A map synthesis engine for compiling multiple geologic maps in the USGS Geologic Map Schema (GeMS): An example using California's statewide 1:250,000-scale Geologic Atlas Map series

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Abstract

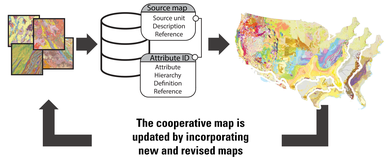
The USGS National Cooperative Geologic Mapping Program's (NCGMP) National Geologic Synthesis (NGS) project developed a "map synthesis engine" for procedurally aggregating and synthesizing geologic maps based on the USGS Geologic Map Schema (GeMS). This system preserves the original interpretations of the published maps, while integrating them with a suite of taxonomic, searchable attributes and a consistent set of map units statewide. We applied this methodology to synthesize the California Geological Survey's (CGS) existing 1:250,000-scale geologic map sheets into a new statewide representation of the state's geology, and to demonstrate the ability to produce derivative map products from GeMS-compliant databases. Derivatives can be developed based on attributes recorded in the database, such as unit age, unit name, lithology, and fault characteristics.

Efforts to compile a statewide geologic map of California began in 1853 and have continued to the present day at various scales and amounts of detail. The 2010 Geologic Map of California published by the CGS is the most current representation of statewide geology for California, albeit at the relatively coarse scale of 1:750,000. However, in 1969 the CGS produced the Geologic Atlas of California, a series of twenty-seven 1:250,000-scale geologic map sheets covering the entire state with a consistent set of map units and harmonized geology across map borders. The CGS recently digitized these map sheets into separate GeMS-compliant geodatabases. The new datasets, standardized as they are to GeMS, proved to be ideal candidates to test the NGS map synthesis engine. The result of this effort provides opportunities to create increasingly detailed, modern representations of California's geology.

1 Geologic maps are prepared by the National Cooperative Geologic Mapping Program and its federal and state partners

2 Maps are procedurally loaded into the synthesis database and standardized attributes are associated with original map units

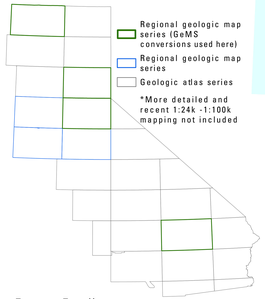
3 Sets of national maps are procedurally generated from contributed maps. Producing a consistent depiction that preserves the connection to source publications



The cooperative map is updated by incorporating new and revised maps

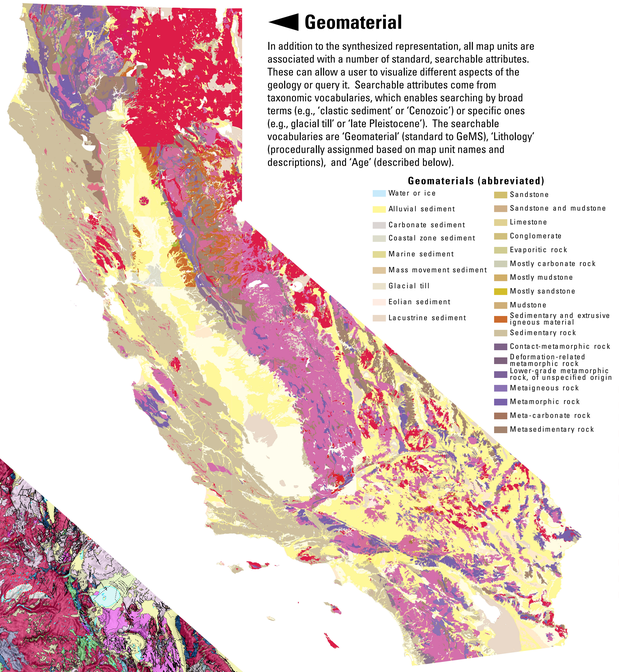
Map index

This synthesis map contains the map data from the California Geologic Atlas Series as well as four of the Regional Geologic Map (RGM) series maps, all prepared in GeMS by CGS. The synthesis map was built from the RGM maps where they were available, and the older maps elsewhere.



