1810	0.1840	0.0530	0.058
OxSumm	90.8000	90.7000	90.8000	90.8000	
Cu	0.0000	0.0000	0.0010	0.0010	
Ni	0.0160	0.0130	0.0180	0.0460	
Co	0.0000	0.0150	0.0080	0.0000	
Zn	0.0030	0.0030	0.0020	0.0040	
Pb	0.0000	0.0000	0.0000	0.0000	
Ag	0.0030	0.0030	0.0020	0.0030	
S	0.0060	0.0040	0.0030	0.0040	
As	0.0000	0.0010	0.0010	0.0010	
Sb	0.0100	0.0100	0.0110	0.0120	
Bi	0.0030	0.0030	0.0030	0.0030	
Te	0.0000	0.0000	0.0000	0.0000	
Y	0.0008	0.0018	0.0005	0.0011	
Nb	0.0016	0.0006	0.0010	0.0011	
Mo	0.0000	0.0000	0.0000	0.0029	
Sn	0.0150	0.0150	0.0150	0.0140	
W	0.0010	0.0000	0.0000	0.0230	
Cl	0.0020	0.0030	0.0030	0.0020	
Th	0.0051	0.0049	0.0044	0.0035	
U	0.0085	0.0090	0.0100	0.0085	
Cs	0.0040	0.0030	0.0020	0.0020	
La	0.0190	0.0200	0.0210	0.0060	
Ce	0.0290	0.0310	0.0290	0.0070	
Ta	0.0040	0.0000	0.0030	0.0020	
LOI	0.0000	0.0000	0.0000	0.0000	
Ga	0.0036	0.0018	0.0028	0.0040	
Si	0.9200	0.9000	0.9800	0.9900	
Ti	0.2030	0.2070	0.2000	0.2000	
Cr	0.0220	0.0220	0.0250	0.0620	
V	0.0430	0.0430	0.0440	0.0430	
Fe	67.8000	67.8000	67.7000	67.8000	67.81
Mn	0.0040	0.0040	0.0040	0.0060	
Mg	0.0400	0.0400	0.0400	0.0400	
Ca	0.1340	0.1420	0.1450	0.0530	
Ba	0.0050	0.0040	0.0030	0.0030	

10 APPENDIX C – BOND WORK INDEX REPORTS

10.1 Bond Rod Mill Report

GEOLOGICAL SURVEY OF FINLAND
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24 February 2014

Determination of Bond Work Index

Blötberget, Upper Level Ore Feed

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PL/PB/P.O. Box 96 FI-02151 Espoo, Finland
PL/PB/P.O. Box 1237 FI-70211 Kuopio, Finland
PL/PB/P.O. Box 97 FI-67101 Kokkola, Finland
PL/PB/P.O. Box 77 FI-96101 Rovaniemi, Finland

Puh. 029 503 0000 • Tel. +358 29 503 0000 • www.gtk.fi • Y-tunnus / FO-nummer / Business ID: 0244680-7

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24 February 2014

Content

1. THE STANDARD BOND ROD MILL GRINDABILITY TEST

The standard Bond Rod Mill grindability test is a locked-cycle dry grinding and screening process, which is carried out until steady state condition is obtained. The Work Index (W_i) indicates the resistance of the material to grinding and it´s expressed in kWh/t. The rod mill measures 305 * 610 mm with smooth walled and lifters. The rod charge consists of two different sizes of rods weighing about 33,380g:

Rod diameter	Rod length
44.5 mm	533 mm
32.0 mm	533 mm

For first grinding period, the mill is run for arbitrary number of revolutions. After first period sample is screened on the selected closing screen size and the undersize material is replaced by fresh unsegregated feed to bring the total initial weight back. The number of revolutions is calculated from the results of the previous period to produce sieve undersize equal to 1/2 of total charge of the mill. Grinding periods are continued until the net grams of sieve undersize produced per mill revolution reaches equilibrium with 100 % circulating load. After equilibrium is reached repeatedly, last of three undersize products are combined and screen analysed. The average of last three net grams per revolution determinations is the rod mill grindability (G_{rp}) in g/rev. The Work Index is calculated using the Bond equation (eq. 1).

$$W_i = \frac{68.4}{P_i^{0.23} * G_{rp}^{0.625} * \left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}}\right)} \qquad (1)$$

Where

P_i	closing sieve size in microns
G_{rp}	grindability value for rod mills, net grams of mill product passing sieve size P_i produces per mill revolution
P_{80}	required product size in microns at which 80 % passes
F_{80}	feed size in microns at which 80 % passes

The standard Work Index can be used to determine the energy consumption by wet grinding in a rod mill of 8 ft (2,44m) diameter operating with 100 % circulating load in a open circuit.

1.1 Sample preparation

The sample of ore was stage crushed to 100% passing 12.5 mm and screen analysed (Table 1). The sample was packed in to a 1,250 ml cylinder using vibrating table. The weight of this volume of sample was the initial ore charge and this weight was maintained throughout the test.

Table 1. **PSD of Blötberget, Upper Level Ore Sample, Rod Mill Feed**

Feed			
Particle size (µm)	Weight (g)	Passing (%)	Weight (%)
12500		**100.0**	
11200	49.7	**95.1**	4.9
10000	160.8	**79.4**	15.7
8000	227.3	**57.3**	22.2
6700	199.7	**37.8**	19.5
5600	68.9	**31.0**	6.7
4000	45.0	**26.6**	4.4
2000	32.6	**23.5**	3.2
1180	37.8	**19.8**	3.7
710	33.8	**16.5**	3.3
500	29.0	**13.6**	2.8
250	49.7	**8.8**	4.9
125	42.1	**4.7**	4.1
90	12.8	**3.4**	1.2
75	8.1	**2.6**	0.8
-75	27.0		2.6
Total	1024.3		100.0

1.2 The Bond Rod Mill Work Index of Blötberget, Upper Level Ore Sample

The initial ore charge was 3 038.8 g which contained 19.80 % -1 180 µm material. The equilibrium state was reached during 8 cycles. The average of the last three net grams per mill revolution (G_{rp}) was 14.231 g. The F_{80} of the sample was 10 042 µm and the P_{80} was 836 µm (Table 2).

The Bond Rod Mill Work Index value of Blötberget, Upper Level Ore sample was 10.4 kWh/t.

Table 2. **PSD of Blötberget, Upper Level Ore Sample, Rod Mill Product**

Product			
Particle size (µm)	Weight (g)	Passing (%)	Weight (%)
1180		**100.0**	
710	36.9	**72.7**	27.3
500	19.7	**58.1**	14.6
250	31.5	**34.8**	23.3
125	23.4	**17.5**	17.3
90	7.9	**11.6**	5.8
75	3.7	**8.9**	2.7
45	5.6	**4.7**	4.1
32	1.6	**3.6**	1.2
-32	4.8		3.6
Total	135.1		100.0

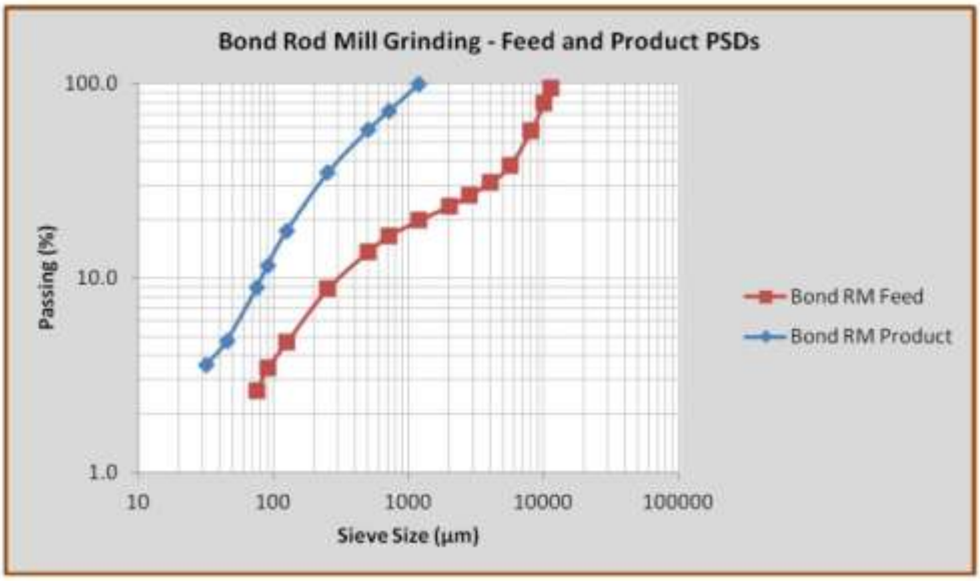

Figure 1. **PSD's of Blötberget, Upper Level Ore Sample**

10.2 Bond Ball Mill Report

GEOLOGICAL SURVEY OF FINLAND
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Outokumpu

May 6, 2014

Determination of Bond Work Index

Blötberget Upper Level Ore Sample

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PL/PB/P.O. Box 96 FI-02151 Espoo, Finland
PL/PB/P.O. Box 1237 FI-70211 Kuopio, Finland
PL/PB/P.O. Box 97 FI-67101 Kokkola, Finland
PL/PB/P.O. Box 77 FI-96101 Rovaniemi, Finland

Puh. 029 503 0000 • Tel. +358 29 503 0000 • www.gtk.fi • Y-tunnus / FO-nummer / Business ID: 0244680-7

GEOLOGICAL SURVEY OF FINLAND
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May 6, 2014

Contents

1. THE STANDARD BOND BALL MILL GRINDABILITY TEST

The standard Bond Ball Mill grindability test is a locked-cycle dry grinding and screening process, which is carried out until steady state condition is obtained. The Work Index (W_i) indicates the resistance of the material to grinding and it´s expressed in kWh/t. The Bond ball mill measures 305 * 305 mm with rounded corners and smooth lining. The ball charge consists of five different sizes of balls weighing about 20 125g:

Ball diameter
38.1 mm
31.7 mm
25.4 mm
19.1 mm
12.8 mm

For first grinding period, the mill is run for arbitrary number of revolutions. After first period sample is screened on the selected closing screen size and the undersize material is replaced by fresh unsegregated feed to bring the total initial weight back. The number of revolutions is calculated from the results of the previous period to produce sieve undersize equal to 1/3,5 of total charge of the mill. Grinding periods are continued until the net grams of sieve undersize produced per mill revolution reaches equilibrium with 250 % circulating load. After equilibrium is reached repeatedly, last of three undersize products are combined and screen analysed. The average of last three net grams per revolution determinations is the ball mill grindability (G_{bp}) in g/rev. The Work Index is calculated using the Bond equation (eq. 2).

$$W_i = \frac{49.1}{P_i^{0.23} * G_{bp}^{0.82} * \left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}}\right)} \qquad (1)$$

Where

P_i	closing sieve size in microns
G_{bp}	grindability value for ball mills, net grams of mill product passing sieve size P_i produces per mill revolution
P_{80}	required product size in microns at which 80 % passes
F_{80}	feed size in microns at which 80 % passes

The standard Work Index can be used to determine the energy consumption by wet grinding in a ball mill of 8 ft (2,44m) diameter operating with 250 % circulating load in a circuit closed by a classifier.

1.1 Sample preparation

The sample of ore was stage crushed to 100% passing 3.35 mm and screen analysed (Table 1). The sample was packed in to a 700 ml cylinder using vibrating table. The weight of this volume of sample was the initial ore charge and this weight was maintained throughout the test.

Table 1. PSD of Blötberget Upper Level Ore Sample, Ball Mill Feed

Feed			
Particle size (µm)	Weight (g)	Passing (%)	Weight (%)
2800	21.0	**91.8**	8.2
2000	54.4	**70.6**	21.2
1400	38.7	**55.5**	15.1
1000	23.0	**46.5**	9.0
710	22.5	**37.8**	8.8
500	18.6	**30.5**	7.3
250	31.7	**18.1**	12.4
125	28.7	**6.9**	11.2
90	2.8	**5.9**	1.1
75	3.6	**4.4**	1.4
45	6.1	**2.1**	2.4
32	2.1	**1.2**	0.8
-32	3.2		1.2
Tot.	**256.4**		**100.0**

1.2 The Bond Ball Mill Work Index of Blötberget Upper Level Ore Sample

The initial ore charge was 1 672.4 g which contained 6.90 % -100 µm material. The equilibrium state was reached during 5 cycles. The average of the last three net grams per mill revolution (G_{bp}) was 0.994 g. The F_{80} of the sample was 2 355 µm and the P_{80} was 80 µm (Table 2).

The Bond Ball Mill Work Index value of the Blötberget Upper Level ore sample was 18.8 kWh/t.

Table 2. PSD of Blötberget Upper Level Ore Sample, Ball Mill Product

Product			
Particle size (µm)	Weight (g)	Passing (%)	Weight (%)
90	5.7	**93.4**	6.6
75	17.1	**73.6**	19.8
45	27.4	**41.6**	31.7
32	8.2	**32.4**	9.5
-32	28.0		32.4
Tot.	**86.4**		**100.0**

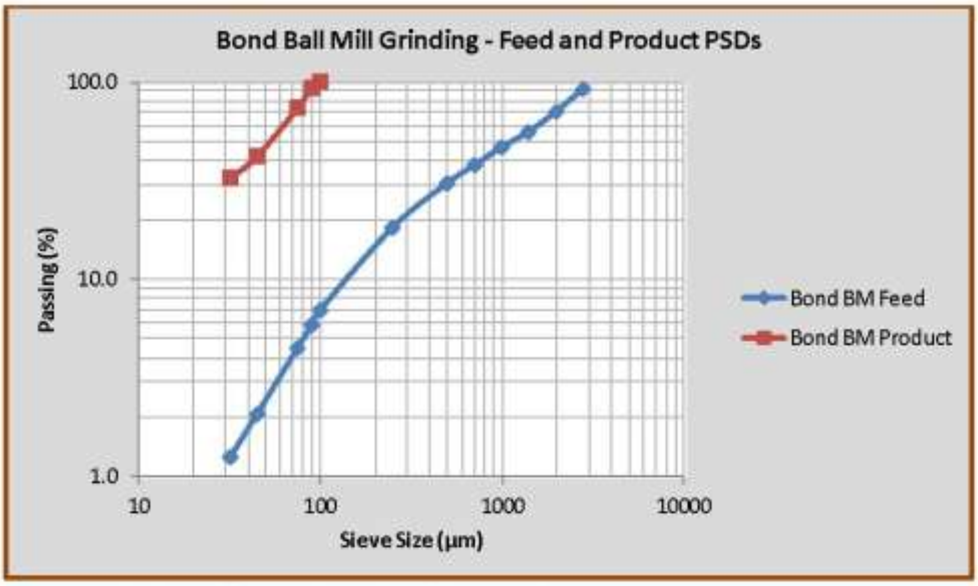


Figure 1. PSD's of Blötberget Upper Level Ore Sample

11 APPENDIX C – CRUSHABILITY AND ABRASION INDEX TESTING

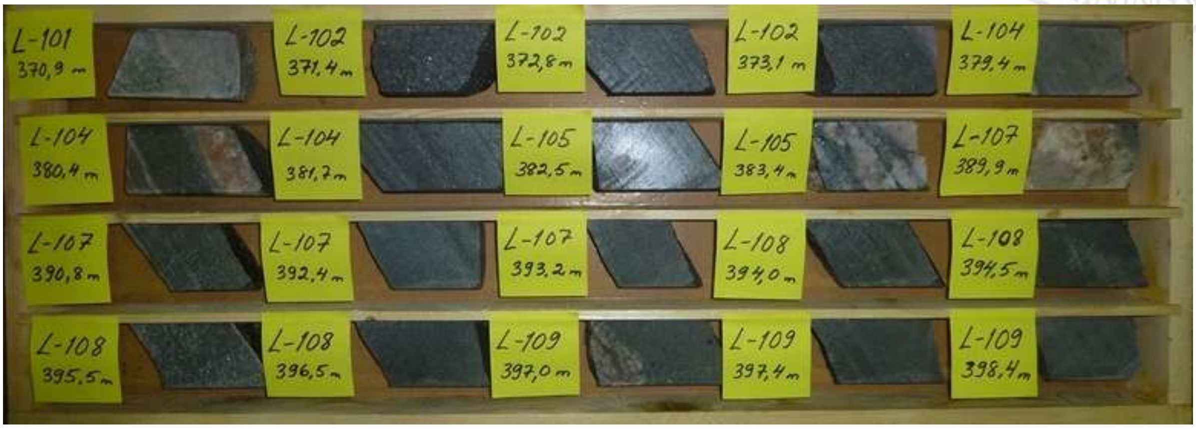


Figure 27: *Core samples sent for crushability and abrasion index testing*

11.1 Crushability and abrasion index report

SANDVIK

Sandvik Mining and Construction
Test and Research Center, Svedala

AI Reg. No.: 5883
WI Reg. No.: 4845
R25 Reg. No.: 2351

Rawmaterial Test

Summary report

Report No: 8887
Sign: LOL

Date 2014-02-20
Box No.: 5762

Customer	**Plant**
GTK MINTEC	OUTOKUMPU
FINLAND	FINLAND

Material
ORE, IRON

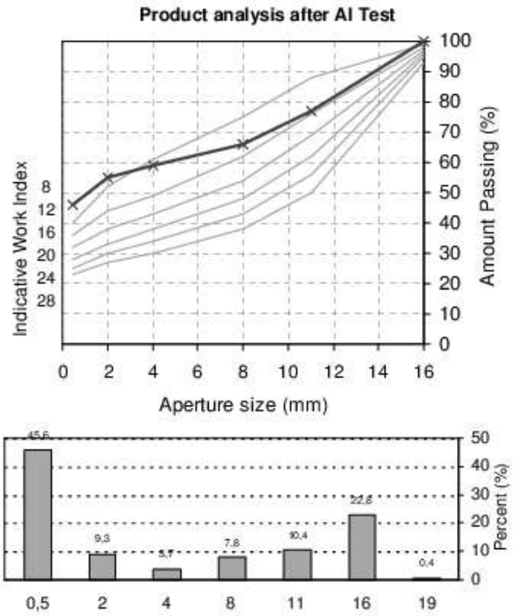
Specification:

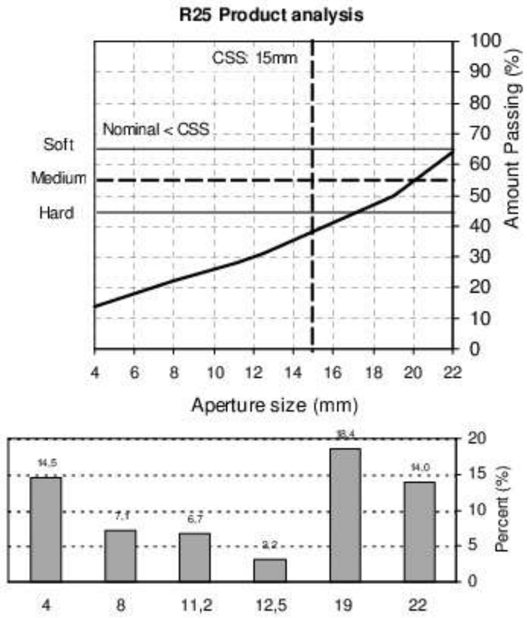
Material Comment
Dark grey. White. Reddish. Fine to medium grained. Heterogenous. Partially magnetic. Drillcore samples.

