ME571/Geol571 Advanced Topics

Geology and Economics of Strategic and Critical Minerals

SAMPLING AND MONITORING

Virginia T. McLemore

Safety

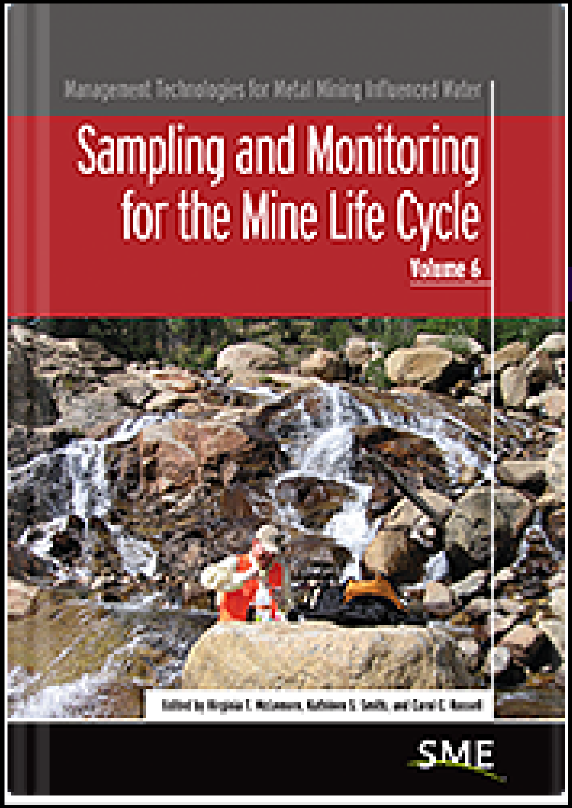
Papers

Next week

- No class—spring break

Only 1 in 300 discoveries becomes a mine, says Louis James. But 92 out of 100 mines get built after a production decision is made #PDAC2017

Speaking about copper, Michael Schwartz, Market Research Manager at Teck Resources (NYSE:TECK), said that after 2019, "there isn't enough copper production in the pipeline to meet even the lowest-case demand scenario."



McLemore, V.T., Smith, K.S., Russell, C.C., editors, 2014, Management Technologies for Metal Mining Influenced Water, volume 6: Sampling and monitoring for the mine life cycle: Society for Mining, Metallurgy, and Exploration, Inc., Littleton, CO.

APPENDIX 5—CASE STUDIES OF SAMPLING AND MONITORING

Compiled by Kathleen S. Smith, Virginia T. McLemore, and Carol C. Russell

Reviewed by Thomas Moyer and David Rathke

Series Title: Management Technologies for Metal Mining Influenced Water

Volume 6: Sampling and Monitoring for the Mine Life Cycle

Editors: Virginia T. McLemore, Kathleen S. Smith, and Carol C. Russell

Publisher: Society for Mining, Metallurgy & Exploration Inc. Englewood, Colorado

APPENDIX 3—SUMMARY OF FIELD SAMPLING AND ANALYTICAL METHODS WITH BIBLIOGRAPHY

Compiled by Virginia T. McLemore, Kathleen S. Smith, and Carol C. Russell

Reviewed by Mary P. Goldade and Thomas R. Wildeman

Series Title: Management Technologies for Metal Mining Influenced Water

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Questa Rock Pile Weathering and Stability Project

CHARACTERIZATION OF GOATHILL NORTH ROCK PILE, NEW MEXICO

New Mexico Bureau of Geology and Mineral Resources

Open-file Report OF-523

Prepared for Chevron Mining Inc., Questa, New Mexico

Chevron Tasks: 1.3.3, 1.3.4, 1.4.2, 1.4.3, 1.11.1.3, 1.11.1.4, 1.11.2.3, B1.1.1, B1.3.2

Revised December 13, 2009

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Project Management by
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New Mexico Bureau of Geology and Mineral Resources
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http://geoinfo.nmt.edu/publications/openfile/downloads/500-599/523/ofr_523.pdf

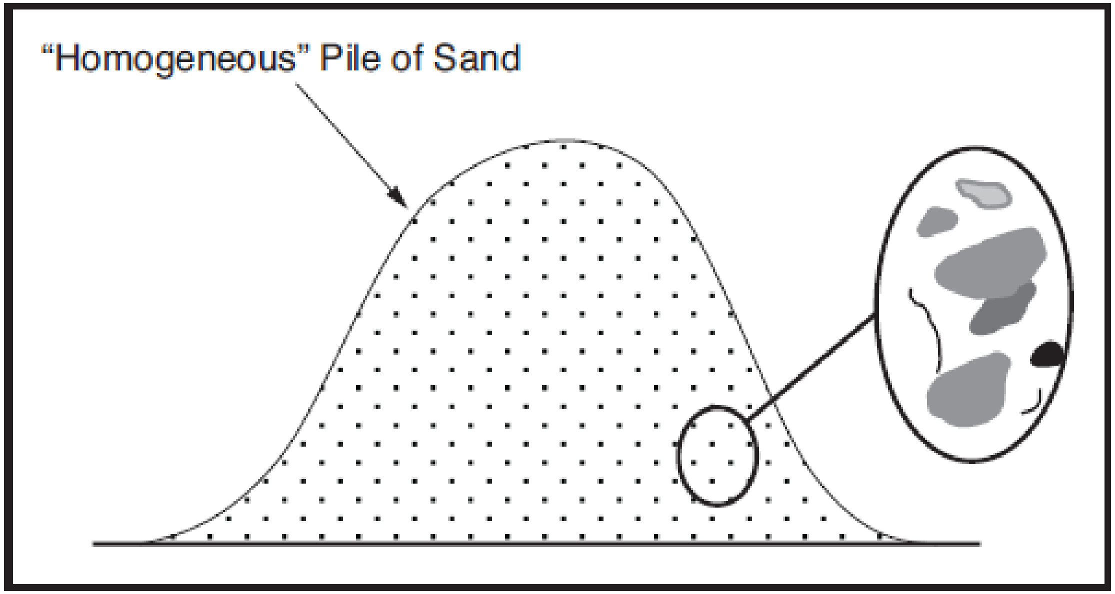
What is a sample?

What is a sample?

- Portion of a whole
- Portion of a population

Sample Collection

- ***Completeness –*** the comparison between the amount of valid, or usable, data you originally planned to collect, versus how much you collected.
- ***Comparability –*** the extent to which data can be compared between sample locations or periods of time within a project, or between projects.
- ***Representativeness*** – the extent to which samples actually depict the true condition or population that you are evaluating



Source: Adapted from Myers 1997.

FIGURE 3.5 **Heterogeneity as a function of the scale of observation**

McLemore et al. 2014

What is a sampling and monitoring program?

Questa Rock Pile Stability Study SP.6 *Page 1*

EFFECT OF WEATHERING ON THE STABILITY OF THE QUESTA ROCK PILES

FIELD SAMPLING PLAN

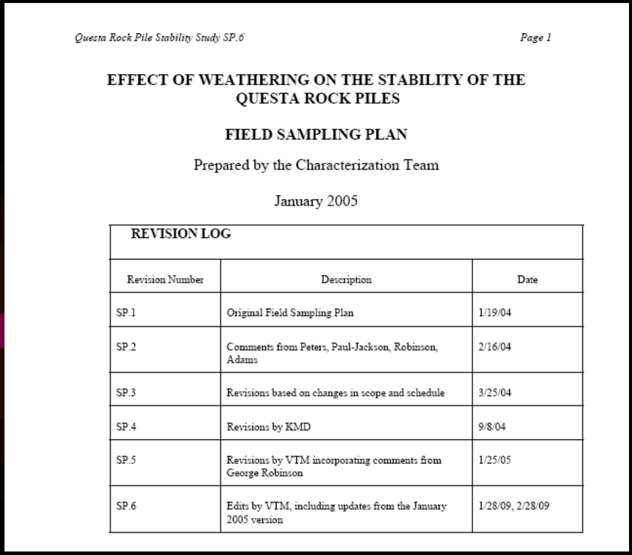
Prepared by the Characterization Team

January 2005

REVISION LOG

Revision Number	Description	Date
SP.1	Original Field Sampling Plan	1/19/04
SP.2	Comments from Peters, Paul-Jackson, Robinson, Adams	2/16/04
SP.3	Revisions based on changes in scope and schedule	3/25/04
SP.4	Revisions by KMD	9/8/04
SP.5	Revisions by VTM incorporating comments from George Robinson	1/25/05
SP.6	Edits by VTM, including updates from the January 2005 version	1/28/09, 2/28/09

What is a sampling and monitoring program?



Questa Rock Pile Stability Study SP.6 — *Page 1*

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- A sampling and monitoring program uses sample analyses to guide decision making, especially with respect to exploration, environmental monitoring and financial risks.
- A sample is that portion of the population that is actually studied and used to characterize the population.

- Sampling and monitoring plans document procedures for obtaining data of sufficient quality to ensure that the resulting samples and analytical data meet the goals and objectives of the program.
- Data will be collected, reviewed, analyzed, and the need for additional data defined.

Sampling and monitoring programs

- Transparent
- Involve the stakeholders
- Document everything
- Site-specific and avoid “cookie-cutter” approaches/techniques for all sites
- Cost effective
- Protect water quality
- Comply with regulations
- Address site specific goals

PHILOSOPHY OF SAMPLING AND MONITORING

PHILOSOPHY OF SAMPLING AND MONITORING

- Sampling and monitoring programs should be designed to account for all aspects of the mine-life cycle.
- All types of sampling media should be sampled at some point during the life of the mine, preferably in the initial stages.
- Sampling and monitoring for closure begins with the exploration stage.
- Context of samples must be defined.

OVERVIEW OF QUALITY CONTROL PROTOCOLS

PERSONNEL—training, experience, hierarchy

PROCEDURES—detailed sequential listing of procedures

TRACEABILITY—detailed listing of sequential responsibility

CORE SPLITTING/SAWING--procedures

SECURITY OF ASSAY SPLITS—specifics, responsible persons

SECURITY OF SAMPLE SPLITS—specifics, responsible persons

SHIPPING SAMPLES—specifics, responsible person

ANALYSIS AND REPORTING--responsibilities

AUDITS—internal, independent

PROCEDURES THAT LEAD TO HIGH QUALITY IN MINERAL EXPLORATION PROJECTS (Rogers 1998)

- Verify qualifications of personnel
- Train field geologists in type of mineralization characterizing the project
- Train field geologists in resource estimation procedures
- Unannounced property visits by management and/or independent auditors
- Verification of drill logging procedures by management or independent auditor
- Random check samples of core splits, bagged samples, transit arrangements, etc.
- Use of accredited assay laboratories
- Internal verification program using duplicate samples, standard reference materials, and blanks
- Assay verification involving an independent laboratory
- Petrographic examination of representative samples of mineralization
- Beneficiation test (lab scale) of representative samples of mineralization
- Comparison of assay results for various sample types.

THE POSSIBILITY OF TAMPERING WITH SAMPLES

Salting: the surreptitious introduction of valuable material into a sample (McKinstry, 1947).

Chain of Custody: systematic procedures for the control of and responsibility for samples from the time they are taken through to eventual storage of reject and pulp material remaining after analyses.

Target Hardening: the strategic strengthening of high risk areas in exploration/exploitation to reduce the risk of tampering (Rogers, 2002).

Analytical Method—secretive methods are suspect.

Bre-X case history

Case study—Bre-X

The Bre-X scandal is reputably the most significant mining scam of modern times with losses said to be of the order of Can$6 billion. In brief, the scam seems to have been perpetrated by a small group of employees who, at an in-transit storage location, reopened bags containing samples and contaminated them with carefully weighed amounts of placer (flour) gold. Difficulties arose in 1996 in reproducing assays, leading to an auditing firm being employed to "verify" the assays.

Bre-X timeline

- 1989: David Walsh founded Bre-X Minerals Ltd. in 1989 as a subsidiary of Bresea Resources Ltd.
- 1993: Walsh bought a property in the middle of a jungle near the Busang River in Borneo, Indonesia.
- 1994: Initial drill results were encouraging.
- 1994: However, it was the project manager, Michael de Guzman, who was filing gold from his wedding ring and mixing the flakes in with the crushed core samples.
- December 1996, Lehman Brothers Inc. recommended a buy on “the gold discovery of the century.”
- Bre-X’s geologist implied 200 million oz of gold, worth over $240 billion in 2014 prices

Bre-X timeline

- 1996: Bre-X hits a snag with the Indonesian government, who claimed that Bre-X was not playing by the rules of the country. Bre-X’s exploration permits are revoked.
- 1997: January fire at Busang destroys many of the sample records.
- 1997: After many major miners express interest in Bre-X, eventually a joint venture is reached that gives Indonesia 40% share, Bre-X 45%, and Freeport McMoRan a 15% share of interests.
- 1997: Freeport begins due diligence on deposit and starts to twin holes that were already drilled.

Bre-X timeline

- 1997: Freeport reports “minor amounts of gold” in some holes, but not much else.
- 1997: On his way to meet the Freeport due diligence team, de Guzman (geologist) mysteriously falls to his death 600 ft from a helicopter. Police rule it a suicide.
- 1997: Shares of Bre-X crash.
- 1997: Report confirms that there is no gold at Busang, and samples were tampered with.

