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U. S. Department of the Interior

Geological Survey

Missouri River Basin

Geologic Mapping and Mineral Resource Investigations

Missouri-Souris Unit

Areal Geology

Preliminary Report on the Geology of the Kermit No. 3 Quadrangle, North Dakota

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1947

48-9

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INTRODUCTION

The present study of the areal geology of the Kermit No. 3, 15 minute quadrangle, completed during the summer of 1946, was made in connection with development of the Missouri-Souris Unit of the Missouri Basin Development Program. The quadrangle is located in northern Williams County and southern Divide County. It lies within the Missouri Plateau section of the Great Plains Province (4, no. 4). Part of the proposed Crosby reservoir enters the area and the route of the proposed Souris canal of the U. S. Bureau of Reclamation crosses the quadrangle.

GEOGRAPHY AND GENERAL GEOLOGY

The Kermit No. 3 quadrangle and surrounding area is covered by thick deposits of glacial drift deposited during the Wisconsin state of Pleistocene glaciation. The drift consists mainly of morainal deposits of late Wisconsin age. The "Altamont" moraine (3, pp. 388 and 393; 6, p. 521; 1, p. 126) occupies the northern three quarters of the area, and earlier ground moraine (1, p. 127) occupies the southern quarter.

The "Altamont" terminal moraine consists of thick till (up to 200 feet) having an irregular, poorly drained surface of high relief. The ground moraine has a relatively smooth surface with rather well integrated drainage patterns.

There are no bedrock exposures in the quadrangle, but mine shafts reach coal at a depth of 30 to 50 feet in the vicinity of Cottonwood Lake east of Alamo. Well borings indicate that the Tongue River member of the Fort Untion formation of Paleocene age underlies the glacial deposits at depths ranging from 30 to 200 feet.

Large gravel outwash deposits are found in Alamo Valley, and in the northwest corner of the quadrangle. Eskers composed of sands and gravels, and veneered in places with varying thicknesses of boulders and till, occur 4 and 8 miles north of Alamo, and east of Cottonwood Lake. Small gravel terraces are located along the banks of Little Muddy Creek and its tributaries in the southern portion of the quadrangle. Isolated gravel knobs are scattered throughout the terminal moraine area.

The climate of the region is semi-arid, the mean annual precipitation being about 14 inches. Summers are generally mild and winters quite rigorous. Secondary lime, occurring chiefly in the form of caliche, has been and is being widely deposited in the subsoil and as encrustations on the undersides of surface stones. Similarly, along road-cuts and entrenched streams, exposed faces of till frequently are case-hardened by deposition of lime, induced by capillary action and evaporation. All of the streams of the area are intermittent and carry little water except after rains and thaws. The drainage, where integrated, is in general to the south and west to Little Muddy Creek.

The original vegetation, where not removed by cultivation, is of the "long grass" prairie type, with patches of "buck brush" and occasional cottonwood trees scattered along the streams. Wheat and grain cereals are the chief agricultural products and the grasslands are utilized extensively for livestock pasturage.

STRATIGRAPHY

Paleocene subsurface deposits

Fort Union formation (Tongue River member).- Formations older than the Tongue River member of the Fort Union formation (Paleocene) are not encountered in this area. No deep well borings are recorded within the quadrangle, so information from that source is lacking. However, one deep well, the California Company's Kamp No. 1, has been drilled to a depth of 10,281 feet in Williams County twenty miles to the south. The following systems and thicknesses were recorded in this well: Tertiary - 800 feet, Cretaceous - 3,820 feet, Jurassic - 900 feet, Triassic - 970 feet, Carboniferous (Mississippian)= 3,160 feet, Devonian - 631 feet. (5, pp. 13-14)

There are no surface exposures of the Tongue River member in this quadrangle. However, information gathered from abandoned coal mines two miles east of Alamo indicates that lignite horizons in this member are present in the valley walls at a depth of about thirty feet below the valley floor and at an elevation of approximately 2,075 feet. In addition to the coal, traces of clinker or "scoria" are present on the dump piles of the mines. Clinker is formed during burning of the lignite, ignited at or near the outcrop by spontaneous combustion, lightning, prairie fires, or artificial means. Heat generated by the fires causes partial baking to complete fusion of the overlying clays, shales, or sandstones, and imparts in them a distinctive coloration in shades of red, orange, or brown through oxidation of the iron-bearing minerals present. Masses of till baked to clinker in nearby areas outside the quadrangle prove postglacial burning of at least some of the coal.

