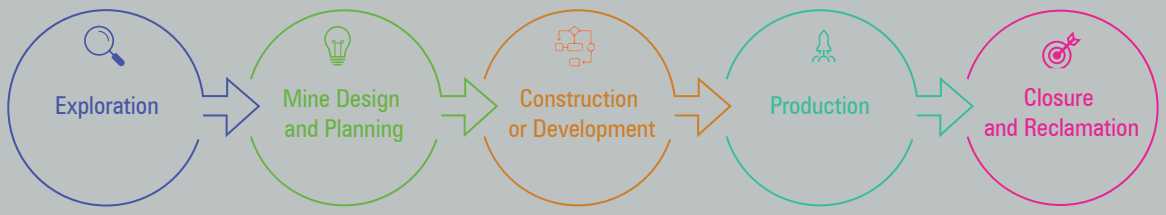
A SUSTAINABLE ECONOMY
WHITE PAPER FROM
SPECTRO ANALYTICAL INSTRUMENTS

Analytical Challenges and Solutions for Mining and Geochemistry

Introduction

Elemental analysis is a must for all stages of the mining cycle, from exploration to production to reclamation. As easy-to-find, high-grade deposits have been discovered and worked, more and more lower-grade deposits are being developed, where volume and ease of surface mining compensate for the lower grade. Direct discovery of deposits from surface outcrops is rare. So, today's analytical techniques must search for deposits under cover by detecting their "halo" and "footprint through cover" signals. This requires the sampling of larger areas; usually a multi-element assay; and the ability to detect weak signatures via capabilities such as high sensitivity or low detection limits.



Highly accurate, single-element traditional wet chemistry methods such as gravimetric assays and titrations are now limited to high-grade commercial samples, since they are too slow and labor-intensive to be used for exploration and processing.

Improved productivity and sensitivity have been achieved with instrumental analytical assays such as atomic absorption spectrometry (AAS) or potentiometric and colorimetric methods, but these are not suited for multi-element analysis.

Therefore, this report will focus on widely used instrumental multi-element assay technologies: specifically energy-dispersive X-ray fluorescence (ED-XRF) spectrometry and inductively coupled plasma optical emission spectrometry (ICP-OES).

ED-XRF and ICP-OES technologies are already well established. And recent advances in software and hardware technology have led to major improvements that are revolutionizing the analytical paradigm, from mine sites to commercial laboratories.

Analytical Challenges

Mining and geochemical operations present numerous challenges for analytical instrumentation.

Multi-element. Users need to determine the composition of ores, concentrates, and tailings containing a range of elements — an extremely wide range: potentially more than half of the periodic table.

Multi-range, from ppb to weight percentages. Analytical tools must also often provide users with accurate measurements of a wide range of concentrations of these elements, across numerous sample types. Multiple analyses must be performed, from feed material evaluation to ongoing process control monitoring.

Minimum time to results. Complex materials and deposits make it difficult to ensure consistent feed quality to a processing plant, even with improved material blending capabilities. Process control needs to be able to respond more quickly and proactively to any change. Efficient processes are more complex and require more accurate dosing of reagents to reduce costs and minimize waste. Turnaround time (TAT) is of the essence.

Challenging sites. Mines may be situated anywhere, from the far north of Alaska to the high altitudes of Chile's Atacama Desert. Remote locations often present logistical and engineering challenges. Unlike commercial hub labs in centralized, accessible places, which can easily receive samples from anywhere on their continent, mine sites are often difficult to access. Supply capabilities may be limited by factors such as air-only transport or seasonal access.

ED-XRF, ICP-OES, or both?

Although many applications can overlap, users often choose between ED-XRF and ICP-OES analyzers based on the specific needs of the analytical tasks their organizations face:

ED-XRF provides a convenient, rapid method for elemental analysis of exploration samples, ores, feed materials, concentrates, and tailings at relevant concentration levels. A major advantage is that it requires far less sample preparation than any other technique, because it can analyze both solid and liquid materials. It also achieves very fast assay times and TATs and provides the lowest cost of ownership. These benefits can be realized nowadays even in portable ED-XRF spectrometers, which allow use at different locations.

For more challenging applications, lab-based ED-XRF instruments using *adaptive excitation (AE)* — which optimizes the excitation beam to get low background and high sensitivity — are recommended, to reach even lower detection limits and higher precision.

Alternatively, when faced with larger numbers of samples from ores, concentrates, and tailings — which require short analysis times and low detection limits — users turn to **ICP-OES**. This technology is easily automated for maximum productivity. It provides detection

limits in the sub-parts per million (ppm) and parts per billion (ppb) ranges, and the best models can analyze a sample in less than a minute.

