

# AREAL GEOLOGY

OF THE

## HARDING AND ERICSON NO.1 QUADRANGLES

STATE OF SOUTH DAKOTA  
JOE FOSS, GOVERNOR

STATE GEOLOGICAL SURVEY  
E.P. ROTHROCK, STATE GEOLOGIST

### EXPLANATION

#### SEDIMENTARY ROCKS

- RECENT**
  - QUATERNARY**
  - PLEISTOCENE**
  - MIDDLE OF PLEISTOCENE**
  - OLIGOCENE**
  - UPPER CRETACEOUS**
  - CRETACEOUS**
- Qal**  
Alluvium  
(Silt, sand, gravel and clay of recent detrital deposits along valley bottoms of modern major streams. 0'-30')
  - Qds**  
Dune Sand  
(Sand, quartz, rounded, forming grassed dunes with a few "blowouts". 0'-40' relief)
  - Qtd**  
Terrace Deposits  
(Silt, sand, gravel, clay and conglomerate of older detrital deposits in terrace valley bottoms, floodplains, channels and pediments. 0'-100')
  - Qig**  
Terrace Gravels  
(Gravel and conglomerate composed of White River limestone, same material, silt and some siliceous pebbles.)
  - Tob**  
Arkaree Formation (t)  
Ogalala Formation (t)  
(Sandstone, greenish gray fine grained, with beds of gray silt; with interbedded green to gray clay concretionary beds, forms city grading somewhat locally capped by sedimentary green quartzite. 80'-145')
  - Tec**  
Brule Formation  
(Clay, pink, sandy in part, nodular, cherty, bentonitic, weathers light gray massive to thick bedded, ferric fragments, forms slopes; 60'-85')
  - Tch**  
Chadron Formation  
(Sandstone, white, unconsolidated, fine grained, locally the basal sandstone develops into gray, consolidated channel gravels; upper part is a mass of purple, bentonitic, clay grading somewhat locally capped by sandy limestone beds. 55'-80')
  - Khe**  
Hell Creek Formation  
(Upper part: Sandstone, yellow to golden brown, coarse grained, porous, flaky, peat clays; log like concretions. Middle part: Siltstone, shaly, sand and peat clay interbedded, gray to black, erodes into "mushrooms" black magnetite-iron concretions, fossil wood; abundant dinosaur bones. Lower part: Sandstone, gray, yellow when oxidized, coarser grained than lower Fox Hills; some peat clays and siltstone beds; basal scouring channels. 280'-400')
  - Kf**  
Fox Hills Formation  
(Sandstone, gray to white, fine grained, silty, quartz and some black mica, weathers rose yellow, thin bedded; tabular crossbedding; friable; locally crossbedded concretions; sharp teeth; 230'-240' magnetite nodules. Locally pink color. Basal part interbedded dark gray sand and gray shale in thin seams; varved carbonaceous shale. 46'-76')
  - Kp**  
Pierre Formation  
(Shale, blue gray to black, thin bedded; greenish yellow bentonitic seams; calcareous, fossiliferous concretions; cone-in-cone concretions, selenitic crystals; weathers into "pumpkin" about 250' exposed)

#### DRAINAGE

Intermittent Streams

#### CULTURE

Buildings  
(House, church, and school)

