NDGS NEWSLETTER

Industrial Commission of North Dakota
North Dakota Geological Survey

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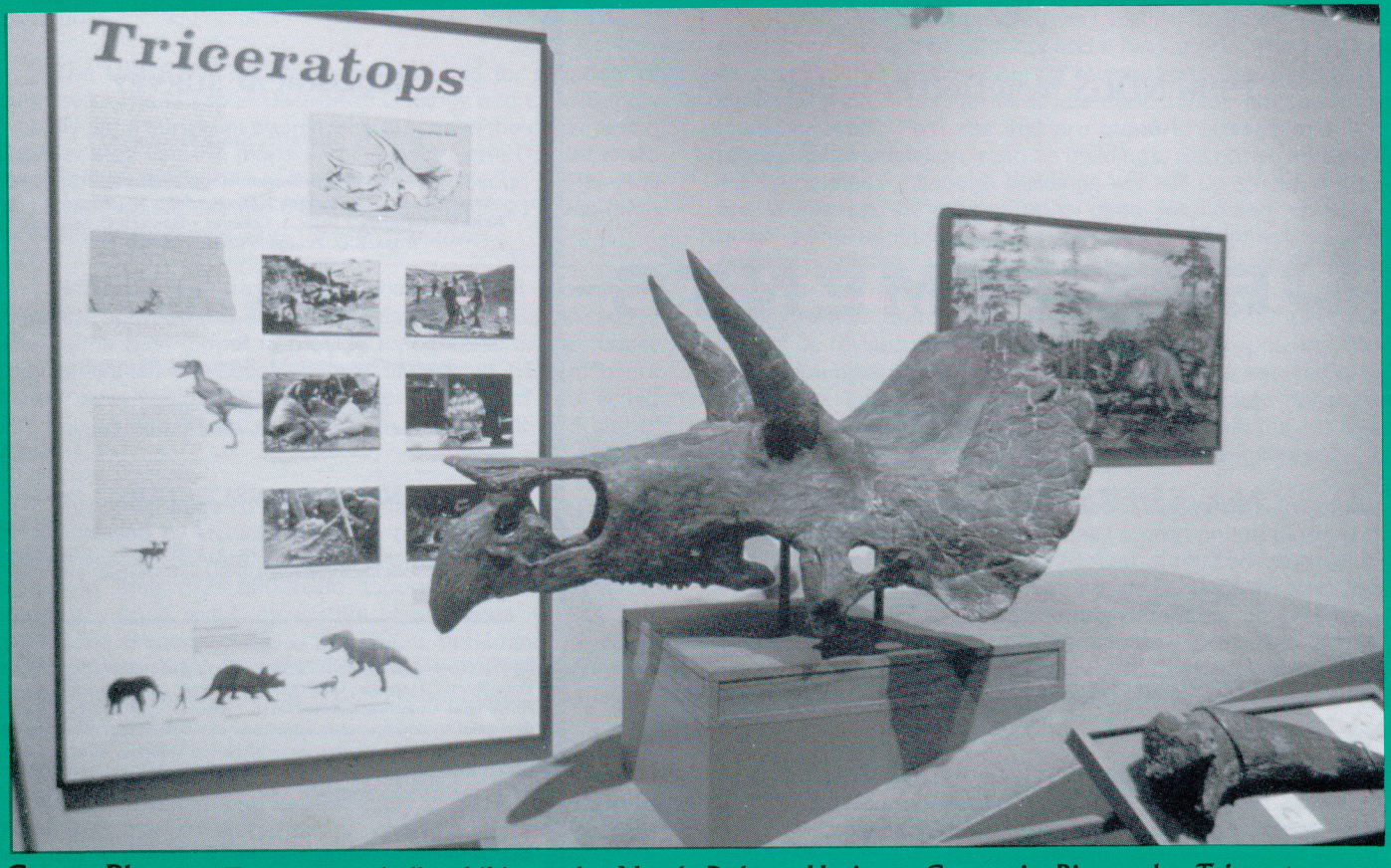


Cover Photo: *Triceratops* skull exhibit at the North Dakota Heritage Center in Bismarck. *Triceratops* was one of the horned dinosaurs that inhabited North Dakota about 65 million years ago. This skull, excavated from Custer National Forest administered land in Slope County, is about five feet long. *Photo by Todd Strand, State Historical Society of North Dakota.* (See *Triceratops* article on page 24.)

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. Correspondence, 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) 328-9700.

When requesting a change of address, please include the number on the upper right hand corner of the mailing label.

FROM THE STATE GEOLOGIST

By John. P. Bluemle

The North Dakota Geological Survey, through our Earth Science Information Center (ESIC), acts as a vendor for most of the published materials of the United States Geological Survey (USGS). Among the most important of these are topographic maps. We sell more than 4,000 topographic maps a year, most of them in the 1:24,000-scale series (7.5 minute or about 2½ inches to a mile). I'd like to discuss some concerns we have about these maps. I've borrowed from two of my colleagues in writing this column, the State Geologists of Tennessee and Missouri.

The USGS 7.5 minute maps are used for a variety of purposes. The Missouri Division of Geology and Land Survey recently did a survey of people who purchase the maps to find out how they use the maps and I expect North Dakota users have similar needs. What they found in Missouri is that 44% of the purchasers use the maps for recreation, 41% use them for business purposes, and 13% for education.

An issue that has been discussed a lot recently in meetings between the State Geologists and USGS officials is what is the best format to provide topographic maps: paper copy or digital. In Missouri, they found that 61% of users prefer paper copies, 2% would prefer digital, and 37% would like to see the maps available in both digital and paper versions.

The other issue I'd like to discuss relates to the policies being followed by USGS relative to revision and updating of existing maps. Several changes are being instituted by the USGS in their 1:24,000-scale topographic map revision program. As a result of a 1994 User Needs Assessment (Open File Report 95-201), the USGS determined that the most significant requirement of their cooperators, customers, and the public at large is data correctness, both for maps and digital data.

The main concern expressed by their customers is that the USGS takes too long to update the maps. Consequently, the USGS has instituted some changes to the National Mapping Program (NMP) revision process that will allow them to provide more current data, often for a lower cost than was possible in the past. These changes include the introduction of digital production techniques (which apply to both limited and standard update revisions), the emphasis on monoscopic revision (limited updates only), and the content of limited update revisions.

Monoscopic revision means that the aerial photography used in the revision does not allow a three-dimensional view. Monoscopic revision is similar to the "photo revisions" that have been done for several decades, except that highly accurate source material is used so revised features can be confidently depicted in standard colors. The former photo revisions were often done from source material with unverifiable accuracy, such as unrectified aerial photos, and new features were shown in purple to indicate questionable accuracy. Limited update revisions use a monoscopic USGS digital orthophoto quadrangle, which is a digital aerial photograph that has been rectified to remove distortion and has the geometric properties of a map. The positional accuracy of planimetric features compiled using monoscopic techniques is comparable to the accuracy of stereoscopic compilation, except that the process is much quicker, and contours cannot be revised.

Under the new procedures, limited updates will not include the revision of contours and a field check. The existing contours will be depicted on the revised map, but a modified symbol will be used in areas where the contours are known to have changed. Features that are prone to change and that require field verification, such as buildings, will not be added or will be deleted. Although buildings will still be shown if they are visible on the photographs used for limited updates, building-use attributes will be deleted on all limited update revisions. Limited updates will include the revision of those features that are most likely to have changed, such as transportation and hydrographic features. Features that cannot be revised confidently using only photographs and that are shown on a previous edition of a map will be retained only if they are not prone to change. Limited update revisions require fewer of the resources of the NMP, so that the number of maps that can be revised each year is greatly increased.

Standard updates will include both revision of all categories of information traditionally shown on the maps and a "field check," which is the verification of revised information by literally visiting the site of the information. Since standard updates are costly and consume more mapping capacity than limited updates, limited updates are now preferred by the USGS in order to provide more current maps and digital data by increasing the number of maps that can be revised each year.

States wishing to have their topographic maps revised on an accelerated schedule, or those that prefer standard updates rather than limited updates, can enter into cooperative, cost-sharing agreements with the USGS. Those states with little or no funding for cooperation, such as North Dakota, will not be totally neglected though. Since the USGS has the responsibility to ensure that maps and digital data are available and current for environmentally sensitive areas or ecosystems, areas prone to natural disasters, federal lands, and other geographically distinct areas where the health and economy of the nation as a whole are affected, these areas will be given preferential treatment.

The impact of all of this will, of course, be felt not only in monetary terms, but in the quality and cultural content (or lack thereof) of the maps that are now being produced. The North Dakota Geological Survey has not yet received any of these new maps, but we know that they have already been distributed to a number of other states.

A number of state geologists believe that the USGS 1994 User Needs Assessment was biased toward GIS users and that traditional users were under-represented. If any of you have concerns, comments, or experience with the newly revised maps, please let me know, and I will forward that information to the Association of American State Geologists Topographic Mapping Committee. The Committee will be working directly with the USGS National Mapping Division to deal with this issue.

As I mentioned at the beginning of this article, the North Dakota Geological Survey sells more than 4,000 topographic maps a year, and we are interested in your thoughts about this matter.

NEWS IN BRIEF

Compiled by Ann M.K. Fritz

Luther, Bassler Leave NDGS Staff

It is difficult to see fellow employees resign, but sometimes opportunities for career advancement are too great to pass up. Both Mark Luther and Rod Bassler accepted positions with a private engineering company in Bismarck, North Dakota. Mark and Rod's resignation was effective November 15.

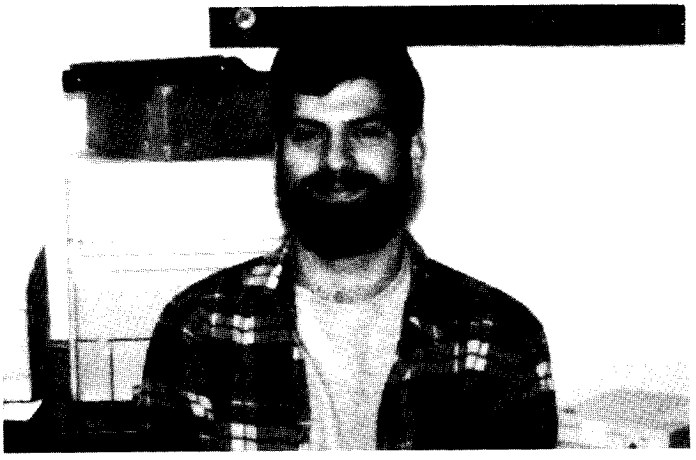
Luther joined the Survey staff in 1989 as a geologist with the geologic mapping program. Mark's primary duty was surficial geologic mapping, focusing on the Red River Valley in eastern North Dakota. In addition to his geologic mapping, Mark helped established the NDGS as an Earth Science Information Center affiliate, as well as establishing the Geographic Information System (GIS) Center. Mark served on various state advisory committees, including the GIS Executive Committee, Global Positioning System Steering Committee, State Mapping Advisory Committee, and the Non-Point Source Pollution Task Force.

Bassler was the GIS Specialist in the GIS Center since February, 1994. Rod was involved in developing the Arc/Info GIS database and the digital production of maps at the Survey, including the Shaded Relief Map of North Dakota (Miscellaneous Map 32). Rod's cartographic and GIS expertise was also utilized in various digital mapping projects. Rod also served on advisory committees such as the GIS Executive Committee. We wish Rod and Mark every success in their new jobs!

Waldkirch Joins NDGS Staff

Ryan Waldkirch joins the North Dakota Geological Survey as the new Cartographer/GIS Manager. Ryan's responsibilities include Chairman of the State Mapping Advisory Committee, member of the GIS Technical Committee, and handling digital information requests for the Earth Science Information Center (ESIC).

Ryan was born and raised in the town of Newburg, Wisconsin, a small farming community 35 minutes north of Milwaukee, Wisconsin. He received a Bachelor of Science in Geography from the University of Wisconsin, Stevens Point, with an emphasis in Cartography, Geographical Information Systems, and Physical Geography. He previously worked for the NDGS in the summer of 1995 as a student intern in the GIS Center.