However, this technique requires sample digestion, partial extraction with single or multiple acids, or a combination of fusion and digestion. The sample matrix (made up of different minerals) is "destroyed" and converted into a homogeneous solution. High concentrations may also be analyzed. Although note that these are more challenging: solubility is limited, a higher degree of dilution is needed, and special methodology such as bracketing is required to achieve high precision and accuracy.

More importantly, one can operate the ICP-OES with one calibration setup per matrix, traceable to gravimetrically prepared reference samples in the same type of matrix.
ICP-OES requires a laboratory location where samples can be safely digested; a controlled environment to minimize contamination; availability of argon gas; and infrastructure for liquid waste disposal.

Consider an ED-XRF analyzer if:

- Laboratory is in a challenging location, with limited infrastructure such as water supply & consumables; device must be easy to set up & move
- Rapid sample analysis (of powder, pellet, liquid) is required, with minimal processing or acid-free mechanized sample fusion
- Time-critical analysis is necessary
- Wide range of concentrations is encountered, from ppm to percent levels
- Ease of use for operator-level personnel is needed, along with relatively high level of accuracy

Consider an AE ED-XRF analyzer if you additionally need:

- Multi-sample capabilities
- Even lower detection limits
- Even higher sensitivity & precision
- High-quality analysis results, especially with samples displaying complex spectra

Consider an ICP-OES analyzer if:

- Location allows for full laboratory infrastructure
- Need to analyze large numbers of samples, often in an automated process, at higher speed
- Need to analyze a wide range of elements, often from different matrix materials used in different applications, utilizing a consistent setup
- Need to accurately analyze both minor & trace elements, e.g., ppm to ppb levels
- Lab follows normative (e.g., ISO, GOST, ASTM, etc.) methods

Almost all the major suppliers of spectrometric solutions for mining and geochemical analysis specialize in products that use a single instrumental analysis technique, such as either ICP-

OES or XRF. One notable exception: SPECTRO Analytical Instruments offers a choice of technologies. This allows users to find the ED-XRF or ICP-OES instrument that best meets their specific needs.

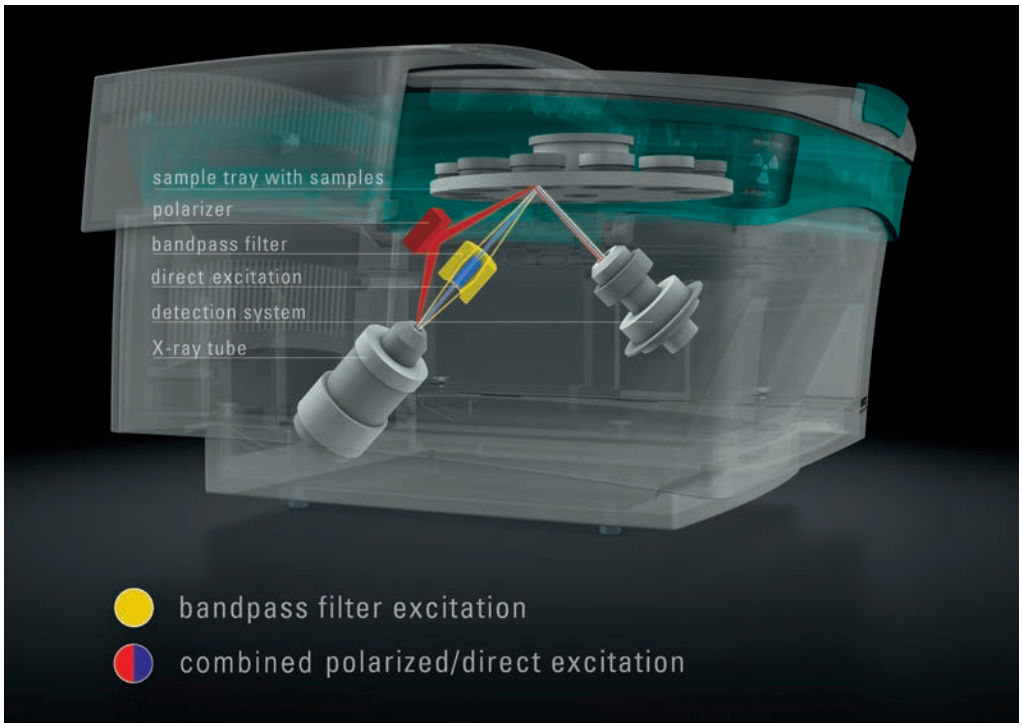
ED-XRF Solutions for Mining and Geochemical Analysis

Today's most advanced ED-XRF models offer performance far surpassing what was possible only a few years ago. ED-XRF technology now provides one of the simplest, most accurate, and most economical analytical methods for determining the chemical composition of many types of mining/geochemical materials. It requires little sample preparation, and the material is still available for additional testing.

