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Alaska Geochemical Database Version 3.0 (AGDB3)—Including "Best Value" Data Compilations for Rock, Sediment, Soil, Mineral, and Concentrate Sample Media

Data Series 1117

U.S. Department of the Interior
U.S. Geological Survey

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2019

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
liter (L)	0.2642	gallon (gal)
	Area	
gram (g)	0.03527	ounce, avoirdupois (oz.)

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:

$$°C=(°F-32)/1.8$$

Datum

Coordinate information is referenced to the World Geodetic System 1984 (WGS84) datum and spheroid.

Supplemental Information

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

List of Acronyms

AA	Atomic absorption spectrometry
AGDB	Alaska Geochemical Database (USGS Data Series 637)
AGDB2	Alaska Geochemical Database Version 2.0 (USGS Data Series 759)
AGDB3	Alaska Geochemical Database Version 3.0
AES	Inductively coupled plasma-atomic emission spectrometry
AFS	Atomic fluorescence spectrometry
AMRAP	Alaska Mineral Resource Assessment Program
BLM	U.S. Department of the Interior Bureau of Land Management
CM	Colorimetric analysis
DCP	Direct-current plasma atomic emission spectrometry
DGGS	Alaska Department of Natural Resources Division of Geological & Geophysical Surveys
DN	Delayed neutron counting
EDX	Energy dispersive X-ray fluorescence spectrometry
ES	Direct current-arc emission spectrography
FA	Fire assay
GV	Gravimetric analysis
HFSE	High field strength elements
HSSR	Hydrogeochemical and Stream Sediment Reconnaissance
ISE	Ion-specific electrode analysis
LILE	Large-ion lithophile elements
LIMS	Laboratory Information Management System
LLD	Lower limit of determination
MDIRA	Minerals Data Information Rescue in Alaska
MIBK	Methyl isobutyl ketone
MS	Inductively coupled plasma-mass spectrometry
NA	Instrumental neutron activation analysis
NGDB	National Geochemical Database
NURE	Atomic Energy Commission National Uranium Resource Evaluation
PLUTO	In-house USGS geochemistry database used from mid-1970s through the mid-1990s
RASS	USGS Rock Analysis Storage System
REE	Rare-earth element
TT	Titrimetric analysis
ULD	Upper limit of determination
USBM	U.S. Department of the Interior Bureau of Mines
USGS	U.S. Geological Survey
WDX	Wavelength dispersive X-ray fluorescence spectrometry
XRF	X-ray fluorescence spectrometry

Chemical Compounds Found in the Text and Tables

FeO	Iron oxide
HBr	Hydrobromic acid
HCl	Hydrochloric acid
$HClO_4$	Perchloric acid
HF	Hydrofluoric acid
HNO_3	Nitric acid
H_2O_2	Hydrogen peroxide
H_3PO_4	Phosphoric acid
H_2SO_4	Sulfuric acid
H_2SiF_6	Fluorosilicic acid
$KClO_3$	Potassium chlorate
KI	Potassium iodide
$KMnO_4$	Potassium permanganate
KOH	Potassium hydroxide
$K_2S_2O_7$	Potassium pyrosulfate
$LiBO_2$-$Li_2B_4O_7$	Lithium metaborate-lithium tetraborate
$NaHSO_4$	Sodium bisulfate
Na_2CO_3	Sodium carbonate
Na_2O_2	Sodium peroxide
NiS	Nickel sulfide
PbO	Lead oxide
ZnO	Zinc oxide

Elements

Al	Silver
Ag	Silver
As	Arsenic
Au	Gold
B	Boron
Ba	Barium
Bi	Bismuth
Br	Bromine
Ca	Calcium
Cd	Cadmium
Cr	Chromium
Cs	Cesium
Cu	Copper
Fe	Iron
Gd	Gadolinium
Hf	Hafnium
Hg	Mercury
I	Iodine
K	Potassium
Li	Lithium
Lu	Lutetium
Mo	Molybdenum
Mn	Manganese
Na	Sodium
Ni	Nickel
Nb	Niobium
O	Oxygen
P	Phosphorous
Pb	Lead
S	Sulfur
Sb	Antimony
Si	Silicon
Sn	Tin
Ta	Tantalum
Te	Tellurium
Th	Thorium
Ti	Titanium
W	Tungsten
Zn	Zinc
Zr	Zirconium

Useful Websites

USGS Main Webpage https://www.usgs.gov/

USGS Publications Search Page https://pubs.er.usgs.gov/

USGS Alaska Science Center https://alaska.usgs.gov/

USGS Mineral Resources On-line Spatial Data https://mrdata.usgs.gov/

USGS Open-File Report 99-433, Rock Analysis Storage System (RASS)
https://doi.org/10.3133/ofr99433

USGS Open-File Report 97-492, National Geochemical Database (NURE, HSSR)
https://doi.org/10.3133/ofr97492

USGS Data Series 637, Alaska Geochemical Database (AGDB) https://doi.org/10.3133/ds637

Alaska Geochemical Database, Version 2.0 (AGDB2) https://doi.org/10.3133/ds759

Alaska Division of Geological & Geophysical Surveys (DGGS) http://dggs.alaska.gov/

DGGS Alaska Geochemistry Database https://doi.org/10.14509/29770

Alaska Geochemical Database Version 3.0 (AGDB3)—Including "Best Value" Data Compilations for Rock, Sediment, Soil, Mineral, and Concentrate Sample Media

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Abstract

The Alaska Geochemical Database Version 3.0 (AGDB3) contains new geochemical data compilations in which each geologic material sample has one "best value" determination for each analyzed species, greatly improving speed and efficiency of use. Like the Alaska Geochemical Database Version 2.0 before it, the AGDB3 was created and designed to compile and integrate geochemical data from Alaska to facilitate geologic mapping, petrologic studies, mineral resource assessments, definition of geochemical baseline values and statistics, element concentrations and associations, environmental impact assessments, and studies in public health associated with geology. This relational database, created from databases and published datasets of the U.S. Geological Survey (USGS), Atomic Energy Commission National Uranium Resource Evaluation (NURE), Alaska Division of Geological & Geophysical Surveys (DGGS), U.S. Bureau of Mines, and U.S. Bureau of Land Management serves as a data archive in support of Alaskan geologic and geochemical projects and contains data tables in several different formats describing historical and new quantitative and qualitative geochemical analyses. The analytical results were determined by 112 laboratory and field analytical methods on 396,343 rock, sediment, soil, mineral, heavy-mineral concentrate, and oxalic acid leachate samples. Most samples were collected by personnel of these agencies and analyzed in agency laboratories or, under contracts, in commercial analytical laboratories. These data represent analyses of samples collected as part of various agency programs and projects from 1938 through 2017. In addition, mineralogical data from 18,138 nonmagnetic heavy-mineral concentrate samples are included in this database. The AGDB3 includes historical geochemical data archived in the USGS National Geochemical Database (NGDB) and NURE National Uranium Resource Evaluation-Hydrogeochemical and Stream Sediment Reconnaissance databases, and in the DGGS Geochemistry database. Retrievals from these databases were used to generate most of the AGDB data set. These data were checked for accuracy regarding sample location, sample media type, and analytical methods used. In other words, the data of AGDB3 supersedes data in the AGDB and the AGDB2, but the background about the data in these two earlier versions are needed by users of the current AGDB3 to understand what has been done to amend, clean up, correct and format this data. Corrections were entered, resulting in a significantly improved Alaska geochemical dataset, the AGDB3. Data that were not previously in these databases because the data predate the earliest agency geochemical databases, or were once excluded for programmatic reasons, are included here in the AGDB3 and will be added to the NGDB and Alaska Geochemistry. The AGDB3 data provided here are the most accurate and complete to date and should be useful for a wide variety of geochemical studies. The AGDB3 data provided in the online version of the database may be updated or changed periodically.

Introduction

The U.S. Geological Survey (USGS) began scientific investigations in Alaska in 1889, shortly after its purchase from the Russian Empire in 1867, but much Alaska scientific data had not always been readily accessible to the public. The USGS and Alaska Division of Geological & Geophysical Surveys (DGGS) participated in the Congressionally funded, multi-agency Minerals Data Information Rescue in Alaska (MDIRA) Program from 1997 to 2003 to make its Alaska scientific data digital, correct, user friendly, and accessible. The MDIRA program and subsequent efforts resulted in release of the Alaska Geochemical Database (Granitto and others, 2011,

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2012). The Alaska Geochemical Database (AGDB) provided comprehensive data on the analytical chemistry, mineralogy, and characteristics of geologic materials collected in Alaska from 1962–2009. Data from the AGDB are maintained in the Oracle-based National Geochemical Database (NGDB; available through the Mineral Resources Online Spatial Data (https://mrdata.usgs.gov/), which currently contains nearly 1.5 million samples and their data. Many of these Alaska geochemical data have been previously published in hardcopy or digital USGS Open-File Reports by the original sample submitters or analysts; however, some had never been published. Because of the complexity and diversity of the data the Alaska Geochemical Database Version 2.0—AGDB2 (Granitto and others, 2013) was created. The AGDB2 contains geochemical data compilations in which each geologic material sample has one designated "best value" determination for each analyzed species, greatly improving speed and efficiency of use. Discussion of archive data compilation, correction, and addition is found in Granitto and others (2011) and in Granitto and others (2013). The AGDB2 was a major data resource in Alaska Critical Minerals project analyses of critical mineral resource potential in selected groups of deposit types (Jones and others, 2015; Karl and others, 2016), and in the creation of the Geochemical Atlas of Alaska (Lee and others, 2016). These projects were enhanced by the addition to the AGDB2 of geochemical data from the Atomic Energy Commission National Uranium Resource Evaluation (NURE) and DGGS Alaska Geochemistry databases. Analyses carried out in the production of prospectivity maps for Karl and others (2016) highlighted inadequacies in the AGDB2 derived from high detection limits for legacy analyses, analyses for limited suites of elements, and sparsely sampled or unsampled regions of the state. To remedy these hindrances, archived samples from poorly represented areas in the state were identified and reanalyzed using higher precision technology for expanded analytical packages. The results of the reanalyses were entered into AGDB2 and "best values" were recalculated for AGDB3. The AGDB3 presented here is created from databases and published datasets of the USGS (AGDB2), NURE, and DGGS, as well as U.S. Department of the Interior Bureau of Mines (USBM) and U.S. Department of the Interior Bureau of Land Management (BLM) datasets that were made digital and published by the DGGS in its Alaska Geochemistry database (DGGS staff and others, 2017). Much of the text in this report is derived from the AGDB and AGDB2 reports.

The AGDB3 includes analyses of rocks, sediments (collected from streams, lakes, and other sources), soils, minerals, heavy-mineral concentrates (derived from stream sediments, soils or rocks) and oxalic-acid leachates (derived from stream and glacial sediments) compiled in part during the MDIRA process (Bailey and others, 1999), together with analyses of a variety of geologic materials from 1996 through 2017. Many of the analyses were the result of mineral resource investigations carried out by the USGS Alaska Mineral Resource Assessment Program (AMRAP) in the mid-1970s through early 1990s, by NURE (1976–1980), by the DGGS (1960–2017), by the USBM (1948–1995), and by the BLM (1996–2006); some of the data were produced in support of other USGS programs such as National Geologic Mapping, Volcano Hazards, Development of Assessment Techniques, and Energy Resources.

The AGDB3 is the most current, complete, and accurate data compilation for new and historical geochemical analyses of Alaska rock, sediment, soil, and concentrate samples, and its data supersedes that obtained from the AGDB or AGDB2. In other words, the data of AGDB3 supersedes data in the AGDB and the AGDB2, but the background about the data in these two earlier versions are needed by users of the current AGDB3 to understand what has been done to amend, clean up, correct and format this data. The AGDB3 also contains mineralogical information from optical examination of the nonmagnetic fractions of heavy-mineral concentrate samples. In addition, geochemical data from USGS re-analyses of NURE sediment samples, USGS and DGGS re-analyses (2007–2014) of AMRAP sediment samples, and DGGS re-analyses of USBM sediment, rock, and concentrate samples (2011–2013) have been included in the AGDB3. Data from other recent projects in Taylor Mountains quadrangle, southwestern Alaska, Fortymile district, Tintina gold province, and the statewide Surveys and Analysis Project are also included in the AGDB3.

Geographic Setting

The geographic boundaries of the AGDB3 include all of Alaska as well as State, Federal and International waters of the Arctic and Pacific Oceans that are reasonable for inclusion. The current AGDB data extents are approximately 50.0° to 71.6°N. latitude, 173.1°E. to 130.0°W. longitude (fig. 1).

