

# DIGITAL MAPPING TECHNIQUES 2021

The following was presented at DMT'21  
(June 7 - 10, 2021 - A Virtual Event)

The contents of this document are provisional

See Presentations and Proceedings  
from the DMT Meetings (1997-2021)

<http://ngmdb.usgs.gov/info/dmt/>

SLIDE 1

# The National Geologic Map Database's role in the US GeoFramework Initiative

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**PRESENTER NOTES:**

In brief, the National Geologic Map Database (NGMDB) project's role in this initiative is the same as its role to the community at large.

(This initiative is in response to the Congressional appropriations for NGMDB's Phase Three; e.g., <https://www.congress.gov/congressional-report/116th-congress/house-report/100/1>.

Renamed the US GeoFramework initiative.)

SLIDE 2

106 STAT. 166 PUBLIC LAW 102-285—MAY 18, 1992

Public Law 102-285  
102d Congress

An Act

May 18, 1992  
[H.R. 2763]

To enhance geologic mapping of the United States, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

National Geologic Mapping Act of 1992. Conservation. Environmental protection. 43 USC 31a note. 43 USC 31a.

**SECTION 1. SHORT TITLE.**  
This Act may be cited as the “National Geologic Mapping Act of 1992”.

**SEC. 2. FINDINGS AND PURPOSE.**

(a) **FINDINGS.**—The Congress finds and declares that—

(1) during the past 2 decades, the production of geologic maps has been drastically curtailed; . . .

(8) a comprehensive nationwide program of geologic mapping is required in order to systematically build the Nation’s geologic-map data base at a pace that responds to increasing demand.

(b) **PURPOSE.**—The purpose of this Act is to expedite the production of a geologic-map data base for the Nation, to be located within the United States Geological Survey, which can be applied to land-use management, assessment, and utilization, conservation of natural resources, groundwater management, and environmental protection.

<https://www.youtube.com/watch?v=tdq8kNtO-wQ>

PRESENTER NOTES:

That is, to fulfill the foundational roles stipulated in the Geologic Mapping Act, as I noted on Monday. As planning for this initiative has gotten underway, the NGMDB did not need a course correction, but instead has been able to accelerate the addition and refinement of database content, and has begun to develop new features and capabilities that will become evident in our Web pages.

(Please view the Association of American State Geologists’ [AASG] YouTube video on the Act, <https://www.youtube.com/watch?v=tdq8kNtO-wQ>.)

## SLIDE 3



# Digital Mapping Techniques 2021

### PRESENTER NOTES:

For the NGMDB to succeed, it must serve as a facilitator and organizer. This meeting is but one example. We are committed to bringing people (and their agencies) together, to address geologic science and information-management challenges from their perspective as well as nationally. This is a collaborative endeavor, that must benefit your agency as well as the USGS. One of our roles is to facilitate development of basic standards and techniques and methods, so that you can take advantage of these, and the well-organized information, to do what you need to do.

**SLIDE 4**

## NGMDB projects and tasks (1995 – present)

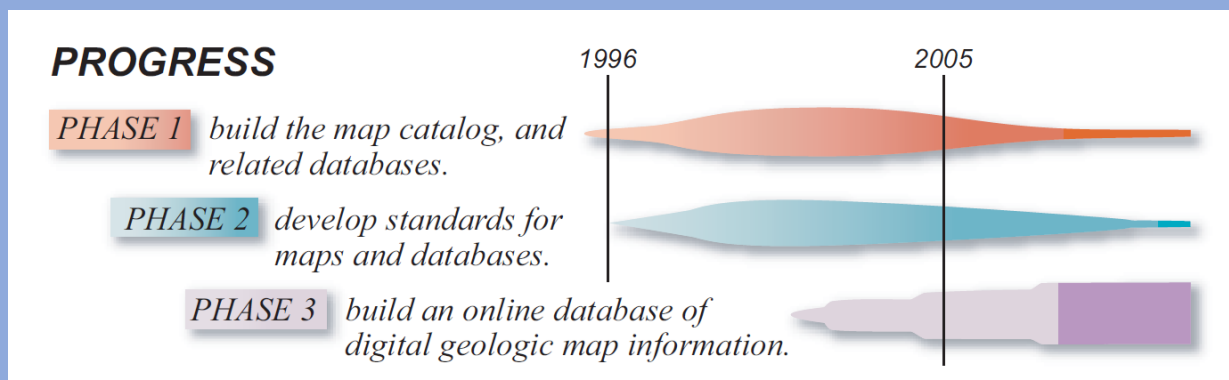
- Phase One
- Phase Two
- Phase Three
- Map Applications Research

**PRESENTER NOTES:**

Here are the NGMDB project's tasks, funded since 1995. Phases One, Two, and Three. So, what are these Phases?