Roads and Trails

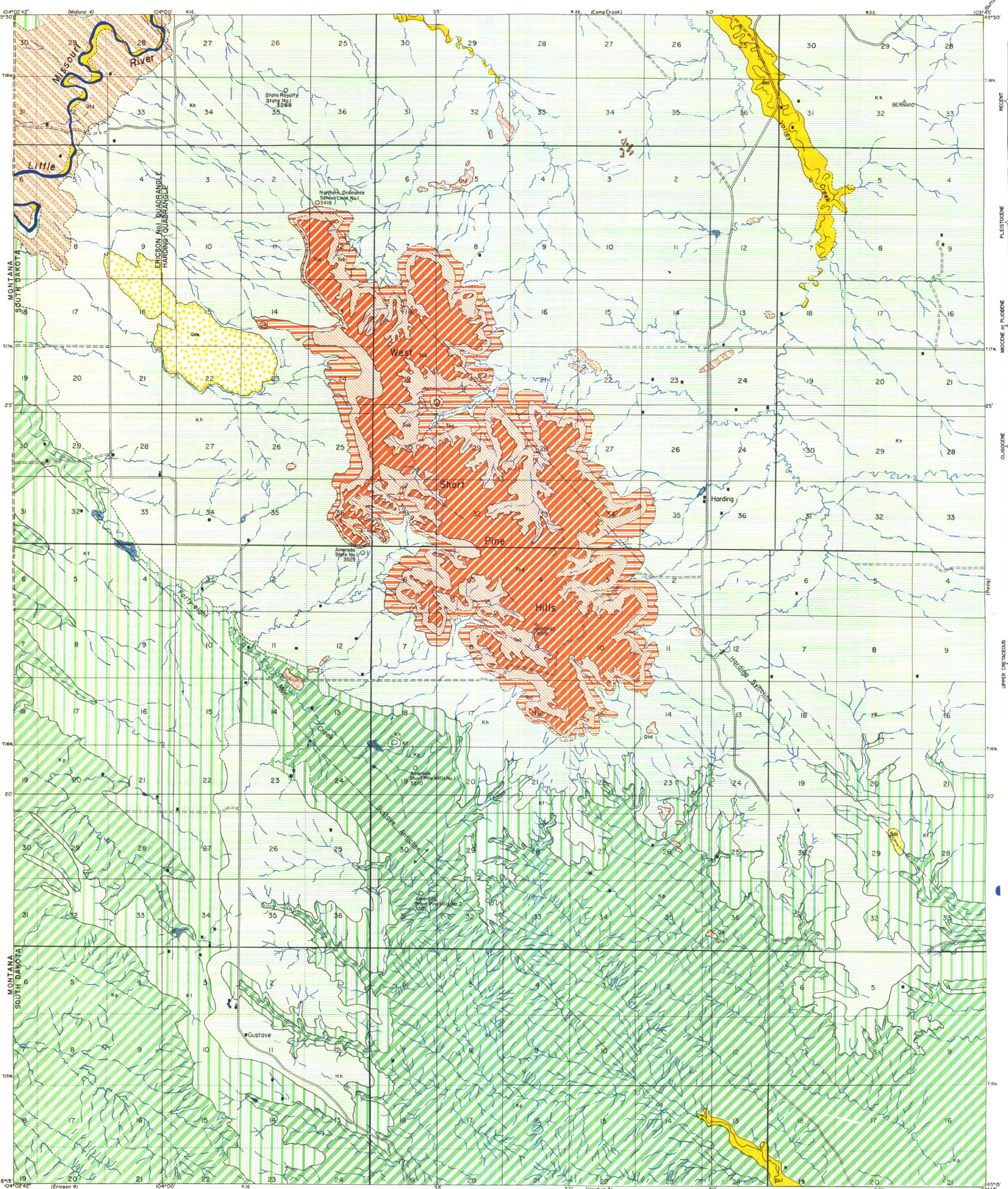
BERNARD

Triangulation Stations  
(U.S. Coast & Geodetic and U.S. Geological Survey monuments marking points of exact geographic location)

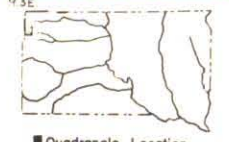
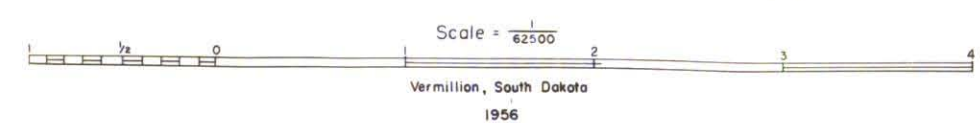
Amerasia State No. 1

