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Second Projet de Renforcement Institutionnel du Secteur Minier de la République Islamique de Mauritanie (PRISM-II)

Database Creation, Data Quality Assessment, and Geochemical Maps—Final Report on Compilation and Validation of Geochemical Data:

Phase V, Deliverable 59

By Robert G. Eppinger, Stuart A. Giles, Gregory K. Lee, and Steven M. Smith

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Multiple spellings are used in various literatures, and may be reflected in the text.

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or for stratigraphic nomenclature.

The report is being released in both English and French. In both versions, we use the French-language names for formal stratigraphic units.

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Files

Folder	File(s)	Contents
BasicStatistics	BasicStatistics.xls	Basic statistics on geochemical data for rocks and unconsolidated materials from the six regions.
MasterChem	MasterChem.mdb	Geochemical data combined from all PRISM-I sources, and separated by region
MasterLocation	MasterLocations.mdb	Locations for samples from all PRISM-I sources
QAQC	Duplicates_Au.xls	Summary tables and graphs for Au analyses
QAQC	Duplicates_BaseDeDonnees.xls	Summary tables and graphs for duplicate samples in the PRISM-I Base de Données database
QAQC	Duplicates_ICP61.xls	Summary tables and graphs for duplicate samples done by the ICP61 method
QAQC	Duplicates_MS61.xls	Summary tables and graphs for duplicate samples done by the MS61 method
QAQC	Standards_BMAA-02.xls	Summary tables and graphs for the BMAA-02 standard
	Standards_G2000_ICP61.xls	Summary tables and graphs for the G2000 standard, ICP61 method
QAQC	Standards_G2000_MS61.xls	Summary tables and graphs for the G2000 standard, MS61 method
QAQC	Standards_GEOMS-03.xls	Summary tables and graphs for the GEOMS-03 standard
QAQC	Standards_GS01-2.xls	Summary tables and graphs for the GS01-2 standard
QAQC	Standards_JWB-JV-1.xls	Summary tables and graphs for the JWB-JV-1 standard
QAQC	Standards_NA-03.xls	Summary tables and graphs for the NA-03 standard
QAQC	Standards_OX5.xls	Summary tables and graphs for the OX5 standard
QAQC	Standards_OX8.xls	Summary tables and graphs for the OX8 standard
QAQC	Standards_PGMS-3.xls	Summary tables and graphs for the PGMS-3 standard
QAQC	Standards_SC-02.xls	Summary tables and graphs for the SC-02 standard

GeochemMaps_SampleSites_1000000

Contains a country-wide area and sample site map at 1:1,000,000 scale

GeochemMaps_Single-Element_1000000

Contains 23 single-element geochemical maps in PDF format, country-wide, 1:1,000,000 scale

GeochemMaps_Multi-Element_1000000

Contains six multi-element maps in PDF format, country-wide, 1:1,000,000 scale

GeochemMaps_Single-Element_500000

Contains 296 single-element geochemical maps in PDF format, broken down by region, 1:500,000 scale

Conversion Factors

SI to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
decimeter (dm)	0.32808	foot (ft)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic kilometer (km^3)	0.2399	cubic mile (mi^3)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)
megagram (Mg)	1.102	ton, short (2,000 lb)
megagram (Mg)	0.9842	ton, long (2,240 lb)
metric ton per day	1.102	ton per day (ton/d)
megagram per day (Mg/d)	1.102	ton per day (ton/d)
metric ton per year	1.102	ton per year (ton/yr)
	Pressure	
kilopascal (kPa)	0.009869	atmosphere, standard (atm)
kilopascal (kPa)	0.01	bar
	Energy	
joule (J)	0.0000002	kilowatt hour (kWh)

ppm, parts per million; ppb, parts per billion; Ma, millions of years before present; m.y., millions of years; Ga, billions of years before present; 1 micron or micrometer (μor μm) = 1 × 10^{-6} meters; Tesla (T) = the field intensity generating 1 Newton of force per ampere (A) of current per meter of conductor

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32
Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C=(°F-32)/1.8
Coordinate information is referenced to the World Geodetic System (WGS 84).

Acronyms

AMT	Audio-magnetotelluric
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVIRIS	Airborne Visible/Infrared Imaging Spectrometer
BIF	Banded iron formation
BLEG	Bulk leach extractable gold
BGS	British Geological Survey
BRGM	Bureau de Recherches Géologiques et Minières (Mauritania)
BUMIFOM	The Bureau Minier de la France d'Outre-Mer
CAMP	Central Atlantic Magmatic Province
CGIAR-CSI	Consultative Group on International Agricultural Research-Consortium for Spatial Information
DEM	Digital Elevation Model
DMG	Direction des Mines et de la Géologie
EC	Electrical conductivity
EMPA	Electron Microprobe Analysis
EM	Electromagnetic (geophysical survey)
EOS	Earth Observing System
eU	Equivalent uranium
GGISA	General Gold International
GIF	Granular iron formation
GIFOV	Ground instantaneous field of view
GIS	Geographic Information System
HIF	High grade hematitic iron ores
IHS	Intensity/Hue/Saturation
IAEA	International Atomic Energy Agency
IOCG	Iron oxide copper-gold deposit
IP	Induced polarization (geophysical survey)
IRM	Islamic Republic of Mauritania
JICA	Japan International Cooperation Agency
JORC	Joint Ore Reserves Committee (Australasian)
LIP	Large Igneous Province
LOR	Lower limit of reporting
LREE	Light rare-earth element
METI	Ministry of Economy, Trade and Industry (Japan)
MICUMA	Société des Mines de Cuivre de Mauritanie
MORB	Mid-ocean ridge basalt
E-MORB	Enriched mid-ocean ridge basalt
N-MORB	Slightly enriched mid-ocean ridge basalt
T-MORB	Transitional mid-ocean ridge basalt

Moz	Million ounces
MVT	Mississippi Valley-type deposits
NASA	United States National Aeronautics and Space Administration
NLAPS	National Landsat Archive Processing System
OMRG	Mauritanian Office for Geological Research
ONUDI	(UNIDO) United Nations Industrial Development Organization
PRISM	Projet de Renforcement Institutionnel du Secteur Minier
PGE	Platinum-group elements
RC	Reverse circulation drilling
REE	Rare earth element
RGB	Red-green-blue color schema
RTP	Reduced-to-pole
SARL	Société à responsabilité limitée
SEDEX	Sedimentary exhalative deposits
SIMS	Secondary Ionization Mass Spectrometry
SNIM	Société National Industrielle et Minière (Mauritania)
SP	Self potential (geophysical survey)
SRTM	Shuttle Radar Topography Mission
SWIR	Shortwave infrared
TDS	Total dissolved solids
TIMS	Thermal Ionization Mass Spectrometry
TISZ	Tacarat-Inemmaudene Shear Zone
TM	Landsat Thematic Mapper
UN	United Nations
UNDP	United Nations Development Program
US	United States
USA	United States of America
USGS	United States Geological Survey
UTM	Universal Transverse Mercator projection
VHMS	Volcanic-hosted massive sulfide
VisNIR	Visible near-infrared spectroscopy
VLF	Very low frequency (geophysical survey)
VMS	Volcanogenic massive sulfide deposit
WDS	Wavelength-dispersive spectroscopy
WGS	World Geodetic System

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By Robert G. Eppinger,[1] Stuart A. Giles,[1] Gregory K. Lee,[1] and Steven M. Smith[1]

1 Introduction

Under the World Bank-funded Second Projet de Renforcement Institutionnel du Secteur Minier de la Republique Islamique de Mauritanie (PRISM-II), this Phase V geochemistry report follows earlier Phase I and Phase II summary reports on geochemical data (U.S. Geological Survey, 2007 and Eppinger, 2007; respectively). All the reports are based on evaluations of geochemical data collected in 1999-2004 under an earlier World Bank program (PRISM-I) by the British Geological Survey (BGS) and the Bureau de Recherches Géologiques et Minières (BRGM) for the Government of Mauritania. There are no associated Phase III or IV reports.

The geochemical sample media collected by the BGS and BRGM under the PRISM-I contract included rock, sediment, regolith, and soil samples. Details on sample collection procedures are in unpublished reports available from PRISM. These samples were analyzed under PRISM-I contract by ALS Chemex Laboratories using various combinations of modern methods including fire-assay inductively coupled plasma-atomic emission spectrometry (ICP-AES) and ICP-mass spectrometry (ICP-MS) for Au; multi-acid digestion, atomic absorption spectroscopy (AAS) for Ag and As; 47-element, four-acid digestion, ICP-MS; 27-element, four-acid digestion, ICP-AES; special four-acid ICP-MS techniques for Pt and B; fire assay followed by ICP-AES for platinum-group elements; whole-rock analyses by wavelength dispersive X-ray fluorescence (XRF); special techniques for loss-on-ignition, inorganic C, and total S; and special ore-grade AAS techniques for Ag, Au, Cu, Ni, Pb, and Zn. Around 30,000 samples were analyzed by at least one technique. However, it is stressed here that: (1) there was no common sample medium collected at all sites, likely due to the vast geological and geomorphologic differences across the country, (2) the sample site distribution is very irregular, likely due in part to access constraints and sand dune cover, and (3) there was no common across-the-board trace element analytical package used for all samples. These three aspects fundamentally affect the ability to produce country-wide geochemical maps of Mauritania. Gold (Au), silver (Ag), and arsenic (As) were the three elements that were most commonly analyzed.

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Following the receipt from Mauritanian PRISM counterparts of the PRISM-I geochemical data and evaluation by the U.S. Geological Survey (USGS), the Phase I summary report identified numerous sample site location problems, indicated the apparent absence of numerous geochemical datasets, and identified only minimal quality-assurance and quality-control (QA/QC) information in the PRISM-I data. In a March, 2007 visit to Mauritania, the USGS delegation was given 118 Microsoft Excel spreadsheets and 59 PDF files by Mauritanian PRISM counterparts in Nouakchott to help address these problems. The spreadsheets and PDF files were copies of the original analytical reports provided by ALS Chemex. The Phase II report described the acquisition and population of new data, creation of Microsoft Access 2003 master location and chemistry databases using the new and existing data, a QA/QC analysis of the data, and the creation of single-element geochemical maps for most of the elements analyzed. The Phase II report also identified in table form problems encountered with the PRISM-I data. The Phase II geochemistry report was reviewed by independent geologist-consultant A. Killick under contract with PRISM.

This Phase V final report on geochemistry incorporates information from the Phase I and particularly the Phase II reports, and incorporates changes recommended by A. Killick. The Phase V report also incorporates changes requested by Mauritanian PRISM counterparts Mohamed Yeslem Ould El Joud and Ahmed Ould Taleb Mohamed during their June, 2012 visit to USGS offices in Denver, Colorado, as part of the country-wide mineral resource assessment. In the Phase II report, the decision was made to produce numerous single-element geochemical maps for six geology-based polygons covering Mauritania, at 1:500,000 scale. These 291 maps were of fundamental importance during the above mineral resource assessment meeting. However, A. Killick pointed out in his review that the PRISM-II contract required country-wide single- and multi-element geochemical maps at 1:1,000,000 scale; these maps are provided in the accompanying files of this Phase V report, in PDF format from data derived from Environmental Systems Research Institute, Inc.(ESRI) shapefiles. For the Phase V report, as a convention, all database tables, filenames, and computer folders (directories) are *italicized* when discussed in the text.

Three tasks, all expanded upon in this report, were undertaken to address issues identified in the Phase I report: (1) A master location Access database was created to house all site coordinates and to correct location errors identified in certain PRISM-I data. Site identifications (IDs) and sample media types are also included in the database. This database is called *MasterLocations.mdb* and is included in the enclosed files. (2) The original ALS Chemex geochemical and associated QA/QC data provided in spreadsheet and PDF formats were entered into an Access database. Then these new geochemical data were combined with other PRISM-I data provided to the USGS on a hard drive in Base_de_données, GGI, Normandie_La_Source and SIG_Geochimie_500 folders. The end result was the creation of a new database containing (nearly) all geochemical data made available to the USGS. This new database, in the accompanying files, is called *MasterChem.mdb*. (3) Finally, the numerous original QA/QC reports from ALS Chemex were systematically entered into a separate Access database for making an assessment of the QA/QC data. Results from these three efforts are described more fully in individual sections below. Also included in this report is a short discussion (section 5) on problems identified in working on the above three tasks. The intent is to capture the essence of the problems so that future users of the PRISM data are aware of or perhaps can solve them.

Once the *MasterLocations.mdb* Access database was created, a country-wide sample location map was created (figure 1.1; file: Geochemistry Areas and Sample Sites.pdf). The file shows sample locations and areas at 1:1,000,000 scale. Immediately apparent on both figure 1.1 and the file is the problem of extreme overprinting at these scales in areas of dense sampling. Also apparent is the uneven distribution of sample sites and the variations in sample media collected across the country. Nevertheless, single- and multi-element maps were prepared at 1:1,000,000 to meet contract requirements (described in section 6 of this report).

To address the overprinting issue, the sampled area was broken into six geology-based regions (Nord-Ouest, Nord-Est, Tasiast-Tijirit, Central Mauritanides, Southern Mauritanides, and Kîffa-Néma; figure 1.2 and file Geochemistry Areas and Sample Sites.pdf). The national-scale geologic map and overall geochemical sample distributions were used to determine approximate boundaries for the six regions. Statistics were calculated separately for the six regions and geochemical maps of these regions were produced at 1:500,000 scale (described in section 7 of this report). An accompanying table describes the gross geochemical sample characteristics of each region (file: Geochemistry Areas and Sample Sites.pdf). Geochemical maps for selected elements were produced for the six regions using the *MasterLocations.mdb* and *MasterChem.mdb* Access databases, as described below.

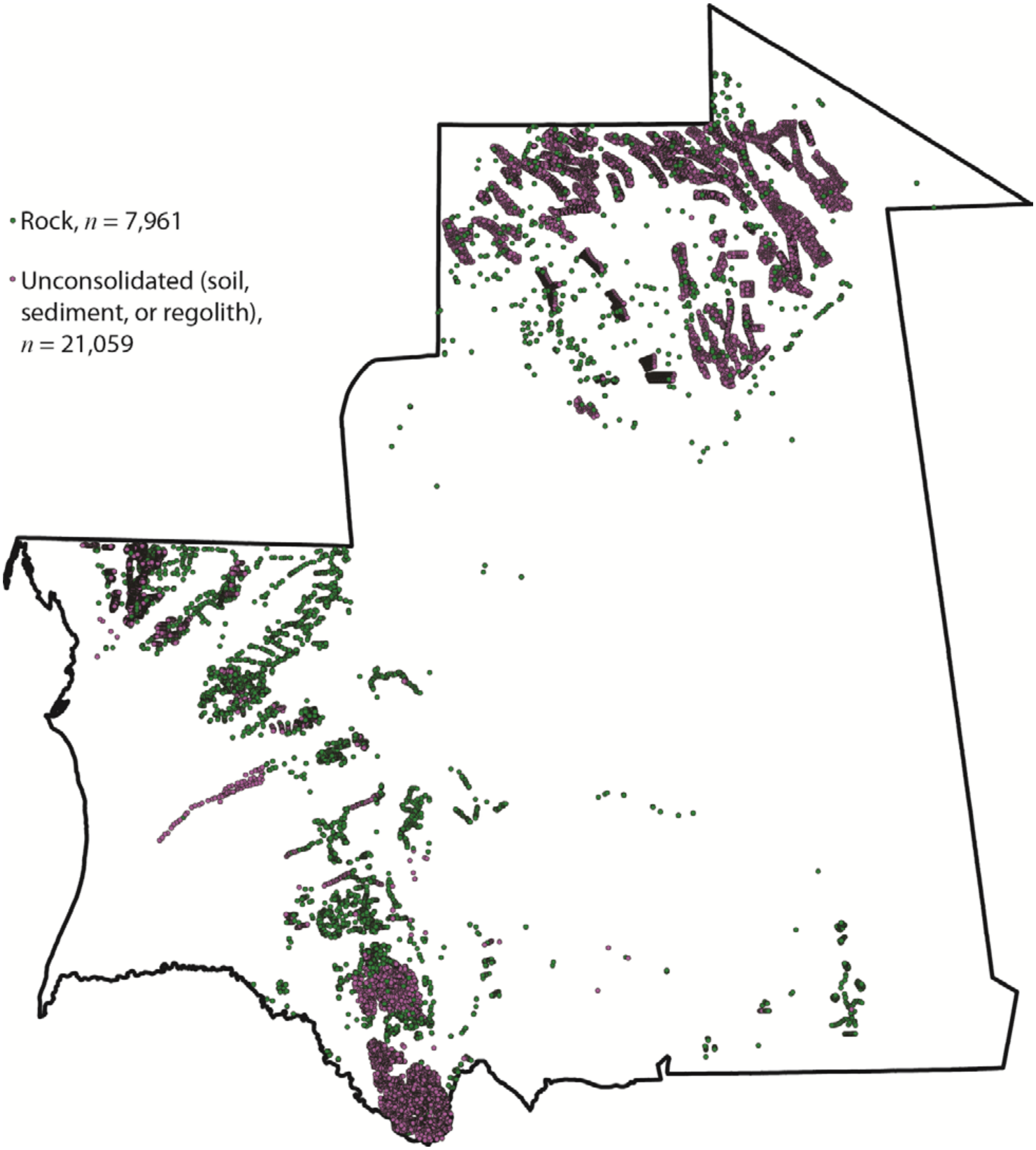

Figure 1.1. Locations of rock and unconsolidated samples collected across Mauritania during the PRISM-I project. Black areas indicate areas of high-density sample collection. Geochemical data are portrayed at 1:500,000 and 1:1,000,000 scale on maps accompanying this report.

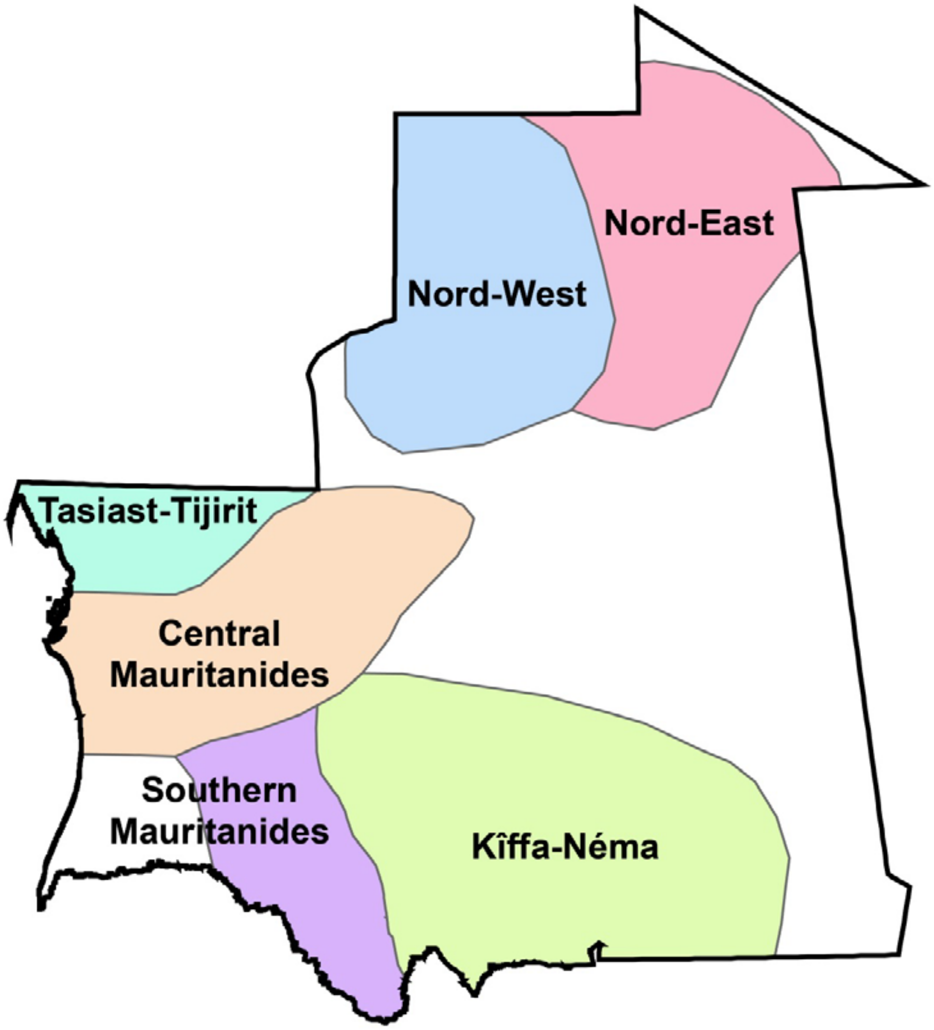

Figure 1.2. Index map of Mauritania and the six informal regions used in discussing geochemistry.

