NDGS NEWSLETTER

Industrial Commission of North Dakota
North Dakota Geological Survey

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A blowout in stabilized eolian dunes one mile south of the town of Lincoln (Township 138N, Range 79W, Section 29). Upwards of 25 feet of windblown sand and silt mantle Cannonball strata in this area. These dunes have been formed over the last 10,000 years as northwesterly winds eroded sediment from the Missouri River Valley and deposited it in these uplands.

FEATURES

DEPARTMENTS

NDGS Newsletter (ISSN: 0889-3594) is published quarterly by the North Dakota Geological Survey, a division of the Industrial Commission of North Dakota. *NDGS Newsletter* is designed to reach a wide spectrum of readers interested in the geology and mineral resources of North Dakota. Single copies of *NDGS Newsletter* are distributed free upon request. Please share the *NDGS Newsletter*; we encourage its reproduction if recognition is given.

Your comments - and contributed articles, photographs, meeting announcements, and news items - are welcome. Correspondance, subscription requests, and address changes should be addressed to: Editor, *NDGS Newsletter*, North Dakota Geological Survey, 600 East Boulevard Avenue, Bismarck, ND 58505-0840 • (701) 328-8000.

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FROM THE STATE GEOLOGIST

By John P. Bluemle

In North Dakota last year, 32.3 million barrels of oil were produced, up 3.0 million barrels from the year before and up 4.7 million barrels from the recent low of 27.6 million barrels recorded in 1994. We are, however, still a long way from our historic production high in North Dakota of 52.6 million barrels, reached in 1984. In August, 1996, Bowman County rose to the number one county in per month production having produced 563,959 BO. The increase from number six at 105,132 BO in October 1994, has been due to production from the ongoing Red River "B" horizontal drilling play centered in western Bowman County. However, in June of 1997, Bowman County per month production was over taken by Stark County production of 605,625 BO. Increased production in Stark County resulted from the jump in Lodgepole production when the Eland Lodgepole waterflood unit was put into operation. The Eland unit's 14 wells alone produced 308,205 BO of the June total. September 1997 production figures from the N.D. Industrial Commission Oil and Gas Division show Stark and Bowman counties still running nearly "neck and neck" for the number-one spot having produced 611,254 BO and 603,963 BO respectively.

I am occasionally asked "how big is a barrel of crude oil?" The technically correct answer to this question is that a "barrel" of oil equals 42 U.S. gallons at 60° F. But why is it 42 gallons? In Canada and most of the rest of the world, oil is measured in terms of cubic meters (one cubic meter contains 6.289 bbls of oil). When I worked in my dad's grocery store in Iowa in the 1950's, he sold bulk vinegar from oak barrels that held between 55 and 60 gallons. When my dad got in a new barrel, I had to auger a hole in it and hammer in a spigot. In the process I think I usually spilled about a gallon of vinegar!

Webster's Dictionary says that a barrel, as a liquid measure, contains 31.5 gallons. However, things are not necessarily that straight-forward. Beer, for example, comes in "16-gallon" containers known as "half-barrels" or "kegs". A keg actually contains 15.5 gallons of beer. Even though the State of North Dakota defines a beer barrel as 32 gallons, a barrel of beer actually contains only 31 gallons. Whiskey, on the other hand, comes in barrels that range from 57 to 61 gallons (essentially the same as my old rough-measure vinegar barrels). The range in whiskey-barrel volume reflects differences that can occur due to evaporation and differences in proof -- the higher the proof, the less the evaporation (for all of this information on spirits, I thank my Secretary, Gina Buchholtz, whose husband, Jeff, deals with wholesale and retail liquor sales).

Given the confusion in measuring liquor, I suppose it's not surprising that oil is no simpler. The origin of the oil-barrel measurement has been widely debated (a summary of some ideas about the origin of a "barrel" of oil is given on page 788 of *The Prize*, Daniel Yergin's 1991 book about the oil industry). The real origin of the 42-gallon oil barrel is lost in history. I'll recount some of the more common explanations that have been suggested, although I can't be sure which, if any of them, are right.

According to one account, when crude oil was first produced commercially in Pennsylvania in the middle of the nineteenth century, a variety of "barrels" were used to catch the liquid - whatever containers were handy. They included those used for wine, beer, whiskey, cider, and other liquids. However, the need for a standard measurement to be used in the oil trade soon became apparent.

The "tierce" was a defined wine measurement of 42 gallons in early use in Britain, as was the herring or spiced meat barrel, and a barrel of spruce beer. These were all 42-gallon containers. These barrels may have become the standard oil-field measurement because they were also in common use in the United States. They were very carefully made, tight, wooden containers. Since they were used for wine, it's logical they would also be made leak-proof! These containers would also hold oil very well.

The *Oil and Gas Journal* of April 15, 1921, recounted a different story. It said, unequivocally, "In 1864-65, the first standard barrel was made by Samuel Van Syckle at Miller Farm, near Titusville, Pennsylvania. It was 42-gallon capacity, the size fixed in the year 1461 in England for the herring barrel, during the reign of Edward IV. Van Syckle specified the size of the staves to be used and made an honest 42-gallon barrel. Almost immediately he had practically a monopoly of the business and the odd-size barrels gradually disappeared."

In still another reported origin of the oil barrel, it is noted that the "lack of a standard measure caused confusion, friction, and short tempers. In 1866, a group of oil producers got together in West Virginia and issued a proclamation that stated they would sell oil only by the gallon, but that an allowance of two gallons (for leakage and impurities) would be made for every 40 gallons, thus making a total of 42 gallons." From this, the 42-gallon barrel emerged, and ten years later a Council of Producers formally adopted the 42-gallon barrel as the standard measure.

These are some of the possibilities that I found for the origin of the "oilman's barrel." There are other explanations too, and obviously they cannot all be correct.

Another related question is how the abbreviation "bbl" came to be used for the oil barrel, because there is not a second "b" in the word "barrel." Oil historian, Paul Giddings, in his book *Standard Oil Co.* (1955), writes that kerosine was shipped in blue painted barrels and gasoline was shipped in red painted barrels. The term "rbl" was used to designate the gasoline barrel, which was red, and "bbl" indicated the blue kerosine barrel. The "bbl" symbol was the designation most commonly seen in refinery shipment records. This ultimately became the general symbol for all oil in barrels. (Incidentally, according to my source, "kerosine" is the petroleum industry spelling. "Kerosene" is the more common spelling. My dictionary says either spelling is acceptable.)

So much for all of these speculations. In the United States, crude oil production is always reported in barrels whereas oil *spills* are almost always reported in gallons. Actually, crude oil never sees the inside of a "barrel." It is generally piped or sent to its destination by tanker. I recall reading a newspaper article several years ago about the nation's strategic oil reserve program. One congressman, (unnamed, but definitely **not** from North Dakota) complained that the program was unworkable because it would be too difficult to store all that oil in so many metal barrels. He had even calculated the space the barrels would occupy! Mountains of 42-gallon barrels! I suppose he'd have North Dakota farmers delivering their wheat to the elevator in thousands of individual bushel baskets. Both would be very hard to handle.

All of this may be more than you ever wanted to know about this particular topic. Much of it is summarized in a new (1997) book I've been reading. Titled *GeoDestinies: The inevitable control of earth resources over nations and individuals*, this interesting and useful 500-page book by Walter Younquist is a kind of geoeconomics that should appeal to geologists, economists, sociologists, and others who are interested in knowing more about how geology has shaped our destiny and how it influences the way we live today. It's an interesting book that can be obtained from the National Book Company, P.O. Box 8795, Portland, OR 97207-8795. The ISBN number is 0-89420-299-5 and the book is priced at $29.95 plus shipping. I recommend it!

NEWS IN BRIEF

Compiled by Ann M.K. Fritz

NDGS Welcomes 3 New Employees

We have a full house now at the NDGS with the addition of Colin Clampet, Sheila Glaser and Elroy Kadrmas. Together with Don Thom and Steve Kranich (introduced in the Fall 1997 *NDGS Newsletter*), Colin, Sheila and Elroy are all working on compiling and digitizing the state soil survey information. All three new hires are highly qualified individuals with diverse backgrounds.

Colin Clampet claims Anchorage, Alaska as his hometown. After graduating from high school there, he joined the U.S. Army and served for seven years in the Special Forces Division. After his military stint was over, he found it difficult to find a civilian position equivalent to that of a Nuclear Biological Chemical Warfare Specialist and decided to take up drafting instead. He attended Black Hills State University and received his Bachelor of Science degree in Industrial Technology. He also has an Associate Degree in Drafting. Prior to working at the Geological Survey, Colin was employed at Toman Engineering in Mandan. Colin and his wife Pam, their two cats and a dog reside in Mandan.

Elroy Kadrmas is a North Dakota native who attended North Dakota State University majoring in Earth Science. He was a supervisor for 15 years with Knife River Coal. Elroy also assisted in both on-site and off-site exploration for the mining industry. Prior to his job at Knife River Coal, Elroy served for four years in the U.S. Air Force. He and his wife Susan reside in Bismarck with their two daughters, Katharine and Emily.

Sheila Glaser has not served in the armed forces, but like Elroy, she worked for several years in coal exploration. Sheila is also a native North Dakotan and grew up near Flasher. She worked several years in the drafting field in telecommunications and underground water systems, including the Southwest Water Pipeline Project in western North Dakota. Sheila is married to Kenneth Glaser and they have two children, seven-year-old Brooke and ten-year-old Dylan.

Stop on by and say "Welcome" to our new soil compilers (pictured at right)!

A Note from the Editor

I probably am no longer considered the "new" editor of the *NDGS Newsletter*, as I have now been at this position for more than a year. With each issue, I strive to continue in the fine tradition that John Bluemle started and Bob Biek continued. When Bob Biek took over editorial responsibilities of the *NDGS Newsletter* in 1992 he wrote a tribute to its founder, John Bluemle. Bob even wrote that he was in 7th grade when the first *NDGS Newsletter* was published. I too, give John Bluemle much credit for developing the *NDGS Newsletter* to the quality publication that it is today (however, I will not share how old I was in 1974). I will say that the *NDGS Newsletter* continues to be a high quality, general interest and free publication of the ND Geological Survey. We have a small staff (eight geologists, one cartographer, five soil compilers, one technician and seven support personnel) and try very hard to put together a high quality publication. I am the third editor of the *NDGS Newsletter* in 23 years. I'm not sure what the national average is for "life expectancy of editorships", but I'll guess that the *NDGS Newsletter* has better than average odds.

I have tried to maintain the format and content that Bluemle started, and Biek polished. You may have noticed there have been some minor changes. One such change is the decision to list "Geologic Projects in North Dakota" every other year rather than every year. "Geologic Projects in North Dakota" is a comprehensive listing of all geologic investigations taking place in North Dakota and adjacent areas; investigations are conducted not only by NDGS staff, but also by academic, research and private industry personnel from all over the world. The listing was typically in the winter issue of each year. After going through the list of geologic projects for the past few years, I realized that many of the projects were of two, three or even four years duration. Consequently, the "Geologic Projects in North Dakota" listing will be generated every other year and printed in the winter issue of the even years (1998, 2000, 2002, etc). For a summary of current field investigation of NDGS staff, please refer to the articles beginning on page 10.

I have also received a number of messages from readers commenting on how much they have enjoyed reading the newsletter. If you have any ideas about future articles or contributions you would like to see in the newsletter, please let me know. Address your letters, comments, and questions, or address corrections to: Editor, *NDGS Newsletter*, 600 East Boulevard Avenue, Bismarck, ND 58505-0840, or you can e-mail me at *afritz@rival.ndgs.state.nd.us*.

~ Ann Fritz

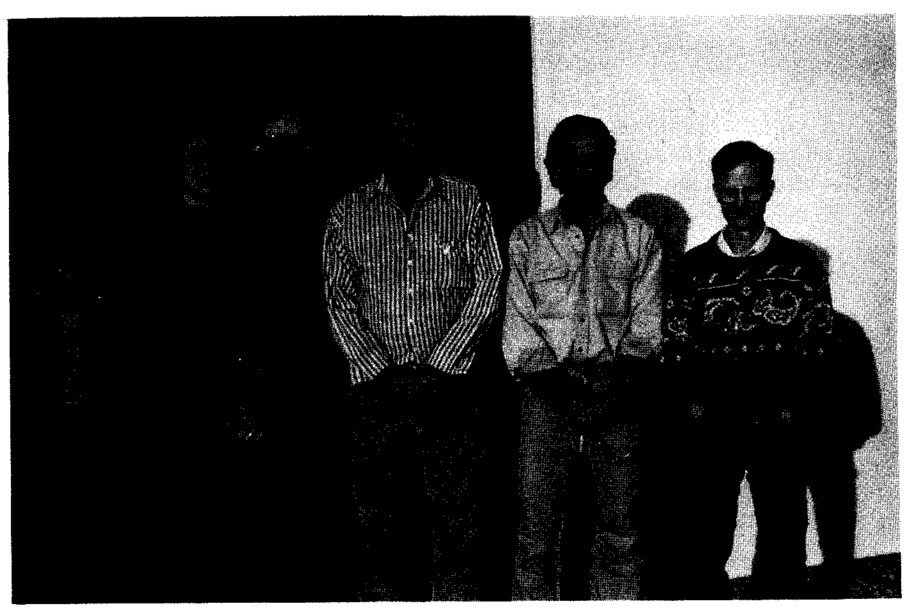
Correction

On page 12 of the Fall, 1997 *NDGS Newsletter*, the bottom right-hand photo has an incorrect caption. The groundbreakers shown in the photo are not University of North Dakota geology faculty members, as stated in the caption, but rather are UND geology graduate students Wally Dow, Doug Morgan and Ted Callender. Sorry for any confusion this may have caused. *Editor's Note: I thought that they were a little under-dressed for faculty members . . .*

MEET OUR NEW SOIL COMPILERS

Pictured left to right . . .

