U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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CONSERVATION AND SURVEY DIVISION,
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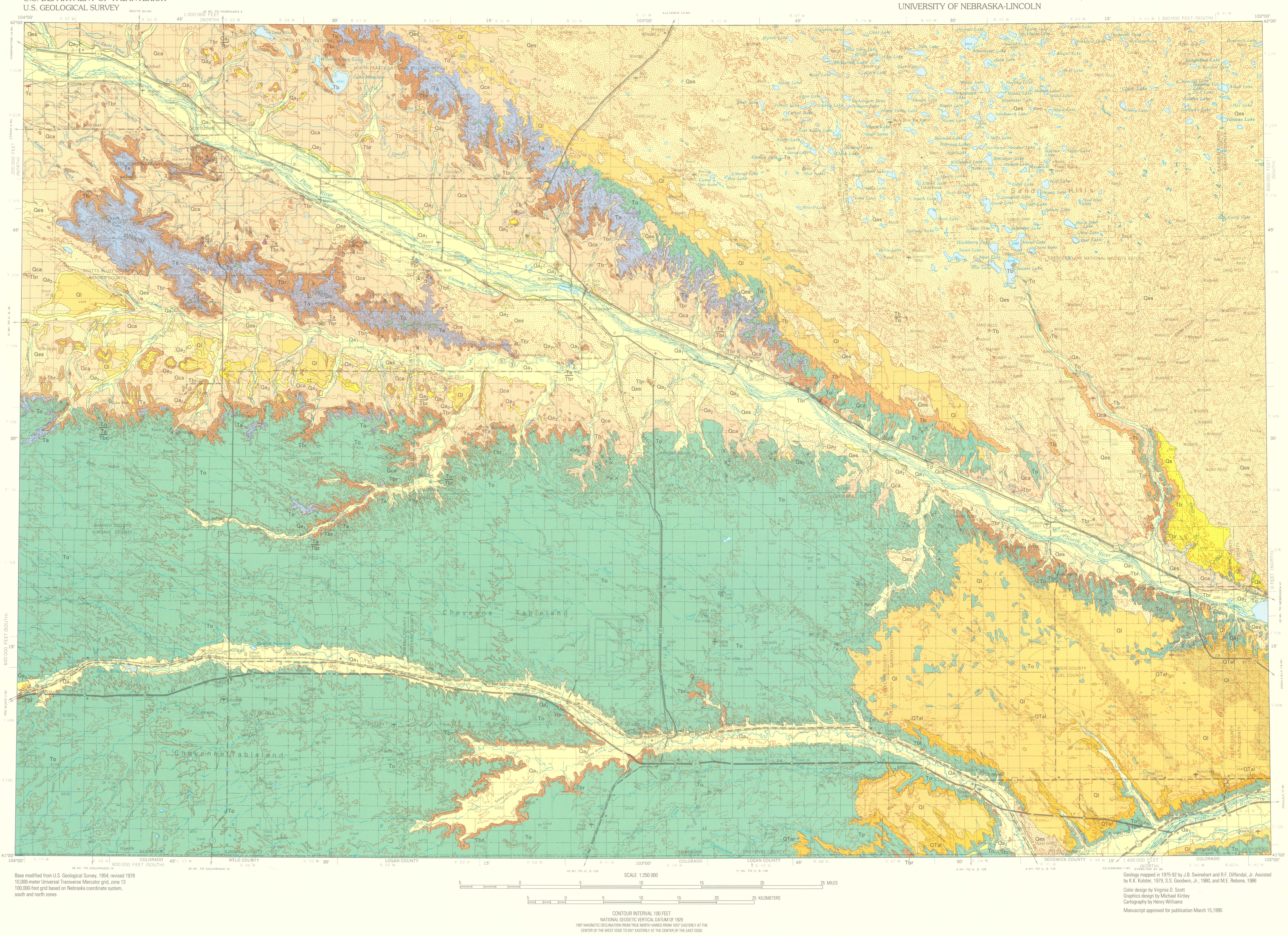
GEOLOGIC INVESTIGATIONS
MAP I-2545



Base modified from U.S. Geological Survey, 1954; revised 1978
10,000-meter Universal Transverse Mercator grid, zone 13
100,000-foot grid based on Nebraska coordinate system, south and north zones

SCALE 1:250 000
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 100 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
1997 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 10½° EASTERLY AT THE CENTER OF THE WEST EDGE TO 9½° EASTERLY AT THE CENTER OF THE EAST EDGE

Geology mapped in 1975-92 by J.B. Swinehart and R.F. Diffendal, Jr. Assisted by K.K. Kolster, 1979, S.S. Goodwin, Jr., 1980, and M.E. Rebone, 1986

Color design by Virginia D. Scott
Graphics design by Michael Kirtley
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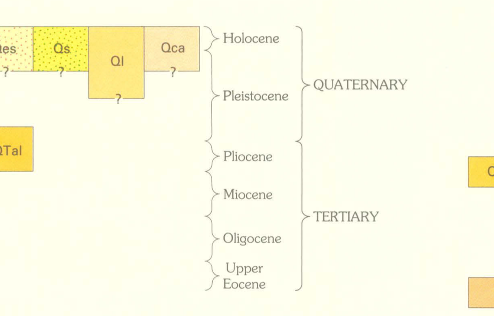
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[In some areas, natural exposures too small to show on the map reveal the nature of the underlying unit. In these areas, the underlying unit is shown as a denominator (for example, Ta/Tbr). Vertebrate fossils diagnostic of the ages and stratigraphic positions of some of the map units have been identified by M.R. Voorhies, R.M. Hunt, Jr., and other paleontologists at the University of Nebraska State Museum and at the American Museum of Natural History. The fossils collected during the mapping are housed principally at these museums.]

