



**Hazen Research, Inc.**

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**ANALYTICAL LABORATORY SERVICES  
FEE SCHEDULE**

**Effective January 1, 2024**

**Fuel and Biomass  
Comminution and Grindability  
Metals  
Mineralogy  
Precious Metals Recovery  
Radiochemistry  
Thermal Analysis  
Waters  
Wet Chemistry**

**[www.hazenresearch.com](http://www.hazenresearch.com)**

*Serving the Mineral and Chemical Industries Since 1961*

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## LIST OF ABBREVIATIONS

Abbreviation	Definition	Page of First Occurrence
AA	atomic absorption	8
ARF	analytical request form	2
ASTM	American Society for Testing and Materials	24
BTU	British thermal unit	16
CDPHE	Colorado Department of Public Health and Environment	6
COC	Chain of Custody	2
DOC	dissolved organic carbon	14
DSC	differential scanning calorimetry	27
DTA	differential thermal analysis	27
EDS	energy dispersive spectrometer	22
EOX	extractable organic halogen	14
FA	fire assay	8
IC	ion chromatography	18
ICP	inductively coupled plasma	8
ISE	ion selective electrode	18
LOI	loss on ignition	10
MS	mass spectrometry	8
OES	optical emission spectroscopy	8
PGM	platinum group metals	13
PSA	particle size analysis	7
PSD	particle size distribution	7
QA	Quality Assurance	3
QC	Quality Control	3
SAG	semiautogenous grinding	25
SEM	scanning electron microscope	23
SMC	SAG mill comminution	25
SUVA	specific ultraviolet absorbance	14
TDS	total dissolved solids	18
TGA	thermogravimetric analysis	24
TKN	total Kjeldahl nitrogen	18
TOC	total organic carbon	8
TX	total halogen	14
TSS	total suspended solids	18
TS	total solid	18
UV	ultraviolet	18
WDS	wavelength dispersive spectrometer	22
XRD	x-ray diffraction	21
XRF	x-ray fluorescence	8

## GENERAL INFORMATION

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### SUBMISSION FORMS

To order analyses at Hazen Research, Inc. please complete our ARF. To order radiochemical analyses complete the COC. The forms can be downloaded from our [website](#).

Please include the completed forms with samples in transport. Provide as much detail as possible about your sample on the second page of the ARF, including composition and matrix information, estimated values or concentrations, if known, as well as any desired reporting units. If you have a previous analytical report and are requesting similar analysis, please include the Lab Control ID or a copy of your previous report with your samples. Required sample quantities can be found on [Page 8](#).

A delay in processing may result if samples arrive without a signed ARF or COC.

Samples arriving at Hazen after 2:00 p.m. may be received into our system on the next business day. Hazen reserves the right to refuse to receive or analyze samples that are deemed unsafe to handle in our facilities, or for any other reason. Samples without an ARF, COC, or missing or incomplete safety information may be returned to sender.

Order confirmations for requested analyses will be emailed within 3 business days of sample receipt. Please review the confirmation email and attached documentation closely, as discrepancies missed at this time may cause delays or inaccuracies in analytical reporting.

### QUOTATIONS

Written quotations are available by request ([analytical@hazenresearch.com](mailto:analytical@hazenresearch.com)). Quotations are valid for 90 days unless otherwise noted. A copy of the quotation must accompany the samples to ensure proper login and billing for the analyses performed. Please include the quote number on the ARF.

### TURNAROUND TIME

Routine analyses are normally reported by email within 15–20 business days for non-radiochemistry analyses but may take longer for radiochemistry analyses. We cannot guarantee specific turnaround times, but we remain committed to superior customer service, so please [contact us](#) to inquire about the status of your analyses.

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## GENERAL INFORMATION

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Priority service is available at a 100% surcharge. Priority service ensures that your samples will be prioritized over standard service samples. Prior arrangement is required to ensure availability – please email [analytical@hazenresearch.com](mailto:analytical@hazenresearch.com) before sending your sample. Results are typically delivered within 5–7 working days. However, these services do not guarantee results within the number of days specified.

### PRICING POLICY

It is the policy of the Hazen laboratories to set prices at a fair and equitable level for quality analytical services. While we attempt to maintain the listed rates, the prices are subject to change without notice. Specific test methods and pricing may not be applicable to all sample types. In these cases, the customer will be notified and, if appropriate, a special price quotation will be provided.

All prices are in U.S. dollars (US\$), and unless otherwise specified, are per sample. (See the Minimum Charges section below).

On large projects, we are frequently able to provide discounts. These are offered by quotation only.

### MINIMUM CHARGES

Our QA program requires, at a minimum, one blank, one duplicate, and one calibration check standard be analyzed with each group of 10 samples, or with each significant matrix. Our minimum charges (minimum samples charged per analysis) help offset the cost of QAQC procedures and other handling costs for small quantity orders. For certain analyses, sample billing minimums are required; the minimums are listed for the applicable determinations.

Replicate analyses requested in addition to the minimum QC samples are charged at the regular rate of a single analysis.