A best-in-class portable ED-XRF solution: SPECTROSCOUT, a compact, truly portable analyzer. Compared to most other small portable or handheld ED-XRF instruments, it can be equipped with a higher-power (10 W) X-ray tube to provide higher sensitivity or faster assays. Its optimized filters allow low detection limits to be achieved — as in the analysis of thorium (Th) and uranium (U) content in phosphate rock, or when analyzing sediment samples. For the determination of low atomic number elements like sodium (Na) and magnesium (Mg), the measurement chamber can be evacuated. This avoids the use of helium (He) purge gas, which might be needed when utilizing other instruments. Another major plus: sample spinning, which allows measurement integration across a larger area of the sample. This is combined with powerful yet easy-to-operate XRF Analyzer Pro software, which provides sophisticated spectra handling where other analyzers use a less advanced region-of-interest approach. Precalibrations or material-matched factory calibrations can be readily extended and optimized with the user's own samples: an industry-leading differentiator.

Another top-of-the-class solution is SPECTRO's AE ED-XRF: the SPECTRO XEPOS line of benchtop adaptive excitation analytical spectrometers. Successive generations of improvement have added quantitative analysis functionality; wider analytical scope for more elements and lower concentration levels; improved precision: higher sample throughput; lower cost of ownership; and greater ease of use. This instrument proves the benefits of using vacuum when analyzing low atomic number elements; of sample spinner technology; and of a multi-position sample changer. SPECTRO XEPOS features an innovative air-cooled X-ray tube with a thick target binary-alloy cobalt-palladium (Co-Pd) anode. Compared to SPECTROSCOUT, this instrument can be run at a significantly higher power — up to 50 W — while still not requiring water cooling. In combination with the analyzer's advanced adaptive excitation, this allows for quasi-monochromatic excitation conditions for different excitation energies, and for a wide range of elements. So SPECTRO XEPOS reduces background signals: leading to lower detection limits; easier deconvolution of the spectrum; and easier use of so-called fundamental parameter

algorithms to determine sample concentrations. For low atomic number elements, the excitation is polarized; placing the excitation, sample, and detector within the spectrometer in a 3-D geometry. This further reduces background, especially when analyzing light matrix samples.



One key result: greater analytical "headroom" than other instruments in their class — to meet some challenging applications in mining and geochemistry.

These particular ED-XRF analyzers provide detection limits at the sub-ppm level for elements from uranium (U) to ~500 ppm for fluorine (F), for high-quality measurements of elemental concentrations up to 100%, easily and simultaneously. Different versions maximize performance for targeted elemental groups in specific matrices — because users need instruments that can handle critical tasks from rapid sample screening analysis to precise process quality control.

Sensitivity/precision/LODs. Meeting key specifications for analytical performance is critical for mining applications. Example: SPECTRO ED-XRF models are equipped with a silicon drift detector (SDD) combined with the latest high-speed readout system, which furnishes an ultra-high count rate — up to 1.5 million counts per second (cps). The combination of breakthroughs in excitation and detection let users see significantly lower limits of detection (LODs) — for the highest possible sensitivity, accuracy, and precision when analyzing trace, minor, or major element geochemical concentrations.

Simplicity, power, usability. The best ED-XRF analyzers should keep things simple and easy to use, without compromising on analytical capabilities. With minimal demands on laboratory infrastructure and an intuitive interface for a rapid learning curve (small footprint, no chillers, simple operation, minimal sample preparation, etc.), SPECTROSCOUT and SPECTRO XEPOS analyzers are often the instruments of choice for remote and/or difficult-to-access mine and processing sites. The instruments can be delivered precalibrated for the analysis of trace and minor element concentrations in a wide range of matrices, directly analyzed from powder or prepared as pressed pellets; and also for the analysis of major elements, with samples prepared as pressed pellets or fused beads. SPECTRO can bundle all required equipment to enable a complete solution.

Rapid sample throughput. Mining analyzer operators and managers want the right results: right now. In a production environment, the extra minutes per measurement that some analyzers — particularly sequential models — exhibit can mean significantly fewer results per shift. On the high end, however, users report that SPECTRO XEPOS can perform a complete quasi-simultaneous analysis of a multi-element geochemical sample in as little as 3 minutes.

