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ANALYTICAL LABORATORY SERVICES
FEE SCHEDULE

Effective January 1, 2026

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

www.hazenresearch.com

Serving the Mineral and Chemical Industries Since 1961

CONTENTS

LIST OF ABBREVIATIONS

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

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GENERAL INFORMATION

SUBMISSION FORMS

To order analyses at Hazen Research, Inc. please complete our Analytical Request Form (ARF). To order radiochemical analyses please complete the Chain of Custody (COC) form. The forms can be downloaded from our website. Please include a copy of the ARF or COC with the samples you submit to Hazen.

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 7.

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. Samples that are not packaged properly may be rejected. Please secure samples in sealed containers to prevent leaking, spilling, and exposure. If the sample is hazardous, label the package properly with the type of hazard(s) and include a safety data sheet (SDS). If a sample is found to be hazardous and was not labeled as such, there will be an additional handling fee of $50 per job. Radioactive material will be charged an additional handling fee of $350 per job for disposal or return shipping.

Order confirmations for requested analyses will be emailed within three 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 by sending an email to 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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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 and must be precoordinated by emailing analytical@hazenresearch.com before sending your sample. Priority results are typically delivered within ten working days. However, Hazen does not guarantee results will be provided within that number of days.

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 ($), and unless otherwise specified, are per sample.

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

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 they do not meet expectations. Upon reasonable request, Hazen will 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. The data include associated raw data, including calibration curve, bracketing QC, 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.

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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.

We accept cash, check, purchase order, electronic payment, or credit card (Visa, MasterCard, American Express, and Discover) for payment of services. The credit card limit is $2,500. Credit card payments can only be made online at 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 the Sample Receiving department at samplereceiving@hazenresearch.com to make arrangements once all outstanding invoices are paid in full.

If requesting disposal, SDS must be provided to verify that samples meet requirements for disposal classification. A fee of $8 per sample will be charged if a disposal agreement is reached.

A $20 per sample surcharge will be added to orders requiring special packaging and labeling as hazardous materials. Packages exceeding a radiation level of 0.5 mrem/h will have an additional shipping fee. Treatment and disposal of samples and containers handled under Hazen's Radioactive Materials License have a $50 minimum fee per sample batch.

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 for a fee of $4 per sample.

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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.

SPECIAL LICENSING

We are certified by CDPHE for drinking water radiochemical and inorganic chemical analyses.

We maintain Radioactive Materials License CO 077-02 to ensure the safe and responsible use and handling of radioactive materials.

We are licensed by the 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.

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SAMPLE PREPARATION

Preparation or Determination	Fee, $
Routine Preparation	
Rock and ore (crushing and grinding to 75 µm or 200 mesh)	$30 for the first 2 lb $3 per lb for each additional lb
Coal	$30 for the first 5 lb $3 per lb for each additional lb
Wood and biomass	$30 for 1 gal container or smaller $100/h for larger quantities
Industrial waste	Time basis, $100/h
Municipal waste	$30 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_2 (up to 10 lb)	$50 per sample
Biohazardous and specialty prep	$50 per sample
Custom Preparation	
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
PSD	
Basic dry screen analysis using Ro-Tap (up to 1 kg, from 1.7 mm to 75 µm, up to 5 size fractions)	$100 per sample
Basic wet screen analysis (up to 1 kg, from 1.7 mm to 38 µm, up to 7 size fractions)	$350 per sample
Additional sample, size fractions, or high clay material	By quote
PSA	
Horiba LA-950V2 laser diffraction size analyzer	$200 per sample
Density	
Bulk density (loose and packed)	$35 per sample
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 the Mineralogy department to find out more.

