Minerals Testing and Research Center (MTRC)

Mission Zero Towards zero emissions by 2030

FLS

FLS mineral testing services

We offer testing services for mineralogical characterisation, metallurgical testing, equipment selection, flowsheet design, plant troubleshooting, and research in our Salt Lake City Minerals Testing and Research Center.

The FLS Minerals Testing and Research Center delivers the quality data you need, forming the cornerstone of proper plant design and optimisation projects. To ensure quality service, all characterisation and testing of mineral processing programs are done through our laboratory facility. As a partner in your success, our services extent to complete in-plant consultations, plant surveys, and grade and recovery optimisation.

State-of-the-art facility

Within our fully equipped centre, we house equipment and instrumentation that provides rapid turnaround, quality results and accurate data. As a comprehensive testing centre, we have the capability to bench-test and characterise complete flowsheets in most mineral processes. We constantly improve equipment, instrumentation and testing practices, in order to exceed industry standards and guarantee that we maintain the integrity of your samples without contamination, loss or delay.

Expertise

Our experienced technical staff includes some of the most recognised names in mineralogy and mineral processing. We back them with unprecedented depth and breadth of knowledge from our worldwide presence, making us the preferred choice when you encounter unique process challenges within your operations. This experienced staff performs all testing and analyses, providing you with insight throughout the program.

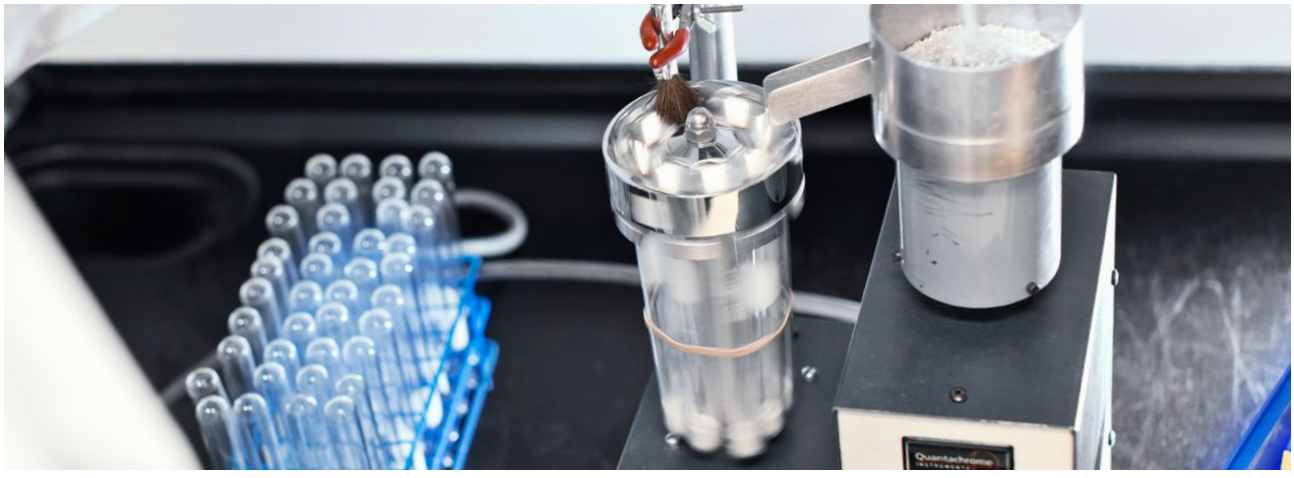
Safety and quality

Complete commitment to safety and quality is the foundation principle that confirms our personnel are safe, our equipment is used properly, and our data is sound. We take safety seriously, whether working in our laboratories or conducting tests in the field. Rigorous quality assurance programs provide the accuracy and precision in test results that you demand. We hold quality, environmental and safety ISO certifications.

This superior combination of facility, equipment, personnel and procedures means you can trust us for complete minerals testing and process development.

Functional areas

- Ore characterisation and process mineralogy
- Comminution
- Dawson Metallurgical Laboratories
- Hydrometallurgy
- Solid/liquid separations
- Analytical services
- Pilot operations



Minerals Characterisation Group

Ore characterisation and process mineralogy

Expand margins, increase returns, and reduce your risk

FLS's Ore Characterisation and Process Mineralogy (OCPM) Laboratory is your best single-source choice for mineralogical support services related to geo-metallurgy, leaching, concentrator optimisation, and characterisation of materials. We provide high-quality, cost-efficient and reliable mineralogy work, performed by a team that has decades of mining and production experience.