Test Results

Work Index (WI):	***3,8*** +/- ***0,8***
Abrasion Index (AI):	***0,2959***
Specific gravity (g/cm³)	***3,27***

Test Result recommendation
Calculated in relation to solid density, an estimated WI at 8 is recommended for calculations.





Comment on AI-test

Comment on WI-test:
WI tested on drillcore samples.

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AI Reg. No.: 5883
WI Reg. No.: 4845
R25 Reg. No.: 2351

Summary report

Date 2014-02-20
Box No.: 5762

Abrasion Index test details

AI: 0,2959

Test paddle: Chrome-Nickel-Molybdenum steel
Dim: 3" x 1" x 1/4"
Hardness: 500+/-15 HB

Weight of paddle before test: 93,9489 g

Weight of paddle after test: 93,6530 g

Feed: 12,5 -19 mm, 4 x 494g/15 min tested

(Standard sample weight 400 g is valid at density 2,65 g/cm^3)

Product analysis after AI-test

Aperture Size (mm)	Weight (g)	Acc. (%)
19,0	8	100,0
16,0	445	99,6
11,2	204	76,8
8,0	153	66,4
4,0	72	58,5
2,0	181	54,9
0,5	891	45,6

Work Index test details

Average Impact Work Index, WI: 3,8+/- ,8

90% confidence limits of WI : 3,0 to 4,6

i.e. Work Index of the lot from which the sample was taken has

- 95% chance to exceed or equal 3,0
- 50% chance to exceed or equal 3,8
- 5% chance to exceed or equal 4,6

Average impact strength: 255 N

Individual data

Thickness (mm)	Angle (deg.)	Energy (Nm)	Impact strength (N)
64	30	17,4	271
66	25	12,1	184
65	25	12,1	187
65	25	12,1	187
66	35	23,4	355
65	30	17,4	267
65	40	30,3	467
67	25	12,1	181
66	30	17,4	263
66	25	12,1	184

Typical Material data

Material	Density (g/cm^3)	Impact strength (N)	Work Index WI	Abrasion Index AI	Life factor Lf
Basalt	2,84	1163±272	19,8+/-3,8	0,25+/-0,01	1,8
Diabase	2,84	1064±222	18,2+/-3,8	0,28+/-0,15	1,5
Dolomite	2,75	697±218	12,3+/-3,7	0,02+/-0,01	6-10
Gneiss	2,72	909±236	16,2+/-4,2	0,48+/-0,18	1,0
Granite	2,68	939±257	17,0+/-4,5	0,46+/-0,16	1,0
Limestone	2,69	721±183	13,0+/-3,3	0,001-0,11	3-15
Quartzite	2,65	967±226	17,0+/-4,2	0,79+/-0,28	0,25-0,9
Magnetite	4,60	756±352	8,0+/-3,9		
Hematite	4,42	1043±388	11,3+/-3,6		

Printed: den 20 februari 2014

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12 APPENDIX E – MODAL MINERALOGY TABLES BY SIEVE FRACTION

45_125_XMOD

Mineral	Wt%	Area%	Area (micron)	Particle Count	Grain Count
Quartz	23.23	31.20	114849.24	9265	9265
Plagioclase	16.06	21.22	78132.19	6303	6303
K_feldspar	3.00	4.13	15197.54	1226	1226
Hedenbergite	0.01	0.01	37.19	3	3
Epidote	0.01	0.01	24.79	2	2
Allanite	0.06	0.05	198.34	16	16
Titanite	0.00	0.00	12.40	1	1
Zircon	0.00	0.00	12.40	1	1
Chlorite	1.16	1.38	5082.37	410	410
Biotite	0.62	0.70	2590.77	209	209
Phlogopite	3.00	3.77	13895.95	1121	1121
Muscovite	0.26	0.33	1214.81	98	98
Berthierite	0.01	0.01	37.19	3	3
Fluorite	0.04	0.05	185.94	15	15
Calcite	0.09	0.12	433.86	35	35
Synchysite	0.00	0.00	0.00	0	0
Apatite	2.24	2.47	9098.69	734	734
Monazite	0.11	0.07	272.71	22	22
Xenotime	0.00	0.00	0.00	0	0
Anatase	0.00	0.00	0.00	0	0
Magnetite	49.76	34.07	125423.06	10118	10118
Fe_hydroxide	0.11	0.10	384.28	31	31
Pyrite	0.01	0.01	24.79	2	2
Pyrrhotite	0.00	0.00	12.40	1	1
Chalcopyrite	0.00	0.00	0.00	0	0
Sphalerite	0.01	0.01	37.19	3	3
Galena	0.00	0.00	0.00	0	0
Unclassified	0.21	0.27	1004.08	81	81
Total	100.00	100.00	368162.17	29700	29700

30.9.2014

125_250_XMOD					
Mineral	Wt%	Area%	Area (micron)	Particle Count	Grain Count
Quartz	21.67	29.56	106175.52	5948	5948
Plagioclase	14.90	19.99	71813.06	4023	4023
K_feldspar	2.29	3.20	11513.65	645	645
Hedenbergite	0.00	0.00	0.00	0	0
Epidote	0.00	0.00	17.85	1	1
Allanite	0.04	0.03	124.95	7	7
Titanite	0.00	0.00	0.00	0	0
Zircon	0.00	0.00	0.00	0	0
Chlorite	1.02	1.23	4426.96	248	248
Biotite	0.67	0.77	2766.85	155	155
Phlogopite	4.90	6.27	22509.64	1261	1261
Muscovite	0.09	0.11	410.56	23	23
Berthierite	0.00	0.00	0.00	0	0
Fluorite	0.05	0.06	214.21	12	12
Calcite	0.03	0.03	124.95	7	7
Synchysite	0.00	0.00	0.00	0	0
Apatite	2.05	2.30	8264.84	463	463
Monazite	0.02	0.01	53.55	3	3
Xenotime	0.00	0.00	0.00	0	0
Anatase	0.00	0.00	0.00	0	0
Magnetite	52.15	36.26	130256.01	7297	7297
Fe_hydroxide	0.04	0.03	124.95	7	7
Pyrite	0.00	0.00	0.00	0	0
Pyrrhotite	0.00	0.00	0.00	0	0
Chalcopyrite	0.00	0.00	0.00	0	0
Sphalerite	0.00	0.00	0.00	0	0
Galena	0.00	0.00	0.00	0	0
Unclassified	0.08	0.12	446.27	25	25
Total	100.00	100.00	359243.83	20125	20125

30.9.2014

250_500_XMOD					
Mineral	Wt%	Area%	Area (micron)	Particle Count	Grain Count
Quartz	17.22	24.83	90038.55	5044	5044
Plagioclase	12.85	18.25	66172.27	3707	3707
K_feldspar	2.46	3.63	13173.76	738	738
Hedenbergite	0.00	0.00	0.00	0	0
Epidote	0.01	0.01	35.70	2	2
Allanite	0.00	0.00	0.00	0	0
Titanite	0.00	0.00	0.00	0	0
Zircon	0.00	0.00	0.00	0	0
Chlorite	0.88	1.13	4087.79	229	229
Biotite	0.71	0.86	3123.86	175	175
Phlogopite	3.61	4.88	17689.97	991	991
Muscovite	0.11	0.14	517.67	29	29
Berthierite	0.00	0.00	17.85	1	1
Fluorite	0.01	0.01	35.70	2	2
Calcite	0.02	0.02	89.25	5	5
Synchysite	0.01	0.00	17.85	1	1
Apatite	1.13	1.34	4855.37	272	272
Monazite	0.01	0.01	35.70	2	2
Xenotime	0.00	0.00	0.00	0	0
Anatase	0.00	0.00	0.00	0	0
Magnetite	60.92	44.78	162404.99	9098	9098
Fe_hydroxide	0.02	0.02	89.25	5	5
Pyrite	0.00	0.00	0.00	0	0
Pyrrhotite	0.00	0.00	0.00	0	0
Chalcopyrite	0.00	0.00	0.00	0	0
Sphalerite	0.00	0.00	0.00	0	0
Galena	0.00	0.00	0.00	0	0
Unclassified	0.04	0.07	249.91	14	14
Total	100.00	100.00	362635.45	20315	20315

30.9.2014

500_710_XMOD					
Mineral	Wt%	Area%	Area (micron)	Particle Count	Grain Count
Quartz	16.29	24.07	84754.77	4748	4748
Plagioclase	11.71	17.05	60049.50	3364	3364
K_feldspar	2.03	3.08	10853.18	608	608
Hedenbergite	0.00	0.00	0.00	0	0
Epidote	0.01	0.02	53.55	3	3
Allanite	0.01	0.01	35.70	2	2
Titanite	0.00	0.01	17.85	1	1
Zircon	0.00	0.00	0.00	0	0
Chlorite	1.14	1.50	5283.79	296	296
Biotite	0.47	0.59	2070.67	116	116
Phlogopite	2.77	3.83	13495.07	756	756
Muscovite	0.18	0.25	874.68	49	49
Berthierite	0.00	0.00	0.00	0	0
Fluorite	0.00	0.01	17.85	1	1
Calcite	0.03	0.04	142.81	8	8
Synchysite	0.00	0.00	0.00	0	0
Apatite	0.62	0.76	2659.74	149	149
Monazite	0.02	0.02	53.55	3	3
Xenotime	0.00	0.00	0.00	0	0
Anatase	0.00	0.00	0.00	0	0
Magnetite	64.68	48.73	171580.21	9612	9612
Fe_hydroxide	0.02	0.02	71.40	4	4
Pyrite	0.00	0.00	0.00	0	0
Pyrrhotite	0.00	0.00	0.00	0	0
Chalcopyrite	0.00	0.00	0.00	0	0
Sphalerite	0.00	0.00	0.00	0	0
Galena	0.00	0.00	0.00	0	0
Unclassified	0.01	0.03	107.10	6	6
Total	100.00	100.00	352121.43	19726	19726

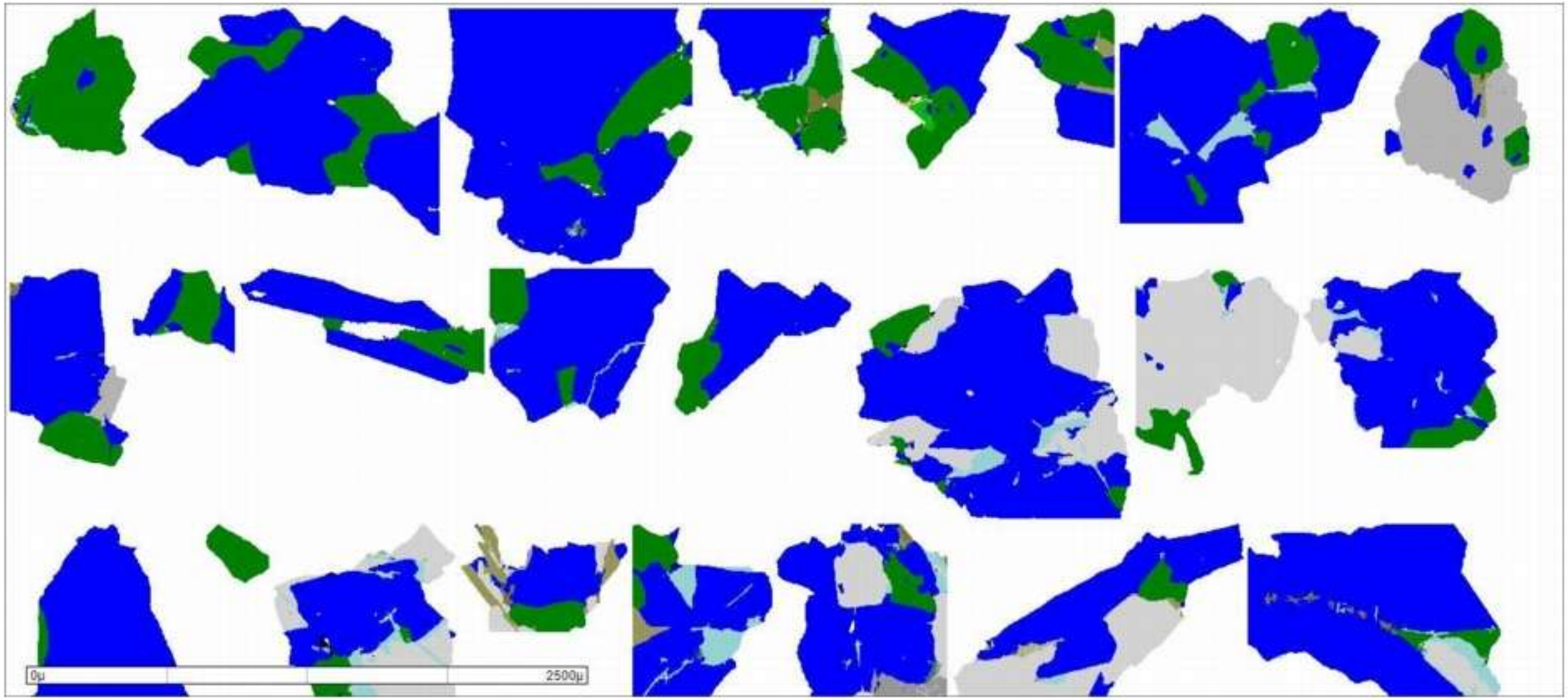
30.9.2014

710_1180_XMOD					
Mineral	Wt%	Area%	Area (micron)	Particle Count	Grain Count
Quartz	23.38	31.16	127257.11	7129	7129
Plagioclase	19.34	25.40	103729.98	5811	5811
K_feldspar	2.76	3.77	15405.09	863	863
Hedenbergite	0.00	0.00	0.00	0	0
Epidote	0.06	0.07	267.76	15	15
Allanite	0.00	0.00	0.00	0	0
Titanite	0.00	0.00	0.00	0	0
Zircon	0.00	0.00	0.00	0	0
Chlorite	0.84	0.99	4052.09	227	227
Biotite	0.81	0.92	3748.63	210	210
Phlogopite	2.30	2.87	11727.86	657	657
Muscovite	0.28	0.35	1428.05	80	80
Berthierite	0.00	0.00	0.00	0	0
Fluorite	0.00	0.00	0.00	0	0
Calcite	0.03	0.03	142.81	8	8
Synchysite	0.00	0.00	0.00	0	0
Apatite	0.76	0.83	3391.62	190	190
Monazite	0.01	0.00	17.85	1	1
Xenotime	0.00	0.00	0.00	0	0
Anatase	0.00	0.00	0.00	0	0
Magnetite	49.39	33.55	137057.10	7678	7678
Fe_hydroxide	0.02	0.02	89.25	5	5
Pyrite	0.00	0.00	0.00	0	0
Pyrrhotite	0.00	0.00	0.00	0	0
Chalcopyrite	0.00	0.00	0.00	0	0
Sphalerite	0.00	0.00	0.00	0	0
Galena	0.00	0.00	0.00	0	0
Unclassified	0.02	0.03	142.81	8	8
Total	100.00	100.00	408458.00	22882	22882