Sheila Glaser, Elroy Kadrmas, Don Thom, Steve Kranich, and Colin Clampet



Shark and Ray Extinctions

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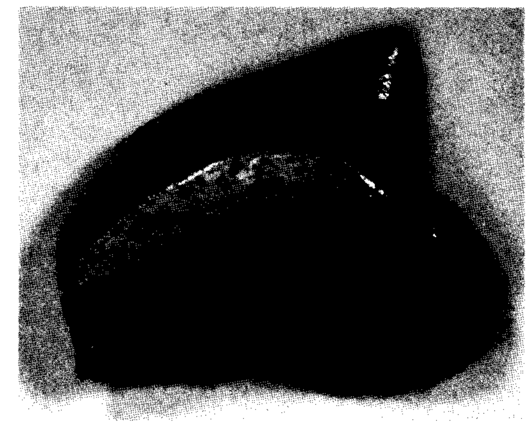
The following report is based on an abstract titled "Terminal Cretaceous extinction event documented by marine cartilaginous fishes from the Fox Hills (Maastrichtian) and Cannonball (Danian/Thanetian) formations, North Dakota", *by J. Hoganson, J.M. Erickson, A.M. Cvancara, and F.D. Holland, Jr. It was presented at the 57th Annual Meeting of the Society of Vertebrate Paleontology. Items in brackets are clarifications to the original article.*

During the disastrous extinction that occurred about 65 million years ago, at the so-called Cretaceous-Tertiary (K-T) boundary, the world lost all of its dinosaurs, as well as many of its land plants and animals dwelling in shallow water. Now add sharks and rays to the list of causalities, say John Hoganson of the North Dakota Geological Survey in Bismarck and his colleagues. Smaller life-forms in the sea, such as plankton and the shellfish called ammonites, are known to have gone extinct in droves at the K-T boundary, when an asteroid is believed to have struck Earth. But extinctions of large marine animals have been tough to document, in part because the sedimentary rocks that may record them are mainly underwater and inaccessible. Now, by combining separate rock records, one dating from before the extinction and other from after it, Hoganson and his colleagues say they can demonstrate large-scale extinctions of sharks and rays in the seaway that covered much of central North America before and after the K-T boundary.



Long gone? *Squalicorax pristodontus* teeth were absent in a Tertiary sample.

Because sharks and rays have skeletons of cartilage, which have long since decomposed, the researchers classified fossilized teeth from marine rocks in two areas, the Fox Hills and Cannonball formations of North Dakota. They found 22 shark and ray species at [the 41 sites in] the Fox Hills Formation, dated to the late Cretaceous by the presence of other fossils, and 15 [species] at the [70] Cannonball sites, which belong to the early Tertiary. None of the Cretaceous species [in the] Fox Hills [Formation] were present in the Cannonball [Formation], indicating that they had all gone extinct, although other species belonging to some of the same families as the sharks and rays did survive from one era to the next.

Not everyone is convinced that the fish went extinct, however. Says paleontologist David Archibald of San Diego State University, "They don't have the [complete] geological sections; they're missing at least one million years, at the K-T boundary." A change in the environment, such as receding seas, could have yielded the same fossil evidence by, for example, forcing fish to move to distant, more hospitable environments. Therefore, he says, "their work says nothing about K-T extinctions." Others find the evidence more persuasive, noting that many extinctions are known only from isolated data points. "There are very few places in the world that have marine rock that span the boundary," says paleobotanist Kirk Johnson of the Denver Natural History Museum. But he adds, "Hoganson has stratigraphic units that come close." For his part, Hoganson suggests that confirmatory evidence might be found in rocks along the Gulf Coast in Texas and Alabama, which have late Cretaceous and early Tertiary marine sediments that can be studied.

More Staff E-Mail Addresses

In the last issue of the NDGS Newsletter, we printed a list of staff areas of specialization and e-mail addresses. Since that time, the Core Library offices in Grand Forks have been brought "on-line". Please save this list for future reference.

Julie Lefever	Directory of the Wilson M. Laird Core and Sample Library; petroleum geology; general geology	*jlefever@rival.ndgs.state.nd.us*
Kent Hollands	Core Library technician	*corelab@rival.ndgs.state.nd.us*

MEETINGS & CONFERENCES

North Dakota Academy of Science

by
John P. Bluemle

I attended the annual meeting of the North Dakota Academy of Science on September 15-16 at the University of North Dakota. The meeting is usually held in the spring, but this year's meeting was postponed from April, a casualty of the flood in Grand Forks.

This year's meeting included a special symposium on the Red River flood. The symposium included 13 papers relating to flooding in the Red River Valley. I gave a talk on "Factors affecting flooding in the Red River Valley". These talks were in addition to the original program. There were also several additional talks given in the Astronomy symposium that hadn't been scheduled for the original April meeting date. The flood and change in schedule did hurt the Denison presentations (papers by undergraduate and graduate students). Of the 33 Denison talks originally scheduled, only 16 were presented.

In addition to my Academy of Science talk on flooding in the Red River Valley, I co-authored a talk on the geology of the Devils Lake area with Dr. John Reid of the University of North Dakota. Dr. Reid presented the Devils Lake paper.

Geological Society of America

by
John P. Bluemle

The annual meeting of the Geological Society of America was held in Salt Lake City on October 19-22. Most of my time there was spent in associated meetings. The Association of American State Geologists (AASG) has a half-day interim meeting in conjunction with GSA. In addition to routine business matters, AASG presents the annual John C. Frye Memorial Award for the best paper in environmental geology. The award is given for the best environmental geology paper published by a state geological survey or in Geological Society of America publications. This year's award went to the Illinois Geological Survey for their excellent 1994 report on the 1993 flood along the Mississippi River.

I also attended the annual meeting of the North American Commission on Stratigraphic Nomenclature while in Salt Lake City. We are working on a revision of the Stratigraphic Code.

TEACHING TOOLS

A NEW WAY TO TEACH MIDDLE-SCHOOL SCIENCE
. . . and a chance to make $500

Making Science *Real*

Event-Based Science is a relatively new way to teach science at the middle school level. Event-Based Science (EBS) modules use videotaped television coverage of real-world events to establish the relevance of related science topics such as chemistry, geology, and meteorology; real-world tasks such as geologist, newspaper editor or city planner are used to create the need-to-know more about those topics; and lively interviews, photographs, and inquiry-based science activities are used to create a desire to know more about those topics. The EBS modules also meet the National Science Education Standards.

The EBS project was developed by Dr. Russell Wright and his colleagues in the Montgomery County Public School System in Maryland. The EBS Project was first funded in 1992 by a $1.03 million grant from the National Science Foundation. Three modules produced under that grant cover concepts from the earth sciences. Hurricanes, floods, and asteroid impacts were used as connections to earth science topics such as meteorology, stream dynamics and astronomy. The current EBS Project is funded by a grant of $850,000 that supports development of nine new modules. With titles like *Gold Medal!, Outbreak!, Thrill Ride!, First Flight!, Fraud!,* and *Blight!,* you can see that the modules are now dealing with both life science and physical science.

Dr. Wright states that the EBS modules allows students to see the true nature of science in the real world. It fosters creativity, openness to new ideas and data, and the skepticism that characterize science. The modules turn students into scientists and makes science both real and relevant. Each unit begins with a videotape showing television news reports and interviews with people that were affected by a particular event (hurricane, earthquake or oil spill, for example). A student guide contains much of the information students need to complete the unit, but more information is always helpful to complete the project. The use of outside resources (libraries, interviews or the Internet) is encouraged, and sometimes a necessity for completion of the project. The EBS website (***http://www.mcps.k12.md.us/departments/eventscience***) also contains links to other websites that contain information that would be pertinent to the different modules.

Your Help is Needed (and a chance for teachers to earn some extra cash!)

Dr. Wright is currently developing four additional units called *Survive?, Blackout!, Fire!,* and *Blight!* and is searching for middle school students to provide him with student voices on those topics. Student voice interviews make Event-Based Science modules unique. They allow students everywhere to vicariously experience events through the words of kids just like them.

Students who have experienced the events that serve as 'hooks' (introductions) for the four units listed below are needed.

- For *Survive!* Dr. Wright needs kids who have discovered deformed frogs.
- For *Blackout!* he is looking for kids who can tell about the hardships of being without electricity during a major power failure.
- For *Fire!* the context is forest fires, although the unit also includes a section on prairie fires; kids who may have witnessed a grassland fire that went out of control are needed (the prairie fire near Turtle Lake this fall is an excellent example), and
- For *Blight!* the context is potato farming and plant disease. For that unit, he needs students who live in a farming region of the United States, whose family has experienced a recent crop failure due to blight.

If you are a middle school teacher, or know a teacher with a diverse group of eight to ten students like those described above, please call the Event-Based Science office. The Institute pays $500 to the teacher selected to obtain student voices interviews. You can reach the EBS Institute by phone at 1-800-ESB-7252, by mail at Event-Based Science Institute, 6609 Paxton Road, Rockville, MD 20852 or by e-mail at ebsievent@aol.com.

For more information . . .

A total of nine Event-Based Science modules on earth science topics are currently available. The units are *Hurricane! Earthquake! Oil Spill! Volcano! Flood! Toxic Leak! Asteroid!* and *Gold Rush*! Each of the units, described on the following pages, is available from either Dale Seymour Publications, or directly from the Event Based Science Institute for a cost of $115 per classroom packet. One classroom packet contains 15 student guides, a teacher's guide and videotape, all re-usable. Free teacher training is offered with the purchase of 36 classroom packages from the EBS Institute.

ASTEROID!

Asteroid! is an Event-Based Science module that is primarily about astronomy, with a minor emphasis on paleontology. It uses an asteroid impact with Earth about 65 million years ago to establish the context for exploring concepts related to solar-system astronomy. The task in *Asteroid!* makes students a public relations firm hired by the United Nations to warn the people of Earth about a new asteroid. This one will impact us in about two years.

EARTHQUAKE!

Earthquake! is a module about the dynamic forces that help to shape the surface of Earth. It uses the 1989 Loma Prieta earthquake in California to establish the context for learning about earthquakes and their effects on people and buildings. The task in *Earthquake!* places students in five different roles on a team responsible for designing a new city for a region of the world where earthquakes are common. As Geologist, Transportation Chief, Utilities Director, City Planner, Architect, and Civil Engineer, each team of students will choose a location and design an earthquake-resistant city.

Up-to-the-minute information about current earthquakes along with seismologic data will add to the authenticity of the study. In addition, students can learn about past earthquakes and the damage they caused. Students can also find world maps of earthquake zones to help choose a location for their city, then actually draw a map using library or Internet resources.

GOLD RUSH!

Gold Rush! is an Event-Based Science module about rocks and minerals. It uses the 1848 discovery of gold at Sutter's Mill in the California Territory to establish the context for the study. The task in *Gold Rush!* places students in the roles of partners in a mining company. Students will acquire, then use their knowledge of rocks and minerals to analyze data from abandoned mines and choose one for their company to reopen.

HURRICANE!

Hurricane! is a module about one of the most devastating weather events that people can experience. The story focuses on the devastation that Hurricane Andrew brought to South Florida in August, 1992. This storm destroyed 25,524 homes, damaged 101,241 more, left 250,000 people homeless and 54 dead.

The task in *Hurricane!* turns your class into teams of experts. Each team will publish a newspaper account of a real hurricane that is approaching one of 11 American cities that have been chosen as the teams' home cities. Each home city has a history that includes hurricane strikes and damage. Each team of 6 students has its own Editor-In-Chief, Hurricane Specialist, Meteorologist, Natural Hazards Planner, Reporter, and Environmental Scientist. As this team receives daily information on the hurricane bearing down on its coastal city, decisions must be made. Action must be taken! The public must be informed!

OIL SPILL!

Oil Spill! is an Event-Based Science module about oceanography. It uses the 1989 spill of over 10 million gallons of oil from the Exxon tanker *Valdez* to establish the context for exploring concepts related to shoreline oceanography. The task in *Oil Spill!* requires students to examine competing sites for a new oil terminal. Students acquire, then use, their new knowledge of tides, currents, marine life, and harbor topography to advise an oil company. Much of the information that students need is provided in the pages of the *Oil Spill!* student guide. However, more information is needed. Students need information about the six cities that are being considered for three terminal sites. They also need information about booms and skimmers -- the tools of the cleanup industry.

