Guidelines for Peer Review of a Geologic Map Product

Version 2

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This document was prepared for the National Cooperative Geologic Mapping Program by L. Sue Beard. It is based in part on "Notes on the Technical review of Geologic Maps and Structure Sections in Areas of Deformed Sedimentary Rocks", by Mitchell Reynolds, Edward T. Ruppel, and Jack E. Harrison, 1990 (USGS informal document). In 2009, a preliminary version of this document was circulated within USGS. The current version addresses the comments provided by many USGS scientists.

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National Cooperative Geologic Mapping Program

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INTRODUCTION

This document describes techniques for a thorough peer (scientific/technical) review of a USGS geologic map product. The USGS requires peer review of all publications, and maps are no exception. According to the USGS Manual, Fundamental Science Practices [http://www.usgs.gov/usgs-manual/500/502-3.html]—'Qualified reviewers must be true peers, must not be associated with the work being performed, and should be selected for their relevant scientific and technical expertise, including those who may apply different methods of study to related scientific questions. Peer reviewers should be sought outside a scientist's own discipline where appropriate. Reviewers should be able to ensure that the science is effectively presented with the intended audience in mind and be cognizant of controversial or high-visibility issues that may be relevant to public policy.'

The purpose of this document is to provide clear guidelines for peer review of geologic maps produced through funding by the National Cooperative Geologic Mapping Program. However, additional information is also included about the map product and digital database that authors will find useful as they prepare a review package.

The following guidelines are adapted from a map review course taught by Mitchell Reynolds in the 1990's. That course was adapted in turn from a seminar taught by E.T. Ruppell and J.E. Harrison from the Branch of Central Regional Geology, U.S. Geological Survey. Because our products are now provided in both paper (analog) and digital form, the review process may require some additional steps to the process that was outlined in the earlier courses. Although use of the digital geologic database during the peer review is not required, those familiar with the databases commonly find having it available for the review process helpful.

Because USGS maps are required to be published with a geologic map database, it is important that USGS geologists become familiar with the digital components of a geologic map. **NCGMP09** (National Cooperative Geologic Mapping Project) is a proposed standard format for geologic map publications, developed under funding by the NCGMP program. It specifies a database schema to construct a traditional geologic map as published by the USGS. The current NCGMP09 database template is available at: http://ngmdb.usgs.gov/Info/standards/NCGMP09/.

The current USGS scientific review process focuses on a cartographic paper map output, whereas a separate digital review focuses on the mechanics and integrity of the digital database from which a cartographic product is derived. We encourage technical reviewers to begin using the digital database, in addition to the cartographic product, to check for geologic integrity. With that in mind, a parallel document (Digital Review of Geologic Maps) includes recommended steps for digital review of the map database that can be useful for peer review as well.

Reviewer and author responsibilities

The traditional policy is that when a USGS scientist is asked to review a geologic map, that review should be made a top priority and completed promptly. If that is not possible, the Science Center Director, Science Center Director designee, or author requesting the review should be informed so that another reviewer can be identified.

The technical reviewer of a geologic map should be an experienced geologist with knowledge of the investigative and interpretative process of making a geologic map. The reviewer should not hesitate to consult others more qualified in specialty fields such as geochronology, paleontology, and geophysical methods. The primary responsibility of the reviewer is to help the author prepare a high-quality publication and so ultimately help the users of the map. The reviewer should:

- Detect errors of omission, flaws in logic in mapping or in interpretation, or other problems that the author may not see because he/she is too close to the subject.
- Point out the problems and suggest reasonable and logical alternative solutions, point out where the map or sections are incomplete, or where interpretations are questionable.

The critical questions to address in a map review are:

- Is the map a well-organized, thoughtful, consistent geologic map product?
- Are the cross-sections, if provided, properly constructed and are the interpretations logical and consistent with the map?
- Is the map ready to be reviewed --is it a 'finished' product according to U.S. Geological Survey standards? For the review process, the materials must be complete, even if not assembled into final format.
- Is the intended publication series appropriate (especially regarding Open-file versus Scientific Investigation Reports— http://www.usgs.gov/usgs-manual/1100/1100-3appendixa.pdf)

Upon return of the map product after review, the author's responsibility is to consider each review comment and either accept it or reject it. The author should respond to every comment. If a comment is accepted, the author can make the necessary changes; if a comment rejected, the author must explain why. The Science Center Director or his/her representative is responsible for verifying that the author responses are complete.