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## GENERAL INFORMATION

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### QUALITY ASSURANCE AND QUALITY CONTROL

We maintain a QAQC program to assure reliable results. We maintain a supply of certified standard reference materials for a wide variety of matrices and analytes, which allows us to provide better matching between reference material and samples. In many cases, we have alternate methods that can be used to confirm values obtained by our standard methods. Our results are reliable, but we encourage customers to contact us if data do not meet expectations. Since quality is important to us, we will, within reason, verify results. If the results confirm the original data, there will be an additional charge for the confirmation analysis.

Our standard report includes client sample results. If QA control sample data are required, a formal report can be provided at an additional 25% surcharge, for a minimum fee of \$50. These data include associated raw data, including adjacent blank, control values, and duplicates associated with your sample(s). [Contact Hazen](#) for information on customized data deliverables and QAQC packages.

### ANALYTICAL REPORTS

Analytical reports are sent by email as signed PDF files. Upon request, reports can be provided by first class mail for \$2 per report. The ARF must include a valid mailing address. Most reports can be supplied in electronic data delivery or other custom electronic reporting formats.

All results are held in strict confidence. Results will be released to a third party only if authorized by the original client in writing.

Any special reporting instructions should be included in your ARF.

### TERMS AND PAYMENT

Terms are net 14 days from the date of invoice. A 1.5% per month surcharge will be assessed on all past due accounts. If a purchase order is used as a form of payment, its terms and conditions do not apply and are not binding on Hazen.

In the event of default on payment, the client is responsible for all reasonable collection and legal fees. By sending samples for analysis, client agrees that services shall be governed by Hazen's analytical terms and conditions included in the ARF and COC; Hazen's terms and conditions supersede all other terms and conditions.

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## GENERAL INFORMATION

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We accept cash, check, purchase order, electronic payment, or credit card (Visa, MasterCard, American Express, and Discover) for payment of services. Credit card limit is \$2,500. Credit card payments can only be made online at [www.hazenresearch.com](http://www.hazenresearch.com)

New clients may be required to pay 50% before beginning analysis.

### LIMITS OF LIABILITY AND WARRANTY

It is the intent of Hazen's laboratories to provide the most reliable data possible for contracted analyses. These services are provided without warranty or liability, implied or otherwise, of any kind. The sole remedy shall be limited to repeating the analyses or refunding the amount paid to Hazen for services provided.

### SAMPLE STORAGE, RETURN, AND DISPOSAL

Any unused portion of samples will be returned to the client at a fee of \$4 per sample (\$16 minimum return fee) unless prior arrangements have been made for pickup or disposal. If requesting pickup or disposal, it remains the client's responsibility to contact Samples Receiving to make arrangements once all outstanding invoices are paid in full.

If requesting disposal, Safety Data Sheets must be provided to verify that samples meet requirements for disposal classification. A fee of \$4 per sample will be charged if a disposal agreement is reached.

A minimum \$50 surcharge will be added to orders requiring special packaging and labeling as hazardous materials.

Samples will be returned to the client 30 days after reporting and all invoices are paid. Radiochemistry water samples will be disposed of 90 days after reporting.

If you waive the return fee in lieu of in-person pickup at the Hazen facility or do not pick up your samples once arrangements have been made, there will be a \$50 per month per order storage charge for remnant samples not picked up within 100 business days of completion of report.



## GENERAL INFORMATION

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### **SPECIAL LICENSING**

We are certified by CDPHE for drinking water radiochemistry and inorganic chemistry analyses.

We are licensed by United States Department of Agriculture Annual and Plant Health Inspection Service to ship, recycle, and dispose of unsterilized soil from foreign sources or domestically quarantined areas. Please [contact us](#) for a copy of our permit before shipment.

Treatment and disposal of samples and containers handled under this permit have a fee of \$50 minimum per sample batch.

## SAMPLE PREPARATION

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Preparation or Determination	Fee, \$
<b>Routine Preparation</b>	
Rock and ore (crushing and grinding to 75 µm or 200 mesh)	\$25 for first the 2 lb \$3 per lb for each additional lb
Coal	\$25 for the first 5 lb \$3 per lb for each additional lb
Wood and biomass	\$25 for 1 gal container or smaller \$100/h for larger quantities
Industrial waste	time basis, \$100/h
Municipal waste	\$25 preparation \$20 moisture analysis
Small samples requiring hand mortar and pestle	\$45 per sample
Metals and alloys requiring drilling (excludes tool steels and extremely hard alloys)	\$45 per sample
Samples over 10 lb	time basis, \$100/h
Cryogenic preparation with liquid N <sub>2</sub> (up to 10 lb)	\$50 per sample
<b>Custom Preparation</b>	
Crushing of rock and ore (up to several tons)	by quote
Drill core sawing and splitting	by quote
Batch grinding (wet and dry) in mild steel and ceramic mills	by quote
Blending, compositing, and sample charge preparation	by quote
<b>PSD</b>	
Basic dry screen analysis using Ro-Tap (up to 1 kg, from 1.7 mm to 75 µm, up to 5 size fractions)	\$100
Basic wet screen analysis (up to 1 kg, from 1.7 mm to 38 µm, up to 7 size fractions)	\$350
Additional sample, size fractions, and or high clay material	by quote
<b>PSA</b>	
Horiba LA-950V2 laser diffraction size analyzer	\$200 per sample
<b>Density</b>	
Bulk density (loose and packed)	\$35
Stereopycnometer (Anton Paar UltraPyc 5000)	Time basis, \$100/h

### ASSAY STANDARD PREPARATION

We offer customized assay standard preparations (i.e., round robin testing). Please call and ask for Mineralogy to find out more.

