NEWSLETTER

NDGS

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ABOUT THIS ISSUE--

In this Newsletter, I am including three short "essays" on various aspects of North Dakota's geology. The articles, which deal with scoria, lignite, and potash, are from a new NDGS publication, "The Face of North Dakota--the Geologic Story." "The Face of North Dakota" is a non-technical treatment of North Dakota geology. It includes a colored geologic highway map, which shows the surface geology of the state (the highway map is also available separately as NDGS Miscellaneous Map 19) as well as numerous maps and photographs to illustrate various geologic features.

Let me know whether you think background items of this type dealing with North Dakota geology belong in the Newsletter or whether I should concentrate on Survey activities.

DRILLING PROGRAM--

This summer's drilling program for geology information consisted of 115 holes, 21 in the New England area (Slope, Hettinger, Adams, and Stark Counties) and an area across southern Dunn County, Mercer, western Oliver and northwestern Morton County. The logs and sample descriptions are being assembled for an open file report which will be available jointly through the Conservation Division of the United States Geological Survey and the NDGS upon final approval by the USGS. The report for the 1975 drilling season is in final review in the Washington, D.C., office and should be released shortly.

SANITARY LANDFILL EVALUATION--

The Survey has been cooperating with the North Dakota State Department of Health in evaluating proposed sanitary landfill sites. The evaluation is mainly aimed at protecting surface water and groundwater resources from pollution. The factors considered are the surface drainage pattern, the surface and near-surface materials, and the location of aquifers. North Dakota is currently in the process of closing down open dumps and consolidating solid-waste disposal into landfills, many of which will serve a whole county or more.

COUNTY GROUNDWATER STUDIES--

Survey personnel are involved in several geologic mapping projects. Kelly Carlson is finishing a report on Bowman and Adams Counties, and continuing work on several other counties southwest of the Missouri River. John Bluemle is finishing a report on Dickey and LaMoure Counties and continuing work on Ransom, Sargent, and Sheridan Counties. Howard Hobbs is completing a report on Ramsey County. All of these reports will be part of our county groundwater studies series, done in cooperation with the North Dakota State Water Commission, the counties involved, and the United States Geological Survey.

Howard Hobbs' report on Ramsey County is nearing completion. He reports that he has recognized deposits of many different glaciations, including till deposited by glacial ice, silt and clay deposited in glacial lakes, and sand and gravel deposited by meltwater. He has distinguished several layers of till by examining the number of shale fragments that the tills contain, among other things. Some of the meltwater deposits were laid down in deep valleys that were subsequently buried by later glaciations. These sand and gravel deposits now serve as buried aquifers. One of these aquifers underlies Devils Lake and apparently provides a significant amount of groundwater to the lake.

Another interesting aspect of Ramsey County is Glacial Lake Cando, which occupied the northwestern part of the county during the melting of the last major ice advance. The lake was surrounded by walls of ice and drained under the ice into Devils Lake, which at that time was much bigger than it is today. Waves in Lake Cando eroded hills and filled in hollows with sediment, making a flat lake plain similar to the larger, better-known Lake Agassiz plain, which occupies the Red River Valley.

Ramsey County also contains several ice-thrust features, the most notable of which is Devils Lake Mountain, in the southern part of the county. This is a large block or group of blocks of bedrock, which was shoved southeast by glacial ice. To the northwest of the mountain is a swampy hollow where the block used to be.

KNIFE RIVER BASIN STUDY--

This past summer the Survey devoted a considerable amount of time to a Regional Environmental Assessment Program (REAP)--funded study of the Knife River basin. The major purposes of the study involve determination of the stratigraphy and groundwater resources in the area.

Activities up to now have included detailed truck-mounted augering and mapping in the Beulah-Hazen area, surficial mapping of two 15-minute quadrangles in the Zap, Beulah, and Hazen areas, and a detailed well inventory for these areas. In addition, 11 deep (150-250 metre) test-holes were drilled. These have been incorporated with existing, stratigraphic data to construct regional cross sections of the Knife River basin.