Review vs. edit

It is important to distinguish between the purpose of a geologic map review (the topic of discussion here) and that of a geologic map edit, which will be performed by the EPN after the review process is complete. In essence, the review focuses primarily on the scientific content of the geologic map manuscript, whereas the edit focuses more on the style and method of presentation. As a simple example, in the case of a line on a geologic map, the reviewer's job is to evaluate whether the line appears to be accurately located and properly interpreted (e.g., as a fault vs. a contact) based on its geologic context, whereas the editor's job is to ensure that the line is correctly symbolized. While some aspects of a review will inevitably spill over into the realm of editing, it is generally best to leave most of the purely editing functions to the EPN. An exception to this is the open-file map, which will not be examined in great detail by the EPN. In this case, the reviewer will need to pay more attention to editorial issues than with a formal publication that will receive a thorough edit.

Tools

The following tools may be helpful to consult during the peer review.

- USGS, Suggestions to Authors (STA; 7th edition, 1991)—http://internal.usgs.gov/publishing/sta/
- Electronic editing resources—http://internal.usgs.gov/publishing/toolboxes/documents/editingtips.pdf
- Copy editing marks (STA)— http://internal.usgs.gov/publishing/sta/sta33.pdf
- Writing tools—http://internal.usgs.gov/electronic-office/writing.html
- GPO Style Manual—http://www.gpoaccess.gov/stylemanual/browse.html
- EPN styles and templates — http://internal.usgs.gov/publishing/toolboxes/templates.html
- Geologic names lexicon, or Geolex—http://ngmdb.usgs.gov/Geolex/geolex_home.html
- FGDC geologic symbol standards — http://ngmdb.usgs.gov/fgdc_gds/geolsymstd/download.php
- Compton, Robert R., 1985, Geology in the field: John Wiley and Sons, Inc., 398 pp.
- Groshong, Richard H. Jr, 2006, 3D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation— http://www.springerlink.com/content/m7k762/

THE GEOLOGIC MAP REVIEW PACKAGE

The review package from the author should include the following:

- Routing sheet—checked through the Science Center Director (or his/her representative). The form is viewable at http://internal.usgs.gov/fsp/toolbox/forms/Form_9-1325.pdf. See also line of authority (steps and responsibilities) http://internal.usgs.gov/fsp/toolbox/product_dev_steps.html.
- Printed copies of map elements (listed below; Elements of a Geologic Map Package). The map and cross-section(s) should be complete and include, at a minimum, the required elements. The map elements must be able to stand alone and to be legible at the scale of intended publication. A completed publication-quality layout is not necessary; however, the author may choose to provide the completed layout, which could speed up the publication process.
- Electronic versions of map elements (recommended). These should be provided for those reviewers who prefer to provide comments electronically. The review process can be streamlined by creating a shared network folder where electronic files can be posted,

including the routing sheet. All review comments can be posted on the electronic documents (e.g., http://ngmdb.usgs.gov/Info/dmt/docs/DMT08_Draft_Hill.pdf).

- Map database (recommended). Reviewers can request a copy of the geologic map database to assist in the review process. The database should include the digital elements listed below in the next section, 'Elements of a Geologic Map Package' (see also **NCGMP09**).

ELEMENTS OF A GEOLOGIC MAP MANUSCRIPT

The geologic map manuscript will include the required elements below, as well as any or all of those listed as optional. These elements are presented in terms of those required for 1) a printed/on-demand map product and 2) the **NCGMP09** database standard format (see link in the introduction), specifically the ArcGIS-based geodatabase schema. Information pertinent to the geologic database follows the 'Geodatabase' heading for each element.

The basic structure of a geologic map geodatabase is as follows (indents mimic the hierarchical structure):

- Geodatabase — this is the container for all the elements of the geologic map database, including both spatial datasets and non-spatial tables.
    - Feature dataset — there are one or more feature datasets in a geodatabase. A feature dataset needs a coordinate system, projection and spatial extent (boundary). An example is a 'geology' feature dataset which contains the geologic map represented as lines, points, and polygons (units).
        - Feature class — each feature dataset contains feature classes that each contain a part of the map, as lines, points or polygons. Examples include lines representing contacts and faults, polygons representing the map units, and points representing the location of attitude data. Each of these would be a separate feature class within the 'geology' feature dataset.
    - Tables — examples of non-spatial tables in the geodatabase include sources of data (references) and Description of Map Units.