Oil-test Borings

Dams



Geology by J.J. Schulte.  
Assisted by M.F. Nielsen.  
Surveyed in 1955.  
Base Map by South Dakota Geological Survey



APPROXIMATE MEAN DECLINATION 1988

Quadrangle Location

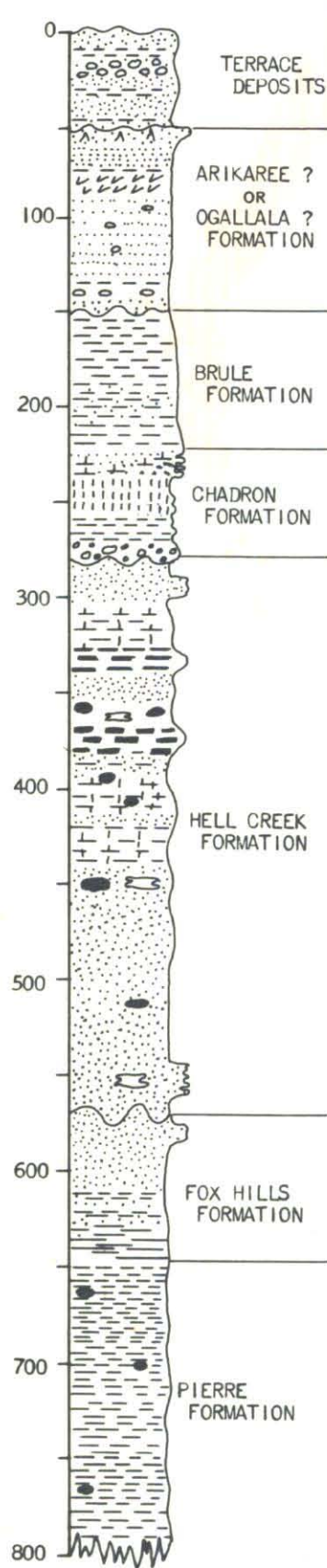


# AREAL GEOLOGY OF THE HARDING AND ERICKSON NO.1 QUADRANGLES

By

John J. Schulte

GENERALIZED COLUMNAR SECTION



- SANDSTONE
- SHALE
- CALCAREOUS SANDSTONE
- CONGLOMERATE AND GRAVEL
- QUARTZITE
- VOLCANIC ASH
- BENTONITE
- PEAT CLAY
- FISSILE SHALE
- CONCRETIONS
- DINOSAUR BONES
- BENTONITIC SHALE

CONSOLIDATED AND FORMS A TABULAR MARINE TYPE OF SHORT CROSS-BEDDING IS VERY PROMINENT; THE PLANT? *HALYMENITES MAJOR* OCCURS ABUNDANTLY; SHARK TEETH WERE FOUND A FEW MILES NORTH OF THESE QUADRANGLES.

THE LOWER PART IS A TRANSITION ZONE BETWEEN THE BLACK PIERRE SHALE AND THE FOX HILLS SANDSTONE; IT CONSISTS OF INTER-BEDDED GRAY SHALE AND SILTY SANDSTONE; A FISSILE (VARVED APPEARING) CARBONACEOUS SILTSTONE IS PROMINENT IN THIS INTERVAL; ALONG FORTY EIGHT MILE CREEK, THE BASAL PART WEATHERS PINK. THE UPPER PART IS 25' THICK AND THE LOWER PART IS ABOUT 50' THICK. THE FOX HILLS FORMATION CONFORMABLE WITH THE PIERRE SHALE BELOW BUT A PRONOUNCED EROSIONAL UNCONFORMITY EXISTS BETWEEN THE FOX HILLS AND THE HELL CREEK FORMATION AT PLACES. A FINELY LAMINATED REDDISH BROWN IRONSTONE CONCRETION (2") IS CHARACTERISTIC OF THE CONTACT BETWEEN THE FOX HILLS FORMATION AND THE HELL CREEK FORMATION.