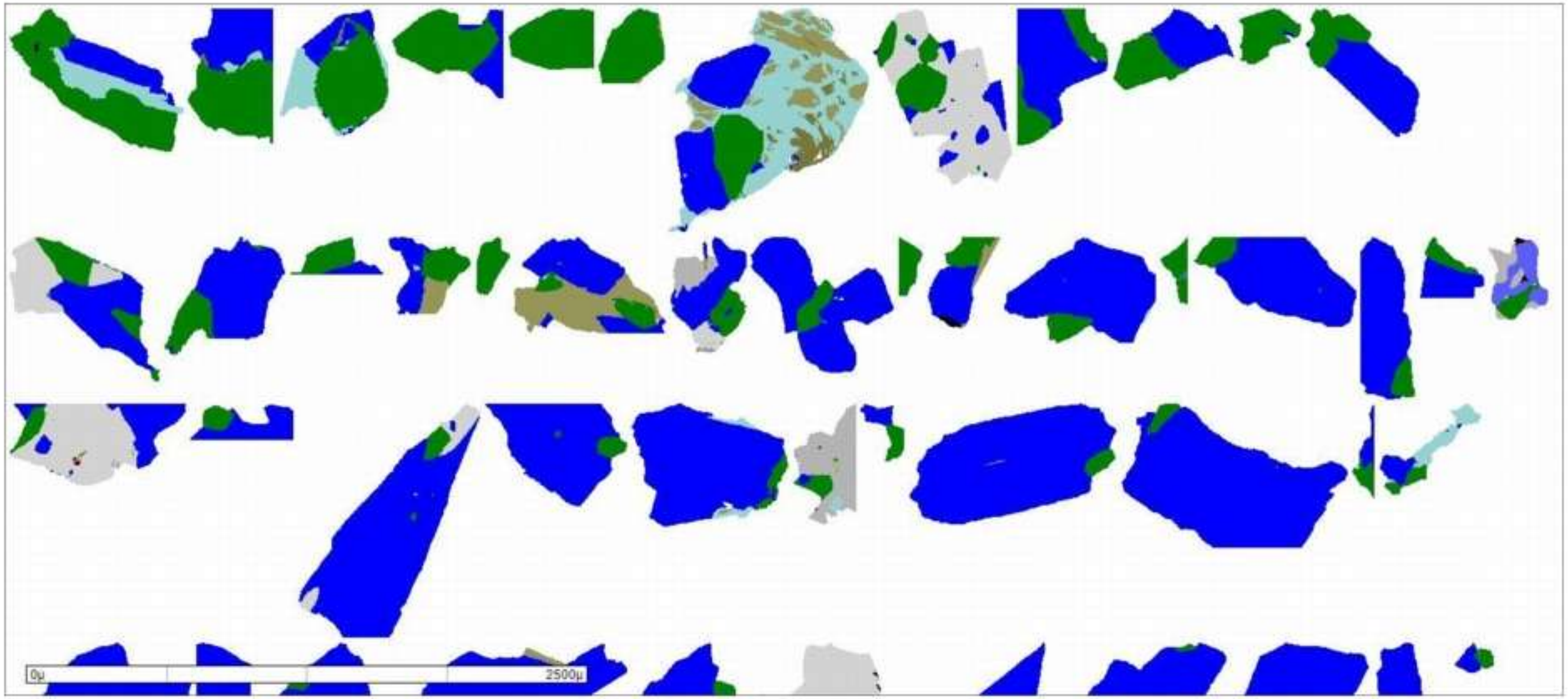
30.9.2014

NIO_XMOD_Calculated_bulk			
Mineral	Wt%	Area%	Analysis Point Count
Quartz	20.45	28.23	32134
Plagioclase	15.33	20.82	23208
K_feldspar	2.52	3.58	4080
Hedenbergite	0.00	0.00	3
Epidote	0.02	0.03	23
Allanite	0.02	0.02	25
Titanite	0.00	0.00	2
Zircon	0.00	0.00	1
Chlorite	0.97	1.20	1410
Biotite	0.68	0.80	865
Phlogopite	3.26	4.25	4786
Muscovite	0.19	0.24	279
Berthierine	0.00	0.00	4
Fluorite	0.02	0.02	30
Calcite	0.03	0.04	63
Synchysite	0.00	0.00	1
Apatite	1.26	1.43	1808
Monazite	0.03	0.02	31
Xenotime	0.00	0.00	0
Anatase	0.00	0.00	0
Magnetite	55.12	39.20	43803
Fe_hydroxide	0.04	0.04	52
Pyrite	0.00	0.00	2
Pyrrhotite	0.00	0.00	1
Chalcopyrite	0.00	0.00	0
Sphalerite	0.00	0.00	3
Galena	0.00	0.00	0
Unclassified	0.06	0.09	134
Total	100.00	100.00	112748

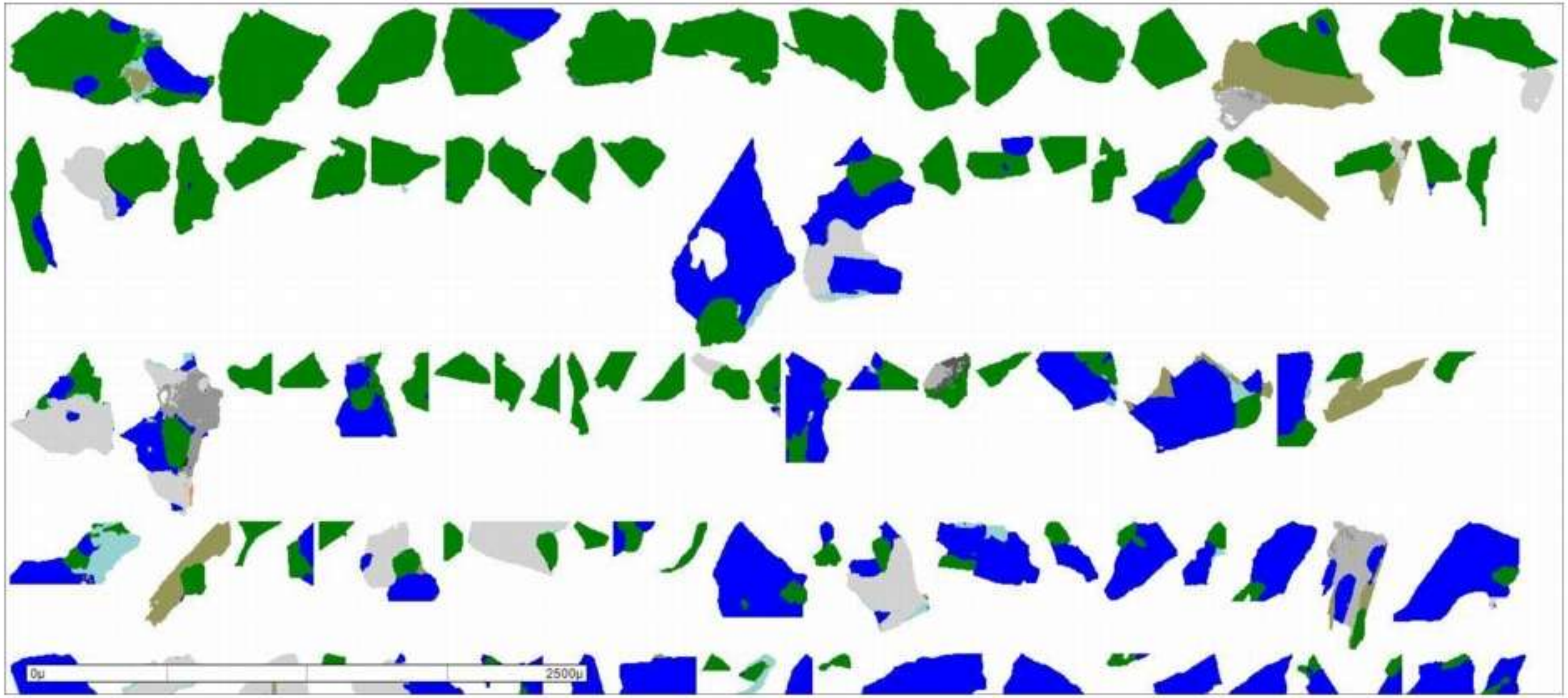
13 APPENDIX F – APATITE (GREEN) GRAIN IMAGE LISTS BY SIEVE FRACTION; SEE APPENDIX H FOR LEGEND COLOURS