The Tongue River member in this quadrangle is covered by Pleistocene glacial deposits ranging from 30 to over 200 feet in thickness.

Pleistocene deposits

Pre-late Wisconsin drift.-Previous studies by several workers indicate two or more advances of ice into this region prior to the late Wisconsin glaciation. Alden's map (1, pl.I) indicates a broad belt of pre-"Altamont" Wisconsin ground moraine stretching southward from the "Altamont" moraine to an east-west trending boundary six to eight miles south of the quadrangle, where there are areas of end-moraine topography. He further mapped as "Illinoian or Iowan", a sheet of drift extending southward from this line to a limit thirty-five to forty miles southwest of the Missouri River, where only scattered boulders and occasional patches of till give evidence of glaciation.

Earlier, Leonard (6, p. 532) considered pre-"Altamont" Wisconsin drift to stretch from the southern boundary of the "Altamont" moraine to the present course of the Missouri River.

No contacts between any of the above-mentioned drifts have been seen in this area, and the boundary here mapped is therefore tentative and approximate. The distinction is made largely on topographic evidence. Furthermore, textural differences in the topography north and south of Alamo valley, due to differences in size, number, and distribution of closed depressions, suggest the possibility of more than one period of deposition in the "Altamont" moraine itself.

Direct evidence of any pre-Illinoian or pre-Iowan glacial advance into the region is lacking. Whether Nebraskan and Kansas drift is present and is buried beneath younger deposits, whether the drift has been largely incorporated into younger deposits, or whether it ever was deposited is not yet known.

"Altamont" moraine.- The "Altamont" moraine represents the southwestern terminus of the Dakota lobe of the late Wisconsin (Mankato?) glaciation. It extends southeasterly in a belt fifteen to twenty miles wide from Canada across North Dakota from the northwest corner to the southcentral part of the state, whence it turns southward toward and beyond Altamont, South Dakota, the type locality. However, the use of the term "Altamont" for the terminal moraine is disputed by Leverett (7, p. 67) who points out that at the type locality another moraine, the Bemis, lies outside it. Whether the moraine here identified as "Altamont" is actually the correlative of the Altamont, South Dakota moraine is therefore open to question, but for convenience of nomenclature, usage of the term is continued here.

The moraine consists chiefly of poorly compacted, calcareous blue-gray till, oxidized to grayish-brown, and containing numerous local deposits and lenses of sand and gravel, and extensively scattered cobble and boulder tracts. Most of the coarse material is foreign to the region, but much of the finer fraction has been derived from the underlying Tongue River sediments. Gray and red granites, pegmatities, and gneisses are the most abundant rock types, but light-gray and pink fossiliferous, dolomitic limestones, "Flaxville" type quartzites, lignite, and basic igneous and metamorphic rocks are present. Boulders ranging up to four or five feet in diameter are common, and all gradations from rude angular fragments to well faceted, polished, and striated stones occur.

The topography of the terminal moraine is of the knob and kettle type, very youthful, with hummocky, ungraded profiles, many large undrained depressions, marshes, alkali lakes, gravel knobs, and till hills. Overall relief exceeds 300 feet and closure on individual kettles and closed depressions is often fifty feet or more. Drainage patterns are poorly developed, with no permanent streams.

Pre-"Altamont" Wisconsin ground moraine.- The pre-"Altamont" ground moraine of Alden (1, Pl. I) covers the southern quarter of the quadrangle and is reflected topographically by a rather well developed drainage pattern and subdued relief. The topography is of the shallow basin or saucer type, in contrast with the terminal moraine. Many of the numerous flat depressions have been connected by minor intermittent stream channels, and a rather complete, fairly well integrated drainage pattern has been formed.