**HELL CREEK FORMATION** (BROWN, 1907) (UPPER CRETACEOUS). THE LOWER PART OF THIS FORMATION CAN VERY READILY BE CONFUSED WITH THE UPPER PART OF THE FOX HILLS SANDSTONE. THIS IS DUE IN PART TO REWORKING OF THE FOX HILLS SANDSTONE INTO THE HELL CREEK SEDIMENTS. BASAL HELL CREEK CHANNELS SCoured DEEPLY (20'-50') INTO THE FOX HILLS FORMATIONS AT VARIOUS LOCALITIES.

UPPER PART: YELLOW TO GOLDEN BROWN SANDSTONE, COARSE GRAINED, POROUS, FLAGGY; WITH SEVERAL PEAT CLAYS (CARBONACEOUS SHALE), LOG-LIKE CONCRETIONS; WITH THE PLANT? *HALYMENITES MAJOR*, MARCASITE CONCRETIONS; IT IS UNCONFORMABLE WITH THE CHADRON FORMATION ABOVE.

## INTRODUCTION

THE AREAL GEOLOGY OF THESE QUADRANGLES WAS MAPPED AS A PART OF THE SOUTH DAKOTA GEOLOGICAL SURVEY'S COAL RESOURCES PROGRAM DURING JULY AND AUGUST, 1955. STRATIGRAPHY WAS DETERMINED BY "WALKING OUT" CONTACTS AND DELINEATING THEM ON AERIAL PHOTOGRAPHS. THERE ARE ABOUT 211 SQUARE MILES IN THE HARDING COUNTY QUADRANGLE AND ABOUT 37 SQUARE MILES IN THE ERICKSON #1 QUADRANGLE.

## LOCATION

THESE QUADRANGLES ARE LOCATED IN SOUTHWESTERN HARDING COUNTY, SOUTH DAKOTA. THE ERICKSON #1 QUADRANGLE BORDERS CARTER COUNTY, MONTANA. THE CENTER OF THE QUADRANGLES IS 20 AIR MILES SOUTHWEST OF BUFFALO, SOUTH DAKOTA, 180 AIR MILES NORTHWEST OF PIERRE, 94 AIR MILES NORTH-NORTHWEST OF RAPID CITY. THESE QUADRANGLES ARE BOUNDED BY PARALLELS 45°15' AND 45°30' NORTH LATITUDE AND MERIDIAN 103°45' AND 104°02'42" WEST LONGITUDE.

## GEOGRAPHY

THE AREA LIES IN THE NORTHERN GREAT PLAINS PROVINCE. IT IS MOSTLY ROLLING, GRASS COVERED PRAIRIE BUT "BAD LAND" TOPOGRAPHY DEVELOPES IN THE NORTHEASTERN CORNER OF THE HARDING QUADRANGLE AND WEST OF THE WEST SHORT PINE HILLS.

THE WEST SHORT PINE HILLS FORM A HIGH MESA AND TOWERS ABOUT 400' ABOVE THE PRAIRIE BELOW. MAXIMUM ELEVATION IS 4019' ABOVE SEA LEVEL ON TOP OF THE WEST SHORT PINE HILLS AND MINIMUM ELEVATION IS ABOUT 3150 FEET ABOVE SEA LEVEL IN THE SOUTHEASTERN CORNER OF THE HARDING QUADRANGLE. THE LITTLE MISSOURI RIVER DRAINS THE WESTERN EDGE AND NORTHERN HALF OF THE QUADRANGLES AND THE SOUTH FORK OF MOREAU RIVER DRAINS THE SOUTHERN HALF OF THE QUADRANGLES. ALL THE STREAMS ARE INTERMITTENT; HOWEVER, SHALLOW SANDS ARE AVAILABLE WHICH CAN FURNISH GOOD WATER IN LARGE QUANTITIES; STOCK DAMS USUALLY CARRY WATER THROUGHOUT THE YEAR.

