Great Lakes Region Geological Conference

March 13 and 14, 2000

Kellogg Center, MSU, East Lansing, MI

Great Lakes Region Geological Conference

Oral Sessions

MONDAY 3/13/00		
Time	**Auditorium**	**Room 103 A/B**
7:00-8:30	CONTINENTAL BREAKFAST – Kellogg Center Lobby	
8:00-8:30	REGISTRATION	
8:30-8:45	**Hal Fitch** – Michigan State Geologist - Opening Remarks	
8:45-9:15	**Rogers** – Future Urban Development and the Geologic Environment in Southeastern Michigan	**Pennington** – A Global Seismograph for Volunteers and Teachers
9:15-9:45	**Kehew, Kozlowski** - Sequence of Late Wisconsinan Events in Kalamazoo & St. Joseph Counties, Michigan	**Cross** - The Mid-Jurassic Age "Red Beds" of the Michigan Basin
9:45-10:00	BREAK – Big Ten B	
10:00-10:30	**Sweat**, Kowalski, **Wilcox**, **Tansy** – Restoration of a Fen to Pre-Settlement Conditions at Seney National Wildlife Refuge	**Hill–Rowley, McClain, Malone** - Static Water Level Mapping in Michigan Townships: A Comparison of Measurements & Well Log Data
10:30-11:00	**Lukey, Scott** - Geology of the Tilden Mine, Marquette Iron Range, Michigan	**Baclawski** - The Mystery is in the History: Frank Leverett, Stannard Bergquist & the MSU Geology Library.
11:00-11:30	**Clarey** - Delineating Late Pleistocene Age Groundwater Using Gamma Ray Logs & Geochemical Data	
11:30-12:00	**Westjohn** - Fracture-controlled Flow of Ground Water and Contaminants in the Marshall Sandstone - a Twenty Year Perspective	
12:00-12:45	LUNCH – Big Ten C	
12:45-1:30	KEYNOTE SPEAKER – **Dr. William Shilts** – Illinois State Geologist - Big Ten C	
1:30-2:00	**Metzger, Rowan** - Development of a Niagaran Reef Storage Field, Washington Twp., Michigan	**Moskowitz** - History & Current Activity at South End of Copper Range in Western U.P.
2:00-2:30	**Grannemann** – Ground-Water Resources of the Great Lakes Region	**McNeary** - Atmospheric Depositional Flux of 7Be, 210Pb, and 210Po in the Detroit Metropolitan Area
2:30-3:00	**Ashley** – Topographic Modification through Subsurface Gypsum Solution & Removal in West Michigan	**Beltman**, Sheahan, Fesko - The Use of Fracture Trace Analysis to Optimize Environmental Well Locations
3:00-3:15	BREAK – Big Ten B	
3:15-3:45	**Howard** – Geochemical Forms of Pb in Urban Soils, Detroit, Michigan	**Murray** - Impact of Groundwater on Surface Water Quality in an Urban Watershed
3:45-4:15	**Pennington** - Surface and Borehole Seismic Methods of Fracture Detection	
4:15-4:45	**Kozlowski** - Three Dimensional Mapping of the East Leroy and Union City 7.5 Minute Quadrangles, Michigan	
4:45-5:00		
5:00-8:00	RECEPTION – Big Ten B	

Great Lakes Region Geological Conference

Oral Sessions

TUESDAY 3/14/00		
Time	**Auditorium**	**Room 103 A/B**
7:00-8:30	CONTINENTAL BREAKFAST – Kellogg Center Lobby	
8:30-9:00	**Fisher** – Ten Years of Wellhead Protection: Where Do We Go in the New Millennium	**Arbogast** - The Emerging Record of Coastal Dune Evolution Along the Southeastern Shore of Lake Michigan
9:00-9:30	**Turpening** - Seventeen Years of Borehole Seismology Around One Pinnacle Reef	**Kincare** - The Great Lakes Geologic Mapping Coalition in Michigan – Finding Partners
9:30-10:00	**Black, Kirst** – Use of GIS for Geologic Mapping of Northeastern Lower Michigan	**Stone** - The USGS Role and Opportunities in the Central Great Lakes Geological Mapping Coalition
10:00-10:15	BREAK – Kellogg Center Lobby	
10:15-10:45	**Sauck** – Geophysical Detection of Abandoned Water Supply and Monitor Wells	**Pavey** - Importance of the Central Great Lakes Geological Mapping Coalition for Surficial Geologic Mapping in Ohio
10:45-11:15	**Catacocinos** – Introduction to the Michigan Basin Geological Society Stratigraphic Nomenclature Project **Reynolds** – Stratigraphic Nomenclature Project - Michigan Basin Geologic Society - Michigan Stratigraphic Column & Lexicon Project	**Patterson** - Practical Uses of Glacial Maps, Examples from Minnesota
11:15-11:45	**Harrison** – The Devonian Interval of the Michigan Basin Geological Society Stratigraphic Nomenclature Project **Westjohn** – Mississippian to Quaternary: Suggested Changes in Nomenclature for Geologic Units in the Michigan Basin	**Stone** - The Morphosequence Concept and its Application in New Detailed Mapping Studies in the Cental Great Lakes Region
11:45-1:15	LUNCH ON YOUR OWN	
1:15-2:15	Stratigraphic Column Breakout	Mapping Coalition Breakout
2:15-2:45	**Tegland, Bygott** – S/N Ratio & Bandwith Considerations When Utilizing Sismic Data in Exploring for Subtle Traps-Examples from the Knox Play	**Werkema** - Vertical Distribution of Apparent Resistivity and Microbial Abundance at a Michigan LNAPL Contaminated Site
2:45-3:15	**Brett** – Breakthrough Drilling & Completion Performance - Case Studies	**Blaske** - Geochemistry & Mineralization of Michigan's Mississippi Valley Type Deposit, Bellevue, Michigan
3:15-3:30		
3:30-4:00		
4:00-4:30		
4:30-5:00		

Great Lakes Region Geological Conference

Poster Displays

All day Monday - Room Big Ten B

PRESENTER	ORGANIZATION	TOPIC
M. J. Sweat	U.S. Geological Survey	The Michigan Source Water Assessment Program - Surface Water Supplies
Denis Healy & John Luna	U.S. Geological Survey	A study of Pathogens in Michigan Ground Water
Cindi Richol	U.S. Geological Survey	GIS Applications in USGS Studies
Steven E. Wilson	DEQ-GSD	Earth Science Week In Michigan wilsonse@state.mi.us
Wayne Pennington	M.T.U.	A Global Seismograph for the Volunteers and Teachers
Jim Duszynski	DEQ/GSD	Southern Michigan Fault/Tectonic Map
Leonard Espinosa	Michigan Basin Geological Society	Michigan Basin Geological Society
Kevin Kincare	Geological Survey Division	Reassessment and Correlation of Lake Algonquin Shorelines in Michigan
Mark S. Wollensak	Michigan Basin Geological Society	Paleozoic Stratigraphic Nomenclature for Michigan (Chart 2000)
Dave Slayton	DEQ/DNR Geologist Outreach Committee	DEQ/DNR Geologist Outreach Committee
Sally Somsel	Inland Seas Education Association	Informational Display
Duane Hattem	SPL Environmental Labs	Informational Display

PRESENTER:
Daniel T. Rogers,[1]
Kent S. Murray,[2] and
Martin M. Kaufman[3]

DATE: Monday, March 13
TIME: 8:45-9:15
ROOM: Auditorium

PROGRAM TITLE:

Future Urban Development and the Geologic Environment in Southeastern Michigan

AFFILIATION:
[1] *Clayton Environmental, 22345 Roethel Drive, Novi, MI 48375, 248-344-1770 drogers@claytongrp.com,*
[2] *University of Michigan, Dearborn, 4901 Evergreen Road, Dearborn MI 48128, 313-593-5445,*
[3] *University of Michigan, Flint, 303 East Kearsley Street, Flint, MI 48502, 810-762-3441*

ABSTRACT:

By the year 2010, the projected population in southeast Michigan will increase by 500,000. In addition, urbanization of once rural areas will increase by 25%. This growth will result in continued and increased pressure on southeast Michigan's environment, which will require informed, scientifically supported and creative environmental land use planning techniques to minimize degradation of soil and water resources. Although these techniques will rely on infrastructural, demographic, historic, and economic information, they must also include an understanding of both the physical and chemical aspects of water quality, the relationship between surface water and groundwater quality, and the movement of pollutants in the soil.

Groundwater vulnerability maps are an important tool in forecasting the movements of pollutants in soil, enabling users to alter the potential occurrence of detrimental conditions, such as groundwater contamination, before serous impacts occur. A groundwater vulnerability map was developed for the Rouge River watershed, located in southeast Michigan, using s PC-based geographic information system and a solute transport model (for Figures 1 and 2 see page 45). The accuracy of the vulnerability map was determined by comparing the location and impact of over 400 sites of environmental contamination with the mapped distribution of each of the vulnerability units. Over 90% of the sites with groundwater contamination, derived from anthropogenic sources, were located on one of the three units with the highest vulnerability rating, while fewer than 1% of the sites with groundwater contamination were located on the three units with the lowest vulnerability rating.

The groundwater vulnerability map developed in the Rouge River watershed in southeast Michigan has provided a clear understanding of areas within the watershed that are sensitive to development. This provides decision-makers with an opportunity to direct future development toward areas of the watershed where the impact on groundwater, particularly potable sources of groundwater, can be minimized.

PRESENTER:
Wayne D. Pennington, Shannon Bair, and Seth Lemke

DATE: Monday, March 13
TIME: 8:45-9:15
ROOM: Room 103 A/B

PROGRAM TITLE:

A Global Seismograph for Volunteers and Teachers

AFFILIATION:
Department of Geological Engineering and Sciences, Michigan Technological University, Houghton, MI 49931, 1-906-487-3573, wayne@mtu.edu

ABSTRACT:

A number of programs exist in which a school may participate in the recording of earthquakes with professional—quality seismographs; the most successful of these is the MichSeis program (and its followers in other states) under the guidance of Dr. Larry Ruff at the University of Michigan. In order to participate in such programs, the school must commit to continual operation and maintenance of the instrument, including highly accurate timekeeping. With support from the SEG Foundation (the Society of Exploration Geophysicists), we have developed a different type of program, one that will allow schools (and volunteers who would like to work with local schools) to temporarily operate a seismograph that, although not quite professional quality, will nonetheless allow the recording of earthquakes from around the world, right in the classroom, with minimal training and effort on the part of the teacher or the volunteer.

Our intention is that volunteers (usually with a background in the earth sciences, such as any member of the audience of this talk) will locate a source of funding for the purchase of a seismograph (less than $3000), probably their employer or a local benefactor. This seismograph can be deployed by the volunteer in any school, usually for about two or three months at a time. The unit can be placed right in the classroom of a teacher interested in using the device and its seismograms in class 'experiments' or exercises; the only requirement is that it be placed in a location that would minimize possible damage to the seismometer, usually in a corner or along a wall away from the door. During the 2-3 month time period, there are usually at least a few earthquakes somewhere in the world that are large enough to be recorded very nicely. Once a week, the teacher, the volunteer, or a student will adjust the time of the computer clock to exactly match Universal Time, using a GPS unit provided as part of the seismograph. With a small amount of training, the volunteer will know how to interpret the seismograms and how to identify where the earthquake occurred (from lists available from research agencies and governments). Lessons and exercises (some of which are made available by the Incorporated Research Institutes in Seismology) typically involve identification of the different seismic phases such as the P wave, S wave, Surface waves, and a variety of core phases. Students locate earthquake prone areas on the globe, discover the great circle path to their town, and learn about global scale distances. They learn about collecting data, making inferences, and following multiple step procedures to obtain results that were far from obvious at the outset. They integrate global social studies, physics, and mathematics with the geosciences, although they rarely recognize that this is what is going on! We have conducted variations of this program with grades from 4 through 12, although middle school earth science classes and high school physics classes are perhaps best suited for the program.

The software we have created is user friendly, intuitive, and insightful. A screen display of one day's recording during development (with no earthquake) is shown here: (for Figures see page 46).

The screen is divided into three main boxes; the largest consists of a series of rectangles across the central area, showing the past 24 hours' activity, in four hour blocks. The current four hour block is shown in yellow, and the previous ones are all shown in gray. The most recent half hour of recording is shown in larger scale in the separate rectangle along the bottom of the screen, and continuously scrolls across the screen as new data is added. Both of these windows can have their display gain adjusted through the use of slider bars nearby. The small squarish box in the lower right is a 'stomp and yell' window, connected to a separate geophone (exploration type) designed to record higher frequencies; here is where one can see the results of stomping or jumping, which may not show up on the earthquake style seismogram because of the high frequency content. Data from the earthquake seismograph is written to disk, but the geophone data simply scrolls off the screen and is not saved. Smaller windows are used to display the date and current local and Universal Times.

Earthquake seismograms may be easily retrieved and saved in separate files for various exercises and to compare with seismograms recorded elsewhere, and available from various internet sites.

This system is not intended to be a part of a permanent installation, and is not quite professional quality. For those schools that would like to maintain a permanent seismograph, we recommend joining the MichSeis program, through the University of Michigan. But for those schools that would like to have a seismograph operating in a classroom for a few months, we hope that this meets their needs, and that a network of volunteers develops whom will assist the schools in these programs.

PRESENTER:
Alan E. Kehew,[1] and Andrew L. Kozlowski

DATE: Monday, March 13
TIME: 9:15-9:45
ROOM: Auditorium

PROGRAM TITLE:

Sequence of Late Wisconsinan Events in Kalamazoo and St. Joseph counties, Michigan

AFFILIATION:
Western Michigan University, Department of Geosciences, Kalamazoo, MI 49008-5150,
[1]alan.kehew@wmich.edu

ABSTRACT:

During the last retreat of glacial ice across southwestern Michigan, the Lake Michigan and Saginaw lobes of the Laurentide Ice Sheet interacted asynchronously. At its maximum extent, sometime after 20 ka BP, the Saginaw lobe occupied a much larger area than the area of its current surficial deposits. Irregular southwest trending trenches, interpreted as subglacial tunnel valleys, indicate the presence of Saginaw lobe ice. As the Saginaw lobe retreated, the Lake Michigan and the Huron Erie lobes overrode terrain formerly occupied by the Saginaw lobe.

In Kalamazoo and St. Joseph Counties, Saginaw lobe tunnel valleys were filled with stagnant ice at the time of the encroachment of the Lake Michigan lobe. The eastward extent of the Lake Michigan lobe was the position of the Tekonsha "moraine". Later, the ice stagnated at the position of the Kalamazoo moraine at the time of a major fan building period. Outwash fans with smooth profiles were deposited over and at right angles to Saginaw-lobe tunnel valleys, indicating that they were still ice-filled at the time. Lake Michigan lobe tunnel valleys formed perpendicular to the ice margin, in an east-west trending orientation.

After stagnation of the Lake Michigan lobe at the Kalamazoo moraine, the ice retreated to the west. Major incision of the Kalamazoo valley occurred after this retreat. The size and geomorphic characteristics of the valley suggest an outburst event, probably from the Saginaw lobe. The large trench-like valley form can be trace northeastward to the Charlotte moraine of the Saginaw lobe. Rapid incision of the valley is indicated by the location of tributary valleys. These short, steeply sloping valleys incise fan deposits associated with the Kalamazoo moraine. In addition they cross Saginaw lobe tunnel valleys at right angles. These cross cutting relationships can only be explained if the tunnel valleys were still ice-filled. This requires formation of the tributaries rapidly, before melting of the buried ice in the tunnel valleys took place. Only later, when the buried ice slowly melted away, did the southwest-trending trenches in the modern landscape develop.

The path of the meltwater discharges that cut the Kalamazoo valley is not yet established. It is likely that this water discharged into a lake (Glacial Lake Dowagiac) that formed along the western margin of the Kalamazoo moraine. Lake Dowagiac most likely drained around margin of the Lake Michigan lobe into a proglacial lake in the Lake Michigan basin.

PRESENTER:
Aureal Cross

DATE: Monday, March 13
TIME: 9:15-9:45
ROOM: Room 103 A/B

PROGRAM TITLE:

The Mid-Jurassic Age "Red Beds" of the Michigan Basin

AFFILIATION:
Department of Geological Sciences, Michigan State University, East Lansing, MI 48824

ABSTRACT:

A sequence of yellowish-tan to purplish-red stained sandstones and gypsum beds intercalated in soft, red and greenish-grey shales, long known as the "Michigan Red Beds", in the west-central Lower Peninsula of Michigan. is clearly identified by palynologlcal analysis as mid-Jurassic (Bajocian-BathOrliarl) in age.

