Minnesota Ground Water Association

Volume 18, Number 1: March, 1999

President's Column

By James Piegat

On behalf of the MGWA Board I would like to thank Ray Wuolo, the outgoing Past President, and Paul Bulger, the outgoing Treasurer, for their good and faithful service to our Association. Their contributions have been essential for the continued health and success of MGWA.

We also welcome Jim Lundy, President Elect, and Lee Trotta, Treasurer, as new members of the MGWA Board. We look forward to working with them during the next few years.

MGWA will face several new and exciting challenges in 1999. The election of last year brought to the capitol a Governor who has no entangling alliances with anyone in the Legislature. The new Governor will also reshape state agencies by his appointments of new agency leadership. The same election results also mean that most members of the Legislature will see party leadership divided between the two houses for the first time during their service. Hence, leaders in state government will be looking at existing problems and plans for the future from new perspectives. And cooperation will be essential among the Governor, the House and Senate, and state agencies if any meaningful accomplishments and progress are to be realized.

MGWA has an opportunity and responsibility to participate in the changes that will be coming. Our primary objectives include promoting not only scientific but also public policy aspects of ground water and providing a forum for persons from different backgrounds who are concerned with ground water. Through its conferences and meetings, the Association can provide a forum where newly elected or appointed leaders can

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Membership Elects Two New Officers

The MGWA membership has elected two new officers to its Board of Directors. **Jim Lundy** is the 1999 President-Elect. Jim earned a BA from Gustavus Adolphus College (1981; geology, geography) and an MS from the University of Minnesota (1985; structural geology). He worked on a geophysics project at the Minnesota Pollution Control Agency (MPCA) in 1986 and as a consultant (ENSR Consulting and Engineering) during 1987-89. After several months as a gold exploration geologist in northern Minnesota, Jim returned to MPCA in 1989 as a hydrologist in the

— Jim Lundy, President-Elect

leaking underground storage tank program. He worked in MPCA's Superfund program from 1993 until last summer's reorganization. For the last several years, he has been a member of MGWA's newsletter editorial team. Jim is currently a senior hydrologist in the MPCA Policy and Planning Division.

Lee Trotta is a licensed professional geologist with U. S. Filter, where he

— Lee Trotta, Treasurer

specializes in water-well design and other technical services. He has been active in development of new monitoring technologies and has been responsible for the technical design of more than 100 ground water remediation systems at sites around the country. Lee is also responsible for the sand lab operation at U. S. Filter. Lee's prior career was with the U. S. Geological Survey where he was in charge of ground water and water use inventories. This work included

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The primary objectives of the MGWA are:

- Promote and encourage scientific and public policy aspects of ground water;
- Establish a common forum for scientists, engineers, planners, educators, attorneys, and other persons concerned with ground water;
- Educate the general public regarding ground water resources; and
- Disseminate information on ground water.

President's Column, cont.

share with us and the public their thoughts about the ways we can wisely use ground water resources.

A second challenge for MGWA is attracting more students to the Association. We need to communicate more effectively to students the value of the information we disseminate through our newsletters and conferences. Just as importantly, we need to help students understand the value of building person-to-person relationships with the professionals they will work with after graduation.

In short, There are challenges for MGWA that are significant. I hope that as an organization, we can help make a difference for the better.

New Officers, cont.

providing technical aid to state regulators in a variety of capacities. In 1984, Lee was the first to design a ground water protection strategy using ARC/INFO digitized land-resource data. Lee has been an active and regular contributor to MGWA over the years. He served as newsletter editor in the early 1980's and most recently, was MGWA's coordinator of the very successful 1998 fall field trip.

We would like to thank Paula Berger and Paul Bulger for their service. These two "PB's" did much to keep MGWA moving in the right direction during their terms. As Paula now becomes Past President, she passes the leadership to Jim Piegat for 1999.

Minnesota's Malformed Frogs—A Ground Water Connection?

Following is a brief summary of an update of the malformed frog situation which was held for Minnesota Pollution Control Agency (MPCA) staff, the media and others in the MPCA board room the afternoon of January 6, 1999. The session featured presentations by Minnesota researchers, as well as invited speakers working on this issue nationwide. **Judy Helgen,** research biologist with MPCA opened the afternoon with an overview of recent findings. Most abnormalities are linked to rear limbs and appear to not be caused by chromosome damage or parasites. A possible link to pesticide use is still being evaluated (see below for recent findings). Examination of historical frog collections shows a 0.1% malformation rate, compared with about 2.5% currently. A goal for establishing a control or reference site today is considered a less than 1% malformation rate.

Jim Burkhardt of the National Institute for Environmental Health Studies in North Carolina then summarized some of their recent findings. Dilution of water from sites with affected frogs produced malformations in laboratory frogs according to a predictable curve and depending on concentrations. Water matrix effects in and of themselves do not appear to be sufficient to account for malformations. Endocrine factors are likely involved and it is possible that a combination of factors may be synergistic.

Carol Meteyer of the National Wildlife Health Center in Madison, WI discussed some overall factors in teratogenesis of Minnesota's frogs. She distinguished between deformations, which are due to trauma, such as an injury inflicted by a predator, and malformations, which are errors that occur early in the development process. She, too, ruled out parasites and infectious agents as causes of frog malformations. Documentation of early development errors has led researchers to look at tadpoles to see if they might hold clues to the earliest causes of malformations, however, just 12 of 142 tadpoles collected in Minnesota in 1998 showed evidence of malformations.

Perry Jones, researcher with the U.S. Geological Survey in Mounds View, MN summarized work that is underway in Minnesota in cooperation with MPCA and others to look at possible links between surface water and ground water as a cause of malformations in frogs. Three study sites are being instrumented with shallow piezometers. One is a forested lake area, with no surrounding agriculture; the second is a combination of forest and residential land use between two lakes; and the third is in an agricultural area with considerable tilling of row crops. This study is in the early stages, but should provide some new data about a possible link between surface and ground water in the mystery of the malformed frogs.

Finally, **Mike Thurman**, head of the U. S. Geological Survey Organic Geochemistry Research Lab in Lawrence, KS, discussed his results of looking at pesticides and several of their metabolites in water samples from malformed frog sites. Extensive herbicide analysis of water samples from three research ponds and ground water samples showed only the Nye pond (the site near Henderson, MN, where malformed frogs were first reported in large numbers) had extensive detections of herbicides and their metabolites. The Nye pond results showed effect of surrounding row crop agriculture, with concentrations of cyanazine and atrazine, acetochlor, alachlor and metolachlor or their metabolites increasing in late spring and early summer at the 2-7 part per billion level. Organophosphate and organochlorine insecticides were not found in any surface or ground waters that were assayed at a reporting limit of 0.05 parts per billion. One pond was checked for TOX, total organic halogen, and a reporting limit of 13 ppb, with no detections noted. This result suggests that high levels of unknown organochlorine compounds are not present in the pond.

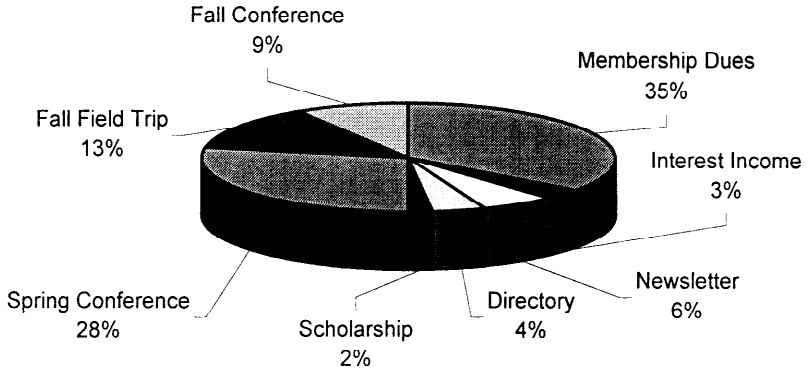
— contributed by Tom Clark

Summary of MGWA Finances

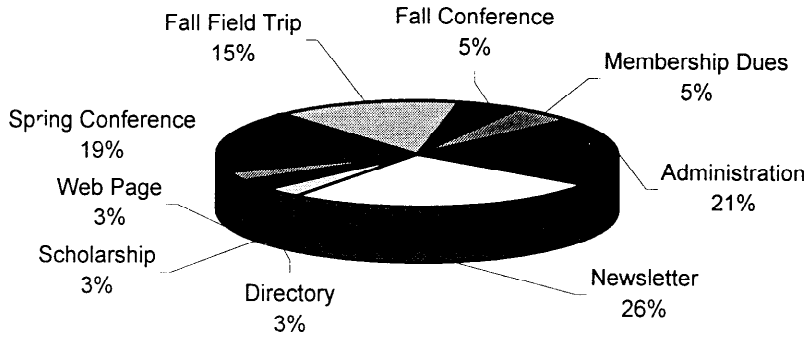
	Income	Expenses	Net
Membership Dues	$9,490.00	$1,326.39	$8,163.61
Interest Income	$776.77		$776.77
Product Sales and Expenses			
Guidebook, Mug, T's	$106.94	$20.40	$86.54
Mailing List $25.00$15.60$9.40			
Administration			
Postage, Supplies		$72.87	($72.87)
Financial, Tax Accounting		$1,504.43	($1,504.43)
Post Office		$105.00	($105.00)
Correspondance		$33.10	($33.10)
Board Meetings		$417.78	($417.78)
Database Maintenance		$2,400.00	($2,400.00)
Member Services			
Newsletter	$1,674.00	$6,602.07	($4,928.07)
Directory	$1,203.00	$694.07	$508.93
Member Correspondance		$755.81	($755.81)
Public Service			
Scholarships	$461.00	$900.00	($439.00)
Web Page		$883.42	($883.42)
Program Expenses			
Spring Conference	$7,792.00	$4,916.31	$2,875.69
Fall Field Trip	$3,565.00	$3,890.03	($325.03)
Fall Conference	$2,390.00	$1,315.64	$1,074.36
Totals 1998	**$27,483.71**	**$25,852.92**	**$1,630.79**

Prepared by 1998 Treasurer Paul Bulger

1998 Income $27,463



1998 Expenses $25,833



1999 Board of Directors

Mower County Geologic Atlas, Part A

John H. Mossler, Minnesota Geological Survey

Introduction

The Mower County Geologic Atlas (Part A) was published by the Minnesota Geological Survey in June 1998. The atlas contains 1:100,000-scale maps showing the data base, bedrock and surficial geology, depth to bedrock, bedrock topography, subsurface stratigraphy, and geologic resources. A Report of Investigations (J.H. Mossler, in prep.) containing supplementary text to Part A of the atlas will be published by the Survey in coming months. Part B, depicting hydrogeology, karst features, and sensitivity of ground water to pollution, will be published in mid-1999 by the Minnesota Department of Natural Resources, Division of Waters.

Because most members of the MGWA probably are already familiar with the county atlas program, I will not dwell on features that are more or less standard for the series; rather, I will discuss the following four new mapping techniques and interpretations that were incorporated into the atlas.