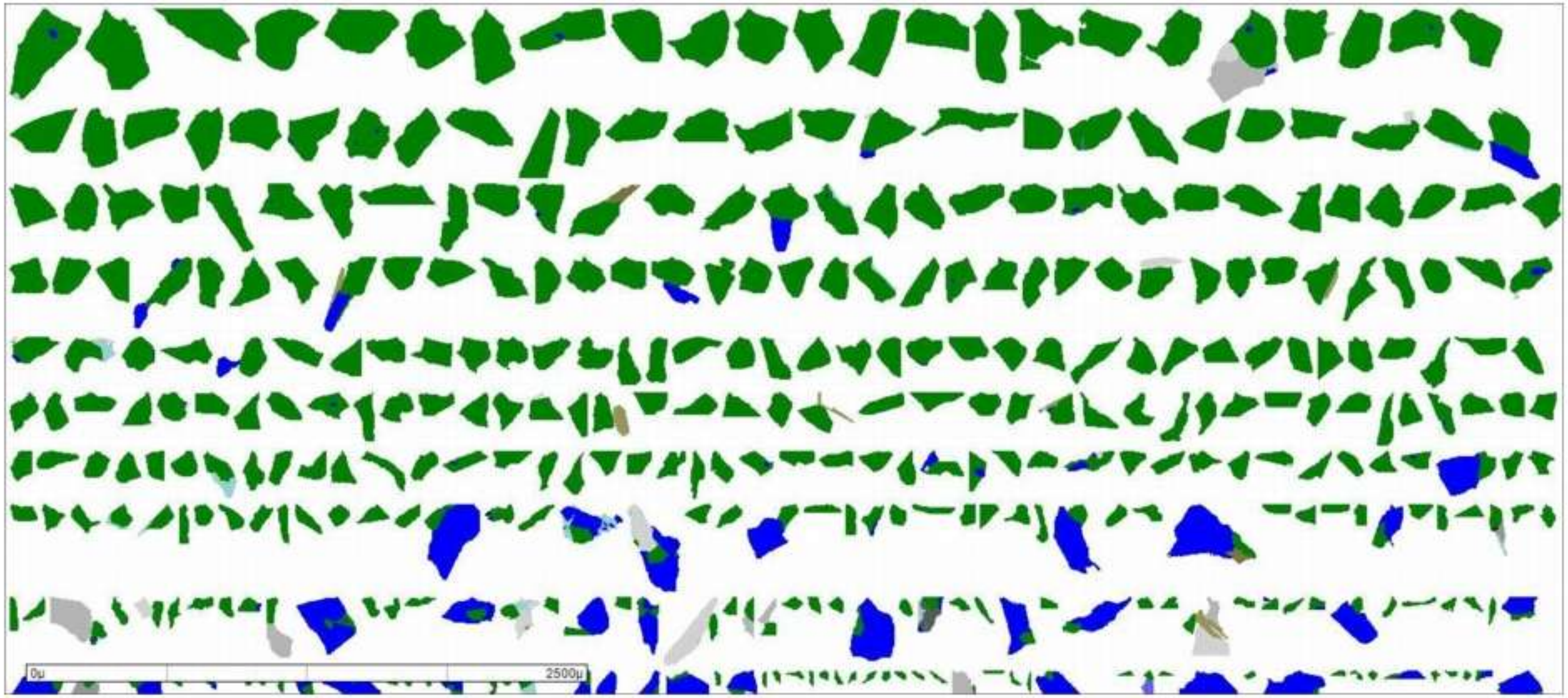
710-1180µm



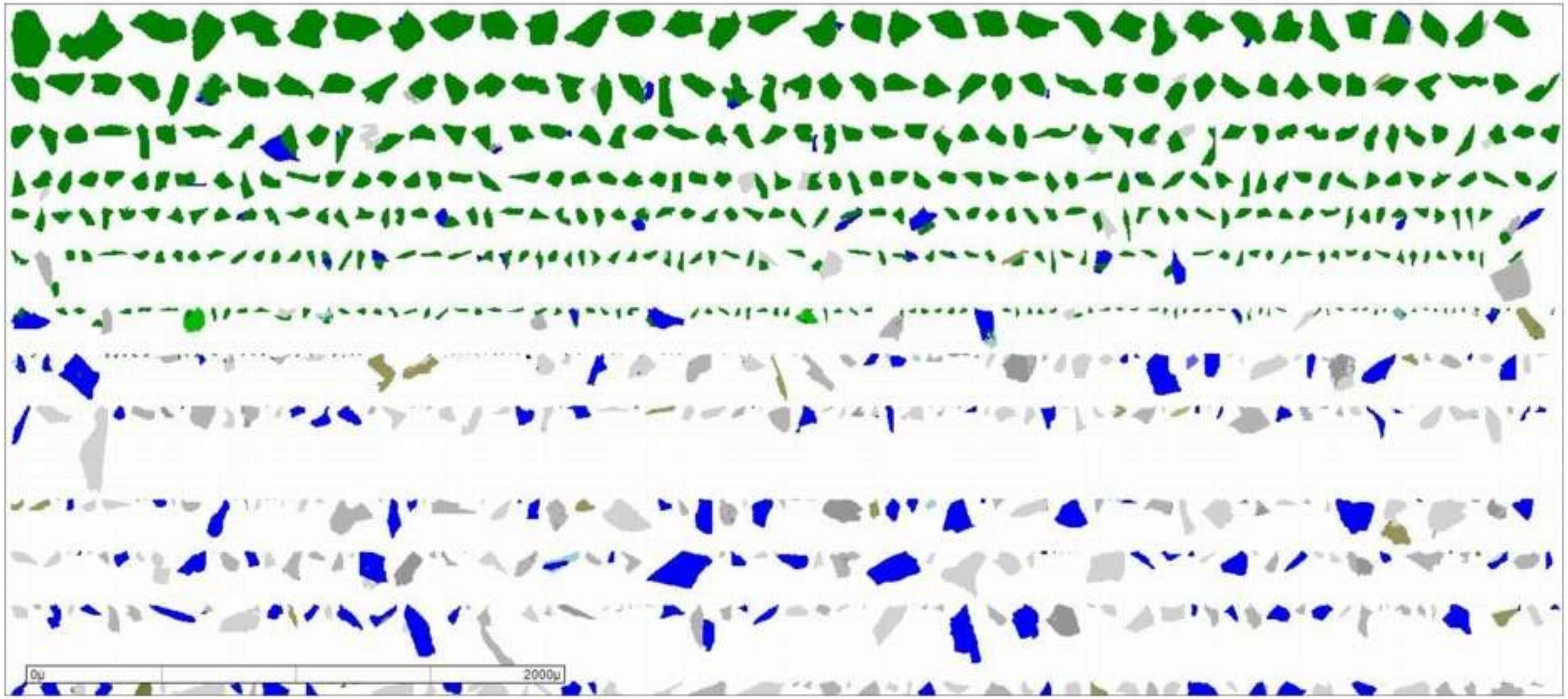
500-710µm



250-500µm



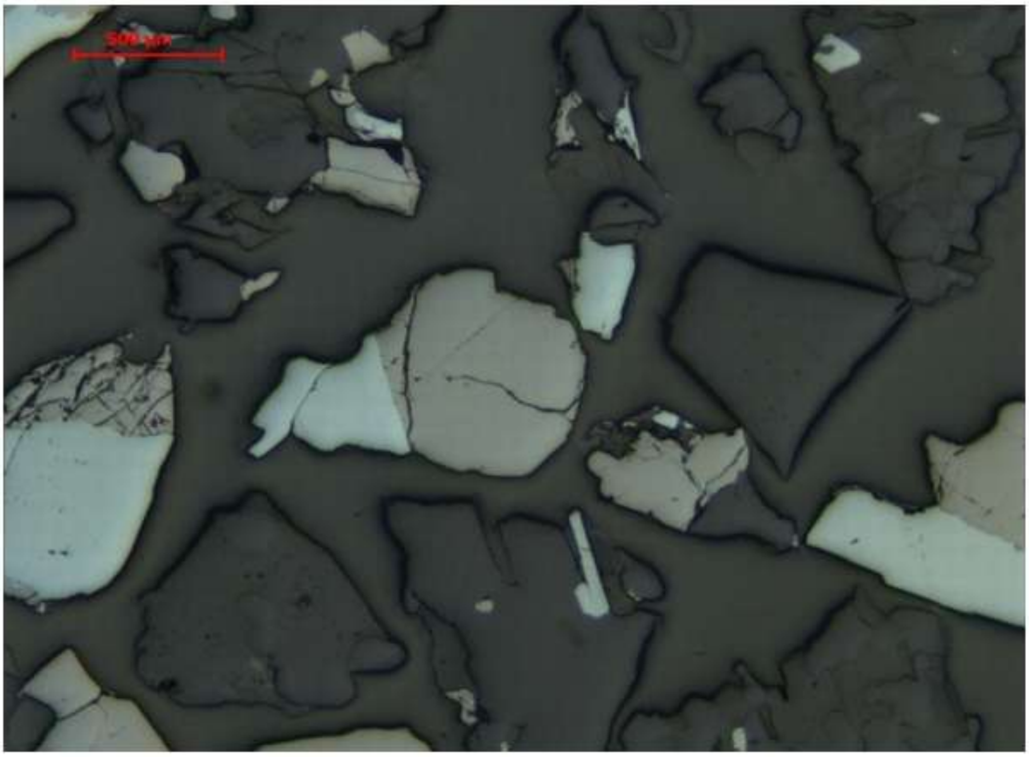
125-250µm



45-125µm

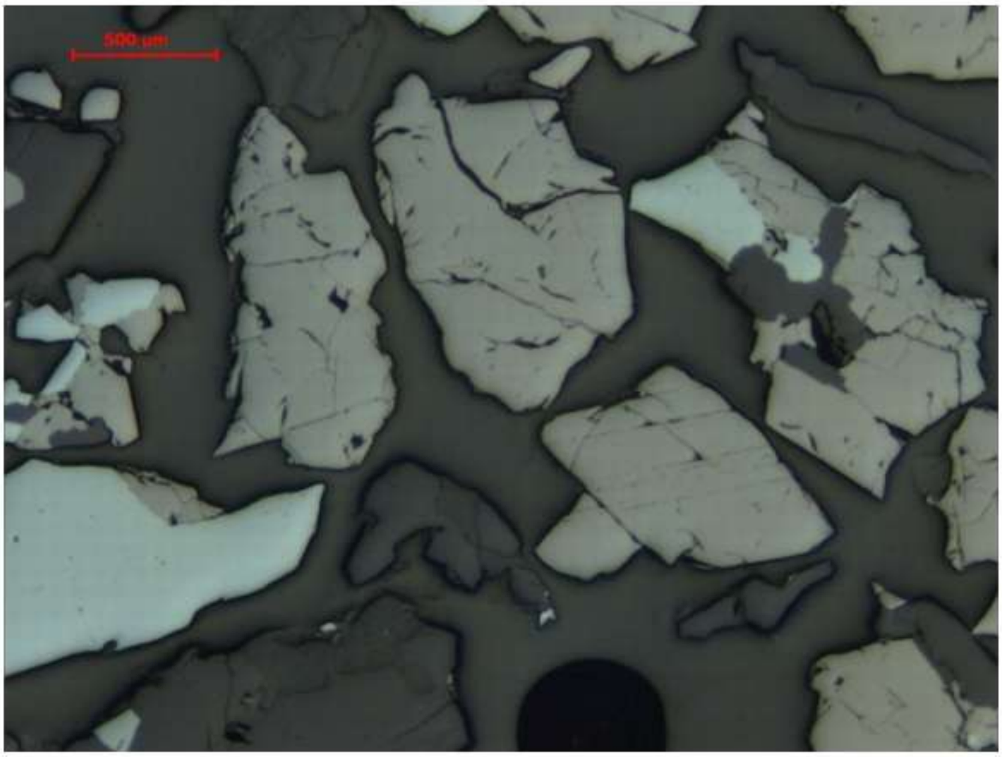
14 APPENDIX G – LEGEND OF COLOURS USED IN THE FALSE-COLOURED GRAIN IMAGES

15 APPENDIX H – PHOTOMICROGRAPHS TAKEN WITH AN ORE MICROSCOPE, BY SIEVE FRACTION

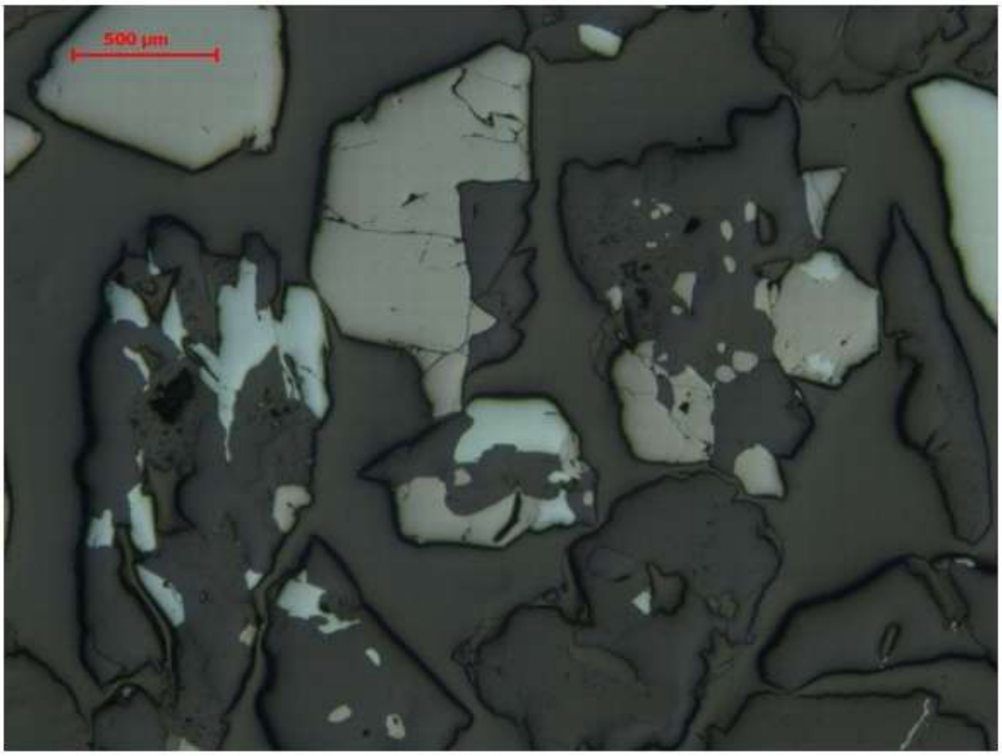


710-1180µm (1)

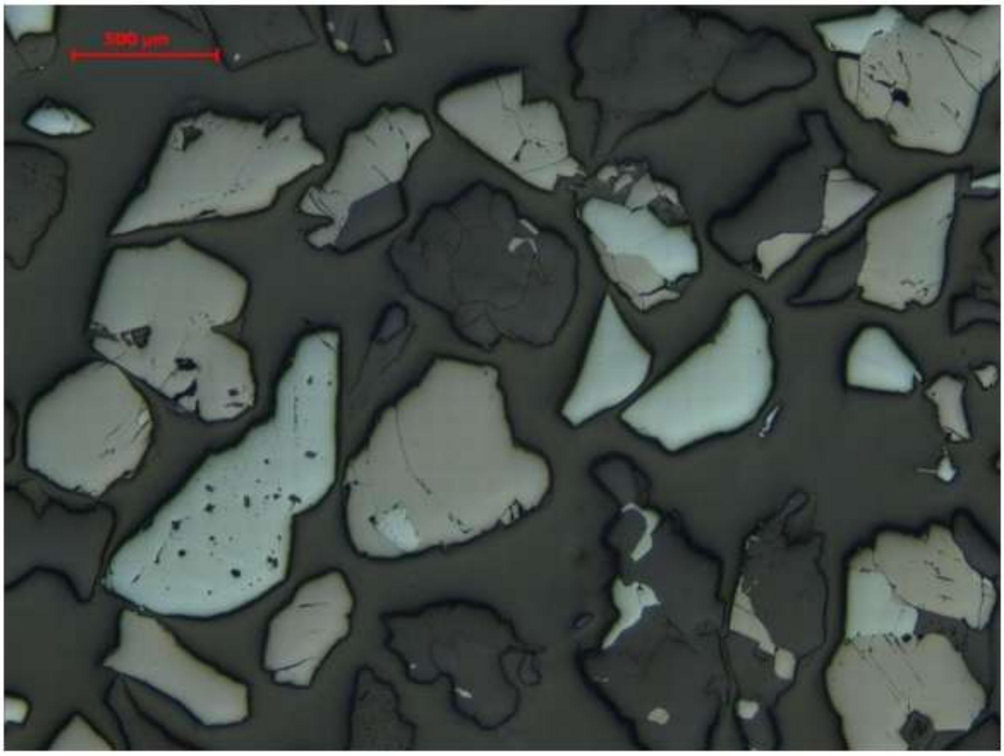
30.9.2014



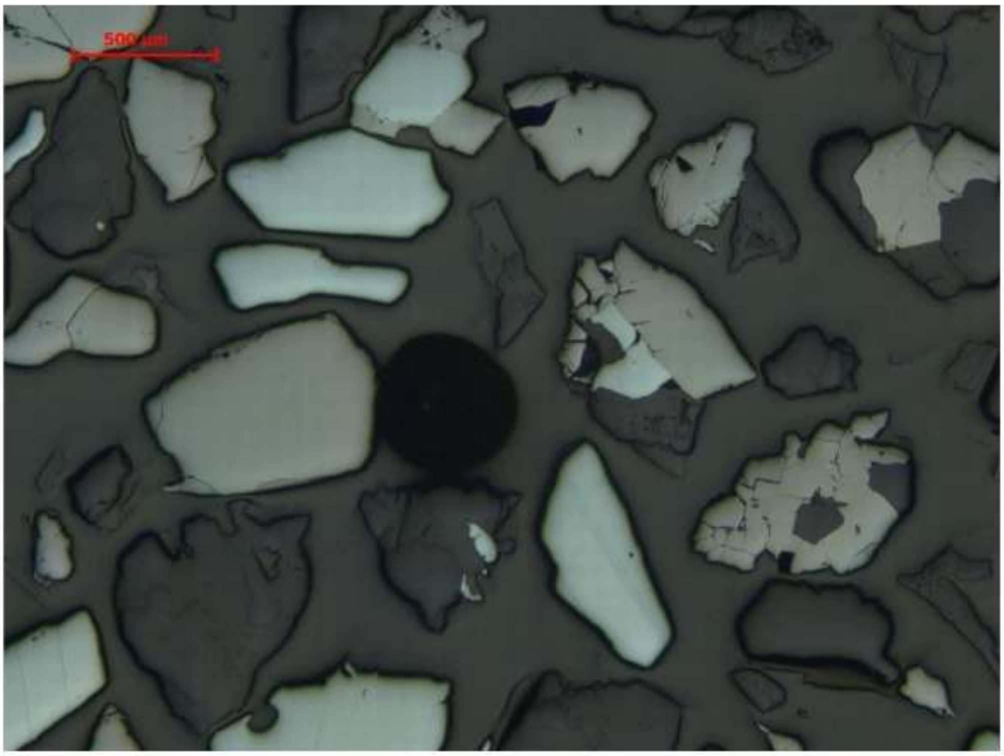
710-1180µm (2)



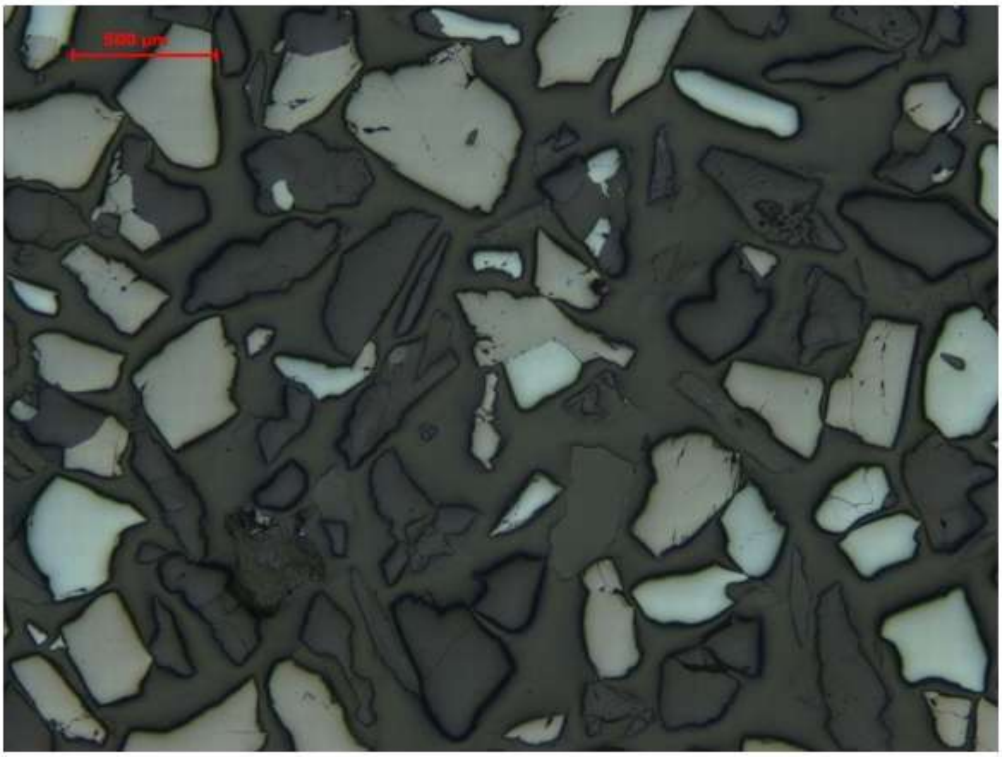
710-1180µm (3)



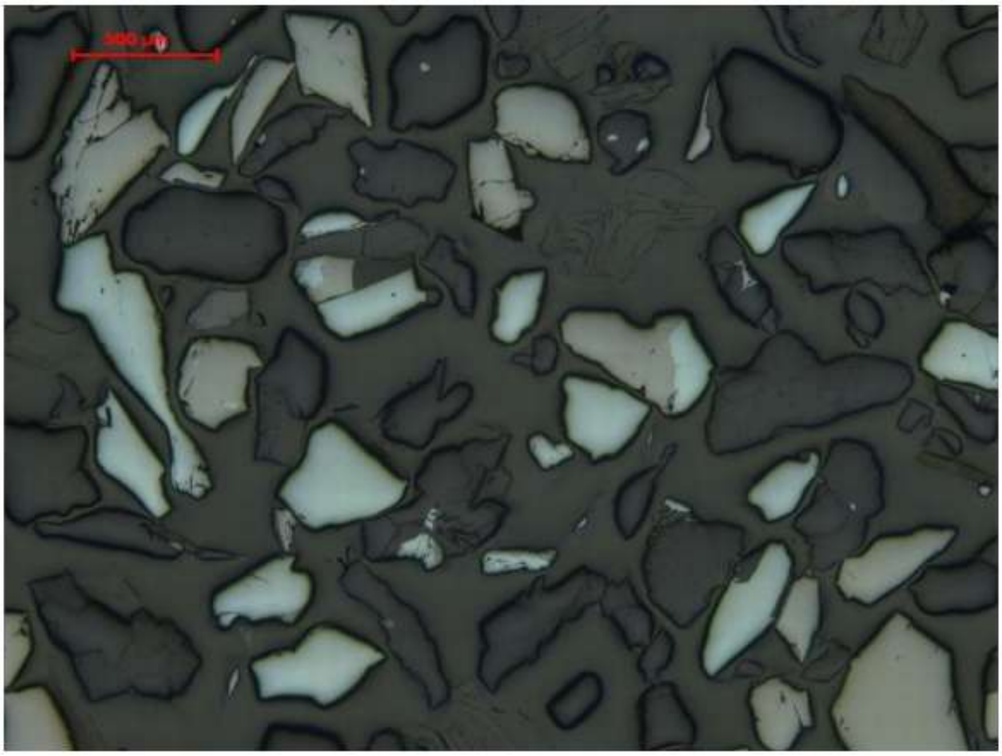
500-710µm (1)



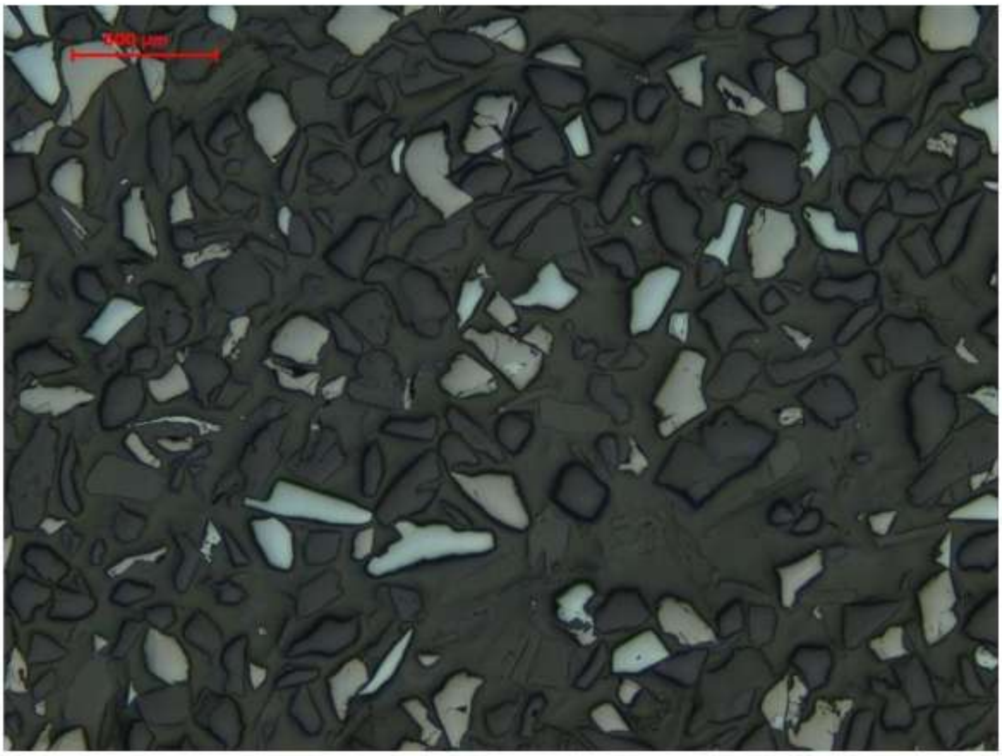
500-710µm (2)



