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Quaternary Geologic Map of the Regina 4° x 6° Quadrangle, United States and Canada

State and Province compilations by David S. Fullerton, Earl A. Christiansen, Bryan T. Schreiner, Roger B. Colton, and Lee Clayton[1]

Edited and integrated by David S. Fullerton, assisted by Charles A. Bush

Prepared in cooperation with the Saskatchewan Research Council and the North Dakota Geological Survey

Pamphlet to accompany Miscellaneous Investigations Series Map I–1420 (NM–13)

[1]Present affiliation: Wisconsin Geological and Natural History Survey, Madison, Wis.

U.S. Department of the Interior
U.S. Geological Survey

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

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1420 (NM–13)

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2007

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

IMPORTANT STRATIGRAPHIC SECTIONS

[Stratigraphic units are listed from youngest to oldest. Rank terms of informal units are not capitalized. Age assignments of units are based on table 2. A given unit thickness in an exposure is the maximum thickness]

SASKATCHEWAN

[The formal stratigraphic nomenclature of Christiansen (1968b, 1992) has not been extended to some test hole records. Test hole logs not otherwise referenced were provided by E. A. Christiansen]

●1 SRC Laura Plots No. 1 test hole, sec. 25, T. 33, R. 10, W. 3, Sask.—Reference section for Dundurn Formation. Pleistocene, 21.4 m silt and sand; middle Pleistocene Warman Formation, 12.8 m unoxidized till; middle Pleistocene Dundurn Formation, 18.6 m oxidized till, 9.5 m silt and sand, 2.1 m unoxidized till, 2.4 m sand; early Pleistocene Mennon Formation, 7.9 m unoxidized till, 0.9 m gravel, 1.2 m unoxidized till, 2.4 m interbedded till and sand, 3.7 m unoxidized till, 1.2 m sand, 1.2 m unoxidized till

●2 SRC Blackstrap Lake test hole, sec. 6, T. 33, R. 3, W. 3, Sask.—Late Wisconsin Battleford Formation, 13.4 m oxidized and unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 11.6 m oxidized till, 18.9 m unoxidized till; middle Pleistocene Warman Formation, 11.6 m unoxidized till, 0.6 m sand, 1.8 m unoxidized till; middle Pleistocene Dundurn Formation, 5.5 m sand, 3.1 m unoxidized till; early Pleistocene Mennon Formation, 11.3 m unoxidized till

●3 SSRIP Conquest No. 3 test hole, sec. 24, T. 30, R. 10, W. 3, Sask.—Late Wisconsin, 4.6 m silt; late Wisconsin Battleford Formation, 3.7 m oxidized till; early Wisconsin and (or) Illinoian Floral Formation, 4.0 m oxidized till, 0.9 m sand, 5.5 m unoxidized till, 0.9 m sand, 4.9 m unoxidized till; middle Pleistocene Warman Formation, 11.3 m oxidized till; middle Pleistocene Dundurn Formation, 29.3 m unoxidized till; early Pleistocene Mennon Formation, 7.9 m silt and sand, 4.9 m unoxidized upper till member, l.2 m sand, 7.6 m unoxidized upper till member, 10.4 m oxidized lower till member; early Pleistocene and (or) late

[1]Present affiliation: Wisconsin Geological and Natural History Survey

Pliocene Empress Group, 25.0 m clay, silt, and sand

●4 SRC Kenaston test hole, sec. 24, T. 29, R. 3, W. 3, Sask.—Late Wisconsin Battleford Formation, 4.0 m oxidized till, 1.8 m unoxidized till; middle Wisconsin Kenaston gyttja, 1.5 m gyttja that yielded a ^{14}C age of 38,000±560 yr B.P. (GSC–104l; wood); early Wisconsin and (or) Illinoian Floral Formation, 35.7 m unoxidized till; middle Pleistocene Warman Formation, 15.9 m unoxidized till; middle Pleistocene Dundurn Formation, 4.3 m unoxidized till