Methods of Study

Sample Media and Collection

Analyses of 178,137 sediment samples, 145,389 rock samples, 8,433 soil samples, 7,560 mineral samples, 53,192 heavy-mineral concentrate samples, and 3,619 oxalic acid leachate samples are incorporated into the AGDB3 (figs. 2 and 3). Samples in the AGDB3 were collected between 1938 and 2017 and prepared according to a variety of USGS standard methods (variously described in Miesch, 1976; Arbogast, 1990, 1996; Taggart, 2002), by NURE methods (described in Smith, 1997), or by DGGS, USBM, and BLM methods that, if recorded, can be obtained from publications linked to samples collected by those agencies and listed in the AGDB3. The database includes analyses of 6,478 NURE sediment samples that were reanalyzed, including, in part, 4,804 for the National Geochemical Survey project between 1998 and 2008 (U.S. Geological Survey, 2004) and 1,640

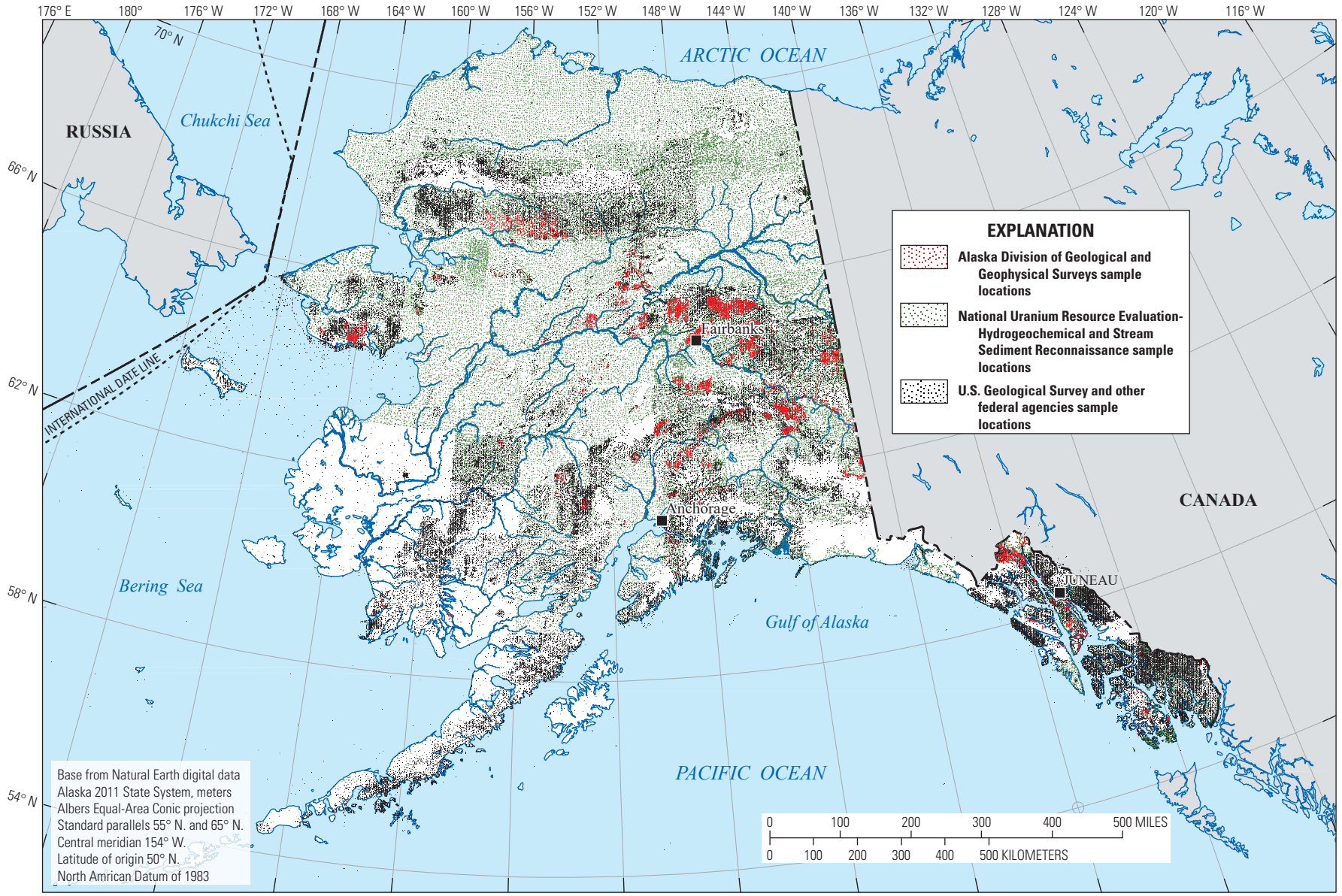

Figure 1. Sample locations in the Alaska Geochemical Database Version 3.0 (AGDB3). The State of Alaska is in the center of the map. The black dots are sample localities of the U.S. Geological Survey (USGS) and other Federal agencies. The green dots are sample localities of the National Uranium Resource Evaluation—Hydrogeochemical and Stream Sediment Reconnaissance (NURE-HSSR). The red dots are sample localities of the Alaska Division of Geological & Geophysical Surveys (DGGS).

Figure 2. Sediment, soil and concentrate sample locations in the Alaska Geochemical Database Version 3.0 (AGDB3). The State of Alaska is in the center of the map. The green dots are sample localities of sediment, soil, and concentrate samples in the AGDB3.

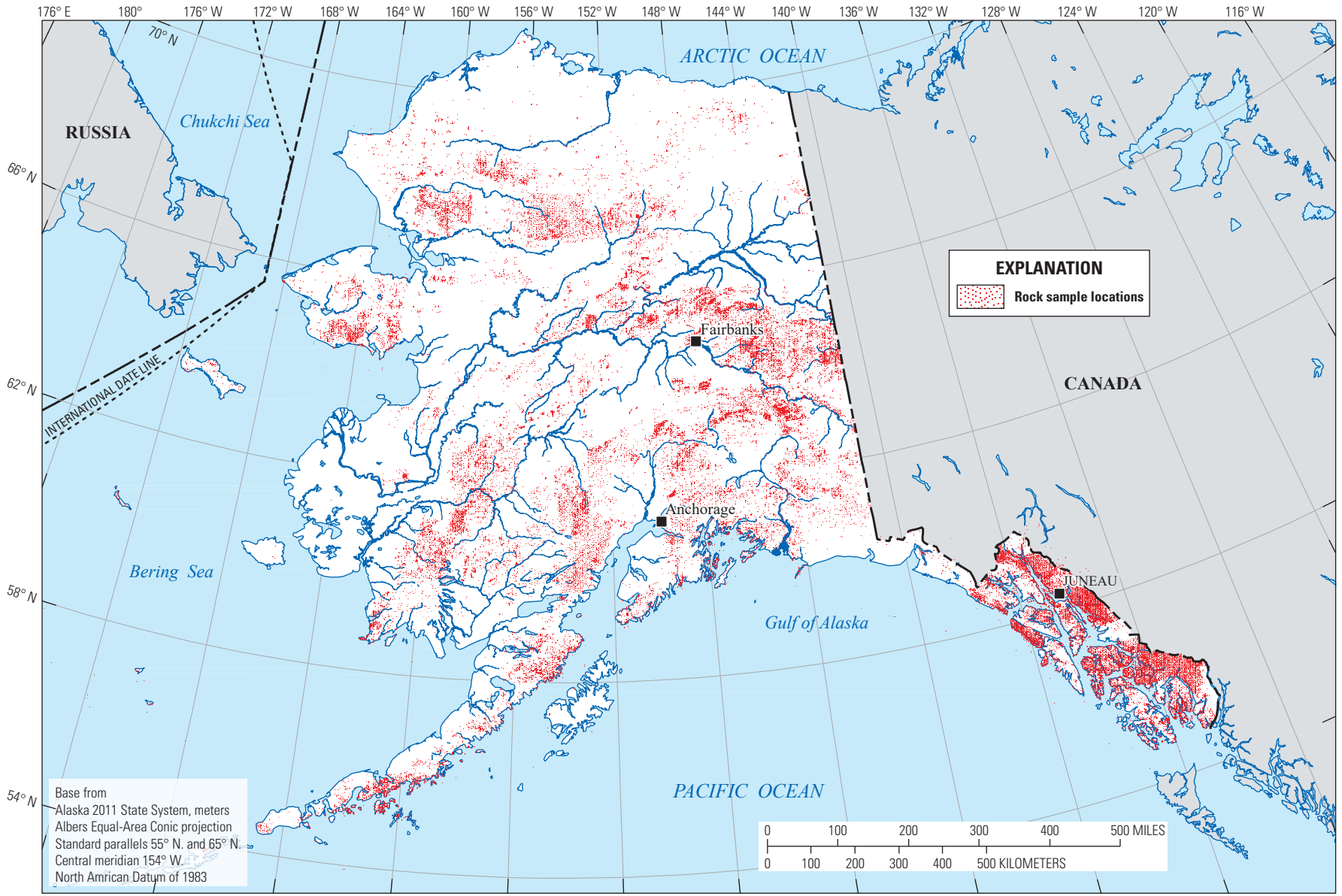

Figure 3. Rock sample locations in the Alaska Geochemical Database Version 3.0 (AGDB3). The State of Alaska is in the center of the map. The red dots are sample localities of rock samples in the AGDB3.

for AMRAP projects; analyses of 3,015 rock, sediment, soil, mineral, and concentrate samples collected during the 2004–2010 Taylor Mountains quadrangle project (Bailey and others, 2007; Klimasauskas and others, 2007; Klimasauskas and others, 2006a, b); analyses of 1,589 stream-sediment samples, originally collected during the USGS Heavy Metals and AMRAP programs (1966–1995), and reanalyzed during 2007–2010 by the Federal Lands in Alaska-Geologic Studies project (Bailey and others, 2010; Gamble and others, 2010); analyses of 719 rock, sediment, and soil samples collected during the 2007–2011 Concealed Deposits—Pebble Cu-Au-Mo porphyry deposit project (Fey and others, 2008, 2009; Anderson and others, 2011); analyses of 4,694 sediment and rock samples, originally collected during the USGS Heavy Metals and AMRAP programs (1966–1995), and reanalyzed during 2014–2017 by the Alaska Strategic and Critical Minerals project (Werdon and others, 2014, 2015a–f). Additionally, 1,231 historical USBM geochemical samples were reanalyzed by DGGS (Blessington and others, 2013; Werdon and Blessington, 2014a–i), and 29,861 of primarily USBM historical samples were digitally compiled and published by DGGS as part of their Alaska Strategic and Critical Minerals Assessment project (Blessington and others, 2016; Reioux and others, 2016); and many additional samples were analyzed as part of DGGS's annual statewide geologic mapping projects from 2007 to 2017 (Graham and Jozwik, 2007; Werdon and others, 2007, 2012; Athey and others, 2008, 2010; Solie and others, 2008; Freeman and others, 2009, 2012, 2016a, b, 2017; Griesel and others, 2010; Lough and others, 2012; Bachmann and others, 2013; Stevens and others, 2013; Sicard and others, 2014; Tuzzolino and others, 2014; Twelker and others, 2014, 2017; Wypych and others, 2014, 2015a, b, 2016a, b, 2017; Werdon, 2015; Naibert and others, 2016). Existing NGDB data from Alaskan water and organic samples (including humus and peat), and from many leachate samples have been excluded from this database.

Analytical Techniques

Geochemical data included in the AGDB3 were produced using 112 different field and laboratory analytical methods. These methods reflect the evolution of analytical chemistry from the 1930s to 2017. Appendix 1 provides a complete list of the analytical methods included in the AGDB3 with descriptive information for each. The **AnalyticMethod** table in the AGDB3 provides detailed information about techniques and the **AnalyticMethod_Biblio** table contains citations for the analytical methods.

Quality Assurance/Quality Control

Quality assurance and quality control (QA/QC) procedures varied over the time of AGDB3 sample processing and analysis and are not included in this database. Data from field sample-site duplicates and analytical replicates (splits of a single sample to check laboratory precision) are included in the database. Agency and contract laboratories reporting these analyses use constituent standards (for example, USGS geochemical reference rock standard STM–1, nepheline syenite) and blanks for their internal QA/QC controls (Arbogast, 1990; Taggart, 2002). Information regarding reference samples is found at the USGS Geology, Geophysics, and Geochemistry Science Center website (https://usgs.gov/energy-and-minerals/mineral-resources-program/science/development-usgs-geochemical-reference) and in Flanagan (1986).

"Best Value" Concept

The comprehensive nature of the first AGDB (Granitto and others, 2011) meant that a single sample may have had as many as four separate values measured by multiple analytical methods for a single element. Species that have the most multiple determination matches are silver (Ag), arsenic (As), gold (Au), bismuth (Bi), cadmium (Cd), copper (Cu), molybdenum (Mo), lead (Pb), antimony (Sb), and zinc (Zn). While these comprehensive data are complete, for many users such multiple analyses raise difficult questions of which value to use in their work.

The Alaska Geochemical Database Version 2.0 (AGDB2; Granitto and others, 2013) first included a subset of data that represents one "best value" per species for each of its samples. Since its introduction, this methodology has been used by several USGS projects and has been modified as different geochemical data situations have been encountered. The AGDB3 contains these enhancements. Where used in this report, the term "best value" means that single value per element per sample chosen by the rubric and reasoning described below. This rubric was designed to provide the best values for mineral exploration and assessment purposes and should not be assumed to be appropriate for other purposes (for example, evaluation of environmental background and baseline geochemical values would require development of a different "best value" ranking). The best values subset greatly reduces the total number of determinations a user must consider for a given sample, and facilitates use of USGS, NURE, DGGS, USBM, and BLM data for geochemical mapping, data synthesis, and regional evaluation in Alaska.

Determining "Best Value" Rankings

Different analytical determinations of the same element for any given sample do not have equal value to a user for different purposes. Some analytical methods result in values that are more quantitative, precise, or accurate than others. When developing a ranking of methods best for any particular use, it is necessary to take into account factors which vary between analytical methods. These include weight of sample analyzed, method of decomposition during sample preparation for analysis, sensitivity and accuracy of the instrument used in each method, upper and lower limits of determination for a given

element by a given method, the age of the method and stage of its development when a specific analysis was performed, and the exact analytical equipment and laboratory used. Creation of the five "BV" tables that make up the AGDB3 "best value" subset (table 1) followed a rubric or decision tree that considered all these factors in ranking the analytical methods in the AGDB3 to determine methods most useful to mineral resource evaluation.