TOXIC LEAK!

Toxic Leak! is an Event-Based Science module about groundwater. It uses gasoline leaks in a Charlotte, North Carolina underground storage tank farm to establish the context for exploring concepts related to the subsurface water that we call groundwater. The task in *Toxic Leak!* places students in the roles of high school students in a small town with a similar problem. A leaking gasoline tank at the community's general store is contaminating some wells in town. Students will acquire, then use, their knowledge of aquifers, groundwater, permeability, porosity, and capillarity to help their town council select a site for a new community well. Their selection of a site will demonstrate an understanding of relevant science concepts.

TORNADO!

Tornado! is an Event-Based Science module about weather. It uses the 1994 Palm Sunday tornado that struck the Goshen United Methodist Church in Piedmont, Alabama, to establish the context for exploring weather concepts. *Tornado!* places your students in one of six different National Weather Service Forecast Offices in the Midwest. As the staff of the forecast office, students acquire, then use, their knowledge about tornadoes, high and low pressure systems, fronts, weather radar, and dew point to track a developing severe weather situation. When conditions worsen, your students will record, then broadcast emergency warnings to their surrounding communities.

As with all Event-Based Science modules, much of the information that students need to complete the task is provided in the pages of *Tornado!*. However, your students will do a better job if they have information about the communities around their weather stations. They will also get a better feel for what it's like to work in a forecast office if they see real-time warnings as they are posted by the weather service.

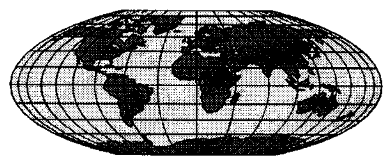
VOLCANO!

Volcano! is an Event-Based Science module about the dynamic forces that help to shape the surface of the Earth. It uses the 1991 eruption of Mt. Pinatubo in the Philippine Islands to establish the context for exploring concepts related to volcanoes. The task in *Volcano*! places students in the roles of producers of a television show about the risks to people living at the foot of Mt. Rainier, in Washington. Students will acquire, then use, their knowledge of plate tectonics, lava flows, debris flows, and the Ring of Fire to assemble the seven segments that make up the show.

FLOOD!

Flood! is an Event-Based Science module about stream dynamics. It uses the Great Flood of 1993 to establish the context for exploring concepts related to streams and their eroding force. The task in *Flood*! places students in the roles of developers of River National Park. Students will acquire, then use, their knowledge of erosion and deposition, the features of streams and rivers of different ages, and map-reading skills to design a new park. The park, along the St. Joe River in Idaho, will demonstrate to the lay-public the dynamic force of a wild river.

ESIC NEWS



The NDGS is an affiliate of the Earth Science Information Center (ESIC) network. Coordinated by the U.S. Geological Survey, the nationwide ESIC network provides information about geologic, hydrologic, topographic and land use maps, books and reports; aerial, satellite, and radar images and related products; earth science and map data in digital form and related applications software; and geodetic data. As an ESIC office, the NDGS can assist the public in locating earth science materials dealing with North Dakota, as well as other states. For more information, contact Ann Fritz or Ryan Waldkirch at (701) 328-8000.

GENERAL INFORMATION/EDUCATIONAL MATERIALS

Electing the Presidents *Teachers Packet*

The *Electing the Presidents* teachers packet, including three lesson plans: Big Places and Small Places, What Makes a Winner, and Who Elected the President, has been declared out-of-print and is no longer available.

An older, general interest publication, *Electing the President 1789-1988* is still available. The $3.50 price for this booklet has been dropped and copies are available free from U.S. Geological Survey Information Services, Box 25286, Denver, CO 80255. The file number is 94-0250. When the supply of this booklet is depleted, it will declared out-of-print.

Free Teachers Packets Available

The North Dakota Geological Survey ESIC office has a complete list of USGS educational resource information that is available to elementary and secondary school teachers. The following teacher's packets are currently available: Teachers Packet of Geologic Materials; Selected Packet of Geologic Teaching Aids; Exploring Maps; Global Change; What do Maps Show?; and Map Adventures.

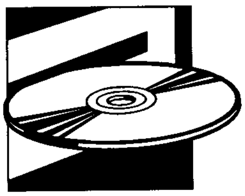
We also have information on how to obtain resource lists and activities, booklets, posters and water-resources education series information from the USGS. For information on how to obtain any of the above information, call the North Dakota Geological Survey at (701) 328-8000.

The NDGS also has its own series of easy-to-read educational publications. Contact the NDGS Publications Clerk at (701) 328-8000 for more information on NDGS publications.

1997 Scout Jamboree Map

The Commemorative Edition of the Rappahannock Academy, VA 7.5' quadrangle, created for the 1997 Scout Jamboree and given to more than 30,000 scouts, is now available for sale to the public.

Printed on polyart, the map has a revised 1994 edition of the topographic map on one side and a color infrared orthophoto of the Fort A.P. Hill area near Fredericksburg, VA on the other. It is available for $4.00 from USGS-Information Services, Box 25286, Denver, CO 80225. Please add $3.50 handling charge for each order. VISA and MasterCard orders, including expiration date, can be faxed to (303) 202-4693. The file number for this map is TVA1232.



DIGITAL DATA

Maps, DRG's and DOQ's on GLIS

Paper maps, Digital Raster Graphics (DRGs) and Digital Orthophoto Quadrangles (DOQs) have now been added to the Global Land Information System (GLIS) at *http://edcwww.cr.usgs.gov/webglis.*

- The inventory of U.S. Geological Survey topographic maps is searchable by geographic coverage or by U.S. place name. World and planetary maps, indexes, catalogs, and map lists are searchable by name.
- County based, JPEG compressed, DOQs are listed under the "Photograph" and the "Digital and Satellite & Aerial Data" categories in GLIS. They are searchable by county name or by state. The majority of county DOQs produced so far have been replicated on CD-ROM. Most of the remaining county DOQ files will be stored in the sales database when completed and will be distributed on recordable compact disc.
- DRGs are listed under the printed map category and are searchable by geographic coverage, U.S. place name, map name or state. DRGs covering multiple states are searchable for any of those states. DRG files are also stored in the sales data base and distributed on CD-R.
- Uncompressed digital orthophoto quarter quadrangles (DOQQ) have also been added to GLIS. DOQQs are listed in the "Photograph" and the "Digital and Satellite & Aerial Data" categories and are searchable by geographic coverage, U.S. place name, acquisition date, browse availability, map name or state. DOQQ files are distributed on CD-R, file transfer protocol (FTP), 8MM tape or 3480 tape. Each file is 45-50 megabytes uncompressed.

Customers can generate reports of selected paper maps, DOQs, DOQQs and DRGs and place an order through GLIS. Customers placing orders through GLIS will be contacted for payment information before the order is produced. If access to the Internet is limited, customers can contact the NDGS GIS Center at (701) 328-8003 for product availability and ordering information.

Digital Data Series New Releases

The following digital data series CD-ROMs are now available for sale:

- **DDS-33** ***3-D Reservoir Characterization of the House Creek Oil Field, Powder River Basin, Wyoming.*** This USGS report details geologic, geochemical, and petroleum geologic history of the Upper Cretaceous Sussex "B" sandstone in the House Creek oil field, Powder River Basin, Wyoming. The CD is a world wide web-style publication; contents are viewable on PC/Windows, Apple, and UNIX computers. The contents are open as local files; compressed versions of Mosaic computer software are located on the CD-ROM. Price is $32.00
- **DDS-42** ***Gravity Data of Nevada.*** This CD-ROM contains gravity data for the entire state of Nevada and adjacent parts of California, Utah, and Arizona. It has ASCII text and data files, as well as Portable Document Format (PDF) files for viewing text and figures. It also contains installers for Adobe Acrobat Reader 3.0 for Windows 95, Windows NT, Windows 3.1 and Macintosh. Price is $32.00
- **DDS-43** ***Status of the Sierra Nevada: The Sierra Nevada Ecosystem Project.*** This CD-ROM is a digital version of the set of reports titled *Sierra Nevada Ecosystem Project, Final Report to Congress,* published in paper from the Centers for Water and Wildland Resources of the University of California, Davis. The CD contains PDF files for viewing text and graphics and installers for Adobe Acrobat Reader 3.0 for both Windows and Macintosh. Price is $32.00

Customers can order from USGS-Information Services, Box 25286, Denver, CO 80225. Please add $3.50 handling charge for each order. VISA and MasterCard orders, including expiration date, can be faxed to (303) 202-4693.

How Geologists Spend Their Summers:
A brief summary of current field investigations by NDGS staff

There are many branches of geology represented by NDGS employees. We have petroleum geologists, glacial geologists, a paleontologist, a carbonate geologist, and an environmental geologist.

One thing that all branches of geology have in common is the necessity of field work. Field work is necessary to create geologic maps, as well as to record valuable information about the rocks and fossils of an area. Geologic maps contain descriptive information about the sediments and bedrock materials, they contain structural information such as faults or folds in the rocks, and they provide an interpretation of how the different geologic materials are related in time and space.

One way geologists make geologic maps is by completing field work. The "field season" is generally during the summer when daylight hours are at their maximum and it is comfortable to be outside for long periods of time. NDGS geologists, though, perform field work year round (see article, *Study of Devils Lake and Stump Lake Outlets* in Summer *NDGS Newsletter*, for example).

The purpose of field investigations that are currently underway by NDGS geologists is to map surficial deposits, unravel Lodgepole stratigraphy, and to unearth million-year old fossils, just to name a few. Field work is attempted in rain or shine, sleet or snow. Obviously, there are some conditions in which it is too dangerous to remain outdoors (drilling in a lighting storm is not advised, nor is field work in a blinding blizzard). The following summaries are an example of how NDGS geologists do field work, what it entails, and the important role that weather can have in determining our schedules.

Washed Out in the West

by

Paul Diehl and Randy Burke

It has been four years since the discovery of the Lodgepole Formation carbonate buildups, but fundamental questions remain regarding Lodgepole stratigraphy in general and buildups specifically. Surface exposures of the strata provide geologists with the best accessible data with which to address the questions of a formation's deposition and stratigraphy. Since the return route from the Canadian Society of Petroleum Geologists meeting in Calgary (early June) would bring Randy through Montana in proximity to the remote Lodgepole buildups reported in the literature, we decided to take this opportunity to resolve the precise geographical and stratigraphic position of several buildups which we had located and reported on a couple of summers ago (see *NDGS Newsletter*, Winter 1995, v. 22, no. 4, pp. 8-20). We also wanted to verify the existance of a buildup reported to be in Horse Thief Canyon. Our last attempt at this failed due to insufficient time, snow, sleet, lightning, rain, and low clouds.

Randy arrived in Lewistown, Montana, late Saturday afternoon and met Paul as a large, slow-moving, rain front settled into the area. It had already been showering off and on, so we decided to make use of the remaining daylight to check conditions of the access roads into the Horse Thief Canyon area. The roads were wet but not too muddy for travel. Getting back to town at about 9:30 p.m., we planned the next days hike. Sunday morning we were treated to heavy overcast skies, standing water, and intermittent showers. Canyon access would have to be by the long route. After three hours of strenuous (for "flat-landers") hiking, we arrived at the south rim of Horse Thief Canyon above some questionable features we had spotted while scouting the previous evening. From a distance of a mile or two the large resistant carbonate masses surrounded by talus appeared to have beds draping off their sides - possible Lodgepole carbonate buildup? After climbing down the canyon wall, closer examination revealed that these bodies were the edges of large karst holes in the Mission Canyon Formation and not Lodgepole carbonate buildups. The apparent draping beds were calcite-cemented breccia armoring the underlying beds resulting in their high relief relative to the surrounding, more easily weathered beds that form the steep talus slopes (*Figure 1*). From a distance using a "Swiss hammer" (binoculars), it was easy to mistake these masses as buildups similar to the Waulsortian-like buildups in Swimming Woman Canyon and elsewhere in the Big Snowy Mountains. Before the moderate showers turned to late afternoon driving rain and lightning, we were able to get some GPS readings at these features.

Figure 1. Note the draped appearance of the beds on this large resistant carbonate mass.

Monday morning the weather was no better than the night before. Rain and worse - a very low-hanging, heavy cloud ceiling - greeted us. The Weather Channel showed a large front had stalled and was predicted to remain stationary for the rest of the week. Rain was an inconvenience (skin's waterproof) but the low clouds sinking into the canyons eliminated visibility and the saturated soils ensured significant damage to roads and off-road trails. Deciding to test the weather forecast and hoping it was wrong, we undertook reconnaissance to the west in the Little Belt Mountains where on a previous trip we had seen, again from a distance, possible Lodgepole buildups. This time while trying to access a location from which we could hike to a possible buildup, we were blocked by several feet of snow *(Figure 2)*.