●5 SRC Drake (#1) test hole, sec. 34, T. 31, R. 23, W. 2, Sask.—Late Wisconsin Battleford Formation, 4.9 m oxidized till, 7.3 m unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 39.0 m unoxidized till; middle Pleistocene Dundurn Formation, 58.9 m unoxidized upper till member, 32.6 m unoxidized lower till member; middle Pleistocene and (or) early Pleistocene, 24.4 m sand, silt, and clay (valley fill inset into Mennon Formation); early Pleistocene Mennon Formation, 4.3 m unoxidized till, 1.2 m sand, 9.2 m unoxidized till, 10.7 m sand and silt, 3.1 m unoxidized till, 3.7 m sand

●6 SRC Drake (#2) test hole, sec. 6, T. 32, R. 22, W. 2, Sask.—Late Wisconsin Battleford Formation, 6.7 m oxidized till, 14.0 m unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 33.6 m unoxidized till; middle Pleistocene Warman Formation, 3.4 m unoxidized till; middle Pleistocene Dundurn Formation, 13.1 m unoxidized upper till member, 3.4 m sand, 4.0 m unoxidized upper till member, 1.8 m sand, 2.4 m unoxidized upper till member, 0.6 m sand, 4.3 m unoxidized upper till member, 0.6 m sand, 9.2 m unoxidized upper till member, 5.5 m sand, 1.2 m unoxidized upper till member, 10.4 m sand, 8.5 m unoxidized lower till member; early Pleistocene Mennon Formation, 9.8 m unoxidized till, 32.9 m interbedded gravel, sand, and till. Repetition of Dundurn Formation units possibly indicates glaciotectonic stacking

●7 SRC Drake (#3) test hole, sec. 3, T. 32, R.22, W. 2, Sask.—Late Wisconsin Battleford Formation, 3.7 m oxidized till, 13.4 m unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 35.4 m unoxidized till; middle Pleistocene Warman Formation, 2.4 m unoxidized till; middle Pleistocene Dundurn Formation, 29.9 m unoxidized upper till member, 22.0 m unoxidized lower till member, 5.5 m sand, 7.6 m unoxidized lower till member; early Pleistocene Mennon Formation, 5.2 m clay, 5.5 m unoxidized till; early Pleistocene and (or) late Pliocene Empress Group, 23.8 m sand

●8 SRC Drake (#4) test hole, sec. 32, T. 31, R. 21, W. 2, Sask.—Late Wisconsin Battleford Formation, 7.3 m oxidized till, 10.1 m unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 4.0 m unoxidized till, 1.8 m sand, 25.6 m unoxidized till; middle Pleistocene Dundurn Formation, 9.8 m oxidized till, 11.6 m unoxidized till; early Pleistocene Mennon Formation, 1.8 m interbedded sand and till, 8.5 m oxidized till, 0.3 m sand and gravel, 1.8 m oxidized till, 1.5 m sand and gravel, 3.7 m oxidized till; early Pleistocene and (or) late Pliocene Empress Group, 61.6 m silt and sand.

●9 SRC Demaine test hole, sec. 27, T. 22, R. 10, W. 3, Sask.—Late Wisconsin Battleford Formation, 10.4 m oxidized and unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 34.8 m sand and silt, 14.7 m unoxidized till, 1.8 m clay and silt, 12.2 m unoxidized till; middle Pleistocene Dundurn Formation, 0.9 m pebbly sand, 13.4 m oxidized till, 40.6 m silt and sand; early Pleistocene Mennon Formation, 1.5 m calcic paleosol(?) in till, 8.6 m oxidized till, 27.1 m unoxidized till; early Pleistocene and (or) late Pliocene Empress Group, 17.4 m silt, 5.5 m interbedded gravel and silt

