USGS National Surveys and Analysis Projects: Preliminary Compilation of Integrated Geological Datasets for the United States

By Suzanne W. Nicholson[1], Douglas B. Stoeser[2], Frederic H. Wilson[3], Connie L. Dicken[1], and Steve Ludington[4]

[1]U.S. Geological Survey
National Center, Mail Stop 954
Reston, VA 20192
Telephone: (703) 648-6344
Fax: (703) 648-6383
e-mail: swnich@usgs.gov
e-mail: cdicken@usgs.gov

[2]U.S. Geological Survey
Box 25046, Mail Stop 973
Denver, CO 80225
e-mail: dstoeser@usgs.gov

[3]U.S. Geological Survey
4200 University Dr.
Anchorage, AK 99508
e-mail: fwilson@usgs.gov

[4]U.S. Geological Survey
345 Middlefield Road, Mail Stop 901
Menlo Park, CA 94025
e-mail: slud@usgs.gov

INTRODUCTION

The growth in the use of Geographic Information Systems (GIS) has highlighted the need for regional and national digital geologic maps attributed with age and rock type information. Such spatial data can be conveniently used to generate derivative maps for purposes that include mineral-resource assessment, metallogenic studies, tectonic studies, human health and environmental research.

In 1997, the United States Geological Survey's Mineral Resources Program initiated an effort to develop national digital databases for use in mineral resource and environmental assessments. One primary activity of this effort was to compile a national digital geologic map database, utilizing state geologic maps, to support mineral resource studies in the range of 1:250,000- to 1:1,000,000-scale. Over the course of the past decade, state databases were prepared using a common standard for the database structure, fields, attributes, and data dictionaries. As of late 2006, standardized geological map databases for all conterminous (CONUS) states have been available on-line as USGS Open-File Reports. For Alaska and Hawaii, new state maps are being prepared, and the preliminary work for Alaska is being released as a series of 1:500,000-scale regional compilations. See below for a list of all published databases.

COMPILATION OF SPATIAL DATA FOR STATE GEOLOGIC MAPS

The first stage in developing state databases for the conterminous United States (CONUS) was to acquire digital versions of all existing state geologic maps. Although a significant number of digital state maps already existed, a number of states lacked them. For these states, new digital compilations were prepared by digitizing existing printed maps either in cooperation with the respective state geologic survey (e.g. OH, SD, TX) or by the USGS (e.g. KY, VT). In a few cases, we created digital state maps by merging existing larger scale digital files (e.g. SC, OK). It is important to note that, for this first round of compilation, we focused on compiling bedrock data for each state, although many state geological maps, especially in the West, combine both bedrock and surficial units on a single map.

All CONUS state databases were fit to a state boundary Arc/Info coverage, which was derived from the USGS 100k scale Digital Line Graphics (DLG) boundary layer quadrangles and has a polygon for each state. The purpose of fitting is so that adjoining state databases can be merged to form regional digital maps without slivers or overlaps at the state boundaries. Fitting was done by examining arcs along the boundary and extending or clipping them to the state boundary, depending on whether the arcs under or overshoot the boundary arc. No "rubber sheeting" was used. No attempt was made to reconcile differences in mapped geology between contiguous states. In the spatial tables, several fields were added in which a consistent set of terms was used for age and rock type, so that multiple spatial databases could be queried at the same time and allow generation of regional and national derivative maps based on age and rock type.

SUPPLEMENTAL ATTRIBUTE TABLES

The second stage was to assign values to a standard set of database fields in each state digital map database. Typically, state geologic maps contain more data than just arcs and polygons. Unit descriptions as well as age, lithologic, and bibliographic information present on the original source map were captured in a series of additional tables, including stratigraphic units, age, lithology, and references. For some older state map databases, more recent information was also captured. Figure 1 provides a schematic illustration of the structure of the spatial database tables and the supplemental tables. Figure 2 provides a more detailed look at the data entry format for the supplemental tables.

