



Department of  
Earth & Atmospheric Sciences  
Minerals Lab; Attn: Dr. Kackstaetter  
Campus Box 22, P.O.Box 173362  
Denver, CO 80217-3362

- Erase &/or replace everything in LIGHT GRAY print with your own writing in black -

[PROJECT TITLE]

[Your title should summarize the purpose of the paper & should include the mineral name.]

[YOUR NAME]

[GROUP PARTNER NAMES IF APPLICABLE]

[DATE]

[COURSE ID]

for

[CLIENT NAME]

[CLIENT CONTACT INFORMATION]

*Disclaimer:* While every care has been taken to correctly identify the submitted specimen, information contained in this report is to be considered "AS-IS" and NO WARRANTY for its correctness is given or implied. Neither Metropolitan State College of Denver, the Department of Earth & Atmospheric Science nor its affiliates, professors and students shall be liable for any loss or damage to submitted mineral samples nor for any damages, including but not limited to injuries, loss of property or profits, or incidental, consequential, exemplary, special or other damages that may result from use of reported analytical results.

CLIENT INFORMATION:

Last Name:	First Name, MI:	Date:
Address:	City:	State, ZIP
Phone:	Email:	

MINERAL SAMPLE INFORMATION & ANALYTICAL REQUEST:

Short Mineral Description:	
Where found (approx. location o.k.):	
<p><b>Requested Laboratory Tests (Check all that apply)</b>  <i>Suggestion: For destructive sample testing, please submit additional secondary sample chips of same material</i></p> <p><input type="checkbox"/> BASIC MINERAL IDENTIFICATION incl. XRF - NON DESTRUCTIVE  <input type="checkbox"/> ADD'L WET CHEMICAL QUALITATIVE ANALYSIS (ICP-MS / AAS / Chromatographic) - DESTRUCTIVE  <input type="checkbox"/> OPTICAL TESTS: <input type="checkbox"/> Grain Mount - DESTRUCTIVE; <input type="checkbox"/> Refractometer -limited to suitable samples (NON DESTR.)  <input type="checkbox"/> X-RAY DIFFRACTION ANALYSIS - DESTRUCTIVE  <input type="checkbox"/> <b>Coming soon!</b> SCANNING ELECTRON MICROSCOPY - NON DESTRUCTIVE</p>	
<p>Comments:</p> <p><input type="checkbox"/> Please Return Sample: <input type="checkbox"/> SASE included or <input type="checkbox"/> Will pick up.  <input type="checkbox"/> Discard sample after analysis: <input type="checkbox"/> Just mail report or <input type="checkbox"/> Will pick up report</p>	<p>Voluntary Suggested Donation:  <input type="checkbox"/> \$60 <input type="checkbox"/> \$30 <input type="checkbox"/> \$15 <input type="checkbox"/> \$8  <i>(Make Checks payable to MSU Denver  Earth Science Foundation)</i></p>

By submitting the mineral sample for analysis I agree to following terms and condition: Neither Metropolitan State University of Denver, the Department of Earth & Atmospheric Science nor its affiliates, professors and students shall be liable for any loss or damage to submitted mineral samples nor for any damages, including but not limited to injuries, loss of property or profits, or incidental, consequential, exemplary, special or other damages that may result from use of reported analytical results.

## **Introduction**

Thank you for choosing the mineral analytical services at the mineral laboratories of the Earth and Atmospheric Sciences Department at the Metropolitan State University of Denver. Your request has aided in the training of future geoscience professionals, endowing them with valuable skills and knowledge in mineral assessment and identification.

The final outcome of our investigation is summarized below followed by the results for each specific analytical procedure as indicated in the Table of Contents. We hope that this report will be helpful to you, further your endeavors and satisfy your curiosity.

Please let us know if we can be of future service which could include larger projects involving an undergraduate researcher. Feel free to contact us if you have any questions.

