Geochemical, Modal, and Geochronologic Data for 1.4 Ga A-type Granitoid Intrusions of the Conterminous United States

Data Series 942

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

Cover. Mesoproterozoic granite augen gneiss at Napias Creek, east-central Idaho (Photo by Karen Lund, U.S. Geological Survey)

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U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

Suggested citation:
du Bray, E.A., Holm-Denoma, C.S., San Juan, C.A., Lund, Karen, Premo, W.R., and DeWitt, Ed, 2015, Geochemical, modal, and geochronologic data for 1.4 Ga A-type granitoid intrusions of the conterminous United States: U.S. Geological Survey Data Series 942, 19 p., http://dx.doi.org/10.3133/ds942.

ISSN 2327-638X (online)

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Introduction

The purpose of this report is to present available geochemical, modal, and geochronologic data for approximately 1.4 billion year (Ga) A-type granitoid intrusions of the United States and to make those data available to ongoing petrogenetic investigations of these rocks. A-type granites, as originally defined by Loiselle and Wones (1979), are iron-enriched granitoids (synonymous with the ferroan granitoids of Frost and Frost, 2011) that occur in an anorogenic, within-continent setting. Relative to other granitic rocks, A-type granites have high FeO*/(FeO*+MgO), high K_2O and K_2O/Na_2O, are metaluminous to weakly peraluminous, and are enriched in incompatible trace elements. Loiselle and Wones (1979) further suggested that A-type granites are relatively anhydrous. Anderson (1983) provides an early compilation of data for the products of 1.4 Ga magmatism in North America and notes the spatial and temporal association of a trio of rock types, which includes gabbro to anorthosite, intermediate composition mangerite, and granitic rapakivi rocks. In North America, the majority of known A-type intrusions were emplaced between 1.5 and 1.3 Ga and are predominantly of the granitic variety (Anderson, 1983).

This report addresses the broadly Mesoproterozoic-age granitic rocks of the conterminous United States. Constituents of this group of intrusive rocks were defined using a variety of spatial, compositional, and geochronologic metrics. Thomas and others (2012) provided an updated synthesis, largely based on new isotopic and geochronologic data (for example, Fisher and others, 2010), for the large-scale geologic and tectonic evolution of the eastern United States. Their findings suggest that the basement rocks of the central and southern Appalachian region are allochthonous relative to the remainder of Laurentia and were accreted along the Grenville front between 1.25 and 1.0 Ga. Accordingly, Mesoproterozoic rocks east of the Grenville front and south of the approximate latitude of New York City do not represent North American magmatism. Consequently, geochemical, modal, and geochronologic data for these rocks are not included in the compilation described herein. Further, the structural styles and compositions of granitoid rocks east of the Grenville front, mostly highly deformed gneissic rocks, are dissimilar to those characteristic of the A-type granitoid rocks described herein.

A variety of compositional and age information further characterizes the 1.4 Ga A-type granitoid rocks in the conterminous United States. Most samples included in this compilation have felsic compositions, although some extend to intermediate compositions. SiO_2 contents range from 56 to almost 78 weight percent, and median and mean SiO_2 contents are 72.0 and 71.1 weight percent, respectively. The majority of these rocks for which modal data are available are composed of monzogranite (Streckeisen, 1976), although the dataset also contains many samples composed of granodiorite and syenogranite. A smaller group of the granitoid rocks in this dataset are composed of quartz monzodiorite and quartz monzonite, and a very small subset of samples is composed of alkali-feldspar granite, tonalite, alkali-feldspar quartz syenite, and quartz syenite (fig. 1). Many of the 1.4 Ga granitoid rocks are further characterized by medium- to coarse-grain size and are also conspicuously porphyritic; alkali feldspar phenocrysts or megacrysts (2–10 cm), often with rapakivi overgrowths, are a common feature of many of these rocks (Anderson, 1983; Anderson and Bender, 1989; Anderson and Cullers, 1978; Condie and Budding, 1979). The age of A-type magmatism in North America ranges from about 1.8 to 1.0 Ga, although Anderson (1983) suggests that more than 70 percent (by volume) of A-type magmatism in this region occurred between 1.49 and 1.41 Ga. In the conterminous United States, ages of A-type granitoid rocks are restricted to the period between about 1.49 and 1.33 Ga (Anderson, 1983; Bauer and Pollock, 1993; Bickford and Mose, 1975; Bickford, Harrower, and others, 1981; Bickford and others, 1989; Dewane and Van Schmus, 2007; Hoppe and others, 1983; Peterman and Hedge, 1968; Van Schmus and Bickford, 1981; Van Schmus and others, 1975). Using these recognition criteria, we identified A-type granitoid intrusions of the conterminous United States; for those intrusions, we compiled available geochemical, modal, isotopic (Sr and Nd) and geochronologic data for inclusion in the databases described herein.