## SAMPLE QUANTITY REQUIREMENTS

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Analysis Requested	Weight or Volume	
	Required	Requested
<b>AA</b>		
Solid	0.2–0.5 g	10 g
Liquid	1 mL	10 mL
<b>FA, FA with AA Finish, FA with ICP–OES Finish</b>		
Solid	30 g	100 g
<b><a href="#">ICP–OES and ICP–MS</a></b>		
Solid	0.2–0.5 g	10 g
Liquid	1 mL	10 mL
<b><a href="#">Carbon, Hydrogen, Nitrogen, Oxygen, or Sulfur</a></b>		
Solid	2 g	10 g
<b>PSA</b>		
Solid Note more sample (1–2 kg) is required for material coarser than 150 µm	1 g	10 g
Liquid (slurry)	50 mL	100 mL
<b><a href="#">Radiochemistry</a></b>		
Gross alpha/beta		
Solid	1 g	5 g
Water	200 mL	1,000 mL
Radium-226 and -228		
Solid per isotope	1 g	5 g
Water per isotope	1 L	2 L
Sludge per isotope	1 g	5 g
Radon (water) (special glass containers)	30 mL	60 mL
Thorium (Total)		
Solid	0.5 g	5 g
Water	1 L	1 L
Uranium		
Solid	0.2–0.5 g	10 g
Water	1 mL	10 mL
<b>Wet Chemistry, <a href="#">Anions</a>, <a href="#">TOC</a></b>		
Solid	1 g	10 g
Liquid	40 mL	120 mL
<b><a href="#">XRF</a></b>		
Solid	25 g	50 g
<b>Fuel and Biomass Analysis</b>	5 gal Ziploc bag filled	

## ANALYTICAL SERVICES – ELEMENTAL ANALYSIS

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The fees listed below include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and or preparation fee ([Page 7](#)) may apply. Individual analytes may be determined by AA, ICP–OES, wet chemistry, or FA.

Determination	Fee, \$	Determination	Fee, \$
Aluminum	25	Molybdenum	20
Ammonium	40	Neodymium	25
Antimony	20	Nickel	20
Arsenic	25	Niobium	25
Barium	20	Nitrogen (Dumas)	25
Beryllium	20	Nitrogen (total chemiluminescence) <sup>a</sup>	50
Bismuth	20	Palladium (FA, ICP–OES finish)	50
Boron	20	Phosphorus (yellow or blue method)	50
Cadmium	20	Phosphorus (ICP–OES)	20
Calcium	20	Platinum (FA, ICP–OES finish)	50
Carbon, total	30	Pt/Pd (FA, ICP–OES finish)	70
Carbon dioxide (carbonate carbon)	30	Pt/Pd/Rh (FA, ICP–OES finish)	90
Carbon, organic	50	Potassium	20
Cerium	25	Praseodymium	25
Chloride, soluble	45	Rhenium	25
Chloride, total	45	Rhodium (FA, ICP–OES finish)	50
Chromium	20	Samarium	25
Cobalt	20	Scandium	20
Copper	20	Selenium	30
Copper, oxide	20	Silicon	20
Dysprosium	25	Silver (FA)	30
Erbium	25	Silver (AA)	20
Fluorine	45	Sodium	20
Gadolinium	25	Strontium	20
Gallium	20	Sulfur, total (solid) / (liquid)	30/20
Germanium	20	Sulfur, sulfate (solid)	35
Gold (bullion)	70	Sulfur, sulfide (solid)	55
Gold (FA, gravimetric)	30	Sulfur, elemental (solid)	45
Gold and silver (FA, gravimetric)	35	Tantalum	20
Gold (FA, AA finish)	40	Tellurium	50
Gold and Silver (FA, AA finish)	45	Thallium	20
Hafnium	25	Thorium	70
Holmium	25	Thulium	25
Indium	20	Tin	20
Iron	20	Titanium	20
Lanthanum	25	Tungsten	40
Lutetium	25	Uranium	45
Lead	20	Vanadium	20
Lithium	25	Yttrium	25
Mercury	70	Ytterbium	25
Magnesium	20	Zinc	20
Manganese	20	Zirconium	20

<sup>a</sup>5 sample billing minimum

## ANALYTICAL SERVICES – ELEMENTAL ANALYSIS

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### ADDITIONAL DETERMINATIONS

Determination	Fee. \$
Acid, insoluble	30
LOI	20
Ash %	30

### SOLID SAMPLE DISSOLUTION

Solid samples may require preparation and dissolution.