●10 SRC Saskatchewan Landing test hole, sec. 14, T. 19, R. 15, W. 3, Sask.—Late Wisconsin Battleford Formation, 1.5 m oxidized till; early Wisconsin Floral Formation, 5.2 m oxidized upper till member, 3.7 m gravel, sand, and silt, 10.1 m oxidized and unoxidized upper till member; Illinoian Floral Formation, 14.7 m unoxidized lower till member, 0.6 m sand; middle Pleistocene Dundurn

Formation, 0.9 m "marl" (calcic paleosol?) in sand and silt, 4.0 m sand and silt, 9.8 m oxidized upper till member, 36.0 m silt, sand, and gravel, 1.8 m sand and gravel, 11.3 m oxidized lower till member, 7.9 m unoxidized lower till member, 2.1 m sand, 24.1 m unoxidized lower till member; early Pleistocene and (or) late Pliocene Empress Group, 6.1 m silt. The Warman Formation is missing, and the calcic paleosol(?) may be the Prelate Ferry paleosol (see table 2). Barendregt and others (1998) assigned the basal silt to the Stewart Valley sediments

● 11 Wellsch Valley site, Sask.—Three exposures represented by a single symbol on map:

West Ridge exposure, sec. 4, T. 20. R. 14, W. 3—Late Wisconsin, 1.6 m clay and silt; late Wisconsin Battleford Formation, 1.6 m oxidized till; early Wisconsin Floral Formation, 12.4 m oxidized upper till member; Illinoian Floral Formation, 4.4 m unoxidized lower till member; middle Pleistocene Warman Formation, 0.8 m sand, 0.8 m oxidized till, 0.6 m gravel, 2.6 m unoxidized till; early Pleistocene Stewart Valley sediments, 3.2 m silt and sand; early Pleistocene and (or) late Pliocene Empress Group, 0.6 m sand and lag gravel. The sediments of the Battleford, Floral, and Warman Formations have normal remanent geomagnetic polarity, and the Stewart Valley sediments have reversed polarity (Barendregt and others, 1998). The polarity of the basal sediments of the Empress Group in this section is not known. This section was measured by E.A. Christiansen and R.W. Barendregt; measured stratigraphic sections in Barendregt (1995) and Barendregt and others (1998) differ from this measured section

North Cliff exposure, sec. 3, T. 20, R. 14, W. 3—Composite stratigraphic sequence from one vertical profile in Mahaney and Stalker (1988) and five vertical profiles measured by E.A. Christiansen, R.W. Barendregt, and B.T. Schreiner. Thicknesses are from E.A. Christiansen. Late Wisconsin, 2.0 m silt and clay; late Wisconsin Battleford Formation, 1.2 m oxidized till; early Wisconsin Floral Formation, 11.8 m oxidized and unoxidized upper till member; Pleistocene, 8.1 m silt, sand, and gravel; Illinoian Floral Formation, 17.0 m oxidized and unoxidized lower till member; Pleistocene, 1.8 m oxidized and unoxidized till of anomalous composition (a glaciotectonic raft?); middle Pleistocene Warman Formation, 0.6 m Prelate Ferry(?) paleosol in oxidized till; middle Pleistocene and (or) early Pleistocene, 2.8 m normal-polarity sand, silt, and clay; early Pleistocene Mennon(?) Formation, 0.8 m paleosol(?) in intensely weathered till, 0.6 m sand and silt, 2.0 m intensely weathered till. Stratigraphic sections in Barendregt (1995) and Barendregt and others (1998) differ from this composite section. The two intensely weathered till units at the base of the section are referred tentatively to the Mennon Formation, primarily on the basis of low carbonate content (Barendregt and others, 1998). They may be either Dundurn Formation till or Mennon Formation till. The apparent normal remanent polarity of both tills (Barendregt and others, 1998) is consistent with the expected polarity of Dundurn Formation tills; Mennon Formation tills are expected to have reversed polarity. Those two tills (of uncertain identity) in this section are intensely weathered and extremely oxidized (Mahaney and Stalker, 1988; Barendregt and others, 1998), and the depositional remanent magnetization cannot be determined with certainty