BRE-X EXAMPLE-1

Situation: a previously explored property (central Kalimantan) with early, poor Au assay results, consistently returned values of several grams Au per tonne for samples submitted by Bre-X personnel. Associated engineering work led to a very large resource being reported by the media. The stated results did not stand up to scrutiny by external auditors and the matter came to a head in 1996 when salting was recognized and the reported resource was deemed non-existent .

BRE-X EXAMPLE-2

Red Flags: many publications arose following this fiasco, pointing to a number of early signs of the scam—most are summarized below.

•Only a 10-cm length of half core was retained per metre. Industry standard is to retain the entire half core.

•Core was classified as mineralized or "in-fill" and the two types were subjected to different preparation, storage and transit procedures.

•Early metallurgical tests showed more than 90 percent of the gold was recoverable by gravity separation. The report stated "*Gold particle shapes were mostly rounded…*"

BRE-X EXAMPLE-3

Red Flags: cont'd

A second metallurgical lab reported "*the gold particles in the Busang composites were liberated as relatively coarse nuggets and minor flakes with an average size range of 60 to 180 microns. The gold grains are typically compact and often nearly spherical in shape*".

- Sample grades were difficult to reproduce by duplicate analyses.

- A comprehensive report on alteration and mineralization of 103 samples of retained 10-cm half core lengths failed to find any gold.

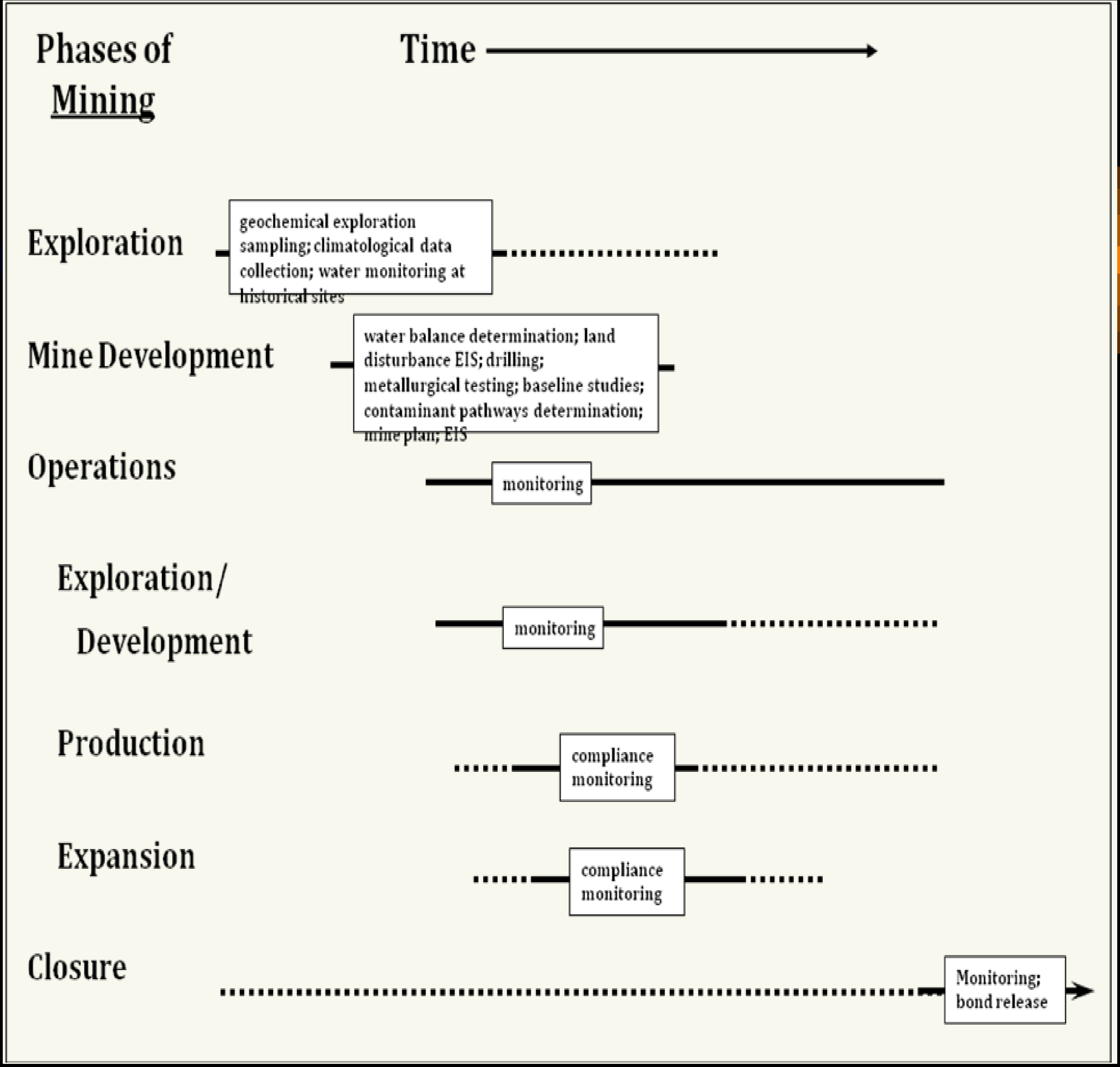
- With the near-surface mineralization reported, one would have expected surface evidence and the presence of artisanal miners as exist elsewhere in the general area.
- Long time lapse for samples leaving property and arriving at analytical lab

- Bre-X scandal changed the entire mining industry on how we sample, why we sample, and how we report sampling results

WHY SAMPLE

WHY SAMPLE

- Exploration stage to locate economic mineral deposits, drill targets.
- Development stage to determine reserves.
- Production stage to maintain grade control.
- Environmental monitoring, compliance.
- To predict, model, and remediate ARD and other drainage problems associated with mine sites.
- To determine how well the predictive models work and how effective the remediation methods are.
- To address research questions to better understand processes


Phases of Mining
Time
Exploration
geochemical exploration sampling; climatological data collection; water monitoring at historical sites
Mine Development
water balance determination; land disturbance EIS; drilling; metallurgical testing; baseline studies; contaminant pathways determination; mine plan; EIS
Operations
monitoring
Exploration/ Development
monitoring
Production
compliance monitoring
Expansion
compliance monitoring
Closure
Monitoring; bond release

Exploration

- Generally looking for anomalies
- Some value above background
- Looking for anomalies in pathfinder elements
- Looking for alteration halos

WHAT IS A PATHFINDER ELEMENT?

SAMPLING MEDIA

A variety of sampling media can be tested

- solid
- liquid
- air
- biological
- Other media

How do you determine an anomaly?

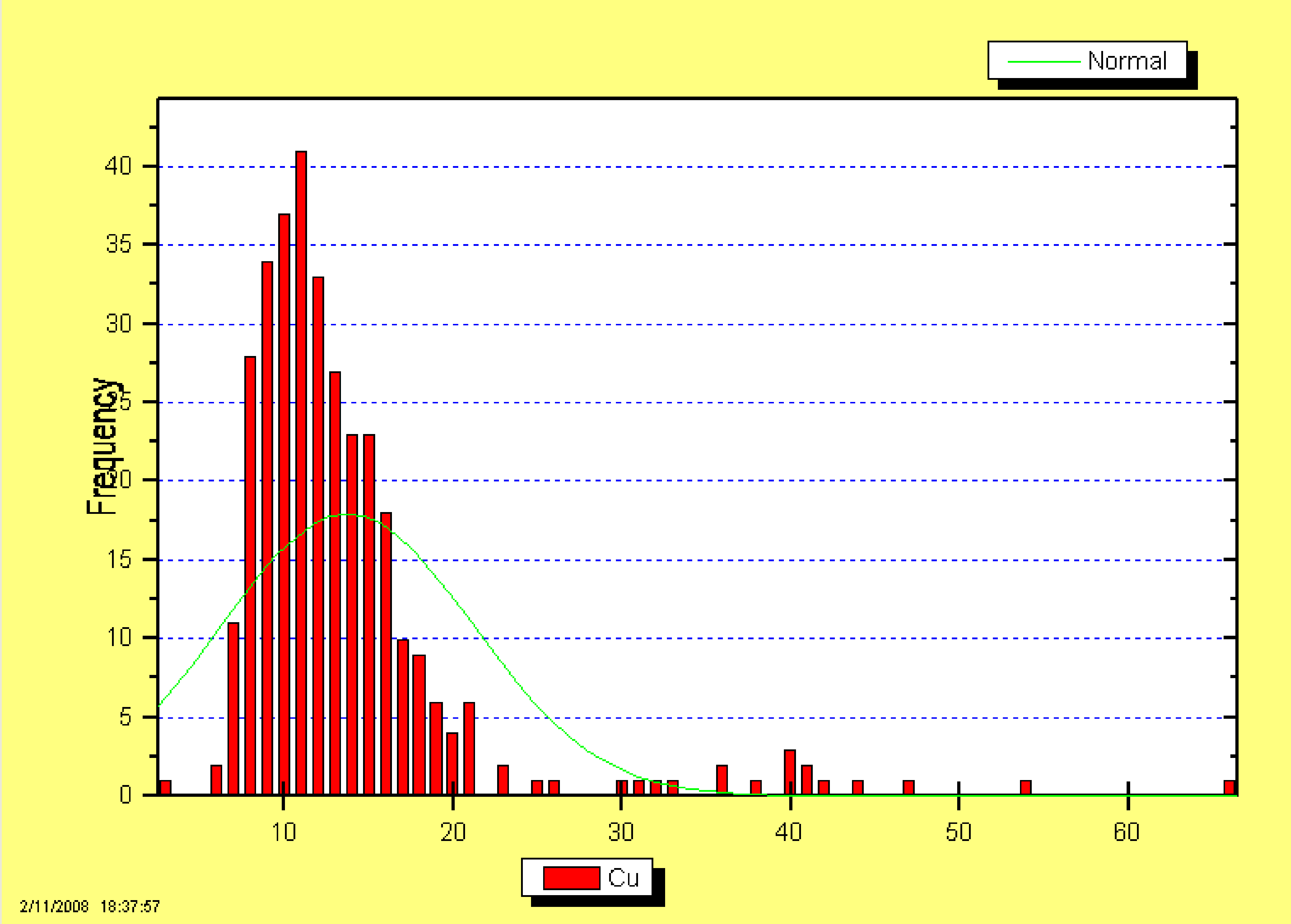
How do you determine an anomaly?

- Knowledge of background
  - Regional survey
  - Published background values for various terrains or lithologies
- Histograms or cumulative frequency plots of data
- Pre-determined thresh hold
  - Mined grades

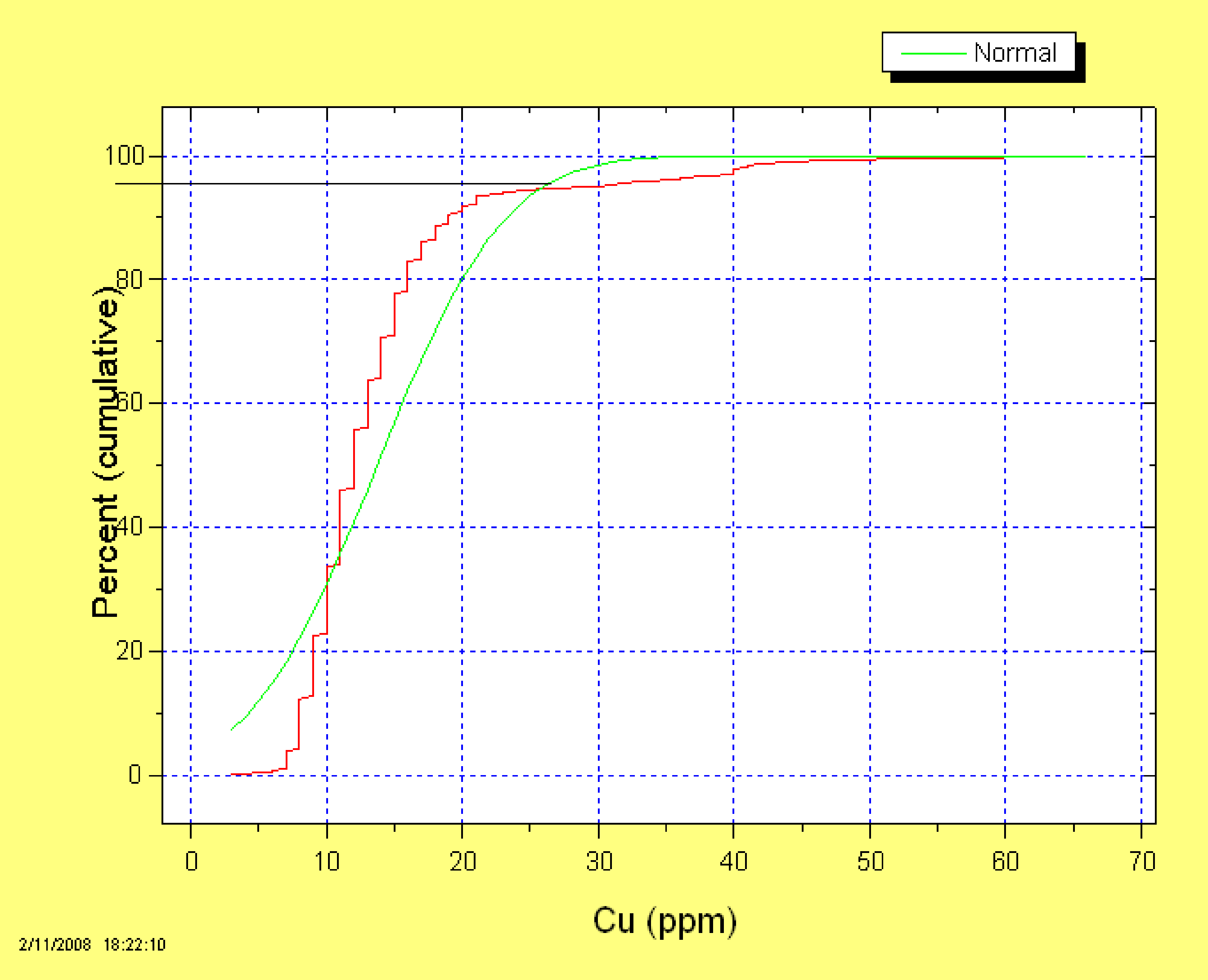
EXAMPLE McGREGOR RANGE, FORT BLISS, NEW MEXICO

Table 2.10 Summary of the Geochemical Data of Stream Sediment Samples Collected from the McGregor Range.[1]

