

# Selected Geochemical Data for Modeling Near-Surface Processes in Mineral Systems

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**Cover.** Two USGS scientists sampling the unmined, natural Napoleon Ridge porphyry copper-molybdenum deposit along Dump Creek near North Fork, Idaho (sample site 05NR002). Iron-stained outcrop is hydrothermally-altered Proterozoic quartzite cut by thin quartz-pyrite veinlets.

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## Abstract

The database herein was initiated, designed, and populated to collect and integrate geochemical, geologic, and mineral deposit data in an organized manner to facilitate geoenvironmental mineral deposit modeling. The Microsoft Access database contains data on a variety of mineral deposit types that have variable environmental effects when exposed at the ground surface by mining or natural processes. The data tables describe quantitative and qualitative geochemical analyses determined by 134 analytical laboratory and field methods for over 11,000 heavy-mineral concentrate, rock, sediment, soil, vegetation, and water samples. The database also provides geographic information on geology, climate, ecoregion, and site contamination levels for over 3,000 field sites in North America.

## Introduction

### Purpose and Scope

Staff of Federal and other land-use management agencies have expressed a need for quantitative mineral deposit data to help differentiate natural background geochemistry from geochemical effects resulting from historical and active mining and land use activities. While the spatial extent of mineral deposits is normally determined using economic criteria and exploration drilling methods, the extent of natural and anthropogenic effects from a deposit upon the surrounding area, the geochemical “footprint”, depends on a variety of factors including landscape, climate, local geology, deposit geology, and the type of mineral deposit. The U.S. Geological Survey (USGS) recently concluded the Near Surface Processes in Mineral Systems Project (NSP), one goal of which was to compile new and existing geologic, geochemical, ecoregion, and climate data for selected mineral deposit types into an integrated database, to facilitate modeling of these deposits types with respect to their impact to the surrounding area. This database meets that goal. The

database is also useful to delineate geochemical baselines, deposit type geochemical signatures, and for exploration in previously mined areas.

### Source of Data in the Database

The data presented in this database was provided by the following USGS geoscientists: George Desborough, Robert G. Eppinger, Jane M. Hammarstrom, Karen D. Kelley, J. Thomas Nash, Geoffrey S. Plumlee, Robert R. Seal II, John Slack, Bradley S. Van Gosen, and Richard B. Wanty. These data, collected under various USGS projects over the last couple of decades, were compiled as part of the NSP project.

### Mineral Deposit Models

U.S. Geological Survey mineral deposit models are descriptive in nature, and 87 were initially compiled in Cox and Singer (1986), and these were augmented in Bliss (1992). A mineral deposit model is a systematically arranged body of information that describes some or all of the essential characteristics of a group of similar mineral deposits (Seal and Foley, 2002). These characteristics include ore and gangue mineralogy, major- and trace-element geochemistry, host rock lithology, wall-rock alteration, physical aspects of ore and geologic setting, and more recently, the geophysical and geochemical characteristics of the genetic processes by which the deposit forms (Plumlee and Nash, 1995). These sets of characteristics can be organized through several different types of models, ranging from empirical models based on observations or measured data, to purely theoretical descriptive models based on conceptual ideas for deposit genesis, and can have overlapping classifications based on commodity, geologic setting, inferred temperatures and pressures of ore formation, and genetic setting (Seal and Foley, 2002).

Environmental characteristics were added for 32 deposit type groups in du Bray (1995), and were called geoenvironmental mineral deposit models. In 2002, the geoenvironmental deposit models were augmented in Seal and Foley (2002). Geoenvironmental models are a recent development of mineral deposit modeling and include factors

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for geochemical, biogeochemical, hydrologic, climatic, and anthropogenic processes that fundamentally affect the environmental conditions that exist in naturally mineralized areas before and as a result of mining activity (Plumlee and Nash, 1995). Detailed information about the fundamentals, anatomy, and applications of geoenvironmental models can be found in Plumlee and Nash (1995), Filipek and Plumlee (1999), Plumlee and Logsdon (1999), and Seal and others (2002).

### Deposit Types Included in this Database

Deposit type classes chosen for inclusion in this database are massive sulfides, epithermal, polymetallic replacements and skarns, polymetallic veins, porphyries, radioactive lodes, placers, distal-disseminated precious metals, sediment-hosted gold, Mississippi-Valley-type lead zinc, and intrusion-related gold deposits. Detailed information about the deposit types and sub-types can be found in the Geologic Settings Deposit Types section of this report.

## Geographic Settings

### Field Site Distribution

Samples and data were collected at field sites within or adjacent to deposits in 16 U.S. States and three Canadian provinces. Table 1 lists all states and provinces with field sites and the number of sites and samples per state. More detailed information about sample statistics can be found in the Characteristics of the Relational Database section of this report.

Plate 1 shows the sample sites in North America included in this database, with sites symbolized according to deposit type. The Geologic Settings section of this report has more detailed information regarding deposit types.

### Climate Data

One of the critical non-geologic factors in the extent and degree of a mineral deposit's geochemical footprint is the influence of climate in weathering of the deposit and transport of weathering products to the adjacent environment. Amounts of precipitation and prevailing temperatures influence the amount of runoff, water table levels, rates of reaction, amounts of organic material, and other parameters that affect the weathering of mineralized rocks and ore (Plumlee and Nash, 1995).

This database includes climate data from the 2002 Climate Atlas of the United States (National Oceanic and Atmospheric Administration, 2002), a period of record between 1961 and 1990. The atlas provided georeferenced data for 14 variable climate factors that were included in the database for each sample site (table 2). The climate data is presented in the Climate table of the database; more detailed information about the table structure can be found in the Characteristics of

**Table 1.** Table of States with count of field sites and samples per state.

State or province	Field sites	Samples
Alaska	521	3,800
Arizona	25	59
California	23	78
Colorado	250	609
Idaho	1,485	4,033
Maine	24	96
Minnesota	1	1
Missouri	9	9
Montana	25	66
Nevada	112	393
New Mexico	19	53
Tennessee	26	54
Utah	2	2
Vermont	497	1,814
Virginia	83	307
Washington	7	7
British Columbia	15	15
Ontario	1	1
Quebec	1	1
Total	3,126	11,398

the Relational Database section of this report. Due to format differences and the low number of sample sites in the current edition of the database, climate data was not derived for the Canadian samples.

## Methodology

The method used to incorporate the climate data is as follows: The Atlas was examined for comprehensiveness, completeness, and spatial coverage integrity of the various factors. Each factor was provided in the Atlas as a georeferenced polygon or point shapefile with an associated data table. Using ESRI ArcGIS 9.2 GIS software, each selected climate factor shapefile was spatially joined to the FieldSite shapefile. For polygon data, the spatial join was based on the climate polygon where the field site was located. For point data, the spatial join was based on the climate measuring station located closest to the field site. After each join any unnecessary fields from the climate data were deleted, leaving only the field listing the climate factor range for that sample site. Due to this field being a text field and therefore

**Table 2.** Climate factors.

Climate factor	Data type	Unit	Range increment	Range field name
Mean daily maximum temperature	Polygon	Degrees F	5°	TempMax_F
Mean daily average temperature	Polygon	Degrees F	5°	TempAvg_F
Mean daily minimum temperature	Polygon	Degrees F	5°	TempMin_F
Mean number of days with temperatures $\geq 90^\circ$ F	Polygon	Days	7 or 15	TempOver90
Mean length of freeze-free period	Polygon	Days	Varies	FreezeFree
Mean number of days with temperatures $\leq 32^\circ$ F	Polygon	Days	30	TempUndr32
Mean sea level pressure	Polygon	Millibars	1	Press_mB
Prevailing wind direction	Point (Alaska)	Compass point	n/a (22.5°)	WindDirect
Mean wind speed	Polygon	Miles per hour	1	Wind_MPH
Mean relative humidity	Point	Percentage	Varies	Humid_RH
Mean number of days with measurable precipitation	Polygon	Days	Varies	PrecipDays
Mean total precipitation	Polygon	Inches	Varies	PrecYr_in
Mean total snowfall	Polygon	Inches	Varies	Snow_in
Mean total hours of sunshine	Polygon	Hours	200	SunYr_hr
	Point (Alaska)			

incapable of having statistical queries and functions run on the data, the high and low values of each range were placed into individual number fields to enable the data to be used in future numeric analyses. These fields are named and described in the `FieldNameDictionary` table of the database. Once all climate tables were joined to the `FieldSite` shapefile table, the climate factors table was exported from the GIS into the geochemical database. Extraneous fields generated by the GIS operations were deleted to avoid data duplication; the table was checked for data integrity.

## Ecoregion Data

To provide ecoregion data for each field site, the Bailey's Ecoregions and Subregions of the United States, Puerto Rico, and the U.S. Virgin Islands (USDA Forest Service, 2004a) ecoregion scheme was chosen due to the completeness of descriptions, rigorous criteria used to delineate regions and subregions, increasing detail at successively larger scales, and availability of georeferenced digital data. Bailey (USDA Forest Service, 2004a) defines an ecoregion as an ecosystem of regional extent, classified according to level of detail:

**Ecodomain**—A major ecoregion, distinguished from other domains by climate, precipitation, and temperature. This is the highest level in the hierarchy of ecoregions, and in North America constitutes five divisions: Polar Domain,

Cool Oceanic Domain, Humid Temperate Domain, Humid Tropical Domain, and Dry Domain. The Cool Oceanic and Humid Tropical domains are not represented in the database because there are no sample sites in these domains.

**Ecodivision**—A subdivision of an ecodomain, and the second level in the hierarchy of ecoregions. An ecodivision represents a climate within a domain and is differentiated from other ecodivisions based on precipitation levels and patterns, as well as temperature. Detailed descriptions of ecodivisions can be found at USDA Forest Service (2004b).

**Ecoprovince**—A subdivision of an ecodivision, and the third level in the hierarchy of ecoregions. An ecoprovince represents variations in vegetation or other natural land covers within an ecodivision. Mountainous areas that exhibit different ecological zones based on elevation are distinguished according to the character of the zonation by listing the elevation zones from lower to upper. Detailed descriptions of ecoprovinces can be found at USDA Forest Service (2004c).

**Ecosection**—A subdivision of an ecoprovince, and the lowest and finest-detailed level in the hierarchy of ecoregions and subregions. An ecosection represents different landform groupings within an ecoprovince. Detailed descriptions of ecosections can be found in McNab and Avers (1996).

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The ecoregion data provided in this database also includes a field for EcoCode. The ecocode is a five-character code that corresponds to a narrative attribute description for the ecosection. The first character is an indication of whether the section is mountainous (M=mountainous, no character=non-mountainous), the next three digits are a code identifying the province, and the last character is a letter identifying the section within the province.

The Canadian ecosystem classification framework is slightly different than that in Bailey's ecoregions, but is roughly analogous (Marshall and Schut, 1999; Government of Canada, 2003). Corresponding classifications in both systems are shown in table 3. Within the Canadian classification system, EcoDistrict is a subdivision more detailed than Bailey's EcoSection; an EcoDistrict represents a numbered subdivision of a Canadian EcoRegion characterized by distinctive assemblages of relief, landforms, geology, soil, vegetation, water bodies, and fauna. Within the database, the Canadian ecoregion classifications are matched to the U.S. classifications where direct correlations are possible, the Canadian equivalent of EcoDomain was estimated, and Canadian EcoDistrict numbers are listed in the EcoCode field.

Plate 1 shows field sites classified by deposit type and subtype, overlaid on Bailey's Ecoregions and Subregions of the United States, Puerto Rico, and the U.S. Virgin Islands (USDA Forest Service, 2004a). The Geologic Settings section of this report contains more information about the geographic distribution of deposit types relative to ecoregions.

## Geologic Settings

### Deposit Types

Samples were taken from 3,126 field sites, representing 35 distinct deposit model types. The deposit types were grouped into 11 primary classes, and then each class was categorized into relevant subclasses. Table 4 lists each deposit class and subclass, the number of sample sites located at or near each deposit subclass, and counts of sample media

collected. Refer to plate 1 for geographic locations of sample sites and deposits. In the database, the DepositModel table lists all deposit models published by the U.S. Geological Survey.

Table 5 lists the ecoregion domains and divisions for sample sites that have specified mineral deposit model number in the records. All model numbers are from Cox and Singer (1986), except 13 (Orris and Bliss, 1991), 11d and 19c (Bliss, 1992), and 26b (Orris, 1998).

### Mine Waste Site Category

In an effort to identify differing levels of environmental impact from anthropogenically-derived sources, scientists providing data were asked to assign a number from 1 to 4 to each sample site. This value is recorded in the MineWasteSiteCat field of the GeolMineSite table. A "1" indicates no known mining-related disturbance at the site, or upgradient or upstream from the sampling site, a "2" indicates potential disturbance, a "3" indicates probable disturbance, and a "4" indicates definite mining-related disturbance. In some cases a "0" was placed into the field when a mine waste site category was not applicable due to sample media type. Sites that do not have an entry in the field indicate that disturbance level was not recorded by the sample collector. Table 6 lists the number of sample sites for each mine waste category.

### Natural Contamination Site Category

Because a near-surface deposit may create natural contamination of the surrounding area without having been disturbed (Giles and others, 2007), scientists providing data were asked to assign a natural site contamination category to each sampling site that identified potential effects from undisturbed mineralization. This value is recorded in the NaturalContamSiteCat field of the GeolMineSite table. A 1 indicates no known effects from undisturbed mineralization upgradient or upstream from the sampling site, a 2 indicates potential effects, a 3 indicates probable effects, and a 4 indicates definite effects from undisturbed mineralization. As with the mine

**Table 3.** Corresponding ecoregion classifications between the United States and Canada.

Bailey's ecoregion classifications <sup>1</sup>	Canadian ecoregion classifications <sup>2</sup>
EcoDomain	n/a <sup>3</sup>
EcoDivision	EcoZone
EcoProvince	EcoProvince
EcoSection	EcoRegion
n/a	EcoDistrict

<sup>1</sup> USDA Forest Service, 2004a.

<sup>2</sup> Government of Canada, 2003.

<sup>3</sup> Three EcoDomains exist in Canada but are not included in the country-wide EcoAtlas (Government of Canada, 2003). The classifications for included sample sites were estimated based on EcoZone.

