SOUTH DAKOTA GEOLOGICAL SURVEY
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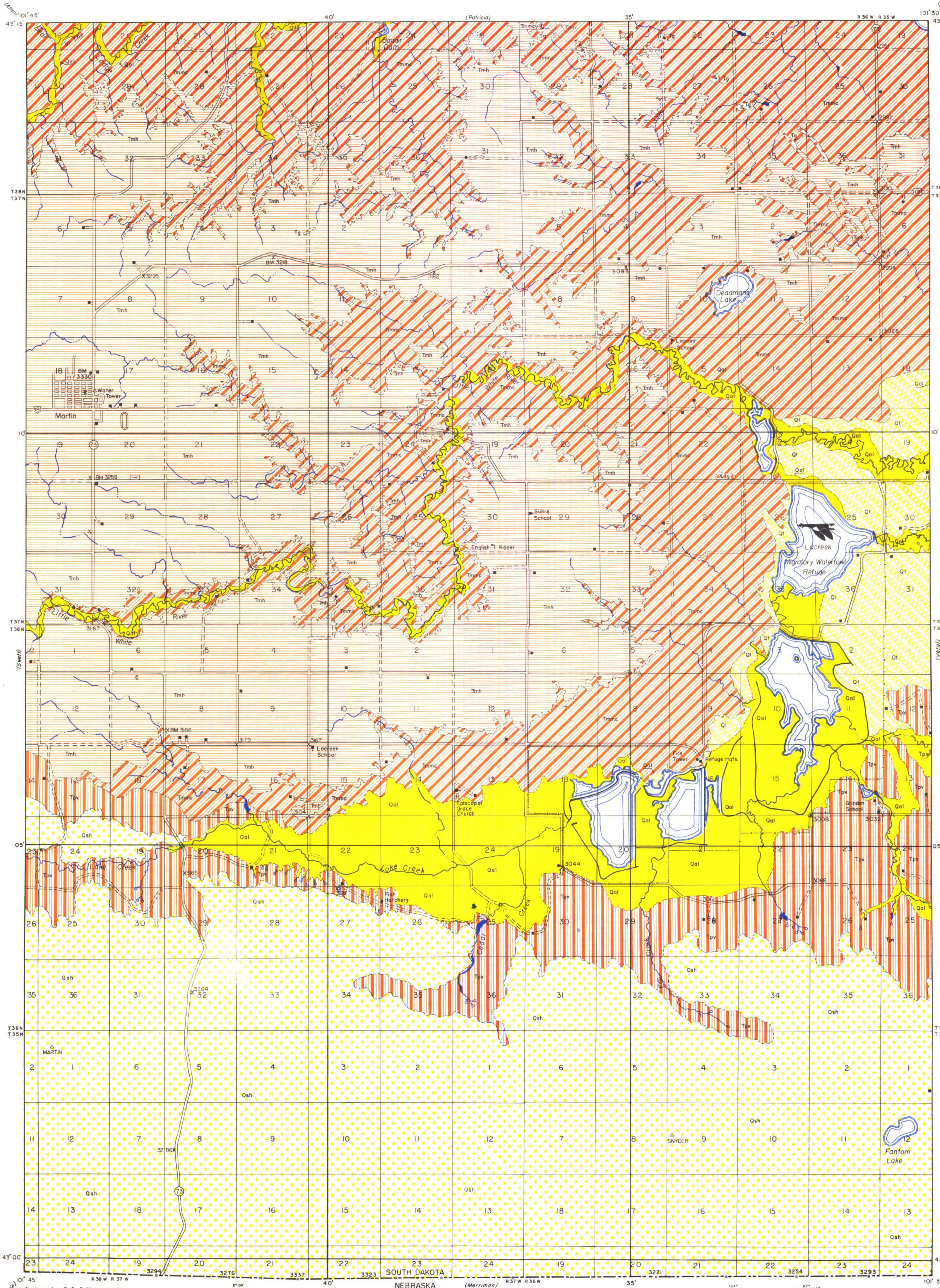
STATE OF SOUTH DAKOTA
RALPH HERSETH, GOVERNOR

GEOLOGY of the MARTIN QUADRANGLE SOUTH DAKOTA



RECENT

Qal — Alluvium (Floodplain deposits of locally derived silt, sand, and gravel in present stream valleys.)