Lab capabilities

FLS's OCPM lab is one of the most advanced integrated mineralogy service labs in the industry. Our senior staff is well versed in mining processes, and can assist you and your operation with any mineralogical challenges – from the exploration site to the tailings pond. We offer:

- Quantitative FTNIR model building
- Optical microscopy
- SEM-EDS analysis
- XRD Rietveld
- Clay analysis
- QEMSCAN/TIMA mineralogy

Mineralogy for exploration and mine-site geology

Modern ore deposit development benefits from large amounts of quantitative mineralogy data related to ore control and processing. We continuously work with clients to optimise exploration, minesite geological models, and ore profiling (geometallurgy), and are committed to provide you with the best ore characterisation possible during early, advanced and feasibility phases. For existing operations, our services focus on assisting in best practices and understanding the variance that is inherent in ore bodies. A robust mineralogical analysis is the best risk-reduction method. We offer these services:

- Quantitative XRD and FTNIR
- Alteration mineralogy
- Quantitative clay mineralogy
- Geo-metallurgy – ore profiles
- Bulk mineralogy – core/cuttings/blast holes
- Leach-residue mineralogy
- Metals deportment

Automated mineral analysis QEMSCAN and TIMA

We employ some of the most advanced automated mineral analysis capabilities available in the mining industry. OCPM supervisory staff has mine-site process mineralogy experience for both daily concentrator and heap leach support, including:

- Bulk modal mineralogy
- Liberation/locking
- Metal deportment
- Mass balanced mineralogy from process streams
- Leach feed/residue mineralogy

Plant and process support

With changing, deeper and lower-grade ore bodies, plants must continuously optimise their circuits and/or troubleshoot unexpected metallurgical problems. That effort applies to both concentrator and leaching operations. We target our mineralogical work to optimise ore routing, better hardness control, and forecasting of problem minerals, such as reagent consumers and/or minerals impacting flotation. Surveys for heaps, grinding and flotation circuits are critical to improved processing.

The FLS OCPM Lab provides extensive production experience from mining operations and mineralogical plant survey projects. We provide extensive:

- Optimised ore blending/routing
- Ore hardness and throughput solutions
- Acid consumption forecasts
- Leach mineralogy
- Concentrator and heap surveys
- Plant de-bottlenecking, restarts and expansions

Analytical services

The FLS Analytical Laboratory provides quality geochemical analyses to support the Minerals Testing and Research Center facility. This service allows us to provide complete mineralogical characterisation and metallurgical testing programs. A combination of well-established methods, coupled with advanced analytical instrumentation, ensures timely, accurate and precise results.

Analytical instrumentation and capabilities include:

- Flame atomic absorption spectroscopy (AA)
- Inductively coupled plasma-optical emission spectroscopy (ICP-OES)
- Inductively coupled plasma-mass spectroscopy (ICP-MS)
- Helios/Eltra Speciation
- Fire assay
- Wet chemistry
- Cyanide Analyzer - Skalar
- DMA - Direct Mercury Analyzer
- Acid-Base automatic titrators
- Redox automatic titrators
- IC - Ionic Cromatograph

Precious metals

- Fire assay gold and silver by lead oxide collection
- Gravimetry or ICP OES/AAS
- Concentrates (5–20 g assays)
- Tails (1AT–50 g assay)
- Carbons
- Resins

Chemical prep

- 4-acid “near” total digestion
- 3-acid microwave digestion
- 3-Acid Hot block digestion at low temperature
- Concentrate digestions
- Silicon-specific digestion
- Potash-specific digestion
- Aqua regia digestion for volatile elements and selective leachables

Carbon and sulfur

- Total sulfur
- Total carbon
- Sulphides
- Sulfates
- Organic carbon

Selective leach test

- Water-soluble copper
- Acid-soluble copper (oxide copper)
- Ferric-soluble copper (Quick Leach Test)
- Cyanide-soluble copper
- Cyanide-soluble gold
- Cyanide-soluble gold with preg-rob

