From "Digital Mapping Techniques '11–12—Workshop Proceedings"
U.S. Geological Survey Open-File Report 2014–1167
http://pubs.usgs.gov/of/2014/1167/

The Alaska State Map: Creation of Draft Map Unit Descriptions Through the Map Database

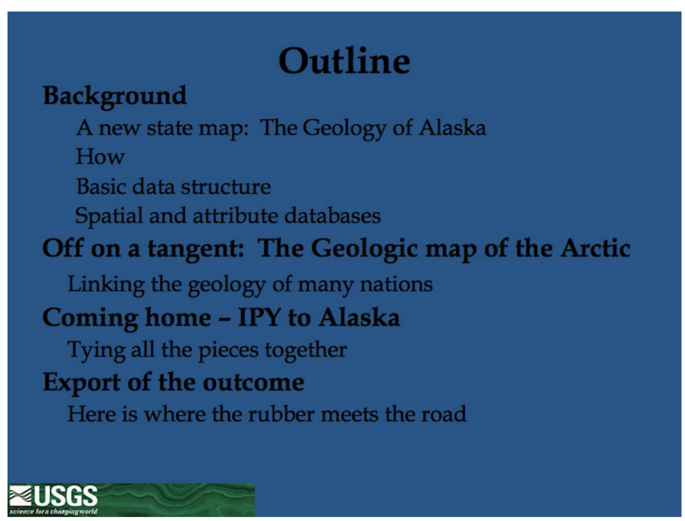
By Frederic H. Wilson and Chad P. Hults

U.S. Geological Survey
4210 University Drive
Anchorage, AK 99508
Telephone: (907) 786-7448
Fax: (907) 786-7401
email: *fwilson@usgs.gov*

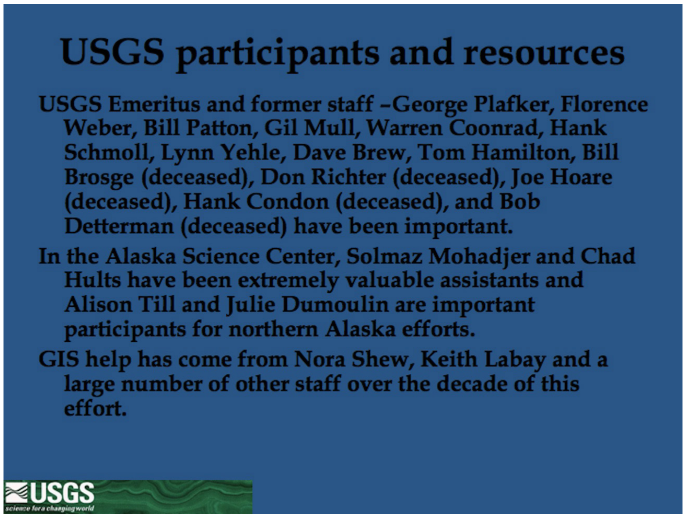
The U.S. Geological Survey (USGS) Mineral Resources Program has engaged in an effort to produce a new geologic map of Alaska to replace the existing, out of date map (Beikman, 1980). Initially part of an effort to prepare for a national mineral resource assessment, creation of this map was recognized to have much wider use and value. The map compilation effort is based on capturing and digitally integrating original source maps at varying scales to produce a spatial database and related attribute databases suitable for use at 1:500,000 scale. However, data typically are captured at 1:250,000 scale and in a number of instances at 1:63,360 scale. To date, nearly 1,000 sources and more than 16,000 individual map unit descriptions have been incorporated.

As part of this ongoing effort to develop a new geologic map, an extensive relational database of geologic information has been developed. This relational database contains abstracted unit descriptions from hundreds of source maps, all linked through a unifying code, that we add, called "NSACLASS." Also linked through this unifying code are lithologic characteristics of the map unit, a rudimentary assignment to a geologic or tectonic setting, and a maximum and minimum age assignment for the linked geologic units. In the process of developing the State map, a series of regional maps have been published, and full unit descriptions from these maps also are incorporated in the database and linked through the unifying code.

Finally, through a related effort to contribute to a Circum-Polar geologic map, a rapid method to characterize geologic units was developed and served to help define links between geologic units across the Circum-Polar region. [The Circum-Polar map was released at the International Union of Geological Sciences (IUGS) meeting in Oslo, Norway, in 2008.] When the time came to define and write unit descriptions for the new Alaska map, a method to reduce the more than 16,000 source map geologic units and more than 1,300 units linked through NSACLASS to a manageable number for the State map was needed. At the same time, we wondered if the database we built could be used to help write the unit descriptions. This paper describes the experiment we attempted. The format for this paper is essentially the text, verbatim from the oral presentation, provided beneath the relevant Powerpoint slide.



Here (above) is the outline of this presentation.



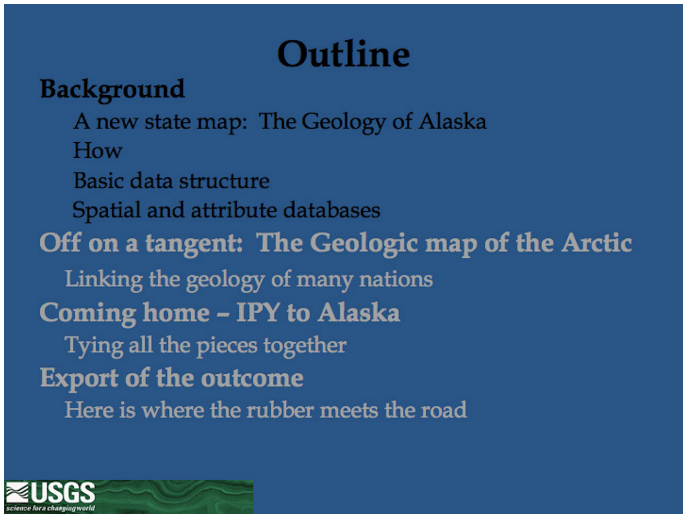
The project would have had little chance of success without the participation of a large number of USGS Emeritus scientists, representing hundreds of years of experience in Alaskan geology. The emeritus included Don Richter for the Wrangell-Saint Elias National Park and Preserve map, Florence Weber for Interior Alaska, Bill Patton for areas throughout western Alaska and Saint Lawrence Island, George Plafker in the eastern Gulf of Alaska region, Warren Coonrad in southwest Alaska, Hank Schmoll and Lynn Yehle in south central Alaska, Dave Brew in southeast Alaska, Tom Hamilton in northern Alaska, and through their notes and maps, Joe Hoare, Bob Detterman, and Bill Brosgé. Special thanks also go to Gil Mull, formerly of the Alaska Division of Geological and Geophysical Surveys (DGGS) and the USGS. In the USGS Alaska Science Center, Solmaz Mohadjer and Chad Hults have been extremely valuable assistants, and Alison Till and Julie Dumoulin are important contributors to the geology of northern Alaska. Geographic information system (GIS) help has come from Nora Shew, Keith Labay, and a large number of other staff over the decade of this effort.

Other collaborators and supporters have included the Alaska Division of Oil and Gas (DOG), which twice has provided financial support for development of our first regional map, covering central Alaska, and for the Cook Inlet regional map of south central Alaska. The Alaska Division of Geological and Geophysical Surveys (DGGS) has contributed detailed mapping in many areas around the State. In addition, the DGGS Web site provides scanned images of all available DGGS and USGS publications about Alaska, a priceless resource.

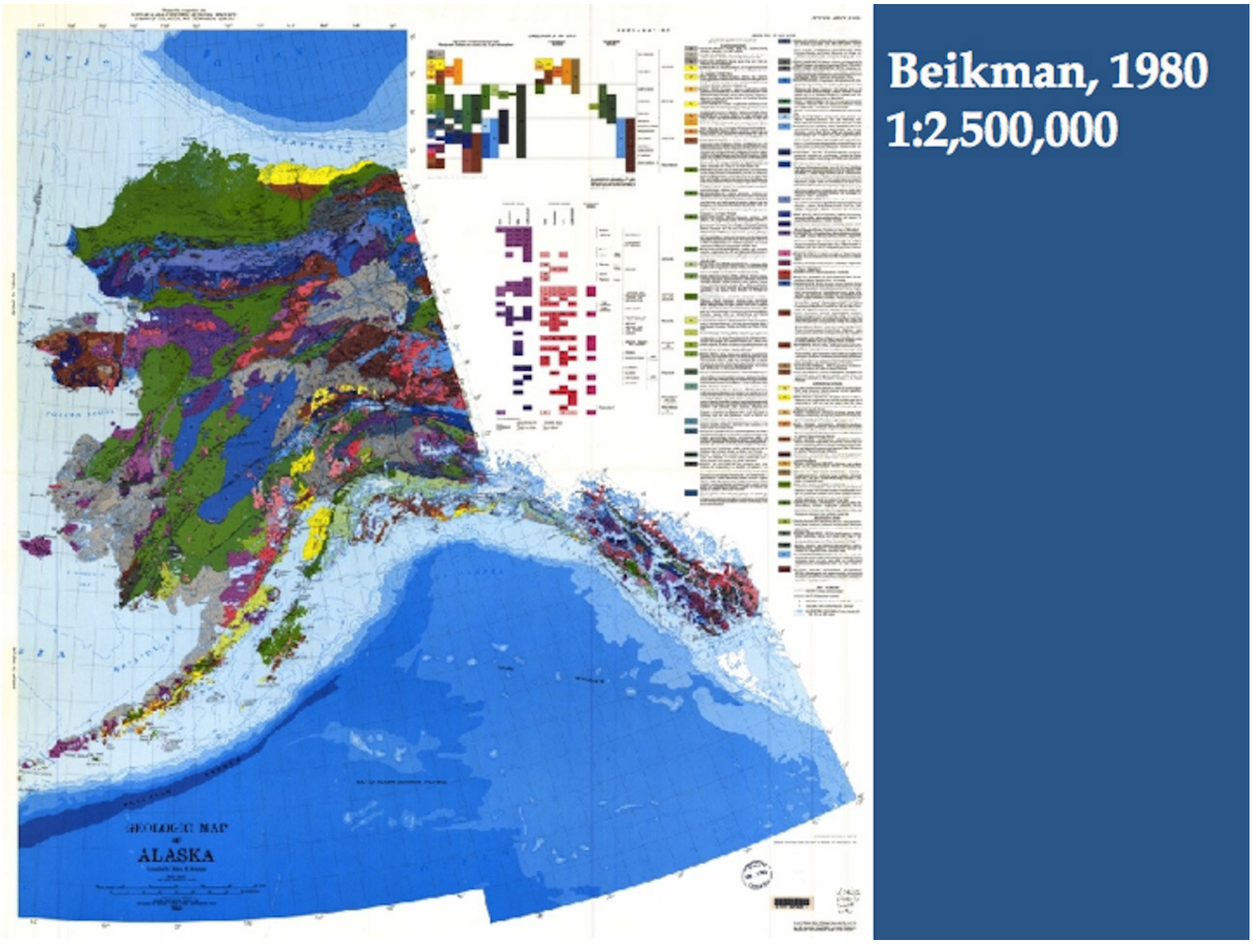
Over the years, Regional Native Corporations, in particular The Aleut Corporation, the Bristol Bay Native Corporation, and the Calista Corporation have provided access to their files, assisting in the map compilation effort.