Qa_1 **Younger alluvium (Holocene and latest Pleistocene)**—Commonly pebbly gravel and sand, minor thin sandy silt beds, yellowish-gray to yellowish-orange; unit underlies the modern flood-plain and low terraces generally less than 20 ft above stream level in North and South Platte River valleys and along Pumpkin Creek, Lodgepole Creek, and other tributaries. North Platte River gravel consists principally of granite, anorthosite, rhyolite, mafic igneous rocks, quartzite, gneiss, schist, sandstone, and chert that were eroded mostly from the Hartville uplift, Laramie Range, and Medicine Bow Mountains in Wyoming (Stout and others, 1971; Diffendal, 1990). Also includes locally derived clasts of Ogallala Group sandstone and calcrete and calcareous concretions and siltstone from the Arikaree and White River Groups. Anorthosite clasts derived from the southern Laramie Range are most abundant in alluvium along Pumpkin Creek. Gravel along Lodgepole Creek consists mostly of clasts reworked from Ogallala Group rocks, Sherman Granite, Laramie Anorthosite, and quartzite from the Medicine Bow Range in Wyoming. Gravel in South Platte River alluvium was reworked from older Cenozoic deposits in the drainage basin and from the Rocky Mountains in Colorado. The composition of clasts in alluvium in tributaries reflects the formations exposed in the drainage basins (Diffendal and Corner, 1983; Stout and others, 1971). Unit includes channel, flood-plain, terrace, and alluvial-fan deposits. Deposits fill valleys eroded into Tertiary bedrock. Locally, the bedrock floor beneath the valley of the North Platte River is cut by deep and narrow anastomosing channels (Wenzel and others, 1946; Souders, 1986); such channels have been called inner channels by Schumm (1977). The unit locally includes areas of colluvium, eolian sand (Qes), and bedrock too small to map separately. Includes deposits equivalent to the alluvium of the T0, T1, and T2 terraces of Schultz and Stout (1945, 1948) and the Qal and Qb units of Scott (1978). Commonly 20–150 ft thick

Qes **Eolian sand (Holocene and late? Pleistocene)**—Well-sorted fine sand, pale-brown, pale-yellowish-brown, and dark-yellowish-brown; laminated cross-stratification and horizontal bedding (Ahlbrandt and Fryberger, 1980); burrows and vertebrate tracks (mostly *Bison*; Loope, 1986) are common. Locally contains several paleosols characterized by A/AC profiles. Primarily forms stabilized compound parabolic dunes and large crescentic dunes as much as 340 ft high north of North Platte River in the Nebraska Sand Hills (Swinehart, 1990). Includes interdune deposits of eolian and lacustrine fine sand, organic-rich sandy silt, mud, muck, and peat. Small dunes and sand sheets locally cover intermediate alluvium (Qa_2) and, to lesser extent, younger alluvium (Qa_1) along North Platte River, south of Pumpkin Creek, and on east side of Lodgepole Creek near its mouth. Locally includes unmapped loess (Ql) north of North Platte River valley and small unmapped outcrops of the Ogallala and Arikaree Groups and Brule Formation. Also includes minor colluvium and alluvium. Radiocarbon ages of paleosols within dune sand and on peat beneath dunes in the Sand Hills indicate several episodes of dune activity during the Holocene (Ahlbrandt and others, 1983; Swinehart and Diffendal, 1990). In the Crescent Lake area, as much as 54 ft of marsh, peat, and lacustrine-rich mud is present in paleovalleys that were blocked by eolian sand during at least two episodes of aridity over the last 12,000 yrs (Loope and others, 1995)

Qs **Silt and sand (Holocene and late? Pleistocene)**—Silt, sandy silt, and silty sand, moderate-yellowish-brown, laminated to thinly bedded. Caps Broadwater and Ash Hollow Formations north of North Platte River in easternmost part of the map area. May be composed of both lacustrine and eolian deposits. Thickness generally less than 30 ft

Ql **Loess (Holocene to middle? Pleistocene)**—Wind deposited silt and sandy silt, noncalcareous to slightly calcareous, moderate-yellowish-brown. Caps old alluvial deposits (QTal) and the Ash Hollow Formation of the Ogallala Group on Cheyenne Tableland and locally older alluvium (Qa_3) and intermediate alluvium (Qa_2), and a broad band of loess extends along the north side of the North Platte Valley. Numerous outcrops of Ash Hollow Formation too small to map separately are included in unit. Locally may correlate with both the Bignell Loess (Holocene) and the Peoria Loess (late Wisconsin) (Schultz and Stout, 1945; Stout and others, 1971; May and Holen, 1993). Includes eolian silt older than Peoria at the eastern end of Cheyenne Tableland (Stout and others, 1971; Diffendal, 1991). Generally less than 20 ft thick but is more than 200 ft thick in southwestern Keith, northeastern Deuel, and southeastern Garden Counties. Thin loess covers Ogallala Group rocks (To) in most of Cheyenne Tableland, but unit is mapped only where thickness exceeds about 10 ft. Stipple pattern indicates loess deposits more than 20 ft thick

Qca **Colluvium and alluvium (Holocene and late? Pleistocene)**—Sand, silt, and minor gravel, moderate-brown to yellowish-gray; exists principally on valley slopes. Unit grades laterally into younger deposits which are correlative with younger alluvium (Qa_1) and into older deposits correlative with intermediate alluvium (Qa_2). Thickness commonly 10–40 ft, locally as much as 80 ft