NEWS IN BRIEF . . . Continued

Survey's GIS Center Assists in Endangered Species Maps

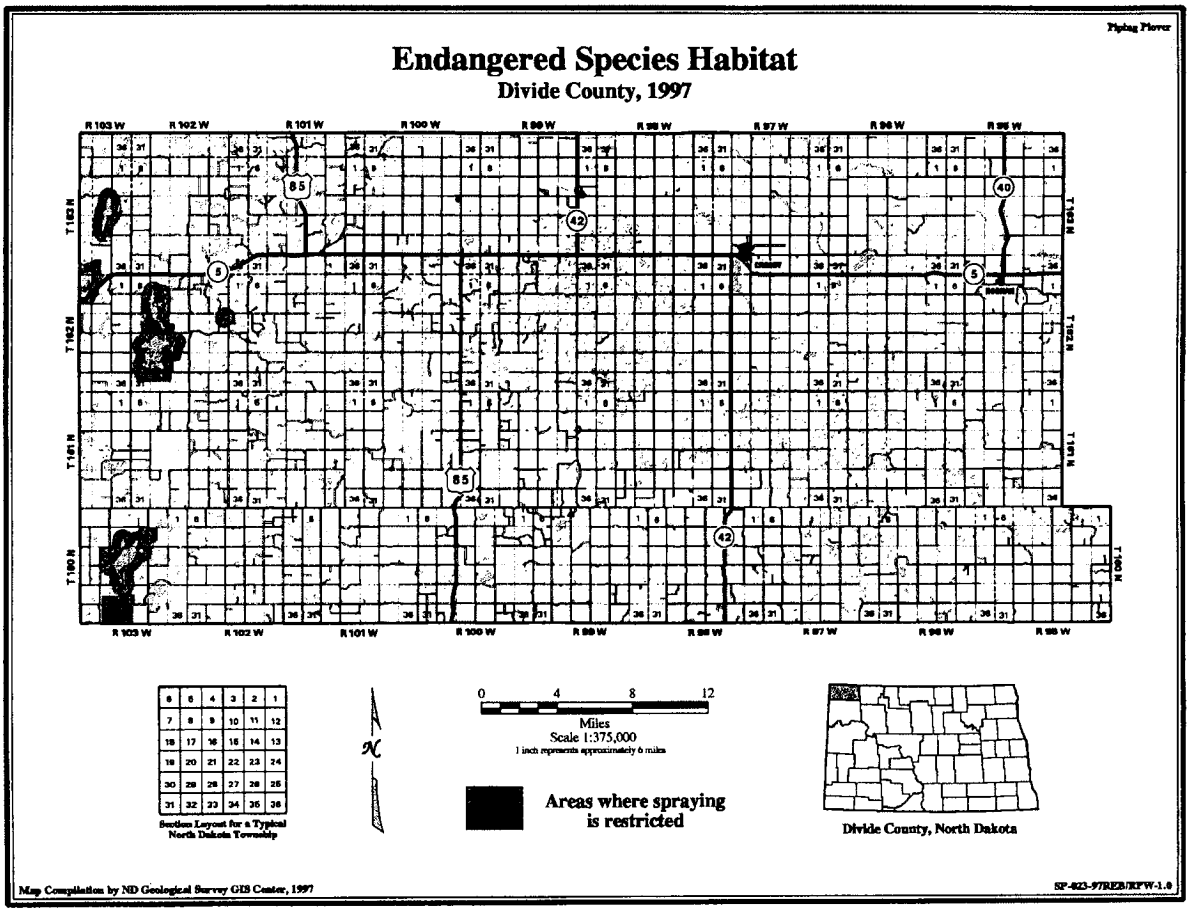
by Ryan Waldkirch

In the fall of 1996 the North Dakota Department of Agriculture in conjunction with the North Dakota Geological Survey's Geographic Information System (GIS) Center produced several Endangered Species Maps. These maps show areas where certain types of pesticide application are prohibited to protect threatened and endangered species. The maps concentrate on four species: the Bald Eagle, the Interior Least Tern, the Pallid Sturgeon, and the Piping Plover. The new, one page bulletins (shown below) will replace the multiple paged, federally produced bulletins. North Dakota is the first and only state in the nation that has approval to use state-produced bulletins instead of the Federal County Endangered Species Bulletins.

In past bulletins, if an endangered or threatened species was noted in an area, the whole area was restricted and prohibited from pesticide application. The restricted area in the new bulletins is now only one-half mile in any direction from where the species breeding habitat is located. This releases approximately 320 acres per section that before could not have certain types of pesticides applied.

North Dakota is the first state in the nation to have initiated such a plan and have it approved by the Environmental Protection Agency and the U.S. Fish and Wildlife Service. The older, federally produced bulletins utilize data that is many years old. As a result some areas have had their restriction removed altogether. The N.D. Department of Agriculture is planning yearly updates of these maps "to provide pesticide applicators with the most accurate data possible" and to provide a healthy balance between humans and threatened and endangered species.

The new bulletins will be available through the N.D. Department of Agriculture, Pesticide Division in mid-spring.



NEWS IN BRIEF . . . Continued

Group Promotes Balanced Environmental Education

Submitted by the Coalition for Conservation and Environmental Education

With conservation and environmental issues becoming more prominent, 63 public and private organizations and individuals came together in September, 1995, to share concerns about *developing a public that is knowledgeable, committed and motivated to take a balanced, active approach for a quality environment.* On October 16, 1996, this group took form as the Coalition for Conservation and Environmental Education (C^2E^2).

A major concern of C^2E^2 is that the line between environmental education and environmental advocacy has become blurred. They are distinctly different in nature. Environmental education is a process (not a specific product) whereby students research issues, consider alternatives and decide what, if any, action would be appropriate. Environmental advocacy refers to the speaking or writing in support of a specific course of action. Environmental education would promote studying *about* land use issues. Environmental advocacy would promote *for* a particular land use. It is important that all of us be able to identify clearly what information has been designed to be used for environmental education, and what is being labeled as environmental education.

In order to promote a balanced, unbiased avenue for educators to obtain materials, C^2E^2 published the *North Dakota Environmental Education Resource Directory*. This directory lists several tested curricula and materials addressing environmental issues. PLT (Project Learning Tree), Project WET (Water Education for Teachers) and Project WILD (Wildlife In Learning Design) are just a few of the sources included. The directory has been made available to school libraries free of charge. Individuals may obtain a copy for $5.

C^2E^2 has been complimented by Lt. Governor Rosemarie Myrdal "for its cooperation among government agencies, public and private organizations and individuals." Dr. Wayne Sanstead, Superintendent of Public Instruction, also commended C^2E^2 on its mission and importance.

If you would like more information about C^2E^2 or the *North Dakota Environmental Education Resource Directory,* please contact Jim Collins Jr. at 701-328-5242.

Changes in GPS Community Base Station

By Thomas J. Heck

The NDGS and other state agencies involved in the Global Positioning System (GPS) community base station (CBS) have recently upgraded the personal computer part of the base station. We experienced hardware problems last December and decided to upgrade the entire computer system. The CBS was online and recording data again on January 29th after being down for nearly a month.

Our users can access the high-accuracy GPS data for the differential correction of field recorded data. Subscriptions to the service are available through the NDGS. Non-government subscribers will remain limited to modem access to the CBS. State and Federal agencies that cooperated in setting up the CBS will have access via FTP on the Internet. Interested parties should contact Tom Heck at the NDGS for information on GPS data. Tom has replaced Mark Luther as chair of the North Dakota GPS Steering Committee after Mark left the agency (see article p. 2). The steering committee continues its study of ways to improve the services and availability of GPS data.

Policy for Removal of Selective Availability on GPS Signals Approved

The Clinton administration has approved a policy that will lead to the removal of selective availability (S/A) from Global Positioning System (GPS) satellites within the next ten years. Selective Availability is the intentional degradation of GPS accuracy by the U.S. Department of Defense to protect military operations. The policy recognizes the worldwide use of GPS free of direct user charges for a variety of technical uses. Presumably the long time frame will allow the military to develop alternative technologies and will allow for the expansion of GPS technologies in many civilian industries.

With S/A turned off, typical civilian units are accurate to the 10 to 15 meter range without differential processing. If your mapping or GIS applications require accuracy of 2 meters or less, for example, then differential processing will still be necessary with current equipment. Improvements in GPS receivers, differential processing software or the GPS satellite system will no doubt improve accuracy for roving units in the near future (from *Earth Observation Magazine*, July, 1996).

The NDGS and other participating state agencies have a GPS base station that has differential processing abilities. The NDGS has recently upgraded the computer at the GPS station in Bismarck (see article at left).

NEWS IN BRIEF . . . Continued

National Program focuses on Water Quality in the Red River Basin

About 60 percent of the total population of North Dakota relies on groundwater for its drinking water needs. The majority (95%) of the rural population of the state rely on groundwater as their only source of drinking water. Protecting this vital resource has become increasingly important in recent years at the local, state and federal level. In 1986, Congress appropriated funds for the National Water Quality Assessment (NAWQA) program to address the need for consistent and scientifically accurate information to protect water resources. The U.S. Geological Survey implemented the NAWQA program in 1991.

The NAWQA Program was designed to accomplish three tasks: 1) describe current water quality conditions for a large part of the nation's freshwater streams, rivers and aquifers, 2) describe how water quality is changing over time; and 3) improve understanding of the primary natural and human factors that affect water-quality conditions. There are 20 basins, or study units, located throughout the U.S. in the first phase of the NAWQA program (Figure 1). The Red River of the North (RRN) was chosen as a study unit in this first phase of the program. The second phase of the program, slated to begin this year, will study an additional 40 basins. The 60 total study units shown in Figure 1 represent the diverse geography, water resources, and land and water use of the nation.

The Red River of the North was chosen as a study unit in the first phase for three reasons: 1) it represents a major agricultural region for assessing nutrients and pesticides in water; 2) the quality of the Red River, which flows northward into Canada, is of international concern; and 3) the northern location and possible interaction of surface water and groundwater are relevant physical factors necessary for a complete national assessment of water quality.

The Red River Basin Study was an unprecedented cooperative effort on the part of 3 states, 2 countries, and numerous cities, towns, and local organizations. A local liaison committee of organizations and people interested in water resources of the Red River Basin assisted the U.S. Geological Survey in identifying important water quality issues. These issues are listed in order of decreasing concern: 1) toxic contamination from nonpoint sources such as fertilizer and pesticide applications; also includes trace metals which may be present in air pollution, 2) salinity and radionuclides from naturally occurring sources, 3) soil erosion and sedimentation, 4) eutrophication - algal blooms and other nuisance plant growth that occurs when water is enriched with nitrogen and phosphorus, and 5) toxic contamination from point sources such as point discharges of treated effluent from municipal and industrial sources.

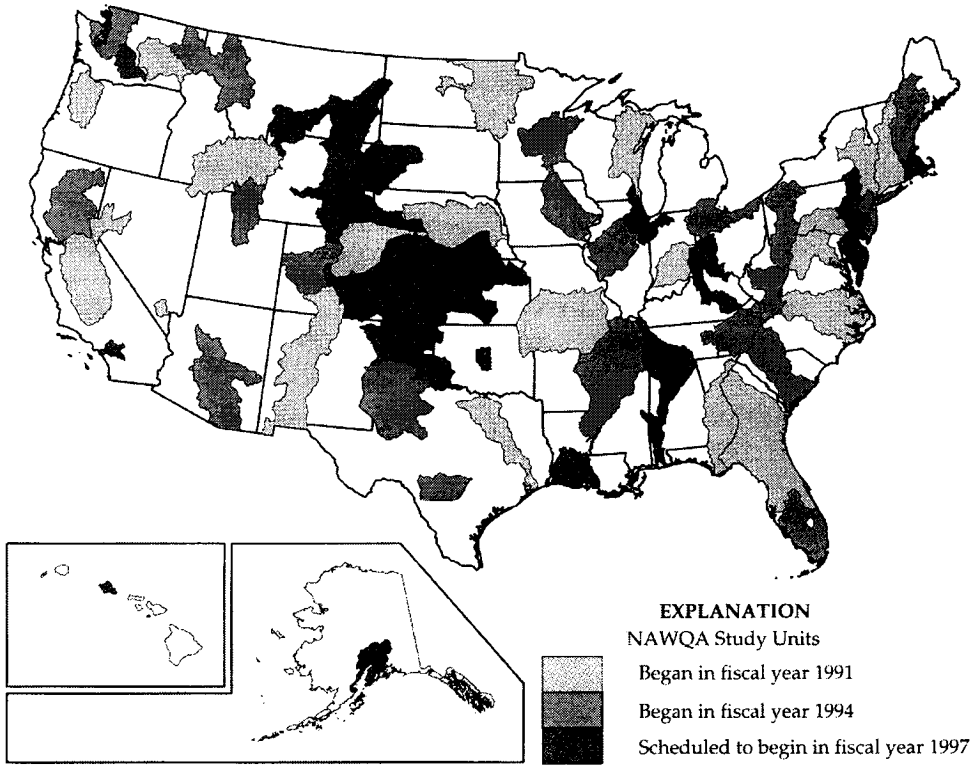


Figure 1. Study units for the National Water Quality Assessment Program (from D.K. Mueller and D.R. Helsel, 1996, Nutrients in the Nation's Waters - Too Much of a Good Thing?, USGS Circular 1136, 24 p.)