PLEISTOCENE

Qsh — Sand Hills Formation (Fine unconsolidated wind-blown dune-sand, as much as 200 feet thick.)

Qt — Terrace Deposit (Stream terrace deposits of western-derived fine to coarse garnetiferous feldspathic sand and gravel.)

QUATERNARY

PLIOCENE

Tpv — Valentine Formation (Light-gray and grayish olive-green fine to medium poorly consolidated feldspathic or arkosic sand, silt, and clay, locally slightly cemented by calcite; as much as 135 feet thick.)

?

MIOCENE

Tg / Tmh — Harrison Member of Arikaree Formation (Light-pink to brown or grayish-buff poorly consolidated mostly calcareous very fine sand and silt with discontinuous zones of calcareous concretionary nodules increasing in abundance upward; upper part contains thin zones of white limey sandstone and local lenses of garnetiferous sandstone, as much as 150 feet thick; local gravel.)

Tmmc — Monroe Creek Member of Arikaree Formation (Poorly consolidated massively bedded blocky very fine well-sorted sandstone, mostly non-calcareous, very uniform in composition; weathers light-gray or buff, at least 250 feet thick.)

TERTIARY

Contact (dashed where approximately located)

Gravel Pit

X BM 3259 Bench Mark (monument showing exact altitude above sea level)

X 3182 Spot Altitude

Oil Test

SNYDER Triangulation Station (monument marking exact geographic location)

House, School, and Church

Geology by S. G. Collins 1958
Assisted by J. C. Harksen

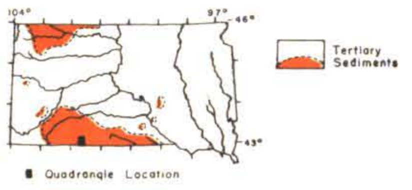
Vertical and Horizontal control surveyed from triangulation and level lines of federal surveys

Map drafted by R. K. Booker 1958-59

APPROXIMATE MEAN DECLINATION, 1958 (11° 05', TRUE N., MAGNETIC N.)

Scale 1:62 500
1 ½ 0 1 2 3 4 Miles

Vermillion, South Dakota
1959

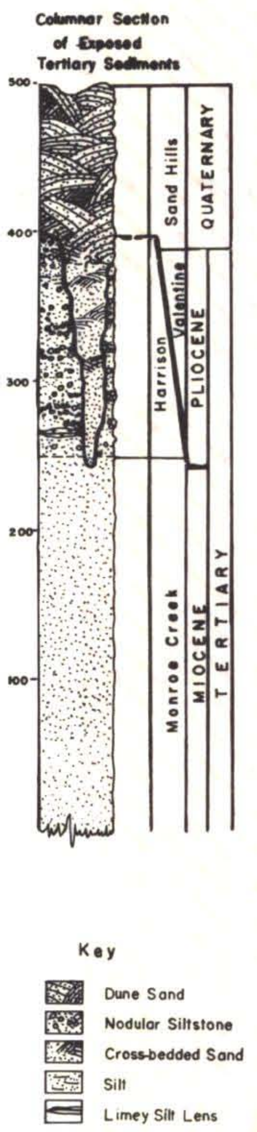


■ Quadrangle Location

MARTIN QUADRANGLE

GEOLOGY OF THE MARTIN QUADRANGLE

by
S. G. Collins



INTRODUCTION

The Martin quadrangle was mapped with the assistance of John Harksen during the summer of 1958, under the supervision of Dr. Allen F. Agnew, State Geologist, as a part of the State Geological Survey's program of mapping the economic geology of south-central South Dakota. Thanks are extended to Warren Johnson of the U. S. Soil Conservation Service, to Bruce Hodson, and many other local residents for the valuable information they furnished.

The mapped area occupies about 221 square miles of the south-central part of Bennett County along the Nebraska state line, and includes the city of Martin, which is the county seat, near the western boundary.