1. An innovative method was used to portray the subsurface distribution of unconsolidated Quaternary materials. Hydrologists should find this method particularly useful in assessing the sensitivity of ground water to pollution.
2. The Upper Carbonate Aquifer System of the previous literature was subdivided into discrete aquifers separated by thin confining layers.
3. The depth and orientation of buried bedrock valleys was determined using a combined gravity–geologic method.
4. Karst landscapes and associated ground-water conditions—not previously documented in the county—were identified and defined.

Quaternary Geologic Mapping

Although Quaternary sediments are not extensively exploited for ground water in Mower County, their composition and distribution are important because they influence the sensitivity of underlying bedrock aquifers to contamination. Where karsted carbonate aquifers are shallower than 50 feet below land surface, as they are in many places throughout Mower County and much of surrounding counties, they can no longer be used for potable water supplies because of contamination by human activities.

It is necessary to discuss briefly the methodology used by the authors of the surficial map (Meyer and Knaeble, 1998) to distinguish Quaternary units and map their surficial distribution before turning to the discussion of the mapping methods used to map the *subsurface* distribution of Quaternary sediments. Except for its far-western margin, glacial deposits that are probably pre-Illinoian in age (Fig. 1) cover Mower County. Therefore, much of the land surface lacks the hummocky topography, abundant lakes and wetlands, and immature drainage networks characteristic of land surfaces more recently glaciated during the late Wisconsinan. Because most of the county has low relief and few exposures of glacial till, numerous soil borings were drilled. In addition, five deep holes were cored across the northern half of the county, water-well cuttings, mostly from the south part of the county, examined and described, and textural analyses and lithic grain counts of the 1–2-mm sand fraction conducted. The soil survey of Mower County aided the delineation of surficial map units (Carlson, 1989).

The pre-late-Wisconsinan glacial drift is divided into three tills and affiliated units of stratified sediment that can be correlated on the basis of till texture, color, and sand lithology with equivalent tills that are present in north-central Minnesota (Meyer, 1986). The deposits of stratified sediment (sand, gravel, and finer sediment) tend to lie at the base of the tills and, with paleosols that formed at the tops of the tills, aid in distinguishing units. During each Quaternary glaciation, the Laurentide ice sheet flowed into Minnesota from two major source areas: the Labrador sector of northeastern Canada and the Keewatin sector of northwestern Canada (Fig. 2). The flow paths of the ice from these centers crossed different rock types, resulting in different sediment compositions and textures for the resulting glacial tills (Table 1). The pre-Illinoian tills of Mower County came from both the northeasterly Labrador and northwesterly Keewatin sectors (Fig. 2) and are of Rainy and Winnipeg provenance (Table 1). Superior-provenance till, which contains a suite of red volcanic and detrital rock fragments, is found in only a few small exposures and is not listed in Table 1.

Late-Wisconsinan Des Moines–lobe ice advanced into Mower County from the west but halted its eastward advance when it reached the valley of the Cedar River, just inside the county line. The late-Wisconsinan New Ulm Formation is of Riding Mountain provenance and came from the Keewatin sector (Table 1; Fig. 2).

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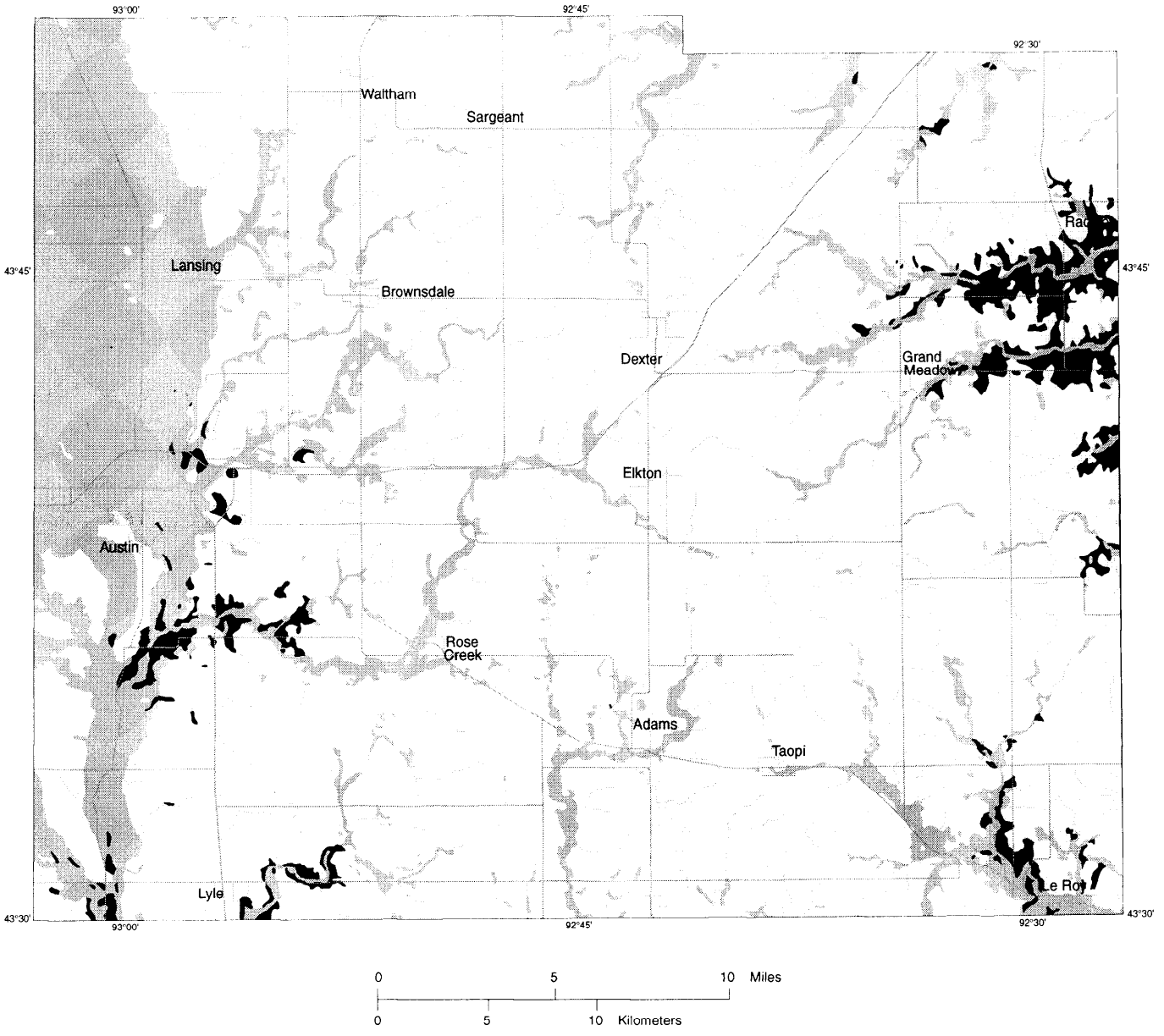
TABLE 1. Characteristics of mapped glacial deposits in Mower County, Minnesota.
[[Modified from Meyer and Knaeble (1998).]

FORMATION	New Ulm	Browerville & Elmdale	Rose Creek
PROVENANCE	Riding Mountain	Winnipeg	Rainy
TILL TEXTURE	Loamy to sandy	Loamy to clayey	Loamy to sandy
COLOR			
Oxidized	Yellow brown to olive brown	Yellow brown	Yellow brown to brown
Unoxidized	Gray	Gray to dark gray	Green gray to gray
SAND-GRAIN LITHOLOGY (UNLEACHED)			
Cretaceous carbonate	Rare	Rare to common	Absent to rare
Paleozoic carbonate	Common	Uncommon to common	Uncommon to common
Dark-gray to gray-green rocks	Uncommon to common	Uncommon to common	Common
Red felsite and sandstone	Rare to uncommon	Absent to rare	Rare
Gray shale	Uncommon to common	Absent to rare	Absent



EXPLANATION

HOLOCENE AND PLEISTOCENE (LATE WISCONSINAN)

Floodplain deposits & New Ulm Fm.—*Riding Mountain provenance.* Loam to sandy loam-textured till; sand and gravel outwash; loamy to sandy alluvium; and minor eolian sand.

PLEISTOCENE (PRE-WISCONSINAN)

Browerville, Rose Creek, and Elmdale fms., undivided—*Winnipeg, Rainy, and Winnipeg provenance, respectively.* Loamy, clayey, and sandy till; clay; paleosol at top of each fm. Some sand, gravel, and silt beds, mostly at bottom of individual units.

CRETACEOUS, DEVONIAN, ORDOVICIAN

Bedrock and saprolith, undivided—Generally limestone or dolostone; less commonly, shale, siltstone, sandstone, or conglomerate. Bedrock is within 10 feet of land surface, generally weathered to saprolith in upper 5 feet.

Figure 1. Simplified surficial geology of Mower County. Modified from Meyer and Knaeble (1998).

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TABLE 2. Classification of Quaternary subsurface map units by presence, order, and thickness of till units and sand beds.
[Modified from Meyer and Mossler (1998); leader (--), not applicable.]

DEPOSITS	THICKNESS		
	More than 10 ft	Patchy to less than 20 ft	Patchy or less than 10 ft
TILL			
New Ulm	N	n	--
Browerville	B	b	--
Rose Creek	R	r	--
Elmdale	E	e	--
SAND BED(S)	G	--	g

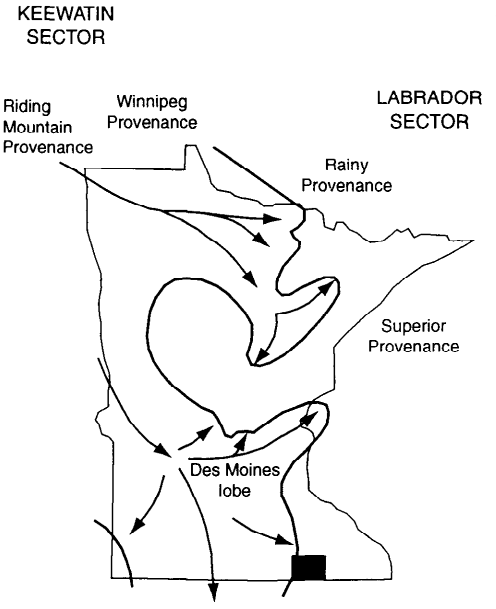
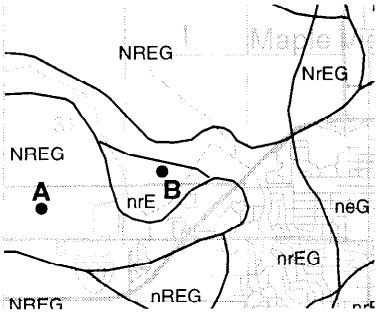


Figure 2. The maximum extent of the Des Moines lobe and related ice advances in Minnesota, and the source area of glacial sediment deposited in Mower County. Modified from Meyer and Knaeble (1998).