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SAMPLE QUANTITY REQUIREMENTS

Analysis Requested	Weight or Volume	
	Required	Requested
AA		
Solid	0.2–0.5 g	10 g
Liquid	1 mL	10 mL
FA, FA with AA Finish, FA with ICP–OES Finish		
Solid	30 g	100 g
ICP–OES and ICP–MS		
Solid	0.2–0.5 g	10 g
Liquid	1 mL	10 mL
Carbon, Hydrogen, Nitrogen, Oxygen, or Sulfur		
Solid	2 g	10 g
PSA	5 g	10 g
PSD	250 g	500 g
Radiochemistry		
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	1,000 mL	2,000 mL
Sludge per isotope	1 g	5 g
Radon (water) (special glass containers)	125 mL	250 mL
Thorium (Total)		
Solid	0.5 g	5 g
Water	1,000 mL	1,000 mL
Uranium and Lead		
Solid	0.2–0.5 g	10 g
Water	1 mL	10 mL
Wet Chemistry TOC		
Solid	1 g	10 g
Liquid	120 mL	500 mL
Anions		
Solid	10 g	20 g
Liquid	20 mL	50 mL
XRF		
Solid	25 g	50 g
Fuel and Biomass Analysis	250 g	1 gal Ziplock bag

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ANALYTICAL SERVICES

ELEMENTAL ANALYSIS

The fees listed in the table include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution or preparation fee (Page 6) may apply. Individual analytes may be determined by AA, ICP–OES, or FA.

Determination	Fee, $	Determination	Fee, $
Aluminum	25	Neodymium	25
Antimony	25	Nickel	25
Arsenic	25	Palladium (FA, ICP–OES finish)	50
Barium	25	Phosphorus (liquids) (ICP–OES)	25
Beryllium	25	Platinum (FA, ICP–OES finish)	50
Bismuth	25	Pt/Pd (FA, ICP–OES finish)	70
Boron	25	Pt/Pd/Rh (FA, ICP–OES finish)	90
Cadmium	25	Potassium	25
Calcium	25	Praseodymium	25
Cerium	25	Rhenium	25
Chromium	25	Rhodium (FA, ICP–OES finish)	50
Cobalt	25	Samarium	25
Copper	25	Scandium	25
Dysprosium	25	Selenium	30
Erbium	25	Silicon	25
Gadolinium	25	Silver (FA, gravimetric)	45
Gallium	25	Silver (FA, AA finish)	55
DIBK Gold (AA)	75	Sodium	25
MIBK Gold (AA)	75	Strontium	25
Gold (bullion)	70	Sulfur (liquid)	25
Gold (FA, gravimetric)	45	Tantalum	25
Gold and silver (FA, gravimetric)	55	Tellurium	50
Gold (FA, AA finish)	55	Thallium	25
Gold and Silver (FA, AA finish)	65	Thorium	25
Holmium	25	Thulium	25
Iron	25	Tin	25
Lanthanum	25	Titanium	25
Lutetium	25	Tungsten	40
Lead	25	Uranium	45
Lithium	25	Vanadium	25
Mercury (Direct mercury analysis)	80	Yttrium	25
Magnesium	25	Ytterbium	25
Manganese	25	Zinc	25
Molybdenum	25	Zirconium	25

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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	20
Fusion	30
Oxygen bomb combustion	20
Leach	10

LIQUID SAMPLE PREPARATION

Preparation Method	Fee, $
Filtration	15

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The fees listed in the following table include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and preparation fee (Page 6) may apply.

INDUCTIVELY COUPLED PLASMA–OPTICAL EMISSION SPECTROSCOPY

Quantitative Multi-Element Analysis

ICP–OES	Fee, $
ICP–OES Single Element An additional charge for the appropriate prep (4-acid or fusion) required based on the selected individual elements.	25
ICP–OES Scan - (Liquid Samples) Elements included: Al, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Re, S, Sb, Se, Si, Sr, Te, Th, Ti, Tl, V, Y, Zn, Zr	155
ICP–OES Scan[a] - (Solid Samples) by 4-Acid Digestion Elements included: Al, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Re, Sb, Sr, Te, Th, Ti, V, Y, Zn, Zr • 4-acid digestion is an additional $20 per sample. • Silicon is not included but is available by request for an additional $45 fee for fusion. • Sulfur is not included but is available by request for an additional $30 fee for LECO analysis.	155
ICP–OES Rare Earth Scan[b] Elements included: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Tm, Y, Yb • Solids require a fusion digestion for an additional $20 per sample.	180

[a]A 4-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, sulfur, titanium, and zirconium are not truly quantitative using this dissolution method and analysis.