Other analyses

- Lithium Borate fusion followed by ICP OES for refractory minerals
- High Copper titration
- Loss on ignition (LOI)
- Percent moisture
- Specific gravity
- pH
- Acid insoluble
- Soil pH
- Potash brine analysis
- Chloride titration by ion-selective electrode

Comminution

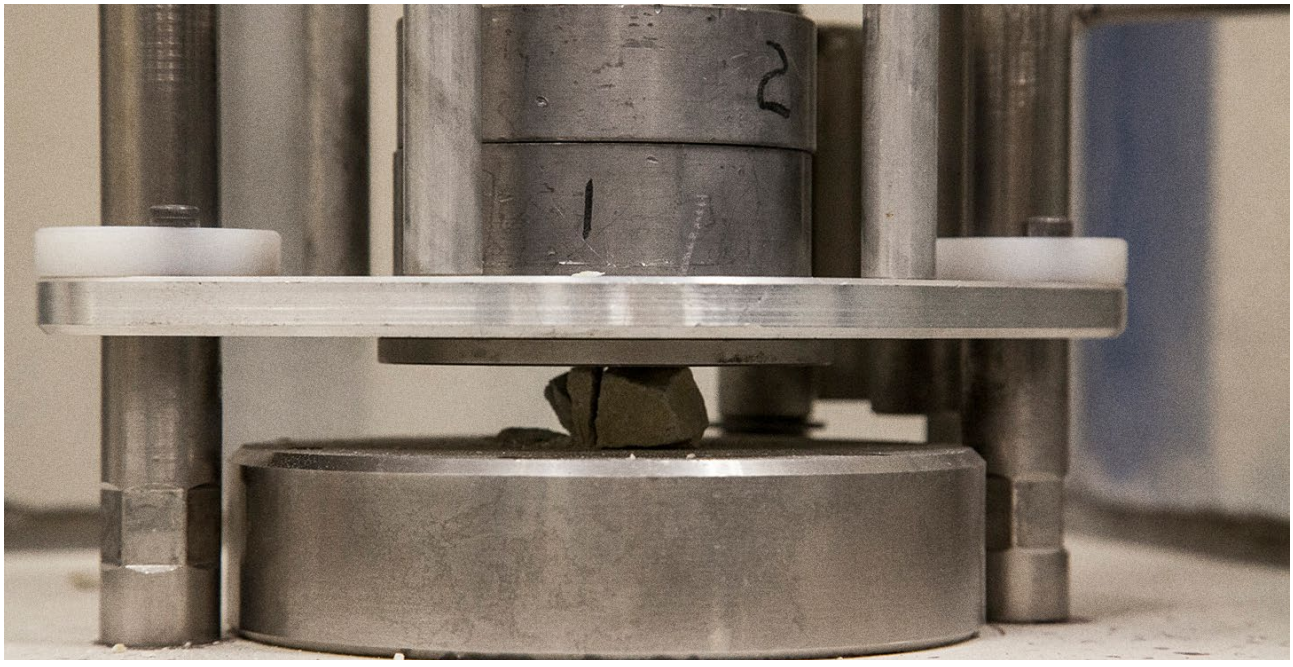
We know your crushing, grinding, blending and splitting equipment represents significant operational and capital costs. Accurate comminution testing reduces the design risk associated with ore and aggregate comminution circuits. That's why we offer a comprehensive range of comminution testing to determine the ideal plant parameters that will optimise your processing plant.

FLS's Comminution Lab offers all testing components for equipment sizing, and we thoroughly train our staff in testing procedures to ensure consistency and accuracy.

We provide:

- Bond Crusher Work Index
- Bond Abrasion Work Index
- Bond Ball/Rod Mill Indices
- J-K Drop Weight Test*
- SMC Test®*
- Starkey SAG Design Test*
- Starkey SAG Variability Test (SVT)*
- Unconfined Compressive Strength (UCS)
- Blaine Test
- Jet Erosion Test
- Atwal
- HPGR
- VRM
- Dynamic Air Classification
- FTM
- VXP

* Licensed to conduct this test work at our facility, data is interpreted and results reported by the parent company.