2 The Master Location Access Database

A master location/sample media database was created by searching all PRISM-I files provided to the USGS for geochemistry (in Access, Excel, shapefiles, etc.) and extracting coordinates, sample IDs, and sample media type information. The master location information is located in the *tblSamples* table in the *MasterLocations.mdb* file in the accompanying files. This file was created in a multi-step process, described in greater detail in Appendix 1. In some cases, coarse or missing coordinates that were identified in the Phase I Summary Report (U.S. Geological Survey, 2007) were refined or corrected by extracting more precise coordinates for the same samples IDs from associated shapefiles. In general, where multiple sets of coordinates were found for the same sample ID, the most precise coordinates were used. However, several thousand samples in the PRISM-I data provided to the USGS had coarse coordinates, with latitude and longitude reported only to the nearest hundredth of a decimal degree. At 20° latitude, a hundredth of a decimal degree is equivalent to about 1,100 m. Since the original coordinates were determined using a GPS in the field, it is suspected that rounding errors were generated during a file conversion process, such as importing a spreadsheet to a database, although the exact source of the error cannot be ascertained. Because of this rounding error, numerous samples that were originally collected in tight patterns had identical coordinates. This coordinate rounding error was emphasized in both the Phase II report and during the 2012 mineral resource assessment meeting. The rounded coordinates problem for around 8,500 sample sites were resolved and incorporated into the Access database and associated GIS project files upon receipt of a new spreadsheet containing coordinates from PRISM on 31 July, 2012. A total of 39,305 unique records with unique coordinates is present in the *tblSamples* table. Extracted from the *tblSamples* table, table 2.1 summarizes the various rock samples within each of the six regions. A total of 10,512 rock samples with coordinates from all six regions were identified throughout the country.

Table 2.1. Rock samples summary.

[BLEG, bulk-leach extractable gold]

Region	Rock										
	All Rocks	Roche or Roche_grab	BLEG	Canal	Petro selectif	Sondage (drillcore)	Other	Affleurement naturel	fond géoch	lag	Rock chip	Rock pit
Central Mauritanides	2,115	2,062	0	43	3	6	1 (quartz)	0	0	0	0	0
Kîffa-Néma	789	788	0	1	0	0		0	0	0	0	0
Nord-Est	829	14	0	0	591	0	0	69	106	49	0	0
Nord-Ouest	615	119	0	0	226	0	0	131	74	1	50	14
Southern Mauritanides	4,043	2,734	1,124	11	0	0	0	0	0	0	174 (Eclat)	0
Tasiast-Tijirit	2,121	1,670	0	0	0	0	451 (not specified)	0	0	0	0	0
TOTAL	10,512	7,387	1,124	55	820	6	452	200	180	50	224	14

Extracted from the *tblSamples* table, table 2.2 summarizes the various unconsolidated (soil, regolith, and stream sediment) samples within each of the six regions. A total of 28,793 records having coordinates for unconsolidated media from all six regions were identified.

Table 2.2. Summary of unconsolidated materials.

Region	Unconsolidated Material				
	All Unconsolidated	Regolith	Sol	Unclassified	Stream Sediment
Central Mauritanides	584	0	512	0	72
Kîffa-Néma	85	0	61	0	24
Nord-Est	6,248	3,900	0	0	2,348
Nord-Ouest	4,461	3,503	0	0	958
Southern Mauritanides	5,093	0	78	23	4,992
Tasiast-Tijirit	12,322	0	214	12,107	1
TOTAL	28,793	7,403	865	12,130	8,395

3 The Master Geochemistry Database

The Master Geochemistry Database file was created in a multi-step process, described in detail in appendix 2. First, 9,644 original chemical analytical results reported by ALS-Chemex (118 Excel spreadsheets and 59 PDF files), were manually entered into an Access database. These original lab reports and associated analytical QA/QC data did not have coordinates attached. These missing geochemical data were identified in the Phase I Report and the above spreadsheets and PDF files were provided to the USGS by Mauritanian PRISM counterparts. These data are located in the *NewDataFromNouakchott-March2007* folder, *MauritaniaNewChemData.mdb* file. Second, the above data were combined with the data provided in various formats (databases, spreadsheets, and shapefiles) in the original Phase I digital files provided to the USGS (Base_de_données, GGI, Normandie_La_Source, and SIG_Geochimie_500 folders), to create a new combined file *MasterChem.mdb*, located in the root *Geochemistry* folder. The original geochemical data from the Phase I digital files are described in the Phase I Summary Report (U.S. Geological Survey, 2007). Third, censored values (those with "<" or ">" symbols) were replaced for statistical and plotting purposes. At the request of Mauritanian PRISM counterparts, the conventions used for replacement are the same as those used in databases in the PRISM-I Base_de_données folders, namely, "<" values were replaced with 0.5 times the lower limit of reporting value, and ">" values were replaced with the upper limit of reporting value itself. Fourth, for those samples having a given element determined by multiple analytical methods, the highest value was chosen for statistical and plotting purposes. The source for each of these values is retained in the *tblMasterChem* table in the *MasterChem.mdb* database.

The *tblMasterChem* table in the *MasterChem.mdb* file lists 30,718 unique sample IDs of all media types for which geochemical data were found. A join query of the *MasterLocations.mdb* and *MasterChem.mdb* databases for all samples having both chemistry and associated latitude and longitude values reveals 29,020 unique samples. Errors in duplicate site IDs for a given sample site cannot be ruled out in this analysis.

4 A Review of the Geochemical Data Quality

Because of the unexpectedly large amount of time required to acquire, enter, and organize the geochemical data, and because sample site duplicates (i.e., duplicate samples taken on-site in the field) were not found in the various datasets, data validation is limited to the analytical data provided in the QA/QC reports. Further geochemical data validation, such as re-analysis of existing samples, re-sampling at selected sites, or analysis of the new samples, was not undertaken in this study. In general, the QA/QC data were deemed adequate for the mineral resource assessment and analytical error is minimal.

4.1 Sources of Geochemical Variation and Methods for Assuring Data Quality

There are several sources and levels of variation in geochemical data, some desirable and others not so desirable. A complete analysis of variation (ANOVA) assessment generally shows that the primary variation in geochemical data is that found between individual samples at different and widely spaced sites ("between-site variation"). This variation is due to differences in sample parent material, local geology, mineralization processes, and possibly anthropogenic influences. This variation is desirable and is the basis upon which geochemical exploration programs operate. The goal of regional geochemical surveys is to maximize "between-site variation" by reducing other sources of geochemical variation.

The next level of geochemical variation is known as "site variation". Soils, sediments, and rocks are usually heterogeneous at any location; a single grab sample from one spot at a sample site may have quite different element concentrations from another grab sample collected a few meters away. This variation can be reduced by compositing several sub-samples within the immediate area of sample collection, resulting in a more representative sample of the entire site. Usually certain percentages (commonly between 10 percent and 20 percent) of sites are sampled twice. These "site duplicates" are then used to measure the efficiency of the sampling design at reducing site variation. Differences between sampling methods, sampling equipment, and individual collectors can also introduce variation as well as contamination to the process. This variation can be reduced by establishing rigorous sampling protocols, providing identical sets of sampling equipment, and collective training of individuals.

Variation is also found within any single sample due to the heterogeneity of the sampled material. This "sample variation" can be reduced by good sample preparation procedures. A process of crushing, grinding, mixing, and splitting the sample creates a fine homogenous powder from the original heterogeneous material. Some sample materials, however, can create problems at this stage. For example, samples with small grains of native gold are notoriously difficult to process. The malleable nature of native gold resists the efforts of crushing and grinding. In addition, the high density of gold grains commonly causes them to settle to the bottom of sample powders. This is known as the "nugget effect". As a result, analyses of these samples can be variable. If the analyst happens to get a "nugget" of gold in the material that is analyzed then the results will commonly show high concentrations of gold. On the other hand, a second analysis of the same sample may miss the "nugget" and, despite the presence of gold in the sample, give results for gold that are quite low. Larger sample aliquots help to reduce this error.

The laboratory analytical procedures also can add variation to the geochemical data. These variations include differences in analysts, analytical instruments, instrument calibration errors, and instrument drift. The combined variation due to sample preparation, aliquot size, and analytical procedures (commonly called “analytical variation”) can be measured by using standard reference materials, analytical duplicates, and blanks.

4.2 Quality Assurance/Quality Control Methods

A quality management system for a standard geochemical survey includes both Quality Assurance (QA) and Quality Control (QC) elements. The QA focus is mainly in the analytical laboratory environment. Under the QA umbrella, the components of standard operating procedures, instrument logs, training records, data acceptance/rejection criteria and lab audits are covered. The QA element is not easily measured. However, the QC element provides measures of the accuracy and precision of geochemical data produced by an analytical method. The accuracy and precision are established through the analysis of standard reference materials (SRMs), analytical duplicates, and blanks.

The precision of an analytical method is measured by the percent relative standard deviation (%RSD) which is calculated by dividing the standard deviation (SD) by the mean and multiplying by 100 percent. One mathematical definition of the SD, as applied to multiple analyses of a single SRM, is defined as the square root of the quantity (sum of squares of deviations of individual results from the mean, divided by one less than the number of results in the set) (Taggart, 2002).

$$SD = \sqrt{\sum_{i=1}^{n} (X_i - \overline{X})^2 / n - 1}$$

The precision of an analytical method can also be determined from the assessment of analytical duplicates: samples that were split before analysis and then analyzed as two separate samples. The %RSD is again calculated by dividing the standard deviation (SD) by the mean and multiplying by 100 percent. However, the standard deviation for duplicate measurements is defined as the square root of the quantity [sum of squares of the difference between the duplicate results (R), divided by two times the number of sets of duplicate samples] (Taggart, 2002).

$$SD_{dupe} = \sqrt{\sum R^2 / 2k}$$

The accuracy of an analytical method is measured by the %Recovery of analyses of SRMs, and is calculated by dividing the mean concentration by the target value of the standard reference material used and multiplying by 100 percent. Target values for standard reference materials may consist of certified values or, when certified values are not available, non-certified values. The %Recovery for non-certified values does not carry as much weight as the %Recovery calculated from the certified values.

Possible contamination during the analytical procedure is assessed through the use of “process blanks”. Blanks are commonly solutions of de-ionized or distilled water that are randomly analyzed with the samples to determine whether contamination has occurred during the final sample dissolution stages or if cross-sample contamination has occurred in the analytical instrument during a run of samples. Some laboratories have also been known to use samples of nearly pure quartz sand as analytical “blanks” for similar purposes.

4.3 Datasets for Review

The PRISM-I geochemical data from Mauritania are assessed in two datasets. The first dataset came from the *Analyses_chimiques* table in the *Base de données des échantillons.mdb* file. This will be referred to as the “Base de données” dataset. The second set of data was compiled from several individual spreadsheet files and from accompanying ALS Chemex QC Certificates provided in PDF format. These data were received by request from Nouakchott in March of 2007 and will be referred to as the “Nouakchott” dataset.

4.4 Evaluation of the “Base de données” Dataset

The *Base de données des échantillons.mdb* database file contains a *Contrôle_qualité* table with 85 records. Sixty-six of these records are identified as duplicate pairs and the other 19 are identified as sample blanks. This identification of “duplicate” is ambiguous since it could mean either a “site duplicate” or an “analytical duplicate” sample, which measure different types of variation. Typically “site variation” is much larger than “analytical variation”. Based upon information received from Mauritanian project personnel, these 66 duplicates are assumed to be site duplicates (Personal commun., Thiam Baidy Abdoulaye, 2007).

When the data for the 66 duplicate “Base de données” samples were retrieved, only 52 pairs had corresponding Sample Identification numbers or chemistry for Ag, As, and Au and only 20 of these had analytical results for additional elements. These duplicate samples represent less than 0.4 percent of the 12,504 sample records in the “Base de données” dataset. Despite this poor representation, statistics were calculated for the duplicates (table 4.1). The calculated %RSD values are plotted and shown in figure 4.1.

Factors that can affect precision are the element solubility, the proximity of concentrations to the lower limit of reporting (LOR), sample homogeneity, and instrument element stability. Generally, precision values are considered acceptable when below 15 or 20 %RSD. For this limited dataset, Ag, Ge, Sb, Ta, Te, Tl, W and Y plot above 20 %RSD whereas As, Au, Bi, Se and Zr plot between 15 and 20 %RSD. The remaining elements are below 15 %RSD. Due to the lack of information about analytical methods and LOR values in the “Base de données” dataset, it is difficult to interpret these results. For many of these, proximity to the LOR may be a significant factor even though the mean values are more than five times the assumed LOR (5 x LOR); the mean values for Au, Bi, Cd, Se, Ta, and Te *appear* to be greater than 5 x LOR because of one or two samples with very high concentrations.

4.5 Evaluation of the “Nouakchott” Dataset

The “Nouakchott” dataset compiled from several individual spreadsheet files contained 9,644 unique sample records. Accompanying these data were several QC Certificates from ALS Chemex that also contained analytical data for 33 standard reference materials (1,112 records), 531 analytical duplicate pairs, and 494 blanks. Therefore, about 18 percent of the “Nouakchott” analyses done by ALS Chemex were QC data. These QC data were compiled to provide the basis for an extensive check on the quality of the “Nouakchott” dataset.

When later combining the new data from the “Nouakchott” dataset with the “Base de données” dataset, 1,792 records were found to be common to both sets. This, along with the facts that only one analytical laboratory was responsible for all analyses, that the same analytical methods were used throughout the study, and that the analyses all were done over a relatively short ~three-year time period, suggests that a QC evaluation of the "Nouakchott" dataset will be fairly representative for the entire database.

4.5.1 Standard Reference Materials (SRM)

From the ALS Chemex QC Certificates, analyses were found for 33 SRMs that tested 148 different combinations of elements and analytical methods. Some of these SRMs were rarely used and some of the element/analytical method combinations were not commonly used. For this QC assessment, data from 12 SRMs were evaluated for 86 different element/analytical method combinations. To illustrate the methodology, only the results for Standard G2000 analyzed by the four-acid digestion, 27-element ICP-AES analytical package (ICP61 method) plus Ag and As by AAS (AA61 method) are shown here. A complete statistical and graphical summary of all combinations of SRMs, elements, and analytical methods evaluated can be found in Appendix 3. Additionally, statistics and graphs for each individual element by method and SRM are available as Excel files. The target values for each element were obtained from target ranges listed in the QC Certificates. None of these SRMs were identified as certified standards. Therefore, the % Recovery values should be treated as non-certified values and not absolute values.

Table 4.2 summarizes the relevant statistics for the SRM G2000. A plot of the %RSD or precision is given in figure 4.2 and a plot of the %Recovery or accuracy is given in figure 4.3. Only Ba and Mo have %RSD values above 15. The Ba value is not unexpected since certain barium minerals, such as barite, are usually not completely dissolved using a typical four-acid digestion. Other elements with the same problem include Hf, Ta, and Zr (additional problem elements for digestion completeness commonly include Cr, Nb, Sn, Ti, Sc, W, and the rare-earth elements). High values for %RSD can be seen for Hf, Ta, and Zr in the graphs in appendix 3. The high %RSD value for Mo is probably due to concentrations that are near the LOR. The mean for Mo by the ICP61 method is 5.4 ppm (table 4.2). This is barely greater than five times the LOR value for Mo (1 ppm). The %Recovery for all elements shown in figure 4.3 is within the acceptable ± 15 percent limits. Some other SRMs also show problems for the %Recovery of Ba, Hf, or Zr. This again is probably due to sample dissolution difficulties.

4.5.2 Analytical Duplicates

The ALS Chemex QC Certificates contained several analytical duplicate samples. All of the identifiable sets of analytical duplicates were used in this evaluation. To illustrate the methodology, only the results for analytical duplicates analyzed by the four-acid digestion, 47-element ICP-MS analytical package (MS61 method) are shown here. A complete statistical and graphical summary of all analytical duplicates by each analytical method evaluated can be found in Appendix 4. Additionally, statistics and graphs for each individual element by method are available as Excel files.

Table 4.3 summarizes the relevant statistics for the MS61 method. A plot of the %RSD or precision for these analytical duplicates is given in figure 4.4. Since there are no known target values for randomly chosen analytical duplicates, it is not possible to evaluate the accuracy of the analyses. The precision values for Ag, B, Hf, Nb, Sb, Se, Ta, and Te are above 20 %RSD whereas the values for Ba, Cd, In, S and Zr are between 15 and 20 %RSD. These high values for Ag, As, Se, Ta, and Te probably are due to their proximity to the LOR; all of these elements have a mean value that is less than five times the LOR. The Ba, Hf, Nb, and Zr values probably reflect sample dissolution problems whereas the values for Cd and Sb may reflect a higher degree of sample heterogeneity found in real samples rather than the rigorously prepared SRMs.

4.6 Summary and Conclusion of the Quality Control Evaluation for the Mauritanian Geochemical Data

QC evaluations tend to focus on those elements or methods that have problems. The present evaluation is no exception. However, it is important to note that this evaluation revealed no precision or accuracy problems for the greater percentage of analytical data. Therefore these data should be useful for evaluating the variation between sample sites and for assessing the mineral resource potential of Mauritania. Some care needs to be taken when interpreting geochemical maps based on a few elements that are frequently reported around their LOR values. These would include Ag, As, Au, B, Cd, Ge, Pd, Pt, Rb, Re, Sb, Se, Sn, Ta, Te, and W. Antimony and W are extreme illustrations of this problem, with %RSD values of 51 and 67, respectively (table 4.1). Concentrations for the above elements in ranges well above (>5 X) the LOR value are less problematic. In addition, it is important to note that values for a few elements like Ba, Hf, Nb, and Zr may not reflect the total amount of these elements in a sample due to sample dissolution problems where near-total (such as four-acid) and not total-dissolution techniques were used.

Table 4.1. Statistics for assessing site duplicate samples from the “Base de données” dataset.