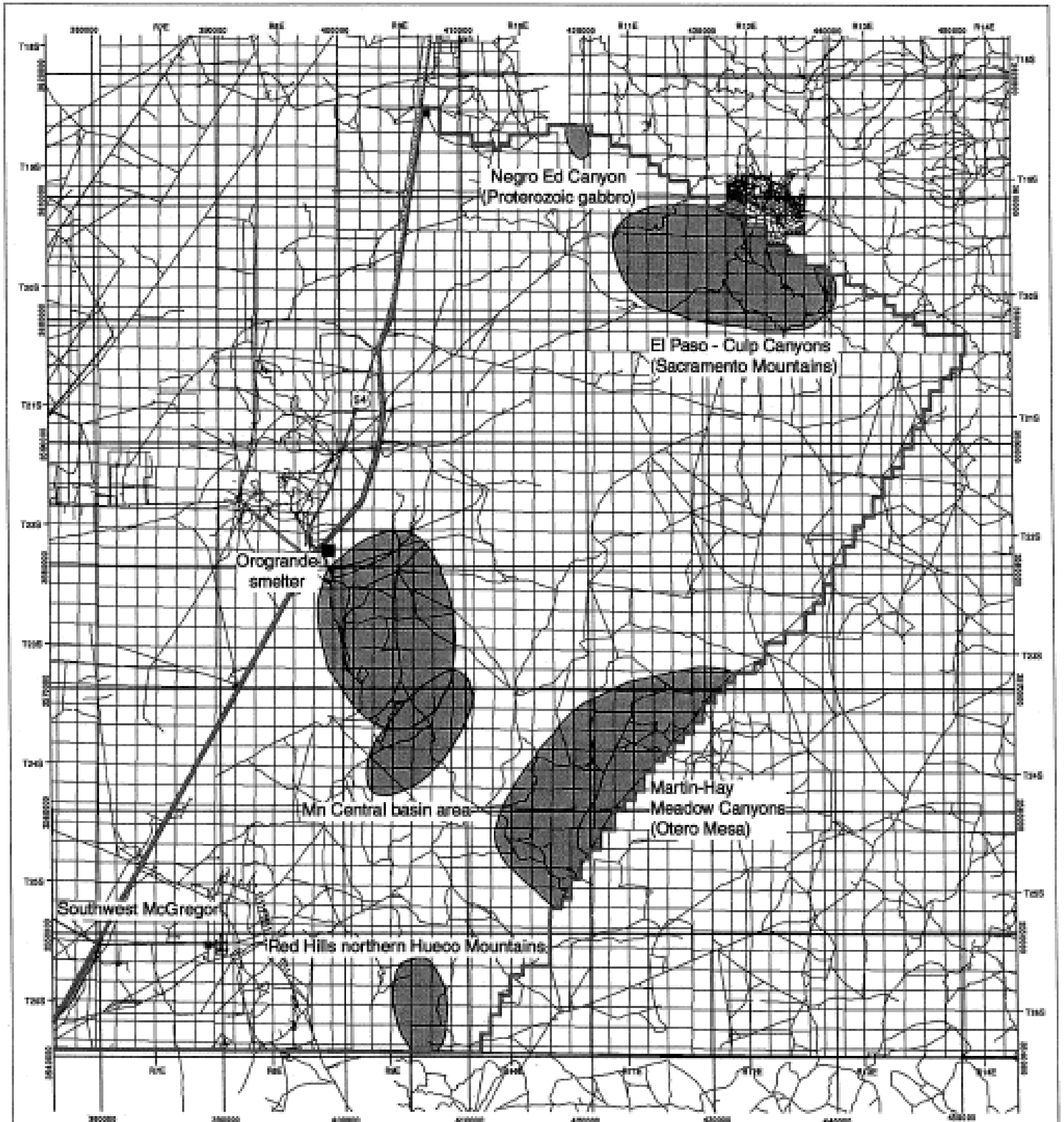
Major (%)	Maximum	Minimum	Mean	Standard Deviation	Anomaly Threshold	Terrestrial Abundance
SiO_2	80.6	8.14	33.24	16	45.0	58.3
Al_2O_3	14.0	0.83	5.05	3	na[4]	15.7
CaO	50.3	1.79	29.84	12	32.0	8.7
MgO	5.96	0.26	1.54	1	na[4]	4.6
Na_2O	3.70	<0.01	0.66	0.7	na[4]	3.1
K_2O	3.37	0.11	1.26	0.8	na[4]	2.2
Fe_2O_3[2]	10.4	0.33	2.17	1.5	4.0	8.9
MnO	1.00	<0.01	0.06	0.1	0.1	0.1
TiO_2	0.90	<0.01	0.29	0.2	0.4	1.1
P_2O_5	0.24	<0.01	0.08	0.01	na[4]	0.3
LOI	40.0	3.25	25.93	9	na[4]	na[4]
S	0.07	<0.01	0.03	0.01	na[4]	0.03
Trace (ppm)						
Ag	1	<1	nc[3]	nc[3]	na[4]	0.08
As	100	<1	6	9	8	1.8
Au	26	<1	11	6	na[4]	4
B	70	<10	nc[3]	nc[3]	na[4]	9
Ba	961	20	306	222	600	390
Be	4	<1	1	0.7	na[4]	2
Bi	6	<5	nc[3]	nc[3]	na[4]	0.008
Br	16	1	6	2	na[4]	2.5
Cd	1	<1	nc[3]	nc[3]	na[4]	0.16
Ce	98	12	38	18	70	66
Co	20	1	6	3	na[4]	29
Cr	65	11	36	21	na[4]	122
Cs	7	<1	2	1	na[4]	2.6
Cu	234	<0.5	12	22	20	68
Eu	1.6	<0.2	0.7	0.3	na[4]	2.1
Hg	2	<1	nc[3]	nc[3]	na[4]	0.08
Hf	13	<1	5	3	na[4]	2.8
La	60	6.6	20.8	10	40	35
Lu	12	0.06	0.30	1	na[4]	nc[4]
Mo	6	<1	3	1	na[4]	1.2
Nb	350	<10	22	30	20	20
Nd	41	6	17	7	na[4]	40



