# Oregon Statewide Geologic Map Data: A pilot project where digital techniques changed the geologic map compilation process and product

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The Oregon Department of Geology and Mineral Industries (DOGAMI) has begun a six-year project to digitally compile geologic data for the entire state. This effort brings together the best available geologic mapping from state and federal sources, student thesis work, and consultants. The project will create a new statewide digitally-compiled geologic map coverage that will become a component of the Geoscience Theme within the Oregon Framework Themes (Figure 1). It will also improve the only digital statewide coverage, the 1:500,000-scale state geologic map.

To accomplish this project, DOGAMI is working in partnership with the USGS National Cooperative Geologic Mapping Program's STATEMAP component and the Oregon Geographic Information Council (OGIC). This partnership shares the funding burden of this ambitious effort, and provides a review process to ensure that the resulting data is consistent in structure, fully documented, and serves the greatest number of potential users.

## COMPILATION METHODOLOGIES

The following list of steps defines the usual way in which new small scale geologic compilation maps have been produced in the past. This process is referred to as "the conventional method".

- Give the best available geologic maps to a geologist or team of geologists.
- The geologist(s) then compiles a new, seamless map by drawing new linework at a particular scale and assigning new unit labels to each polygon.
- The new unit linework is then digitized and, based on the newly written explanation of map units, the unit information is entered into a database.

The DOGAMI compilation team decided to use a different method to compile a new statewide digital map. This process is referred to as "the Oregon Pilot method." Many of the differences between this method and the conventional method were driven by the expanded opportunities created by providing a digital-only version of the map. The compilation team used the following list of steps to make the statewide digital product, using the Oregon Pilot method.

- Digitize the original polygons/units for each of the best available source geologic maps (Figures 2 and 3).
- Enter the information from the source map author's explanation of units, into a relational database (Figure 4).
- Rank the maps in terms of the quality of the geological mapping and then decide on the order of supersedure for appending the maps together. In this ranking, a newer, 1:24,000-scale map by a professional geologist would replace an area or part of an older map at a smaller scale or one created by a graduate student.
- Put the best available polygonal/spatial information together into a single layer, primarily using the more detailed or better quality maps, but retaining the less detailed or poorer quality maps in areas where no other coverage is available. This process creates an "appended" map that contains all of the best geologic unit polygons (Figure 5).
- Create new compilation merge unit labels for each of the original source map unit polygons that have been appended together in the map. These new labels effectively merge the units from all of the different source maps into a coherent stratigraphic