[data good to three significant figures at best]

Element	Pairs (k)	Mean	Standard Deviation for Duplicates	%RSD
Ag ppm	52	1.9756	0.4509	22.82
Al %	20	8.9475	0.1889	2.11
As ppm	52	226.0788	43.2200	19.12
Au ppm	52	0.1080	0.0210	19.41
Ba ppm	20	1381.2800	37.1063	2.69
Be ppm	20	2.9475	0.2936	9.96
Bi ppm	20	14.5660	2.4560	16.86
Ca %	20	7.4265	0.0954	1.28
Cd ppm	20	2.4710	0.1709	6.91
Ce ppm	20	125.5075	10.3049	8.21
Co ppm	20	41.5400	0.7113	1.71
Cr ppm	20	158.5000	21.8483	13.78
Cs ppm	20	3.6038	0.1851	5.14
Cu ppm	20	387.1050	14.4724	3.74
Fe %	20	10.9105	0.1377	1.26
Ga ppm	20	26.6050	0.6644	2.50
Ge ppm	20	0.7113	0.1916	26.94
Hf ppm	20	5.3625	0.6978	13.01
In ppm	20	0.1025	0.0051	5.00
K %	20	2.1785	0.0576	2.64
La ppm	20	62.1500	3.5320	5.68
Li ppm	20	81.5600	4.4745	5.49
Mg %	20	2.5570	0.0567	2.22
Mn ppm	20	1365.0000	29.3684	2.15
Mo ppm	20	6.8525	0.4083	5.96
Na %	20	2.0135	0.0659	3.27
Nb ppm	20	15.6550	1.8165	11.60
Ni ppm	20	118.0200	5.7845	4.90
P ppm	20	889.5500	37.7823	4.25
Pb ppm	20	905.7750	44.3211	4.89
Pt ppm	20	0.1050	0.0112	10.65

Table 4.1. Statistics for assessing site duplicate samples from the "Base de données" dataset.—Continued

[data good to three significant figures at best]

Element	Pairs (k)	Mean	Standard Deviation for Duplicates	%RSD
Rb ppm	20	87.5500	5.7103	6.52
Re ppm	20	0.0034	0.0005	14.71
S %	20	0.1875	0.0065	3.48
Sb ppm	20	2.0100	1.0207	50.78
Se ppm	20	10.0250	1.5391	15.35
Sn ppm	20	2.9100	0.1817	6.24
Sr ppm	20	711.1800	18.6776	2.63
Ta ppm	20	0.9950	0.2377	23.89
Te ppm	20	1.2450	0.3991	32.06
Ti %	20	0.6418	0.0345	5.37
Tl ppm	20	0.5940	0.1938	32.62
U ppm	20	6.2850	0.3956	6.29
V ppm	20	403.8500	16.8070	4.16
W ppm	20	5.3575	3.5742	66.71
Y ppm	20	37.4400	10.6989	28.58
Zn ppm	20	736.0500	8.9791	1.22
Zr ppm	20	187.5250	31.6529	16.88

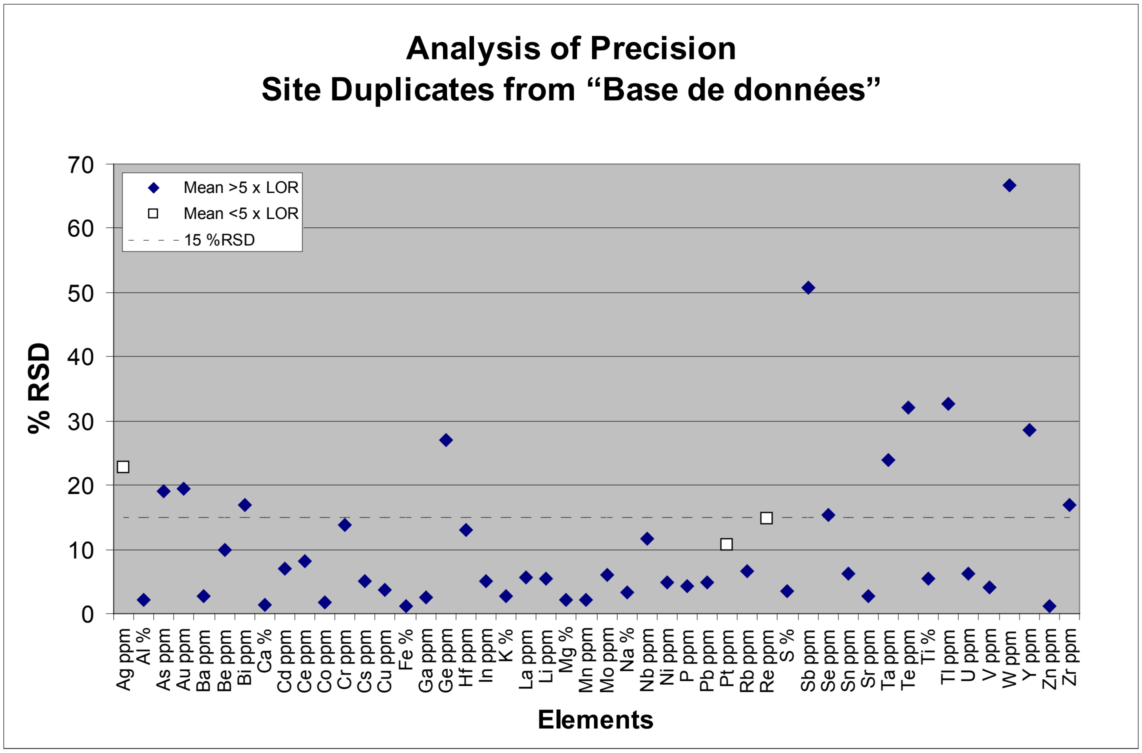

Figure 4.1. Precision plot of analyses of site duplicates from "Base de données" dataset.

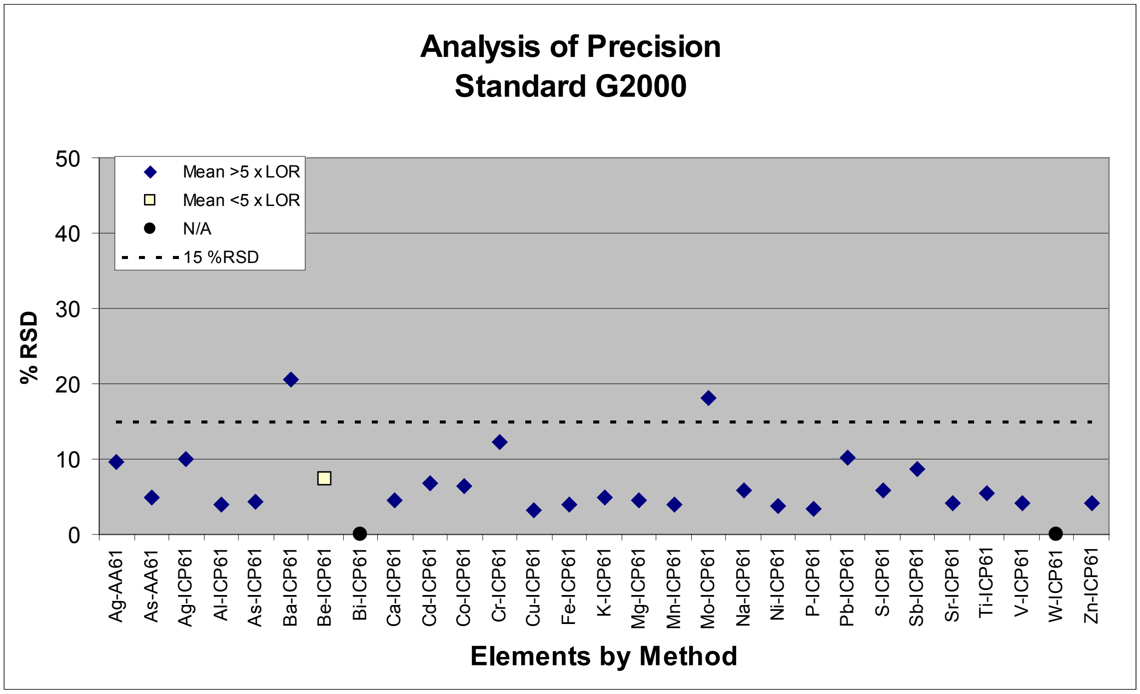

Figure 4.2. Precision plot of results from analyses of the G2000 standard reference material.

Table 4.2. Statistics for the evaluation of SRM G2000 analyzed by the ICP61 method.

[data good to three significant figures at best. N/A, not applicable]

Method	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Standard Deviation	% RSD	% Recovery
Ag-AA61	0.5	67	3.55	2.7	4.4	3.7313	0.3606	9.67	105.11
As-AA61	5	69	484	435	533	497.4058	24.4951	4.92	102.77
Ag-ICP61	0.5	21	3.55	2.7	4.4	3.6000	0.3606	10.02	101.41
Al-ICP61	0.01	21	5.03	4.66	5.4	5.0595	0.1990	3.93	100.59
As-ICP61	5	21	484	435	533	485.8095	21.0870	4.34	100.37
Ba-ICP61	10	21	2230	2000	2460	2213.3333	456.2054	20.61	99.25
Be-ICP61	0.5	21	1.4	0.8	2	1.4095	0.1044	7.41	100.68
Bi-ICP61	2	21	2.5	1	4	<2	---	N/A	N/A
Ca-ICP61	0.01	21	0.58	0.51	0.65	0.5924	0.0274	4.62	102.13
Cd-ICP61	0.5	21	7.6	6.3	8.9	7.4571	0.5016	6.73	98.12
Co-ICP61	1	21	25.5	22	29	24.5238	1.5690	6.40	96.17
Cr-ICP61	1	45	74	66	82	75.6222	9.2104	12.18	102.19
Cu-ICP61	1	45	303	272	334	305.7556	9.6322	3.15	100.91
Fe-ICP61	0.01	21	3.8	3.41	4.19	3.9029	0.1534	3.93	102.71
K-ICP61	0.01	21	1.3	1.16	1.44	1.2729	0.0630	4.95	97.91
Mg-ICP61	0.01	21	0.76	0.67	0.85	0.7567	0.0337	4.45	99.56
Mn-ICP61	5	21	568	506	630	576.3810	23.1959	4.02	101.48
Mo-ICP61	1	21	6	4	8	5.4286	0.9783	18.02	90.48
Na-ICP61	0.01	21	0.155	0.13	0.18	0.1429	0.0085	5.92	92.17
Ni-ICP61	1	36	286	256	316	283.5000	10.7291	3.78	99.13
P-ICP61	10	21	945	840	1050	964.7619	33.4094	3.46	102.09
Pb-ICP61	2	21	670	601	739	691.2381	70.6137	10.22	103.17
S-ICP61	0.01	21	0.265	0.23	0.3	0.2624	0.0151	5.77	99.01
Sb-ICP61	5	21	32	24	40	31.6190	2.7654	8.75	98.81
Sr-ICP61	1	21	116	103	129	114.2857	4.7554	4.16	98.52
Ti-ICP61	0.01	21	0.355	0.31	0.4	0.3424	0.0187	5.46	96.45
V-ICP61	1	21	108	96	120	104.1905	4.3545	4.18	96.47
W-ICP61	10	21	12.5	5	20	<10	---	N/A	N/A
Zn-ICP61	2	21	1257.5	1130	1385	1276.9048	53.1854	4.17	101.54

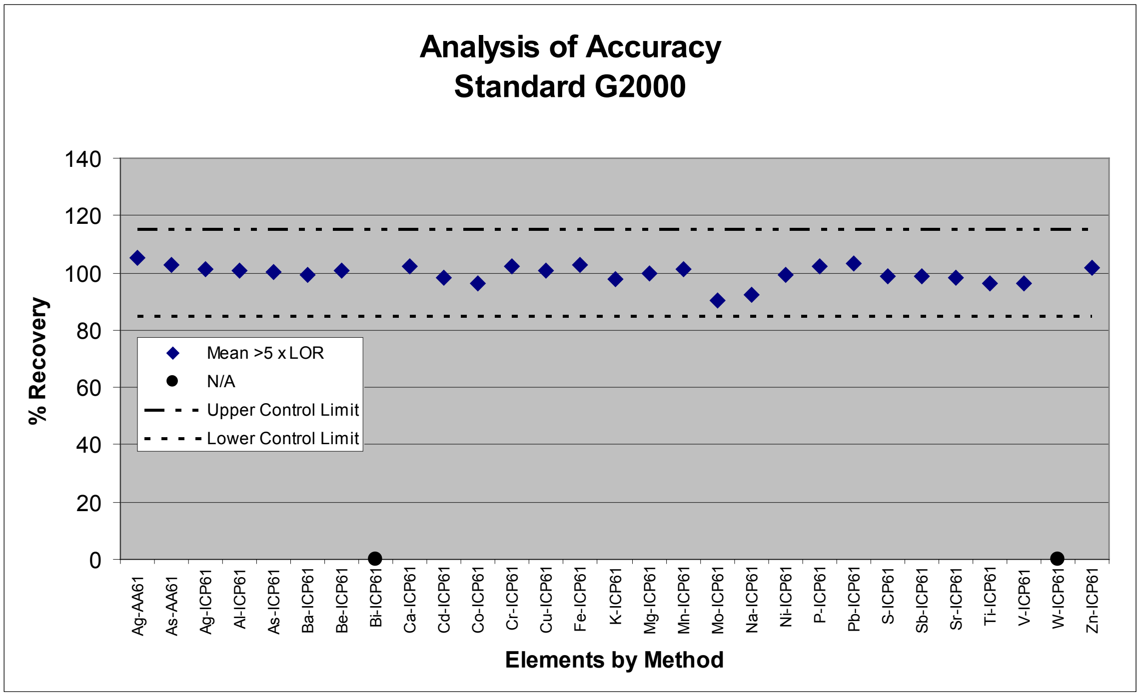

Figure 4.3. Accuracy plot of the G2000 standard reference material.

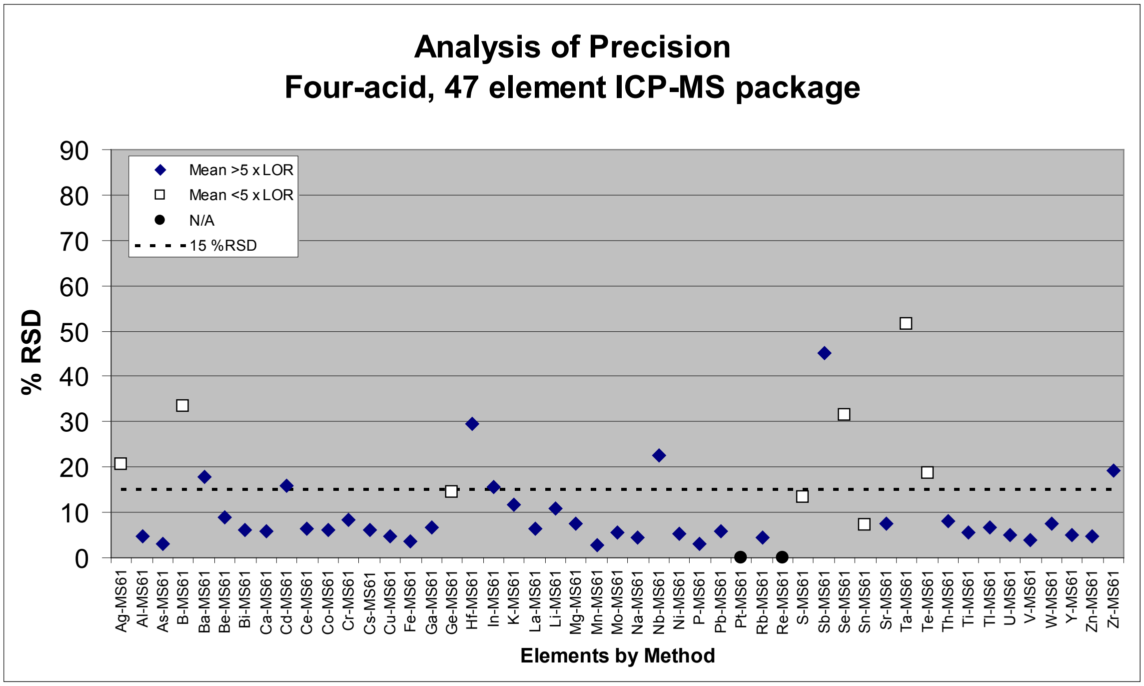

Figure 4.4. Precision plot of analyses of analytical duplicate samples analyzed by the MS61 package.

Table 4.3. Summary statistics for analytical duplicates analyzed by ICP-MS.

[data good to three significant figures at best. N/A, not applicable]

Element/ Method	Units	LOR	Pairs (k)	Per Pair (n)	Min	Max	Sum	Mean	Std Dev for Duplicates	% RSD
Ag-MS61	ppm	0.01	59	2	0.01	0.35	6.58	0.0558	0.0115	20.62
Al-MS61	%	0.01	59	2	0.03	10.6	585.29	4.9601	0.2305	4.65
As-MS61	ppm	0.02	59	2	0.1	5800	13177.7	111.6754	3.3948	3.04
B-MS61	ppm	10	49	2	5	280	4370	44.5918	14.8805	33.37
Ba-MS61	ppm	0.5	59	2	20	5860	81330.8	689.2441	123.4178	17.91
Be-MS61	ppm	0.05	59	2	0.025	3.49	99.8	0.8458	0.0748	8.84
Bi-MS61	ppm	0.01	59	2	0.005	10	28.83	0.2443	0.0152	6.23
Ca-MS61	%	0.01	59	2	0.01	25	384.04	3.2546	0.1875	5.76
Cd-MS61	ppm	0.02	59	2	0.01	15.5	55.97	0.4743	0.0750	15.81
Ce-MS61	ppm	0.01	59	2	2.86	284	4900.17	41.5269	2.6069	6.28
Co-MS61	ppm	0.1	59	2	0.4	77.3	2066.5	17.5127	1.0523	6.01
Cr-MS61	ppm	1	59	2	0.5	836	8864.5	75.1229	6.2777	8.36
Cs-MS61	ppm	0.05	59	2	0.025	4.79	96.53	0.8181	0.0506	6.18
Cu-MS61	ppm	0.2	59	2	2.4	10000	23801.8	201.7102	9.8242	4.87
Fe-MS61	%	0.01	59	2	0.34	25	455.81	3.8628	0.1397	3.62
Ga-MS61	ppm	0.05	59	2	0.46	46.6	1418.82	12.0239	0.8178	6.80
Ge-MS61	ppm	0.05	59	2	0.025	0.56	20.585	0.1744	0.0252	14.44
Hf-MS61	ppm	0.1	59	2	0.05	6.5	159.95	1.3555	0.3997	29.49
In-MS61	ppm	0.005	59	2	0.0025	4.93	13.3935	0.1135	0.0177	15.56
K-MS61	%	0.01	59	2	0.005	3.52	98.585	0.8355	0.0976	11.68
La-MS61	ppm	0.5	59	2	0.5	412	3120.1	26.4415	1.6583	6.27
Li-MS61	ppm	0.2	59	2	0.2	32.7	1230.2	10.4254	1.1371	10.91
Mg-MS61	%	0.01	59	2	0.005	7.45	167.625	1.4206	0.1053	7.41
Mn-MS61	ppm	5	59	2	32	10000	126502	1072.0508	31.3093	2.92
Mo-MS61	ppm	0.05	61	2	0.14	10.15	250.03	2.0494	0.1129	5.51
Na-MS61	%	0.01	59	2	0.005	5.5	128.03	1.0850	0.0469	4.32
Nb-MS61	ppm	0.1	59	2	0.1	42.1	571.6	4.8441	1.0997	22.70
Ni-MS61	ppm	0.2	59	2	2.1	687	6226.5	52.7669	2.7858	5.28
P-MS61	ppm	10	59	2	30	10000	82190	696.5254	22.1513	3.18
Pb-MS61	ppm	0.5	59	2	0.9	526	2023.3	17.1466	1.0229	5.97
Pt-MS61	ppm	0.1	59	2	0.05	0.4	6.81	<0.1	---	N/A

Table 4.3. Summary statistics for analytical duplicates analyzed by ICP-MS.—Continued

[data good to three significant figures at best. N/A, not applicable]

Element/ Method	Units	LOR	Pairs (k)	Per Pair (n)	Min	Max	Sum	Mean	Std Dev for Duplicates	% RSD
Rb-MS61	ppm	0.1	59	2	0.05	361	4533.7	38.4212	1.6681	4.34
Re-MS61	ppm	0.002	59	2	0.001	0.004	0.181	<0.002	---	N/A
S-MS61	%	0.01	58	2	0.005	0.2	4.045	0.0349	0.0047	13.38
Sb-MS61	ppm	0.05	59	2	0.025	113	269.58	2.2846	1.0331	45.22
Se-MS61	ppm	1	59	2	0.5	7	160	1.3559	0.4269	31.48
Sn-MS61	ppm	0.2	59	2	0.1	9.6	133.1	1.1280	0.0818	7.25
Sr-MS61	ppm	0.2	59	2	2.7	3430	29531.4	250.2661	18.7680	7.50
Ta-MS61	ppm	0.05	59	2	0.0025	1.76	21.675	0.1837	0.0948	51.62
Te-MS61	ppm	0.05	59	2	0.025	2.2	9.56	0.0810	0.0151	18.67
Th-MS61	ppm	0.2	59	2	0.1	32.1	716.2	6.0695	0.4892	8.06
Ti-MS61	ppm	0.01	59	2	0.005	0.73	25.14	0.2131	0.0116	5.47
Tl-MS61	ppm	0.02	59	2	0.01	1.54	21.39	0.1813	0.0121	6.68
U-MS61	ppm	0.1	61	2	0.05	78.1	455.25	3.7316	0.1858	4.98
V-MS61	ppm	1	61	2	0.5	356	9122	74.7705	2.8943	3.87
W-MS61	ppm	0.1	59	2	0.1	49.6	338.7	2.8703	0.2173	7.57
Y-MS61	ppm	0.1	59	2	0.9	109.5	1778.1	15.0686	0.7646	5.07
Zn-MS61	ppm	2	59	2	2	1605	8273	70.1102	3.3000	4.71
Zr-MS61	ppm	0.5	59	2	0.25	181	4604.05	39.0174	7.4563	19.11

5 Problems Identified For Future Solving

In the creation of the master location and master chemistry databases, several problems were identified in the existing PRISM-I geochemical data. Some of these problems were first identified in the Phase I and Phase II summary reports on PRISM-I data (U.S. Geological Survey, 2007, and Eppinger and others, 2007, respectively). Where problems could be solved or errors corrected, this was done in the *MasterChem.mdb* and *MasterLocations.mdb* databases, and the changes were documented. However, in some cases information is lacking to confidently solve identified problems. Table 5.1 captures the essence of these problems so that future users of the PRISM-I data are aware of or perhaps can solve the problems. For large databases, minor (and sometimes major) inconsistencies and/or errors are generally not unexpected. However, solving these can be problematic and time consuming (the 80-20 rule is relevant here, where it can take 80 percent of the time to finalize the last 20 percent of the data). In many cases, going back to the original ALS Chemex laboratory reports and the original field maps and notes may be necessary to solve the problems.