[b]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 in the following table include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and preparation fee (Page 6) may apply.

INDUCTIVELY COUPLED PLASMA–MASS SPECTROMETRY

Quantitative Single and Multi-Element Analysis

ICP–MS[a]	Fee, $
First element	70
Any additional element	10 per element
ICP–MS Rare Earth Scan Elements included: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Tm, Y, Yb • Solids require a fusion digestion for an additional $20 per sample.	230
Full Scan (ICP—MS and ICP–OES Scan) Elements included: Ag, Al*, As, Au, Ba, Be, Bi, Ca*, Cd, Co, Cr, Cs, Cu, Fe*, Ga, Ge, In, Ir, K*, Li, Mg*, Mn, Mo, Na*, Nb, Ni, P*, Pb, Pd, Pt, Rb, Rh, Ru, S*, Sb, Se, Sn, Sr, Th, Ti, Tl, U, V, Zn*, Zr *Elements analyzed by ICP–OES. • Solids require a 4-acid digestion for an additional $20 per sample.	400
ICP–MS Waste Determination Elements included: Ag, As, Ba, Be, Cd, Co, Cr, Hg, Mo, Ni, Pb, Se, Th, Zn • Mercury by direct mercury analysis.	280

[a]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 (μg/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.

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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 6) may apply.

XRF	Fee, $
Semiquantitative and Qualitative Multi-Element Analysis[a] 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, Zn, Zr	65
Quantitative Multi-Element Analysis[b] Borate Fusion Whole Rock Package Borate fusion analytes by XRF: Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, SiO_2, SO_3, TiO_2, Ba, Ce, La, Nb, Sr, Ta, Th, U, Y, Zn, Zr, LOI	130

[a]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 parameter concentrations are assigned to the specified intensities. This is a qualitative method only and is appropriate for general material characterizations.

[b]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.

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The fees listed in the following table include the determination for an aliquot appropriate for the analytical technique and instrument used. For solid samples an additional dissolution and preparation fee (Page 6) may apply.

ANALYSIS FOR ORGANIC HALOGEN (Cl+Br reported as Cl)	**Matrix**	**Fee, $**
Total Organic Halogen (TOX) — Duplicate analysis required for EPA SW-846-9020	Water	100
EOX	Soil	100
TX	Any	80

ION CHROMATOGRAPHY	**Fee, $**
Quantitative Anion Determination (F^-, Cl^-, Br^-, SO_4^{2-})	150
First anion	55
Each additional anion	25

ANALYSIS FOR ORGANIC CARBON	**Matrix**	**Fee, $**
TOC	Water	35
Trace TOC[a]	Water	45
DOC	Water	
Total		50
Trace		60
Total Organic Carbon by Difference	Soil	50
Colorado State Drinking Water Package for TOC[b]	Water	180
Colorado State Drinking Water Package for SUVA[c]	Water	185
Certified Clean TOC Bottles (per bottle)	Water	3 ($10 minimum)

[a]Trace implies a detection limit below 1 mg/L (usually 0.05 mg/L).

[b]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.

[c]For State of Colorado reporting, SUVA package requires TOC package.

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OTHER DETERMINATIONS	Fee, $
Nitrogen (chemiluminescence detection to sub ppm levels)	55
Basic Nitrogen	35
Density or Specific Gravity (liquid)	25
Flash Point (closed cup Pensky-Martens)	60
Water, Karl Fischer Direct Injection for liquids (add $15 surcharge for solvent dilution)	40
Water, Karl Fischer for solids (furnace drying, purging water into Karl Fisher titrator)	60