THE CLIMATE IS SEMI-ARID WITH AN AVERAGE ANNUAL RAINFALL OF 11 INCHES. RANCHING IS THE ONLY OCCUPATION. THERE ARE NO TOWNS BUT A POST OFFICE IS MAINTAINED AT A STORE CALLED HARDING. THERE ARE NO RAILROADS; ROADS ARE ALL SECONDARY OR COUNTY ROADS.

VEGETATION IS MAINLY PRAIRIE GRASSES EXCEPT FOR YELLOW PINE (*Pinus ponderosa*) AND BIRCH TREES ON THE WEST SHORT PINE HILLS. SHORT SAGE BRUSH GROWS IN WASHED OUT AREAS.

ROCK EXPOSURES ARE VERY GOOD IN THE QUADRANGLES EXCEPT ALONG THE EAST SIDE OF THE WEST SHORT PINE HILLS.

## STRATIGRAPHY

SURFACE FORMATIONS CONSIST OF SEDIMENTS OF UPPER CRETACEOUS, OLILOCENE, MIOCENE? OR PLIOICENE? AND QUATERNARY AGE. UPPER CRETACEOUS FORMATIONS FORMS THE BEDROCK OF FOUR FIFTHS OF THE QUADRANGLES; NEW EVIDENCE SUGGESTS THAT A PRONOUNCED EROSIONAL UNCONFORMITY EXISTS BETWEEN THE HELL CREEK FORMATION AND THE FOX HILLS FORMATION. COMPLETELY EXPOSED FORMATIONS ARE THE FOX HILLS, HELL CREEK, CHADRON, BRULE, AND OGALLALA?. THE FOX HILLS SANDSTONE REPRESENTS THE RETREAT OF MARINE DEPOSITION FROM THE GREAT PLAINS PROVINCE. ALL YOUNGER SEDIMENTS IN THESE QUADRANGLES ARE CONTINENTAL DEPOSITS OF FLUVIAL, EOLIAN AND LACUSTRINE ORIGIN.

**PIERRE FORMATION** (MEEK AND HAYDEN, 1862) (UPPER CRETACEOUS). THE MAPPED OUTCROP AREA OF THE PIERRE SHALE HAS BEEN ENLARGED OVER PREVIOUS MAPPING IN THESE QUADRANGLES. THE FORMATION IS MADE UP OF DRAB, BLUE GRAY TO BLACK, SOFT SHALE; IT IS WAXY AND GREASY WITH NUMEROUS YELLOW BENTONITE SEAMS; IT IS THIN-BEDDED AND JOINTED, WITH SCATTERED, CALCAREOUS, FOSSILIFEROUS, CONCRETIONS; WITH CONE-IN-CONE CONCRETIONS AND SELENITE CRYSTALS; IT WEATHERS INTO LIGHT GRAY OR LIGHT BROWN COLOR; IT FORMS STICKY GUMBO WHEN WET; IT BECOMES LOOSE AND CRACKED WHEN DRY. ABOUT 250' IS EXPOSED ON THE SOUTH-EAST EDGE OF THE HARDING QUADRANGLE. VEGETATION GROWING ON THIS SHALE IS SPARSE AND STUNTED.

**FOX HILLS FORMATION** (MEEK AND HAYDEN, 1861) (UPPER CRETACEOUS). THIS INVESTIGATION SHOWS AN INCREASE IN THE MAPPED EXTENT OF THE FOX HILLS FORMATION IN THE SOUTHERN HALF OF THESE QUADRANGLES. THE UPPER PART CONSISTS OF GRAY TO WHITE, FINE TO MEDIUM GRAINED SANDSTONE; COMPOSED OF SUB-ANGULAR QUARTZ AND BIOTITE; IT IS SILTY AND CALCAREOUS; IT WEATHERS TO PALE YELLOW; AT INTERVALS IT BECOMES 2" THICK LEDGE OF THIN-BEDDED (1/8") SANDSTONE.