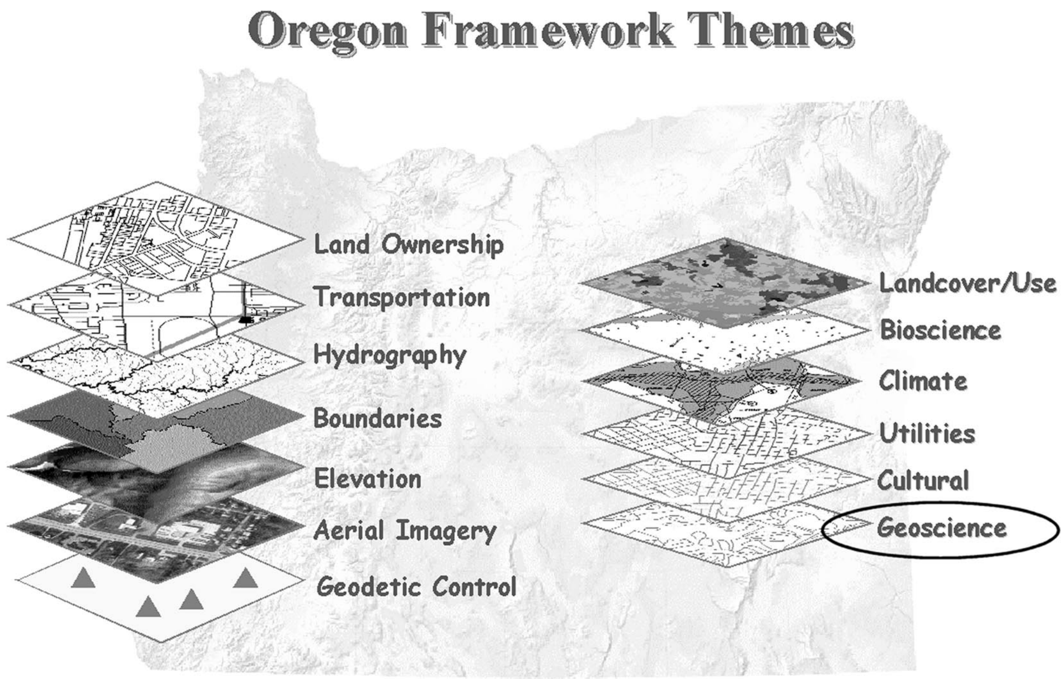



**Figure 1.** The Oregon Geographic Information Council has identified for statewide development thirteen Framework Themes. A workgroup for each theme is charged with developing a content standard and implementation plan. Geoscience members are from state and federal natural resource and transportation agencies, as well as academia. The Geoscience Theme presently consists of Geology and Soils layers.

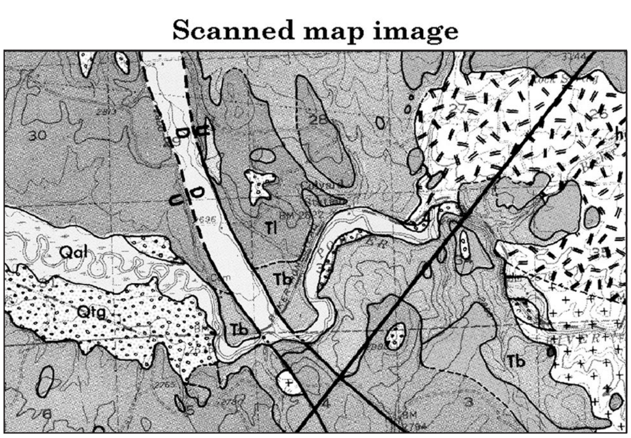



**Figure 2.** Image of part of a published geologic map. Raster scanning yields a high resolution image which then is georeferenced and projected prior to vectorizing the linework (image projection performed using Blue Marble Geographics software).

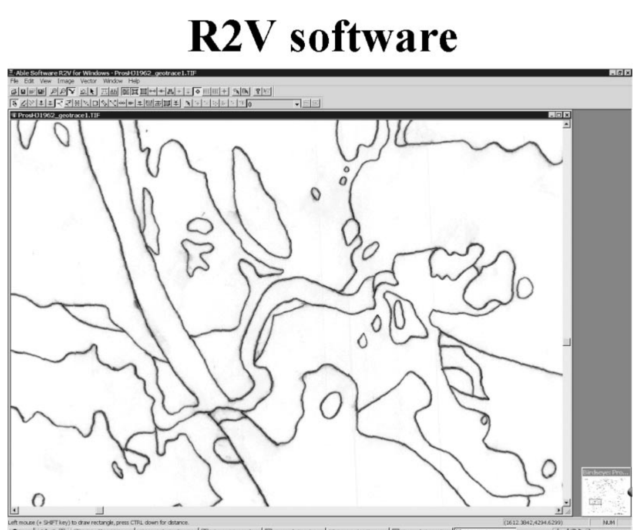
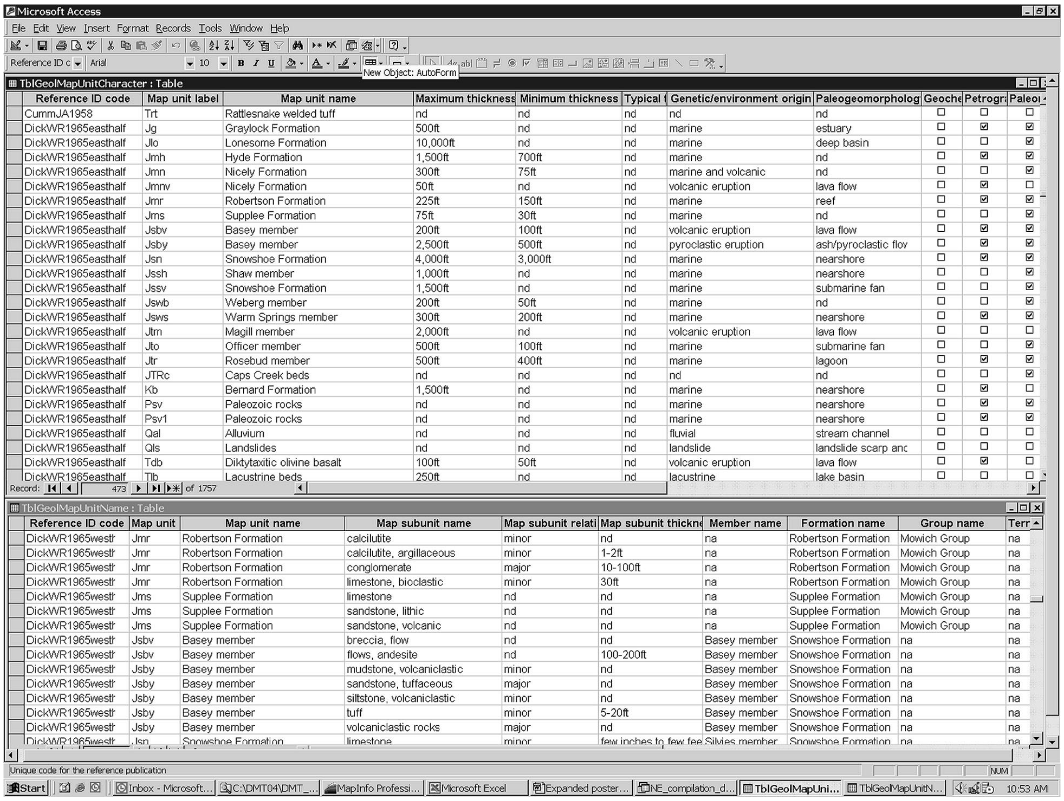