Preparation Method	Fee, \$
4-acid digestion	20
2-acid digestion	10
Fusion	20
Oxygen bomb combustion	20
Leach	10

### LIQUID SAMPLE PREPARATION

Preparation Method	Fee, \$
Filtration	15

## ANALYTICAL SERVICES – ELEMENTAL ANALYSIS

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The fees listed below include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and preparation fee ([Page 7](#)) may apply.

### INDUCTIVELY COUPLED PLASMA–OPTICAL EMISSION SPECTROSCOPY

#### Quantitative Multi-Element Analysis

ICP–OES	Fee, \$
<b>ICP–OES Scan<sup>a</sup></b> Elements included: Al, As, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Re, S, Sb, Sr, Te, Th, Ti, V, Y, Zn, Zr	155
<b>ICP–OES Rare Earth Scan<sup>b</sup></b> Elements included: Al, Be, Ca, Ce, Cr, Dy, Er, Eu, Fe, Gd, Hf, Ho, K, La, Lu, Mg, Mn, Na, Nb, Nd, P, Pr, Sc, Si, Sm, Ta, Tb, Th, Ti, Tm, Y, Yb, Zr	180

<sup>a</sup>A four-acid digestion method is used to bring samples into solution, and the solution is analyzed by ICP–OES. This suite is appropriate for non-refractory materials. Aluminum, arsenic, barium, sulfur, titanium, and zirconium are not truly quantitative using this dissolution method and analysis. Silicon is not included and must be requested if required – will require an additional dissolution.

<sup>b</sup>Lithium metaborate/lithium tetraborate fusion is used for solid samples, followed by acid dissolution, and solution analysis on ICP–OES. This method is appropriate for highly refractory materials and other difficult-to-digest samples.

For custom ICP–OES analysis suites, please [contact us](#).

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The fees listed below include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and preparation fee ([Page 7](#)) may apply.

### INDUCTIVELY COUPLED PLASMA–MASS SPECTROMETRY

#### Single and Quantitative Multi-Element Analysis

ICP–MS <sup>a</sup>	Fee, \$
First element	70
Any additional element	10 per element
<b>ICP–MS Rare Earth Scan</b> Elements included: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Tm, Yb	230
<b>ICP–MS and ICP–OES Scan</b> Elements included: Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Dy, Eu, Fe, Ga, Gd, Ge, Ho, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pd, Pr, Pt, Rb, Rh, Ru, S, Sb, Sc, Se, Sm, Sn, Sr, Tb, Th, Ti, Tl, Tm, U, V, Y, Yb, Zn, Zr	470

<sup>a</sup>Most elements from atomic mass 6 to 238 can be determined by this technique. In clean matrices, such as deionized water, detection limits are sub parts per billion ( $\mu\text{g/L}$ ) for the majority of elements. Quantifiable elements and actual detection limits vary with sample matrix and required sample decompositions. Our ICP–MS capabilities include both reaction and collision cell technology. This allows for the elimination of isobaric ICP–MS interferences for a variety of elements, providing lower detection limits and improved precision and accuracy.

## ANALYTICAL SERVICES – ELEMENTAL ANALYSIS

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### X-RAY FLUORESCENCE

#### Bruker S8 Wavelength Dispersive XRF

XRF can analyze elements sodium through uranium at concentrations ranging from 50 ppm to 100%. Loose powders, pressed powder pellets, and borate fusion preparation methods are used. For solid samples that are received coarser than 75 µm or 200 mesh an additional preparation fee ([Page 7](#)) may apply.

XRF	Fee, \$
<b>Semiquantitative and Qualitative Multi-Element Analysis<sup>a</sup></b> QuantExpress Loose Powder Analysis Elements reported: Ag, Al, As, Au, Ba, Bi, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, I, In, Ir, K, La, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pd, Pr, Pt, Rb, Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, U, V, W, Y, Yb, Z, Zr	65
<b>Quantitative Multi-Element Analysis<sup>b</sup></b> Borate Fusion Whole Rock Package Borate fusion analytes by XRF: Al <sub>2</sub> O <sub>3</sub> , CaO, Fe <sub>2</sub> O <sub>3</sub> , K <sub>2</sub> O, MgO, MnO, Na <sub>2</sub> O, P <sub>2</sub> O <sub>5</sub> , SiO <sub>2</sub> , SO <sub>3</sub> , TiO <sub>2</sub> , Ba, Ce, La, Nb, Sr, Ta, Th, U, Y, Zn, Zr, LOI	130

<sup>a</sup>A finely ground sample is mixed with binder, pressed into a pellet, and a full XRF scan is conducted. Specific wavelength intensities are measured and fundamental parameters concentrations are assigned to the specified intensities. This is a qualitative method only, and is appropriate for general materials characterizations.

<sup>b</sup>Following sample fusion into a glass disc, major mineralogical elements are determined and reported as oxides. Loss on ignition is also determined. This method is suitable for non-sulfide ores, silicates, feldspar, gypsum, bauxite, and limestone. It is not appropriate for sulfide content greater than 1%, precious metals, or PGM analysis.



## ANALYTICAL SERVICES – ELEMENTAL ANALYSIS

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The fees listed below include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and preparation fee ([Page 7](#)) may apply.