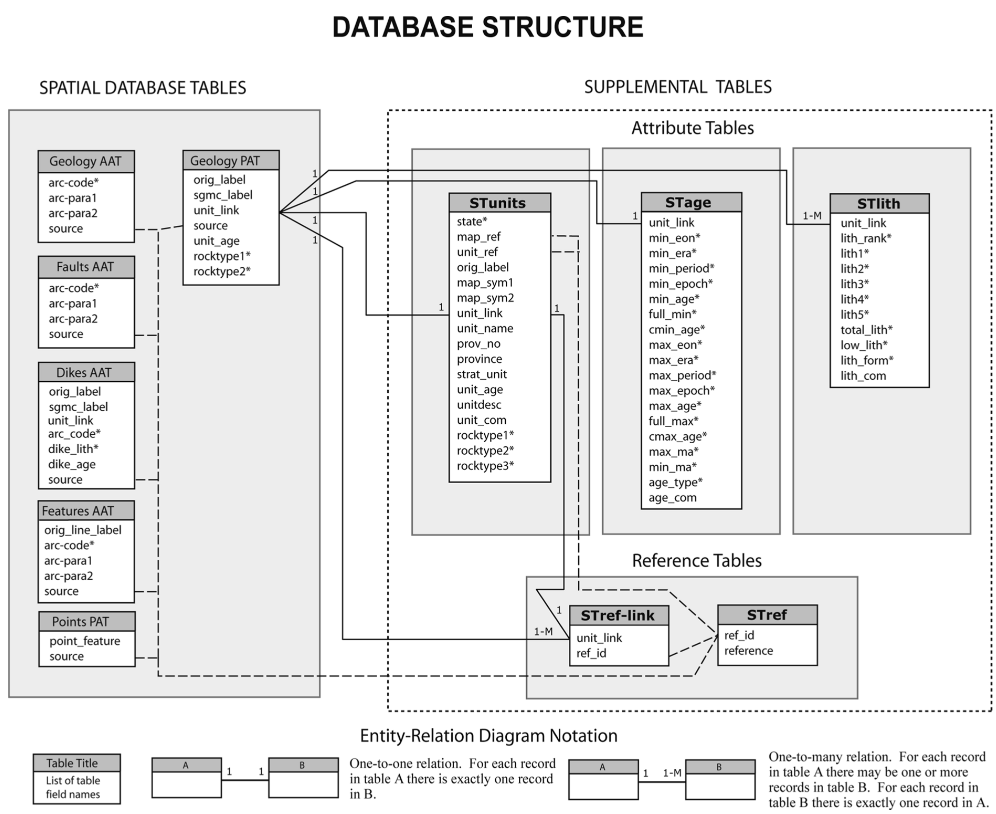

Figure 1. Data model for conterminous U.S. databases. Solid lines show links between tables through the unit_link field. Dashed lines indicate that the values in these fields have a one-to-one relationship to the ref_id field of the STref table. All values in the source, map_ref, and unit_ref fields are generated from the ref_id field in the STref table, though the definitions for each field are different. Fields marked with an asterisk are populated from a data dictionary. Figure is more legible in the web version.