Jaw Face exposure, sec. 4, T. 20, R. 14, W. 3—Composite stratigraphic sequence in a slump block exposure, from vertical profiles measured by Churcher and Stalker (written commun., 1972), a composite section by Stalker and Churcher (1972) and Stalker (1976), and vertical profiles measured by E.A. Christiansen. Pleistocene, 1.7 m Saskatoon Group till and lake clay and silt juxtaposed by faulting, 1.9 m sand and silt; middle Pleistocene normal-polarity Warman Formation, 0.3 m oxidized till, 0.1 m pebbly sand and silt, 0.4 m silt, 0.2 m oxidized till, 0.1 m pebbly sand; early Pleistocene Stewart Valley sediments, 0.3 m silt, 0.2 m reversed-polarity "Wellsch Valley tephra," 6.9 m reversed-polarity

silt, clay, and sand containing early Irvingtonian vertebrate fossils and scattered, redeposited glacial erratics; late Pliocene, 3.0 m unnamed indurated lag deposit and sheetwash alluvium(?) containing late Blancan vertebrate fossils and no redeposited glacial erratics (remanent polarity of upper part is reversed; polarity of lower part has not been determined). Measured stratigraphic sections in Churcher and Stalker (written commun., 1972), Foster and Stalker (1976), Barendregt (1984, 1995), and Barendregt and others (1991, 1998) differ markedly, and they all differ from this composite section

The "Matuyama-Brunhes paleomagnetic reversal" above the tephra (Foster and Stalker, 1976; Barendregt, 1984, 1995; Barendregt and others, 1991) here is interpreted to be an erosional unconformity. In one place, the paraconformity is the upper (eroded) contact of the tephra (Barendregt, 1984; Barendregt and others, 1991); elsewhere it probably is within the silt unit that overlies the tephra (Foster and Stalker, 1976). Till of the Dundurn and Mennon Formations, present in other exposures and test holes in the region and representing as many as four distinct glaciations in southern Saskatchewan, was removed by erosion prior to deposition of the normal-polarity sediments. The oldest normal-polarity sediments in the measured section are significantly younger than the Matuyama-Brunhes paleomagnetic reversal, and the youngest reversed-polarity sediments probably are older than the Jaramillo Normal Polarity Subchron. The lacuna includes both normal-polarity and reversed-polarity sediments. The "Brunhes/Matuyama Boundary (0.78 Ma)" of Barendregt and others (1998, fig. 8) in the Wellsch Valley–Swift Current Creek area is a boundary between reversed-polarity and normal-polarity sediments; however, in no published exposure, bore hole record, or test hole record does that boundary necessarily represent the Matuyama-Brunhes paleomagnetic reversal.

Glass fission-track ages for the Cascade Range-source "Wellsch Valley tephra" are >630±60 ka and >690±110 ka (Westgate and others, 1978; Westgate and Gorton, 1981). A fossil bone older than the tephra yielded an amino acid racemization age (measured by J.L. Bada) of >300 ka (Barendregt and others, 1991). Electron-spin resonance ages for a fossil tooth older than the tephra were 148–417 ka (Schwarcz and Zymela, 1985; Zymela, 1986) and >280±35 ka (Zymela and others, 1988), depending on the uranium-uptake model used to calculate the age. The fission-track, amino acid racemization, and electron-spin resonance ages are minimum ages; they do not date any of the sediments. The reversed remanent polarity indicates that the tephra and the underlying fossiliferous Stewart Valley sediments are older than 778 ka.

