

Annual Report 2021-2022

Summary

Throughout the world, geological survey agencies mandated by government maintain the systematic subsurface information that is needed for government and society to function optimally. As with other federal systems, the US has a federal survey – the US Geological Survey (USGS) that has a budget over \$1.5B and ~8,000 employees – and state geological surveys that presently receive total annual funding of ~\$260M, and have almost 1900 employees. The Minnesota Geological Survey (MGS), established as part of the University of Minnesota in 1872, has been located at 2609 West Territorial Road in St Paul since 2015, and has a budget of \$3.4M/year and a staff of 36 that has grown by a third and stabilized over the past decade. Current MGS focus is on the goals of Legislative water resource planning that specify the need for statewide completion within a decade or so, accompanied and followed by updating, of multi-layered County Geologic Atlases constructed in partnership with MN Department of Natural Resources (DNR) and with local governments. There is concurrent focus on federal critical minerals priorities, as well as the research, databases, outreach, and statewide mapping needed to optimize the Atlases. MGS is active and committed in our determination to fulfil goals regarding justice, equity, diversity, and inclusion.

MGS Mission

Minnesota Geological Survey serves the people of Minnesota by providing systematic geoscience information needed to support stewardship of water, land, and mineral resources. MGS geological mapping and research evolve with the progress of

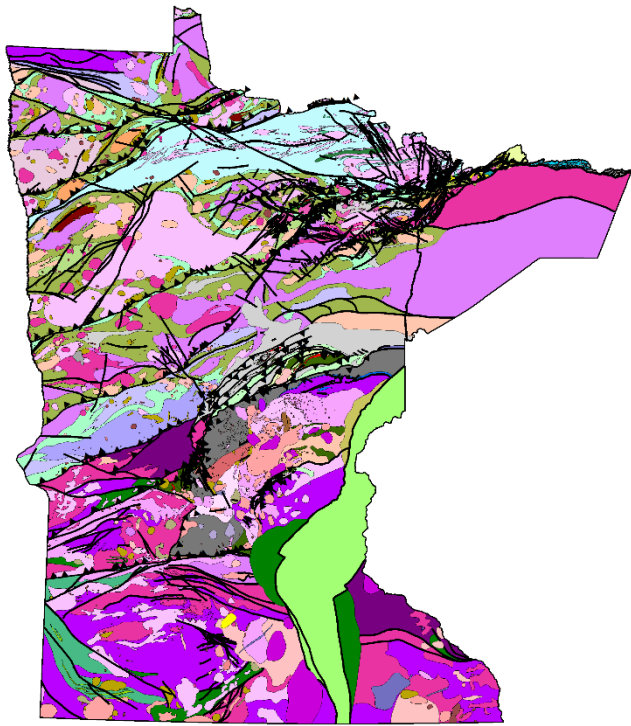
science and technology, and the MGS works closely with university, government, industry, and community partners to ensure that we respond to the diverse needs of the people.

MGS History

In 1872, the Legislature established the Geological and Natural History Survey of Minnesota as part of the University of Minnesota, with Newton Horace Winchell as 1st Director. The Survey was discontinued upon Winchell's retirement in 1900 and publication of his Final Report on The Geology of Minnesota in 1901, although the natural history function later became the Bell Museum. In 1911, new Department Chair William H. Emmons of USGS specified reinstatement of a State Geological Survey as a condition of his acceptance, and he became 2nd Director of the Survey. Ensuing Directors, based in Pillsbury Hall, were Frank F. Grout in 1944, George M. Schwartz in 1948, and Paul K. Sims in 1961 – their era culminated with 'Geology of Minnesota: A Centennial Volume' in 1972, and a move off-campus, to Eustis Street in 1970, and to University Avenue in 1983. Matt S. Walton, appointed Director in 1973, oversaw expanded geophysical surveys to support mineral exploration, as well as initiation of drillhole databases and the County Geologic Atlas program. Priscilla C. Grew of California became Director in 1986, MGS geologist David L. Southwick succeeded her in 1993, and L. Harvey Thorleifson of the Geological Survey of Canada was appointed Director in 2003. The post-~2000 focus has been on optimizing statewide geoscience information needed for groundwater management.