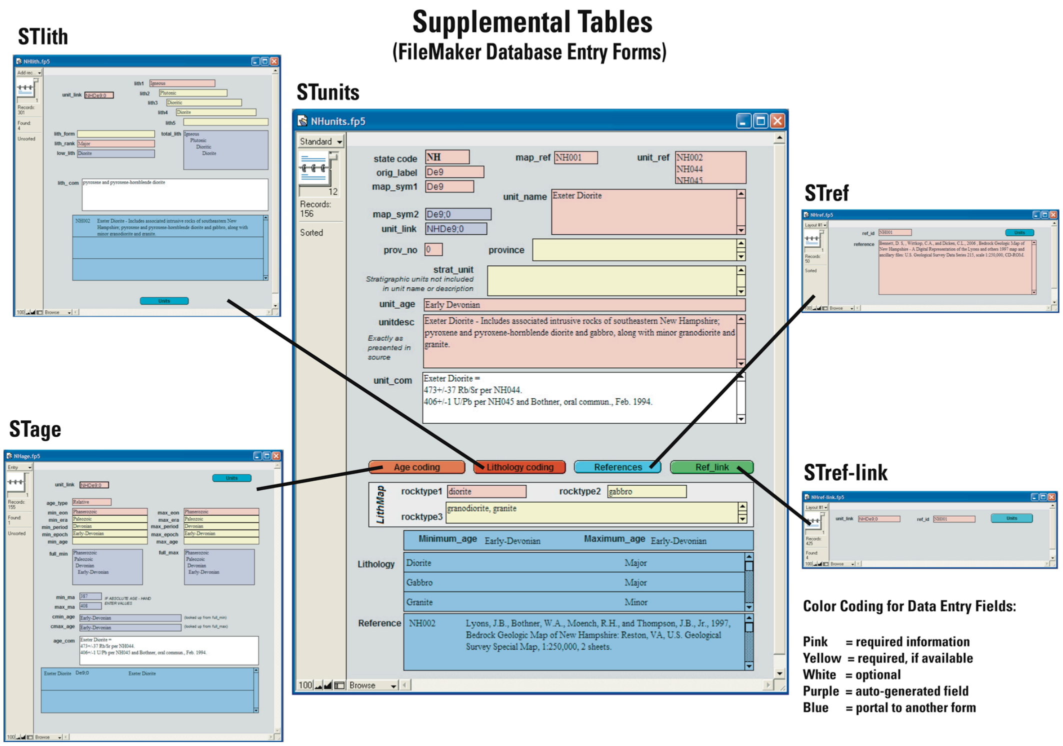

Figure 2. Illustration of the five supplemental tables (STunits, STlith, STage, STref, and STref-link, where ST stands for the two-letter abbreviation for each state). FileMaker 5, 5.5, or 6.0 was used to compile the supplemental tables, but it is not necessary to use this program in order to use the tables. Figure is more legible and in color in the web version.

STANDARD FILE SET

Conus

The files supplied for each state consist of (1) one or more spatial databases (Figure 1), and (2) a set of related supplemental tables (Figure 2). Each state database has the same database structure and attribution fields, which use terminology from standardized data dictionaries. At a minimum, the standard file set consists of a geology (polygon and arc, i.e. network coverage) spatial database, metadata, and supplemental attribute tables; however, additional spatial databases for other line or point features present on the source map may also be included (e.g., faults (when presented on the published maps), dikes, fold axes, volcanic vents, etc.). Detailed documentation of the standards, procedures, data dictionaries, and formats used accompanies each report.

The spatial databases are provided in ESRI export (.e00) and shapefile (.shp) formats. All spatial databases are provided both in geographic coordinates and a Lambert Conformal Conic projection for CONUS and geographic coordinates and UTM projection in Alaska, using a datum of NAD 27. The spatial database metadata are provided in three formats: ASCII text (.txt), Microsoft Word (.doc), and HTML (.htm). The supplemental data consist of related attribute tables (Figure 2): units (UNITS), age (AGE), lithology (LITH), and bibliographic references (REF). An additional table (REF-LINK) links spatial data and attributes to bibliographic references. The tables provide standardized attribution for the geologic map units for each map. These tables are available in comma-separated value (.csv), dBASE (.dbf), and FileMaker Pro (.fp5) formats, and for Alaska datasets as a runtime Filemaker Pro application. [Note, the .dbf format truncates all text fields at 256 characters, which impacts unit descriptions and, potentially, reference citations.]