Element 1—Geologic map

Required. This is the fundamental element of the manuscript. A paper copy of the map, at the intended publication scale and complete with topographic or alternative base (e.g., shaded-relief), should be included in the review package and be of good quality print. The map should be colored, labeled, and symbolized as intended for publication. The digital file from which the map is printed (typically a pdf) can be requested by the reviewer.

Geodatabase: The geologic map database should include the following feature classes within the geology feature dataset:

1. Map-unit polygons — ***Required***.

2. Contacts and faults line layer or layers — ***Required***.

3. Other lines — ***Optional***. *Includes folds, facies boundaries, dikes, cross-section lines, marker beds, alteration zones, breccias zones, measured sections, etc. Can be one or more feature classes.*

4. Structural point data — ***Optional***. *Includes point data such as bedding attitudes, site-specific fault data, fold axes, foliations, lineations, etc.*

5. Other point data — ***Optional***. *Includes sample locations, drill holes, etc. Can be one or more feature classes.*

In addition, the digital geologic map database should include the following, which are used to symbolize the feature classes within the geology feature dataset:

1. *Symbology for map units* — **Required for digital geologic map database.** This is presented in the geologic map database within a style.
2. *Style or cartographic representation of lines and points, using FGDC standards* — **Required.**

Element 2—Geologic cross-section

Not required, but highly recommended. Cross-sections, which are vertical slices through the earth, represent the third dimension of a map. If included, the line(s) of the section(s) must be shown on the geologic map. Cross-sections should be colored, labeled, and symbolized to match the geologic map.

Geodatabase: Under **NCGMP09,** the cross-section(s) are included as a one or more cross-section feature datasets within the geodatabase. To see how a cross-section is created within the ArcGIS environment, see http://pubs.usgs.gov/of/2005/1428/thoms/index.html; also http://arcscripts.esri.com/details.asp?dbid=15530. Alternatively, cross-sections can be constructed as separate graphics outside the database structure.

Element 3—Geologic reference information

Correlation of map units (CMU)

Required. Shows interrelationship of all mapped units, portrayed as map-unit boxes grouped with age brackets.

Geodatabase: **Under NCGMP09, the CMU is** included in the geodatabase as a *CorrelationOfMapUnits* feature dataset. Because this is not a geographically referenced feature dataset, the coordinate system, projection, and spatial extent are artificial. Alternatively, the CMU can be constructed as a separate graphic outside the database structure.

Description of map units (DMU)

Required. Describes units in order of age and rock type.

Geodatabase: **Under NCGMP09, the** DMU is included in the geodatabase as a non-spatial table, 'DescriptionOfMapUnits'. Alternatively, the DMU can be constructed as a separate graphic outside the database structure.

List of map units (LMU)

Required if the DMU will be included in a map pamphlet rather than presented on the map sheet. The list will be placed on the map and should include the map-unit symbol, the unit name, and the unit age. In addition, a brief, abbreviated description can be included when the separate DMU is detailed and lengthy.

Geodatabase: Created from the 'DescriptionOfMapUnits' table. Alternatively, the LMU can be constructed as a separate graphic outside the database structure.

Geologic symbol explanation

Required. Describes all symbols used in the geologic map, including structural symbols and other symbols such as sample localities and wells.

Geodatabase: Created from the pertinent feature classes in the geology feature dataset. Alternatively, the symbol explanation can be constructed as a separate graphic outside the database structure.

Explanatory and interpretative text

Optional. Describes geologic setting, structure, economic geology, etc., and may include interpretations resulting from mapping. Can be accompanied by geochemical, geochronologic and structural data plots, tables and graphics, photographs, and tectonic and other supplemental maps or figures. This information can either be placed on the map or in a separate map pamphlet.

Geodatabase: Typically included in the digital map package as a .pdf file.

Stratigraphic column

Optional. Recommended if there are complex relations between stratigraphic units.

References

Required if any references are cited in the manuscript.

Geodatabase: Sources of geologic features shown on the map (e.g., the contacts, map units, structural measurements derived from previous mapping) are provided in the *DataSources* table in **NCGMP09**.

Element 4—Basic map reference information

The basic map information listed below is required for all geologic map manuscripts. This information must appear on the final map layout.

Map series and number

Agency credit

Base map credit

Projection of base map

Geographic coordinates

Magnetic orientation

Scale

Contour interval (if a topographic map is used as base)

Geologic Credit/Index to geologic mapping

Location map (index map)

Title

Authorship

Date of publication

Geodatabase: Most of this information is captured in the metadata report for the map database (although metadata contains much more information than that listed below.) Metadata is a r**equired** component of a digital database. Metadata is 'data about data'—that is, it provides documentation of the data contained within the map database. See section on metadata in **NCGMP09** for more information.