The National Park Service has been a consistent supporter of this effort and has provided a continuing level of financial support toward production of regional maps that cover Park lands.

The USGS Energy Program was an important contributor to the effort to produce the recent Cook Inlet region map, which helped us to further refine the databases as well as producing new quadrangle maps on the north slope of Alaska (Mull and others, 2004, 2005, 2006a, 2006b, 2008). Also, maps and data provided by the USGS Alaska Volcano Observatory have been a significant help in the Aleutian Islands region of the State.

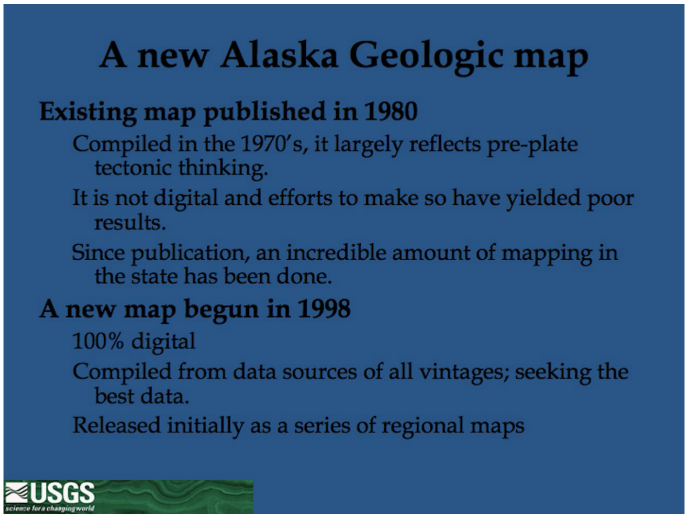


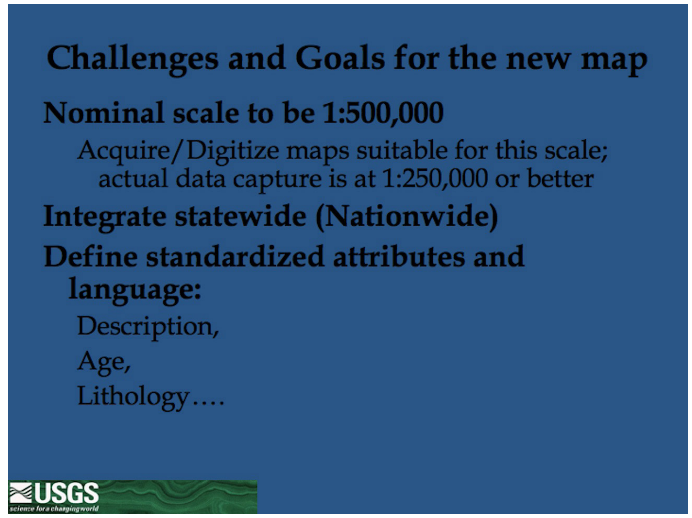
Here, we describe the ultimate goal of the effort, the first digital geologic map of Alaska and the first map that incorporates information and insights developed as a result of plate tectonic theory and the terrane concept.



The effort began as part of the USGS Mineral Resources Program National Surveys and Analysis (NSA) project, which had a national focus and a goal to produce a 50-state compilation. In the conterminous United States, many of the maps produced from the NSA project were simply digitized versions of already-published State maps. In Alaska, we realized that we did not have a suitable State map for this effort; we had the Beikman's (1980) Geologic map of Alaska, as well as a series of earlier 1939 and 1957 vintage state maps. Unfortunately, these maps were all produced in a pre-Plate Tectonic era and do not reflect current thinking.

Additionally, these maps were produced at a scale of 1:2,500,000, but our goal was compilation at 1:250,000 scale, with regional maps published at 1:500,000 scale and the ultimate State map at 1:1,584,000 scale (the traditional Alaska Map B).



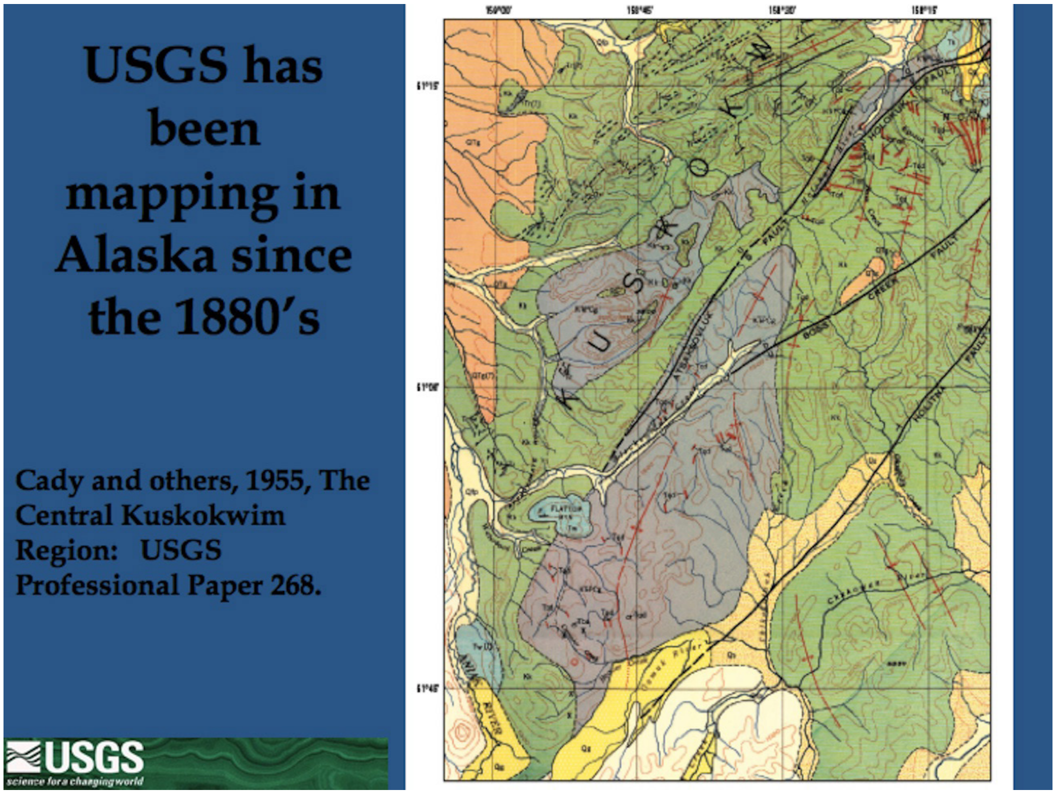


The existing map (Beikman, 1980) was compiled mostly in the early to middle 1970s. Because its sources largely predated plate tectonics, the map reflects pre-plate tectonic thinking. In the 1990s, we tried to digitize the map and encountered many problems; the primary one is that although the latitude and longitude grid printed with the map is a reasonably well-defined Albers Equal Area projection, the map underneath is not. We were never able to discover the projection for the geologic base, and rubber-sheeting was very unsatisfying. Ultimately, we gave up.

One important incentive for abandoning that effort was the publication of a large amount of new mapping as a result of the Alaska Mineral Resource Assessment Program, which was active from about 1975 to 1995. We began the new map compilation effort in 1997, developing the tools as we went, but pressed to produce the first regional map only 18 months later. This was quite a learning experience.

The data sources for the new map have included published geologic map data, original field notes and field sheets, unpublished draft maps, journal articles, remotely sensed data, and various other sources. USGS publications as old as the early 20th century as well as recently published journal articles or even preprints have been incorporated as the map compilation effort progresses. Given the size of the job, we resolved to produce a series of regional maps, to develop our techniques, as well as make data available to users more quickly.