Sincerely



Prof. Dr.rer.nat. Uwe Richard Kackstaetter (Dr.K)  
*Full Professor of Geology - Specializing in Applied Geology and Mineralogy*  
Department of Earth & Atmospheric Sciences  
Metropolitan State University of Denver  
Office: SI2025 (303) 615-0789 kackstae@msudenver.edu

**Table of Contents**

MINERAL IDENTIFICATION RESULTS .....	4
RESULTS COMPARISON - ANALYTICAL vs. MINERAL DATA.....	5
SPECIFIC GRAVITY DETERMINATION .....	6
HYDROSTATIC PAN METHOD .....	6
PYCNOMETER METHOD .....	6
HARDNESS, COLOR, LUSTER, STREAK .....	7
MOHS HARDNESS (HM) TEST .....	7
COLOR TEST.....	7
LUSTER TEST.....	8
STREAK TEST.....	8
MAGNETISM, RADIOACTIVITY, ORGANOLEPTIC, UV .....	9
MAGNETISM TEST .....	9
RADIOACTIVITY TEST .....	9
ORGANOLEPTIC TEST.....	10
UV LIGHT EMISSION TEST .....	10
SIMPLE CHEMISTRY & FLAME TESTING.....	12
FUSIBILITY & FLAME COLOR .....	12
OPEN & CLOSED TUBE TEST .....	12
SOLUBILITY TEST.....	13
ION CHROMATOGRAPHY PAPER TEST.....	13
DRY XRF and XRD ANALYSIS .....	16
XRF (X-RAY FLUORESCENCE) SEMI QUANTITATIVE CHEMICAL ANALYSIS .....	16
XRD (X-RAY DIFFRACTION) CRYSTALLOGRAPHIC ANALYSIS with DATA INTERPRETATION .....	17
WET GEOCHEMICAL ANALYSIS .....	19
SAMPLE DIGESTION AND ANALYSIS.....	19
OPTICAL MINERAL IDENTIFICATION.....	20
GEM REFRACTOMETER ASSESSMENT.....	20
POLARIZED LIGHT MICROSCOPE (PLM) ASSESSMENT OF SAMPLE GRAINS.....	21
CITATIONS.....	22

## MINERAL IDENTIFICATION RESULTS

Mineral name: **[Mineral Name]**

*Mineral group:* **[Mineral Group]**

Chemical Formula: **[Chemical Formula]**

[(Paste Picture of Client Sample here)]

**Locality:**

[Describe collection locality as indicated by the client or “unknown”]

**Sample submitted by:**

[List client name and contact information]

[Conclusion / Interpretation of results goes here. Write a few short paragraphs in professional, but simple laymen terms explaining the outcome of your investigation.

**OBJECTIVE:** Interpretation of results and support for all of your conclusions, using ascertained experimental or observational evidence. The significance of findings should be clearly described.

Explain a phenomenon by describing mechanisms and/or supporting evidence that may account for the observation. Interpret the results holistically by connecting individual analytical results., e.g.; paper chromatography, XRF data and wet geochemical analysis confirm the presence of Fe and Ti in the sample.

Try to offer alternative explanations if reasonable alternatives exist. If needed, imply that a decision can not be made with confidence based on detailed reasoning.

Refer to any of the subsequent analytical results pages.

AVOID rehashing results here!]