**Table 4.** Deposit classes, subclasses, and sample media counts.

Deposit type class	Deposit type subclass	Sample sites	Concentrate samples	Mineral samples	Organic samples	Rock samples	Sediment samples	Soil samples	Water samples
Massive sulfide	Besshi-type	534	0	51	0	276	146	5	1,414
	Blackbird Co-Cu	436	20	2	0	399	30	12	178
	Kuroko-type, except extensional setting	63	0	2	18	44	20	0	263
	Kuroko-type	57	0	14	0	12	7	2	144
	Noranda-type	24	0	0	0	0	0	0	96
	Sedimentary-exhalative	215	16	0	0	211	40	553	700
	Algoma banded Fe, Co-rich, or uncertain	2	0	0	0	0	0	0	2
	<i>Total</i>		1,331	36	69	18	942	243	572
Polymetallic replacement and skarns	Replacement, base, precious, and other metal	117	3	17	0	99	110	0	131
	Replacement, base and precious metal	23	4	1	0	65	13	0	13
	Skarn, precious and base metal	21	0	2	0	8	30	0	36
	Skarn, precious, base, and other metals	12	0	5	0	3	20	0	16
	Skarn, base metal	11	1	0	0	5	14	0	27
	Carbonate-hosted	9	0	0	0	0	0	0	9
	Skarn, W	9	0	1	0	10	2	0	21
	Sandstone-hosted	5	0	0	0	0	0	0	5
	Calc-silicate skarn	4	0	0	0	0	0	0	4
	Skarn Mo-W	4	0	1	0	5	0	6	0
	Igneous-hosted	3	0	0	0	0	0	0	3
	Replacement, Fe	3	1	0	0	0	2	0	7
	Replacement, base metal	1	0	0	0	1	0	0	0
	<i>Total</i>		222	9	27	0	196	191	6
Epithermal	Hotspring, precious metal	110	4	8	0	134	67	13	169
	Hotspring, precious and base metal	38	0	9	0	28	35	0	31
	High-sulfidation	37	0	0	0	0	0	0	37
	Hotspring, active	15	0	3	0	1	0	0	72
	Creede-type	13	0	0	0	0	0	0	13
	Fluorspar	10	1	0	0	32	6	0	14
	Au-telluride	3	0	0	0	0	0	0	3
	<i>Total</i>		226	5	20	0	195	108	13
Polymetallic vein	Precious, base, and other metals	96	72	4	0	36	63	0	85
	Precious metal, base metal	50	7	2	0	48	51	0	70

**Table 4.** Deposit classes, subclasses, and sample media counts.—Continued

Deposit type class	Deposit type subclass	Sample sites	Concentrate samples	Mineral samples	Organic samples	Rock samples	Sediment samples	Soil samples	Water samples
	Precious metal, base metal, and fluorspar	21	0	1	0	17	21	0	40
	Precious metal	18	1	1	0	5	13	0	17
	Porphyry, other	16	0	0	0	0	0	0	16
	Base metal	12	0	0	0	0	0	0	12
	<i>Total</i>	213	80	8	0	106	148	0	240
Porphyry	Cu-Au-Mo	127	0	0	141	0	8	945	407
	Cu-Mo	44	3	0	0	10	18	0	161
	W-Mo	9	5	0	0	6	8	0	15
	Cu-Mo-W	8	2	0	0	10	2	0	21
	Stockwork Mo	3	0	4	0	3	6	0	11
	Climax-type Mo	2	0	0	0	0	0	0	2
	Other	2	2	0	0	0	0	0	0
	<i>Total</i>	195	12	4	141	29	42	945	617
Radioactive lodes	Uranium in arkosic carbonaceous rocks	37	0	4	0	21	44	0	68
	Uranium in veins and fractures	14	0	0	0	20	13	0	14
	Thorite veins with REE, base, and other metals	12	9	0	0	17	2	0	7
	Uranium, roll front	5	0	0	0	0	0	0	5
	Radioactive lode, undetermined	2	0	0	0	0	2	0	7
	<i>Total</i>	70	9	4	0	58	61	0	101
Placer	Gold	65	38	0	0	0	38	0	154
	Rare earth elements (REE)	1	1	0	0	0	0	0	0
	<i>Total</i>	66	39	0	0	0	38	0	154
Distal-disseminated	Precious and base metal	12	8	0	0	5	1	0	0
	Precious metal	5	5	0	0	0	0	0	0
	<i>Total</i>	17	13	0	0	5	1	0	0
Sediment-hosted	Precious metal	13	0	0	0	0	0	0	13
	Precious and base metal	1	0	0	0	5	0	0	0
	<i>Total</i>	14	0	0	0	5	0	0	13
Mississippi-Valley-type	Jasperoid-poor	6	0	0	0	0	0	0	6
	Jasperoid-rich	6	0	0	0	0	0	0	6
	<i>Total</i>	12	0	0	0	0	0	0	12
Other	No known deposit in vicinity	287	177	0	0	0	125	6	537
	Mesothermal Au	40	0	0	0	6	19	1	88

**Table 4.** Deposit classes, subclasses, and sample media counts.—Continued

Deposit type class	Deposit type subclass	Sample sites	Concentrate samples	Mineral samples	Organic samples	Rock samples	Sediment samples	Soil samples	Water samples
	Mixed deposit types	16	2	2	0	2	33	0	29
	Stratiform	11	0	0	0	26	0	0	0
	Phosphate	6	4	0	0	2	0	0	0
	Undetermined	6	6	0	0	0	0	0	0
	Carbonatite (REE + other elements)	3	2	0	0	0	2	0	7
	Coal	2	2	0	0	0	0	0	0
	Unspecified Au veins	2	2	0	0	0	0	0	0
	Magmatic segregation (Fe-Ni-Cu)	1	0	0	0	0	0	0	1
	Pegmatite	1	1	0	0	0	0	0	0
	Unknown or unspecified	385	0	0	0	0	0	0	1,373
	<i>Total</i>	760	196	2	0	36	179	7	2,035
<i>All types</i>		3,126	399	134	159	1,572	1,011	1,543	6,580

Table 5. Ecoregion–Mineral deposit model array.

EcoDomain	EcoDivision	State	Model number	Model name	Sample sites <sup>1</sup>		
Polar	Subarctic Regime Mountains	AK	21a	Porphyry Cu-Mo	19		
			36a	Low-sulfide Au-quartz veins	14		
	Tundra Regime Mountains	AK	31a	Sedimentary exhalative Zn-Pb	215		
Humid Temperate	Marine Regime Mountains	AK	24b	Besshi massive sulfide	4		
			36a	Low-sulfide Au-quartz veins	20		
			WA	28a	Kuroko massive sulfide	7	
		Mediterranean Regime Mountains	CA	28a	Kuroko massive sulfide	4	
		Hot Continental Regime Mountains	TN	24b	Besshi massive sulfide	26	
	VA		24b	Besshi massive sulfide	7		
		Warm Continental Regime Mountains	VT	24b	Besshi massive sulfide	497	
		Subtropical Division	VA	28a	Kuroko massive sulfide	45	
	36a			Low-sulfide Au-quartz veins	20		
	Dry	Tropical/Subtropical Steppe Division	AZ	17	Porphyry Cu	2	
30c				Sandstone U	5		
		Tropical/Subtropical Desert Division	AZ	25e	Epithermal quartz-alunite Au	1	
		Temperate Desert Division	CA	25a	Hot-spring Au-Ag	3	
NV			26a	Carbonate-hosted Au-Ag	10		
		Temperate Desert Regime Mountains	NV	26a	Carbonate-hosted Au-Ag	3	
		Temperate Steppe Regime Mountains	CO	16	Climax Mo	2	
				17	Porphyry Cu	3	
				19a	Polymetallic replacement	12	
				22b	Au-Ag-Te veins	3	
				22c	Polymetallic veins	35	
				25b	Creede epithermal veins	13	
				25e	Epithermal quartz-alunite Au	28	
				ID	10	Carbonatite	3
					11d	Thorium-rare-earth veins	12
					13	Pegmatites	3
					14a	W skarn	21
					16	Climax Mo	1
					17	Porphyry Cu	2
					18c	Zn-Pb skarn	44
		19a	Polymetallic replacement	149			
		19c	Distal disseminated Ag-Au	17			
		21a	Porphyry Cu-Mo	23			
		21b	Porphyry Mo, low-F	12			
		22c	Polymetallic veins	182			
		24b	Besshi massive sulfide	41			
		24d	Blackbird Co-Cu	437			
		25a	Hot-spring Au-Ag	55			
		25c	Comstock epithermal veins	86			
		25d	Sado epithermal veins	86			

**Table 5.** EcoRegion–Mineral deposit model array.—Continued

EcoDomain	EcoDivision	State	Model number	Model name	Sample sites <sup>1</sup>
			26b	Fluorite veins	10
			34c	Upwelling-type phosphate	6
			39a	Placer Au-PGE	63
		MT	18a, 18b, 18c	multiple types	4
			19a	Polymetallic replacement	3
			22c	Polymetallic veins	3
		UT	19a	Polymetallic replacement	2
			n/a <sup>2</sup>		1,006

<sup>1</sup> Sample sites may have multiple deposit model types assigned. Refer to the DepositTypeCode field in the GeolMineSite table of the database.

<sup>2</sup> Sites assigned as none or not applicable, or with no assigned model, are listed here as not applicable.

waste site category, a “0” in the field indicates that a category assignment is not appropriate due to sample media type. Sites that do not have an entry in the field indicate that effects from mineralization were not recorded by the sample collector. Table 6 lists the number of sample sites for each natural contamination site category and counts the combination of values for each site in an array.

## Methods of Study

### Sample Media

In order to allow for accurate assessment of the various environmental effects possible from near-surface mineral deposits, a wide array of sample media types was incorporated into the database, including concentrates, minerals, organic (vegetation), rock, sediment, soil, and water samples. Counts of sample media types are located in table 4.

### Sample Collection and Preparation

Samples were collected between 1977 and 2007 and prepared according to a variety of USGS standard methods.

Refer to the field site reference publication, located in the FieldSitePubl\_Name field in the FieldSiteRefs table, for information on particular sample collection details and protocols used at a given field site. Some data subsets collected for other past or ongoing USGS projects have been included in the database because of their relevance.

## Analyses

### Analytical Techniques

A total of 134 different analytical field and lab methods were used to determine sample geochemistry. Refer to table A1-1 in Appendix A for a list of the analytic method short name, analyzed media, and a simple description of the method. Refer to the AnalyticMethod table in the database for more detailed information about techniques, and citations for analytic methods.

### Quality Assurance / Quality Control

Data on quality assurance/quality control (QA/QC) is incorporated into the database where available. Field

**Table 6.** Mine waste site category–Natural contamination site category array.

		Natural contamination site category						
		category	none	0	1	2	3	4
Mine waste site category	sample sites		322	992	1,220	226	208	158
	none	322	322	0	0	0	0	0
	0	1,131	0	916	37	53	107	18
	1	631	0	13	387	71	57	103
	2	101	0	2	33	37	23	6
	3	169	0	12	104	49	2	2
	4	772	0	49	659	16	19	29

duplicates were left in the database, and information on these are found in the SiteLocationInfo and SiteComment fields of the FieldSite table. QA/QC information can also be found in the QA-QC field of the analysis tables. USGS and contract laboratories utilize constituent standards and blanks for in-house QA/QC (Taggart, 2002); however, data for these reference samples are not included in the database.

## Characteristics of the Relational Database

Because of the scope and complexity of data collected as part of the NSP, a relational database structure was designed for data storage. The NSP relational database (hereafter called the database) was constructed in Microsoft Access as a tool to be used for data synthesis and analysis and as an archive of data collected during the study. The database is a tabular relational database with field site and sample measurements and observations, and laboratory analyses of samples collected at point locations.

### Contents of the Database

The database contains a total of 34 tables, which are described in table 7. There are 13 core tables, the first eight consisting of quantitative and qualitative results, sample data, field site information, and publication references, and data on climate, ecoregion, and geology. The other five core tables are lookup tables with descriptions of analytic methods and parameters, laboratories, and mine disturbance and natural contamination levels. From 13 relational datasets, 18 analytical output data tables were created of various sections of data. Two tables consist of information on deposit models and their publication references. Finally, a reference table of data field name definitions was included to assist the user in understanding field names and contents.

### Database Structure

Data are grouped into 13 core entities (tables), and relationships are defined to link the tables. This structure provides efficient storage of information, and provides for built-in data verification checks. For example, all valid results must have corresponding site, sample, and parameter information. The principal tables in the database are the **FieldSite**, **Sample**, **QuantResult**, and **QualResult** tables (fig. 1).

Relationships between these tables are depicted as lines in figure 1. The **FieldSite** table is linked to the **Sample** table by including a common field (*FieldSiteNumber*) in both tables. Therefore, a sample cannot exist without having a site in the **FieldSite** table. The symbols “1” and “∞” at the ends of the relationship line indicate a one-to-many relationship, that is, a single site may have many samples. Similarly, a sample may have many results, and a parameter may also have many

results. The **FieldSite** table is linked to the **GeolMineSite** table by including the same common field (*FieldSiteNumber*) in both tables. Therefore, all field sites found in the **FieldSite** have data in the **GeolMineSite** table. The symbol “1” at each end of the relationship line indicates a one-to-one relationship, that is, a single site has data in each table. Data may be extracted from the database to meet specific user needs by constructing user-defined queries.