THE REVIEW PROCESS

First view of the map

Get familiar with the map, sections and explanation. The purpose of this first look at the map is to get a general knowledge of the map area, and a general sense of the quality of the map—ranging from whether the map is good with few problems to an incomplete map that is not even ready for peer review. If the required map elements are incomplete, return the map to the author with a list of what is needed.

- Learn the map units, and understand their areal distribution, sequence, and characteristics such as general lithology and thickness.
- Evaluate the overall purpose of the map. Who is the intended audience? Is this a reconnaissance, preliminary or thorough map? This will help guide your review.
- Gain a general view of the third dimension, including the structure, both on the map and the cross-sections.
- Look for obvious problems—detailed examination will come later. Make note of those errors on the review copy to remind you to look more closely.

Order of review

- Use a systematic approach to check clarity, accuracy of presentation, logic and consistency of information presented on the map elements.
- A suggested review process is to proceed from the geologic reference material (element 3) to the geologic map (element 1), and then to the cross sections (element 2). However, the review process should include cross-checking among all the map elements. It is also important to check element 4--the basic map reference material.

Step 1. Review Element 3—Geologic reference information

As listed above, this includes the CMU, DMU/LMU, symbols, descriptive text and references, and any supplementary maps or figures. Although many of the items in the list below will also be scrutinized later by the EPN editor, careful peer review of these items often identifies problems of scientific importance in addition to purely editorial mistakes.

1) Overview of DMU/LMU and CMU

a. It generally works best to review the DMU/LMU and CMU jointly, back and forth. As a geologic unit description is reviewed, check that the unit is shown on the CMU and accurately positioned in relation to adjacent units and time boundaries. Check that age brackets in the CMU are clear and carefully drawn, and that they are consistent with unit ages shown in the DMU/LMU.
b. Check that the order of listing of units in the DMU/LMU matches the CMU order, starting from the upper left corner of the upper left box, and proceeding left to right, then down, then left to right again.
c. Check that map unit colors shown in the CMU and DMU/LMU are consistent with those shown on the map, and that they are distinctive so that units can be easily distinguished.
d. Check that units and symbols for all map units on map and sections are in both DMU/LMU and CMU.
e. Map unit symbols are best kept to four or fewer letters (although sometimes there is a need for longer symbols), and conform to conventions of stratigraphic nomenclature:
    1. If rocks mapped belong to two systems, the symbol for the younger system is listed first; e.g., QT for Quaternary-Tertiary.
    2. Letters after the age are lowercase and stand for the stratigraphic or deposit name, usually chosen from the first letters of the name applied to that unit, whether formal or informal.
    3. If there is no formal name, a suitable lithologic term is used, and the first letter of first word generally becomes part of the symbol.

2) Detailed review of DMU

The most important part of reviewing the Description of Map Units is determining whether the units are adequately described. The DMU should include the information needed to identify and distinguish the unit—how can it be recognized, does it change through the area, and if there are different facies are they adequately described. Check the following:

a. The DMU should be written in telegraphic style rather than complete sentences.
b. Map unit names and ages should conform to standards of nomenclature. This is particularly important for open-file maps, for which a subsequent GNU review is not required, but should not be overlooked even for formal maps that will receive GNU review.
c. Descriptions should include such characteristics as fresh color, weathered color, grain size and shape, mineralogy-petrology, bedding, foliation, induration, fossil content, degree of cover, and thickness of unit. Other features that can be included are general outcrop characteristics, the means of distinguishing one unit from another, and the locations where exposed.
d. Map unit descriptions should not include significant amounts of geologic interpretation.

e. It is particularly important for contact relations with adjacent units, including unconformities, to be described in the DMU.
f. Geographic names in the DMU should appear on the map or in an index map.

3) Detailed review of CMU

The purpose of the Correlation of Map Units is to show the detailed relations of the units in geologic time. Check the following:

a. Verify that boxes are aligned with youngest at top to oldest at base, and units with overlapping ages are arranged from younger at left to older at right.
b. Units of the same age are placed in separate boxes in separate columns but at same horizontal position.
c. Boxes should typically be simple; complex intertonguing or diachronous relations can be shown in a separate diagram.
d. If CMU has grouping of units distinguished by physiographic provinces, geographic regions, or tectonic or structural domains, check for consistency with mapped unit distributions.
e. Age brackets placed to the right of the map-unit boxes can include, from left to right, group or supergroup, complex, suite or super suite, series or epoch, and system or period. Alternatively, the lithostratigraphic brackets (group, supergroup, etc) can be placed to the left.