Palynomorphs of late-Mesozoic age in the Michigan "Red Beds" were reported by Cross and Shatter in 1 964. More recent studies in Canada and western Europe have made more precise age determination and correlation possible. The presence of *Classo poll's* in profusion, and a diverse mix of podocarp, tsugoid, laricoid, araucarian and other gymnosperms. cycadecids, ginkgoaleans, the absence of angiosperms, and paucity of Anemia-type ferns, now indicate preCretaceous mid-Jurassic age. No Pennsylvanian pollen or spores are found except occasional recycled specimens.

The Michigan "Red Beds" are closely correlated with the Mistuskwia Beds based on the similarity of the pollen and spores extracted from the lower samples of two test cores out of seven drilled in the Moose River Basin of the James Bay Lowland, Ontario. The palynoflora is also similar to that of the Shaunavon and Gravelbourg Formations of western Saskatchewan and eastern Alberta, and to the Sawtooth and Rierdon Formations at northwestern Montana. Extensive study of the lithology, thickness, and extent of the "Red Beds", and relative effect on resources of adjacent water-bearing strata has recently been published by the U.S. Geological Survey.

The lower part of this stratigraphic sequence, which varies from 0-Born in thickness, was exposed in quarries of Ionia Sandstone near low-water level along the Grand River between Ionia and Lyons. Ionia County. It has been penetrated by numerous oM, gas and water wells. It generally overlies either the Pennsylvanian-age Grand River or Saginaw Formations unconformably, and is overlain unconforrnably by Pleistocene or Recent glacial deposits.

The "Red Beds" seem to have accumulated in a large inland playa with internal drainage on a broad, structurally controlled, intemittently reactivated, shallow depression. Absence of acritarchs/dinoflagellates in all but one of over a hundred samples analyzed indicate a nonmarine origin. However, a brief transgression of an epeiric sea through a restricted channel from the north or northwest, and development of a sabkha-like environment on a broad coastal plain of low-relief might also be considered.

PRESENTER:
M.J. Sweat, Kowalski, Wilcox and Tansy

DATE: Tuesday, March 13
TIME: 10:00-10:30
ROOM: Auditorium

PROGRAM TITLE:

Restoration of a Fen to Pre-Settlement Conditions at Seney National Wildlife Refuge

AFFILIATION:

U.S.G.S. 517-887-8903
U.S., Biological Resources Division
Fisheries & Wildlife Service

ABSTRACT:

PRESENTER:
Richard Hill-Rowley, Thomas McClain and Matthew Malone

DATE: Monday, March 13
TIME: 10:00-10:30
ROOM: Room 103 A/B

PROGRAM TITLE:

Static Water Level Mapping in Michigan: A Comparison of Measurements and Well Log Data.

AFFILIATION:
Center for Applied Environmental Research, University of Michigan-Flint, Flint, MI 48502, rhr@umich.edu

ABSTRACT:

Groundwater protection is facilitated by information appropriate to the geographic area under consideration and the sort of strategies it is called upon to support. Commercial and residential growth in Genesee, Livingston and Oakland counties and the Huron River Watershed have prompted the townships in these areas to be concerned about the vulnerability of groundwater resources which provide drinking water in much of this new development. A map of the static water level (SWL) is a critical component to evaluation of this vulnerability analysis. It allows the identification of groundwater flow direction and, when combined with surface topography, the derivation of a depth to water map which is often the most important source document for groundwater protection.

Static water level maps are produced by interpolating a surface from a set of measurements at point locations. The points are geographic representations of the well locations and the measurement is the level of water in the well subtracted from the surface elevation at that point. These elements are present in well log records found in the Michigan Statewide Groundwater Database (SGDB), however, SWL data can contain significant variability. Well logs will typically contain records of wells drilled in different years and seasons and by drillers with variable experience. In addition SWL's in drift aquifers do not remain stable over time. The quantity of precipitation, the amount of recharge and the withdrawal rate of adjacent wells influence them. Surface elevations are also critical to the actual SWL recorded and for many records in the SGDB these values have been estimated from 1:24,000 topographic maps. An alternative to utilizing SWL's found in well log records is to collect a new measurement for existing wells and use global positioning system technology to obtain locational and topographic information for the sites.

A study in Tyrone Township, Livingston County compared maps of the static water level prepared from SWL's obtained from wells recorded for the area in the SGDB with maps prepared from SWL data measured at a series of wells identified in the field. Mapping was conducted using the Krieging Option in the SURFER software. The data from the SGDB were mapped using subsets segmented by several temporal criteria, segmented by seasonal criteria and by well drilling contractor. Maps were also prepared using the complete SGDB data set and from several random sampling schemes using the SGDB data set. The field data were obtained from two randomly located wells within each section of the township and the map prepared from these data was considered the ground truth and used as the base from which to compare the SGDB based maps. The map which best approximated the ground truth map was prepared using a random sample of two wells per section obtained from the unsegmented well log database for Tyrone Township.

Using the sampling methodology developed in Tyrone Township at the scale of the Huron River Watershed did not provide an acceptable map. The map had the form that would be expected for a regional groundwater surface in glacial deposits, but close inspection of the contours in relation to the point SWL's showed that a significant number of locations violated basic hydrologic principles. Hydrologic anomalies were eliminated by manual interpretation to create a more accurate map and a limited accuracy test identified a good correspondence between measured and predicted static water levels.

Static water level mapping from well log records in the SGDB will always be problematical. At a township level, in glacial drift material a sample of two randomly located wells from each section supplemented by surface water level points provided the best map when compare to a map derived from field data. Expanding the sampling methodology to a larger area introduced unacceptable errors.

PRESENTER:
Helene M. Lukey and Glenn W. Scott

DATE: Monday, March 13
TIME: 10:30-11:00
ROOM: Auditorium

PROGRAM TITLE:

Geology of the Tilden Mine, Marquette Iron Range, Michigan

AFFILIATION:
Mine Engineering Department, Tilden Mining Company, P.O. Box 2000, Ishpeming, MI 49849, 906-475-3583,

ABSTRACT:

The Tilden Mine produces iron ore from the Negaunee Iron Formation, Menominee Group, and Marquette Range Supergroup in the Upper Peninsula of Michigan. As the base of the iron formation is not exposed at the Tilden Mine, the stratigraphic thickness is unknown. [The thickness exceeds 1000 feet and is probably underlain by and is gradational into undifferentiated clastics and iron formation of the Empire Mine.] The iron ore deposit at the Tilden Mine has been divided into geologic domains based in part on lithology but, more importantly on the metallurgical response based on bench tests and in the processing plant. The interaction of sedimentation and diagenesis within growth fault controlled basin, metamorphism and supergene oxidation has resulted in a complex suite of ore types, each with specific, if not entirely objective, blending characteristics and problems. Production since 1974 has been 126 million long tons of pellets from 355 million long tons of ore at a stripping ratio of 0.94. As of January 1,1999, the proven and probable long range (30 year) mine plan reserve was 628 million long tons of ore containing 233 million long tons of pellets at a stripping ratio of 0.77.

Chlorite schist defines the footwall of the Tilden ore body. The Martite and main pit Carbonate domains lie stratigraphically below the CDIII Footwall and Main Pit Hanging wall intrusives. This is metallurgically "good ore" and is typically characterized by high weight recovery (35-45+%), low phosphorous, low slime iron and good grinding media. The West Pit/CDIH Hematite domain in the west pit is stratigraphically between the CDII hanging wall and footwall. In contrast to the martite domain, this is metallurgically 'poor' ore with higher slime iron and phosphorous and poor grinding. Mineralogically and texturally, this domain differs from the martite domain in being dominantly platey hematite with thin (mm scale) chert laminae. The Magnetite domain is the stratigraphically equivalent to the West Pit/CDIII. Mineralogically, the ore consists primarily of magnetite-siderite-chert with variable hematite and silicates. This mineralogy, along with the thin laminations, appears to indicate a restricted basin and a reducing environment of deposition.

There are several igneous horizons at the Tilden Mine. The term 'intrusive' or 'dike' is used for diabasic to porphyritic to aphanitic bodies, which vary from (semi) conformable sill-like horizons, usually interpreted as synsedimentary sills but which may be flows, to obviously crosscutting bodies, interpreted as dikes that may be feeders. The sills and majority of the dikes appear to be of early Proterozoic age, related to the Clarksburg Volcanics and/or the Hemlock and Emperor Volcanics, but there are several dikes that are interpreted to be of Keweenawan age based on the magnetic signature.

PRESENTER:
Diane K. Baclawski [1]

DATE: Monday, March 13
TIME: 10:30-11:00
ROOM: Room 103 A/B

PROGRAM TITLE:

The Mystery is the History: Frank Leverett, Stannard Bergquist and the MSU Geology Library

AFFILIATION:
MSU Geology Library, Room 5 Natural Science Building, East Lansing, MI 48824-1115, 517-353-7988
[1]baclaws2@pilot.msu.edu

ABSTRACT:
The Geology Library at Michigan State University is at present the only library in the state devoted to geosciences and the study of the Michigan Basin through geologic time. Since its beginning as a small departmental reading room in the 1920's, the Geology Library has evolved to full branch library status with a collection in excess of 35,000 volumes and 16,000 maps. One of its priorities has been the development of materials for research and reference to serve the needs of the geoscience community in Michigan. Major recent acquisitions include atlases from the Seattle Collection, the T (Tornado Ted) Fujita papers, and a set of letters and papers given to Stannnard Berquist. This set of papers have helped solve the mystery of a set of anonymous hand-colored maps of the glacial surface features of eighteen quadrangles in central Michigan that bear the cryptic note "After Leverett's original".

PRESENTER:

Timothy L. Clarey, [1]
Susan M. Rosin,
Linda R. Bearss, and
Suzanne, Mau

DATE: Monday, March 13

TIME: 11:00-11:30

ROOM: Auditorium

PROGRAM TITLE:

Delineating Late Pleistocene-Age Groundwaters Using Gamma Ray Logs and Geochemical Data

AFFILIATION:

Assistant Professor, Geology Department/Delta College, Office D-125, University Center, MI 48710, 517-686-8736, [1]tlclarey@alpha.delta.edu

ABSTRACT:

Six water-monitoring wells were recently installed on the campus of Delta College to provide laboratory and research opportunities for community college students. The well field, located in southern Bay County, encountered a regional, sand aquifer that is confined by 40-50 feet of glaciolacustrine clay. The hydraulic conductivity for the sand aquifer has been estimated at 5.5x 10-4 ft/sec (0.017 cm/sec). Drilling depths in the wells varied between 65-90 feet, and screens were installed over the bottom 10 feet. William Montgomery using a natural gamma radiation tool, in cooperation with Western Michigan University logged all of the wells.

Students at Delta College have been collecting various data from the well field since 1997, including water depth, temperature, pH, electrical conductivity, alkalinity, total hardness, calcium hardness, and nitrate and chloride concentrations. Analysis of the geochemical data has consistently shown one well (Well #4) to be significantly different from the other wells in the field. These differences in water chemistry indicated that the water in Well #4 was being influenced by an unknown external factor.

Eliot Atekwana then performed stable isotope analysis on water samples from four of the wells, including Well #4, at Western Michigan University. The hydrogen and oxygen ratios in Well #4 were found to be more depleted compared to adjacent wells. The water from Well #4 has a delta 0-18 value of -14.9 per mil (with respect to SMOW) versus delta 0-18 values between -11.2 and -11.5 per mil for the other well waters. These data indicate a source difference for water in Well #4, likely originating during a cooler climate. Other researchers in Michigan and Ontario have identified similar Late Pleistocene-age (Ice Age) waters trapped beneath glaciolacustrine clays with delta 0-18 values approaching -17 per mil. We suggest that the geochemical differences found in Well #4 are the result of mixing of Late Pleistocene-age groundwaters with more modern, Holocene-age groundwaters, giving an isotopic signature that is between the two end-member values. Well #4 likely tapped into an isolated sand layer that has been partially sealed from modern groundwaters by the surrounding glaciolacustrine clay.

Gamma ray log analysis indicates the presence of two sand layers within the well field that are not uniform in extent or in thickness. The deeper sand layer appears to be thickest in Well #4, possibly serving as the source of Ice Age water. Both sand layers appear channeled and follow a northeast/southwest trend. Additional drilling may become necessary to better define the extent of the two sand layers.

This on-going study has provided unique research and learning opportunities for the undergraduate students at Delta College. We anticipate continuing to collect additional geochemical data and to examine these data for trends with respect to time.

PRESENTER:

DATE: Monday, March 13

TIME: 11:00 – 11:30

ROOM: Room 103 A/B

Concurrent Session Not Planned

PRESENTER:

Dave Westjohn, Richard Boice, and Mart Baltusis

DATE: Monday, March 13

TIME: 11:30-12:00

ROOM: Auditorium

PROGRAM TITLE:

Fracture-Controlled Flow of Ground Water and Contaminants in the Marshall Sandstone—A Twenty-Year Perspective

AFFILIATION:

U.S. Geological Survey, 6520 Mercantile Way/Suite 5, Lansing, MI 48911 517-887-8903 westjohn@usgs.gov,
U.S. Environmental Protection Agency, BOICERICHARD@epamail.epa.gov, and
Michigan Department of Environmental Quality, baltusim@state.mi.us

ABSTRACT:

The Marshall Sandstone is a prolific producer of groundwater in the southern part of Michigan, largely because of the presence of numerous bedding plane partings and large open fracture zones. Chlorinated solvents and other organic contaminants were first detected in ground water at and adjacent to the Verona Well Field (Battle Creek, Michigan) in 1981. Conversion of several production wells to extraction wells (blocking wells) combined with removal of impacted production wells from service prevented contamination from entering the City's water distribution system (action taken in 1984). This remediation measure substantially reduced the production capacity, and the U.S. Geological Survey (USGS) worked in cooperation with the City throughout the 1980's to model ground-water flow and look for alternative ways to increase production while maintaining a safe water supply. Subsequent studies by various consulting firms generated information that continued to improve understanding of contaminant transport at the well field.

A 1999 study at the well field was a cooperative effort by the USGS, the U.S. Environmental Protection Agency (USEPA), and the Michigan Department of Environmental Quality (MDEQ). The goals of this study were to: 1) determine the time of travel of contaminants in different aquifer units at the site, 2) assess the degree of hydraulic connection of vertical and horizontal fractures in Marshall Sandstones, and 3) determine the degree of hydraulic continuity of fractures in Marshall Sandstone units.

Dye-tracer tests show flow rates of contaminants are variable, but travel times can be as fast as 1,400 feet per day. Dye-tracer tests also indicate that fracture-controlled flow is the dominant process only in the lower Marshall Sandstone; flow in the upper Marshall Sandstone appears to be matrix controlled. Acoustic-televiewer logs, camera logs, and gamma-ray logs show that there is at least one horizontal fracture zone with extensive lateral continuity. This fracture zone is stratiform, and appears to be related to localization of potassium-rich mineral phases (authigenic adularia cements, and clay precipitation in open fractures). The presence of these potassium cements indicates the fracture zone was a paleoconduit in early mineral diagenesis. The acoustic televiewer and camera logs also show that vertical fractures are more common than previously thought.

PRESENTER:

DATE: Monday, March 13

TIME: 11:30 – 12:00

ROOM: Room 103 A/B

Concurrent Session Not Planned

PRESENTER:
Fredrick W. Metzger[1],and
Matthew C. Rowan

DATE: Monday, March 13
TIME: 1:30-2:00
ROOM: Auditorium

PROGRAM TITLE:

Washington 10 – Development of a Southeastern Michigan Gas Storage Field

AFFILIATION:
Michigan Consolidated Gas Co., Detroit, MI 48226, [1]fredric.metzger@michcon.com

ABSTRACT:
In 1992, Washington 10 Storage Corporation and Michigan Consolidated Gas Company, both affiliates of MCN Energy Group (soon to be DTE Energy), began planning for conversion of a Niagaran gas field to natural gas storage. The initial planning and design led to regulatory approval in 1994. Market conditions resulted in a delay in final design and construction until 1997. By that time rapid growth in Washington Township, Macomb County, 30 miles north of Detroit, caused the engineering team to re-evaluate the development plans.

The initial discovery well for Washington 10 was drilled in 1969 and production began later that year. By 1998 over 95% of the original 53 Bcf of gas had been produced from 23 wells scattered throughout the Village of Romeo and Washington Township. Initial storage plans included re-completing 17 original wells and drilling 13 new vertical wells. However, with the growth of the community and MichCon's positive experience with drilling nine horizontal wells in central Michigan, this plan was deemed impractical and too costly. As a result, the Reservoir Engineering Department recommended drilling directional wells from four surface locations. This plan would maintain the 41.7 Bcf of working volume and 800 MMcf per day peak withdrawal requirements, while reducing the number of wells, limiting the amount of pipeline and the amount of surface acreage.