**RESULTS COMPARISON - ANALYTICAL vs. MINERAL DATA**

Analytical Results Summary			Mineral Data	
			Likely Mineral:	[Suspected Mineral Name]
Density (Avg):	[methods avg] g/cm <sup>3</sup>	±[avg spread] g/cm <sup>3</sup>	Density:	[Researched Density] g/cm <sup>3</sup>
Mohs Hardness:	[hardness]		Mohs Hardness:	[Researched Hardness]
Color (fresh):	[descriptive]	[Munsell]	Color:	[Researched color(s)]
Luster (fresh):	[descriptive]		Luster:	[Researched Luster]
Streak:	[descriptive]	[Munsell]	Streak:	[Researched Streak]
Magnetism:	[yes - no]	[Tesla] μT	Magnetism:	[Researched Magnetism]
Radioactivity:	[yes - no]	[counts] cps	Radioactivity:	[Researched Radioactivity]
Organoleptic:	[descriptive]		Organoleptic:	[Researched Organoleptic]
UV Light (LW):	[descriptive]		UV Light (LW):	[Researched UV LW]
UV Light (SW):	[descriptive]		UV Light (SW):	[Researched UV SW]
Fusibility:	[Fus. #]		Fusibility:	[Researched Fus. #]
Solubility:	[descriptive]		Solubility:	[Researched solubility]
Ion Chromat.:	[list ions detected]		<b>Chemical Formula</b>	
XRF Analysis:	[list major elements detected]		[Researched chemical sum formula]	
Wet Geochem:	[list major elements detected]			
XRD Crystal.:	[insert mini XRD pattern]		XRD Crystal.:	[insert res. mini pattern]
<b>Optical</b>			<b>Optical</b>	
Cleavage:	[descriptive]		Cleavage:	[Researched cleavage]
Color:	[descriptive PPL color]		Color:	[Researched PPL color]
Relief:	[descriptive PPL relief]		Relief:	[Researched PPL relief]
RI:	[measured RI or RI range]		RI:	[Researched RI]
Optics:	[list isotropy, optic axis, sign extinction]		Optics:	[researched isotropy, optic axis, sign, extinction]

## SPECIFIC GRAVITY DETERMINATION

### HYDROSTATIC PAN METHOD

Method:

Equation / Calculation: [insert equation; use equation editor]	where: [explanation of equation symbols and space holders]
---	---

Density:	[measured avg] g/cm <sup>3</sup>	±[spread] g/cm <sup>3</sup>		
	Precision Error:	[percent] %	Precision:	[percent] %
	Accuracy Error:	[percent] %	Accuracy:	[percent] %

### PYCNOMETER METHOD

Method:

Equation / Calculation: [insert equation; use equation editor]	where: [explanation of equation symbols and space holders]
---	---

Density:	[measured avg] g/cm <sup>3</sup>	±[spread] g/cm <sup>3</sup>		
	Precision Error:	[percent] %	Precision:	[percent] %
	Accuracy Error:	[percent] %	Accuracy:	[percent] %

Comments: [if applicable]

**HARDNESS, COLOR, LUSTER, STREAK**

**MOHS HARDNESS (HM) TEST**

Method:

Mohs Hardness (HM):	[numeric Mohs hardness value]	Comments: [if applicable]

**COLOR TEST**

Method:

Overall Color Assessment:		<input type="checkbox"/> Idiochromatic	<input type="checkbox"/> Allochromatic	<input type="checkbox"/> Pseudochromatic
FRESH SURFACE	Munsell Color Code: [Enter Munsell Code]	Descriptive Color: [enter short Munsell color descriptor, eg, reddish yellow brown]		
WEATHERED SURFACE	Munsell Color Code: [Enter Munsell Code]	Descriptive Color: [enter short Munsell color descriptor, e.g., reddish yellow brown]		

Comments: [if applicable]



**LUSTER TEST**

Method:

Overall Luster Assessment:	<input type="checkbox"/> Metallic <input type="checkbox"/> Non-Metallic
----------------------------	---

Descriptive Luster:

**STREAK TEST**

Method:

Streak Color Fresh Surface:	Munsell Color Code: [Enter Munsell Code]	Descriptive Color: [enter short Munsell color descriptor, eg, reddish yellow brown]
--------------------------------	--	---

Streak Color Weathered Surface:	Munsell Color Code: [Enter Munsell Code]	Descriptive Color: [enter short Munsell color descriptor, eg, reddish yellow brown]
------------------------------------	--	---

Overall Streak Color Assessment:

Possible Minerals: [ use STREAK in conjunction with HM ]

Comments: [if applicable]

**MAGNETISM, RADIOACTIVITY, ORGANOLEPTIC, UV****MAGNETISM TEST**

Method:
---------

	Magnetic Field Strength	$\pm$ Precision	% Precision Error
Non-Magnetic Background Reference Reading	[insert instrument gauss reading average]	[insert $\pm$ spread in gauss]	[insert Precision Error in percent] %
Ferrous Magnet Reference Reading	[insert instrument gauss reading average]	[insert $\pm$ spread in gauss]	[insert Precision Error in percent] %
Magnetite Mineral Reference Reading	[insert instrument gauss reading average]	[insert $\pm$ spread in gauss]	[insert Precision Error in percent] %
SAMPLE	[insert instrument gauss reading average]	[insert $\pm$ spread in gauss]	[insert Precision Error in percent] %
SAMPLE heat treated	[insert instrument gauss reading average]	[insert $\pm$ spread in gauss]	[insert Precision Error in percent] %