Relationships between the **FieldSite** table and other tables in the database are shown in figure 1. The **FieldSite** table contains information about each of the 3,126 sites in the database. *FieldSiteNumber* is the key field that uniquely identifies each site, which has additional attribute fields named *SiteLocationInfo*, *SiteDesc*, and *SiteComment*. *FieldSiteNumber* is also the linking field between the **FieldSite** and **Sample** tables in a one-to-many relationship (one site may have many samples). The **FieldSite** table also includes GPS geographic coordinates (*FieldLatitude* and *FieldLongitude*) as well as other geographic data. The **FieldSite** table is linked to four additional tables (**Climate**, **Ecoregion**, **FieldSiteRefs**, and **GeolMineSite**) that provide more information regarding these sampling sites. The **Climate** table contains temperature, precipitation, and other climatic data that was compiled by the National Oceanic and Atmospheric Administration (2002). Specific climate factors selected for inclusion in the database are listed in table 2 and discussed in the ‘Climate data’ section of this report. This GIS-derived climate information exists for all sample sites except for those in Canada. The **Ecoregion** table contains GIS-derived ecoregion data for each sample site that was derived from digital vector data compiled by the U.S. Forest Service (USDA Forest Service, 2004a, b, c) and is discussed in the ‘Ecoregion data’ section of this report. The **FieldSiteRefs** table contains bibliographic data referring to specific sites, listing the publications, if any, that first described or presented analytical results for sample sites in the database. It contains the publication name and authorship, publication code (if a USGS publication), and relevant URL links; some sites have more than one reference. The **GeolMineSite** table contains geologic, mineral deposit, and mine site characteristics for all sample sites in the database. This table contains data regarding mines and mineral deposits for each site in this study. Each field site is related to a single geologic mine site. In addition, two tables—**DepositModel** and **DepositModelRefs**—have been included in this database to provide further description and references for these deposit type models listed in the field *DepositTypeCode* in the **GeolMineSite** table. **DepositModel** lists and describes the Cox and Singer (1986), Orris and Bliss (1991), Bliss (1992), and Orris (1998) mineral deposit model numbers, model classes, general references, and model URLs. These two tables are linked to each other but are not linked to **GeolMineSite** because some mines include multiple deposit model types where no indication of priority was given. **GeolMineSite** also includes the field *MRDS\_ID* as a link to the USGS Mineral Resource Data System (MRDS) database (U.S. Geological Survey, 2005). The **GeolMineSite** table contains data that

**Table 7.** Database tables and statistics.

Table name	Table type	Table description	Primary key field	Fields	Records
QuantResult <sup>1</sup>	Core	Quantitative chemical and physical data yielded from samples collected and analyzed for the NSP project	QuantResultID	12	426,898
QualResult <sup>1</sup>	Core	Qualitative chemical and physical data yielded from samples collected and analyzed for the NSP project	QualResultID	9	2,313
FieldSiteRefs	Core	References for field sites	FieldSiteCitationID	7	3,305
Climate	Core	Climatic data for field sites	FieldSiteNumber	42	3,109
Ecoregion	Core	Ecoregion data for field sites	FieldSiteNumber	6	3,126
FieldSite	Core	Spatial and descriptive attributes for field sites	FieldSiteNumber	26	3,126
GeolMineSite	Core	Geologic and mining-related descriptive attributes for field sites	FieldSiteNumber	25	3,126
Sample	Core	Descriptive attributes for samples collected and analyzed for the NSP project	SampleID	31	11,398
AnalyticMethod	Core-lookup	Analytic methods used to obtain chemical and physical data	AnalyticMethodShortName	7	134
LabName	Core-lookup	Laboratories providing analytic data for the NSP project	LabShortName	2	21
MineWasteSiteCat	Core-lookup	Mine waste site categories used to classify field sites	MineWasteSiteCat	2	5
NaturalContamSiteCat	Core-lookup	Natural contamination site categories used to classify field sites	NaturalContamSiteCat	2	5
Parameter <sup>1</sup>	Core-lookup	Parameters used to describe chemical and physical data yielded from samples collected and analyzed for the NSP project	ParameterCode	5	509
Conc_ES-Mnrlgy	Output	Chemical and physical data for concentrate samples	SampleID	56	399
H2O_Acidified	Output	Chemical data for acidified aqueous samples from analytic methods other than inductively coupled plasma–mass spectroscopy	SampleID	92	3,492
H2O_ICPMS	Output	Chemical data from inductively coupled plasma–mass spectroscopy for aqueous samples	SampleID	140	2,334
H2O_Unacidified	Output	Chemical and physical data for unacidified aqueous samples	SampleID	58	3,725
Slds_EPA1312Lch	Output	Chemical and physical data from EPA 1312 leached geologic material samples	SampleID	111	388
Slds_FLTLch	Output	Chemical and physical data from passive Field Leach Test of geologic material samples	SampleID	85	642
Slds_ICPAES10P	Output	Chemical data from inductively coupled plasma–atomic emission spectroscopy 10-element partial digestion of geologic material samples	SampleID	18	686
Slds_ICPMS-AR	Output	Chemical data from inductively coupled plasma–mass spectroscopy aqua regia digestion of geologic material and organic samples	SampleID	121	223
Slds_Total-Acid	Output	Chemical data from “total” acid digestion of geologic material and organic samples	SampleID	132	2,013
Slds_Total_Nonacid	Output	Chemical data from “total” nonacid digestion of geologic material and organic samples	SampleID	150	697
Slds_WholeRx	Output	Chemical and physical “whole rock” data from geologic material and organic samples	SampleID	1,747	85

**Table 7.** Database tables and statistics.—Continued

Table name	Table type	Table description	Primary key field	Fields	Records
Soil_GCMS-SGH	Output	Gas chromatography–mass spectroscopy soil gas hydrocarbon chemical data from soil samples	SampleID	167	91
Soil_ICPMS-BLch	Output	Inductively coupled plasma–mass spectroscopy BioLeach chemical data from soil samples	SampleID	63	91
Soil_ICPMS-CHHLch	Output	Inductively coupled plasma–mass spectroscopy cold hydroxylamine hydrochloride leach chemical data from soil samples	SampleID	70	82
Soil_ICPMS-EELch	Output	Inductively coupled plasma–mass spectroscopy enhanced enzyme leach chemical data from soil samples	SampleID	74	90
Soil_ICPMS-MMILch	Output	Inductively coupled plasma–mass spectroscopy mobile metal ion leach chemical data from soil samples	SampleID	50	82
Soil_ICPMS-NaPLch	Output	Inductively coupled plasma–mass spectroscopy sodium pyrophosphate leach chemical data from soil samples	SampleID	66	91
Soil_ICPMS-TSLch	Output	Inductively coupled plasma–mass spectroscopy TerraSol leach chemical data from soil samples	SampleID	74	90
DepositModel	Deposit	Mineral deposit models that characterize field sites	Model_Number	11	97
DepositModelRefs	Deposit	References for mineral deposit models that characterize field sites	ModelCitationID	10	136
FieldNameDictionary	Reference	Field name descriptions for all tables in the NSP project database	FieldName	4	1,128

<sup>1</sup> Table not included in Excel spreadsheet files.

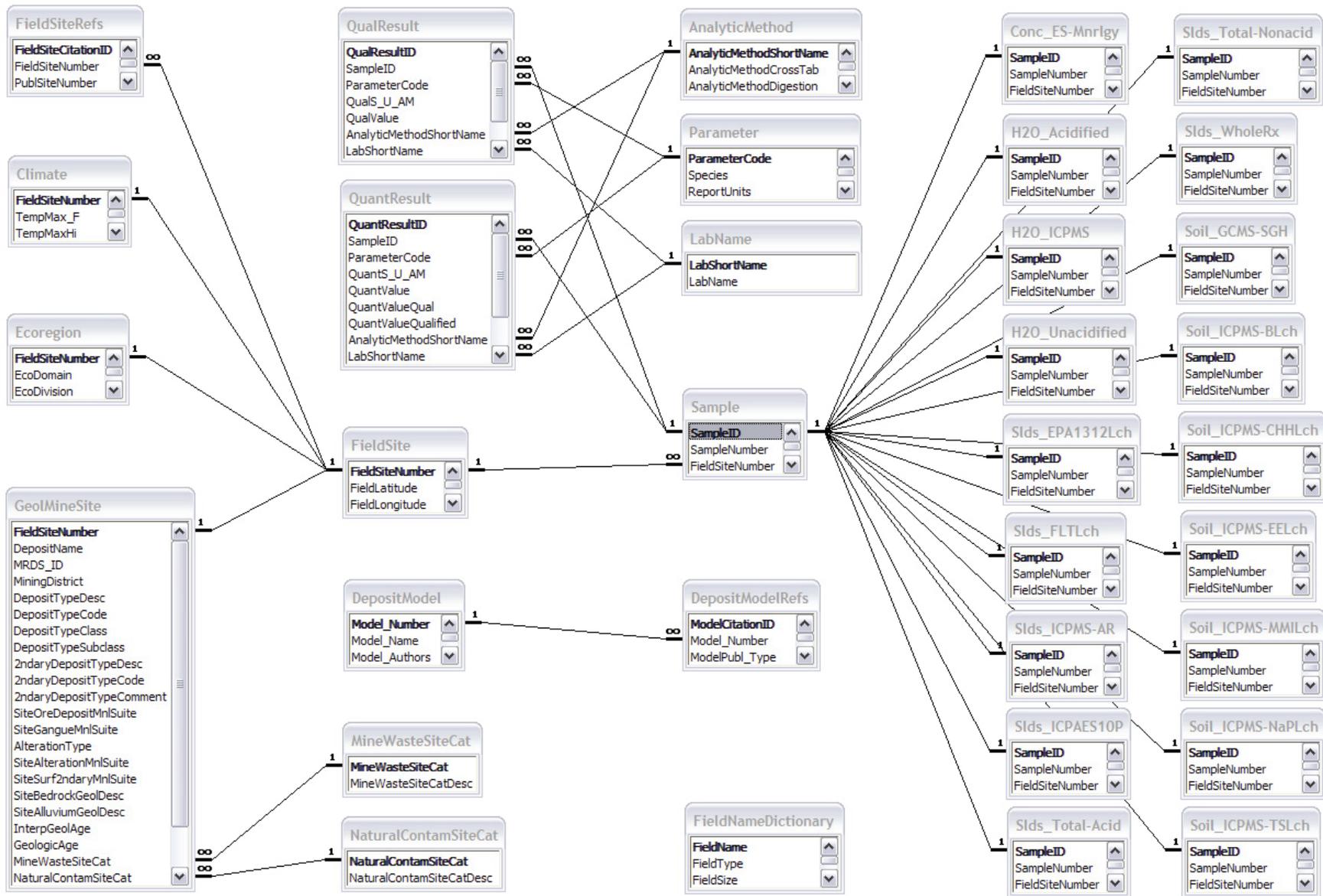


Figure 1. Table relationships in the Near-Surface Processes database.

codifies the effects from mining (in the field *MineWasteSiteCat*) or the effects from unmined, naturally occurring contamination (in the field *NaturalContamSiteCat*). These two fields link the tables **MineWasteSiteCat** and **NaturalContamSiteCat** which are look-up tables that define these code entries.

Relationships between the **Sample** table and other tables in the database are shown in figure 1. The **Sample** table contains information about the sample material collected at each site. Each analyzed sample has a unique *SampleID*, as well as a *SampleNumber* that was provided by the sample collector. *SampleID* is a software-assigned integer key field that links the sample to its chemical and physical data found in the **QuantResult** and **QualResult** tables. The time and date of sample collection are stored in the *SampleTime* and *SampleDate* fields; however, not all samples have a date or time recorded. The field *SampleMediaGross* defines the sample material type, while *SampleMediaDetail* and *SampleDesc* provide more detailed information about the sample medium. Media type should be carefully noted when assessing data so that data from different sample types are not mistakenly equated. For example, the database contains analyses for copper found in eight different subsample media types (described in *SampleMediaDetail*) that were derived from one soil sample site at a certain mineral deposit. Information regarding the collection and preparation of the sample may be found in the fields *CollectionMethod*, *FieldSamplePrep*, *LabSamplePrep*, and *SieveSize*. The *LAB\_ID* and *JOB\_ID* information created by the various analytical laboratories is also found in the **Sample** table. Most of these *LAB\_ID*'s represent samples that were entered in the USGS laboratory information management system and whose data has been archived in the National Geochemical Database (NGDB) (Smith and others, 2003). Thus, this database can be linked to data within the NGDB.

The **QuantResult** table contains laboratory and field measurements, expressed as numeric values, whereas the **QualResult** table contains qualitative measurements that are expressed as text values. Generally, the two tables function in the same way. Most of the project geochemical data are found in the **QuantResult** table, where measurements consist of a numeric *QuantValue* and an optional *QuantValueQual*, which is used to qualify results such as non-detects or estimates based on limits of instrumental detection (for example, “less than” values, such as < 2). *QuantValueQual* entries are “<” or “N”, meaning that the element was not detected at concentrations above the lower limit of determination for the method, “>”, meaning that the element was measured at a concentration greater than the upper limit of determination for the method, and “H”, meaning that an accurate analytical value could not be confidently determined due to physical, chemical, or spectral interference. The field *QuantValueQualified* was populated by synthesizing the data in *QuantValue* with its complement in *QuantValueQual*, according to the following conventions: *QuantValue* entries that are accompanied by “<” or “N” entries in the *QuantValueQual* field are represented in the *QuantValueQualified* field as negative numbers (for example, “-2”); and *QuantValue* entries that are accompanied

by “>” entries in the *QuantValueQual* field are represented in the *QuantValueQualified* field as integers with 0.99999 added to them (for example, 10.99999). The measured characteristic is identified using a *ParameterCode*, a succinct 25-character-length field that can be used as a column name in a data report or spreadsheet. The *ParameterCode* links both result tables to the **Parameter** look-up table, which contains a complete description of each characteristic measured. While *ParameterCode* is a short description of the characteristic measured, due to the highly specific nature of laboratory measurements, a lengthier description (*ParameterName*) also is needed. For example, the *ParameterCode* “Cu\_ug/L” has a *ParameterName* of “Copper, lab, micrograms per liter.” The **Parameter** table also includes a *ConstituentName* field to group results according to the element or compound (zinc or sulfate, for example), and a *ReportUnits* field that shows the units in which values are reported. Information regarding the method of analysis or measurement used to obtain data is found in the field *AnalyticMethodShortName*, an abbreviated label linked to the **AnalyticMethod** look-up table which provides additional information on 134 field and laboratory techniques used for sample analysis of aqueous, solid, and organic samples. It includes a description of the analytic methods and relevant references to them. Likewise, *LabShortName* is an abbreviated label linked to the **LabName** look-up table, and provides information regarding the laboratory or work group responsible for the analysis. Any further remarks regarding the *Value* or the analytic process are found in the *QuantValueComment* field. Relationships between the **QuantResult** and **QualResult** tables and other tables in the database are shown in figure 1.