Lower cost of ownership. Inexpensive ED-XRF analyzers shortchange performance; many higher-end WD-XRF models incur additional hidden expenses. In fact, instruments in both categories possess features that will add consumables and maintenance premiums, year in and year out. However, a reasonable purchase price, lack of chillers, low power consumption, and lower installation expenses all help provide a high-performance analyzer like SPECTRO XEPOS with surprisingly low costs of investment and maintenance. (Users estimate a component life cycle of 5-7 years before component replacement.)

Compared to other elemental analysis techniques, the described ED-XRF instruments are also easier to deploy onsite, as there are typically no requirements for consumable gases. Since samples are analyzed with simple prep and without any digestion-using acids, the lab avoids dealing with hazardous waste from acidic solutions.

Mining applications for ED-XRF instruments

All the advantages discussed above allow an advanced ED-XRF analyzer to provide excellent performance in the following mining/geochemical operations:

Analysis at the point of process / minesite

Minimal footprint, low or no sample preparation demands, freedom from chillers, little or no required gas supply — these can be necessities for an analyzer sited at many relatively inaccessible mining industry locations. To illustrate the point, these characteristics help SPECTROSCOUT and SPECTRO XEPOS bring substantial analytical power to mining sites and refining operations, especially at remote locations.

Analysis of trace elements

In many cases, such as exploratory examination of rock for trace elements, users need accurate analysis of elements present in low concentrations. For example, when searching for an element of interest or mineral such as graphite, SPECTRO XEPOS provides low LODs for fast, reliable screening of large numbers of associated trace impurities. (Find further details here.) The same is true when looking, for example, at the analysis of trace element contents of cadmium (Cd) and uranium (U) in phosphate rock, which are especially important in fertilizer production. (Find further details here.) Other examples of critical trace elements are so-called "penalty elements"; a few examples are discussed below.

Analysis of trace elements (pathfinders)

In some cases, for example when analyzing gold (Au) ores, instead of looking at the rather small signals of the element itself, the analysis of pathfinder elements can give the right guidance on the qualification of a deposit. In the case of gold ores, arsenic (As), molybdenum (Mo), silver (Ag), tin (Sn), antimony (Sb), tellurium (Te), tungsten (W), and bismuth (Bi) are considered pathfinder elements.

Analysis of ores and industrial minerals, concentrates, and tailings

Many ore, concentrate, or tailings samples make considerable demands on analyzer capabilities. Example: for nickel laterite, concentrations of nickel (Ni) must be accurately analyzed. Concentrations of cobalt (Co) and iron (Fe) present in these ores must also be measured, despite multiple overlapping spectral lines that hinder their identification. Fortunately, a design like that of SPECTRO XEPOS — with its high stability, combined with high count rates and sophisticated spectra handling — allows analysis of the majority of these materials with great precision and accuracy. (Find further details here.)

In another example, analysis to determine copper (Cu) concentrations is conventionally carried out by AAS instrumentation. However, this technique cannot provide good measurements for traces of unwanted elements such as arsenic (As), lead (Pb), cadmium (Cd), mercury (Hg), selenium (Se), and tellurium (Te). However, a high-performance ED-XRF analyzer (such as SPECTRO XEPOS) can deliver high accuracy for copper as well as for these penalty elements. In addition, it can assay high-grade intermediate products from copper smelters, such as copper telluride (CuTe).

Analysis of iron ore

Testing iron (Fe) ore has traditionally been performed in classical laboratory settings using wet chemistry, for iron determination by titration and wavelength-dispersive X-ray fluorescence (WD-XRF) instruments for the penalty elements (ISO 9516). While standard ED-XRF spectrometers still lack the performance to comply with the ISO standard, due to the challenging dilution of the fusion bead and tight tolerances — the XEPOS series AE ED-XRF instruments are achieving performance that pushes the limits on traces such as selenium (Se). (Find further details here.) AE ED-XRF allows for a reduced cost of ownership and offers significant energy and consumable savings compared to WD-XRF (e.g., no cooling water, P10 gas).

Also, processors have found increasing need for quality control at every stage, including mining, transport, sinter processing, and more. An AE ED-XRF analyzer like SPECTRO XEPOS allows users to move some aspects of iron ore analysis closer to the production site and save time.

In particular, this kind of instrument provides high accuracy for analysis of minor and trace element components associated with iron — particularly deleterious contaminants such as phosphorus (P) and sulfur (S). (Find further details here.)