## SLIDE 5

### The general plan for the NGMDB, ca. 1996 -



from NGMDB Progress Report, DMT'05 Proceedings <http://pubs.usgs.gov/of/2005/1428/soller1/>

#### PRESENTER NOTES:

In 1992, rather than attempting a direct launch into the vision that most of us had for Phase Three, the Association of American State Geologists (AASG) and this project agreed to the following plan, in three phases. First, we would take stock of what exists, and organize it (e.g., get our houses in order), and evaluate the content. Then, develop standards, and eventually address the long-term vision of Phase Three, through a series of prototypes.

## SLIDE 6

### A commonly-held vision for the NGMDB, ca. 1996

*The NGMDB should be a repository of GIS data for geologic maps and related information, managed in a complex system distributed among the USGS and State geological surveys.*

*It should offer public access to attributed vector and raster geoscience data, and allow users to perform queries online, create derivative maps, and download source and derived map data.*

*Further, all information (including GIS features) in the database would retain metadata that clearly indicates its source.*

**... an inspiring vision that was not feasible in 1996. But now...**

background: Houston and others, 2018, OR Dept Geol Min Ind, Geol Map 121



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#### PRESENTER NOTES:

Regarding Phase Three, when the project began in the mid-1990's, the geologic community in USGS and AASG had this sense for how to interpret the Geologic Mapping Act. It was heavily slanted toward a vector-based geologic map compilation, somehow distributed among all agencies, that relied on standards and technology that were not, and may not yet be, available.

[Slide background: portion of Houston, R.A., and others, 2018, Geologic map of the Devine Ridge North 7.5' quadrangle, Harney County, Oregon: Oregon Department of Geology and Mineral Industries, Geological Map Series 121, scale 1:24,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_108224.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_108224.htm)).]

## SLIDE 7

### NGMDB projects and tasks (1995 – present)

- Phase One
- Phase Two
- Phase Three
- Map Applications Research

#### PRESENTER NOTES:

Returning to the NGMDB project tasks, you'll note "Map Applications Research." That is a small task with major benefits. Under it, we've produced several regional and national GIS products for your use. Including the GIS files for the geologic map of North America ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_86688.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_86688.htm)), the surficial materials map and database of the conterminous U.S. ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_86735.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_86735.htm)), the updated GIS files of my glacial character and thickness map of the U.S. east of the Rockies ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_96638.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_96638.htm)), the bedrock topography and sediment thickness of those glacial sediments ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_106843.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_106843.htm)), as well as a major report on aquifers in Quaternary sediments of the conterminous U.S. (<https://pubs.er.usgs.gov/publication/sir20185091>).



## SLIDE 8

### NGMDB Phase Three Tasks:

1. Extend the NGMDB's Trusted Digital Repository
2. GeMS support and development for map compilations
3. Convert high-priority geologic maps to GeMS format
4. NGMDB Catalog enhancement
5. Assistance in addressing stratigraphic nomenclature issues across map boundaries
6. Development and support of ancillary databases
7. Data delivery

background: Heinrich and McCulloh, 2019, LA Geol Survey OFM-2019-1



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#### PRESENTER NOTES:

When the new funding was appropriated in late 2019 to accelerate development of the NGMDB's Phase Three, we defined these tasks to apply for the new funding.

Regarding Task 1 —As mandated in the Geologic Mapping Act, a fundamental purpose of the NGMDB is to maintain a National Archive —in other words, a repository of geoscience content. We're now extending the capability to manage and serve geologic map data in vector GIS format, specifically in the standard geologic map schema (GeMS; <https://ngmdb.usgs.gov/Info/standards/GeMS/>).