**Figure 3.** Image of the traced/vectorized linework from the geologic map shown in Figure 2. Conversion to vector format is done through on-screen digitizing or through use of R2V software (Able Software Corp.).



TblGeolMapUnitCharacter : Table

| Reference ID code | Map unit label | Map unit name | Maximum thickness | Minimum thickness | Typical t | Genetic/environment origin | Paleogeomorpholog | Geoche | Petrogra | Paleo |
|---|---|---|---|---|---|---|---|---|---|---|
| CummJA1958 | Trt | Rattlesnake welded tuff | nd | nd | nd | nd | nd | ☐ | ☐ | ☐ |
| DickWR1965easthalf | Jg | Graylock Formation | 500ft | nd | nd | marine | estuary | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jlo | Lonesome Formation | 10,000ft | nd | nd | marine | deep basin | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jmh | Hyde Formation | 1,500ft | 700ft | nd | marine | nd | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jmn | Nicely Formation | 300ft | 75ft | nd | marine and volcanic | nd | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jmnv | Nicely Formation | 50ft | nd | nd | volcanic eruption | lava flow | ☐ | ☑ | ☐ |
| DickWR1965easthalf | Jmr | Robertson Formation | 225ft | 150ft | nd | marine | reef | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jms | Supplee Formation | 75ft | 30ft | nd | marine | nd | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jsbv | Basey member | 200ft | 100ft | nd | volcanic eruption | lava flow | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jsby | Basey member | 2,500ft | 500ft | nd | pyroclastic eruption | ash/pyroclastic flov | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jsn | Snowshoe Formation | 4,000ft | 3,000ft | nd | marine | nearshore | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jssh | Shaw member | 1,000ft | nd | nd | marine | nearshore | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jssv | Snowshoe Formation | 1,500ft | nd | nd | marine | submarine fan | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jswb | Weberg member | 200ft | 50ft | nd | marine | nd | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jsws | Warm Springs member | 300ft | 200ft | nd | marine | nearshore | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Jtm | Magill member | 2,000ft | nd | nd | volcanic eruption | lava flow | ☐ | ☐ | ☐ |
| DickWR1965easthalf | Jto | Officer member | 500ft | 100ft | nd | marine | submarine fan | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Jtr | Rosebud member | 500ft | 400ft | nd | marine | lagoon | ☐ | ☑ | ☑ |
| DickWR1965easthalf | JTRc | Caps Creek beds | nd | nd | nd | nd | nd | ☐ | ☐ | ☑ |
| DickWR1965easthalf | Kb | Bernard Formation | 1,500ft | nd | nd | marine | nearshore | ☐ | ☑ | ☐ |
| DickWR1965easthalf | Psv | Paleozoic rocks | nd | nd | nd | marine | nearshore | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Psv1 | Paleozoic rocks | nd | nd | nd | marine | nearshore | ☐ | ☑ | ☑ |
| DickWR1965easthalf | Qal | Alluvium | nd | nd | nd | fluvial | stream channel | ☐ | ☐ | ☐ |
| DickWR1965easthalf | Qls | Landslides | nd | nd | nd | landslide | landslide scarp anc | ☐ | ☐ | ☐ |
| DickWR1965easthalf | Tdb | Diktytaxitic olivine basalt | 100ft | 50ft | nd | volcanic eruption | lava flow | ☐ | ☑ | ☐ |
| DickWR1965easthalf | Tlb | Lacustrine beds | 250ft | nd | nd | lacustrine | lake basin | ☐ | ☐ | ☐ |