Minnesota Geological Survey staff, May 2022



The new state basement map

MGS Publications, Mapping, and Databases

MGS is fulfilling its role primarily through 1:100,000 and 1:500,000 mapping of surficial geology, bedrock geology, bedrock topography, sediment thickness, and subsurface geology. The geological mapping is first published as authored and peer-reviewed geological maps, and is also being assembled as a 2-resolution, layered set of regularly-updated databases that includes the offshore, that underlies bathymetric and soil mapping, and that is as compatible as possible with neighbors. Efforts to refine stratigraphic nomenclature are ongoing. Progressively more seamless geological polygons, at 1:100,000 and 1:500,000, are tending to have thickness indicated, while properties, heterogeneity, and uncertainty will gradually be more specified. Parsing of legends, to facilitate queries, is using broadly accepted, well-defined terminology, to facilitate inference of properties. A layered 1:500,000 state bedrock geologic map is now complete, with a new state Quaternary geology map in 2019, and mapping of thickness for Precambrian layers and basement geology completed in 2020. New 1:100,000 mapping is being completed as County Geologic Atlases, is meant to be complete statewide within a decade or so, and is focused on societal needs, with an emphasis on groundwater protection and management, while taking a broad approach. Where required to resolve issues, 1:24,000 mapping is conducted. The geological mapping is accompanied by associated spatial databases. The publication database, which is spatial through publication footprints, includes over 50,000 pages, and 700 scanned maps, both searchable and web accessible. Geological databases include field observations, drillhole data, as well as sediment texture and lithology. Geological collections include cuttings, geochemical samples, hand samples, sediment samples, and thin sections. Geophysical databases include borehole geophysics, gravity, magnetic, rock properties, and soundings; geochemical databases include groundwater, soil, and soil parent material; geochronological

databases are in development. MGS coordinates with the DNR drill core library and mineral exploration document archive, the Bell Museum fossil collection now stored in Ohio, and the DNR aquifer properties and karst databases.

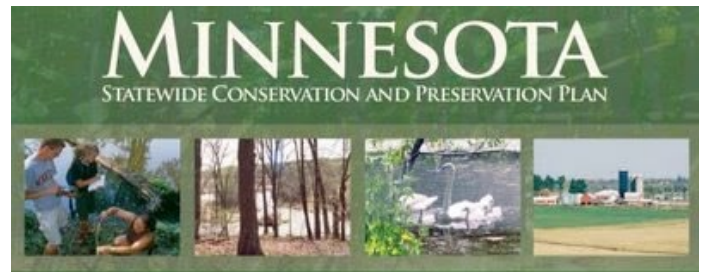
County Geologic Atlas Program

County Geologic Atlases provide information essential to sustainable management of groundwater resources, for applications such as aquifer management, groundwater modeling, monitoring, permitting, remediation, water allocation, well construction, and wellhead protection. Atlases define aquifer properties and boundaries, as well as the connection of aquifers to the land surface and to surface water resources. They also provide a broad range of information on county geology, mineral resources such as construction materials, and natural history. The atlases thus are also useful to consultants, exploration efforts, educators, and the public.

A complete atlas consists of a Part A prepared by MGS that includes the water well database and 1:100,000 scale geologic maps showing properties and distribution of sediments and rocks in the subsurface, and a Part B constructed by DNR that includes maps of water levels in aquifers, direction of groundwater flow, water chemistry, and sensitivity to pollution. Atlases in most cases are initiated by a request from a county and an offer to provide in-kind service. A [User's Guide to Geologic Atlases](#) helps non-geologists understand the information products and their uses. Atlases are available in print, or in [digital formats](#), including pdfs and GIS files.

Planning and Progress

MGS priorities have been specified by a series of broadly consultative State resource planning exercises.



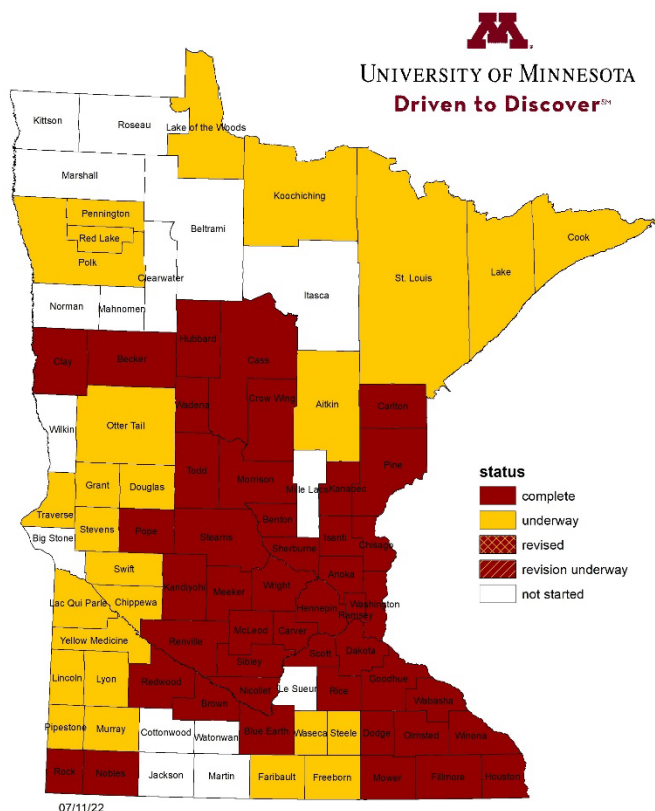
The Statewide Conservation and Preservation Plan was commissioned in 2006, and completed in 2008. The intent was to create an integrated inventory and assessment of Minnesota's environment and natural resources that could guide decision-makers on future short and long term planning, policy, and funding. A recommendation to improve understanding of groundwater resources focused on development of a large-scale, hydrologic-system framework for understanding how today's decisions may affect tomorrow's needs. This recommendation specified statewide coverage of county geologic atlases or comparable information products as being needed.