The reversed-polarity "Wellsch Valley tephra" was expected to be either the Lake Tapps tephra (Westgate and others, 1987) or the Rio Dell (Centerville) tephra (Izett, 1981; Sarna-Wojcicki and others, 1987). However, electron microprobe analysis by A.M. Sarna-Wojcicki and instrumental neutron activation analysis by J. R. Budahn indicated that the "Wellsch Valley tephra" is a compositionally distinct Cascade Range–source tephra. A sample of the tephra, collected by R.W. Barendregt, was submitted to the U.S. Geological Survey Argon Geochronology Laboratory in Denver, Colo., and to the New Mexico Geochronology Research Laboratory in Socorro, N. Mex. The sanidine crystals were too small for single-crystal analysis, and the separation consisted of more feldspar contaminants than sanidine crystals (D.P. Miggins and Lisa Peters, written commun., 2006). A reliable $^{40}Ar/^{39}Ar$ age could not be obtained.

The Stewart Valley sediments are fill deposits in a buried paleovalley. The aggradation occurred subsequent to one or more late Pliocene continental glaciations in southern Saskatchewan and prior to early Pleistocene ("Mennon") glaciation in the region. The contact between the Stewart Valley sediments (containing early Irvingtonian vertebrate fossils and scattered redeposited glacial erratics) and the unnamed indurated

basal stratigraphic unit in the Jaw Face exposure (containing late Blancan vertebrate fossils and no redeposited glacial erratics) here is interpreted to be an erosional unconformity. Late Pliocene continental glaciation ≈2.15 Ma, from a source in Manitoba and Saskatchewan, is represented by till in South Dakota, Minnesota, Wisconsin, Iowa, Missouri, and Nebraska. It is represented by residual glacial deposits (erratic boulders) in North Dakota and Montana, and also in the Wood Mountain region of Saskatchewan south-southeast of the Wellsch Valley and Swift Current Creek sections (Fullerton and others, 2004b). The indurated basal sediments in the Jaw Face exposure probably antedate the late Pliocene glaciation(s).

Till of the Dundurn Formation has been identified in one core hole and one test hole in the Swift Current Creek area ("Important Stratigraphic Sections," #13), but it has not been identified in the Wellsch Valley area. Both of those sections were illustrated by Barendregt and others (1998, fig. 5), but the Dundurn Formation till in those sections, identified by E.A. Christiansen, apparently was not sampled for paleomagnetic analysis. Till of the Mennon Formation has not been identified in the Wellsch Valley area or the Swift Current Creek area. The tills of the Mennon and Dundurn Formations were deposited during the time interval represented by the erosional unconformity between the Stewart Valley sediments and the Warman Formation. Consequently, the apparent absence of Matuyama Reversed-Polarity Chron till is not evidence that reversed-polarity tills were not deposited in the Wellsch Valley–Swift Current Creek area. The geographic distribution of sites (test holes, core holes, and exposures) in which till units of the Mennon and Dundurn Formations have been identified in the region (E.A. Christiansen, unpublished stratigraphic data, 1991–2002) is such that the Wellsch Valley site was necessarily covered by Mennon and Dundurn ice sheets. Till of the Mennon Formation is expected to have reversed remanent geomagnetic polarity. Barendregt and Irving (1998) and Barendregt and others (1998) concluded that there is no record of Laurentide continental glaciation on the prairies of Saskatchewan and southern Alberta during the Matuyama Reversed-Polarity Chron (between 2.582 Ma and 0.778 Ma). However, no till units assigned by E.A. Christiansen to the Mennon Formation in Saskatchewan were sampled for paleomagnetic analysis by Barendregt and others (l991, 1998). Therefore, that conclusion was based on negative evidence. Conclusive remanent polarity data for till units of the Mennon Formation must be obtained from samples of unoxidized till in stratigraphic sections in which the formation has been identified with certainty

●12 Wellsch Valley, Sask.—One core hole and one test hole represented by a single symbol on map:

U of S Eagle No. 145 Wellsch Valley core hole, sec. 3, T. 20, R. 14, W. 3—Late Wisconsin, 3 m clay and silt; late Wisconsin Battleford Formation, 2 m oxidized till; early Wisconsin Floral Formation, 3 m oxidized upper till member; Illinoian Floral Formation, 4 m oxidized lower till member, 1 m gravel, 7 m oxidized lower till member, 1.5 m unoxidized lower till member; middle Pleistocene Warman Formation, 2.5 m oxidized till; early Pleistocene Stewart Valley sediments, 10.5 m silt, 4 m silt and sand. Preconsolidation pressure and other engineering properties of the Floral Formation till in this core hole were published by Sauer and others (1993a, b)