ANALYSIS BY WET CHEMISTRY	Fee, $
Ammonium	40
Carbon, total	30
Carbon dioxide (carbonate carbon)	30
Carbon, organic	50
Chloride, soluble	55
Chloride, total	55
Fluorine (solid)	75
Ferrous[a]	40
Nitrogen (Dumas)	25
Nitrogen (total chemiluminescence)	55
Phosphorus (yellow method)	75
Sulfur, total (solid)/(liquid)	30/25
Sulfur, sulfate (solid)	50
Sulfur, sulfide (Na_2CO_3) (solid)	60
Sulfur, sulfide (HCl) (solid)	60
Sulfur, sulfide (NaOH) (solid)	80
Sulfur, elemental (solid)	50

[a]Ferrous determination requires a 48 h hold time. Please notify us in advance when requesting this analysis.

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FUEL AND BIOMASS

The fees listed in the following table 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 6) is applied.

Fuel, Biomass, and Refuse-Derived Analysis	Fee, $
Preparation	
Ash preparation	30
Dry screen (up to 12 size fractions)	100
Bulk density (loose and packed)	35
Analysis	
Ash %	30
Moisture, ash, sulfur, BTU (short proximate)	100
Elemental ash analysis (includes ash preparation and acid digestion of sample) Al_2O_3, CaO, Fe_2O_3, MgO, MnO, P_2O_5, K_2O, SiO_2, Na_2O, SO_3, TiO_2	270
Gross calorific value, heat of combustion (BTU)	40
Carbon dioxide/carbonate carbon *There is an additional $30 fee if ash preparation is required.	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
Mercury (mercury direct analyzer)	80
Proximate, BTU, S	140
Ultimate (C, H, N, S, ash %, moisture, and O by difference)	155
Ultimate, proximate (O by difference)	180
Ultimate, proximate, BTU (O by difference)	215
Volatile matter	30
Fluorine	75
Chlorine	55
Water, Karl Fischer Direct Injection for liquids (add $15 surcharge for solvent dilution)	40
Water, Karl Fischer for solids (furnace drying, purging water into Karl Fisher titrator)	60
Water-soluble alkalis[a]	50

[a]Single or group metals available, see Page 8. Call and ask for price information.

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ELEMENTAL MICROANALYSIS

Elemental Microanalysis (Solids) Samples with limited sample amount (<2 g)	Fee, $
Carbon and hydrogen	55
Carbon, hydrogen, and nitrogen	75
Nitrogen (chemiluminescence)	55
Nitrogen (instrumental Dumas)	25
TKN	80
Sulfur (total)	30
Ash	30
Sulfated ash	40
Carbonate carbon	30
Total carbon	30
TOC by difference (includes total and carbonate carbon determinations)	50
Moisture, loss on drying	25

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WATER ANALYSIS

The fees listed in the following table include the determination for an aliquot appropriate for the analytical technique and instrument used. An additional fee (Page 9) is applied to water or wastewater samples requiring filtration, digestion, or other sample preparation prior to analysis in compliance with certain methods and protocols.

Water Analysis	Fee, $
Acidity	30
Alkalinity (total as $CaCO_3$)	25
Alkalinity (OH^-, CO_3^{2-}, HCO_3^-, total)	35
Bromide	See IC
Carbon dioxide	30
Chloride by titration (can also be determined by IC)	55
Conductance, specific	20
Fluoride by ISE (can also be determined by IC)	75
Metals	See Page 8
Nitrogen, ammonia (NH_4^+)	40
Nitrogen, nitrate (NO_3^-)	See IC
TKN	80
Nitrogen, total (chemiluminescence)	55
pH liquid/solids	20/30
Phosphorus, total (yellow)	75
Solids, dissolved (TDS)	40
TSS	40
TS	30
Sulfur, total	30
Sulfur, sulfate	See IC
UV absorbance	40

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RADIOCHEMISTRY

Hazen is CDPHE-certified for Gross Alpha/Beta, combined radium (Radium-226 and Radium-228), and uranium analyses in drinking water.

Please complete a Chain of Custody (COC) form for the following analyses, which is available at www.hazenresearch.com.