The quadrangle lies in the Missouri Plateau subdivision of the Great Plains physiographic province, in the area of south-central South Dakota that is covered with Tertiary sediments. The quadrangle contains a variety of topographic features; the northwestern part is deeply dissected by small streams flowing northward to Bear-in-the-Lodge Creek; the west-central part is a succession of mesas that occupy increasingly higher elevations westward toward Martin; the east-central part is a broad alluvial and colluvial swampy flat; the northeastern part is gently rolling with generally poor drainage and numerous small undrained depressions formed by deflation; the entire southern third of the quadrangle is covered by the great dunes of the "Sand Hills". Lake Creek and the Little White River traverse the central part of the quadrangle from west to east, with a gradient of approximately 10 feet per mile. The Sand Hills have no surface drainage, but subsurface water percolates downward through the underlying Valentine Formation, issuing from a multitude of springs near the base of the Valentine Formation. The springs drain into Lake Creek. Shallow ephemeral lakes and swamps are present in deflated areas during wet weather. The Lacreek Migratory Waterfowl Refuge is maintained by an extensive system of dikes that impound large ponds and marshes in the valley of Lake Creek in the eastern part of the quadrangle. A diversion dam on the Little White River just north of the Refuge also impounds a sizeable lake. Many small stock dams are scattered throughout the area.

Maximum topographic relief in the quadrangle is approximately 500 feet, with altitudes ranging from 2933 feet to 3420 feet above sea level. Local relief seldom exceeds 250 feet, and is greatest in the northward-draining gullies in the northwestern part of the quadrangle.

Martin, population 989 (1956 estimate), is the only settlement, and rural population is relatively sparse (about one family in four square miles). Farming and ranching are the major occupations. The area has a fairly well developed network of graded but unsurfaced farm roads which are passable in all but extreme conditions of rain or snow, owing to the sandy nature of the soil. Only a few of the rural homes are accessible by ungraded trails. U. S. Highway 18 and State Route 73 are hard-surfaced, connecting the city of Martin with points to the east and west, and north and south, respectively.

The climate is typical of the temperate high plains. Temperatures range from 27 degrees below zero to as high as 111 degrees above. Rainfall in the area averages 16 inches yearly, according to records of the U. S. Weather Bureau Station at Martin. Strong winds are the rule, prevailing from the northwest in winter and from the south in summer.

EXPOSED ROCKS

The Miocene Arikaree Formation underlies the entire quadrangle. It is divided into the Monroe Creek (lower) and Harrison (upper) members, both of which crop out extensively in the northern two-thirds of the area. The Monroe Creek is exposed at lower altitudes and in the valleys, and the Harrison occupies the uplands at the general level of the high plains. The Pliocene Valentine Formation occurs in the southern third of the quadrangle, filling an extensive low area in the post-Miocene eroded surface. The Quaternary Sand Hills sediments overlie the Valentine, and consist of material derived therefrom and reworked by wind action. Quaternary alluvial and colluvial deposits occur in stream valleys and in the broad flats along Lake Creek.

Miocene Series. Arikaree Formation Darton, 1899

The Arikaree Formation was named for the Arikaree Indians who inhabited western Nebraska. The Arikaree was originally assigned formation rank, and was later subdivided and redefined as a group by Lugn (1939). The Arikaree Formation is represented in the Martin quadrangle by the Monroe Creek and Harrison members.

Monroe Creek Member Hatcher, 1902

The Monroe Creek Member (Tmmc) was named from exposures along Monroe Creek canyon near Harrison, Nebraska, about 115 miles west-southwest of Martin. In the Martin quadrangle the Monroe Creek is exposed at the lower altitudes, and can best be seen in the gullies north of U. S. Highway 18. The unit consists of pink to medium-brown very fine well-sorted mostly quartzose non-calcareous sandstone, which is uniform in composition and contains only a little clay. It is poorly consolidated, massively bedded and blocky, and weathers grayish to very light-buff. There is little variation in the character of the Monroe Creek throughout the area surrounding the Martin quadrangle, although concretionary sandstone bodies somewhat similar to the "pipy concretions" of western Nebraska occur in the western part of Bennett County. The lithology of the member in the Martin quadrangle differs from the description given by Lugn (1939) for exposures in western Nebraska, in that no "pipy concretions" and very little conglomeratic material or torrential cross-bedding are present, although the lithologies are otherwise very similar. A sandy light yellowish soil is developed on the Monroe Creek. A rolling topography without flat-topped prominences is developed on the Monroe Creek, and where it is not protected by soil cover, the formation is characterized by peculiar smoothly-rounded surfaces, normally stained with black splotches of lichen.