Alaska and Hawaii

For Alaska and Hawaii, new state map compilations are being prepared. The data structure for Alaska is very similar, but not identical, to the data structure for the lower 48 states. The preliminary data for portions of Alaska are being released in a series of nominal 1:500,000-scale regional compilations. To date, ten new geologic compilations that cover more than two-thirds of the state of Alaska have been published (Figure 3). Additional compilations are currently being prepared for the

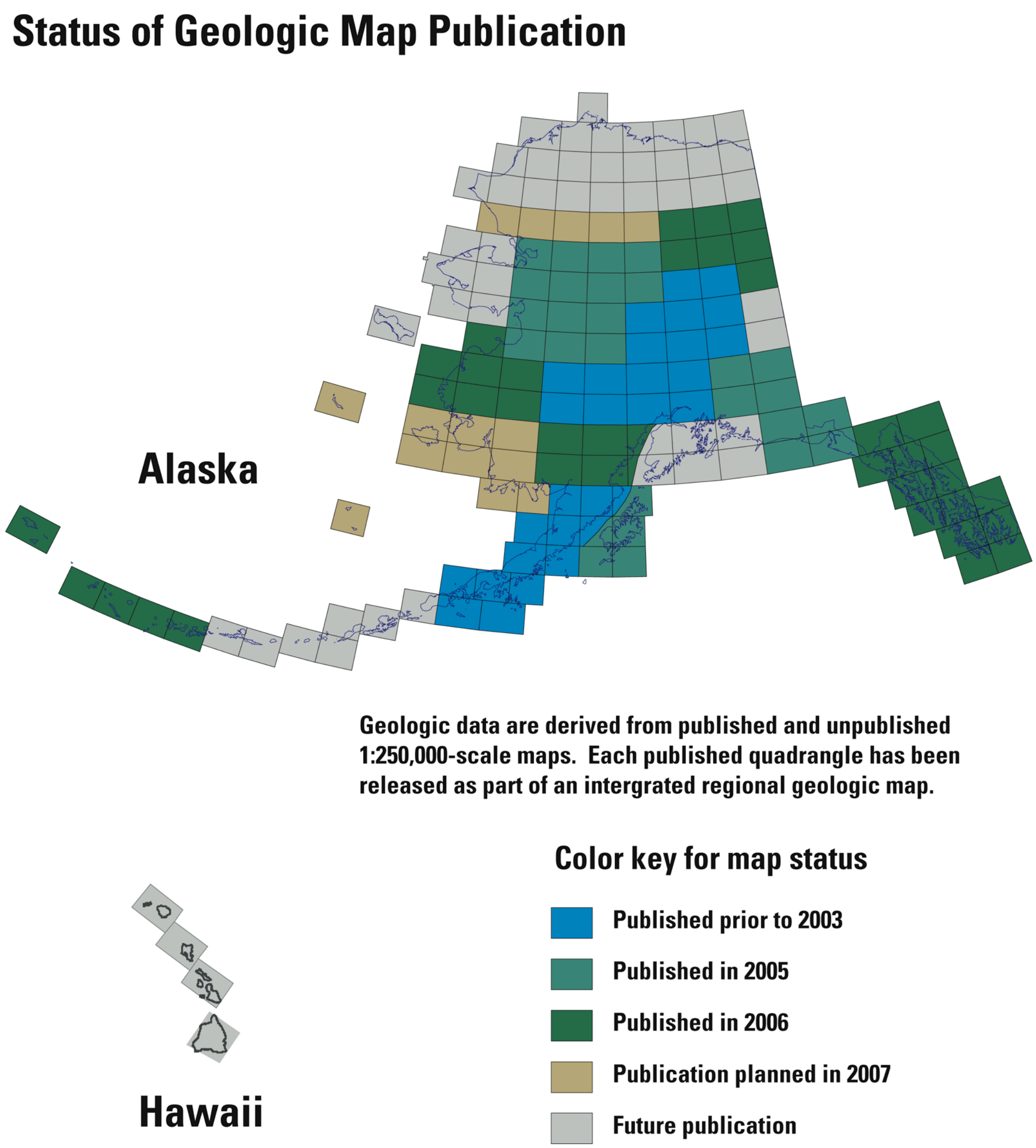

Figure 3. Map showing status of geologic map publication for quadrangles in Alaska and Hawaii. Figure is more legible and in color in the web version.

remaining portions of Alaska and for the state of Hawaii. Detailed documentation of the standards, procedures, data dictionaries, and formats used accompanies each report.