Qa_2 **Intermediate alluvium (late? Pleistocene)**—Commonly pebbly gravel and sand and locally thin beds of pale-orange to yellowish-brown silt. Locally includes minor lacustrine silt. Clast composition similar to that of younger alluvium (Qa_1). Deposit underlies a discontinuous terrace about 80–90 ft above river level along both sides of North Platte River west of Bridgeport and along south side of the river east of Bridgeport (Babcock and Visher, 1951). Also underlies terrace south and east of Pumpkin Creek in Morrill and Banner Counties (Diffendal, 1984). North Platte and Pumpkin Creek terraces merge southeast of Bridgeport. Includes alluvial deposits that locally cap elongate hills south of Pumpkin Creek (Babcock and Visher, 1952; Diffendal and Corner, 1983). Qa_2 deposits underlie discontinuous terraces along tributaries of the North Platte River in southeastern Garden County (Diffendal and Leite, 1989). Small areas of unmapped loess, colluvium, and bedrock are locally included in the unit. Unit is commonly covered by thin deposit of unmapped eolian sand. Surface of underlying bedrock (Brule Formation and Ogallala Group) is irregular and has features like those of the bedrock surface beneath the younger alluvium (Qa_1). No age-diagnostic fossils known. Equivalent to T3 terrace of Schultz and Stout (1945, 1948). Thickness about 10–100 ft

Qa_3 **Older alluvium (early Pleistocene)**—Commonly pebbly gravel and sand, pale-orange. Forms terrace remnants about 200–300 ft above creek level south of Pumpkin Creek in Morrill and Banner Counties (Diffendal and Corner, 1983), a remnant between Pumpkin Creek and the North Platte River, and remnants 150–350 ft above river level north of the North Platte River in Morrill and Scotts Bluff Counties. South of Pumpkin Creek, clasts are dominantly Sherman Granite and Laramie Anorthosite derived from the southern Laramie Range. Locally derived clasts of Brule Formation siltstone and concretions, Arikaree Group concretions, and Ogallala Group calcrete and silcrete are also present. Trough cross-stratification exposed in gravel pits (Diffendal and Corner, 1983). Fossils of *Mammuthus meridionalis* (Nesti) and *Equus* sp. cf. *E. scotti* Gidley, exposed along Pumpkin Creek, indicate an Irvingtonian North American land mammal age (NALMA) (Corner and Diffendal, 1983). Probably includes two or more ages of alluvium on north side of North Platte River valley. Thickness ranges from 10 to 90 ft

QTal **Old alluvial deposits (Pleistocene and Pliocene)**—Gravel and coarse sand, light-brown to grayish-orange; minor alluvial silt and lacustrine deposits. Deposit between the South and North Platte Rivers near the southeast corner of the map area contains dark-gray quartzite and rhyolite clasts (Diffendal, 1991; Diffendal and others, 1996). Trough cross-stratification exposed in gravel pits. Apparently equivalent in part to Broadwater Formation (Tb). Thickness generally less than 100 ft

Tb **Broadwater Formation (Pliocene)**—Fluvial pebble to cobble gravel and sand; locally includes minor silt, clay, and diatomite beds; pale yellow to grayish orange. Divided into an upper unnamed unit and a lower unit informally named the Remsburg Ranch beds (Swinehart and Diffendal, 1987, 1995). Upper unnamed unit corresponds to Broadwater Formation as originally defined by Schultz and Stout (1945); however, members named by those authors not recognized in the map area. Formation is exposed on north side of North Platte River valley. Pliocene age of Broadwater based on vertebrate faunas (Repenning, 1987). Composite thickness of Broadwater Formation as much as 300 ft

Upper unnamed unit—Not shown on map. Pebbly gravel and sand. Crops out along the North Platte River valley north and east of Broadwater and southeastward to the valley of Blue Creek. Contains as many as three silt, silty sand, and diatomite subunits in outcrop and in test holes (Swinehart, 1979; Swinehart and Diffendal, 1987). Distinctive gravel clasts include quartzite from Medicine Bow Mountains of southeastern Wyoming (Swinehart and Diffendal, 1987) and anorthosite from Laramie Range of Wyoming (Stanley and Wayne, 1972; Swinehart and Diffendal, 1990). Other clasts are granite, granodiorite, quartz, mafic plutonic rocks, gneiss, chert, sandstone, siltstone, and acidic volcanic rocks. Southeastern and south-central Wyoming were principal source areas for these clasts. Maximum intermediate diameter (b axis) of clasts is 3 in. Vertebrate fossils typical of the upper unnamed unit include *Sorex* sp., *Megalonyx* sp., *Lepus* sp., *Stegomastodon mirificus primitivus*, *Equus*, spp., *Camelops* sp., and *Gigantocamelus fricki* (Barbour and Schultz, 1937; Schultz and Stout, 1945, 1948). Mammal fossils from Lisco quarries in Garden County are early Blancan in age whereas those from Broadwater quarries in Morrill County are medial Blancan (Voorhies and Corner, 1986). Fish (Bennett, 1979), amphibian, and reptile fossils (Holman and Schloeder, 1991), are in fine-grained deposits of the upper unnamed unit in Lisco quarries. Unit commonly 50–150 ft thick; maximum exposed thickness 200 ft

Remsburg Ranch beds of Swinehart and Diffendal (1987)—Not shown on map. Composed of pale-brown to grayish-orange cobble gravel and sand. Silt and diatomite beds present locally. Gravel clast composition is similar to that in the upper unnamed unit, but the informal Remsburg Ranch beds contain more clasts of mafic plutonic rocks and fewer clasts of sandstone and siltstone (Swinehart, 1979; Swinehart and Diffendal, 1987). Average intermediate diameter of the ten largest clasts (mostly quartzite) at several localities range from 4 to 5.5 in. These clasts are considerably larger than the largest clasts in the upper unnamed unit. Sedimentary structures include horizontal stratification, gravel imbrication, and crossbeds that are as much as 10 ft thick. Remsburg Ranch beds primarily represent fill deposits of anastomosing inner stream channels (Schumm, 1977, p. 188) incised into bedrock. Unit crops out discontinuously along north side of North Platte River valley from northeast of Torrington, Wyoming, to Garden County in eastern part of the map area. In map area unit caps bedrock hills from northeast of Bridgeport to west of Lake Alice. Identifiable vertebrate fossils are rare but include *Gigantocamelus*, *Canis*, and *Megatylopus(?)* (Voorhies and Corner, 1986). Maximum exposed thickness of Remsburg Ranch beds about 150 ft