The FLS P150 High-Pressure Grinding Roll (HPGR) sizing machine is used for all initial HPGR lab-scale test work. The pilot-scale crusher is designed to process ore in the identical manner of an industrial unit, as it employs the exact same breaking mechanism. We have determined that the P150 HPGR is the minimum size applicable to provide accurate data for scale-up.

Vertical Stirred Mills

The FLS FTM and VXP10 offer fine/ultra-fine grinding capabilities. A pendulum grinding test in this mill determines the residence time and energy input to achieve a specific size reduction, based on progressive sizing reduction as the material passes through the mills. Test results can then be used to determine the operating parameters for full-scale production mills.

Dawson Metallurgical Laboratories

FLS's Dawson Metallurgical Laboratories provide metallurgical testing for ore amenability, process development, flowsheet layout and plant design. We analyse new and existing ore bodies and flowsheets to optimise grade and recovery, improving your productivity.

Flotation concentration

Process development tests generally apply test series to establish the primary grind size, reagents, residence time and cleaner (regrind) requirements to characterise ore response. Locked cycle tests recirculate water and intermediate products to simulate closed-circuit process operation. We have extensive experience with different mineral separation procedures, including sulphide ores, oxide or transition ores, and industrial minerals. Frequently, we use nonselective bulk sulphide flotation tests to recover precious metals associated with pyrite or other sulphides. We also can incorporated gravity pre-concentration and magnetic separation into any test program. Selective flotation tests can separate different mineral combinations, such as copper from pyrite or copper, from molybdenum.

Other mineral separations we conduct include: coppermolybdenum, copper-gold, molybdenum-talc, copperlead-zinc-pyrite, silver-lead-zinc-pyrite, silver from sulfosalts, enargite-pyrite, lead zinc-pyrrhotite, nickelpyrrhotite, cobalt-pyrrhotite, and iron ore processing.

The FLS Dawson Metallurgical Lab is a world leader in flotation testing and flowsheet design. We offer testing services in most chemical and physical processing applications, including:

- Flotation
- Gravity separation
- Magnetic separation
- Size classification

Pilot offerings

- 1.5m3 flotation cells
- WEMCO®
- Dorr-Oliver®
- nextSTEP™
- XCELL®
- RFC™
- CA™

Bench scale flotation tests can also target the recovery of industrial minerals such as cassiterite, potash, phosphates, talc, silica “frac” sands, silicates and barite; and energy minerals such as coal, resin-coal and tar sands.

Gravity concentration testing

When the specific gravity of the desirable minerals is sufficiently different than the gangue mineral, we recommend our customers consider gravity separation. Gravity separation equipment will reliably test the amenability of the ore to gravity concentration, and we offer a dedicated suite of gravity equipment and personnel with extensive experience for this purpose.

Flotation

- Batch (0.2 – 40 L cells)
- Locked cycle
- Sulphide, oxide and industrial minerals

Gravity concentration

- Knelson bowl
- Deister table
- Mozley table
- Gemini table
- REFLUX™ Classifier
- Duplex jig

Magnetic concentration

- Wet low-intensity
- Wet high-intensity
- Davis tube

Attrition scrubbing

Classification

- Wet/dry sieves (4” – 10µ)
- Malvern size analysis (to 0.02µ)
- Elutriation

Hydrometallurgical Testing

Our pressure and thermal oxidation units have been in use prior to 1995 and have been used for both Placer Dome Inc and Barrick Gold's ores in various parts of the world. FLS purchased the units in 2019.

In recent years they have been used to establish the design and operating parameters for Goldstrike and Pueblo Viejo's full-scale autoclaves, and they have been used to troubleshoot and verify results for feasibility studies.

Equipment highlights:

2L bench-top autoclaves (BTAC) supplied by Parr Instruments allows for individual samples to be pressure oxidized on batch scale.

Our pilot autoclaves unit is a 27L continuous feed system with on demand temperature control quench water, and flash let down. It also includes a heating unit for non-autogenous ores.

We have various leaching methodologies, for primarily gold but experience allows for client specified leaching. The benchtop roaster can be operated up to 1100C under different gas environments.