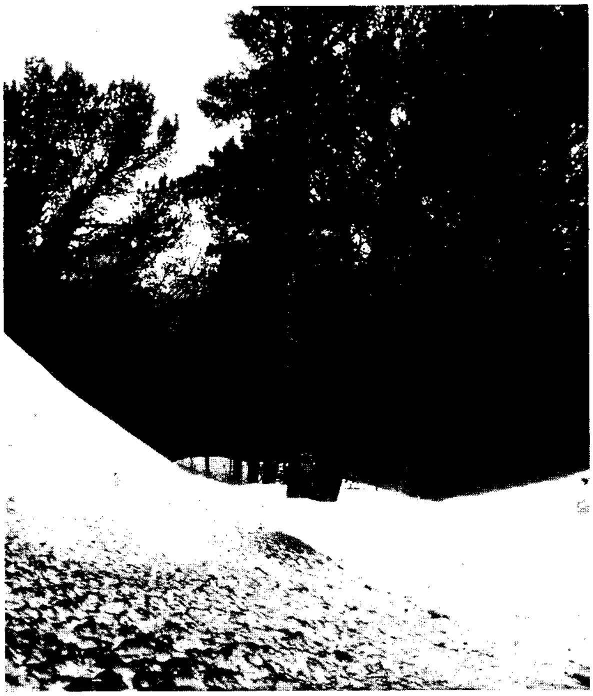


Figure 2. Paul surveys the snowdrift roadblock.

Tuesday morning it appeared the weather forecast was right. Skies and clouds looked just as they did on Monday. The chances of being able to accomplish what we had planned looked remote during the next several days so we disappointedly returned to Bismarck with hopes of returning later as time would permit. Unfortunately, that did not happen this summer.

In anticipation of a cooperative project to gain a better understanding of the lower Paleozoic strata of the Williston Basin, geologists from the Canadian Geological Survey, Saskatchewan Energy and Mines, University of Calgary, University of Saskatchewan, and the North Dakota Geological Survey joined in an August field trip to examine and sample outcrops of the formations which produce oil and gas in the subsurface of the basin. Paul represented the NDGS in examining the outcrops of the Red River, Winnipeg, and Ashern formations in Manitoba where the group was guided by Ms. Ruth Bezys, a geologist with the Manitoba Energy and Mines. The group also stopped at the NDGS Core and Sample Library to inspect and sample some cores of the Deadwood, Winnipeg, and Red River Formations. This time, it only rained about one-half of the field days and one of the days while we were inside the core library.

On the way from Grand Forks to Spearfish on Saturday, Randy joined the trip for the opportunity to examine outcrops of several formation type sections with the benefit of being accompanied by local experts who have spent years studying the stratigraphy and geology of the Black Hills. Late Saturday night, as we approached the Black Hills, a thick cloud bank once again obscured the stars that had shone brightly since nightfall. Sunday morning we met Dr. Jack Redden, Professor Emeritus, South Dakota School of Mines and Technology, who led us to some outstanding exposures of the basal Deadwood Formation in contact with the Precambrian quartzite. These exposures contained Deadwood boulders *(Figure 3)*, some of which contained clasts of Precambrian conglomerates as well as pebble conglomerates, and quartzites. At this locality, about 200 feet of relief can be demonstrated on the pre-Deadwood erosional surface. The morning rain ended and we enjoyed merely overcast skies and an occasional light sprinkle the rest of the day. We weren't so luck on Monday. It rained steadily all day. Dr. Mark Fahrenbach, whose Ph.D. dissertation was on the Englewood Formation in the Black Hills, volunteered to guide us to outcrops where we could examine and discuss the Englewood (Bakken age equivalent), Whitewood (Red River equivalent), Winnipeg, and Deadwood Formations. It was a soggy day, but we did manage to examine the stratigraphy, collect some samples for study and find a few ostracoderm plate pieces in the Icebox Shale. A highlight was discovering a spectacular array of trace fossils, possibly of museum quality, covering bedding planes in the Whitewood *(Figure 4)*.

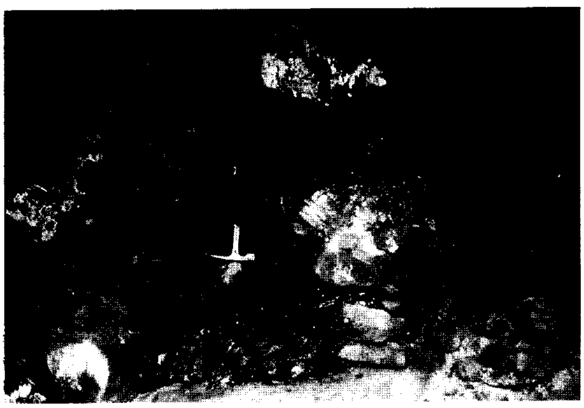


Figure 3. Boulders in the basal unit of the Deadwood Formation.

Figure 4. Trace fossils discovered in the Whitewood Formation.

Paleontological Fieldwork on the Little Missouri Grassland with the United States Forest Service

by

John W. Hoganson

Management of paleontological resources on public lands in the United States has become a major concern for many federal agencies and state governments because of the scientific and educational importance of fossils. During the past three summers the North Dakota Geological Survey has been working closely with the United States Forest Service--Custer National Forest to identify, map, and assess the significance of fossil sites located in the Little Missouri Grassland area of North Dakota. Custer National Forest has management responsibilities for fossil resources on vast tracts of land in the Little Missouri Grassland, and in 1986 (reaffirmed in 1995) the Survey signed an agreement with Custer National Forest to cooperatively manage fossil resources on those lands. A cooperative field study program between the two agencies has resulted in the discovery of hundreds of fossil sites. Fossil resource information is being used in overall resource management planning for the Forest Service and the State of North Dakota. The following are a few of the most significant fossil discoveries.

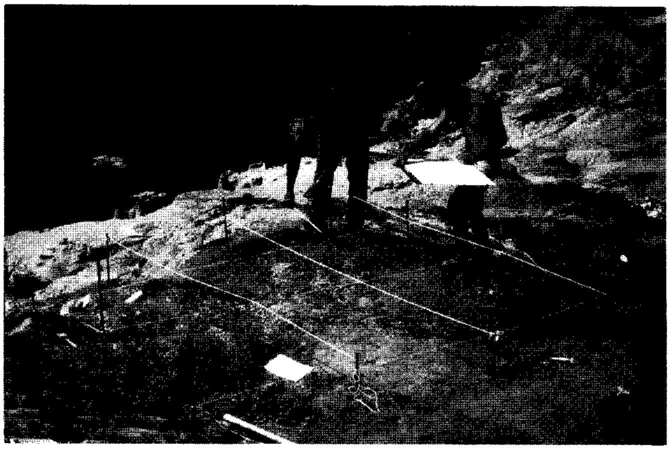


Figure 1. Dr. J. Mark Erickson (Professor of Geology, St. Lawrence University, Canton, New York) and Glenn Kays (geology graduate student, University of North Dakota) mapping the position of fossils in outcrop at the Ash Coulee turtle fossil site.

Hell Creek Dinosaur Discoveries

The dinosaur fossil-bearing Hell Creek Formation is exposed in the southern portion of the Little Missouri Grassland area of North Dakota. The need to identify the locations of significant fossil sites in this area was in part prompted by the dramatic increase in petroleum exploration activities and the concern that these activities may impact significant fossil sites. Over two hundred fossil sites, most of which contained vertebrate fossils in the Late Cretaceous (about 65 million years old) Hell Creek Formation, were mapped during a two-week survey of fossil sites in Slope County. Three of the sites contained partial dinosaur skeletons. These fossils appear to all be ceratopsian remains, probably *Triceratops*. One of the *Triceratops* skulls has been excavated and restored. It is now on exhibit at the North Dakota Heritage Center in Bismarck. Excavations have begun on the other two dinosaur fossils near Marmarth and will continue during the summer of 1998.

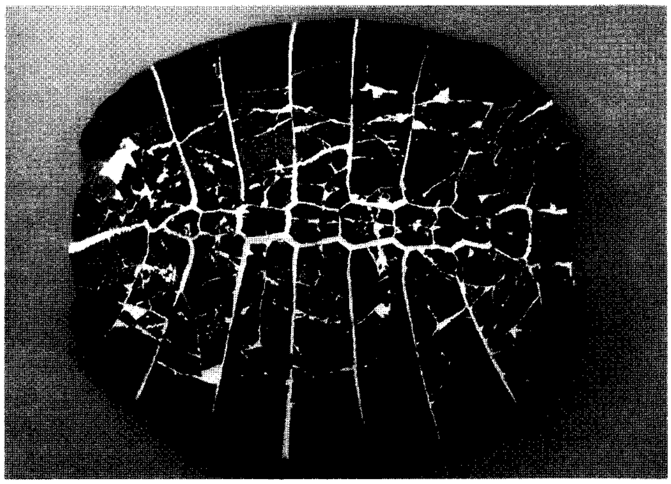


Figure 2. Carapace of one of the turtle fossil specimens identified as *Plastomenus* recovered from the Ash Coulee turtle fossil site.

Ash Coulee Turtle Fossil Site

The Ash Coulee turtle fossil site, located near Fairfield, Billings County, was discovered during a survey before this Forest Service land was turned over to the Clay Banyai family *(Figure 1)*. Management responsibilities for fossil resources on lands exchanged by the Forest Service are retained by the Forest Service. At this badlands locality, the Paleocene age (about 59 million years old) Sentinel Butte Formation is exposed. Turtle fossils, including carapaces, plastrons, skulls, and other skeletal parts of the soft shell turtle *Plastomenus*, are found in a thin, carbonaceous layer in the formation *(Figures 2 and 3)*. We estimate that perhaps hundreds of turtles died at this site in a mass-mortality event. Three excavations have been completed at this site. Glenn Kays, a graduate student in the Department of Geology and Geological Engineering at the University of North Dakota, is working with us on this project. In his Master's study, Glenn will describe the turtle fossils which may be a previously undescribed taxon and will try to determine the cause of death of these animals.

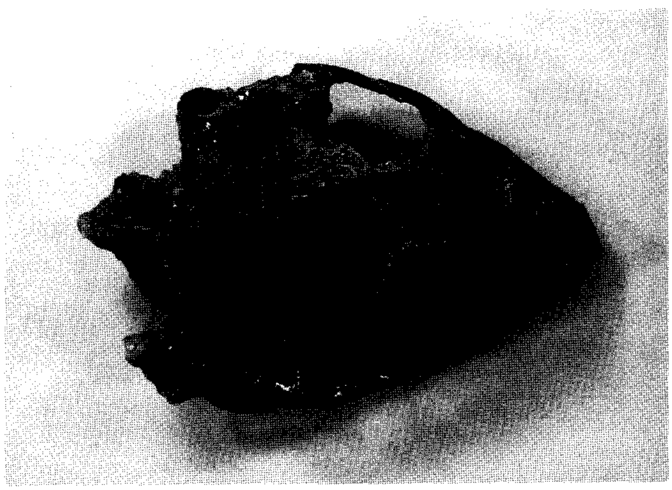


Figure 3. Dorsal view of a *Plastomenus* skull collected at the Ash Coulee turtle fossil site.

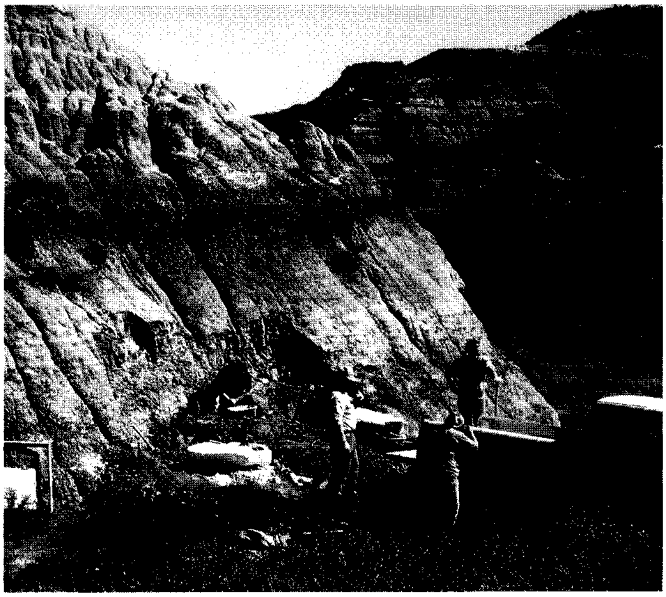


Figure 4. Plaster field packages containing crocodile fossils being removed from the Lone Butte crocodile fossil site by USFS and NDGS personnel.

Figure 5. Mike Matozevich (USFS) and Johnathan Campbell (NDGS) excavating the *Titanoides* specimen at the Poker Jim *Titanoides* site.

Figure 6. Prepared *Titanoides* skull and lower jaws from the Poker Jim *Titanoides* site.

Tracy Mountain Champsosaur Fossil Site

Mark Luther (formerly with the NDGS) and Chris Quinn (Dickinson) reported to us the occurrence of vertebrate fossils weathering out of an organic-rich layer in the Paleocene age (about 59 million years old) Sentinel Butte Formation at a locality near Fryburg, Billings County now called the Tracy Mountain champsosaur fossil site. Field work at the site, which will continue over the next few years, has already produced an extensive array of fossils including the remains of turtles, crocodiles, alligators, champsosaurs, giant salamanders, fish, mammals, freshwater snails, freshwater clams, and plants. The most significant finds so far have been the fairly complete skeletons of two champsosaurs. Champsosaurs were crocodile-like animals that lived in lakes and ponds in North Dakota during the Paleocene. One of these skeletons has been restored as a 3-dimensional skeletal mount and is now on exhibit at the North Dakota Heritage Center in Bismarck. The other skeleton has been restored and will be exhibited at the USFS National Headquarters in Washington, D.C. Funding for restoration of the Heritage Center specimen was provided by the USFS.