Sample Weight

The amount of sample required for analysis varies widely between methods. On the high end, 15 to 30 grams (g) of sample are needed to determine gold or the platinum group elements by fire assay (FA) methods, and 10 to 15 g for the detection of Au by atomic absorption spectrometry (AA) or direct current plasma-atomic emission spectrometry (DCP). On the low end, only 10 milligrams (mg) of sample are needed for direct-current arc emission spectrography (ES), a method that was used to detect concentrations of 33 to 65 elements. In general, larger sample aliquots provide a more accurate and representative assessment of a sample's chemical makeup, so determinations by ES, for example, are less quantitative than those by analytical methods that require larger sample amounts.

Sample Decomposition

The methods used to decompose a geologic sample to be analyzed vary by material (for example, rock versus soil) and effectiveness, and are an important factor to consider in determining "best" methods. In general, methods which digest or dissolve a sample vary from near-total ("complete") to partial decomposition of a sample. The AGDB3 does not include results from any analytical methods that use passive or weak leaches of geologic material samples, except for oxalic acid leachates from sediments that were used in the early years of AMRAP. Decomposition methods that result in complete or near-complete digestion are herein referred to as "total." Instrumental neutron activation analysis (NA), delayed neutron counting (DN), energy dispersive X-ray fluorescence spectrometry (EDX) and wavelength dispersive X-ray fluorescence spectrometry (WDX) on pressed-powder samples, which compose 23.1 percent of AGDB3 analyses, are non-destructive techniques that analyze the entire sample without requiring digestion, and thus usually represent the best total decomposition of the sample. WDX, inductively coupled plasma-atomic emission spectrometry (AES), inductively coupled plasma-mass spectrometry (MS), DCP, AA, colorimetric spectrophotometry (CM), and ion-specific electrode analysis (ISE) employ highly effective fusion digestion, usually using lithium metaborate-lithium tetraborate ($LiBO_2$-$Li_2B_4O_7$) as the fusion flux, which compose 3.0 percent of AGDB3 analyses, yield near "total" analyses of the elements of interest, and is particularly effective when analyzing for the major, rare earth (REE), high field strength (HFSE) and large-ion lithophile (LILE) elements. However, the high temperature of fusion may drive off volatile elements such as As, mercury (Hg), sulfur (S), Sb, or tellurium (Te) in the process. AES, MS, DCP, AA, and CM also employ sinter digestion, usually using sodium peroxide (Na_2O_2) as the sinter flux, which compose 3.2 percent of AGDB3 analyses, yielding near "total" analyses of the elements of interest. The lower temperature of the sintering process provides a more accurate analysis of the volatile elements, making the sinter method very effective for a wide range of elements. Fire assay decomposition coupled with an AA, AES, DCP, MS, NA, atomic fluorescence spectrometry (AFS), or ES finish provides very accurate detection of gold, silver and platinum group element concentrations. Sample decomposition by combustion or ignition is employed in 48 percent of AGDB3 analyses, especially with ES analytical methods. AES, MS, DCP, AA, CM, ISE, and fluorometry may also employ strong acid digestions that usually include hydrofluoric acid (HF) provide for virtually complete decomposition. A common "total" acid digestion technique using a four-acid solution (HF, perchloric acid [$HClO_4$], nitric acid [HNO_3], and hydrochloric acid [HCl]) is sufficient for many elements of interest, but may not be effective in putting barium (Ba), chromium (Cr), hafnium (Hf), niobium (Nb), scandium (Sc), tin (Sn), tantalum (Ta), titanium (Ti), tungsten (W), zirconium (Zr), and REEs into solution. Decomposition techniques that employ HF account for 9.9 percent of AGDB3 analyses. Partial-digestion acid solution methods such as aqua regia or hot HNO_3, and partial fusion methods (9.6 percent of AGDB3 analyses) are moderately effective for some elements but ineffective for others. Most analytical methods are designed for the detection of one or a specific suite of elements and employ decomposition techniques suitable for those elements at the expense of accurate determinations of other elements.

Analytical Instrumentation

The sensitivity and reliability of individual analytic instruments is another factor which affects the method's ranking in the "best values" rubric. The types of instruments most commonly used for analysis of Alaska samples are: (1) ES, 47.4 percent of the determinations, (2) NA, 17.4 percent, (3) AES, 15.2 percent, (4) XRF (X-ray fluorescence spectrometry), 7.9 percent, (5) MS, 5.5 percent, and (6) AA, 5.2 percent. For the determination of most elemental concentrations, NA, AES, MS, and XRF are more sensitive and more quantitative than ES which was usually employed as a scoping or summary semi-quantitative method of determination. In general, newer models of instruments are more sensitive than older ones, which matters in the case of NA as more than 85 percent of NA analyses in the AGDB3 are at least 35 years old. For some instruments, spectral interferences, background shifts, matrix effects, and mineralogical and other structural effects cause some element determinations to be less accurate than others. Analytical methods that use WDX spectrometers have developed modifications in sample decomposition, or correction factors that yield more accurate chemical determinations (Taggart and others, 1987).

Limits of Determination

The lower limit of determination (LLD) is the lowest quantity of a substance that can be distinguished from the absence of that substance within a stated confidence limit (Taggart, 2002). As an analytical method becomes more sensitive and can detect lower elemental concentrations, its LLD moves lower. One analytical method may have multiple LLDs for a single element due to preconcentration or dilution of a specific sample, improved sensitivity as newer models of instruments are used, varying dates of analysis for the same method, or different analytical laboratories using varying procedures for the same analytical method. The presence of interfering elements also can affect the LLD. Upper limits of detection are the highest quantity of an analyte that can be determined within a stated confidence limit without further dilution of the digestate. The methods and procedures of USGS, DGGS, and USBM laboratories and their contracted laboratories reported in AGDB3 are comparable, since contract laboratories are held to the agencies' quality assurance and quality control standards as well as to those of the contract laboratories.

Review of Analytical Methods

A thorough understanding of all USGS analytical protocols used over the past 50 years was crucial in verifying the chemical analytical data in the AGDB. Publications describing analytical methods used by the USGS since the 1950s were compiled (see table **AnalyticMethod_Biblio** in the AGDB3), and chemists knowledgeable in various methods were frequently queried through phone calls, emails, and personal visits. These efforts were continued when developing the AGDB2 to capture the details of analytical methods and rank methods on an element by element basis. In December 2011, USGS emeritus chemists James G. Crock, Paul J. Lamothe, and Richard M. O'Leary, representing more than 110 cumulative years of USGS operational and research chemistry (1970 through 2012) along with senior author Matthew Granitto, systematically ranked all the AGDB species and elements by the quality of the analytical methods used. This ranking was refined and contributed significantly to the creation of the AGDB2 "best values" subset. The review of analytical methods was greatly expanded in the Global Geochemical Database for Critical Metals in Black Shales (Granitto and others, 2017) which included geochemical data from the laboratories of various national and international scientific agencies, universities, and private corporations. For the AGDB3, the analytical methods used to produce the NURE, DGGS, USBM, and BLM data sets have been researched in the publications that sourced the geochemical data of these agencies and have been evaluated and integrated with those methods listed in the AGDB2. These publications are listed in the AGDB3 table **Agency_Biblio**, and the assistance of USGS research geologist Alan E. Koenig was instrumental in evaluating the numerous cases where sufficient analytical method information was lacking.

"Best Value" Ranking Tables

The review of analytical methods discussed above resulted in a series of tables (**BestValue_Rank.xlsx**) which rank, from best to least preferred, the analytical methods that produced the "best values" for each element within the AGDB3. The ranking for each element contains two subsets—methods that employ "total" decomposition techniques (for example, rated as "01") are listed above, and separate from methods that use partial decomposition techniques (for example, "P01"). The method ranking tables are compiled in the AGDB3 as the table **Parameter_Rank**.

The method ranking tables for each element contain the same field names (column headers). *SPECIES* is the symbol, abbreviation or name of the chemical entity for which samples have been analyzed, and *SPECIES_NAME* is its name. Analytical method data in the fields *TECHNIQUE*, *DIGESTION*, and sometimes *DECOMPOSITION* from the AGDB3 chemistry data tables **Chem_A_Cs**, **Chem_Cu_Ru**, and **Chem_S_Zr Zr** (henceforth, known as the chemistry data tables) are compiled to create *ANALYTIC_METHOD* which contains the short name of the analytical method as used in the AGDB3. *PARAMETER* is a concatenation of the fields *SPECIES*, *UNITS* and *ANALYTIC_METHOD* from the chemistry data tables. *BESTVALUE_RANK* is the numeric ranking of the analytical methods used in the determination of each species. *NONDETECT_RANGE* contains the range of non-detect values for the analytical method. Wherever the species concentration is lower than the LLDs of the method used, yielding a negative value entry in the *QUALIFIED_VALUE* field of the chemistry data tables, the *NONDETECT_RANGE* value is the negative value of the LLD for that method. Non-detect values of a method vary due to sample preconcentration or dilution, instrumental sensitivity, the laboratory performing analyses, or the date of analysis. Non-detect ranges in parentheses represent approximately 90 percent of the non-detects in the AGDB3 for that analytical method species combination. Non-detect ranges such as "<0.28" for the parameter Al_pct_MS_AR_P (aluminum, expressed in weight percent and determined by MS after partial digestion in aqua regia) indicate that no non-detects were encountered, and that 0.28 percent was the lowest detected value in the AGDB3 for that particular analytical method and species. Other non-detect ranges such as "1.0 – 2.0 – 2.0 – 2.0 – 5.0" for Ag_ppm_FA_AA (silver, expressed in parts per million [ppm], and determined by fire assay with an atomic absorption finish) indicate that when sorted, the 5th percentile non-detect value is 1.0 ppm, the 25th, 50th and 75th percentile values are 2.0 ppm, and the 95th percentile value is 5.0 ppm. The field *LLD_RANGE* is the range of LLDs reported in agency publications or in-house laboratory manuals and does not represent actual analytical determinations in the AGDB3. The entry "na" indicates that no published LLD was found for the analytical method and species. *NONDETECT_RANK* is the ranking of LLD entries in *LLD_RANGE.* No distinction is made between methods employing total or partial digestion, and *NONDETECT_RANK* reflects only the sensitivity of the

method in recognizing the presence of the species. The field *COUNT* contains the total number of determinations of each species in the AGDB3 by the analytical method listed. Further method information is available in the field *ANALYTIC_METHOD_DESC* of the **AnalyticMethod** table.

Characteristics of the Relational Database

Because of the scope and complexity of the Alaska geologic materials analyzed, a tabular relational database which contains both field site and sample observations and laboratory analyses was designed for data storage. The AGDB3 was constructed in Microsoft Access 2016 as an archive and a tool to be used for data synthesis and analysis. The database structure and format are a modification of that used by the NGDB because more than 85 percent of the USGS data were originally retrieved from the NGDB (Smith and others, 2003).

Contents

The AGDB3 (4.2 gigabytes) is composed of nine linked databases, AGDB3_Geol.accdb, AGDB3_Chem_A_Cs.accdb, AGDB3_Chem_Cu_Ru.accdb, AGDB3_Chem_S_Zr.accdb, AGDB3_BV_A_Cr.accdb, AGDB3_BV_Cs_Lu.accdb, AGDB3_BV_Mg_Sb.accdb, AGDB3_BV_Sc_Zr.accdb, and AGDB3_BV_WRMajors.accdb to accommodate the Microsoft Access limitation of 2 gigabytes for a single database, 256 data fields for a single table, and 6 kilobytes of data for a single record. Data are contained in 19 tables, which are described in table 1 of this report pamphlet. The 11 primary database tables contain quantitative analytical results, sample data, field site information, and geologic and mineralogic data. Analytical method information and analytical method bibliography lookup tables provide references for quantitative results. A reference table of field name definitions and a Federal Geographic Data Committee (FGDC) metadata record can assist the user in understanding the names and content of database fields. In this report, names of tables cited are in boldface; field names within tables are italicized.

Structure

AGDB3 data are contained in 11 primary tables, **Geol_AllSpls**, **Geol_DeDuped**, **Chem_A_Cs**, **Chem_Cu_Ru**, **Chem_S_Zr**, **BV_A_Cr**, **BV_Cs_Lu**, **BV_Mg_Sb**, **BV_Sc_Zr**, **BV_WRMajors**, and **Mineralogy**, and relationships are defined to link these tables (fig. 4). This structure provides for efficient storage of information and for data verification. Data may be extracted from the AGDB3 to meet specific user needs by constructing user-defined queries. Relationships between these tables are depicted as lines in figure 4 and are defined in appendix 4.1.