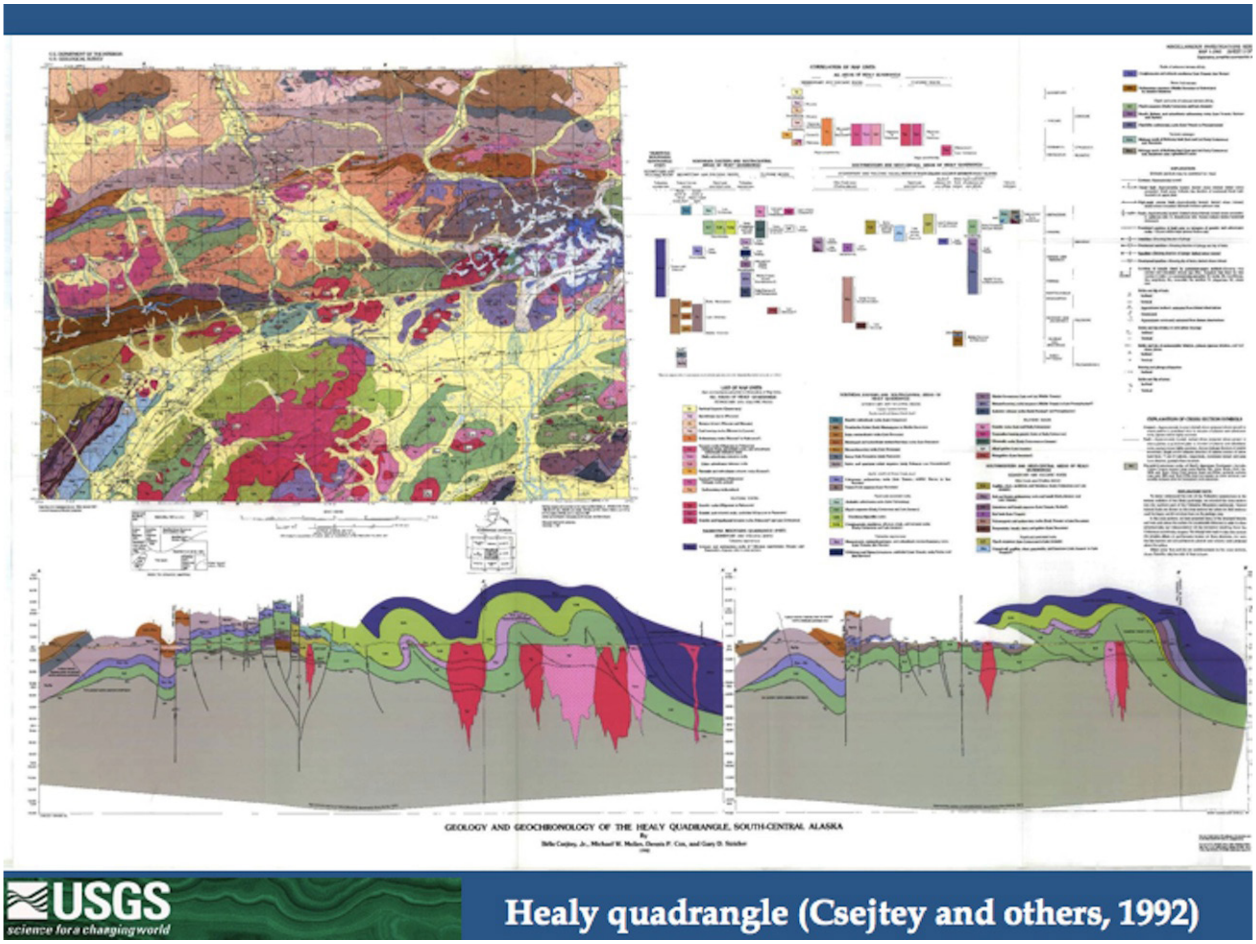
Meanwhile, we worked nationally to set goals and standards for the NSA project. Principally, we would acquire digital geologic map data for all 50 States. It would nominally be at a scale of 1:500,000 and would integrate into a national dataset. We created a standardized attribute schema that included unit age, description, lithology, and other characteristics. And ultimately, all the States would be linked into a seamless database. Most of these goals were met. However, seamlessness is still a challenge, more so in the conterminous United States than Alaska, but it remains a universal issue.



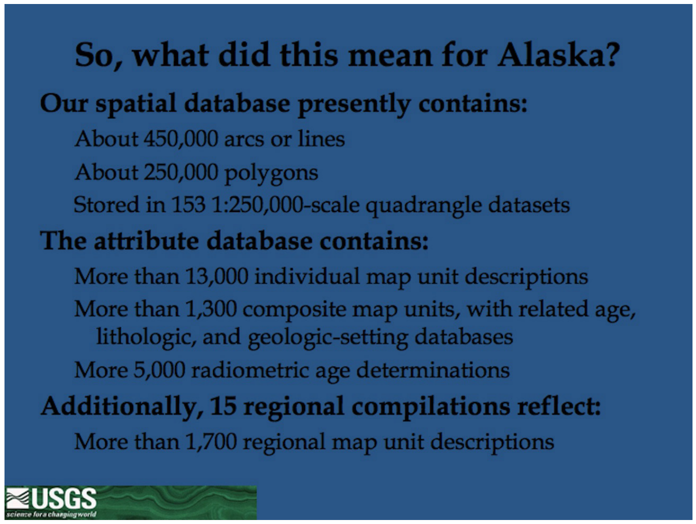
The Alaska effort, which also included Hawai'i, proceeded as part of the overall NSA effort. An attempt at seamlessness was required because we were integrating the geology of 153 1:250,000-scale quadrangle components. In Alaska, we thought of this as the conceptual equivalent of linking 48 conterminous U.S. States together.

The USGS has a long history in Alaska and has been mapping Alaska since the 1880s. As a result, for some areas in Alaska there are many generations of published and unpublished geologic maps. Yet in other areas, there are no published maps at scales more detailed than 1:1,000,000 or 1:500,000.

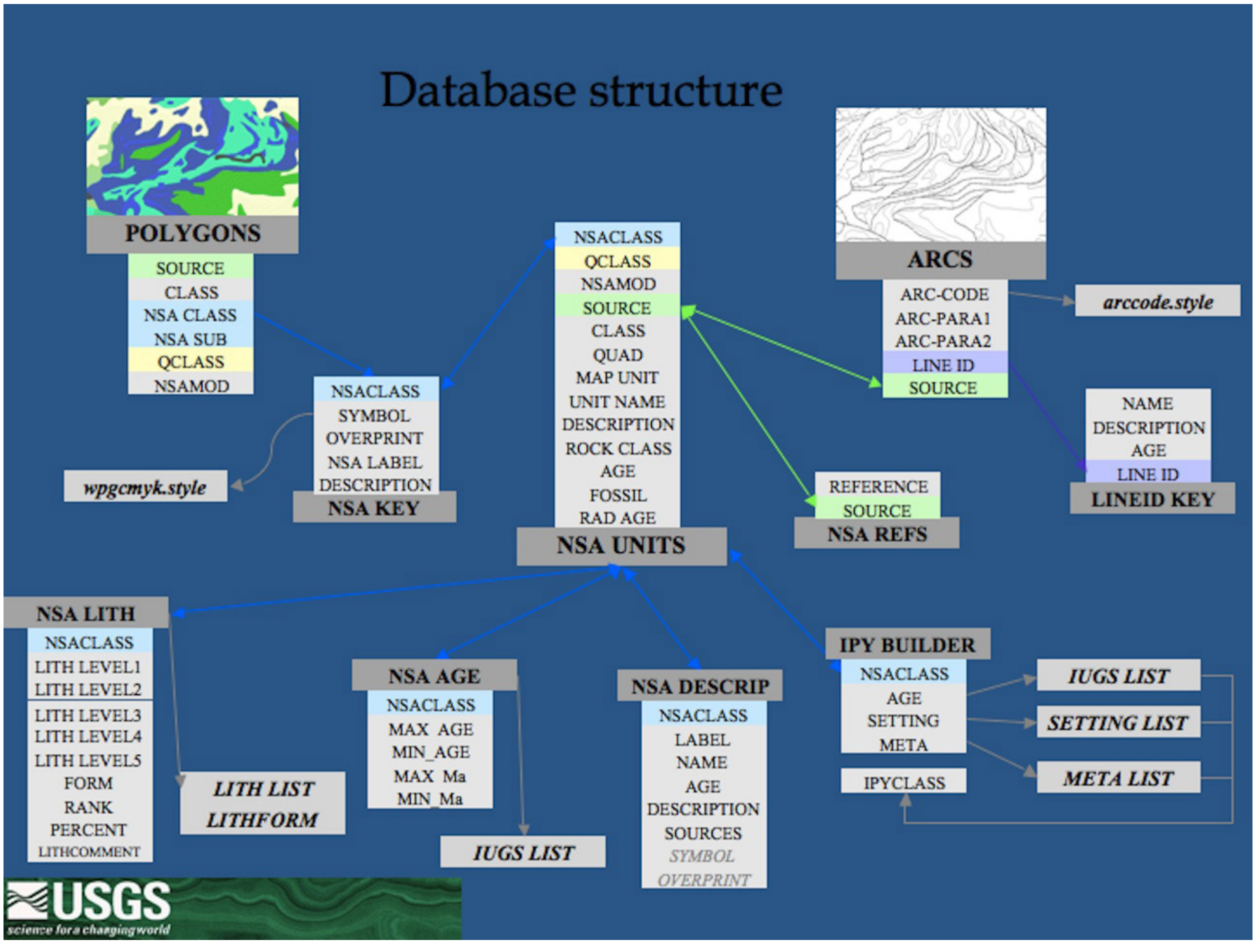
In the area shown in this slide, J.B. Mertie conducted mapping in the 1930s and published his interpretation and data as a USGS Bulletin (Mertie, 1938). The map shown here reflects additional fieldwork during the 1940s and early 1950s, which was published as a USGS Professional Paper (Cady and others, 1955). J.M. Hoare, W.L. Coonrad, and W.H. Condon did additional fieldwork in this area in 1969 and 1970, the DGGS conducted mapping in the 1980s, and Marti Miller and coworkers of the USGS continue to work in this area today. Fundamentally, the mapping is never done.