To **Ogallala Group (upper and middle Miocene)**—Principally fluvial deposits locally subdivided, in descending order, into the informal Angora sand and gravel beds of Swinehart and Diffendal (1995), Ash Hollow Formation, and informal Duer Ranch beds of Swinehart and Diffendal (1987) along north side of North Platte River valley in Morrill County (Swinehart and Diffendal, 1995). Only Ash Hollow Formation crops out widely south of the North Platte valley. Individual units not mapped separately because of their limited areas of outcrop at map scale. Deposits commonly fill paleovalleys (fig. 2), including some that cut deeply into older strata (Scott, 1982; Swinehart and others, 1985). Map unit locally includes areas of post-Ogallala deposits and older bedrock units too small to map separately

Angora sand and gravel beds of Swinehart and Diffendal (1995) (upper Miocene)—Not shown on map. Consists of grayish-pink sand and gravel and interbeds of silt and diatomite (Swinehart and Diffendal, 1995). Similar in lithology to the Broadwater Formation but contains about 10 percent acidic volcanic rock clasts and lacks anorthosite. Exposed continuously north of the North Platte River from north of Broadwater northwestward to U.S. Highway 385. Vertebrate fossils include horses and camels provisionally assigned to the Hemphillian NALMA (M.R. Voorhies, oral commun., 1987). Commonly 80–150 ft thick; maximum thickness about 300 ft in drill holes and 200 ft in outcrop

Ash Hollow Formation (upper Miocene)—Not shown on map. Sandstone, pebbly sandstone, and siltstone, gray, olive, olive-brown, brown, and reddish-brown; gravel, sand, and conglomerate, very pale orange to moderate-orange-pink; also contains diatomite, volcanic ash, calcrete, and silcrete (Diffendal, 1987). North of North Platte River, gray, greenish-yellow and olive colors are more common; south of the North Platte, brown and orange colors are more common. Gravel and sand bodies more common south of the North Platte River and Pumpkin Creek valleys. Stratification in sandstone, pebbly sandstone, and siltstone usually obliterated by bioturbation and soil development. Gravel, sand, and conglomerate typically trough cross-stratified; individual troughs as much as 6 ft thick; some horizontal planar bedding (Goodwin and Diffendal, 1987). Some bodies of conglomerate, sand, and gravel are tabular, others are braid-like in plan view and fill valleys incised into bedrock. Gravel clast composition is variable; in Banner and Morrill Counties, some clasts are similar to the Broadwater Formation (Tb). For example, the Ash Hollow Formation contains as much as 21 percent anorthosite (Diffendal, 1982b). Typically, 4–10 percent acidic volcanic rock clasts are present. Valley fill includes many locally derived clasts, some as large as 30 ft in length (Diffendal, 1983, 1990). At least two volcanic ash beds are north of the North Platte River, at least eight ash beds are exposed south of Broadwater along an unnamed tributary of the river, and seven ash beds are south of Bridgeport along eastern tributaries of Greenwood Creek. Multiple ash beds are also present along Ash Hollow and Lodgepole Creeks. These beds are horizontally stratified, trough crossbedded, or massive; some minor contorted bedding is present. Individual ash beds rarely form outcrops of more than 2 mi^2; some fill former gullies and ponds. Calcrete and silcrete beds exist in the Ash Hollow Formation (Gardner and others, 1992) but rarely form outcrops of more than 1 mi^2. Common plant fossils are diatoms, charophytes, grass husks, nutlets, endocarps, and wood (Diffendal and others, 1996; Thomasson, 1990). Invertebrate fossils of ostracode carapaces and gastropod molds and shells are also present. Ash Hollow vertebrate fossils include a large number of distinctive taxa, such as large land tortoises, rhinoceroses, camels, horses, and carnivores (Breyer, 1981; Diffendal, 1982b; Swinehart and Diffendal, 1987; Voorhies and others, 1987; Voorhies, 1990) of Clarendonian and Hemphillian NALMA. Vertebrate fossils exist most commonly in olive sand, diatomite, and gravel. Fission-track ages of volcanic glass from ash beds in southern Morrill and Garden Counties range from about 7 to 9 Ma (Boellstorff, 1978). Formation unconformably overlies the Duer Ranch beds. The Ash Hollow Formation on the north side of the North Platte Valley exceeds 300 ft in thickness near the Morrill-Garden County line but is thinner to the west-northwest. Exposed thickness in the southern part of the map area exceeds 400 ft; in the subsurface the thickness is as much as 500 ft (Swinehart and others, 1985; Souders, 1986)

Duer Ranch beds of Swinehart and Diffendal (1987) (middle Miocene)—Not shown on map. Dominantly fluvial, brown silty sandstone, lesser amounts of siltstone and conglomerate, and some colluvium. Crops out discontinuously over 4 mi^2 about 7 mi southeast of Broadwater (Swinehart and Diffendal, 1987). Sandstone shows indistinct stratification, but coarse-grained sandstone and conglomerate locally are trough crossbedded. The informal Duer Ranch beds fill steep-gradient paleogullies and show primary dips of as much as 7° along gully axes and as much as 20° near gully sides. Similar paleovalley fills in the basal part of Ogallala reported from test holes in southern Morrill County and also in Banner, Kimball, and Cheyenne Counties (Diffendal, 1982b; Swinehart and others, 1985). Vertebrate fossils include *Cosoryx* sp., which led Voorhies (1990) to assign this unit to an early Clarendonian NALMA. Maximum thickness about 100 ft