In other reclamation-related activities, we are hoping for funding for a study of piping, subsidence, and related problems in recontoured strip-mine spoil areas of western North Dakota.

STATE CABINET OF FOSSILS--

Lee Gerhard, Assistant State Geologist, reports that collections of North Dakota fossils are being cataloged as a State Cabinet of Fossils. The fossils, collected as thesis material and on field trips, are presently part of a number of University of North Dakota collections. Now, a separate catalog is in preparation, one which will give location of specimen fossils, and describe each as to formation, collection locality, and identification. This catalog will guide geologists to specimen fossils for comparative identification of newly-collected fossils, to systematic study of faunas, and to paleoecologic interpretations of North Dakota rock units.

CARBONATE STUDIES UNDERWAY--

Subsurface carbonate studies by UND graduate students in geology are progressing in North Dakota's Williston basin rocks. Tom Heck is studying the Lodgepole (Mississippian) to determine depositional environments and sedimentation history of lithologic units. Potential hydrocarbon accumulation areas are one of the main interests of Tom's study. Kipp Carroll is studying the depositional and diagnostic history of the Red River Formation in an attempt to determine the factors that localize hydrocarbons in producible quantities. His study is in the preliminary stages.

TWO GEOLOGISTS LEAVE NDGS--

Dr. B. Michael Arndt and Dr. Stephen R. Moran have left the North Dakota Geological Survey. Mike came to the NDGS in 1968 and specialized in engineering geology. He is now in Denver, Colorado, with the Rocky Mountain Arsenal. Steve came to the Survey in 1969, specializing in glacial stratigraphy and glacial geology. He is now with the Alberta Research Council in Edmonton, Alberta.

BASIC DATA COMPILATION FOR LAND-USE PLANNING--

The Survey has helped to compile a series of maps showing suitability of the land (with respect to geologic constraints) for such things as septic systems, sewage lagoons, general construction conditions, and sanitary landfills, as well as the pollution hazard for groundwater. These maps were prepared for the ten-county area of the Lewis and Clark Resource Conservation and Development Project in Bismarck. Each map covers one county. Most of the maps were prepared with the assistance of University of North Dakota geology students under the supervision of Survey personnel.

In a separate project for the Williston Basin Resources Council for Development, the Survey is completing a basic data study consisting of a text and a series of maps relating to mineral reserves, water reserves, suitability of soils for cultivation and irrigation, and the pollution hazard for groundwater.

DAKOTA-LAKOTA TO BE USED FOR POTASH BRINE DISPOSAL--

In October, 1976 the North Dakota State Industrial Commission approved the application of PPG Industries, Inc., to use the Cretaceous Dakota-Lakota Series for two years for disposal of saline water. PPG expects to construct a test facility to mine potash in Burke County. Such a facility would generate highly saline waste waters in amounts greater than could be readily disposed of by evaporation from surface containers.

Disposal of potash brine waters in the Dakota-Lakota Series will avoid damage to the surface and pollution of potable waters. The Dakota-Lakota occurs throughout the Burke County area, so PPG will have some latitude in selecting a location for its test facility. The Dakota-Lakota is already being used as a disposal reservoir for oil field brines and liquids in several locations in Burke County. Its natural waters are too salty to be used for domestic purposes.

OIL PRODUCTION UP IN 1976--

Jack Wilborn, NDGS Petroleum Engineer, reports that North Dakota oil production in 1976 will show an increase over 1975, the second year in a row to show such a rise. During the period from January 1 to September 1, 1976, oil production was 16,140,223 barrels. During the comparable 1975 period, only 15,073,227 barrels were produced. So far in 1976, we have had 16 new pools discovered. This compares with eight during 1975.

As of December 1, 1976, North Dakota had 2,047 oil wells capable of production. On the same date last year we had 1,958 wells.