Geol_DeDuped is the central table of the database and is linked to **Geol_AllSpls** by the common field *AGDB_ID* in a one-to-one so that all records in **Geol_DeDuped** are also in **Geol_AllSpls**. Relationships between **Geol_DeDuped** and other tables in the AGDB3 are shown in figure 4. **Geol_AllSpls** contains 396,343 records but 26,945 of them represent samples in the AGDB3 that have been reanalyzed. For these samples, the original and the reanalyzed data might coexist because the samples were issued a second laboratory identification number on submission for reanalysis, effectively creating a second data record in the database, and as many as five. For these samples with multiple records, the attributes of these duplicate records have been compiled into a single record, producing the table **Geol_DeDuped** with 369,398 records. **Geol_DeDuped** and **Geol_AllSpls** have 59 fields describing sample sites and the sample material collected at each site. Each analyzed sample has a unique *AGDB_ID*, as well as a *FIELD_ID* that is a field identifier assigned by the sample collector. *FIELD_ID* may have been corrected by the data renovator due to truncation of data entry or modified to promote list sorting. *AGDB_ID* is a unique identifier assigned to each record by the database designer, and it is the key field that links the sample to its chemical, physical and mineralogical data in chemistry data, best value and mineralogy tables. *LAB_ID* is a unique identifier that was assigned to each submitted USGS sample by the Sample Control officer that received the sample. Duplicate records are reanalyzed samples that have entries in one or more of the *PREV_LAB_ID* fields that can be linked back to *LAB_ID* entries in **Geol_AllSpls**. *NURE_REC_NO* is a unique identifier that was assigned to each NURE sample record by NURE database compiler Steven M. Smith (Smith, 1997). NURE samples that have been reanalyzed by the USGS (6,478) also have *LAB_ID* entries. *DGGS_ID* is a unique identifier adapted from the DGGS *SAMPLE ID* or *Sample No* (DGGS Staff, 2017). DGGS, BLM and most USBM samples have a *DGGS_ID*, and 1,471 samples reanalyzed by the DGGS have *PREV_DGGS_ID* entries. USBM and BLM samples also have *DGGS_IDs* as their data sets were made digital and published by the DGGS (Blessington and others, 2016; Reioux and others, 2016).

SUBMITTER contains names of scientists who submitted the samples to laboratories for analysis. This is not necessarily the sample collector but may be the name of the agency responsible for sample submittal (NURE), or the names of authors who first published the data (DGGS, USBM, and BLM). *PROJECT_NAME* contains the names of projects, at times derived from a project account number, of work groups funded for the collection and analysis of submitted samples. The project names of the DGGS, USBM, and BLM were not recorded in the DGGS database and are absent here. Dates of sample submission and collection are stored in the *DATE_SUBMITTED* and *DATE_COLLECT* fields; fewer than 27 percent of samples have a collection date recorded. Sample submittal dates for NURE, DGGS, USBM, and BLM samples is the estimated end of the field season for that year. *LATITUDE* and *LONGITUDE* contain the geographic

Table 1. List of tables in Alaska Geochemical Database Version 3.0 (AGDB3)

Table name	Type	Description	Primary key field	Fields	Records
Geol_AllSpls	Primary	Spatial, geologic and descriptive attributes for geologic material samples; includes records for both original and resubmitted samples; in database AGDB3_Geol.accdb	*AGDB_ID*	57	396,343
Geol_DeDuped	Primary	Spatial, geologic and descriptive attributes for geologic material samples; data for resubmitted samples are compiled with original samples; in database AGDB3_Geol.accdb	*AGDB_ID*	57	369,398
Chem_A_Cs	Primary	All chemical data—acid insoluble residue through cesium–compiled for geologic material samples; in database AGDB3_Chem_A_Cs.accdb	*CHEM_A_Cs_ID*	17	4,612,275
Chem_Cu_Ru	Primary	All chemical data—copper through ruthenium–compiled for geologic material samples; in database AGDB3_Chem_Cu_Ru.accdb	*CHEM_Cu_Ru_ID*	17	5,108,474
Chem_S_Zr	Primary	All chemical data—sulfur through zirconium–compiled for geologic material samples; in database AGDB3_Chem_S_Zr.accdb	*CHEM_S_Zr_ID*	17	4,732,735
BV_A_Cr	Primary	"Best value" chemical data—acid soluble residue through chromium–for geologic material samples; in database AGDB3_BV_A_Cr.accdb	*AGDB_ID*	74	369,398
BV_Cs_Lu	Primary	"Best value" chemical data—cesium through lutetium–for geologic material samples; in database AGDB3_BV_Cs_Lu.accdb	*AGDB_ID*	101	369,398
BV_Mg_Sb	Primary	"Best value" chemical data—magnesium through antimony–for geologic material samples; in database AGDB3_BV_Mg_Sb.accdb	*AGDB_ID*	98	369,398
BV_Sc_Zr	Primary	"Best value" chemical data—scandium through zirconium–for geologic material samples; in database AGDB3_BV_Sc_Zr.accdb	*AGDB_ID*	71	369,398
BV_WRMajors	Primary	"Best value" chemical "whole rock" data for rock samples; major elements expressed as oxides; in database AGDB3_BV_WRMajors.accdb	*AGDB_ID*	65	26,018
Mineralogy	Primary	Mineralogy data for non-magnetic heavy mineral concentrate samples; in database AGDB3_Geol.accdb	*LAB_ID*	25	18,138
Parameter	Primary-lookup	Analytical method parameters used to obtain chemical and physical data; in database AGDB3_Geol.accdb	*PARAMETER*	4	1,302
Parameter_Rank	Primary-lookup	Analytical method parameters, sorted by species and ranked by preference (best value); in database AGDB3_Geol.accdb	*PARAMETER*	9	1,302
AnalyticMethod	Primary-lookup	Analytic methods used to obtain chemical and physical data; in database AGDB3_Geol.accdb	*ANALYTIC_METHOD*	4	114
AnalyticMethod_Biblio	Primary-lookup	References for analytic methods used to obtain chemical data; in database AGDB3_Geol.accdb	*ANALYTIC_METHOD_PUB_ID*	7	507
LabName	Primary-lookup	Laboratories, agencies or organizations that performed chemical analysis; in database AGDB3_Geol.accdb	*LAB_NAME*	2	55
Agency_Biblio	Primary-lookup	References for agency publications linked to chemical data; in database AGDB3_Geol.accdb	*PUBL_ID*	5	200
MineralName	Reference	Mineral names and their abbreviations used in Mineralogy table; in database AGDB3_Geol.accdb	*MNRL_ABBRV*	2	126
DataDictionary	Reference	Field name descriptions for all tables in the database; in database AGDB3_Geol.accdb	*FIELD_NAME*	8	480

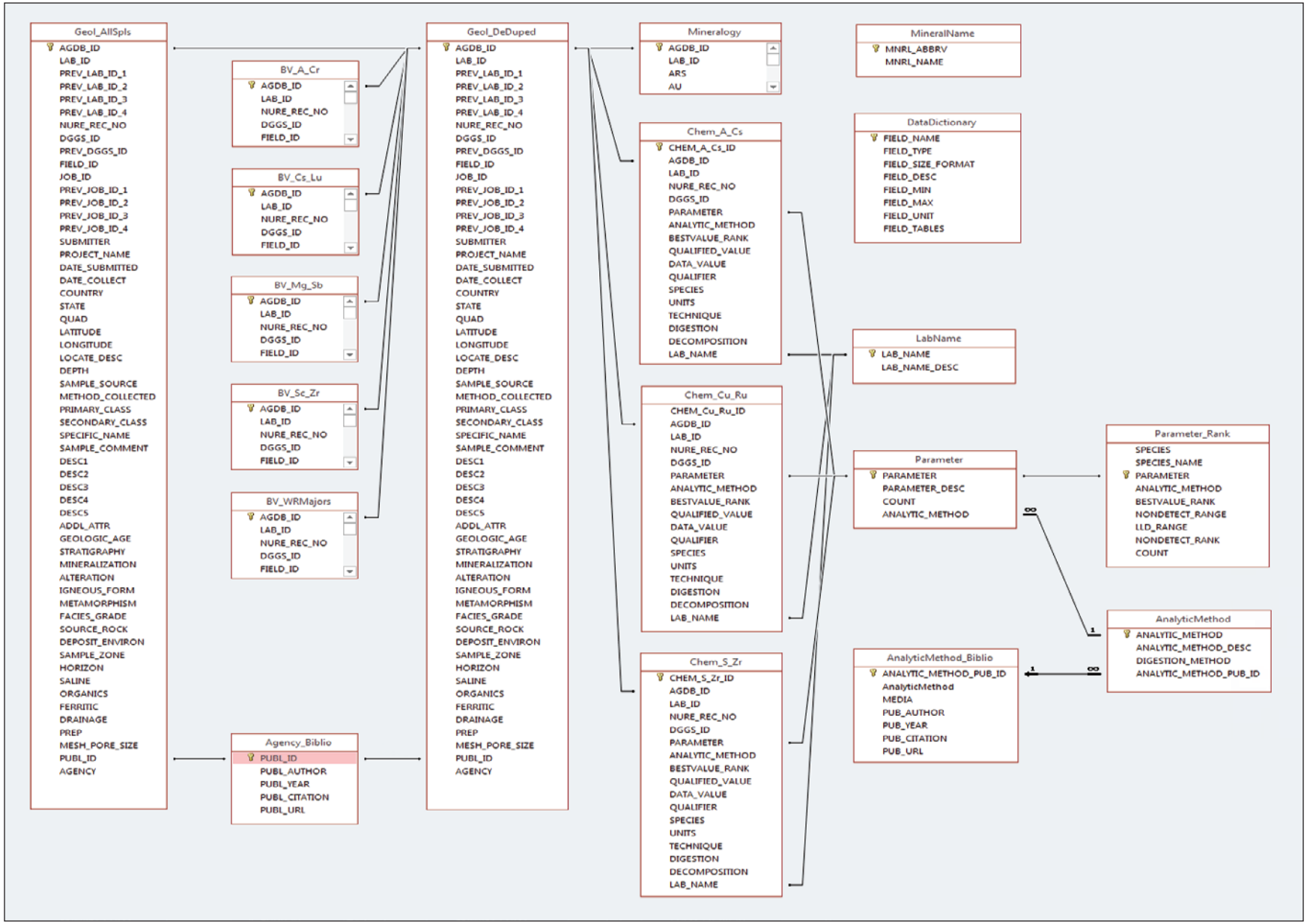

Figure 4. Table relationships in the Alaska Geochemical Database Version 3.0 (AGDB3)

coordinates, whose precision is set at 0.0001 degree using World Geodetic System 1984 (WGS84) datum and spheroid. The precision encountered in agency data sets varies from the nearest degree to less than a millionth of a degree. In the AGDB3, most spatial data for samples collected prior to the use of global positioning system (GPS) devices in the mid-1990s are inferred to have been in North American Datum of 1927 (NAD27), though this was seldom recorded in archive data sets. Most records do not include datum information. Known and assumed NAD27 locations have been transformed to WGS84 datum. Further discussion of spatial data issues is provided in appendix 3 of the AGDB (Granitto and others, 2011). *PRIMARY_CLASS* defines the type of sample medium; *SECONDARY_CLASS* and *SPECIFIC_NAME* provide more detail about the sample medium. Media type is carefully noted so that data from different sample types are not mistakenly equated. For example, AGDB3 contains copper analyses for multiple subsamples (described in *SPECIFIC_NAME)* derived from one sediment sample site (for example, bulk sediment of various size-fractions, and their panned concentrate fractions of various magnetic susceptibilities). *SAMPLE_COMMENT* is an attribute used to modify *PRIMARY_CLASS*, *SECONDARY_CLASS*, or *SPECIFIC_NAME*. *DESC1*, *DESC2*, *DESC3*, *DESC4*, and *DESC5* also modify these three fields but only for DGGS database samples, as indicated by the field *AGENCY* that is linked to the table **Agency_Biblio** by the field *PUBL_ID*. Information regarding the collection and preparation of the sample is found in *METHOD_COLLECTED*, *PREP*, and *MESH_PORE_SIZE*. Most of the *LAB_ID* entries are samples entered in the USGS laboratory information management system, archived in the NGDB (Smith and others, 2003).

The chemistry data tables **Chem_A_Cs**, **Chem_Cu_Ru**, and **Chem_S_Zr** contain 14,453,484 records in 17 fields with laboratory and field analytical measurements, expressed as numeric values. These data are compiled in three linked databases due to the size limitations of MS Access 2016. Central table **Geol_DeDuped** is linked to **Chem_A_Cs**, **Chem_Cu_Ru**, and **Chem_S_Zr** by the common field *AGDB_ID* (fig. 4). Therefore, all chemical values have corresponding sample information in **Geol_DeDuped**. This is a one-to-many relationship; that is, a single sample may have many analytical results (for example, different elements, same element by multiple methods, and so forth). *CHEM_A_Cs_ID*, *CHEM_Cu_Ru_ID* and *CHEM_S_Zr_ID* are the unique identifiers assigned to each measurement in the chemistry data tables and are key fields of software-assigned integers. Measurements in the chemistry data tables consist of a numeric *DATA_VALUE* and an optional *QUALIFIER*. *QUALIFIER* entries include "<" or "N," meaning that the element was not detected at concentrations above the lower limit of determination for the method; "L," meaning that the element was detected, but at concentrations below the lower limit of determination for the method; and ">" or "G," meaning that the element was measured at a concentration greater than the upper limit of determination for the method. *QUALIFIED_VALUE* presents the chemical values in a machine-readable format and was populated by combining the data in *DATA_VALUE* with its complement in *QUALIFIER*, according to the following conventions: *DATA_VALUE* entries that are accompanied by "<," "N," or "L" entries in *QUALIFIER* are represented in *QUALIFIED_VALUE* as negative numbers (for example, "-2"); and *DATA_VALUE* entries that are accompanied by ">" or "G" entries in *QUALIFIER* are represented in *QUALIFIED_VALUE* as values with 0.00111, 0.01111 or 0.11111 added to them (for example, >0.25 becomes 0.25111, >0.5 becomes 0.51111, and >10 becomes 10.11111).