GSC Wellsch Valley test hole, sec. 3, T. 20, R. 14, W. 3—Late Wisconsin, 4.6 m clay and silt; late Wisconsin Battleford Formation, 3.7 m oxidized till; early Wisconsin Floral Formation, 5.8 m oxidized upper till member; Illinoian Floral Formation, 8.2 m oxidized lower till member, 4.0 m unoxidized lower till member; middle Pleistocene Warman Formation, 1.8 m unoxidized till; early Pleistocene Stewart Valley sediments, 10.7 m silt and sand. The Stewart Valley sediments have reversed remanent

geomagnetic polarity (Barendregt and others, 1998)

13 Swift Current Creek, Sask.—One core hole, one exposure, and one test hole represented by a single symbol on map:

U of S Eagle No. 144A Swift Current Creek core hole, sec. 10, T. 19, R. 13, W. 3—Late Wisconsin, 1 m clay; late Wisconsin Battleford Formation, 5 m oxidized till; early Wisconsin Floral Formation, 10.5 m oxidized upper till member; Illinoian Floral Formation, 5 m sand and gravel, 7 m oxidized lower till member, 3.5 m unoxidized lower till member; middle Pleistocene Warman Formation, 2.5 m silt, 6 m oxidized till; middle Pleistocene Dundurn Formation, 5 m oxidized till; early Pleistocene Stewart Valley sediments, 14 m silt; early Pleistocene or late Pliocene Empress Group, 1 m gravel. The "Swift Current Creek borehole" section in Barendregt (l995) and Barendregt and others (1998) differs markedly from the measured section here; till of the Dundurn Formation was not recognized by those authors

EAC Swift Current Creek exposure, sec. 10, T. 19, R. 13, W. 3—Early Wisconsin Floral Formation, 13.1 m oxidized upper till member; Illinoian Floral Formation, 1.5 m silt, 5.2 m sand and gravel, 2.4 m interbedded till, sand, and gravel, 14.9 m oxidized lower till member; middle Pleistocene Warman Formation, 3.1 m silt, 6.7 m oxidized and unoxidized till; 3.9 m covered interval; early Pleistocene Stewart Valley sediments, 3.1 m silt

SRC Swift Current Creek test hole, sec. 10, T. 19, R. 13, W. 3—Late Wisconsin, 2.7 m clay and silt; late Wisconsin Battleford Formation, 1.5 m oxidized till; early Wisconsin Floral Formation, 11.9 m oxidized upper till member, 0.3 m sand; Illinoian Floral Formation, 9.8 m oxidized lower till member; middle Pleistocene Warman Formation, 3.7 m silt and sand, 4.0 m oxidized till; middle Pleistocene Dundurn Formation, 4.3 m oxidized till; early Pleistocene Stewart Valley sediments, 9.8 m silt. The "Swift Current Creek borehole" section in Barendregt (1995) and Barendregt and others (1998) differs markedly from the measured section here; till of the Dundurn Formation was not recognized by those authors

14 Swift Current Accreditation Hole, sec.19, T. 15, R. 13, W. 3, Sask.—Late Wisconsin(?), 11.3 m sand and silt; late Wisconsin Battleford Formation, 28.4 m unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, weathered zone in 2.4 m oxidized till, 2.7 m unoxidized till, 1.2 m sand, 1.2 m silt and clay, 3.7 m unoxidized till, 2.1 m sand, 3.7 m unoxidized till, 0.6 m cobble gravel and sand, 1.3 m unoxidized till; middle Pleistocene and (or) early Pleistocene Sutherland Group, weathered zone in 0.6 m marly, pebbly, cobbly sand, weathered zone in 4.9 m oxidized till, 0.6 m sand, 4.0 m unoxidized till, 0.6 m sand, 1.8 m unoxidized till, 0.6 m sand, 2.4 m unoxidized till, 0.6 m sand, 1.2 m unoxidized till, 5.5 m sand and silt, 1.2 m unoxidized till; middle Pleistocene and (or) early Pleistocene Empress Group sediments containing scattered reworked glacial erratics, 9.8 m sand, silt, and clay, 5.8 m gravel and sand; Pliocene(?) Empress Group sediments devoid of reworked glacial erratics, 4.9 m silt and sand, 4.0 m gravel, sand, and silt