Fluvio-glacial deposits.- Meltwaters discharging from the late Wisconsin ice front deposited outwash gravels and sands as extensive valley trains in Alamo Valley and in the northwest corner of the quadrangle in the topographic low believed to be the buried channel of the preglacial Yellowstone River (1, Pl. I). Nearness of the ice front during deposition of the outwash material is indicated by the pitted nature of the outwash surface. Ice blocks, large and small, must have been partially to completely buried under loads of debris. Cottonwood Lake east of Alamo appears to have had just such an origin, for it is completely enclosed by fluvio-glacial gravels.

Projecting into the east end of Cottonwood Lake, and trending easterly through the valley, and northeasterly toward and beyond Corinth, lies an esker having an overall length exceeding eight miles. It is braided and sinuous throughout most of its course and in places is discontinuous, disappearing under an outwash apron which partially surrounds it, and reappearing further on. Apparently subglacial streams utilized Alamo Valley prior to the disappearance of the ice there. As stagnation and retreat of the front proceeded, a large ice block was left behind to protect the site of Cottonwood Lake from complete aggradation, but the esker was left exposed and detritus laden waters discharging from the glacier buried its lower segments. Again, it is completely mantled in places with a veneer of till, retaining however, its original topographic expression. This till is probably englacial drift let down during ablation. Small gravel pits for local use have been opened in many places along the length of this esker.

Four miles north of Alamo in the westcentral portion of the quadrangle is an elongated fluvio-glacial tract of knobby, gravel hills, trending northeast-southwest for about 2 1/2 miles. In part it is of eskerlike form, but much of it consists of clusters of rounded, fairly symmetrical knobs. Heavy boulder concentrations cover most of the gravel surface, and in other places it is mantled with varying thicknesses of till. Gravel pits have been opened near the western end.

Similar to the above, but smaller, is a tract near the northeast corner of the quadrangle in sections 1 and 2, T. 160 N., R. 98 W.

Recent alluvium

Recent alluvial deposits, probably in part fluvio-glacial outwash, occur in a narrow belt along the channel of Little Muddy Creek in the southern part of the quadrangle. The floodplain consists of dark gray clays and silts up to five or six feet in thickness. Mixed with the clays and silts are sands and fine gravels, crudely bedded and with a fair degree of sorting. Below this thickness a coarse sand layer extends to an unknown depth, and is responsible for the pools of fresh water which remain in the channel through underground flowage during the entire summer.

Alluvium also covers the bottom of most of the larger lakes and undrained depressions, consisting for the most part of reworked glacial clay, silt, and fine sand. The valley trending five miles eastward from Alamo and south of Cottonwood Lake is floored to an unknown depth with colluvium, mainly reworked till from the adjacent valley walls.

GEOLOGIC STRUCTURE

Well borings into the Dakota sandstone indicate that western North Dakota is structurally a large, gently sloping trough to which the name Dakota (or Williston) Basin has been given (2, p. 1568). The Kermit No. 3 quadrangle lies on the northern flank of the basin. The Tongue River member of the Fort Union formation underlying the glacial deposits in this area has been only slightly, if at all, disturbed since deposition, the beds being essentially horizontal with a slight southeastward dip to the Dakota Basin. Inasmuch as there are no outcrops in the quadrangle, the structure can be interpreted only through well logs. The limited amount of this data indicates dips of less than one degree. No evidence of faulting has been observed in the quadrangle.

GEOLOGIC HISTORY

Paleocene epoch

Warm, continental conditions persisted throughout Fort Union time, and extensive forests probably covered much of North Dakota. The Tongue River member of the Fort Union contains numerous remains of terrestrial and fresh water plants and animals. Previous workers (6, p. 3) have identified a large assemblage of conifers and deciduous trees, including sequoia, cypress, juniper, poplar, fig, dogwood, hickory, oak, and ginko, all occurring chiefly in the lignite. In addition, various turtles and alligators as well as invertebrates have been described.

Swampy, humid conditions must have occurred repeatedly and persistently for long periods of time, as indicated by the presence of several thicknesses of lignite in nearby areas outside the quadrangle.