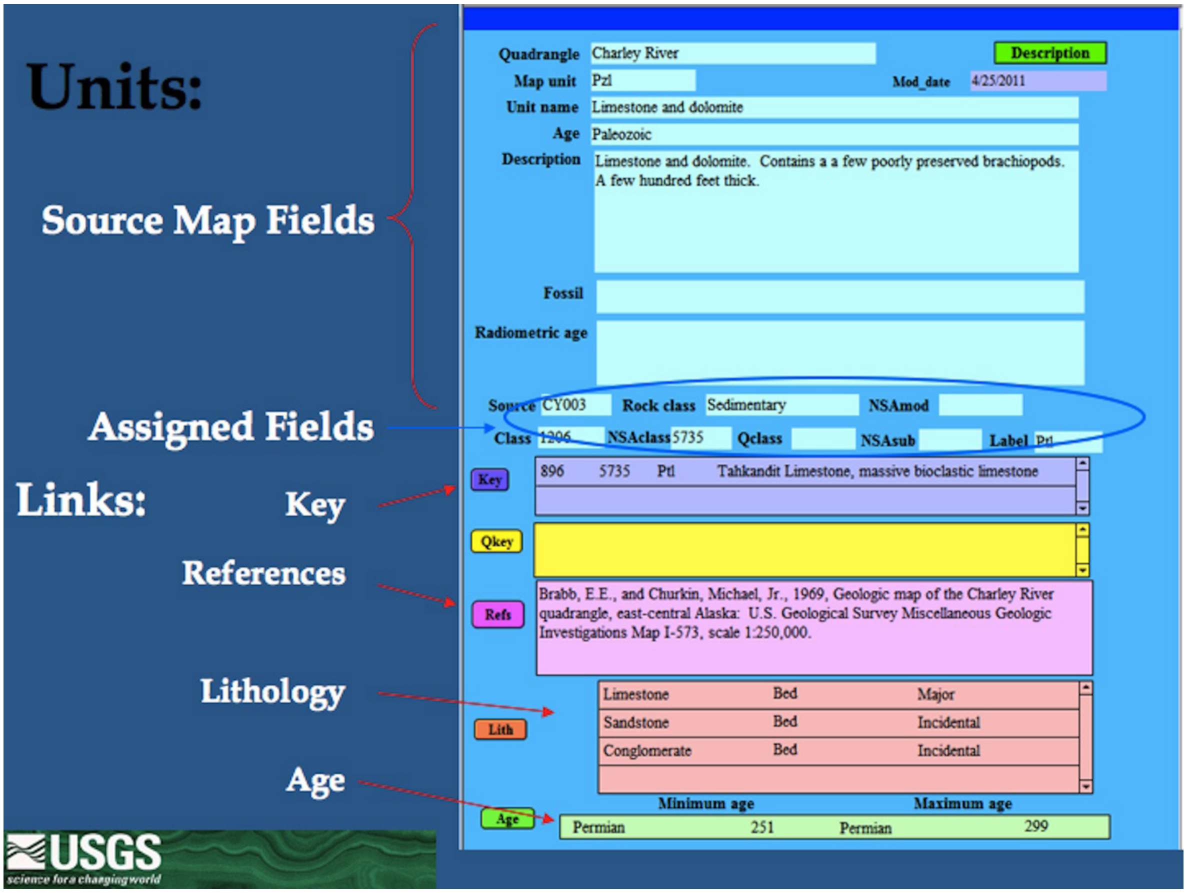
We digitized and incorporated information from those early efforts, as well as recently completed published maps, such as the map of the Healy quadrangle in central Alaska (Csejtey and others, 1992). The best maps we capture provide solid and consistent geologic data and information. Less useful maps are highly interpretive, and recently some are steeped in terrane terminology, obscuring the basic geologic information.



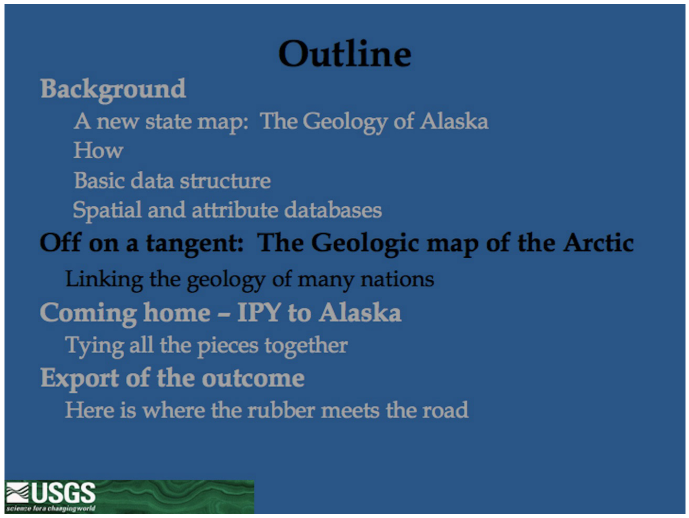
Our first effort was to inventory existing information, in published and unpublished form. What was already digital? Where do we start compiling? How do we structure the data? We had already experimented with creating digital map products on the Alaska Peninsula, so we had some idea what we were getting into. But, in the end we needed to develop a functional and hopefully user-friendly geologic map database that could be used for spatial analysis and as a base for a proposed national mineral resource assessment. To date, the active part of the data is massive; from it we have published 15 regional compilations. As we have moved ahead, some of the map products we initially digitized have been supplanted by better or more detailed sources. Since presentation of this talk, the number of individual map unit descriptions has increased to over 16,000 and more than 7,500 radiometric age determinations have been done.



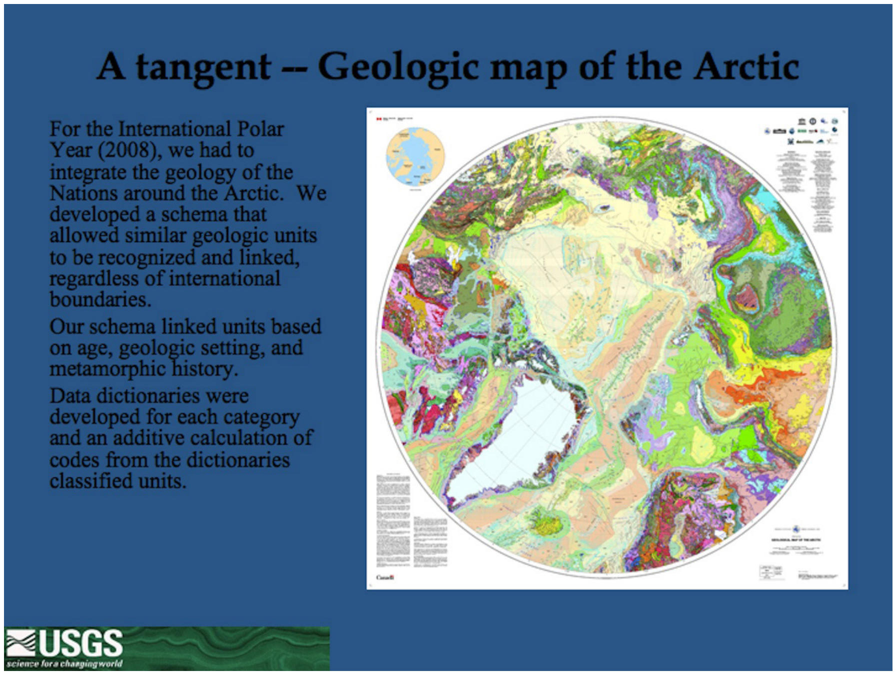
Ultimately, we structured the database around a units table compiled from the source maps. Linked to this units table (containing the 16,000+ unit descriptions) is the source reference through a reference code. The critical link is called "NSACLASS," which links specific geologic units together; for example the Kuskokwim Group, which appears on several maps, is linked across them by a common code. NSACLASS also links map units to unit age, lithology, and geologic settings database tables. For each of these additional attribute tables, explicit data dictionaries were developed to control the vocabulary.