15 Wascana Creek, Sask.—Two test holes and one exposure represented by a single symbol on map:

SRC Wascana Creek test hole, sec. 29, T. 18, R. 2l, W. 2—Late Wisconsin, 10.7 m clay and silt; late Wisconsin Battleford Formation, 0.8 m oxidized till; middle Pleistocene Dundurn Formation, 9.8 m oxidized upper till member, 2.4 m unoxidized upper till member, 1.2 m sand and gravel, 1.2 m oxidized lower till member, 6.7 m unoxidized lower till member; early Pleistocene Mennon Formation, 3.7 m sand and gravel, 5.8 m unoxidized till; early Pleistocene or late Pliocene Empress Group, 2.1 m silt

EAC Wascana Creek exposure (Westgate and others, 1977; E.A. Christiansen, written commun., 2002), sec. 29, T. 18, R. 21, W. 2—Late

Wisconsin, 6.7 m clay and silt; late Wisconsin Battleford Formation, 2.7 m oxidized till; middle Pleistocene Dundurn Formation, 0.1 m clay (deglacial pond sediment) containing lentils of normal-polarity Lava Creek B ("Wascana Creek") tephra, 5.8 m oxidized upper till member, 10.7 m oxidized and unoxidized upper till member. Six fission-track ages were determined for the tephra (Westgate and others, 1977): four glass ages by John Boellstorff (range 560±80 ka to 670±90 ka), one glass age by J.A. Westgate (600±120 ka), and one zircon age by J.A. Westgate (680±150 ka). See table 2 for discussion of the Lava Creek B tephra

SRC Wascana Creek test hole, sec. 28, T. 18, R. 21, W. 2—Late Wisconsin, 8.2 m silt and clay; late Wisconsin Battleford Formation, 1.5 m oxidized till; middle Pleistocene Warman Formation, 0.9 m sand, 0.9 m oxidized till, 0.9 m gravel, 4.3 m oxidized till, 1.8 m unoxidized till; middle Pleistocene Dundurn Formation, 1.5 m silt and clay (stratigraphic unit that contains the Lava Creek B tephra in the adjacent exposure), 4.3 m unoxidized upper till member, 5.2 m silt, 1.2 m sand, 7.0 m unoxidized lower till member; early Pleistocene Mennon Formation, 5.2 m unoxidized till; early Pleistocene and (or) late Pliocene Empress Group, 18.9 m silt and sand

16 DOE Regina No. 502 test hole, sec. 12, T. 18, R. 20, W. 2, Sask.—Late Wisconsin, 2.1 m clay; late Wisconsin Battleford Formation, 2.1 m oxidized till; late Wisconsin, 0.9 m silt, 19.5 m sand, 8.8 m sand and gravel; early Wisconsin and (or) Illinoian Floral Formation, 9.5 m unoxidized till, 2.1 m silt, 10.4 m sand and gravel, 7.3 m silt and sand; middle Pleistocene Warman Formation, 24.1 m oxidized till; middle Pleistocene Dundurn Formation, 5.5 m oxidized till, 17.1 m unoxidized till, 0.6 m sand, 11.3 m unoxidized till; early Pleistocene Mennon Formation, 6.7 m oxidized till, 6.7 m unoxidized till. The youngest till and the underlying stratified sediments constitute the Condie kame moraine