Line-bounded, lettered units represent a composite thickness and stratigraphic order of tills and sand beds from the surface downward (see Table 2)

A

NREG — Lettered unit, bounded by black lines, indicates:

- N — uppermost till is New Ulm, and it is more than 10 ft thick,
- R — next lower till is Rose Creek, and it is more than 10 ft thick, and
- E — lowest till is Elmdale, and it is more than 10 ft thick.
- G — G as the last letter indicates that there are no more tills in the sequence, and that sand beds thicker than 10 ft are present within the vertical section.

B

nrE — Lettered unit, bounded by black lines, indicates:

- n — uppermost till is New Ulm, and it is patchy or less than 20 ft thick,
- r — next lower till is Rose Creek, and it is patchy or less than 20 ft thick, and
- E — lowest till is Elmdale, and it is thicker than 10 ft.

The absence of a G as the last letter indicates that sand beds are unlikely to be present in the sequence.

Figure 3. Explanation of line-bounded, lettered units as used in the Quaternary Subsurface Stratigraphy map of Mower County. Modified from Meyer and Mossler (1998).

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Mower County Atlas, cont.

Subsurface Stratigraphy Plate

The Subsurface Stratigraphy plate (Meyer and Mossler, 1998) incorporates several innovations not included on similar plates in the past, some of which cannot be reproduced for this article. For example, the plate has six cross sections that show the succession of stratigraphic units in both the Paleozoic bedrock and the unconsolidated Quaternary units. The sections span the county west to east and are spaced four miles apart north to south. The sections and the map accompanying them should be very useful for making assessments about ground-water sensitivity.

One of the two theme layers of the Quaternary Subsurface Stratigraphy map that accompanies the sections illustrates Quaternary subsurface geology using line-bounded polygons. Letters inside each such polygon (Fig. 3; Table 2) present the stratigraphic order, from the land surface downward, of tills and sand beds that are interpreted to lie within the polygon. The map is too detailed to produce in its entirety for this article; therefore, only a small part is shown in Figure 3. The four tills mapped are those described on the Surficial Geology plate: till of the New Ulm Formation (N, n), the Browerville Formation (B, b), the Rose Creek Formation (R, r), and the Elmdale Formation (E, e). A capital letter indicates the till is thicker than 10 feet, whereas a lower-case letter indicates till that is patchy to less than 20 feet thick (Table 2). In any given unit, the first letter in the series represents the uppermost till, and the last letter in the series represents the lowermost till. If the first or surficial unit is stratified sediment, such as sand or gravel, the first letter in the grouping represents the till immediately below the stratified sediment. The presence of a sand and (or) gravel bed between the lowermost till and bedrock within a map unit is indicated by the letter G or g at the end of the group of letters. An upper-case G indicates at least one bed greater than ten feet thick; a lower-case g indicates the sand beds are patchy or commonly less than ten feet thick. Absence of a G or g next to the till-unit letters indicates that sand units are uncommon or absent. Map units that generally lack till between the surface and bedrock contain only the symbol G. For example, REg would indicate the presence of more than 10 feet of both the Rose Creek and Elmdale Formations over a basal sand bed that is patchy or less than 10 feet.

The second theme layer portrayed on the same map has color units representing both surficial sediment type and depth to bedrock. The limitations imposed by use of gray tones instead of color make it impossible to represent within a page-size figure all the units present on the published 1:100,000-scale map. Instead, a simplified version of this map (Fig. 4) presents depth to bedrock in shades of gray and surface sediment by pattern.

Depth to bedrock is commonly the only criterion used for assessing the sensitivity of an area to pollution. That approach assumes that all material between the land surface and bedrock is till, and that all tills are equivalent and behave the same. Both assumptions are false. Buried sand and gravel deposits offer no protection and are conduits to underlying aquifers. Conversely, clay loam till that contains few sand and gravel bodies can be expected to offer significant protection. Sandy loam till is intermediate in effectiveness. The cross sections and map on the Subsurface Quaternary plate provide a starting point for assessing the sensitivity of aquifers to pollution.

Subdivision of the Upper Carbonate Aquifer System

As in other counties in southeastern Minnesota, Mower is underlain by a thick sequence of Paleozoic sedimentary rock. These rocks formed from sediments deposited within and along the margins of shallow seas that periodically covered the region 523–374 million years ago. A composite section may be thicker than 1800 feet in parts of Mower County, but absolute thickness is unknown because no wells penetrate the entire thickness of Paleozoic rock. Thin units of conglomerate, sandstone, claystone, and iron-formation, provisionally assigned to the Late Cretaceous (and therefore less than approximately 100 million years old), are present atop the Paleozoic strata in patches as thick as 50 feet (Fig. 5). The bedrock is covered by Pleistocene deposits and Holocene sediment that vary greatly in thickness (Fig. 4) but may be as great as 275 feet in places near the western edge of the county. Consequently, geologic interpretations largely rely on subsurface geologic data derived from water-well drilling.

Mower County is underlain by Middle to Upper Ordovician and Middle Devonian carbonate rocks that Delin and Woodward (1984) and others assigned to the Upper Carbonate Aquifer System. However, studies by the Iowa Geological Survey Bureau (Libra and others, 1984; Libra and Hallberg, 1985) in north-central Iowa show that equivalent Devonian rocks are quite heterogeneous and can be divided into three major aquifers separated by two confining layers. The bedrock mapping done as part of this atlas showed that the stratigraphic sequence developed in north-central Iowa can be extended into Mower and adjoining counties in Minnesota. In addition, thin shale beds in the Dubuque and basal part of the Maquoketa Formations form a third confining layer in the upper part of the Ordovician sequence.

The three principal confining layers in the Paleozoic section of Mower County are the Chickasaw shale in the middle of the Devonian Cedar Valley Group, the Pinicon Ridge Formation of the Devonian Wapsipinicon Group, and the Dubuque Formation. Owing to size limitations, only the Chickasaw and Dubuque are mapped separately in Figure 5. The Pinicon Ridge has lithic similarities to basal Cedar Valley Group rocks—both are dark, silty to shaly dolostone, but it also has thin shale beds, which serve as confining layers, as well as minor limestone and chert. The Cedar Valley Group overlying the Chickasaw has an upper unit composed of the Lithograph City Formation and a lower unit composed of the middle part of the Cedar Valley Group. Both units are predominantly dolostone, but the upper one, the Lithograph City Formation, also has numerous limestone beds and has the most karst of any unit in the county. Together with the middle part of the Cedar Valley Group, the

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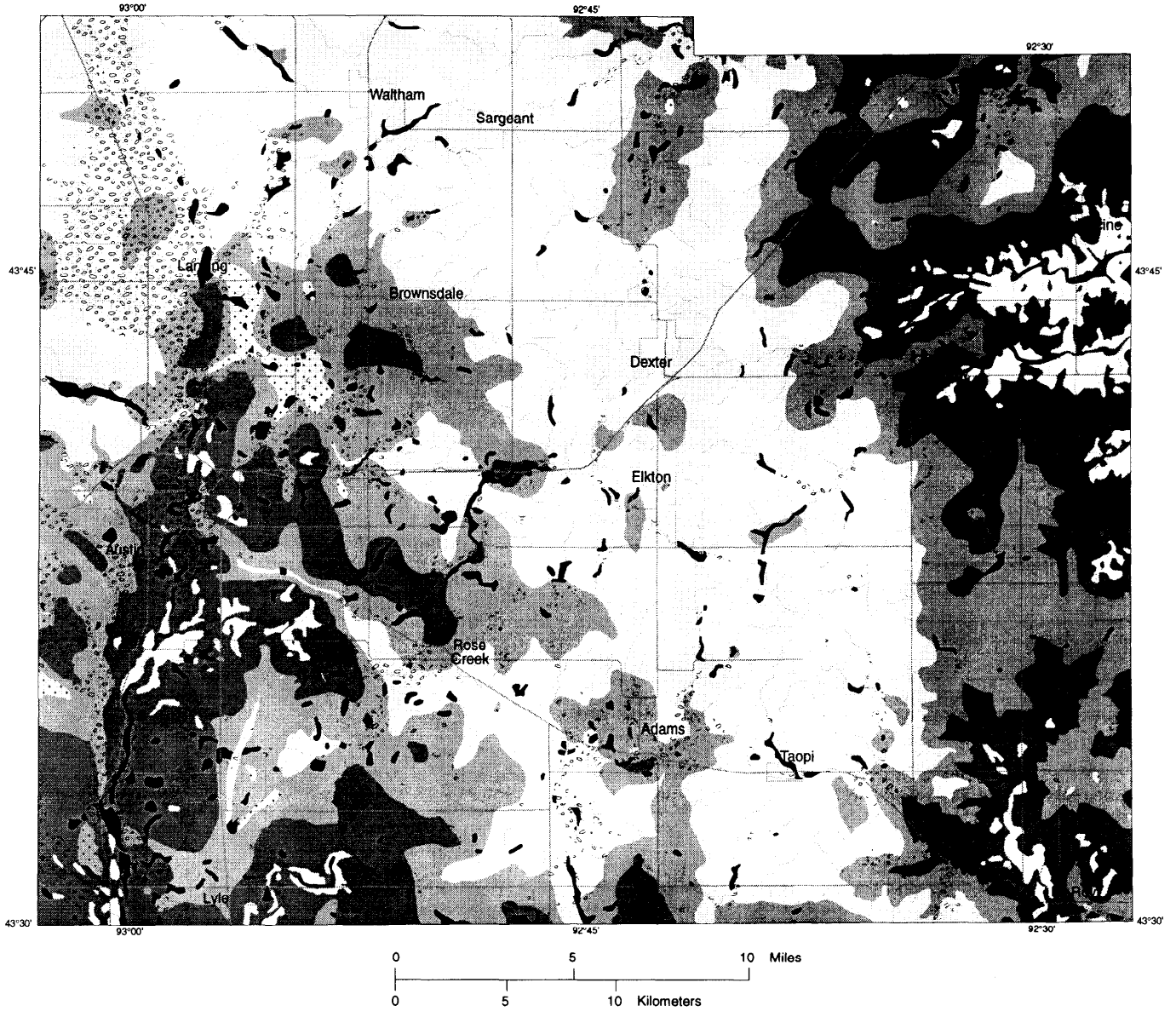

DEPTH TO BEDROCK

SURFACE SEDIMENT	Less than 50 feet	50–100 feet	More than 100 feet
Till, paleosol, or clayey alluvium			
Till and sand or sandy loam alluvium			
Sand to gravel			
Less than 10 ft thick over bedrock			

Figure 4. Simplified map showing type of surface sediment and depth to bedrock in Mower County. Modified from Meyer and Mossler (1998).

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Lithograph City Formation forms an important aquifer. However, it cannot be used for water wells where it has less than 50 feet of cover because of the possibility of contamination. Dolostone and dolomitic limestone of the basal Devonian Spillville Formation form another productive aquifer. Like the Lithograph City, its suitability as a source for water is dependent on the thickness of protective Quaternary cover.

A thick section of Ordovician strata unconformably underlies Devonian rocks. The uppermost unit, the Maquoketa Formation, is dolostone and minor limestone that contains thin interbedded shale beds near its base. Dolomitic limestone and limestone of the Galena Group underlie the confining layer formed by the intervening Dubuque Formation. Galena carbonate rock serves as an aquifer, particularly in those areas where its porosity has been enhanced by dissolution along fractures and bedding planes.