**RADIOACTIVITY TEST**

Method:
---------

	Gamma Emission	$\pm$ Precision	% Precision Error
Background Reference Reading	[insert instrument CPS reading average]	[insert $\pm$ spread in CPS]	[insert Precision Error in percent] %
SAMPLE	[insert instrument CPS reading average]	[insert $\pm$ spread in CPS]	[insert Precision Error in percent] %

**ORGANOLEPTIC TEST**

Method:

TEST	DESCRIPTIVE OBSERVATION
TASTE	[short descriptive observation]
SMELL unmoistened	[short descriptive observation]
SMELL moistened	[short descriptive observation]
SMELL slightly heated	[short descriptive observation]

Comments: [if applicable]

**UV LIGHT EMISSION TEST**

Method:

TEST	Observation	Possible Activators	Photo
Long Wave UV Light (365 nm) Response: <input type="checkbox"/> Yes <input type="checkbox"/> No	[color & intensity, e.g.; weak blue- green]	[elemental or mineral activators]	[insert photo]
Long Wave activated Phosphorescence Response: <input type="checkbox"/> Yes <input type="checkbox"/> No	[color & intensity, e.g.; weak blue- green] [time: e.g. for ~ 60s]		[insert photo]

<p>Short Wave UV Light (254 nm) Response: <input type="checkbox"/>Yes <input type="checkbox"/>No</p>	<p>[color &amp; intensity, e.g.; weak blue- green]</p>	<p>[elemental or mineral activators]</p>	<p>[insert photo]</p>
<p>Long Wave activated Phosphoresence Response: <input type="checkbox"/>Yes <input type="checkbox"/>No</p>	<p>[color &amp; intensity, e.g.; weak blue- green] [time: e.g. for ~ 60s]</p>		<p>[insert photo]</p>
<p>Thermoluminescence Response: <input type="checkbox"/>Yes <input type="checkbox"/>No</p>	<p>[color &amp; intensity, e.g.; weak blue- green] [time: e.g. for ~ 60s]</p>	<p>[elemental or mineral activators]</p>	<p>[insert photo]</p>
<p>Triboluminescence Response: <input type="checkbox"/>Yes <input type="checkbox"/>No</p>	<p>Descriptive Observation:</p>		

Comments: [if applicable]

**SIMPLE CHEMISTRY & FLAME TESTING****FUSIBILITY & FLAME COLOR**

Method:
---------

Fusibility: [describe: e.g. "Fuses to black globule"]	Fusibility #:	Comments:
Flame Color:		Possible Elements:
Flame Color w/ blue filter:		Possible Elements:

**OPEN & CLOSED TUBE TEST**

Method:
---------

Open Tube Test:	Descriptive Observation & Interpretation:	[insert picture]
Closed Tube Test:	Descriptive Observation & Interpretation:	[insert picture]

**SOLUBILITY TEST**

Method:

Test Solution	Solubility	Reaction	Odors
Water			
1:5 HCl			
1:1 HCl			
1:1 H <sub>2</sub> SO <sub>4</sub>			
1:1 HNO <sub>3</sub>			
Aqua Regia			

**ION CHROMATOGRAPHY PAPER TEST**

Method:

**Untreated Chromatograph**

[insert edited sideways photo of untreated chromatograph. Erase this text!]

Comments:

### 8-Hydroxyquinoline treated Chromatograph

[insert edited sideways photo of 8-Hydroxyquinoline treated chromatograph Erase this text!]

Comments:

### Treated Chromatograph under UV light

[insert edited sideways photo of treated chromatograph under UV light. Erase this text!]

Comments:

### NH<sub>4</sub>OH treated Chromatograph

[insert edited sideways photo of NH<sub>4</sub>OH treated chromatograph, if applicable. Erase this text!]