Ta **Arikaree Group (lower Miocene and upper Oligocene)**—Divided into three major units (Swinehart and Diffendal, 1995): informal Camp Clarke unit, Harrison and Monroe Creek Formations, undivided, and Gering Formation. Camp Clarke unit and Harrison and Monroe Creek Formations are predominantly volcaniclastic sediment of eolian origin. Gering is predominantly fluvial volcaniclastic sediment. Individual units not mapped separately because of their limited areas of outcrop at map scale

Camp Clarke unit of Swinehart and Diffendal (1995) (lower Miocene)—Not shown on map. Sandy siltstone and silty sandstone, volcaniclastic; yellowish gray to pale yellowish brown. Crops out along southward-flowing tributaries of North Platte River from north of Broadwater northwestward into the northeastern part of Scotts Bluff County. In the eastern 13 mi of outcrop belt the unit is massive, resembles loess, and contains potato-shaped calcareous concretions as much as 3 in. in diameter. The Camp Clarke unit contains abundant calcrete layers (paleosols) with siliceous rhizoliths. Unit is coarser grained in the western half of its outcrop belt. Swinehart and Diffendal (1995) recognized two well-exposed subunits in the lower part of the Camp Clarke unit on Indian Creek about 9 mi north-northwest of Bridgeport: the informal Indian Creek beds and an unnamed unit composed of conglomerate, gravel, and sand. Vertebrate fossils, locally abundant in Camp Clarke unit, are late Arikareean NALMA (Swinehart and others, 1984). Camp Clarke unit commonly 60–100 ft thick; maximum thickness 120 ft

Indian Creek beds of Swinehart and Diffendal (1995)—Not shown on map. Sandstone, siltstone, and claystone, pale-greenish-yellow to light-gray; as much as 110 ft thick

Conglomerate, gravel, and sand—Not shown on map. Light gray; clasts as much as 2 ft in diameter of locally derived calcareous siltstone concretions from older Arikaree and White River strata; subunit is time transgressive because it is in the basal part of both the Camp Clarke unit and the Indian Creek beds. Subunit is as much as 60 ft thick

Harrison (lower Miocene) and Monroe Creek (upper Oligocene) Formations, undivided—Not shown on map. Silty sand and silty, very fine to fine-grained sandstone, gray, brownish-gray, grayish-brown, and yellowish-gray, volcaniclastic, massive to poorly defined planar bedding; locally crossbedded; primarily of eolian origin; zones of siliceous rhizoliths common; evidence of bioturbation extensive. Unit contains conspicuous calcium carbonate-cemented concretions as much as tens of feet long called pipy concretions (Darton, 1903c; Schultz, 1941; Aadland, 1959). Schultz (1941) reported the concretions to be a hundred yards or more long. Locally derived conglomerate fills anastomosing channels eroded into older parts of Harrison and Monroe Creek strata (Goodwin, 1987). Unit extensively exposed along Wildcat Ridge and north of North Platte River; minor exposures along south side of Pumpkin Creek valley west from Redington. Volcanic ash beds uncommon and are best exposed along south-flowing tributaries of North Platte River and on Wildcat Ridge (Vondra and others, 1969; Swinehart and Loope, 1987). A basal ash bed (informally named Olsen's third ash; Swinehart and Diffendal, 1995; Tedford and others, 1996) yielded an $^{40}Ar/^{39}Ar$ age of 27.76±0.30 Ma (ash-bed locality 1, sec. 13, T. 19 N., R. 53 W.). Typically, contact with underlying Gering Formation appears conformable but locally is erosional. Unit commonly 80–120 ft thick on north side of North Platte River valley and 200–300 ft thick on Wildcat Ridge; maximum thickness as much as 400 ft

Gering Formation (upper Oligocene)—Not shown on map. Fine- to medium-grained sandstone, silty sandstone, and sandy siltstone; gray, brownish gray, and brown, volcaniclastic. Locally includes conglomerate, marl, and volcanic ash beds. Two major lithofacies represented in outcrops along flanks of Wildcat Ridge (Tedford and others, 1996). The upper lithofacies, primarily of fluvial origin, is very thin to thin-bedded, horizontally stratified, fine-grained sandstone and sandy siltstone, but locally includes some strata of eolian and shallow lacustrine (playa?) origin. Fossil animal tracks (Loope, 1986) and calcite pseudomorphs after gypsum crystals are locally common. Contains as many as five superposed ash beds; best exposures immediately south of Chimney Rock (4 mi south of Bayard) and at Scotts Bluff National Monument (Swinehart and Loope, 1987). Typically 25–70 ft thick; maximum thickness 90 ft. The lower lithofacies is a fluvial sequence of horizontal, thin- to medium-bedded sandstone, locally crossbedded and characterized by sand- to pebble-size pumice clasts, possibly derived from north-central Colorado (Izett, 1975). Pumice most easily recognized where it forms pebbles in conglomerate lenses in medium-grained sandstone, but it also exists as scattered medium-size grains in sandy siltstone. Pumice-bearing lithofacies also crops out north of Broadwater and is recognized in drill holes in east-central Morrill County. Commonly 60–80 ft thick; maximum thickness 115 ft. Along Lawrence Fork multiple fluvial cut-and-fill deposits that grade vertically into finer grained, massive, bedded strata of possible eolian origin appear also to fill some paleogullies (Diffendal, 1982a). We do not use the member designations of the Gering proposed by Vondra and others (1969). They included parts of what we have mapped as Brule Formation (brown siltstone unit and Whitney Member) in their lowest unit, the Helvas Canyon Member. They placed their Twin Sisters Pumice Conglomerate Bed at the base of their highest unit, the Mitchell Pass Member, but did not recognize the presence of sand-size pumice as much as 35 ft below the base of the Twin Sisters Bed. Mammalian fossils common, especially in fluvial deposits (Martin, 1973; Swisher, 1982). Species are typical of the early Arikareean NALMA (Tedford and others, 1996). Swisher (*in* Swinehart and Diffendal, 1995) obtained three $^{40}Ar/^{39}Ar$ ages on Gering ash beds: 28.28±0.15 Ma from pumice clasts 38 ft above the base of the Gering in the NE¼NW¼ sec. 6, T. 20 N., R. 55 W. (ash-bed locality 2), Scotts Bluff County; 28.11±0.18 Ma from an ash bed near the top of the pumice-bearing lithofacies in the NE¼SW¼ sec. 21, T. 19 N., R. 51 W. (ash-bed locality 3), Morrill County; and 28.28±0.10 Ma on ash bed 1 ft above base of the upper lithofacies in the SW corner, sec. 17, T. 20 N., R. 52 W. (ash-bed locality 4), Morrill County. Formation commonly 50–100 ft thick; maximum thickness about 130 ft