Measurement characteristics such as units and analytical techniques are identified using a *PARAMETER* code, which is a concatenation of data from the fields *SPECIES*, *UNITS* and *ANALYTIC_METHOD*. Data from the fields *TECHNIQUE*, *DIGESTION*, and *DECOMPOSITION* were used to create the 112 analytical method codes that populate *ANALYTIC_METHOD*. For example, the parameter "Sb_ppm_AA_F_HNO3_P" represents the concentration of antimony, expressed in parts per million, as detected by flame atomic absorption spectrometry after a partial digestion (dissolution) with HNO_3. *PARAMETER* is a 25-character-length field that contains a method summary that can be used as a column name in a data report or spreadsheet. Each species in the AGDB3 has one unit of expression, so that species such as the noble metals that often have multiple units of expression are expressed in parts per million in the AGDB3, and the major elements are expressed in weight percent.

The chemical and physical data of the chem tables have been used to compile the "best value" tables **BV_A_Cr**, **BV_Cs_Lu**, **BV_Mg_Sb**, **BV_Sc_Zr**, and **BV_WRMajors** (henceforth, known as the "best value" tables). The data are presented in multiple tables due to the 255-field limit and 6-kilobyte record limit of Access software. These data are derived from all the determinations in the chemistry data tables of the AGDB3 and are presented in "best value" format. Central table **Geol_DeDuped** is linked to the "best value" tables by the common field *AGDB_ID* since chemical values cannot exist without corresponding sample information in **Geol_DeDuped** (fig. 4). This is a one-to-one relationship; that is, a single sample record in **Geol_DeDuped** has one or more analytical results in the chemical data tables. In **BV_A_Cr**, the best analyses for acid-insoluble residue through chromium (Cr) are reported for all samples. Data for major elements aluminum (Al) and calcium (Ca) are reported in this table as elemental concentrations. **BV_Cs_Lu** includes data for cesium (Cs) through lutetium (Lu) for all samples. Data for major elements iron (Fe) and potassium (K) are reported in this table as elemental concentrations. **BV_Mg_Sb** includes data for magnesium (Mg) through Sb for all samples. Data for major elements Mg, manganese (Mn), sodium (Na), and phosphorous (P) are reported in this table as elemental concentrations. **BV_Sc_Zr** includes data for Sc through Zr for all samples. Data for major elements silicon (Si) and Ti are reported in this table as elemental concentrations. **BV_WRMajors** contains whole-rock data for samples, most of which are rock. This data set was compiled of samples with quantitative values

for all 10 major elements. For these samples, major element chemical determinations are expressed as oxide concentrations and fields are named accordingly (for example, *Al2O3_pct_WDX_Fuse* rather than *Al_pct_WDX_Fuse)*. *AGDB_ID*, the key field of the "best value" tables, is described above.

The "best value" tables contain fields of the type "*Species_ppm*" (for example, *Ag_ppm*) that contain the "best value" for the species entered as qualified values from the *QUALIFIED_VALUE* field of the chemistry data tables. The "best value" tables contain fields of the type "*Species_AM*" (for example, *Ag_AM*) which include the abbreviated name of the analytical method used to determine the "best value" for the species. These are the same methods and names found in the AGDB3 chemistry data tables, **AnalyticMethod**, **Parameter** and **Parameter_Rank**. The "best value" tables also contain fields of the type "*Species_ppm_ALL*" (for example, *Ag_ppm_ALL*) that concatenate in order from best method to least, all available values and their respective analytical methods for the species and sample. For example, sample AGDB_ID 62306 (LAB_ID C437308) has a *Ag_ppm_ALL* entry "32, MS_ST; 50, ES_SQ_1; 28, AA_F_AZ_H2O2_P_1." This indicates that the best value for Ag in this sample is 32 ppm by MS_ST, the second best value is 50 ppm by ES_SQ, and the third best value is 28 ppm by AA_F_AZ_H2O2_P. Descriptions of all analytical methods are found in the **AnalyticMethod** table. All determinations in the chemistry data tables are contained in these "*Species_ppm_ALL*" fields of the "best value" tables.

The Mineralogy table contains 25 fields with optical mineralogical data for 18,138 nonmagnetic heavy-mineral concentrate samples. These fields record the occurrence of 18 discrete ore-related minerals; *NORM* field indicates that no ore-related minerals were observed. Details and ore-related minerals beyond the 18 are recorded in *OreRelatedMnrl_Comment*; data regarding rock-forming minerals are in *RockFormingMnrl_Comment*. Appendix 2 lists the mineral name abbreviations in **Mineralogy**. Central table **Geol_DeDuped** is linked to **Mineralogy** by the common field *AGDB_ID* in a one-to-one relationship; that is, every sample with mineralogical data has geospatial and sample media data in **Geol_DeDuped** (fig. 4). More than 75 percent of these data were generated by former USGS mineralogist Richard B. Tripp (deceased) from1975 through 2009 in support of various USGS mineral resource assessment projects. Mineralogic data were originally recorded in hardcopy with mineral abundances variously reported as: (1) "present" or "not present," (2) "abundant" or "moderate" or "trace" or "absent," (3) as a percentage or as a percentage range, or (4) as numbers of mineral particles. The field *Inferred_Comment* contains R.B. Tripp's comments based on chemical analyses and previous USGS map publications, and those that were noted during the Federal Lands in Alaska–Geologic Studies project (2007–2009) for samples that had been hand ground or consumed during analysis. Appendix 3 contains a bibliographic list of these USGS map publications as well as other USGS publications containing relevant mineralogical information.

AnalyticMethod, **Parameter**, **Parameter_Rank**, **AnalyticMethod_Biblio**, and **LabName** are reference tables in the AGDB3. **AnalyticMethod** is a lookup table with additional information on the 112 field and laboratory techniques used for analysis of the various geologic materials. **AnalyticMethod** includes a description of the methods and relevant published references and is linked by *ANALYTIC_METHOD_PUB_ID* to references in **AnalyticMethod_Biblio**. In the chemistry data tables, details of sample preparation methods are found in *DECOMPOSITION*, and *LAB_NAME* indicates the laboratory or work group responsible for the analysis. **Parameter** is a lookup table of analytical method parameters used to describe measurement characteristics of chemical and physical data and is linked by *PARAMETER* to the chemistry data tables. There are 1,302 unique parameters in the AGDB3. The **Parameter_Rank** table contains the ranking of analytical method parameters of the AGDB3 listed by species and is linked by *ANALYTIC_METHOD* to the **AnalyticMethod** table, and by *PARAMETER* to the **Parameter** table. The **LabName** table names laboratories, agencies or organizations that performed chemical analyses and is linked to the chem data tables by *LAB_NAME*. The **DataDictionary** table contains the field name, size, definition, and general data type of the 481 fields used in the AGDB3 tables as well as the names of tables in which these fields appear. The minimum and maximum values of numeric fields are also recorded in **DataDictionary**. Relationships between chemical data tables and all other tables in the AGDB3 are shown in figure 4.

Other Data Formats

To serve a wider audience of potential users of the AGDB3, the geospatial and chemical data have been exported from Access tables into comma-delimited ASCII files (.txt) that may be used by various applications (table 2).

Relational databases can be implemented using a variety of proprietary or nonproprietary software packages. This can be done by using the field relationships between tables depicted in figure 4 and described in appendix 4 to join the comma-delimited ASCII files. AGDB3 data are reported here in proprietary (Microsoft Office Access 2016) and nonproprietary (ASCII comma-delimited) formats.

"Best Value" Data Population

The AGDB3 "best value" chemical data tables were populated element by element with chemical determinations and corresponding analytical method data from the chemistry data tables of the AGDB3 using Microsoft Access select and update queries. Though an analytical method may determine multiple species concentrations, each species in the AGDB3 was ranked individually to consider the many factors that have been mentioned in the section Determining "Best Value" Rankings (sample size, decomposition, instrument used,

Table 2. List of comma-delimited ASCII files containing data from Alaska Geochemical Database Version 3.0 (AGDB3).

File name	Information contained in file
Geol_AllSpls.txt	Spatial, geologic and descriptive attributes for geologic material samples; includes records for both original and resubmitted samples
Geol_DeDuped.txt	Spatial, geologic and descriptive attributes for geologic material samples; data for resubmitted samples are compiled with original samples
Chem_A_Cs.txt	All chemical data—Acid insoluble residue through cesium—Compiled for geologic material samples
Chem_Cu_Ru.txt	All chemical data—Copper through ruthenium—Compiled for geologic material samples
Chem_S_Zr.txt	All chemical data—Sulfur through zirconium—Compiled for geologic material samples
BV_A_Cr.txt	"Best value" chemical data—Acid soluble residue through chromium—For geologic material samples
BV_Cs_Lu.txt	"Best value" chemical data—Cesium through lutetium—For geologic material samples
BV_Mg_Sb.txt	"Best value" chemical data—Magnesium through antimony—For geologic material samples
BV_Sc_Zr.txt	"Best value" chemical data—Scandium through zirconium—For geologic material samples
BV_WRMajors.txt	"Best value" chemical "whole rock" data for rock samples
Mineralogy.txt	Mineralogy data for non-magnetic heavy mineral concentrate samples
Parameter.txt	Analytical method parameters used to obtain chemical and physical data
Parameter_Rank.txt	Analytical method parameters sorted by species and ranked by preference (best value)
AnalyticMethod.txt	Analytical methods used to obtain chemical and physical data
AnalyticMethod_Biblio.txt	References for analytical methods used to obtain chemical data
LabName.txt	Laboratories, agencies or organizations that performed chemical analysis
Agency_Biblio.txt	References for agency publications linked to chemical data
MineralName.txt	Mineral names and their abbreviations used in Mineralogy file
DataDictionary.txt	Field name descriptions for all files derived from the database

limits of detection, interferences, method complexity, and so forth). Using Ag (silver) as an example, the process of "best value" data population is described here. The "best value" analytical method ranking table for Ag (Ranking of Analytical Methods used in the Determination of Silver in the file Best-Value_Rank.xlsx) was used for reference (fig. 5). The AGDB3 fields to be populated with Ag data in the table **BV_A_Cr** are *Ag_ppm*, *Ag_AM*, and *Ag_ppm_ALL*.

Detected Values

The first criterion used to select best values is detected values (*QUALIFIED_VALUE* >0) by analytical methods using "total" digestion techniques. These methods correspond to "best value" rank 01 through 24 in the *BESTVALUE_RANK* field of the ranking table for silver. Rank 01 corresponds to 128 FA_GV determinations (fire assay with a gravimetric finish) for Ag in the **Chem_A_Cs** table. The detected values of this data set were populated from *QUALIFIED_VALUE* to *Ag_ppm*, the corresponding analytical method from *ANALYTIC_METHOD* to *Ag_AM*, and the concatenations of the value and method populated in *Ag_ppm_ALL*. Ranks 02 through 24 were then populated in sequence but each in the following order: (1) if *Ag_ppm* is not null (has already been populated), then populate *Ag_ppm_ALL* with its existing concatenation entry followed by a semi-colon and the new concatenation; and (2) if *Ag_ppm* is null (has yet to be populated), the population scheme of rank 01 is repeated. In this way, the "best value" is reported and all other values are entered as well. The second set of values to be populated contains detected values by analytical methods employing partial digestion techniques and was executed in the same manner as ranks 01 through 24. These partial digestion methods correspond to "best value" rank P01 through P12 in the *BESTVALUE_RANK* field of the ranking table for silver. This second step was skipped for species that didn't employ partial digestion techniques. Best value ranks that are missing in figure 5 are "total" or partial digestion methods that were not used in the determination of Ag in these Alaska samples. After populating the field *Ag_ppm* in **BV_A_Cr**, it was checked for "best values" that are greater than the upper limit of determination (ULD) for the analytical method used. These ULD values in *Ag_ppm* end in ".11111." If these were accompanied in *Ag_ppm_ALL* by values that are not ULD values and are higher concentrations of Ag, these non-ULD values were substituted in *Ag_ppm* as they reflect a higher and more accurate concentration of Ag.