The significance of 1.4 Ga granitoid rocks relative to the geologic evolution of the conterminous United States remains unclear, despite Anderson's (1983) compilation and synthesis

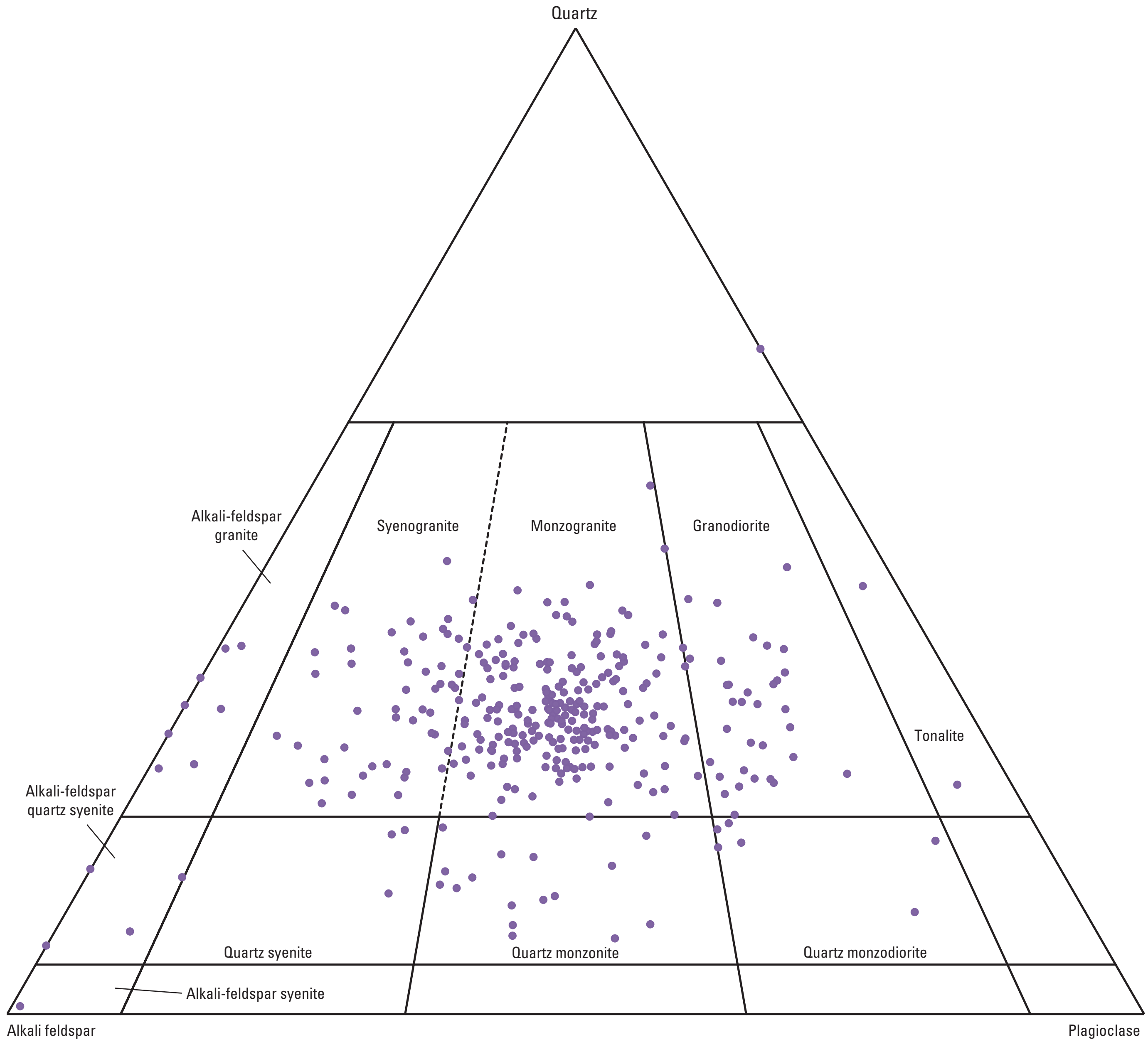

Figure 1. Quartz-alkali feldspar-plagioclase ternary diagram showing modal compositions (solid purple dots) of 1.4 Ga granitoid intrusions of the conterminous United States. Classification grid and rock names are those of Streckeisen (1976).

of compositional data pertinent to these rocks. The large-volume magmatic events indicated by these rocks, as well as their broad geographic distribution, tectonic significance, and association with mineral deposits, underscore their importance. The broad distribution of these rocks, from the northern midcontinent to the southwestern United States (in New Mexico, Arizona, California, and southernmost Nevada), throughout the Rocky Mountains in New Mexico and Colorado (and sporadically in southern Wyoming and central Idaho), and beneath much of the Plains region (as indicated by drilling), has led to the large-scale tectonic and magmatic processes responsible for genesis of the associated magmas being actively studied.

In addition, Kisvarsanyi (1972) suggests that iron-copper deposits in the St. Francois Mountains of southeastern Missouri are petrogenetically associated with 1.4 Ga A-type granitoids that occur in that region. Similarly, Dall'Agnol and others (2012) summarize important global associations between A-type granitoid rocks and a variety of important ore deposit types, particularly tin, high-field-strength elements (Zr, Hf, Nb, Ta), rare-earth elements, and iron oxide-copper-gold deposits. Consequently, the need to better understand relations between A-type granitoid rocks, tectonic setting, and magma petrogenesis, as well as their genetic associations with important types of ore deposits, suggests that developing a definitive geochemical, modal, and geochronologic database for these rocks in the conterminous United States is of considerable value.