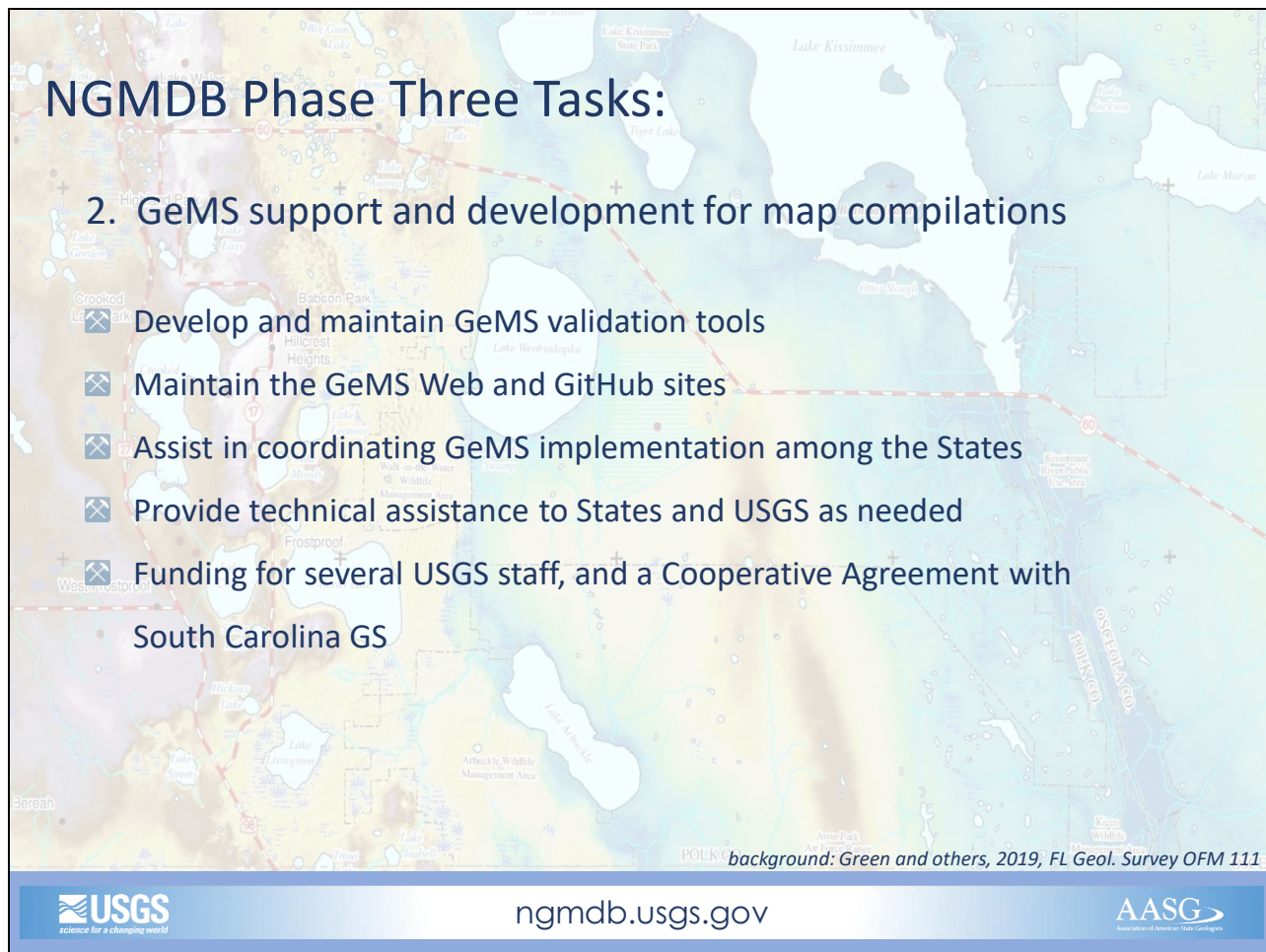
[Slide background: portion of Heinrich, P.V., and McCulloh, R.P., 2019, Breaux Bridge 7.5-minute geologic quadrangle: Louisiana Geological Survey, Open-File Map (1:24,000) 2019-01, scale 1:24,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_108736.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_108736.htm)).]

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### NGMDB Phase Three Tasks:

#### 2. GeMS support and development for map compilations

- ✦ Develop and maintain GeMS validation tools
- ✦ Maintain the GeMS Web and GitHub sites
- ✦ Assist in coordinating GeMS implementation among the States
- ✦ Provide technical assistance to States and USGS as needed
- ✦ Funding for several USGS staff, and a Cooperative Agreement with South Carolina GS