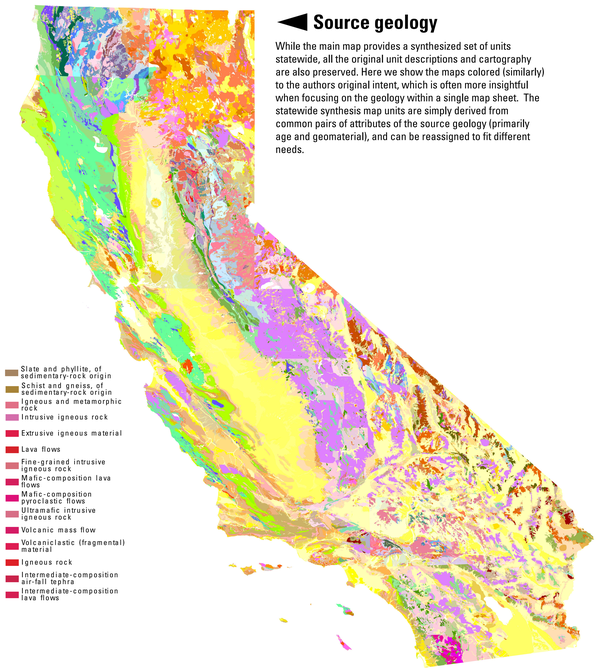
Geomaterial

In addition to the synthesized representation, all map units are associated with a number of standard, searchable attributes. These can allow a user to visualize different aspects of the geology or query it. Searchable attributes come from taxonomic vocabularies, which enables searching by broad terms (e.g., 'clastic sediment' or 'Cenozoic') or specific ones (e.g., glacial till' or 'late Pleistocene'). The searchable vocabularies are 'Geomaterial' (standard to GeMS), 'Lithology' (procedurally assigned based on map unit names and descriptions), and 'Age' (described below).



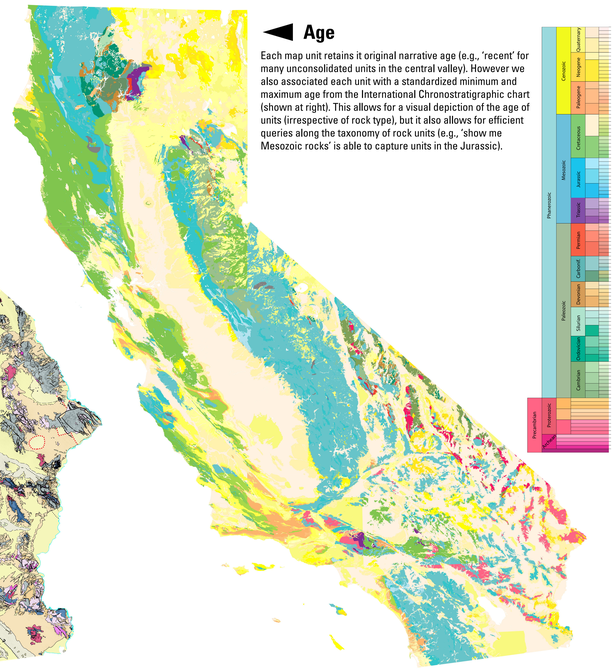
Source geology

While the main map provides a synthesized set of units statewide, all the original unit descriptions and cartography are also preserved. Here we show the maps colored (similarly) to the authors original intent, which is often more insightful when focusing on the geology within a single map sheet. The statewide synthesis map units are simply derived from common pairs of attributes of the source geology (primarily age and geomaterial), and can be reassigned to fit different needs.



Age

Each map unit retains it original narrative age (e.g., 'recent' for many unconsolidated units in the central valley). However we also associated each unit with a standardized minimum and maximum age from the International Chronostratigraphic chart (shown at right). This allows for a visual depiction of the age of units (irrespective of rock type), but it also allows for efficient queries along the taxonomy of rock units (e.g., 'show me Mesozoic rocks' is able to capture units in the Jurassic).



Statewide geologic synthesis*

For this poster, synthesis units were adapted from a national schema and should be considered provisional. In particular the names and ages are more general than what is likely most relevant for California.