The NAWQA study in the Red River Basin is being completed in two phases, a 3-year, intensive data collection phase and a 6-year, low-intensity monitoring phase. The intensive phase began in 1993 and concluded in 1995. The low-intensity phase began in 1996 and will continue through 2001.

The types and location of the data collected were intended to provide multiple lines of evidence at various

Continued on next page . . .

NEWS IN BRIEF . . . Continued

scales to assess water quality. Sample collection was completed at selected sites throughout the year to determine effects of the seasons and to increase sample confidence.

In 1996, the large amount of data collected during the intensive phase was tabulated and analyzed. Some of the preliminary results from the study indicate that the concentration of pesticides detected is small; in fact, detections were far below the established drinking water standard. Tornes and Brigham, authors of U.S. Geological Survey Open File Report 95-283, state that:

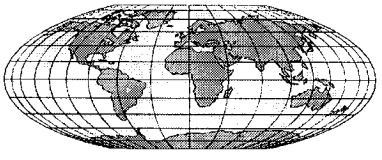
"The pesticides detected comprise less than 2% of the amount applied and usually are at concentrations far less than established drinking water standards. Most of the detected pesticides seem to come from sources near the headwaters in the southern part of the basin. Although low, concentrations are related to pesticide application and runoff. Flat land slope, organic soils, pesticide management, and degradation all may limit pesticide contamination that reaches Red River Basin streams".

Tornes and Brigham's report is just one of a comprehensive body of information that has been prepared by the U.S. Geological Survey and other cooperating agencies. Other Fact Sheets, Open File Reports and Water Resources Investigation Reports have been completed describing the sampling design; nutrients, suspended sediments and pesticides in streams; groundwater quality in sand and gravel aquifers; salinity of surface water; and aquatic communities. A complete summary report of the intensive phase is anticipated this fall.

For more information on the NAWQA-RRN Program contact:

Red River NAWQA Coordinator
U.S. Geological Survey
2280 Woodale Drive
Mounds View, MN 55112
(612) 783-3100

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) 328-9700.

FREE Middle School Educational Materials Available

The U.S. Geological Survey has released a new educational CD-ROM containing an interactive tour of Washington, D.C. that uses topographic maps. Designed for middle school students, the Topographic Field Trip uses hypermedia to interactively navigate through layers of information by linking sounds, graphics, text, and animation in a game-like adventure. Students will learn to measure distance and direction, determine latitude and longitude, learn map features, look at digital orthophotos, determine elevation, find general geographic information on post cards and examine historical maps.

The Topographic Field Trip requires a Macintosh system with 256-color, 13-inch or greater monitor; at least 8 MB of RAM; system 7.1 or greater; and a Macintosh compatible CD-ROM drive.

A demonstration copy of the CD-ROM is available at the NDGS office. This copy can be loaned out to educators for a period of two weeks. The CD-ROM may be picked up and returned, for no charge, at the North Dakota Geological Survey office at 1022 E. Divide Ave, Bismarck, ND. The CD-ROM can be mailed for a fee of $2.50 to cover postage and handling, plus return postage. Educators can also obtain a free CD-ROM for their school by requesting it on school letterhead from: USGS Information Services, Box 25286, Denver, CO 80225. (Reprinted from *ESIC Information Bulletin No. 339*)

Another New Educational Tool: GeoMedia CD-ROM

The USGS has announced the introduction of another CD-ROM for middle to junior high school students. The USGS, in partnership with InterNetwork Media, Inc, has developed GeoMedia, a CD-ROM for students between the

ESIC NEWS. . . Continued

ages of 10-14. Using motion pictures, sound, text and computer animation, the CD presents exciting interactive materials on earthquakes, water and carbon cycles, the greenhouse effect, measuring environmental change, geologic time scales and understanding maps. Study guides and activity sheets are included for classroom use.

GeoMedia is both IBM-PC and Macintosh compatible. IBM-PC system requirements include: 486-66MHz processor with VLB, Windows 3.1x or Windows 95, 8MB RAM, DOS 5.0 or later, Super VGA, double speed CD-ROM, and Windows compatible 16 bit sound card, mouse and keyboard. Macintosh system requirements include: 68040 or Power PC processor, minimum 33MHz RAM, color monitor, double speed CD-ROM, system 7.1 or later, a mouse and keyboard.

The GeoMedia CD-ROM can be ordered from InterNetwork Media, Inc. 411 Seventh Street, Del Mar, CA 92014 for $49.95 plus $3.00 handling. California residents should add applicable sales tax. To order with Visa or MasterCard, call (619) 755-0439 or (888) 755-3041. The InterNetwork Media fax number is (619) 481-8181. Because this CD was produced in partnership with InterNetwork Media, the USGS, and consequently the NDGS, does not have any demonstration copies available. (Reprinted from *ESIC Information Bulletin No. 344*)

Digital Raster Graphic Media

The National Mapping Division has discontinued production of Digital Raster Graphic's (DRG's) on CD-ROM's for distribution from Denver. The one-degree DRG product will continue to be produced and is available to customers on-demand from the Mid-Continent Mapping Center (MCMC). In the future, sales will be from the Sales Data Base at EROS Data Center (EDC), through a compact disc-recordable (CD-R) duplication capability.

During fiscal year 1996, the Division published DRG's on CD-ROM's through a Government Printing Office contractor. These products were distributed from Denver by the Information Services Branch. Experience has shown that it is very expensive to replicate substantial numbers of CD-ROM's and stock them in Denver. Reduced funding for CD-ROM replications, slow sales, and the discovery of some data "bugs" in the header files of shelf stock in Denver point to even higher costs for trying to manufacture what would eventually be coast-to-coast DRG's on tens of thousands of stock CD-ROM's. Data and Information Delivery will pursue a more prudent strategy of working with commercial partners to package these data for public consumption and also provide ongoing user support.

As of February of this year, DRGs are available for the entire state of North Dakota from the MCMC. Contact the NDGS - GIS Center for more information. (Reprinted from *ESIC Information Bulletin No. 342*)

DMAMUSE Software CD-ROM

For the cartographically minded, the National Imagery and Mapping Agency (NIMA)'s DMAMUSE CD-ROM is now available for sale to the public from the USGS. MUSE stands for Mapping, Charting, and Geodesy (MC&G) Utility Software Environment and is a self-contained set of computer programs and computer utilities designed to work with NIMA MC&G data and information. The CD-ROM contains three cartographic activities: Build Your Own Map, Access and Prepare NIMA Digital Data, and Run Specialty Applications; nine applications programs; and user guides for each application program. It is public domain software capable of displaying, manipulating and analyzing data such as NIMA's Digital Terrain Elevation data (DTED) Level 0. DMAMUSE can be run on IBM-PC with Windows, Macintosh, Sun, Hewlett-Packard and Silicon Graphics systems.

Customers can find more information about DMAMUSE and also down load the software from NIMA World Wide Web site **http://www.nima.mil/DMAMUSE2/**. This NIMA page is password protected and customers must fill out a registration page, including complete address, e-mail address, phone number, and fax number to get the login and password.

DTED level 0 is 30 arc second terrain data which may be of value to scientific, technical, and other communities. It is a uniform matrix of terrain elevation values which provides basic quantitative data for systems and applications that require terrain elevation, slope and/or surface roughness information. DTED level 0 data was extracted from DTED level 1 (3 arc second data) and other publicly releasable data, and is a step toward a worldwide digital terrain dataset. DTED level 0 datasets are available online at the following address: **http://164.214.2.59/geospatial/products/DTED/dted.html**.

The DMAMUSE CD-ROM can be ordered either directly through the USGS-Information Services, PO 25286, Denver, CO 80225, or through the NDGS-ESIC office (701) 328-9700. The price is $11.50 plus $3.50 handling charge per order. (reprinted from *ESIC Information Bulletin No. 345*)

U.S. Geological Survey 1995 Yearbook

The USGS Yearbook for 1995 is available electronically for the first time, in both CD-ROM format and on the World Wide Web at **http://yearbook.usgs.gov.**

Traditionally, a compilation of brief articles on the progress of major research and data-gathering programs of the USGS, the Yearbook also includes a list of key USGS personnel, partner organizations, and budget information. The on-line version also provides a gateway to thousands of pages of data and information that the USGS has available on the World Wide Web.

ESIC NEWS. . . Continued

The CD-ROM contains video clips of the 1995 flooding of Madison County, Virginia and USGS Director Gordon Eaton describing recent changes at the USGS. It allows the user to connect to the world wide web for additional information. It is both Macintosh and Windows compatible and contains color graphics.

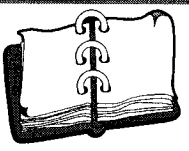
The 1995 Yearbook on CD-ROM is available free from the USGS-Information Services, PO 25286, Denver, CO 80225. Fax requests can be sent to (303) 202-4693. (Reprinted from *ESIC Information Bulletin No. 340*)

USGS Has Free Information for K-12 Teachers

The following USGS web site has been updated: **http://www.usgs.gov/education/**. The site describes itself as *"The Learning Web - a portion of the USGS web dedicated to K-12 education, exploration, and life-long learning. Consider the Learning Web to be your pathfinder for Earth Science education information. The Earth is here to teach us, let's start learning!"*

Within the site are listed various free publications available from the USGS, including teachers packets. Currently, there are three main 'units' on the site: Volcanoes, Teaching Guide, and Living on the Earth (a basic earth science unit). There are also links to other USGS web sites for more information. The teaching guide contains background information, classroom activities and discussion starters for topics such as working with maps, global change and earth science. A grade appropriateness listing is given for each lesson plan. A complete listing of educational products available from the USGS is located at **http://www.usgs.gov/education/edulist.html**. If you do not have access to the Internet, you may obtain free copies of the paper teaching packets by calling the USGS's Earth Science Information Center at (800) USA-MAPS.

Upcoming Meetings & Conferences



North Dakota Academy of Science 89th Annual Meeting
April 24-25, 1997 - University of North Dakota - Grand Forks, ND

The Academy is sponsoring a series of symposia on topics highly relevant to the state of North Dakota. The expertise of state scientists will be extremely valuable in the resolution of certain problems that face North Dakota residents. For example, we have heard various solutions to the Devils Lake 'problem' from the political and economic viewpoints with less than satisfactory consideration of scientific issues. Therefore, the Academy is sponsoring an all-day symposium "Examination of Water Management in the Devils Lake Basin: The Scientific Perspective". Other half-day symposia will focus on "Technical Aspects of Coal Combustion By-Products Commercial Utilization" and "Problems and Prospects for Community Development in North Dakota". The Academy is also offering other symposia that should be of interest to scientists of the state, "Applications of Statistical Modeling Methods" and "Astronomy in North Dakota: From the Solar System to the Universe of Galaxies". For more information, check out the NDAS Home Page at **http://www.gfhnrc.ars.usda.gov/ndas**. Or send a request for information to Eric Uthus, Secretary-Treasurer, NDAS, PO Box 7081, Grand Forks, ND 58202.