During the eleven-month period from January 1, to December 1, 1976, the Survey issued 221 drilling permits. This is 23 fewer than during the comparable period last year. During the past six months (June 1--December 1) the Survey issued 144 permits, compared to the 172 permits issued during the same six-month period last year.

In a departure from tradition (most new oil fields are named for nearby geographic features), one of our new oil fields, discovered during this, our nation's bicentennial year, was named the "Bicentennial Field." The initial discovery in the Bicentennial Field is from the Red River Formation, although there may possibly be other producing zones. There has been a confirmation well drilled, and there appears to be yet a third good producing well in the field. The two wells now producing in the Bicentennial Field may level off at a total of about 1,000 barrels/day. The Bicentennial Field is located about 40 miles southwest of Watford City in southwestern McKenzie County.

NORTH DAKOTA SCORIA--

During early October, 1976, prairie fires burned over several areas of southwestern North Dakota. These fires ignited underground lignite seams in at least 30 locations over a 7,000-acre area near Amidon. According to ranchers, fire officials, and U.S. Forest Service personnel, attempts to extinguish the underground fires have been generally unsuccessful.

Everyone who lives in or has travelled through western North Dakota has noticed the colorful reddish layers and brick-like masses of baked and fused clay, shale, and sandstone. These layers of natural brick formed in areas where seams of lignite burned, producing heat that baked the nearby sediments to a form of natural brick. The baked material is known locally as "scoria."

Range fires have ignited lignite beds over the years as they did in October of this year. Spontaneous combustion, lightning, and the actions of man may have been responsible for other burned lignite seams. Such a large number of lignite seams have burned over such a broad area and under such a variety of situations that it seems likely spontaneous combustion has been responsible for many of the fires. Lignite that contains a high percentage of sulfur is most likely to ignite spontaneously. The ideal situation for such combustion is a finely divided condition of the coal, a slight amount of heat from an outside source, and several feet of overburden to retard heat losses by radiation.

Lignite exposed to air by the removal of the overlying sediment due to erosion loses moisture and tends to slack or crumble to fragments. The powdered coal, with a greatly increased surface area, promotes rapid oxidation; in fact, powdered coal absorbs oxygen in quantities at least two to three times its own volume. This absorption of oxygen takes place at ordinary temperatures and, because the process generates heat, it is self-accelerating.

The presence of the minerals pyrite and marcasite (forms of iron sulfide) and moisture results in the production of heat. As this chemical reaction takes place at ordinary temperatures, it is a means by which the coal is heated to the point at which it ignites spontaneously. Pyrite and marcasite are nearly always present in relatively large quantities in and near lignite seams that have ignited.

Regardless of how it starts, burning is most likely to persist where coal beds crop out on a fairly steep bank, making it possible for large quantities of fine coal dust to accumulate over the lower part of the outcrop. Thin lignite beds commonly do not burn long because piles of powdered coal large enough to retain self-generated heat cannot accumulate along their outcrop. An overburden thickness of 100 feet or more over the coal also prevents ignition unless the coal bed is exceptionally thick.

In two places in western North Dakota, lignite seams have been burning for many years. One of these fires is in the South Unit of Theodore Roosevelt Park near Medora and the other is near Amidon. And now, of course, we have about 30 new fires.

As lignite beds burn, the heat produced bakes and fuses the overlying sediments. As the lignite burns out to an ash that takes up little space, the overburden collapses into the burned-out space. By the time the overlying materials collapse, they have been baked to a hard material, and they are commonly partially fused as well. As they slump, they hold together, producing a rock that is as much as 75 percent air space. Oxygen is then admitted through this porous, fractured rock, and combustion gases are carried out so the coal can burn farther back. After the scoria cools, the spaces that resulted from collapsing of the materials are convenient places in which rattlesnakes and other animals can live.

Scoria commonly contains fragments that look as though they have melted. According to one theory, these fragments were formed when the material overlying a burning coal bed collapsed, plunging it into the exceptionally hot areas beneath so that it melted.