Data Compilation Methods

Background documentation for some samples and (or) analytical data presented in this report may be incomplete, misleading, or incorrect, any of which could result in the inclusion of some inappropriate information in the database. Every effort has been made to exclude inappropriate samples and (or) misleading data; the amount of inappropriate data inadvertently included in the database is probably small and is unlikely to significantly adversely affect data interpretation.

Sample locations were determined from information provided in source publications or estimated from published descriptions. All location data has been converted to decimal degrees relative to the NAD27 datum.

The Map

An important goal of the effort described here was to develop an accurate and current portrayal of the spatial distribution of 1.4 Ga A-type granitoid intrusions in the conterminous United States. Among other potential uses, this map was required as a base on which to plot the locations of samples for which available geochemical, modal, and geochronologic data could be displayed.

As described by Stoeser and others (2005), the Mineral Resources Program of the U.S. Geological Survey created Geographic Information System (GIS)-compatible digital versions of existing State geologic maps. This process culminated in the State Geologic Map Compilation (SGMC; http://mrdata.usgs.gov/geology/state/), in which the information contained in these maps was recast using a consistent coding schema for lithologic and age parameters. Contents of the SGMC can be displayed and queried in the ArcGIS framework and constitute the primary information used to establish the distribution of 1.4 Ga A-type granitoid intrusions exposed at or near the surface in the conterminous United States. In order to identify constituent polygons within the SGMC that might represent 1.4 Ga A-type granitoid intrusions, all polygons coded as Mesoproterozoic intrusive rock were extracted. Metadata for the geologic component of ArcGIS files are embedded in the geospatial database and are also contained as a freestanding file (MetaDataIntrsAType1_4Ga.html).

The characteristics of each polygon defined by this process were further analyzed relative to the published literature and the framework provided by the National Geologic Map Database (NGMD) (U.S. Geological Survey, 2013). Each identified polygon within the SGMC that might represent 1.4 Ga A-type granitoid intrusions was compared to the contents of the NGMD to identify geologic maps more detailed than the State geologic map from which each Mesoproterozoic intrusive rock polygon was extracted. If available literature and the NGMD contents failed to yield information that confirmed a particular polygon's association (as described above in the Introduction) with 1.4 Ga A-type granitoid magmatism, then the associated polygon was identified as having an uncertain membership in the set of 1.4 Ga A-type granitoid intrusion polygons. For these polygons, in the associated ArcGIS database, "maybe" was entered in the Intrs1_4Ga field, and the Intrs_Name entry was set to Yg- followed by a locality name useful in establishing the geographic setting of each polygon (for example, Yg-Black Canyon is the potentially 1.4 Ga A-type granitoid intrusion at Black Canyon).

In some cases, information derived from the NGMD indicated that the rock in particular Mesoproterozoic intrusive rock polygons was demonstrably not associated with 1.4 Ga A-type granitoid magmatism. For these polygons, "no" was entered in the Intrs1_4Ga field, and the contents of the Intrs_Name field were modified to indicate the type of rock actually contained within these polygons. Alternatively, when literature-derived information and (or) larger scale geologic mapping identified by the NGMD contained sufficient information to definitively identify a polygon as having an age and composition appropriate for classification as a 1.4 Ga A-type granitoid intrusion, then the entry in the Intrs1_4Ga field was set to "yes," and the Intrs_Name entry was modified to a locality name appropriate to that intrusion.

Using the ArcGIS coding described above, primary data derived from the SGMC were modified to produce a map that differentiates three types of polygons: (1) those representative of 1.4 Ga A-type granitoid intrusions, (2) those representative of intrusions that are potentially members of the set of 1.4 Ga A-type granitoid intrusions, and (3) those that are not part of this set. Accordingly, the distribution of three types of polygons is displayed on plate 1.

Some SGMC polygons that delineate the geospatial distribution of 1.4 Ga A-type granitoid intrusions consist of more than a single pluton. Subdividing these polygons along contacts that delineate individual plutons is beyond the scope of the effort described here. However, recently completed resyntheses of available data for igneous rocks in the Colorado segment of the Rocky Mountains (Ed DeWitt, U.S. Geological Survey, written commun., 2013) allowed new or revised geospatial delineation of seven partially documented 1.4 Ga A-type granitoid intrusions in Colorado (the Twin Spruce, Mount Epworth, Mount Evans, Oak Creek, Custer Creek, and Apache Falls plutons and the Arizona stock). The distribution of 1.4 Ga A-type granitoid intrusions in Colorado derived from the SGMC was updated to incorporate this new knowledge. Otherwise, the digital geologic data included in our compilation of the distribution of 1.4 Ga A-type granitoid intrusions (plate 1) do not vary from primary data extracted from the SGMC.