Besides the coal, the Tongue River member consists predominantly of well stratified clay and shale. Stable, quiet conditions must have attended their deposition, though the presence of coarser sand and silt, often strongly cross-bedded, indicates transporting currents of considerable velocity. For the most part, conditions of deposition must have fluctuated, causing interfingerings of coarser material to successively fill and bury the coal swamps and shallow lakes.

Pleistocene epoch

During the long period of erosion between the deposition of the Paleocene sediments and the invasion of the Pleistocene glaciers, normal dissection of the area had been in progress, and northeastward flowing streams and their tributaries probably had produced a topography in the Kermit No. 3 quadrangle similar to that now found in the badland areas along the Little Missouri River in southwestern North Dakota.

The preglacial Yellowstone River (1, p.58) is believed to have followed a course up the valley of the present Little Muddy Creek, flowing northward across the adjoining Zahl No. 4 quadrangle to the west, and cutting the northwest corner of the Kermit No. 3 quadrangle before flowing into Canada northwest of Crosy, N. Dak.

With the advance of the first ice sheet, the northward courses of the preglacial Yellowstone and Missouri were blocked. No evidence of ponding has been found in the area, and presumably the streams assumed southward courses approximating their present-day channels. In addition, the preglacial topography was greatly modified as the overriding ice abraded the hills and filled the valleys with debris.

Several "ghost" channels, presumably filled valleys, cross the southern half of the quadrangle. Alamo Valley is such a channel. Information regarding depth to bedrock in these is lacking, but well borings at Alamo indicate outwash sands and gravels to a depth of at least 60 feet. These valleys are believed to represent ice marginal channels carved by diverted drainage, possibly the confluent Missouri-Yellowstone flowing eastward as it was pushed progressively southward by the advancing ice. Alden (1, p.58) believes the preglacial Yellowstone to have flowed up the course of the present Little Muddy Creek just beyond the southwest corner of the quadrangle. The possibility cannot be ignored that some of the channels, at least, represent valleys of preglacial streams. However, the striking parallelism which they exhibit, and the general northwestward slope of the country do not seem compatible with this notion. It also is possible that escape waters from the ice sheet, if not overloaded, could have accomplished the cutting. At any rate, the channels must have been carved in advance of the last ice because except for Alamo Valley, most are undrained at both ends, contain kettles, and are floored with till. Closure, in many cases exceeding 50 feet, and absence of sorted sediments in the floors of most refute the possibility that they might have been carved by meltwaters from a retreating or stagnating ice front.

The present width of the valleys, averaging 400 to 500 feet, may not seem adequate to accommodate a stream the size of the Missouri-Yellowstone. However, the buried channels are probably considerably wider. This is evidenced in many places by widening where they are floored with kettles. Ice blocks at these places must have prevented some of the constriction and filling due to burial that occurred elsewhere. The present result is a beaded appearance. It also must be remembered that filling probably was contributed by more than one period of glaciation.

Similar channels are present beyond the southern boundary of the quadrangle and in the adjoining Zahl No. 4 quadrangle to the west. In the Zahl No. 4, Scoria Valley, also believed to be such a channel, has widths commonly as much as half a mile. Here the Fort Union formation outcrops in the valley walls. Alamo Valley in places has comparable width without bedrock exposures.

The Great Northern Railroad has utilized Alamo Valley and adjoining channels to the eastward in routing its Grenora branch line through the rough terrain of the moraine.

The "Illinoian" or "Iowan" glacier (1, p. 88) advanced far beyond the limits of the quadrangle, further diverting the drainage, and depositing drift in the Missouri channel near Williston. The ice did not remain long enough for deep re-entrenchment of the drainage to occur however, for the Missouri re-occupied its present channel when the glacier withdrew.

An early Wisconsin ice sheet advanced approximately six to eight miles beyond the southern boundary of the quadrangle, and remained long enough to deposit a fairly large end moraine. Erosion has since reduced this to isolated patches of morainal topography.