Fourteen horizontal wells were drilled over a 7-½ month period. The use of two drilling rigs reduced the project time by 3-½ months. Detailed pre-drill planning and review of multiple drilling scenarios allowed the project team to make rapid informed decisions during the drilling operations. On-site drilling supervision resulted in immediate decision-making and saved considerable costs. The depleted state of the reservoir required that the reservoir section of each well be drilled with air and foam. Initial plans were to drill the reservoir section with a downhole motor; however, experience on the initial well caused the drilling team to change to a combination fluid and air-foam system. Fluid was utilized until the desired angle was achieved or the fluid loss exceeded a maximum range, a lock assembly was then employed and an air and foam system was used to total depth. This method proved very successful, and all remaining wells were completed using this technique. Flexibility and teamwork resulted in a project that was completed on time and under budget.

Drilling directionally from multi-well pads provided the geologic challenge of identifying the flanks of very steep pinnacle reefs. Drilling at a high angle through alternating sequences of carbonate, salt and anhydrite before encountering reef rock made the determination of casing point at the top of the reef difficult. The anhydrite is considerably thinner at the flanks, and directional drilling does not provide optimal samples. Picking the casing point became a team effort by combining the expertise of geologists, engineers and drillers. Comparison of the pre-drill geologic maps with the post drill interpretation shows remarkable similarity. The added well control enhanced the definition of the flanks of the pinnacle reefs and the downhole logs proved that the reef top was picked with great consistency.

For Figure see page 47

PRESENTER:
Charles J. Moskowitz

DATE: Monday, March 13
TIME: 1:30-2:00
ROOM: Room 103 A/B

PROGRAM TITLE:

History and Current Activity at South End of Copper Range in Western U. P.

AFFILIATION:
Oil & Gas Producer, P.O. Drawer 463, Mt. Pleasant, MI 48804-0463, 517-772-0860

ABSTRACT:
The great anomaly of Michigan's Copper Country is the fact that the overwhelming majority of the ore mined is native copper - which is relatively rare in other commercial copper deposits. For 42 years (1845-1887) "NATIVE" Keweenaw Copper was king of the copper industry in North America. Then copper ores at Butte, MT. & Bisbee, Arizona surpassed it. Native copper appears in other parts of the world, but nowhere else in the quantity found in Upper Michigan. Copper deposits in Upper Michigan occur in late Pre-Cambrian Age of the Keweenaw series. Over 95% of the copper produced is from a narrow belt west of the Keweenaw fault 26 miles long, lying mostly in Houghton County but including parts of Keweenaw & Ontanogan County. The copper bearing Keweenaw rocks dip to the Northwest at an average angle of 40 from the horizon towards the axis of the Lake Superior Syncline. Levels rich in native copper are called Lodes. There are 3 types of copper deposits, Amygdules, where gas bubbles are trapped at the top of a flow forming cavities called Vesicles & when filled by copper, silver & 20 other minerals, these are called Amygdaloidals Lodes. Of particular interest is the Calumet & Hecla Red Conglomerate Lode, which parallels the inclined strata of the Lake Superior Syncline, mined along the dip for a distance of 10,000 feet. The vertical depth is 6000 feet. Over 43% of the copper came from the C&H Conglomerate principally in the vicinity of Calumet - where buildings to this day still stand where the offices of C&H were located. The original library building. has been kept up and is in mint condition. The home of Louis Agazzis is directly across the street from the library to the north, and an amazing statue of Louis Agazzis, with its lifelike face, sits east of the library. He ran the C.& H. operation for 39 years. You can see many shaft houses with their inclined roofs slanting down toward the northwest. This is the strike & dip mining followed down the Keweenawan Lode towards the Lake Superior Syncline Axis. An example of C&H conglomerate will be exhibited. The Fissure Lode is where large, individual masses of copper were found, from cracks cut across the stratification of the Keweenaw rocks.
The most famous "fissure" deposit is a 2 ton chunk of solid copper known as the "Ontonagon Boulder", torn loose by a Pleistocene Glacier & dropped along the Ontonagon River, discovered an estimated 9000 years later. After many attempts to move it, the Ontonagon boulder ended up in the Smithsonian Institute. An excellent sample of fissure copper will be shown. Also presented will be silver in copper known as a half-breed'. Discussion on the eastward extension of the Keweenaw Fault into Ontario. Canada, where rich deposits of gold were found at lower levels in Chalcocite deposits. The gold was finely disseminated requiring refining. The gold discovery resulted as a direct result of Dr. Jim Trow's subsurface analysis that chalcocite could be gold bearing in relationship to the Keweenaw Fault where fluid movement could deposit gold in chalcocite. Professor Emeritus Jim Trow taught structural geology for 50 years at MSU. My presentation ends on the currently active Caledonia mine near Mass City in SW Houghton County.

PRESENTER:
Norman G. Grannemann

DATE: Monday, March 13
TIME: 2:00-2:30
ROOM: Auditorium

PROGRAM TITLE:

Ground-Water Resources of the Great Lakes Region

AFFILIATION:
U.S. Geological Survey, 6520 Mercantile Way/Suite 5, Lansing, MI 48911 517-887-8903

ABSTRACT:
Ground-water resources in the Great Lakes Region are often overlooked because surface-water resources in the region are so large. Ground water, however, plays a more important hydrologic role in the region than is commonly understood because it directly and indirectly contributes 20 to 40 percent of the inflow to the Great Lakes. In addition, ground water is the source of drinking water for millions of people in the region. It is also the source of supply for agriculture and many industries, and it sustains important plant and animal species by discharging water to ecologically sensitive areas. Therefore, it is important to have a better understanding of the role that ground water plays in the overall analysis of Great Lakes water-resources issues. This understanding will require better evaluations of both indirect and direct ground-water discharge, better estimates of ground-water recharge, and more accurate accounting for the amount and effects of ground-water withdrawals. Evaluation of the role of ground water for maintaining wetlands and healthy habitat of aquatic ecosystems is also needed.

PRESENTER:
Daphne McNeary, and Mark Baskaran

DATE: Monday, March 13
TIME: 2:00-2:30
ROOM: Room 103 A/B

PROGRAM TITLE:

The Depositional Fluxes of Pb-210, Be-7, and Po-210 in Detroit, Michigan

AFFILIATION:
Graduate Research Assistant, Department of Geology/Wayne State University, Detroit, Michigan 48206, ab7174@wayne.edu

ABSTRACT:

Beryllium-7, lead-210 and Polonium-210 are all naturally occurring radionuclides. Beryllium-7 (half-life = 53.3 days) is produced in the stratosphere as a result of cosmic ray spallation of oxygen and nitrogen atoms. Lead-210 (half-life=22.1 years) and polonium-210 (half-life=138 days) are produced from the decay of radon-222 (half-life =3.84 days), which primarily emanates from the continents. The daughter products of 222Rn have proved to be valuable as tracers in atmospheric research.

Previous studies have shown that Be-7 and Pb-210 are highly particle-reactive; they attach themselves to aerosols in the atmosphere soon after their production; they are then scavenged from the atmosphere by precipitation. Beryllium-7 and the daughter products of 222Rn have also been used to study aerosol residence time as well as rates of removal of aerosols. The behavior of 210Pb and 7Be provides knowledge on the behavior of other chemical species in atmospheric aerosols. These radionuclides have been utilized as tracers of particle-reactive pollutants in the coastal, marine and lake environments. To be useful as tracers in aquatic environments, the depositional fluxes of these nuclides in surface waters must be known. There is limited data on the depositional fluxes of these nuclides in the Midwestern United States.

The purposes of this study are: (1) to determine depositional fluxes of these radionuclides in the bulk and dry fallout; (2) to determine the concentrations of 7Be and 210Pb in the aerosols; and (3) to determine the deposition velocities of aerosols.

In September 1999, at a Department of Environmental Quality (DEQ) site in Southwest Detroit, a bulk rain collector was deployed. In October of this year, a dry collector was deployed on the roof of the DEQ building, approximately 10-ft above ground. The bulk samples were collected after each significant rainfall event and after approximately ten days of dry weather for the dry collector. The samples were taken to the lab for radiochemical processing. Beryllium-7 and 210Pb concentrations were determined using gamma-ray spectrometry; polonium-210 concentration was determined by using alpha-ray spectrometry.

During the three months period we have collected precipitation and air samples, the 210Pb flux ranges from 0.37 to 2.73 (DPM) cm2 y1, with a mean of 1.79 dpm cm2 y-1, the 7Be flux ranges from 8.46 to 40.6 dpm cm-2y-1 with a mean of 21.3 dpm cm y. The 7Be/210Pb activity ratios range from 5.99 to 22.7, with a mean value of 14.5. The dry depositional flux accounted for about 12% and 4.8% of the bulk depositional flux for 210Pb and 7Be, respectively. The 210Po/210Pb ratios in the dry and bulk fallout are comparable to the values reported in the literature. In the two air samples, the calculated depositional velocity of aerosols based on the atmospheric flux and the concentration of 210Pb in air samples are 0.94 cm/s and 0.55 cm/s. The bulk depositional flux of 210Pb and 7Be, the fraction of the dry fallout of these radionuclides, and the depositional velocity based on 210Pb are comparable to the range of values reported in the literature.

PRESENTER:
James Ashley

DATE: Monday, March 13
TIME: 2:30-3:00
ROOM: Auditorium

PROGRAM TITLE:

Topographic Modification through Subsurface Gypsum Solution & Removal in West Michigan

AFFILIATION:
EncoTech Midwest, Inc., 39255 Country Club Drive-Suite B40, Farmington Hills, MI 48331, 248-489-0809,

ABSTRACT:
Abstract text

PRESENTER:

Bruce K. Beltman, Joseph W. Sheahan, and Steven F. Fesko

DATE: Monday, March 13

TIME: 2:30-3:00

ROOM: Room 103 A/B

PROGRAM TITLE:

The Use of Fracture Trace Analysis to Optimize Environmental Well Locations

AFFILIATION:

Ground Water Solutions Inc, 2500 Kerry Street/suite 202., Lansing, MI 48912, 517-346-5080, bbeltman@voyager.net

ABSTRACT:

Ground water flow in bedrock aquifers occurs preferentially along flow paths created by fractures in the rock. Installation of investigatory wells in such zones of preferred flow permits understanding ground water movement in the bedrock and its potential influence on flow in overlying, unconsolidated sediments and distributions of ground water quality. Significant fractures are often expressed as subtle lineaments on aerial photographs. These surface expressions of fractures, sometimes covered by substantial thickness of overburden, typically reflect subtle differences in soil moisture. Aerial photographs of the Marshall, Michigan area were examined, permitting mapping of several photolineaments extending into the area of investigation. A stratigraphic boring location on a major photolineament was selected.

The relevant stratigraphy at the study site comprises 45 to 55 feet of unconsolidated sediments overlying the Marshall Sandstone, a regional aquifer. The Marshall is, in turn, underlain by the Coldwater Shale, a regional aquitard.

Sonic drilling methods were used to sample the complete stratigraphic sequence with continuous core sampling from the ground surface to the base of the Marshall Sandstone. The samples clearly indicated the presence of a buried bedrock valley. The erosion of the bedrock valley was likely controlled by the fracture responsible for the photolineament. A monitor well nest was installed at this location with wells completed in the shallow unconsolidated sediments, at the base of the buried bedrock valley, and below the valley in competent fractured bedrock. The base of the buried bedrock valley contains a sequence of alluvial deposits consisting of alternating beds of well-sorted sand and gravel.

Water levels from all available well nests were used to characterize ground water flow patterns in: the shallow unconsolidated zone; the composite of the shallow weathered bedrock and the alluvium at the buried valley base; and the competent bedrock. Equipotential contour maps and cross sections were developed to analyze horizontal and vertical ground water flow. Resulting flow patterns demonstrated that the highly permeable alluvial deposits at the base of the buried valley acted as a path of preferred flow and influenced local ground water movement in the shallow bedrock and unconsolidated hydrostratigraphic zones. Knowledge of the presence and nature of a large-scale bedrock fracture permitted a complete and coherent characterization of local ground water flow and the potential for contaminant migration.

PRESENTER:
Jeffrey L. Howard

DATE: Monday, March 13
TIME: 3:15-3:45
ROOM: Auditorium

PROGRAM TITLE:

Geochemical Forms of Lead in Urban Soils, Detroit, Michigan

AFFILIATION:
Department of Geology, Wayne State University, Detroit, Michigan 48202, 313-577-2506, aa2675@wayne.edu

ABSTRACT:

Sequential extraction analysis of heavy metals in soils along Interstate Highway 96. and in parks and vacant lots, shows that Pb contamination is widespread in the Detroit area. Total Pb levels are generally 50-175 ppm. but range up to 375 ppm at the most severely contaminated site along 1-96 (rural background level is <10-20 ppm). The principal source appears to be airborne deposition from automobile emissions, but demolition debris (paint?) has contaminated a vacant lot soil after only 16 years of chemical weathering. Pb levels are generally highest in the surface horizon (0-15 cm depth) where Pb is predominantly in an organically bound form. but carbonate- and Fe-oxide-occluded forms predominate at the most heavily contaminated sites. Carbonate is variable in the studied soils but where abundant, both organically bound and carbonate-occluded forms of Pb are significant. Carbonate is generally low (<1%), especially in surface horizons, but may be up to 25% in glaciolacustrine parent materials in which case carbonate may sorb high amounts of Pb. Weathering of demolition debris may cause Pb contamination, but decomposition of cement may generate carbonate as an immobilizing agent

For Figure see page 48.

PRESENTER:

Kent S. Murray [1,and]

Zhou Xun [2]

DATE: Monday, March 13

TIME: 3:15-3:45

ROOM: Room 103 A/B

PROGRAM TITLE:

Impact of Groundwater on Surface Water Quality in an Urban Watershed

AFFILIATION:

1 Department of Natural Sciences/University of Michigan, 4901 Evergreen Road, Dearborn, MI, kmurray@umich.edu,

2 Department of Hydrology/China Geosciences University, Beijing, PR China

ABSTRACT:

A study was conducted to evaluate the impact of groundwater on surface water quality along the lower, highly urbanized branch of the Rouge River, a major tributary to the Detroit River and the primary drainage for the city of Detroit and the surrounding metropolitan area. A monitoring network consisting of 54 groundwater monitoring wells and 18 well points was installed along the lower branch of the Rouge River in southeastern Michigan during the summer of 1999 (Figure 1). The wells were installed in nine clusters of three wells on each side of the river. Two well points were driven into the bed sediment of the river at each of the nine locations. The well points were installed to sample the pore water beneath the bed sediment/surface water interface at depth of 0.25 and 0.75 meters. Water samples from the wells, the well points and surface water have been collected and analyzed on a monthly basis for 10 months. Each water sample has been analyzed for major cations, anions, nutrients and a suite of six heavy metals (As, Cu, Hg, Ni, Pb and Zn).

The Rouge River watershed is a fan-shaped drainage basin consisting of four branches (lower, middle, upper and main), numerous tributaries and over 400 lakes and ponds. The watershed encompasses an area of over 650 square kilometers, includes 42 separate municipalities and is home to 1.5 million people. The International Joint Commission however, has listed the river as one of the 42 areas of greatest concern within the Great Lakes basin. All four branches are considered highly polluted and contain excessive levels of bacteria, heavy metals and organic chemicals. In an effort to restore the river for recreational purposes, the Wayne County Department of the Environment obtained a multi-million dollar grant from the U.S.EPA in the early 1990s to develop a National Wet Weather Demonstration Project. The primary function of the grant was to design and construct 12 experimental retention basins to capture the overflow from the city's combined sewer system. The capture and treatment of the overflow will prevent the discharge of wastewater directly to the Rouge River. Once the various designs of the experimental basins have been evaluated, one or two of the most cost-effective and efficient designs will be selected for implementation throughout the watershed. The cost for this eventual construction is expected to exceed $3 billion. The premise behind this project is that discharges from combined sewer overflows (CSOs) are the primary source of pollution to the Rouge River. Therefore once the discharges are eliminated, the river will be restored to pre-development conditions.