DERIVATIVE PRODUCTS OF THE STATE GEOLOGIC MAP COMPILATION

When the spatial databases are merged, these standardized tables allow development of derivative maps based on stratigraphy, lithology, and age. Figure 4 shows a map of the dominant rock type for each polygon, which was generated by plotting the controlled vocabulary values that appear in the *rocktype1* field. In Figure 5, the distribution of two rock types was generated by querying the *rocktype1* field in the state databases for *shale* and *granite*. A generalized geologic age map (Figure 6) was produced by generalizing the values in the free-form field *unit_age* in the spatial databases.

Another example of a use of these digital geologic state map data is the preliminary mineral resource assessment of North America, which is now underway by the USGS. The state geologic map datasets were used as base layers along with mineral occurrence data to outline tracts of favorable conditions for specific mineral deposit types.

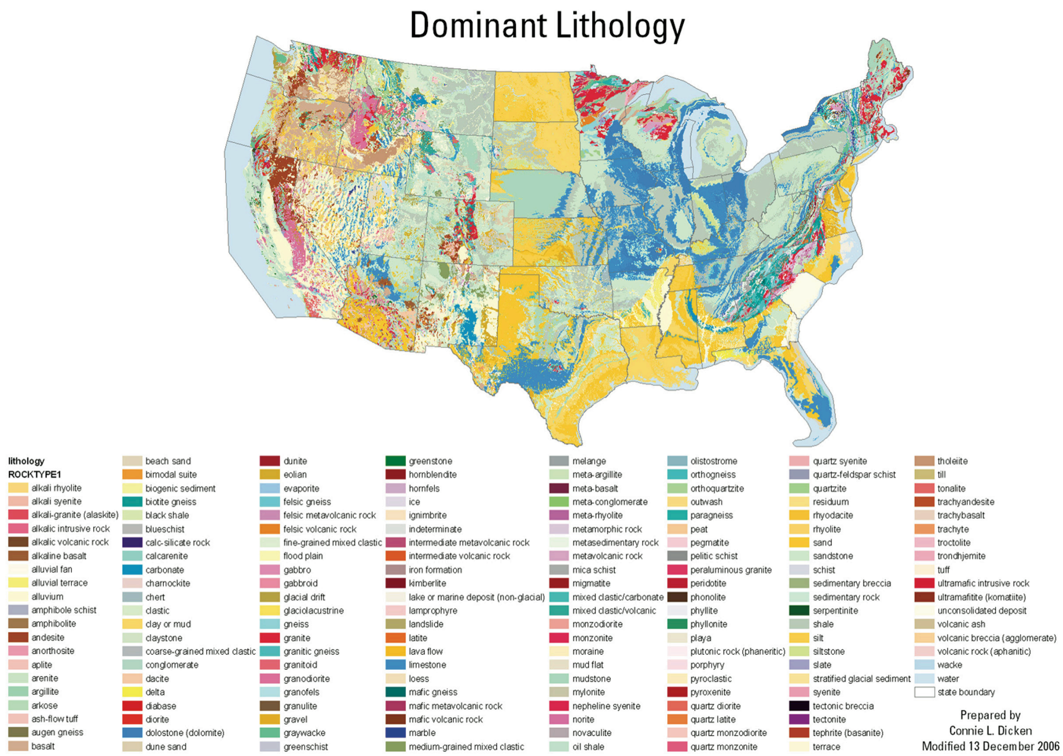

Figure 4. Distribution of dominant rock type for each polygon. Map was generated by querying the single-valued field *rocktype1*, which uses a controlled vocabulary. Figure is more legible and in color in the web version.