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Ranking of Analytical Methods used in the Determination of Silver

SPECIES	SPECIES_NAME	PARAMETER	ANALYTIC_METHOD	BESTVALUE_RANK	NONDETECT_RANGE	LLD_RANGE	NONDETECT_RANK	RANK_COUNT
Ag	silver	Ag_ppm_FA_GV	FA_GV	01	< 0.1	< 0.1	33	128
Ag	silver	Ag_ppm_FA_AES	FA_AES	02	0.1	0.1 - 0.4	05	740
Ag	silver	Ag_ppm_FA_AA	FA_AA	03	1.0 - 2.0 - 2.0 - 2.0 - 5.0	0.1 - 6.86	32	541
Ag	silver	Ag_ppm_FA_NA	FA_NA	04	< 0.2		08	4
Ag	silver	Ag_ppm_MS_AZ_HF	MS_AZ_HF	06	0.08		09	35
Ag	silver	Ag_ppm_AES_HF_AG	AES_HF_AG	07		1	23	32
Ag	silver	Ag_ppm_AES_AZ_HF	AES_AZ_HF	08		0.5	16	557
Ag	silver	Ag_ppm_EDX	EDX	09	1.0	1.0	24	64372
Ag	silver	Ag_ppm_MS_ST	MS_ST	10	1.0	1.0	22	7712
Ag	silver	Ag_ppm_MS_HF	MS_HF	12	0.02 - 1.0 - 1.0 - 2.0 - 3.0	0.5 - 2.0	25	8492
Ag	silver	Ag_ppm_MS_Fuse	MS_Fuse	14		0.5	15	582
Ag	silver	Ag_ppm_DCP_Fuse	DCP_Fuse	15		0.5	13	286
Ag	silver	Ag_ppm_AES_HF	AES_HF	16	2.0 - 2.0 - 2.0 - 2.0 - 4.0	2.0	31	25290
Ag	silver	Ag_ppm_NA_LC	NA_LC	17	2.0	1.0	28	3619
Ag	silver	Ag_ppm_ES_Q	ES_Q	20	0.5 - 1.0 - 1.0 - 1.0 - 4.0	0.2 - 1.0	26	455
Ag	silver	Ag_ppm_EDX_Slab	EDX_Slab	21	10	< 10	37	259
Ag	silver	Ag_ppm_AA_F_HF	AA_F_HF	22	0.1 - 1.0 - 2.0 - 2.0 - 3.0	0.2	30	625
Ag	silver	Ag_ppm_ES_SQ	ES_SQ	24	0.5 - 0.5 - 0.5 - 1.0 - 1.0	0.1 - 4.0	21	212433
Ag	silver	Ag_ppm_AES_AZ_P	AES_AZ_P	P01	0.045 - 0.067 - 0.067 - 0.08 - 0.08	0.045 - 0.08	03	17376
Ag	silver	Ag_ppm_MS_AR_P	MS_AR_P	P02	0.05	na	02	1601
Ag	silver	Ag_ppm_AA_F_AR_P	AA_F_AR_P	P03		0.1 - 0.5	11	19149
Ag	silver	Ag_ppm_AA_F_AZ_H2O2_P	AA_F_AZ_H2O2_P	P04	0.05 - 0.2 - 4.0 - 20 - 40	0.1	36	3044
Ag	silver	Ag_ppm_AA_F_AZ_Fuse_P	AA_F_AZ_Fuse_P	P06	0.05 - 0.05 - 0.1 - 0.1 - 0.1	0.1	04	278
Ag	silver	Ag_ppm_AA_F_AZ_HCl_P	AA_F_AZ_HCl_P	P07	0.1	0.05	06	205
Ag	silver	Ag_ppm_AA_F_HNO3_P	AA_F_HNO3_P	P08	0.05 - 0.2 - 0.2 - 0.5 - 0.5	0.5 - 1.0	12	2969
Ag	silver	Ag_ppm_DCP_AR_P	DCP_AR_P	P09	0.5		17	48
Ag	silver	Ag_ppm_AES_Acid_P	AES_Acid_P	P11		na	19	102
Ag	silver	Ag_ppm_AES_AR_P	AES_AR_P	P12	0.2 - 0.3 - 0.3 - 0.6 - 1.2	na	18	19909

Figure 5. "Best value" analytical method ranking table for silver used in the Alaska Geochemical Database Version 3.0 (AGDB3).

Non-Detected Values

The third set of values to be populated contains non-detect values (*QUALIFIED_VALUE* <0). The analytical methods for these values correspond to non-detect rank 02 through 37 in the *NONDETECT_RANK* field of the ranking table for silver. As before, non-detect ranks that are missing in figure 5 are "total" or partial digestion methods that were not used in the determination of Ag in these Alaskan samples. Rank 02 corresponds to 1,601 MS_AR_P determinations for Ag in the **Chem_A_Cs** table. The non-detect values in this data set were populated from *QUALIFIED_VALUE* to *Ag_ppm*, the analytical method from *ANALYTIC_METHOD* to *Ag_AM*, and the concatenations of the value and method populated in *Ag_ppm_ALL*. Ranks 02 through 37 were then populated in ascending order, but each in the following order: (1) if *Ag_ppm* is not null (has already been populated), then populate *Ag_ppm_ALL* with its existing concatenation entry followed by a semicolon and the new concatenation; and (2) if *Ag_ppm* is null (has yet to be populated), the population scheme of rank 02 is repeated.

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Database References

Within the database, references are cited for analytical methods that were used to determine elemental concentrations in the chemical data tables. Information regarding the method of analysis or measurement used to obtain data is found in **AnalyticMethod_Biblio** (table 1). Refer to the *ANALYTIC_METHOD_PUB_ID* when researching the analytical method in question.

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Appendix 1. Analytical Methods

Appendix 1 contains a table of analytical method names and descriptions of the analytical techniques that provided the chemical data of the Alaska Geochemical Database version 3.0 (AGDB3).

Table A1.1. Alaska Geochemical Database Version 3 (AGDB3) analytical methods.

[MIBK, methyl isobutyl ketone; $K_2S_2O_7$, potassium pyrosulfate; HCL-KI, hydrochloric acid-potassium iodide; H_2O_2, hydrogen peroxide; $LiBO_2/Li_2B_4O_7$, lithium metaborate/lithium tetraborate; HBr-Br, hydrobromic acid-bromine; HF, hydrofluoric acid; HNO_3, nitric acid; $KClO_3$, potassium chlorate; Na_2O_2, sodium peroxide; $HClO_4$, perchloric acid; HNO_3, nitric acid; H_2SO_4, sulfuric acid; $KMnO_4$, potassium permanganate; KOH, potassium hydroxide; $NaHSO_4$, Sodium bisulfate; H_2SiF_6, fluorosilicic acid; Na_2CO_3, sodium carbonate; ZnO, zinc oxide; PbO, lead oxide; NiS, nickel sulfide; H_3PO_4, phosphoric acid; FeO, iron oxide; Cu-Mo-Ni-P-Pb-W-Zn, copper-molybdenum-nickel-phosphorous-lead-tungsten-zinc; Sb, antimony; °C, degrees Centigrade; pH, potential of hydrogen; aka, also known as]

Analytic Method	Description
AA_CV	Mercury by cold-vapor atomic absorption spectrometry after multi-acid digestion and solution.
AA_CV_AR	Mercury by cold-vapor atomic absorption spectrometry after digestion with aqua regia and solution.
AA_F_Acid_P	Nickel and zinc by flame atomic absorption spectrometry after partial digestion with acid.
AA_F_AR	Mercury by flame atomic absorption spectrometry after digestion with aqua regia and solution.
AA_F_AR_P	Major and minor elements by flame atomic absorption spectrometry after partial digestion with hot aqua regia.
AA_F_AZ_Fuse_P	Silver, arsenic, bismuth, cadmium, copper, molybdenum, lead, antimony and zinc by flame atomic absorption spectrometry after partial digestion by $K_2S_2O_7$ fusion, HCl-KI, and selective organic extraction with 336-MIBK.
AA_F_AZ_H2O2_P	Silver, arsenic, bismuth, cadmium, copper, molybdenum, lead, antimony and zinc by flame atomic absorption spectrometry after partial digestion with HCl-H_2O_2 and selective organic extraction with 336-MIBK.
AA_F_AZ_HCl_P	Silver, arsenic, bismuth, cadmium, antimony and zinc by flame atomic absorption spectrometry after partial digestion by HCl-KI, and selective organic extraction with 336-MIBK.
AA_F_Fuse	Major and minor elements by flame atomic absorption spectrometry after $LiBO_2/Li_2B_4O_7$ fusion digestion.
AA_F_Fuse_P	Molybdenum by flame atomic absorption spectrometry after $K_2S_2O_7$ fusion, partial acid digestion, and selective organic extraction with 336-MIBK.
AA_F_HBr	Gold and tellurium by flame atomic absorption spectrometry after HBr-Br_2 digestion and selective organic extraction with 336-MIBK.
AA_F_HCl_OE_P	Antimony by flame atomic absorption spectrometry after partial digestion with HCl and selective organic extraction with 336-MIBK.
AA_F_HCl_P	Copper and manganese by flame atomic absorption spectrometry after partial digestion with HCl.
AA_F_HF	Major, minor and trace elements by flame atomic absorption spectrometry after multi-acid digestion with HF.
AA_F_HNO3_P	Silver, arsenic, bismuth, cadmium, cobalt, copper, nickel, lead and zinc by flame atomic absorption spectrometry after partial digestion with hot HNO_3.
AA_F_KClO3_P	Bismuth, antimony and tin by flame atomic absorption spectrometry after partial digestion with $KClO_3$.
AA_F_ST	Tin by flame atomic absorption spectrometry after Na_2O_2 sinter digestion.
AA_FE	Sodium and potassium by flame emission spectrometry (flame photometry) after HF-$HClO_4$ dissolution or $LiBO_2$ fusion.
AA_GF_AR_P	Gold, palladium and platinum by graphite furnace atomic absorption spectrometry after partial digestion with hot aqua regia.
AA_GF_HBr	Gold and tellurium by graphite furnace atomic absorption spectrometry after HBr-Br2 digestion and selective organic extraction with 336-MIBK.
AA_GF_HF	Gold, indium, lead, antimony, tellurium and thallium by graphite furnace atomic absorption spectrometry after multi-acid digestion with HF and selective organic extraction with 336-MIBK.

Table A1.1. Alaska Geochemical Database Version 3 (AGDB3) analytical methods.—Continued

[MIBK, methyl isobutyl ketone; $K_2S_2O_7$, potassium pyrosulfate; HCL-KI, hydrochloric acid-potassium iodide; H_2O_2, hydrogen peroxide; $LiBO_2/Li_2B_4O_7$, lithium metaborate/lithium tetraborate; HBr-Br, hydrobromic acid-bromine; HF, hydrofluoric acid; HNO_3, nitric acid; $KClO_3$, potassium chlorate; Na_2O_2, sodium peroxide; $HClO_4$, perchloric acid; HNO_3, nitric acid; H_2SO_4, sulfuric acid; $KMnO_4$, potassium permanganate; KOH, potassium hydroxide; $NaHSO_4$, Sodium bisulfate; H_2SiF_6, fluorosilicic acid; Na_2CO_3, sodium carbonate; ZnO, zinc oxide; PbO, lead oxide; NiS, nickel sulfide; H_3PO_4, phosphoric acid; FeO, iron oxide; Cu-Mo-Ni-P-Pb-W-Zn, copper-molybdenum-nickel-phosphorous-lead-tungsten-zinc; Sb, antimony; °C, degrees Centigrade; pH, potential of hydrogen; aka, also known as]

Analytic Method	Description
AA_GF_ST	Thallium by graphite furnace atomic absorption spectrometry after Na_2O_2 sinter, HCl-HNO_3 dissolution, and selective organic extraction with DIBK.
AA_HG_Acid	Selenium by flow injection or continuous flow hydride generation-atomic absorption spectrometry after digestion with HNO_3-HCl-H_2SO_4-$KMnO_4$.
AA_HG_AR	Arsenic, bismuth, antimony and tin by flow injection or continuous flow hydride generation-atomic absorption spectrometry after digestion with aqua regia.
AA_HG_HF	Arsenic, antimony, selenium and tellurium by flow injection or continuous flow hydride generation-atomic absorption spectrometry after multi-acid digestion with HF.
AA_HG_ST	Arsenic and antimony by flow injection or continuous flow hydride generation-atomic absorption spectrometry after Na_2O_2 sinter digestion.
AA_TR	mercury by thermal release and atomic absorption spectrometry after multi-acid digestion (Vaughn-McCarthy method).
AES_Acid_P	Major and minor elements by inductively coupled plasma-atomic emission spectrometry after unknown partial acid digestion.
AES_AR_P	Major, minor and trace elements by inductively coupled plasma-atomic emission spectrometry after partial digestion with aqua regia.
AES_AZ_HF	Silver, cadmium, cobalt, copper, lithium, molybdenum, nickel, lead, scandium and zinc by inductively coupled plasma-atomic emission spectrometry after digestion with HF-HCl-HNO_3-$HClO_4$.
AES_AZ_P	Silver, arsenic, gold, bismuth, cadmium, copper, molybdenum, lead, antimony and zinc by inductively coupled plasma-atomic emission spectrometry after partial digestion with HCl-H_2O_2.
AES_Fuse	Major and minor elements by inductively coupled plasma-atomic emission spectrometry after fusion digestion.
AES_HF	Major, minor and trace elements by inductively coupled plasma-atomic emission spectrometry after digestion with HF-HCl-HNO_3-$HClO_4$.
AES_HF_AG	Silver, arsenic, chromium, copper, nickel, phosphorus, lead, sulfur and zinc in ore-grade samples by inductively coupled plasma-atomic emission spectrometry after digestion with HF-HCl-HNO_3-$HClO_4$.
AES_HF_REE	Rare earth elements by ion exchange and inductively coupled plasma-atomic emission quantitative spectrometry after HF-HCl-HNO_3-$HClO_4$ digestion.
AES_IE	Molybdenum, niobium and tungsten by inductively coupled plasma-atomic emission quantitative spectrometry after HF-HCl-HNO_3-$HClO_4$ digestion and ion exchange separation.
AES_ST	Major and minor elements by inductively coupled plasma-atomic emission spectrometry after Na_2O_2 sinter digestion.
AFS_CV	Mercury by flow injection-cold vapor-atomic fluorescence spectrometry after HNO_3-HCl digestion.
CB_CHN	Carbon, hydrogen and nitrogen by gas chromatography/thermal conductivity (CHN elemental) analyzer after combustion.
CB_HCl	Organic carbon by infrared detection after combustion and digestion with HCl.
CB_IRC	Forms of carbon and sulfur by infrared detection after combustion.
CB_TC	Total carbon by thermal conductivity detection after combustion.
CB_TT	Sulfur and sulfate by iodometric titration after combustion.
CM_Acid	Bromine by colorimetry after acid digestion.
CM_Acid_P	Arsenic, copper, molybdenum, nickel, lead and zinc by modified Gutzeit apparatus confined-spot method colorimetry after partial digestion in KOH-HCl and chemical separation (As), or colorimetry after partial digestion in acid.
CM_EL	Copper, nickel, silicon and vanadium by colorimetry after acid(?) digestion and electrolytic separation.