The problem with this National Demonstration Project is that CSOs actually account for only 10% to 15% of the pollutant loading to urban river systems, while nonpoint sources e.g. groundwater discharges, airfall deposition and rural and urban runoff account for the remaining 85% to 90%. Consequently, although CSOs contribute to the contamination of the Rouge River, their role is relatively minor and the construction of retention basins will probably have a negligible impact on the water quality of the river. Alternatively, contaminated groundwater and storm water, which discharge continually to the river, are likely major nonpoint sources of contamination to the river. The purpose of this study is to quantitatively evaluate the role of groundwater in contributing to the degradation of surface water quality. This will be accomplished by investigating the fate and transport of nutrients, major elements and heavy metals as they are transported from the groundwater, through the bed sediment to the surface water of the river. A geochemical-transport model will be used to simulate the subsurface movement of nutrients and elements and their fate under natural Eh and pH conditions. The analysis of groundwater, surface water and pore water derived from the sediment column beneath the bed sediment/surface water interface will be used to calibrate the model. Specific goals of the project include 1) evaluation of methods to assess nonpoint sources of pollution to urban rivers, the assessment of near surface aquifers in contributing to nonpoint source pollution and 3) quantification of the pollutant loading to river systems contributed by groundwater flow. Preliminary results at the time of this writing have shown that groundwater discharge is highly dependent on the near surface geology (Figure 2), but can be quantified, and can be significant.

Figure 1. Location of monitoring well stations along the Lower Branch of the Rouge River in southeastern Michigan. Arrows indicate the generalized groundwater flow direction along the river.

Figure 2. Subsurface cross-sections drawn approximately north south across the Lower Branch of the Rouge River. The near surface geology conforms closely to recently published surface geologic maps of the Rouge River Watershed

PRESENTER:

Wayne D. Pennington, and Roger Turpening

DATE: Monday, March 13

TIME: 3:45-4:15

ROOM: Auditorium

PROGRAM TITLE:

Surface and Borehole Seismic Methods of Fracture Detection

AFFILIATION:

Michigan Technological University, Houghton, MI 49931, 906-487-3573, wayne@mtu.edu, Massachusetts Institute of Technology

ABSTRACT:

Fractured rocks play host to a significant percentage of oil and gas production within the state of Michigan, yet they are perhaps the most difficult of all reservoir types to predict or identify from traditional techniques. Over the past several years, a large effort has gone into detecting and characterizing fractures in the subsurface, particularly from seismic techniques and borehole imaging; that effort is now paying off. These methods involve conventional surface seismic, multi—component recording for converted waves or from a shear source, and borehole variations on these approaches.

Conventional (P—wave) surface techniques should be used for fracture characterization only when the response has been calibrated (either through multi—component studies or by drilling and modeling the seismic based on well logs) and all other possible interpretations have been eliminated. In some specific cases, this is feasible, but in many cases, the ambiguity in interpretation of compressional data is too great to allow its general use for fracture detection.

Multi—component surface seismic studies have occasionally been shown to provide very useful results, due to the splitting and polarization of shear waves by aligned fractures. But in some cases, these studies have been disappointing. In nearly all cases, they have been quite expensive, and a clear expectation of results is needed before it is reasonable to budget for such work.

The technology for the study of converted waves has been advanced considerably in recent years by the need to image large oil or gas fields beneath gas 'clouds' in the marine environment. [Converted waves originate from a conventional 'P—wave' source and are converted to shear waves at some interface in the subsurface, then recorded as shear waves at the land surface or the sea floor; in the marine environment, only compressional—wave sources are feasible, and the use of converted waves essential if shear waves are to be used in the subsurface.] Some of this technology may be appropriate to use on land in places where shear—wave information is badly needed.

In a borehole environment, two new technologies are available: shear—wave logging, including a 'crossed—dipole' measurement that can directly determine the anisotropic properties of the formation, even behind casing; and a new powerful downhole seismic source. The logging measurements are fairly easy to relate to fracture density, particularly if there has been some local calibration of the elastic anisotropy to borehole image logs; this technique is likely to prove very useful in the Antrim shale for recompletion designs and for other plays behind pipe. The new downhole seismic source can be recorded at the surface, and larger—scale-fracturing patterns may be discernable, particularly if experiments using large surface arrays of receivers prove fruitful.

PRESENTER:

DATE: Monday, March 13

TIME: 3:45-4:15

ROOM: Room 103 A/B

Concurrent Session Not Planned

PRESENTER:
Andrew L. Kozlowski,[1]
A.E. Kehew, A.C. Flint,
S.H. Chowdhury, J.N. Lee, and
L.P. Nicks

DATE: Monday, March 13
TIME: 4:15-4:45
ROOM: Auditorium

PROGRAM TITLE:

Three Dimensional Mapping of the East Leroy and Union City 7.5 Minute Quadrangles, Michigan

AFFILIATION:
[1]*Geosciences Department/Western Michigan University, Kalamazoo, MI 49008, x96kozlowsk1@wmich.edu*

ABSTRACT:

Results of a recently completed USGS EDMAP project in Calhoun and Branch Counties, Michigan has provided important stratigraphic information for ongoing hydrologic investigations. The Saginaw Lobe of the Laurentide Ice Sheet impacted the terrain in the study area most recently. Digital water well records, gamma ray logs and test wells provided the necessary stratigraphic and hydrogeologic information.

The stratigraphy and hydrogeology of the study area are constrained by the bedrock topography of Mississipian Coldwater shale. The bedrock topography of the shale is a result of fluvial and glaciofluvial action. Thick drift deposits that comprise the aquifer systems for the study area occupy several bedrock valleys. The drift deposits in the study area range from 13 feet to nearly 200 feet thick and are Wisconsinan in age with older deposits subcropping in the bedrock valleys and elsewhere in the region. Drift in the northern portion of study area is comprised of a brown sandy supraglacial diamicton at the surface with underlying glaciofluvial deposits and a massive gray diamicton at depth. Surface deposits in the southern portion of the study area are characterized by a subglacial landform sediment assemblage. However, the stratigraphy is similar to that in the north.

The village of Athens has experienced nitrate contamination levels exceeding MCLs in their groundwater. A possible explanation exists in the orientation of the bedrock valleys, the drift comprising the valleys and the regional direction of drainage. The village is situated at the confluence of two bedrock channels that may provide avenues for groundwater recharge, flow and possible contamination. Large-scale agricultural operations are abundant in and around the village. The glaciofluvial deposits and sandy diamicton occurring in the study site provide little protection for the groundwater resources the village depends on.

PRESENTER:

DATE: Monday, March 13

TIME: 4:15-4:45

ROOM: Room 103 A/B

Concurrent Session Not Planned

PRESENTER:
Brant O. Fisher

DATE: Tuesday, March 14
TIME: 8:30-9:00
ROOM: Auditorium

PROGRAM TITLE:

Ten Years of Wellhead Protection: Where We Have Been-Where We are Going?

AFFILIATION:
Michigan Department of Environmental Quality, Drinking Water & Radiological Protection Division, 517-335-9187

ABSTRACT:

Michigan's Wellhead Protection Program (WHPP) was developed in response to amendments to the federal Safe Drinking Water Act (SDWA) in 1986. The purpose of the WHPP is to protect public water supply systems that use ground water from potential sources of contamination. The program focuses groundwater management strategies in areas known to contribute ground water to public water supply system wells, thereby providing an elevated level of protection to public water supply systems using groundwater as a source.

The WHPP was developed in accordance with edicts of the U.S. Environmental Protection Agency (EPA) and the 1986 amendments. Michigan's program was developed and submitted to the EPA, and program approval received in 1994. Unlike many other programs administered by the EPA the program is not per se mandatory. States are required to have a program although participation by PWSSs otherwise regulated by the SDWA is optional. However, PWSSs that participate in the program are required to address seven fundamental elements outlined by the EPA for all wellhead protection programs. The seven elements include the following:

1. Roles and responsibilities
2. Delineation of the wellhead protection area
3. Inventorying of sources of contamination
4. Wellhead protection area management
5. Contingency planning
6. Incorporation of new wells into the program
7. Public education and outreach

One of the approaches for which Michigan's program was unique was a requirement that delineation of wellhead protection areas be accomplished by modeling of ground water flow. While much of the modeling is completed with simple analytical models there are requirements for the confirmation of aquifer hydraulic characteristics and confirmation of the direction and gradient of ground water flow. PWSSs completing a delineation must obtain aquifer hydraulic characteristics by completion of an aquifer test. Confirmation of the direction and gradient of ground water flow is accomplished by the collection of static water elevations from the aquifer in which the PWSS wells are completed. The information collected is than used in construction and validation of ground water flow models used to delineate the wellhead protection area.

The WHPP has driven beneficial changes in Michigan's PWSS program relative to management of the ground water resource. The construction of new wells serving a PWSS requires the completion of a standardized aquifer test and measurement of static water elevations. More recently programs have been developed that aid in the promotion of the WHPP. In 1998 the Wellhead Protection Grant Program was developed. This program provides seed money for wellhead protection by providing a match to local dollars spent on wellhead protection activities. Two rounds of funding have provided approximately $2.1 million to PWSSs and local units of government for development of local WHPPs. A program to provide funding for the proper plugging of abandoned wells in wellhead protection areas, the Michigan Abandoned Well Management Program, is currently under development.

PRESENTER:
Alan F. Arbogast

DATE: Tuesday, March 14
TIME: 8:30-9:00
ROOM: Room 103 A/B

PROGRAM TITLE:

The Emerging Record of Coastal Dune Evolution along the Southeastern Shore of Lake Michigan

AFFILIATION:
Assistant Professor, Department of Geography/Michigan State University, 315 Natural Science, East Lansing, MI 48824-1115, 517-355-5262, arbogas2@pilot.msu.edu

ABSTRACT:

The largest concentration of freshwater coastal sand dunes in the world occurs along the eastern shore of Lake Michigan. South of Manistee these dunes consist of massive (> 30 m high) parabolic features that mantle lake terraces. The dunes have historically been the source of much interest and utilization; nonetheless, their detailed geomorphic history (i.e., stability vs. dune enlargement) is poorly understood. In general, the working hypotheses have historically been: 1) the dunes formed sometime during the Nipissing interval; and 2) most sand was supplied to the dunes as lake level fell and beaches enlarged. Although these hypotheses have been widely accepted, they have not been rigorously tested.

Recent studies have focused on determining the age of the dunes, and to correlate their evolution with known lake level fluctuations, through radiocarbon dating of buried soils. [Emerging data] indicates that dune evolution is complex and does not necessarily correlate between sites or with known lake-level phases. Near Holland, it appears that eolian sand began to accumulate approximately 5500 calendar years before present (cal. yr. BP), which correlates nicely to the Nipissing period. Dunes enlarged rapidly until approximately 3000 cal. yr. BP, with only brief periods of stability that resulted in weakly developed soils (i.e., inceptisols). Subsequently, the dunes stabilized for approximately 2000 years, allowing the formation of moderately developed spodosols. The dunes reactivated episodically in the past 500 years, both through vertical accretion and horizontal migration. Between Grand Haven and Ludington, in contrast, coastal dunes began to form later (i.e., between 4300 and 2900 cal. yr. BP). Some of these dunes enlarged rapidly to their current height and then stabilized, whereas other dunes were built episodically. Correlations between radiocarbon ages and reconstructed lake-level fluctuations suggest that dune enlargement has occurred along the shore both during rising and falling lake stages.

PRESENTER:

Roger Turpening[1], Renald J. Kulis[2], and Wayne D. Pennington[3]

DATE: Tuesday, March 14

TIME: 9:00-9:30

ROOM: Auditorium

PROGRAM TITLE:

Seventeen Years of Borehole Seismology Around One Pinnacle Reef

AFFILIATION:

[1] Earth Resources Laboratory, Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, 42 Carelton Street, Building E34, Cambridge, MA 02142, 617-253-7850, roger@erl.mit.edu,

[2] Great Lakes Petroleum Land Co., Thompsonville, MI,

[3] Department of Geological Engineering, Michigan Technological University, Houghton, MI

ABSTRACT:

One pinnacle reef in Manistee County's Springdale Township has served as a research laboratory in borehole seismology for the past seventeen years and it continues today. Various seismic methods, such as vertical seismic profiling (VSP), cross-well tomography, cross-well reflection, and reverse vertical seismic profiling (RVSP) can trace some portion of their development to this one reef in northwestern lower Michigan. As testing continued our image of the reef became sharper and better resolved making the object increasingly more valuable for seismic imaging research.

There are many aspects to borehole seismology from data acquisition hardware (sources and receivers) to borehole engineering to imaging algorithms and each has had its own pace of development. Ancillary information in the form of well logs and gyroscopic surveys are also important to the imaging process and they have seen their own history of improvement over the seventeen years.

The spectral band of the downhole sources and receivers and the strength of the sources has always been a crucial aspect of the research with signal frequencies ranging from tens of hertz to several kilohertz. This variation coupled with the wide velocity variation between the glacial till and the carbonate formations has given us wavelengths ranging from hundreds of feet to ten feet and this in-turn has produced large differences in image resolution.

Downhole seismic sources have, in particular, had an interesting history with energy being derived from explosives, propellants, springs, compressed air, piezoelectric cylinders and bars, rotating eccentric masses, and downhole hydraulic pumps. Receivers have varied from unclamped hydrophones and piezoelectric cylinders to clamped geophones and accelerometers. Recently one downhole source has become strong enough to allow us to receive the signals on the surface in random spreads of geophones.

This last development, termed reverse vertical seismic profiling, has moved borehole seismology away from two-dimensional images to three-dimensional volumes of data and forced a corresponding change in the processing algorithms. The high frequency nature of the hydraulic, axial vibrator has made the always difficult statics problem even more difficult.

Today the research continues as we plan for the deployment of a single, random spread of 20,000 channels on the surface with the downhole, hydraulic, axial vibrator as the source. The resulting three dimensional image will be compared with the image obtained from 3-D VSP using hundreds of random dynamite shots on the surface.

PRESENTER:
Kevin A. Kincare, and Harold R. Fitch

DATE: Tuesday, March 14
TIME: 9:00-9:30
ROOM: Room 103 A/B

PROGRAM TITLE:

The Great Lakes Mapping Coalition in Michigan: Finding Partners

AFFILIATION:
Michigan Geological Survey Division, Department of Environmental Quality, 735 East Hazel St, Lansing MI 48912, 517-334-6908

ABSTRACT:

Efforts to evaluate earth resources have undergone a steady de-emphasis in Michigan over the past 20 years. The rise of the "user-pay" concept has meant that the programs that gain support tend to be those which have an immediate economic payoff for a large, politically cohesive, vocal user group.

Geologic mapping has suffered as a result. The beneficiaries of mapping tend to be spread across the state's business and community sectors, and there has not been a unifying effort among them to advocate mapping. Also, the benefits of mapping are not immediate, but tend to be spread many years into the future.

MGSD has no staff dedicated to geologic mapping. We are producing about six new geologic maps per year through grants to universities under the STATEMAP program. Only eight percent of the glacial geology of Michigan has been mapped at a scale of 1:100,000 or better. Our Coalition partnership with Illinois, Indiana, Ohio and the USGS is the cornerstone to revitalize geologic mapping in Michigan.

Michigan plans to pull together a variety of business partners that have a stake in geologic mapping to support the Coalition efforts. Potential partners include environmental consultants, businesses that generate or handle potential pollutants, aggregate and other mineral extraction industries, and municipalities and industries seeking water supplies. We also plan to use our STATEMAP university partners to provide geologists under contract to meet demands for staffing and expertise.

In order to garner support for these efforts, we must prove to others what we already know: that there is a crucial need for geologic mapping by society. A strong outreach effort combined with demonstrations of useful derivative products is the key to success in this area. We have our work cut out for us, but we believe that the Coalition offers a very promising strategy for bringing geology back to the forefront in maintaining a healthy economy and environment.