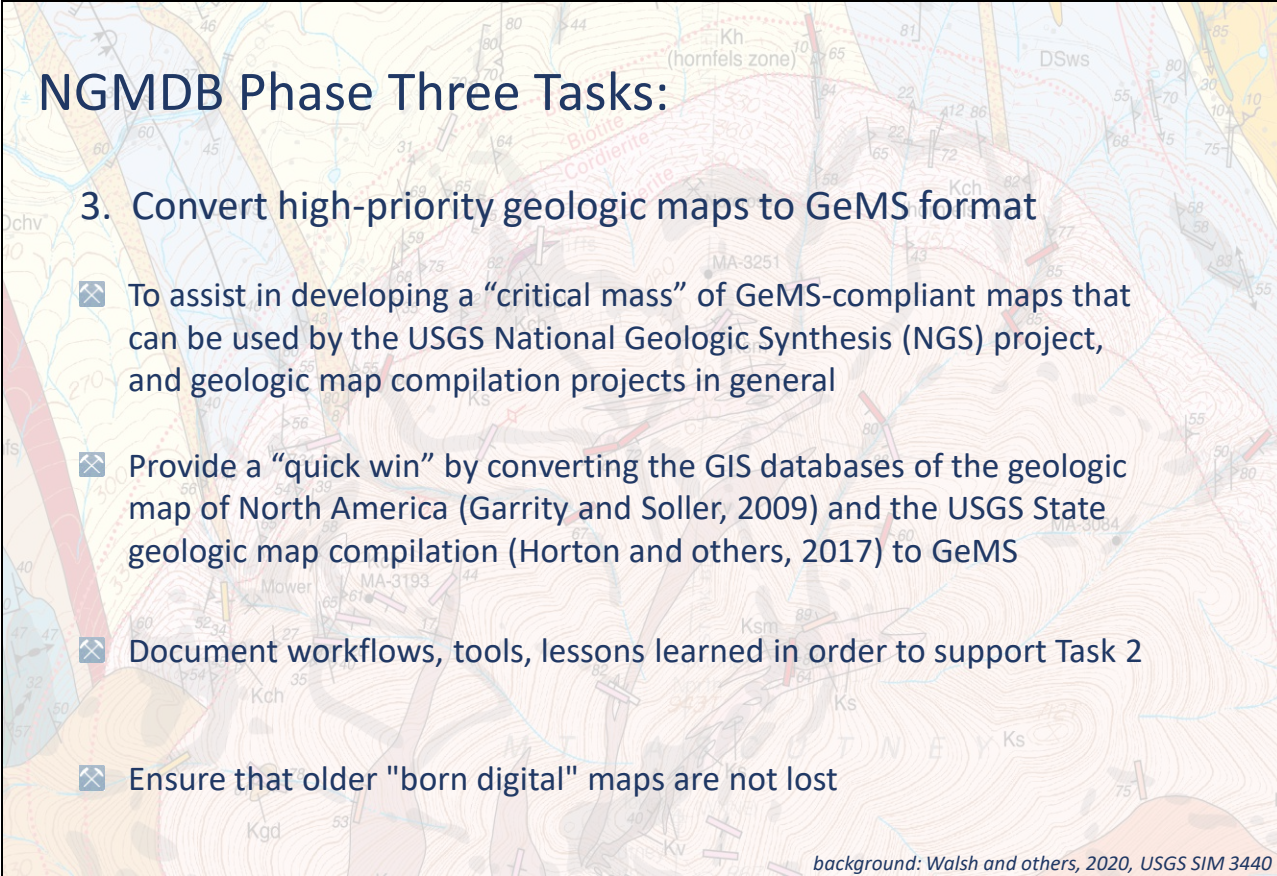


#### PRESENTER NOTES:

Task 2 —Facilitate development of expertise among staff in AASG and USGS, in the efficient implementation of GeMS for production of geologic maps.

[Slide background: portion of Green, R.C., and others, 2019, Geologic map of the USGS Bartow 30 x 60 minute quadrangle, central Florida: Florida Geological Survey, Open-File Map Series 111, 3 plates, scales 1:100,000, 1:180,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_109256.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_109256.htm)).]

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### NGMDB Phase Three Tasks:

#### 3. Convert high-priority geologic maps to GeMS format

- ✘ To assist in developing a “critical mass” of GeMS-compliant maps that can be used by the USGS National Geologic Synthesis (NGS) project, and geologic map compilation projects in general
- ✘ Provide a “quick win” by converting the GIS databases of the geologic map of North America (Garrity and Soller, 2009) and the USGS State geologic map compilation (Horton and others, 2017) to GeMS
- ✘ Document workflows, tools, lessons learned in order to support Task 2
- ✘ Ensure that older "born digital" maps are not lost

*background: Walsh and others, 2020, USGS SIM 3440*

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### PRESENTER NOTES:

Task 3 —Create GeMS files for high priority paper maps and older GIS map files

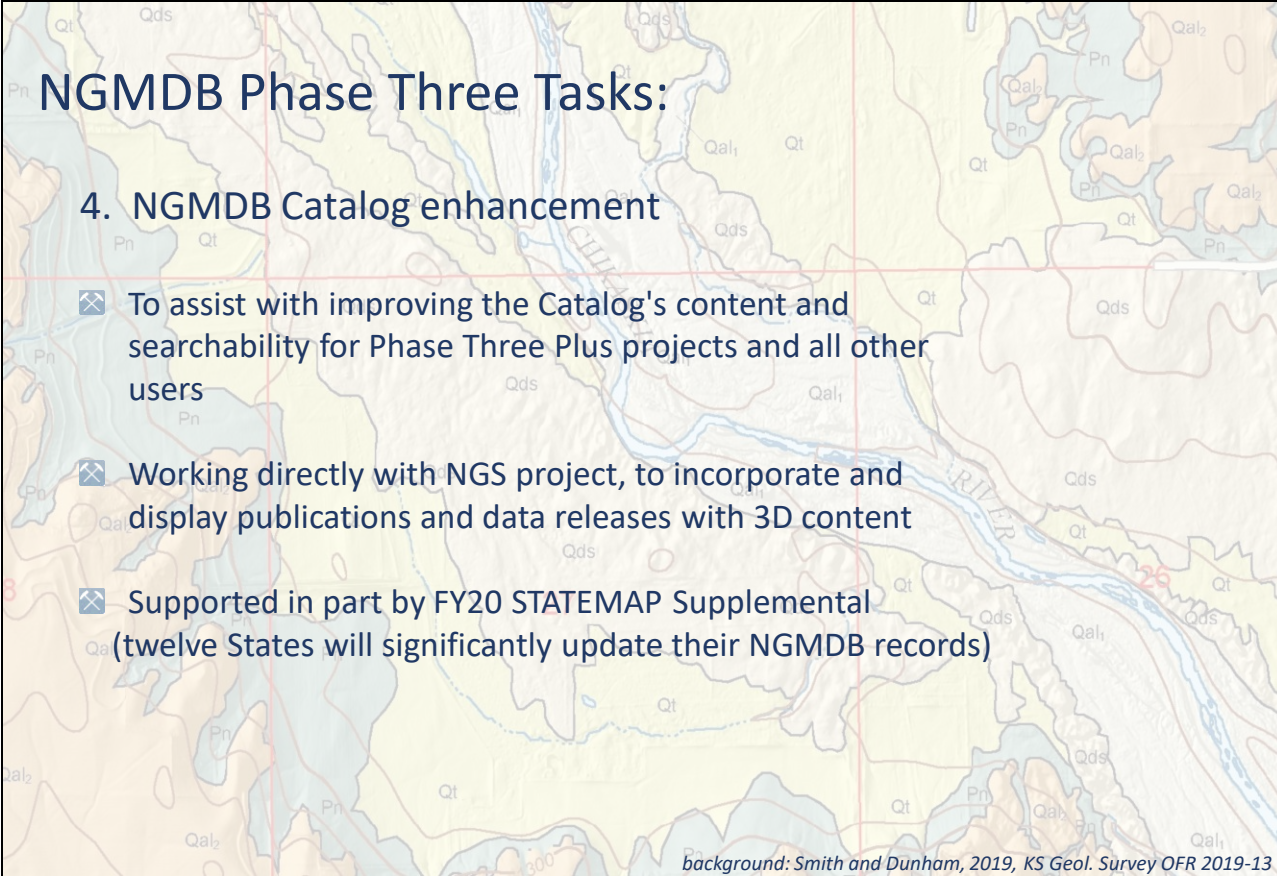
- Quickly support development of the critical mass of GeMS files needed for future geologic mapping
- Rescue many published born digital GIS maps that are at risk of being lost to future use.

### References:

Garrity, C.P., and Soller, D.R., 2009, Database of the geologic map of North America —adapted from the map by J.C. Reed, Jr. and others (2005): USGS Data Series DS-424, scale 1:5,000,000, <https://ngmdb.usgs.gov/gmna/>.  
Horton, J.D., San Juan, C.A., and Stoeser, D.B., 2017, The State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States: USGS Data Series DS-1052, scale 1:1,000,000, <https://mrdata.usgs.gov/>.

[Slide background: portion of Walsh, G.J., and others, 2020, Bedrock geologic map of the Mount Ascutney 7.5- x 15-minute quadrangle, Windsor County, Vermont, and Sullivan County, New Hampshire: U.S. Geological Survey, Scientific Investigations Map SIM-3440, scale 1:24,000. Prepared in cooperation with the Vermont Geological Survey, New Hampshire Geological Survey, and the National Park Service. Funded by NCGMP FEDMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_110059.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_110059.htm)).]

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### NGMDB Phase Three Tasks:

#### 4. NGMDB Catalog enhancement

- ☒ To assist with improving the Catalog's content and searchability for Phase Three Plus projects and all other users
- ☒ Working directly with NGS project, to incorporate and display publications and data releases with 3D content
- ☒ Supported in part by FY20 STATEMAP Supplemental (twelve States will significantly update their NGMDB records)

background: Smith and Dunham, 2019, KS Geol. Survey OFR 2019-13

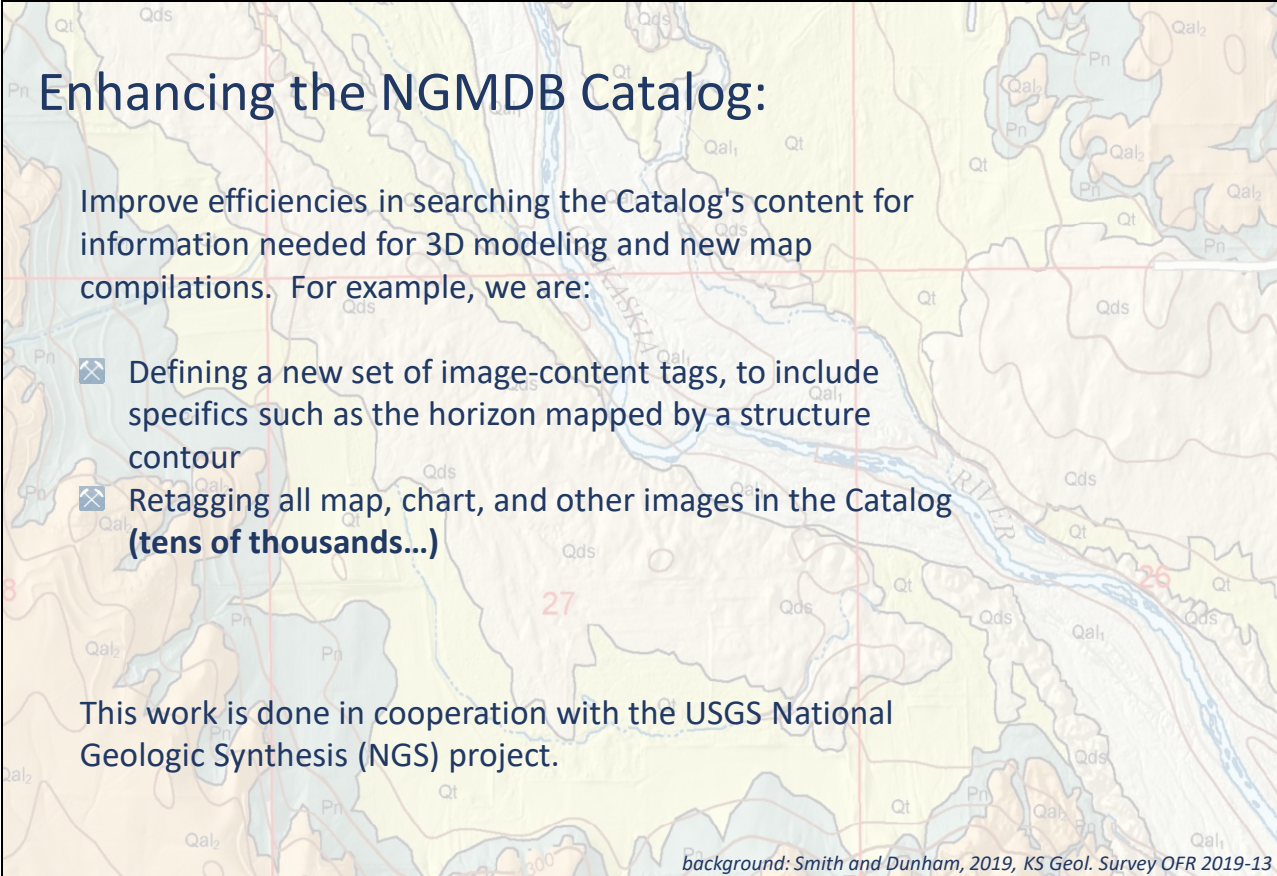
 [ngmdb.usgs.gov](https://ngmdb.usgs.gov) 

### PRESENTER NOTES:

Task 4 —In order to facilitate more efficient access to the desired content (e.g., cross sections, structure contour maps, stratigraphic and hydrostratigraphic charts, lithology of specific geologic units, availability of 3D models, and so forth), we're devoting a substantial effort to several aggressive initiatives that enable scientists, and the public, to more precisely search for this content.

[Slide background: portion of Smith, J.J., and Dunham, J.W., 2019, Preliminary surficial geology of the Argonia quadrangle, Harper and Sumner counties, Kansas: Kansas Geological Survey, Open-File Report OFR 2019-13, scale 1:24,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_108833.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_108833.htm)).]

## SLIDE 12





### Enhancing the NGMDB Catalog:

Improve efficiencies in searching the Catalog's content for information needed for 3D modeling and new map compilations. For example, we are:

- ✘ Defining a new set of image-content tags, to include specifics such as the horizon mapped by a structure contour
- ✘ Retagging all map, chart, and other images in the Catalog **(tens of thousands...)**

This work is done in cooperation with the USGS National Geologic Synthesis (NGS) project.