Table 5.1. Problems identified during the creation of master location and master chemistry databases.

Problem Identified	**Table/File Location**	**Action Taken**	**Recommended Actions to Solve Problem(s) in the Future**
413 samples do not have sample media type specified (same samples as above)	*TST_413Anal_Maj_Tr_Brgm.xls* spreadsheet; *Normandie_La_Source* folder	Data excluded from the *tblSamples* table; however, the element analysis suite includes major oxides, suggesting that media type is rock	Mauritanian PRISM personnel should ascertain sample media type from the responsible parties
38 samples do not have sample media type specified	*TST_38Anal_Maj_Tr_Hadji.xls* spreadsheet; *Normandie_La_Source* folder	Media type changed to rock in the *tblSamples* table; the element analysis suite includes major oxides, suggesting that media type is rock	Mauritanian PRISM personnel should ascertain sample media type from the responsible parties
6,554 samples do not have sample media type specified	*FEDSTRA.xls* spreadsheet; *Normandie_La_Source* folder	Only Au analyses were reported; media type changed to soil in the *tblSamples* table, but this might be erroneous	Mauritanian PRISM personnel should ascertain sample media type from the responsible parties
2,438 samples do not have sample media type specified	*FEDTACT.xls* spreadsheet; *Normandie_La_Source* folder	Only Au analyses were reported; media type changed to soil in the *tblSamples* table, but this might be erroneous	Mauritanian PRISM personnel should ascertain sample media type from the responsible parties
3,116 samples have locations and 2,345 of these have associated Au data; however, there is no way to determine whether the Au value is valid or not as all "< X" values are listed as X	*FED_FTJ_Soil.shp* shapefile; *Normandie_La_Source* folder	Data excluded from the *tblMasterChem* table in the *MasterChem.mdb* database	Mauritanian PRISM personnel should acquire the original geochemical data from which the shapefile was created. Note that the shapefile contains locations for 3,116 soils, but only 2,345 soils have associated geochemical data (Au)
22 samples do not have coordinates; see listing in Phase I report on PRISM-I data	*Identification* table in the *Geochemique.mdb* database	Data excluded from the *tblSamples* table	Mauritanian PRISM personnel should get the original coordinates from the responsible parties

Table 5.1. Problems identified during the creation of master location and master chemistry databases.—Continued

Problem Identified	Table/File Location	Action Taken	Recommended Actions to Solve Problem(s) in the Future
6,134 samples may have truncated IDs and duplication in sample ID numbers for various media	*m40_regblegsample_9697.dbf* *m40_regdrainsample_9697.dbf* *m40_regrocksample_9697.dbf* files in the GGI shapefile folders	A prefix consisting of "m40" plus a letter indicating the sample type (b=bleg, d=drain, s=soil) was added to the beginning of each 4-digit sample ID in the *MasterLocation.mdb* and *MasterChem.mdb* databases, solving the problem for 3,205 samples.	If possible, Mauritanian PRISM personnel need to ascertain the sources of these duplications in sample IDs. See Appendix 1 for more information.
Analysis of the master location and chemistry databases identify numerous sample (?) sites where no matching geochemistry was found	*MasterChem.mdb* and *MasterLocations.mdb* databases (based on data derived from all PRISM-I data sources provided to the USGS)	None; data used "as is" after attempts were made to try to solve this problem. The discrepancy is greatest in the Tasiast-Tijirit (> 6000 locations) and Southern Mauritanides (> 3000 locations) regions. Perhaps not all of the site locations have associated samples collected for geochemistry. Or perhaps there are ID mismatches between location and geochemical sample IDs.	Mauritanian PRISM personnel should request ALL of the original ALS Chemex laboratory reports from the responsible parties. Mauritanian PRISM personnel should request all original sample site maps and field notes from the responsible parties. These may be needed to solve this major problem.

6 Country-wide Geochemical Maps at 1:1,000,000 Scale

Figure 1.1 and the 1:1,000,000-scale file *Geochemistry Areas and Sample Sites.pdf* illustrate the difficulties of making maps for chemical elements on a country-wide basis for all of Mauritania. Spatial distributions of sample sites, analytical determinations, and sample media types are inconsistent among different areas. This problem is exacerbated by the fact that only Au, Ag, and As were determined on the majority of the samples. Other trace elements were not determined on many thousands of the samples analyzed. To overcome these shortcomings and to provide a country-wide "geochemical snapshot" for selected element distributions, single-element maps were produced as described below. Single-element maps at 1:1,000,000 scale are provided as PDF files in the accompanying files for the following 23 elements: Ag, As, Au, Ba, Bi, Ce, Co, Cr, Cu, Fe, La, Mn, Mo, Ni, P, Pb, Pt, Sn, Th, Ti, U, W, and Zn.

Statistics were calculated separately for two groups of samples (rocks and unconsolidated) collected from each of the six geology-based regions: Nord-Ouest, Nord-Est, Tasiast-Tijirit, Central Mauritanides, Southern Mauritanides, and Kîffa-Néma (figure 1.2).

Statistical distinctions among the sample groups are important because of real lithologic (and hence geochemical) differences among the six areas. Element concentration means were, as expected, found to vary among the six areas. Unconsolidated materials (soils, sediments, regolith) were combined as a population group separate from the rock samples in each area. A normalization procedure (Z-scores) was used on the two groups of samples for each of the six areas, thereby producing 12 separate normalizations for each element. The Z-score (see http://en.wikipedia.org/wiki/Standard_score) is calculated using the formula:

$$Z = \frac{x - \mu}{\sigma}$$

where x = sample element concentration,
μ = mean of the population, and
σ = standard deviation of the population.

This normalizing procedure results in a shifted population with a mean of zero and a standard deviation of 1. The Z-score is a dimensionless quantity. After normalizing, because Z-scores for all 12 groups had the same mean and standard deviation, they could reasonably be combined for each element. Each selected element was then plotted on the map and with proportional symbols expressed in units of standard deviation. An explanation table for each element includes parts-per-million equivalents for the standard deviation ranges displayed for both the rocks and unconsolidated materials. The results are single-element maps for the entire country at 1:1,000,000-scale, showing concentrations in both rocks and unconsolidated materials, and that reflect the individual population characteristics for each of the six geologic domains. In the Central and Southern Mauritanides regions, mean concentrations of Cu in rocks were unusually high due to highly skewed distributions of analytical determinations. The skewed distributions are the result of included analyses of ore-grade rock samples collected in the areas. In these cases, highly-skewed values were removed from the statistical calculations to reduce this outlier effect on Z-scores. The Z-score calculations were performed for each of the 64 elements in the geochemical data, and have been provided as additional attributes for each sample.

Multi-element maps were produced for the following six element combinations: Ag-As-Au; Co-Cu-Pb-Zn; Cr-Ni-Pt; Fe-Mn-Ti; P-U-V; and Bi-Sb-Sn-W. These combinations were derived by first using inverse distance weighting with 10-km search radius to interpolate gridded Z-values for each element, and then systematically combining elements by assigning values of 1, 2, 4, or 8 to Z-scores greater than 2 for each of the elements to be combined. The sums of those re-assigned values uniquely identify the combinations of elements for each location. For example, by assigning 1 to all interpolated Ag Z-scores >2, 0 otherwise; 2 to all interpolated As Z-scores >2, 0 otherwise; and 4 to all interpolated Au Z-scores scores >2, 0 otherwise, the sum of those 3 interpolated grids becomes 1 for Ag alone, 2 for As alone, 3 for Ag combined with As, 4 for Au alone, 5 for Ag combined with Au, 6 for As combined with Au, and 7 for the combination of Ag and As and Au.

7 Geochemical Maps for the Six Regions

Single-element geochemical maps for selected elements were produced for each of the six regions, at 1:500,000 scale. These 296 maps and the associated GIS layers from which they were produced are value-added products provided in addition to the maps required under contract. The GIS layers for these maps were of fundamental importance in producing mineral resource assessment products. In addition, a sample site location map (file: *Geochemistry Areas and Sample Sites.pdf*) at 1,000,000 is also provided. The geochemical maps were created as follows:

1. For each region, a "join query" was made between the master location and master chemistry databases to extract all samples coded "rock" (all rock sub-categories in table 2.1 combined). A similar query was made to extract all soil + regolith + stream sediment samples (all unconsolidated categories in table 2.2 combined). Note that, for simplicity in the regional maps, there has been a gross lumping together of unconsolidated media including soil, regolith, and stream sediment samples. Future, more detailed geochemical map production of specific areas should probably treat these sample media separately, as was probably the intent during initial collection of the samples. Table 6.1 lists the numbers of samples extracted using the join queries for the six regions.
2. The 12 data subsets were extracted from the database and saved as Excel files.
3. The 12 Excel files were processed with the Statsoft Statisica© software package to determine basic statistics (means, minimum values, maximum values, standard deviations, percentiles, and correlations) for each subset. These basic statistics subsets are provided in Microsoft Excel 2003 format in the accompanying files in the *BasicStatistics* folder. As a word of caution, these statistics were calculated on data where "<" censored values were replaced with 0.5 times the lower limit of reporting value, and ">" censored values were replaced with the upper limit of reporting value itself. Thus, the statistics are skewed, particularly for those elements with numerous censored values, such as Ag. This problem is exacerbated for those elements having multiple detection limits, such as Ag. As a whole, the data are deemed inappropriate for applying multivariate exploratory statistical techniques such as factor analysis or principal components analysis because of uncertainties in how some of the data have been treated (for example, uncertainty in exactly how many and which variables in the *Base de données des échantillons.mdb* database have been replaced for "<" and ">" values), because of the multiple lower determination limits across methods, and because of non-systematic element suites. However, multivariate procedures are probably appropriate for isolated high-density sub-groups of samples where multi-element data exist.
4. Using percentiles calculated on each data subset, single-element plots were created for selected elements. Elements for plotting were chosen based on the range of variability, on the number of samples having data for a given element (larger populations desirable), and on the elements known to be useful for mineral resource assessment purposes for the deposit types under consideration. However, even though the lower percentiles (such as the 2.5th) were calculated, the uncertainties expressed in paragraph #3 above (multiple lower limits and corresponding multiple replacement values) render the data inappropriate to speculate on element depletions. For these data in their present form, it is safest to use single-element plots and to put most emphasis on the extreme high concentrations for a given variable.
5. Proportional-symbol point plots were created for rock samples. For soil + regolith + stream sediment samples, the data were grid-contoured using the ESRI ArcGIS software package. Certain highly censored elements (such as Au, Ag, and Pt) having numerous replacements are inappropriate for contouring and are shown as proportional-symbol

point plots. Similarly, widely scattered sample points, such as in the Kîffa-Néma region do not warrant gridding. Further details on gridding procedures are in appendix 5.

Table 7.1. Rock and unconsolidated records having both chemistry and coordinates, extracted from the *MasterLocations.mdb* and *MasterChem.mdb* databases.

[see tables 2.1 and 2.2 for the various types of rock and unconsolidated sample types grouped together here]

Region	Combined Rock Records	Combined Unconsolidated[1] Records	All Records
Central Mauritanides	1,935	288	2,223
Kîffa-Néma	775	78	853
Nord-Est	628	6,027	6,655
Nord-Ouest	519	4,456	4,975
Southern Mauritanides	2,868	3085	5,953
Tasiast-Tijirit	1,236	7,125	8,361

[1] unconsolidated includes soil + regolith + stream sediment samples

A total of 296 geochemical maps produced for the six regions are provided in the accompanying files as PDF files, along with a sample site map. Table 7.2 lists all of the single element maps.

Table 7.2. List of single-element geochemical maps for the six regions produced as PDF files. Maps are provided as PDF files in the accompanying files.

[rock, rock, including bleg, samples; uncon, soil + regolith + stream sediment samples]

Element	Nord-Est		Nord-Ouest		Tasiast-Tijirit		Central Mauritanides		Southern Mauritanides		Kîffa-Níma	
	rock	uncon	rock	uncon	rock	uncon	rock	uncon	rock	uncon	rock	uncon
Ag	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
As	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Au	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ba	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Be			✓				✓		✓			
Bi	✓		✓		✓		✓	✓	✓		✓	
Cd	✓		✓		✓		✓		✓		✓	
Ce	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Co	✓		✓		✓		✓		✓	✓	✓	
Cr	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Cu	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓
Fe	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓

Table 7.2. List of single-element geochemical maps for the six regions produced as PDF files. Maps are provided as PDF files in the accompanying files.—Continued

[rock, rock, including bleg, samples; uncon, soil + regolith + stream sediment samples]

Element	Nord-Est		Nord-Ouest		Tasiast-Tijirit		Central Mauritanides		Southern Mauritanides		Kîffa-Níma	
	rock	uncon	rock	uncon	rock	uncon	rock	uncon	rock	uncon	rock	uncon
Hg					✓							
K	✓	✓	✓	✓	✓		✓		✓		✓	
La	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Li					✓		✓		✓			
Mn	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Mo	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Ni	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
P	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Pb	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
Pt	✓	✓	✓	✓	✓		✓		✓		✓	
S	✓	✓	✓	✓	✓		✓	✓	✓			
Sb	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Se	✓		✓				✓		✓			
Sn							✓					
Sr	✓	✓	✓	✓	✓		✓	✓	✓		✓	
Te	✓				✓		✓		✓		✓	
Th	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Ti	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Tl	✓		✓		✓		✓		✓			
U	✓	✓	✓	✓	✓		✓	✓	✓		✓	
V	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
W	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
Zn	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Total	31	24	31	24	32	3	34	24	33	11	28	16

8 References

Eppinger, R.G., Smith, Steven, M., Giles, Stuart A., Sipeki, Julianna, and O'Leary, Richard M., 2007, Phase II, Geochemistry—Database creation, data quality assessment, and geochemical maps: U.S. Geological Survey Administrative Report provided to PRISM, 45 p., 4 appendices, 13 pl., DVD with 291 geochemical maps.

Taggart, J.E., ed., 2002, Analytical methods for chemical analysis of geologic and other materials, U.S. Geological Survey: U.S. Geological Survey Open-File Report 02–223, chap. ZZ, p. 6.

U.S. Geological Survey, 2007, Phase I summary report—USGS evaluation of PRISM-I data: U.S. Geological Survey Administrative Report, provided to PRISM, 107 p., 6 appendixes.

Appendix 1. Notes on Compiling and Merging Sample Location and Media Types for the Master Location File, *MasterLocations.mdb*

The first step in preparing the geochemical data for GIS analysis was to review the PRISM-I data provided to identify tables, spreadsheets and shapefiles that contain sample numbers. These data were found in the *\SIG_M\L'information\Geochimie* folder. Of the data files with sample numbers, those with any associated location coordinates were reviewed. For many samples, coordinates and associated geochemical data were found only in shapefile database tables. Many samples were also duplicated in several tables of the *Enchantillons_sud_phase1.mdb* and *Base de données des échantillons.mdb* databases. As a result of these disparities, a Master Locations database (*MasterLocations.mdb*) was constructed in Access to provide a single consistent table of all known samples, their coordinates, and their media type. Table A1.1 lists the files and Access tables that were used to create the *MasterLocations.mdb* database.

Table A1.1. Table of database and shapefile tables used to provide sample numbers and geographic coordinates for the MasterLocations database.

Origin database or file	Origin table
Base de données des échantillons.mdb, Access database	*Identification*
Enchantillons_sud_phase1.mdb, Access database	*Annexe1_1-1_4 Echantillons de roche de les Mauritanides australe* *Annexe3 Majors* *tbl_Enchantillons_200k500k*
echantill_BGS folder; Excel spreadsheet files	*1812.xls* *1913.xls* *BGS-Baidy Echantillons Jan03.xls* *BGS-MPH Echantillons – sacs Jan03.xls* *Dahmane_samples_dec.xls* *Expl_Geochem_Form_mh.xls* *ExplGeoch-samplesAkjoujt_pp.xls* *FIELDDATACNW.xls*

Table A1.1. Table of database and shapefile tables used to provide sample numbers and geographic coordinates for the MasterLocations database.—Continued

Origin database or file	Origin table
GGI folder; ESRI shapefiles	*m40_regblegsample_9697.dbf* *m40_regdrainsample_9697.dbf* *m40_regrocksample_9697.dbf*
Normandie_La_Source folder; ESRI shapefiles	*FED_FTJ_Soil.dbf* *Fedstra.dbf* *Fedtact.dbf* *tasiast_analyses_brgm.dbf* *tasiast_analyses_hadji.dbf*
SIG_Geochimie_500 folder; ESRI shapefiles	*Géochimie_nord_phase1.dbf* *Géochimie_Sud_Phase1.dbf*

GIS analysis requires consistent decimal geographic coordinates in a dataset in order to generate shapefiles. Coordinates for the samples located in the shapefiles in the *GGI* folder are provided only in eastings and northings. ArcGIS 9.2 was used to calculate latitude and longitude for these samples, and the tables were imported into the *MasterLocations.mdb* database.

The shapefiles in the *GGI* folder have only four-digit sample IDs for some 6,134 records, which differs from the 9-digit sample IDs commonly found for most of the PRISM-I geochemical samples. In addition, inspection of the *GGI* shapefiles reveals that different sample media (bleg, stream sediment, and soil) have the same four-digit sample ID, but sample differing coordinates. It is surmised here that there was possibly: (1) a truncation of the five-digit prefix that indicated the sample's degrees of latitude and longitude for the *GGI* shapefiles, and (or), (2) duplication in the usage of sample numbers, rendering them non-unique. With these uncertainties in the GGI shapefile data, we decided that it was safest to add a prefix consisting of "m40" plus a letter indicating the sample type (b=bleg, d=drain, s=soil) to the beginning of each 4-digit sample ID for the *MasterLocations.mdb* and *MasterChem.mdb* databases. This solved the problem for 3,205 samples, but we were not able to tie geochemistry to the remaining 2,929 samples.

The *tbl_Enchantillons_200k500k* table initially had insufficiently precise coordinates; coordinates for all 8,518 samples in the table were truncated to two decimal places (resulting in a precision of ±1,107 m at 20° latitude). However, this problem was rectified upon receipt of a new coordinate file for this table from PRISM on 31 July, 2012. The new sample numbers have five-decimal coordinates (~1-meter ground precision).