Lithologic and age coding contained within the SGMC do not identify all known 1.4 Ga A-type granitoid intrusions. For example, the geochemical, modal, and geochronologic data presented here define the existence of 1.4 Ga A-type granite intrusions at Barrel Spring, Mountain Pass, and Parker Dam, which are all located in California. However, these intrusions were not identified using the Mesoproterozoic intrusive rock query relative to the contents of the SGMC. In addition, the scale of most State geologic maps (1:500,000) does not allow depiction of small intrusions. Consequently, the geochemical, modal, and geochronologic data presented here can also be used to augment knowledge of the spatial distribution of 1.4 Ga A-type granite intrusions in the conterminous United States.

Geochemical and Modal Data

Many significant investigations designed to acquire and compile compositional data for 1.4 Ga A-type granitoid intrusions in the conterminous United States preceded the present effort; these constitute significant contributions to the data compilation documented here. The publications that summarize the results of earlier data acquisition and compilation efforts are itemized as the sources tabulated in the Chem_Src field (table 1).

Original data source materials (subsequently referred to as sources), including published reports and theses, were used to add information to the database. For a sample to be included in the database, sample identification and a major oxide analysis were required, at a minimum. The existence of additional data was optional and was added, as available. Data were compiled using Microsoft Excel and can be accessed using software compatible with .xlsx files. The database release file (Appendix 1) is titled 1.4GaIntrsChemModData.xlsx. Altered samples were identified using standard geochemical criteria. Specifically, for the purposes of this compilation, altered samples are those with any of the following characteristics: SiO_2 abundances greater than or equal to 78 weight percent, Na_2O abundances greater than 6.5 weight percent or less than 0.5 weight percent, K_2O abundances greater than 10 weight percent (except ultrapotassic rocks from the Mountain Pass district, California), CO_2 concentrations greater than 0.35 weight percent, or total volatile concentrations greater than 3 weight percent. Samples with any of these characteristics probably do not preserve primary igneous rock compositions; consequently, the associated data were not included in the primary dataset.

In addition, samples with entries in the Total_I_pct field greater than 103 or less than 97 probably reflect inaccurate analyses; data for these samples were omitted from the primary dataset as well. Information for the unaltered samples is in Appendix 1; workbook tab labeled “Data.” Information for altered samples can be accessed via the workbook tab labeled “Alt” and can be used to evaluate the effects of alteration on primary rock compositions. Row entries in the derivative dataset for altered samples are sorted into subsets of samples that share the same alteration characteristics (indicated in red, at the top of each data row subset).

The locations of samples for which geochemical and modal data were compiled as part of this endeavor were combined with the ArcGIS map data (see metadata file, MetadataIntrsChemModal) to create a PDF file (PlateIntrsChemChron14Ga_24x18.PDF) (Plate 1). Metadata for the geochemical and modal components of ArcGIS files are embedded in the geospatial database and are also contained in a freestanding file (MetaDataChemModal.html). Sample location information for a small subset of samples either could not be established or was so imprecise that it was meaningless. Geochemical data for these samples were excluded from the primary compilation because, lacking a meaningful sample location, it is not possible to adequately characterize the type of intrusive rock represented by the associated sample. Data for these samples were removed from the primary compilation but can be accessed via the workbook tab labeled PoorLocSamps (in 1.4GaIntrsChemModData.xlsx).

Compiling analytical methods and associated estimates of precision and accuracy associated with the reported data is beyond the scope of this effort. Analytical protocols, precision, and accuracy were highly variable among sources. Fortunately, most sources document these parameters, and this type of documentation can be retrieved by referring to the appropriate data source.

Reference lists contained in the data sources were examined and used to identify additional potential data sources. In this way, data for 1,162 samples from 79 sources were identified and included in the database. This process has resulted in identification and incorporation of the majority of compositional data available for known samples of 1.4 Ga A-type granite intrusions of the conterminous United States.

Starting with original information extracted from the sources, the geochemical data were processed to enhance their usability. Specifically, all censored values were replaced by blank cells. Also, because different sources report iron concentrations determined by different analytical protocols, iron-abundance data required standardization. For some samples, abundances of both ferric and ferrous iron were reported in the source. In contrast, other sources report only total iron abundances as either Fe_2O_3 or FeO. In most samples, reported ferrous and ferric iron abundances are unlikely to represent magmatic values because of oxidation during late- to post-magmatic processes. Therefore, to facilitate meaningful comparison of oxide abundances, all iron abundances were converted to ferrous iron (reported in the FeO_pct column under the “Data” tab) and each major oxide analysis was recalculated to 100 percent on a volatile-free basis.

Modal data, the relative proportions of minerals in particular rock samples, have been determined for many 1.4 Ga A-type granitoid samples for which geochemical data are also available. These data are acquired by microscopic examination of (1) rock slabs stained to enhance identification of particular mineral species and (or) (2) thin sections; both types of examination involve point counting and recording the mineral present at each of a large number of pre-determined grid points. These data are a standard form of granitoid rock characterization and were included in many of the publications from which geochemical data for the 1.4 Ga A-type granitoid rocks were compiled. All modal data contained in the source publications are included in the data compilation (Appendix 1).