*background: Smith and Dunham, 2019, KS Geol. Survey OFR 2019-13*

 [ngmdb.usgs.gov](https://ngmdb.usgs.gov) 

### PRESENTER NOTES:

In my presentation on the NGMDB earlier this week, I mentioned this ambitious reassessment of tens of thousands of images, so that specific information could be searched for directly (e.g., find all structure contour maps on the top of the Mancos). This task is enabled by funding for this Initiative.

[Slide background: portion of Smith, J.J., and Dunham, J.W., 2019, Preliminary surficial geology of the Argonia quadrangle, Harper and Sumner counties, Kansas: Kansas Geological Survey, Open-File Report OFR 2019-13, scale 1:24,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_108833.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_108833.htm)).]

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### Enhancing the NGMDB Catalog:

Enable users to search for any content in a geologic map's Description of Map Units (DMU), by:

- ☒ OCR thousands of DMUs on geologic maps judged to be of priority for analysis, recompilation, or conversion to GIS; and
- ☒ Use machine-learning techniques to increase efficiency in parsing OCR text into appropriate GeMS tables and fields.

This work is done in cooperation with the USGS GeoML project (Chris Garrity, Chief).

*background: Smith and Dunham, 2019, KS Geol. Survey OFR 2019-13*



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#### PRESENTER NOTES:

Also as noted in my NGMDB presentation earlier this week, we'll be OCR'ing and using machine learning to parse thousands of geologic map Description of Map Units (DMUs) into GeMS tables and fields, and storing that information in the NGMDB to facilitate search, retrieval, and spatial visualization of maps meeting user-specified criteria.

[Slide background: portion of Smith, J.J., and Dunham, J.W., 2019, Preliminary surficial geology of the Argonia quadrangle, Harper and Sumner counties, Kansas: Kansas Geological Survey, Open-File Report OFR 2019-13, scale 1:24,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_108833.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_108833.htm)).]

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### NGMDB Phase Three Tasks:

#### 5. Assistance in addressing stratigraphic nomenclature issues across map boundaries

- ✘ To assist in compilation of Geolex and to continue our development of standard stratigraphic nomenclatural guidelines for seamless map compilation
- ✘ Supports objectives of the U.S. Geologic Names Committee
- ✘ We are reinstating the Geologic Names Committee's formal, peer-reviewed USGS "Stratigraphic Notes Series," specifically designed to expedite publication of short papers
- ✘ NGMDB's stratigraphic work is in direct support of the NGS project, and all other NCGMP-funded projects, grants, and contracts

background: Mattheus and others, 2020, DE Geol Survey Geol Map 25



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#### PRESENTER NOTES:

Task 5 —The NGMDB project will assist with stratigraphic nomenclature issues by:

- Improving awareness, understanding, and use of the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature [NASCN], 2005, AAPG Bulletin, vol. 89, no. 11, p. 1547-1591), and its amendments ;
- Staffing the U.S. Geologic Names Committee (GNC) with regional experts from the AASG and USGS, with the goals of:
  - (a) facilitating (but not forcing) reconciliation or an "agree to disagree" consensus among geologic mappers; and
  - (b) developing documentation through that process that can be used by the GNC Secretary to evaluate content of the U.S. Geologic Names Lexicon (Geolex).

[Slide background: portion of Mattheus, C.R., and others, 2020, Geologic Map of Offshore Delaware: Delaware Geological Survey, Geologic Map Series 25, scale 1:40,000. Funded by U.S. Department of Interior, Bureau of Ocean Energy Management. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_109709.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_109709.htm)).]

SLIDE 15

## NGMDB Cooperative Agreements focusing on stratigraphic nomenclature issues:

- ✕ FY20 -- Cooperative Agreements with Delaware, Maryland, Oregon, and Utah geological surveys.
- ✕ FY21 -- Cooperative Agreements proposed by Kentucky, Pennsylvania, Alabama, Kansas, Delaware, and New England States.

*background: Mattheus and others, 2020, DE Geol Survey Geol Map 25*



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[Slide background: portion of Mattheus, C.R., and others, 2020, Geologic Map of Offshore Delaware: Delaware Geological Survey, Geologic Map Series 25, scale 1:40,000. Funded by U.S. Department of Interior, Bureau of Ocean Energy Management. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_109709.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_109709.htm)).]



## NGMDB Phase Three Tasks:

### 6. Development and support of ancillary databases

First, identify "who has what" -- i.e., conduct nationwide inventories, for:

- ☒ Geochronology
- ☒ Borehole and well data
- ☒ Geophysical logs and seismic lines
- ☒ Engineering properties

Second, increase accessibility to these data, wherever they reside.

This task is a relatively short-term effort by the NGMDB, to support long-term Phase Three acquisition of these data for compilation and 3D modeling.