The intensity of the reddish color of scoria depends on the mineral composition and grain size of the material that was baked and on the intensity of the temperature reached during the baking process. The reddish color is due primarily to the presence of the mineral hematite (iron oxide, the same as common rust).

Much of the scoria in western North Dakota is now found at elevations where the water table is too high for lignite to burn. This scoria probably formed at a time when the climate was drier and the water table was lower than it is today. This may have happened during a warm, dry period of time that began about 7,000 years ago and ended about 2,500 years ago.

NORTH DAKOTA LIGNITE--GENERAL GEOLOGY--

Western North Dakota has a huge reserve of lignite, about 16 billion tons of strippable reserves in beds greater than 5 feet thick, and another 17 billion tons in beds 2½ to 5 feet thick. This amounts to about 80 percent of the recoverable lignite reserves in the United States.

Lignite is one of four "ranks" of coal: the other three ranks are anthracite, bituminous, and sub-bituminous coal. The rank of coal is a classification system that considers the heat value, the fixed carbon ratio, and agglomerating characteristics (binding quality). North Dakota lignite is a nonagglomerating coal with a heating value of about 5,600 to 7,700 Btu's (British thermal units) per pound.

Most of the current lignite production in North Dakota is consumed in the generation of electric power. A much smaller amount is used for various industrial heating purposes. If lignite conversion plants for the production of synthetic natural gas and hydrocarbon liquids become a reality, production will increase dramatically. North Dakota's lignite resources would last over 1,300 years at the current rate of production (about 10 million tons in 1976). Even if large-scale coal gasification becomes a reality, North Dakota's lignite will go a long way. Assuming continued increases in electric generation capacity and six lignite conversion plants by 1990, the lignite would last over 150 years. The total amount of lignite produced in North Dakota to January 1, 1976 is approximately 173 million tons, or slightly over one percent of the total strippable resource.

The lignite is found interbedded with layers of sediment that make up what geologists refer to as the Bullion Creek Formation and the Sentinel Butte Formation (the Bullion Creek Foramtion used to be called the Tongue River Formation). These two formations and the lignite beds within them were deposited during the Paleocene Epoch, about 65 million years ago. Trees and plants that grew in ponds and swamps along ancient streams that flowed through western North Dakota later were transformed to lignite.

Near the newly-formed Rocky Mountains in Wyoming and Montana, the Paleocene rivers and streams flowed swiftly and carried large amounts of coarse materials such as gravel. At the point where the rivers flowed from the mountains eastward out onto the plain, they lost much of their carrying power as their velocity decreased and they deposited the coarser gravel and sand near the mountains. The finer materials, such as clay, silt, and fine sand, were carried farther eastward to the Dakotas where they were deposited in the layers exposed today in the badlands. The deposition was not uniform and blanket-like, but rather, as the rivers and streams meandered from side to side, they deposited materials in one area for a few years and somewhere else a few years later.

Central North Dakota at this time was covered by a shallow sea and as the sediment-laden rivers flowed into this sea, they formed broad deltas at its margin. The sea gradually filled with sediment--the Bullion Creek and Sentinel Butte Formation deposits--and the warm, coastal environment supported a luxuriant plant growth.

As the plants died and fell into the swamps, they began to decay due to the action of bacteria. However, before the plants could be completely decomposed, the bacterial action stopped because the bacteria "committed suicide" by filling the stagnant swamp water with their body poisons to such an extent that they died. When the streams changed course, as the Mississippi River does on its delta on the Gulf of Mexico at times, they deposited sand on top of the partially decomposed vegetation, burying it and allowing lignite to form.

In places, chemical conditions were slightly different and instead of forming lignite, the plants became petrified wood. Petrified stumps of trees related to our modern Sequoias, stand above the surface in many places, especially in badlands areas.