Geochronologic Data

The ages of approximately 1.4 Ga (roughly 1.5–1.35 Ga) A-type intrusive rocks were compiled in order to document the distribution of ages of these rocks in the conterminous United States. The database release file is titled 1.4GaIntrsGeochronData.xlsx (Appendix 2). The locations of samples for which geochronologic data were compiled were also combined with the ArcGIS data to create a map (PlateIntrsChemChron14Ga_24x18.PDF) (plate 1). Metadata for the geochronology component of the ArcGIS files are embedded in the geospatial database and are also contained in a freestanding file (MetaDataIntrsGeochron.html). Geochronologic data for samples from the mid-continent are largely derived from drill-core and well-cutting samples. Designations of most samples derived from wells are alpha-numeric identifiers that encode the State and county that contain the drill site as well as the associated drill hole number (Van Schmus and others, 1996). In addition, operator, well name, and location data were tabulated to catalog optimally accurate descriptions of sample source locations. Much of the data presented in the compilation has been included in numerous other compilations (for example, Van Schmus and others, 1996; Bickford and others, 2015); unfortunately, some sample names and descriptions presented in these syntheses do not replicate those in the publications where these data were first recorded. In the data compilation described here, the original data sources and most consistently used sample identifiers for samples derived by drilling were compiled to enhance the future usability of these data.

Most intrusion ages compiled in this database were determined by U-Pb zircon and by mineral and whole-rock Rb/Sr isochron geochronologic methods. However, ages of other samples were determined by Th-Pb (monazite), U-Pb (xenotime), and Sm/Nd isochron methods. In several instances, cell entries in the method field are given as “estimated.” These entries identify corresponding ages (in the Age field) determined by U-Pb zircon geochronology; however, associated analytical data have high uncertainties and knowledge of the local geologic context was used to refine the estimated age. When available, initial Sr and Sm/Nd radiogenic isotope data were also compiled. For instances in which Nd-depleted mantle model ages (field T_dm) were determined, a derivative termed ‘Delta Age’ (field Delta_Age) was calculated as the difference between the crystallization age (U-Pb zircon or Rb/Sr age) and the Nd depleted mantle model age. Calculated Nd model ages predict the time of “crustal extraction,” when significant fractionation of Sm/Nd from the mantle occurred (DePaolo and Wasserburg, 1976). The depleted mantle model age (T_{DM}) of DePaolo (1981) is based on studies of Proterozoic rocks in the Colorado Front Range, and is considered applicable to determinations of “crustal extraction” age, even for rocks with complicated geological histories. “Delta Age” is a proxy for the duration of lower crustal residency and thus constrains how juvenile the 1.4 Ga A-type source magmas were prior to granitoid crystallization.

To the extent possible, only those age determinations that are demonstrably reliable were included in the geochronology compilation. For example, ages for samples with initial Sr ratios greater than 0.7250 were rejected because these samples probably include a high proportion of radiogenically evolved crustal material that can contribute to spurious age determinations. Some areas that contain 1.4 Ga intrusions have been affected by fluids that mediated kilometer-scale isotopic homogenization (Das and others, 2004) resulting in modified Rb-Sr isotope systematics and altering ages determined for Mesoproterozoic igneous rocks of interest. Consequently, the potential influence of these types of processes has been carefully considered and the geochronologic compilation contains only primary crystallization ages that have been deemed reliable. Most Rb-Sr mineral and whole-rock ages determined prior to 1977 employed an Rb decay constant of 1.39×10^{-11} /year; however, since 1977, the most commonly used Rb decay constant used is 1.42×10^{-11} /year, as established by international convention (Steiger and Jäger, 1977). This database includes ages as reported in original source materials. Unless otherwise noted, Rb-Sr ages are as originally reported and have not been recalculated to account for the presently accepted Rb decay constant. Finally, samples with Rb/Sr less than 1 characteristically have Rb-Sr whole rock ages with large associated errors (typically greater than or equal to 10 percent). Most U-Pb zircon ages that have large errors (greater than 10 percent) reflect samples that have discordant analyses and (or) poor statistics along a discordia curve (for example, few data points or disturbed systematics).

The age of some intrusions has been determined from multiple samples and (or) from multiple minerals from a single sample. The geochronologic compilation presented here contains all published data. However, the database can be queried to filter age data by source and geochronologic method, which permits identifying the most meaningful age data for a given intrusion.

Data Fields

Geochemical, modal, isotopic, and geochronologic data are presented in columns or sets of related columns (Appendixes 1 and 2) in two Microsoft Excel 2010 workbooks (.xlsx format). The contents of Appendix 1 (data fields defined in table 1) include geochemical and modal data for analyzed samples. Appendix 2 (data fields defined in table 2) contains geochronologic data for 1.4 Ga A-type granites of the conterminous United States. Geochemical data in some worksheet cells may appear to be more precise than displayed values, but the implied precision is a misleading artifact of computational processes (for instance, recalculation to 100-percent volatile free) used to create data-cell contents. Blank cells in the worksheet appendixes indicate null values or that no data are available. In Appendix 1 (geochemical data), some blank cells reflect abundances that were reported as “less than the detection limit”; these values were replaced by blank cells to enable statistical analysis of the uncensored data.

Table 1. Definition and characterization of data fields included in Appendix 1 (geochemical and modal data).