*background: Thompson and others, 2020, USGS SIM 3447*



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#### PRESENTER NOTES:

Task 6 —To improve the geologic community's understanding of where critically important ancillary information that is necessary for geologic mapping is published, or managed in a database, we're focusing the development of national inventories.

Identifying "who has what", and the level of detail, quality, and accessibility of these data is an essential first step in support of this initiative. To the extent feasible, resources also will be directed toward populating those databases with content, especially for geochronology, as required by the Act.

[Slide background: portion of Thompson, R.A., and others, 2020, Geologic map of Petroglyph National Monument and vicinity, Bernalillo County, New Mexico: U.S. Geological Survey, Scientific Investigations Map SIM-3447, scale 1:24,000. Prepared in cooperation with the National Park Service. Funded by NCGMP FEDMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_109803.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_109803.htm)).]

## SLIDE 17

### NGMDB Phase Three Tasks:

#### 6. Development and support of ancillary databases – Phase Three Funding:

- ☒ National Geochronology Database –Four USGS staff (including new hires), and Cooperative Agreements with Alaska and Utah geological surveys
- ☒ Borehole and water wells and databases –national inventory conducted by Illinois State Geological Survey. Done in cooperation with the USGS National Geological and Geophysical Data Preservation Program (NGGDPP) and USGS Water Resources National Water Information System (NWIS)
- ☒ Downhole geophysical logs –national inventory conducted by Texas Bureau of Economic Geology
- ☒ Engineering properties and databases –national inventory conducted by Illinois State Geological Survey

background: Thompson and others, 2020, USGS SIM 3447



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#### PRESENTER NOTES:

Here's what we're supporting: geochronologic data, borehole and water well information, geophysical logs and seismic data, engineering properties data, and other ancillary information.

[Slide background: portion of Thompson, R.A., and others, 2020, Geologic map of Petroglyph National Monument and vicinity, Bernalillo County, New Mexico: U.S. Geological Survey, Scientific Investigations Map SIM-3447, scale 1:24,000. Prepared in cooperation with the National Park Service. Funded by NCGMP FEDMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_109803.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_109803.htm)).]

## SLIDE 18

### NGMDB Phase Three Tasks:

#### 7. Data delivery

- Initially, delivery of content will be relatively straightforward, relying on the codebase and current and newly-released NGMDB interfaces
- As the multi-map GeMS-compliant database is developed, the new system will build upon the prototype released ca. 2009 (the Pacific Northwest Data Portal)
- Cooperative Agreement with Alaska DGGs, to support development of their multi-map enterprise GeMS data management system

*background: Lynds and others, 2020, WY Geol Survey OFR 19-3*



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#### PRESENTER NOTES:

Task 7 —In the first years of the Initiative, delivery of content will be relatively straightforward, relying on the codebase and current and soon-to-be-released NGMDB interfaces. In future years, as the multi-map GeMS-compliant database is developed, new requirements for data delivery will arise. The new system likely then will build upon the prototype released ca. 2009 (the Pacific Northwest Data Portal).

This new system will manage multiple files, perhaps ranging from individual GIS map files to seamless statewide compilations. Therefore, modifications to the GeMS schema are required because GeMS is intended to support publication of individual geologic maps. Extension of the GeMS schema to the "enterprise", multi-map level is being conducted by the Alaska Division of Geological and Geophysical Surveys (Alaska DGGs), which is in part supported by the NGMDB via a Cooperative Agreement, and by the USGS Intermountain West project, which you heard about yesterday.

[Slide background: portion of Lynds, R.M., and others, 2019, Preliminary geologic map of the Garden Gulch quadrangle, Carbon County, Wyoming: Wyoming State Geological Survey, Open-File Report 19-3, scale 1:24,000. Funded in part by NCGMP STATEMAP. Image downloaded from the National Geologic Map Database ([https://ngmdb.usgs.gov/Prodesc/proddesc\\_108734.htm](https://ngmdb.usgs.gov/Prodesc/proddesc_108734.htm)).]

## NGMDB task restructuring for FY22

### **Current task structure:**

- Phase One
- Phase Two
- Phase Three
- Map Applications Research

### **New task structure:**

- Science Content
- Standards Development
- Repository Management
- Web applications development and information delivery
- Map Applications Research

**PRESENTER NOTES:**

Conceptually, Phases are sequential, and this concept served us well to articulate the overall NGMDB plan. However, the term “Phase” loses its original meaning as the project progresses because the phases run concurrently. To more effectively convey the overall NGMDB structure, and to more effectively manage the original tasks and those developed in response to the U.S. GeoFramework Initiative, we'll be changing the project structure, as noted here.

\*END OF PRESENTATION\*