Record: 473 of 1757

TblGeolMapUnitName : Table

| Reference ID code | Map unit | Map unit name | Map subunit name | Map subunit relati | Map subunit thickne | Member name | Formation name | Group name | Terr |
|---|---|---|---|---|---|---|---|---|---|
| DickWR1965westh | Jmr | Robertson Formation | calcilutite | minor | nd | na | Robertson Formation | Mowich Group | na |
| DickWR1965westh | Jmr | Robertson Formation | calcilutite, argillaceous | minor | 1-2ft | na | Robertson Formation | Mowich Group | na |
| DickWR1965westh | Jmr | Robertson Formation | conglomerate | major | 10-100ft | na | Robertson Formation | Mowich Group | na |
| DickWR1965westh | Jmr | Robertson Formation | limestone, bioclastic | minor | 30ft | na | Robertson Formation | Mowich Group | na |
| DickWR1965westh | Jms | Supplee Formation | limestone | nd | nd | na | Supplee Formation | Mowich Group | na |
| DickWR1965westh | Jms | Supplee Formation | sandstone, lithic | nd | nd | na | Supplee Formation | Mowich Group | na |
| DickWR1965westh | Jms | Supplee Formation | sandstone, volcanic | nd | nd | na | Supplee Formation | Mowich Group | na |
| DickWR1965westh | Jsbv | Basey member | breccia, flow | nd | nd | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsbv | Basey member | flows, andesite | nd | 100-200ft | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsby | Basey member | mudstone, volcaniclastic | minor | nd | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsby | Basey member | sandstone, tuffaceous | major | nd | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsby | Basey member | siltstone, volcaniclastic | minor | nd | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsby | Basey member | tuff | minor | 5-20ft | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsby | Basey member | volcaniclastic rocks | major | nd | Basey member | Snowshoe Formation | na | na |
| DickWR1965westh | Jsn | Snowshoe Formation | limestone | minor | few inches to few fee | Silvies member | Snowshoe Formation | na | na |

Unique code for the reference publication

**Figure 4.** Screenshot of two of the Oregon Pilot method's Microsoft Office Access database tables, showing the typical data entry method and language.

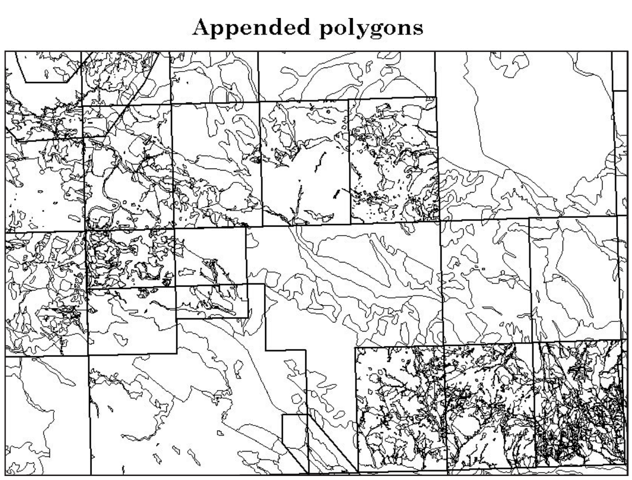



**Figure 5.** Screenshot of polygons appended from various source maps into the draft digital compiled map. Bold, rectangular lines are the neatlines of original geologic maps. Fine lines are appended polygon boundaries.