Other Bedrock Aquifers

The St. Peter Sandstone, which is separated from the Galena Group by the Decorah–Platteville–Glenwood confining layer, is used locally as an aquifer, but its fine grain size and friability cause problems in screening formation sand from well bores. Many St. Peter wells pump sand; as a result, many drillers prefer to drill deeper wells that produce from Prairie du Chien Group dolostone and sandstone.

The Jordan Sandstone is used for water supply by some municipalities and industries. Although considered an important aquifer in Minnesota, in Mower County it is only 65–70 feet thick and the permeable quartzose facies that constitutes the aquifer is only 20–25 feet thick. The remaining rock is fine-grained, feldspathic sandstone that is much less permeable and acts as a confining layer (Runkel, 1996). Little is known about Cambrian aquifers beneath the Jordan, but they, like the Jordan, are not as thick as equivalent beds to the north and east.

The Gravity–Geologic Method And Bedrock Valleys

The gravity–geologic method of Imbrahim and Hinze (1972) was used to determine depth and orientation of buried bedrock channels. The method employs a regional residual anomaly separation scheme that incorporates geologic control from drill holes, outcrops, and seismic studies. Although not as precise as seismic refraction profiling, which was also used in Mower, gravity surveying is much faster, less expensive, and the results provide an interpretation of the bedrock topography over a broader area (Fig. 6). Much of the county is covered by glacial till (Fig. 1), which is so highly eroded that it provides few clues about the position and orientation of pre-existing valleys. Also, water-well data are sparse and unevenly distributed. The substantial gravity data base for Mower was augmented by new measurements to fill gaps in coverage. Residual anomalies caused by density contrasts between unconsolidated sediment and denser carbonate bedrock had to be separated from regional anomalies caused by underlying Precambrian rocks. This procedure is very difficult in extreme western Mower County, where there are huge gravity anomalies due to thick sequences of Proterozoic volcanic rocks of the Midcontinent rift. The gravity–geologic method worked best in central and eastern Mower, where regional anomalies are gentler. The residual anomaly signature was transformed into estimates of bedrock topography and depth to bedrock. Computer-generated maps of these estimates (Fig. 6) were used as guides for contouring the bedrock topography and the thickness of overlying Quaternary deposits.

Karst Features

Although Mower County is entirely underlain by carbonate rock, it is not located in what is generally considered the karst region of southern Minnesota. However, karst is present throughout the county and is particularly well developed in the area around Le Roy (Fig. 5), where highly soluble limestone of the Lithograph City Formation lies at or near the surface. Numerous sinkholes, as well as sinking streams and karst springs, have been identified and mapped. A study compiled in conjunction with Part A of the atlas documents the occurrence of karst in the Le Roy area (Green and others, 1997). The investigation of karst geology and hydrogeology is currently being expanded to include the rest of the county by Prof. E. Calvin Alexander, Jr., University of Minnesota, and Jeff Green, Minnesota Department of Natural Resources, Division of Waters, and will be included in Part B of the atlas.

For Further Information

County geologic atlases are available from the Minnesota Geological Survey, (612) 627-4780, extension 238. Additional information on current atlas and related studies is posted on the Survey's web page, http://www.geo.umn.edu. For further information, including availability of data and ARC/INFO coverages of maps in the Mower County geologic atlas, contact the Survey at (612) 627-4780 or the Department of Natural Resources, Division of Waters, at (651) 296-4800.

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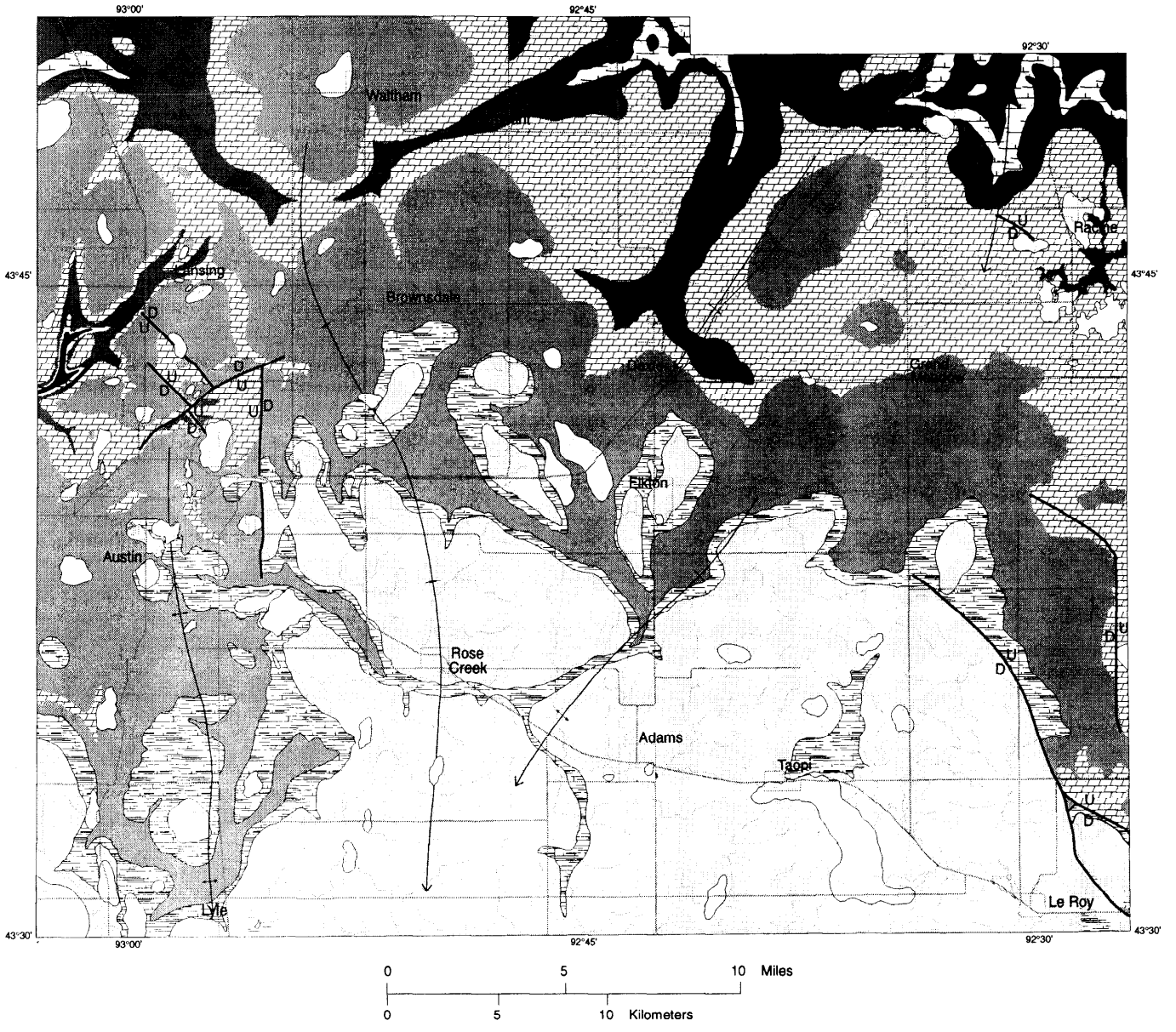

EXPLANATION

CRETACEOUS

Windrow Fm., undivided—Siltstone, iron-formation, quartzose sandstone, and conglomerate.

DEVONIAN

Upper & Middle Cedar Valley Gp., undivided — Limestone, dolostone, shale, and limey shale of Lithograph City, Coralville, and upper part of Little Cedar Fms.

Chickasaw Mbr. of Little Cedar Fm. —Limey shale

Bassett Mbr. of Little Cedar Fm. and Pinicon Ridge Fm., undivided—Silty to shaly dolostone; thin shale beds at base.

Spillville Fm.—Dolostone; minor limestone in upper part.

ORDOVICIAN

Maquoketa Fm.—Dense dolostone; shaly at base.

Dubuque Fm.—Interbedded limestone and shale.

Stewartville Fm. of Galena Gp.—Dolomitic limestone.

D/U **Fault**—Inferred; U upthrown side, D, downthrown side.

Anticline—Showing trace of axial surface and plunge of fold.

Syncline—Showing trace of axial surface and plunge of fold.

Figure 5. Simplified bedrock geology of Mower County. Modified from Mossler (1998).

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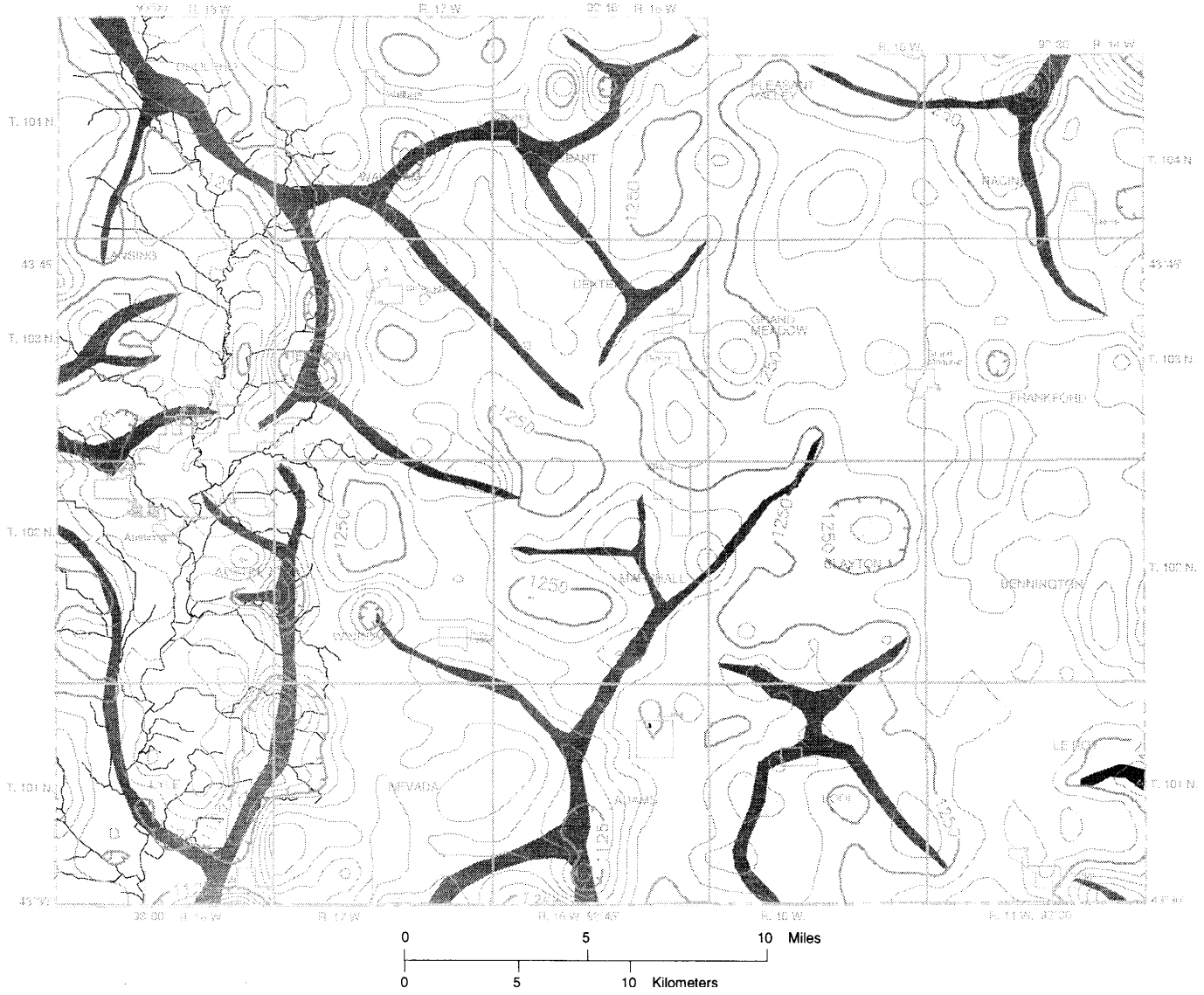

Figure 6. Elevation of the pre-Cretaceous bedrock surface as determined through the gravity geologic method. Prepared by Val W. Chandler. Contour interval, 25 ft; stipple delimits main bedrock valleys.