North Central Section Geological Society of America 31st Annual Meeting
May 1-2, 1997 - Concourse Hotel - Madison, WI

Hosted by the Wisconsin Geological and Natural History Survey and the Department of Geology and Geophysics, University of Wisconsin, Madison. Symposia planned should be of interest to a wide spectrum of earth scientists and educators: History of Wisconsin Geologists; Paleoglaciology; Importance of Field Trips in Undergraduate Education; Special Poster Session on Undergraduate Research; New Ideas for Field Trips in the Upper Midwest; K-6 Teachers: Collaborative Educators for Earth Science Literacy; Recent Studies in Precambrian Geology of the Mid-Continent Region; Hydrogeology of Non-Point Source Pollution; Hydrogeologic Studies in Fractured Media; Basement Structural Influences on Phanerozoic Sedimentation; Temporal Trends in Ethology, Ecology and Taphonomy. Various pre- and post-meeting field trips are also planned that highlight geologic research in southern Wisconsin and the surrounding area. Pre-registration deadline is March 28. Registration fees are $60 for professional GSA members and $20 for GSA student members. Individuals not associated with GSA may pre-register for $65; students for $25. K-12 teachers are invited to register for $20. On-site registration cost is $10 more for professionals and students. For more information contact Tom Evans, Wisconsin Geological and Natural History Survey, 3817 Mineral Point Road, Madison, Wisconsin 53705, (608) 263-4125, fax (608) 263-8086.

Meetings & Conferences . . . Continued

North Dakota
Geological Survey

Saskatchewan
Energy & Mines

★★ INVITATION ★★

The *North Dakota Geological Survey* and *Saskatchewan Energy and Mines* are pleased to announce the upcoming **Fifth International Williston Basin Horizontal Well Workshop** to be held in Regina, Saskatchewan, April 13-16, 1997. We invite your participation!

As before, the workshop will provide an informal setting in which to make contacts, identify future opportunities, and exchange information on horizontal drilling in the Williston Basin. The workshop, sponsored by Saskatchewan Energy and Mines and the North Dakota Geological Survey, will focus on horizontal well applications in the Williston Basin. The basin continues to experience a great deal of horizontal drilling activity with growing interest in deeper horizons. Horizontal wells have been used very successfully in reviving production in old fields and improving production rates and recoveries in newly discovered fields.

The workshop will concentrate on specific topics of interest to operators who are active or would like to become active in horizontal projects in the basin on both sides of the border. As a participant, you are encouraged to play an active part in making this endeavor a success, and we hope that through the workshop you will advance your insight of the opportunities to apply horizontal technology in exploration and production in North Dakota, South Dakota, Montana, Saskatchewan, and Manitoba. In addition, this workshop will facilitate and encourage you to develop and/or renew contacts with other Williston Basin petroleum companies, consultants, service companies, and government agencies interested in horizontal well technology and application.

This year, a portion of the workshop will focus on deeper plays within the basin and discuss the regulatory aspects of Deep Rights Reversion in Saskatchewan. Plenary sessions will combine oral presentation by individuals with horizontal well experience in the Williston Basin with time for you to examine notice/poster board displays. There will also be ample opportunity for informal one-on-one discussion.

Held at the Ramada Hotel in Regina, Saskatchewan, the workshop will begin with an "ice-breaker" on Sunday evening April 13. Monday's session will focus on engineering and Monday evening hosts "Casino Night" at *Casino Regina*. Tuesday's focus is on geology, including deeper prospects. For those interested, there will be core from deeper strata on display at the Subsurface Geological Laboratory in Regina on Wednesday morning.

The advance registration fee is $60 ($85 Canadian) with on-site registration increased to $75 ($100 Canadian). The registrants' cost of the workshop is kept affordable as a result of industry sponsorship. If you would like to attend or provide sponsorship for the workshop, please contact Brenda Maximuik (306) 787-7632/fax (306) 787-2333 or Gina Buchholtz (701) 328-9700/fax (701) 328-9898.

We look forward to seeing you at the Fifth International Williston Basin Horizontal Well Workshop. Thank you for making this workshop a success.

Sincerely,

Malcolm Wilson
Director, Energy Development
Saskatchewan Energy and Mines

John P. Bluemle
State Geologist
North Dakota Geological Survey

Prospects and Swindles

by John P. Bluemle

In the early years of this century, numerous efforts were made to find oil and gas in various parts of North Dakota. However, it's likely that more energy was expended soliciting for investments in stock in the small corporations formed to explore for the oil and gas than in actually looking for oil. These solicitations invariably involved testimonials from eminent people: geologists, engineers, and other "credible" people.

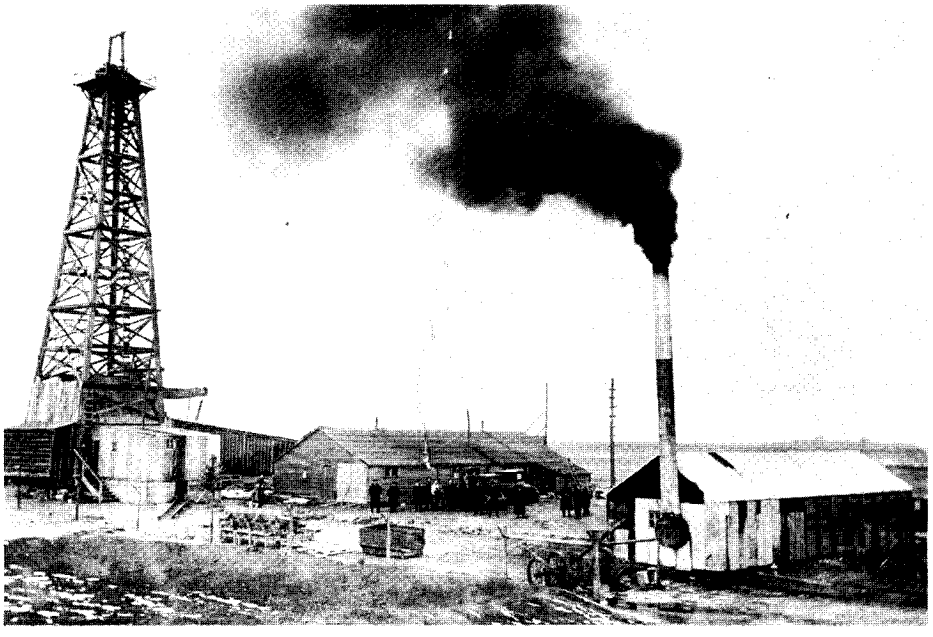
Time has shown which of the oil-exploration ventures were realistic ones, which were misguided, and which were out-and-out swindles. Almost all of them were wildly optimistic in their claims and promises, with pictures of "gushers" and promises to investors that they might become millionaires overnight for only a few dollars invested. The "geological evidence" for the oil-bearing structures promoted in the stock offers often consisted simply of a scribbled "map", or maybe a circle or oblong figure to represent an "anticline" insofar as the average person understood in those days. *(See the map of the* "New England Structure", *a promotional "geologic map" that was widely circulated as part of the effort to sell stock in a drilling venture.)*

A dollar a share was a typical price for stock in these companies. The stock prospectus usually extolled the virtues of this or that oil company and explained why certain areas were sure to be rich in oil or natural gas.

I'll quote from just a few pieces of correspondence I found in the North Dakota Geological Survey files. In a letter to the State Geologist, A.G. Leonard, dated May 15, 1925, M.W. Duffy, a lawyer from Cooperstown wrote that *". . . there is a party now operating in this territory, claiming to be a geologist in the employ of the federal government and telling the people here that there is every indication of oil in this county."* In his response, Leonard noted that he had not seen any evidence that oil is present in the Cooperstown area. He went on to say: *"I hardly think the man you mention, who claims to be a geologist in the employ of the Federal Government, can be a Government geologist or he would not go about making efforts to supervise drilling for his expenses. I doubt very much whether the Government would allow its employees to do this."*

A.C. Townley
Photo courtesy of William E. Shemorry

In the New England area, a considerable effort was made to raise funds in the early 1920's. The effort is an involved story that apparently included mainly local people until the initial venture folded in about 1923. According to an article in the Hettinger County Herald on April 4, 1927, *"A.C. Townley himself"* became involved. Townley was an interesting man who played a fascinating role in North Dakota history, to say the least, but that's a story in itself, better told by historians.



A.C. Townley's Robinson, N.D. oil camp as it appeared in 1925. These facilities were principally for the hundreds who were hauled to the camp to hear Townley's money-raising lectures. *~Photo courtesy of William E. Shemorry and the Fargo Forum.*

A typical Townley venture: in response to a request from a person in Moline, Illinois for information on a reported oil discovery in Kidder County, Leonard wrote: *". . . the oil found in Kidder County is refined oil and analyses show it to be Red Crown Gasoline. The oil found in the water wells has evidently been poured in from above . . . boring of test wells will result in nothing but failure."* Townley was a colorful promoter. In this instance, Townley (or perhaps someone else) apparently "salted" the well with gasoline.

Another letter, this one written in 1926 by Leonard to Professor Glenn Dille of Coe College in Cedar Rapids, Iowa, refers to oil developments in the Burnstad area of Logan County. Leonard recommended against drilling for oil in the area, and he went on to say that several men claiming to be oil geologists claim to have found favorable structures. However, he

stated, *"One of these men I know to be a fake who will find oil indications anywhere for a good fee."*

Usually, Leonard wrote letters designed to let anxious investors down gently, but not always. In a response to Herman Hanson, President of Herman Hanson Oil Syndicate in Turtle Lake, Leonard wrote the following letter in 1925:

"I was interested in receiving your letter of November 17 and the report of the findings made with a 'Mineral Indicator'. I am sorry you believe the ridiculous stuff contained in that report and by the time you have spent many thousands of dollars drilling for oil and finding none, you will realize what a fake the man was. His findings are almost too absurd to deserve notice. No instrument has yet been invented which will locate oil below the surface as has been abundantly proved again and again. There is absolutely no evidence of any anticline in McLean County and if there were, the 'Indicator' would never locate it.

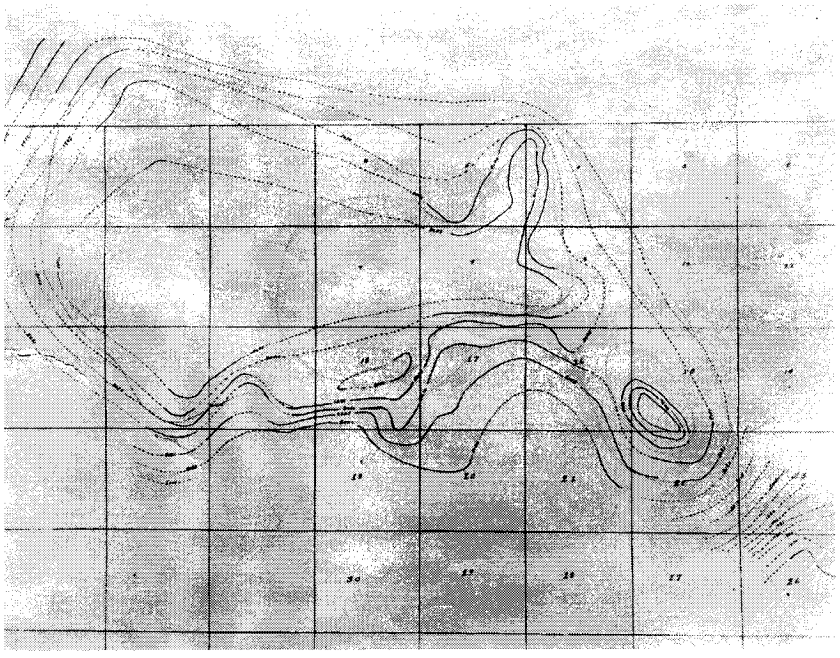
I know, of course, that you will drill one or more holes in search of oil and I certainly wish you might find the oil, but I am satisfied that the conditions are not favorable and that no oil is present below the surface. For this reason I feel that I should warn you beforehand that your money spent in drilling will be wasted and no oil will be found."

Leonard went on to point out that there had been many so-called geologists in North Dakota the past year promoting oil exploration ventures, but most of them were not reputable.

One of the prospect areas in North Dakota included the Pembina Hills Region, which was promoted in 1927 by a "former Montana geologist". The area was written up in the April 14, 1928 issue of the *Montana Oil Journal.* The article included a complete report on the "Pembina River Oil Structure". Another important area of interest was near Marmarth in 1917. Here, testimonials were solicited from several people, including State Geologist, A.G. Leonard. And, of course, the Cedar Creek Anticline ultimately became an important gas-producing structure and still is. In 1927, the Turtle Lake area in McLean Co. was promoted by yet another Montana geologist. Apparently, being from Montana, where gas was already being produced, and being somehow associated with the Montana Bureau of Mines (this is implied from the article) helped to assure potential North Dakota investors that these people and, of course, the prospect, were reliable.