## MIDDLE PART:

THIS PART CONSISTS OF THE SOMBER BEDS WHICH ARE THE INTER-BEDDED DARK GRAY SHALES, PEAT CLAYS AND LENSING, IMPURE SANDS. THEY ARE PROBABLY OF EOLIAN ORIGIN; THE SHALE BEDS ARE THUS TOUGH OR COHESIVE AND THE PEAT CLAYS ARE SO COMPACT THAT THEY ARE VERY RESISTIVE TO EROSION; THUS THESE SOMBER BEDS FORM THE MUDSTACKS PROMINENT IN THE BADLAND AREAS; BENTONITE MAKES UP A LARGE PART OF THE SOMBER BEDS AND CAUSES SMALL MUD CRACKS WHEN DRY; DINOSAUR BONES AND FOSSIL WOOD ARE COMMON IN THIS ZONE AS WELL AS NUMEROUS BLACK MANGANESE-IRON CONCRETIONS.

**LOWER PART:** GRAY, COARSE-GRAINED, POROUS, FLAGGY SANDSTONE; YELLOW WHEN WEATHERED; FREQUENTLY UNCONSOLIDATED; CALCAREOUS; SPARSELY WITH BLOCKY CONCRETIONS AND SANDSTONE LENSES; DINOSAUR BONES; OCCASIONAL GRAY SHALE AND PEAT CLAY. THESE FLUVIAL CHANNELS CUT DEEPLY INTO THE FOX HILLS SANDSTONE CAUSING IRREGULAR THICKNESS OF BOTH FOX HILLS AND HELL CREEK FORMATIONS. THE HELL CREEK, AS A WHOLE, VARIES FROM 280' TO 400'.

**CHADRON FORMATION** (DARTON, 1899) (OLIGOCENE). THE CHADRON FORMATION ENCIRCLES THE WEST SHORT PINE HILLS AT THEIR BASE. THIS FORMATION CONSISTS OF WHITE, FINE-GRAINED SANDSTONE. LOCALLY THIS SANDSTONE DEVELOPS INTO A GRAY, CONSOLIDATED CHANNEL GRAVEL. THE UPPER PART OF THE CHADRON FORMATION IS A MAROON TO PURPLE, BENTONITIC, CLAY GRADING UPWARD INTO "CALICHE LIKE" SANDY LIMESTONE BEDS. THE THICKNESS VARIES FROM 55' TO 80'. IT IS UNCONFORMABLE WITH THE HELL CREEK FORMATION BELOW AND GRADES INTO THE BRULE FORMATION ABOVE.

**BRULE FORMATION** (N. H. DARTON, 1898) (OLIGOCENE). THE BRULE FORMATION ENCIRCLES THE MIDDLE PART OF THE WEST SHORT PINE HILLS. THIS FORMATION CONSISTS OF PINK CLAY WHICH IS SANDY IN PART AND BENTONITIC; IT HAS SILICEOUS CONCRETIONS AND CHALCEDONY SEAMS; IT IS THICK-BEDDED TO MASSIVE; TURTLE FRAGMENTS ARE COMMON; LOWER BRULE FOSSILS (*HYRACODON*) WERE FOUND IN THE SAME INTERVAL IN THE ADJACENT EAST SHORT PINE HILLS. THIS FORMATION FORMS SLOPES AT THE CONTACT WITH THE CLIFF-MAKING OR VERTICAL ARIKAREE? (OGALLALA) SANDSTONE ABOVE; THE BRULE IS UNCONFORMABLE (ANGULAR AND EROSIONAL) WITH THE ARIKAREE? ABOVE AND IS CONFORMABLE WITH THE CHADRON FORMATION BELOW; THE THICKNESS VARIES FROM 60' TO 85'.