or lithologic framework, thus creating "logical seamlessness" for the map. Logical seamlessness occurs when a number of source datasets are integrated into one and the resulting disjointed features are not edgematched (modified geometrically) to fit together. Instead, these features are associated through attributing (FGDC, 1995). The merge unit labels are based on the current understanding of the geologic history of the area, as well as any new geochemical analyses. Professional geologists, who have been working in and have a broad understanding of the geology of a particular area of the state, assign the compilation merge unit labels. Several types of compilation merge unit labels can be made or modified to suit the end user's needs, but the DOGAMI product includes labels for geology, lithology and general geologic type (sedimentary, volcanic, intrusive, etc.).

## GOALS OF THE OREGON PILOT METHOD

Several of the compilation team members have experience in making compilation maps using the conventional methodology. Out of these experiences grew the goals of the compilation project and therefore of the Oregon Pilot methodology:

- New geologic information is always becoming available. Therefore, the process must break free of a methodology that requires recompiling the state's geologic information from scratch every few years.
- As the complexity of management decision-making increases, the need to factor in geologic information becomes more widespread among different governmental agencies and non-governmental organizations. The method must create a product that is readily understood and can be easily used by a wide range of disciplines, not just by geologists.
- The new Oregon Framework Themes process provides statewide coverage of the best available information for each of the themes. Thus, the geologic layer in that Framework must be capable of being constantly updated, in order to provide the most current or "best" geologic information. The Oregon Framework themes will serve not only state decision-making processes, like the Oregon Department of Transportation's siting of a new aggregate pit, but possibly will also be useful to federal and local efforts.
- Geological science uses complex, often difficult-to-understand vocabulary. To minimize confusing terminology, we have limited the amount of non-mnemonic language in the database information.
- The compilation map also must refrain from re-interpreting the original authors' map polygons or the explanation of units. Thus, maintaining a linkage to the source maps and to their authors' original interpretations is a very important part of the methodology.
- The task of putting together a new statewide layer, especially one that is accompanied by complex, descriptive information, is arduous. Therefore, the method must take advantage of the efficiencies of relational databases, i.e., the descriptive geologic information in the original source map explanation is entered into the respective database tables only one time for each unit.

## ADVANTAGES AND DISADVANTAGES

Each of these two methods has advantages and disadvantages. Of course, we chose to use the "new" Oregon Pilot method because we felt that its advantages outweighed its disadvantages. The advantages and disadvantages of each method are listed below.

### Conventional method

*Advantages*

- It provides seamless, uniform coverage without "map faults" between the different geologic interpretations and/or map scales.
- It is simple to use because it contains only a single set of descriptive data for every compiled map unit.
- It speeds up and simplifies the process of entering the digital information because it requires entering only a single set of polygons and a single set of map unit descriptors.

*Disadvantages*

- The map is not updateable. It is a snapshot of the best geologic information available at a particular time. New mapping cannot be added to it. Every new compilation project must start with the original source maps.
- The varying quality of the geologic information is not transparent. The compiled map does not necessarily retain either the original author's polygons or unit descriptions. The seamless coverage at a single, small scale masks the areas of poor quality mapping.
- The final product is not flexible. The compiled data and map unit labels result only in a single standalone, conventional geologic map, not providing for other derivative map products.
- It is not scaleable. The map is a single, fixed scale, and does not retain the larger-scale, detailed information that may have been available in some of the original source maps.

### Oregon pilot method

*Advantages*

- It is updateable. New mapping can be added as soon as it is completed, and any of the compilation merge unit labels can be easily changed to reflect the new information and interpretation. To make a new version of the compilation map, the method fits the new source geologic maps into the previously appended mapping. Thus, the statewide compilation map can be continuously modified/updated.
- It is transparent. The author's original polygons and descriptive explanation are in the database, and are always available to the end-user. Digital versions of the original geologic maps, both as scanned images and converted vectors, are part of the compiled map package. The compiled map also clearly conveys the areas of lesser-quality, usually small-scale mapping (see Figure 5). The obvious differences between areas of detailed versus reconnaissance mapping can direct future mapping efforts to those parts of the state with the most critical management issues, which may require mapping of higher qual-

ity and resolution than currently available.