Possibly this is a kind of "mineral indicator" mentioned by Leonard. *~ Photo courtesy of William E. Shemorry*

Still another venture took place, this one in 1926, by the Beaver Lake-Shell Butte Oil Company in Logan, McIntosh, and Emmons Counties. It involved the Red Lake and Shell Butte areas of the Beaver Creek District, according to the prospectus. In the prospectus, three Montana geologists are quoted as saying (apparently in unison) that the Beaver Creek District is "one of the largest and best defined structures it has been my pleasure to examine," (it's not clear which of the three is writing). One of the geologists goes on to say, *"In view of the intensive and world wide search for petroleum, and of the stratigraphic and structural features here obtaining, I believe this district affords the most remarkable opportunity for a test well of any of the unexplored and undeveloped portions of the North American Continent."* This promotion included a curious drawing that was purported to be a "structural sketch map." At best, the "map" may have shown some glacial moraine features, but I can't tell for sure.



"Geologist's map" of the "New England Structure", supposedly an anticline, that appears on many promotional brochures in 1923. On the brochures, the map is always less clear and much harder to read than is the copy I've reproduced here. I can't guess what geologic information was used to compile the map, and the geologist who compiled it is not identified.

There were many questionable ventures and promotions during the 1920's and 30's. I hope I've given you some idea of what went on. The oil industry, and geology in general, were very poorly understood by an almost totally unsophisticated public. However, the perception was that there was a lot of money to be made, simply by investing a small sum. Consequently, it was an ideal target for shysters and others looking to make some easy money. Some things have changed, some have not.

Paleontology of Theodore Roosevelt National Park

by John W. Hoganson and Johnathan Campbell

Introduction

In the Spring of 1994, Roger Andrascik, Resource Management Specialist at Theodore Roosevelt National Park, contacted the North Dakota Geological Survey to see if we would be interested in conducting a study of the paleontological resources of Theodore Roosevelt National Park. Like many federal agencies, the National Park Service is developing programs to characterize paleontological resources on properties they administer. At this time, funding had become available for paleontological studies of several national parks, including Theodore Roosevelt National Park. The paleontology of Theodore Roosevelt National Park was particularly poorly known because few paleontological investigations had been previously conducted in the park. The objectives of this proposed study would be to identify, map, and assess the significance of fossils and paleontological sites in the park. That information would be used in overall resource management planning. In 1994, the National Park Service and the Survey entered into a cooperative agreement to conduct an inventory and assessment of the paleontological resources of Theodore Roosevelt National Park. Funding was available for 50 days of field work for two people over a period of 2½ years. Field investigations for the project and laboratory curation of fossil specimens collected during the field work were completed this year.

Theodore Roosevelt National Park consists of a North Unit, near Watford City (McKenzie County) and a South Unit, near Medora (Billings County) (Figure 1). Between the two units, 70,228 acres (about 110 square miles) of land are included in the park boundaries. The task of providing a meaningful paleontological assessment of the park initially seemed overwhelming because of the immensity of the park and the limited resources available to conduct the project. The ideal plan would have been to survey on foot the entire area of rock outcrop in the park. This was, of course, not practical and it was decided that the best approach would be to thoroughly survey selected one-square-mile sections. Sections selected for comprehensive fossil resource assessments were chosen primarily because of accessibility and extent of rock outcrops. All rock formations and stratigraphic levels were included in the survey. In this way, density of fossil sites per section and other findings could be

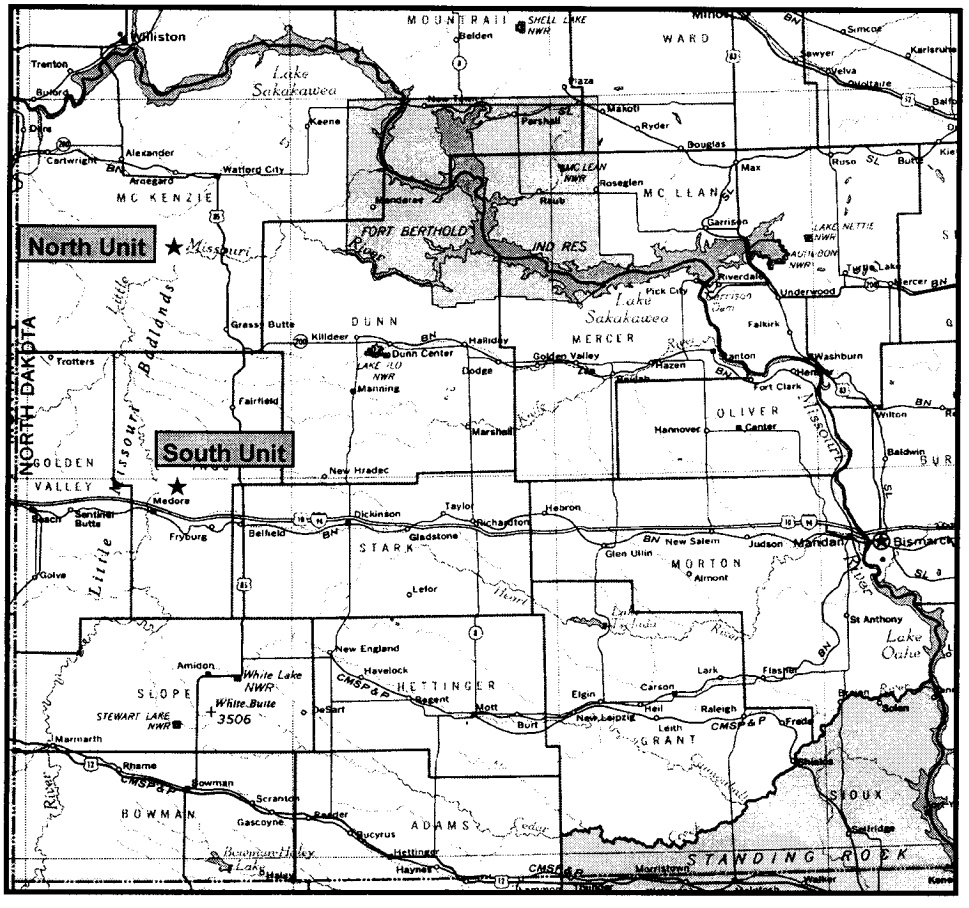


Figure 1. Location of North and South Units, Theodore Roosevelt National Park (★ indicates location).

applied to the entire park in a quasi-statistical way. Fossil sites were mapped and plotted on USGS 7.5 minute quadrangle maps. The actual collecting of fossil specimens was kept to a minimum to expedite the inventory. Only enough collecting was done to sufficiently characterize the sites.

Geology and Stratigraphy

The badlands of Theodore Roosevelt National Park, formed mainly through erosion by the Little Missouri River, have attracted geological interest since the days of the early scientific explorers primarily because of the well exposed rock formations and the scenic beauty of the area. Two primary rock formations are exposed in the park, the Bullion Creek Formation and the overlying Sentinel Butte Formation (Figures 2 & 3). These rocks were deposited by fluvial and lacustrine systems during the Paleocene Epoch between about 60-55 million years ago when sediments were carried from the rising Rocky Mountains and deposited on the Central Plains. In the park, these formations are generally flat-lying and the stratigraphy is not confused by structural complexities.

The Bullion Creek Formation is exposed only in the South Unit of the park. It generally consists of brightly colored (yellows and tans) and poorly lithified claystones, mudstones, and siltstones with subordinate amounts of fine-grained sandstones and lignite (Figure 2). These sediments were deposited in a dynamic system containing rivers, streams, ponds, lakes, and swamps. The Bullion Creek Formation reaches a thickness of over 200 feet in the South Unit.

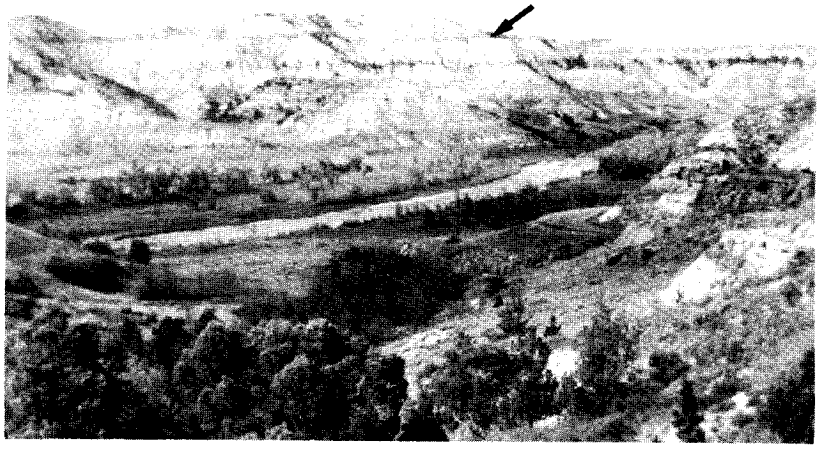


Figure 2. Bullion Creek Formation exposed along the Little Missouri River in the South Unit. Arrow points to contact between the Bullion Creek Formation and overlying Sentinel Butte Formation. View is to the north. Cottonwood Campground is in the grove of trees on the east side of the river.

The Sentinel Butte Formation overlies the Bullion Creek Formation in the South Unit and is the only one of these two formations exposed in the North Unit (Figures 2 & 3). It generally consists of lithologies similar to the Bullion Creek Formation but usually exhibits somber gray to brown colors. Both formations were deposited in similar settings. A gray sandstone, that may attain a thickness of 100 feet in the North Unit, is present at the base of the Sentinel Butte Formation. The Sentinel Butte Formation can be over 700 feet thick in the North Unit and 300 feet thick in the South Unit. In isolated outcrops it is, in places, difficult to distinguish the two formations because dark-colored beds are sometimes present in the Bullion Creek Formation and light-colored beds are sometimes observed in the Sentinel Butte Formation.

In addition to color, several other characteristics are useful to help differentiate the Bullion Creek and Sentinel Butte formations in the park. The contact between the two formations is generally easy to recognize because it is usually at the base of a pink clinker bed called the HT Butte clinker. In places, the HT Butte lignite is at the contact and the contact is then placed at the top of the lignite (Figure 2). The HT Butte clinker can be 40 feet thick and results from burning of the HT Butte lignite. An extensive petrified wood bed, often with tree stumps still in growth position, occurs above the basal sandstone in the lower part of the Sentinel Butte Formation in the South Unit. A widespread ash/bentonite deposit called Sentinel Butte ash, at times 25 feet thick, occurs in the Sentinel Butte Formation in the North Unit (Figure 4). Also, the Sentinel Butte Formation generally forms steeper weathering slopes than the Bullion Creek Formation.

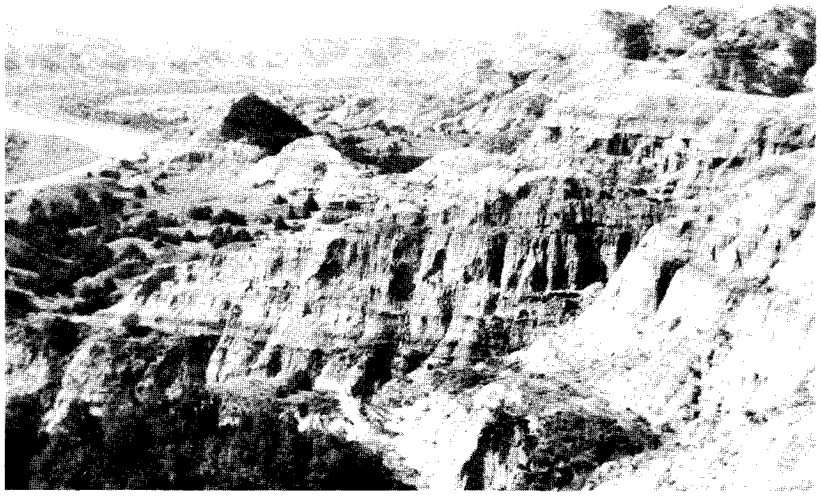


Figure 3. Sentinel Butte Formation exposed along the Little Missouri River in the North Unit. View is to the west taken from near River Bend Overlook.