FIELD_NAME	FIELD_DESCRIPTION
Field_Number	Field-assigned sample identifier; Field_Number entries link data for individual rows (for U.S. Geological Survey samples) to the National Geochemical Database
Intrs_Name	Formal or informal stratigraphic nomenclature for intrusion represented by sample
Shorthand	A brief name intended to facilitate reference to particular intrusions
Lithology	Sample composition according to the classification scheme of Streckeisen (1976); capitalized entries indicate compositions supported by modal data, whereas un-capitalized entries reflect compositional estimates
Ign_Form	Form (pluton, ring dike, batholith, plug, stock, sill, and so forth) of the igneous intrusion represented by each sample
Longitude	In decimal degrees, relative to the North American Datum of 1927. Locations with five significant figures are accurate within several meters; those with four significant figures are accurate within tens of meters; those with three significant figures are accurate within hundreds of meters; those with two significant figures are accurate within thousands of meters; those with one significant figure are accurate within tens of thousands of meters. Longitude is reported as a negative value (western hemisphere)
Latitude	In decimal degrees, relative to the North American Datum of 1927. Locations with five significant figures are accurate within several meters; those with four significant figures are accurate within tens of meters; those with three significant figures are accurate within hundreds of meters; those with two significant figures are accurate within thousands of meters; and those with one significant figure are accurate within tens of thousands of meters. Latitude is reported as a positive value (northern hemisphere)
SiO2_pct	Silicon, as silicon dioxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
TiO2_pct	Titanium, as titanium dioxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
Al2O3_pct	Aluminum, as aluminum trioxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
FeO_pct	Total iron, as ferrous oxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
MnO_pct	Manganese, as manganese oxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
MgO_pct	Magnesium, as magnesium oxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
CaO_pct	Calcium, as calcium oxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
Na2O_pct	Sodium, as sodium oxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
K2O_pct	Potassium, as potassium oxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
P2O5_pct	Phosphorus, as phosphorus pentoxide, in weight percent; based on major oxide data recalculated to 100 percent on a volatile-free basis
LOI_pct	Volatile content lost on ignition, in weight percent
H2Ob_pct	Structurally bound or essential water, in weight percent
H2Om_pct	Nonessential moisture, in weight percent
CO2_pct	Carbon dioxide, in weight percent
Cl_pct	Chlorine, in weight percent
F_pct	Fluorine, in weight percent
S_pct	Sulfur, in weight percent
Total_I_pct	Initial, pre-recalculation sum of oxide abundances, in weight percent
Volatile_pct	Total volatile content, in weight percent; calculated as the sum of moisture, bound water, carbon dioxide, chorine, fluorine, and sulfur or as the content lost on ignition

Table 1. Definition and characterization of data fields included in Appendix 1 (geochemical and modal data).—Continued

FIELD_NAME	FIELD_DESCRIPTION
Ba_ppm	Barium, in parts per million
Be_ppm	Beryllium, in parts per million
Cs_ppm	Cesium, in parts per million
Rb_ppm	Rubidium, in parts per million
Sr_ppm	Strontium, in parts per million
Y_ppm	Yttrium, in parts per million
Zr_ppm	Zirconium, in parts per million
Hf_ppm	Hafnium, in parts per million
Nb_ppm	Niobium, in parts per million
Th_ppm	Thorium, in parts per million
U_ppm	Uranium, in parts per million
Ga_ppm	Gallium, in parts per million
La_ppm	Lanthanum, in parts per million
Ce_ppm	Cerium, in parts per million
Pr_ppm	Praeseodymium, in parts per million
Nd_ppm	Neodymium, in parts per million
Sm_ppm	Samarium, in parts per million
Eu_ppm	Europium, in parts per million
Gd_ppm	Gadolinium, in parts per million
Tb_ppm	Terbium, in parts per million
Dy_ppm	Dysprosium, in parts per million
Ho_ppm	Holmium, in parts per million
Er_ppm	Erbium, in parts per million
Tm_ppm	Thulium, in parts per million
Yb_ppm	Ytterbium, in parts per million
Lu_ppm	Lutetium, in parts per million
Ag_ppm	Silver, in parts per million
Au_ppm	Gold, in parts per million
Co_ppm	Cobalt, in parts per million
Cr_ppm	Chromium, in parts per million
Ni_ppm	Nickel, in parts per million
Sc_ppm	Scandium, in parts per million
V_ppm	Vanadium, in parts per million
Cu_ppm	Copper, in parts per million
Mo_ppm	Molybdenum, in parts per million
Pb_ppm	Lead, in parts per million
Zn_ppm	Zinc, in parts per million

Table 1. Definition and characterization of data fields included in Appendix 1 (geochemical and modal data).—Continued