ICP-OES Solutions for Mining and Geochemical Analysis

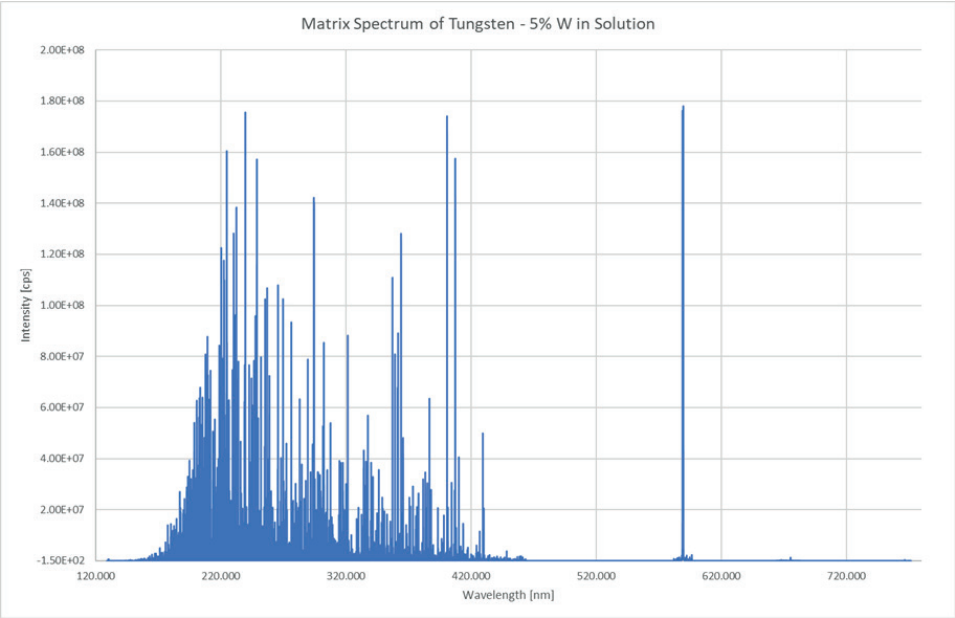
ICP-OES technology has been utilized in numerous mining/geochemical applications for decades. Continual refinement and development have greatly broadened its scope. Today, it's the analysis of choice for most analytical tasks across the industry.

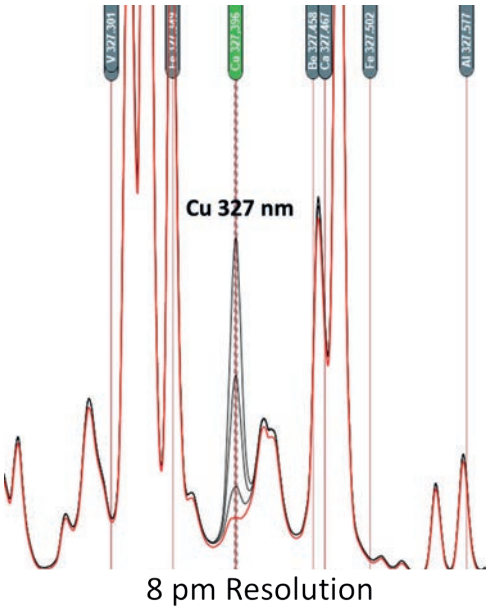
Specifically, the SPECTRO ARCOS line of benchtop analyzers has been designed to perform at the pinnacle of ICP-OES achievement. These instruments are currently available in six versions. Each is optimized for the user's choice of plasma viewing technology and elemental wavelength range. And each offers unusual capability and flexibility in a single instrument. (Find further details here.)

Ideally, users look for an analyzer possessing the greatest available capabilities in terms of speed, ruggedness, analytical headroom, and ease of use. These can make all the difference in measuring up to the most challenging mining applications.

Highest possible sensitivity, precision, and matrix compatibility. Each ICP-OES plasma optical observation method brings distinct advantages and disadvantages. Axial view delivers higher sensitivity but more interferences; radial view trades the highest sensitivity for more stability and freedom from matrix interferences. Different analyzers choose one or the other. Or they utilize workarounds such as periscopes to attempt "dual" views — though these inevitably favor one view and compromise the other. The single exception: SPECTRO ARCOS. It offers true axial and true radial (single or dual) plasma observation in one instrument. This is accomplished by its periscope-free MultiView mechanism, an option that lets an operator literally "turn" a radial-view instrument into an axial-view device, or vice-versa, in 90 seconds or less. Additionally, a dual side-on interface (DSOI) plasma observation option furnishes two optical interfaces that add sensitivity and eliminate contamination/matrix compatibility issues. With this kind of analyzer, users get ultimate flexibility; eliminate the need to buy two instruments; and achieve analytical performance without compromise. (Find further details here.)