POTASH IN NORTH DAKOTA--

Several companies have recently expressed an interest in North Dakota's potash deposits and one company, PPG Industries, Inc., has drilled a testhole in northwestern North Dakota to explore for potash. It might be interesting to see what has aroused this interest and to take a look at what potash is and how it formed.

Vast deposits of rock salt (halite) and potash that were discovered during drilling for oil, lie buried beneath the northwestern North Dakota plains. It is estimated that at least 1,700 cubic miles of salt and potash is buried beneath the surface in North Dakota. North Dakota's potash resource amounts to over 500 billion tons, a huge reserve.

Our potash occurs with rock salt as the mineral sylvite in a mixture with halite (common table salt). The mixture is known as sylvinite. Potash is used primarily as fertilizer for agricultural purposes. North Dakota's potash is attracting increasing attention lately, mainly due to the fact that the production just across the Canadian boundary in Saskatchewan may be nationalized by the Provincial Government. As a result, producers are taking a close look at North Dakota, even though our potash reserves are somewhat deeper in most places than in Saskatchewan, ranging from 5,600 feet to 12,500 feet deep.

Both rock salt and potash can be recovered by solution-mining methods that require the injection of water into the salt bed and the pumping out and processing of the resulting brine. Solution-mining for recovering potash, as now used in Saskatchewan, appears to be feasible in North Dakota.

North Dakota's potash was precipitated during Devonian until Jurassic time, between about 400 million years ago until perhaps 150 million years ago. The potash was precipitated from brines, extremely salty sea waters, in shallow, rapidly subsiding, evaporite basins where the normal influx and circulation of fresh and open marine waters were restricted. The barriers that caused the restrictions may have been reefs or shoals that grew above the sea bottom and restricted normal circulation or layers or currents of high-density brine, which restricted the entry or passage of lower density saline and fresh waters. Other thinner, marginal marine salt deposits resulted from precipitation of salt brines in salt marshes, along marine shorelines. A third type of salt deposition resulted from precipitation in continental arms of the sea that became completely landlocked. The salt deposits found in North Dakota probably formed in all of the ways I have described, definitely in marine evaporite basins and shoreline salt marshes, and possibly in continental salt lakes.

At the present time, salt (halite, not potash) is being produced from a 200-foot thick bed at a depth of 8,000 feet by the Hardy Salt Company plant at Williston. Recovery is by the injection of fresh water into the salt bed to dissolve it and then by evaporation of the resulting brine. The salt produced at the Williston plant is Mississippian in age, about 300 million years old.

It appears certain that potash demand will continue to exceed current production capability, prices will continue to climb, and it will be necessary to add production to meet projected demands. United States production will probably increase only slightly, and most of the increased demand will have to come from Canada unless we develop new production. Currently, U.S. production is centered in New Mexico, but the capacity for expansion there is small. No substitute exists for potash in agriculture, and its importance as an essential plant food cannot be overemphasized. So look for North Dakota to have a new industry in the not-too-distant future.

RECENT PUBLICATIONS--

The Survey recently published "A Mechanical Well Log Study of the Poplar Interval of the Mississippian Madison Formation in North Dakota" by C. W. Cook. This report, RI-52, provides a detailed look at the lithology of the Poplar interval based on studies of mechanical logs throughout the area it is present. It provides an interpretation of depositional environments and structural influences as well as a look at the future economic potential of this interval. RI-52 consists of 20 pages of text, 4 maps, and 5 cross sections and sells for $2.00.

Also available, free of charge, is a new publication entitled "Ground Water Basic Data for Dunn County, North Dakota" by Robert L. Klausing of the U. S. Geological Survey. This report includes geologic and hydrologic data for 1,216 wells and data on testholes, 134 springs, water level measurements in 140 observation wells, lithologic and geophysical logs of 632 testholes and wells, chemical analyses of groundwater from 351 wells and 36 springs, 15 chemical analyses from streams at low flow and core analyses for heavy minerals and hydraulic parameters. The report consists of 501 pages of text and data and one map showing location of wells and testholes.