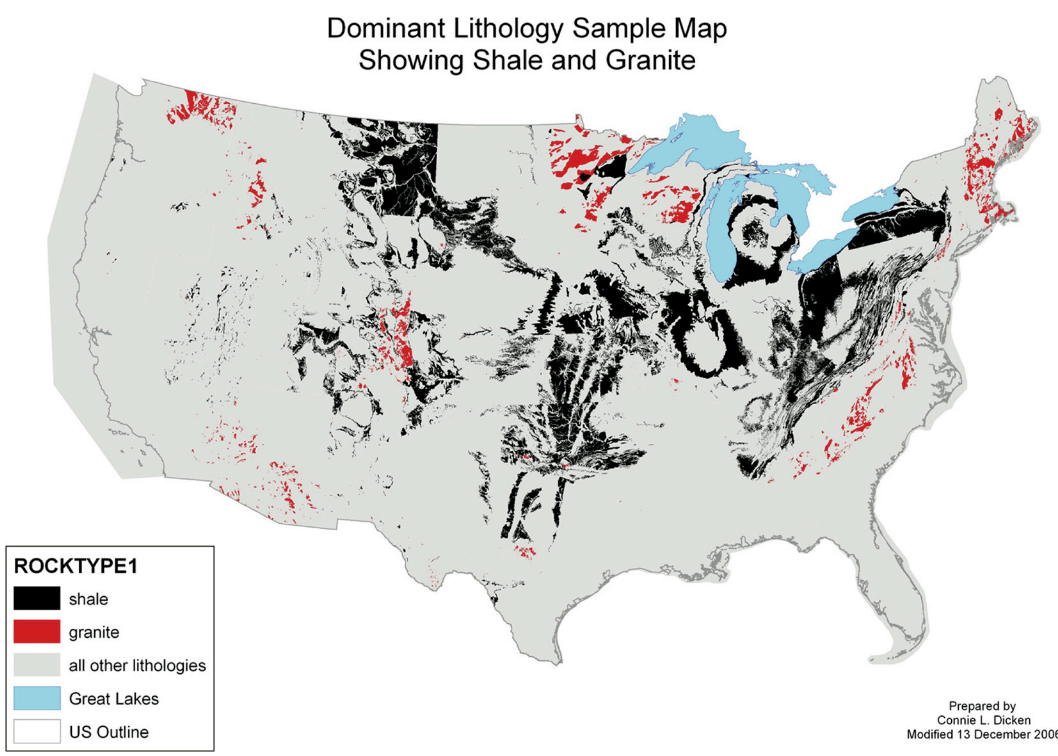

Figure 5. Map of the distribution of two rock types—shale and granite—was generated by querying the *rocktype1* field in the attribute table of the state databases for just those two rock types. Figure is more legible and in color in the web version.