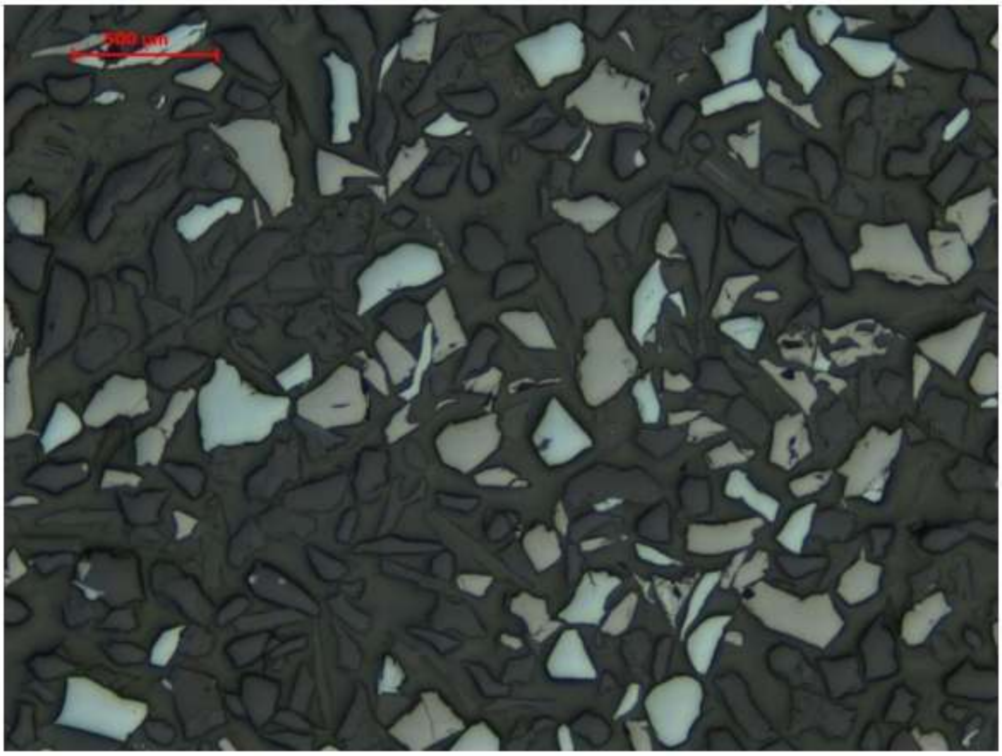
250-500µm (1)



250-500µm (2)

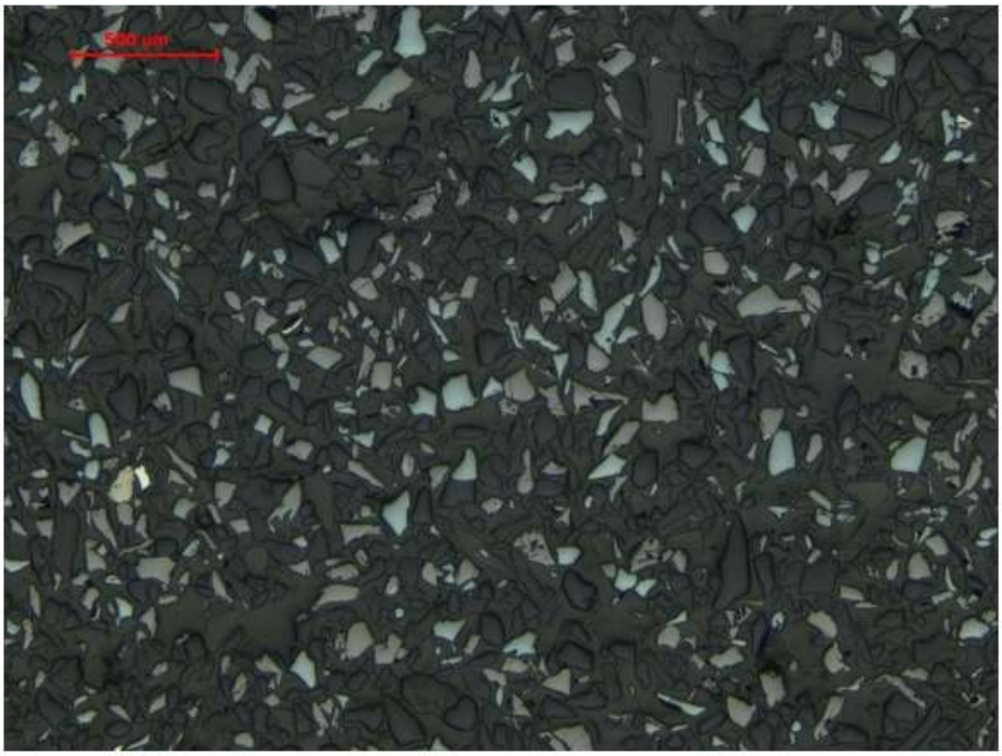


125-250µm (1)

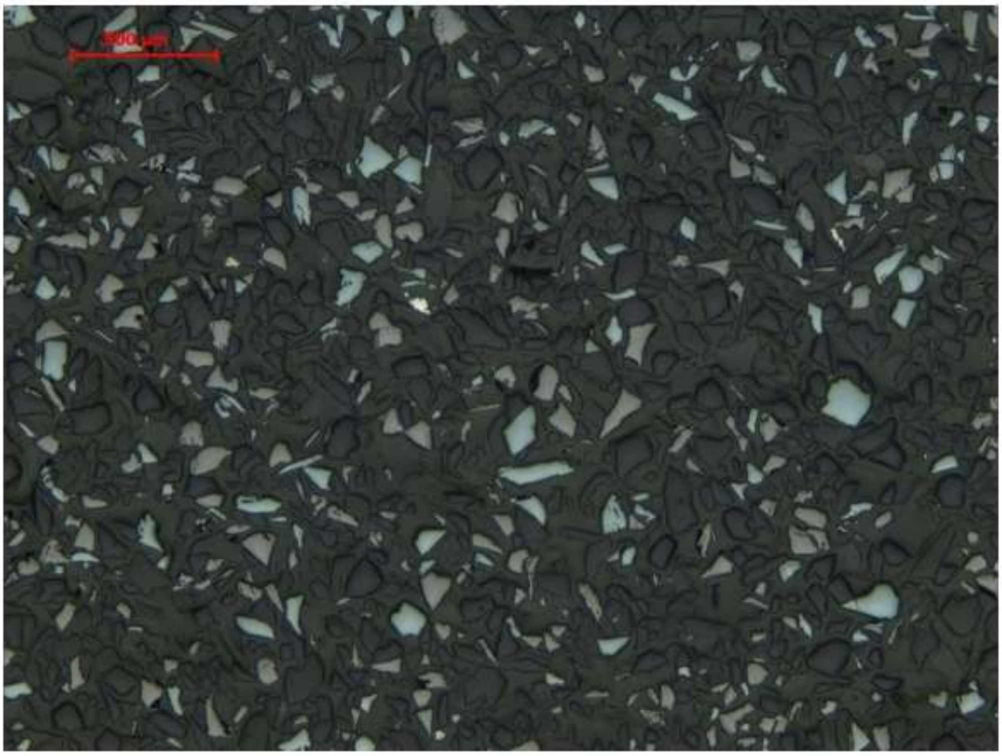


125-250µm (2)

30.9.2014



45-125µm (1)



45-125µm (2)

16 APPENDIX I – EMPA ANALYSIS

Geologian Tutkimuskeskus (GTK)

Etelä-Suomen Yksikkö

April 4th, 2014

EPMA- lab

Hematite (h) and magnetite (m) analyses, first analysis from the core of the grain, second from the rim

Index #	SiO2	TiO2	Al2O3	Cr2O3	V2O3	FeO	MnO	MgO	CaO	ZnO	P2O5	SO2	Total	X	Y	Sample / grain	Mn (ppm)	Mg (ppm)	P (ppm)
3004.15	0.00	0.02	0.39	0.00	0.12	90.51	0.01	0.02	0.00	0.01	0.00	0.02	91.10	-15623	-3494	OK13550 h1	127	219	0
3005.15	0.00	0.01	0.35	0.01	0.11	90.25	0.00	0.00	0.05	0.01	0.00	0.01	90.80	-15827	-3697	OK13550 h1	0	0	0
3006.15	0.00	0.00	0.45	0.00	0.11	90.59	0.00	0.00	0.00	0.00	0.00	0.00	91.16	-18719	-2111	OK13550 h2	0	0	0
3007.15	0.00	0.00	0.35	0.00	0.10	90.26	0.00	0.02	0.00	0.01	0.00	0.00	90.74	-18718	-1671	OK13550 h2	0	234	0
3008.15	0.00	0.00	0.47	0.00	0.08	90.27	0.02	0.00	0.00	0.00	0.02	0.00	90.86	-16786	7306	OK13550 h3	157	0	161
3009.15	0.00	0.00	0.46	0.00	0.09	90.20	0.00	0.00	0.00	0.01	0.00	0.00	90.78	-16149	6986	OK13550 h3	25	0	0
3010.15	0.00	0.03	0.53	0.00	0.13	90.62	0.03	0.02	0.00	0.00	0.00	0.00	91.36	-6804	1670	OK13550 h4	281	180	0
3011.15	0.00	0.00	0.49	0.00	0.08	90.27	0.00	0.00	0.00	0.03	0.01	0.00	90.87	-6895	1440	OK13550 h4	0	0	52
3012.15	0.00	0.01	0.58	0.00	0.09	90.84	0.02	0.00	0.00	0.01	0.03	0.00	91.56	-6242	3723	OK13550 h5	177	4	300
3013.15	0.00	0.05	0.51	0.00	0.10	90.32	0.01	0.00	0.00	0.00	0.00	0.00	90.99	-6085	3580	OK13550 h5	77	0	0
3014.15	0.00	0.01	0.51	0.00	0.08	90.68	0.00	0.00	0.00	0.00	0.00	0.00	91.28	-7353	8121	OK13550 h6	0	0	0
3015.15	0.00	0.00	0.43	0.00	0.08	90.01	0.00	0.00	0.00	0.00	0.01	0.00	90.53	-7649	8204	OK13550 h6	0	0	92
3016.15	0.00	0.00	0.17	0.00	0.10	93.48	0.05	0.01	0.00	0.00	0.00	0.00	93.81	-18870	-8034	OK13550 m1	505	137	0
3017.15	0.00	0.00	0.10	0.00	0.11	93.35	0.06	0.00	0.00	0.01	0.03	0.00	93.66	-19062	-7982	OK13550 m1	597	0	270
3018.15	0.00	0.00	0.17	0.00	0.09	93.78	0.07	0.00	0.00	0.04	0.00	0.01	94.16	-18982	-3879	OK13550 m2	741	22	0
3019.15	0.00	0.00	0.05	0.00	0.09	93.70	0.07	0.00	0.00	0.02	0.03	0.00	93.97	-18971	-3761	OK13550 m2	697	0	293
3020.15	0.00	0.00	0.08	0.01	0.08	93.75	0.06	0.02	0.00	0.00	0.01	0.02	94.03	-18269	2837	OK13550 m3	648	186	133
3021.15	0.00	0.00	0.09	0.01	0.09	93.82	0.08	0.00	0.00	0.00	0.01	0.00	94.10	-17710	2707	OK13550 m3	787	0	110
3022.15	0.00	0.00	0.07	0.00	0.01	93.86	0.14	0.00	0.00	0.00	0.00	0.00	94.09	-6635	4407	OK13550 m4	1434	0	0
3023.15	0.00	0.00	0.13	0.00	0.00	93.59	0.14	0.00	0.00	0.01	0.00	0.00	93.88	-7207	4608	OK13550 m4	1447	0	0
3024.15	0.00	0.00	0.03	0.00	0.10	93.79	0.07	0.00	0.00	0.00	0.01	0.00	94.00	-15882	-5697	OK13550 m5	672	0	52
3025.15	0.00	0.00	0.03	0.00	0.10	93.62	0.05	0.00	0.00	0.00	0.00	0.01	93.80	-15721	-5819	OK13550 m5	454	0	0
3026.15	0.00	0.00	0.05	0.02	0.09	93.97	0.06	0.00	0.00	0.00	0.01	0.01	94.20	-2452	9026	OK13550 m6	616	0	115
3027.15	0.00	0.00	0.11	0.00	0.11	93.64	0.08	0.01	0.00	0.01	0.00	0.00	93.95	-2632	9179	OK13550 m6	773	62	0

Analytical conditions: Acceleration voltage = 20 kV, Electron beam current and diameter = 40 nA & 1 µm, respectively.

Microprobe / operator = Cameca SX100 / Mia Tiljander

Average detection limits per element (ppm) in the above analyses

Si	Ti	Al	Cr	V	Fe	Mn	Mg	Ca	Zn	P	S
n.d.	225	286	264	194	686	225	387	130	468	205	166

n.d. = not determined (all concentrations = 0.00 w%)

17 APPENDIX J – LABTIUM ASSAY PROCEDURES

LABTIUM

Mining and Metallurgy
Mineral processing samples
Assay methods

Analysis of commodity elements of samples from various stages of the processing plant (heads, tailings, concentrates, midlings, slags) are extremely important not only for defining the value of the end-products but also for optimisation of the recovery of the plant. Additionally the concentration of **main components and deleterious, penalty elements** is also important.

The selection of the analytical procedures depends on the use of the results (**calibration of on-line analysers, process control, shipment, commercial or umpire analyses**) and is done together with the laboratory so that the procedure can be tailored individually.

Larger analytical packages are available for analysis of the commodity elements together with major and trace components. They involve either digestion with aqua regia or more aggressive sodium peroxide fusion by ICP-OES or ICP-MS. These element packages can also be tailored for specified requirements. Also analysis by XRF can be used for process control.

Additional components are analysed by **individual determinations** such as combustion (elemental analysers) and potentiometry.

Labtium has methods for **chemical phase analysis** e.g. for determination of Ni and Cu -oxide and -sulphide phases or gold in cyanide soluble and refractory form.

The analytical methods used for high precision assays (e.g. commercial assays) for **individual commodity elements** range from traditional, gravimetric and titrimetric methods to modern instrumental analytical methods. Analysis of precious metals (Au, Ag, Pd, Pt) is mostly based on Fire Assay procedures.

Your expert of analyses

LABTIUM

Your expert of analyses

	Multi - element assays.
514P	Aqua Regia digestion. Multi - element analysis by ICP-OES (10 elements).
514M	Aqua Regia digestion. Multi - element analysis by ICP-MS (13 elements).
721P	Peroxide fusion. Multi - element analysis by ICP-OES (20 elements).
502A/U	Fuming nitric acid digestion. Element analysis by FAAS.or GFAAS
309A	Multi-acid digestion. Element analysis by FAAS.
721M	Peroxide fusion. Multi - element analysis by ICP-MS (18 elements, REE's, U, Th)
000P	Multi - element analysis of process waters and client's solutions by ICP-OES.
000M	Multi - element analysis of process waters and client's solutions by ICP-MS.
	Individual methods.
810L	S -analysis by pyrolytical method (Eltra).
811L	C -analysis by pyrolytical method (Eltra).
820L	C - and N -analysis by pyrolytical method.
310M	I - and Br -analysis by ICP-MS. Microwave total digestion.
822L	Hg -analysis by pyrolytical method.
143G	Solid matter by gravimetry.
891G	Saturation magnetisation (magnetite content) by Satmagan.
814G	Moisture and dry matter by gravimetry.
830G	Specific gravity by gas pycnometer.
813G	Loss on ignition (LOI) at 1000°C by gravimetry.
301T	Fe^{2+} by titrimetry. HF/H_2SO_4 digestion.
811L/816L	Carbonate and non-carbonate carbon by pyrolytical method (Eltra)
725I	F -analysis by ion selective electrode. NaOH fusion.
	Scannig X-Ray fluorescence (XRF)
180X	Multi - element analysis by XRF from pressed pellets
	Cu and Ni. Chemical phase analyses or sequental leach.
206A/P	Ni, Cu, Co. Water leach . Analysy by FAAS or ICP-OES.
280A/P	Ni, Cu, Co. Acetic Acid leach. Analysis by FAAS or ICP-OES.
531A/P	Ni, Cu, Co. Sulphuric acid/ Sodium sulphite leach. Analysis by FAAS or ICP-OES.
240A/P	Ni, Cu, Co. Ammonium Citrate/Hydrogen peroxide leach. Analysis by FAAS or ICP-OES.
250A/P	Ni, Cu, Co. Bromine/Methanol leach. Analysis by FAAS or ICP-OES.
309A/P	Ni, Cu, Co. Total digestion. Analysis by FAAS or ICP-OES.
	High-Precision assays, classical methods.
740G/A/P	Au or Ag or Au, Pd, Pt in concentrate by Fire Assay and gravimetry, FAAS or ICP-OES.
742G	Au in bullion by Fire Assay and gravimetry.
743G	Au in concentrate by Fire Assay and analysis by gravimetry or FAAS.
895G	Cu in concentrate by electrogravimetry.
881T	Zn in concentrate by titrimetry.
896G	Ni in concentrate by gravimetry.