To facilitate ease of use, 18 “ChemData” output tables have been created from the database with each table containing a unique dataset of analytical results for the analysis of a specific sample media and determined by a certain analytic or sample treatment method (media/method specific datasets). For example, the table **Slds\_EPA1312Lch** contains chemical and physical data from leached geologic material samples collected and analyzed following the EPA 1312 leaching protocol (U.S. Environmental Protection Agency, 1994). The concentration values in these tables are in the *QuantValueQualified* format described previously. These output tables have results for each parameter in their own columns (crosstab format) for ease of analysis in Excel.

## Other Data Formats

All of the Access tables in the database except the **QuantResult**, **QualResult**, and **Parameter** tables were exported into Excel as 31 spreadsheets for use by the non-database user. The **QuantResult** and **QualResult** tables were excluded because all of their data is presented in the 18 analytical ChemData output tables, and the **Parameter** was excluded because it consists of attributes of the **QuantResult** and **QualResult** tables. Table 8 lists the spreadsheet files included in the data release.

**Table 8.** List of spreadsheets.

Spreadsheet name	Spreadsheet description
AnalyticMethod.xls	Analytic methods used to obtain chemical and physical data
Climate.xls	Climatic data for field sites
Conc_ES-Mnrlgy.xls	Constituents in concentrates by various methods
DepositModel.xls	Mineral deposit models that characterize field sites
DepositModelRefs.xls	References for mineral deposit models that characterize field sites
Ecoregion.xls	Ecoregion data for field sites
FieldNameDictionary.xls	Field name descriptions for all tables
FieldSite.xls	Field site criteria
FieldSiteRefs.xls	References for field sites
GeolMineSite.xls	Geologic and mining related descriptive attributes for field sites
H2O_Acidified.xls	Constituents in acidified water by analytic methods other than ICP-MS
H2O_ICPMS.xls	Constituents in acidified water by ICP-MS
H2O_Unacidified.xls	Constituents in unacidified water by various methods
LabName.xls	Laboratory name
MineWasteSiteCat.xls	Mine waste site categories used to classify field sites
NaturalContamSiteCat.xls	Natural contamination site categories used to classify field sites
Sample.xls	Descriptive attributes for samples collected and analyzed
Slds_EPA1312Lch.xls	Constituents in geologic material by various methods after EPA 1312 leach
Slds_FLTLch.xls	Constituents in geologic material by various methods after passive Field Test leach
Slds_ICPAES10P.xls	Ten cations in geologic material by ICP-AES after partial acid digestion
Slds_ICPMS-AR.xls	Cations in soil and organic material by ICP-MS after aqua regia leach
Slds_Total-Acid.xls	Constituents in soil and organic media by various methods after "total" acid digestion
Slds_Total-Nonacid.xls	Constituents in geologic material by various methods after "total" nonacid digestion
Slds_WholeRx.xls	"Whole rock" constituents in soil and organic material by various methods
Soil_GCMS-SGH.xls	Hydrocarbon compounds in soil by gas chromatography–mass spectroscopy
Soil_ICPMS-BLch.xls	Constituents in soil by ICP-MS after BioLeach
Soil_ICPMS-CHHLch.xls	Constituents in soil by ICP-MS after cold hydroxylamine hydrochloride leach
Soil_ICPMS-EELch.xls	Constituents in soil by ICP-MS after enhanced enzyme leach
Soil_ICPMS-MMILch.xls	Cations in soil by ICP-MS after mobile metal ion leach
Soil_ICPMS-NaPLch.xls	Constituents in soil by ICP-MS after Na-pyrophosphate leach
Soil_ICPMS-TSLch.xls	Constituents in soil by ICP-MS after TerraSol leach

The Access tables also are exported to tab-delimited ASCII flatfile form and may be accessed using any text editor, but is best used by loading each flatfile into a relational database and re-establishing the links as shown in the accompanying relationship diagram (fig. 1).

The table **FieldNameDictionary** contains the field name, field size, definition, and general data type of the 1,128 fields that are used in the tables of the database, as well as the table or tables in which these fields appear. This is of particular importance for the non-database user as it also contains the field names and descriptions of the eighteen output chemical data tables.

Relational databases can be implemented using a variety of proprietary or non-proprietary software packages. The database is attached to this report in a proprietary (Microsoft Office Access 2000) and non-proprietary (ASCII tab-delimited) format. The spreadsheets are presented in Microsoft Office Excel 2003 format.

## Database Query Examples

Within relational database software packages, queries may be constructed and saved to retrieve data using user-defined criteria. This database contains several examples of Access queries that aid the user in viewing and extracting selected datasets. The graphical Query Design Views of these queries are translated into Structured Query Language (SQL) statements that are displayed within the database by clicking on the SQL View of the View box of the Query. Examples of three query types—summary, select, and cross-tab queries—are presented in Appendix 2.

## Abbreviations

The tables in the database were designed to be as self-explanatory as possible. Abbreviations used in an entry are

usually described within the same table. Abbreviations used in field names are described in detail in the FieldNameDictionary table. Other abbreviations are also listed and described in the AnalyticMethod and Parameter tables. Table 9 lists

abbreviations used in this manuscript and selected database abbreviations that are not described in the database tables, plus names of chemical formulas listed in the Description field of the AnalyticMethod table.

**Table 9.** Selected abbreviations and chemical formulas.

Abbreviation	Description
Ag	Silver
ALK	Alkalinity
Au	Gold
B	USGS Bulletin (also boron, depending on context)
Br <sub>2</sub>	Bromine
CaCO <sub>3</sub>	Calcium carbonate
CD-ROM	Compact disc – read only memory
CIR	USGS Circular
CO <sub>2</sub>	Carbon dioxide
Co	Cobalt
Cu	Copper
DIBK	Diisobutylketone
EPA	Environmental Protection Agency
FA	Filtered, acidified
Fe	Iron
FeO	Ferrous oxide
FU	Filtered, unacidified
GIS	Geographic information system
GPS	Global positioning system
H <sub>2</sub> O	Water
H <sub>2</sub> SO <sub>4</sub>	Sulfuric acid
HBr	Hydrogen bromide
HCl	Hydrochloric acid
HCO <sub>3</sub>	Hydrogen carbonate
HClO <sub>4</sub>	Perchloric acid
HF	Hydrofluoric acid
HNO <sub>3</sub>	Nitric acid
ID	Identification
ISE	Ion selective electrode
ISO	International Organization for Standardization
KMnO <sub>4</sub>	Potassium permanganate
KNO <sub>3</sub>	Potassium nitrate
KOH	Potassium hydroxide
LiBO <sub>2</sub>	Lithium metaborate
Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	Lithium tetraborate
LED	Light emitting diode
LIMS	Laboratory Information Management System
lut	Lookup table
MAS	Mineral Availability System
MIBK	Methyl isobutyl ketone
Mo	Molybdenum
MR	USGS Mineral Resource map
MRDS	Mineral Resource Data System
n/a	Not applicable
NH <sub>4</sub> NO <sub>3</sub>	Ammonium nitrate
NaOH	Sodium hydroxide
Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub>	Sodium dichromate
Na <sub>2</sub> O <sub>2</sub>	Sodium peroxide
Ni	Nickel
NO <sub>3</sub>	Nitrate
NSP	Near-Surface Processes in Mineral Systems project

**Table 9.** Selected abbreviations and chemical formulas.—Continued

Abbreviation	Description
O <sub>2</sub>	Molecular oxygen
OFR	USGS Open-File Report
Pb	Lead
PP	USGS Professional Paper
QA-QC, QA/QC	Quality assurance – quality control
RA	Raw, acidified
REE	Rare-earth elements
RU	Raw, unacidified
SI	International System of Units (metric system)
SIR	USGS Scientific Investigations Report
SPLP	Synthetic precipitation leaching procedure
SO <sub>4</sub>	Sulfate
U	Uranium
URL	Universal resource locator
USDA	United States Department of Agriculture
USGS	United States Geological Survey
W	Tungsten
WGS84	World geodetic system of 1984

## Analytical Units

Table 10 lists and describes the analytical units used in the database.

## Field Numbers

Field numbers in the database were chosen by the data collector/submitter, and were customized for the particular project that the sample was collected for. Thus, field number styles are not consistent across all field sites in the database, and would be impractical to describe here. For explanations of the collectors' field number styles, refer to the sample site's original publication listed in the FieldSiteRefs table. In general, a field site number with a letter suffix indicates a site where duplicate samples were taken; this can be confirmed by referring to the SiteLocationInfo or SiteComment field. For more information on where to find information about field duplicates, refer to the Quality assurance/control, field duplicates, blanks, and analytical standards section of this report.

## Coordinates

Geographic coordinates in the database are provided in decimal degree format to facilitate generation of shapefiles with a GIS. In cases where the original coordinates were provided as degrees, minutes, and seconds, a calculation was performed to convert the coordinates to decimal:

Latitude: degrees+(minutes/60)+(seconds/3600)

Longitude: -(degrees+(minutes/60)+(seconds/3600))

For consistency, all coordinates were converted into the World Geodetic System of 1984 (WGS84) datum using ERDAS Imagine GIS software. All coordinates were truncated to five decimal places, not only to save logical space, but because location accuracy is no better than this and in most cases not even this good.

## References Cited

### Database References

Within the database, references are cited for: Samples, field sites, and geochemistry already published in other publications, analytic methods, and mineral deposit models. Refer to the appropriate table listed below for references contained within the database.

### Field Site References

The references for published samples, field sites, and geochemistry are located in the FieldSiteRefs table. Refer to this table for information on previously published geochemistry. 892 records do not have matching field site references because data submitters didn't always provide references, or the site has never been previously published.

### Mineral Deposit Model References

The references for mineral deposit models are located in the DepositModelRefs table. Refer to this table for

Table 10. Analytical units.

Analytical unit	Unit description	Measurement type
pH	Potential of hydrogen	Acidity / basicity
mB	Millibars	Air pressure
ppk	Parts per thousand	Concentration
ppm	Parts per million	Concentration
ppb	Parts per billion	Concentration
ppt	Parts per trillion	Concentration
mg/L	Milligrams per liter	Concentration
ug/L, µg/L	Micrograms per liter	Concentration
ng/L	Nanograms per liter	Concentration
RH	Relative humidity	Humidity
mi	Miles	Length
in	Inches	Length
m	Meters	Length
mm	Millimeters	Length
Kg-CaCO <sub>3</sub> /ton	Kilograms of calcium carbonate per ton	Net neutralization potential
cfs	Cubic feet per second	Rate
Lpm	Liters per minute	Rate
uS/cm, µS/cm	Micro-Siemens per centimeter	Specific conductivity
MPH	Miles per hour	Speed
2sigma, 2σ	Standard mean error	Statistic
grains	Grains, absolute count	Statistic
grains/Kg	Grains per Kilogram	Statistic
pct, %	Percent	Statistic
per-mil, ‰	Per mil (tenth of a percent)	Statistic
C, °C, degC	Degrees centigrade (Celsius)	Temperature
F, °F	Degrees Fahrenheit	Temperature
hr	Hours	Time
FTU	Formazine turbidity units	Turbidity
NTU	Nephelometric turbidity units	Turbidity
mV	Millivolts	Voltage
gal, G	Gallons	Volume
L	Liters	Volume
mL	Milliliters	Volume
Kg	Kilograms	Weight
g	Grams	Weight

information on models, publications, authors, and URLs to selected model publications.

### Analytic Method References

The references for analytic methods are not located in a separate table, but are incorporated into the AnalyticMethodRef field of the AnalyticMethod table. Refer to this table for information on analytic method descriptions, elemental sensitivities, limits of determination, analytic performance, and detailed references.

### Manuscript References

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# **Appendix 1**

## **Analytical Methods**

Table A1-1. Analytical methods.

Analytic method short name	Analyzed media	Description
AA-Aq	Water	Metals in acidified aqueous samples determined by atomic absorption spectrometry.
AA-Aq_C	Water	Metals in acidified aqueous samples determined by a contract lab using atomic absorption spectrometry.
Color_CN fld	Water	Cyanide in unacidified water is determined in the field with a spectrophotometer.
Color_Fe+2 fld	Water	Ferrous iron in unacidified water is determined in the field with a spectrophotometer.
Color_Fe+2_lab	Water	Ferrous iron in acidified aqueous samples is determined by visible spectrometry using a spectrophotometer.
Color_Fe+2_lab_C	Water	Ferrous iron in acidified aqueous samples is determined by a contract lab using visible spectrometry with a spectrophotometer.
Color_Fe-Tot fld	Water	Total iron in unacidified water is determined in the field with a spectrophotometer.
Color_Fe-Tot_lab	Water	Total iron in acidified aqueous samples is determined by visible spectrometry (ferrozine) using a spectrophotometer.
Color fld	Water	Nitrite, nitrate, or sulfate in unacidified water are determined in the field with a spectrophotometer.
Color_lab	Water	Nitrite, nitrate, phosphate, silica, or ammonia in unacidified water are determined by spectrophotometry.
Color_SO4_ABA1	Solids	Sulfate in solids is determined for acid/base accounting method 1 by spectrophotometry after 5 g of sample and 20 mL of 3N HCl are heated to a boil.
Color_SO4_ABA2	Solids	Sulfate in solids is determined for acid/base accounting method 2 by spectrophotometry after 5 g of sample and concentrated HCl are boiled for 30 minutes.
Comb_C-Org	Solids	Dissolved organic carbon in acidified water is determined by carbon analyzer with an infrared detector.
Comb_C-Tot	Solids	Total carbon is determined by carbon analyzer with an infrared detector after combustion.
Comb_C-Tot_C	Solids	Total carbon is determined by a contract lab using carbon analyzer with an infrared detector after combustion.
Comb_S-Tot	Solids	Total sulfur is determined by sulfur analyzer with an infrared detector after combustion.
Comb_S-Tot_ABA	Solids	Total sulfur is determined by sulfur analyzer with an infrared detector after combustion in support of an acid/base accounting method.
Comb_S-Tot_C	Solids	Total sulfur is determined by sulfur analyzer by a contract lab using an infrared detector after combustion.
Comp_C-Org_C	Solids	Organic carbon is determined by the calculated difference between total carbon and carbonate carbon when determined by a contract lab using combustion and coulometric titration.
Comp_Fe(III)	Solids	Ferric iron in acidified aqueous samples is determined by the calculated difference between total iron and ferrous iron when determined by spectrophotometry.
Comp_MPA_ABA1	Solids	Maximum potential acidity is calculated as product of sulfide sulfur values obtained in acid/base accounting method 1 multiplied by 31.22.
Comp_MPA_ABA2	Solids	Maximum potential acidity is calculated as product of sulfide sulfur values obtained in acid/base accounting method 2 multiplied by 31.22.
Comp_NNP_ABA1	Solids	Net neutralization potential is calculated from neutralization potential values minus maximum acidity potential values obtained in acid/base accounting method 1.
Comp_NNP_ABA2	Solids	Net neutralization potential is calculated from neutralization potential values minus maximum acidity potential values obtained in acid/base accounting method 2.
Comp_Sulfide_ABA1	Solids	Sulfide sulfur in solids is calculated from total sulfur minus sulfate sulfur values obtained in acid/base accounting method 1.
Comp_Sulfide_ABA2	Solids	Sulfide sulfur in solids is calculated from total sulfur minus sulfate sulfur values obtained in acid/base accounting method 2.
CVAA_Hg	Solids	Mercury is determined by cold vapor atomic absorption spectroscopy after HNO <sub>3</sub> -Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> digestion.
CVAA_Hg_C	Solids	Mercury is determined by a contract lab using cold vapor atomic absorption spectroscopy after HNO <sub>3</sub> -HCl-H <sub>2</sub> SO <sub>4</sub> -KMnO <sub>4</sub> digestion.