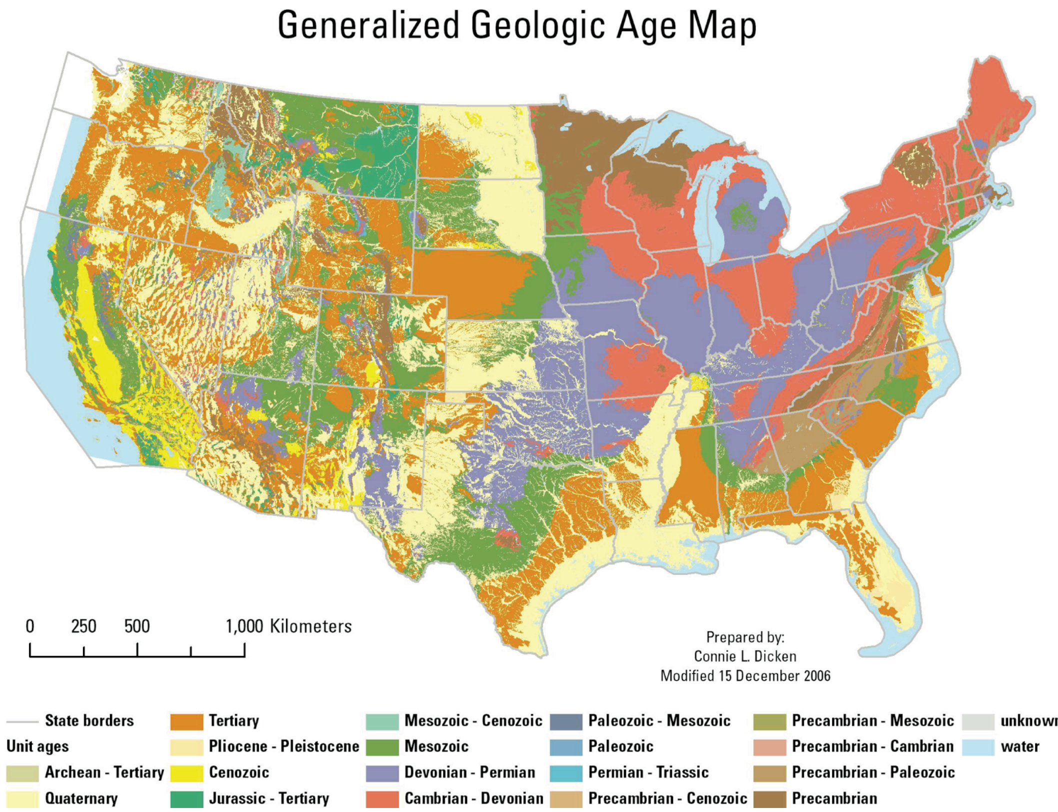

Figure 6. Generalized geologic age map produced by generalizing the values in the free-form *unit_age* field. Figure is more legible and in color in the web version.

BIBLIOGRAPHY OF DIGITAL STATE GEOLOGIC MAP COMPILATIONS

As of December 2006

Conterminous States:

Dicken, C.L., Nicholson, S.W., Horton, J.D., Foose, M.P., and Mueller, J.A.L., 2005, Preliminary Integrated Geologic Map Databases for the United States: Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina: U.S. Geological Survey Open-File Report 2005-1323, on-line only, http://pubs.usgs.gov/of/2005/1323/.

Dicken, C.L., Nicholson, S.W., Horton, J.D., Kinney, S.A., Gunther, Gregory, Foose, M.P., and Mueller, J.A.L., 2005, Preliminary Integrated Geologic Map Databases for the United States: Delaware, Maryland, New York, Pennsylvania, and Virginia: U.S. Geological Survey Open-File Report 2005-1325, on-line only, http://pubs.usgs.gov/of/2005/1325/.

Ludington, Steve, Moring, B.C., Miller, R.J., Stone, P.A, Bookstrom, A.A., Bedford, D.R., Evans, J.G., Haxel, G.A., Nutt, C.J., Flyn, K.S., and Hopkins, M.J., 2005, Preliminary Integrated Geologic Map Databases for the United States: Western States: California, Nevada, Arizona, Washington, Oregon, Idaho and Utah, Version 1.2 (updated 12/01/06): U.S. Geological Survey Open-File Report 2005-1305, on-line only, http://pubs.usgs.gov/of/2005/1305/.

Nicholson, S.W., Dicken, C.L., Foose, M.P., and Mueller, Julie, 2004, Integrated Geologic Map Databases for the United States: The Upper Midwest States: Minnesota, Wisconsin, Michigan, Illinois, and Indiana: U.S. Geological Survey Open-File Report 2004-1355 on-line only, http://pubs.usgs.gov/of/2004/1355/.

Nicholson, S.W., Dicken, C.L., Horton, J.D., Labay, K.A., Foose, M.P. and Mueller, J.A.L., 2005, Preliminary Integrated Geologic Map Databases for the United States: Kentucky, Ohio, Tennessee, and West Virginia: U.S. Geological Survey Open-File Report 2005-1324, on-line only, http://pubs.usgs.gov/of/2005/1324/.

Nicholson, S.W., Dicken, C.L., Horton, J.D., Foose, M.P., Mueller, J.A.L., and Hon, Rudi, 2006, Preliminary Integrated Geologic Map Databases for the United States: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Rhode Island and Vermont: U.S. Geological Survey Open-File Report 2006-1272, on-line only, http://pubs.usgs.gov/of/2006/1272/.