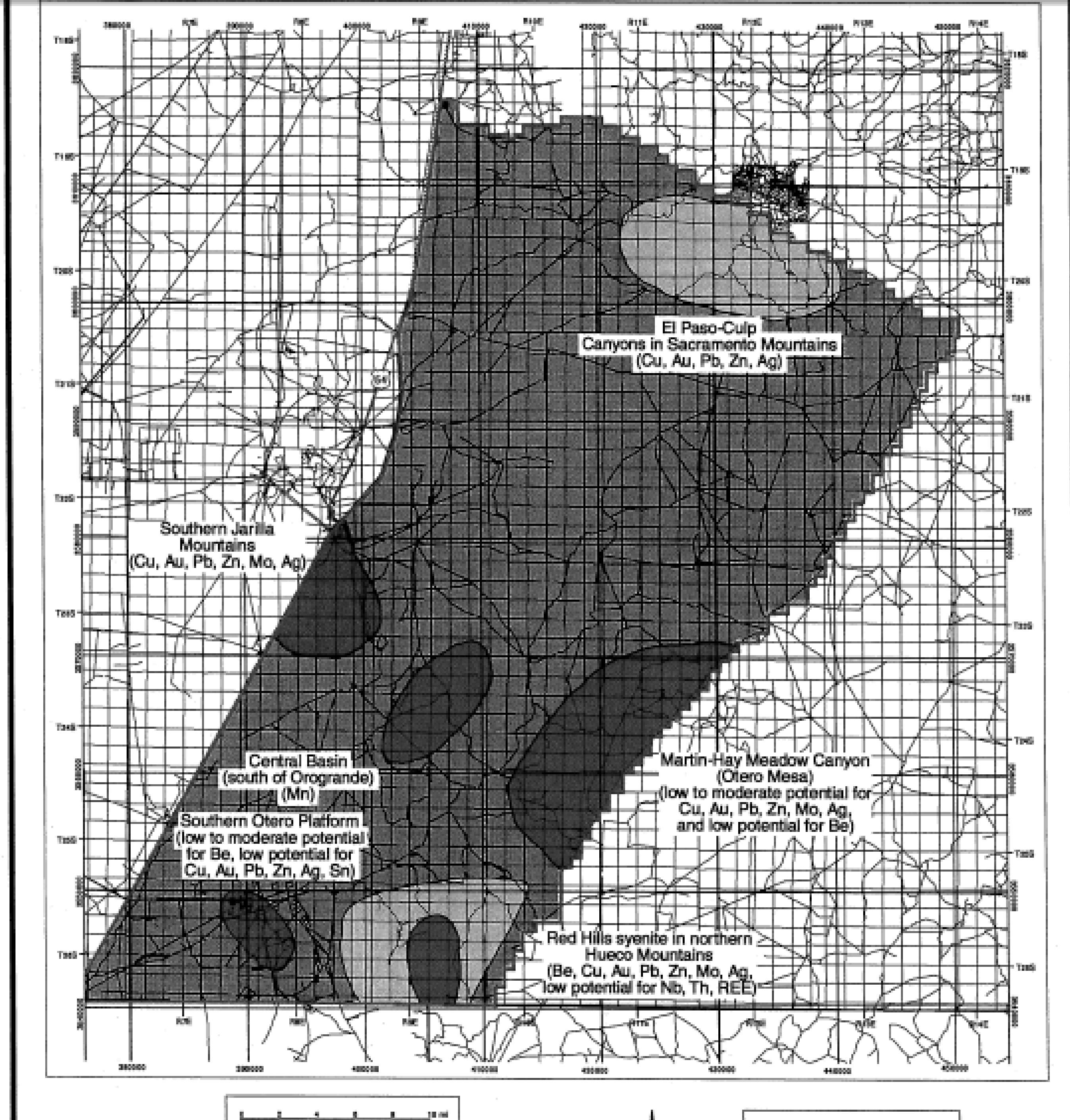
Stream Sediments McGregor Range

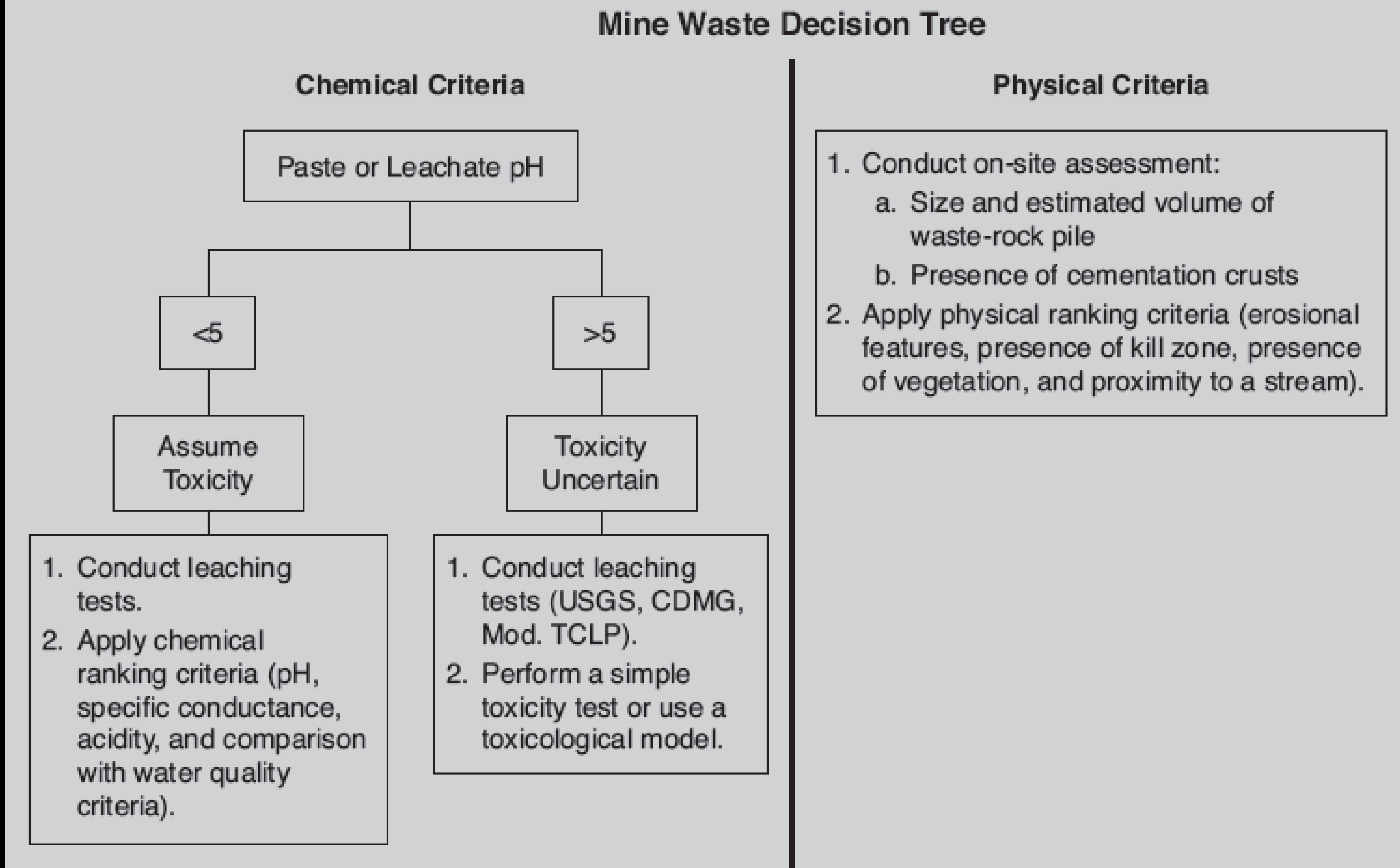


Stream Sediments McGregor Range



Negro Ed Canyon
(Proterozoic gabbro)
El Paso - Culp Canyons
(Sacramento Mountains)
Orogrande
smelter
54
Mn Central basin area
Martin-Hay
Meadow Canyons
(Otero Mesa)
Southwest McGregor
Red Hills northern Hueco Mountains


El Paso-Culp
Canyons in Sacramento Mountains
(Cu, Au, Pb, Zn, Ag)
Southern Jarilla
Mountains
(Cu, Au, Pb, Zn, Mo, Ag)
Central Basin
(south of Orogrande)
(Mn)
Southern Otero Platform
(low to moderate potential
for Be, low potential for
Cu, Au, Pb, Zn, Ag, Sn)
Martin-Hay Meadow Canyon
(Otero Mesa)
(low to moderate potential for
Cu, Au, Pb, Zn, Mo, Ag,
and low potential for Be)
Red Hills syenite in northern
Hueco Mountains
(Be, Cu, Au, Pb, Zn, Mo, Ag,
low potential for Nb, Th, REE)



Source: Adapted from Ranville et al. 2006 and Wildeman et al. 2007.

McLemore et al. 2014

COMPONENTS OF A SAMPLING PLAN

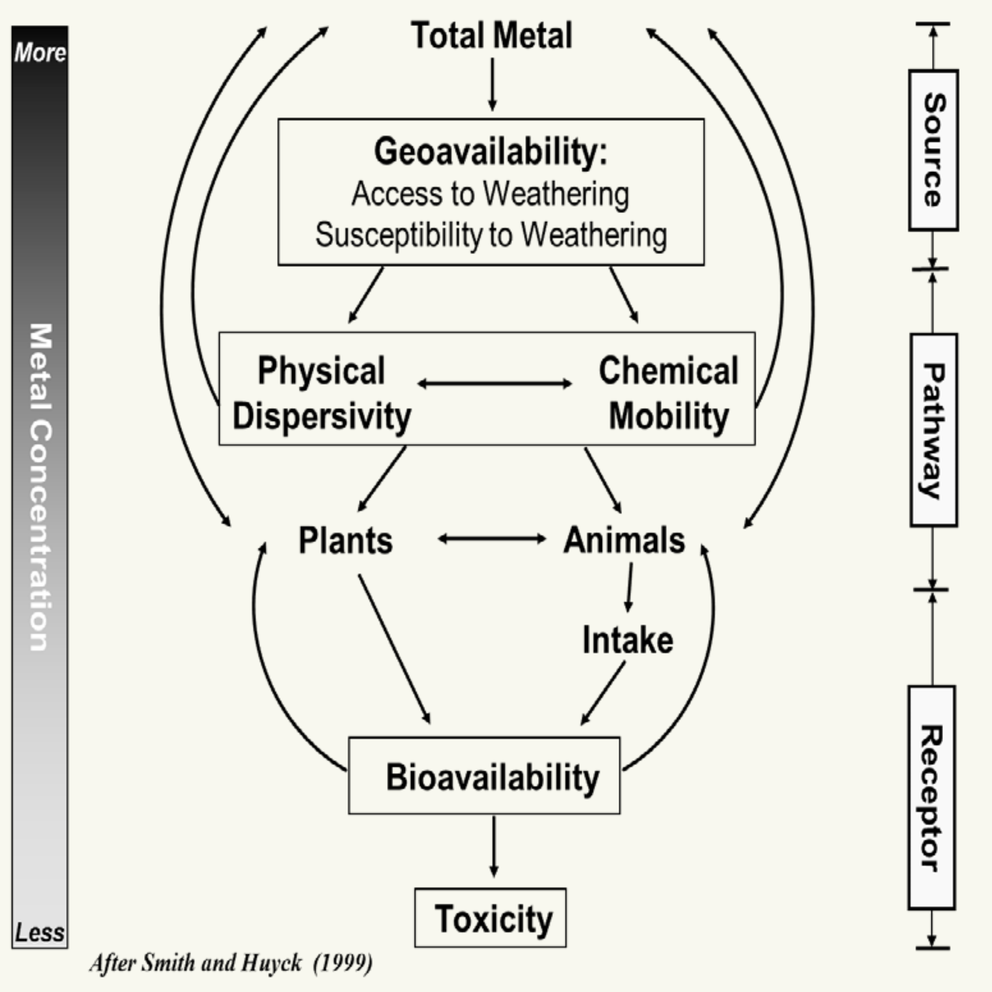
- Define questions and objectives
- Develop site conceptual models
- Costs and potential consequences of not sampling
- Identify types of data and information needed
- Define confidence level and quantity of data required to answer questions
- Design the sampling plan

COMPONENTS*—continued*

- Develop protocols
- Conduct an orientation or pilot study before implementation
- Conduct sampling plan
- Analyze and manage data (interpretation)
- Make decisions (risk management)
- Educate and inform the parties involved

1. DEFINE QUESTIONS AND OBJECTIVES

- Identify sources, transport, and effects of potential contamination of soil and drainage quality.
- Validate predicative models.
- Validate mitigation/remediation/reclamation efforts.
- Preventative and remediation monitoring.
- Establish background or existing conditions.
- Identify impacted areas vs. pristine areas.
- Potential use of water in operations
- Operational compliance monitoring.
- Validate reclamation efforts
- Identify markets and customer specifications



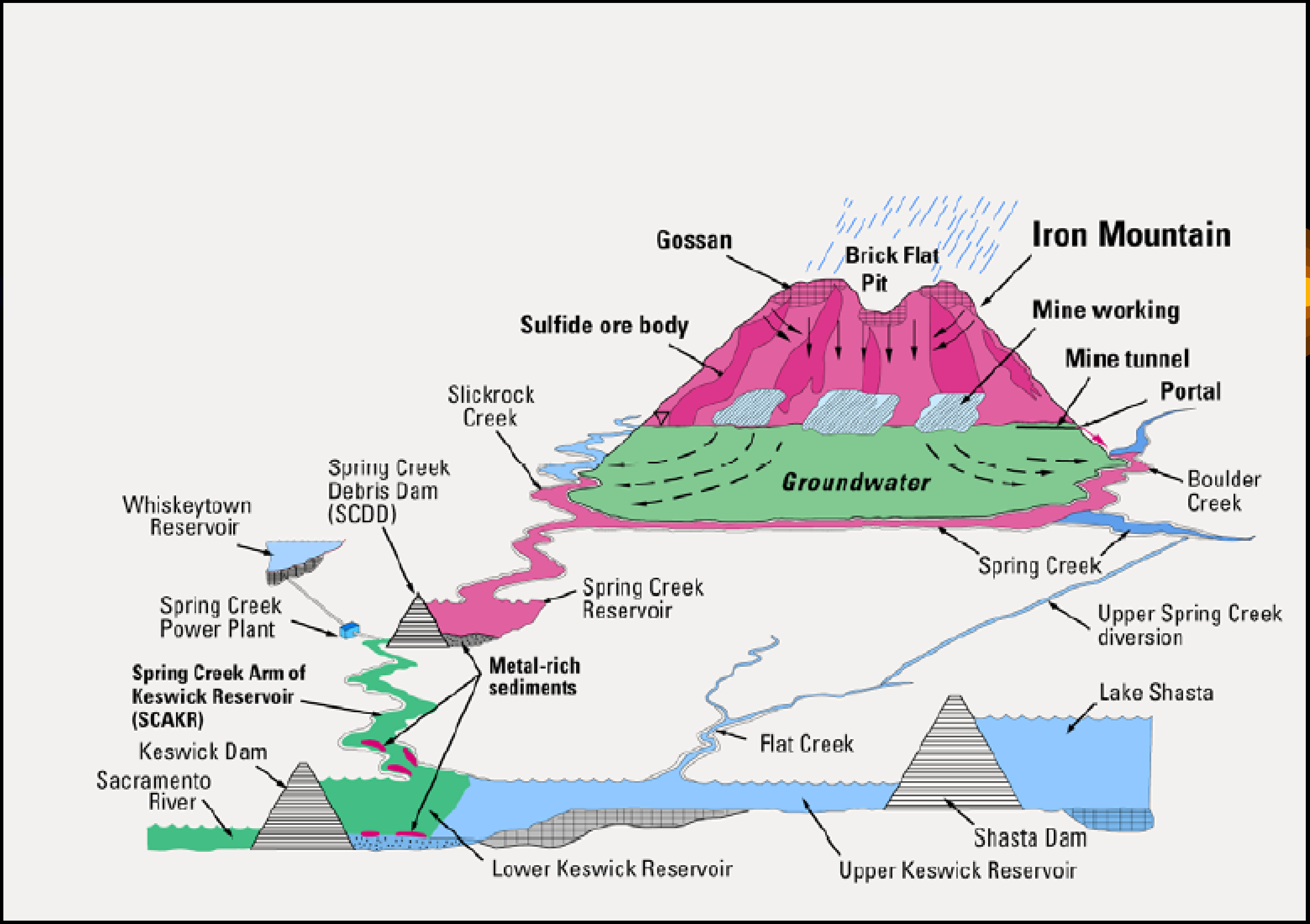
Source-pathway-receptor risk diagram (modified from Smith and Huyck, 1999).

2. DEVELOP SITE CONCEPTUAL MODELS

Review existing data

- Climatic data
- Physical data
- Geology (mineralogy)
- Hydrogeology (Surface-ground water interaction)
- Mining history and impacts of mine workings
- Biology
- Other data available

We suggest that a watershed or district approach be taken.



Conceptual model showing the main sources of metal contaminants from massive sulfide deposits mined underground at Iron Mountain discharging from mine tunnel portals into Boulder Creek, a tributary of Spring Creek which is a tributary of the Sacramento River. Alpers *et al.* (2003)

3. COSTS AND POTENTIAL CONSEQUENCES OF NOT SAMPLING

- Avoid being data rich but information poor.
- Public perceptions of risk.
- Perceptions of chemicals associated with the mining industry, such as cyanide.
- Some long-term and widespread environmental problems should be considered relatively high-risk even if the data on which the risk assessment is based are somewhat incomplete and uncertain.

4. IDENTIFY TYPES OF DATA AND INFORMATION NEEDED

- What sampling media (solid, liquid, biological/wetlands, air)?
- What are sources, transport mechanisms, and receptors?
- What other parameters must be monitored?
- What type of sample is to be collected and is it representative of sampling?
- What field measurements are required?
- What is the feasibility of sampling?

5. DEFINE CONFIDENCE LEVEL AND QUANTITY OF DATA REQUIRED TO ANSWER QUESTIONS

- What is the confidence level needed?
- How many samples are required to get the needed results?
- What is the precision required?