Within the database, we created a master sample location table with fields for sample number, latitude, longitude, original database containing the coordinates, original table containing the coordinates, French sample type, English sample type, and informal sampling region. The final master sample locations table (*tblSamples*) in the *MasterLocations.mdb* database contains a total of 39,294 unique sample numbers with coordinates.

Appendix 2. Notes on Compiling and Merging Geochemistry Datasets for the Master Geochemistry File, *MasterChem.mdb*

These notes describe in detail the process of creating the *MasterChem.mdb* geochemical database from the various existing Excel, Access, and shapefiles created under PRISM-I, and merged with additional data in analytical reports done by the contract laboratory ALS-Chemex under PRISM-I. These analytical reports were provided to the USGS by Mauritanian PRISM counterparts in March, 2007 in Nouakchott, to address the issue of missing geochemical data described in the Phase I Summary Report (U.S. Geological Survey, 2007). The individual PRISM-I sources of geochemical data are in bold below, followed by details describing the merge procedure for each source.

(1) ***Base de données des échantillons***: Original was an Access MDB file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Base_de_donnees

Within this database, the *Analyses_chimiques* table was found to contain 12,504 records with 72 fields of geochemical data. No censored data were identified. However, a review of the individual fields strongly suggests that the censored data have already been replaced using the same rules given to us by Mauritanian PRISM counterpart Thiam Baidy Abdoulaye, namely, "<" values were replaced with 0.5 times the lower limit of reporting value, and ">" values were replaced with the upper limit of reporting value itself; hereafter, these are referred to as the "Mauritanian rules"). All 12,504 records were added to the *MasterChem.mdb* database file without modification.

A recent review of these data reveals 104 standards or sample duplicates (all starting with the first four digits of 2440). To this point, these samples have not been a problem since there is no corresponding location coordinates for the ID numbers in the *MasterLocations.mdb* database.

(2) ***NouakchottData-March2007***: This is the dataset provided in Nouakchott by Mauritanian PRISM counterparts and compiled by USGS personnel from the XLS files found in:
\\mrcicfs1\mauritania_work\Geochemistry\NewDataFromNouakchott-March2007

The process of importing the data is described in detail in a PDF file entitled "Importing Adobe Files and Excel Spreadsheets" found in
\\mrcicfs1\mauritania_work\Geochemistry\Literature\Instruction Notes
and the compiled data are in the MauritaniaNewChemData.mdb file under:
\\mrcicfs1\mauritania_work\Geochemistry\NewDataFromNouakchott-March2007

MauritaniaNewChemData.mdb contains the following tables:

ALSChemexMethodCodes – a compiled key of various numerical and abbreviation codes used by ALS Chemex to describe their analytical methods with method descriptions.

Chem_CharacterizedMethods – the chemistry from Nouakchott XLS files where the element field names were given with abbreviations that characterized the analytical method used.

Chem_NumberedMethods – the chemistry from Nouakchott XLS files where the element field names were given a number code that represented the analytical method used. The number codes in field names were later changed based upon the linked values recorded in the *ALSChemexMethodCodes* table.

<u>*Chem_CharacterizedMethods_Modified*</u> and <u>*Chem_NumberedMethods_Modified*</u> – the same two tables listed above with all censored values converted based upon the Mauritanian rules.

<u>*LOR Data*</u> – A table listing the "limit of reporting" or lower detection limits for all methods. This information was compiled from the PDF QA/QC files provided by Mauritanian PRISM counterparts.

<u>*QA-QC_PDFS*</u> and <u>*QA-QC_PDFS_Modified*</u> – tables containing all the geochemistry for Standards, Blanks, and Duplicate Pairs used for QA/QC from the PDF QA/QC files provided by Mauritanian PRISM counterparts.

<u>*Target Range Values 1*</u> and <u>*Target Range Values 2*</u> – two tables containing the expected ranges of values for various standards analyzed by ALS Chemex. Because of the large number of analytical fields, it was necessary to break the table into two parts.

The two chemistry tables in the Noackchott data were combined into a single table in the *MasterChem.mdb* database file – *NouakchottChem_combChar&NumbMethods*. Since there were several methods for each element, it was necessary to create a single combined field for every single element or constituent. A table – *NouakchottCombinationOrder* – lists the order in which different analytical methods were combined in order to populate the single combined element field. This order is only important where two or more methods reported results for the same element in the same samples. In general, the following order of analytical methods was used:

A. Methods that were used to reanalyze specific elements in order to give precise values for concentrations reported in the primary method as "greater than a specified detection limit."
B. Fire Assay methods [for specific precious metals, base metals, and platinum group metals (PGM)].
C. XRF methods (used only for major element oxides).
D. ICP-MS multi-element package methods.
E. ICP-AES multi-element package methods.
F. Any remaining methods such as AAS with poorer LOR values.

Cryptic comments in the *NouakchottCombinationOrder* table identify individual reasons for each decision. The number of records added for each step is also listed.

Before merging with the *tblMasterChem* table, a test was done to identify records with non-unique Sample IDs. Ninety-six records were found for 47 unique Sample IDs. All 96 records were removed from the *NouakchottChem_combChar&NumbMethods* table and preserved in the *Prob_NouakchottChem_MultipleSamplesPerSite* table.

When the Nouakchott data (9,644 records) were merged with the data from the *Base de données des échantillons.mdb* database, 3,736 records were found that shared the same 1,868 Sample IDs (2 records per Sample ID). The problems were resolved as follows:

A. A total of 2,334 records (1,167 Sample IDs) was found to consist of exact duplicates—all chemistry matched. For each pair, the Nouakchott Data record was deleted to leave only one record per ID.
B. A total of 1,250 records (625 Sample IDs) was found to consist of duplicates EXCEPT that the new Nouakchott Data records included additional data for thorium. The only

other difference noted was that occasionally, the new Nouakchott Data in these pairs also contained correct "replaced censored values" for B or P. For each pair, the *Base de données des échantillons.mdb* data record was deleted to leave only one record per ID.

C. Twenty records (10 Sample IDs) appeared to be analyzed twice in different batches or lots. The chemistry that overlapped did not vary much. (An alternate interpretation for these records is that one of the records in each pair is an erroneous Sample ID.) One record appeared to be a multi-element suite and the other was often only gold and silver. For each of these, the record with the fewer constituents was removed and preserved in the *ProbRecs_tblMasterChem* table. It could be argued that all 20 records should have been removed rather than just 10.
D. A total of 132 records (66 Sample IDs) appeared to be analyzed twice in different batches or lots and the chemistry differed significantly between record pairs. It was assumed that at least one of the records in each pair was an erroneous Sample ID. All 132 records were removed and preserved in the *ProbRecs_tblMasterChem* table.

(3) *Enchantillons_sud_phase1*: Original was an Access MDB file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Base_de_donnees

Within this database were two tables containing geochemical data – *Annexe3Majors* and *Annexe3Traces*. Each table contained 76 records that could be linked on the ID number found in the ECHANTILLON field. All 76 records were merged together to be added to the *MasterChem.mdb* database file. None of the geochemistry data associated with single mineral analyses were evaluated or added to the *MasterChem.mdb* database file.

None of the element/constituent fields contained an indication of the reporting unit. Major elements and oxides were *assumed* to be in percent. Gold was *assumed* to be in parts-per-billion and were converted to ppm. All other trace and metal elements were *assumed* to be in parts-per-million. Censored data were recorded with "<" symbols and were replaced based on the Mauritanian rules before merging with the *MasterChem.mdb* database file.

When the *Enchantillons_sud_phase1.mdb* data were added to the *MasterChem.mdb* database file, there was an additional problem with multiple Sample IDs in the database. Fifty-six records were found with 28 unique Sample IDs. These problems were resolved as follows:

a. Twenty-two records (eleven Sample IDs) were found where the overlapping chemistry between a *Base de données des échantillons.mdb* record and a *Enchantillons_sud_phase1.mdb* record were very similar. These two records were combined into a single record by filling blanks in one record with the values found in the corresponding record. The resultant combined record can be identified in the *tblMasterChem* table by the value "Enchantillons_sud_phase1 and Base de données comb." in the TABLE field. The extra record was preserved in the *ProbRecs_tblMasterChem* table. (It could be argued that all 22 records should have been removed.)
b. Fourteen records (seven Sample IDs) were found where the overlapping chemistry between a *NouakchottData-March2007* record and a *Enchantillons_sud_phase1.mdb* record were very similar. These two records were combined into a single record by filling blanks in one record with the values found in the corresponding record. The resultant combined record can be identified in the *tblMasterChem* table by the value

“Enchantillons_sud_phase1 and Nouakchott combined” in the TABLE field. The extra record was preserved in the *ProbRecs_tblMasterChem* table. (It could be argued that all 14 records should have been removed.)

c. Twenty records (ten Sample IDs) were found where the overlapping chemistry between the two records was significantly different. It was assumed that at least one of these records contained an erroneous Sample ID. All 20 records were removed and preserved in the *ProbRecs_tblMasterChem* table.

(4) ***Echants_phase1a_24305***: Original was an Access MDB file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Base_de_donnees

Within this database were three tables containing geochemical data – *A404027_majors*; *A404027A_trace elements*; and *A404027B_metals*. A fourth table (*A404027A*) also contained geochemistry but this was found to be identical with the *A404027A_traces* table. Each table could be linked based on an ID found in the SAMPLES field. Some work was needed to repair values in the SAMPLES field from individual tables before merging – some values included embedded spaces or were missing suffixes. In addition, a couple of samples were found that were completely duplicated. These duplicates were compared and reduced to one complete record. Records identified either in the ID fields or in a comment field as a “Standard” were removed. Out of the original 89 (or 87) records recorded in the various tables, only 81 were merged together and kept to be added to the *MasterChem.mdb* database file.

None of the element/constituent fields contained an indication of the reporting unit. Major elements and oxides were *assumed* to be in percent. Gold was *assumed* to be in parts-per-billion and were converted to ppm. All other trace and metal elements were *assumed* to be in parts-per-million. Censored data were recorded with “<” symbols and were replaced based on the Mauritanian rules before merging with the *MasterChem.mdb* database file.

(5) ***m40_regional_BLEG_sample_9697***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\GGI

The header in the file identifies this dataset as being from the “GENERAL GOLD INTERNATIONAL SA Mauritania South Project” and containing “Drainage Sampling Results (BLEG Sample Type)” from a “Regional Programme. 1996-1997”.

The file contained 1,127 records. Sample numbers were only given as four digits (for example, 1020). Based on the method used in the *MasterLocations.mdb* database, a prefix of “M40b0” was appended to each Sample ID (for example, 1001 = M40b0 1001). Only 97 records contained any geochemical data—gold (ppb) ± eight other metals in ppm.

Censored data were recorded with“<”symbols. Gold data were converted to ppm and censored values were replaced based on the Mauritanian rules before merging with the *MasterChem.mdb* database file.

(6) ***m40_regionaldrainagesample_9697***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\GGI

The header in the file identifies this dataset as being from the “GENERAL GOLD INTERNATIONAL SA Mauritania South Project” and containing “Drainage Sampling Results (-132 micron samples)” from a “Regional Programme”.

The file contained 5,007 records. Sample numbers were only given as four digits (for example, 1020). Based on the method used in the *MasterLocations.mdb* database, a prefix of "M40d0" was appended to each Sample ID (for example, 1020 = M40d01020). Fifteen records were identified in the %Gravel field as STANDARDs. There were absolutely no data in any field associated with records labeled STANDARD. Only 2,988 records contained any geochemical data—gold (ppb) ±10 other metals in ppm (two elements—Ag and Mo—were only analyzed for a smaller subset of samples (492 records) and show almost no variation above their detection limits.

Censored data were recorded with"<"symbols. Gold data were converted to ppm and censored values were replaced based on the Mauritanian rules before merging with the *MasterChem.mdb* database file.

(7) ***m40_regional_soil_sample_9697***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\GGI

The header in the file identifies this dataset as being from the "GENERAL GOLD INTERNATIONAL SA Mauritania South Project 1996-1997" and containing "Soil Sampling Results" for "Regional Soils".

The file contained 23 records; only 22 contained geochemical data—gold (ppb) ±eight other metals in ppm (no Ag or Mo). Sample numbers were only given as five digits (for example, 10300). Based on the method used in the *MasterLocations.mdb* database, a prefix of "M40s" was appended to each Sample ID (for example, 10300 = M40s10300).

Censored data were recorded with"<"symbols. Gold data were converted to ppm and censored values were replaced based on the Mauritanian rules before merging with the *MasterChem.mdb* database file.

(8) ***Normandie_La_Source_FEDSTRA***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Normandie_La_Source

The file contained 6,554 records with only 4,628 geochemical values for gold. (Six more records contained values of 0 (zero) for gold—these were not kept.) The column labeled INDC was used as the Sample ID after comparing records with the *MasterLocations.mdb* database. Censored gold values were recorded as negative numbers. No indication was given for the analytical measurement unit. Because the LOR values in this dataset were <5, it was *assumed* that the values were in parts-per-billion. Therefore all values were converted to ppm (LOR=<0.005 ppm) before merging with the *MasterChem.mdb* database file.

(9) ***Normandie_La_Source_FEDTACT***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Normandie_La_Source

The file contained 2,438 records with only geochemical values for gold. The column labeled INDC was used as the Sample ID after comparing records with the *MasterLocations.mdb* database. Censored gold values were recorded as negative numbers. No indication was given for the analytical measurement unit. Because the LOR values in this dataset were <5, it was *assumed* that the values were in parts-per-billion. Therefore all values were converted to ppm (LOR=<0.005 ppm) before merging with the *MasterChem.mdb* database file.

(10) ***TST_38Anal_Maj_Tr_Hadji***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Normandie_La_Source

The file contained 38 records with whole rock major oxides, trace elements, metals and REE. The first 25 records have no censored values but contain numerous values of 0 (zero). The last 13 records do not have any 0 values but have numerous values of "<DL". No information was found concerning the LOR values for these samples nor was there any obvious correlation between lowest real values for individual elements in this table and the list of LOR values by element and method recorded when entering the additional March, 2003 data from Nouakchott. In the end, 0's and <DL's were treated as equivalent and simply replaced with a value of "Null".

It was obvious that at least two analytical methods were used to determine trace elements—one method reported values to two significant figures and the other method reported values to four decimal places without regard for significant figures. About five elements had analyses by the two different, but unspecified, methods. The values for these analytical pairs were visually compared and few significant differences were observed. For purely aesthetical reasons, when faced with a choice between two analyses for an element the values from the method reported to two significant figures were retained. If there was a "Null" value (originally a 0 or <DL) in the analyses that were kept, values (using only two significant figures) were added to the final column from the second analytical method.

(11) ***TST_413Anal_Maj_Tr_Brgm***: Original was an XLS file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\Normandie_La_Source

The file contained 413 records with whole rock major oxides, trace elements, and metals. In the original table, censored values were recorded as negative numbers. Some of these elements had high LOR values (for example, Bi <10 ppm; Pb<10 ppm; La <20 ppm). These high LOR values were converted using the Mauritanian rules for treatment of censored values, which could cause problems when used in a regional geochemistry evaluation.

Mafic element (Cr, Ni, and so on) concentrations seemed high whereas REEs and felsic element concentrations were generally low. Au_ppb was converted to ppm and P2O5_ppm was converted to percent before merging. Odd characters or formatting in the first row of the file caused problems during conversion from XLS to Access MDB. *Although these samples are tentatively identified as soils, the chemistry seems more characteristic of selected rock samples.*

A comparison of sites with the coordinates found in the *MasterLocations.mdb* database show that all 413 samples plot at only six precise coordinates. Because of this irregularity and because of the ambiguity in sample media type, these 413 samples were excluded from the *MasterChem.mdb* database. More precise coordinates were received on 31 July 2012, and these new coordinates may in fact correct the coarse locations for the 413 samples, but it was too late to incorporate these data into the present report and maps.

(12) ***Géochimie_nord_phase1***: Original was a DBF file found in:
\\mrcicfs1\mauritania\NewData\SIG_M\L'information\Geochimie\SIG_Geochimie_500

File contained 200 records with petrographic information plus whole-rock major oxides, trace elements, and metals. Note: There were NO censored values in this dataset. However, there were several values of 0 (zero) in various fields. Although these could have been replaced “less than” values, it is also possible that they represent “not analyzed” values. All values of 0 were removed before combining with the *MasterChem.mdb* database file.

Appendix 3. Summary of Results for QC Evaluation of Standard Reference Materials

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Ag-AA61	BMAA-02	0.5	62	13.3	11.9	14.7	13.6984	0.4229	3.09	103.00
Ag-AA61	G2000	0.5	67	3.55	2.7	4.4	3.7313	0.3606	9.67	105.11
Ag-AA61	GS01-2	0.5	44	23.1	21	25.2	22.5136	0.7581	3.37	97.46
Ag-AA61	JWB-JV-1	0.5	65	22.5	20	25	23.1308	0.9432	4.08	102.80
Ag-AA63	BMAA-02	1	89	13.3	11.9	14.7	13.6067	0.9246	6.80	102.31
Ag-AA63	JWB-JV-1	1	85	22.5	20	25	22.8471	0.9941	4.35	101.54
Ag-ICP61	G2000	0.5	21	3.55	2.7	4.4	3.6000	0.3606	10.02	101.41
Ag-ICP61	GS01-2	0.5	20	23.1	21	25.2	23.3550	1.1993	5.14	101.10
Ag-MS61	G2000	0.01	106	3.55	2.7	4.4	3.8233	1.2279	32.12	107.70
Ag-MS61	GEOMS-03	0.01	31	0.76	0.67	0.85	0.7365	0.0411	5.58	96.90
Al-ICP61	G2000	0.01	21	5.03	4.66	5.4	5.0595	0.1990	3.93	100.59
Al-ICP61	GS01-2	0.01	20	7.38	6.63	8.13	7.5060	0.2721	3.63	101.71
Al-MS61	G2000	0.01	106	5.03	4.66	5.4	5.0752	0.1892	3.73	100.90
Al-MS61	GEOMS-03	0.01	31	5.13	4.61	5.65	5.3023	0.1986	3.75	103.36
As-AA61	BMAA-02	5	57	188	170	206	190.2456	9.4704	4.98	101.19
As-AA61	G2000	5	69	484	435	533	497.4058	24.4951	4.92	102.77
As-AA61	GS01-2	5	66	363	322	404	366.7121	17.4803	4.77	101.02
As-AA61	JWB-JV-1	5	63	520	478	562	534.6508	19.6076	3.67	102.82
As-AA63	BMAA-02	5	58	188	170	206	180.8276	10.0562	5.56	96.18
As-AA63	JWB-JV-1	5	78	520	478	562	535.6795	27.3992	5.11	103.02
As-ICP61	G2000	5	21	484	435	533	485.8095	21.0870	4.34	100.37
As-ICP61	GS01-2	5	20	363	322	404	380.8500	20.5945	5.41	104.92