The upper contact of the Monroe Creek with the conformably overlying Harrison Member is gradational and very difficult to locate precisely. The Monroe Creek was mapped mostly on the basis of comparatively low rolling topography and uniformity of composition. No identifiable fossils were found in the formation, but chips and fragments of vertebrate remains were present at several localities.

The thickness of Monroe Creek exposed in the Martin quadrangle is at least 250 feet, measured in a composite section along the road from Martin northward to Bear-in-the-Lodge Creek.

Harrison Member Hatcher, 1902

The Harrison Member (Tmh) was named from outcrops at the general level of the high plains in the vicinity of Harrison, Nebraska, about 120 miles southwest of Martin. In the Martin quadrangle, also, the Harrison forms the general level of the high plains. A deeply eroded post-Miocene disconformity marks the upper limit of the Harrison, and cuts completely through it into the underlying Monroe Creek in the southern and eastern parts of the quadrangle.

The lower part of the Harrison is composed of light-pink to brown massive and very fine sand and silt, mostly non-calcareous and poorly cemented. It is similar to the Monroe Creek sediments, but also contains thin discontinuous zones of calcareous concretionary nodules. The concretions range from one to five or more inches in size, and occur mostly in thin stratified zones; in some localities they form more or less continuous ledges six to more than ten inches thick, and three to ten or more feet apart.

The Harrison becomes progressively less uniform in composition upward. In the upper part it is mostly grayish to buff fine sand and silt, generally calcareous, with discontinuous lenses of platy white sandy limestone or limy sandstone, up to 15 inches thick. Many isolated nodular concretions are disseminated throughout the less-cemented sandstone. In the Pine Ridge, about thirty-five miles southwest of Martin, the concretionary sandstone ledges of the lower Harrison are mostly continuous and generally about one foot thick.

Channel deposits.--The recognition of the upper Harrison is complicated in the Martin area by the presence of many channel deposits of varying thickness and composition. These deposits are generally a little more coarse than the rest of the unit, and in some localities are conglomeratic. Lenticular masses of soft calcareous caliche-cemented sandstone, light yellowish-gray on fresh surfaces but commonly discolored to a dull medium-gray by lichen, are very common in the channel deposits, particularly in the northwestern part of the quadrangle. Both the cemented and uncemented zones of the channel deposits are probably correlative in age with part of the Ogallala Group, but are lithologically so similar to the Harrison sands that they are almost indistinguishable.

Conglomeratic and Gravelly Deposits.--In the northeastern part of the Martin area several small gravel deposits occur in close relationship to the channels of finer material. Typical of these is a deposit in the southwest corner of sec. 22, T. 38 N., R. 36 W., where a small topographic nose is formed by 25 to 30 feet of poorly sorted channel sand, silt, and gravel at the Monroe Creek-Harrison contact. Fragments ranging up to five inches across are included, but most of the gravel is one inch or less in size. The deposit is mostly sand, but it includes about six feet of sandy gravel, composed of about 70% igneous rock fragments and 30% nodular limestone material. Medium to poorly rounded quartz and feldspar fragments make up most of the coarse fraction. The gravels are locally cemented by silica to a hard, very coarse conglomerate that resembles low-grade concrete. Garnet seems to be a characteristic component of nearly all the conglomeratic and gravelly deposits, and many small seams in the sandy material, a fraction of an inch thick, contain abundant garnets.

Teeth of the early Pliocene horses *Nannippus* sp. and *Neohipparion* sp. (identifications by Morton Green, South Dakota School of Mines and Technology) were found in deposits of this type.