PRESENTER:
Tyrone J. Black[1], and Frank J. Krist, Jr.[2]

DATE: Tuesday, March 14
TIME: 9:30-10:00
ROOM: Auditorium

PROGRAM TITLE:

Use of GIS for Geologic Mapping of Northeastern Lower Michigan

AFFILIATION:
[1]Michigan Department of Environmental Quality, Geological Survey Division, Gaylord, MI 49734, 517-275-5328, Blackt@state.mi.us,
[2]Michigan Department of Natural Resources, Pacific Meridian Resources, Roscommon, MI 48653, 517-275-5151, Krist@state.mi.us

ABSTRACT:
Using a Geographic Information System (GIS) bedrock topography, drift thickness, bedrock geology, and bedrock structure maps were generated. Data was from outcrop locations, and water, oil and gas, and geologic test wells. The bedrock topography map displays several significant buried channels that have affected Antrim Shale gas production. These channels are also significant to aquifer delineation and protection in areas of shallow bedrock. Drift thickness reveals areas for aquifer protection considerations during installation of water and industrial wells, and for drain field and loss hazards. In particular, there are concerns with the effects of shallow drift cover over karst formations across parts of Presque Isle and Alpena counties. These maps have increased accuracy over a wider area. This resulted in more reliable detail in bedrock geology and structure maps. Bedrock structure generated from the bedrock topography and formation data reveals wider structural coverage of details. This detail was enhanced and extended by integrating multiple data types to generate maps

PRESENTER:
Byron D. Stone[1], and
Wayne L. Newell[2]

DATE: Tuesday, March 14
TIME: 9:30-10:00
ROOM: Room 103 A/B

PROGRAM TITLE:

The USGS Role and Opportunities in the Central Great Lakes Geologic Mapping Coalition

AFFILIATION:
U.S Geological Survey, National Center, MS 926-A, Reston, VA 20192,
[1]bdstone@usgs.gov [2]wnewell@usgs.gov

ABSTRACT:
The Central Great Lakes Geologic Mapping Coalition brings together geologists and staff specialists from four State geological surveys and the Federal geological survey to jointly map the three-dimensional extent and character of thick, complex glacial deposits that blanket the region. This State-Federal collaboration presents an opportunity to leverage local, State, and Federal resources cost-effectively for meeting the Earth-science information needs of the region. In the Coalition, the USGS has unique roles in contributing existing and new technical resources, and synthesizing the common database into regional maps of multi-State areas. Regional-scale knowledge of the glacial geology here will improve the interpretation of glacial geology elsewhere in the northern U.S. Expanded knowledge of surficial geologic resources and hazards, and the environment on a national scale will better equip the USGS to serve the proprietary needs of Federal lands and installations, and information needs of regulatory agencies, industry, local government, and land owners. Opportunities presented by mapping projects in the Coalition program include the development and application of new drilling technology, geophysical tools, and 3-D analytical techniques for assessing resources and modeling flow paths of ground water in complex aquifers. New emphasis on geochemistry of stratigraphic units will improve sedimentation and diagenetic models of glacial deposits, as well as provide background data for contamination studies. All participants will have the opportunity to cross-train in various mapping related disciplines and techniques. Broadly trained staff will increase the agencies ability to respond rapidly to a variety of dynamic hazards including floods, coastal erosion, earthquakes, or toxic spills. Both State and Federal geological surveys have limited staffs of geologists who are prepared to work in Coalition projects. Recognizing this, in 1997, the USGS developed a workshop known as SURFSCHOOL to train USGS and State survey geologists in field techniques and the interpretation of surficial geologic data. Numerous examples of sedimentation models of glacial, coastal, and river deposits were studied and presented in the context of geomorphic systems that create allostratigraphic deposits. A team mapping exercise in Berrien County, Michigan, produced a new surficial geologic map of part of the County. Our training exercise had demonstrated that a team approach to detailed geologic mapping can effectively gather and assemble data into GIS format in the field. Future SURFSCHOOL activities are planned for studies of modern glacial, fluvial, lacustrine, and coastal marine environments at the USGS camp at the Bering Glacier in coastal Alaska. These efforts are designed to provide all participants with common paradigms for mapping the surficial geology of the Great Lakes Region.

PRESENTER:

William A. Sauck,[1]
Justin M. Bailey, and
Adrian I. Ezeagu

DATE: Tuesday, March 14

TIME: 10:15-10:45

ROOM: Auditorium

PROGRAM TITLE:

Geophysical Detection of Abandoned Water Supply and Monitor Wells

AFFILIATION:

Associate Professor, Department of Geosciences/Western Michigan University, Kalamazoo, MI 49008, 616-387-5513, [1]sauck@wmich.edu

ABSTRACT:

Lost and abandoned water wells and monitor wells are a threat to the quality of the aquifers which so much of Michigan depends upon for drinking water. Such wells, estimated to number at least 10,000 in the State, can provide direct paths for surface spills and contaminants in runoff to reach the aquifer. Under a contract from the MI Department of Environmental Quality (DEQ), Drinking Water & Radiological Protection Division, Abandoned Well Management Program (AWMP), we began research on the feasibility of using geophysical techniques to locate such wells in the fall of 1999. Experiments were done at the WMU Geophysical Test Site, located on the Asylum Lake parcel of the WMU Farms property in SW Kalamazoo.

Types of well casing investigated were 2" and 4" steel, 2" stainless steel, and PVC. Measurements were repeated for each type of well casing using lengths of 21', 42', and 84'. Additionally, each of these lengths of casing were surveyed for burial depths to top-of-casing of 1', 4', and 8'. Recording geophysical instruments used were the Geometries G-858 magnetometer/gradiometer, the Geonics EM-3 1, Geonics EM-61, and the Geophex GEM-2 electromagnetic (EM) induction devices. A GSSI SIR-10 ground-penetrating radar (GPR) unit with 300 MHz and 500 MHz antenna was tested with several different antenna configurations. Non-recording magnetometers (vertical fluxgate gradiometers) used were the Fisher FX-3 and Schonstedt GA-72CV. Non-recording EM utility locator/metal detectors used were the Fisher M-96 and the Fisher Gemini-3 (TW-6). These non-recording instruments were included in the study, as they may be very inexpensive options for some of the well location tasks.

Rather than install more than 40 wells to investigate all of the permutations defined above, a single 6" diameter PVC-cased research borehole was installed to 100', with the top of its casing at ground level. Inside this borehole, all of the different metallic casings were suspended in turn from a wooden beam 1' above ground level by a block and tackle system which was non-magnetic, and had minimal stainless steel metal in its construction. With the recording instruments, 7 profiles, spaced 2' apart and 100' long, were surveyed over the well, allowing a narrow contour map to be constructed for each case. The long lines also provided typical background data for evaluation of geological and instrument noise. The low suspension system facilitated the passage of the various sensors at their normal operating heights directly over the well along the central survey line. The non-recording instruments were traversed only along the centerline and notations made of maximum response, and distance from the well at which departure from background values could be detected.

The PVC wells were a special case, as they are not directly detectable with either EM induction devices (which depend on electrical conductivity), or the magnetometers. After verifying this, several cases were devised to simulate lost PVC wells. The first was the case for which the well (typically a monitor well) had a metallic flush-mount well protector installed. For this, 3 sets of 3 different models of well protectors were buried to the prescribed depths of 1', 4', and 8'. They were of 6" diameter steel, 10" steel, and 8" aluminum. The second PVC case was for that in which a submersible pump and its electrical cable were still in the abandoned well. Suspending 3-conductor, 12 Ga. wiring in the 6" master borehole at the 3 prescribed depths simulated this. A third possibility for PVC wells was that 1" galvanized steel drop pipe was left in place, and this case was also tested using 1" pipe suspended in the 6" borehole.

Results showed that vertical pipes with their small horizontal cross sections have a very small response to the conventional EM induction methods, most of which are designed to couple best with conductive objects whose principal axes are horizontal. The best system could get only marginal response from some of the well casings at 8' burial depths. By contrast, the magnetic response of vertical steel pipe is maximal, or better than horizontal pipes, as the vertical orientation is near the geomagnetic field direction, and they show a large induced magnetization in the present earth's field. Thus, all 3 of the magnetometer systems were capable of locating the tops of the steel pipes at 8' depth. However, the stainless steel pipe had no magnetic response, and so its detection was restricted to the much weaker signal from the EM induction devices Additional casing length had negligible effect on the EM responses, but changed the magnetic response considerably. This is because the steel pipe sections also retain a permanent magnetization from their time of initial cooling in the mill, which has a strong component along the axis of the pipe. Hence they act as long bar magnets, and may either add to or diminish the magnetization induced by the ambient geomagnetic field, depending upon which end is installed up. In joining multiple pipe lengths, the dominant response is controlled by the magnetization direction in the upper pipe, but if the second pipe is attached with its polarity opposite, the net result can be a magnetic field weaker than that of a single pipe. The GPR is unlikely to detect any but the shallowest metallic pipe, and that only if the antenna passes directly over the well. The magnetic gradiometers could begin to detect the steel wells at a radial distance in the 5'-10' range, depending on the numbers of sections and the depth to the top.

Field time, data processing time, and hence the expenses for surveying 100' x 100' blocks were tallied for the different instruments. Magnetometers could easily detect steel pipes at 8' or greater burial depths. The best EM induction system could only detect metallic pipe reliably to 4' depths. No geophysical system can directly detect abandoned PVC wells, unless they retain pump wiring, metal drop pipes, protective metallic well covers, or other associated metallic hardware. Hence, to forestall future serious problems with locating lost PVC wells, it may be necessary to mandate the emplacement of an inexpensive magnetic marker when each new PVC well is installed. This could be as simple as a 5' length of 3/8"steel reinforcing rod driven in next to the well, or strapped to the uppermost section of the casing.

For Figure see page 49.

PRESENTER:
Richard Pavey

DATE: Tuesday, March 14
TIME: 10:15-10:45
ROOM: Room 103 A/B

PROGRAM TITLE:

Importance of the Central Great Lakes Geological Mapping Coalition for Surficial Geologic Mapping in Ohio

AFFILIATION:
Ohio Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224, rick.pavey@dnr.state.oh.us

ABSTRACT:
Glacial geology studies over the last 100-plus years have produced a wealth of scientific knowledge, but resultant maps generally have shown only deposits exposed at the surface. Modern geologic map users increasingly require a three-dimensional framework that describes all surficial deposits. Therefore, the Ohio Geological Survey (OGS) recently began a reconnaissance-detail, 1:100,000-scale surficial geology mapping program to characterize all deposits above bedrock. Program design was determined by a significant institutional need for statewide coverage within a reasonable time frame and limited mapping resources. However, a documented majority of map users require detailed mapping at 1:24,000-scale to address the multitude of issues confronting Ohio's many expanding metropolitan areas. These issues include environmental (e.g., ground-water protection, brownfield redevelopment), resource (e.g., aggregate availability, agricultural land loss), and hazard (e.g., seismic risk, landslides) concerns.

The State Geological Surveys of Ohio, Illinois, Indiana, and Michigan and the U.S. Geological Survey formed a coalition to meet the challenge of providing detailed, three-dimensional surficial mapping in the four-state region. No individual state currently has the resources to perform this enormous task in less than a century. The need for geologic information of sufficient extent, accuracy, and quality can be met only by pooling the human, equipment, and other resources of the five organizations. The results of detailed mapping in the priority metropolitan areas will also provide an improved understanding of Ohio's entire geologic framework that will refine regional mapping products.

PRESENTER:
Paul A. Catacosinos[1], and Robert Reynolds[2]

DATE: Tuesday, March 14
TIME: 10:45-11:15
ROOM: Auditorium

PROGRAM TITLE:

[1]Introduction to the Michigan Basin Geological Society Stratigraphic Nomenclature Project

[2]Stratigraphic Nomenclature Project-Michigan Basin Geologic Society-Michigan Stratigraphic Column and Lexicon Project

AFFILIATION:
[1] *Delta College, Albuquerque, NM 87123, 505-299-3544, paulcat@attglobal.net*

ABSTRACT: [1]

This project is the combined effort of Government, Industry and Academic geologists whose work was sponsored by the Michigan Basin Geological Society. It is an outstanding example of co-operation among the diverse members that comprise the Basin's geological community. In 1990, a group of interested MBGS geologists met to discuss the formation of this project. The last detailed stratigraphic publication on Basin stratigraphy and nomenclature was Michigan Geological Survey Publication 50 prepared by Helen Martin and Muriel Straight and published in 1956. In 1964, the Survey published the stratigraphic Chart I, compiled by Gar Ells and his colleagues. Both have served geologists well, but there was concern that by 1990 a great deal of new stratigraphic information had been obtained by the drilling of some 45,000 [or more] wells in the search for hydrocarbons. The project was launched to update the Basin's stratigraphy and the Lexicon is the result. It is close to completion and publication is planned shortly.

The Lexicon has been dedicated to Helen Martin and Muriel Straight in appreciation for their hard work, dedication and contribution to Basin stratigraphy. The book's structure is simple: a brief introduction, a section on examples of stratigraphic problems that presently exist in the geologic record, followed by most (but not all) of the units, both formal and informal, that have been used in the Basin. It concludes with a detailed bibliography and also contains appendices of the 1964 Chart I along with the newly proposed charts for the Basin.

The section on stratigraphic problems gives examples of stratigraphic units from almost every time period present in the Basin. There are many more than have been discussed, but they provide some insight into the method by which the Lexicon was constructed. It is the intent of the editors that future stratigraphers will have the necessary information to untangle the complex web of names that now exists. The stratigraphic section presents in bold print those units that are also shown on the proposed charts as well as other stratigraphic units. Information provided includes the age, related units, type section, and author if known, and other comments deemed useful. The bibliography that follows is as complete as possible for those involved in solving nomenclatural problems. It should be pointed out that some units present in areas close to the Michigan Basin are also included, where necessary. We hope that this book will be as useful as its predecessors have been.

PRESENTER:
Carrie Patterson

DATE: Tuesday, March 14
TIME: 10:45-11:15
ROOM: Room 103 A/B

PROGRAM TITLE:

Practical Uses of Glacial Maps – Examples from Minnesota

AFFILIATION:
Senior Scientist, Minnesota Geological Survey, 2642 University Avenue W, St. Paul, MN 55114, patte018@tc.umn.edu

ABSTRACT:

The artificial geologic maps produced by the Minnesota Geological Survey have been used in a variety of applications that range from the predictable to the unusual. Based on substantial experience with mapping approaches, and feedback from map users, we conclude that maps based on the most complete understanding of the geology are the most useful.

A map of the geologic material that is hidden beneath our fields and parking lots is necessarily based on widely spaced date points. The mapper must understand the origin of the deposits based on limited observations and accurately predict what remains buried. The ability to predict requires an understand of how surfcial agents especially glaciers work, and the history of glacial activity over the last 2 million years.

In the Minnesota approach to surficial geologic mapping, the mapper first develops a model for the evolution of the landscape based on preliminary interpretation of air photos, topographic maps or digital elevation models, soils maps, and archived sediment samples. Making new field observations at natural and artificial exposures and augering or coring where exposures are limited then tests this model or preliminary map. The final map is complied after one or more field seasons. The map and associated test emphasize the glacial depositional environment as well as the properties (texture, color, variability) of the deposits.

Public officials commonly are concerned with site-specific geological problems. Although targeting the specific geological feature of interest may seem efficient, preparing site-specific maps without regional context may be just as labor intensive and expensive as a regional geological mapping. When no model for the evolution of the landscape is developed, data points must be more densely spaced because the prediction of complex and discontinuous glacial units without an understanding of their genesis is difficult. In addition, if other needs or problems arise in the area, much effort expended in the first site-specific study must be duplicated in the next. Thus, we advise regional mapping to obtain regional geological understanding as cost-effective public policy in the long run.

Our surfical geologic maps have been used to:

Evaluate gravel and crushed rock resources.
Address agricultural concerns such as the siting of large animal confinement facilities and associated manure storage pits and spreading fields.
Evaluate the sensitivity of near surface aquifers to contamination.
Constrain the original distribution of native plant species.
Predict the potential for the presence of archeological artifacts.
Estimate sinkhole probability.
Develop wellhead protection plans for municipalities.
Prospect for groundwater.
Evaluate the balance of natural vs. artificial sediment loading in rivers.
Provide the framework for may site-specific environmental investigations.

Our support of the map product goes beyond simply delivering or selling it to the user. We host training sessions for map users and present what we have learned in our mapping to the general public in talks, print material and on our website. We also summarize our work in peer reviewed journals and present the ideas at scientific meetings. We continue to refine and re-evaluate our interpretations, as new date becomes available.

It is beyond the ability of the private secor to maintain the extensive geological database, qualified personnel, and the long term commitment to data reinterpretation that is necessary to construct a geologic map that is useful to a broad audience and has a long shelf life. Your state geologic survey is the ideal group to undertake this effort.

PRESENTER:
William Harrison III[3]

DATE: Monday, March 14
TIME: 11:15-11:45
ROOM: Auditorium

PROGRAM TITLE:

[3]The Devonian Interval of the Michigan Basin Geological Society Stratigraphic Nomenclature Project

AFFILIATION:
Professor of Geology and Director, Michigan Basin Core Research Laboratoy, Department of Geology/Western Michigan University, Kalamazoo, MI 49008, 616-387-5488, william.harrison_iii@wmich.edu

ABSTRACT:

The Stratigraphic Lexicon for the Michigan Basin has many formal and informal names that have been applied to Devonian rocks in Michigan. We have compiled and annotated all these names and tired to suggest which have formal stratigraphic validity and should be consistently used. There are however, some portions of the Devonian section that have not yet been satisfactorily defined by formally proposed names. We suggest that traditional nomenclature continue to be used until more extensive study resolves the proper stratigraphic terminology.