<b>ANALYSIS FOR ORGANIC HALOGEN (Cl+Br reported as Cl) (3 samples per test billing minimum)</b>	<b>Matrix</b>	<b>Fee,\$</b>
Total Organic Halogen (TOX) – Duplicate analysis required for EPA SW-846-9020	Water	100
EOX	Soil	100
TX	Any	80

<b>ION CHROMATOGRAPHY (3 samples per test billing minimum)</b>	<b>Fee, \$</b>
Quantitative Anion Determination (F <sup>-</sup> , Cl <sup>-</sup> , Br <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , PO <sub>4</sub> <sup>3-</sup> )	
First anion	55
Each additional anion	25
Anion Scan (F <sup>-</sup> , Cl <sup>-</sup> , Br <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , PO <sub>4</sub> <sup>3-</sup> )	150

<b>ANALYSIS FOR ORGANIC CARBON (3 samples per test billing minimum)</b>	<b>Matrix</b>	<b>Fee, \$</b>
TOC	Water	35
Trace TOC <sup>a</sup>	Water	45
DOC	Water	
Total		50
Trace		60
Total Organic Carbon by Difference	Soil	50
Colorado State Drinking Water Package for TOC <sup>b</sup>	Water	180
Colorado State Drinking Water Package for SUVA <sup>c</sup>	Water	185
Certified Clean TOC Bottles (per bottle)	Water	3 (\$10 minimum)

<sup>a</sup>Trace implies a detection limit below 1 mg/L (usually 0.05 mg/L).

<sup>b</sup>The TOC and SUVA packages include certified sample bottles, cooler, field blank, fortified sample, and laboratory QC, and reporting on forms as required by the State of Colorado for sampling one treated and one untreated water source.

<sup>c</sup>For State of Colorado reporting, SUVA package requires TOC package.

## ANALYTICAL SERVICES – ELEMENTAL ANALYSIS

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<b>OTHER DETERMINATIONS (3 samples per test billing minimum)</b>	<b>Fee, \$</b>
Nitrogen (chemiluminescence detection to sub ppm levels)	50
Basic Nitrogen	35
Density or Specific Gravity (liquid)	25
Flash Point (closed cup Pensky-Martens)	60
Water, Karl Fischer Direct Injection (add \$15.00 surcharge for solvent dilution)	40
Water, Karl Fischer (furnace drying, purging water into Karl Fisher titrator)	60

## ANALYTICAL SERVICES – FUEL AND BIOMASS

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The fees listed below include the determination for aliquot appropriate for the analytical technique and instrument used. For solid samples that are received coarser than 250 µm or 60 mesh an additional sample preparation fee ([Page 7](#)) is applied.

Fuel, Biomass, and Refuse-Derived Analysis	Fee, \$
Ash Preparation	30
Ash %	30
Moisture, Ash, Sulfur, BTU (short proximate)	100
Elemental Ash Analysis (requires ash preparation of sample) Al <sub>2</sub> O <sub>3</sub> , CaO, Fe <sub>2</sub> O <sub>3</sub> , MgO, MnO, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O, SiO <sub>2</sub> , Na <sub>2</sub> O, SO <sub>3</sub> , TiO <sub>2</sub>	220
Gross Calorific Value, Heat of Combustion (BTU)	40
Carbon Dioxide	30
Moisture	25
Carbon	30
Hydrogen	25
Nitrogen	25
Carbon, Hydrogen, and Nitrogen	75
Sulfur	30
Proximate Analysis (Moisture, Ash, Volatile Matter, Fixed Carbon)	80
Proximate, BTU, S	140
Ultimate (C, H, N, S, Ash, Moisture, and O by Difference)	155
Ultimate (C, H, N, S, Ash, Moisture, and Direct O)	185
Ultimate, Proximate (O by Difference)	180
Ultimate, Proximate (Direct O)	210
Ultimate, Proximate, BTU (O by Difference)	215
Ultimate, Proximate, BTU (Direct O)	245
Volatile Matter	30
Fluorine	45
Chlorine	45
Dry Screen (up to 12 size fractions)	100
Bulk Density (Loose or Packed)	35
Fusion Temperatures of Ash (Ox or Red) per sample	55
Water-soluble Alkalis <sup>a</sup>	50

<sup>a</sup>Single or group metals available. Call and ask for price information.

Petroleum fuel and hazardous wastes analyses will be 25% more per analysis per sample.

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## ANALYTICAL SERVICES – COAL AND BIOMASS

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<b>Elemental Microanalysis (Solids) Samples with limited sample amount (&lt;2 g) (3 samples per test billing minimum)</b>	<b>Fee, \$</b>
Carbon and Hydrogen	35
Carbon, Hydrogen, and Nitrogen	75
Hydrogen	25
Nitrogen (chemiluminescence)	50
Nitrogen (instrumental Dumas)	25
TKN	70
Oxygen	70
Oxygen (Merz) in the presence of reducible metals or phosphorus	90
Phosphorus	35
Sulfur (Total)	30
Ash	30
Sulfated Ash	40
Carbonate Carbon	30
Total Carbon	30
TOC by Difference (includes Total and Carbonate Carbon determinations)	45
Moisture, Loss on Drying	25

## ANALYTICAL SERVICES – WATER ANALYSIS

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The fees listed below include the determination for an aliquot appropriate for the analytical technique and instrument used. An additional fee ([Page 10](#)) is applied to water or wastewater samples requiring filtration, digestion, or other sample preparation prior to analysis in compliance with certain methods and protocols.