In the road along the west side of sec. 2, T. 37 N., R. 37 W., and in a gravel pit in the southeastern corner of sec. 22, T. 37 N., R. 36 W., are gravel deposits of somewhat different character, and possibly different age than those described above. This gravel is mostly quartz, igneous rock, and chert fragments from two to four inches in size, mostly very well-rounded, in a matrix of very fine sand and silt. Little material of intermediate size is included. These deposits appear to be of greater lateral extent and much thinner (generally less than two feet thick) than the first-mentioned gravels. No fossils were found in the better-rounded gravels, and it is not possible to determine the precise stratigraphic relationship of the two types of deposits.

The sandy channel deposits were included with the Harrison in the mapping, although they are undoubtedly younger, probably correlating in age with part of the Ogallala Group, or possibly in part with the Hemingford Group of Lugn (1939). Several attempts were made to differentiate the channel materials in the field but, owing to their very close resemblance to true Harrison sediments, it was not practical to do so. Gravel bodies in the channel material were separated in the mapping (Tg).

The final phases of Harrison deposition might have been as channel filling, but it appears more likely that most of the channel deposits were laid down later than Harrison time. Some may have been associated with streams developed on the late Miocene erosion surface, but most of them probably mark early stages of Pliocene deposition.

The nodular zones in the Harrison, as well as the sandy and partly cemented channel material, cause an irregular succession of well- to poorly-defined mesas and escarpments. These characteristic topographic levels become less distinct and less easily recognized lower in the Harrison, and it is nearly impossible to differentiate the lower Harrison from the Monroe Creek. Consequently, the contact between the two units is approximately located at best, and in some localities is quite arbitrary.

No identifiable fossils were found in the typical Harrison Member. Approximately 150 feet of the formation is exposed in the Martin quadrangle.

Pliocene Series. Ogallala Group Darton, 1899

The Ogallala Group was named from exposures in western Nebraska near Ogallala Station (about 145 miles south of Martin). It is represented in the Martin quadrangle by the Valentine Formation, and possibly also by the deposits of uncertain position mapped with the Harrison as previously mentioned.

Valentine Formation (Barbour and Cook, 1917)

The Valentine Formation (Tpv) was named from exposures east of the town of Valentine, Nebraska (about 65 miles southeast of Martin). In the Martin quadrangle the Valentine lies disconformably upon the Arikaree Group in the southern third of the area, apparently filling a broad, deep post-Miocene pre-Pliocene topographic low. In the western part of the quadrangle Valentine sediments occur at least 220 feet lower than do Harrison sediments only a few miles away.

Both the lower and upper limits of the Valentine are difficult to locate in the field with certainty. Owing to the very poor consolidation of the sand unit, it slumps and washes easily and all lower contacts are covered. The upper limit is almost everywhere obscured by the dunes of the Sand Hills Formation, which have developed on the Valentine wherever it is exposed. Good exposures are present only in the valleys of the short, spring-fed creeks (such as Elm and Cedar Creeks), which constitute the only surface drainage that is developed on the Valentine sediments.

The Valentine Formation consists of light-gray and light olive-greenish fine to medium very poorly consolidated feldspathic or arkosic sand, generally well-sorted, sub-angular to sub-round, and with many somewhat frosted grains. The sand is mostly non-calcareous, massive to thick-bedded, and has local cross-bedding. Some zones are slightly cemented by calcite. Local lenses of light olive-greenish silty clay occur, a fraction of an inch to a foot or more thick. The highly silicified sandstone of the Bijou facies, common in areas farther east, does not seem to occur in the Martin area. Pebbles (up to half an inch) of quartz and feldspar are scattered throughout the lower part of the formation, though such coarse grains constitute less than one per cent of the material.

Owing to the very high porosity and permeability of the Valentine sand, rainfall does not run off at the surface, but sinks in immediately and percolates to the water table. Drainage is accomplished through multitudes of small springs and seeps. Some of these springs (notably Elm and Cedar Creeks) have enough volume to erode the loose sand, and have cut gullies of considerable length. Elm Creek has extended its course by headward erosion more than two miles back into the area of Valentine sediments.

The Valentine sands generally contain a considerable amount of stringy calcareous and siliceous material, probably fossilized plant rootlets and stems. Many fragments of silicified wood and vertebrate teeth and bones occur at good exposures. Several vertebrate specimens were collected in the Cedar Creek area, and have been identified as *Neohipparion* (identification by Morton Green of the South Dakota School of Mines and Technology).