Stoeser, D.B., Green, G.N., Morath, L.C., Heran, W.D., Wilson, A.B., Moore, D.W., and Van Gosen, B.S., 2005, Preliminary Integrated Geologic Map Databases for the United States: Central States: Montana, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Iowa, Missouri, Arkansas, and Louisiana: U.S. Geological Survey Open-File Report 2005-1351, version 1.1 (updated 9/30/06) on-line only, http://pubs.usgs.gov/of/2005/1351/.

Alaska:

Gehrels, G.E. and Berg, H.C., 2006, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Geology of Southeast Alaska: U.S. Geological Survey Open-File Report 2006-1290, on-line only, http://pubs.usgs.gov/of/2006/1290/.

Labay, K.A., Crews, Jesse, Wilson, F.H., Shew, Nora, and Hults, C.K., 2006, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Generalized Bedrock Geologic Map, Yukon Flats region, East-central Alaska : U.S. Geological Survey Open-File Report 2006-1304, on-line only, http://pubs.usgs.gov/of/2006/1304/.

Richter, D.H., Preller, C.C., Labay, K.A., and Shew, N.B., compilers, 2006, Geologic map of the Wrangell-Saint Elias National Park and Preserve: U.S. Geological Survey Scientific Investigations Map 2877, scale 1:350,000, available online at http://pubs.usgs.gov/sim/2006/2877.

Wilson, F.H., Detterman, R.L., and Dubois, Gregory, 1999, Digital Data for the Geologic Framework of the Alaska Peninsula, Southwest Alaska, and the Alaska Peninsula Terrane: U.S. Geological Survey Open-File Report 99-317 on-line only, http://geopubs.wr.usgs.gov/open-file/of99-317/.

Wilson, F.H., Dover, J.H., Bradley, D.C., Weber, F.R., Bundtzen, T.K., and Haeussler, P.J., 1998, Geologic Map of Central (Interior) Alaska: U.S. Geological Survey Open-File Report OF 98-133-A, Version 1.2, available as paper copy, on-line, and CD, http://pubs.usgs.gov/of/1998/of98-133-a/.

Wilson, F.H., Labay, K.A., Mohadjer, Solmaz, and Shew, Nora, 2005, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Reconnaissance Geologic Map of the Kodiak Islands, Alaska: U.S. Geological Survey Open-File Report 2005-1340 on-line only, http://pubs.usgs.gov/of/2005/1340/.

Wilson, F.H., Labay, K.A., Shew, Nora, and Hults, C.K., 2006, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Reconnaissance Geologic Map of the lower Yukon River region, Alaska: U.S. Geological Survey Open-File Report 2006-1292, on-line only, http://pubs.usgs.gov/of/2006/1292/.

Wilson, F.H., Labay, K.A., Shew, Nora, Mohadjer, Solmaz, and Patton, W.W., Jr., 2005, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Reconnaissance Geologic Map of the Yukon-Koyukuk Basin, Alaska: U.S. Geological Survey Open-File Report 2005-1341 on-line only, http://pubs.usgs.gov/of/2005/1341/.

Wilson, F.H., Labay, K.A., Shew, Nora, Preller, C.C., Mohadjer, Solmaz, and Richter, D.H., 2005, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Geology of Wrangell-Saint Elias National Park and Preserve, Alaska: U.S. Geological Survey Open-File Report 2005-1342 on-line only, http://pubs.usgs.gov/of/2005/1342/.

Wilson, F.H., Mohadjer, Solmaz, Labay, K.A., and Shew, Nora, 2006a, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Reconnaissance Geologic Map of the Western Aleutian Islands, Alaska: U.S. Geological Survey Open-File Report 2006-1302, on-line only, http://pubs.usgs.gov/of/2006/1302/.

Wilson, F.H., Mohadjer, Solmaz, Labay, K.A., and Shew, Nora, 2006b, Preliminary Integrated Geologic Map Databases for the United States: Digital Data for the Reconnaissance Bedrock Geologic Map for the Northern Alaska Peninsula area, Southwest Alaska: U.S. Geological Survey Open-File Report 2006-1303, on-line only, http://pubs.usgs.gov/of/2006/1303/.