**Table A1-1. Analytical methods.—Continued**

Analytic method short name	Analyzed media	Description
CVAA-Aq_Hg	Water	Mercury is determined in acidified water and leachates by cold vapor atomic absorption spectroscopy.
CVAF_Hg	Water	Mercury is determined in acidified water and leachates by cold vapor atomic fluorescence spectroscopy.
CVAF_Hg_C	Water	Total mercury and (or) methyl mercury are determined in acidified water and leachates by a contract lab using cold vapor atomic fluorescence spectroscopy.
DC-ARC_Spec	Solids	Thirty or more elements are determined in solids by visual 6-step direct-current arc semi-quantitative emission spectrography.
DissO2	Water	Dissolved O <sub>2</sub> in unacidified water is determined in the field using an electrode.
DissO2_C	Water	Dissolved O <sub>2</sub> in unacidified water is determined in the field by a non-USGS field party using an electrode.
DissO2_lab	Water	Dissolved O <sub>2</sub> in unacidified water is determined in the lab using an electrode.
DissSolids_calc	Water	Dissolved solids in water determined by summing up the concentrations of analytical results.
FAA_Au	Solids	Gold is determined by flame atomic absorption spectrophotometry after HBr-Br <sub>2</sub> digestion and methyl isobutyl ketone (MIBK) extraction.
FA-DCP_Au_C	Solids	Gold is determined by a contract lab using direct current plasma-atomic emission spectroscopy or atomic absorption spectrophotometry after fire assay fusion.
FA-ICP_Au-Pt-Pd_C	Solids	Gold, platinum and palladium are determined by a contract lab using inductively coupled plasma-mass spectroscopy after fire assay fusion.
FieldMethods	All	Odor, color, turbidity and stream flow determined in the field using various methods.
Fizz-Rating	Solids	Fizz rating is determined by visually estimating the reaction of 0.5 g of sample with 25 percent solution of HCl in support of an acid/base accounting method.
GC-MS_C	Solids	Hydrocarbon compounds in solids are determined by a contract lab using a proprietary method of gas chromatography and mass spectroscopy in a weak leach simulation.
GFAA_Au_C	Solids	Gold is determined by a contract lab using graphite furnace atomic absorption spectrophotometry after HBr-Br <sub>2</sub> digestion and MIBK extraction.
GFAA_Tl_C	Solids	Thallium is determined by a contract lab using graphite furnace atomic absorption spectrophotometry after Na <sub>2</sub> O <sub>2</sub> fusion/HCl-HNO <sub>3</sub> dissolution.
GFAA-Aq	Solids	Metals in acidified aqueous media are determined by graphite furnace atomic absorption spectrophotometry.
GrainCount	Solids	Mineral grain count by optical microscopy.
Grav_H2O-Tot_C	Solids	Total water is calculated by a contract lab as the addition of H <sub>2</sub> O+ (bound water) and H <sub>2</sub> O- (moisture), where H <sub>2</sub> O- is determined by weight loss after heating at 105°C for 2 hrs, and H <sub>2</sub> O+ is determined by H <sub>2</sub> O weight lost at 950°C.
Grav_LOI	Solids	Loss on ignition is determined by weight loss after heating at 900° C.
Grav_LOI_C	Solids	Loss on ignition is determined by a contract lab as weight loss after heating at 900° C.
Hardness	Water	Hardness is computed from specific conductance and alkalinity measurements determined in the field.
HGAA_As	Solids	Arsenic is determined by hydride generation atomic absorption spectrophotometry after HF, HNO <sub>3</sub> , HClO <sub>4</sub> , H <sub>2</sub> SO <sub>4</sub> digestion.
HGAA_As_C	Solids	Arsenic is determined by a contract lab using hydride generation atomic absorption spectrophotometry after Na <sub>2</sub> O <sub>2</sub> fusion-HCl dissolution.
HGAA_Sb_C	Solids	Antimony is determined by a contract lab using hydride generation atomic absorption spectrophotometry after Na <sub>2</sub> O <sub>2</sub> fusion-HCl dissolution.

Table A1-1. Analytical methods.—Continued

Analytic method short name	Analyzed media	Description
HGAA_Se	Solids	Selenium is determined by hydride generation atomic absorption spectrophotometry after HNO <sub>3</sub> -HF-HClO <sub>4</sub> digestion.
HGAA_Se_C	Solids	Selenium is determined by a contract lab using hydride generation atomic absorption spectrophotometry after Na <sub>2</sub> O <sub>2</sub> fusion-HCl dissolution.
HGAA_Te_C	Solids	Tellurium is determined by a contract lab using hydride generation atomic absorption spectrophotometry after HNO <sub>3</sub> -HF-HClO <sub>4</sub> digestion.
HGAA_Tl_C	Solids	Thallium is determined by a contract lab using graphite furnace atomic absorption spectrophotometry following Na <sub>2</sub> O <sub>2</sub> fusion/HCl-HNO <sub>3</sub> dissolution.
ICPAES10	Solids	Ten elements are determined by inductively coupled plasma-atomic emission spectroscopy after partial HCl-H <sub>2</sub> O <sub>2</sub> digestion and diisobutylketone (DIBK) extraction.
ICPAES10_C	Solids	Ten elements are determined by a contract lab using inductively coupled plasma-atomic emission spectroscopy after partial HCl-H <sub>2</sub> O <sub>2</sub> digestion and DIBK extraction.
ICPAES-1312	Solids	Twenty-seven elements in modified 1312 EPA synthetic precipitation leaching procedure (SPLP) leachates are determined by inductively coupled plasma-atomic emission spectroscopy.
ICPAES16_C	Solids	Sixteen elements are determined by a contract lab using inductively coupled plasma-atomic emission spectroscopy after a LiBO <sub>2</sub> fusion.
ICPAES40	Solids	Forty elements are determined by inductively coupled plasma-atomic emission spectroscopy after a HF-HCl-HNO <sub>3</sub> -HClO <sub>4</sub> digestion.
ICPAES40_C	Solids	Forty elements are determined by a contract lab using inductively coupled plasma-atomic emission spectroscopy after a HF-HCl-HNO <sub>3</sub> -HClO <sub>4</sub> digestion.
ICPAES42_C	Solids	Eighteen of forty-two elements are determined by a contract lab using inductively coupled plasma-atomic emission spectroscopy after an HF-HCl-HNO <sub>3</sub> -HClO <sub>4</sub> digestion.
ICPAES55_C	Solids	Nineteen of fifty-five elements are determined by a contract lab using inductively coupled plasma-mass spectroscopy after a Na <sub>2</sub> O <sub>2</sub> sinter digestion.
ICPAES-FLT	Solids	Twenty-seven elements in field leach test deionized water leachates are determined by inductively coupled plasma-atomic emission spectroscopy.
ICPAES-FUSION	Solids	Boron and zirconium are determined by inductively coupled plasma-atomic emission spectroscopy after Na <sub>2</sub> O <sub>2</sub> sinter digestion.
ICPAES-H2O	Water	Twenty-seven elements in acidified natural and mine waters are determined by inductively coupled plasma-atomic emission spectroscopy.
ICPAES-H2O-PC	Water	Twenty-eight elements in pre-concentrated acidified natural and mine waters are determined by inductively coupled plasma-atomic emission spectroscopy.
ICPMS_C	Solids	Sixty-four elements are determined by a contract lab using inductively coupled plasma-atomic emission spectroscopy after a LiBO <sub>2</sub> /Li <sub>2</sub> B <sub>4</sub> O <sub>7</sub> fusion.
ICPMS-1312	Solids	Twenty-one or more elements are determined in modified 1312 EPA SPLP leachates by inductively coupled plasma-mass spectroscopy.

**Table A1-1. Analytical methods.—Continued**

Analytic method short name	Analyzed media	Description
ICPMS42_C	Solids	Twenty-four of forty-two elements are determined by a contract lab using inductively coupled plasma-atomic emission spectroscopy after an HF-HCl-HNO <sub>3</sub> -HClO <sub>4</sub> digestion.
ICPMS55_C	Solids	Thirty-six of fifty-five elements are determined by a contract lab using inductively coupled plasma-mass spectroscopy after a Na <sub>2</sub> O <sub>2</sub> sinter digestion.
ICPMS-ACID	Solids	Twenty-one or more elements are determined in solids by inductively coupled plasma-mass spectroscopy after a HF-HCl-HNO <sub>3</sub> -HClO <sub>4</sub> digestion.
ICPMS-AR_C	Solids	Thirty-six elements are determined in solids by a contract lab using inductively coupled plasma-mass spectroscopy after aqua regia digestion.
ICPMS-AR-Org_C	Organic	Fifty-three elements are determined in raw organic media by a contract lab using inductively coupled plasma-mass spectroscopy after aqua regia digestion.
ICPMS-BLch_C	Solids	Fifty-eight constituents are determined in proprietary BioLeach leachates of solids by a contract lab using inductively coupled plasma-mass spectroscopy.
ICPMS-CHHLch_C	Solids	Sixty-three elements are determined in cold hydroxylamine hydrochloride leachates of solids by a contract lab using inductively coupled plasma-mass spectroscopy.
ICPMS-EELch_C	Solids	Sixty-nine constituents are determined in a proprietary enhanced enzyme leachates of solids by a contract lab using inductively coupled plasma-mass spectroscopy.
ICPMS-FLT	Solids	Fifty-six constituents are determined in field leach test deionized water leachates by inductively coupled plasma-mass spectroscopy.
ICPMS-H2O	Water	Twenty-one or more elements are determined in acidified water by inductively coupled plasma-mass spectroscopy.
ICPMS-HR-H2O_C	Water	Sixty elements are determined in acidified water by a contract lab using high resolution inductively coupled plasma-mass spectroscopy.
ICPMS-HR-Org_C	Organic	Sixty elements are determined in raw organic media by a contract lab using high resolution inductively coupled plasma-mass spectroscopy after 2-stage HNO <sub>3</sub> and aqua regia digestion.
ICPMS-MMILch_C	Solids	Forty-six elements are determined in a proprietary mobile metal ion leachates of solids by a contract lab using inductively coupled plasma-mass spectroscopy.
ICPMS-NaPLch_C	Solids	Sixty-one constituents are determined in sodium pyrophosphate leachates of solids by a contract lab using inductively coupled plasma-mass spectroscopy.
ICPMS-REE	Solids	Rare-earth elements are determined by inductively coupled plasma-mass spectroscopy after Na <sub>2</sub> O <sub>2</sub> sinter digestion.
ICPMS-TSLch_C	Solids	Sixty-seven constituents in proprietary TerraSol leachates of solids by a contract lab using inductively coupled plasma-mass spectroscopy.
IonBalance	Water	Balance of cations and anions in a sample is determined by calculation.
IONC-Aq	Water	Anion (F, Cl, NO <sub>3</sub> , SO <sub>4</sub> ) concentrations in unacidified aqueous samples are determined by ion chromatography.
IONC-Aq_C	Water	Anion (F, Cl, NO <sub>3</sub> , SO <sub>4</sub> ) concentrations in unacidified aqueous samples are determined by a contract lab using ion chromatography.
ISE_Cl	Solids	Chloride is determined by ion specific electrode after KOH-NH <sub>4</sub> NO <sub>3</sub> fusion.
ISE_Cl_C	Solids	Chloride is determined by a contract lab using an ion specific electrode after KOH-NH <sub>4</sub> NO <sub>3</sub> fusion.
ISE_F	Solids	Fluoride is determined by ion specific electrode after NaOH-KNO <sub>3</sub> fusion.
ISE_F_C	Solids	Fluoride is determined by a contract lab using an ion specific electrode after NaOH-KNO <sub>3</sub> fusion.