In 2011, the Minnesota Water Sustainability Framework further advocated that a measure of our progress in obtaining a complete picture of groundwater resources in Minnesota should be the rate of completion of county geologic atlases by MGS and DNR. The report therefore advocated that the pace of completion of the county geological atlases by the MGS should, at a minimum, be doubled to allow completion within a decade, followed by review and updating on a regular schedule. These

recommendations then guided the Six-Year Strategic Plan for Minnesota's Environment and Natural Resources Trust Fund (ENRTF), which is administered by the Legislative-Citizen Commission on Minnesota Resources (LCCMR). The Plan, completed in 2013, advocated statewide acquisition of County Geologic Atlases by the year 2020. MGS therefore is focused on completion and updating of County Geologic Atlases, while ensuring that we take a broad approach, and that we optimize the scientific quality of all related activities.



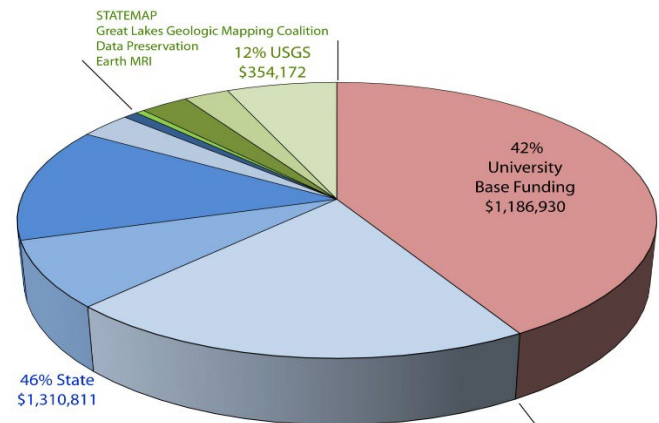
Atlases are complete for 45 counties and of these, 5 have been revised and 2 revisions are underway. There are 26 new atlases underway; 16 counties have not yet been started. At the current pace and a completion rate of ~5 per year, statewide coverage will be achieved within a decade.



Status of County Geologic Atlas mapping

Resources

Funding: Whereas funding to the ~8,000 USGS employees is over \$1.5B/year, total revenue to the ~1885 employees at State Geological Surveys in FY22 is ~\$263M, which is an all-time-high, even more than the level of \$237M reached in 2012 that related to the federal stimulus. The average state geological survey thus consists of ~38 staff, who receive ~\$5.3M in funding. In contrast, the 36 members of MGS staff were supported by \$3.4M this past year, similar to the level of the year before. MGS funding averaged \$2.4M from 2003 to 2011, and the average since then has been \$3.2M. MGS relies on about \$1.2M in base funding and ~\$2.2M in grants and contracts, primarily from the ENRTF through LCCMR. Additional funding from both sources covers non-personnel costs such as travel, drilling, equipment, supplies, and services. A comprehensive financial and administrative audit found no concerns.



Recent sources of funding

Staffing: MGS staffing was stable at 28 full-time-equivalents (FTE) from 2003 to 2011; since then, staffing has averaged 35 FTE. Last year, MGS was one of 14 state geological surveys in the USA whose staff is 40% or more female. This compared to 38% nationwide. We currently are 24 geologists, 4 information professionals, 2 administrative staff, and 6 students equivalent to ~4 FTE. A group consisting of our longest serving staff members has retired, so transferring their knowledge to the next generation has been a priority in recent years.



Building: MGS was located in Pillsbury Hall from 1890 until 1970. After a brief stay in Jones Hall, MGS moved in 1970 to a building on Eustis Street in Saint Paul, followed by relocation to University Avenue in Saint Paul in 1983. In 2015, we moved to our current location on West Territorial Road in St Paul. The new building has worked out well. Nearly every desk is in use, and the fit and function of the facility are very good.

Current Activities

Mapping: Mapping at a resolution of 1:24,000 and a publication scale of 1:100,000 is focused on the county geologic atlas projects that are underway.