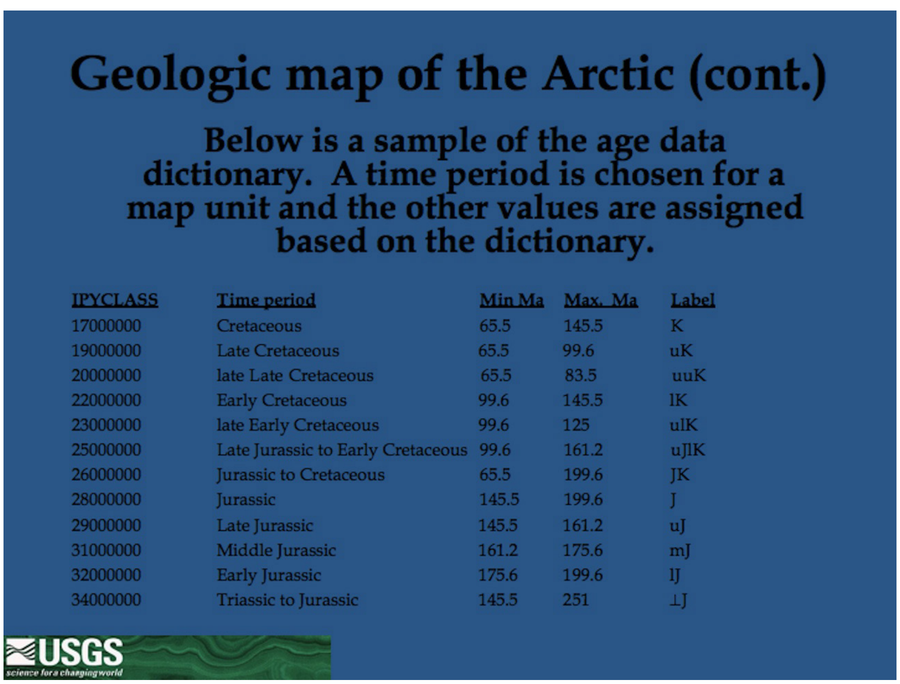
We use a File Maker pro database because it is simple to use and can store unlimited text fields (unlike Access that can only hold 250 characters). The NSAunits table contains the fields that are directly related to the source map. For every source map unit we assign a CLASS value, an NSACLASS, an additional QCLASS for Quaternary map units, and Label. The CLASS value and SOURCE code in combination describe a specific source map unit in the database, which allows us to trace any polygon in the spatial database back to its original source. The NSACLASS is used to integrate all Alaskan geologic maps with one another. The units database is also linked to many of the other tables.



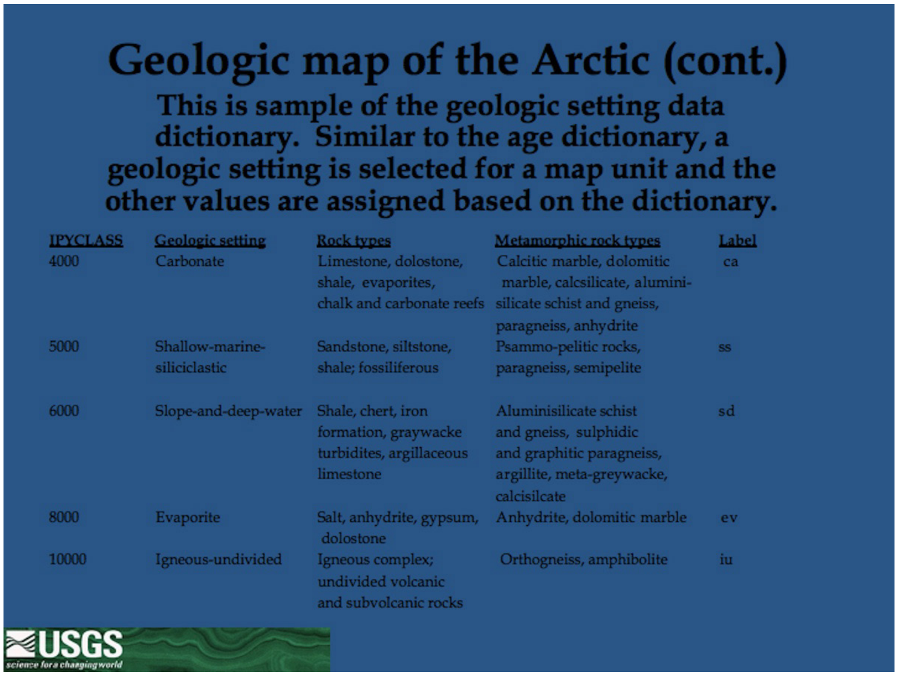
Late in the process of acquiring data for the State map, we became part of an effort to develop a new Circum-Polar bedrock geologic map for the International Polar Year (2008). This map was to cover the north-Polar region of the Earth from 60 degrees north. The challenge here, beyond the politics, was not only to link the geology for many of the 153 1:250,000-scale quadrangles of Alaska together, as the map area covered the majority of Alaska, but to link our geology to that of all countries in the Polar region. National mapping styles, philosophies of what constitutes a geologic map, and even cultural differences all had to be integrated into a seamless whole. As part of the Alaska map effort, we had already developed a schema to integrate the published geologic map of the Yukon, Canada, so we had already begun to travel down the path.



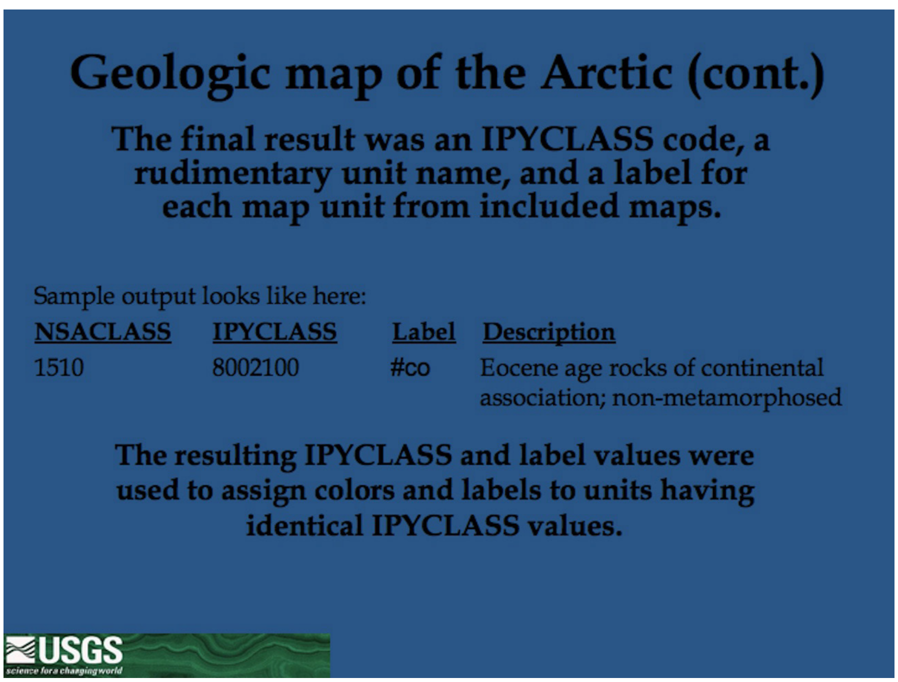
For the International Polar Year (2008), we had to integrate the geology of the Nations around the Arctic. We developed a schema that allowed similar geologic units to be recognized and linked, regardless of international boundaries. Our schema linked units based on age, geologic setting, and metamorphic history. Data dictionaries were developed for each category and an additive calculation of codes from the dictionaries classified units.



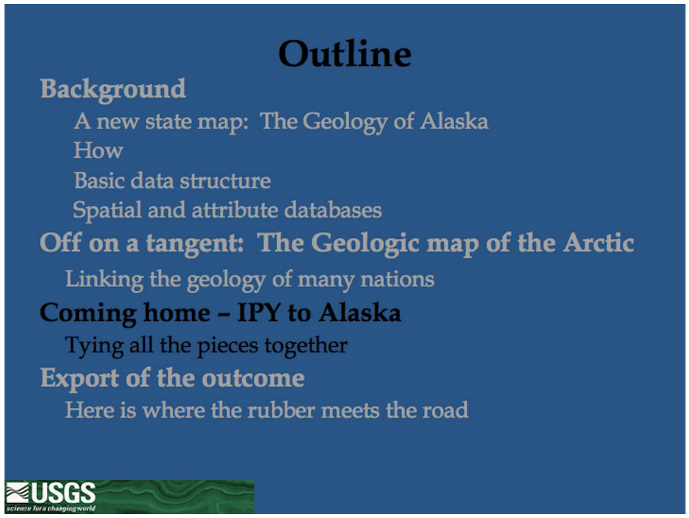
Each of the categories in the schema was assigned a range of numbers, such that when all categories are combined, the assigned IPYCLASS specifies uniquely the classification of the map unit.



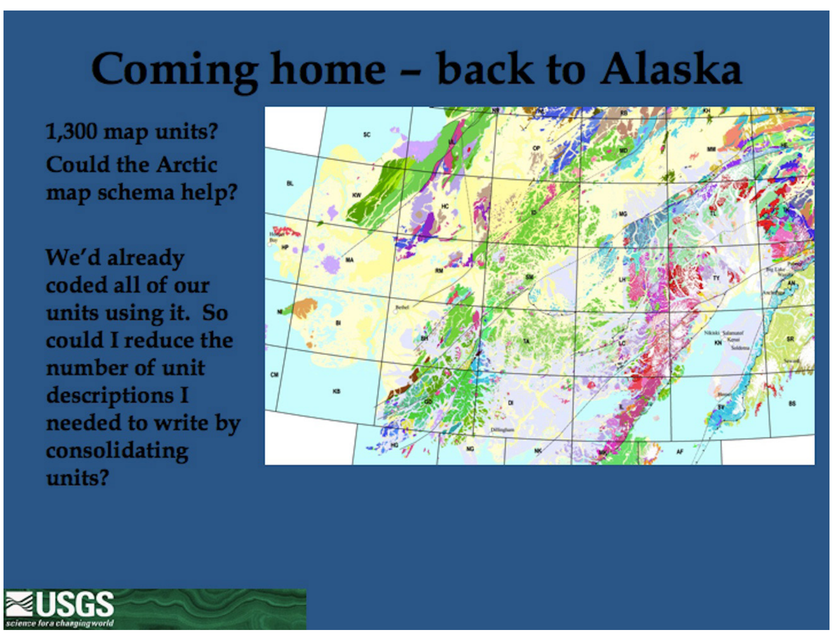
The lithologic classification was based on the rock types expected in a given geologic environment or setting.