Table A1-1. Analytical methods.—Continued

Analytic method short name	Analyzed media	Description
ISE-Aq_C	Water	Anion (F, Cl) concentrations in unacidified aqueous samples are determined by a contract lab using an ion specific electrode.
MS-ISOTOPE	Water	Isotopes of elements, as ratios, are determined in unacidified aqueous samples by mass spectroscopy.
NAA_W_C	Solids	Tungsten is determined by a contract lab using instrumental neutron activation analysis.
NAA-LC_C	Solids	Elements are determined by a contract lab using instrumental neutron activation analysis.
ORP fld	Water	Oxidation-reduction potential (ORP) of unacidified water is determined in the field using an ORP electrode.
ORP_lab	Water	Oxidation-reduction potential (ORP) of unacidified aqueous solution is determined in the lab using an ORP electrode.
pH fld	Water	pH of unacidified water is determined in the field using a digital pH meter.
pH fld_C	Water	pH of unacidified water is determined in the field by a non-USGS field party using a digital pH meter.
pH_lab	Water	pH of unacidified aqueous media is determined in the lab using a digital pH meter.
pH_lab_C	Water	pH of unacidified aqueous media is determined in the lab by a contract lab using a digital pH meter.
pH-paste_ABA	Solids	pH of a saturated paste formed with deionized (DI) water slurried with equal volume of <2 mm material sample is determined by electrode in support of an acid/base accounting method.
pH-paste fld	Solids	pH of a saturated paste formed with DI water slurried with equal volume of soil sample is determined in the field using a digital pH meter.
pH-paste_lab	Solids	pH of a saturated paste formed with DI water slurried with equal volume of soil sample is determined in the lab using a digital pH meter.
SEM	Solids	Minerals or elements are identified by scanning electron microscopy.
SpCond fld	Water	Specific conductivity of water is determined in the field using a conductivity meter.
SpCond fld_C	Water	Specific conductivity of water is determined in the field by a non-USGS field party using a conductivity meter.
SpCond_lab	Water	Specific conductivity of an aqueous solution measured with a conductivity meter.
SpCond_lab_C	Water	Specific conductivity of an aqueous solution measured by a contract lab using a conductivity meter.
SpCond-paste_lab	Solids	Specific conductivity of a saturated paste formed with DI water, pressure squeezed with 30lb Baroid press, resulting water diluted 1:10, is determined with a conductivity meter.
SuspSolids	Water	Suspended solids is determined in the lab by drying and weight loss.
Temp fld	Water	Temperature of water is determined in the field using a digital thermometer.
Temp fld_C	Water	Temperature of water is determined in the field by a non-USGS field party using a digital thermometer.
Temp_lab	Water	Temperature of aqueous media is determined in the lab using a digital thermometer.
Titr_Acidity fld	Water	Water acidity is determined in unacidified water samples in the field with a field titration kit.
Titr_Acidity_lab	Water	Aqueous solution acidity is determined in unacidified aqueous samples the lab with a field titration kit.
Titr_Alk fld	Water	Alkalinity, expressed in concentrations of CaCO <sub>3</sub> or HCO <sub>3</sub> , is determined in unacidified water samples in the field with a field titration kit.
Titr_Alk fld_C	Water	Alkalinity, expressed in concentrations of CaCO <sub>3</sub> or HCO <sub>3</sub> , is determined in unacidified water samples in the field by a non-USGS field party using a field titration kit.
Titr_Alk_lab	Water	Alkalinity, expressed in concentrations of CaCO <sub>3</sub> , is determined in unacidified water samples by acid titration.

**Table A1-1. Analytical methods.—Continued**

Analytic method short name	Analyzed media	Description
Titr_CO-C_C	Solids	Carbonate carbon and CO <sub>2</sub> are determined by a contract lab using coulometric titration after hot 2N HClO <sub>4</sub> digestion.
Titr_FeO	Solids	FeO is determined by potentiometric titration after H <sub>2</sub> SO <sub>4</sub> -HF-HCl digestion.
Titr_FeO_C	Solids	FeO is determined by a contract lab using potentiometric titration after H <sub>2</sub> SO <sub>4</sub> -HF-HCl digestion.
Titr_NP	Solids	Neutralization potential of solids is determined by titration, based on fizz rating in support of an acid/base accounting method.
Turbidity	Water	Turbidity of water is determined in the field with a turbidity meter using an infrared LED light source.
UV-Fluor-Aq	Water	Uranium in acidified aqueous samples determined by ultraviolet fluorescence.
UV-Fluor-Aq_C	Water	Uranium in acidified aqueous samples determined by a contract lab using ultraviolet fluorescence.
WDXRF	Solids	Ten major elements are determined by wavelength dispersive X-ray fluorescence after LiBO <sub>2</sub> fusion.
WDXRF_C	Solids	Ten major elements are determined by a contract lab using wavelength dispersive X-ray fluorescence after LiBO <sub>2</sub> fusion.
XRD_Interp	Solids	Compounds or minerals calculated by using chemical analyses and mineralogy together.
XRD_Qual	Solids	Minerals identified by qualitative analysis by X-ray diffraction simply as present/absent with no further quantification.
XRD_SQ	Solids	Minerals identified semi-quantitative analysis performed using Siroquant computer program that utilizes the full X-ray diffraction profile in a Rietveld refinement.

## Appendix 2

### Database Query Examples

#### Summary Queries

The query “qsumSampleType” was created to display the various types and subtypes of sample media that were collected and analyzed. This query displays data from the *SampleMediaGross* and *SampleMediaDetail* fields of the **Sample** table, while providing a count of the number of samples in each subtype (fig. A2-1). This data is sorted first by *SampleMediaGross* and then by *SampleMediaDetail*.

The query “qsumEcoregionType-State” was created to show the various types and subtypes of ecoregion domains, regions and provinces that are represented by sample sites in the database, and how these subtypes are distributed in states or provinces. This query displays data from the *EcoDomain*, *EcoDivision* and *EcoProvince* fields of the **Ecoregion** table, while providing a count of the number of samples in each subtype (fig. A2-2). This data is combined with the entries in the *State\_Province* field of the **FieldSite** table by the linking of the two tables by the common field *FieldSiteNumber*, which provides a count of the number of sites in each *EcoProvince* by state or province. Figure A2-2 shows that the sort order for the displayed data will be in fields from left to right.

The query “qsumDepositType-State” is similar in design to “qsumEcoregionType-State” as it was created to show the various classes and subclasses of mineral deposit types that are represented by sample sites in the database, and how these subtypes are distributed in states or provinces. This query displays data from the *DepositTypeClass* and *DepositTypeSubclass* fields of the **GeolMineSite** table, while providing a count of the number of samples in each subtype (fig. A2-3). This data is combined with the entries in the *State\_Province* field of the **FieldSite** table by the linking of the two tables by the common field *FieldSiteNumber*, which provides a count of the number of sites in each *DepositTypeSubclass* by state or province. The sort order for the displayed data will be in fields from left to right. Note that the query “Criteria” of the *DepositTypeSubclass* “count” field is not null. This criteria specification filters out all field sites that do not have entries in the field *DepositTypeSubclass*.

#### Select Queries

A series of queries were constructed to select data for water samples in the database. The select query “qselMassive-Sulfide-Temperate\_ICPAES-pH” was created to retrieve all geochemical data determined by the ICP-AES analytic method from water samples collected from sites in temperate ecoregions and in massive sulfide deposit type. In addition, data

selected were restricted for Zn values greater than 500 µg/L, and Cu and Pb values equal to or greater than their lower limits of detection for this specific analytic method (fig. A2-4).

The query combines data from six tables: the **FieldSite** table (containing the *FieldSiteNumber*, *FieldLatitude*, *FieldLongitude*, and *State\_Province* data), the **Sample** table (*SampleDate*), the **Ecoregion** table (*EcoDomain*), the **GeolMineSite** table (*DepositTypeClass*), the **H2O\_Acidified** table (containing *SampleNumber*, *SampleAnalyzed*, and numerous fields of chemical data from acidified water samples), and the **H2O\_Unacidified** table (containing numerous fields of chemical data from unacidified water samples). A close look at the “Criteria” line of the Query Design View shows the conditions placed on this query: *EcoDomain* of **Ecoregion** contains the word “temperate” within its entries, *DepositTypeClass* of **GeolMineSite** contains the words “massive sulfide” within its entries, *pH\_SI\_Fld* of **H2O\_Unacidified** is not null, *Zn\_ug/L\_AES* of **H2O\_Acidified** contains values greater than 500 µg/L, and *Cu\_ug/L\_AES* and *Pb\_ug/L\_AES* of **H2O\_Acidified** contain values greater than zero as negative numbers represent the lower limits of detection for these fields. The data will be sorted by *SampleNumber*.

In much the same manner, the select query “qselMassive-Sulfide-Temperate\_ICPMS-pH” (fig. A2-5) was created to retrieve all geochemical data determined by the ICP-MS analytic method from water samples collected from sites in temperate ecoregions and coded massive sulfide for deposit type as samples are within or proximal to massive sulfide zones. The only samples retrieved by this query need to satisfy certain filtering criteria: Zn values greater than 500 µg/L, and Cu and Pb values equal to or greater than their lower limits of detection for this specific analytic method. The one difference between “qselMassiveSulfide-Temperate\_ICPMS-pH” and “qselMassiveSulfide-Temperate\_ICPAES-pH” is that the table **H2O\_ICPMS** replaces the table **H2O\_Acidified** in the query. The addition of the table **H2O\_Unacidified** to both queries was done in order to view the unacidified water data along with the acidified.

A summary query “qsumMassiveSulfide-Temperate\_ICPMS-pH” (fig. A2-6) was created so that the user can determine the minimum, maximum, and average pH for water samples collected from sites in temperate ecoregions and coded massive sulfide for mineral deposit type, and where samples have Zn values greater than 500 µg/L, and Cu and Pb values equal to or greater than their lower limits of detection for this specific analytic method.

A summary query similar to “qsumMassiveSulfide-Temperate\_ICPMS-pH” can be created that queries the select query “qselMassiveSulfide-Temperate\_ICPAES-pH”. By executing these two summary queries, a table was created that illustrates the telescoping nature gained when increasing the specificity of a query’s search criteria (Table A2-1). The average pH for the water samples with higher concentrations of Zn, Cu, and Pb in solution is significantly lower than it is when lower metal concentrations were determined. This is true for both ICP-AES and ICP-MS datasets. The user can

easily add other species such as SO<sub>4</sub>\_mg/L\_IC, As\_ug/L\_MS, Fe\_ug/L\_MS, or Sb\_ug/L\_MS to this query to observe the ranges of these species as well.

The select query “qselIDChem\_H2O” was created to retrieve all quantitative geochemical data from water samples collected in Idaho (fig. A2-7). This query combines data from five tables: **FieldSite** table (FieldSiteNumber, coordinates, and site information), the **GeolMineSite** table (mineral deposit information), the **Sample** table (SampleNumber, sample media, and sample description information), the **QuantResult** table (chemical parameter and results), and the **Parameter** table (detailed parameter information). The criteria for this query are *State\_Province* = ID and *SampleMediaGross* = water. The data are sorted first by *SampleNumber* and then by *QuantS\_U\_AM* (chemical parameter such as Ag\_ug/L\_AES, for example). Running select query “qselIDChem\_H2O” produces a Datasheet View containing 58,319 rows, each one containing one chemical value.

## Crosstab Query

Note that in the select query “qselIDChem\_H2O” the field *QuantValueQualified* was used which combines the

determined value in *QuantValue* and its qualifier in *QuantValueQual*. Likewise, *QuantS\_U\_AM* was used rather than *ParameterCode* so that analytic method information could be included with the information regarding determined species and units of expression for all results. These two fields are critical when constructing the crosstab query “qctabIDChem\_H2O” which further aids the user by displaying the data in a flatfile or spreadsheet view (fig. A2-8).

This crosstab query was constructed using the select query “qselIDChem\_H2O” so that *SampleNumber* is the key row headings, the unique entries in *QuantS\_U\_AM* become the column headings, and the cells in each column are filled by the entries in *QuantValueQualified*. Fields providing coordinate, deposit type, and sample description were also added as row headings to the query so that relevant descriptive information would be available in one Datasheet View. Running crosstab query “qctabIDChem\_H2O” produces a Datasheet View containing 1,808 rows, each one containing one unique water sample from Idaho and its chemical data. Like the 18 Chem Data tables provided in the database, crosstab queries can be constructed to create unique datasets containing analytical data gathered from a specific sample media collected within specific geographic, climate, ecoregion, and mineral deposit regimes, and determined by certain analytic methods.

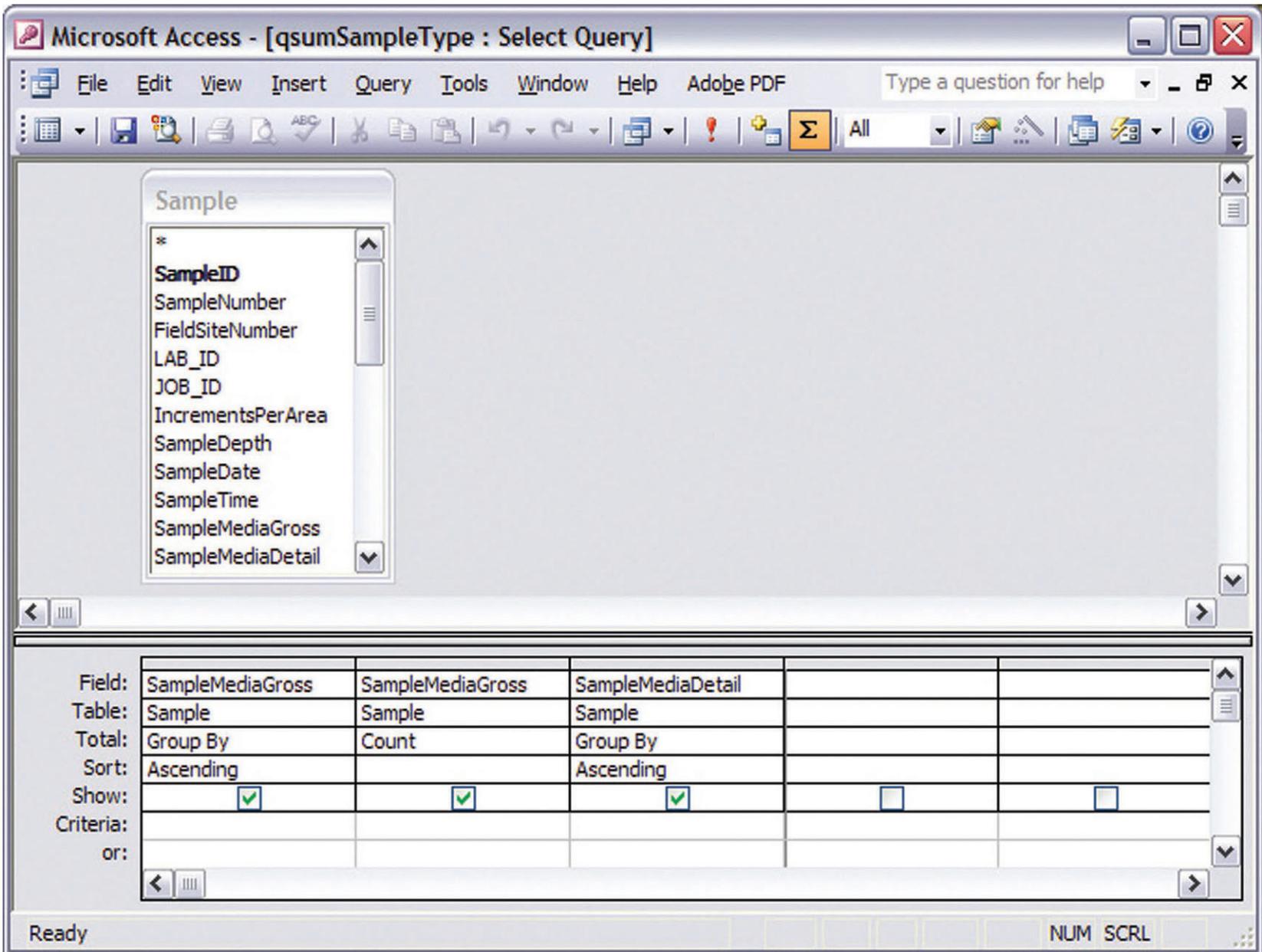


Figure A2-1. Summary query qsumSampleType in Query Design View.