Comments:

## Paper Chromatography Results [Insert add'l row if more ions are detected]

Probable Detected Ions with corrected $R_f$		$R_f$ Correction Factor: [ $R_f$ value]
[Chem. Symbol Ion 1; $R_f$ (corrected)]	[Chem. Symbol Ion 2; $R_f$ (corrected)]	[Chem. Symbol Ion 3; $R_f$ (corrected)]
Interpretation:		



**DRY XRF and XRD ANALYSIS**

**XRF (X-RAY FLUORESCENCE) SEMI QUANTITATIVE CHEMICAL ANALYSIS**

Non-destructive XRF (x-ray fluorescence) measurements help qualify elemental composition. This test is effective for trace elements with an atomic number of Fe (iron) and greater. Estimates for other elements, such as Si, Ca, Mg can also be obtained if the concentrations are sufficiently high.

Method:

[Insert Low Energy XRF Spectra - 15.00kV.]

Elements present:

Probable Element Traces:

Comments:

<p>[Insert High Energy XRF Spectra - 40.00kV.]</p>	<p>Elements present:</p>  <p>Probable Element Traces:</p>  <p>Comments:</p>
--	---

**XRD (X-RAY DIFFRACTION) CRYSTALLOGRAPHIC ANALYSIS with DATA INTERPRETATION**

The X-ray diffractometer (XRD) identifies unique crystal structures of minerals by assessing the internal crystal lattice spacings. Because lattices and unit cell dimensions in a crystal are unique for specific minerals, a XRD pattern acts like a fingerprint when identifying an unknown sample. Mineral mixtures or phases can also be assessed, especially when some of the sample mineralogy is known. This method is destructive and requires a small amount of finely powdered sample.

<p>Method:</p>
----------------

**XRD Analysis:**

[(Paste your MEASURED XRD pattern graphic here)] [Label peaks especially for multiple phases]

X-ray Pattern

Major Peaks and d-spacing: [Sorted according to your measurement]

2 $\theta$			
d Å			
I/I <sub>1</sub>	100		

[only change if a different x-ray tube is used]  $\lambda$  1.5405 Rad: CuK $\alpha$ <sub>1</sub>

XRD pattern interpretation / comments:

**WET GEOCHEMICAL ANALYSIS**

**SAMPLE DIGESTION AND ANALYSIS**

Digestive Method:	
Analytical Method:	

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	Fe <sub>2</sub> O <sub>3</sub>	MnO	TiO <sub>2</sub>	P <sub>3</sub> O <sub>4</sub>	Cr <sub>2</sub> O <sub>3</sub>	LOI <sup>1</sup>
%												

	As <sup>2</sup>	B <sup>3</sup>	Ba	Be	C <sup>4</sup>	Co	Cu	Li <sup>3</sup>	Mo	Ni	Pb	Rb	S
ppm													

	Sb <sup>2</sup>	Se	Sn	Sr	Te <sup>2</sup>	V	W	Zn	Zr	Radioactive	
ppm										Th	U

	Precious Metals			Rare Earth and others									
	Ag	Au	Pt	Ce	Dy	Er	Eu	Ga	Gd	Ge	Hf	Ho	Ir
ppm													

	Rare Earth and others											
	La	Lu	Nb	Nd	Pr	Sc	Sm	Ta	Tb	Tm	Y	Yb
ppm												

<sup>1</sup> Loss on ignition

<sup>2</sup> Volatile! Partial loss on digestion.

<sup>3</sup> Part of lithium borate flux used for digestion. Value inaccurate.

<sup>4</sup> Inaccurate! Graphite crucibles used for digestion

[Leave all fields blank that show NO or Zero detection]

### OPTICAL MINERAL IDENTIFICATION

#### GEM REFRACTOMETER ASSESSMENT

Method:
---------

Sample IR or IR Range	Sample Birefringence	Sample Optic Axis	Sample Optic sign

Result Interpretation:
------------------------

Comments::
------------



## **CITATIONS**

[insert citations in USGS format]

[Cite the Munsell Color chart if used]

[Cite any software apps used, e.g.; radioactivity, magnetism cell phone apps]

[For XRD, cite any software used, as well as webmineral.com and RRUFF data bases when used]