Table A1.1. Alaska Geochemical Database Version 3 (AGDB3) analytical methods.—Continued

[MIBK, methyl isobutyl ketone; $K_2S_2O_7$, potassium pyrosulfate; HCL-KI, hydrochloric acid-potassium iodide; H_2O_2, hydrogen peroxide; $LiBO_2/Li_2B_4O_7$, lithium metaborate/lithium tetraborate; HBr-Br, hydrobromic acid-bromine; HF, hydrofluoric acid; HNO_3, nitric acid; $KClO_3$, potassium chlorate; Na_2O_2, sodium peroxide; $HClO_4$, perchloric acid; HNO_3, nitric acid; H_2SO_4, sulfuric acid; $KMnO_4$, potassium permanganate; KOH, potassium hydroxide; $NaHSO_4$, Sodium bisulfate; H_2SiF_6, fluorosilicic acid; Na_2CO_3, sodium carbonate; ZnO, zinc oxide; PbO, lead oxide; NiS, nickel sulfide; H_3PO_4, phosphoric acid; FeO, iron oxide; Cu-Mo-Ni-P-Pb-W-Zn, copper-molybdenum-nickel-phosphorous-lead-tungsten-zinc; Sb, antimony; °C, degrees Centigrade; pH, potential of hydrogen; aka, also known as]

Analytic Method	Description
CM_Fuse	Major and minor elements by colorimetric spectrophotometry after fusion digestion.
CM_Fuse_P	Copper, molybdenum, nickel, phosphorus, lead, antimony, tungsten and zinc by colorimetry after partial digestion by $K_2S_2O_7$ fusion (Cu-Mo-Ni-P-Pb-W-Zn), or $NaHSO_4$ fusion-HCl digestion (Sb, rhodamine B).
CM_HClO4_P	Arsenic by colorimetry after partial digestion by $HClO_4$.
CM_HF	Major and minor elements by colorimetric spectrophotometry after multi-acid digestion with HF.
CM_HNO3_P	Copper, molybdenum, lead and zinc by colorimetry after partial digestion with HNO_3.
CM_HSF	Fluoride by colorimetric spectrophotometry after H_2SiF_6 digestion and chemical separation.
CM_PC_P	Uranium by paper chromatography after partial digestion with HNO_3.
CM_ST	Chloride by colorimetric spectrophotometry after Na_2CO_3 and ZnO sinter digestion.
CM_ST_P	Tungsten by colorimetry after partial digestion with carbonate sinter.
CP	Forms of carbon, iron and sulfur by computation.
DCP_AR_P	Silver, boron, beryllium, cadmium, copper, germanium, manganese, nickel, lead, vanadium and zinc by direct current plasma-atomic emission spectrometry after partial digestion with hot aqua regia.
DCP_Fuse	Major and minor elements by direct current plasma-atomic emission spectrometry after fusion digestion.
DCP_HF	Major elements by direct current plasma-atomic emission spectrometry after multi-acid digestion with HF.
DCP_ST	Tin by direct current plasma-atomic emission spectrometry after Na_2O_2 sinter.
DN	Uranium and thorium by delayed neutron activation counting.
EDX	Major, minor and trace elements by energy-dispersive X-ray fluorescence spectrometry.
EDX_Slab	Major, minor and trace elements in a polished rock slab by energy-dispersive X-ray fluorescence spectrometry.
ES_Q	Major, minor and trace elements by quantitative emission spectrography.
ES_SQ	Major, minor and trace elements by semi-quantitative visual 6-step or direct-reader emission spectrography.
FA_AA	Silver, gold, chromium, iron, tin and platinum group elements by graphite furnace atomic absorption spectrometry after PbO fire assay chemical separation.
FA_AES	Silver, gold and platinum group elements by inductively coupled plasma-atomic emission spectrometry after PbO fire assay chemical separation.
FA_AES_AG	Gold in ore-grade samples by inductively coupled plasma-atomic emission spectrometry after PbO fire assay chemical separation and aqua regia digestion.
FA_AFS	Gold, palladium and platinum by atomic fluorescence spectrometry after PbO fire assay chemical separation.
FA_DCP	Gold, palladium and platinum by direct current plasma-atomic emission spectroscopy after PbO fire assay chemical separation.
FA_ES	Gold and platinum group elements by direct-current arc quantitative emission spectrography after PbO fire assay chemical separation.
FA_GV	Silver, gold and platinum by gravimetry after PbO fire assay chemical separation.
FA_MS	Gold and platinum group elements by inductively coupled plasma-mass spectrometry after NiS fire assay chemical separation.
FA_MS_AG	Palladium and platinum in ore-grade samples by inductively coupled plasma-mass spectrometry after NiS fire assay chemical separation.
FA_NA	Gold and platinum group elements by instrumental neutron activation after PbO fire assay chemical separation.
FL_HF	Uranium by fluorometry after multi-acid digestion with HF.

Table A1.1. Alaska Geochemical Database Version 3 (AGDB3) analytical methods.—Continued

[MIBK, methyl isobutyl ketone; $K_2S_2O_7$, potassium pyrosulfate; HCL-KI, hydrochloric acid-potassium iodide; H_2O_2, hydrogen peroxide; $LiBO_2/Li_2B_4O_7$, lithium metaborate/lithium tetraborate; HBr-Br, hydrobromic acid-bromine; HF, hydrofluoric acid; HNO_3, nitric acid; $KClO_3$, potassium chlorate; Na_2O_2, sodium peroxide; $HClO_4$, perchloric acid; HNO_3, nitric acid; H_2SO_4, sulfuric acid; $KMnO_4$, potassium permanganate; KOH, potassium hydroxide; $NaHSO_4$, Sodium bisulfate; H_2SiF_6, fluorosilicic acid; Na_2CO_3, sodium carbonate; ZnO, zinc oxide; PbO, lead oxide; NiS, nickel sulfide; H_3PO_4, phosphoric acid; FeO, iron oxide; Cu-Mo-Ni-P-Pb-W-Zn, copper-molybdenum-nickel-phosphorous-lead-tungsten-zinc; Sb, antimony; °C, degrees Centigrade; pH, potential of hydrogen; aka, also known as]

Analytic Method	Description
FL_HNO3	Selenium by fluorometry after digestion with HNO_3-H_3PO_4.
GRC	Uranium by gamma counting.
GV	Density, moisture, volume, weight, saturation by gravimetry; ash or loss on ignition by weight loss after heating at 900–930 degrees Celsius.
GV_Acid	Aluminum, calcium and magnesium by gravimetry after acid digestion.
GV_CR	Major, minor and trace elements by gravimetry for Classical (Standard) Rock Analysis after unknown digestion method.
GV_Flux	Moisture, bound water and total water by heating and weight loss with flux.
GV_Fuse	Potassium, sodium and silicon by gravimetry after fusion digestion.
GV_HF	Aluminum, calcium, magnesium by gravimetry after multi-acid digestion with HF.
IC_ST	Chloride, nitrate and sulfate by ion chromatography after sinter digestion.
INST	pH (potential of hydrogen) by standard method combination pH electrode.
ISE_Fuse	Chloride and fluoride by ion specific electrode after fusion digestion.
ISE_HF	Chloride by ion specific electrode after multi-acid digestion with HF.
MS_AR	Mercury by inductively coupled plasma-mass spectrometry after digestion with aqua regia.
MS_AR_P	Major and minor elements by inductively coupled plasma-mass spectrometry after partial digestion with aqua regia.
MS_AZ_HF	Silver, arsenic, gold, bismuth, cadmium, copper, molybdenum, lead, antimony and zinc by inductively coupled plasma-mass spectrometry after digestion with HF-HCl-HNO_3-$HClO_4$.
MS_Fuse	Minor and trace elements by inductively coupled plasma-mass spectrometry after $LiBO_2/Li_2B_4O_7$ fusion digestion.
MS_Fuse_REE	Rare earth and high field strength elements by inductively coupled plasma-mass spectrometry after $LiBO_2/Li_2B_4O_7$ fusion digestion.
MS_HF	Major, minor and trace elements by inductively coupled plasma-mass spectrometry after HF-HCl-HNO_3-$HClO_4$ digestion.
MS_ST	Minor and trace elements by inductively coupled plasma-mass spectrometry after Na_2O_2 sinter digestion.
MS_ST_REE	rare earth and high field strength elements by inductively coupled plasma-mass spectrometry after Na_2O_2 sinter digestion.
NA_LC	Major, minor and trace elements by long count instrumental neutron activation analysis.
NA_PG	Boron by prompt gamma instrumental neutron activation analysis.
NA_REE	Rare earth and high field strength elements by long count instrumental neutron activation analysis.
NA_SC	Major, minor and trace elements by short count instrumental neutron activation analysis.
TB_AR	Sulfide by turbidimetry after aqua regia digestion.
TT_AR_P	Zinc by titration after partial digestion with aqua regia.
TT_Flux	Total and bound water by Karl Fischer coulometric titration with flux after combustion.
TT_Fuse	Ferric iron as iron trioxide by titration after fusion, decomposition and precipitation.
TT_HCl	Carbonate carbon and carbon dioxide (acid soluble carbon) by coulometric titration after $HClO_4$ digestion and extraction.
TT_HF	ferrous oxide, calcium and lead by colorimetric or potentiometric titration after HF-H_2SO_4 (FeO) or multi-acid digestion with HF.

Table A1.1. Alaska Geochemical Database Version 3 (AGDB3) analytical methods.—Continued

[MIBK, methyl isobutyl ketone; $K_2S_2O_7$, potassium pyrosulfate; HCL-KI, hydrochloric acid-potassium iodide; H_2O_2, hydrogen peroxide; $LiBO_2/Li_2B_4O_7$, lithium metaborate/lithium tetraborate; HBr-Br, hydrobromic acid-bromine; HF, hydrofluoric acid; HNO_3, nitric acid; $KClO_3$, potassium chlorate; Na_2O_2, sodium peroxide; $HClO_4$, perchloric acid; HNO_3, nitric acid; H_2SO_4, sulfuric acid; $KMnO_4$, potassium permanganate; KOH, potassium hydroxide; $NaHSO_4$, Sodium bisulfate; H_2SiF_6, fluorosilicic acid; Na_2CO_3, sodium carbonate; ZnO, zinc oxide; PbO, lead oxide; NiS, nickel sulfide; H_3PO_4, phosphoric acid; FeO, iron oxide; Cu-Mo-Ni-P-Pb-W-Zn, copper-molybdenum-nickel-phosphorous-lead-tungsten-zinc; Sb, antimony; °C, degrees Centigrade; pH, potential of hydrogen; aka, also known as]

Analytic Method	Description
VOL	Carbon dioxide or carbonate carbon by evolution after acid decomposition; also known as “gasometric” or “manometric”.
VOL_HCl	Calcium carbonate and carbon dioxide by evolution after digestion with HCl.
WDX_Fuse	Major, minor and trace elements by wavelength-dispersive X-ray fluorescence spectrometry after $LiBO_2/Li_2B_4O_7$ fusion digestion.
WDX_PP	Major, minor and trace elements by wavelength-dispersive X-ray fluorescence spectrometry on pressed pellet samples.
WDX_PP_AG	Tin and tungsten by wavelength-dispersive X-ray fluorescence spectrometry on pressed pellet ore-grade samples.
WDX_Slab	Major, minor and trace elements in a polished rock slab by wavelength-dispersive X-ray fluorescence spectrometry.

Appendix 2. Mineral Name Abbreviations

Appendix 2 contains a table of abbreviations for mineral names used in the **Mineralogy** table of the Alaska Geochemical Database Version 3.0 (AGDB3).

Table A2.1. Mineral name abbreviations used in the Alaska Geochemical Database Version 3 (AGDB3).