White River Group (lower Oligocene and upper Eocene)—Predominantly volcaniclastic eolian and fluvial sedimentary rocks that are mostly finer grained than those of Arikaree Group. Group divided into Brule Formation and underlying Chadron Formation which crops out at only one locality

Tbr **Brule Formation (lower Oligocene)**—Sandy siltstone and silty sandstone, grayish-brown to yellowish-orange. Principally eolian volcaniclastic sediments and some minor fluvial deposits. Contains several volcanic ash beds that can be correlated regionally (Swinehart and others, 1985). Brule subdivided into three units (from youngest to oldest): a brown siltstone unit, the Whitney Member, and the Orella Member. Units were not mapped separately because of scale of map. Brule Formation underlies almost all of the quadrangle and crops out along the valleys of Lodgepole Creek, Ash Hollow, Blue Creek, Lawrence Fork, Pumpkin Creek, and South and North Platte Rivers

Brown siltstone unit—Not shown on map. Sandy siltstone and silty, very fine grained sandstone, brown to yellowish-brown; volcaniclastic (contains as much as 60 percent glass shards). Mudstone and fine- to coarse-grained sandstone exist locally. Eolian part of unit commonly contains beds 2–5 ft thick or is massive; fluvial channel-fill deposits are medium to thin bedded (1 in. to 2 ft thick) and cross-stratified. Invertebrate bioturbation features are common. Calcareous concretion zones common in massive sandy siltstone. Exposed along north side of North Platte River valley northwestward from Broadwater, and along south side from Ash Hollow westward to just east of Rush Creek. Also exposed along flanks of Wildcat Ridge and along south side of Pumpkin Creek valley. At least two ash beds present in lower part of unit (Nonpareil ash zone of Swinehart and others, 1985). Swisher and Prothero (1990) reported a $^{40}Ar/^{39}Ar$ age of 30.05±0.19 Ma for the basal Nonpareil ash bed at Round Top in northwestern Nebraska. Two or more additional ash beds are in fluvial deposits (Tedford and others, 1996). One, the Roundhouse Rock ash (NE¼SW¼ sec. 21, T. 19 N., R. 51 W., Morrill County; ash-bed locality 5) has a $^{40}Ar/^{39}Ar$ age of 28.6±0.96 Ma (Swisher and Prothero, 1990). Those authors, however, assigned this ash to the Gering Formation. Unit commonly 50–150 ft thick; maximum thickness about 320 ft

Whitney Member—Not shown on map. Siltstone, grayish-orange to yellowish-brown; composed of eolian volcaniclastic sediment. Mudstone and fine- to medium-grained fluvial sandstone present locally. Siltstone generally massive to very thick bedded (2–5 ft thick). Siltstone cemented with authigenic clay and calcite (Swinehart, 1979). Lacustrine silt and diatomaceous silt are present locally. Whitney Member underlies the brown siltstone unit and crops out in essentially the same areas. Whitney Member conformable on Orella Member. Whitney has two regionally correlative ash beds (upper ash and lower ash; Schultz and Stout, 1955; Swinehart and others, 1985). Evidence for bioturbation by invertebrates common in volcanic ash beds (Schwartman, 1989). Invertebrate fossils are present in lacustrine sediments and in paleosols. Fossil turtles and mammals generally represented by isolated fragments; oredonts are most common taxa. Swisher and Prothero (1990) reported $^{40}Ar/^{39}Ar$ age of 30.58±0.61 Ma on the upper ash and 31.85±0.02 Ma on the lower ash from Scotts Bluff National Monument (ash-bed locality 6, NE¼NE¼ sec. 33, T. 22 N., R. 55 W.). Member commonly 200–250 ft thick; maximum thickness about 300 ft

Orella Member—Not shown on map. Mudstone and siltstone, brown, greenish-gray to pink, volcaniclastic. Fine- to medium-grained, fluvial, crossbedded sandstone and thin-bedded mudstone are present locally (Blodgett, 1974), especially in upper half of the member. Crops out on north side of Scotts Bluff National Monument and locally in Lodgepole Creek valley. A regionally correlative ash bed (M ash) in the lower part of Orella Member that is known only in the subsurface is present in this quadrangle (Swinehart and others, 1985). Member commonly 300–350 ft thick; maximum thickness about 400 ft

Tc **Chadron Formation (upper Eocene)**—Claystone and mudstone, gray, greenish-gray, and pink; bentonitic. Lower part of Chadron not exposed. Drill-hole data (Swinehart and others, 1985) reveal fine- to coarse-grained sandstone, claystone, and mudstone occupying paleovalleys in the unexposed part of the formation (fig. 1). Chadron Formation underlies almost all of quadrangle but crops out only in small area just south of North Platte Valley at west boundary of quadrangle. New radiometric dates from the Eocene-Oligocene boundary stratotype in Italy and other areas indicate that the boundary is at about 34.0 Ma (Berggren and others, 1992). New ages for ash beds from White River equivalent strata in Wyoming suggest that the Chadron Formation is older than 34.0 Ma (Prothero and Swisher, 1992). Therefore, we consider the Chadron in the quadrangle to be late Eocene in age. Exposed thickness is 25 ft; maximum thickness in subsurface is about 270 ft (Souders, 1986)