Lone Butte Crocodile Fossil Site

Another important Sentinel Butte Formation site was discovered during one of our fossil site inventories. This site is called the Lone Butte crocodile fossil site because of the occurrence of several partial crocodile skeletons in a Sentinel Butte mudstone near Lone Butte, McKenzie County. Fossil crocodile parts are often found in the Sentinel Butte Formation in North Dakota but partially articulated skeletons are extremely rare. We conducted an exploratory excavation at the site this summer and collected the partial skeletons of at least three crocodiles *(Figure 4)*. These fossils are tentatively identified as remains of the common Paleocene crocodile, *Leidyosuchus*. We estimate that some of the crocodiles were twelve feet long, perhaps longer. Beautifully preserved leaf fossils, including the dawn redwood *Metasequoia*, are found with the crocodile bones. This site will be a focus of our research for quite some time because the bone bed is extensive. We feel confident that at least one of the skeletons will be complete enough to restore for exhibit at the Heritage Center in our continuing effort to provide exhibits of North Dakota's prehistoric life for the enjoyment and education of the public.

Poker Jim *Titanoides* Site

Mike Matozevich, USFS - Watford City, discovered an important mammal fossil site in the Paleocene age Sentinel Butte Formation this summer. Mike observed an upper jaw tooth row consisting of four mammal teeth exposed in the Sentinel Butte Formation at this McKenzie County site. Our excavation and preparation of the fossil exposed a complete skull and lower jaws of the pantodont *Titanoides (Figures 5 and 6)*. The skull is flattened but all the teeth in the upper and lower jaws are present. Other *Titanoides* remains have been found in North Dakota but this specimen may be the most complete skull and lower jaws yet discovered. *Titanoides* was one of the largest mammals that lived during the Paleocene in North Dakota. These animals were about three feet tall at the shoulder and weighed perhaps 200 pounds. They were apparently herbivores and fed on roots and tubers. It is possible that more than one *Titanoides* lived in the site area. Fragments of large leg bones, presumed to be from that mammal, were found in another part of the butte exposure. Remains of crocodiles, champsosaurs, turtles, fish, freshwater snails, and freshwater clams are found with the mammalian remains. This important fossil site will require additional study.

Surficial Geology of the North Dakota Portion of the Grafton Quadrangle Area

by
Ann Fritz

The Grafton 30 x 60 minute quadrangle area (GQA) contains some of the state's most valuable agricultural, groundwater and gravel resources. The GQA encompasses the northern portion of Grand Forks County, southern Walsh County, and the northeastern corner of Nelson County. A lithology-based geologic map is being constructed for the GQA and will be disseminated as an NDGS digital publication. A geologic map that is in digital format will be used, in part, to minimize conflicts between competing natural resource interests and to meet other current and upcoming needs for digital data. The digital format also facilitates use in a geographic information system.

Mark Luther, former NDGS Geologist, began mapping the area in 1996. Former NDGS Geologist John Graham and I spent time in June and July, 1997 completing field work for the project. In mid-June, John and I traveled to the far reaches of our mapping area on a reconnaissance mission. In July, we completed a whirlwind tour of the mapping area with the purpose of drilling geologic boreholes using a Giddings truck-mounted soil probe *(Figure 1)*. The wet conditions in the eastern part of the state made for difficult working conditions, as we couldn't even attempt to access drilling localities in low lying areas or we'd get hopelessly stuck.

One of the many interesting geologic features we discovered was field evidence of permafrost. Permafrost features are sometimes visible on aerial photographs, but are difficult to see in the field. Evidence of permafrost has been found elsewhere in North Dakota, but each new documented occurrence can assist us in piecing together information about climatic conditions during de-glaciation of North Dakota. The ice wedge cast shown in *Figure 2* was discovered in a gravel pit southeast of Lankin (Township 156N, Range 56W, Section 33).

We also had some unusual visitors to one of our field localities near Pisek *(Figure 3)*. The woodland vegetation near the edge of the Lake Agassiz basin provides excellent habitat for moose. The extremely wet conditions this spring created even more temporary wetland habitat for this moose.

In the near future, I will be completing the combination compilation and new mapping in the Grafton area and the final digital map will be available after June 30, 1998. This mapping is being completed with funds from the U.S. Geological Survey Cooperative Mapping Program and matching funds from the State of North Dakota.

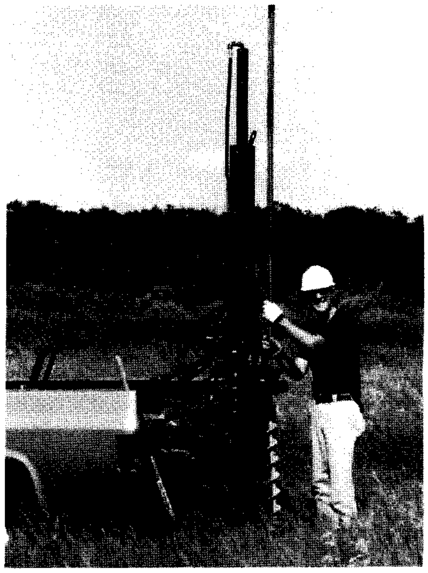


Figure 1. Former NDGS geologist John Graham, operating the Giddings soil probe.

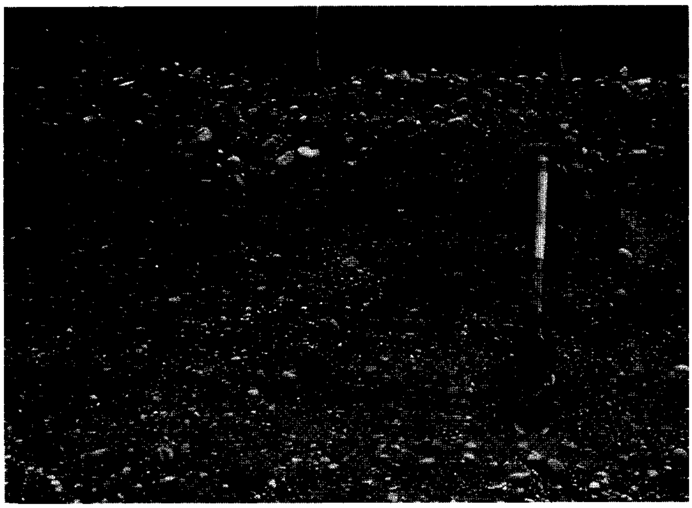


Figure 2. Relict frost wedge is possible field evidence of permafrost conditions.

Figure 3. This young moose seemed to welcome the wet conditions in the Red River Valley.

Bismarck-Mandan Surficial Geology Map

by
Ed Murphy

In the fall of 1996, the North Dakota Geological Survey began mapping the Bismarck-Mandan area with funding provided by Statemap, a cooperative mapping program between state surveys and the U.S. Geological Survey. The surface geology of nine, 7.5 minute quadrangle maps (approximately 440 square miles) are scheduled to be mapped by December, 1998. The Jamestown and Dickinson areas, as well as Theodore Roosevelt National Park, were previously mapped by the North Dakota Geological Survey under this program.

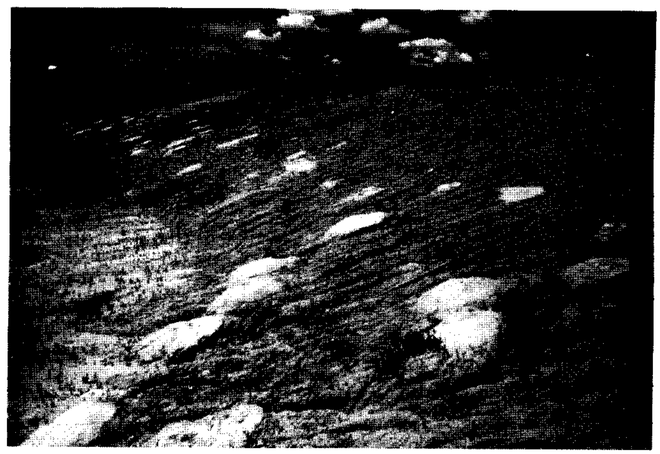
The surface and near-surface bedrock geology in the Bismarck-Mandan area consists primarily of alternating beds of sandstone, siltstone, claystone, mudstone, and occasionally lignite of the Hell Creek (Upper Cretaceous), Ludlow (Paleocene), Cannonball (Paleocene), Slope (Paleocene), and Bullion Creek (Paleocene) formations. The sandstones and mudstones of the Cannonball Formation are the dominant bedrock lithologies in the upland areas and are often covered with a thin layer of till or windblown deposits. The Missouri River bottoms contain thick deposits of late Pleistocene and Quaternary sand and gravel.

Many parts of the map area contain little or no rock exposures. Therefore, hundreds of holes have been drilled by Ann Fritz, Jon Ellingson (geology graduate student at the University of North Dakota) and myself to determine the geology beneath the soil cover. Aeriai photographs taken in the 1930s and 1950s are useful in mapping areas in the cities that are now obscured by development.

Mapping in an urban area is much different than mapping in a rural setting. Concrete and asphalt often cover what rock exposures would normally have been present. Surface recontouring by developers often mask subtle topographic features that might otherwise have been useful mapping tools. Underground cables abound and drilling has to be carefully planned to avoid them. In addition, obtaining permission to drill is more time consuming because the area surrounding the cities is often broken into small privately owned tracts. On the positive side, excavations for basements often provide detailed geologic information not always available from a single drill hole. Timing is the key, as walls are generally poured and backfilled in a very short period of time. In addition, city engineers are valuable sources of data as numerous holes have been drilled over the years for various city projects.

There are several issues in the Bismarck-Mandan area that surface mapping can address. Sand and gravel in the old terraces of the Missouri River south of Bismarck is an important mineral resource. In some areas the development of this resource has already been hampered by housing developments. Several municipalities in the U.S. have wrestled with the problem of protecting sand and gravel deposits without hindering growth. The steep walls of the Missouri River trench are often unstable and numerous slumps have developed in the area, especially in areas where Hell Creek strata are exposed in the cliff face. It is important to identify the areas that contain unstable slopes so that problems can be avoided by not building structures too close to the edge.

Erratics (rocks transported into the area by glaciers) dot a hillside northwest of Bismarck. The erratics are float (that is they weathered out of glacial sediment that once covered this area) on the Cannonball Formation at this site. The truck-mounted Giddings probe was used to obtain shallow cuttings and core.



An excavation by a contractor in north Bismarck created this excellent exposure of concretionary sandstone from the Cannonball Formation. These round concretions often are similar in appearance to 18th and 19th Century cannonballs which is how the formation came to be named.

A slump or slope failure in Hell Creek strata (right of road) just north of Huff Hills Ski Area. Most slope failures in this area occur in bentonites (swelling clays) within the Hell Creek Formation.

Impact Craters - Part II

by

Tom Heck

Continuing last issue's article on extraterrestrial bodies that have impacted the earth, I will discuss four craters that are closer to North Dakota than the Chicxulub Crater on the Yucatan Peninsula. The largest of the four craters is the Manson Impact Structure (MIS) in Iowa. The other three are the Red Wing Creek, Newporte, and Crater oil fields in western North Dakota all of which have been interpreted to be impact craters.

MANSON CRATER, IOWA

The Manson Impact Structure (MIS) is located in north-central Iowa near the town of Manson for which it is named. The MIS has been studied extensively and is one of the better known North American craters. A forthcoming publication from the Iowa Geological Survey Bureau is in the form of a CD prepared for the 125th anniversary of the Town of Manson. The CD is a slide show with a soundtrack describing the history of investigations at the MIS, the geology and origin of the impact crater, some possible effects of the impact on animal life in the region, and other data much of which is original research conducted by the Iowa Geological Survey Bureau. I was able to borrow an early version from Dr. Ray Anderson at the Iowa Geological Survey Bureau and I look forward to viewing the final version when it becomes available.

The MIS is approximately 35 kilometers (km) in diameter. Anderson and Hartung (1992) theorized that a body approximately 2.1 km in diameter impacted the earth *(Figure 1)* at Manson. The impact formed a crater that can be divided into three parts *(Figure 2)*, a central peak or uplift, a crater moat, and what was named the megablock zone. The central peak is approximately 10 km in diameter and is comprised of a variety of Precambrian rocks and impact melts and glasses. The middle third of the crater, the crater moat, is a depression surrounding the central uplift that was filled with breccia which, in order of increasing abundance, is comprised of blocks of Precambrian, Paleozoic, and Mesozoic strata all in a matrix of clay to sand-size Cretaceous rocks. The outer third was named the megablock zone and is an area of down-dropped fault blocks and overturned strata surrounding the crater moat.