4) Geologic Map symbols (Explanation)

The Explanation should include a descriptive listing (in telegraphic style)and graphic portayals of all line and point symbols used on the geologic map. The graphics should match exactly those on the geologic map itself. The list of symbols should be ordered as follows: contacts, faults, and other planar features, followed by fold axes and other linear features, and finally bedding and foliation attitudes and other point locality symbols. All symbols should conform to the FGDC digital cartographic standard for geologic map symbolization. Check the following:

a. Are all the symbols shown on the map and sections and are they adequately described? Conversely, are all symbols shown on the map included in the explanation? In addition, check that the correct symbol is used. If there is a question, check the FGDC geologic symbol standard.
b. Are dashed and dotted lines used and, if so, explained?
c. Are line weights used on map and sections distinctive so they can be identified easily?
d. Are traces of axial surfaces of folds, including fold type and plunge, clearly identified as to what the lines and symbols represent?
e. Are faults and fault attributes adequately described? For example: U/D, T, T/A, saw teeth, barbs, bar and ball, slip arrows, slickenline arrows, etc.
f. Dip and strike symbols and linear features associated with attitudes should be adequately described.
g. Verify all other point symbols, such as mine, prospect, drill hole, oil well, gas well, locational information for sample sites, are described.

5) Map text

Explanatory text that will be placed on the map sheet should be short and concise; longer text belongs in a map pamphlet or a separate interpretive manuscript. Description of structure, other important map features, and interpretation can be included. To keep text easier to follow, 'Suggestions to Authors' recommends that the author add headings (e.g., Introduction, Stratigraphy, Structure). Check the following:

a. Map units must be discussed in reverse stratigraphic order (i.e., oldest to youngest).
b. Make sure that every geographic and geologic feature discussed in the text can be found on the map or on an accompanying illustration on the map sheet.
c. When a map unit is mentioned for the first time, its map symbol should be shown in parentheses.
d. Abstract and/or introduction should describe the geologic, geographic and cultural setting of the map area.
e. Check that figure and table references are appropriate and correctly ordered. Information on map sheet is referred to as 'on map sheet', or if more than one, 'on sheet 1 (or 2, etc)'. Information in pamphlet is referred to as 'in pamphlet'.
f. The text should not contain personal opinions (as opposed to interpretations) or material that is sensitive or against USGS policy.

6) References

a. Make sure all references cited in the DMU, explanatory text, figures, and index to mapping are listed in reference section.
b. Make sure all references listed follow USGS reference style and that they are listed in proper alphabetical and temporal order.

Step 2. Review Element 1 –Geologic map

This is the most important part of the review, yet one that is often neglected. The review should verify that 1) the map is complete, carefully drawn, and internally consistent, and 2) geologic interpretations are supported by mapped data. A good approach is to first think about what geologic stories emerge from the first view of the map, and whether the unit colors and mapping styles enhance or obscure the main themes. If not, the reviewer can suggest ways to improve the visual impact. The next step —checking every inch of the map methodically— is key to a high-quality review. It is best to examine the map systematically, starting in one corner and work in a linear or zigzag fashion. Check the following:

1) Contacts, faults, and other lines

a. Are there any line styles on the map that are not in the list of map symbols?
b. Check for superfluous contacts within a unit.
c. Do the contacts make sense relative to other stratigraphic and structural data?
d. Do contacts make sense relative to the topography (e.g., do contacts "V" properly on ridges and in valleys) and do the contact intersections with older units make sense geologically?
e. Do the trends of contact lines make sense relative to bedding attitudes and topography (check by using contours)?
f. Are thicknesses portrayed on map consistent with the DMU and cross section?
g. Do intrusive contacts and contact intersections make sense for relative ages of units, e.g., do they cut older units and structures?
h. Is fault slip sense properly shown by fault symbols?

i. Is fault slip sense consistent with offset of units, structural deflections or sheared rock symbols?
j. Do contacts change elevation (dip-slip) or lateral position (strike-slip) properly and consistently for inferred slip sense of fault?
k. Are mapped fault offsets consistent with interpreted age and movement history of fault? For example, a fault interpreted to have moved only in the Proterozoic cannot be shown cutting younger units.
l. Are fold-axis symbols (e.g., anticline vs. syncline; plunge arrow) correct and supported by bedding attitudes and unit distributions on the map?
m. Are the orientations, positions, shapes of fold axes consistent with the bedding attitudes and topography?
n. Are cross-cutting relations of faults, folds, and unit contacts depicted on map consistent with interpreted relative ages of faulting, folding, and deposition or intrusion?