Devonian strata in the Michigan Basin are represented by variably thick sequences of open shelf, tidal flat and sabhka carbonates, interbedded with basin-centered and sabhka evaporites (anhydrite and halite). Coarse (sandstone) and fine (shale) clastics also occur at several intervals throughout the succession. Most of the strata in the Michigan Basin Devonian are part of the Kaskaskia cratonic depositional sequence (Sloss, 1963). The sequence begins with the southeast to northwest transgression of a quartz arenite sandstone facies (Sylvania Ss.) onto a weathered, cherty carbonate (Bois Blanc Fm.).surface developed on Lower Devonian strata exposed during the post-Tippecanoe unconformity. With rising sea level, the basin sediments became dominated by open shelf, biohermal and locally restricted lagoon carbonates (Amherstberg Fm.) Much of the Middle Devonian is represented by thick basin-centered sabhka and salina evaporates and restricted-environment carbonates (Lucas Fm.) These interbedded and laterally gradational evaporite/carbonite facies are cyclic, showing gradual salinity changes during accumulation. Overlying this restricted sequence are again open shelf, biohermal, and local restricted sabhka carbonate deposits (Dundee Fm.). Thin, but widespread and eastwardly thickening, terrigenous shales and mudstones are intercalated within another shelf carbonate/shale package (Traverse Group). Black shales (Antrim Fm.) cap Devonian deposits in the Michigan Basin.

The Antrim and Lucas have been formally divided into member units, however, some stratigraphic problems still exist with the use of formal and informal terms in the Lucas. There is also confusion as to the proper (stratigraphic) relationship between the Antrim and the Ellsworth shales in the western part of the basin. The transitional unit between the Antrim Shale and the Traverse Limestone, formerly termed the "Traverse formation" is now properly assigned to the Squaw Bay Fm. The Traverse Group has been successfully separated into formations and members in the outcrop, but application of the subdivisions to the subsurface has not been effective and needs much more work to result in formal nomenclature. The effect of the sequence boundary near the base of the Devonian is to confuse the relationships of the Sylvania SS., the Bois Blanc Fm., and the basal member of the Lucas Fm. More research of the stratigraphic relationships around this unconformity is needed

PRESENTER:
Dave Westjohn[4]

DATE: Tuesday, March 14
TIME: 11:15-11:45
ROOM: Auditorium

PROGRAM TITLE:

[4]Mississippian to Quaternary: Suggested Changes in Nomenclature for Geological Units in the Michigan Basin

AFFILIATION:
U.S. States Geological Survey, 6520 Mercantile Way/Suite 5, Lansing, MI 48911 517-887-8903

ABSTRACT:

The U.S. Geological Survey (USGS) Regional Aquifer-Systems Analysis (RASA) program completed a 10-year study of ground-water resources in the central part of the Michigan Basin in 1994. Thickness and surface configuration maps of Mississippian and younger geologic units were prepared by use of geophysical and geological logs of oil, gas, and water wells as part of this hydrogeologic investigation. This mapping led to some concerns regarding geological units in the basin, as they are depicted on the "Stratigraphic Succession in Michigan" chart (Michigan Department of Conservation, 1964).

The Stratigraphic Nomenclature Committee of the Michigan Basin Geological Society has made numerous revisions in stratigraphic nomenclature for the Michigan Basin. The committee has prepared a draft chart that depicts the "Stratigraphic Succession in Michigan". Additions, deletions, and/or changes in Mississippian and younger geologic units include: 1) graphic patterns have been added to the new chart to depict lithologic differences within Pleistocene glacial deposits, 2) Jurassic "red beds" (informal stratigraphic name) form a distinct mappable stratigraphic unit of significant areal extent, and assignment of formal stratigraphic nomenclature; Dr. Aureal Cross (Michigan State University) is currently working to get these deposits formally named, 3) member names for subunits of the Grand River Foundation (Ionia, Eaton, and Woodville Sandstone) refer to single outcrop localities; the actual position of the so-called Ionia Sandstone is debatable (sandstone at Ionia are probably Jurassic according to Dr. Cross) and these obscure names have been dropped from the charts, 4) there is no indication that the Verne Limestone Member of the Saginaw Formation forms a mappable stratigraphic unit—in fact there are multiple limestone horizons within the Saginaw Formation, all of which are laterally discontinuous; the obscure term "Verne Limestone" has been deleted, 5) no evidence was found for an unconformity between Bayport Limestone and Parma Sandstone, and the unconformity depicted on the chart has been queried because there is no definitive evidence to confirm or reject this unconformity.

Please see pages 35 and 36 for presentations in the Auditorium.

PRESENTER:
Bryon D. Stone[1], Wayne L. Newell, and Carl Koteff

DATE: Tuesday, March 14
TIME: 11:15-11:45
ROOM: Room 103 A/B

PROGRAM TITLE:

The Morphosequence Concept and its Application in New Detailed Mapping Studies in the Central Great Lakes Region

AFFILIATION:
U.S Geological Survey, National Center, MS 926-A, Reston, VA 20192, [1]bdstone@USGS.gov,

ABSTRACT:
Glacial geologists first recognized the significance of individual ice-marginal meltwater deposits, such as a single glaciofluvial outwash plain in one valley or an ice-contact delta in a glacial-lake basin, with the advent of topographic base maps in the 1890's. In the early years of the USGS-Massachusetts cooperative geologic project, R.H. Jahns produced the first 7.5' quadrangle geologic map of detailed glacial geology of eastern Massachusetts. Jahns recognized repeated patterns in morphologic features from south to north, particularly esker-fed plains and lake-bottom deposits. He combined physically related features, deposited contemporaneously at and beyond the edge of the ice sheet, in a single map unit, which he called a morphologic sequence. The expanded and renamed morphosequence-mapping concept is applied to meltwater deposits at a scale of 1:24,000. A morphosequence is a body of meltwater deposits composed of a continuum of land forms, grading from ice-contact forms (eskers, kames) to non-ice-contact forms (flat valley terrace, delta plains), that were deposited simultaneously at and beyond the margin of a glacier, graded to a specific base level. Morphosequences occur at decoupled stagnant ice zones; each deposit is an informal allostratigraphic unit that records the systematic retreat of the glacial ice margin. These units typically reflect the continuum of meltwater depositional environments where sediments accumulated: ice tunnel; ice-contact stream, delta, or subaqueous fan; progradational non-ice-contact delta or fan; distal stream or lake. The units summarize the overall downstream fining and sorting of sediments in each deposit that resulted from processes active in each environment. Deposits range from ice-proximal coarse, bouldery gravel to distal silt-clay couplets in lake beds. Detailed interpretations and focussed subsurface data collection in the deposits effectively predict aquifer and aggregate-resource properties. Our initial work in Berrien County, MI, indicates that morphosequences are mappable in valleys and glacial lake basins of the Great Lakes region. In the Valparaiso moraines, numerous morphosequences record the stagnation of local belts of glacier ice 1 to 2 miles in width and a few miles in length. Bedrock topography is not an important control of the distribution of these deposits; however, the antecedent topography of pre-existing deposits did shape the lake basins that received sediment. The effects of readvancing glacier margins are more apparent in morphosequences in southwestern Michigan than in the northeastern U.S. In southern Berrien County we have mapped a readvance recorded in the outer Lake Border moraine over deposits of the Valparaiso belt. This readvance overrode at least 10 to 15 miles of pre-existing deposits. In the northern part of the county, similar juxtaposition of younger Lake Border moraine deposits against or over Valparaiso deposits has been observed in outcrops that reveal actual duplex-thrust faults at the head of a morphosequence.

PRESENTER:
E. R Tegland, and
P. H. Bygott

DATE: Tuesday, March 14
TIME: 2:15-2:45
ROOM: Auditorium

PROGRAM TITLE:

S/N Ratio and Bandwidth Considerations When Utilizing Seismic Data in Exploring for Subtle Traps Examples from the Knox Play

AFFILIATION:
Exploration Development Inc., 10970 South Pikes Peak Drive, Parker, CO 80138, 303-840-7021

ABSTRACT:

The concepts of bandwidth and SIGNAL TO NOISE (S/N) ratio are highly interrelated and for the most part are controlled by the acquisition technique employed and the near surface geology over which the seismic data collection is carried out. External forces such as wind noise, cultural/traffic noise, and instrumental problems may also play a part in defining the final quality of information. These latter items can be countered in part by diligent efforts of the seismic acquisition contractor. The question, "What constitutes noise?" is briefly reviewed.

What is S/N ratio? Generally, this is defined as the ratio of peak signal amplitude to RMS noise level in the general time window of interest. In areas where there is significant amplitude variation between different geologic events one normally defines this by the behavior of the stronger reflectors. The seismic interpreter should remember that at best the normal seismic display could reveal a 20 dB (10 to 1) amplitude ratio. That is to say if two reflected events have amplitude levels that are more widely separated than this only the larger event will be observed unless extreme display measures are taken. By the same measure if noise amplitudes exceed 10 times the amplitude of the desired signal one has little chance of interpreting the data.

What is bandwidth? Bandwidth is the difference between the highest and lowest measurable frequency present in the data. More important to the seismic interpreter is the "useable bandwidth". This is the frequency range low to high over which coherent interpretable data can be detected. In other words the useable bandwidth is that which has a S/N ratio that allows the signal to be seen and tracked in space. The relationship between time dip rate and useable bandwidth will also be reviewed.

Model data created from an Ohio Knox synthetic Seismogram will be used to illustrate what this means to the person observing seismic data in traditional display format. This model data is also used to illustrate the role of processes such as stacking. Real Beakmantown data examples will be used to illustrate the more advanced processes.

Presented in this discussion will be some basic concepts that are aimed at maximizing the "useable bandwidth" from the data processing point of view. The pros and cons of various steps that influence the useable bandwidth will be examined with samples of actual Knox seismic data. Also discussed will be some broader concepts in the interpretation of the seismic data, i.e. escaping from the "one line one zone syndrome".

The interpreter/end user should be aware that there is no silver bullet that will slay all the dry hole vampires. Therefore the up-and downside aspects of various techniques must be understood. Various noise attenuation techniques are in everyday use and the relative merits of each are discussed. Where possible, real data examples will be used to illustrate key points. Obviously one could move a few hundred feet away and be in another problem world. Therefore each project should be viewed as somewhat unique until it is proven otherwise.

PRESENTER:
D. Dale Werkema Jr.,[1] Estella Atekwana,[2] William Sauck, Silvia Rossbach, and Joseph Duris

DATE: Tuesday, March 14
TIME: 2:15-2:45
ROOM: Room 103 A/B

PROGRAM TITLE:

Vertical Distribution of Microbial Abundances and Apparent Resistivity at a Michigan LNAPL Contaminated Site

AFFILIATION:
Western Michigan University, [1] Department of Geosciences, [2] Department of Biological Sciences, Kalamazoo, MI 49008, [1]d.werkema@wmich.edu

ABSTRACT:
Geoelectrical detection and monitoring of Light Non-Aqueous Phase Liquid (LNAPL) contamination has been predominately based on the electrical "insulating model" response, where the geoelectrical response is more resistive than background. Recent field observations have provided results contrary to this model and suggest that LNAPL contaminated zones undergoing natural biodegradation generate a low resistivity (high conductivity) zone. In an attempt to better understand the anomalously high conductivities in and below free product/residual LNAPL plumes, continuous soil samples were obtained from four locations in the Carson City Park, which is located adjacent to the former Crystal Refinery in Carson City, MI. The samples were taken from borings next to monitoring wells, and Vertical Resistivity Probes (VRPs). Two of the collection sites, considered the controls, extend off the free product plume and two sample locations are within the LNAPL free product plume. Sub-samples, used for counts of cultured bacteria, were removed from the original cores at small vertical intervals. The bacterial counts were correlated with the bulk apparent resistivities measured in the corresponding VRPs, and with the sediment descriptions. (For Figure see page 50.) Populations of microorganisms at this site ranged from 4.7 x 102 to 5.0 x I04 CFU/g (colony forming units/gram) soil. Our data indicate that there is a peak in total heterotrophic microorganisms and in oil degrading microorganisms at 120-cm (48-in.) depth coincident with the capillary fringe and water saturated zone interface. The counts of oil degrading bacteria parallel the total heterotrophic counts at each depth, but are consistently-less, on the order of 5.0 x I03 to 3.0 x 104 CFU/g soil-than the total heterotrophic counts.

The following figure shows the results from VRP5, which represents the response indicative of an area contaminated with LNAPL. Beginning at the surface and progressing with depth, the apparent resistivity results reveal a highly variable but higher apparent resistivity vadose zone. At a depth of 120 cm (48 in.), and coincident with the first encounter of LNAPL. (For Figure see page 50.)

Populations of microorganisms at this site range from 4.0 x 102 to 7.0 x I05 CFU/g soil with oil degrading microorganisms representing 13-23% of the total heterotrophic microorganisms. There is a large peak in population size (7.0 x I 05 CFU/g soil) at 244 cm (88 in.) in depth. Also at this depth, the percentage of oil degrading microorganisms jumps from 23% to 100% of the total heterotrophic microorganisms. Interestingly, this peak of hydrocarbon degrading bacteria converges with the heterotrophs count and corresponds to the Wenner boundary response and a low apparent resistivity (20-30 Qm) observed from 250 - 265 cm (102 in.) depth. This depth also corresponds to a change from a darker tan coarse sand and gravel with slight gasoline odor ('C') to a gray, sand and gravel with strong gasoline odor ('D'). When the resistivity returns to normal at greater depths, the percentage of oil degrading microorganisms begins to decrease as well.

In general, at the LNAPL contaminated location there is an orders-of-magnitude increase in bacterial abundance at the levels where the apparent resistivity is at a minimum. The control site reveals the natural vertical and lateral background variability of apparent resistivity in the absence of LNAPL. The results indicate that apparent resistivity measurements can provide a window into the biogeochemical processes ongoing at LNAPL-impacted sites and continue to encourage the use of resistivity as an option to monitor the natural or enhanced bioattenuation of such sites.

PRESENTER:
J. Ford Brett

DATE: Tuesday, March 14
TIME: 2:45-3:15
ROOM: Auditorium

PROGRAM TITLE:

Breakthrough Drilling & Completion Performance-Case Studies

AFFILIATION:
Oil & Gas Consultants International, 4111 South Darlington Avenue, Tulsa OK 74135-6377, 918-742-1982, fbrett@ogci.com

ABSTRACT:

"*The prospect of hanging wonderfully concentrates the mind*" - Sir Winston Churchill

With product prices the lowest they have been in real terms in over 30 years, many in the petroleum industry can sympathize with Sir Winston Churchill. Clearly, the current economic situation presents petroleum engineers with very serious challenges. Product price being such a problem, the industry has no choice but to find some way to address costs. Even during times of reduced activity. drilling and completion costs are typically 40 to 60% of an E&P organization's total costs. The purpose of this presentation is to show how some organizations have significantly reduced drilling and completion costs, and to show the impact of that performance on bottom line economics.

To accomplish this purpose the presentation will:

- Review several examples of true breakthroughs in drilling and completion performance — cases where drilling and completion costs were reduced by 20 to 50% compared to the industry' s benchmark.
- Describe the factors and approach common to each of these successful cases.
- Suggest positive steps other organizations can take to achieve similar breakthroughs in performance.

As an industry, the challenge of finding more cost-effective ways to drill and complete wells will be found, or like Winston Churchill. the industry will face dire consequences. This presentation presents one possible road map to achieving more cost-effective drilling and completion operations.

PRESENTER:
Allan R. Blaske

DATE: Tuesday, March 14
TIME: 2:45-3:15
ROOM: Room 103 A/B

PROGRAM TITLE:

Geochemistry and Mineralization of Michigan's Mississippi-Valley Type Deposit, Bellevue, Michigan

AFFILIATION:

Blaske Geoscience, 8313 Hartel, Grand Ledge, MI 48837, alblaske@gateway.net

ABSTRACT:

The Bayport Limestone is exposed in quarrying operations at Bellevue, in southwestern Eaton County, Michigan. Mining has been active around Bellevue since the mid-1800's. Approximately 25 feet of the Bayport is exposed in the quarrying operations, and consists of a gray to buff colored thin-bedded limestone. A gray-green sandy limestone is present at the bottom of the quarry, and is not mined. The upper one-third of the limestone in the quarry has been oxidized. Limestone in a second quarry, located approximately 1 mile to the south, is completely oxidized.

The Bayport limestone is late Mississippian in age, and comprises the upper portions of the Grand Rapids Group. It is underlain by the Michigan Formation, also of the Grand Rapids Group. The early Mississippian Marshall Sandstone and Coldwater Shale lie below the Grand Rapids Group. The Bayport is overlain by the early Pennsylvanian Saginaw Formation.