6. DESIGN THE SAMPLING PLAN

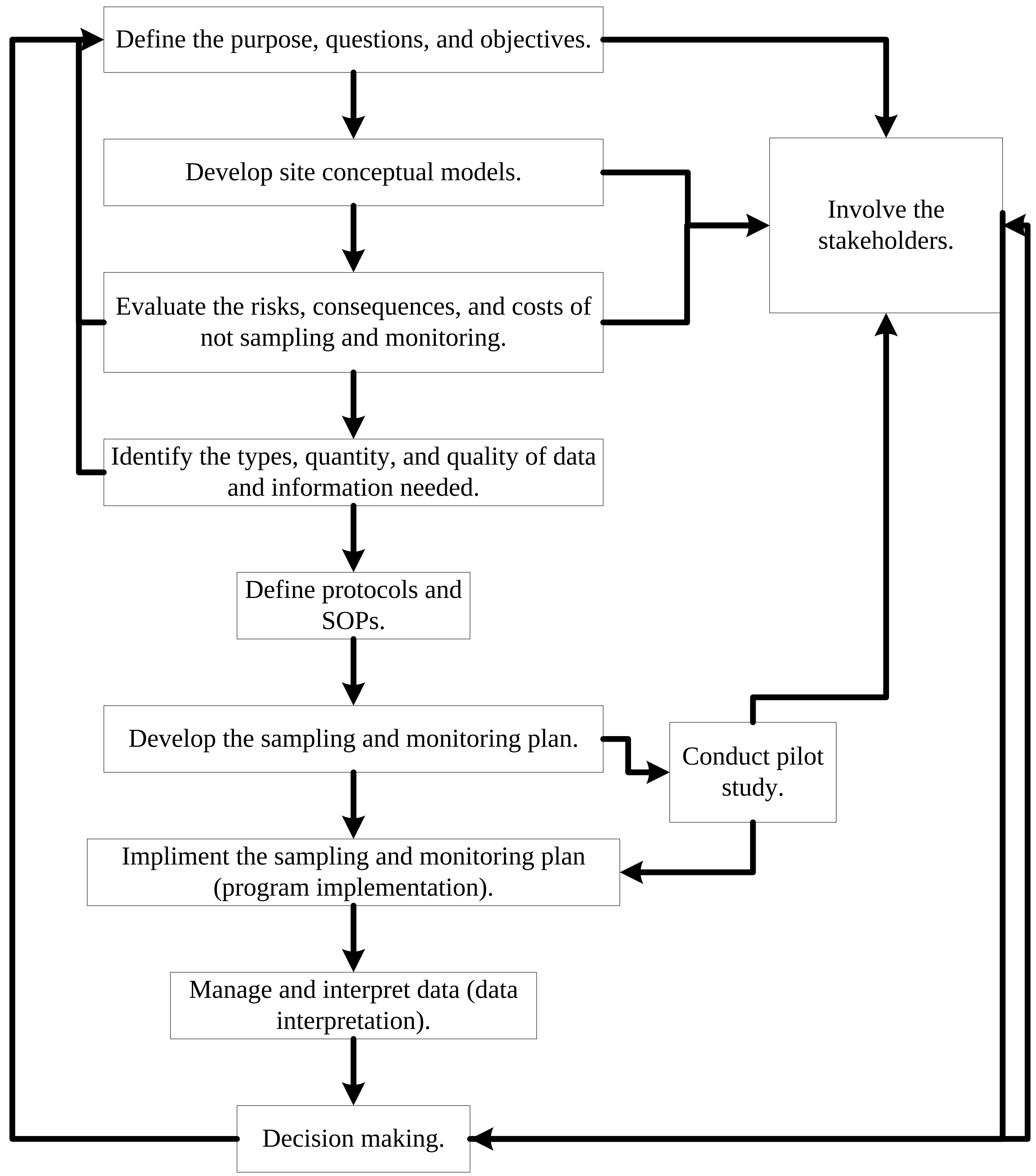
- QA/QC
- Data format
- Safety issues (OSHA vs. MSHA vs. local, state vs. good neighbor/employer)
- Sample location, number of samples, and frequency of sampling, proper labeling of samples (site specific)
- What constituents or parameters are required for each media

7. DEVELOP PROTOCOLS

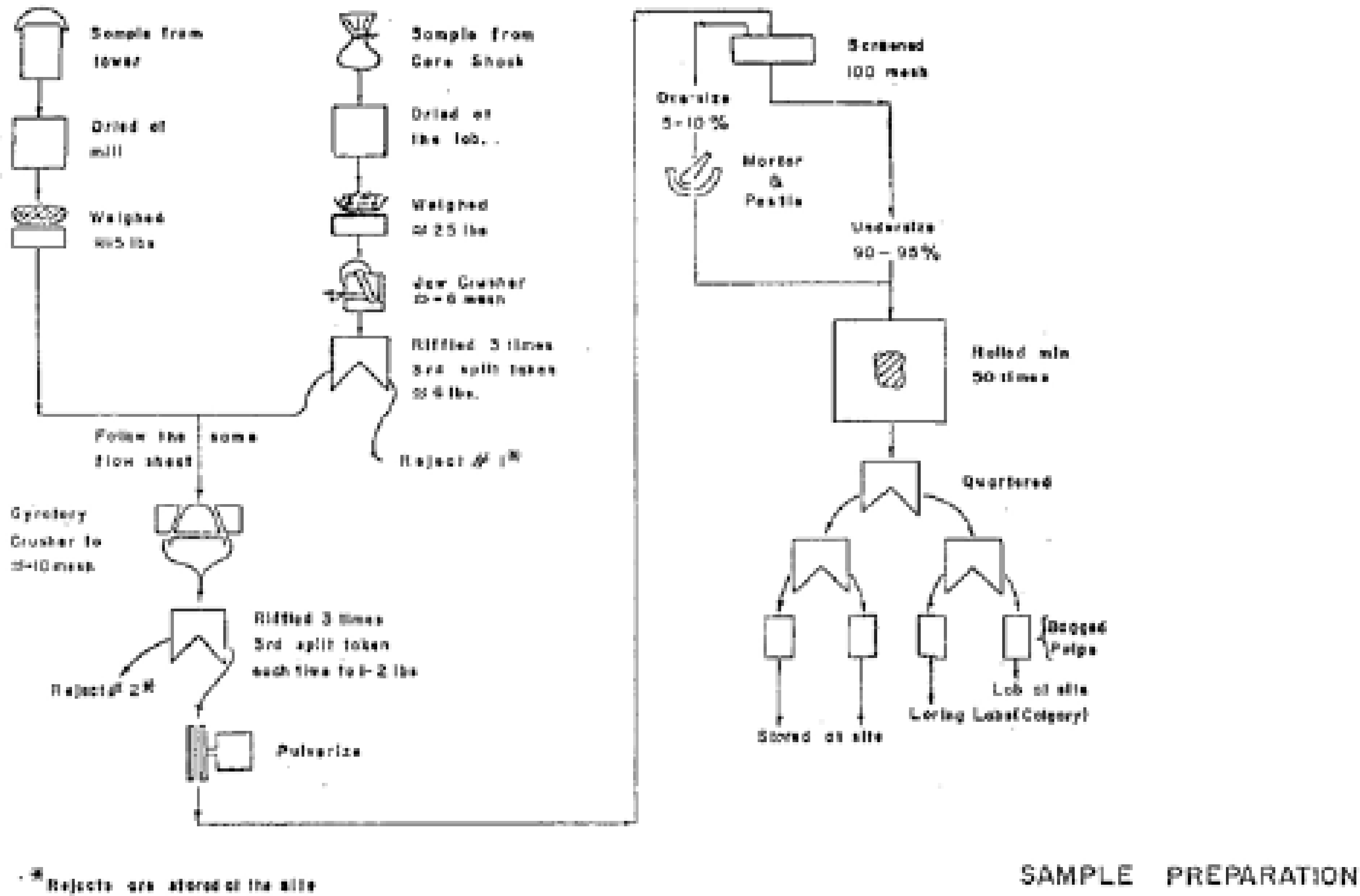
- Collection techniques
- Sample collection
- Observational field data
- Modify sampling plan and deviations
- Opportunistic sampling
- Contamination
- Handling/transport
- Preservation and storage (from field to laboratory)

7. DEVELOP PROTOCOLS—continued

- Sample pre-treatment in the laboratory
- Filtration
- Sample preparation
- Sample separation
- Archival/storage
- Analytical procedures and techniques


Define the purpose, questions, and objectives.
Develop site conceptual models.
Evaluate the risks, consequences, and costs of not sampling and monitoring.
Identify the types, quantity, and quality of data and information needed.
Define protocols and SOPs.
Develop the sampling and monitoring plan.
Impliment the sampling and monitoring plan (program implementation).
Manage and interpret data (data interpretation).
Decision making.
Involve the stakeholders.
Conduct pilot study.

EXAMPLE OF A FLOW SHEET



8. ORIENTATION OR PILOT STUDY

- Clear understanding of target type
- Understanding of surficial environments
- Nature of dispersion from mineralized areas
- Sample types available
- Sample collection procedures
- Sample size requirements

8. ORIENTATION OR PILOT STUDY

- Sample interval, depth, orientation, and density
- Field observations required
- Sample preparation procedures
- Sample fraction for analyses
- Geochemical suite for analyses
- Data format for interpretation

9. CONDUCT SAMPLING PLAN (PROGRAM IMPLEMENTATION)

10. ANALYZE AND MANAGE DATA

- Reporting data
- Presentation of data
- Interpretation
- Data interpretation approaches
  - Statistical
  - Spatial
  - Geochemical
  - Geological

10. ANALYZE AND MANAGE DATA—continued

- Reporting and dissemination
- What becomes of data (storage)
- Common data formats
- Use the data
- Reliability and limitations of findings
- Evaluate the data (statistics)

Relational database in ACCESS that will ultimately be put on line with GIS capabilities

- ACCESS is commercial software and this design can be used by others
- metadata (supporting definitions of specific fields) can be inserted into the database
- ACCESS is flexible and data can be easily added to the design