Mower County Atlas, cont.

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MGWA Calendar

Contact information for the major event-holders is listed at the end of the column. If you become aware of a relevant event which may not be widely publicized, please send the information to the attention of the editor. Thank you.

March 24, 1999 Minnesota Department of Health (MDH) Annual Well Conference, Thunderbird Hotel, Bloomington, Minnesota. Contact: Ed Schneider, (651)215-0827.

March 22-25, 1999 Analysis and design of aquifer tests including slug tests and fracture flow, San Diego, CA. Contact: NGWA.

March 25-26, 1999 Risk assessment for the environmental professional: contaminant fate and transport modeling using API decision software, San Diego, CA. Contact: NGWA.

April, 1999 Fracture trace and lineament analysis: applications to ground water resources characterization and protection, Penn State. Contact: NGWA.

April 12-14, 1999 Desktop GIS and remote sensing techniques and technologies for environmental hydrology, Chicago, IL. Contact: NGWA.

April 19-20, 1999 Fundamentals of ground water geochemistry, Dallas, TX. Contact: NGWA.

April 21-22, 1999 Assessment and management of MTBE impacted sites, Dallas, TX. Contact: NGWA.

April 21-23, 1999 Applications of ground water geochemistry, Dallas, TX. Contact: NGWA.

April 22-23, 1999 North-Central Section, Geological Society America at Champaign-Urbana, Illinois. For information check the GSA web site at www.geosociety.org.

April 26-27, 1999 Low cost remediation strategies for contaminated soil and ground water, Philadelphia, PA. Contact: NGWA.

April 28-30, 1999 Principles and practice of forced air remediation systems, Philadelphia, PA. Contact: NGWA.

April 28-30, 1999 Assessment and management of MTBE impacted sites, Philadelphia, PA. Contact: NGWA.

This Newsletter brought to you by:

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MGWA Newsletter Deadlines for 1999

Issue	Copy to Editor	Copy to Publisher
June (v.18, no. 2)	5/7/99	5/14/99
September (v. 18, no. 3)	8/6/99	8/13/99
December (v.18, no. 4)	11/5/99	11/12/99

Your newsletter editorial team would like to welcome Charles (Charlie) Tiller as a new member. Charlie came to Minnesota in 1992 to pursue an MS in Geology at the University. While there, he studied and taught at the Limnological Research Center where his research contributed to the understanding of recent Yellowstone Lake and Caldera history. He received his degree in 1995 and now consults clients on a variety of sediment and ground water contamination problems for American Engineering Testing.

April 30, 1999 MGWA Spring Conference – "New Leadership in Evolving GW Policy" Minnesota History Center

May 10-12, 1999 Natural attenuation of fuel hydrocarbons and chlorinated solvents: processes, monitoring and modeling with BIOSCREEN and BIOPLUME III, Phoenix, AZ. Contact: NGWA.

May 10-13, 1999 Karst Workshop see page 15.

May 12-14, 1999 Ground water and environmental data management, Phoenix, AZ. Contact: NGWA.

May 18-19, 1999 Natural attenuation for remediation of contaminated sites, Raleigh, NC. Contact: NGWA.

May 16-17, 1999 Groundwater in Tomorrow's Europe, Castle Donnington, UK. Organized by the IAH British National Chapter in association with the Hydrogeology Group of the Geological Society, the UK Groundwater Forum, Environment Agency and Euo-GeoSurveys. Contact Justine Huddart, Conference Nottingham, +44 115 985 6533, E-mail: info@confnottingham.co.uk

June 8-9, 1999 Natural attenuation for remediation of contaminated sites, Seattle, WA. Contact: NGWA.

June 10-12, 1999 The Second Approximation International Conference on Soil Resources: Their Inventory, Analysis, and Interpretation for Use in the 21st Century. Minneapolis, MN. Contact: Tracey Benson, 1-800-367-5365, E-mail and internet addresses: tbenson@extension.umn.edu, http:// soil.resources.umn.edu/99conf

June 14-16, 1999 Principles of ground water – flow, transport and remediation, Portland, OR. Contact: NGWA.

June 17-18, 1999 Assessment and management of MTBE impacted sites, Portland, OR. Contact: NGWA.

June 22-23, 1999 Water Quality: Don't Let It Slip Through the Cracks, 1999 State Water Planners Conference, Rochester, MN. Contact: Bea Hoffman, SE MN Water Resources Board, 507-457-5223, hoffman@vax2.winona.msus.edu

June 22-25, 1999 Computer modeling of natural attenuation and bioremediation systems, Atlanta, GA. Contact: NGWA.

September 1999 Natural Attenuation. Contact: NGWA.

September 14-16, 1999 7th Symposium on the Chemistry and Fate of

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MGWA Calendar, cont.

Modern Pesticides, Lawrence, KS. Contact E. Michael Thurman (785)832-3564.

October 13-15, 1999 Midwest Ground Water Conference, St. Paul, MN. Contact Sarah Tufford, Minnesota Department of Natural Resources, 651-297-2431, or e-mail sarah.tufford@dnr.state.mn.us.

October 25-28, 1999 GSA Annual Conference, Denver, CO. Contact: GSA

November 1999 Natural Attenuation. Contact: NGWA.

November 7-10, 1999 Fourth USA/CIS joint conference on environmental hydrology and hydrogeology: hydrologic issues for the 21st century: ecology, environment and human health. American Institute of Hydrology (AIH), Cathedral Hill Hotel San Francisco, CA. Contact: AIH, 2499 Rice Street, Suite 135, St. Paul, MN 55113. 651-484-8169 E-mail: AIHydro@aol.com

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www.h2o-ngwa.org

for Nielsen Environmental Field School events:
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Galena, OH 43021
614-965-5026
614-965-5027 (fax)
email: nielsenfieldschool@juno.com

for GSA events:
www.geosociety.org

for Princeton's events:
PO Box 273776
Tampa, FL 33688-3776
813-964-0800, 813-964-0900 (fax)
www.princeton-groundwater.com;
email: info@princeton-groundwater.com

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American Institute of Hydrology
2499 Rice Street, #135
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http://www.aihydro.org
email: aihydro@aol.com

1999 GSA Birdsall-Dreiss Lecture on Geyser Activity

On February 3,1999, Dr. Stuart Rojstaczer of Duke University presented the 22nd Annual Birdsall-Dreiss Lecture: "Geysers: Why are they so rare and what might they indicate about deformation in areas of active tectonics?" Dr. Rojstaczer delivered a straightforward, interesting, and, at times, humorous lecture on a topic that easily could have degraded into an hour of differential equations. Yet not one equation was offered to diminish the presentation's appeal.

Dr. Rojstaczer began by noting that geysers are far less common than warmsprings and gas fumaroles, probably as a result of specific hydrologic requirements intermediate between those two end members of the liquid-gas continuum. The limited range of suitable conditions implies that geyser activity should be sensitive to perturbations. Periodicities of geyser eruptions do change over time, particularly in response to large earthquakes. Researchers have suggested that smaller static (temporary and reversible) deformations affect geyser periodicity as well, resulting in chaotic trends of cycle length and structure over time. Even deformation due to changes in atmospheric loading and earth tides has been recruited to explain these poorly documented chaotic trends.

Dr. Rojstaczer first discussed a Fracture-Zone Model of geyser activity that simulates hydrothermal fluid flow in a fractured pipe within less permeable country rock. This model permits a liquid-to-steam transformation and steam-rise to the surface under prevailing hydrostatic pressure conditions, and does not require flow blockage and pressure-buildup like the traditional Constricted-Pipe Model. Simulated eruption cycles and mass discharge from the modeled "Old Stuart Geyser" appear to be somewhat sensitive to perturbations in various hydrologic parameters, but particularly permeability. A permeability contrast between geyser and country rock of only one order of magnitude causes nearly continuous steam discharge throughout the cycle. Further increasing the permeability contrast drives the system to become a fumarole. If the permeability contrast is too small, the system becomes a warm spring.

In order to gauge the geyser sensitivity to small static deformations, Dr. Rojstaczer incorporated nonlinear permeability functions that simulate changes during deformation. Increasing nonlinearity enhances bimodality in the structure of eruptive cycles, resulting in a lengthening eruption followed by a shortening dramatic eruption. This discharge time-series may approximate a chaotic trend in some instances. However, Dr. Rojstaczer noted that the more important consideration in hydrologic terms is the cycle length (the interval between eruptions), which responds randomly rather than chaotically to nonlinearity in permeability functions. The cycle length is a direct result of groundwater recharge to the system, and trends over time should document dynamic (permanent) deformation, not static deformation caused by recurrent phenomena such as barometric changes and earth tides.

Dr. Rojstaczer applied these theoretical findings to real-life geysers in the Upper Geyser Basin of Yellowstone National Park. Eruptive activity in several geysers was monitored by self-logging instrumentation for approximately one year. Eruption cycle lengths for Daisy Geyser exhibited a gaussian (random) distribution, although the structure of eruptive cycles correlates with barometric changes during the year. Small static deformations due to atmospheric pressure changes may affect some geysers. However, Old Faithful, Plume, Big Anemone, and Little Anemone Geysers showed no indication of chaotic behavior related to static deformation induced by barometric changes, earth-tides, or other external factors. In conclusion, Dr. Rojstaczer noted that most geysers do not appear to respond to small static deformations. When geyser periodicities do change, it is most likely a response to tectonic events, dynamic deformation, and permeability changes. For readers who are interested in investigating these phenomena personally, Dr. Rojstaczer mentioned that you can purchase the man-made Calistoga Geyser in California for the small sum of $600,000.

— contributed by Charles Tiller

Ground Water Recharge in Arid Settings

One of the original developers of MODFLOW, Michael McDonald, presented "Representations of Ground Water Recharge Mechanisms - Lessons from an Arid Setting" on January 21 1999 at the University of Minnesota Department of Geology and Geophysics. The lecture was given as part of the department's winter quarter lecture series.