- It is flexible. Derivative geologic or other types of maps can be made for any purpose. Users can easily modify the compilation merge unit labels which DOGAMI geologists have assigned, to fit their own stratigraphic or lithologic interpretations. Because the map is intended for use as a digital product, the compilation merge unit labels are not restricted to the length of typical geologic map unit labels (i.e., Qal). Thus, more information, like lithology, formation, age, etc, can also be conveyed in the compilation merge unit labels. Using period delimiters in the merge unit labels allows them to be parsed into individual themes that can then be made into their own derivative geologic maps.
- It is scaleable. Because it retains the original source map's information, those areas of the state that contain detailed (1:24,000) information from the original map can be used at that scale; while the compilation merge unit labels create maps that are more appropriate for intermediate-scale (e.g., 1:100,000) and small-scale (1:250,000 or greater) usage.

### *Disadvantages*

- It produces a seamed coverage with obvious "map faults", or seams, between areas of differing original geologic interpretations and/or source map scales. Edgematching among the units of the original source maps is only addressed by the compilation merge unit labels.
- It is not a static product, so at any point in time there is no single, official "Geologic Map of the State of Oregon". Rather, versioned databases will be periodically released to keep the state's digital geologic coverage as up-to-date as possible.
- It is more difficult for the casual, non-professional audience to access and use the information. The digital seamed coverage requires that the user be capable of choosing the type of derivative map product that they want to produce, as well as the map scale displayed.
- It is not easily printable in its entirety. Local and regional land and resource management projects are the intended audience for the digital product. The entire statewide layer is too large and detailed to be printed at a single scale, and on a single sheet of paper.
- The final digital product varies in quality from one area of the map to another. The older source maps, and their explanations of map units that are entered into the database, often contain information that is from previous, now discarded, generations of geologic interpretation. However, they are still used in the compiled map because they are the best available information for that particular area.
- A large volume of information must be digitized at the beginning of the compilation process. The final digital product is a patchwork of many geologic maps instead of a single coverage; many sets of unit descriptions are attached to the merged polygons instead of a single set of unit descriptions.

## ROLE OF DIGITAL CONCEPTS

As noted earlier, the digital concepts and techniques that are available now, such as raster-to-vector conversion (R2V) and relational databases, were a driving force behind our ability to create the Oregon Pilot method. Our choice to produce a digital-only statewide compilation product changed the way that we looked at compilation mapping and therefore led to the differences between the Oregon Pilot method and the conventional method. Some of those conceptual and methodological changes are listed below.

1. Digital maps do not have to be made at a particular scale and do not have to be printable on standard paper sheet sizes. Thus, they can include a range of different-scaled mapping.
2. Digital techniques make it easy to convert maps individually into digital products and then splice or append them together to make the final single layer of polygons. This simplicity allows the Oregon Pilot method to carry along, unchanged, the original source map linework and unit descriptions. Without the digital methodology, the compilation work would be forced to revert to the old method of drawing completely new linework and writing a new explanation of units.
3. Compact digital storage media (e.g., DVDs) now have sufficient capacity to store scanned and digitized original maps as well as a final, single, appended statewide digital map layer. Thus, the original source maps, which may be out-of-print or difficult to access, are more easily available to the end-user.
4. Most federal, state, and local governments use GIS systems to make management decisions. These entities need a digital geologic coverage that is as detailed as possible, and that can be easily understood by non-geologists. The appended source maps provide the best available spatial information at the largest possible scale and the greatest detail, while the new compilation merge unit labels provide the most current geologic interpretation.
5. Digital geologic data can be layered with other digital spatial themes to provide a more complete understanding of a project area or a management issue. Thus, the digital product makes both the

original source maps, and the compiled and merged data, more accessible to the end-user.

## REFERENCES

Federal Geographic Data Committee, 1995, Development of a National Digital Geospatial Data Framework, section 5.2 Technical Context, accessed at http://www.fgdc.gov/framework/framdev.html.

## SOFTWARE VENDOR CONTACT INFORMATION

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