GIS

- Geologic Information System
  - Arc Map
  - Arc Catalog

11. MAKE DECISIONS (RISK MANAGEMENT)

12. Educate and inform the parties involved

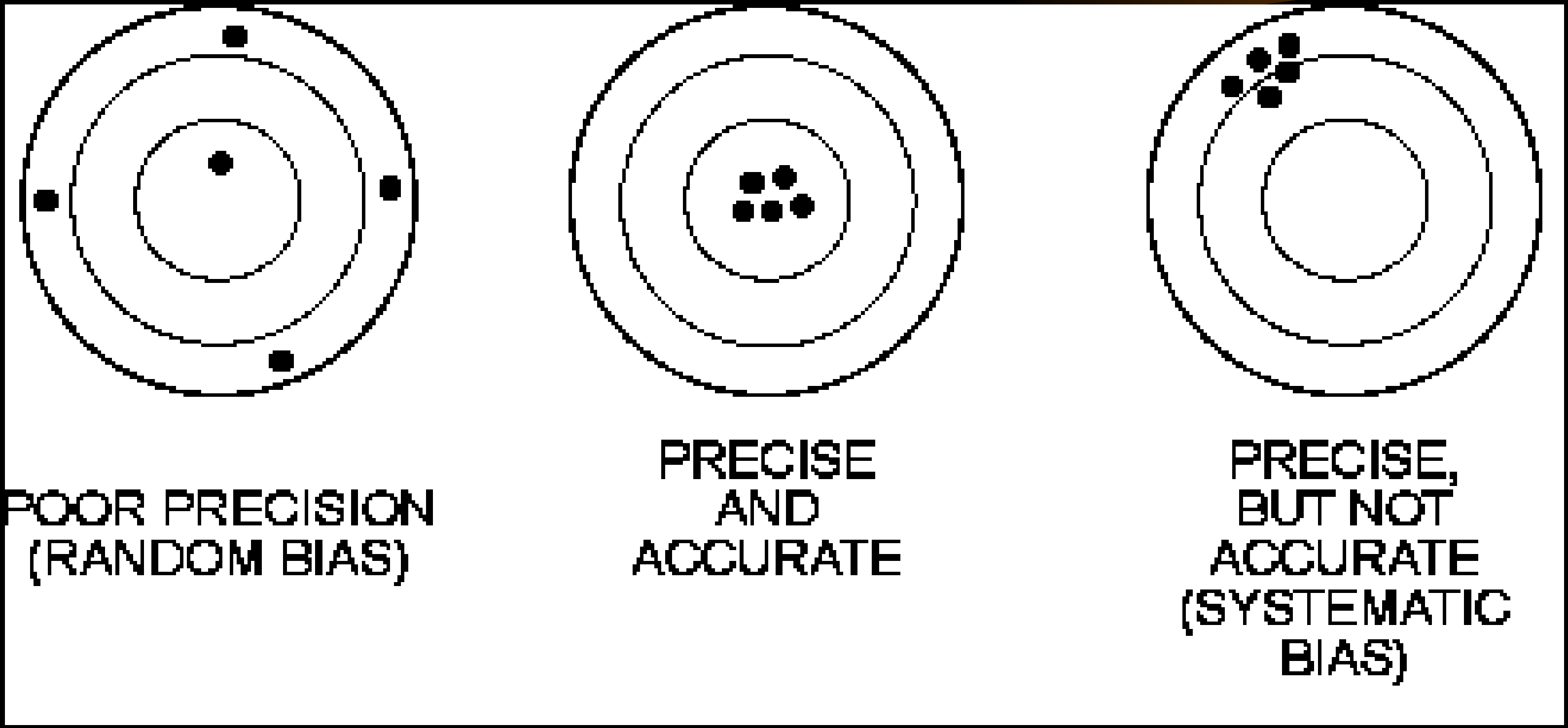
DATA VERTIFICATION

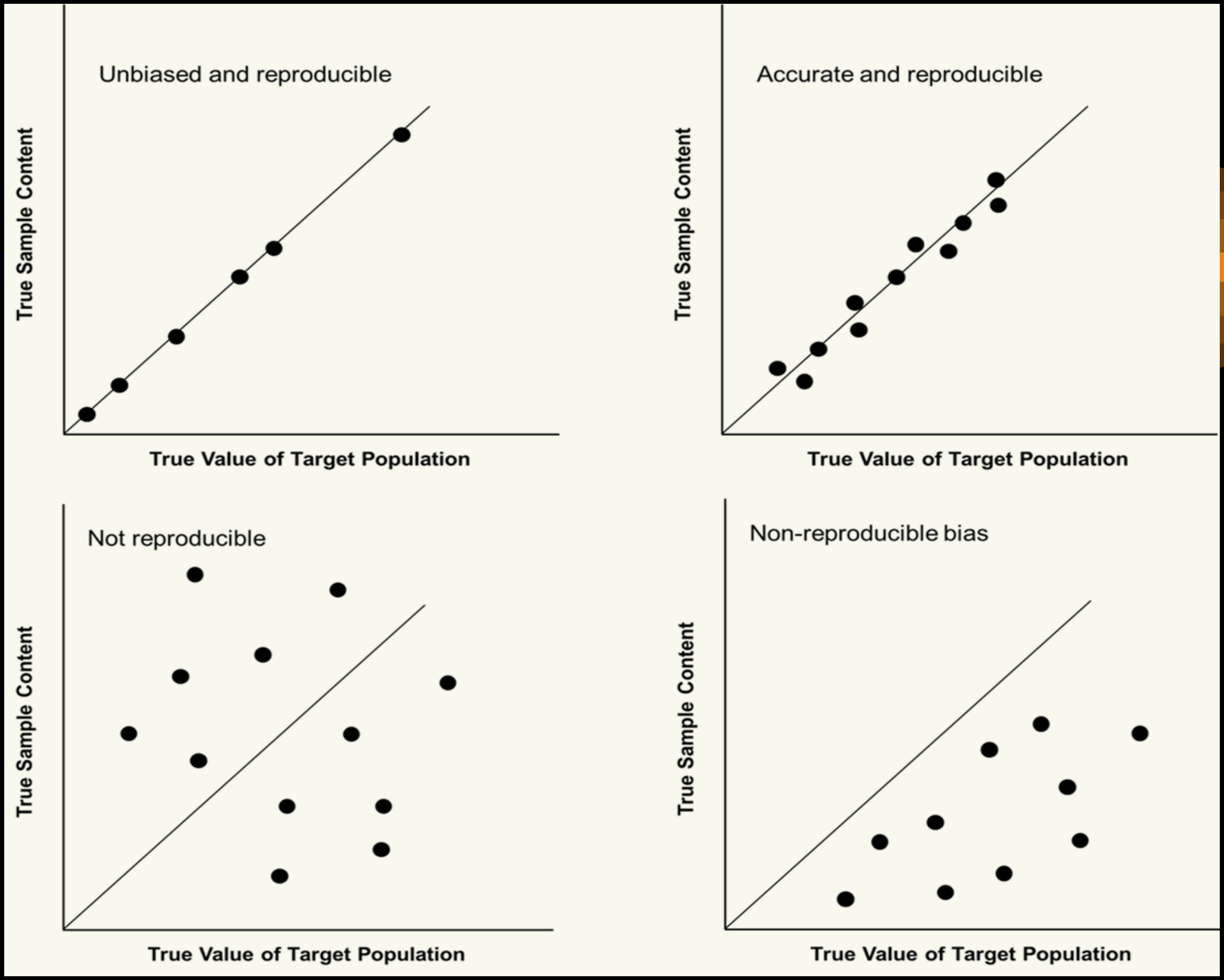
"All analytical measurements are wrong: it's just a question of how large the errors are, and whether they are acceptable" **(Thompson, 1989).**

DEFINTIONS

- ***Precision --*** the degree of agreement among repeated measurements of the same characteristic. Precision is monitored by multiple analyses of many sample duplicates and internal standards.
- ***Accuracy --*** measures how close your results are to a *true* or expected value and can be determined by comparing your analysis of a standard or reference sample to its actual value. Analyzing certified standards as unknown samples and comparing with known certified values monitors accuracy.
- ***Completeness*** -- the comparison between the amount of valid, or usable, data you originally planned to collect, versus how much you collected.
- ***Comparability --*** the extent to which data can be compared between sample locations or periods of time within a project, or between projects.

The difference between precision and accuracy





reproducibility, accuracy, and bias in sampling (modified from Pitard 1993)

PRECISION

The degree to which a set of observations or measurements of the same property, usually obtained under similar conditions, conform to themselves; determined from multiple analysis of many sample replicates or standards.

ACCURACY

The degree of agreement between an observed value and an accepted reference value; determined by analyzing certified standards as if they were unknown samples and comparing those values with known certified values.

REPRESENTATIVENESS

The extent to which measurements actually reflect the sampling unit from which they were taken, as well as the degree to which samples actually represent the target population at the time the samples were collected.

BIAS

The systematic or persistent distortion of a measurement process.

COMPARABILITY

The degree to which different methods, data sets, and/or decisions agree or can be represented as similar.

CONFIDENCE INTERVAL

A range of values that spans from the lower confidence limit to the upper confidence limit and encompasses the population parameter of interest with a specified degree of certainty.

COMPLETENESS

The amount of valid data obtained compared to the planned amount, and usually expressed as a percentage.

QUALITY CONTROL/QUALITY ASSURRANCE

- **QC is referred to a program designed to detect and measure the error associated with a measurement process. QC is the program that ensures that the data are acceptable.**
- **QA is the program designed to verify the acceptability of the data using the data obtained from the QC program. QA provides the assurance that the data meets certain quality requirements with a specified level of confidence.**

QUALITY CONTROL/QUALITY ASSURRANCE

- What is the purpose of your project?
- What do you need the analyses for and how accurate should they be?
- Where are the results going to be released or published?
- What is the mineralogy?
- What are appropriate certified standards (may need to develop lab standards)?
- What are the detection limits (both upper and lower)?
  - Analytical errors vary from element to element, for different ranges of concentration, and different methods
- Duplicate or more analyses of standards and unknowns verses duplicate runs of same sample

QUALITY CONTROL/QUALITY ASSURRANCE

- Analyze a separate set of standards rather than standards used for calibration
- Send samples and standards to other laboratories
- Establish written lab procedures
- Are blanks and field blanks used and analyzed?
- What are the custody procedures (collection date, preservation method, matrix, analytical procedures)?
- Does the chemical analyses make geological sense? Is it consistent with the mineralogy and type of mineral deposit?
- Sometimes there is more paper work than making sure the data is accurate
- What do you do if there are problems with QA/QC?

TYPES OF ERRORS

- Systematic verses bias (constant, unintentional)
- Random errors (unpredicted but nonsystematic errors, imprecise practices)
- Gross or illegitimate errors (procedural mistakes)
- Deliberate errors

MEASUREMENT ERRORS

- Wrong sample
- Wrong reading
- Transposition or transcription errors
- Wrong calibration
- Peak overlap
- Wrong method
- Contamination
- Losses
- Inattention to details
- Sampling problems
- Instrument instability
- Reagent control
- Variability of blank
- Operator skill
- Sample variability

Why do we need full chemical analyses on some solid samples?

- Identification of lithology
- Identification and abundance of mineral species
- Identification, rank, and intensity of alteration
- Prediction of composition of waters within rock piles
- Chemical and mineralogical zonation of rock piles
- Be able to compare, contrast, and coordinate all phases of the project with each other and with existing work (common thread)

How much solid sample is needed for **complete** *characterization?*

- Archive powder 250 gr
- Clay mineralogy 1 lb
- DI leach 50 gr
- ICP 50 gr
- XRF 100 gr
- XRD few gr
- Particle size analyses 2 lb to a bucket
- Thin section fist size
- UFA centrifuge analyses 500 gr
- Pore water chemistry 5 kilos
- Stable isotopes
- Paste pH, paste conductivity 25 gr
- geotechnical ???
- **TOTAL 15 lbs**

Standard Operating Procedures

- Develop SOPs prior to initiation of project
- SOPS should be written and changed to reflect changing procedures—only if procedures can be changed
- SOPs are a written record of procedures in use
- Everyone follows SOPs

Tailgate Safety Meeting Form

Date:	12/8/2003
Time:	8:50 AM
tailgate_number:	1
Site_location:	Guard shack, core shack
Task:	logging and photographing core, mineralogy
Safety_topics:	emergency number 555, unplug heaters, turn off lights, lock door
Protective_clothing:	hard hats, safety glasses
Chemical_hazards:	bleach to disinfect for Hanta virus if needed, buiiding was disinfected
Physical_hazards:	n/a
Special_equipment:	n/a
emergency_procedures:	call guard shack
phone:	555
weather:	cloudy, cold
attendees:	VTM, LFG, GKH, JSR, STM, Adam Sobeck
comments:	combination to door lock is 7628, bathrooms in chemical lab at mill site
Meeting conducted by:	BMW
signature:	

FIELD ACTIVTY FORM

Date:	12/9/2003
field_activity_number:	4
tailgate_number:	2
Subject:	log drill core
Description:	log and photograph sonic core S-1 and S-2 and sample for pyrite; visitors examined outcrops and rock piles led by BMW
sup_intials:	JSR
total_man_hours:	64
Personnel:	LFG, GKH, JSR, STM, GHB,A V, VTM
Visitors:	BMW, Dave Jacobs, Peter Scholle, ARC, VWL, George Robinson, Adam S
Weather:	COLD, CLEAR
Changes:	refinements in drill log, sample form, and SOPs
Comments:	Tour stopped at core building, two near miss accidents, geologist fainted, geologist slipped and fell; safety notified and incident reports

CHAIN OF CUSTODY AND REQUEST FOR ANALYSES

Field_id: MID-GHB-0001 Last_Field_id: MID-GHB-0060 No_samples: 60

Sample_id: Last_Sample_id:

Date_collected: 12/10/2003 Person collected: GHB

Sample_container: cloth bags in white plastic bu

Custody_seals: ☐

Quantity: less than 500 gr

Preservation_methods: sealed lid in bucket

Deviation_chain_of_custody: none

Corrective_action:

chain_of_custudy_transferred to

Date_ transferred	Transferred to	Laboratory _id
12/10/2003	VTM	Molycorp
12/12/2003	BMW	shipping
		shipped tc

Record: 1 of 7

SOP_number: 34 Deviation_SOP: SOP not completely written

Comments:

sample_analyses_request_subform

thin_section ☐ thin_section_comp ☐ bulk_density ☐ bulk_density_comp ☐

Weathering_cells ☐ samples_from_Kim ☐ samples_from_Kim_after ☐

petrographic ☐ petrographic_comp ☐ clay_min ☐ clay_min_comp ☐

Alteration ☐ carbonates ☐ paste_pH ☐ paste_pH_com ☐ MC ☐ MC_comp ☐

mineralogy ☐ pyrite ☐ paste_conductivity ☐ paste_conductivity_com ☐

Crushed ☐ pyrite_reserve ☑ part_size ☐ part_size_comp ☐

DI_leach ☐ DI_leach_comp ☐ part_size_chem ☐ part_size_chem_comp ☐

reflect_spect ☐ microbes ☐ XRD ☐ XRD_comp ☐ Ar_Ar ☐ Ar_Ar_comp ☐

probe ☐ probe_comp ☐ XRF ☐ XRF_comp ☐ ICP ☐ ICP_comp ☐

stable_isotopes ☐ stable_isotopes_comp ☐ pore_water ☐ pore_water_comp ☐

Comments:

FIELD SAMPLE FORM

Field_id: CAP-MLJ-0001 **Feature_id:** 23 **Collected by:** MLJ

Media: solid **Date_collected:** 7/7/2003 **weather_conditions:**

Elevation: **Depth:** 0 **Method_of_obtaining_elevation:**

UTM_easting: 453402 **UTM_northing:** 4062833 **UTM_zone:** 13

Location_assurance: HHGPSoff **Waypoint:** **Point_of_location:** field location

SAMPLING

Method_of_sample_collection: grab for standard

Decontamination:

Type_of_sample: grab **Sample_descrition:** waste dump

Reason_for_sampling: internal standard

Sample_location: Capulin

Location_description_of_sample: top of Capulin waste rock pile

Location comments:

SOP_number: **Deviation_SOP:** no SOP written at time

HAND SPECIMEN DESCRIPTION

field_description: heterogeneous mine waste rock grab sample for std

color: yellowish gray 5Y 7/2 to mod yell **Color_of_Rind:**

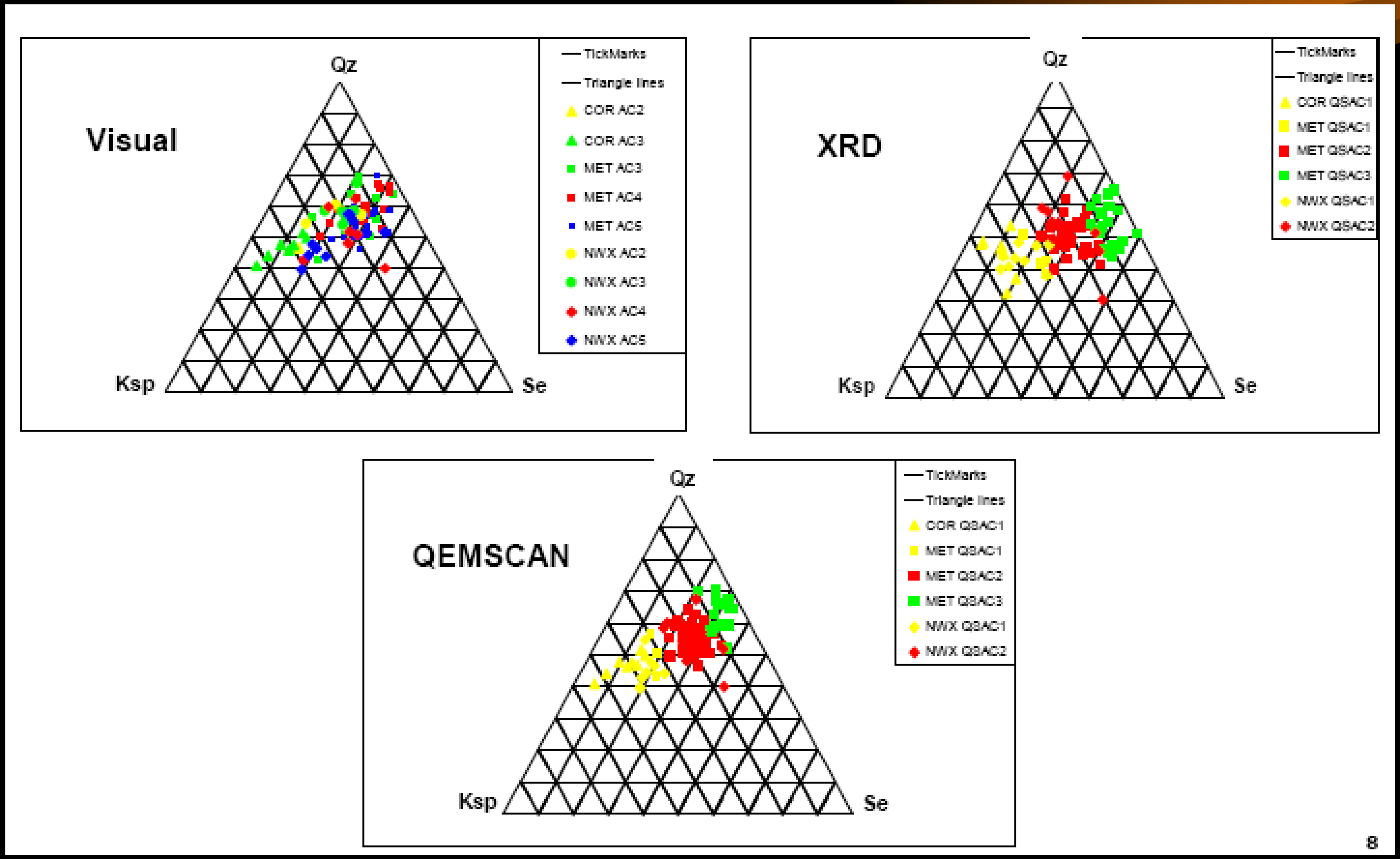
Rind_Thickness: **Color_of_Core:**

Sorting: poor **grain_size:** < 2 inches **Hardness:**

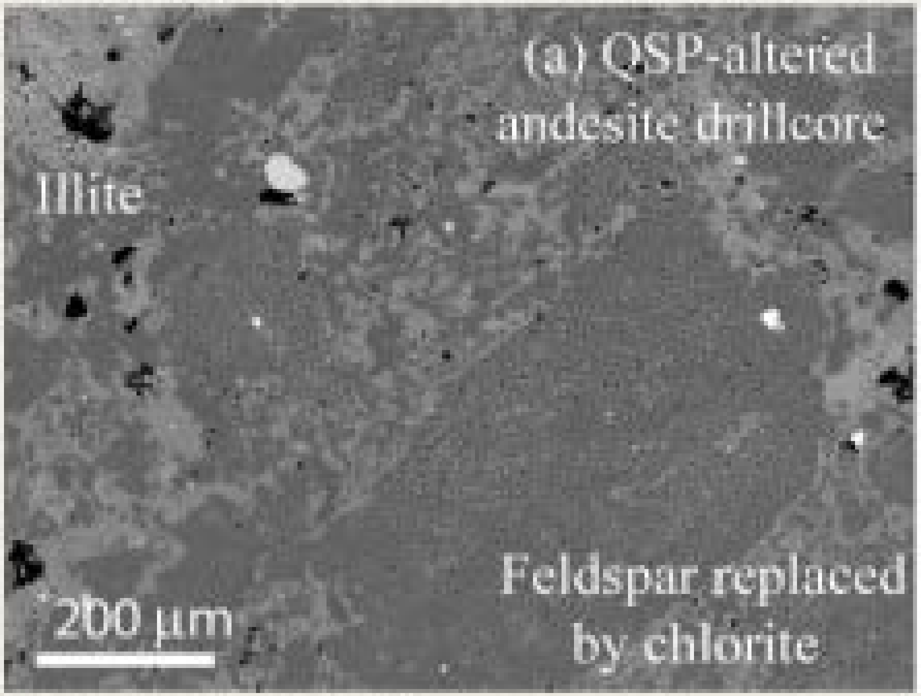
alteration: altered **Structure:**

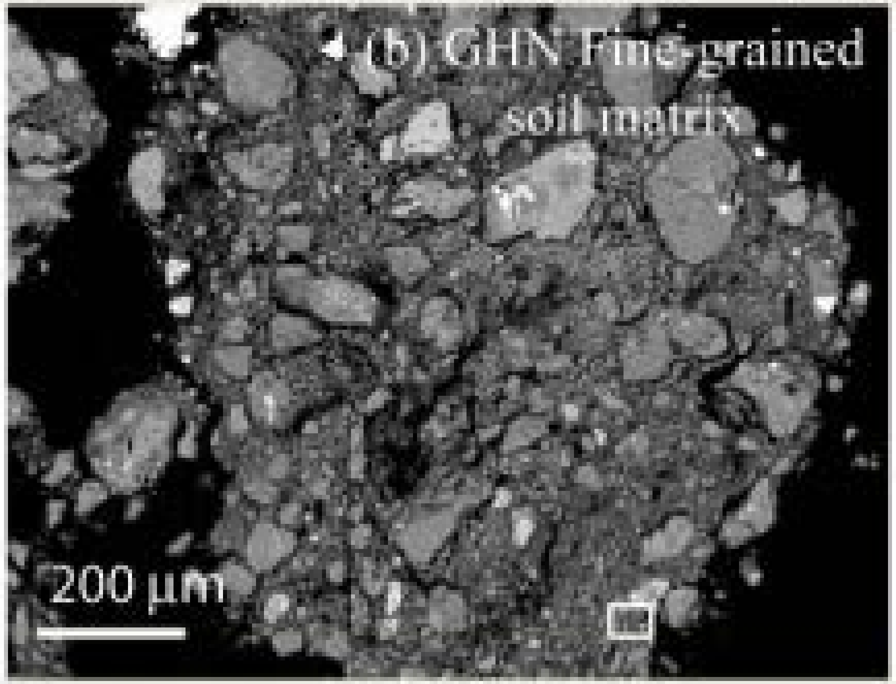
ecord: 1 of 128

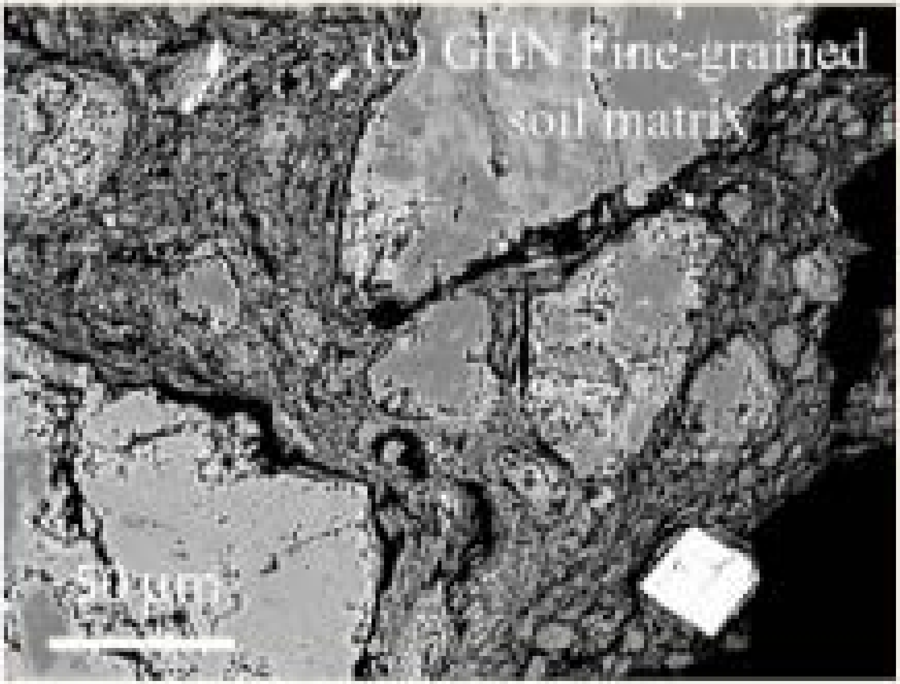
What methods to use in mineralogy?