2) Units

a. Are all units shown on map in the DMU/LMU and CMU, and vice-versa?
b. Are map-unit symbols (labels) and colors consistent and do they match the DMU/LMU and CMU?
c. Are the map units adequately labeled?

3) Structural symbols

a. Are all symbols used on the map shown in the explanation?
b. Are symbols appropriate for the unit that contains them? For example, igneous foliation symbols should not be plotted within a surficial sedimentary unit.

Step 3. Review Element 2—Cross section(s)

Some maps (e.g., surficial-deposit geologic maps) do not need cross-sections, but in general, cross-sections are very useful illustrations of map content. If there are no cross-sections, recommend that the author construct cross sections if you think one or more sections are important for the geologic interpretation (such as in areas of structural complexity). If there are cross-sections, check the following:

a. Sections should not have vertical exaggeration, unless well-justified by author (for example, to show stacking or lateral relations between very thin units, such as surficial deposits).
b. In structurally complex areas, check if lines of profiles are drawn approximately perpendicular to structural trends. Doing so shows the author's interpretation of the structure best and helps avoid distortion of bedding dips, unit thicknesses or fault dips. It also is very instructive to construct one section line perpendicular to serial sections that themselves are perpendicular to the main structures. This one section ties others together and forces agreement among the sections.
c. Are the stratigraphic and structural relations shown on the cross section consistent with the geologic map? Do the positions and dips of contacts and faults and the unit designations agree with the map?
d. The most important part of reviewing the cross-sections is checking that the stratigraphic and structural relations shown on the cross-section are consistent with the geologic map. Are all units there and are the contacts at the same places as on the map?

e. Are thicknesses portrayed on cross-section consistent with map and DMU? Are apparent dips and thicknesses correct for features oblique to the line of section?
f. Are units properly labeled and colored on the section and do they match the DMU/LMU, CMU and map?
g. Do the topographic profile of the section and the vertical elevation-scale units and tics match the base map?
h. Check letter designations of cross-sections against line(s) on the map.
i. Ensure that any bends in the section line are identified in the cross-section.
j. Are major hydrographic and physiographic features labeled on the base map identified in the section?
k. Structural features—any named features on the map should be identified on the cross-section.
l. Drill-hole identification and information should be labeled if shown on section.
m. Make sure vertical scale numbers are along side of section, and any vertical exaggeration is specified.

Step 4. Review Element 4—Basic map reference information
Check that the following are present and correct, if needed.

1) Base Map Credit
List of credit for topographic maps and/or other bases, such as DEM, Lidar, etc. Should include publication date (and revision date, if applicable) and original scale if different from map scale.

2) Magnetic orientation
Use current information, available online from NOAA.

3) Scale and contour interval
Verify that scale and contour interval are correct for the base map.

4) Geologic Credit/Index to geologic mapping
It is important that mapping credit is given to authors and field assistants, as well as GIS specialists. This credit is placed at lower right corner of map neatline. If needed, especially for a map that has compilation of previous mapping, an index map should show authorship, type, and quality of mapping that has been assembled. Previously published maps should also be listed in the references.

5) Location map (index map)
A small index map showing general location of map area in the state is required. An additional, more detailed map can be used to show location of map area in relation to adjacent published maps, as well as county, state or larger areas.

6) Title
The title can identify the type of map. For example—'Geologic map of', 'Reconnaissance geologic map of', 'Preliminary geologic map of', 'Structural geologic map of', 'Surficial geologic map of ' [quadrangle name].

7) Authorship

List of authors and GIS specialists, if desired.

8) ***Agency Credit***
Should include cooperating and funding agencies.

FINALIZING THE PEER REVIEW

The final step is to return and review the comments for steps 1 to 4 above in a single, comprehensive reevaluation of the map and its contents. Sometimes, 'big picture' items are caught in this step, after the details have been considered in the previous steps.

Upon completion, the review process should result in a clearly marked copy of the original map product and all the elements, either in paper or electronic/digital format. Make sure that you have used standard editing and proofing marks and that all comments are clear. It is generally helpful to include a summary memorandum that outlines your major findings—remember that positive feedback, tactful criticism, and measured thoughtful comments are the hallmark of a professional review.