The final advance of the ice into this region produced the great "Altamont" moraine which covers most of the quadrangle. All of the major outwash deposits, most of the gravel knobs, and the eskers are products of this substage. The pitted nature of the outwash plains, including the channel of the preglacial Yellowstone, and the presence of the eskers suggest that the ice finally disappeared from the area through stagnation due to thinning for lack of nourishment rather than through orderly retreat of an active ice front. Presence of a thin till veneer in places completely mantling the eskers, however, leaves open the question as to whether fluctuating readvances occurred, or whether englacial drift merely was let down as a blanket during ablation and final disappearance of the ice.

In the northwest part of the quadrangle a lobe or block of ice is believed to have stood temporarily in the channel of the preglacial Yellowstone, and marginal streams flowing between the valley sides and the ice itself are thought to have deposited the kame-terrace gravel deposits located there.

Postglacial erosion

Since the retreat of the last glacier, normal erosional processes have been in progress, but such a short time geologically has elapsed, that only slight and minor modification of the glacial topography has occurred. A few intermittent streams now drain the older southern portion of the area, although dissection there is by no means complete. The remainder of the quadrangle is essentially as the ice sheet left it. The banks of some of the larger kettle ponds have been modified to some degree by wave action, as at Cottonwood Lake, but aside from this, minor sheet flood erosion, rill action, and wind erosion, especially in areas now under cultivation, are the only processes operative.

ECONOMIC GEOLOGY

Lignite

Small lignite mines have been operated in the vicinity of Alamo and Corinth, but little information is available as to the nature of the coal beds. Near Cottonwood Lake the coal is reported to lie in the valley wall twenty-five to thirty feet below the surface. Test borings might prove this area to be feasible for small scale strip mining.

Construction materials

Sand and gravel.- The best sources of sand and gravel in the area are in the large outwash channels in the vicinity of Alamo and in the northwest part of the quadrangle. Esker deposits and gravel knobs provide material for many local requirements. Isolated patches of alluvial gravel occur along Little Muddy Creek and some of its tributaries. Most of these areas have been exploited to some extent for road material and local construction work. The deposits generally are not well sorted and usually contain considerable amounts of sand. Lignite slack is sometimes present, and calichification is common. As taken from the pits, the material usually is suitable for secondary road material, and with preliminary screening and washing may be used for general construction work.

Materials probably deleterious to use for concrete aggregate with high alkali cements are present to some degree in most deposits. These include chert, chalcedony, and rhyolite and related rocks. As percentages vary widely in different deposits, individual samples should be studied before high alkali cements are used.

Riprap.- Boulder piles, heaped up by farmers in clearing their fields for cultivation, are present in nearly all sections of the quadrangle. At best the supply is limited, and size, shape, and composition of the stones may further limit their use to small scale construction work. In this regard, schistose rocks, which are quite common, are particularly unsuitable and some hand sorting therefore would be necessary.

Other boulder concentrations occurring naturally in morainal ridges and knobs could be gathered for riprap.

REFERENCES CITED

1. Alden, W. C., Physiography and glacial geology of eastern Montana and adjacent areas: U. S. Geol. Survey Prof. Paper 174, 1932.

2. Ballard, Norval, Regional geology of the Dakota Basin: Am. Assoc. of Pet. Geologists Bull., vol. 23, no. 10, 1942.

3. Chamberlain, T. C., Preliminary paper on the terminal moraine of the second glacial epoch: U. S. Geol. Survey 3d Annual Report, 1883.

4. Fenneman, N. M., Physiographic divisions of the United States: Association American Geographers Annals, vol. 18, no. 4, 1928.

5. Laird, W. M., Subsurface stratigraphy of the Nesson Anticline; N. D. Geol. Survey Bull., 21, 1946.

6. Leonard, A. G., The Pre-Wisconsin drift of North Dakota: Jour. Geol., vol. 24, 1916.
   The lignite deposits of North Dakota: N.D. Geol. Survey Bull. 4, 1925.

7. Leverett, Frank, Quaternary geology of Minnesota and parts of adjacent states: U. S. Geol. Survey Prof. Paper 161, 1932.