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
As-MS61	G2000	0.2	106	484	435	533	481.9434	20.8134	4.32	99.58
As-MS61	GEOMS-03	0.2	31	633.5	570	697	649.3548	16.8058	2.59	102.50
Au-AA23	NA-03	0.005	35	0.194	0.172	0.216	0.1933	0.0065	3.36	99.62
Au-AA23	OX5	0.005	14	0.9655	0.866	1.065	0.9689	0.0354	3.66	100.35
Au-AA23	OX8	0.005	11	0.19	0.162	0.218	0.1905	0.0110	5.79	100.24
Au-AA23	SC-02	0.005	31	0.7	0.625	0.775	0.7145	0.0196	2.75	102.07
Au-ICP21	NA-03	0.001	75	0.194	0.172	0.216	0.1924	0.0087	4.53	99.18
Au-ICP21	OX5	0.001	22	0.9655	0.866	1.065	0.9872	0.0560	5.67	102.25
Au-ICP21	OX8	0.001	34	0.19	0.162	0.218	0.1917	0.0098	5.10	100.90
Au-ICP21	SC-02	0.001	81	0.7	0.625	0.775	0.7188	0.0332	4.63	102.69
Au-ICP23	OX5	0.001	8	0.9655	0.866	1.065	0.9570	0.0565	5.91	99.12
Au-ICP23	PGMS-3	0.001	13	0.33	0.296	0.364	0.3328	0.0244	7.33	100.84
Au-ICP23	SC-02	0.001	10	0.7	0.625	0.775	0.7137	0.0514	7.20	101.96
B-MS61	G2000	10	91	12.5	5	20	<10	---	N/A	N/A
B-MS61	GEOMS-03	10	16	7.5	5	10	<10	---	N/A	N/A
Ba-ICP61	G2000	10	21	2230	2000	2460	2213.333	456.205	20.61	99.25
Ba-ICP61	GS01-2	10	20	610	540	680	375.000	311.423	83.05	61.48
Ba-MS61	G2000	0.5	106	2230	2070	2390	2049.151	484.194	23.63	91.89
Ba-MS61	GEOMS-03	0.5	31	2435	2180	2690	2499.677	125.020	5.00	102.66
Be-ICP61	G2000	0.5	21	1.4	0.8	2	1.4095	0.1044	7.41	100.68
Be-ICP61	GS01-2	0.5	20	0.925	0.25	1.6	1.3500	0.0513	3.80	145.95
Be-MS61	G2000	0.05	106	1.44	1.29	1.59	1.4701	0.1159	7.88	102.09
Be-MS61	GEOMS-03	0.05	31	1.47	1.27	1.67	1.5081	0.2515	16.68	102.59
Bi-ICP61	G2000	2	21	2.5	1	4	<2	---	N/A	N/A
Bi-ICP61	GS01-2	2	20	33	28	38	33.7500	1.9967	5.92	102.27

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Bi-MS61	G2000	0.01	106	1.07	0.98	1.16	1.1083	0.0538	4.86	103.58
Bi-MS61	GEOMS-03	0.01	31	0.36	0.31	0.41	0.3710	0.0237	6.39	103.05
Ca-ICP61	G2000	0.01	21	0.58	0.51	0.65	0.5924	0.0274	4.62	102.13
Ca-ICP61	GS01-2	0.01	20	5.29	4.75	5.83	5.3325	0.1592	2.98	100.80
Ca-MS61	G2000	0.01	106	0.58	0.53	0.63	0.5902	0.0224	3.79	101.76
Ca-MS61	GEOMS-03	0.01	31	0.4	0.35	0.45	0.3897	0.0130	3.34	97.42
Cd-ICP61	G2000	0.5	21	7.6	6.3	8.9	7.4571	0.5016	6.73	98.12
Cd-ICP61	GS01-2	0.5	20	24	21.1	26.9	24.5900	1.7947	7.30	102.46
Cd-MS61	G2000	0.02	106	7.6	7.04	8.16	7.6750	0.3253	4.24	100.99
Cd-MS61	GEOMS-03	0.02	31	0.36	0.3	0.42	0.3571	0.0194	5.42	99.19
Ce-MS61	G2000	0.01	106	50.7	47.1	54.3	51.4821	2.0470	3.98	101.54
Ce-MS61	GEOMS-03	0.01	31	53	47.7	58.3	51.2258	2.0973	4.09	96.65
Co-ICP61	G2000	1	21	25.5	22	29	24.5238	1.5690	6.40	96.17
Co-ICP61	GS01-2	1	20	96	85	107	94.1500	3.8426	4.08	98.07
Co-MS61	G2000	0.1	106	25.2	23.3	27.1	25.4660	1.0661	4.19	101.06
Co-MS61	GEOMS-03	0.1	31	12	10.7	13.3	12.2742	0.3941	3.21	102.28
Cr-ICP61	G2000	1	45	74	66	82	75.6222	9.2104	12.18	102.19
Cr-ICP61	GS01-2	1	40	64	57	71	63.4750	4.9717	7.83	99.18
Cr-MS61	G2000	1	106	72	64	80	69.3962	7.0247	10.12	96.38
Cr-MS61	GEOMS-03	1	31	80	71	89	83.4839	9.1465	10.96	104.35
Cs-MS61	G2000	0.05	106	12.475	11.55	13.4	12.6137	0.4946	3.92	101.11
Cs-MS61	GEOMS-03	0.05	31	9.77	8.74	10.8	10.1345	0.3080	3.04	103.73
Cu-ICP61	G2000	1	45	303	272	334	305.7556	9.6322	3.15	100.91
Cu-ICP61	GS01-2	1	40	6060	5450	6670	6258.250	213.912	3.42	103.27
Cu-MS61	G2000	0.2	106	303	281	325	307.3962	13.9848	4.55	101.45

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Cu-MS61	GEOMS-03	0.2	31	134	120.5	147.5	143.6129	32.9380	22.94	107.17
Fe-ICP61	G2000	0.01	21	3.8	3.41	4.19	3.9029	0.1534	3.93	102.71
Fe-ICP61	GS01-2	0.01	20	3.72	3.34	4.1	3.7870	0.1238	3.27	101.80
Fe-MS61	G2000	0.01	106	3.8	3.52	4.08	3.8427	0.1280	3.33	101.12
Fe-MS61	GEOMS-03	0.01	31	4.06	3.64	4.48	4.2290	0.1546	3.66	104.16
Ga-MS61	G2000	0.05	106	12.375	11.45	13.3	12.6580	0.5384	4.25	102.29
Ga-MS61	GEOMS-03	0.05	31	13.375	12	14.75	13.8565	1.7260	12.46	103.60
Ge-MS61	G2000	0.05	106	0.26	0.19	0.33	0.2101	0.0611	29.06	80.81
Ge-MS61	GEOMS-03	0.05	31	0.17	0.1	0.24	0.1587	0.0593	37.34	93.36
Hf-MS61	G2000	0.1	106	1	0.8	1.2	0.9085	0.1455	16.01	90.85
Hf-MS61	GEOMS-03	0.1	31	0.65	0.5	0.8	0.8484	0.2743	32.33	130.52
In-MS61	G2000	0.005	106	0.38	0.348	0.412	0.3925	0.0155	3.96	103.29
In-MS61	GEOMS-03	0.005	31	0.044	0.035	0.053	0.0433	0.0052	11.95	98.39
K-ICP61	G2000	0.01	21	1.3	1.16	1.44	1.2729	0.0630	4.95	97.91
K-ICP61	GS01-2	0.01	20	1.77	1.58	1.96	1.8435	0.0550	2.98	104.15
K-MS61	G2000	0.01	106	1.3	1.2	1.4	1.2934	0.0431	3.33	99.49
K-MS61	GEOMS-03	0.01	31	1.16	1.03	1.29	1.1387	0.0363	3.19	98.16
La-MS61	G2000	0.5	106	29.3	26.7	31.9	28.9925	1.4160	4.88	98.95
La-MS61	GEOMS-03	0.5	31	28.4	25.1	31.7	28.5968	1.5698	5.49	100.69
Li-MS61	G2000	0.2	106	38.1	35.2	41	38.6311	2.7080	7.01	101.39
Li-MS61	GEOMS-03	0.2	31	41.15	36.8	45.5	39.9968	3.2580	8.15	97.20
Mg-ICP61	G2000	0.01	21	0.76	0.67	0.85	0.7567	0.0337	4.45	99.56
Mg-ICP61	GS01-2	0.01	20	1.74	1.56	1.92	1.7595	0.0654	3.72	101.12
Mg-MS61	G2000	0.01	106	0.76	0.7	0.82	0.7642	0.0245	3.20	100.55
Mg-MS61	GEOMS-03	0.01	31	0.54	0.48	0.6	0.5284	0.0177	3.35	97.85
Mn-ICP61	G2000	5	21	568	506	630	576.3810	23.1959	4.02	101.48

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Mn-ICP61	GS01-2	5	20	2430	2180	2680	2316.000	85.6799	3.70	95.31
Mn-MS61	G2000	5	106	568	523	613	566.0377	16.5615	2.93	99.65
Mn-MS61	GEOMS-03	5	31	542	483	601	550.0968	57.5849	10.47	101.49
Mo-ICP61	G2000	1	21	6	4	8	5.4286	0.9783	18.02	90.48
Mo-ICP61	GS01-2	1	20	1267.5	1140	1395	1232.750	58.9709	4.78	97.26
Mo-MS61	G2000	0.05	111	6.13	5.65	6.61	6.2202	0.3318	5.34	101.47
Mo-MS61	GEOMS-03	0.05	32	3.34	3.05	3.63	3.4709	0.2077	5.99	103.92
Na-ICP61	G2000	0.01	21	0.155	0.13	0.18	0.1429	0.0085	5.92	92.17
Na-ICP61	GS01-2	0.01	20	2.855	2.56	3.15	2.7130	0.1164	4.29	95.03
Na-MS61	G2000	0.01	106	0.15	0.13	0.17	0.1459	0.0090	6.19	97.30
Na-MS61	GEOMS-03	0.01	31	0.08	0.06	0.1	0.0845	0.0077	9.08	105.65
Nb-MS61	G2000	0.1	106	9.1	8.4	9.8	8.8396	0.8779	9.93	97.14
Nb-MS61	GEOMS-03	0.1	31	10.45	9.3	11.6	10.3484	1.1619	11.23	99.03
Ni-ICP61	G2000	1	36	286	256	316	283.5000	10.7291	3.78	99.13
Ni-ICP61	GS01-2	1	31	4190	3770	4610	4237.097	141.756	3.35	101.12
Ni-MS61	G2000	0.2	106	286	266	306	283.3491	9.0880	3.21	99.07
Ni-MS61	GEOMS-03	0.2	31	53.7	48.1	59.3	54.4323	1.5001	2.76	101.36
P-ICP61	G2000	10	21	945	840	1050	964.7619	33.4094	3.46	102.09
P-ICP61	GS01-2	10	20	1360	1210	1510	1382.500	38.2340	2.77	101.65
P-MS61	G2000	10	106	950	870	1030	974.5283	45.9012	4.71	102.58
P-MS61	GEOMS-03	10	31	1120	1000	1240	1107.097	32.5775	2.94	98.85
Pb-ICP61	G2000	2	21	670	601	739	691.2381	70.6137	10.22	103.17
Pb-ICP61	GS01-2	2	20	244	218	270	245.8500	15.9019	6.47	100.76
Pb-MS61	G2000	0.5	106	670	622	718	674.4811	24.2170	3.59	100.67
Pb-MS61	GEOMS-03	0.5	31	6.55	5.4	7.7	7.3935	1.4047	19.00	112.88
Pd-ICP23	OX5	0.001	8	0.0013	0.0005	0.002	<0.001	---	N/A	N/A

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Pd-ICP23	PGMS-3	0.001	13	0.59	0.53	0.65	0.6065	0.0239	3.94	102.79
Pd-ICP23	SC-02	0.001	10	0.0013	0.0005	0.002	<0.001	---	N/A	N/A
Pt-ICP23	OX5	0.005	8	0.0063	0.0025	0.01	<0.005	---	N/A	N/A
Pt-ICP23	PGMS-3	0.005	13	0.13	0.112	0.148	0.1365	0.0094	6.89	104.97
Pt-ICP23	SC-02	0.005	10	0.0063	0.0025	0.01	<0.005	---	N/A	N/A
Pt-MS61	G2000	0.1	107	0.125	0.05	0.2	<0.1	---	N/A	N/A
Pt-MS61	GEOMS-03	0.1	31	0.125	0.05	0.2	<0.1	---	N/A	N/A
Rb-MS61	G2000	0.1	106	65.1	60.4	69.8	67.0491	2.6622	3.97	102.99
Rb-MS61	GEOMS-03	0.1	31	59.1	53.1	65.1	59.0871	2.8048	4.75	99.98
Re-MS61	G2000	0.002	106	0.006	0.003	0.009	0.0060	0.0012	19.81	99.53
Re-MS61	GEOMS-03	0.002	31	0.0025	0.001	0.004	0.0021	0.0010	49.80	83.87
S-ICP61	G2000	0.01	21	0.265	0.23	0.3	0.2624	0.0151	5.77	99.01
S-ICP61	GS01-2	0.01	20	1.21	1.08	1.34	1.2435	0.0618	4.97	102.77
S-MS61	G2000	0.01	106	0.26	0.23	0.29	0.2601	0.0140	5.40	100.04
S-MS61	GEOMS-03	0.01	31	0.04	0.03	0.05	0.0384	0.0037	9.74	95.97
Sb-ICP61	G2000	5	21	32	24	40	31.6190	2.7654	8.75	98.81
Sb-ICP61	GS01-2	5	20	666	594	738	598.0000	74.5329	12.46	89.79
Sb-MS61	G2000	0.05	106	32.2	29.9	34.5	31.9896	1.4540	4.55	99.35
Sb-MS61	GEOMS-03	0.05	31	16.15	14.5	17.8	16.1806	1.0031	6.20	100.19
Se-MS61	G2000	1	106	5.5	4	7	5.2075	1.0754	20.65	94.68
Se-MS61	GEOMS-03	1	31	3	2	4	2.7742	0.8450	30.46	92.47
Sn-MS61	G2000	0.2	106	2.2	1.8	2.6	2.2472	0.1236	5.50	102.14
Sn-MS61	GEOMS-03	0.2	31	2.55	2.1	3	2.5323	0.1869	7.38	99.30
Sr-ICP61	G2000	1	21	116	103	129	114.2857	4.7554	4.16	98.52
Sr-ICP61	GS01-2	1	20	711	639	783	731.0000	30.9618	4.24	102.81
Sr-MS61	G2000	0.2	106	116	107.5	124.5	118.2406	3.5951	3.04	101.93

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Sr-MS61	GEOMS-03	0.2	31	171.5	154	189	176.3226	4.7461	2.69	102.81
Ta-MS61	G2000	0.05	106	0.4	0.32	0.48	0.3493	0.1274	36.46	87.33
Ta-MS61	GEOMS-03	0.05	31	0.26	0.18	0.34	0.3039	0.1435	47.23	116.87
Te-MS61	G2000	0.05	106	0.155	0.09	0.22	0.1648	0.0431	26.16	106.33
Te-MS61	GEOMS-03	0.05	31	0.13	0.07	0.19	0.1148	0.0245	21.31	88.34
Th-MS61	G2000	0.2	106	7.7	6.8	8.6	7.5943	0.3964	5.22	98.63
Th-MS61	GEOMS-03	0.2	31	7.1	6.2	8	7.9903	1.1728	14.68	112.54
Ti-ICP61	G2000	0.01	21	0.355	0.31	0.4	0.3424	0.0187	5.46	96.45
Ti-ICP61	GS01-2	0.01	20	0.325	0.28	0.37	0.3145	0.0139	4.43	96.77
Ti-MS61	G2000	0.01	106	0.355	0.32	0.39	0.3471	0.0129	3.73	97.78
Ti-MS61	GEOMS-03	0.01	31	0.46	0.4	0.52	0.4667	0.0139	2.98	101.46
Tl-MS61	G2000	0.02	106	0.98	0.89	1.07	1.0076	0.0437	4.33	102.82
Tl-MS61	GEOMS-03	0.02	31	1.19	1.05	1.33	1.2094	0.0800	6.61	101.63
U-MS61	G2000	0.1	111	3.3	3	3.6	3.3018	0.1618	4.90	100.05
U-MS61	GEOMS-03	0.1	32	3.65	3.2	4.1	3.5250	0.1849	5.25	96.58
V-ICP61	G2000	1	21	108	96	120	104.1905	4.3545	4.18	96.47
V-ICP61	GS01-2	1	20	213	191	235	216.1500	4.8262	2.23	101.48
V-MS61	G2000	1	111	108	99	117	107.4324	4.5898	4.27	99.47
V-MS61	GEOMS-03	1	32	120	107	133	118.5000	2.5145	2.12	98.75
W-ICP61	G2000	10	21	12.5	5	20	<10	---	N/A	N/A
W-ICP61	GS01-2	10	20	12.5	5	20	<10	---	N/A	N/A
W-MS61	G2000	0.1	106	15.4	14.2	16.6	15.4915	0.7137	4.61	100.59
W-MS61	GEOMS-03	0.1	31	18.9	16.9	20.9	18.5355	1.0704	5.77	98.07
Y-MS61	G2000	0.1	106	19.3	17.8	20.8	19.9717	0.8248	4.13	103.48
Y-MS61	GEOMS-03	0.1	31	19.55	17.5	21.6	19.6677	0.9108	4.63	100.60
Zn-ICP61	G2000	2	21	1257.5	1130	1385	1276.905	53.1854	4.17	101.54

Table A3.1. Summary statistics for all combinations of elements, analytical methods, and 12 different standard reference materials.—Continued

[data good to three significant figures at best. N/A, not applicable]

Method	Standard	LOR	N	Target Value	Lower Control Limit	Upper Control Limit	Mean	Std Dev	% RSD	% Recovery
Zn-ICP61	GS01-2	2	20	3855	3470	4240	3906.500	171.841	4.40	101.34
Zn-MS61	G2000	2	106	1257.5	1165	1350	1276.321	45.0095	3.53	101.50
Zn-MS61	GEOMS-03	2	31	47	40	54	47.6774	2.2418	4.70	101.44
Zr-MS61	G2000	0.5	106	31	27.4	34.6	27.0575	6.2379	23.05	87.28
Zr-MS61	GEOMS-03	0.5	31	21.3	18.7	23.9	19.6613	8.8417	44.97	92.31

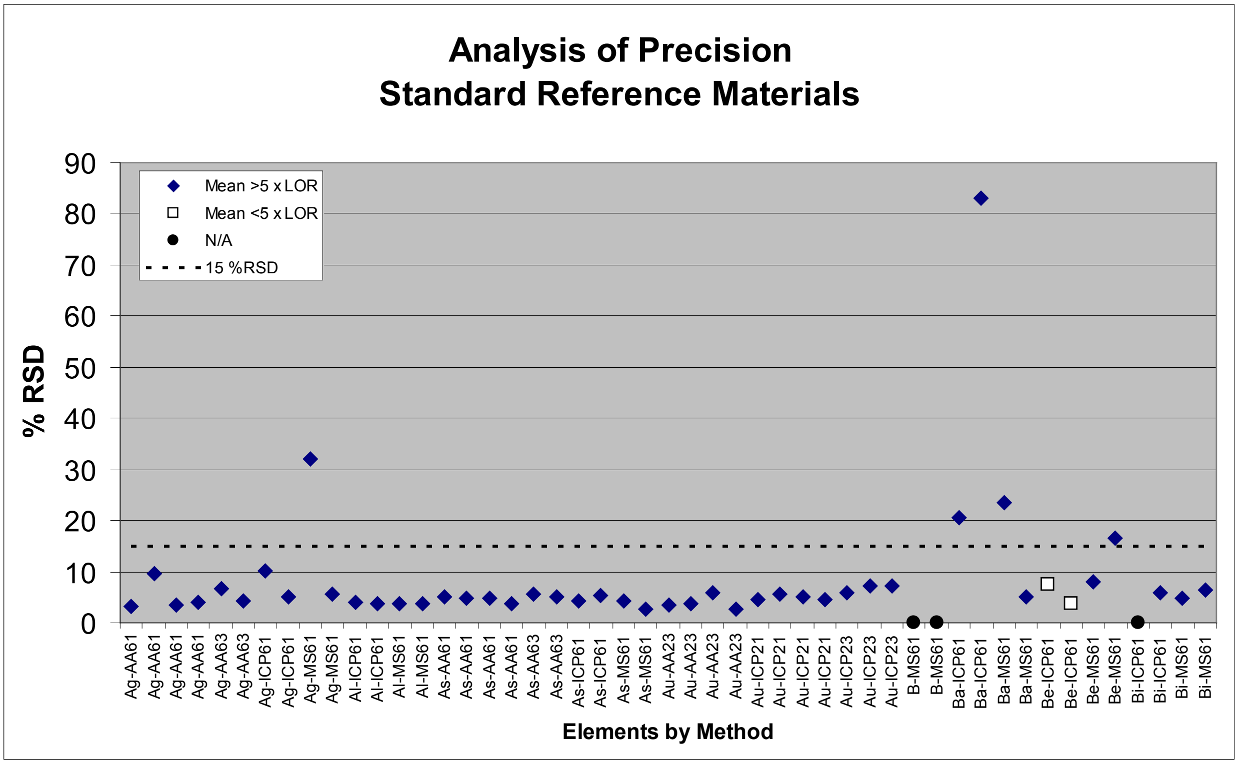

Figure A3.1. Precision plot of analyses of standard reference materials (Ag–Bi).