Mr. McDonald, currently of McDonald and Morrissey Associates, and formerly with the U.S. Geological Survey, described a study in northeastern Nevada with active gold mining, both surface and underground. The study area is located within the Basin and Range region, an area of complex subsurface geology. The study area includes six hydrographic areas, roughly equivalent to surface watershed basins, with varying annual precipitation of about 8 inches in valleys and 20 inches at mountain tops. Active mining in the area requires about 1600 vertical feet of dewatering.

Questions posed at the start of the study included defining short and long term dewatering and mining impacts on surface and ground water, costs and allocation between mining companies for operation and mitigation and behavior and impacts of post-mining pit lakes. Mr. McDonald noted that attempting to answer all these questions in a single study was especially difficult since they were such diverse issues.

The conceptual model of the area included: precipitation (snow) in the mountains which then melts, filling stream channels. Surface water exited the area via the Humboldt River or entered higher permeability rock and sediment Losses to the atmosphere were high. Estimating recharge proved to be difficult, as was evapotranspiration. Both are crucial to modeling and understanding hydrologic processes. Several methods of estimating recharge were described including lumped basin coefficients, and a variation that included "excess" precipitation based on known streamfiows. Model results using MODFLOW and River2 identified several cases where surface water boundaries were not ground water boundaries.

In summary, Mr. McDonald noted the importance of good precipitation and surface water records. He also noted that evapotranspiration, although so important to hydrologic understanding, is difficult to measure.

— Contributed by Jan Falteisek

Annual MDH Well Conference

The Minnesota Department of Health (MDH) Well Conference is scheduled for March 24, 1999, at the Thunderbird Hotel in Bloomington, Minnesota. Proposed topics for the conference include:

- Information Sources, Equipment, and Strategies for Locating Abandoned Wells
- Hydrofracturing
- Well Maintenance and Rehabilitation
- The Minnesota Arsenic Study (MARS) in West-Central Minnesota
- Steam Injection Remediation at the Milwaukee Railroad Depot, Minneapolis, Minnesota
- Aquifer Testing for Wellhead Protection
- Proposed Revisions of the Explorer and Exploratory Boring Rules

The registration fee is $50 or $60 at the door. Contractors who attend the conference can earn all six continuing education credits necessary for their annual license/registration renewal. If you have any questions about the conference, please call Michael Convery at (651)215-0818.

Join the Minnesota Ground Water Association!

If you are reading this newsletter second-hand, we'd like to take this opportunity to invite you to become a member of **MGWA** for 1999. Annual dues are $20 for professional members and $15 for students. Members are entitled to purchase the annual membership directory for $7. Additional donations toward our scholarships and/or the use of recycled paper will be gratefully accepted.

*Dues paid to MGWA are **not** deductible as charitable contributions for federal income tax purposes. However, dues payments are deductible as ordinary and necessary business expenses to the extent allowed by law.*

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1999 Minnesota Karst Workshop

The Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Natural Resources (DNR) will present a 4 day workshop on the landscape, geology and hydrology of karst and on conducting appropriate environmental investigations in this terrain.

The workshop will be taught principally by Dr. E. Calvin Alexander, Jr. of the University of Minnesota, Jeff Green of the Minnesota DNR, and Dr. Nick Crawford of Western Kentucky University. The workshop will include a substantial field component to complement the classroom lectures. The workshop is scheduled for May 10-13, 1999 and will be held at the Rochester Community and Technical College, Rochester, Minnesota.

This workshop is designed to complement the release of the MPCA guidance document "*Guidelines for Investigation of Ground Water Contamination at Petroleum Release Sites in Karst Areas*" in its final and mandatory form.

A draft version of this guidance (MPCA Fact Sheet # 3.42) was released in April 1996 for field testing. Experiences and feedback from the 1996, 1997, and 1998 field seasons were included in the revisions that produced the final document. Copies of the revised, final document will be available by April 1,1999 and will be mailed to environmental consultants and other relevant parties. Copies can also be obtained after April 1,1999 from the MPCA by calling Lisa Heesch at (651)297-8578, or by emailing to: Lisa.Heesch@pca.state.mn.us.

Workshop information as well as registration details are being mailed to potential interested persons, and are also available by calling Melanie Miland of the MPCA at (507)285-7151, or by emailing to: Melanie.Miland@pca.state.mn.us.

Support Your Association — Invite A Colleague to Join

New from MPCA

The next in a series of chemical fact sheets, *Arsenic in Minnesota's Ground Water*, is now available. Copies may be obtained by contacting the Ground Water Monitoring and Assessment Program (GWMAP) from the Minnesota Pollution Control Agency (MPCA) staff in the Environmental Monitoring and Analysis Section or Tom Clark in the Environmental Research and Reporting Section of the Environmental Outcomes Division. As with previous chemical fact sheets, information on distribution of the chemical in ground water was based on data generated from sampling of over 900 wells in GWMAP's statewide baseline network. Peer input was also received from active research programs to determine occurrence and distribution of arsenic in Minnesota ground water currently being conducted by the Minnesota Department of Health and the Minnesota Geological Survey. A chemical fact sheet on occurrence of volatile organic compounds (VOCS) in Minnesota ground water is currently in preparation, and should be available by the end of March.

Newsletter Advertising Policy for 1999

Display ads:

		Quarterly Newsletter	**1999 Membership Directory**
Size	inches H x V	Annual Rate 4 issues	Annual Rate 1 issue
Business Card	3.5 x 2.3	$60	$45
Quarter Page	3.5 x 4.8	$110	$90
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Full Page	7.5 x 9.75	$385	$325
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A one-time e-mailing to the membership costs $10 for an individual (e.g. seeking a job), and $50 for an organization (e.g., announcing a job opening). The advantage of e-mail is the speed of dissemination.

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Paleozoic Hydrogeology of Southeastern Minnesota: Meeting Summary

— Robert Tipping, Minnesota Geological Survey

On December 3, 1998, 30 representatives from the Department of Health (MDH), Division of Waters (DNR Waters), Pollution Control Agency (MPCA), private consulting firms, county governments, and the University of Minnesota [Dept. of Geology and Geophysics and Minnesota Geological Survey (MGS)], met at MPCA to review the classification and characterization of Paleozoic hydrogeologic units, with an emphasis on field data, in southeastern Minnesota. The desired outcome of the meeting was not to reach a consensus, but rather to identify areas of shared concern and interest, and to discuss the ways and means to answer questions raised during the meeting. Jackie Lind, Manager of Employee Development at the DNR, facilitated the discussion.

The meeting began with a general overview by Tony Runkel (MGS) of the current hydrogeologic frarnework for southeastern Minnesota. Tony pointed out what he believes are shortcomings of the current conceptual hydrogeologic column:

1) The column is based on lithostratigraphic boundaries that do not correspond to the water- bearing characteristics of the rocks;

2) hydrologic evidence for the current model is primarily based on static water levels, which provide an incomplete and possibly misleading picture of ground-water flow.

As an example, Tony compared hydrogeologic data, including static water levels, from the Franconia Fm. and Ironton-Galesville Ss. at the Aquifer Thermal Energy Storage (ATES) site in St. Paul with data on static water level from the same rocks near the St. Croix River. The presence of similar head levels at the ATES site in both the Franconia and the Ironton-Galesville has been used as justification for lumping these units into a single aquifer, even though interval packer testing at the same site shows markedly lower conductivity values for the lower Franconia than for the upper Franconia and Ironton- Galesville. In contrast, the site near the St. Croix shows head differences of 50 ft above and below the lower Franconia where the Ironton-Galesville is de-watered because of discharge into the river. The de-watering of the Ironton-Galesville creates a large vertical gradient that is not present at the ATES site. This example was used to demonstrate that water levels alone are insufficient to identify low-conductivity units that behave as confining units under stressed conditions. Tony said that all hydrogeologic evidence must be considered to create an accurate depiction of ground-water conditions.

In the next presentation, Roman Kanivetsky (MGS) argued that the ground-water flow system as represented by potentiometric surfaces is the foundation for the development of a hydrogeologic framework. A mapped aquifer is defined by the regional potentiometric surface of a heterogeneous system. For example, regional similarities in head levels among wells finished in the Prairie du Chien Gp. and Jordan Ss. depict the hydrologic system as a whole, even though these rock units have very different porosity and permeability. Despite large withdrawals from the Prairie du Chien and Jordan in the Twin Cities area since the beginning of urban development, no large cone of depression exists. This is in contrast to the Mt. Simon, in which the cone of depression reached 200 ft in the 1980s. Roman stated that these differences imply substantial leakage to the Prairie du Chien-Jordan from upper aquifer units and surface water, whereas leakage to the Mt. Simon is slow.

Ray Woulo (Barr Engineering) gave his perspective on the treatment of the Prairie du Chien from the standpoint of ground-water modeling. He presented the results from aquifer tests at the Shiely Shakopee Quarry, the Freeway Landfill in Burnsville, and the Ashland Refinery in St. Paul Park. Ray said that the best fit for the test data from these sites was obtained by treating the Jordan as a leaky confined system, in contrast to the current conceptual model that treats the Prairie du Chien and Jordan as a single aquifer unit having uniform hydraulic conductivity.

In the final presentation, Sandeep Burman (MPCA, Rochester) outlined the approach used by the MPCA for site-scale investigations, including assessing the "value" of the aquifer, evaluating pathways to a receptor, defining impact, and engineering alternatives. All tasks, he pointed out, rely heavily on the current hydrogeologic framework and conceptual model of ground-water flow. The current hydrogeologic framework does not always address the reality of contamination at the local scale.

The meeting was opened for general discussion. Participants were asked to contribute what they felt to be the major concerns in regard to the current Paleozoic hydrogeologic column and what kind of data is needed to resolve those concerns. It was pointed out that aquifer units should be defined in a manner accepted by most hydrogeologists, using sound geologic and hydrologic principles. The criteria should be both explicit and consistent. Issues that need to be resolved include the following: How should aquifer units be grouped and mapped? How should the results be conveyed for use in the hydrogeologic community? Do potentiometric surfaces alone identify confining units and aquifers?

Other issues raised were related to the scale of investigation. For example, data gathered at large scales or intermediate (region or county) are being applied to small-scale, site-specific problems. Should aquifers be defined from large-scale features downward, adding detail as necessary, or from the small-scale features upward, generalizing only where there is enough hydrogeologic information to do so? Has the regional model been forced into local settings, thereby obscuring confining characteristics of certain bedrock units?

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Hydrogeology of SE Minnesota, cont.

Some general comments and observations were offered concerning the definition of aquifers. With regard to potentiometric surfaces, it was pointed out that head distribution is an outcome of permeability and stress distribution, and that the stress condition is commonly overlooked when interpreting head values. In contrast, hydrostatic pressure was described by another participant as the signature of an aquifer unit; if it is the same between rock units, then those units constitute a single aquifer. Aquifers were also defined as a function of scale and need; the definition of an aquifer in one area may not be an aquifer in another. Finally, is there a full understanding of the geologic framework? If not, how can our understanding of hydrologic-flow regimes be improved. Can both be improved simultaneously?