Fossil sites mapped in the park are tied to stratigraphic "marker beds". In the South Unit, the following stratigraphic references are used:

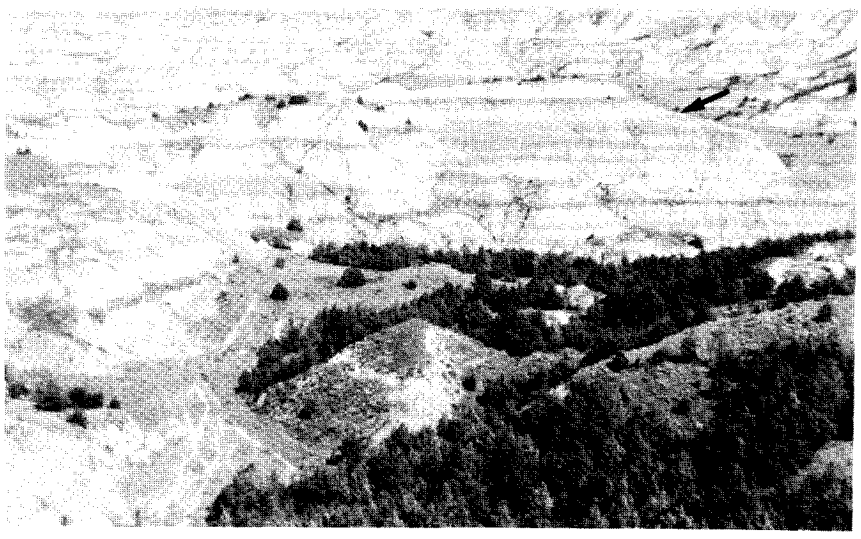


Figure 4. Sentinel Butte bentonite/ash (arrow) and overlying "yellow siltstone" in the Sentinel Butte Formation, North Unit. View is to the east taken from Bentonite Clay Overlook.

Figure 5. Fossil tree stumps in growth position in the lower part of the Sentinel Butte Formation, Petrified Forest Plateau, South Unit. Large stump in foreground is 3 feet tall.

Figure 6. Unusually well preserved piece of petrified wood from the Sentinel Butte Formation. Width = 4½ inches.

1) the contact between the Bullion Creek and Sentinel Butte formations at either the HT Butte lignite or clinker (Figure 2); and 2) the extensive fossil tree stump-bearing petrified wood bed near the base of the Sentinel Butte Formation (Figure 5). In the North Unit the fossil sites are tied to: 1) the Sentinel Butte ash/bentonite bed (Figure 4); and 2) a bright yellow siltstone ("yellow bed") above the Sentinel Butte ash/bentonite (Figure 4).

Even though the Bullion Creek and Sentinel Butte formations are the primary fossil-bearing units in the park, other geologic units are present. On some of the higher hills in the North Unit, blocks of silcrete (silicified quartz siltstone) form lag deposits believed to be the Taylor bed of the Golden Valley Formation. Sand and gravel deposits unconformably overlie the Sentinel Butte Formation in many places in both the South and North Units. The age of the sand and gravel is unknown. Loess (wind blown silt) veneers the surface in many areas of the North and South Units and glacial erratics found on the upland surfaces in the North Unit mark the maximum extent of glacial advance in that part of the state. Quaternary alluvium and colluvium are found along the Little Missouri River and the steep cliff faces and several terraces of alluvial deposits have been mapped along the Little Missouri River.

Paleontology

Paleocene age continental rock formations in North Dakota have generally been considered sparsely fossiliferous. Our detailed study of ten square miles of the park (about 1/10 of the entire area of the park) suggests that both the Bullion Creek and Sentinel Butte formations are often quite fossiliferous, particularly with the remains of freshwater mollusks (snails and clams). We mapped 400 fossil sites in the ten-square-mile study area, which is an average of 40 fossil sites per square mile. Most of these sites are freshwater mollusk sites.

The most common kind of fossil found in the park is petrified wood. Petrified wood occurs sporadically at several stratigraphic levels in both the Sentinel Butte and Bullion Creek formations, but is most common in the lower part of the Sentinel Butte Formation, in most places about 20 feet above the contact with the Bullion Creek Formation. Because of the abundance of these fossils, it was impractical to map the location of all petrified wood sites. Unusual sites were mapped, such as where fossil tree stumps were found in growth position in the Petrified Forest Plateau area of the South Unit (Figure 5). Forest conditions prevailed during deposition of at least the lower Sentinel Butte sediments reflected by the prolific in situ petrified stumps found at that stratigraphic position in many areas of the South Unit. Some of these trees were huge, leaving stumps seven to eight feet in diameter. It is believed that most of these trees were conifers, although poor preservation has hindered specific identification of the wood types. The well preserved specimen shown in Figure 6 is an exception. The tree stumps are generally fluted without roots. Lack of root preservation suggests that these trees were probably rooted underwater and were growing in a swampy environment, similar to the bald cypress today. The bases of these stumps are generally embedded in lignite also suggesting growth in an aqueous environment. Some of the fossil stumps and logs show evidence of damage by insects and birds (Figure 7). However, only one insect fossil, a Coleoptera (beetle) was found during this study. Leaf fossils (angiosperm, ferns, etc.) are also found in the Bullion Creek and Sentinel Butte formations in the park (Figure 8). They can be found in most lithologies but preservation is best in clinkers and fine-grained sandstones. Fossil seeds, including *Cercidiphyllum* (katsura tree), were also recovered during this study. Fossil twigs, roots, and branches are found in the Taylor bed (Golden Valley Formation) in areas of the North Unit.

Remains of freshwater mollusks are common in the Bullion Creek and Sentinel Butte formations in the park (Figures 9-12). These fossils can be found in most lithologies from carbonaceous claystone to medium-grained sandstone but appear to be most abundant in siltstone. They are so abundant at some localities that they form coquina beds. Freshwater mollusks are particularly abundant in the yellow

Figure 7. Petrified log in the Sentinel Butte Formation, South Unit, showing damage probably caused by birds.

Figure 8. Leaf fossil in fine-grained sandstone, Sentinel Butte Formation, South Unit. Width = 2 inches.

siltstone about 20 feet above the Sentinel Butte ash in the North Unit (Figure 10). That mollusk fossil-bearing siltstone persists throughout most of the North Unit. Several taxa of snails (including *Campeloma, Lioplacodes, Viviparus*), mussels (including *Pleiselliptio*), and pill clams (including *Sphaerium*) were identified during this study (Figures 9-12). Small snail opercula were also found. Ostracodes, small bivalved crustaceans, were recovered from some sites.

Vertebrate fossils were found at 51 sites; 23 in the South Unit and 28 in the North Unit. All but four of these sites are in the Sentinel Butte Formation. The most common of the vertebrate fossils are remains of crocodile-like creatures called champsosaurs (Figure 13 & 14). Because they are robust, champsosaur vertebrae are often preserved in Paleocene age rocks in North Dakota. Two champsosaur taxa were identified, the common *Champsosaurus* and the extremely rare *Simoedosaurus*. Two fairly complete *Champsosaurus* skeletons were discovered and excavated from the South Unit during this study, one from the Bullion Creek Formation and the other from the Sentinel Butte Formation. Champsosaurs were one of several extinct kinds of crocodile and crocodile-like creatures that inhabited the park during the Paleocene. Champsosaurs, although not true crocodiles, resembled in some ways the living, long-snouted gavial crocodilians. They grew to lengths of about 10 feet. Inhabiting ponds and swamps, they were probably aggressive underwater predators that fed on fish. This is suggested by the hydrodynamic shape of their bodies, powerful back legs, and long snouts lined with sharp, pointed teeth. It is believed that these animals would lie on the bottom of ponds waiting for prey. As a fish swam by, the champsosaur would lunge off the bottom with its powerful back legs and attack the fish.

The remains of crocodilians, both crocodiles and alligators, were also found in the park. These finds, however, consisted only of disarticulated skeletal parts, mostly scutes (hard bony plates imbedded in the animals skin) and teeth (Figure 15). The crocodile remains are probably *Leidyosuchus*, the common crocodile that inhabited North Dakota during the Paleocene. They grew to lengths of 12 to 14 feet. Like the champsosaur fossils, the crocodilian remains were found mostly in carbonaceous claystones and mudstones indicating that these animals lived and died in ponds and swampy habitats (Figure 16).

Other pond and near-pond dwelling vertebrate animals are also represented by fossils in the park, including turtles and fish. Two kinds of turtles have been identified, the chelydrid (snapping turtle), *Protochelydra* (Figures 17 & 18), and the plastomenid (soft-shelled turtle), *Plastomenus* (Figures 19 & 20). One fairly complete *Protochelydra*

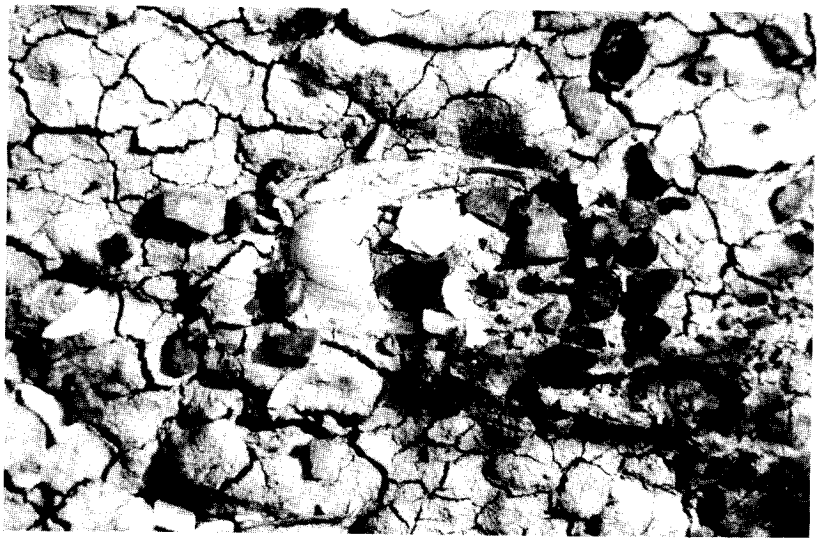


Figure 9. Freshwater clam (mussel) in a Sentinel Butte Formation claystone. Width = 3 inches.

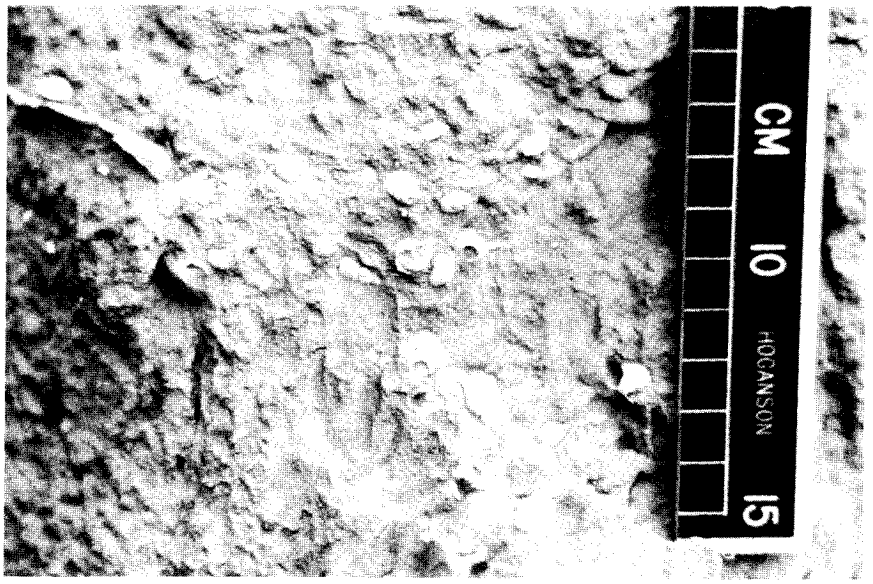


Figure 10. Freshwater snails in the "yellow siltstone", Sentinel Butte Formation, North Unit.