[REE, rare earth elements; mnrls, minerals]

Abbreviation	Description
AB	Albite
AG	Silver
ALN	Allanite
AMG	Amalgam
AMP	Amphibole
AMP/PYX	Amphibole/pyroxene
AND	Andalusite
ANG	Anglesite
ANT	Anatase
APT	Apatite
ARG	Aragonite
ARS	Arsenopyrite
AU	Gold
AZR	Azurite
BAR	Barite
BI	Bismuth
BIO	Biotite
BIS	Bismuthinite
BLG	Boulangerite
BRK	Brookite
CAS	Cassiterite
CDT	Cordierite
CER	Cerussite
CHR	Chromite
CIN	Cinnabar
CLB	Columbite
CLN	Clinochlore
CLR	Chlorite
CONT	Contamination
COR	Corundum
CPY	Chalcopyrite
CR-D	Cr-diopside
CUP	Cuprite
CUS/O	Copper sulfide/copper oxide

Table A2.1. Mineral name abbreviations used in the Alaska Geochemical Database Version 3 (AGDB3).—Continued

[REE, rare earth elements; mnrls, minerals]

Abbreviation	Description
CYR	Cyrtolite
DUM	Dumortierite
ENG	Enargite
EPD	Epidote
FE/MN	Iron oxide/manganese oxide
FLR	Fluorite
FUC	Fuchsite
GAL	Galena
GAL/CER	Galena/cerussite
GAL/MIN	Galena/minium
GAR	Garnet
GHN	Gahnite
GRP	Graphite
HB	Hornblende
HMP	Hemimorphite
HMT	Hematite
ILM	Ilmenite
JAM	Jamesonite
KYN	Kyanite
LCX	Leucoxene
LIM	Limonite
LTH	Litharge
MAL	Malachite
MAR	Marcasite
MAS	Massicot
MGT	Magnetite
MIC	Mica
MIM	Mimetite
MIN	Minium
MLY	Molybdenite
MNZ	Monazite
MTZ	Metazeunerite
MUS	Muscovite
MUS/CLR	Muscovite/chlorite
NORM	No ore-related minerals
OL	Olivine
OL/SRP	Olivine/serpentine
ORP	Orpiment
PHN	Phenakite

Table A2.1. Mineral name abbreviations used in the Alaska Geochemical Database Version 3 (AGDB3).—Continued

[REE, rare earth elements; mnrls, minerals]

Abbreviation	Description
POW	Powellite
PRS	Proustite
PYC	Pyrochlore
PYH	Pyrrhotite
PYM	Pyromorphite
PYR	Pyrite
PYR/ARS	Pyrite/arsenopyrite
PYR/MAR	Pyrite/marcasite
PYX	Pyroxene
Q/F	Quartz/feldspar
Q_FE	Iron stained quartz
QTZ	Quartz
R1	Rock fragments–graphitic
R2	Rock fragments–grey
R3	Rock fragments–chloritic
R4	Rock fragments–tan
R5	Rock fragments–pelitic
R6	Rock fragments–pyritic
REE-M	REE-rich mnrls
RLG	Realgar
RUC	Rucklidgeite
RUT	Rutile
RUT/ANT	Rutile/anatase
RUT/ANT/BRK	Rutile/anatase/brookite
RUT/BRK	Rutile/brookite
RX	Rock fragments
SAF	Safflorite
SAP	Sapphire
SCH	Scheelite
SCH/POW	Scheelite/powellite
SIL	Sillimanite
SLF	Sulfide
SMA	Smaltite
SMI	Smithsonite
SPH	Sphalerite
SPN	Sphene
SPN-REE	REE-rich sphene
SPN-TH	Thorium-rich sphene
SRC	Sericite

Table A2.1. Mineral name abbreviations used in the Alaska Geochemical Database Version 3 (AGDB3).—Continued

[REE, rare earth elements; mnrls, minerals]

Abbreviation	Description
SRP	Serpentine
STB	Stibnite
TET	Tetrahedrite
TH-M	Th-rich mnrls
THN	Thorianite
THR	Thorite
TPZ	Topaz
TRN	Tourmaline
URN	Uraninite
UTH	Uranothorite
WOL	Wolframite
WUL	Wulfenite
XEN	Xenotime
ZIR	Zircon

Appendix 3. Mineralogical Data References

Appendix 3 contains a bibliographic list of U.S. Geological Survey (USGS) map publications containing mineralogical information. Some of these publications have been cited in the field Inferred_Comment of the Mineralogy table in the Alaska Geochemical Database version 3.0 (AGBD3).

Allen, M.S., and Slaughter, K.E., 1990, Mineralogical data and sample locality map of nonmagnetic, heavy-mineral-concentrate samples collected from the eastern part of the Lime Hills quadrangle, Alaska: U.S. Geological Survey Open-File Report 90–67, 64 p. 1 pl., scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/ofr9067.

Bennett, G.J., and Church, S.E., 1987, Mineralogy and sample locality map of the nonmagnetic heavy-mineral-concentrate samples from the Mt. Katmai quadrangle and portions of the Naknek, Afognak, and Iliamna quadrangles, Alaska: U.S. Geological Survey Open-File Report 87–615, 39 p., accessed July 18, 2018, at https://doi.org/10.3133/ofr87615.

Bennett, G.J., Gray, J.E., and Taylor, C.D., 1988, Mineralogy and sample locality map of the nonmagnetic, heavy-mineral-concentrate samples, Iditarod quadrangle, Alaska: U.S. Geological Survey Open-File Report 88–32, 37 p., accessed July 18, 2018, at https://doi.org/10.3133/ofr8832.

Cathrall, J.B., Albanese, M., VanTrump, G., Jr., Mosier, E.L., and Lueck, L., 1989, Geochemical signatures, analytical results, mineralogical data, and sample locality map of placer and lode gold, and heavy-mineral concentrates from the Fortymile mining district, Eagle quadrangle, Alaska: U.S. Geological Survey Open-File Report 89–451, 32 p., l pl., accessed July 18, 2018, at https://doi.org/10.3133/ofr89451.

Cathrall, J.B., McDanal, S.K., VanTrump, G., Jr., Mosier, E.L., and Tripp, R.B., 1988, Analytical results, geochemical signatures, mineralogical data, and sample locality map of lode gold, placer gold, and heavy-mineral concentrates from the Tolovana mining district, Livengood quadrangle, Alaska: U.S. Geological Survey Open-File Report 88–578, 32 p., accessed July 18, 2018, at https://doi.org/10.3133/ofr88578.

Cathrall, J.B., Tripp, R.B., McDanal, S.K., Mosier, E.L., and VanTrump, G., Jr., 1988, Analytical results, geochemical signatures, mineralogical data, and sample locality map of placer gold, and heavy-mineral concentrates from the Circle mining district, Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 88–676, 48 p., accessed July 18, 2018, at https://doi.org/10.3133/ofr88676.

Church, S.E., and Bennett, G.J., 1990, Mineralogical maps showing the distribution of selected minerals identified in nonmagnetic heavy-mineral concentrates from the Mount Katmai and parts of the Afognak and Naknek quadrangles, Alaska: U. S. Geological Survey Miscellaneous Field Studies Map 2021–D, 1 sheet, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf2021D.

Frisken, J.G., Church, S.E., and Willson, W.R., 1988, Mineralogical map showing the distribution of selected ore-related minerals identified in nonmagnetic heavy-mineral concentrates from the Ugashik, Bristol Bay, and western Karluk quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 1539–H, 1 sheet, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf1539H.

Gray, J.E., Detra, D.E., Eppinger, R.G., Hill, R.H., Slaughter, K.E., and Sutley, S.J., 1990, Geochemical data and sample locality maps for stream-sediment and heavy-mineral-concentrate samples, and mineralogical data of nonmagnetic, heavy-mineral-concentrate samples, collected near five cinnabar-stibnite mineral occurrences in the Kuskokwim River region, southwestern Alaska: U.S. Geological Survey Open-File Report 90–299–A, 73 p., accessed July 18, 2018, at https://doi.org/10.3133/ofr90299A.

Gray, J.E., Detra, D.E., Eppinger, R.G., Hill, R.H., Slaughter, K.E., and Sutley, S.J., 1990, Geochemical data and sample locality maps for stream-sediment and heavy-mineral-concentrate samples, and mineralogical data of nonmagnetic, heavy-mineral-concentrate samples, collected near five cinnabar-stibnite mineral occurrences in the Kuskokwim River region, southwestern Alaska: U.S. Geological Survey Open-File Report 90–299–B, 1 disk (5¼ in.), accessed July 18, 2018, at https://doi.org/10.3133/ofr90299B.

Kelley, K.D., Frisken, J.G., and Sutley, S.J., 1993, Maps showing geochemistry and mineralogy of nonmagnetic heavy-mineral-concentrate samples from the southern part of the Chandler Lake quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 2144–B, 2 sheets, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf2144B.

Kelley, K.D., Mull, C.G., and Barton, H.N., 1995, Geochemistry and mineralogy of heavy-mineral concentrates from the Killik River 1 degree by 3 degrees quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 2225–D, 2 sheets, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf2225D.

King, H.D., Smith, S.C., and Werschky, S., 1989, Mineralogical maps showing the distribution and abundance of selected minerals in nonmagnetic heavy-mineral-concentrate samples from stream sediment, Solomon and Bendeleben 1 degree by 3 degrees quadrangles, Seward Peninsula, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 2071–C, 4 p., 1 sheet, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf2071C.

McDanal, S.K., Cathrall, J.B., Mosier, E.L., Antweiler, J.C., and Tripp, R.B., 1988, Analytical results, geochemical signatures, mineralogical data, and sample locality map of placer gold and heavy-mineral concentrates from the Manley Hot Springs, Tofty, Eureka, and Rampart mining districts, Tanana and Livengood quadrangles, Alaska: U.S. Geological Survey Open-File Report 88–443, 54 p., accessed July 18, 2018, at https://doi.org/10.3133/ofr88443.

Tripp, R.B., and Cathrall, J.B., 1983, Mineralogical map showing the distribution of selected minerals in non-magnetic fraction of heavy-mineral concentrates from stream sediments, Petersburg area, Southeast Alaska: U.S. Geological Survey Open-File Report 83–420–X, 1 sheet, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/ofr83420X.

Tripp, R.B., and Crim, W.D., 1978, Mineralogical map showing the distribution and abundance of gold, scheelite, chalcopyrite, arsenopyrite, minium and sapphire corundum in heavy-mineral concentrates in the Seward and Blying Sound quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 880–G, 2 sheets, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf880G.

Tripp, R.B., Crim, W.D., Hoffman, J.D., O'Leary, R.M., and Risoli, D.A., 1986, Mineralogical and geochemical maps showing the distribution of selected minerals and elements found in the minus-80-mesh stream-sediment and related minus-30-mesh heavy-mineral-concentrate samples from the Circle quadrangle, Alaska: U.S. Geological Survey Open-File Report 83–170–F, 7 p., 6 sheets, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/ofr83170F.

Tripp, R.B., Curtin, G.C., Day, G.W., O'Leary, R.M., and Carten, R.B., 1976, Maps showing mineralogical and geochemical data for heavy-mineral concentrates in the Tanacross quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 767–O, 2 sheets, scale 1:500,000, accessed July 18, 2018, at https://doi.org/10.3133/mf767O.

Tripp, R.B., Curtin, G.C., Nokleberg, W.J., Huston, D.L., and Hampton, J.R., 1993, Mineralogical maps showing distribution of selected ore-related minerals in the non-magnetic, heavy-mineral-concentrate fraction of stream sediment from the Mount Hayes 1 degree by 3 degrees quadrangle, eastern Alaska Range, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 1996–E, 13 p., 3 sheets, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf1996E.

Tripp, R.B., and Detra, D.E., 1980, Maps showing mineralogic data for selected minerals in nonmagnetic heavy-mineral concentrates of stream sediments in the Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 1053–I, 2 sheets, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf1053I.

Tripp, R.B., Carlson, R.C., and Curtin, G.C., 1978, Maps showing mineralogical data for nonmagnetic heavy-mineral concentrates in the Talkeetna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 870–I, 1 sheet, scale 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf870I.

Tripp, R.B., and King, H.D., 1993, Maps showing distribution of selected minerals in the nonmagnetic heavy-mineral fraction of stream-sediment samples, Medfra quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 2207, 1 sheet, scale, 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf2207.

Tripp, R.B., King, H.D., and Light, T.D., 1995, Mineralogical maps showing the distribution of ore-related minerals in the minus-30-mesh, nonmagnetic heavy-mineral fraction of stream sediment, Healy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map 2058–D, 2 sheets, scale, 1:250,000, accessed July 18, 2018, at https://doi.org/10.3133/mf2058D.

Appendix 4. Table of Field Relationships of the Alaska Geochemical Database Version 2.0 (AGDB3)

Table A4.1. Field Relationships of the Alaska Geochemical Database Version 3.0 (AGDB3).

Table	Shared Field	Relationship	Table
Geol_DeDuped	AGDB_ID	One-to-one	Geol_AllSpls
Geol_DeDuped	AGDB_ID	One-to-one	BV_A_Cr
Geol_DeDuped	AGDB_ID	One-to-one	BV_Cs_Lu
Geol_DeDuped	AGDB_ID	One-to-one	BV_Mg_Sb
Geol_DeDuped	AGDB_ID	One-to-one	BV_Sc_Zr
Geol_DeDuped	AGDB_ID	One-to-one	BV_WRMajors
Agency_Biblio	PUBL_ID	One-to-many	Geol_DeDuped
Agency_Biblio	PUBL_ID	One-to-many	Geol_AllSpls
Geol_DeDuped	AGDB_ID	One-to-one	Mineralogy
Geol_DeDuped	AGDB_ID	One-to-many	Chem_A_Cs
Geol_DeDuped	AGDB_ID	One-to-many	Chem_Cu_Ru
Geol_DeDuped	AGDB_ID	One-to-many	Chem_S_Zr
Parameter	PARAMETER	One-to-many	Chem_A_Cs
Parameter	PARAMETER	One-to-many	Chem_Cu_Ru
Parameter	PARAMETER	One-to-many	Chem_S_Zr
Parameter	PARAMETER	One-to-one	Parameter_Rank
LabName	LAB_NAME	One-to-many	Chem_A_Cs
LabName	LAB_NAME	One-to-many	Chem_Cu_Ru
LabName	LAB_NAME	One-to-many	Chem_S_Zr
AnalyticMethod	ANALYTIC_METHOD	One-to-many	Parameter
AnalyticMethod_Biblio	ANALYTIC_METHOD_PUB_ID	One-to-many	AnalyticMethod

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