**ARIKAREE FORMATION** (N. H. DARTON, 1899) (LOWER MIOCENE) OR **OGALLALA FORMATION** (N. H. DARTON, 1898) (LOWER PLIOICENE). THESE SEDIMENTS DO NOT CONTAIN ENOUGH FOSSILS TO ESTABLISH AGE AND CORRELATION WITH OTHER AREAS. THE SEDIMENTS ARE AT LEAST UPPER MIOCENE OR OF THE HEMINGFORD GROUP AND THUS COULD NOT BELONG TO LOWER MIOCENE OR ARIKAREE GROUP. GENERAL TEXTURE, VOLCANIC ASH, VEGETABLE MATTER AND THE GREEN SEDIMENTARY QUARTZITE SUGGESTS A RELATIONSHIP TO THE OGALLALA FORMATION OF NEBRASKA. DR. ELIAS IDENTIFIED FOSSIL SEED FRAGMENTS WHICH WERE NOT COMPLETE ENOUGH TO BE DIAGNOSTIC.

THE FORMATION CONSISTS OF GREENISH GRAY, FINE-GRAINED SANDSTONE WITH INTER-BEDDED LIGHT GRAY VOLCANIC ASH BEDS; LOCALLY ABUNDANT SMALL GREEN CLAY CONCRETIONS OCCUR; THE BASAL PART IS LOCALLY THIN-BEDDED AND IS A FINE GRAVEL; THE UPPER PART IS THICK-BEDDED OR MASSIVE; CALCAREOUS FOSSIL VEGETABLE MATTER OCCURS IN THE UPPER PART; LOCALLY THIS FORMATION IS CAPPED BY A GREEN SEDIMENTARY QUARTZITE; IT IS THE CLIFF-MAKING FORMATION THAT CAPS THE WEST SHORT PINE HILLS; THE THICKNESS VARIES FROM 80' TO 145'.

**QUATERNARY DEPOSITS.** THESE SEDIMENTS CONSIST OF RECENT AND OLD ALLUVIUM, DUNE SANDS, RECENT AND PLEISTOCENE TERRACES; MOST PROMINENT ARE THE RECENT AND PLEISTOCENE TERRACES ALONG THE LITTLE MISSOURI RIVER AND THE PLEISTOCENE TERRACES AND PEDIMENTS SLOPING OFF THE WEST SHORT PINE HILLS.

## STRUCTURE

THE QUADRANGLES OCCUPY A POSITION ON THE SOUTHWESTERN FLANK OF THE WILLISTON BASIN WHERE THE BASIN HAS BEEN ELEVATED BY THE EXTENSION OF THE BLACK HILLS UPLIFT AND DISTURBED BY FOLDS OFF THE CEDAR CREEK ANTICLINE. REGIONAL STRIKE IS NORTHWEST-SOUTHEAST ALONG THE BLACK HILLS UPLIFT AND REGIONAL DIP IS NORTHEAST INTO THE DEEPER PART OF THE BASIN. REGIONAL DIP IS NORMALLY 45' PER MILE OR ABOUT 1/2° BUT IN THESE QUADRANGLES, THE REGIONAL DIP IS INTERRUPTED BY THE NORTHWEST-STRIKING HARDING SYNCLINE AND THE GUSTAVE ANTICLINE. THE OGALLALA (ARIKAREE?) BEDS ARE FLAT-LYING AND DO NOT REFLECT REGIONAL DIP OR PLUNGE.