Along State Route 73 south of the Lake Creek bridge, a composite thickness of 135 feet of Valentine was measured, although no individual exposure showed more than about 75 feet. This figure is probably considerably less than the maximum thickness present within the Martin quadrangle.

Surficial deposits. Quaternary and Recent

An extensive sand Terrace (Qt) extends into the Martin area from the east along the valleys of the Little White River and Lake Creek. It is nearly indistinguishable as a terrace level within the quadrangle itself, but can be definitely recognized as such in localities less than a mile outside the eastern boundary. Just east of the village of Tuthill (two miles east of the Lacreek Refuge), the terrace deposits rise 25 to 35 feet above the bed of Lake Creek. The stream has cut down into the sand deposits, and they are well exposed along its banks. The torrentially cross-bedded terrace material is made up of fine to coarse sand and gravel that is moderately to poorly sorted, and for the most part poorly rounded. Eighty-five to ninety per cent of the sand and gravel is quartz, feldspar, and other minerals and igneous rocks, and includes much garnet. Ten to fifteen per cent of the gravel is locally derived fragments of concretionary and nodular sandstone and limestone. Locally the deposits are slightly cemented by calcite. Many fragments of partly mineralized vertebrate bones are present. The degree of cementation and the incipient mineralization of the fossil remains indicate that the terrace is at least as old as Late or Middle Pleistocene, and most of the material appears to have been derived either directly from western mountain areas, or possibly from older clastic sediments containing much coarse material, originally laid down west of the Martin area. Definite terrace characteristics become increasingly obscure westward, and the contact separating the terrace from alluvial deposits in the quadrangle is somewhat arbitrary. The entire thickness of the terrace was not seen in mapping, but it is at least thirty-five feet thick along the valley of Lake Creek east of Tuthill.

Sand Hills Formation Lugn, 1934.--The Sand Hills Formation (Qsh) covers most of the southern third of the Martin area. It consists of fine sands derived from the underlying Valentine Formation, reworked by Pleistocene and Recent wind action into a succession of great unconsolidated dunes. Neither a surface drainage system nor more than a very thin soil cover has been developed on the dunes, indicating that they have been actively migrating until very recent time. Grasses now restrain the sands from significant further movement, but small local blowouts are still forming. The present static condition of the dunes is due to the fact that they receive just enough rainfall to support the grass cover, but not enough to develop integrated surface drainage. A small decrease in the amount of yearly rainfall would probably allow the entire duned area to become actively migrant again.

Individual dunes may rise as much as 160 feet above their base, and most are 80 to 120 feet in height. The total maximum thickness of material affected by eolian reworking is estimated to be about 200 feet.

Locally derived alluvial floodplain deposits of sand and silt along major streams are mapped as Alluvium (Qal), as are the generally thin alluvial and colluvial deposits covering the broad Lake Creek flat in and adjacent to the Lacreek Migratory Waterfowl Refuge. Lack of exposures prevented the determination of the maximum thickness of these sediments. It is unlikely that they are of great thickness anywhere, and in many localities they are very thin, as older sediments lie less than five feet below the surface. No significant deposits of coarser material were observed in the alluvium.

SUBSURFACE ROCKS
(by Allen F. Agnew)

Information available on the subsurface rocks of the Martin area is provided by the English #1 Kocer oil test, in sec. 30, T. 37 N., R. 36 W. This wildcat, drilled from a surface elevation of 3,079 feet and completed at a total depth of 3,370 feet, penetrated the following rock units:

Name and Lithology		Depth feet
Tertiary :	Arikaree and White River silts, sands, clay	0-1208
Cretaceous :	Pierre shale	-1855
	Niobrara marl	-2060
	Carlile shale	-2382
	Greenhorn limestone	-2440
	Belle Fourche-Mowry shales	-2715
Cretaceous?-Jurassic?:	Newcastle?-Morrison? siltstone, sandstone	-2902
	shale	-2940
	sandstone	-3110
Permian? :	Opeche? shale	-3165
Permo-Pennsylvanian?:	Minnelusa? sandstone, shale	-3315
	shale, sandstone	-3370

The sandstones from 2940-3110, 3165-3205, and 3240-3315 are well-developed and permeable.