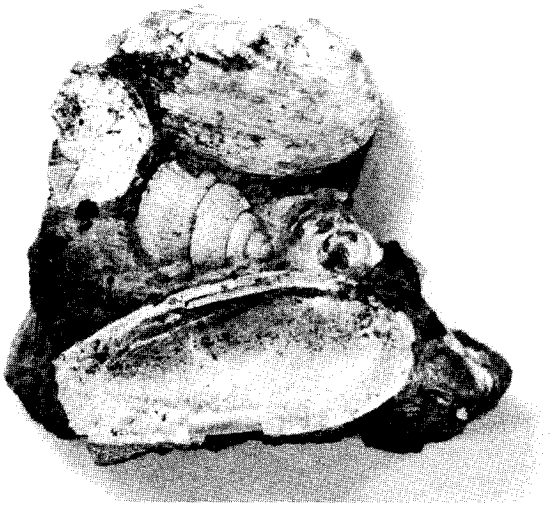


Figure 11. Freshwater clams (mussels) and snail (*Campeloma*), Sentinel Butte Formation, South Unit. Width of largest clam = 2½ inches.

Figure 12. Pill clam (*Sphaerium*), Sentinel Butte Formation, North Unit. Width = ¼ inch.

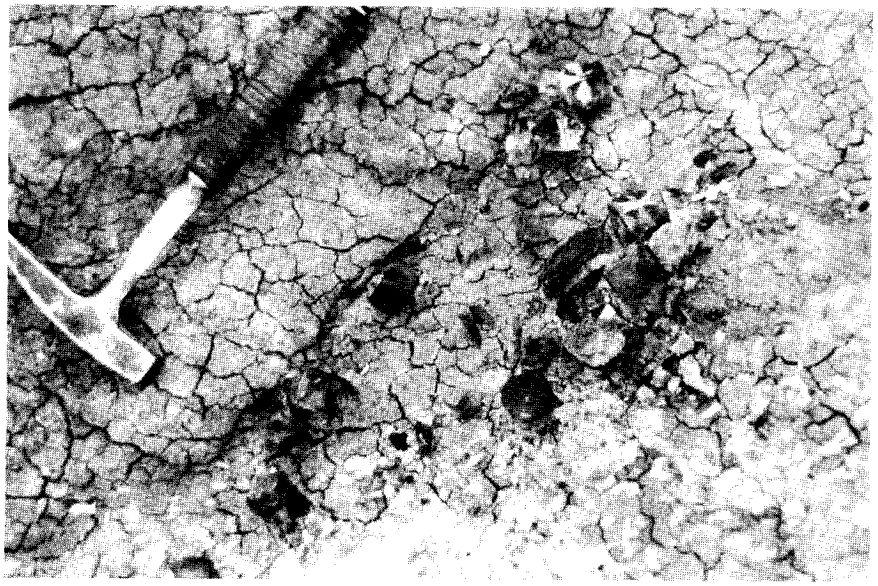


Figure 13. *Champsosaurus* vertebrae weathering out of the Sentinel Butte Formation, South Unit. Rock hammer is 12 inches long.

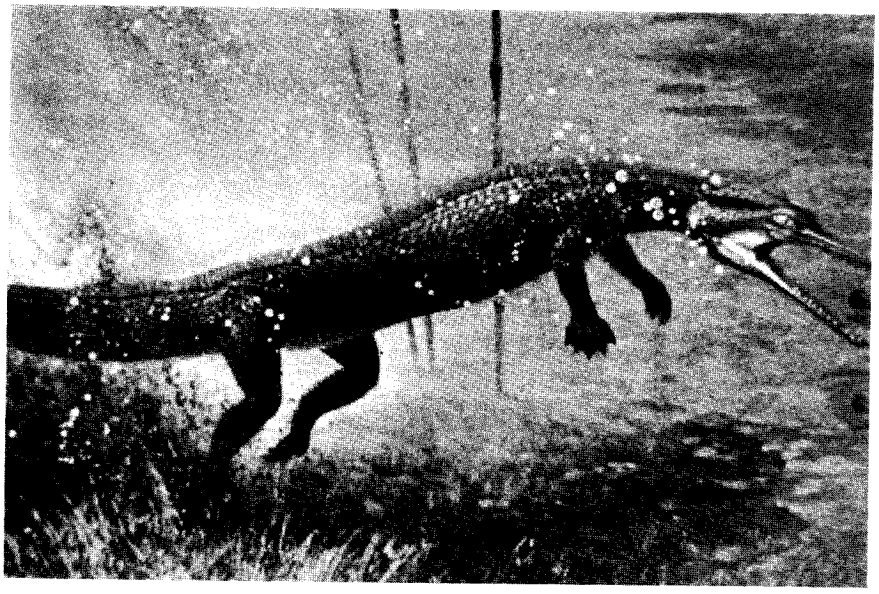


Figure 14. Life restoration of *Champsosaurus* lunging off the bottom of a pond after a fish. Painting by Jerome Connolly, The Science Museum of Minnesota, St. Paul.

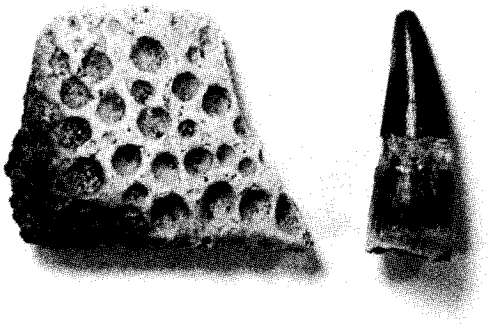


Figure 15. Crocodile scute (left) and tooth (right), Sentinel Butte Formation, North Unit. Height of tooth = ¾ inch.

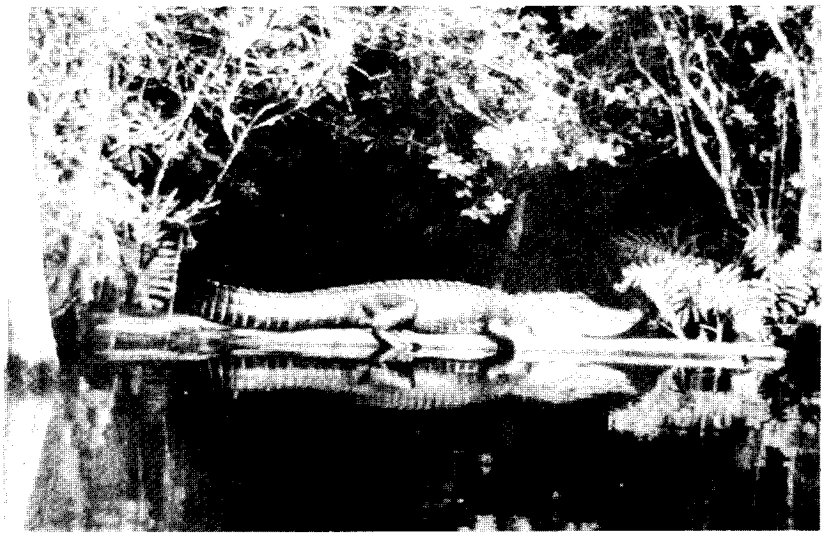


Figure 16. Photo of a living crocodile in a swampy habitat.

carapace exhibits partially healed tooth puncture marks, probably indicating an attack by an alligator (Figure 18). At least two kinds of fish lived in the aquatic habitats at this time, *Amia* (bowfin) and *Lepisosteus* (gar). These taxa are represented only by skeletal fragments, mostly teeth and vertebrae. The vertebrae of another interesting animal, the giant salamander, *Piceoerpeton,* were found in the Sentinel Butte Formation.

Only four mammal fragments were discovered during this study, two teeth and two jaw fragments, all from the lower Sentinel Butte Formation in the North Unit. From these fossils, the lemur-like *Plesiadapis,* has been identified.

It should be noted that fossil *Bison* bones were often observed in Quaternary alluvial and colluvial deposits in both the North and South Units.

Figure 17. Johnathan Campbell restoring *Protochelydra* carapace collected from the Sentinel Butte Formation, North Unit. Long dimension of carapace = 16 inches.

Paleoenvironmental Interpretations

The fossils found in Theodore Roosevelt National Park and other fossil sites outside the park provide information about the environment and climate in North Dakota between about 60 million and 55 million years ago. During that time, sediments derived from erosion of the rising Rocky Mountains were carried to western North Dakota and were deposited in rivers, river floodplains, lakes, ponds, and swamps. These sediments, now at least partially lithified, are called the Bullion Creek and Sentinel Butte formations. The climate was subtropical, probably similar to the southern part of the United States today. This hot and humid swampy lowland, at times containing extensive, well established forests, provided a habitat for exotic plants and animals (Figure 21).

Invertebrate animals, including pill clams, mussels, snails, insects, and minute crustaceans, lived in the rivers, streams, ponds, and swamps. Many kinds of vertebrates also lived in and near these aquatic habitats. The primary predators were crocodiles, alligators, and champsosaurs. The crocodiles and alligators preyed on turtles and the champsosaurs and snapping turtles preyed on fish. In turn, the fish preyed on the mollusks and insects in the ponds. Lush forests containing ferns, cycads, figs, bald cypress, *Ginkgo,* katsura, *Magnolia,* sycamore, giant dawn redwoods and other subtropical plants flourished at times in western North Dakota. Insects and birds lived on and ate these plants. Lemur-like mammals inhabited the swampy woodlands. Mammals were beginning to become established during this time because the extinction of the last of the dinosaurs had occurred just a few million years earlier.

Geology Exhibit Planned for Park Visitors Center, Medora

Under the direction of Bruce Kaye, Chief of Interpretation at Theodore Roosevelt National Park, work has begun on an exhibit to provide an interpretation of the geology and paleontology of the park. That exhibit will be installed at Medora in the Park Visitor Center at the entrance to the South Unit and will include many of the fossils collected in the park during this study. The most spectacular of those fossils will be a restored three-dimensional skeletal mount of one of the champsosaurs excavated in the South Unit (Figure 22). The exhibit will also include restored turtle fossils and examples of other vertebrate, invertebrate, and plant fossils found in the park. A *NDGS Newsletter* article about the exhibit will appear in the near future.

Figure 18. *Protochelydra* carapace showing healed tooth puncture marks on the posterior part of the carapace (same specimen as in Figure 17).

Figure 19. Johnathan Campbell collecting a *Plastomenus* carapace from the Sentinel Butte Formation, North Unit.

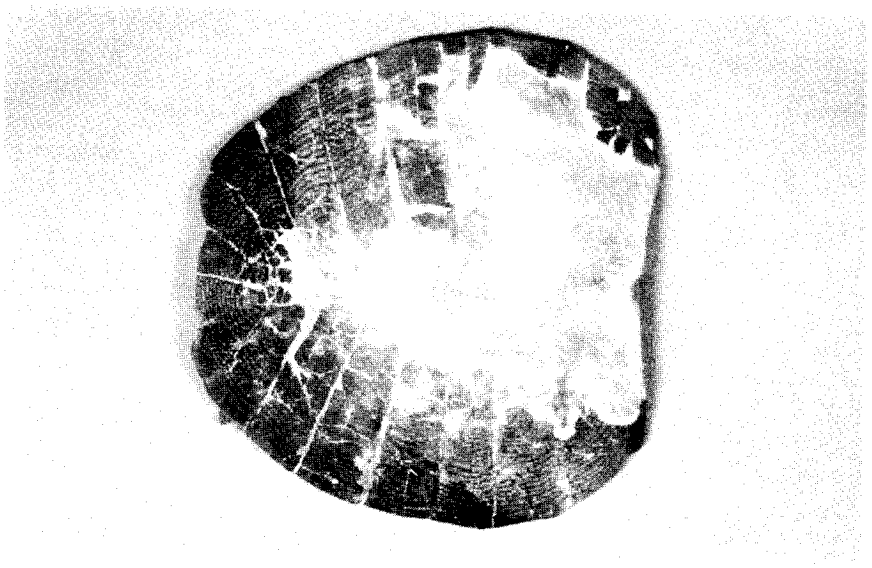


Figure 20. Restored *Plastomenus* carapace (same specimen as in Figure 19). Long dimension of carapace = 10½ inches.