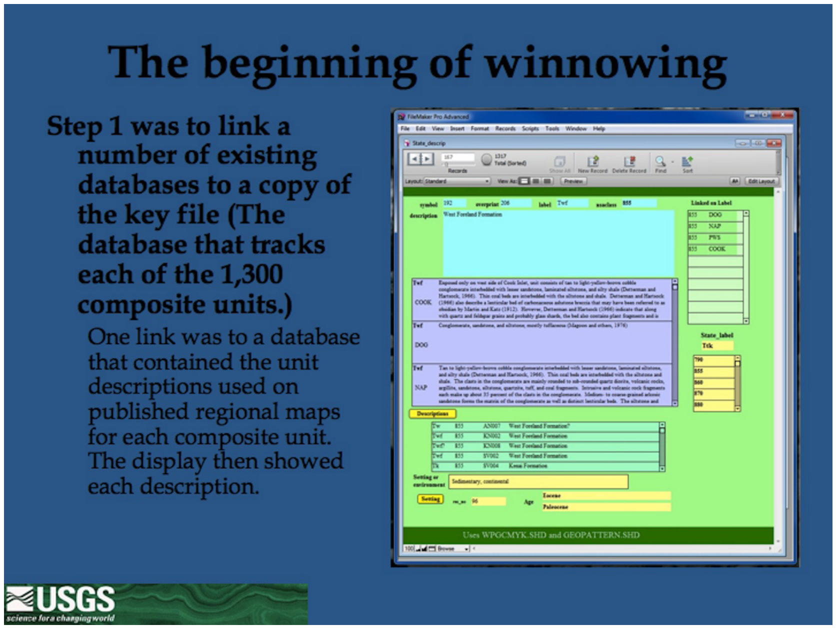
The final result was an IPYCLASS code, a rudimentary unit name, and a label for each map unit from included maps. The resulting IPYCLASS and label values were used to assign colors and labels to units having identical IPYCLASS values. Of course, units can be grouped on the basis of similar IPYCLASS values at user discretion. [NOTE: In the Label code “#co,” the “#” should be the symbol for Eocene.]



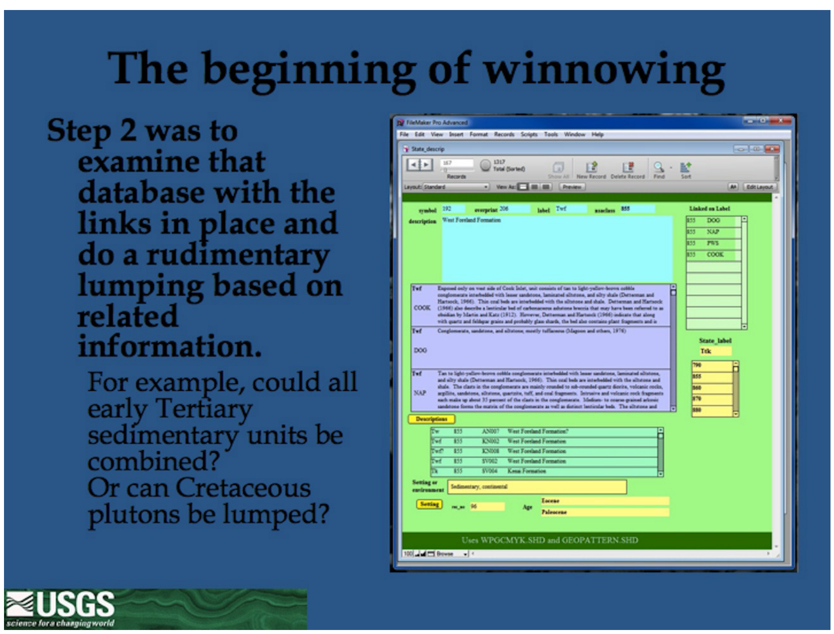
Having completed the IPY effort, our primary focus returned to the Alaska map. Our thought was, during the IPY effort, we had used the database to create the unit descriptions used on the map. Realizing that these unit descriptions were extremely succinct, if not cryptically abstracted, we wondered if the database could help us produce more complete unit descriptions. So, we developed another linked database, hopefully to pull everything together, leveraging off of the IPY coding we had done and seeing where it took us.



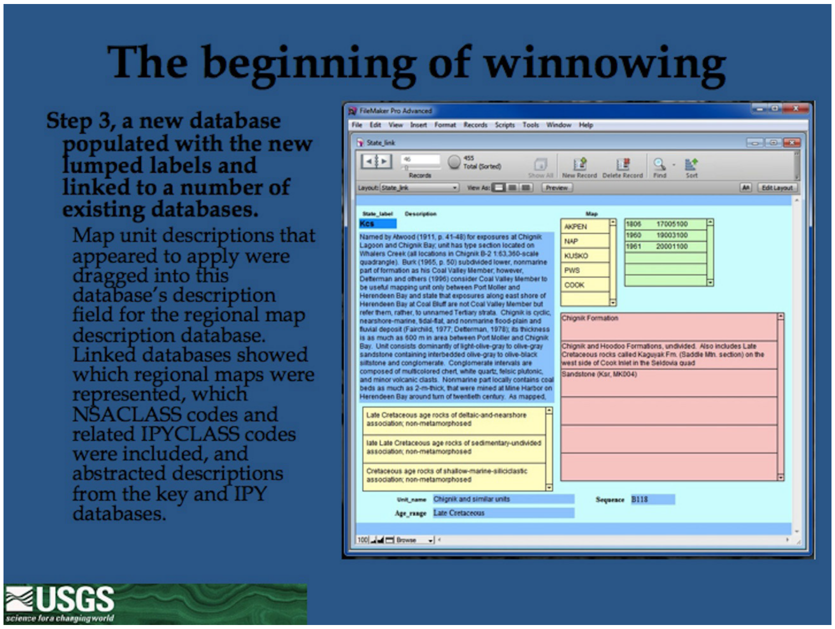
At this point in the process, the Alaska map had 1,300 map units. Because the Alaska and Circum-Polar map shared the same map unit coding scheme, the Alaska map units were consolidated according to the process described below.



Step 1 was to link a number of existing databases to a copy of the key file (the database that tracks each of the 1,300 composite units). We added a view into the database that included the unit descriptions from each of the regional maps; as these all had assigned NSACLASS values already, this was a simple step. One link was to a database that contained the unit descriptions used on published regional maps for each composite unit. The display then showed each description. This view not only showed the complete unit description from each regional map based on assigned NSACLASS, but it also showed a list of which regional maps contained the unit. A new field was added, called "State Label," which nominally would be the label for this unit used on the final State map.



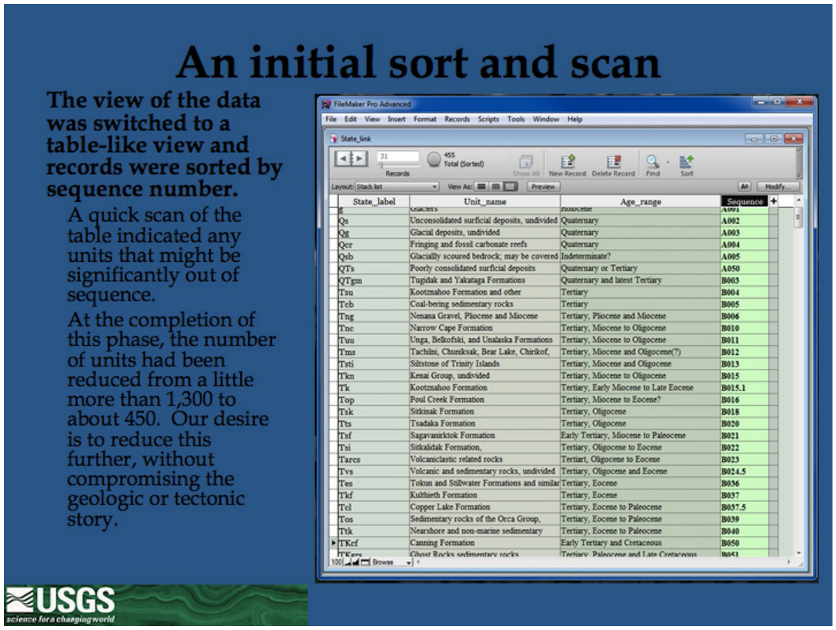
Step 2 was to examine that database with the links in place and do a rudimentary grouping based on related information. For example, could all early Tertiary sedimentary units, or all Cretaceous plutons, be combined? The new State Label field would become the link tying selected NSACLASS values together for the eventual State map. It was recognized that Tertiary sedimentary units were too varied to group all together, but based on descriptions, some certainly could be. The NSACLASS values from Cretaceous plutons originally divided them into three age classes and four to six compositional ranges. However, there was enough overlap compositionally that some of these could be readily combined for the developing State map.