<b>Water Analysis (3 samples per test billing minimum)</b>	<b>Fee, \$</b>
Acidity	30
Alkalinity (Total as CaCO <sub>3</sub> )	25
Alkalinity (OH <sup>-</sup> , CO <sub>3</sub> <sup>2-</sup> , HCO <sub>3</sub> <sup>-</sup> , Total)	35
Bromide	<a href="#">See IC</a> or <a href="#">ICP-MS</a>
Carbon Dioxide	30
Chloride by Titration (can also be determined by <a href="#">IC</a> )	45
Conductance, Specific	20
Fluoride by ISE (can also be determined by <a href="#">IC</a> )	40
Hardness (calculation)	45
Metals	<a href="#">See Page 9</a>
Nitrogen, Ammonia (NH <sub>4</sub> <sup>+</sup> )	40
Nitrogen, Nitrate (NO <sub>3</sub> <sup>-</sup> )	<a href="#">See IC</a>
TKN	70
Nitrogen, Total (chemiluminescence)	50
pH	20
Phosphorus, Total	20
Silica, Dissolved (as SiO <sub>2</sub> )	40
Solids, Dissolved (TDS)	40
TSS	40
TS	30
Sulfur, Total	20
Sulfur, Sulfate	<a href="#">See IC</a>
Sulfur, Sulfide	55
UV Absorbance	40

## ANALYTICAL SERVICES – RADIOCHEMISTRY

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Determination <sup>a</sup>	Fee, \$ per sample	Volume or Weight Requested
Filtration (for samples containing an excess of solids not removed with single filter paper)	50 per analyte preparation	
Gross Alpha		
Liquid	48	1,000 mL
Solid	71	5 g
Sludge	71	400 mL
Gross Alpha/Beta		
Liquid	55	1,000 mL
Solid	77	5 g
Sludge	162	400 mL
Radium-226		
Liquid	77	2,000 mL
Solid	98	5 g
Sludge	98	400 mL
Radium-228		
Liquid	118	2,000 mL
Solid	139	5 g
Sludge	139	400 mL
Radon in water	57	40 mL × 2 glass bottles
Thorium (Total) by ICP-MS	85	5 g
Uranium by ICP-MS		
Liquid	70	250 mL
Solid	85	5 g
Drinking water composition	35	
Moisture	25	
Sample preparation	25	
Environmental waste management	4	
Sampling containers and shipping <sup>b</sup>	2 per bottle plus shipping	
CDPHE data upload	10	
Minimum charge	100 per order	

<sup>a</sup>For analysis in this group, please use a COC, which is available on our website ([See Page 1](#)).

<sup>b</sup>To request sample bottles, please email [analytical@hazenresearch.com](mailto:analytical@hazenresearch.com). Hazen is CDPHE-certified for Gross Alpha/Beta, combined radium (Ra-226 and Ra-228), and uranium analyses in drinking water.

## PRECIOUS METALS RECOVERY

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### **GRAVITY SEPARATION..... By Quote**

Mineral Technologies spirals; diagnostic heavy liquid separation; jigs; Wilfley, Deister, and Gemeni shaking tables; Gold Strake Knelson KC-MD3 centrifugal concentrator; Falcon L-40 concentrator; and cyclone size separators are available for gold, silver, and platinum recovery.

### **CHEMICAL PROCESS DEVELOPMENT ..... By Quote**

Heap, cyanidation, bottle roll, and agitation leaching, zinc precipitation, carbon-in-pulp process, pressure oxidation, chlorination, roasting, and effluent treatment.

### **PLACER GOLD RECOVERY ..... By Quote**

Pound to ton quantities of deposit material evaluated by gravity and fire assay techniques. Please contact Hazen for more information.

### **MINERALOGICAL CHARACTERIZATION OF GOLD ORE ..... \$5,000**

Samples will be subjected to a sizing and upgrading procedure that provides preliminary information on the response to gravity concentration and on liberation–locking and other characteristics pertinent to processing. This procedure also enhances the detection of a statistically valid number of gold particles.

### **METALLIC ASSAY PROCEDURE ..... \$350**

## MINERALOGY

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**POLARIZING LIGHT MICROSCOPY**..... \$875  
Research microscopes with complete accessories, including digital photomicrographic equipment; used for polarized, transmitted, and reflected light microscopic analysis of rock, ore, and metallurgical product samples, to include mineral identification, paragenesis determination, textures, liberation characteristics, and grain sizes and distributions. Sample preparation not included.

**SEMI-QUANTITATIVE X-RAY DIFFRACTOMETRY**..... \$300  
Semi-quantitative XRD utilizes a Bruker D8 Advance with Davinci design and a Lynxeye detector and state-of-the-art software packages to analyze rock samples or mineral mixtures to identify the crystalline phases and determine the relative amounts. Sample preparation includes pulverizing to very fine powder and scanning the powder on the XRD instrument. The technique requires very little material for analysis (minimum of 0.5 g). In some cases, distinct peaks can suggest multiple phases, or interferences due to overlapping peaks that can lead to erroneous interpretation or inconclusive results. In situations like this knowledge of the chemical composition is essential.