High resolution and wide wavelength range to "FREE the lines!" All major ICP-OES analyzer makers (except one) use echelle-type optical systems, whose several shortcomings include low resolution over 270 nanometers (nm). Copper (Cu) at 327 nm — a prominent emission line for the determination of trace-level concentrations in a line-rich tungsten (W) matrix — is a good example of the necessity for high resolution in the higher wavelength ranges. With a resolution of 20 picometers (pm), a common value for echelle-type optical systems, the surrounding peaks would be almost three times broader, rendering the analytical line impossible to use.

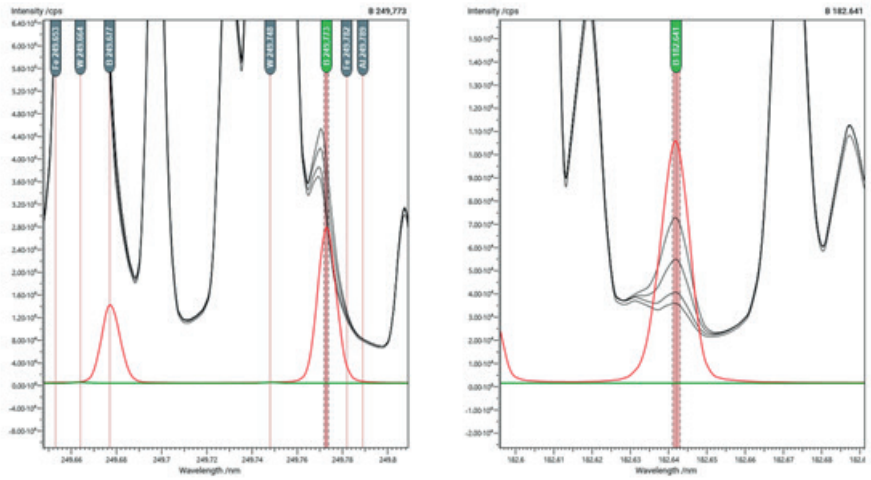




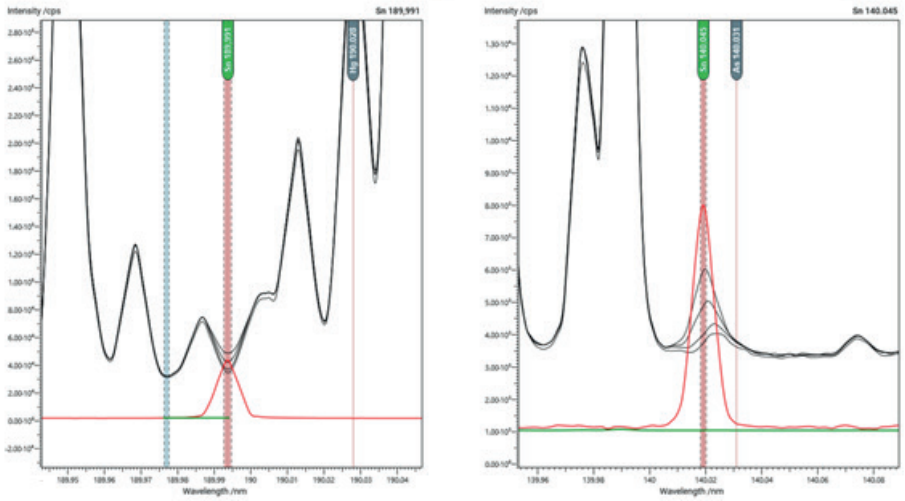
By contrast, the unique ORCA optical system utilized in SPECTRO ICP-OES analyzers achieves simultaneous spectrum capture for elements from 130 to 770 nm wavelengths, with up to 5x more sensitivity than echelle-based systems — plus best-in-class performance in the UV/VUV range. The analysis of boron (B) and tin (Sn) in a line-rich tungsten (W) matrix shows why the VUV range helps with the selection of uninterfered lines. While the common boron emission line at 249 nm is heavily interfered with by the matrix, the UV line at 182 nm is relatively clear. For tin, the prominent line at 189 nm is strongly affected, while the line in the VUV at 140

nm is relatively clear. Without the need for strong corrections, the accuracy of the analysis is improved.

Boron in W matrix - Interfered lines @ 249 nm – Rather clear UV line @ 182 nm



Tin in W matrix - Interfered line @ 189 nm – Rather clear VUV line @ 140 nm



Results of these analyzers' design: high light throughput, wide spectral range, fewer optical components, low stray light levels, and uniform resolution — for fewer corrections and greater accuracy in line-rich matrices. (Find further details here.)