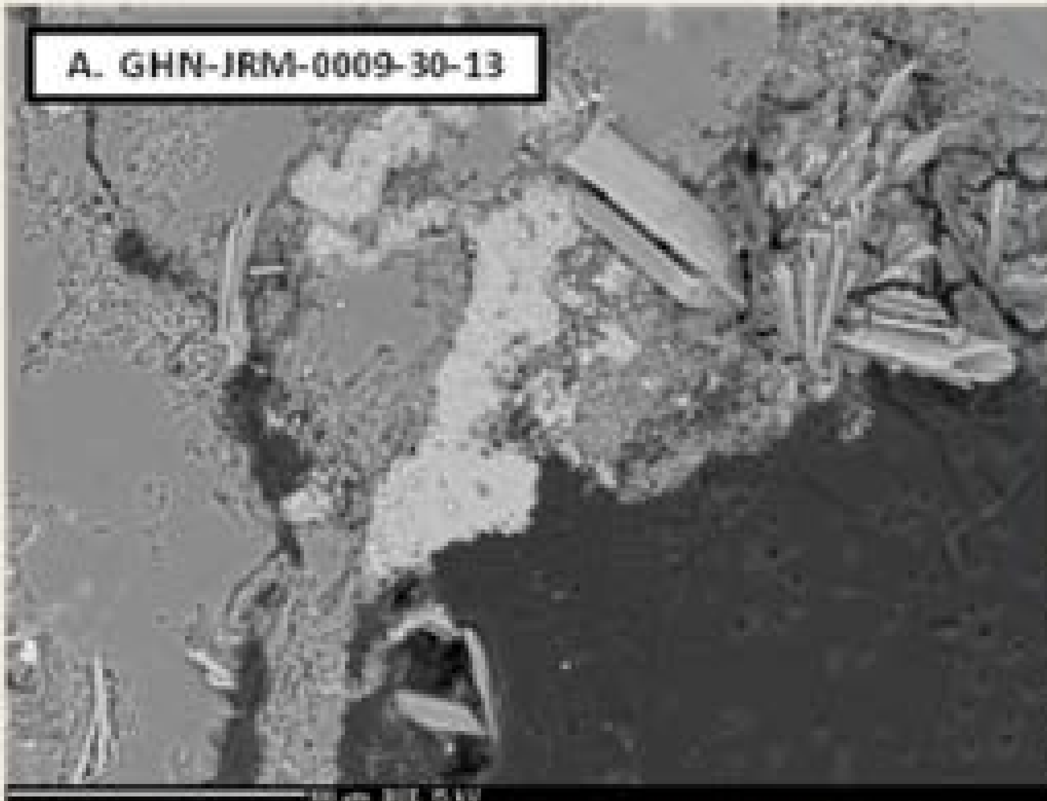
Electron microprobe studies

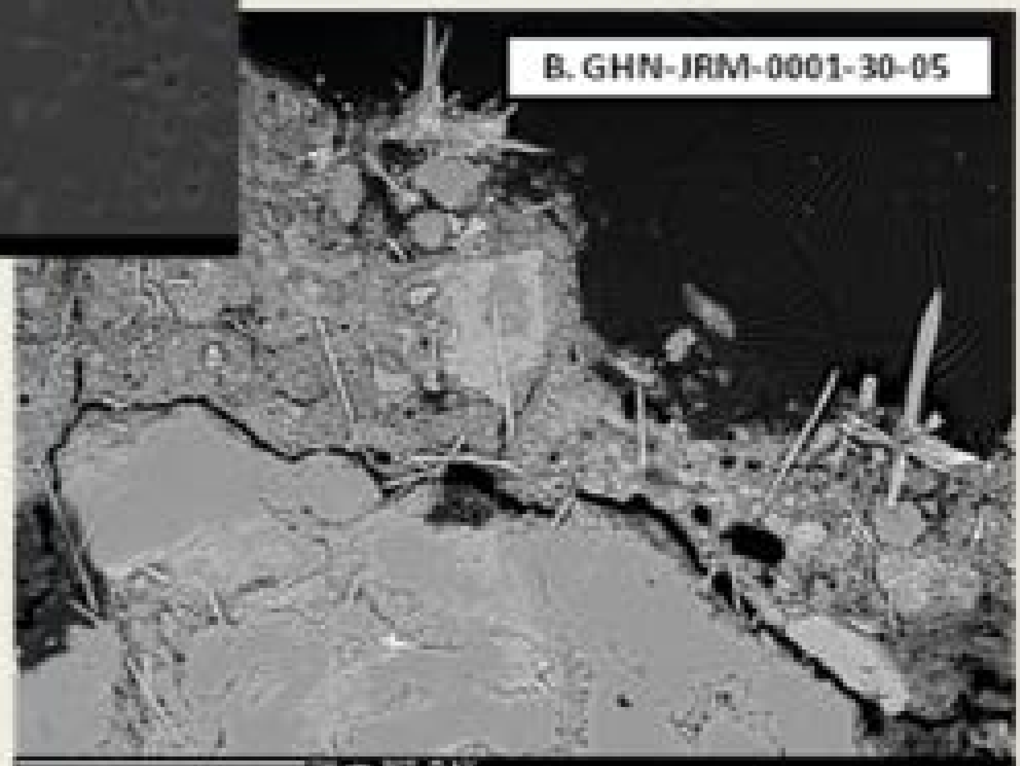






Weathering—In rock piles, the fine-grained soil matrix is weathered, while interiors of rock fragments are not





These are typical weathering textures. Note the lack of weathering of the rock fragments.

NATIONAL INSTRUMENT 43-101

Depends on a “**Qualified Person**”—an experienced person who is registered with an appropriate **professional organization** and
who can demonstrate **sufficient experience** (min. 5 years) in major aspects of the work being reported.
QP can be one or several individuals.

Who can sample?

"Sampling theory cannot replace experience and common sense. Used in concert with these qualities, however, it (sampling theory) can yield the most information about the population being sampled with the least cost and effort (Kratochvil and Taylor, 1981)"

SOME GENERAL GUIDELINES TO EVALUATION OF DUPLICATE DATA

1. Numeric duplicate data lend themselves to quantitative analysis by statistics.

2. Use relatively simple, straight-forward methods.

3. Keep an introductory statistics text handy

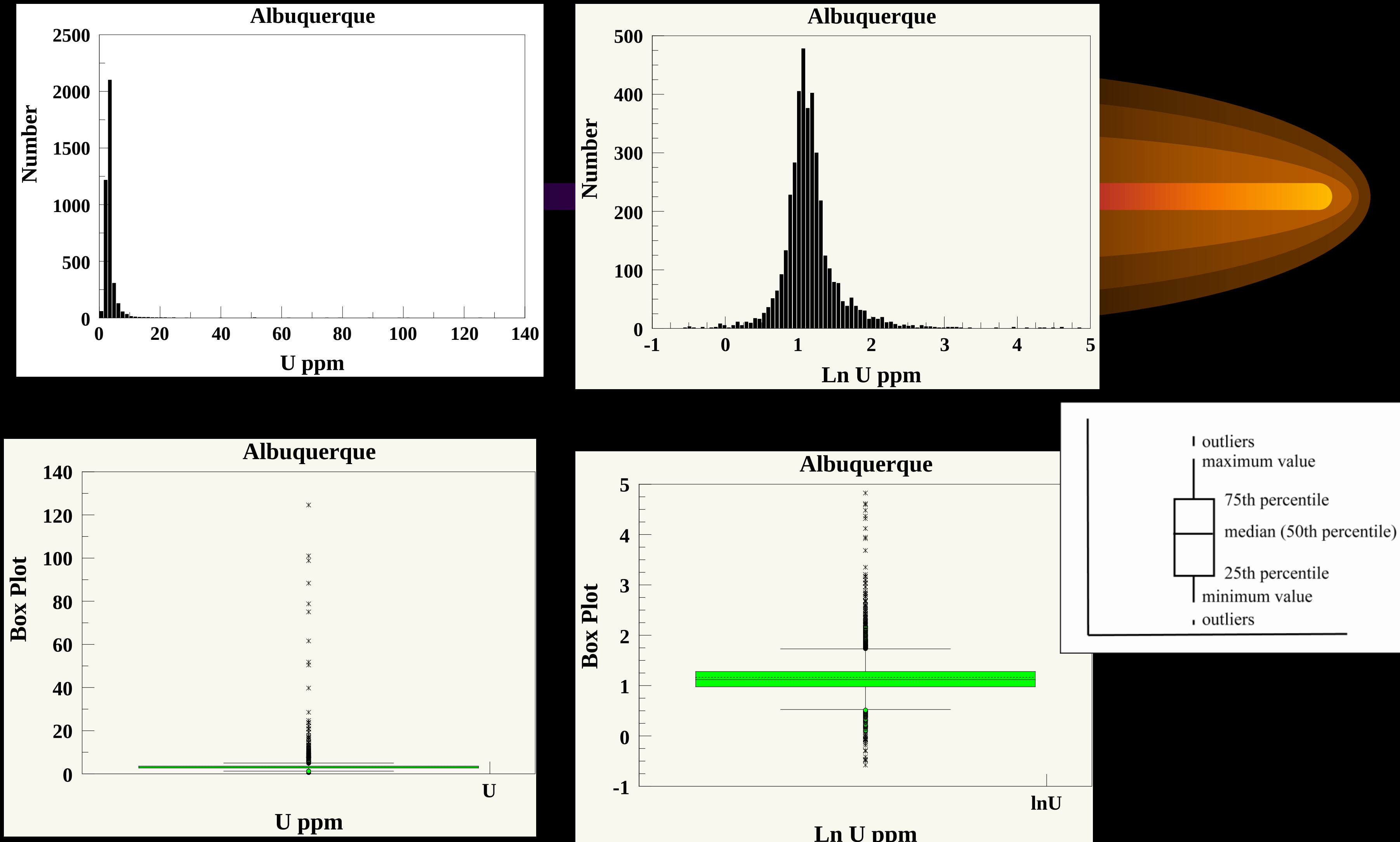
4. Understand conceptually, any procedure you use.

5. Graphical output is highly informative.

6. Quantitative statistical methods are the true test for identifying, understanding and quantifying random errors and bias.

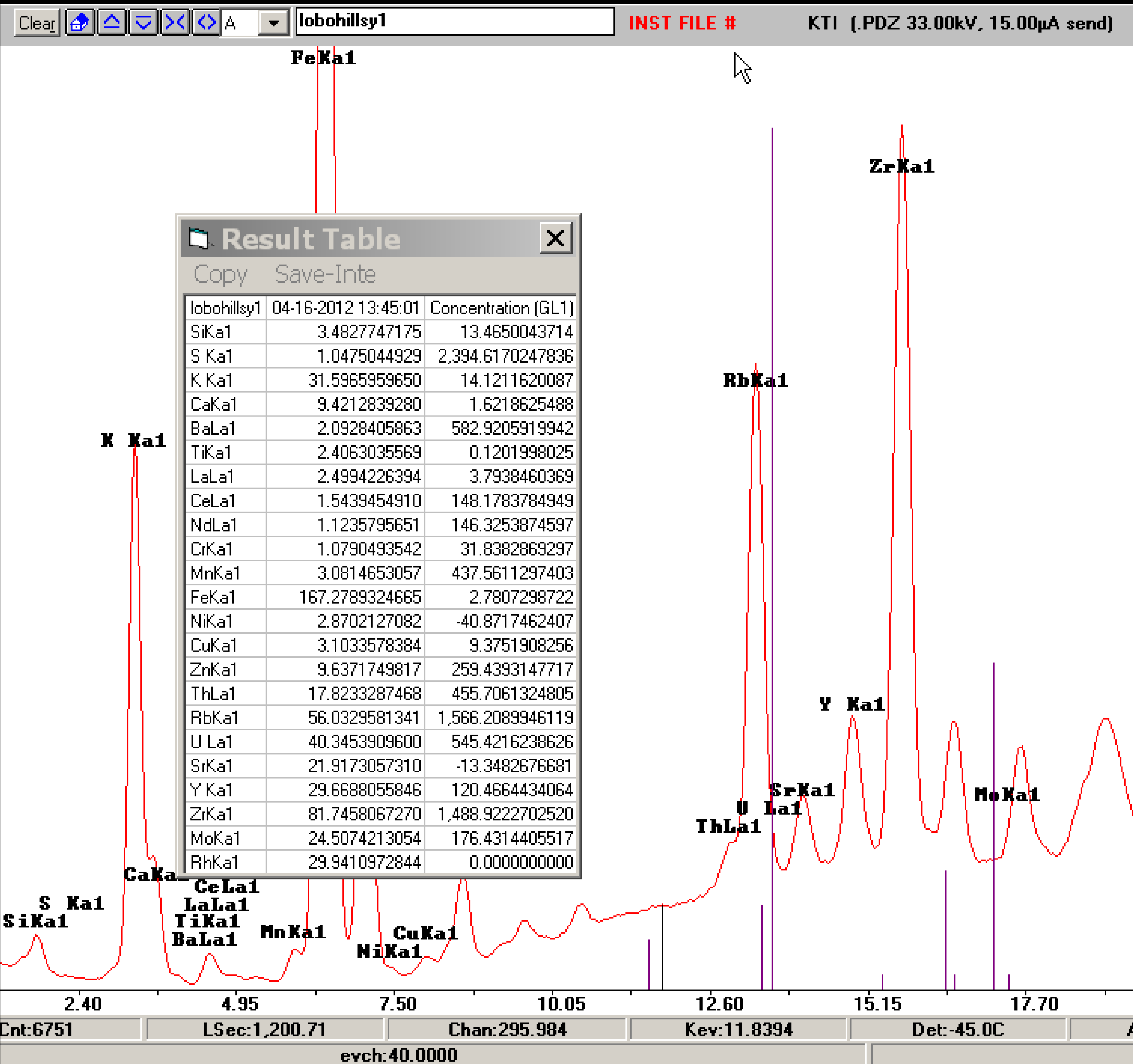
OUTLIERS

A SMALL PROPORTION OF VALUES THAT ARE DISTINCTLY DIFFERENT FROM THE GREAT MAJORITY OF DATA



Histograms and box plots of uranium analyses for the Albuquerque quadrangle (McLemore, 2010). Lower figure explains the box plot.

Interferences



Result Table

Copy Save-Inte

lobohillsy1	04-16-2012 13:45:01	Concentration (GL1)
SiKa1	3.4827747175	13.4650043714
S Ka1	1.0475044929	2,394.6170247836
K Ka1	31.5965959650	14.1211620087
CaKa1	9.4212839280	1.6218625488
BaLa1	2.0928405863	582.9205919942
TiKa1	2.4063035569	0.1201998025
LaLa1	2.4994226394	3.7938460369
CeLa1	1.5439454910	148.1783784949
NdLa1	1.1235795651	146.3253874597
CrKa1	1.0790493542	31.8382869297
MnKa1	3.0814653057	437.5611297403
FeKa1	167.2789324665	2.7807298722
NiKa1	2.8702127082	-40.8717462407
CuKa1	3.1033578384	9.3751908256
ZnKa1	9.6371749817	259.4393147717
ThLa1	17.8233287468	455.7061324805
RbKa1	56.0329581341	1,566.2089946119
U La1	40.3453909600	545.4216238626
SrKa1	21.9173057310	-13.3482676681
Y Ka1	29.6688055846	120.4664434064
ZrKa1	81.7458067270	1,488.9222702520
MoKa1	24.5074213054	176.4314405517
RhKa1	29.9410972844	0.0000000000

Summary

- Data are only as good as the samples collected—what is the context of the sample
- Sampling plans are key to provide good quality and repeatable data
- Monitoring plans are vital to modern mine planning
- Report errors or deviations from SOPs—life happens, don't be afraid of admitting mistakes
- Multiple hypotheses