**QUANTITATIVE X-RAY DIFFRACTOMETRY** ..... \$375  
Quantitative XRD utilizes a Bruker D8 Advance with Davinci design and a Lynxeye detector and state-of-the-art software packages to analyze rock samples or mineral mixtures. Results are reported as weight percent of minerals and can be performed using Rietveld Refinement procedures on all crystalline phases. Sample preparation includes pulverizing to a very fine powder and scanning the powder. The technique requires 3 to 5 g of material for analysis. In some cases, distinct peaks can suggest multiple phases, or interferences due to overlapping peaks that can lead to erroneous interpretation or inconclusive results. In situations like this knowledge of the chemical composition is essential.



## MINERALOGY

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### **CLAY CHARACTERIZATION** ..... By Quote

Clay identification can be done on particle size or clay mineral speciation. All mineral particles  $\leq 2 \mu\text{m}$  are of a clay particles size, but do not necessarily represent a clay mineral species.

Settling, filtration and other associated dewatering problems can be caused by both the particle size distribution and/or speciation of the clay mineral phases present.

This clay characterization scope of work aims to address both these issues and may include, but is not limited to:

- Attrition (where and if necessary)
- Wet screening to acquire either the minus 45, minus 25 or minus 20  $\mu\text{m}$  size fraction. If not agreed upon with the client upfront, screening will take place at 25  $\mu\text{m}$ .
- Filtration of the fines slurry to produce a damp filter cake
- Particle size distribution by Horiba laser diffraction size analyzer on a re-slurried aliquot of the damp filter cake
- XRD by Bruker D8 Advance, with Davinci design and Lynxeye detector on a dried pulverized aliquot of the filter cake to identify the clay mineral species and estimate the proportion of swelling and non-swelling clays. XRD will be conducted on an aliquot of the sample:
  - As is
  - Glycolated
  - Heated to 550°C

### **ELECTRON MICROPROBE – POINT MINERAL AND PHASE ANALYSIS** ..... By Quote

Hazen offers, in conjunction with our business partners at renowned research institutions in Colorado, USA a comprehensive electron microprobe analysis service.

This service includes, but is not limited to, quantitative (standardized) point analysis by EDS and or WDS on various phases, including minerals, metals, manufactured products, and contaminants. The detection limit is approximately 0.1 wt% for the EDS and approximately 0.05 wt% for the WDS. These detection limits are sample and phase dependent. Samples are usually set in epoxy resin, as polished blocks and or thin sections.

## MINERALOGY

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### **QEMSCAN – AUTOMATED QUANTITATIVE SCANNING ELECTRON MICROSCOPY**

..... By Quote

The QEMSCAN is an automated SEM based instrument, similar to the MLA and TIMA. It provides rapid quantitative analysis of minerals and other inorganic materials. The Hazen QEMSCAN is based on a Thermo Fisher-FEI Quanta 650FEG SEM, with a large specimen chamber, two high speed Bruker XFlash 6/30 SDD EDS and state-of-the-art iDiscover automated quantitative image analysis software.

The QEMSCAN can analyze a wide range of sample types, including geological samples, such as hand specimens, drill cores and chips, and metallurgical samples, such as concentrator and other processing plant feeds and products. Samples can include both natural and manufactured products. These are usually set in epoxy resin, as polished blocks and or thin sections.

The most common datasets produced include, but are not limited to:

- Bulk mineral composition
- Elemental deportment
- Mineral liberation analysis
- Mineral grain size distribution (GSD)
- Mineral association analysis
- Particle characterization and classification
- Particle size distribution (PSD)
- Precious metal (Au, PGM, and Ag) deportment studies
- Trace mineral search analysis, including rare earth elements
- SEM-microscopy
- Secondary electron imaging
- Backscatter electron imaging
- Qualitative and quantitative (without standards) EDS analysis
- Mineral and elemental mapping

**POLISHED SECTION PREPARATION..... \$100 per specimen**

- Vacuum and pressure epoxy impregnated 30 mm mounts
- Using automated Struers Equipment

## LIMESTONE SORBENT CHARACTERISTICS

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**LIMESTONE SO<sub>2</sub> REACTIVITY STUDY** ..... \$950

Limestone SO<sub>2</sub> reactivity study by TGA provides a graphic representation of a sorbent's ability to absorb SO<sub>2</sub> from a gas stream. Useful for comparing characteristics of individual sorbents to a database for qualitative rankings.

**THERMAL DECREPITATION TEST (STATIC TEST)** ..... \$300

Certain limestones lose their structural bond when heated, thereby reducing the particle size distribution of the overall sample by decrepitating to smaller particles. Size retention is important for bubbling fluidized-bed applications. Decrepitation may be beneficial in some circulating fluidized-bed applications. Using this test, potential limestone sources are compared and ranked for their relative abilities to resist decrepitation.