The Manson area was known to be geologically anomalous since 1905 when a water well drilled for the city of Manson encountered an unusual stratigraphic section. Instead of a thick section of Cretaceous rocks, the well penetrated granitic-like rocks at a depth of approximately 1,250 feet (Hartung and Anderson, 1996). Other wells near Manson also encountered unusual stratigraphic sections, confirming the presence of a geologic oddity *(Figure 3)*.

From cores recovered during 1953, the MIS was interpreted to be a cryptovolcanic feature, or circular structure thought to have been formed by volcanic explosions. Any direct evidence of volcanism, however, is absent. It was not until 1966 that the MIS was first proposed to be the site of a meteorite impact (Short, 1966). Proof that the MIS was a meteorite impact crater was found in the presence of shocked mineral grains in cores (French, 1984). French also thought that the MIS might have been the meteorite impact that caused the mass extinction at the end of the Cretaceous Period because the initial age-dates derived from shocked minerals were around 65 million years ago (Ma). Because the meteorite landed in Upper Cretaceous strata close to the K-T boundary Anderson and others (1996) also thought

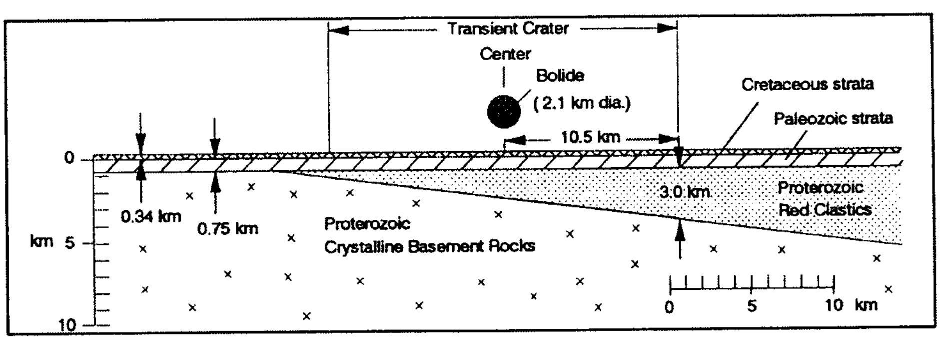


Figure 1. Schematic cross section of the pre-impact geologic setting at Manson, Iowa. The meteorite, or bolide, is shown as are the dimensions of the transient crater which became the central uplift and crater moat. Note the thicknesses of the stratigraphic section the meteorite impacted. Parts of all of these strata are found associated with the crater (modified from Anderson and Hartung, 1992).

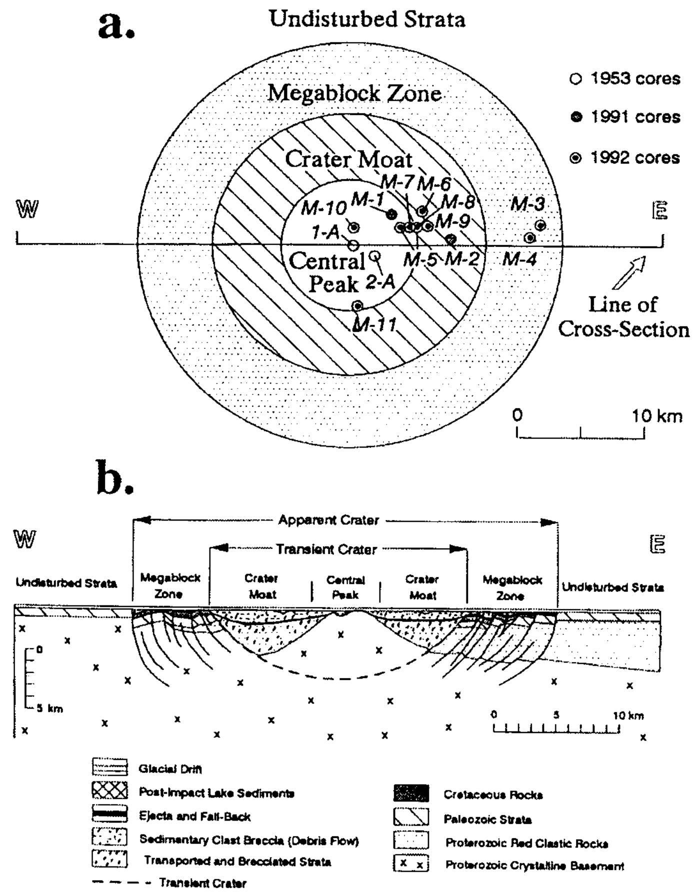


Figure 2. Generalized map view of the crater (a) and schematic cross section across the Manson Crater (b) with the three crater zones shown on both. The locations of cored wells and the year the cores were cut are shown of the crater map view (modified from Anderson and Hartung, 1992).

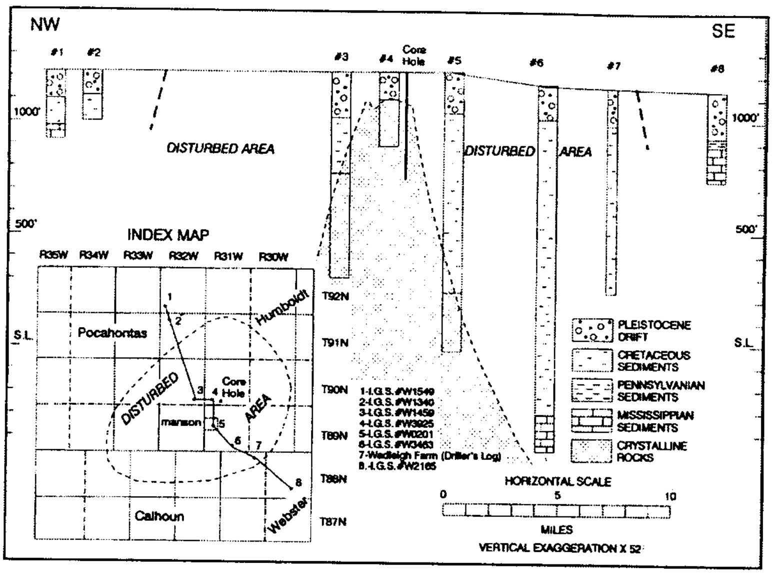


Figure 3. Dryden's (1955) original cross section across the Manson Crater when the crater was interpreted to be a cryptovolcanic feature (from Hartung and Anderson, 1996).

this crater might have been the dinosaur killer. However, Izett and others (1993) used $^{40}Ar/^{39}Ar$ to date samples of the mineral Sanidine, found only rarely in mineral melts in cores from the MIS, and measured an age of 73.8 ± .3 Ma proving the MIS could not be the end of the Cretaceous impact site. This $^{40}Ar/^{39}Ar$ age-date remains the best date for the time of impact so far.

To confirm the age-date, Izett and his co-authors looked for supporting evidence in the Pierre Shale in South Dakota and found both shocked quartz and shocked feldspar grains in the Crow Creek Member of the Pierre Shale. Shocked minerals were also found in this member at several other locations in South Dakota and a decrease in grain size from east to west, away from the MIS, was noted. The stratigraphic position of the Crow Creek member places it in the late Campanian and age dates from bentonite beds surrounding the Crow Creek Member ranged from 74.83 ± 0.72 and 72.32 ± 0.39 Ma (Obradovich, 1993), bracketing the impact date measured by Izett and others. The occurrence of shocked mineral grains that decrease in grain-size away from the MIS and independently derived age-dates from beds around the stratigraphic unit containing the shocked grains that bracket the age-date of the MIS event are evidence that the shocked grains are related to the Manson impact.

The Crow Creek Member is an unusual unit in the Pierre Shale. The Pierre Shale is comprised of mostly black shale, but the Crow Creek Member records a change. The member is thin, only a few meters thick, and contains sand-sized grains while the Pierre Shale normally contains nothing larger than silt-sized particles. The Crow Creek Member also contains shale rip-up clasts, and has been found only in central and southeastern South Dakota and northern Nebraska (Steiner and Shoemaker, 1996). Izett and others (1993) have proposed that the Manson impact caused a tsunami, or tidal wave, which deposited the Crow Creek Member. If true, the effects of the tsunami reached at least as far as central South Dakota, a distance of 500 km, because the Crow Creek Member is exposed along the Missouri River near Pierre, SD *(Figure 4)*. It is possible that the equivalent strata were deposited in southeastern North Dakota because it too is less than 500 km from the MIS but no outcrops have yet been found.

The Manson impact probably had a significant impact on life in the area causing several species to either become extinct or be greatly reduced in numbers or diversity (Anderson, in preparation). The energy released by the impact affected a large area *(Figure 5)*. All the plants across the entire state of Iowa that were above water would have been burned. Land animals would have been killed as far as 1,000 km from the impact site and the blast would have been felt even

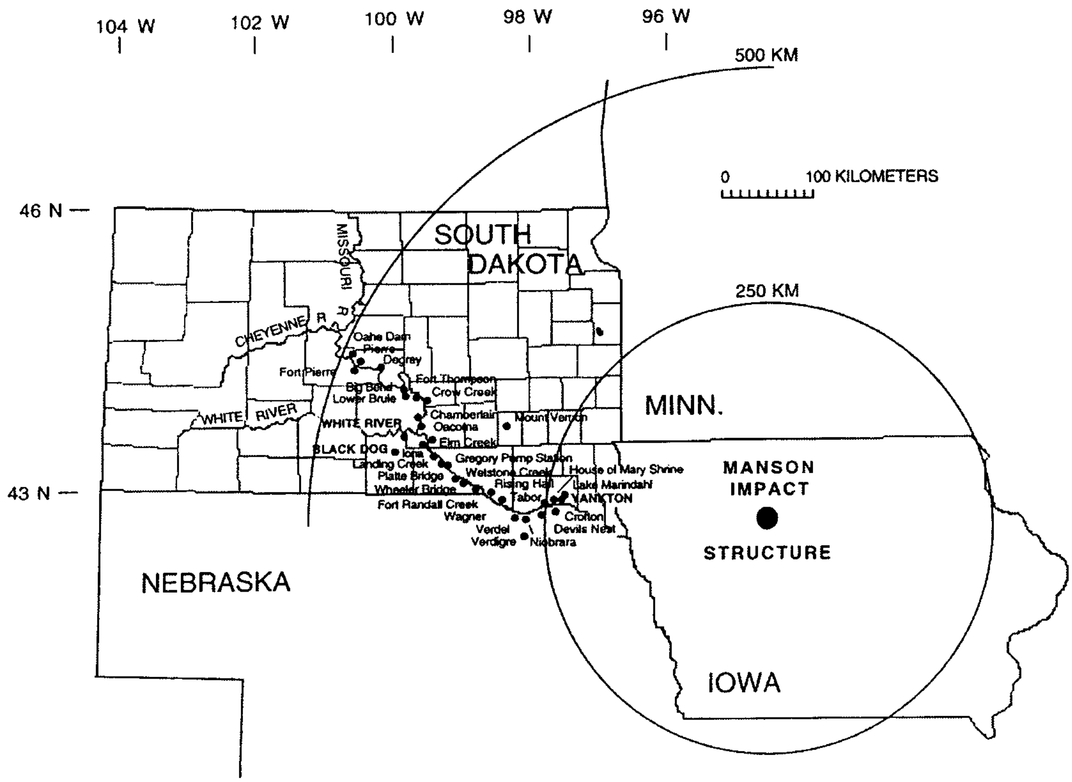


Figure 4. Location map of exposures of Crow Creek Member in South Dakota and their position relative to the Manson Crater. The area in southwestern North Dakota where the Crow Creek Member might have been deposited is shown (modified from Stiener and Shoemaker, 1996).

farther away. The effects on marine life are less well known but it seems unlikely that marine animals within a few hundred kilometers would have survived the impact blast and resulting tsunami. Animals that became extinct or endangered in the region include the giant crocodile *Phobosuchus*, hadrosaur, centrosaur, and porchycephalosaurs *(Figure 6)*. The effect within the boundaries of present day North Dakota are unknown, not only because it was covered by the Western Interior Seaway, but also because it has not been studied. Perhaps some day we will know more about whether and how the Manson impact directly affected North Dakota.

NORTH DAKOTA IMPACT CRATERS

At least three structures in North Dakota have been interpreted to be meteorite impact craters. They are significant because all three are producing oil fields: the Red Wing Creek, Newporte, and Crater fields. There is no reason to think that there aren't more impact features in the state and it is possible that some of them have been drilled. If so, we may only know about them by rumor because the wells were dry holes and no data was made public. It is also likely that other impact craters have not yet been found.

Red Wing Creek Field, located in T148N-R101W in McKenzie County, was discovered in 1972 by True Oil Company. They completed the #22-27 Burlington Northern flowing 750 barrels of oil (BO) + 563 thousand cubic feet of gas per day (MCFGPD). The well drilled an abnormally thick section, more than 3,000 feet, of steeply dipping and faulted Madison Group strata. Parson and others (1975) reported that this, and subsequent wells, were drilled into the central uplift of a meteorite impact crater. The discovery of Red Wing Creek Field was an important event in North Dakota's petroleum history. It proved that it was still possible to find 10 million barrel oil fields in the Williston Basin. The timing of the field's discovery was important as it happened just before the Arab oil embargo in 1974. The discovery of a new, large oil field in North Dakota helped initiate new drilling in the state.