A number of suggestions were offered on the topic of data needs and solutions. Pump test design and analysis can be improved; the tests need to be modified to characterize aquitards as well as aquifers. More data loggers and observation points are needed; where practical, wells can be installed next to pump sites. Also, analysis software offering several possible solutions to pump-test data can be used, including confined, unconfined, and leaky conditions. Characterizing flow within the borehole was also listed as a priority. Specific tools include high-resolution flow measurements, such as heat pulse and EM flow meters and hydrophysical logs; gamma logs; caliper logs, and temperature and resistivity measurements. Other data needs include lab tests on permeability; pumping tests at different scales; mapping of potentiometric surfaces; determination of groundwater age using Carbon-14, CFC, and tritium; thermal data to identify temperature anomalies; environmental tracers; and more rigorous calculation of the hydrologic budget.

There was agreement that creating a new hydrogeologic framework requires a multi-faceted approach. Ideally, all data, including estimated heads, ground-water age, pump tests, borehole tests, and tracer results, should conform to one another. It was pointed out that a ground-water model, conceptual or computational, is a effective method of comparing these different types of data, and, in turn, testing the assumptions on which the model is based.

It was agreed that state agencies and the University could better coordinate efforts to acquire good hydrogeologic data. A common ground is needed to build on existing data or to request funds for additional work. For example, it was pointed out that our understanding of the geologic framework away from the major river courses is limited, and that state agencies could collectively push for a dedicated program to drill "n" holes at "n" locations, to be accompanied by a full hydrogeologic analysis of the boreholes. The ATES site was offered as a model of the type of analysis needed to provide useful and reliable data. Coordination among state agencies would increase the chance to find "holes of opportunity", e.g., pumps pulled, wells abandoned, new wells drilled, that by their nature offer a limited time for acquiring useful data. Coordination with neighboring states is also needed to decide if the current nomenclature has merit, or if changes are necessary

At the close of the meeting, the participants were asked to vote by a show of hands on several statements of intent. There was consensus on the following:

1) The current geologic column is adequate and useful for certain purposes, e.g., standard bedrock geologic maps;

2) the hydrogeologic column needs revision on a regional scale, e.g., add "system" terms;

3) the hydrogeologic column must be useful at smaller scales, e.g., county level of 1:100,000;

4) the form of the hydrogeologic framework should move from a column to a cross section (2-D) to a block diagram (3-D) (most agreed); and

5) common ground must be found among agencies to pursue funding for future research.

Since the December meeting, a small group of geologists and hydrologists was formed to address the need for revision of the current hydrogeologic column. The following persons will contribute their time toward preparing a publication that presents a new hydrogeologic framework for Paleozoic rocks in southeastern Minnesota:

Calvin Alexander, Dept. of Geol. & Geophys., U. of M., Mpls., 612-624-35l7; alexa001@tc.umn.edu

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Geoff Delin, USGS, 612-783-3231, delin@usgs.gov

Jeff Green, MnDNR, 507-285-7429, jeff.green@dnr.state.mn.us

Roman Kanivetsky, MGS, 612-627-4780, ext. 209; kaniv001@tc.umn.edu

Jim Lundy, MPCA, 651-296-7822, jim.lundy@pca.state.mn.us

John Mossler, MGS, 612-6274780, ext. 218; mossl001@tc.umn.edu

Tony Runkel, MGS, 612-6274780, ext. 222; runke001@tc.umn.edu

Bob Tipping, MGS, 612-6274780, ext. 226; tippi001@tc.umn.edu

Please contact members of this group and make suggestions that might be incorporated into the proposed publication. The new hydrogeologic column for southeastern Minnesota should serve the needs of those working in the area.

New GWMAP Report

The Ground Water Monitoring and Assessment Program (GWMAP) has just released a report titled *Water Quality in the Upper Fifteen Feet of a Shallow Sand Aquifer in a Variable Land Use Setting.* The results from 46 surface and ground water sampling points suggest that ground water is strongly affected by land use. The report is available on the MPCA web page at www.pca.state.mn.us/water/groundwater/gwmap/gwpubs.html. For information call Jennifer Maloney at (651)296-8544.

Capillary Fringe

Ethics Ain't So Easy

The following is a December 20, 1998 posting to Ground Water Digest, a list-server managed by Ken Bannister of Bannister Research and Consulting.

I have been watching the discussion on ethics with some interest As a tribal employee, my job has elements of advocacy and other elements of scientific "neutrality", which can sometimes be confusing indeed. However, I take as an article of faith that the traditional knowledge of indigenous people, acquainted since "time immemorial" with a specific patch of the earth is of fundamental, primary importance. I see nail polish, jet skis, golf courses, gold jewelry and a thousand other practices as frivolous practices by comparison. My ethics are compatible with challenging the sacrifice of traditional indigenous practice on such altars. They lead me to distrust someone who serves such sacrifices for the purposes of financial remuneration.

I do not make as much money as perhaps I could, given my education and abilities. However, I am satisfied that my life is enriched in ways not measured in dollars for my choices.

Members of this list have criticized me (mostly in private messages) for displaying advocacy, as directed by my employer, the Tribal Council, in matters relating to mines posing threats to the tribe's culture and tradition. At the same time, I work hard to get the facts and concepts 'right', for common sense reasons. For one thing, if you don't define a problem well, your chances of implementing an effective solution are diminished. For another, if you get your facts all garbled up, you will be discredited, and your efforts will bear little fruit. This, in fact, has been perhaps my most powerful tool in fighting off mining operations unwelcome by the tribe. This is because mining companies, through the pens of their paid consultants, have a tendency to make preposterous, inconsistent, easily debunked claims. For example, the copper mine wrote that it only consumed some modest amount of acid per ton of ore to be processed. However, if you do the algebra problem working backwords from the amount of ore they are promising to deliver (for potential investors), you come up with a disquieting figure of 200 tons of sulfuric acid required to keep the mine operating. The acid would arrive by truck; no method for its removal was proposed. Local residents, familiar with sometimes-treacherous mountain roads, get an entirely different picture of what such an operation might mean; a picture entirely separate from differences of opinion regarding the life-expectancy of a heap leach liner. In consultant-prepared documents I have reviewed, I have found many whose objective appears to be solely to explain away potential problems so profit-taking can move forward.

To get an idea of how far wrong things can go, one need only consider the example of the Summitville Mine, a notorious case of acid mine drainage a bit upstream on the Rio Grande from where I live. Predictions of how much remediation would be needed meant an initial reclamation bond of roughly a million dollars. As problems started to appear, this was increased to $2.2 million. When the company was asked to increase that bond to $7 million, they opted to file bankruptcy instead. (In Canada, outside the jurisdiction of American courts.) Several years ago, clean-up costs topped $120 million, with no end in sight. There were mine company technical consultants involved in making the case for bonds which are obvious in retrospect as being woefully inadequate. They may have been sincere in that work, but I end up wondering how they ended up missing so many problems which seem quite evident today. I submit that various pressures, primarily financial (including peer pressure regarding status), play a subliminal role in the process. Honest, ethical behavior is often not the path of least resistance.

Ultimately, society (at least in the United States, I am less familiar with other countries) is organized such that technical people are advisors, advocates or apologists. Increasingly, this extends to academic scientists as well engineers and other consultants. It is probably unavoidable that "he that pays the piper calls the tune". Everyone's understanding of reality is unavoidably biased towards perceived necessities of their own daily survival. Our professional training, depending which path it has followed, contains all sorts of unstated assumptions. These are designed for the benefit and protection of the profession, and this is not always in complete accord with the benefit of other sectors of society.

I became interested in the O.J. Simpson trial because the paradigms of "truth" in the laboratory are so profoundly different than those of the courtroom. I did some graduate work in fish physiology which required familiarity with the fundamentals of DNA, as DNA concepts were part of the array of data and techniques employed. And so, I was curious (and appalled) to see attorneys slashing and burning some of my most cherished values regarding what determines what is and isn't so.

I think most of us, if we're honest, have to recognize that we encounter scores of small decisions of an ethical nature as we go about our work. So simple a question whether to employ the verbs "may", "will" or "does" with regard to some impact can boil down to an ethical question. When does "some" become "many" become "most"? After all, people making policy decisions seldom (rarely?) analyze the data, relying instead on Executive Summaries where words like those just considered play a key role.

Agencies (i.e. their employees), which are funded by political processes, can't help but be influenced by non-technical policy considerations. Following directives of one's superiors, directors and supervisors is necessary to remain employed; sometimes the pension, health coverage, etc. - even the paycheck - can be deemed more important than some minor point of honor. Sorting out these dilemmas is not always easy. So, for one example,

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Capillary Fringe, *Ethics Ain't so Easy*, cont.

our nation's public health care policies can affect professional ethics in subtle, pernicious ways.

In grad school, I had the opportunity to study "Data Analysis" with a tough, sharp professor. You dreaded having him in the audience when you were speaking, because he'd sit there with a sophisticated calculator and pose rigorous challenges to statistical methods. I've even seen him question calculations. In class, we reviewed an array of scientific literature, identifying serious flaws in widely regarded, frequently cited papers, and being exposed to sound, elegant work executed with modest budget. In my opinion, scientific and technical fields would benefit from more such training.

I am obliged, from time to time, to review EIS's, permit applications and the like as part of my job. I am grateful to that professor, who taught me that people too often do sloppy, hack work rather than perform thorough and rigorous exercises and projects (another of the pressures imposed by the almighty dollar). Reading these documents, I usually get upset at the ethical compromises I see in what has been written, and which regulators approve.

I believe our times suffer from a surfeit of pious, self-righteous hypocrites. Both those of us challenging and defending our colleagues with regard to ethics would benefit from a few deep breaths. "Truth" is as slippery a fish as any of us will every lay our hands on. It is difficult to have the wisdom to know when to speak and when to be silent. None of us will ever know but a tiny, insignificant proportion of all there is to know. With humility and thoughtfulness, I believe all of us have much to strive for in what we write and what we say. Too often, we don't think deeply about the consequences of our actions. Perhaps, we should do so more often.

— posted by Elizabeth Winter, Taos, New Mexico, ewinter@newmex.com

USGS Digital Orthoimagery for Minnesota Completed

The U.S. Geological Survey (USGS) recently completed statewide coverage of USGS Digital Orthophoto Quandrangles (DOQs) in Minnesota. The USGS, Minnesota Planning's Land Management Information Center, and the Legislative Commission on Minnesota Resources supported an 8-year effort to complete the "Base Maps for the 1990's" program in the State. The completion of DOQs highlights the culmination of another part of the Base Maps Program, which included the production of traditional paper maps, aerial photos, and computer-readable data sets for Geographic Information System applications.

The DOQ is a digital image of an aerial photograph in which displacements caused by the camera and terrain have been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. DOQs can be viewed on a computer and users can zoom in on areas of interest and print a copy. Users of DOQs also can evaluate their data for accuracy and completeness, make real-time modifications to their data, and even generate new files.

"These images give Minnesota an edge shared by few other states," said Ann Schluter, director of Minnesota Planning. "Our local governments, state agencies, nonprofit groups and many businesses can do their jobs better with this important resource."