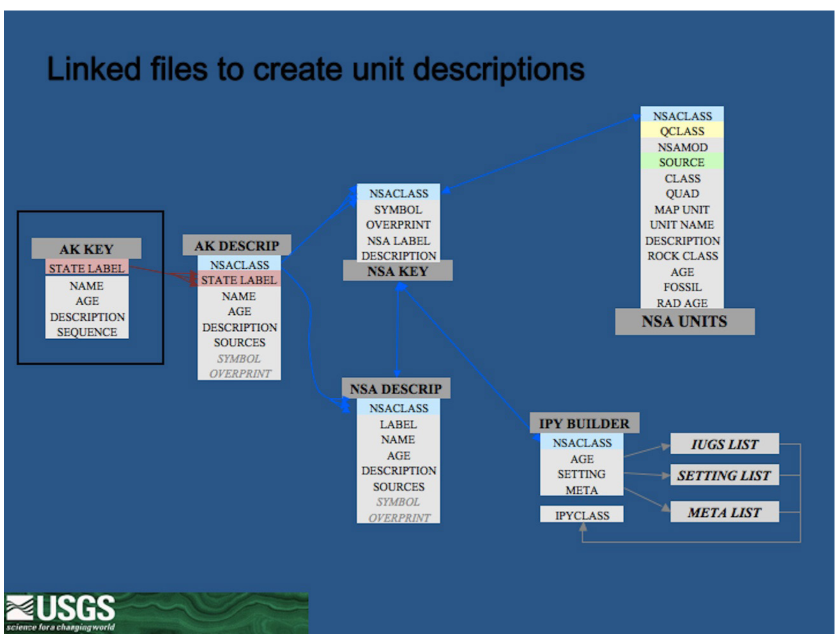
Step 3, a new database (table) was populated with the new grouped labels and linked to a number of the existing databases. The key link was through the State label to the NSAKEY field; this is a "1 to many" relation and, through the NSAKEY value, ties to NSACLASS and makes the other database tables accessible.

Map unit descriptions from the regional maps that appeared to apply to the unit statewide were brought into this database's description field (the blue one in the figure) from the regional map description database. Linked databases showed which regional maps were represented in the statewide unit (the upper yellow box), which NSACLASS codes and related IPYCLASS codes were included in it (the green box), and abstracted descriptions from the key and IPY databases (the pink and lower yellow boxes, respectively).

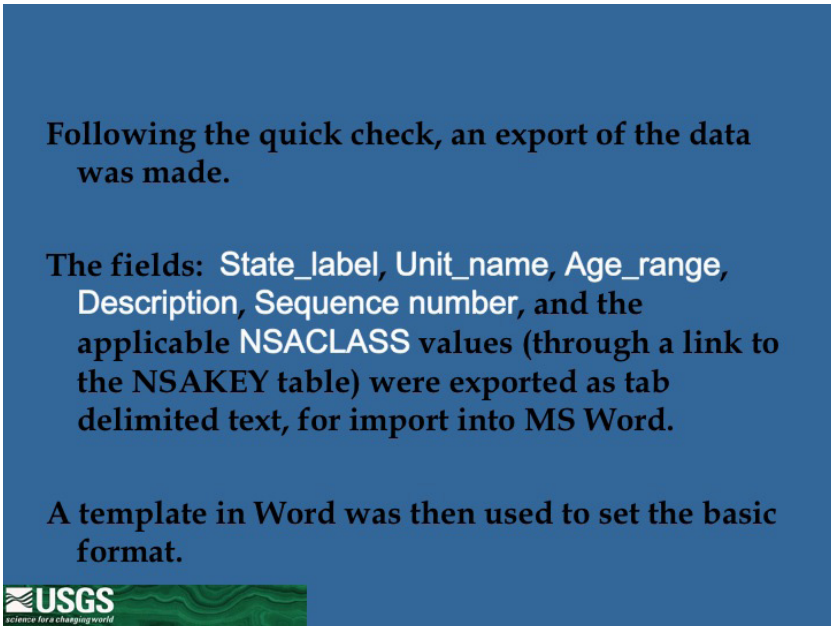
A unit name and age range for the unit were added and a sequence code was assigned to nominally set the order in which units would appear in the Description of Map Units for the State map. The sequence code was a combined letter and number, "A" for Quaternary unconsolidated deposits map units, "B" for sedimentary rock units, "C" for volcanic rock units, "D" for plutonic rock units, "E" for metamorphic rock units, and "F" for tectonic units (such as mélange) as well as problematic rock units, that is, those that did not seem to fit anywhere else.



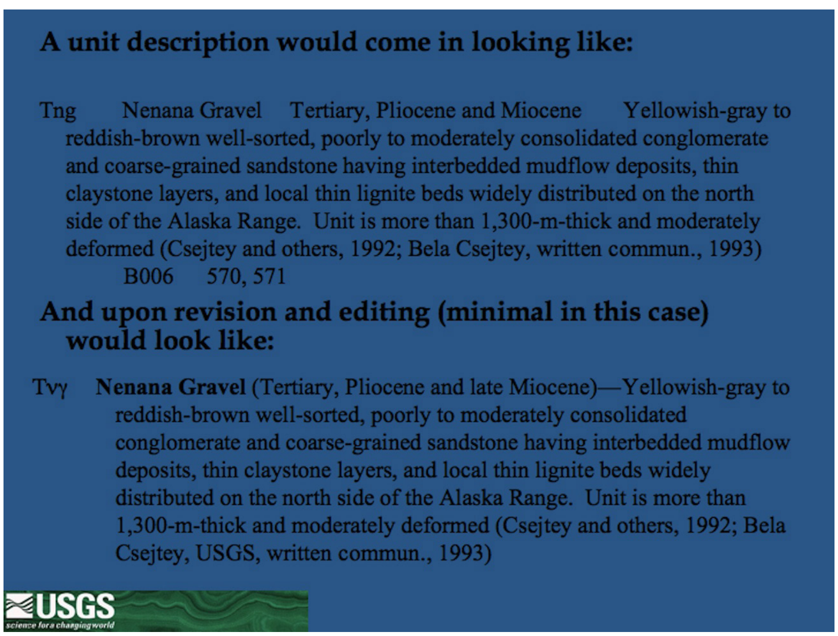
The view of the data then was switched to a table-like view and records were sorted by sequence number. A quick scan of the table indicated any units that might be significantly out of sequence. At the completion of this phase, the number of units had been reduced from about 1,300 to about 450. Our desire is to reduce this further, without compromising the geologic or tectonic story. As the draft map unit descriptions are fleshed out, occasionally it has been necessary to reassign NSACLASS codes, do additional grouping or splitting, and revise sequence codes as we refine the age for the units.



The files that were linked to derive the draft unit descriptions all tied back to the original units database through the NSACLASS code. They also tied to each of the previously written unit descriptions for the regional compilations as well as to the IPYCLASS codes. So, using a database table eventually named “State_link,” I was able to readily view much of the information that I needed to refine the unit descriptions.

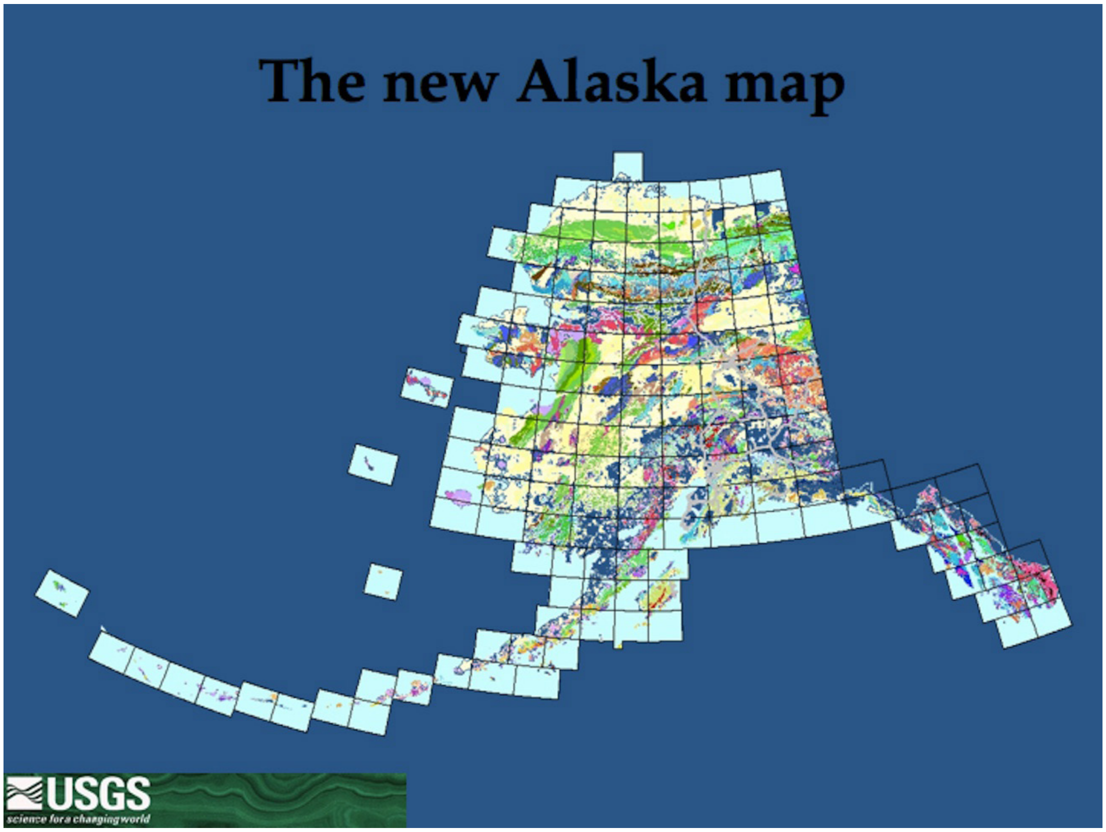


Following the quick check, an export of the data was made as a tab delimited text file for import to MS Word. The exported fields were: State_label, Unit_name, Age_range, Description, Sequence number, and the applicable NSACLASS values through a link to the "NSAKEY" table. Then, the USGS template for map descriptions was attached to set the basic format of the unit descriptions.