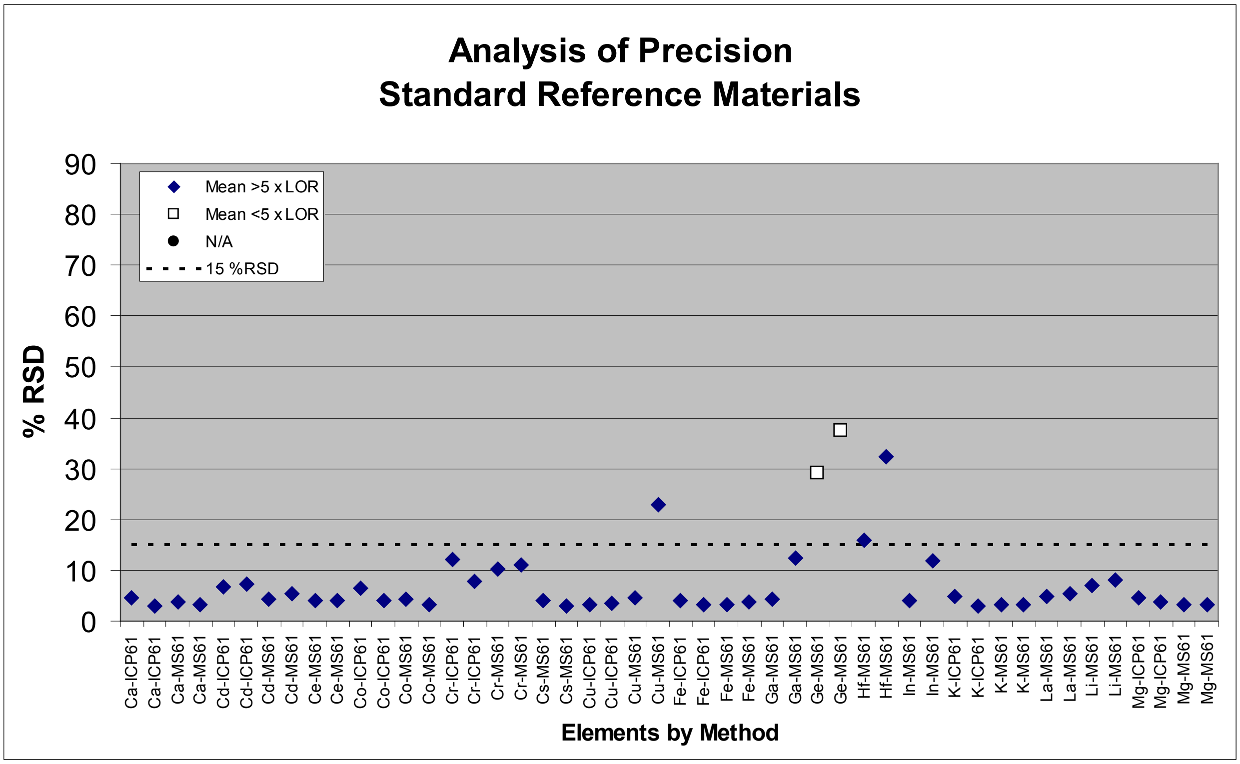

Figure A3.2. Precision plot of analyses of standard reference materials (Ca–Mg).

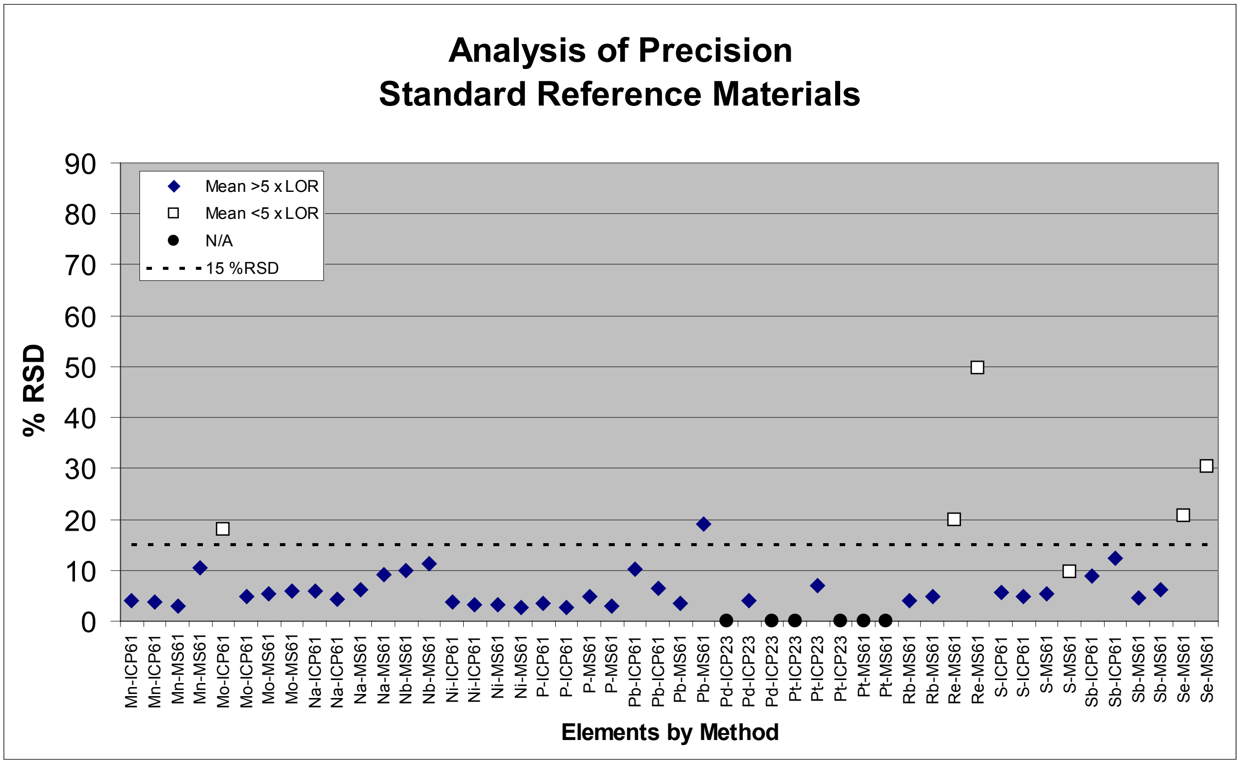

Figure A3.3. Precision plot of analyses of standard reference materials (Mn–Se).

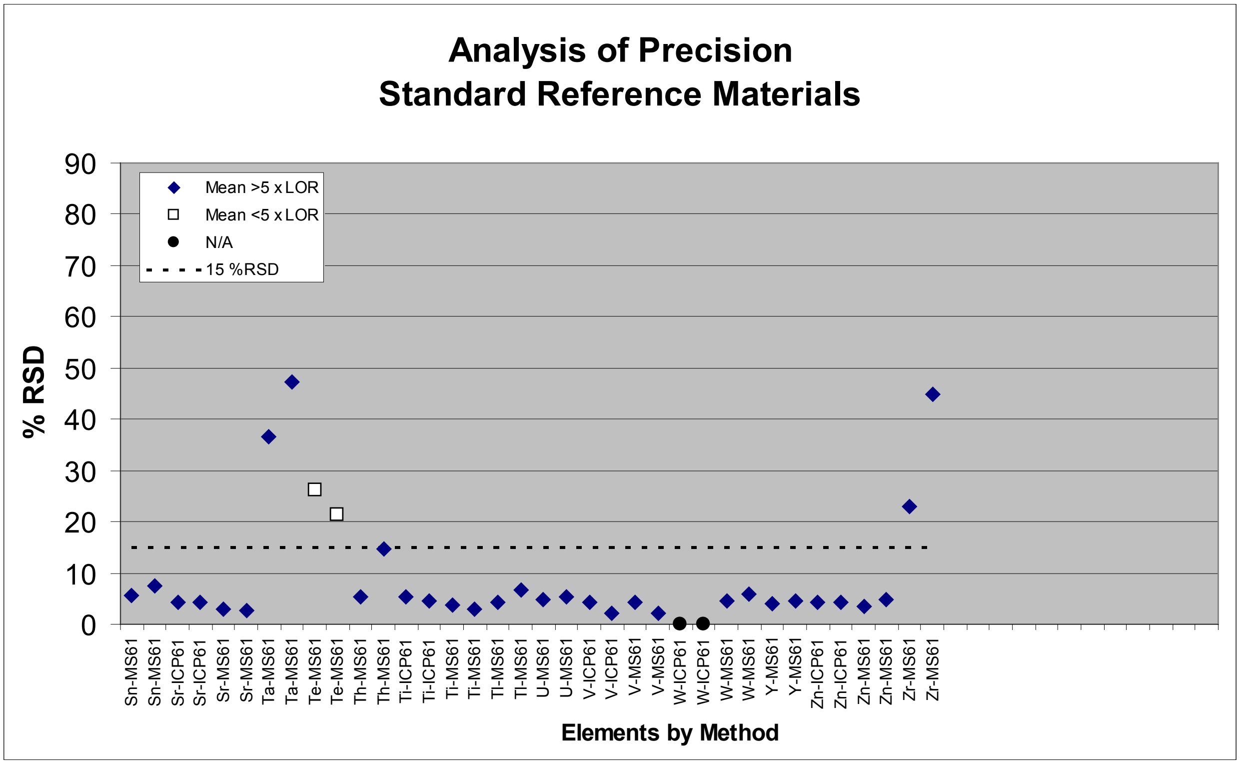

Figure A3.4. Precision plot of analyses of standard reference materials (Sn–Zr).

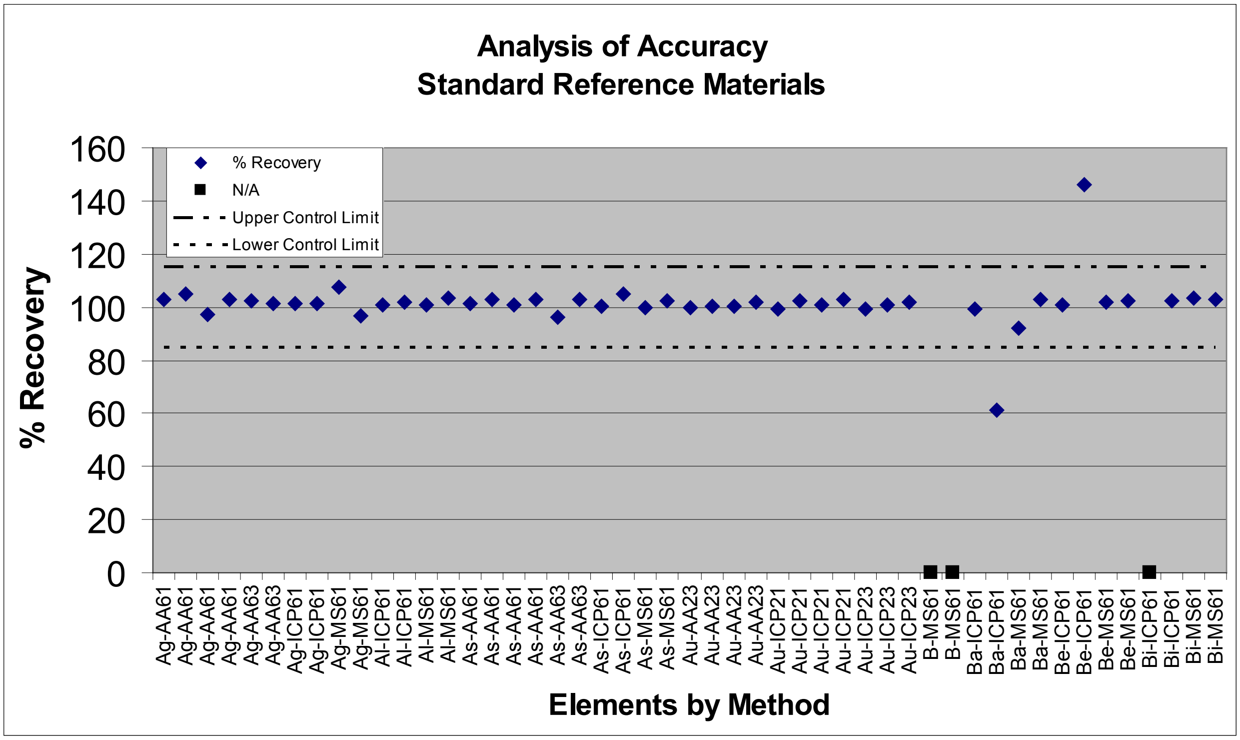

Figure A3.5. Accuracy plot of analyses of standard reference materials (Ag–Bi).

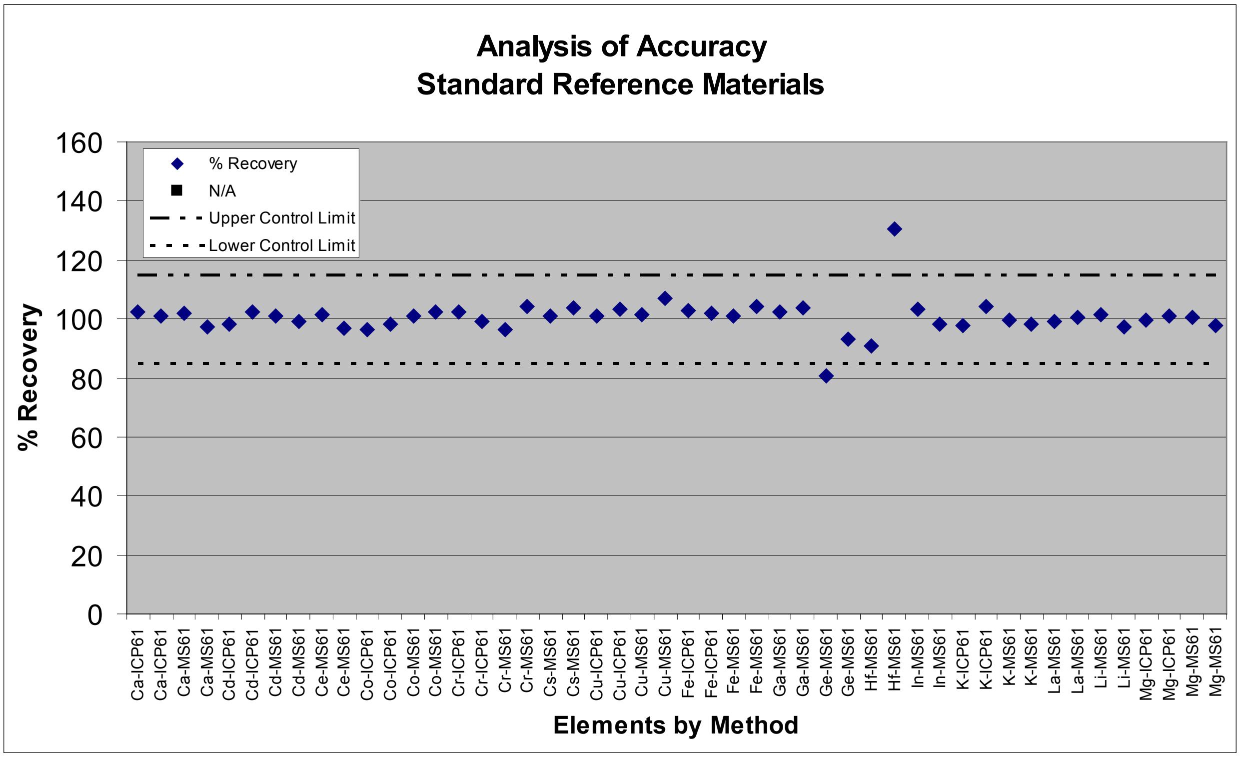

Figure A3.6. Accuracy plot of analyses of standard reference materials (Ca–Mg).

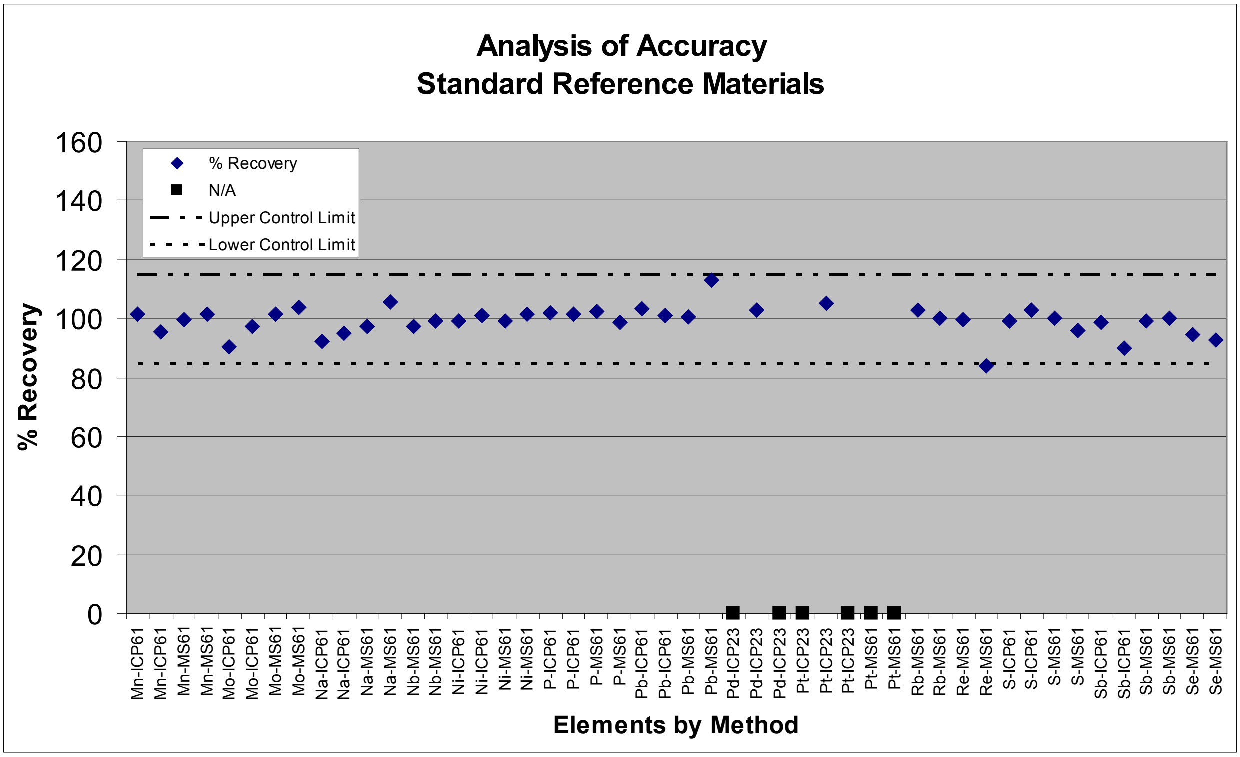

Figure A3.7. Accuracy plot of analyses of standard reference materials (Mn–Se).