——— **Contact**

×2 **Volcanic ash-bed locality**—Number indicates number of exposed ash beds when more than one

① **Volcanic ash-bed locality**—Dated by $^{40}Ar/^{39}Ar$ method; age given in Description of Map Units

3 **Strike and dip of beds**

NOTE

This map is necessarily generalized. For more detailed information, consult the geologic data stored in files of the Conservation and Survey Division, University of Nebraska-Lincoln. Other geologic maps at different scales that include all or parts of the map area are by Darton (1903a,b,c), Lugn (1939), Weeks and Gutentag (1981), and Weeks and others (1988). Detailed groundwater investigations of parts of the map area were done by Wenzel and others (1946), Babcock and Visher (1951, 1952), Bjorklund (1957), Bjorklund and Brown (1957), Smith (1966, 1969), Smith and Souders (1971, 1975), Souders (1986), Gottula (1993), and Verstraeten and others (1995).

INTRODUCTION

The Scottsbluff 1° × 2° quadrangle, in western Nebraska, is in the northern part of the High Plains section of the Great Plains Physiographic Province (Fenneman, 1931). The map area is mostly a constructional plain that has been dissected principally since the Pliocene by the rivers and streams that drain the area. Most of the southern half of the map area contains the partly eroded remnant of the High Plains known as the Cheyenne Tableland, a region occupying about 3,600 mi^2. Lodgepole Creek, and to a lesser extent Lawrence Fork, Ash Hollow, and tributaries of Pumpkin Creek, and the North Platte and South Platte Rivers have modified the topography of the tableland (Condra, 1946). The part of the High Plains north of the valley of the North Platte River is mostly in the Sand Hills but includes a small part of the Box Butte Tableland. Between the Cheyenne Tableland and the Box Butte Tableland and Sand Hills are the Pumpkin Creek valley and Wildcat Ridge, a remnant of the High Plains capping the deeply dissected divide separating Pumpkin Creek from the North Platte Valley. These parts of western Nebraska are historically important, because they were crossed by the Mormon Trail, Oregon Trail, Sidney-Deadwood Trail, the Pony Express (remnants of all of these can be seen today), and the Union Pacific Railroad along Lodgepole Creek. Famous landmarks include Ash Hollow, Chimney Rock, Jail and Courthouse Rocks, and Scotts Bluff.

The geologic history of the rocks exposed in the map area began some 30 million years after the Cretaceous seas withdrew from the Western Interior Seaway, and the land was subjected to subaerial processes. In the map area, the oldest Cenozoic rocks of the upper Eocene Chadron Formation were deposited in a paleovalley system (fig. 1) eroded into Cretaceous rocks. Upland areas during late Eocene time were mainly in the southwestern and western parts of the quadrangle. A north-trending branch of a paleovalley system along the east side of the quadrangle may have been controlled by the Rush Creek structure (Diffendal, 1980; Swinehart and others, 1985). After fluvial deposition of the Chadron ceased, dominantly eolian volcaniclastic sediments (upper part of the Chadron Formation and the Brule Formation of the White River Group) were deposited during the late Eocene and early Oligocene. The middle part of the Brule Formation does, however, locally contain thick alluvial deposits (Blodgett, 1974; Swinehart and others, 1985).

A narrow paleovalley was formed across the quadrangle before deposition in the late Oligocene of the Gering Formation (Arikaree Group). The long axis of Wildcat Ridge generally coincides with the paleovalley, which contains most of the Gering Formation in the quadrangle (Swinehart and others, 1985; Tedford and others, 1966). Although the Gering is mostly composed of fluvial sediments, most of the overlying upper Oligocene and lower Miocene Arikaree Group (Harrison and Monroe Creek Formations, undivided, and beds of the informal Camp Clarke unit) are composed of eolian volcaniclastic deposits.

In contrast to the White River and Arikaree Groups, the Ogallala Group (middle and upper Miocene) is dominantly fluvial, paleovalley-fill deposits. Most of the alluvial material was derived from erosion of rocks in the Southern Rocky Mountains (Stanley, 1976). The principal Ogallala paleovalley system extends across the southern part of the quadrangle (fig. 2). Toward the end of Ogallala Group deposition, a southeast-trending paleovalley was eroded north of the present North Platte Valley and later filled with the informal Angora sand and gravel beds.

The Broadwater Formation (Pliocene) consists principally of fluvial sand and gravel and fills a major paleovalley north of the present North Platte River (Swinehart and others, 1985; Swinehart and Diffendal, 1987).

The North Platte River system probably began to form during erosion of the valley that was filled by the Angora sand and gravel beds (upper Miocene), but principal tributaries like Pumpkin Creek apparently developed later, during or after the early Pleistocene (Diffendal and Corner, 1983). From western Garden County westward across the quadrangle, the North Platte River has migrated generally southward and has entrenched several times, whereas Pumpkin Creek has migrated northward and has also entrenched several times.

The map area is mostly covered by surficial deposits composed chiefly of eolian sand, loess, colluvium, and alluvium (Mortlock and others, 1920; Hayes, 1921; Wolfanger and others, 1924; Clocker and others, 1962; Sautter and others, 1965; Yost and others, 1968; Helzer and others, 1985; and unpublished preliminary soil surveys of Banner, Cheyenne, Garden, and Keith Counties being prepared by the Soil Conservation Service).