Other materials

water - Water and ice (Modern)

af - Artificial fill (Modern)

unmapped - Unmapped areas (Not applicable)

Quaternary units, undifferentiated

Qu - Quaternary units, undifferentiated (Quaternary)

Qr - Riverbank formation (Pleistocene)

Ql - Lacustrine sediment (Quaternary)

Qg - Glacial till, undifferentiated (Quaternary)

Qe - Eolian sediment (Quaternary)

Qa - Alluvial sediment, undifferentiated (Quaternary)

Qao_u - Alluvial sediment (Recent and Pleistocene)

Qay - Young alluvial sediment (Holocene)

Qao - Alluvial sediment (Recent and Pleistocene)

Qv - Volcanic rocks (Quaternary)

Quaternary and Tertiary rocks

QTs - Clastic sediments, undifferentiated (Quaternary and Tertiary)

QTv - Volcanic rocks (Quaternary and Tertiary)

Tertiary rocks

Ts - Sedimentary rocks (Tertiary)

ngTs - Sedimentary rocks (Neogene)

plTs - Sedimentary rocks (Pliocene)

mTs - Sedimentary rocks (Miocene)

oTs - Sedimentary rocks (Oligocene)

eTs - Sedimentary rocks (Eocene)

paTs - Sedimentary rocks (Paleocene)

Tvi - Extrusive igneous rocks (Tertiary)

Ti - Intrusive rocks (Tertiary)

Tva - Intermediate volcanic rocks (Tertiary)

Tvr - Felsic volcanic rocks (Tertiary)

Tvm - Mafic volcanic rocks (Tertiary)

Tvs - Volcaniclastic rocks (Tertiary)

Undifferentiated Tertiary and Mesozoic rocks

TMZu - Undifferentiated Tertiary and Mesozoic rocks (Tertiary to Mesozoic)

paTKs - Clastic sedimentary rocks (Paleocene to Cretaceous)

Mesozoic rocks

MZms - Sedimentary and metasedimentary rocks (Mesozoic)

Ks - Sedimentary rocks (Cretaceous)

Ksl - Sedimentary rocks (Late Cretaceous)

Kse - Sedimentary rocks (Early Cretaceous)

Js - Sedimentary rocks (Jurassic)

TRs - Sedimentary rocks (Triassic)

MZum - Ultramafic rocks (Mesozoic)

MZm - Metamorphic rocks (Mesozoic)

MZim - Undifferentiated igneous and metamorphic rocks (Mesozoic)

MZv - Volcanic rocks (Mesozoic)

MZgr - Granitic rocks (Mesozoic)

MZvs - Volcaniclastic rocks (Mesozoic)

Undifferentiated Mesozoic and Paleozoic rocks

MZPZu - Undifferentiated Mesozoic and Paleozoic rocks (Mesozoic to Paleozoic)

Undifferentiated Paleozoic rocks

PZu - Undifferentiated Paleozoic rocks (Paleozoic)

PZms - Sedimentary and metasedimentary rocks (Paleozoic)

Ps - Sedimentary rocks (Permian)

PNs - Sedimentary rocks (Pennsylvanian)

Ms - Sedimentary rocks (Mississippian)

Cs - Sedimentary rocks (Pennsylvanian to Mississippian (Carboniferous))

Ds - Sedimentary rocks (Devonian)

Ss - Sedimentary rocks (Silurian)

Os - Sedimentary rocks (Ordovician)

CAs - Sedimentary rocks (Cambrian)

CAm - Metamorphic rocks (Cambrian)

PZi - Paleozoic igneous and metaigneous rocks (Paleozoic)

PZm - Undifferentiated metamorphic rocks (Paleozoic)

Undifferentiated Paleozoic to Precambrian rocks

PZpCms - Metasedimentary rocks (Paleozoic to Precambrian)

Undifferentiated Precambrian rocks

pC - Undifferentiated Precambrian rocks (Precambrian)

PRu - Undifferentiated Proterozoic rocks (Proterozoic)

Rocks of tectonic origin

scz

Igneous and metamorphic rocks of unspecified age

TpCim - Igneous and metamorphic rocks of unspecified age (Tertiary to Precambrian)

0 25 50 100 Miles

Scale: 1:1,000,000