Most robust power. Most ICP-OES systems use generators rated between 1150 and 1600 W, which limits their usefulness for certain higher plasma load applications. In contrast, SPECTRO ARCOS was designed with likely the most powerful plasma generator on the market: an extremely agile LDMOS model that puts out up to 2000 W. The 27 MHz free-running design enables the system to react quickly and adjust to changing and/or elevated

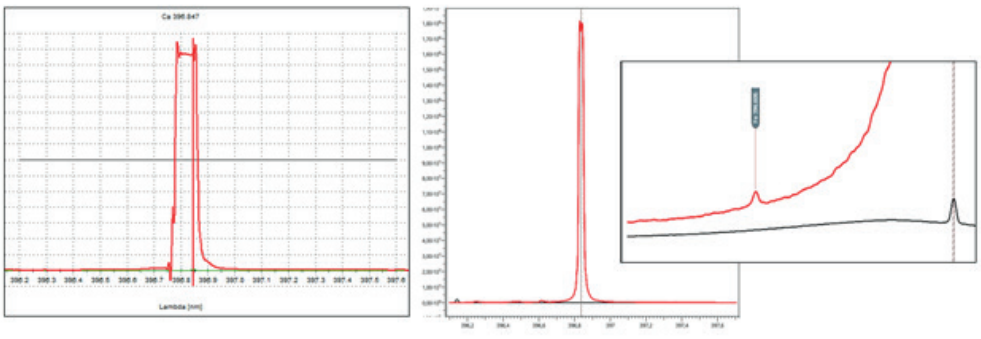
loads while maintaining a stable plasma. So it provides high matrix compatibility, allows samples to be analyzed in lower dilutions, drives lower LODs, and may sometimes eliminate extensive sample preparation.

Highest possible dynamic range. The greater an analyzer's dynamic range and the wider the concentration range that can be analyzed, the smaller the need for additional dilutions in case trace elements as well as major concentrations need to be measured. SPECTRO ARCOS offers perhaps the greatest dynamic range currently available in an ICP-OES analyzer. Its readout system boosts spectra processing and transport speeds, acquiring signals up to 1.2 billion cps. Covering 9 orders of magnitude, this enables still-sharp, nonsaturated line profiles even for elements at higher concentration levels, enabling detection from ppb up to percent levels.

Avoiding blooming (and icing). How a detector behaves at extreme light intensities is one critical factor for producing quality results. Most ICP-OES instruments utilize traditional charge-coupled device (CCD) two-dimensional (2-D) detectors. Unfortunately, this technology has always been susceptible to allowing charges caused by intense spectral lines to migrate (bloom) to adjacent pixels, affecting nearby lines. SPECTRO ARCOS instead employs advanced line-array detectors based on complementary metal-oxide semiconductor (CMOS) technology. This eliminates any blooming effect. So the signals from trace elements can be read even in the vicinity of intense matrix lines. The analyzer's CMOS line-array detection design can be optimized to the relevant wavelength range, and — without the need for zero cooling — eliminates chip icing and failure.

The below graphic demonstrates this nicely. While the highly intense calcium (Ca) line at 396 nm is saturated, the visual at left demonstrates the blooming effect of CCD detectors with a broadened peak. The visual at right shows analysis of the same sample using CMOS technology. Even though the line is saturated, there is no broadening, no migration of charges, no influence on the flanks.

CMOS Performance for Intense Lines



Maximizing throughput. ICP-OES analyzers are often employed for high-volume geochemical analyses by contract services laboratories. Here sensitivity, precision, and accuracy must be paired with productivity. Therefore, an analyzer like SPECTRO ARCOS incorporates features to throttle up throughput. True, direct-light-path radial and axial plasma observation in a single instrument already provides the best possible performance for the relevant viewing mode. Now the recently introduced dual side-on technique combines the capabilities of the two observation modes — with sensitivity, precision, and robustness — in a single-view measurement. Coupled with the capability for simultaneous full-spectrum capture, it enables sample analysis in under a minute. With a full valve integration and the integration of a wide range of samplers, the system can be easily automated. The SPECTRO intelligent valve system (IVS) option shortens the sample path and facilitates effective rinsing of the path and sample loop, while injecting the sample into the ICP nebulizer for analysis. Throughput is increased via faster sample loading and signal stabilization, plus shorter washout times.

Solid stability. The stability that's critical for accurate ICP-OES measurement stems from multiple system components. Take SPECTRO ARCOS. Its high-performance generator provides stable power even with rapidly changing plasma loads. Its hermetically sealed, thermally stabilized optical system eliminates any peak drift. And all gas flows are volume-flow-controlled for stability in the plasma and within the transfer optic. Stability, both daily and long-term, is ensured — resulting in few reworks as a result of failed control measurements.