DETERMINATION OF STRUCTURE OF SURFACE ROCKS IS HINDERED BY THE SLUMPING, FLOWING OR SETTLING OF THE INCOMPETENT CRETACEOUS SEDIMENTS. FOR THAT REASON, MORE THAN 50% OF THE DIPS, STRIKES AND PLUNGES ARE PSEUDO. BY ESTABLISHING AREAL GEOLOGY OF THE QUADRANGLES IN COMBINATION WITH LOCAL AND REGIONAL STRUCTURAL TRENDS AND RELATIVE POSITION OF BEDS, IT HAS BEEN POSSIBLE TO DELINEATE TRUE DIP, STRIKE AND PLUNGE. INSTEAD OF A NORTH-SOUTH STRIKING CAMP CROOK ANTICLINE, A NORTHWEST STRIKING SYNCLINE IS INDICATED IN THE NORTHERN PART OF THE QUADRANGLES. THE GUSTAVE ANTICLINE ALSO STRIKES NORTHWEST-SOUTHEAST AND PLUNGES 2° TO THE NORTHWEST AND IS LOCATED 5 MILES SOUTH OF THE HARDING SYNCLINE. THERE IS NO REVERSAL OF REGIONAL PLUNGE APPARENT ALONG THE GUSTAVE ANTICLINE. THERE IS SO MUCH SLUMPING, LANDSLIDING AND SETTLING ON THE WEST SIDE OF THE WEST SHORT PINE HILLS WHERE THE HARDING SYNCLINE INTERSECTS THE PINE HILLS, THAT SUSPECTED FAULTING COULD NOT BE DELINEATED.

THESE FOLDS PARALLEL THE CEDAR CREEK ANTICLINE TO THE NORTH AND THE BLACK HILLS UPLIFT TO THE SOUTH.

## ECONOMIC GEOLOGY

NO MINERAL PRODUCTS ARE BEING EXPLOITED ON A COMMERCIAL SCALE IN THESE QUADRANGLES.

**COAL** IS NOT PRESENT IN THESE QUADRANGLES. **URANIUM** IS PRESENT IN THE OGALLALA (ARIKAREE?) AND CHADRON BEDS IN LOW GRADE, NEARLY COMMERCIAL QUANTITIES. SOME OF THIS URANIUM MIGHT HAVE LEACHED DOWN INTO THE UPPER PART OF THE HELL CREEK FORMATION.

**OIL** IN COMMERCIAL QUANTITIES IS POSSIBLY PRESENT IN THESE QUADRANGLES. IT IS BELIEVED THAT THE RESERVOIR BEDS, SOURCE BEDS AND CAPPING BEDS ARE PRESENT AT DEPTH BENEATH THESE QUADRANGLES. HOWEVER, THE PLUNGE OF THE GUSTAVE ANTICLINE DOES NOT APPEAR TO REVERSE ITSELF IN THESE QUADRANGLES, AND PREVENTS COMPLETE CLOSURE FOR AN OIL TRAP. STRUCTURAL CONDITIONS COULD CHANGE AT DEPTH THOUGH; SUSPECTED FAULTING COULD PROVIDE A TRAP IF IT CUTS THE ANTICLINE AND CARRIES WITH DEPTH.

**GRAVEL** AND SAND OCCUR CONTAMINATED WITH TALUS MATERIAL, CONGLOMERATE AND HUMIC MATERIAL IN THESE QUADRANGLES IN CHANNELS, TERRACE DEPOSITS AND STREAM BOTTOMS. THE ONLY DEPOSIT LARGE ENOUGH TO EVALUATE IS LISTED BELOW.

TABLE I

SECTION	TWP	R&E	ACRES	AVE. THICKNESS	EST. CUBIC YARDS
11 & 14	16 N	1 E	27.8	15'	672,000

**RIP RAP.** THE SEDIMENTARY GREEN QUARTZITE OF THE OGALLALA (?) FORMATION THAT CAPS PART OF THE WEST SHORT PINE HILLS CAN BE USED AS RIP RAP OR OTHER TYPES OF BUILDING MATERIAL.