The USGS's National Mapping Division coordinated the production of nearly 7,000 DOQ images by using a combination of Federal funds from the USGS and U.S. Department of Agriculture, matched by Minnesota State funding. "This joint venture to produce DOQ coverage for the entire State of Minnesota illustrates how cooperative efforts between the USGS and other partners have major benefits or all levels of the government and for the general public as well," said Max Ethridge, USGS, Chief, Mid-Continent Mapping Center. USGS's Mid-Continent Mapping Center, Rolla, Missouri, coordinated the planning, production, and management of the DOQ program for Minnesota.

Additional information about Minnesota's Base Maps for the 1990's program and DOQ information is available at the Land Management Information Center's website at http://www.lmic.state.mn.us/.

Other USGS Program News

As the nation's largest water, earth and biological science and civilian mapping agency, the USGS works in cooperation with more than 2000 organizations across the country to provide reliable, impartial, scientific information to resource managers, planners, and other customers. This information is gathered in every state by USGS scientists to minimize the loss of life and property from natural disasters, contribute to the sound conservation, economic and physical development of the nation's natural resources, and enhance the quality of life by monitoring water, biological, energy, and mineral resources.

This press release and in-depth information about USGS programs may be found on the USGS home page: http://www.usgs.gov.

Subscription to USGS listservers

To receive the latest USGS news releases automatically by email, send a request to: listproc@listserver.usgs.gov. Specify the listserver(s) of interest from the following names: water-pr; geologic-hazards-pr; biological-pr; mapping-pr; products-pr; lecture-pr. In the body of the message write:

subscribe (name of listserver) (your name)

Example: subscribe water-pr joe smith

— from a USGS press release.

Announcement and Call For Abstracts
44th Annual Midwest Ground Water Conference
October 13-15, 1999
Ramada Inn, St. Paul, Minnesota

Host Agency -- Minnesota Department of Natural Resources

The Midwest Ground Water Conference

The Midwest Ground Water Conference is an informal annual meeting held at the invitation of a participating state. The conference provides an opportunity for hydrologists, geologists, engineers, students, and others studying ground water resources in their respective states to meet and exchange ideas, discuss mutual problems affecting the midwest, and summarize results of field and laboratory studies.

Suggested Session Topics

- Ground water and surface water interaction
- Aquifer characterization and aquifer studies
- Wellhead and source water protection
- Aquifer remediation
- Water law
- Water use, water quality, and ground water resource management
- Public information and education
- Karst and karst policy
- Water monitoring networks

Abstract Submissions

Oral presentations are limited to 20 minutes including discussion. Equipment available includes a single screen and slide and overhead projectors. The conference is not able to accommodate computer projections. A separate poster session will be held. Poster presentations are encouraged. Please state preference for oral or poster presentation.

Abstracts of papers to be presented at the Conference **should be received by June 25, 1999**. Abstracts are limited to 300 words, and should include title, author name(s), their affiliation, contact address, phone number, and e-mail address if available. Abstracts will be bound and distributed as conference proceedings. Submit abstracts on PC diskette (WORD 7 or less, or ASCII text) or electronically via e-mail to:

James Lundy, MGWC Technical Subcommittee
Minnesota Pollution Control Agency--Policy and Planning Division
520 Lafayette Road
St. Paul, MN 55155-4194
e-mail: jim.lundy@pca.state.mn.us
MPCA toll-free 1-800-657-3864

For additional conference information contact Sarah Tufford, Minnesota Department of Natural Resources, (651)297-2431 or e-mail: sarah.tufford@dnr.state.mn.us.

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USGS Report Signals Trend: More People Using Less Water

Newly released statistics on water use by the U.S. Geological Survey (USGS) show that the nation is using less water — 402 billion gallons per day (bgd) for all uses, which is 2 percent less than in 1990 and nearly 10 percent less than in 1980, despite a continuous increase in population over that same time period.

Freshwater per-capita use also decreased for 1995. Total per-capita use was 1,280 gallons per day (gal/d), compared to 1,340 gal/d in 1990. The USGS has compiled and reported national water-use statistics once every 5 years since 1950.

Freshwater per-capita use also decreased slightly in Minnesota. In 1995, per-capita use was 736 gal/d, down 1.3 percent from the 746 gal/d used in 1990. Per-capita freshwater use in Minnesota in 1995 was nearly half—53.5 percent—the national average of 1,280 gal/d.

After continual increases in the nation's total use of surface and ground water for the years reported from 1950 to 1980, water use declined and has remained fairly constant since the mid-1980s, according to the USGS report.

"If you were to ask people if the nation was using more or less water now than say 15 or 20 years ago, the vast majority probably would say that we are using more water now," said Robert Hirsch, USGS chief hydrologist. "The overall decline in water use is an encouraging signal."

"The nation is clearly using surface- and ground-water resources more efficiently," Hirsch said. "Enhanced citizen awareness of the value of water and conservation programs in many communities across the country have helped to cut water use in spite of continued population growth. Improved irrigation techniques and more efficient use of water by industry have contributed to reduced water use as well."

Long-term concerns remain about the quality of available water, however.

"With increased demands for water for instream uses such as river-based recreation, esthetic enjoyment and fish and wildlife habitat, the overall competition for good quality water will continue to increase," Hirsch said.

Irrigation is the top freshwater use category— 134 bgd in 1995. When fresh and saline water are combined, more water continues to be withdrawn for thermoelectric power generation (190 bgd, of which 58 bgd is saline) than for any other category.

In a state-by-state comparison, California accounts for the largest total water use (46 bgd), followed by Texas, Illinois and Florida. Two dozen states and Puerto Rico had less water withdrawn during 1995 than during 1990. The USGS water-use report, searchable by county and watershed, along with an expanded section on trends, is available on the World Wide Web at: http://water.usgs.gov/public/watuse/

Single copies of the 71-page report (with numerous tables, charts, and diagrams of source, use, and disposition of water), published as Estimated Use of Water in the United States in 1995, (USGS Circular 1200) are available free upon request to USGS Information Services, Box 25286, Denver Federal Center, Denver, CO, 80225; or telefax requests to: 303-202-4693. Please be sure to specify USGS Circular 1200.

MGWA Board Meeting

Minutes

December 4, 1998

Location and Time — Egg & I, University and 280, St. Paul, MN, 7:30 a.m.

Attending — Paula Berger, President; Ray Wuolo, Past-President; Jan Falteisek, Secretary; Paul Bulger, Treasurer; Tom Clark, Newsletter Coordinator; Charles Tiller, guest.

Approval of Minutes — Paula Berger called the meeting to order at 7:40 a.m. Minutes for the regular Board meeting held November 5, 1998 were approved.

Fall Field Trip and Fall Conference Follow-up — Paul noted that the Fall Field Trip posted a deficit of $150, but that the Fall Conference shows an approximate net income of $1000.

Bylaws — Paula noted that petitions were assembled. The Secretary is to tabulate them and coordinate with WRI on ballot preparation.

1999 Officer Elections — At this time, Charles Tiller and Lee Trotta are on the ballot for Treasurer. Potential candidates were identified but none had confirmed. Paula and Ray are to check with potential candidates and confirm.

Newsletter/Directory — Tom and Jan provided an update of the December newsletter preparation. The Newsletter team will meet on December 15th. An advertising update was not available.

1999 Scholarships — Paula said she will be sending out the letters announcing the scholarships.

Children's Water Festival — Paula showed the certificate presented to MGWA for sponsoring the Children's Water Festival. Tom Clark showed the t-shirt received for participation.

Karst Training Workshop — Jan noted the request she had received from the MPCA asking the MGWA to be a sponsor for a proposed 5-day karst training workshop planned for May, 1999. She will provide addi-

January 7, 1999

Location and Time — Egg & I, University and 280, St. Paul, MN, 7:30 a.m.

Attending — Paula Berger, Past-President; Jim Piegat, President; Jan Falteisek, Secretary; Jeanette Leete, Sean Hunt, WRI; Tom Clark, Newsletter Editor; Leigh Harrod, Advertising Coordinator; Charles Tiller, guest. Prior to the meeting Jennie distributed 1998 financial summaries (attached) and the proposed 1999 WRI contract.

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MGWA Board Meeting Minutes, Cont.

Approval of Minutes – Jim Piegat called the meeting to order at 8:05 am. Minutes for the regular Board meeting held December 4, 1998 were approved as corrected.

Financial Summary – 1998 financial summaries were reviewed, noting that for the year MGWA had a net profit of approximately $1000. Tom Clark asked that WRI provide financial summary pie charts for the March newsletter. Jim Piegat asked about the status of the MGWA CD's; Paul Bulger is to provide an update of CD status.

Membership – Jennie noted attrition of members, in particular loss of members working for consulting companies. Several solutions were suggested, including: 1. Identifying a contact in consulting companies to act as a recruiter, 2. Use the licensed geoscientist list and sent out a mass mailing, 3. Recruiting students. Jim Piegat proposed the issue be continued to next month. Leigh Harrod is to call about using the geoscientist list. Paula said she would update and refine the University/College contact list.

1999 Officer Elections – Jennie noted that ballots are coming in. She suggested a list of write-ins be kept. Jan asked the write-in list be compiled for next month's meeting.

By-Laws – Assuming the revised by-laws are approved, they will be published in the March newsletter.

Midwest Ground Water Conference – Jan provided an update on plans for the conference Oct. 13-15, 1999. Jim Piegat proposed field trips both before and after to showcase Minnesota. Coordination will be needed with AIPG and conference organizers.

Birdsall-Driess Lecture – Jan to contact Olaf Pfannkuch about MGWA sponsorship of refreshments.

Karst Training Workshop – MPCA, the workshop organizer, has asked for EPA funding; they are waiting to hear if the request is approved. MGWA has been asked to help sponsor.

Spring Conference – Jennie was asked to check available dates of the 3M Hall at the Minnesota History Center. A number of topics were suggested.

Budget – Jim Piegat asked if MGWA used an annual budget. Jennie explained that each activity (i.e., conferences) is budgeted separately.

WRI Contract – The proposed 1999 WRI contract was approved.

AIPG Coordination – Jennie noted she was contacted by AIPG about using the MGWA email notice list to announce their monthly meetings. This was deferred for further discussion.

Next meeting – The next Board meeting will be Thursday February 4th, 1999, 7:30 a.m. at Egg & I.

Meeting adjourned 9:15 am.

GSA 1999 Annual Meeting Denver, Colorado

Abstracts Due: July 12, 1999
Preregistration Due: Sept. 17, 1999
Contact e-mail address:
meetings @geosociety.org

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New Leadership in Evolving Ground Water Policy

April 30, 1999

8:00 am - noon
breakfast and registration
7:15 am

Minnesota History Center
3M Auditorium, St. Paul

Member Pre-registration $55

For conference information contact:

Jim Piegat: (612)470-6075
E-mail: <mn_homebase@worldnet.att.net>

To register, FAX to WRI at: (651)426-5449

For FAXed registrations include VISA/MC number, expiration date, and signature. Purchase orders must also be signed.