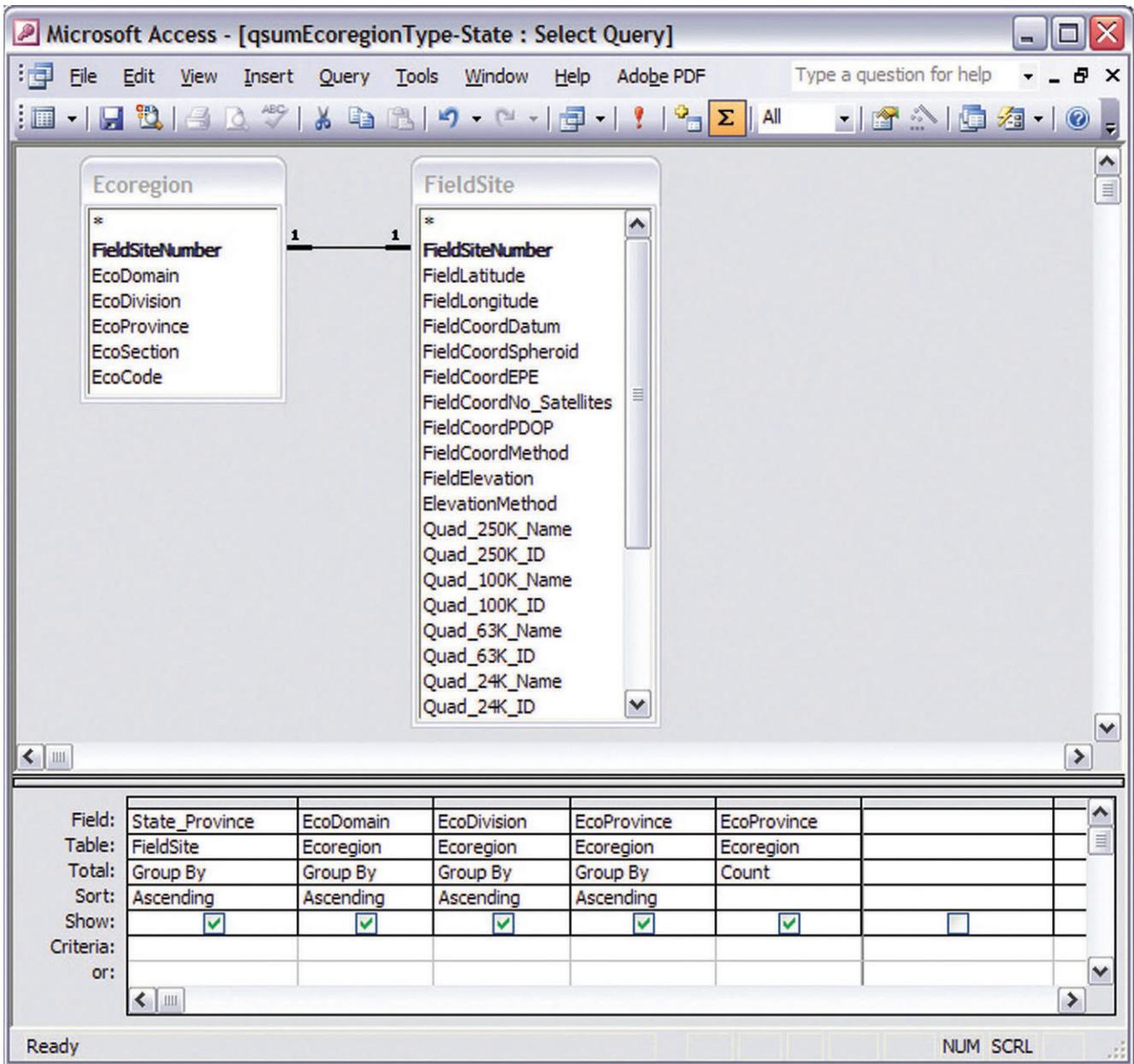


Figure A2-2. Summary query qsumEcoregionType-State in Query Design View.

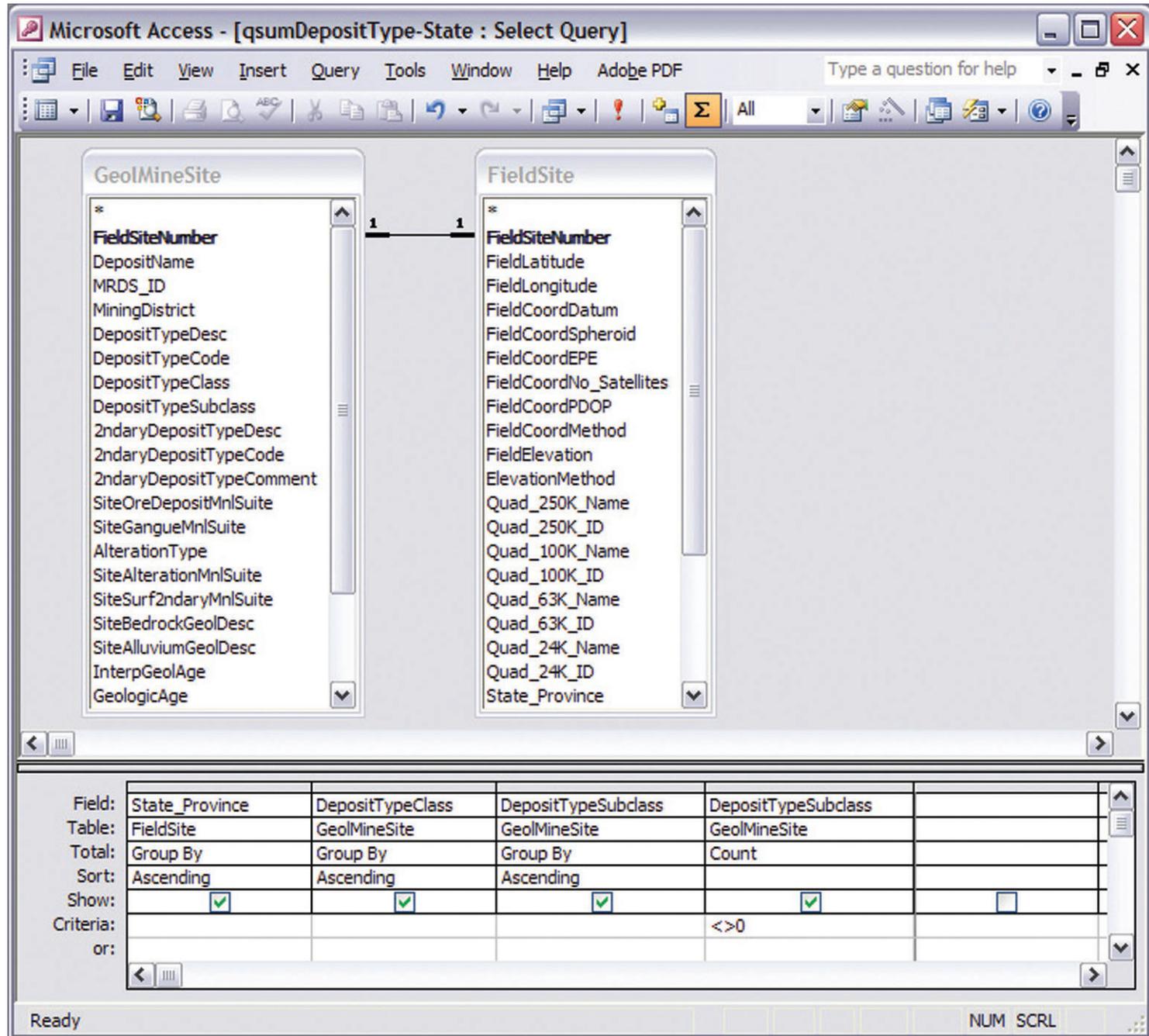


Figure A2-3. Summary query qsumDepositType-State in Query Design View.

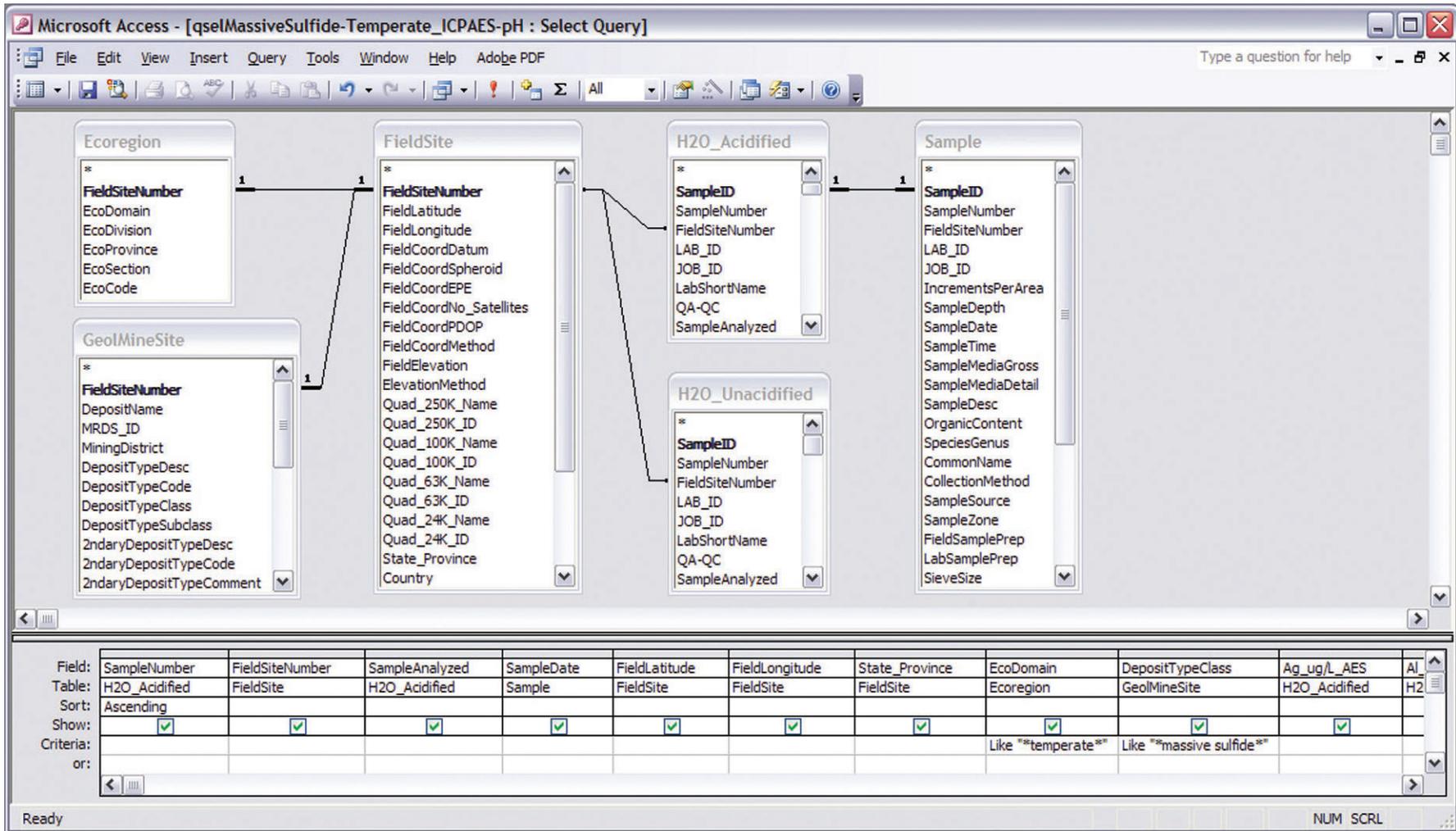


Figure A2-4. Select query qselMassiveSulfide-Temperate\_ICPAES-pH in Query Design View.