Determination	Fee, $ per sample
Filtration (for samples containing an excess of solids not removed with single filter paper)	50 per analyte preparation
Gross Alpha	
Liquid	50
Solid/sludge	75
Gross Alpha/Beta	
Liquid	60
Solid/sludge	85
Radium-226	
Liquid	90
Solid/sludge	100
Radium-228	
Liquid	120
Solid/sludge	145
Radon in water	60
Lead by ICP–MS	
Liquid	70
Solid	90
Uranium by ICP–MS	
Liquid	70
Solid	90
Drinking water metals (ICP–MS)	
(As, Ba, Be, Cd, Cr, Cu, Fe, Pb, Hg, Mn, Ni, Se, Tl, Zn)	250
Hardness (Ba, Ca, Mg, Sr)	85
Composite of quarterly drinking water	35
Moisture—sludge only	25
Sample preparation for solids	25
Environmental waste management	4
Sampling containers [a]	2 per bottle plus shipping
CDPHE data upload per job	10

[a]To request sample bottles, please email analytical@hazenresearch.com.

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PRECIOUS METALS RECOVERY

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

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MINERALOGY

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.

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CLAY CHARACTERIZATION …… By Quote

Clay identification can be done on particle size or clay mineral speciation. All mineral particles ≤2 µm 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 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 µm size fraction. If not agreed upon with the client upfront, screening will take place at 25 µm.
- Filtration of the fines slurry to produce a damp filter cake
- Particle size distribution (PSD) by Horiba laser diffraction size analyzer on a re-slurried aliquot of the damp filter cake
- X-ray diffraction (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 under the following conditions:
    - 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 WDS on various phases, including minerals, metals, manufactured products, and contaminants. The detection limit is approximately 0.1 wt% for EDS and approximately 0.05 wt% for WDS. These detection limits are sample and phase dependent. Samples are usually set in epoxy resin, as polished blocks or thin sections.

QEMSCAN – AUTOMATED QUANTITATIVE SCANNING ELECTRON MICROSCOPY …… By Quote

QEMSCAN technology is an automated SEM-based system, similar to MLA and TIMA, providing rapid quantitative analysis of minerals and other inorganic materials. The Hazen QEMSCAN instrument is based on a Thermo Fisher-FEI Quanta 650FEG SEM, with a large specimen chamber, two high speed

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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 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
- PSD
- Precious metal (Au, PGM, and Ag) deportment studies
- Trace mineral search analysis, including rare earth elements
- SEM
- 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

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LIMESTONE SO_2 REACTIVITY STUDY $950

Limestone SO_2 reactivity study by TGA provides a graphic representation of a sorbent's ability to absorb SO_2 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 2 h period of high temperature fluidization. The test is conducted in a 2 in. 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 8 h. 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 to receive a quotation.

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COMMINUTION AND GRINDABILITY

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.

Description	Fee, $
JKTech Full drop-weight test procedure (requires 80–100 kg of minus 4 in. material)	6,000
SMC test (SAG Mill Comminution) (requires 15 kg of 1/4 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
RW Bond rod mill grindability (requires 25 kg of minus 1/2 in. material)	1,000
Bond ball mill grindability at a closing size of 200–400 mesh (requires 10–15 kg of minus 6 mesh material)	2,000
Bond abrasion test (requires 2 kg material, 3/4 by 1/2 in.)	450
SAG feed belt cut particle size distribution, up to 500 kg	3,500

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VISCOMETRY

Listed prices are for determinations performed on common matrices and at standard or noted conditions. High temperatures and 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 6) is applied to solid samples that are received coarser than 100 µm or 150 mesh.

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

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THERMAL ANALYSIS

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

Thermal Analysis	Fee, $
Limestone	
SO_2 Reactivity Study by TGA	950
Limestone SO_2 reactivity study by TGA provides a graphic representation of a sorbent's ability to absorb SO_2 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
TGA	
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.	
Simultaneous Analyses	
TGA and DSC	
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.	
TGA and DTA	
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.	
Heat Capacity	
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.	

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