FIELD_NAME	FIELD_DESCRIPTION
Sn_ppm	Tin, in parts per million
W_ppm	Tungsten, in parts per million
Ta_ppm	Tantalum, in parts per million
As_ppm	Arsenic, in parts per million
Sb_ppm	Antimony, in parts per million
B_ppm	Boron, in parts per million
Chem_Src	Source of chemical data; for a few samples, data were culled from two or more sources; for example, major oxide data may have been compiled from one source and trace element data from another. Chem_Src entries are indexed to numbered entries below: 1. Lowell and others (2010) 2. Van Schmus and others (1993) 3. Cullers, R.L., unpublished data (2013) 4. Kisvarsanyi (1972) 5. Anderson and Cullers (1978) 6. Anderson and others (1980) 7. Anderson (1983) 8. Bickford, Sides, and Cullers (1981) 9. Evans, K.V., unpublished data (2013) 10. Enz and others (1979) 11. Flanagan (1973) 12. Hansen (1964) 13. Eggler (1968) 14. Kellogg, K.S., unpublished data (2013) 15. Silver and others (1981) 16. Condie and Budding, (1979) 17. Lanphere and others (1964) 18. Berg (1977) 19. Coney and Reynolds (1980) 20. Evans (1981) 21. Podruski (1979) 22. Anderson and Bender (1989) 23. Drewes (1976) 24. Dexter and others (1983) 25. Krieger (1965) 26. Banks (1980) 27. Hillesland (1982) 28. Davidson (1928) 29. Kessler (1976) 30. Krass (1980) 31. Kwok (1983) 32. Evans and Zartman (1990) 33. Lewis and Frost (2005) 34. Cullers and others (1992) 35. Edwards (1993) 36. Cullers and others (1981) 37. Anderson and Thomas (1985) 38. Bryant and others (2001) 39. Gleason and others (1994) 40. Gleason (1988) 41. Collier (1982) 42. Zielinski and others (1981) 43. Bryant and Wooden (2008) 44. Van Schmus and others (1998) 45. Snyder (1978)

Table 1. Definition and characterization of data fields included in Appendix 1 (geochemical and modal data).—Continued

FIELD_NAME	FIELD_DESCRIPTION
Chem_Src	46. Lee (1984) 47. Gable (1985) 48. Aleinikoff and others (1993) 49. Barker (1969) 50. Cullers and others (1993) 51. Stone (1988) 52. Geist and others (1989) 53. Houston and Marlatt (1997) 54. Mussard (1982) 55. Vasek (1995) 56. Waddell-Sheets (1991) 57. Galipeau (1976) 58. Fleck (1983) 59. Majumdar (1985) 60. Anderson, J.L., unpublished data (2013) 61. Plymate and others (2005) 62. Marlatt (1989) 63. DeWitt and others (2002) 64. Earley (1987) 65. Urbani (1971) 66. Griffin (1987) 67. Thompson (1996) 68. Urbani (1975) 69. Laughlin (1991) 70. Verplanck and others (1999) 71. Woodward (1987) 72. Lund, Karen, unpublished data (2013) 73. U.S. Geological Survey, National Geochemical Database, 2013 74. Day, W.C., unpublished data (2013) 75. Olson and others (1954) 76. Castor (2008) 77. Haxell, 2007 78. DeWitt, Ed, unpublished data (2014) 79. Crow (1984)
Abd_Pl	Modal abundance of plagioclase relative to the whole rock, in volume percent
Abd_AlkFld	Modal abundance of alkali feldspar relative to the whole rock, in volume percent
Abd_Qtz	Modal abundance of quartz relative to the whole rock, in volume percent
Abd_Hbl	Modal abundance of hornblende relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts
Abd_Opx	Modal abundance of orthopyroxene relative to the whole rock, in volume percent
Abd_Cpx	Modal abundance of clinopyroxene relative to the whole rock, in volume percent
Abd_Bt	Modal abundance of biotite relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts
Abd_Mu	Modal abundance of muscovite relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts
Abd_Opq	Modal abundance of opaque iron-titanium oxide minerals relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts
Abd_Tot_mafics	Modal total mafic mineral content relative to the whole rock, in volume percent
Abd_Acc	Modal total accessory mineral content relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts
Abd_Acc (incl opq)	Modal total accessory mineral (including opaque oxide minerals) content relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts
Abd_Alt	Modal total alteration mineral content relative to the whole rock, in volume percent; TR, trace (<0.5 volume percent) amounts

Table 2. Definition and characterization of data fields included in Appendix 2 (geochronologic data).