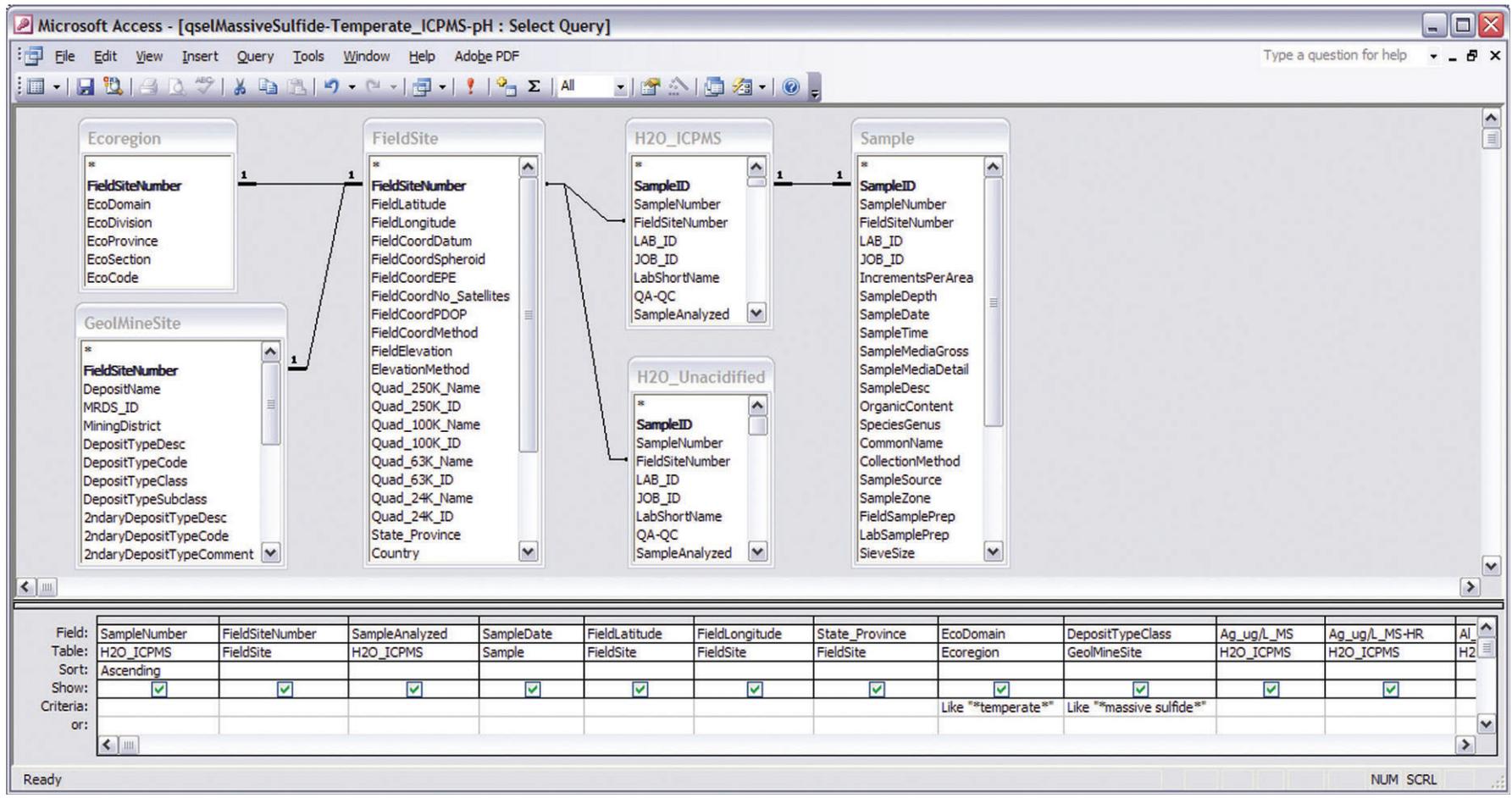


Figure A2-5. Select query qselMassiveSulfide-Temperate\_ICPMS-pH in Query Design View.

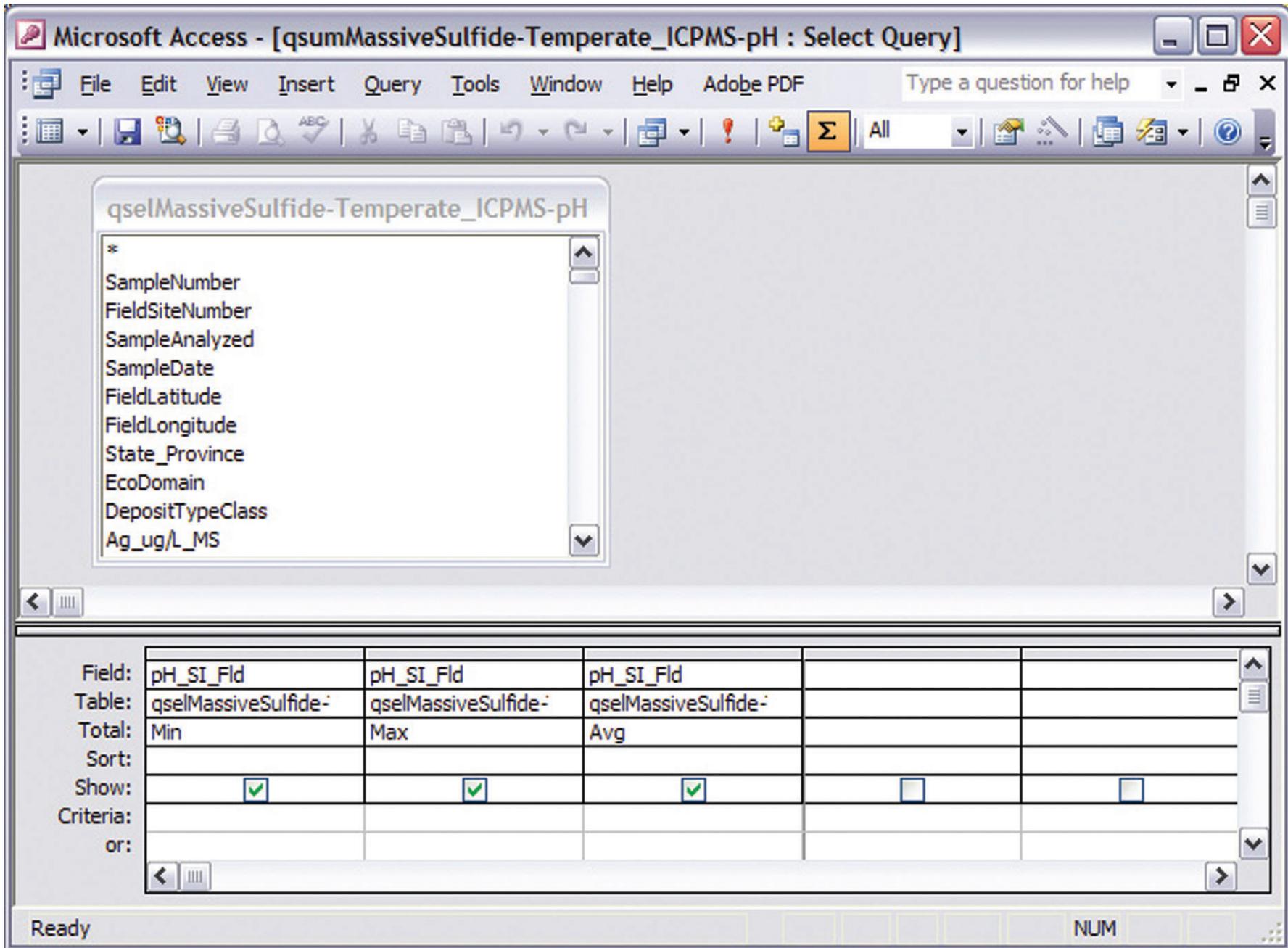


Figure A2-6. Select query qsumMassiveSulfide-Temperate\_ICPMS-pH in Query Design View.

**Table A2-1.** Table of sample counts and pH ranges observed when using queries qselMassiveSulfide-Temperate\_ICPAES-pH, qselMassiveSulfide-Temperate\_ICPMS-pH, and qsumMassiveSulfide-Temperate\_ICPMS-pH.

Method used to analyze water samples	Total Samples	Samples in temperate ecoregion	Samples in areas of massive sulfide deposits	Samples in areas of massive sulfide deposits in temperate ecoregion	Samples in areas of massive sulfide deposits in temperate ecoregion, where Zn >500 ug/L, Cu >0 and Pb >0
ICP-AES samples	2111	757	936	707	50
pH range of ICP-AES samples				1.84 to 8.44	2.09 to 4.98
pH avg of ICP-AES samples				4.94	3.05
>>>> increasing specificity >>>>>					
ICP-MS samples	2150	874	1027	816	222
pH range of ICP-MS samples				1.1 to 8.44	1.1 to 6.42
pH avg of ICP-MS samples				5.01	3.21

Microsoft Access - [qsellIDChem\_H2O : Select Query]

File Edit View Insert Query Tools Window Help Adobe PDF

Type a question for help

FieldSite

- FieldSiteNumber
- FieldLatitude
- FieldLongitude
- FieldCoordDatum
- FieldCoordSpheroid
- FieldCoordEPE
- FieldCoordNo\_Satellites
- FieldCoordPDOP
- FieldCoordMethod
- FieldElevation
- ElevationMethod
- Quad\_250K\_Name
- Quad\_250K\_ID
- Quad\_100K\_Name
- Quad\_100K\_ID
- Quad\_63K\_Name

Sample

- SampleID
- SampleNumber
- FieldSiteNumber
- LAB\_ID

GeolMineSite

- FieldSiteNumber
- DepositName
- MRDS\_ID
- MiningDistrict
- DepositTypeDesc
- DepositTypeCode
- DepositTypeClass

QuantResult

- QuantResultID
- SampleID
- ParameterCode
- QuantS\_U\_AM
- QuantValue
- QuantValueQual
- QuantValueQualified
- AnalyticMethodShortName
- LabShortName
- SampleAnalyzed
- AnalOrder
- QuantValueComment

Parameter

- ParameterCode
- Species
- ReportUnits
- ParameterName
- ConstituentName

Field:	SampleNumber	FieldSiteNumber	DepositName	DepositTypeClass	DepositTypeSubclass	FieldLatitude	FieldLongitude	State_Province	SiteDesc	SiteLoca
Table:	Sample	FieldSite	GeolMineSite	GeolMineSite	GeolMineSite	FieldSite	FieldSite	FieldSite	FieldSite	FieldSite
Sort:	Ascending									
Show:	<input checked="" type="checkbox"/>									
Criteria:								"ID"		
or:										

Ready NUM SCRL

Field:	SiteLocationInfo	SiteComment	SampleMediaGross	SampleMediaDetail	SampleDesc	SampleCom	QuantS_U_AM	QuantValueQualified	ParameterName
Table:	FieldSite	FieldSite	Sample	Sample	Sample	Sample	QuantResult	QuantResult	Parameter
Sort:							Ascending		
Show:	<input checked="" type="checkbox"/>								
Criteria:			"water"						
or:									

Ready NUM SCRL

Figure A2-7. Select query qsellIDChem\_H2O in Query Design View.

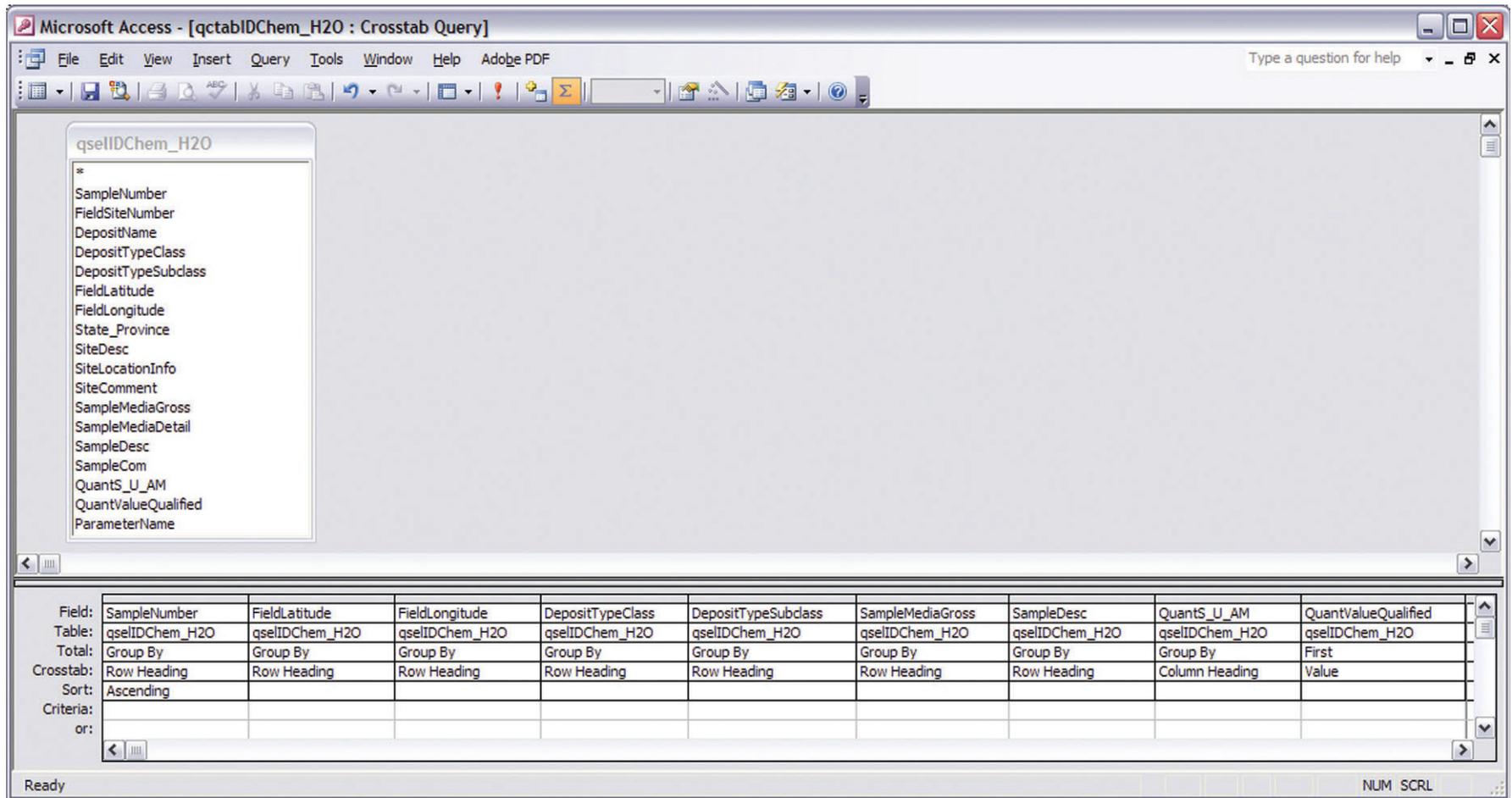


Figure A2-8. Crosstab query qctabIDChem\_H2O in Query Design View.