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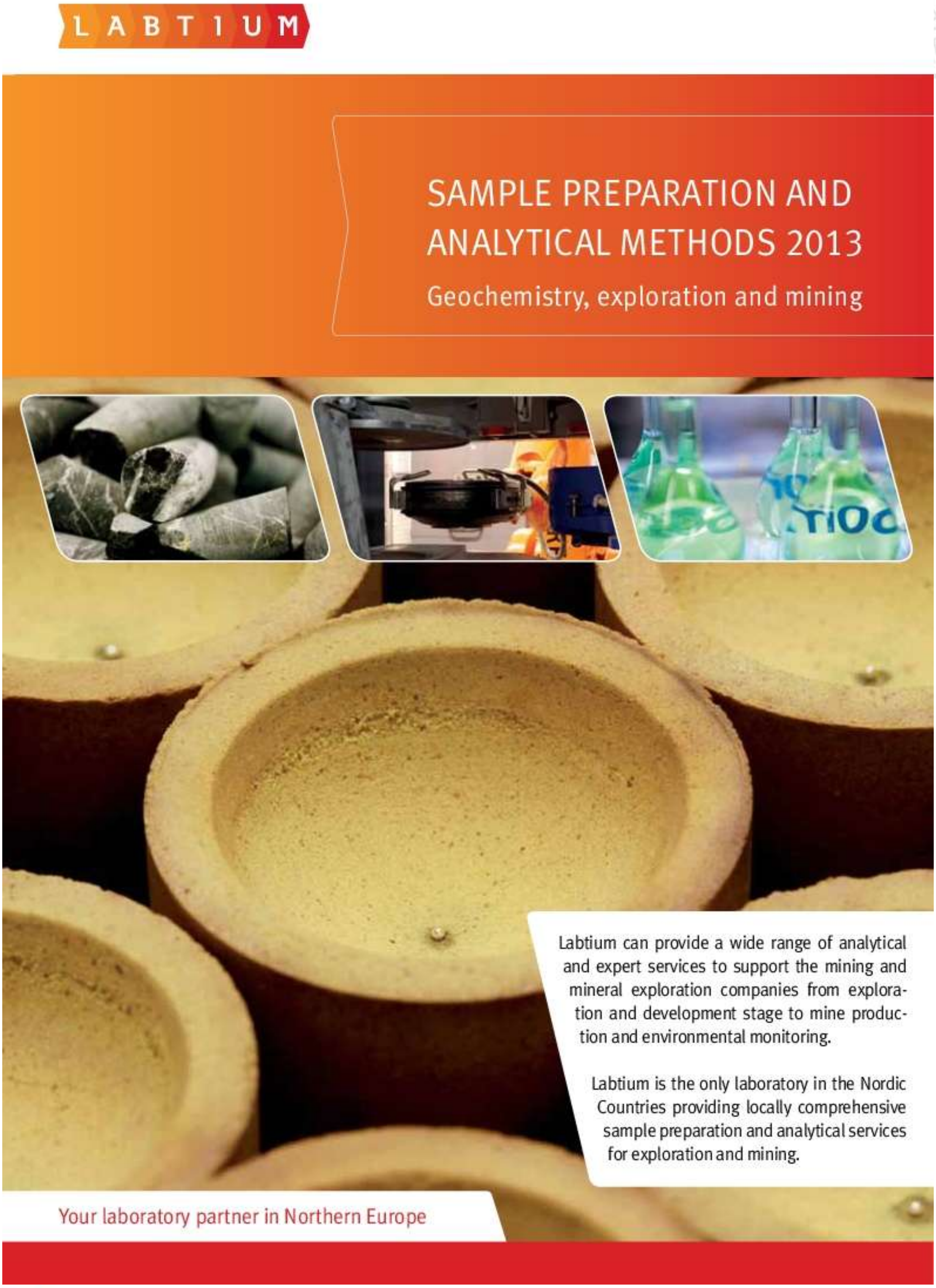
LABTIUM
SAMPLE PREPARATION AND ANALYTICAL METHODS 2013
Geochemistry, exploration and mining
Labtium can provide a wide range of analytical and expert services to support the mining and mineral exploration companies from exploration and development stage to mine production and environmental monitoring.
Labtium is the only laboratory in the Nordic Countries providing locally comprehensive sample preparation and analytical services for exploration and mining.
Your laboratory partner in Northern Europe

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SAMPLE PREPARATION AND ANALYTICAL METHODS 2013
Geochemistry, exploration and mining

Rock samples

The objective of a precise sample preparation scheme is to produce a representative and meaningful test sample (regularly about 100 - 150 g) from a large bulk sample. The grain size of the prepared sample must be so fine that the element of interest (or host mineral) can be properly liberated from the bulk matrix and distributed in the pulp to produce a homogeneous distribution to ensure sufficient representativity for the following analytical methods. This is particularly important for low-concentration ores (e.g. Au and PGE's) where the number of mineral particles producing ore concentration is always low.

It is commonly accepted that poor sample preparation is, next to poor sampling, the largest source of bias in an exploration or resource evaluation project. If the representatitivity of the sample is lost during sample preparation, the subsequent assaying cannot correct the damage done. Sample preparation methods should therefore be selected as carefully as the actual analytical methods.

For routine sample preparation Labtium recommends high quality robotic sample preparation.

Conventional, manual sample preparation (crushing, splitting, pulverising) is available in our laboratories in Rovaniemi, Kuopio and Sodankylä

Drying

All samples are always dried no matter what the earlier sample preparation history is (Methods 10/12). Exceptionally wet and large samples (RC-, chip-samples etc.) require longer drying in elevated temperature (Method 14).

Preparation Method	Description	Maximum weight	Labtium method
Drying in forced air ovens In stainless steel/aluminium trays	Drying at 70 °C (Rock samples)	4000 g	10
	Drying at < 40 °C	4000 g	11
	Drying at 105°C (RC- and chip samples)	4000 g	12
	Sorting and drying of exceptionally large or wet samples at > 105 °C (e.g. RC – and chip samples)	10000 g	14

Crushing

Two options for crushing are available. If the weight of the crushed sample has to be reduced for subsequent steps of sample preparation (subsampling; splitting), the particle size of the crushed sample must be as small as possible. For this purpose fine crushing must be used (method 31).

If the whole sample is to be pulverized a more robust crushing can be used (method 30).

Preparation Method	Description	Maximum weight	Labtium method
Crushing by jaw crusher	Standard coarse crushing using Mn-steel jaws to nominal < 10mm	4000 g	30
	Fine crushing using Mn-steel jaws to nominal > 70 % < 2 mm	4000 g	31

SAMPLE PREPARATION

Pulverising

Pulverising will always cause unavoidable contamination of wear metals at trace level from the grinding surfaces. This contamination may vary depending on material of the bowl, hardness of the sample material, pulverising time etc. The pulverising method must be selected to best serve the requirements of the client.

Some examples of bowl materials used at LABTIUM and expected contamination:
- carbon steel (< 0.2 % Fe, no base metals)
- hardened steel (< 0.2 % Fe, low Mn, Ni, Cu, Cr, Co)
- low chrome steel (up to 200 ppm Cr, < 0.2 % Fe, traces Mn, Cu, Co)
- tungsten carbide (W, Co)
- agate (Si)

Different minerals behave differently during pulverising – most (brittle) minerals will easily break down to small particles while some (e.g. native gold) will just change their shape if proper sample preparation methods are not used.

Preparation Method	Description	Maximum weight	Labtium method
Pulverising in ring mill Quartzite cleaner included Grain size of the pulp > 90 % < 100 µm	Pulverising the split sample in carbon steel bowl	150 g	40
	Pulverising the split sample in tungsten carbide bowl (petrological samples)	100 g	43
	Pulverising a large sample in low-chrome steel bowl (LM5) (e.g. Drill cores, RC - or chip samples)	3500 g	50
	Pulverising a large sample in continuous flow chrome steel bowl, splitting by rotary splitter included (e.g. RC-, chip or feasibility samples)	20 kg	51

To minimise cross-contamination, cleaning of pulverising bowls between samples (pulverising with barren quartzite) is included in the price in all Labtium pulverising methods. The pulverisers and jaw crushers are cleaned with compressed air between every sample.

Other preparation methods

Preparation Method	Description	Maximum weight	Labtium method
Miscellaneous Sample Preparation	Separate splitting / subsampling by riffle splitter (max 5 runs) to 100–150 g subsample	4000 g	35
	Separate homogenisation / subsampling by mat-rolling to 100–150 g subsample.	4000 g	36
	Separate splitting / subsampling by rotary splitter	4000 g	37
	Wet sieving to 100 µm, (QC for pulverising) and weighing the +100 µm	200 g	28
	Compositing / homogenising large pulps in rotary mixer	50 kg	

Cutting of drill cores and rock samples	Sawing to two equal halves by diamond saw, returning the other half to original core case, packing the other half to plastic bags or aluminium trays for further processing

Core-logging facilities can be leased in Sodankylä for exclusive use on daily basis.

Rock samples

Manual sample preparation packages

MAN 2

The standard scheme for manual sample preparation consists of direct one–stage fine crushing using a special type of jaw crushers to nominal particle size > 70 % < 2 mm (method 31), precision riffle splitting (method 35) and pulverising the split subsample of 70–100g (method 40) . This is a suitable method if crushed reject is needed for future work. The use of this method is meaningful to maximum size of 2000 g samples, because if more than 3 - 4 splittings are required the representativity of the split subsample cannot be assured.

For high – precision whole rock analysis by XRF tungsten carbide pulverising bowl (Method 43) must be used.

MAN 1

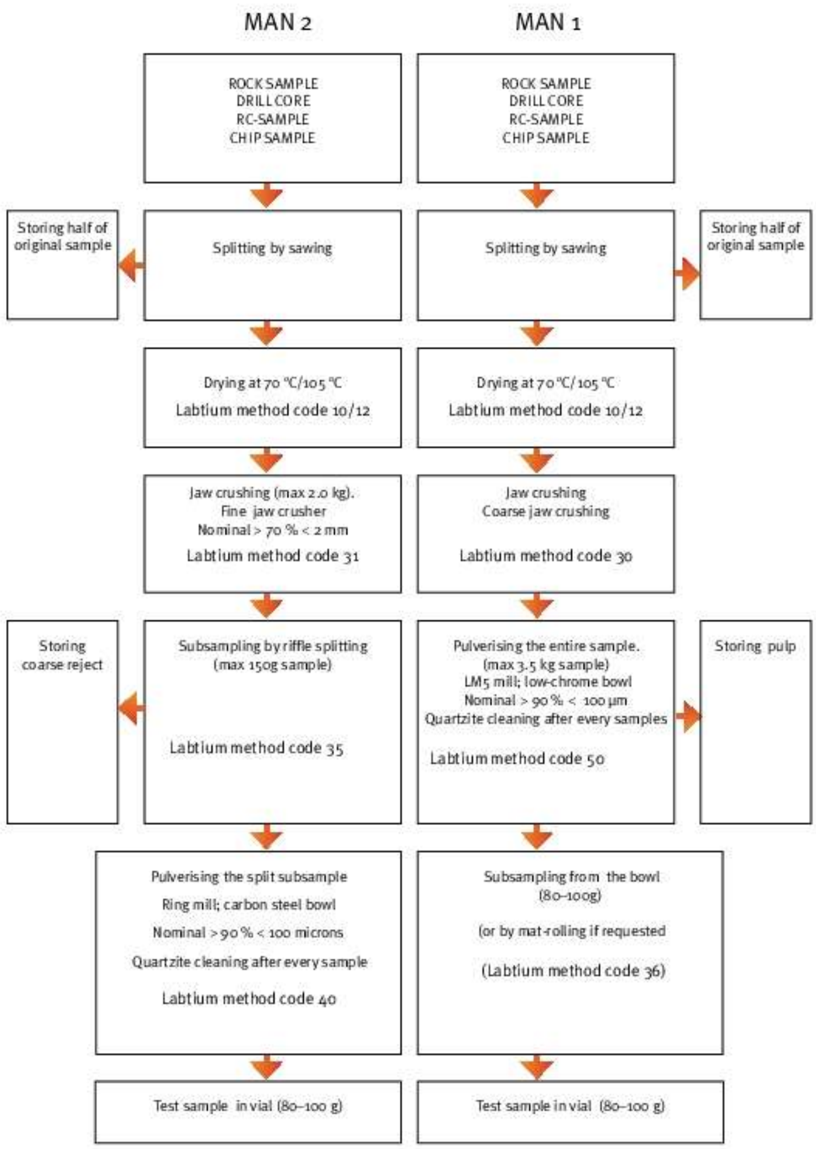
For samples containing visible gold and/or for unusually big or heterogeneous samples, (max. 3.5 kg) we recommend standard crushing (method 30) and followed by pulverising the entire test sample (methods 50, low-chrome steel bowl) using Essa LM5 mills, avoiding any sample splitting which may deteriorate representativity of large samples. The pulverising takes place in large bowl and provides a large homogenised test sample for representative subsampling directly from the bowl without any further sample handling. The grinding action in LM5 is based on impact and hence smearing of gold particles (which are a problem with ring and disc mills) on bowl surfaces is minimised, which is an addition advantage of the technique. The Method 50 is also suitable for pulverising RC (reverse circulation) samples and for percussion drill chip-samples, making crushing and splitting unnecessary. If sample size exceeds 3.5 kg the sample must be pulverised by separate millings and homogenised before subsampling to analytical sample. In this case additional charge is invoiced for each kg exceeding 3.5 kg.

If crushed reject is required for future work the crushed material can be split to two (e.g. 1–2 kg) splits (riffle splitting Method 35) – the other for storage and the other for pulverising (Method 50).

SAMPLE PREPARATION

Rock samples

Manual sample preparation schemas



Additionally riffle splitting (35) can be included after crushing to retain 50 % of the crushed reject. However coarse crushing (30) has to be replaced by fine crushing (31).

Rock samples
Robotic Sample Preparation

Labtium recommends as a routine method for sample preparation of rock samples a totally automated sample preparation.

Through the use of a totally automated sample preparation system several benefits are attained. The consistency (accuracy/ repeatability) of the process is something that can never be attained in manual sample preparation where a number a different people are carrying out the work. Even though the procedures are well documented and regulated the individuals do not carry out tasks exactly the same way and human errors are still possible. The most critical thing in the whole process, maintaining the sample representativity during the reduction of particle and sample size is carried out by state-of–the-art rotary splitters. Contamination control is a profound issue in the QC of sample preparation. Also this can be carried out more precisely and consistently in automated systems. Loss of fines, segregation of materials by density, shape and size of the particles, cross contamination from previous sample etc can be minimized by sealed compartments and optimizing the system parameters of e.g. splitters, controlled dedusting, cleaning of the machine working surfaces. The Labtium concept utilizes a unique glass bead blasting in cleaning of the pucks and bowls. The quality of the cleaning procedure can also be monitored by human eye which is not possible in flow-through type pulverizers. Surely the increased capacity will affect the turn-around times and also cost-efficiency. However still the most important benefits are the improved working conditions - by sealing the equipment noise and exposure to mineral dust can be controlled and minimized. Laboratory staff is liberated from the physically hard repetitive work to more challenging and versatile work. The benefit of robotized sample preparation for the client is shorter turnaround time and better quality control in sample preparation.

The sample preparation line includes

- sample logging and recording the sample weight
- fine crushing of the rock sample to > 70 % < 2 mm particle size
- splitting with a rotary splitter to a nominal 0.7 kg or 1.2 kg subsample and a crushed reject (min 0.1 kg).
- bagging and bar code labelling with track record of the crushed reject (minimum of 0.1 kg).
- pulverising the split subsample by LM2 mills to > 90 % < 100 µm grain size using low- chrome bowls
- subsampling the sample to one or two vials with bar code labelling and Fire Assay sample if requested
- cleaning pulverising bowl and puck with efficient glass bead blasting after every sample
- adding the Fire Assay flux to the FA-subsample and mixing the sample

Maximum weight of the sample that can be prepared in the unit is 10 kg. However samples weighing > 4 kg are subject to additional charge. Minimum weight of the sample is 0.8 kg.
Additional vial subsample can be representatively split e.g. to be send to a second laboratory.

Robotic sample preparation	Sample preparation of drill cores, rock and chip samples. Crushing, splitting, pulverising of 0.7 kg and subsampling	0.8–10 kg	ROBO1
	Sample preparation of drill cores, rock and chip samples. Crushing, splitting, pulverising of 1.2 kg and subsampling	1.3–10 kg	ROBO2

SAMPLE PREPARATION

Soil and sediment samples

Manual sample preparation methods

For soil samples (e.g. till), we recommend drying at 70 °C (Method 10) and sieving to < 0.06 mm fraction (Method 24). If mercury or other volatile components are to be determined, lower drying temperatures must be used. High drying temperatures may also cause oxidation of some minerals. Other sieve fractions (< 0.125, < 0.25, < 0.5 mm) can be used upon client's request. When requesting sieving, please indicate the fraction to be analysed. If coarse sieve fractions are used for analysis, additional pulverizing is regularly required (Method 40).

For some purposes, the entire soil (or weathered bedrock) sample or a coarse sieved fraction of the sample can also be crushed and/or pulverised.

Preparation Method	Description	Maximum weight	Labtium method
Drying in permeable bags in forced air ovens	Drying at 70 °C	2000 g	10
	Drying at 40 °C	2000 g	11
Sieving with nylon sieves	Sieving to < 0.06 mm fraction	1000 g	24
	Sieving to other fraction (< 2 mm; 0.5 mm; 0.125 mm)	1000 g	27
Pulverising in ring mill	Pulverising the split sample in carbon steel bowl	150 g	40

Base metal analysis

To obtain the best quality and cost-efficiency in a particular geological project it is important to decide the strategy of analysis by selecting the appropriate analytical methods (element suit, digestion / pretreatment method, detection limits, optimum measurement area etc.) to fit the objectives of the project. Selecting a wrong method may end up in attaining optimised results in wrong concentration levels and introducing problems in laboratory (contamination, additional sample dilutions) which may deteriorate accuracy and precision. Typically the precision of geochemical methods is in the range of 5 - 10 % and for assays 1 – 5 %.

Methods

The specialists of Labtium will also assist you in selecting the optimised methods of analysis for your project.