Mineralogy of the deposits is simple, consisting predominantly of pyrite, marcasite, and calcite. Pyrite is most commonly found as encrustations of cubic crystals, formed directly on limestone. Marcasite is generally lighter in color than the pyrite, and often in iridescent, platy crystal groups. Two generations of calcite are observed. Early calcite is found as small dusty crystals lining cavities as drusy coatings. The second generation of calcite is found in large, euhedral crystals and cleavable masses. Early-stage calcite is also found in small vugs within the massive limestone, unrelated to sulfide mineralization. Trace amounts of barite have been observed, but not associated with the sulfides. Early calcite lines the cavities filled with barite. Fluorite, sphalerite, and celestite have also been reported. Pyrite appears to have formed first, in association with the early calcite. Marcasite is later than the early calcite, and is usually coated with late euhedral calcite. Tiny crystals of marcasite can also be found on the large calcite.

Iron sulfides and calcite are present predominantly in breccia zones and vein structures within the Bayport Limestone. The formation of these breccias appears to be by solution activity. Two types of breccia have been observed. The most common consists of small, angular clasts surrounded by open-space filling of sulfides and calcite. The second type of breccia consists of larger, rounded clasts, with the interstitial spaces filled with a muddy limestone and pyrite. Orientation and size of the mineralized zones within the limestone is not known, due to lack of exposure within the quarry and insufficient historical mapping. Fine-grained pyrite is observed as replacement structures, along apparent solution fronts within the massive limestone. Some pyrite is also present as massive (up to 8-inches thick) vein-like replacements within the limestone.

The geochemistry of the sulfides indicates the simplicity of the mineralization. 36-element ICP analysis of pyrite and marcasite separates, as well as a composite breccia sample, indicates very low concentrations of trace elements. Copper, lead and zinc are found at less than 60 ppm. Nickel is less than 30 ppm, and cadmium and cobalt less than 5 ppm. Barium is also low, generally less than 20 ppm. Manganese is high in the breccia, and lower in the sulfide separates, while chromium is high in the sulfides (150-PPM) and low in the breccia.

Sulfur isotopic compositions were analyzed on separated samples of pyrite and marcasite. These isotopic values provide an indication of mode of origin of the mineralizing fluids within the deposit. Unpublished data obtained from the USGS as part of the RASA program indicate a large range of $\delta^{34}S$ in samples collected from the underlying Marshall sandstone and Michigan formation, as well as the overlying Saginaw formation and the Jurassic Red Beds. Pore water, sulfide, and sulfate sulfur isotope compositions for the underlying formations exhibit average $\delta^{34}S$ near 20°/$_{oo}$, while the average $\delta^{34}S$ within the overlying formations is closer to 17 °/$_{oo}$. Sulfur isotopic composition data of the sulfide phases from the Bayport limestone indicate slightly lower isotopic composition. S composition of the pyrite is 14.5, and 12.8 for the marcasite. These compositions indicate a source of mineralizing fluids from within the surrounding Mississippiam and Pennsylvanian formations.

The quarries at Bellevue are located within one township to the northwest of the known northwest end of the Albion-Scipio Oil Field Trend. This structure is located within the Trenton-Black River (Middle Ordovician) rocks. Evidence of the structure, however is present in the lower Mississippian Sunbury shale formation, approximately 3,800 feet higher that the Middle Ordovician rocks. The Bayport formation lies only approximately 1,000 feet to 1,500 feet above Sunbury shale. If movements associated with the Albion-Scipio Trend are evident to the lower Mississippian Sunbury, it seems likely that the upper Mississippian Bayport formation would also be affected by faulting associated with the structure. Minor fractures associate with the Trend may be responsible for small structures in the Bayport, allowing for brecciation, subsequent fluid migration, and sulfide precipitation.

Appendix A - Illustrations for Abstracts

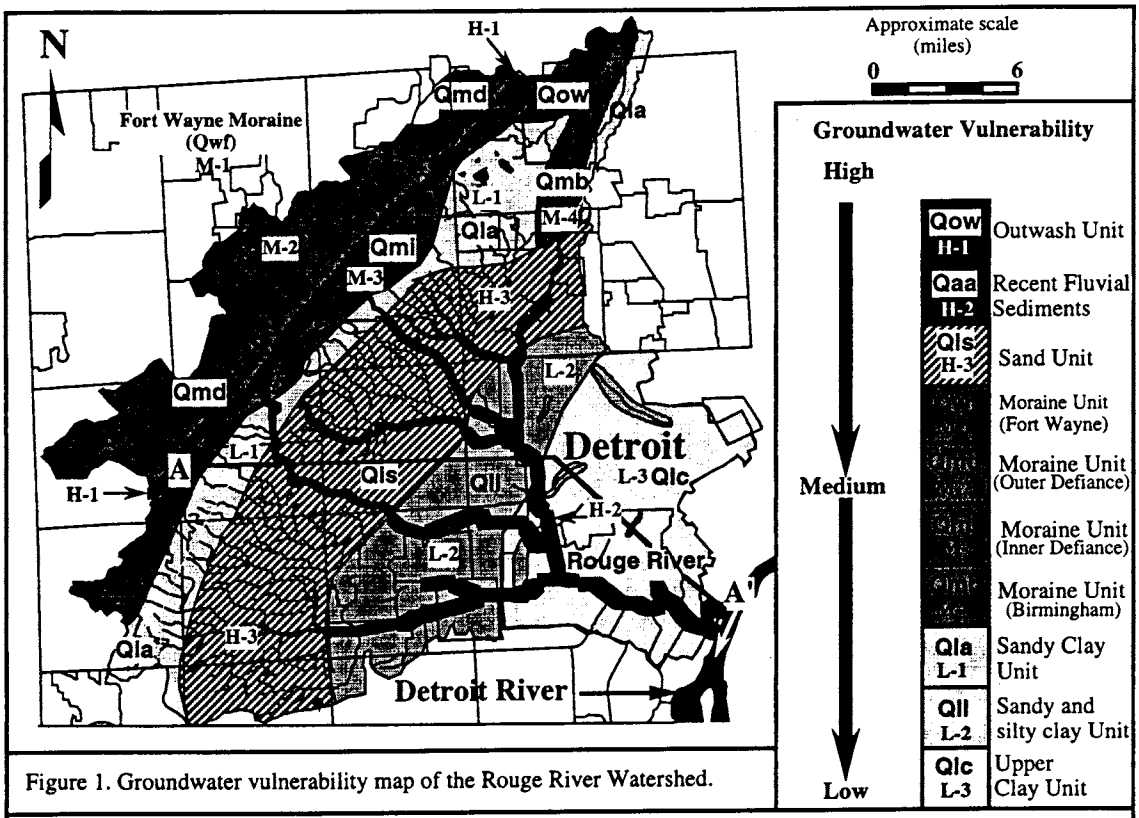


Figure 1. Groundwater vulnerability map of the Rouge River Watershed.

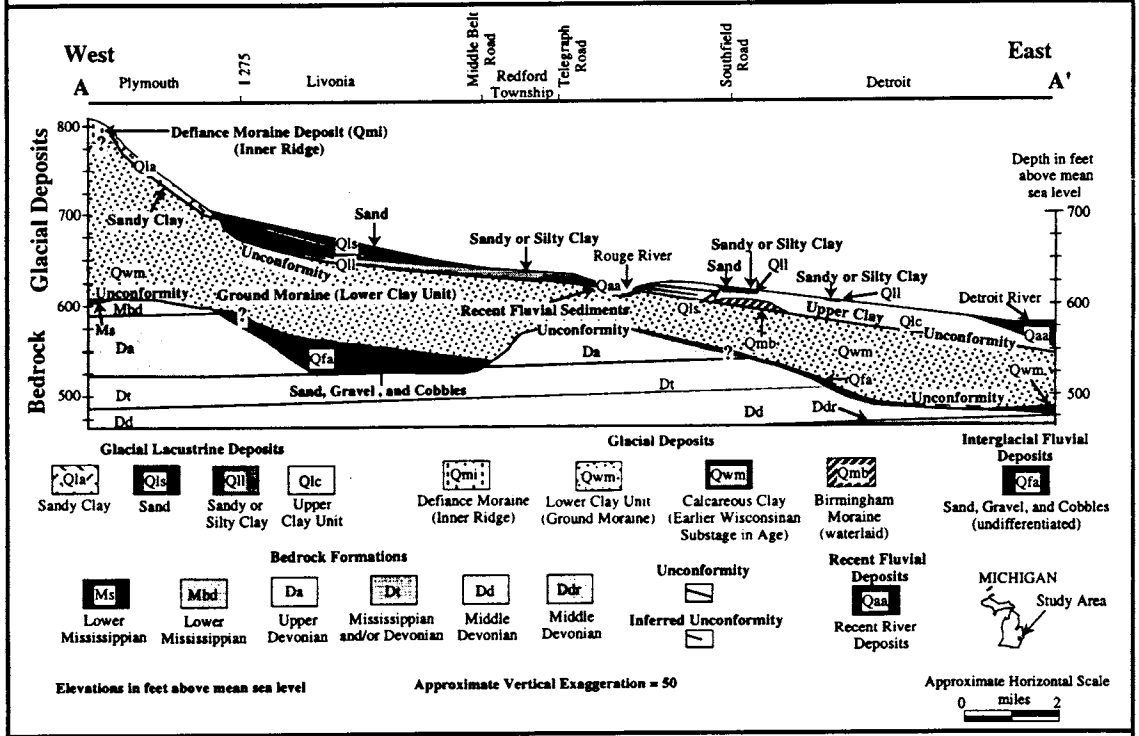


Figure 2. Generalized geologic cross section.

Figures 1 & 2 from Rogers – Future Urban Development ... – see page 1 of abstracts.

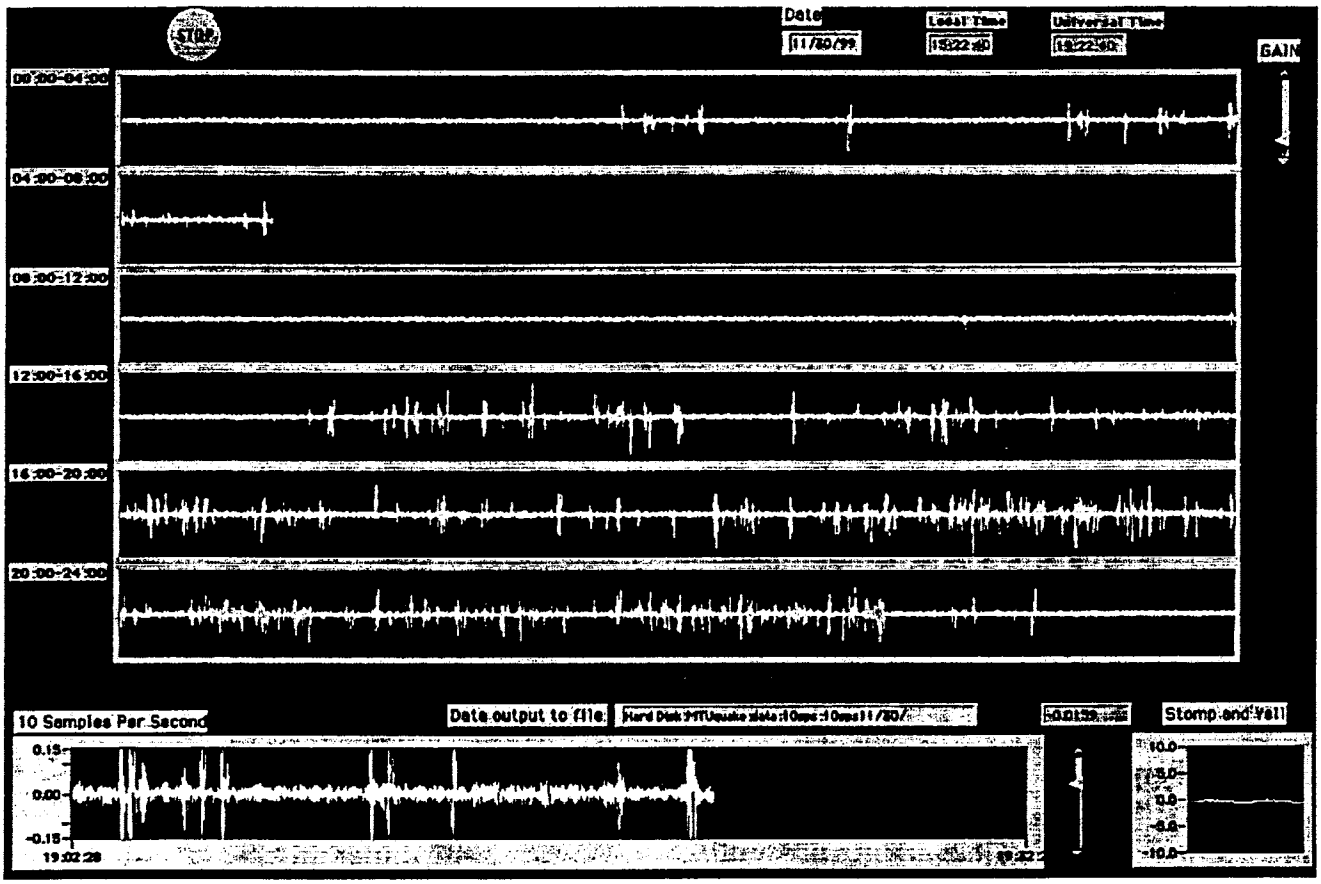
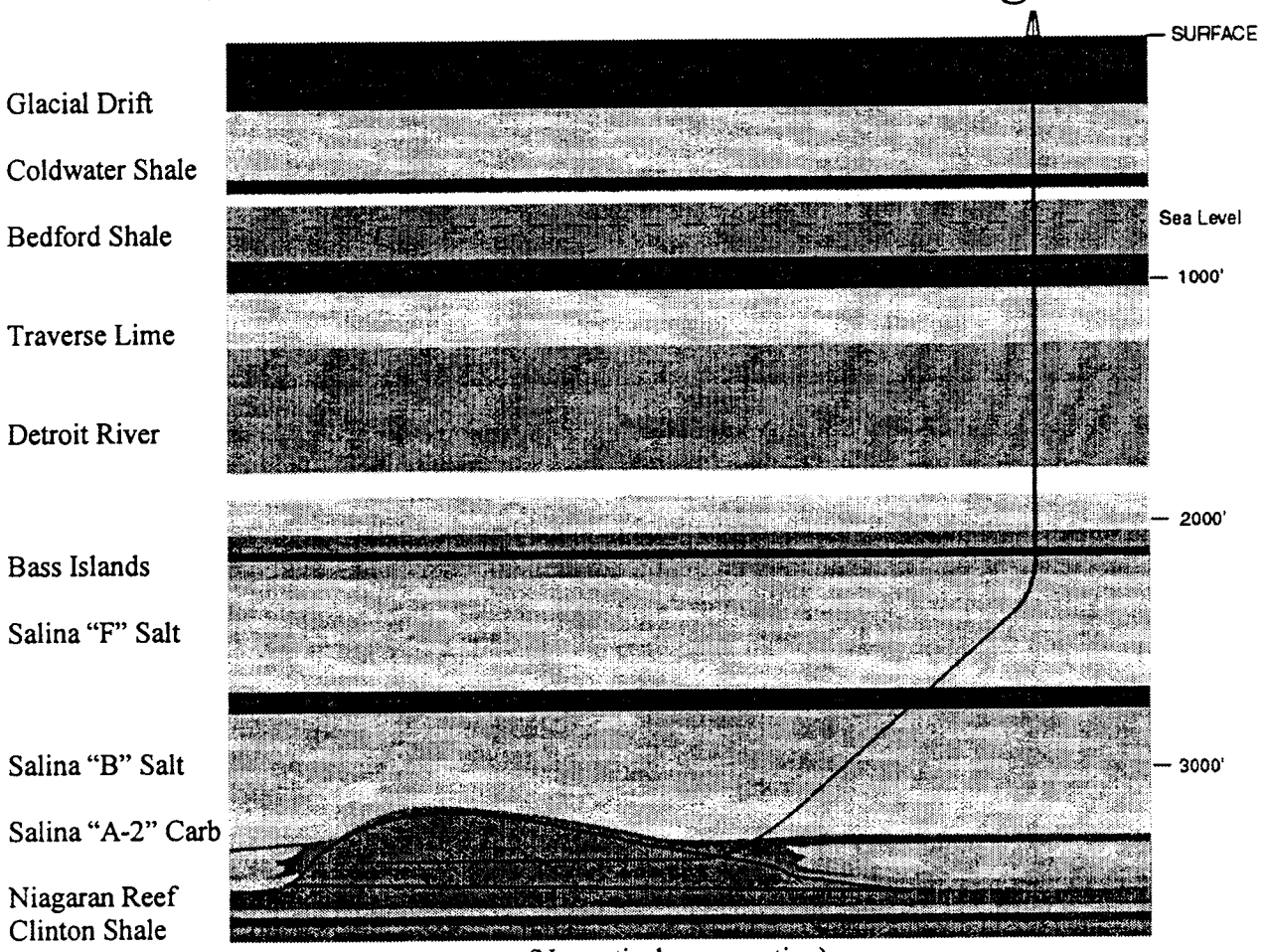