STRUCTURAL GEOLOGY
(by Allen F. Agnew)

The Martin quadrangle lies on the northeastern slope of the Chadron Arch and is at the northern edge of the small Kennedy Basin of northern Nebraska. No reliable datum is exposed at the surface in the quadrangle, but a number of rather inexact measurements on the base of the Harrison Formation indicate an easterly dip of 10-20 feet per mile.

This dip is corroborated in the subsurface, as the Greenhorn limestone and Newcastle sandstone show easterly dips of 50 and 40 feet per mile, respectively. Two structural datum surfaces below, and the Precambrian Surface, show dips of the same magnitude to the southeast and south.

ECONOMIC GEOLOGY

Sand and gravel, and ground water are the only mineral deposits that have been developed in the Martin quadrangle. Oil and gas, clay materials, volcanic ash, and uranium may also be potentially economic there.

Sand and Gravel

The sand and gravel deposits in the Harrison Formation are very poorly sorted, but in some the composition is such that screening would yield material suitable for concrete or bituminous aggregate, or other construction work. The deposits are small, and the quality is variable. Lenses of silt and calcareous matter are commonly interbedded with the gravel. The deposits have been developed on a small scale for local roadwork in several places. The unprocessed gravel generally contains much material that is either too coarse or too fine for road metal of good quality, but it is adequate as subbase material.

All other sand deposits in the quadrangle are too fine-grained for concrete work. The sands of the Valentine Formation and the Sand Hills Formation have been used with some success in bituminous highway mat in Nebraska.

Ground Water

Ground water of good quality is available in quantities sufficient for household and livestock requirements throughout the Martin quadrangle. Shallow wells and springs in the Sand Hills and Valentine formations furnish practically unlimited amounts of excellent soft water. Wells in the Harrison and Monroe Creek formations generally are deeper, though seldom more than 200 feet; this water contains more dissolved solids, but is not unfit for household use. Water from alluvial deposits is also generally of good quality.

Partial chemical analyses of water samples from five typical wells within the area appear in the following table.

Chemical Analysis of Water from Selected Wells in the Martin Quadrangle

Farm Name and Location	Well Source	Solutes in Parts Per Million											
		Fe	Mn	Mg	Ca	Na	*OH	F	Cl	NO_3	SO_4	Hardness $CaCO_3$	Total Solids
Erwin Kamerzell sec. 27, T. 38 N., R. 37 W.	Qal	0	0	12	82	31	41.2 284	.4	5	1.2	25	253	412
Michael Bros. sec. 24, T. 36 N., R. 38 W.	Tpv	0	0	2	25	8	4.0 62.0	.6	1	0.3	11	70	144
Donald Hines sec. 13, T. 36 N., R. 36 W.	Tpv	0	0	11	86	50	47.2 318	0	7	0.4	58	261	479
Kocer sec. 12, T. 36 N., R. 37 W.	Tmmc	0	0	7	95	12	27.6 172	0	28	28	30	267	494
A. D. Johnson sec. 8, T. 36 N., R. 37 W.	Tmh	Tr	0	26	125	28	46.0 223	-	54	0.2	115	421	696

*Concentrations given above are determined by phenolphthalein; below by methyl orange.

Analysis by D. J. Mitchell, State Chemist, Vermillion, 1958.

Other Economic Deposits

Clay materials, probably from the upper part of the Harrison Formation, have been tested for firing properties according to local reports, and may be a potential raw material for the manufacture of brick or other ceramic products.

Gas and oil, and uranium are found elsewhere in the Great Plains where similar rock units and geologic structures occur, so further exploration may locate these valuable mineral resources in the Martin quadrangle.

Volcanic ash is known in nearby areas, where it occurs in the Arikaree Group and Valentine Formation. None is known in the Martin quadrangle, but it may be present in the subsurface.

REFERENCES CITED

Lugn, A. L., 1939, Classification of the Tertiary System in Nebraska: Bull. Geol. Soc. America, v. 50, p. 1245-1275.