Superior software. Ideally, analyzers in this class will use software that can balance effortless user interaction with superior analytical capabilities. An instructive example: ICP Analyzer Pro software from SPECTRO. It relies on the Material Design visual language developed and proven by Google. The user is guided intuitively via "flat" design with minimalist use of simple elements, incorporating animations and shadows for depth effects. The design makes it clear which areas of a screen view or a dialog box contain information, and where interaction is expected. An "overview to detail" workflow consistently implemented in the software; a clear orientation; reduction to only essential information; and self-explanatory buttons complete this concept and make ICP Analyzer Pro extremely easy to use — even for beginners.

The software also includes advanced options. Its exclusive bracketing feature helps improve accuracy for major compound analysis. This ISO-described method (ISO 11494, 11495) achieves highest accuracies when determining major compounds, for example in precious metal analyses.

High uptime with low operating costs. Consumables and accessories add costs. But for proper functioning, most ICP-OES instruments require strategies such as ongoing argon gas purging of their optical systems, and troublesome external cooling assemblies. An exception: SPECTRO ARCOS requires no purge gas for its sealed optical system. And its unique air-cooled design saves up to 25% in annual running costs. These and other features promise exceptionally low operating expenses over a long, reliable service life.

Mining applications for ICP-OES instruments

Mining may seem like a relatively straightforward operation. But in fact, accurate analysis is required at a large number of processing steps. Many capabilities highlighted above let advanced ICP-OES analyzers deliver outstanding results in the following mining/geochemical applications:

Multi-element analysis of whole rocks

Geochemical exploration typically involves analyzing large numbers of rock or soil samples with relatively lower concentrations of metals of interest. These analyses often form the basis of resource/reserve estimates. Analyzers must determine concentrations of the metal of interest, as well as of trace impurities. The work requires analyzers with high levels of robustness, sensitivity, and speed.

SPECTRO ARCOS may serve as a case in point. Its attributes that are especially valuable for these tasks include fully simultaneous detection, the ultra-fast sample-to-sample measurement times, high sensitivity, and high matrix compatibility. Helping make the difference are this instrument's highest-power LDMOS generator and its uniquely flexible MultiView triple-interface technology.

Analysis of ores, concentrates, slags, residues

Ore analysis is required for medium- to high-grade mineralized rock or core samples containing percent levels of target elements. This category may also include process control analyses, needed to monitor an ongoing metallurgical or mining process. Materials to be tested may range from feed or head samples to concentrates, metals, tailings, slags, and/or residues.

Sample types may vary, but all these missions typically demand a robust analyzer which offers sensitivity as well as dynamic range, stability, and robustness.

One excellent fit: SPECTRO ARCOS. Its highest-power LDMOS generator, combined with its MultiView triple interface technology, can deliver high sensitivity, precision, and stability with high matrix compatibility and robustness — all in a single instrument.

Analysis of pure metal

Pure metal testing is most often undertaken to generate highly precise, accurate data for commercial transactions. The analytical goal is quantitative determination of the major, payable elements in a given material. Typically, this is achieved by the determination of all impurities, then their subtraction from 100%. Here again, besides other qualities, the primary characteristic required is high sensitivity.

One excellent solution for this application is SPECTRO ARCOS. Example: with its MultiView optical system configured for axial plasma observation, ultimate sensitivity is attained, and a purity level up to 99.9995% in gold (Au) and 99.9997% in silver (Ag) can be achieved.

Analysis of alloys

Later refining stages require precise identification and quantification of alloying elements as well as of the matrix element of interest. The most critical analytical requirements remain precision and accuracy.

Most major ICP-OES analyzers are capable of providing the requisite precision on routine measurements. For example, by employing techniques like internal standardization, precision levels below 0.5% may be reached. Particularly in the case of expensive materials, however, these levels are not sufficient. This is where the SPECTRO ARCOS bracketing tool offers a special solution. Fully integrated into the instrument's software, it can achieve a relative precision for major compound analyses of less than 0.1%.

Analysis of environmental samples

Most mining/refining processes produce hazardous waste, requiring the control of wastewater emissions to meet environmental standards and regulations. Careful analysis is critical. Where trace amounts of heavy metals exceed limiting values, analyzers must perform with high sensitivity.

Here an analyzer such as SPECTRO ARCOS, with its MultiView technology, offers a welcome flexibility. It provides needed characteristics from sensitivity to traceability: offering a no-compromises analytical solution for production, plus environmental monitoring and control in a single instrument.

Conclusion

Analysis of mining and geochemical samples presents considerable and varied challenges for analytical instruments. The wide array of elements encountered, plus the large number of applications across the industry, demand high performance and maximal flexibility. Fortunately, the best ED-XRF and ICP-OES analyzers are equal to these tasks.

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