FIELD_NAME	FIELD_DESCRIPTION
Sample_Name	Assigned sample name (if available) for rock that has been dated using radiometric methods
Intrusion_Location_Name	Assigned geologic unit (formal and informal) and (or) location name if intrusion name is not determined
Operator_Well_Name	Well-derived samples have the operator name and well name associated with the borehole
State	State in which the analyzed sample was collected
Longitude	In decimal degrees, relative to the North American Datum of 1927. Locations with five significant figures are accurate within several meters; those with four significant figures are accurate within tens of meters; those with three significant figures are accurate within hundreds of meters; those with two significant figures are accurate within thousands of meters; and those with one significant figure are accurate within tens of thousands of meters. Longitude is reported as a negative value (western hemisphere)
Latitude	In decimal degrees, relative to the North American Datum of 1927. Locations with five significant figures are accurate within several meters; those with four significant figures are accurate within tens of meters; those with three significant figures are accurate within hundreds of meters; those with two significant figures are accurate within thousands of meters; and those with one significant figure are accurate within tens of thousands of meters. Latitude is reported as a positive value (northern hemisphere)
Rock_Type	Lithology of the sample as described in source literature
Age	Radiometric age, in millions of years (m.y.). Rb-Sr ages are as originally reported and have not been recalculated to account for the presently accepted Rb decay constant
Error	2σ uncertainty of the radiometric age, in millions of years (m.y)
Method	Radiometric method used to determine the age of the rock/mineral sample(s)
Sr_I	Initial isotope ratio of ^{87}Sr (generated by radioactive decay of ^{87}Rb) to ^{86}Sr. Initial ratios are calculated from measured ^{87}Sr/^{86}Sr ratios and determined sample ages
εNd_0	Epsilon Nd value at present
εNd_t	Epsilon Nd value at time of crystallization
T_dm	Depleted Mantle model age
Delta_Age	Difference between T_dm and crystallization age in millions of years (Ma)
Source	Source of radiogenic isotope age data. Source entries are indexed to numbered entries below: 1. Bickford and Lewis (1979) 2. Bickford and Mose (1975) 3. Bickford, Harrower, and others (1981) 4. Hoppe and others (1983) 5. Van Schmus and others (1996) 6. Steeples and Bickford (1981) 7. Thomas and others (1984) 8. Van Schmus and others (1987) 9. Turek and Robinson (1982) 10. Van Schmus and others (1989) 11. Van Schmus and others (1993) 12. Dewane and Van Schmus (2007) 13. Bickford and others (1989) 14. Ferguson and others (2004) 15. Bryant and others (2001) 16. Peterman and others (1968) 17. Anderson (1983) 18. Evans (1981) 19. Frost and others (1999) 20. Gonzales and others (1994) 21. Jessup and others (2006) 22. Jones and Connelly (2006)

Table 2. Definition and characterization of data fields included in Appendix 2 (geochronologic data).—Continued

FIELD_NAME	FIELD_DESCRIPTION
	23. Jones, Rogers, and Connelly (2010) 24. Jones, Siddoway, and Connelly (2010) 25. Amato and others (2011) 26. Bickford and others (2015) 27. Rohs and Van Schmus (2007) 28. Fisher and others (2010) 29. Barnes and others (2002) 30. Barnes and others (1999) 31. Goodge and Vervoort (2006) 32. Silver and others (1981) 33. Bryant and Wooden (2008) 34. Gleason and others (1994) 35. Hansen and Peterman (1968) 36. Silver and Barker (1968) 37. Harrison and others (2000) 38. Stewart and Carlson (1978) 39. Brookins and others (1980) 40. Bauer and Pollock (1993) 41. Van Schmus and others (1975) 42. Frost and others (1990) 43. Evans and Zartman (1990) 44. Swan (1976) 45. Silver (1978) 46. Shakel and others (1977) 47. Keith and others (1980) 48. Kessler (1976) 49. Silver and McKinney (1962) 50. Lanphere (1964) 51. Davis and others (1982) 52. Peterman and Hedge (1968) 53. Lund, Karen, unpublished data (2013) 54. Bickford and others (1969) 55. Bickford and Cudzillo (1975) 56. Mose and Bickford (1969) 57. Doe and Pearson (1969) 58. Tweto (1987) 59. Pearson and others (1966) 60. Register and Brookins (1979) 61. Steiger and Wasserburg (1966) 62. Mukhopadyay and others (1975) 63. Muehlberger and others (1966) 64. White (1978) 65. Condie and Budding (1979) 66. Subbarayudu and others (1975) 67. Geist and others (1990) 68. Premo and others (2013) 69. Premo, W.R., unpublished data (2014) 70. Aleinikoff and others (1993) 71. Nourse, J.A, unpublished data (2010) 72. Liviccari and others (2001) 73. Eisele and Isachsen (2001) 74. Jones, J.V. III, unpublished data (2015)

Acknowledgments

Data compilation undertaken for this study was conducted as part of the Basement Tectonic Framework Project funded by the U.S. Geological Survey Mineral Resources Program. Many geologic researchers kindly agreed to help track down missing bits of unpublished data and information, especially sample locations, that allow this database to be as complete as it is. These individuals include J.L. Anderson, R.L. Cullers, K.S. Kellogg, Bruce Bryant, A.G. Thompson, Carol Waddell-Sheets, and P.L. Verplanck. J.V. Jones III was particularly helpful with regard to identifying geochronologic data, especially unpublished results. Constructive reviews by A.B. Wilson and B.S. Van Gosen are much appreciated and helped clarify data presentation.

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Publishing support provided by:

Denver Publishing Service Center

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Appendix 1. Geochemical and Modal Data for 1.4 Ga Granitoid Intrusions of the Conterminous United States (1.4GaIntrsChemModData.xlsx)

Appendix 2. Geochronologic Data for 1.4 Ga Granitoid Intrusions of the Conterminous United States (1.4GaIntrsGeochronData.xlsx)

du Bray and others—**Geochemical, Modal, and Geochronologic Data for 1.4 Ga A-type Granitoid Intrusions of the Conterminous U.S.**—Data Series 942

ISSN 2327-638X (online)
http://dx.doi.org/10.3133/ds942