Red Wing Creek Field also is one reason why the prolific Billings Nose oil fields were discovered. Red Wing Creek Field is located on the northern end of the Billings Nose and companies simply tested the Red Wing Creek pay farther south in structurally favorable locations and found more than 100 million BO.

From its discovery, Red Wing Creek Field was thought to be an impact structure (Parson, 1974; Parson and others, 1975). The first indication was the shape of the structure *(Figure 7)*. Oil production was found in the central uplift, which is surrounded by a depression, or moat. Beyond the moat lies a raised crater rim. The strata in the central uplift are intensely deformed and the uplift is around 3,000 feet high from its base to the crest. The normal stratigraphic section in the general area is incomplete over the crater as there are no Triassic, Permian, or Pennsylvanian strata overlying the uplift. The strata above and

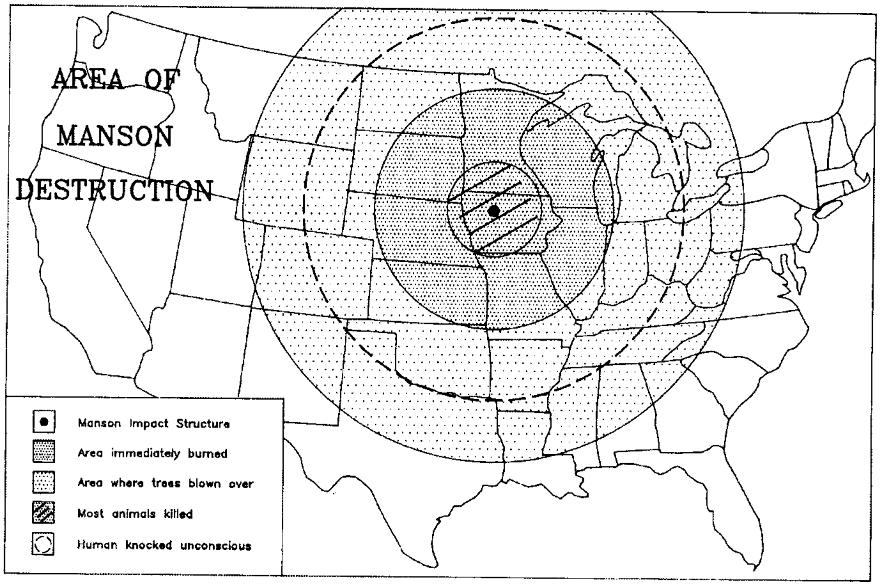


Figure 5. Map of the United States with the area and degree of blast affects from the Manson impact (modified from Anderson, in preparation).

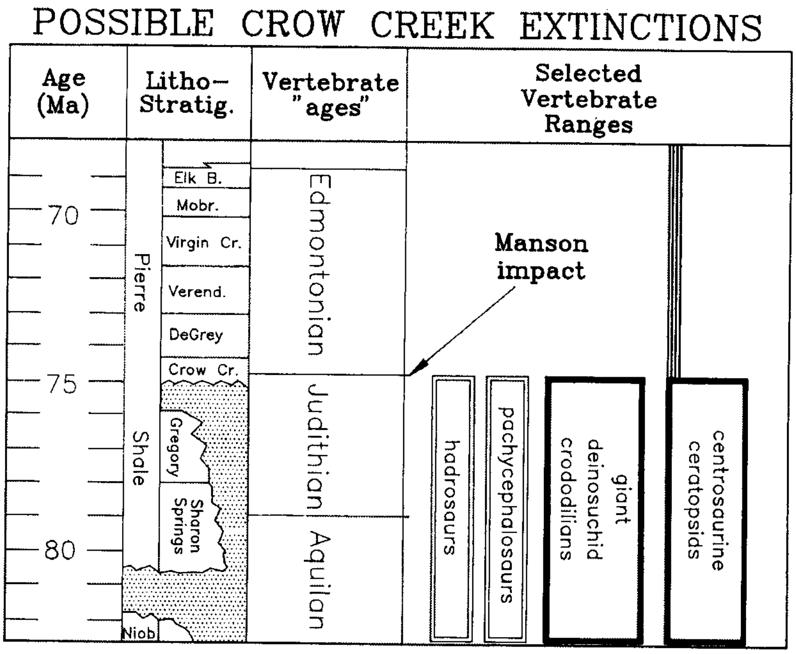


Figure 6. Stratigraphic section of the Pierre Shale with the vertebrates affected by the impact. Population decreases are reported in the hadrosaurs and pachycephalosaurs. The crocodiles became extinct while the diversity of centosaurs was greatly reduced (modified from Anderson, in preparation).

below the central uplift show little evidence of deformation indicating it was not a normal tectonic event that formed Red Wing Creek Field.

More evidence of a meteorite impact came in the form of shatter cones found in cores. Shatter cones are striated conical rock fragments that can be up to several meters long. The striations radiate outward from a common point in a horsetail fashion and are formed by shock or impact pressures. Finally, evidence of shock deformation, in the form of brecciated rocks and shocked quartz, was also found in cores from the central uplift.

The Red Wing Creek impact is thought to have happened during the Jurassic Period. The central uplift is composed of Mississippian rocks. Pennsylvanian through Triassic strata are missing over the uplift, but these strata are present outside the crater. The central uplift and crater are covered by Jurassic rocks so the impact occurred before the Jurassic strata were deposited and the force of the impact removed the Pennsylvanian through Triassic rocks and formed a central uplift of deformed Mississippian rocks.

Red Wing Creek Field was the first meteorite impact crater found in North Dakota. Its origin has been well-known, since its discovery was an important event in the history of the Williston Basin. Newporte Field, located in T163-164N, R87W in Renville County approximately one mile south of the Canadian border, also was an important find.

Shell Oil Company discovered the Newporte Field in 1977 when they drilled and completed their #23X-9 Larson. The field produces from the Cambrian Deadwood Formation and drill-stem tests of pay held the promise of high production rates, some calculated to be as high as 128 BO/hour. Unfortunately, reality did not live up to the promise as the Larson well was completed for only 127BO and between 800 and 1,400 MCFGPD. However, this discovery did generate a lot of interest in the oil potential of the Lower Paleozoic (Winnipeg and Deadwood Formations) section.

Newporte Field is also unique in North Dakota because it has the only Precambrian oil production in the state. The Shell Oil Co. #14-34 Mott had an initial potential (IP) of 168 BO + 101 MCFG + 1 barrel of water (BW) per day from the Precambrian.

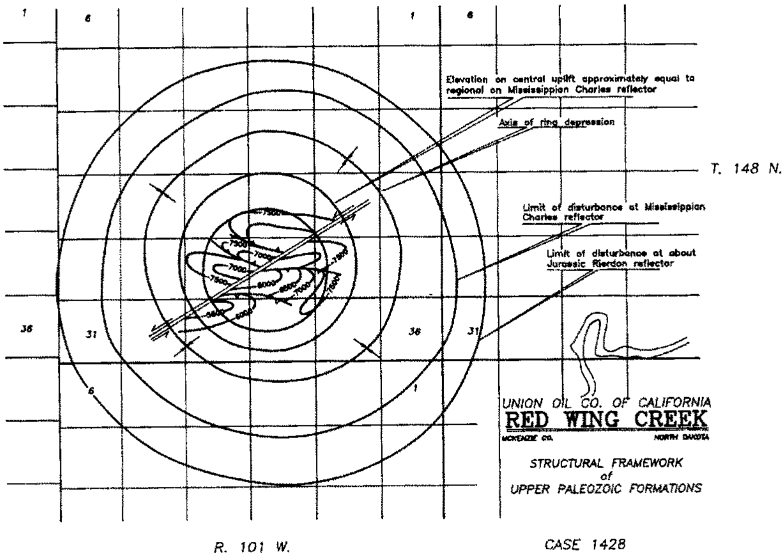


Figure 7. Exhibit by Union Oil Co. of California for the N.D.I.C. Case 1428 hearing. The limits of various parts of the Red Wing Creek crater are shown as is the structure on the top of the central uplift.

Recently the Larson well was recompleted by Eagle Operating Inc. of Kenmare, ND who added significant new reserves to the field. Eagle's success has helped renew interest in the Lower Paleozoic section that approaches the level generated by the original discovery.

The origin of Newporte Field has been somewhat controversial. Clement and Mayhew (1979) acknowledged that some thought the field was an impact structure, but they believed that differential and recurrent movement along vertical faults formed the structure and caused the stratigraphic variations seen in the field. Gerlach (1994) studied the field using seismic data obtained from Shell Oil Co., cores, thin sections, and well logs. He concluded that, while not conclusive, the data are consistent with an impact origin. Evidence that supports an impact origin includes a circular shape with a raised rim *(Figure 8)*, a poorly developed or possibly highly eroded central uplift, possible impact breccias, planar deformation features (PDFs) in mineral grains, and kink-banding in biotite grains. None of the evidence, either alone or together, is conclusive proof of a meteorite impact. For example, PDFs are evidence of high stresses but other processes like explosive volcanism have produced similar features in mineral grains.

Alexopoulos and others (1988) studied PDFs from several known impact craters, nuclear explosions, explosive volcanic events, an ophiolite sequence, and two enigmatic sites. They concluded that PDFs from impact craters can be distinguished from those of other sources and list some parameters to distinguish those formed by impact from those with other origins. One of the characteristics of PDFs formed by an impact is that at least 80% of the PDFs are within 3° of being parallel to one of three specific crystallographic axes. Koeberl and others (1995) studied several breccias found in Newporte Field cores and discovered PDFs in quartz grains with a predominant orientation parallel to one of those three crystallographic axes. This discovery confirmed the impact origin of Newporte Field.

The age of the Newporte impact is poorly defined, ranging from as early as Middle-Late Proterozoic to as recent as Late Cambrian-Early Ordovician (Gerlach, 1994; Clement and Mayhew, 1979)). The Winnipeg Formation thins over the rim of the structure, evidence that the uplifted rim was present before Winnipeg deposition. Breccias containing clasts of Precambrian rocks are present in the Deadwood Formation but can be interpreted in either of two ways. Either an existing structure was being eroded shedding large clasts of Precambrian rocks or the breccias are impact breccias, formed by the impact during Deadwood deposition. In either case, the presence of Precambrian rocks in Deadwood strata places an upper time-limit for the formation of the crater to Late Cambrian-Early Ordovician when the Deadwood was being deposited.

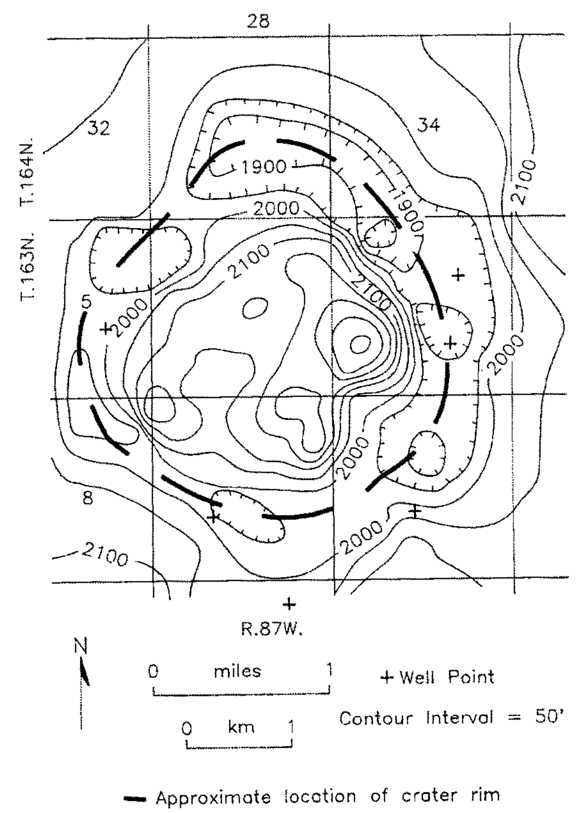


Figure 8. Isopach map of the Prairie Formation to Winnipeg Icebox Shale interval constructed by converting seismic isochron (equal time) contours to equal thickness contours. The approximate limits of the crater are shown (modified from Gerlach, 1994).

The lower age-limit would be the Hudsonian orogeny which occurred 1.6-1.9 billion years ago. Gerlach (1994) thought that either post-orogeny erosion or the tectonic forces of the orogeny itself would have destroyed the crater had it been present. The only way to get a better age-date would be if diaplectic, or impact glasses were found and age-dated. A new well in the center of the structure would be the most likely way to find impact glasses, as none have been found in the existing wells.

The third impact crater cum oil field in North Dakota is, appropriately named, Crater Field. Ironically, it is also the only one of the three fields that has not been proven to be an impact crater.

Armstrong Operating Inc. discovered the field when they drilled their Heidt #24-1. The well is located in section 24 of T138N-R97W in Stark County approximately 8 miles southwest of Dickinson and was completed for 185 BO + 93 MCFGPD and no water in the Silurian Interlake Formation.