**DYNAMIC ATTRITION TEST** ..... By quote

The static test is not adequate for making comparisons in certain applications. A dynamic test is more appropriate. This procedure evaluates the change in mean particle size of a limestone having a close size range during a two-hour period of high temperature fluidization. The test is conducted in a two-inch fluidized-bed furnace.

**COMBUSTION TESTING**

The most accurate method for determining the sorbent requirement for reducing sulfur dioxide emissions to an acceptable level is to conduct an actual test. Hazen uses pilot plant fluidized-bed test equipment to conduct these determinations.

Each test requires eight hours. This includes the time required to heat the test stand to thermal equilibrium and to establish steady-state operating conditions.

A cost quotation will be provided upon request. Because of the extensive test work required, this procedure is reserved for making final comparisons. Candidates for testing are usually the two or three highest ranking limestones.

**QUICKLIME PROPERTIES**

Properties of the quicklime produced from the limestone material are important if the quality of the sample warrants lime production. Standard ASTM procedures can be used to measure characteristics of quicklime produced from calcining the limestone. Slaking rate and hydrate acid neutralization potential are included. Contact us and ask for our pyrometallurgy department for a quotation.

## COMMINUTION AND GRINDABILITY

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The fee per test includes sample preparation, engineer oversight, and reporting. For larger samples (greater than four times the sizes listed below), please [contact us](#) for pricing. Sample disposal or shipping is not included in the cost.

<b>Breakage Characterization – JKTech Procedures</b>	<b>Fee, \$</b>
Full drop-weight test procedure (requires 80–100 kg of minus 4 in. material)	6,000
SMC test (requires 12 kg of <sup>1</sup> / <sub>4</sub> core or 20 kg of minus 2 in. rock)	2,500
Integrated full drop weight and SMC test (requires 80–100 kg of minus 4 in. material)	7,000
Bond rod mill grindability (requires 25 kg of minus <sup>1</sup> / <sub>2</sub> in. material)	1,000
Bond ball mill grindability (requires 12 kg of minus 6 mesh material)	1,000
Bond abrasion test (requires 1.6 kg material, <sup>3</sup> / <sub>4</sub> by <sup>1</sup> / <sub>2</sub> in.)	450
SAG feed belt cut particle size distribution, up to 500 kg	3,500

## VISCOMETRY

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Listed prices are for determinations performed on common matrices and at standard or noted conditions. High temperatures and or unusual matrix requests are quoted individually.

The fees listed below include the determination for an aliquot appropriate for the analytical technique and instrument used. A sample preparation fee ([Page 7](#)) is applied to solid samples that are received coarser than 100 µm or 150 mesh.

<b>Viscometry</b>	<b>Instrument</b>	<b>Fee, \$</b>
Rheology, rotational, non-Newtonian materials	Anton-Paar RheolabQC	200
Viscosity, rotational, Newtonian fluids	Brookfield LVT	150
Viscosity, falling sphere, Newtonian fluids	Gilmost	125

Temperature control at 0–90°C for all methods; determination at higher temperature upon request.

## THERMAL ANALYSIS

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Thermal Analysis	Fee, \$
<b>Limestone</b>	
<b>SO<sub>2</sub> Reactivity Study by TGA</b>	950
Limestone SO <sub>2</sub> reactivity study by TGA provides a graphic representation of a sorbent's ability to absorb SO <sub>2</sub> from a gas stream; useful for comparing characteristics of individual sorbents as a qualitative ranking.	
Customized run conditions, simultaneous techniques, and analytical interpretation assistance available on request, by quote.	By Quote
<b>TGA</b>	
Samples up to 1,000°C	450
Samples up to 1,400°C	650
Determines weight losses or gains of a sample as a function of temperature and or time to study weight changes and oxidation reactions under programmed heating rate conditions.	
Macro TGA (Samples up to 1,100°C)	750
Determines the weight loss or gains of a sample as a function of temperature using a sample cup up to 5 mL to generate a larger sample for additional analysis.	
<b>Simultaneous Analyses</b>	
<b>TGA and DSC</b>	
Samples up to 1,100°C	750
Samples up to 1,400°C	950
Simultaneously measures the weight losses or gains of a sample and the heat associated with the chemical or physical changes occurring in the material as a function of temperature or time.	
<b>TGA and DTA</b>	
Samples up to 1,100°C	750
Samples up to 1,400°C	950
Simultaneously measures the weight loss or gain of a sample and detects the temperature difference between a sample and an empty reference cup. The DTA records the temperature difference as endothermic or exothermic reactions occurring in the sample. Can be used to measure temperatures of phase transitions, melting points, volatilizations, and dehydrations.	
<b>Heat Capacity</b>	
Samples up to 1,100°C	1,500
Samples up to 1,400°C	2,000
Measures the heat capacity of a material by comparing the DSC signal to a known reference material in an inert atmosphere at a slow heating rate. This can be useful in determining the heat requirement of a material within a system. For multiple analyses, each additional sample cost is \$750. Customized run conditions (heat rate, soak temperature/time, atmospheres), simultaneous techniques, and analytical interpretation assistance are available on request, by quote.	