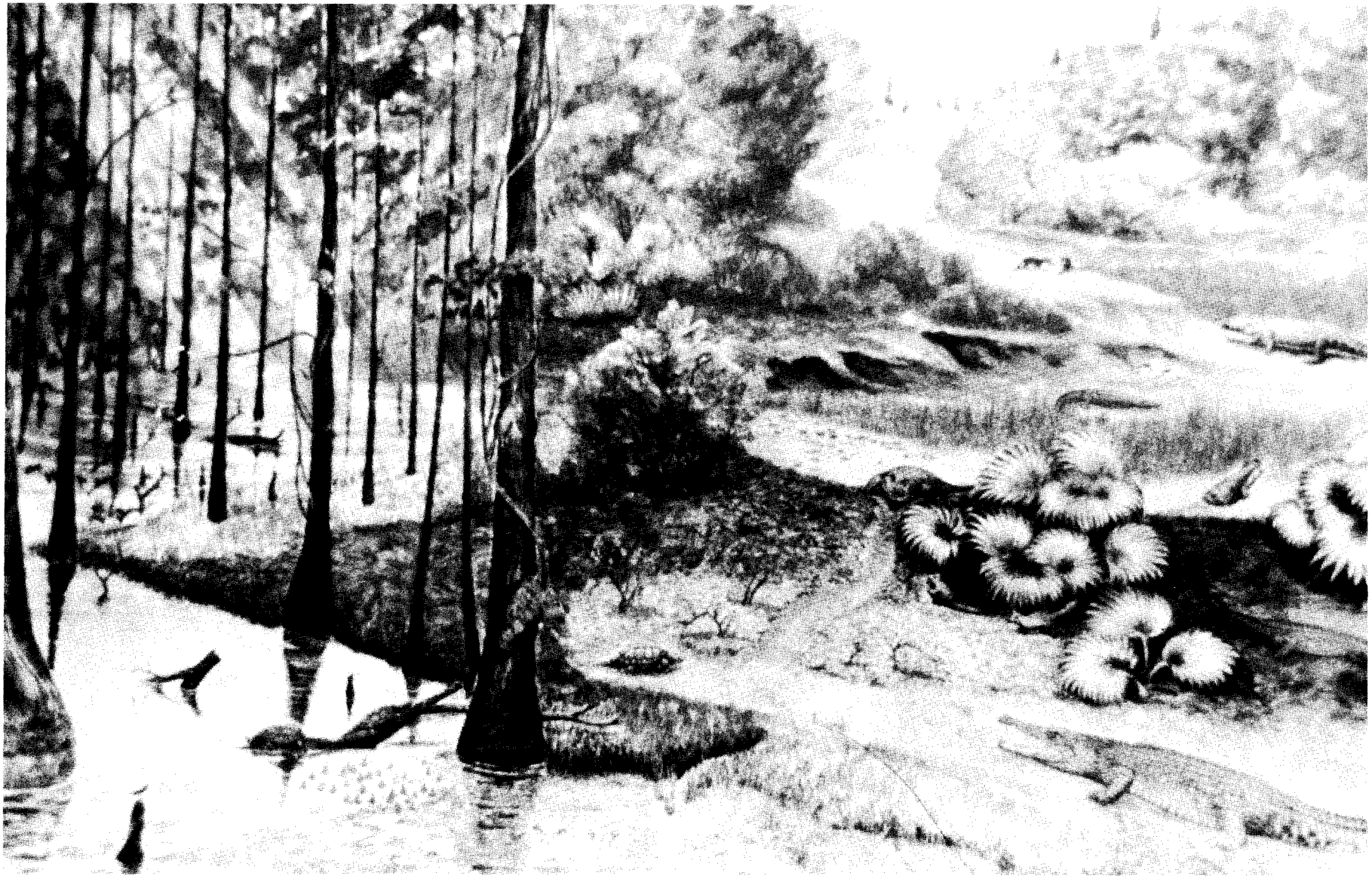


Figure 21. Paleoenvironmental reconstruction of Theodore Roosevelt National Park during part of the Paleocene. This reconstruction by Bruce R. Erickson, Science Museum of Minnesota, St. Paul, is based on fossils found in the Bullion Creek Formation at the Wannagan Creek fossil site, just west of the South Unit.

The following photographs (22a - 22f) are of the collection and restoration of one of the fairly complete *Champsosaurus* skeletons found in the Sentinel Butte Formation, South Unit.

Figure 22a. National Park Service mule, "Bo", used to carry supplies and equipment into the remote excavation site.

Figure 22b. Champsosaur skeleton being encased in a large plaster field jacket at the excavation site.

Figure 22c. Field jacket containing champsosaur skeleton at the excavation site.

Figure 22d. Field jacket containing champsosaur skeleton being air-lifted from the excavation site. Photograph by Bruce Kaye, Theodore Roosevelt National Park.

Figure 22e. Champsosaur skeleton still in the plaster field jacket being worked on by Johnathan Campbell in the Survey's paleontology laboratory at the Heritage Center.

Figure 22f. Backbone of the champsosaur being reconstructed by Johnathan Campbell in the Survey's paleontology laboratory.

Triceratops Skull Exhibited at North Dakota Heritage Center

by John W. Hoganson

In 1986 the North Dakota Geological Survey and U.S. Forest Service--Custer National Forest signed an agreement to cooperatively manage paleontological resources on Custer National Forest administered lands in North Dakota, particularly in the Little Missouri National Grasslands area of western North Dakota. That commitment was reaffirmed in 1995 when the agreement was updated and re-endorsed. As a result of this partnership, inventories have been conducted in paleontologically sensitive areas in the Little Missouri National Grasslands. As a result, many important fossil sites have been mapped and their significance assessed. In 1995, during one of these inventories, a skull of the dinosaur *Triceratops* was found weathering out of the 65-million-year-old Hell Creek Formation north of Marmarth, Slope County. That specimen was subsequently excavated by a crew consisting of North Dakota Geological Survey and U.S. Forest Service personnel assisted by numerous volunteers (Figures 1 & 2). The skull was restored at the Geological Survey paleontology laboratory in the Heritage Center by Johnathan Campbell (Figures 3 & 4). After the restoration was completed, the specimen was transported to Billings, Montana and was temporarily exhibited at the Custer National Forest headquarters. The specimen is now back at the Heritage Center for permanent exhibit (see *Newsletter* cover). An interpretive panel accompanies the skull and an additional *Triceratops* brow horn is included in the exhibit to encourage a "hands on" experience by the museum visitor.

Figure 1. Jeff Silkwood (USFS) pointing to a *Triceratops* brow horn partially exposed in the Hell Creek Formation.

Triceratops (derived from the Greek words meaning three-horned face) was one of the largest and heaviest of the numerous species of horned dinosaurs. This dinosaur grew to lengths of 30 feet and could weigh as much as five tons (Figure 5). Even though the front legs of *Triceratops* were short, they were powerfully built to support the weight of its enormous head. The skull of *Triceratops,* often 6 feet long in adult specimens, is distinctive because it is equipped with two long brow horns, one short nose horn, and a large, solid, bone frill that covered its neck. It had powerful jaws that ended in a parrot-like beak. These jaws contained batteries of teeth adapted for shearing fibrous plants. Damage (like is seen on the Heritage Center specimen) to many *Triceratops* skulls suggests that these animals probably sparred with one another by locking horns and shoving and twisting, possibly to win mates or establish territory. It has been suggested that *Triceratops* may have charged predators, such as its contemporary *Tyrannosaurus rex*, similar to an enraged rhinoceros. The remains of *Triceratops* are some of the most common dinosaur fossils found in North Dakota.

The North Dakota that *Triceratops* inhabited during the Cretaceous was quite different from the North Dakota of today. At that time, a well-drained lowland corridor existed between the rising Rocky Mountains and the Western Interior Seaway to the east. Western North Dakota was part of this lowland. Sediments eroded from the Rocky Mountains were carried to the lowland by rivers and streams and were deposited in a huge delta complex similar to today's Mississippi River delta in Louisiana. These sediments, now called the Hell Creek Formation, contain dinosaur fossils and are exposed in the badlands near Marmarth and in buttes south of Bismarck and Mandan. It is the only rock formation exposed in North Dakota that contains abundant dinosaur fossils.

Figure 2. Michele Gutenkunst (volunteer) and Carol McCoy Brown (USFS) excavating part of the *Triceratops* frill.

North Dakota's climate during the late Cretaceous was probably subtropical, similar to that of south Florida today. Woodlands, ponds, and swamps that existed on this deltaic coastal plain provided abundant habitats for many kinds of exotic plants and animals, including several species of dinosaurs (Figure 5). In addition to *Triceratops*, several other dinosaur taxa are represented by fossils in the Hell Creek Formation of North Dakota including *Torosaurus*, *Tyrannosaurus*, *Albertosaurus*, *Thescelosaurus*, *Pachycephalosaurus*, *Stygimoloch*, *Edmontosaurus*, *Troodon*, *Saurornitholestes*, and *Dromaeosaurus*. Freshwater fishes, salamanders, lizards, turtles, crocodiles, birds, snails, and clams coexisted with the dinosaurs. Fossils of small, rodent-size mammals are also found, but rarely, in the Hell Creek Formation. *Triceratops,* and the other dinosaurs that inhabited North Dakota at the same time were some of the last dinosaurs to live on earth before the mass extinction event at the end of the Cretaceous about 65 million years ago. The top of the Hell Creek Formation marks the extinction of the last of these dinosaurs.

Restoration and display of the *Triceratops* skull results from a cooperative effort between the North Dakota Geological Survey, United States Forest Service--Custer National Forest and State Historical Society of North Dakota. Funding for excavation and restoration of the skull from the United States Forest Service is gratefully acknowledged.

Figure 3. Johnathan Campbell restoring one of the *Triceratops* brow horns in the Survey's paleontology laboratory at the North Dakota Heritage Center.

Figure 4. Johnathan Campbell with nearly completed *Triceratops* skull in the Survey's paleontology laboratory.

Figure 5. About 65 million years ago western North Dakota was a deltaic coastal plain containing woodlands, swamps, and ponds. This painting, by Eleanor Kish of the Canadian National Museum of Natural Sciences, depicts that kind of habitat. In this picture, two of the great horned dinosaurs, *Triceratops*, are shown on a bayou mudflat in a forest of bald cypress and gum trees.

1996 NDGS NEWSLETTER SUBJECT INDEX

1996 NDGS NEWSLETTER AUTHOR INDEX

NEW PUBLICATIONS

Map Products Available from USGS

Satellite View of the Conterminous United States. The map is a mosaic of 16 false-color infrared images from the Advanced Very High Resolution Radiometer (AVHRR) sensors on meteorological satellites. The map depicts state boundaries on one side; the other side contains descriptions of 24 interesting geologic features such as the Red River Valley, Black Hills and South Dakota Badlands, and Mount St. Helens. Part of the U.S. Atlas Series maps (1:7,500,000 scale).

$4.00

Routes of the Explorers is a great map for historians or those interested in when various areas of the U.S. were explored. The map shows the routes of principal explorers of conterminous U.S. from 1501 to 1844. These explorers' work had an important bearing on the settlement of the country and the fixing of its successive boundaries. Part of the U.S. Atlas Series maps (1:7,500,000 scale).

$4.00

Landforms of the Conterminous U.S. A digital shaded relief portrayal (1:3,500,000 scale). Shaded relief image displayed was made by the computer processing of 12 million terrain heights contained in a digital elevation model of the U.S. The map was made of 6,096 cells in an east-west direction and 3,800 cells in a north-south direction. Distance between cells is 805 meters, or approximately 2 miles on the ground. Cost includes a pamphlet that discusses the landforms and technical details of the map.

$6.00

Shipping and Handling Charges for Maps

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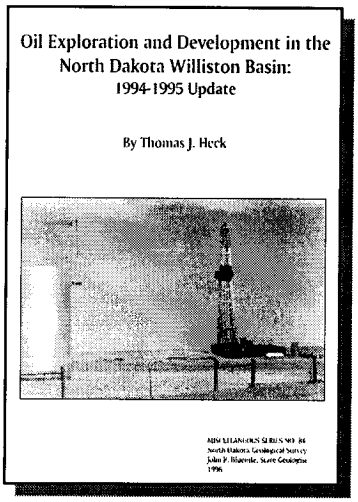
6 - 30 maps	**$4.00**
31 + maps	**$6.00**

Oil Exploration and Development in the North Dakota Williston Basin: 1994-1995 Update

Thomas J. Heck



Miscellaneous Series No. 84, entitled *Oil Exploration and Development in the North Dakota Williston Basin: 1994-1995 Update*. This publication is the most recent in a series extending back to 1979 that reviews oil industry activity and discoveries. Each issue in the series gives a short historical review of the 1980's and 1990's but focuses on the events during the most recent two-year period. During 1994 and 1995, exciting new field discoveries were made in North Dakota that drew the attention of oil companies from many different parts of North America.

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