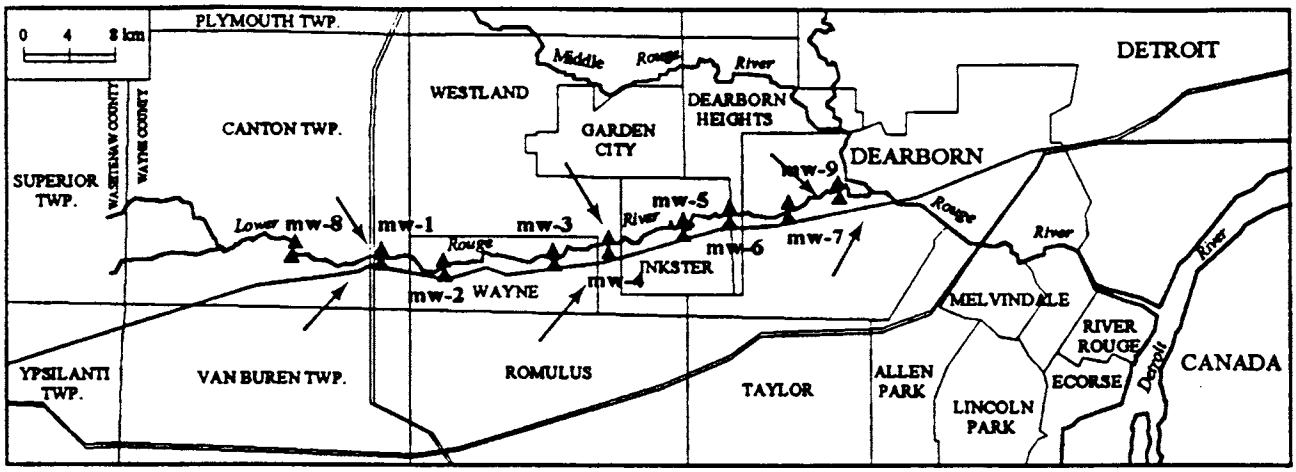
Figure from Pennington – A Global Seismograph for Volunteer and Teachers – see page 2 of abstracts

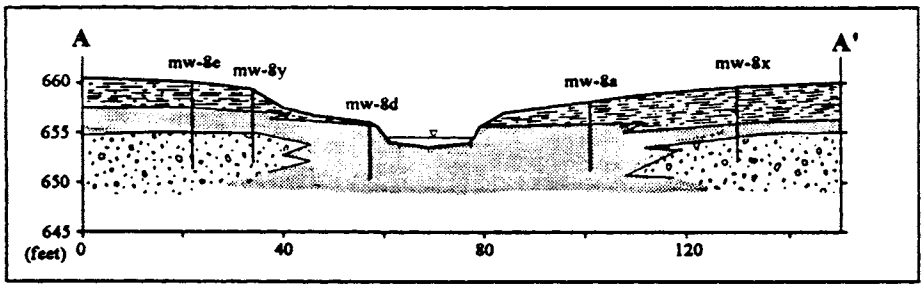
West-East Cross Section Washington 10

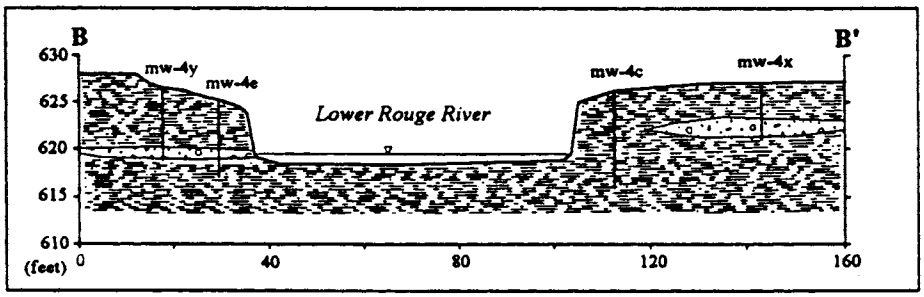


(No vertical exaggeration)

Figure from Metzger – Washington 10 ... – see page 13 of abstracts







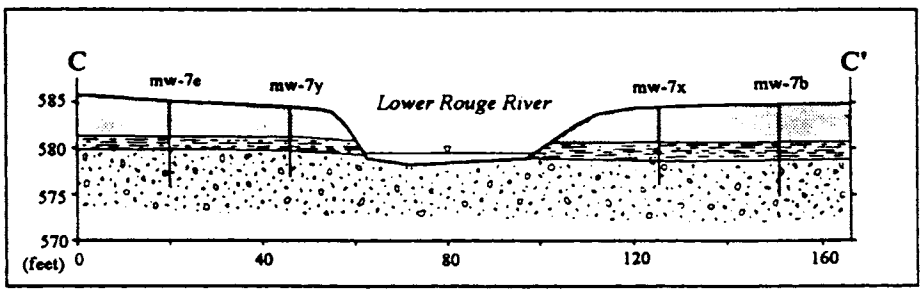


Figure from Howard – Geochemical Forms of Lead ... – see page 19 of abstracts

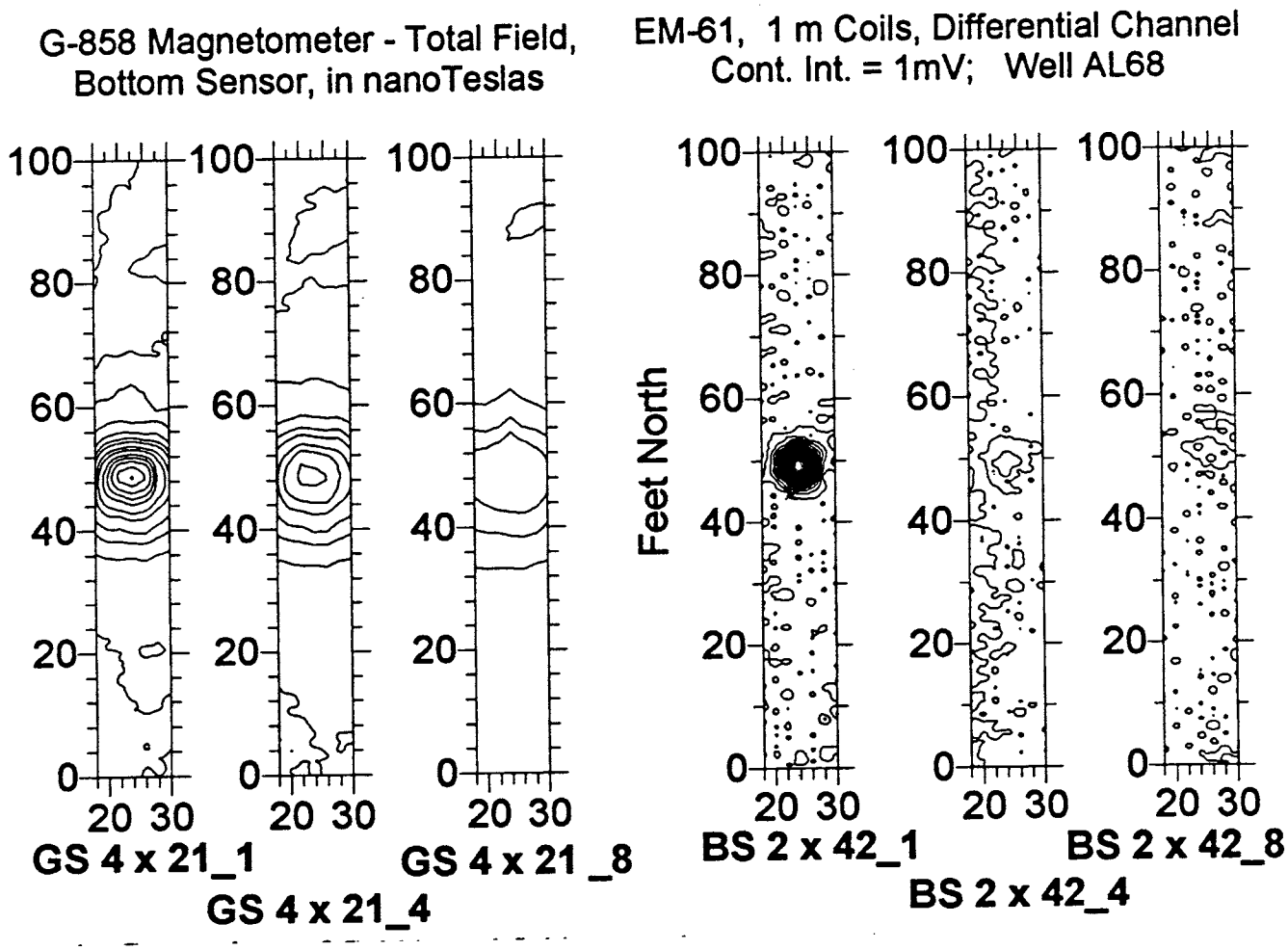
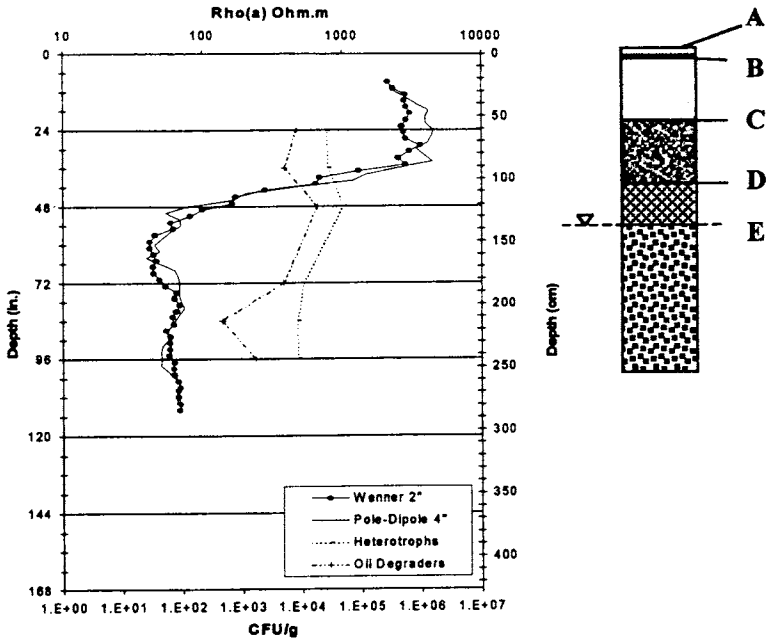
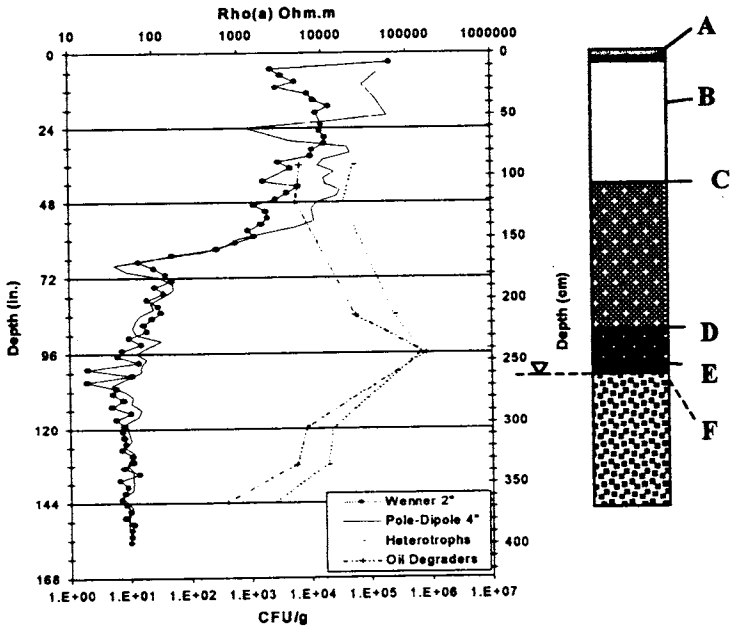


Figure from Sauck – Geophysical Detection ... – see page 31 of abstracts



VRP7, Apparent resistivity, bacterial count and sediment description.
No LNAPL observed.

A. organic black top soil
B. fine-medium tan sand
C. fine-medium moist tan sand
D. sand and gravel, moist
E. saturated gravel with some sand



VRP 5 from Carson City,ML, Apparent resistivity, bacterial count, and sediment description. LNAPL thickness = 8.3" above water table.

A. organic black top soil
B. fine-medium grained tan sand
C. darker tan coarse sand and gravel, moist, slight gasoline
D. gray, sand and gravel with strong gasoline odor
E.gravelly sand with saturated free product
F.water saturated sand and gravel

Figures from Werkema – Vertical Distribution ...– see page 42 of abstracts

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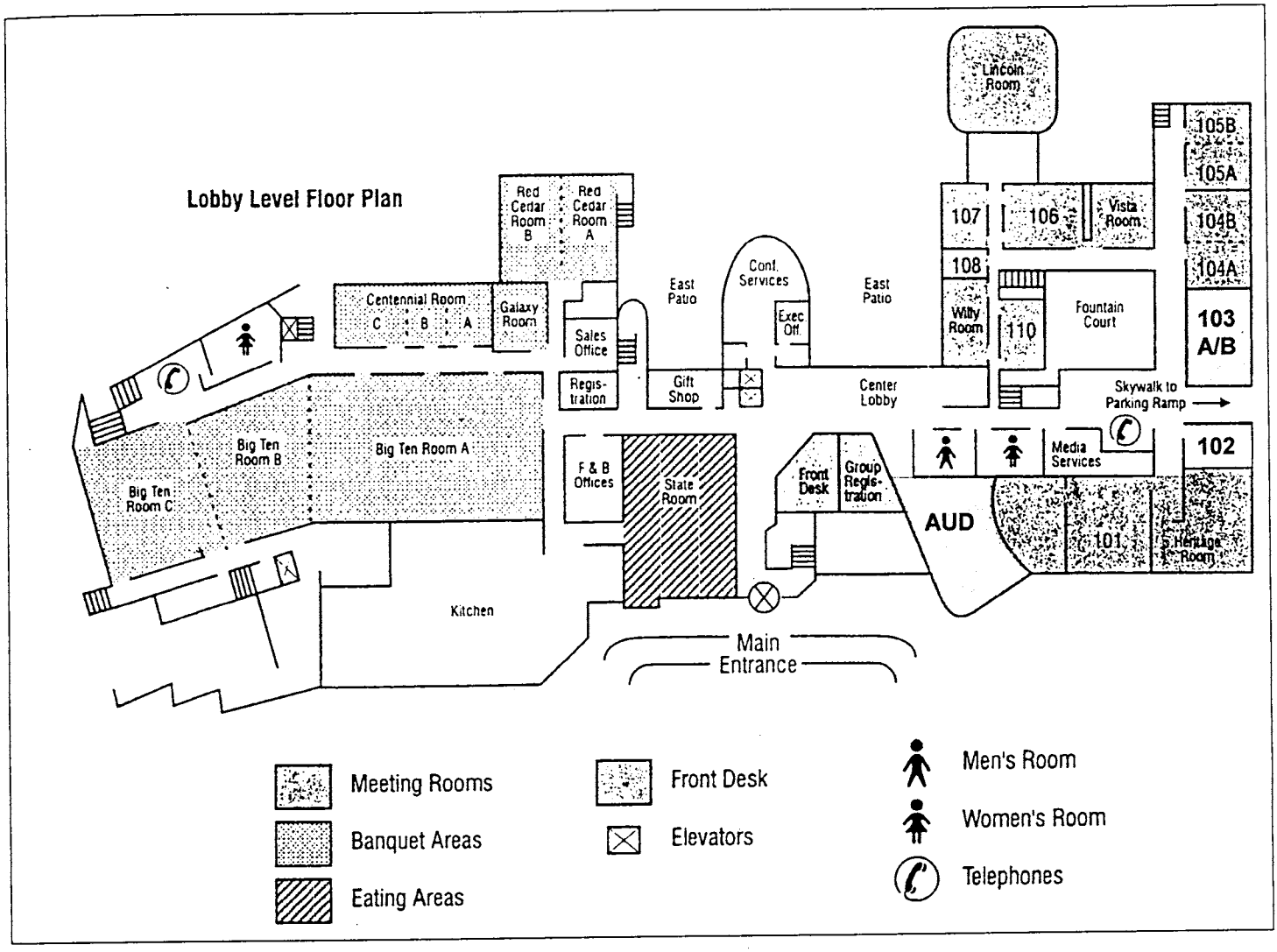

Floor Plan of the Kellogg Center at the Lobby Level.