The unit description would initially look like this (with field names added here in brackets): Tng [Unit label] Nenana Gravel [Unit name] Tertiary, Pliocene and Miocene [Unit age] Yellowish-gray to reddish-brown well-sorted, poorly to moderately consolidated conglomerate and coarse-grained sandstone having interbedded mudflow deposits, thin claystone layers, and local thin lignite beds widely distributed on the north side of the Alaska Range. Unit is more than 1,300-meter-thick and moderately deformed (Csejtey and others, 1992; Bela Csejtey, USGS, written commun., 1993) [Draft description] B006 [Sequence number] 570, 571 [Applicable NSACLASS values].

The text would then be edited for clarity, the Sequence number and NSACLASS values formatted as hidden text, and the revised description pasted back into the database. As needed, references would be added to a references-cited list in the document, and a list of place names would be maintained in the document in order to facilitate ensuring that the final map contained all necessary place names.



This is a draft of the planned map; as the number of units is gradually winnowed down, the map may become simpler in appearance, yet its digital version will retain the full source information.

Selected References and Maps of Interest

[For links to published maps and data, see these Web sites, or those for the specific map of interest below: http://tin.er.usgs.gov/geology/state/ and *http://minerals.usgs.gov/alaska/prodxdgt.html*.]

Beikman, H.M., 1980, Geologic map of Alaska: U.S. Geological Survey Special Map, scale 1:2,500,000, 2 sheets, *http://ngmdb.usgs.gov/Prodesc/proddesc_19462.htm*.

Cady, W.M., Wallace, R.E., Hoare, J.M., and Webber, E.J., 1955, The central Kuskokwim region, Alaska: U.S. Geological Survey Professional Paper 268, 132 p., scale 1:312,500, *http://ngmdb.usgs.gov/Prodesc/proddesc_4246.htm*.

Csejtey, Bela, Jr., Mullen, M.W., Cox, D.P., and Stricker, G.D., 1992, Geology and geochronology of the Healy quadrangle, south-central Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–1961, scale 1:250,000, *http://ngmdb.usgs.gov/Prodesc/proddesc_10041.htm*.

Carter, L.D., and Galloway, J.P., 2005, Engineering geologic maps of northern Alaska, Harrison Bay Quadrangle: U.S. Geological Survey Open-File Report 2005–1194, *http://pubs.usgs.gov/of/2005/1194/*.

Mertie, J.B., Jr., 1938, The Nushagak district, Alaska: U.S. Geological Survey Bulletin 903, 96 p., scale 1:250,000, *http://ngmdb.usgs.gov/Prodesc/proddesc_21079.htm*.

Mull, C.G., Houseknecht, D.W., Pessel, G.H., and Garrity, C.P., 2004, Geologic map of the Umiat quadrangle, Alaska: U.S. Geological Survey Scientific Investigations Map 2817–A, *http://pubs.usgs.gov/sim/2004/2817a/*.

Mull, C.G., Houseknecht, D.W., Pessel, G.H., and Garrity, C.P., 2005, Geologic map of the Ikpikpuk River quadrangle, Alaska: U.S. Geological Survey Scientific Investigations Map 2817–B, *http://pubs.usgs.gov/sim/2005/2817b/*.

Mull, C.G., Houseknecht, D.W., Pessel, G.H., and Garrity, C.P., 2006a, Geologic map of the Lookout Ridge quadrangle, Alaska: U.S. Geological Survey Scientific Investigations Map 2817–C, *http://pubs.usgs.gov/sim/2006/2817c/*.

Mull, C.G., Houseknecht, D.W., Pessel, G.H., and Garrity, C.P., 2006b, Geologic map of the Utukok River quadrangle, Alaska: U.S. Geological Survey Scientific Investigations Map 2817–D, *http://pubs.usgs.gov/sim/2006/2817d/*.

Mull, C.G., Houseknecht, D.W., Pessel, G.H., and Garrity, C.P., 2008, Geologic map of the Point Lay Quadrangle, Alaska: U.S. Geological Survey Scientific Investigations Map 2817–E, *http://pubs.usgs.gov/sim/2008/2817-E/*.

Patton, W.W., Jr., Wilson, F.H., Labay, K.A., and Shew, Nora, 2009, Geologic map of the Yukon-Koyukuk Basin, Alaska: U.S. Geological Survey Scientific Investigations Map 2909, *http://pubs.usgs.gov/sim/2909/*.

Patton, W.W., Jr., Wilson, F.H., Labay, K.A., 2006, Digital data for the reconnaissance geologic map of the lower Yukon River region, Alaska: U.S. Geological Survey Open-File Report 2006–1292, *http://pubs.usgs.gov/of/2006/1292/*.

Patton, W.W., Jr., Wilson, F.H., and Taylor, T.A., 2011, Geologic map of Saint Lawrence Island, Alaska: U.S. Geological Survey Scientific Investigations Map 3146, *http://pubs.usgs.gov/sim/3146/*.

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

Shew, N.B., Peterson, C.S., Grabman, Nathaniel, Mohadjer, Solmaz, Grunwald, Daniel, Wilson, F.H., and Hults, C.K, 2006, Digital data for the geology of southeast Alaska by George E. Gehrels and Henry C. Berg: U.S. Geological Survey Open-File Report 2006–1290, *http://pubs.usgs.gov/of/2006/1290/*.

Till, A.B., Dumoulin, J.A., Harris, A.G., Moore, T.E., Bleick, Heather, and Siwiec, Benjamin, 2008, Digital data for the geology of the southern Brooks Range, Alaska: U.S. Geological Survey Open-File Report 2008–1149, *http://pubs.usgs.gov/of/2008/1149/*.

Till, A.B., Dumoulin, J.A., Phillips, J.D., Stanley, R.G., and Crews, Jesse, 2006, Digital data for the generalized bedrock geologic map, Yukon Flats region, east-central Alaska: U.S. Geological Survey Open-File Report 2006–1304, *http://pubs.usgs.gov/of/2006/1304/*.

Till, A.B., Dumoulin, J.A., Werdon, M.B., and Bleick, H.A., 2011, Bedrock geologic map of the Seward Peninsula, Alaska, and accompanying conodont data: U.S. Geological Survey Scientific Investigations Map 3131, *http://pubs.usgs.gov/sim/3131/*.

Wilson, F.H., 2005, Digital data for the reconnaissance geologic map of the Kodiak islands, Alaska: U.S. Geological Survey Open-File Report 2005–1340, *http://pubs.usgs.gov/of/2005/1340/*.

Wilson, F.H., Blodgett, R.B., Blome, C.D., Mohadjer, Solmaz, Preller, C.C., Klimasauskas, E.P., Gamble, B.M., and Coonrad, W.L., 2006, 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, *http://pubs.usgs.gov/of/2006/1303/*.

Wilson, F.H., Detterman, R.L., 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, *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 Haeusler, P.J., 1998, Geologic map of central (interior) Alaska: U.S. Geological Survey Open-File Report 98–133–A, *http://pubs.usgs.gov/of/1998/of98-133-a/*.

Wilson, F.H., and Hults, C.P., 2008, Digital data for the reconnaissance geologic map for Prince William Sound and the Kenai Peninsula, Alaska: U.S. Geological Survey Open-File Report 2008–1002, *http://pubs.usgs.gov/of/2008/1002/*.

Wilson, F.H., and Hults, C.P., 2012, Geology of the Prince William Sound and Kenai Peninsula region, Alaska, including the Kenai, Seldovia, Seward, Blying Sound, Cordova, and Middleton Island 1:250,000-scale quadrangles: U.S. Geological Survey Scientific Investigations Map 3110, 38 p., 1 sheet, scale 1:500,000, *http://ngmdb.usgs.gov/Prodesc/proddesc_98145.htm*.

Wilson, F.H., Hults, C.P., Mohadjer, Solmaz, and Coonrad, W.L., 2008, Digital data for the reconnaissance geologic map for the Kuskokwim Bay region of southwest Alaska: U.S. Geological Survey Open-File Report 2008–1001, *http://pubs.usgs.gov/of/2008/1001/*.

Wilson, F.H., Hults, C.P., Schmoll, H.R., Haeussler, P.J., Schmidt, J.M., Yehle, L.A., and Labay, K.A., 2012, Geologic map of the Cook Inlet region, Alaska, including parts of the Talkeetna, Talkeetna Mountains, Tyonek, Anchorage, Lake Clark, Kenai, Seward, Iliamna, Seldovia, Mount Katmai, and Afognak 1:250,000-scale quadrangles: U.S. Geological Survey Scientific Investigations Map 3153, *http://pubs.usgs.gov/sim/3153/*.

Wilson, F.H., Mohadjer, Solmaz, and Grey, D.M., 2008, Digital data for the reconnaissance geologic map of the western Aleutian Islands, Alaska, U.S. Geological Survey Open-File Report 2006–1302, *http://pubs.usgs.gov/of/2006/1302/*.