Compilation: Mapping is being compiled as seamless 1:100,000 surficial and bedrock databases that cover Counties with a complete Atlas only, and also as statewide, consistent 1:500,000 maps and incrementally updated databases. The most recent state bedrock map was published in 2011, and a Precambrian map followed in 2012. In 2020, a database for a state basement map, from which Precambrian cover rocks had been removed, was released. A new state Quaternary map was published in 2019. This is an update to the 1982 Geologic Map of Minnesota, Quaternary Geology, by H.C. Hobbs and J.E. Goebel. The work was largely funded by a 1:1 cost-sharing agreement with the Great Lakes Geologic Mapping Coalition of the USGS. This multi-year project stitched together many maps created by the County Geologic Atlas program and other mapping programs, and also filled in areas not yet mapped at the more detailed scale. New CGA mapping will be added to the database as it becomes available. At present, subsurface Quaternary geology is being mapped statewide as cross-sections at a 5-km spacing.

Databases: MGS manages several important geological and geophysical databases and collections that support our mapping, and activity by others across the state. The largest and most commonly used is the water well database, which includes records for more than 600,000 wells, of which about 70% have accurate digital locations. We interpret the driller's description of the materials encountered in drilling and assign rock types and formation names. We work closely the co-manager of this database, the Minnesota Department of Health. As another example, we are in the third year of a comprehensive enhancement of the MGS collection of ~5,860 drill cuttings sets.

Research: MGS undertakes much research that is needed to optimize our mapping, such as enhanced hydrogeological characterization of sediment and rock strata. Our research most commonly is funded through state sources, as the results have direct applications to societal issues. We continue to support multiagency efforts to address PFAS contamination in the eastern Metro, by providing maps, data, and guidance for the construction of models to inform how to best provide clean drinking water for people in the region. This work was funded via the Minnesota Pollution Control Agency from the 3M PFAS/PFC settlement with the State of Minnesota. We also are continuing with efforts to better understand nitrate transport in southeastern Minnesota, by providing information necessary to more accurately determine whether improvements in agricultural practices are improving groundwater quality in the region. We are working with University colleagues on the feasibility of aquifer storage and recovery to alleviate groundwater quantity problems where aquifer drawdown has impacted baseflow to streams and lakes. We also are collaborating with University and Federal partners on drainage issues in the Twin Cities. We are supporting MDH watershed

planning under the Groundwater Restoration and Protection Strategies (GRAPS) - including compilation of Quaternary and bedrock geology for five watersheds – Zumbro, St. Louis, Cannon, Missouri, and Redeye. We also are supporting USGS work in coordination with the Department of Defense regarding a groundwater flow and transport model for the Twin Cities Army Ammunition Plant (TCAAP), by providing 3D geology to support definition of hydrostratigraphic units. A noteworthy recent discovery is evidence for a buried meteorite impact crater near Inver Grove Heights, MN. This was found by MGS geologists while mapping the bedrock geology of Dakota County for the County Geologic Atlas.

Plans for 2022-2023

Proposals: Submit proposals to USGS Data Preservation, STATEMAP, and Great Lakes Geologic Mapping Coalition

Data Preservation Program: MGS is working with the UMN Natural Resources Research Institute (NRRI), and the MN Department of Natural Resources (DNR) on this year's data preservation work, co-funded by USGS. Included are scanning of drill logs, geophysical databases, the 3rd year of work on cuttings storage, comprehensive efforts by DNR on the drill core library, and further synthesis of minerals-related information.

County Geologic Atlas Program: We will publish atlases for St. Louis, Aitkin, Steele, and Otter Tail Counties; conduct field work for surficial geologic map of Lake of the Woods, Faribault, Waseca, Ramsey, Swift and Lyon counties; conduct rotasonic drilling in Lake of the Woods, Waseca, Faribault, and Ramsey Counties; complete surficial geologic maps and cross sections for Dakota, Pipestone, Lincoln, Chippewa, Yellow Medicine, and Scott Counties; complete bedrock geologic maps for Pennington, Ottertail, Dakota, and Lac Qui Parle Counties; support partner well locating in Koochiching, Freeborn, Murray, Stevens, and Traverse counties.

STATEMAP Program: Surficial and bedrock mapping for Waseca and Lake of the Woods Counties; Surficial for Lyon and Faribault Counties; Bedrock for portions of Cook County.

Great Lakes Geologic Mapping Coalition: Complete statewide cross sections at 5 km spacing across northern Minnesota; stratigraphic drilling and correlation in CGA counties to support cross section interpretation at 1- and 5- km spacing; test methods for model construction using 5-km cross-section data

Earth MRI: For the USGS Earth Mapping Resources Initiative, with NRRI and DNR, we will map NW MN geology, based on a new aeromagnetic survey, and start work in the Cuyuna region

Research: Continued work on funded projects addressing contaminant transport; publication of results from sponsored projects, and other research with broad relevance.

Outreach: Outreach ranging from public inquiries to academic collaboration – focus on ensuring that our information products can be used efficiently by peer agencies such as the Pollution Control Agency, DNR, industry, and Counties; concurrent with active fulfillment of diversity, equity, and inclusion goals

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