We provide:

- Pressure Oxidation (POX)
  Bench and Pilot Scale (27L)

Leaching

- Direct cyanidation Leaching
- Thiosulfate
- Carbon in Leach (Bottle or Agitated)
- Column (varying sizes)
- Acid digestion and other Speciality leaching upon client request or process requirement
- Bench scale testing Rapid Oxidative Leaching (ROL)
- Carbon Elution and Regeneration
- Hot Cure
- Lime Boil (to treat oxidation products)
- Cyanide Detox
- Benchtop Roaster
- Diagnostic Leaching (Parallel and Sequential)
- Bench scale and continuous stir reactor leach
- Solvent extraction
- Lithium-nickel bench scale processing

Hydrometallurgy

- Cyanidation (CIP, CIL, CIC)
- Pressure/oxidation leach
- Bottle rolls
- Mixed reactor
- Column leach
- Chemical oxidation
- Gold and copper diagnostic leach RFC™ and CA™

Solid/liquid separations

The FLS Separations Laboratory offers experienced engineers to assist you in the evaluation of new or existing processes, either to optimise your operation or to determine design criteria for new equipment selection. Services include contract testing, process engineering, bench testing, pilot testing, and research and development.

These separations experts perform testing both in the lab and in the field. We also can commission and optimise full-scale FLS equipment. FLS laboratories are backed by testing methodology refined through thousands of studies, combined with an encyclopaedic database that reflects more than five decades of solid/liquid separation experience. Your test results will offer material- and process-specific conditions, which will ultimately provide efficiency throughout your plant system, with improved effluent quality and a reduction in operating costs.

We offer solid/liquid separations testing, including:

- Full sample characterisation
- Particle density and size analysis
- Rheology
- Sedimentation
- Filtration

Pilot offerings

FLS's Pilot Operations Group offers a variety of pilot-scale equipment to support solid/liquid separation testing. We build pilot units as plug-and-play installations, and include the required major pieces of process equipment, control panels and ancillary equipment – all skid-mounted for easy transportation and installation. We offer thickening and filtration units in a variety of sizes, and include:

- Thickeners – high rate and deep cone design
- Granular media filters
- Vacuum filters – rotary drum and belt
- Pressure filters – manual and automated

Sedimentation

We use typical sedimentation bench-scale testing to simulate:

- Clarification
- Thickening
- Counter-current decantation
- MaxR® particle growth to enhance separations
- Hydroseparation

Rheology

- Measurements of thickened slurry flowability
- Essential to properly design thickener rake and drive torque
- Essential to size thickener underflow pump
- Necessary to determine thickener type (high-rate, high-density, paste, etc.)

Filtration

We employ typical filtration bench-scale testing to simulate:

- Pressure filtration
- Vacuum filtration
- Precoat filtration

FLS mineral testing laboratories

FLS's Minerals Testing and Research Center in Salt Lake City provides expansive facilities for bench and pilot-scale testing, including analytical laboratory support services.

Plant surveys

We employ world-renowned experts in metallurgy, who provide inventive solutions through plant surveys while working with your plant personnel. Senior metallurgical staff have performed numerous plant surveys in copper – gold, copper/moly, copper smelter slag, primary moly and potash. By improving recovery and grade based on recommendations from our plant surveys, you can see an immediate positive impact on your revenue. Onsite reviews support operations, commissioning, ore transitions, reagent modification, new technologies and troubleshooting. Surveys often lead to recommendations for revised circuit configuration, automation, bench-scale testing and revised reagents – with minimal capital investment.

Field service

Most of our solid/liquid separations laboratory services can be provided in the field. In many cases, an onsite assessment of existing systems and process conditions will result in achieving maximum operating efficiency. Services include both testing and equipment evaluation. Metallurgical testing can also be arranged for onsite completion, using your lab or a local facility.

Research and development

The Minerals Testing and Research Center houses the FLS Minerals Research and Development group. This group focuses its efforts on improving existing process and unit operations technologies, as well as developing ideas and proving concepts that will take FLS into new technology areas.

Arranging for test work

If you would like for us to perform any testing for your operation, please make your request through your FLS sales representative or lab contact. We will ask for appropriate process information in order to prepare a detailed proposal that specifies job scope, estimated time and cost.

Samples

We require an SDS with the sample's arrival for any work conducted at the Minerals Testing & Research-Center.

References

FLS has performed testing and developmental services for numerous large mineral, chemical, energy and engineering firms worldwide. Feel free to request a list of relevant references.

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