For geochemical exploration for the base metals, we recommend aqua regia digestion of the sample and multi-element analysis by ICP-OES (Method 511P). The package can be upgraded by additional ICP-OES-elements or ICP-MS- analysis to include larger set of elements and lower detection limits (Method 511PM).

Although aqua regia is a powerful leaching agent, it still produces a partial dissolution for many elements. The dissolution of silicates and refractory minerals (e.g. baryte, chromite and other spinelles, zircon, cassiterite, tourmaline) varies depending on various factors. Most of the sulphide and oxide minerals (ore forming minerals) are, however, dissolved. The data will also give information on alteration and weathering of rock and till samples.

Near total concentrations of trace elements including rare earth elements in geochemical samples can be analysed using multi-acid total digestions and ICP-OES and ICP-MS –analysis (306PM or 307M).

Method 510P is an economic choice when only ore forming base metals are of importance. The method is suitable for mineralised samples with moderate grades. There are limitations in the solubility of Ag and Pb at high concentrations, and samples expected to contain more than 5 % of sulphur should be analysed for sulphur using an alternative method (e.g. by combustion technique, S-analyser, Method 810L).

Refractory ore minerals (e.g. chromite, magnetite, ilmenite, columbite, cassiterite etc.), high-grade base metal (e.g. Ni ores) and iron ores and concentrates can also be analysed using alkaline peroxide fusion and multi-element analysis by ICP-OES and ICP-MS (720P or 720PM) or XRF-analysis (179X). Total concentrations are obtained also for major elements.

When high quality assays of base metals (e.g. high grade base metal ores and concentrates) are required, more representative subsamples and traditional high-precision procedures either by ICP-OES (514P) as a multi-element package or by FAAS (514A) using single element methods can be used.

An additional assay is required for samples exceeding the range of the used analytical method.

SAMPLE ANALYSIS

Base metal analysis
Geochemical analyses (non-mineralised samples)

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppm)	Labtium method
Aqua Regia Digestion	ICP-OES	0.15 g	Ag	1–200	511P
			Al	20–200 000	
			As	10–10 000	
			B	5–100 00	31 elements
			Ba	1–10 000	
			Be	0.5–1 000	
			Ca	50–250 000	
			Cd	1–1 000	
			Co	1–10 000	
			Cr	1–10 000	
			Cu	1–10 000	
			Fe	50–300 000	
			K	200–100 000	
			La	1–10 000	
			Li	1–10 000	
			Mg	50–250 000	
			Mn	1–50 000	
			Mo	2– 10 000	
			Na	50–100 000	
			Ni	3–10 000	
			P	50–50 000	
			Pb	10–10 000	
			S	20–20 000	
			Sb	20–10 000	
			Sc	0.5–10 000	
			Sr	0.5–10 000	
			Ti	1–100 000	
			V	1–10 000	
			Y	0.5–1000	
			Zn	1–10 000	
			Zr	1–1000	
Additional elements by ICP-OES that can be included in the 511P package			Bi	10–10 000	511P Xx
			Hg	2–10 000	
			Rb	2–10 000	
			Se	40–10 000	
			Sn	10–10 000	
			Te	20–1 000	
			Th	10–10 000	
			U	20–10 000	
			W	5–10 000	
511P package can be upgraded by ICP-MS analyses to include either individual elements or whole package 511M	ICP-MS		Ag	0.01–200	511M Xx or 511PM Combined 40 elements
			Be	0.05–1000	
			Bi	0.01–10 000	
			Ce	0.02–1000	
			In	0.02–1000	
			Mo	0.01–1 000	
			Sb	0.03–1000	
			Se	0.05–10 000	
			Te	0.006–1 000	
			Th	0.05–10 000	
			U	0.05–10 000	
			W	0.05–10000	
			Yb	0.02–1000	

Xx
add the requested element´s symbol

SAMPLE ANALYSIS

Base metal analysis

Geochemical analyses (non-mineralised samples)

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppm)	Labtium method
HF-$HClO_4$-HCl-HNO_3-digestion	ICP-OES	0.2 g	Ag	5–200	306P 31 elements
			Al	100–200 000	
			As	20–10 000	
			B	10–100 00	
			Ba	20–10 000	
			Be	1–1 000	
			Ca	100–250 000	
			Cd	2–1 000	
			Co	5–10 000	
			Cr	20–10 000	
			Cu	10–10 000	
			Fe	50–300 000	
			K	200–100 000	
			La	5–10 000	
			Li	20–10 000	
			Mg	50–250 000	
			Mn	10–50 000	
			Mo	10–10 000	
			Na	300–100 000	
			Ni	10–10 000	
			P	150–50 000	
			Pb	20–10 000	
			S	50–20 000	
			Sb	20–10 000	
			Sc	1–10 000	
			Sr	10–10 000	
			Ti	100–100 000	
			V	10–10 000	
			Y	1–1000	
			Zn	50–10 000	
			Zr	5–1000	

Off range samples are analysed with method 175X or 720P for base metals and major elements, method 810L for S and method 704G for Ag.

SAMPLE ANALYSIS

Base metal analysis
Geochemical analyses (non-mineralised samples)

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
$HF-HClO_4-HCl-HNO_3$-digestion	ICP-OES ICP-MS	0.2 g	Ag Al As B Ba Be Bi Ca Cd Co Cr Cs Cu Fe Ge Hf K La Li Mg Mn Mo Na Nb Ni P Pb Rb S Sb Sc Sn Sr Ta Th Ti U V W Y Zn Zr	0.2 100 2 10 20 1 5 100 0.5 5 20 1 5 50 1 0.5 200 0.5 20 50 10 2 300 1 10 150 10 2 50 0.2 1 10 10 0.5 0.1 100 0.1 10 2 0.2 50 5	306PM 42 elements
			Ce Dy Er Eu Gd Ho La Lu Nd Pr Sc Sm Tb Tm Yb Y	0.5 0.05 0.05 0.05 0.05 0.01 0.5 0.05 0.3 0.1 1 0.05 0.01 0.05 0.05 0.2	306M2 16 elements REE
Combined	ICP-OES ICP-MS				306PM2 55 elements

Base metal analysis

Geochemical analyses (non-mineralised samples)

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
HF-$HClO_4$-digestion	ICP-MS	0.2 g	As	2	307M1 20 elements
			Ba	20	
			Be	1	
			Bi	2	
			Cd	0.5	
			Co	5	
			Cr	15	
			Cu	5	
			Li	10	
			Mo	2	
			Ni	5	
			Pb	10	
			Rb	1	
			Sb	0.2	
			Sn	2	
			Sr	2	
			Ti	50	
			Tl	0.5	
			V	5	
			Zn	50	
			Ce	0.5	307M2 18 elements
			Dy	0.05	
			Er	0.05	
			Eu	0.02	
			Gd	0.05	
			Ho	0.01	
			La	0.3	
			Lu	0.01	
			Nd	0.3	
			Pr	0.05	
			Sc	1.0	
			Sm	0.05	
			Tb	0.01	
			Th	0.1	
			Tm	0.01	
			U	0.05	
			Y	0.2	
			Yb	0.05	
Combined	ICP-MS				307M 38 elements

SAMPLE ANALYSIS

Base metal analysis

Ore grade analyses

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppm)	Labtium method
Aqua Regia Digestion	ICP-OES	0.15 g	Ag As Cd Co Cr Cu Fe Mn Mo Ni Pb S Sb Zn	1–200 10–1.0 % 1–1 000 1–5.0 % 1–2.0 % 1–10.0 % 50–30.0 % 1–5.0 % 2–5.0 % 3–10.0 % 10–2.0 % 20–5.0 % 20–1.0 % 1–1.0 %	510P 14 elements

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (%)	Labtium method
Aqua Regia Digestion	FAAS	1.0 g	Ag As Cd Co Cu Ni Pb Zn	1–200 ppm 0.05–10.0 1–100 ppm 0.01–5.0 0.01–30.0 0.01–30.0 0.01–2.0 0.01–5.0	514A Xx
	ICP-OES	1.0 g	Ag As Cd Co Cu Ni Pb S Zn	1–200 ppm 0.05–10.0 1–100 ppm 0.01–10.0 0.01– 30.0 0.01–30.0 0.01– 2.0 0.01–5.0 0.01–5.0	514P 9 elements

Xx
add the requested element´s symbol

Off range samples are analysed with method 720P for base metals, method 810L for S and method 704G for Ag.

Analyses of processed samples (concentrates and other metallurgical products etc.) on request.
Check also chemical phase analysis of base metals (additional assays).

SAMPLE ANALYSIS

Base metal analysis

Ore grade analyses

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (%)	Labtium method
Sodium peroxide fusion	ICP-OES	0.2 g	Al	0.01–50.0	720P 27 elements
			As	0.01–50.0	
			Ba	0.002–1.0	
			Be	0.001–1.0	
			Ca	0.01–50.0	
			Co	0.001–30.0	
			Cr	0.003–30.0	
			Cu	0.002–30.0	
			Fe	0.01–70.0	
			K	0.05–30.0	
			La	0.002–1.0	
			Li	0.001–5.0	
			Mg	0.02–50.0	
			Mn	0.001–10.0	
			Mo	0.005–10.0	
			Ni	0.005–30.0	
			P	0.05–25.0	
			Pb	0.01–30.0	
			S	0.02–50.0	
			Sb	0.01–10.0	
			Sc	0.002–1.0	
			Si	0.05–35.0	
			Sr	0.003–1.0	
			Ti	0.01–30.0	
			V	0.005–5.0	
			Y	0.001–1.0	
			Zn	0.005–35.0	

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
Sodium peroxide fusion	ICP-MS	0.2 g	B	100	720M
			Be	1	
			Bi	10	
			Co	5	
			Ge	10	
			Rb	5	
			Sb	0.5	
			Se	10	
			Ta	0.5	
			Te	5	
			Th	0.5	
			U	1	
			W	5	
			Ce	0.5	
			Dy	0.1	
			Er	0.1	
			Eu	0.1	
			Gd	0.1	
			Ho	0.1	
			La	0.5	
			Lu	0.1	
			Nd	0.3	
			Pr	0.1	
			Sc	20	
			Sm	0.1	
			Tb	0.1	
			Tm	0.1	
			Yb	0.1	
			Y	0.5	
Combined	ICP-OES ICP-MS				720PM 52 elements

SAMPLE ANALYSIS

Base metals analysis

Oxide ore package for Iron and Uranium ores

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
Pressed powder pellets	XRF	7.0 g	Al	100	179X
			Ba	20	
			Ca	30	31 elements
			Cd	30	
			Ce	30	
			Cl	60	
			Cr	30	
			Cu	20	
			F	2000	
			Fe	100	
			K	30	
			La	30	
			Mg	200	
			Mn	30	
			Na	500	
			Nb	7	
			Ni	20	
			P	60	
			Pb	30	
			Rb	10	
			S	60	
			Si	100	
			Sr	10	
			Ta	30	
			Th	10	
			Ti	30	
			U	10	
			V	30	
			Y	7	
			Zn	20	
			Zr	10	

Precious metal analysis

To obtain the best quality and cost-efficiency in a particular geological project it is important to decide the strategy of analysis by selecting the appropriate analytical methods (element suit, digestion / pretreatment method, detection limits, optimum measurement area etc.) to fit the objectives of the project. Selecting a wrong method may end up in attaining optimised results in wrong concentration levels and introducing problems in laboratory (contamination, additional sample dilutions) which may deteriorate accuracy and precision. For geochemical method the precision is lower than for assay methods.Typically the precision of geochemical methods is in the range of 5 - 10 % and for assays 1 – 5 %.

Methods

In gold and PGE-exploration, both the careful selection of sample preparation method and the choice of analytical method (including the weight of analytical sample) are critical. Figure 2 shows the effect of the grain size of nugget gold on sample weight for obtaining acceptable precision in gold analysis. We recommend carrying out a pilot study with selected, typical samples of the specified mineralization at an early stage of a large resource evaluation program. The mode of occurrence of gold can be studied using the so-called diagnostic leach and screen fire assay. Replicate analyses of samples can be carried out to study which of the available analytical techniques (and subsample weight) will give acceptable precision (e.g. < 5 %) for reliable resource evaluation. Based on this data, a scheme of sample preparation and analysis can be selected for optimum accuracy and precision. A tailored QA/QC-protocol for the project can be planned. The study will also provide information to be used as baseline data for more thorough metallurgical tests.

Sample weight	Diameter of gold sphere (mm)
0.1 g	0.012
1 g	0.025
5 g	0.045
20 g	0.06
50 g	0.10
100 g	0.125
500 g	0.22
5000 g	0.5

Figure 2. Minimum subsample weight required to contain the expected 20 particles of gold as a function of gold particle size at 4 ppm Au grade (Figure 3 in: Clifton et al. 1969, Sample Size and Meaningful Gold Analysis, U.S.Geol. Surv. Prof Pap. 625-C,17pp.).

Different pretreatment and preconcentration /separation methods are available (aqua regia digestion, fire assay, cyanide leach) combined with different methods of determination (FAAS; GFAAS; ICP-MS; ICP-OES; gravimetric), each method having its benefits and limitations. Our specialists will assist in the selection of a suitable analytical method.

In the geochemical exploration for the precious metals (Au, Pd and Pt), we recommend aqua regia leach, followed by pre-concentration by Hg co-precipitation and analysis with GFAAS (Methods 520U and 521U; 5 g subsample). Sub-ppb detection limits can be attained for Au and Pd giving meaningful anomaly contrasts. Alternatively a larger sample weight of 20 g can be used (Method 522U). The methods are applicable to non-mineralised samples (till, weathered bedrock, stream sediments, humus, rock).

The use of pathfinder elements in geochemical prospecting – particularly for gold is known to give more information of element dispersion in secondary environments and assist in the classification of the type of mineralization. This set can be complemented by Methods 511P or 511PM. Another option is a multi-element package using ICP-OES and ICP-MS analysis (515PM). This package will give totally 39 elements including Au with ultra-trace level detection limits.

Note that these methods are not suitable for mineralised samples.

SAMPLE ANALYSIS

Method 521U or 522U is recommended for low level Au-analyses.

The Method 522U, using a 20 g subsample, is best suited for prospecting or for preliminary ore assay. In some cases, depending on the mineralogy of the sample, the aqua regia leach may give slightly lower recoveries for Au as compared with fire assay. Information on high graphite content, which interferes in the aqua regia leach procedure, should be conveyed to the laboratory. Also dissolution of some PGE-minerals is not complete to aqua regia.

Ore grade assays of gold and the platinum metals are performed by a high-precision classical Pb-fire assay method using either 25 g or 50 g subsamples (704/705), combined with alternative finishes (FAAS, ICP-OES, gravimetric). If only Au (or Pd/Pt) is to be analysed, we recommend the Method 704A (or 705A) where Au is determined by FAAS. If, however, Au, Pd and Pt are to be analysed we recommend the Method 704P (or 705P). Special precautions need to be taken if samples contain appreciable amounts of graphite, S, As, Te, Se, Ni, Cu. For sample with high concentrations of these metals smaller subsample weight may have to be used deviating from the original request.

Gravimetric determination after the fire assay (704G) gives the best precision and accuracy for high-grade (10 –1000 ppm) gold samples. For concentrates use the methods 740G -743G.

When all six of the PGE's are to be analysed, the method of choice is the NiS fire assay (714M). Our method includes Te co-precipitation for better Au recovery. Detection limits at the ppb range are obtained by our ICP-MS determination. Osmium is an optional element in this method and should be specified in the request for analysis. The routine method sample weight is 15 g, but alternative sample weights can be used.

As a routine method for cyanide soluble gold we recommend Labtium method 236A which involves the use of PAL1000 –machine. The method enables the simultaneous pulverizing and cyanide leach of crushed rock samples, percussion samples or soil samples. A 0,500 kg subsample can be used. The leaching is very effective due to aggressive leaching conditions which promote the liberation and breaking of gold nuggets. Graphite, organic matter (humus) and sulphides interfere in the cyanide leach, lowering the recovery of gold.

The concentration of cyanide soluble free gold may also be analysed the traditional 3 hour tumbling with the LeachWELL accelerator (235A). A large, representative subsample (0.5 kg) can be used. Pulverising of total sample (sample preparation Method 50) must be done before leaching.

The cyanidation methods are the best possible routine method in the case of coarse-grained gold for grade control and resource evaluation samples (e.g. RC-samples, chip samples). The results attained by this partial extraction are comparable to technical CIP- and CIL- extraction techniques and are of benefit in the metallurgical testing of the mineralisation. The method is not suitable when the total content of gold is needed.

Additional methods for gold analysis include screen fire assays for coarse grained gold, diagnostic leaches to evaluate mode of occurrence of gold in different mineralogical phases and analysis of the "total gold", which includes cyanide leach and analysis of the tailing (and head, if requested) sample by fire assay.

The most suitable analysis method for silver is by acid digestion with aqua regia and finish with FAAS (511A/514A) or ICP-OES (510P/514P; see base metals). However, there are potential limitations in the solubility of Ag in high concentrations (Ag > 100 ppm). Fire Assay and gravimetric finish (704G) with a more representative sample and better precision can be used for ore grade samples (Ag > 50 ppm). In addition to gold metallic silver and copper can be analysed with cyanidation methods 235A and 236A.