The structure at Crater Field was seismically defined and a classic crater shape, consisting of a central uplift or plume *(Figure 9)* surrounded by a moat and an outer crater rim, can be seen on a seismic line across the structure. In map view *(Figure 10)*, the central uplift and location of the Heidt well are shown as is the axis of the crater moat (annular syncline). More than 250 feet of structural closure exists on the crater uplift. None of Armstrong Operating Inc.'s exhibits showed the areal extent of the crater but, in order for there to be a central uplift, the crater must be two or more miles in diameter.

The impact can been interpreted to have occurred during deposition of the Lower to Middle Interlake or during the Middle Silurian. This date can be arrived at because the crater rim is shown to contain Lower Interlake strata *(Figure 11)* while the same section is missing from the crater moat. The crater moat is also shown to contain a thicker Middle Interlake section, evidence of increased sedimentation in a topographic low presumably formed by the impact. Thus, the impact must have occurred after Lower Interlake rocks were deposited but before Middle Interlake deposition or approximately Middle Silurian.

No cores were cut in the Heidt well, but drill cuttings from the top of the Interlake Formation down are different from the normal Interlake section. The rocks are darker in color, more dolomitic, and well logs across the Interlake Formation do not correlate readily with a normal Interlake section. As no cores were cut, it is unlikely that any other features like shatter cones, breccias, diaplectic glasses, or shock metamorphosed quartz grains would be recognized and found. These are the most diagnostic features of a meteorite impact so without them, proof of an impact origin is unlikely. The data from seismic, well logs, and drill cuttings, however, are strong evidence that the field is an impact feature.

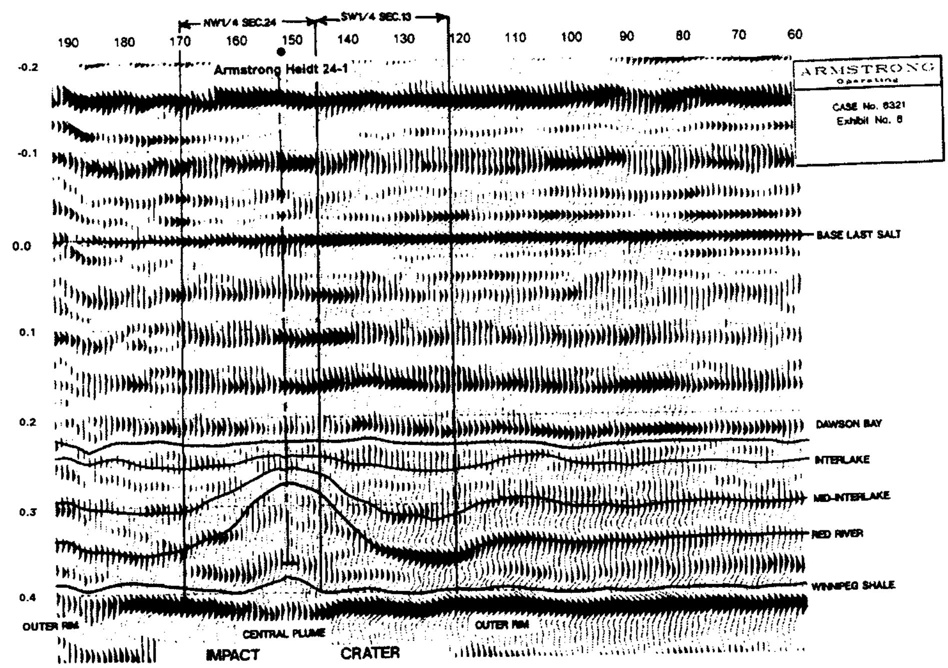


Figure 9. Seismic line across Crater Field showing the location of the discovery well on the crater, the central uplift, the crater moat, and crater rim (modified from Armstrong Operating Inc.'s Exhibit 6, Case 6321 before the N.D. Industrial Commission).

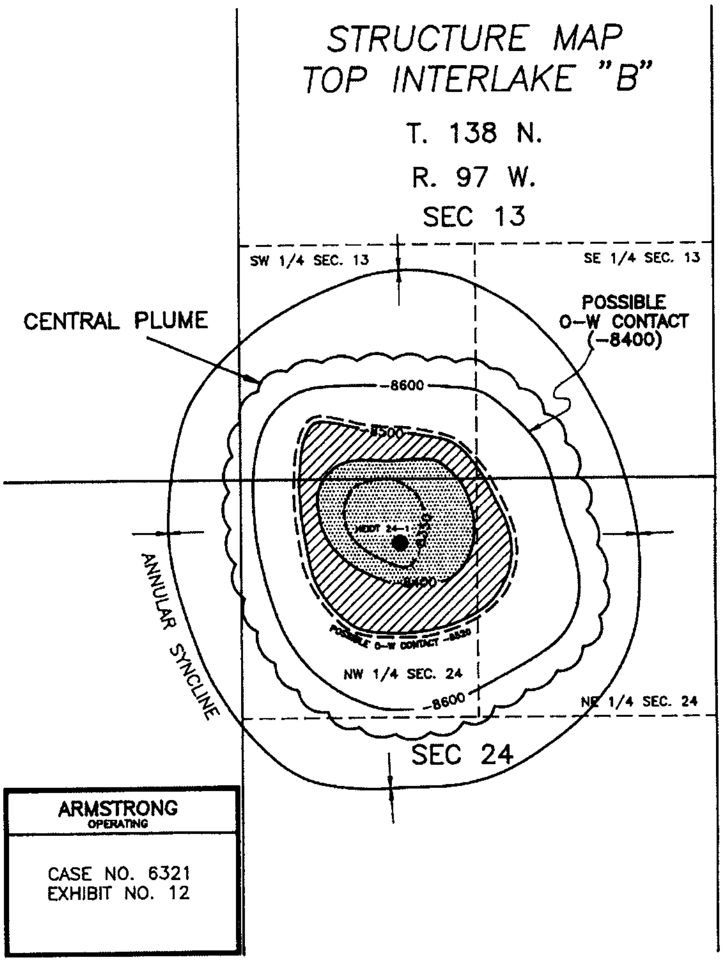


Figure 10. Map view of Crater Field with the central uplift (called *Central Plume* on diagram), axis of crater moat (called annular syncline by operator), and possible oil-water contacts shown by stipled and lined patterns (modified from Armstrong Operating Inc.'s Exhibit 12, Case 6321 before the N.D. Industrial Commission).

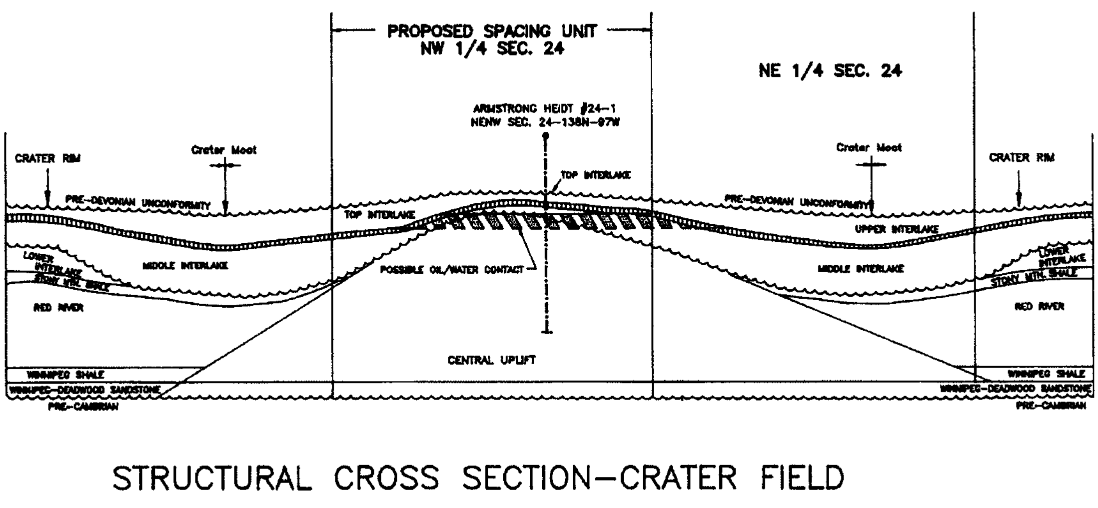


Figure 11. Generalized structure cross section across Crater Field with crater features shown (modified from Armstrong Operating Inc.'s Exhibit 11, Case 6321 before the N.D. Industrial Commission.

SUMMARY

There have been several meteorite impacts close to or in North Dakota that have had an effect on the state. The first article in this series (*NDGS Newsletter*, Fall 1997) discussed the Chicxulub impact at the end of the Cretaceous Period which had a profound effect on life world-wide. Closer to home is the Manson Crater in Iowa and, within North Dakota, there are three meteorite impact structures that eventually became oil fields. The economic effect of two of these three meteorite impacts has been, and continues to be, a significant influence on the oil industry in North Dakota. These are not the only meteorite impacts in the region. There are other, similar meteorite impact craters to the north in Manitoba and Saskatchewan. I leave them for you to discover.

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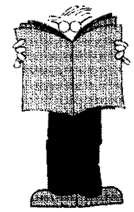
NEW PUBLICATIONS



NDGS Initiates New Publication Series

In an effort to provide important geologic information of interest, mainly at the local level, the NDGS has begun a new series of reports entitled *Geologic Investigation*. In contrast to our other reports (*Reports of Investigation, Miscellaneous Series, Miscellaneous Maps*, etc.) our new *Geologic Investigation* series will not be widely distributed. We currently distribute approximately 250 copies of our other reports to libraries throughout the United States and other countries. The *Geologic Investigation* series will generally deal with topics that we judge to be of local interest.

The first publication in our new *Geologic Investigation* series is titled **Dickinson Geology: A Guide to the Geology, Mineral Resources, and Geologic Hazards of the Dickinson Area**. *Geologic Investigation No. 1*, by Robert Biek and Edward C. Murphy, is an 80-page report that contains discussions on the general geologic history and mineral resources of the Dickinson area. Two road guides of the surrounding area point out geologic points of interest. A 2 x 3 foot colored map of the surface geology is included with the report.

Geologic Investigation No. 1 **$5.00**

Other New Publications

The Jerusalem and Tolna Outlets in the Devils Lake Basin, North Dakota, by Edward C. Murphy, Ann M.K. Fritz, and R. Farley Fleming.

In this 36-page report, the authors discuss the sedimentologic history of the Jerusalem Outlet from East Devils Lake to Stump Lake and the Tolna Outlet from Stump Lake to the Sheyenne River. The report is the result of sediment samples obtained during drilling and trenching the outlets during the winter of 1996-97. Palynology and radiometric dating were used to determine the geologic history of the two outlet sites. The results of the outlet study added considerably to our knowledge of the fluctuating water levels of the Devils Lake system during the past 10,000 years.

Report of Investigation No. 100 **$3.00**

Abstract

Terminal Cretaceous extinction event documented by marine cartilaginous fishes from the Fox Hills (Maastrichtian) and Cannonball (Danian/Thanetian) Formations, North Dakota, by John W. Hoganson (North Dakota Geological Survey), J. Mark Erickson (St. Lawrence University), Alan M. Cvancara , and F.D. Holland, Jr. (University of North Dakota).

Shallow water marine sediments of the Timber Lake Member of the Fox Hills Formation and Cannonball Formation document the last major marine incursions into North Dakota during the latest Cretaceous and Paleocene, respectively. Biochronological indicators establish a Maastrichtian age (*Jeletzkytes nebrascensis* zone) for the Timber Lake Member and a Danian/Thanetian age for the Cannonball Formation. Both formations contain diverse cartilaginous fish faunas represented primarily by teeth and dental plates.

Twenty-two cartilaginous fish species represented by 20 genera in 15 families occur in the Timber Lake Members. Fifteen cartilaginous fish species represented by 13 genera in 10 families were identified from the Cannonball Formation. None of the identified species occur in both rock units and only four genera (*Carcharias, Palaeogaleus, Dasyatis*, and *Ischyodus*) were common to both units. None of the Cannonball species range into the Cretaceous anywhere and four of the Cannonball genera (*Megasqualus, Palaeohypotodus, Otodus*, and *Hypolophodon*) originate in the Paleocene. Eight genera (*Hybodus, Squalicorax, Paranomotodon, Archaeotriakis, Pseudohypolophus, Ischyrhiza, Ptychotrygon*, and *Rhombodus*) recovered from the Timber Lake Member do not range into the Tertiary anywhere. All but four families found in the Timber Lake Member range into the Tertiary and only one family represented in the Cannonball Formation does not range into the Cretaceous.

The end Cretaceous extinction event did not drastically affect the cartilaginous fish faunas at the family level. This extinction event did, however, have a major effect on the shallow water Western Interior Seaway cartilaginous fish faunas at the generic and, particularly the specific, levels. The Cannonball fauna is 35% smaller at the generic level than the Fox Hills with reductions coming from genera of varied ecological niches. Paleocene originations are genera with similar ecological preferences.

***** This abstract appeared in the *Journal of Vertebrate Paleontology*, Volume 17, Supplement to Number 3, September 4, 1997, and was presented at the 57th Annual Meeting of the Society of Vertebrate Paleontology in Chicago, Illinois.**