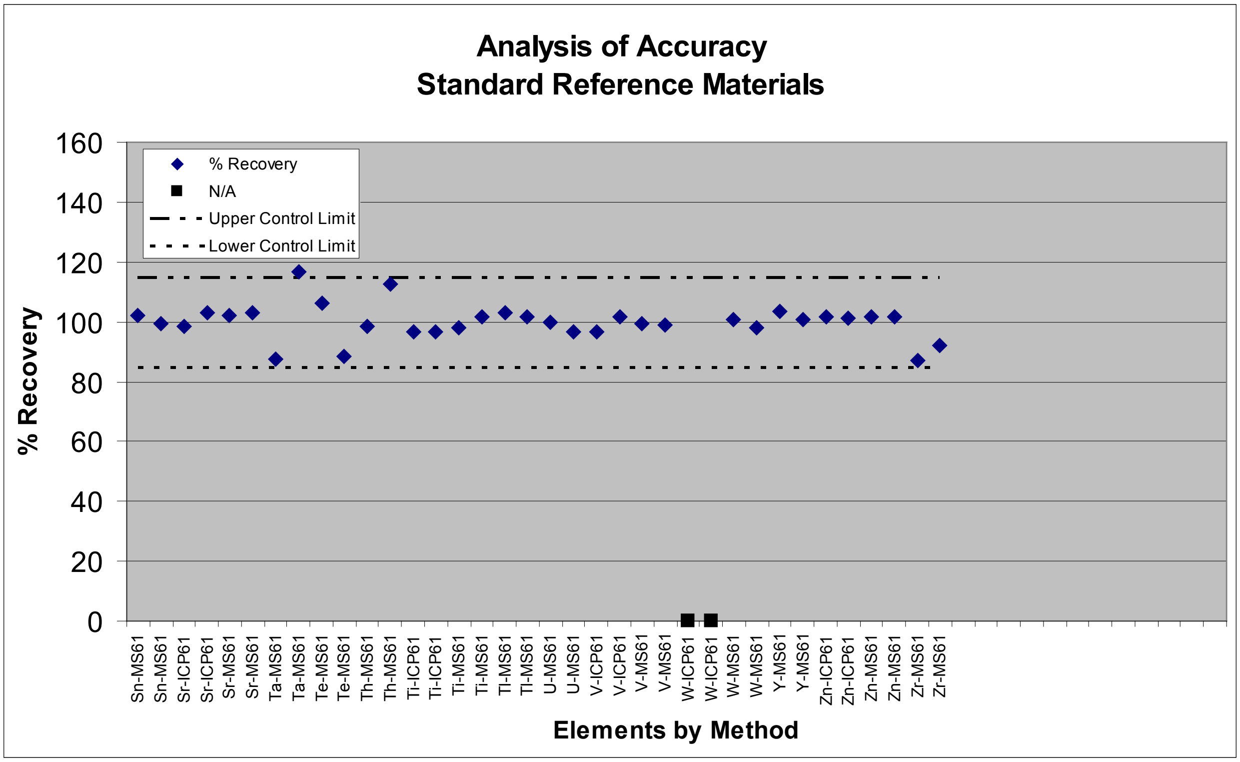

Figure A3.8. Accuracy plot of analyses of standard reference materials (Sn–Zr).

Appendix 4. Summary of Results for QC Evaluation of Analytical Duplicate Samples

Table A4.1. Summary statistics for all analytical duplicate samples by analytical method.

[data good to three significant figures at best. N/A, not applicable]

Element/ Method	Units	LOR	Pairs (k)	Per Pair (n)	Min	Max	Sum	Mean	Std Dev for Duplicates	% RSD
Ag-AA61	ppm	0.5	61	2	0.25	13	67.8	0.5557	0.1103	19.85
Ag-AA63	ppm	1	81	2	0.5	1	91	<1	---	N/A
Ag-ICP61	ppm	0.5	12	2	0.25	1.4	8	<0.5	---	N/A
Ag-MS61	ppm	0.01	59	2	0.01	0.35	6.58	0.0558	0.0115	20.62
Al-ICP61	%	0.01	12	2	0.45	9.67	112.41	4.6838	0.1555	3.32
Al-MS61	%	0.01	59	2	0.03	10.6	585.29	4.9601	0.2305	4.65
As-AA61	ppm	5	59	2	2.5	133	984.5	8.3432	1.0922	13.09
As-AA63	ppm	5	81	2	2.5	32	526	<5	---	N/A
As-ICP61	ppm	5	12	2	2.5	368	1113.5	46.3958	3.3370	7.19
As-MS61	ppm	0.02	59	2	0.1	5800	13177.7	111.6754	3.3948	3.04
Au-AA23	ppm	0.005	76	2	0.0025	2.59	6.432	0.0423	0.0162	38.24
Au-ICP21	ppm	0.001	199	2	0.0005	1.15	2.6345	<0.005	---	N/A
Au-ICP23	ppm	0.001	27	2	0.0005	0.014	0.0835	0.0015	0.0006	36.55
B-MS61	ppm	10	49	2	5	280	4370	44.5918	14.8805	33.37
Ba-ICP61	ppm	10	12	2	50	1660	11010	458.7500	16.9558	3.70
Ba-MS61	ppm	0.5	59	2	20	5860	81330.8	689.2441	123.4178	17.91
Be-ICP61	ppm	0.5	12	2	0.25	7.5	41.8	1.7417	0.1080	6.20
Be-MS61	ppm	0.05	59	2	0.025	3.49	99.8	0.8458	0.0748	8.84
Bi-ICP61	ppm	2	12	2	1	18	69	2.8750	1.7912	62.30
Bi-MS61	ppm	0.01	59	2	0.005	10	28.83	0.2443	0.0152	6.23
Ca-ICP61	%	0.01	12	2	0.03	24	70.38	2.9325	0.1265	4.31
Ca-MS61	%	0.01	59	2	0.01	25	384.04	3.2546	0.1875	5.76
Cd-ICP61	ppm	0.5	12	2	0.25	9.5	33.6	1.4000	0.2380	17.00
Cd-MS61	ppm	0.02	59	2	0.01	15.5	55.97	0.4743	0.0750	15.81
Ce-MS61	ppm	0.01	59	2	2.86	284	4900.17	41.5269	2.6069	6.28
Co-ICP61	ppm	1	12	2	0.5	75	442.5	18.4375	0.9186	4.98
Co-MS61	ppm	0.1	59	2	0.4	77.3	2066.5	17.5127	1.0523	6.01
Cr-ICP61	ppm	1	34	2	7	10000	54842	806.5000	15.8902	1.97

Table A4.1. Summary statistics for all analytical duplicate samples by analytical method.—Continued

[data good to three significant figures at best. N/A, not applicable]

Element/ Method	Units	LOR	Pairs (k)	Per Pair (n)	Min	Max	Sum	Mean	Std Dev for Duplicates	% RSD
Cr-MS61	ppm	1	59	2	0.5	836	8864.5	75.1229	6.2777	8.36
Cs-MS61	ppm	0.05	59	2	0.025	4.79	96.53	0.8181	0.0506	6.18
Cu-AA62	%	0.01	7	2	1.02	14.05	60.49	4.3207	0.0454	1.05
Cu-ICP61	ppm	1	34	2	2	10000	24392	358.7059	3.2854	0.92
Cu-MS61	ppm	0.2	59	2	2.4	10000	23801.8	201.7102	9.8242	4.87
Fe-ICP61	%	0.01	12	2	0.4	25	196.83	8.2013	0.2191	2.67
Fe-MS61	%	0.01	59	2	0.34	25	455.81	3.8628	0.1397	3.62
Ga-MS61	ppm	0.05	59	2	0.46	46.6	1418.82	12.0239	0.8178	6.80
Ge-MS61	ppm	0.05	59	2	0.025	0.56	20.585	0.1744	0.0252	14.44
Hf-MS61	ppm	0.1	59	2	0.05	6.5	159.95	1.3555	0.3997	29.49
In-MS61	ppm	0.005	59	2	0.0025	4.93	13.3935	0.1135	0.0177	15.56
K-ICP61	%	0.01	12	2	0.01	2.93	20.7	0.8625	0.0324	3.76
K-MS61	%	0.01	59	2	0.005	3.52	98.585	0.8355	0.0976	11.68
La-MS61	ppm	0.5	59	2	0.5	412	3120.1	26.4415	1.6583	6.27
Li-MS61	ppm	0.2	59	2	0.2	32.7	1230.2	10.4254	1.1371	10.91
Mg-ICP61	%	0.01	12	2	0.01	3.71	21.46	0.8942	0.0695	7.77
Mg-MS61	%	0.01	59	2	0.005	7.45	167.625	1.4206	0.1053	7.41
Mn-ICP61	ppm	5	12	2	31	2190	22704	946.0000	33.0025	3.49
Mn-MS61	ppm	5	59	2	32	10000	126502	1072.0508	31.3093	2.92
Mo-ICP61	ppm	1	12	2	0.5	4	26.5	1.1042	0.6847	62.01
Mo-MS61	ppm	0.05	61	2	0.14	10.15	250.03	2.0494	0.1129	5.51
Na-ICP61	%	0.01	12	2	0.005	5.14	30.525	1.2719	0.0494	3.88
Na-MS61	%	0.01	59	2	0.005	5.5	128.03	1.0850	0.0469	4.32
Nb-MS61	ppm	0.1	59	2	0.1	42.1	571.6	4.8441	1.0997	22.70
Ni-ICP61	ppm	1	34	2	2	3480	40319	592.9265	9.2092	1.55
Ni-MS61	ppm	0.2	59	2	2.1	687	6226.5	52.7669	2.7858	5.28
P-ICP61	ppm	10	12	2	110	7030	25060	1044.1667	73.8805	7.08
P-MS61	ppm	10	59	2	30	10000	82190	696.5254	22.1513	3.18
Pb-ICP61	ppm	2	12	2	1	39	336	14.0000	1.7795	12.71
Pb-MS61	ppm	0.5	59	2	0.9	526	2023.3	17.1466	1.0229	5.97
Pd-ICP23	ppm	0.001	27	2	0.0005	0.03	0.2525	0.0047	0.0007	15.19

Table A4.1. Summary statistics for all analytical duplicate samples by analytical method.—Continued

[data good to three significant figures at best. N/A, not applicable]

Element/ Method	Units	LOR	Pairs (k)	Per Pair (n)	Min	Max	Sum	Mean	Std Dev for Duplicates	% RSD
Pt-ICP23	ppm	0.005	27	2	0.0025	0.079	0.5395	0.0100	0.0026	25.83
Pt-MS61	ppm	0.1	59	2	0.05	0.4	6.81	<0.1	---	N/A
Rb-MS61	ppm	0.1	59	2	0.05	361	4533.7	38.4212	1.6681	4.34
Re-MS61	ppm	0.002	59	2	0.001	0.004	0.181	<0.002	---	N/A
S-ICP61	%	0.01	12	2	0.005	0.81	2.44	0.1017	0.0035	3.48
S-MS61	%	0.01	58	2	0.005	0.2	4.045	0.0349	0.0047	13.38
Sb-ICP61	ppm	5	12	2	2.5	5	62.5	<5	---	N/A
Sb-MS61	ppm	0.05	59	2	0.025	113	269.58	2.2846	1.0331	45.22
Se-MS61	ppm	1	59	2	0.5	7	160	1.3559	0.4269	31.48
Sn-MS61	ppm	0.2	59	2	0.1	9.6	133.1	1.1280	0.0818	7.25
Sr-ICP61	ppm	1	12	2	27	520	3375	140.6250	4.4861	3.19
Sr-MS61	ppm	0.2	59	2	2.7	3430	29531.4	250.2661	18.7680	7.50
Ta-MS61	ppm	0.05	59	2	0.0025	1.76	21.675	0.1837	0.0948	51.62
Te-MS61	ppm	0.05	59	2	0.025	2.2	9.56	0.0810	0.0151	18.67
Th-MS61	ppm	0.2	59	2	0.1	32.1	716.2	6.0695	0.4892	8.06
Ti-ICP61	%	0.01	12	2	0.02	1.02	6.42	0.2675	0.0138	5.18
Ti-MS61	ppm	0.01	59	2	0.005	0.73	25.14	0.2131	0.0116	5.47
Tl-MS61	ppm	0.02	59	2	0.01	1.54	21.39	0.1813	0.0121	6.68
U-MS61	ppm	0.1	61	2	0.05	78.1	455.25	3.7316	0.1858	4.98
V-ICP61	ppm	1	12	2	7	900	4705	196.0417	8.3989	4.28
V-MS61	ppm	1	61	2	0.5	356	9122	74.7705	2.8943	3.87
W-ICP61	ppm	10	12	2	5	10	165	<10	---	N/A
W-MS61	ppm	0.1	59	2	0.1	49.6	338.7	2.8703	0.2173	7.57
Y-MS61	ppm	0.1	59	2	0.9	109.5	1778.1	15.0686	0.7646	5.07
Zn-ICP61	ppm	2	12	2	2	515	2324	96.8333	3.2914	3.40
Zn-MS61	ppm	2	59	2	2	1605	8273	70.1102	3.3000	4.71
Zr-MS61	ppm	0.5	59	2	0.25	181	4604.05	39.0174	7.4563	19.11

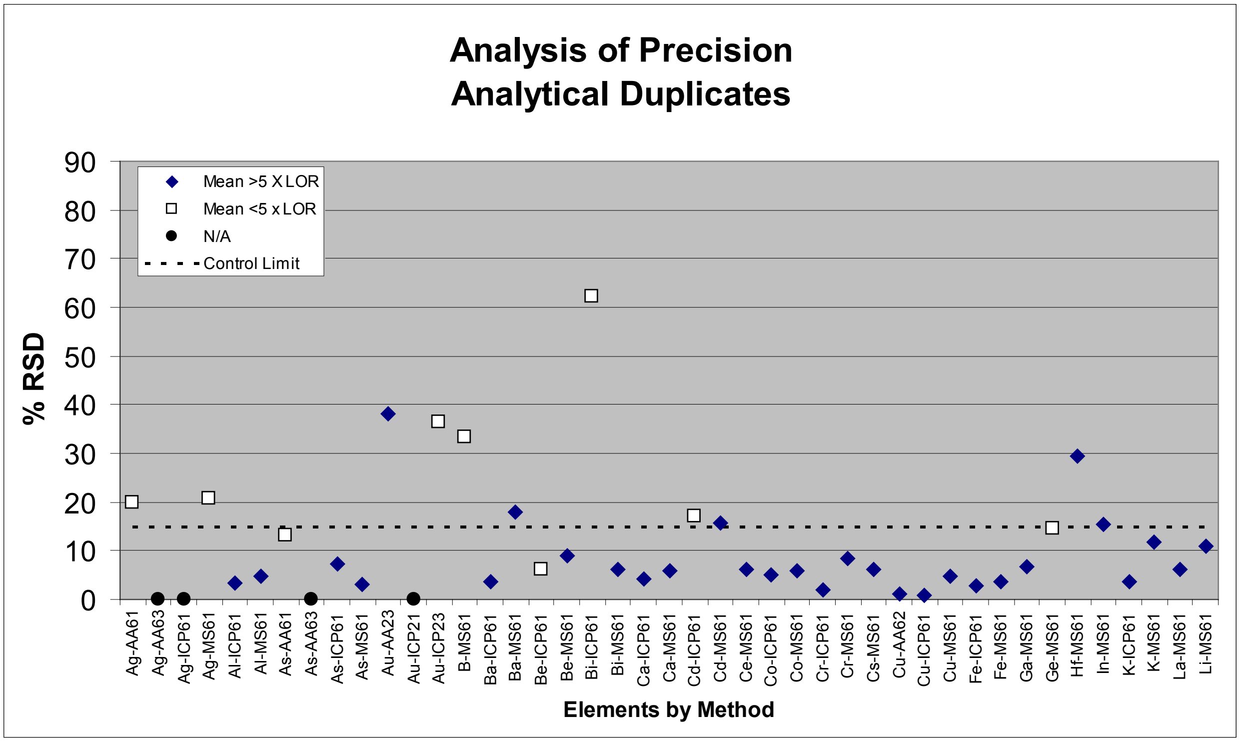

Figure A4.1. Precision plot of analyses of analytical duplicate samples (Ag–Li).

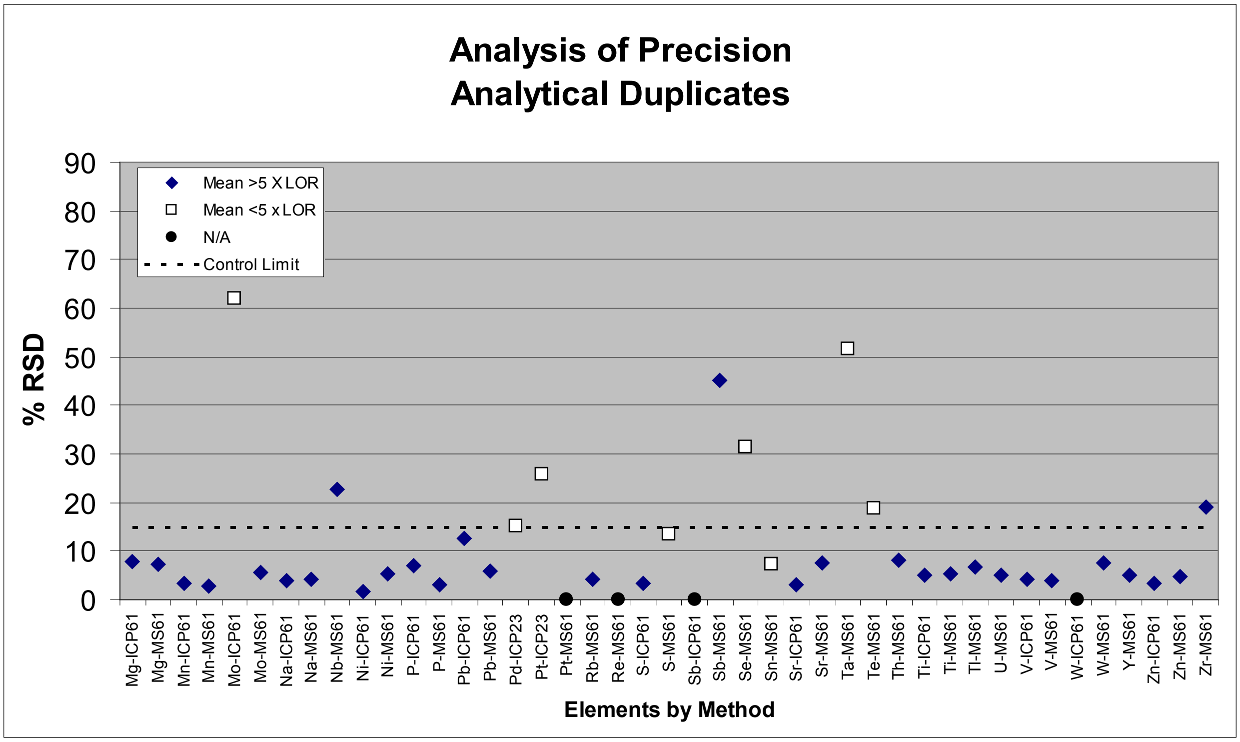

Figure A4.2. Precision plot of analyses of analytical duplicate samples (Mg–Zr).

Appendix 5. GIS Parameters Used for Creating Contour Maps for the Six Regions at 1:500,000

The following contour parameters were used:

- Software: Geostatistical Wizard, ESRI Geostatistical Analyst extension for ArcGIS 9.2
- Method: Inverse Distance Weighting (IDW)
- Reason for method: IDW is a quick, exact interpolator that requires few decisions about model parameters or assumptions of the data. It provides a good first look at an interpolated surface, though there is no assessment of prediction errors and it can be susceptible to generating “bulls-eyes” for samples with extreme relative values.
- Null values: Use NODATA value of 0.00 when dataset includes null values (no analysis for particular element). Null values in these datasets are not indicators of limits of determination, therefore it is important they are not included in the analysis.
- Coincidental samples: Use the maximum value for sample points that exist at the same geographic location.
- IDW power: 4
- Searching neighborhood: Smooth
- Smoothing factor: 1
- Ellipse angle: 0
- Ellipse semiaxes: 1000 meters (1 km) in Nord-Est and Nord-Ouest regions; 500 meters (0.5 km) in Tasiast-Tijirit region; 2000 meters (2 km) in all other regions. These ellipse sizes appear appropriate for each region’s sampling distribution.
- Symbology: Filled contours
- Color ramp: Geochemistry blue-to-red (custom color ramp)
- Quality: Presentation, refine on zoom
- Classification: Percentiles (2.5th, 5th, 10th, 25th, 75th, 90th, 95th, 97.5th, 99th), with the number of categories dependent on the distribution of analytical values (see BasicStatistics folder in the accompanying files). Highly-censored elements are classified by parts-per-million, not percentiles.

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