SAMPLE ANALYSIS

Precious metal analysis

Geochemical analyses (non-mineralised samples)

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppm)	Labtium method
Aqua Regia Leach Hg-coprecipitation	GFAAS	5 g	Au	0.001–10.0	520U Xx
			Bi	0.002–10.0	
			Sb	0.005–10.0	
			Se	0.005–10.0	
			Te	0.002–10.0	
		5 g	Au	0.001–10.0	521U Xx
			Pd	0.001–10.0	
			Te	0.002–10.0	
Aqua Regia digestion	ICP-OES and ICP-MS	5 g	Ag	0.01–100	515PM 39 elements
			Al	15–200 000	
			As	0.05–5 000	
			Au	1–1 000 ppb	
			B	5–5 000	
			Ba	1–5 000	
			Be	0,2–5000	
			Bi	0.005–500	
			Ca	50–100 000	
			Cd	0.01–500	
			Co	0.1–5 000	
			Cr	1–5 000	
			Cu	1–5 000	
			Fe	50–100 000	
			K	100–100 000	
			La	1–5 000	
			Li	1–5 000	
			Mg	10–300 000	
			Mn	1–100 000	
			Mo	0.01–5 000	
			Na	50–10000	
			Ni	1–5 000	
			P	50–5 000	
			Pb	0.01–5 000	
			Pd	1–1 000 ppb	
			S	20–50 000	
			Sb	0.01–2 000	
			Sc	0.5–1 000	
			Se	0.01–500	
			Sr	0.5–5 000	
			Te	0.002–500	
			Ti	1–5 000	
			Th	0,01–2 000	
			Tl	0.02–2 000	
			U	0.01–1 000	
			V	1–5 000	
			W	0.05–1 000	
			Y	0.5–1 000	
			Zn	1–5 000	
			Zr	1 - 1 000	

Xx
add the requested element´s symbol

Off range samples are analysed with method 720P or 175X for base metals, method 810L for S and method 704P for Au, Pd.

SAMPLE ANALYSIS

Precious metal analysis

Precious metal assay

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppm)	Labtium method
Aqua Regia Leach Hg-coprecipitation (Preroasting Included)	GFAAS	20 g	Au Pd Pt Te	0.01–5.0 0.01–5.0 0.02–5.0 0.01–5.0	522U Xx
Pb-Fire Assay	FAAS	25 g	Au Pd Pt	0.05–100 0.05–100 0.1–100	704A Xx
		50 g	Au Pd Pt	0.02–100 0.02–100 0.05–100	705A Xx
	ICP-OES	25 g	Au Pd Pt	0.01–100 0.01–100 0.01–100	704P Au or AuPdPt
		50 g	Au Pd Pt	0.005–100 0.005–100 0.005–100	705P Au or AuPdPt
NiS-Fire Assay Te-coprecipitation	ICP-MS	15 g	Au Pd Pt Rh Ir Ru (Os	1–10 000 ppb 1–10 000 ppb 1–10 000 ppb 0.5–10 000 ppb 1–10 000 ppb 0.5–10 000 ppb 1–10 000 ppb)	714M Additional
PAL1000-analysis. Pulverizing and Cyanide leach using LeachWELL™	FAAS	0.5 kg	Au Ag Cu	0.1–1 000 0.1–1 000 1–100 000	236A Xx

Xx
add the requested element´s symbol

For the analyses of high grade Au- and Ag-ores or off range assays Labtium recommends Fire Assay with gravimetric finish. High grade gravimetric Fire Assay of Ag can be combined with FAAS/ICP-OES determination of Au.

Analyses of Ag see also Base Metals (methods 510/514P).

Pb-Fire Assay	Gravimetric	25 g	Au or Ag	2–10 000 5–10 000	704G Xx
Pb-Fire Assay	Gravimetric and FAAS/ICP-OES	25 g	Ag and Au	2–10 000 0.01–100	704G 704A/P

Xx
add the requested element´s symbol

Precious metal analysis

Special analyses for gold in metallurgical samples

Concentrates (e.g flotation concentrates) Pb-Fire Assay (sample weight varies 5 - 30 g) with gravimetric finish. Includes sample preparation and representative subsampling using precision rotary splitter. Concentration range 100 – 10 000 ppm Au .	740G
Assay of Au, Pd and Pt by ICP-OES	740P
High grade concentrates (e.g. gravity concentrates) Pb-Fire Assay (sample weight varies 5 - 30 g) with gravimetric finish. Includes sample preparation and representative subsampling using precision rotary splitter. Concentration range 0.1 – 50 % Au	741G
Gold in carbon Ashing, digestion with aqua regia, analysis by ICP-OES (Au, Ag,)	518P1
ICP-OES (Au, Ag, As, Cd, Co, Cu, Ni, Pb, Zn)	518P
Gold in carbon Fire assay analysis by gravimetry (ASTM E1568)	740G
Commercial assay	743G
Bullion assay	742G
Screen Fire Assay for coarse gold Sieving of a 0.5 kg subsample with a 125 µm (120 mesh) sieve. Weighing each fraction. Fire assay (Method 705A/P) of the entire + 125 µm fraction. Duplicate Fire assay (Method 705A/P) of - 125 µm fraction. Calculation of weighted concentrations of gold (total and fractions).	709P
Free and refractory gold Cyanide leach of a 0.5 kg subsample (Method 236A). Washing, neutralising and homogenising the tailing. Duplicate Fire Assay (Method 705A) of the tailing.	239A
Gold in cyanide liquor by extraction and FAAS	237A

Additional analyses

When the ore forming mineral is exceptional or when total concentrations for geochemical or petrological studies (trace levels of elements) are required, please contact the laboratory for assistance in selecting the best possible digestion/ pre-treatment method for your purpose (e.g. total digestion Method 306 P/M, XRF Method 175X; see Whole Rock Analysis;).

The XRF technique is also a versatile tool in the analysis of the base metals (Method 175X). For more information on the XRF technique see the section on Petrological Analyses.

In addition to classical geochemical methods, a selection of selective leaches (using water extraction, ammonium acetate, pyrophosphate etc.) combined with ICP-MS-analysis is also available for geochemical exploration of buried ore deposits. The set of elements is comparable to method 511PM or 515PM.

Elements in specific mineral phases of the sample can also be determined, such as Ni in the sulphide phase or elements in the carbonate phase of the sample.

Special methods are available e.g. for the determination of mercury, total sulphur and carbon or sulphur and carbon mineral phases.

Volatiles

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit	Labtium method
Combustion technique	Hg -Analyzer	0.1 g	Hg	0.005 ppm	822L
Ignition	Gravimetric	1 g	Loss on ignition at 1000 °C	0.01 %	813G
Combustion technique	S/C-Analyzer	0.2 g	S C	0.01 % 0.01 %	810L 811L

Determination of carbonate carbon and non-carbonate carbon

Combustion technique Treatment with HCl	C-Analyzer	0.5–1.0 g	C-tot. C-carb. C-noncarb.	100 ppm 100 ppm 100 ppm	811L 816L

Chemical phase analysis of base metals

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppm)	Labtium method
Ni, Cu and Co in sulphide minerals					
Ammonium Citrate-H_2O_2-leach	ICP-OES	0.15 g	Cu Ni Co	10–10 000 10–10 000 10–10 000	240P
Bromine-Methanol-leach	FAAS	0,5 g	Cu Ni Co	5–100 000 5–100 000 5–100 000	250A
Ni, Cu in oxide minerals					
Sulphuric acid – Sodium sulphite -leach	ICP-OES	0.2 g	Cu Ni	10–10 000 10–10 000	531P

Individual and sequential leaches can be tailored for the chemical phase analysis of base metals.

Other parameters

Specific gravity	Gas pycnometer	SG	0.01g/cm^3	830G
Saturation magnetization	Satmagan	Fe_3O_4	0.01%	891G

Petrological analyses

Whole rock analyses are carried out using high precision methods applying state-of–the-art instrumentation (XRF, ICP-OES, ICP-MS).

Major, minor and many trace elements are determined by XRF. Determinations are made on pressed powder pellets (Method 175X). The use of fundamental parameters program enables analysis of major and trace elements from pressed powder pellets.

The XRF analysis can be supplemented by determination of the rare earth elements and other trace elements by ICP-MS and/or ICP-OES after the total digestion of the sample (Method 307PM). PGE at low concentration levels (Method 714M) can be included for petrological studies. Carbon (Method 811L) and loss on ignition (Method 813G) are recommended for complete whole rock analysis. Individual determinations, which are often required in whole rock analysis, such as iron (II), fluoride, H_2O+ and H_2O-, are also available.

The XRF method is applicable to rocks and soil samples, such as sand, gravel, till and sediments. Technical products and ash of similar composition can also be analysed. The prerequisite for applicability of the XRF method is that the chemical composition of the sample remains unchanged during the fine grinding (< 10 mm) as the pressed powder pellet is prepared. Samples containing > 20 % S cannot be analysed by this method.

Whole rock analysis

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
Pressed powder pellets Determination of carbon is recommended (Method 811L).	XRF	7.0 g	Al	100	175X
			As	20	
			Ba	30	
			Bi	30	
			Ca	30	
			Ce	30	
			Cl	60	
			Cr	20	
			Cu	20	
			Fe	100	
			Ga	30	
			K	30	
			La	30	
			Mg	200	
			Mn	60	
			Mo	10	
			Na	500	
			Nb	10	
			Ni	20	
			P	60	
			Pb	30	
			Rb	30	
			S	60	
			Sb	100	
			Sc	30	
			Si	100	
			Sn	30	
			Sr	10	
			Th	10	
			Ti	30	
			U	10	
			V	30	
			Y	10	
			Zn	20	
			Zr	10	
Additional			Cd	30	
			F	2000	
			Ta	30	

Precious metals

Decomposition pretreatment method	Determination	Sample weight	Elements	Range (ppb)	Labtium method
NiS-Fire Assay Te-coprecipitation	ICP-MS	15 g	Au	1–10 000	714M
			Pd	1–10 000	
			Pt	1–10 000	
			Rh	0.5–10 000	
			Ir	1–10 000	
			Ru	0.5–10 000	
			(Os	1–10 000)	Additional

PETROLOGICAL ANALYSES

Rare earth elements

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
$HF-HClO_4$-digestion Lithium metaborate- Sodium perborate fusion	ICP-MS	0.2 g	Ce Dy Er Eu Gd Ho La Lu Nd Pr Sc Sm Tb Th Tm U Y Yb	0.5 0.05 0.02 0.02 0.05 0.01 2 0.01 0.1 0.05 1.0 0.05 0.01 0.1 0.01 0.05 0.2 0.05	308M
	Additional elements:				
			Co Hf Nb Rb Ta V Zr	5 0.5 0.1 0.5 0.05 5 20	308M
	For other elements contact laboratory				

Individual determinations

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (%)	Labtium method
Ignition	Gravimetric	1 g	LOI Loss on ignition 1000 °C	0.01	813G
Acid digestion $HF - H_2SO_4$	Titrimetric	0.5 g	Fe^{2+}	0.02	301T
NaOH-fusion	Potentiometric	0.1 g	F^-	0.01	725I

Industrial mineral analyses

Determination of hydrochloric acid soluble elements (Recommended method)

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
Hydrochloric acid digestion	ICP-OES	0.1 g	Al Ca Mg Fe Mn	200 600 150 150 2	407P

Determination of hydrochloric acid soluble elements and insoluble residue of the sample

Decomposition pretreatment method	Determination	Sample weight	Elements	Detection limit (ppm)	Labtium method
Hydrochloric acid digestion	ICP-OES	1.0 g	Al Ca Mg Fe Mn	200 400 100 100 1	406P
	Gravimetric	1.0 g	Insoluble residue	0.3 %	406G

CHARACTERISATION OF WASTE

Characterisation of waste

Leaching tests

Compliance test for leaching of granular waste materials and sludges	EN 12457-1 EN 12457-2 EN 12457-3 EN 12457-4
Leaching behaviour test. Up-flow percolation test	CEN/TS 14405
pH and EC	EN 12506
Element analyses by ICP-OES and ICP-MS	EN 12506
Hg	EN 17852
Anions	EN 12506 EN 13370
Total dissolved solids (TDS)	EN 15216
Dissolved organic carbon (DOC)	EN 13370

Acid Generation Potential Evaluation

Acid–Base Accounting (ABA). Static test for sulfidic waste. Neutralisation Potential, NP Acid Potential, AP Neutralisation Potential Ratio, NPR Net Neutralisation Potential, NNP	Draft: CEN/TC WI292053
Net Acid Generation (NAG) Single NAG Sequential NAG	AMIRA ARD Test Handbook Australia
pH	EN 12506
Total Sulfur (pyrolysis)	ISO 15178
Total Carbon (pyrolysis)	CEN15104
Carbonate Carbon	EN 13137 (Mod.)

Sample management and storage

Systematic and well-organised sample archiving is not always thought to be included in the quality management of an exploration project. Good archiving helps the future retrieval of samples for e.g. feasibility testing and replicate or umpire analysis. During future audits of the project, well organised archiving is one of the fundamental issues. At Labtium special attention is paid on labelling and storing of all materials. The laboratory samples are placed in plastic ampoules and stored in impact resistant styrofoam cases. Pulps and /or rejects are stored in sealed plastic bags in pallets. All the packing materials except for pallets are included in the prices.

Sample batch reception (901) includes checking the sample numbering, sorting etc. and packing materials.

The cost for long term storage of drill cores, rejects and pulps (906) and laboratory samples in vials (907) can be negotiated.

For all samples a laboratory waste management fee is invoiced to cover the expense of hazardous waste disposal (903). If the client does not want the rejects and pulps to be returned a waste management levy is invoiced (902).

If sample batches are arriving in the laboratory highly disorganised the laboratory is forced to invoice also the reorganising of the field samples (904). Also if the sample bags or containers are damaged, the replacement of the samples to new containers has to be invoiced (905).

Reception fee for a batch of samples	901
Waste disposal fee for reject sample materials	902
Disposal fee of laboratory waste	903
Organising received disorganised samples	904
Removing samples from damaged/unsuitable containers to new containers/bags	905
Storage of pulps/rejects after 1 months from reporting	906
Storage of laboratory samples after 1 months from reporting	907
Disposal of cyanide waste	915

ABBREVIATIONS

Abbreviations

Analytical technique	Description	Labtium code
GFAAS	Atomic Absorption Spectrometry, electrothermal atomisation	U
FAAS	Atomic Absorption Spectrometry, flame atomisation	A
AFS	Atomic Fluorescence Spectrometry	F
XRF	Wavelength Dispersive X-ray Fluorescence Spectrometry	X
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry	P
ICP-MS	Inductively Coupled Plasma Mass Spectrometry	M
S/C-ANALYZER	Combustion, IR-detection, Sulphur or Carbon analyser	L
Weighing	Gravimetric	G

Units
ng = 10^{-9} g
µg = 10^{-6} g
mg = 10^{-3} g
ppb = ng/g = µg/kg = mg/t
ppm = µg/g = mg/kg = g/t

LABTIUM

FINAS
Finnish Accreditation Service
T025 (EN ISO/IEC 17025)

ilac-MRA

Accreditation

Labtium Ltd. is an accreditaded testing laboratory. The accreditation according to ISO/IEC 17025 was received originally in 1994 from the Finnish Accreditation Service FINAS at the MIKES (The Centre for Metrology and Accreditation). The accreditation code of Labtium is FINAS T025.
The up-to-date scope of the accreditation can be found in www.mikes.fi/scope/T025/fi and then FINAS service.

The FINAS accredited bodies may state in their reports and certificates that they are accredited by FINAS, which is a signatory of the EA (European co-operation for Accreditation), ILAC (International Laboratory Accreditation Cooperation http://www.ilac.org/) or IAF (International Accreditation Forum Inc.; http://www.iaf.nu/) recognition agreement. Thus a global acceptance and recognition of the accreditation and quality system of Labtium Ltd is achieved.

Labtium Ltd is continuously participating in independent, international proficiency tests in the mineral sector run by e.g. Geostats Pty Ltd, Australia and the GeoPT sponsored by the International Association of Geoanalysts (IAG). In addition Labtium participates in a proficiency test for Canadian accredited mineral testing laboratories (CANMET PTP-MAL). These tests are used to evaluate the performance and validity of our methods in comparison to other international mineral testing laboratories. The reports are available to clients on request.

Hanna Kahelin

Quality Manager

Labtium Oy / Tekniikantie 2, FIN- 02150 Espoo FINLAND/ Tel: +358 10 653 8000

LABTIUM

Labtium Oy/Ab/Ltd.

Business ID 2128301-1
tel. +358 10 65 38000

www.labtium.fi
E-mail: firstname.lastname@labtium.fi

Contacts:

Heikki Niskavaara
Business Area director.
Exploration and Mining.
+358 40 080 7935

Espoo

Kaarina Fagerholm, Laboratory manager
+358 40 829 4548

Tekniikantie 2
PL 57
02151 ESPOO

Jyväskylä

Markku Herranen, Business Area Director
+358 10 617 1110

Koivurannantie 1

40400 JYVÄSKYLÄ

Kuopio

Susanna Arvilommi, Laboratory manager
+ 358 50 572 2265

Neulaniementie 5
PL 1500
70211 KUOPIO

Outokumpu

Pekka Parvinen, Expert
+358 50 547 0477

Tutkijankatu 1
PL 45
83501 OUTOKUMPU

Rovaniemi

Juha Virtasalo, Laboratory manager
+358 40 573 2558

Raidetie 1
96900 SAARENKYLÄ
PL 8601
96101 ROVANIEMI

Sodankylä

Toni Malila, Expert
+358 50 564 5605

Poikajuntintie 34
PL 97
99601 SODANKYLÄ