Deformation has affected parts of the quadrangle (DeGraw, 1969; Diffendal, 1980; Sonnenberg and Weimer, 1981; Swinehart and others, 1985; Ahlbrandt and Groen, 1987). Surface rocks from Sidney Draw in southwestern Cheyenne County northeastward to southwestern Garden County are folded. Contour maps of the base of the Ogallala Group (fig. 2) and on the base of the Cenozoic rocks (fig. 1) show highs and lows that correspond with fold axes shown by Sonnenberg and Weimer (1981).

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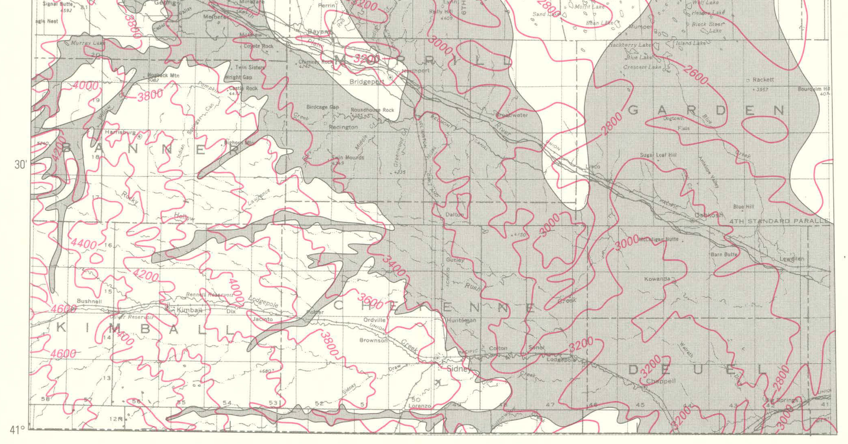
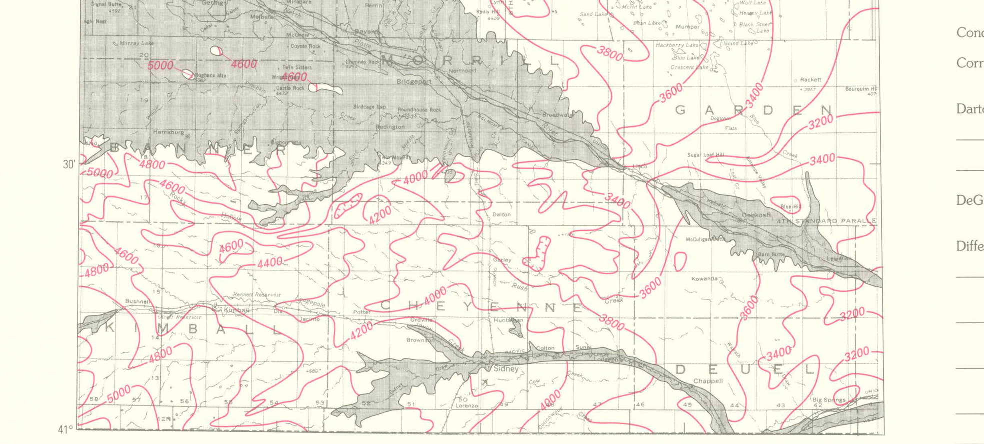


Base from U.S. Geological Survey Nebraska, 1969

SCALE 1:1,000,000
0 5 10 15 20 25 30 MILES
0 5 10 15 20 25 30 35 40 KILOMETERS

Figure 1. Contour map drawn on the base of Cenozoic rocks, Scottsbluff 1° × 2° quadrangle. This surface represents a pre-late Eocene unconformity, and the unconformity is overlain by the Chadron Formation (upper Eocene). Shading indicates areas where paleovalleys commonly contain 10-100 ft of fluvial sandstone in lower part of Chadron. Maximum local thickness of sandstone is 160 ft in southeastern Morrill County (Souders, 1986). The locations of the paleovalleys are not always well defined by contours because of post-Chadron deformation. Map compiled by H. M. DeGraw and V.L. Souders of the Conservation and Survey Division (CSD) based on data from electric logs from about 10,000 oil and gas test wells and from sample logs and electric logs from 30 test holes drilled by the CDS and cooperators. Contour interval 200 ft. Datum is mean sea level.



Base from U.S. Geological Survey Nebraska, 1969

SCALE 1:1,000,000
0 5 10 15 20 25 30 MILES
0 5 10 15 20 25 30 35 40 KILOMETERS

Figure 2. Contour map drawn on the base of the Ogallala Group, Scottsbluff 1° × 2° quadrangle. This surface represents multiple episodes of erosion between 18 and 5 million years ago. Shading indicates areas where the Ogallala has been removed by erosion or was not deposited. Map compiled by V.L. Souders, J.B. Swinehart, and R.F. Diffendal, Jr., based on data from electric logs from about 1,000 oil and gas test wells, sample logs and electric logs from about 280 test holes drilled by the Conservation and Survey Division and cooperators, and geologic mapping. Contour interval 200 ft. Hachures on contour lines indicate enclosed depression. Datum is mean sea level.

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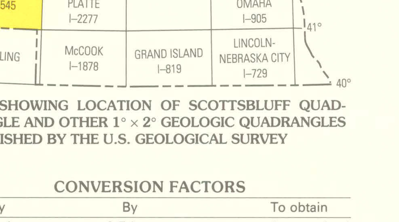

INDEX SHOWING LOCATION OF SCOTTSBLUFF QUADRANGLE AND OTHER 1° × 2° GEOLOGIC QUADRANGLES PUBLISHED BY THE U.S. GEOLOGICAL SURVEY

CONVERSION FACTORS

Multiply	By	To obtain
inches (in)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

GEOLOGIC MAP OF THE SCOTTSBLUFF 1° × 2° QUADRANGLE, NEBRASKA AND COLORADO

By
J.B. Swinehart and R.F. Diffendal, Jr.
1997

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