17 Fort Qu'Appelle, Sask.—One test hole and one exposure represented by a single symbol on map:

SRC Fort Qu'Appelle test hole, sec. 12, T. 21, R. 14, W. 2—Late Wisconsin Battleford Formation, 18.3 m oxidized and unoxidized till; early Wisconsin Floral Formation, 5.5 m oxidized upper till member, 25.6 m unoxidized upper till member; Illinoian Floral Formation, 14.0 m unoxidized lower till member, 4.9 m interbedded till and sand, 2.1 m unoxidized lower till member; middle Pleistocene Echo Lake gravel, 9.8 m sand and gravel; middle Pleistocene Dundurn Formation, 0.6 m unoxidized upper till member, 1.2 m sand and gravel, 21.0 m interbedded till and sand, 4.0 m oxidized lower till member, 11.0 m interbedded till and sand, 4.6 m silt and clay, 23.5 m sand, 13.0 m interbedded till and sand, 1.2 m unoxidized lower till member; early Pleistocene and (or) late Pliocene Empress Group, 9.2 m sand

Bliss gravel pit (Christiansen, 1960, 1972a, 1991; Khan, 1970), sec. 7, T. 21, R. 13, W. 2—Type locality for Fort Qu'Appelle vertebrate local fauna in Echo Lake gravel. Illinoian Floral Formation, 3.1 m lower till member; middle Pleistocene Echo Lake gravel, 4.9 m sand containing pelecypod tests [^{14}C age >34,000 yr B.P. (GSC–987)], 0.3 m gravel (lag deposit), 1.2 m channel gravel containing Rancholabrean vertebrate fossils and woody debris, 14.2 m gravel (augered interval)

18 SRC Fort Qu'Appelle test hole, sec. 17, T. 21, R. 13, W. 2, Sask.—Late Wisconsin, 11.0 m silt and clay; late Wisconsin Battleford Formation, 12.5 m oxidized till; early Wisconsin Floral Formation, 4.0 m oxidized upper till member, 17.4 m unoxidized upper till member; Illinoian Floral Formation, 34.2 m oxidized and unoxidized lower till member; middle Pleistocene Echo Lake gravel, 2.7 m sand and gravel; middle Pleistocene Dundurn Formation, 5.5 m unoxidized till, 0.3 m sand and gravel, 3.7 m unoxidized till, 0.6 m sand and gravel, 1.2 m unoxidized till, 3.7 m sand and silt containing charcoal(?)

fragments, 9.8 m unoxdized till, 6.5 m sand and silt, 3.7 m unoxidized till, 20.0 m sand, silt, and clay, 1.2 m unoxidized till; early Pleistocene and (or) late Pliocene Empress Group, 24.7 m sand containing zones of wood and charcoal, 0.6 m gravel

●19 DOE Yorkton 521 test hole, sec. 26, T. 24, R. 6, W. 2, Sask.—Late Wisconsin Battleford Formation, 3.4 m unoxidized till; early Wisconsin Floral Formation, 12.2 m unoxidized upper till member; Illinoian Floral Formation, 12.5 m unoxidized lower till member; middle Pleistocene Warman Formation, 3.0 m unoxidized till; middle Pleistocene Dundurn Formation, 3.0 m interbedded unoxidized till and silt, 8.2 m unoxidized till, 0.3 m sand, 2.4 m unoxidized till; early Pleistocene Mennon Formation, 5.2 m silt and sand, 1.2 m unoxidized till, 3.0 m sand and silt, 1.5 m unoxidized till.

This section illustrates the difficulty of differentiating superposed unoxidized tills (having no weathering zones) in test hole records and exposures. The upper 31 m of unoxidized till in this record represents four glaciations. In the absence of analytical data, all of the till units in that interval might be inferred to be the product of a single glaciation (some workers might infer that all of the till units and intertill sediments in the section are late Wisconsin in age)

●20 SRC Driscol Lake test hole (Whitaker, 1965), sec. 14, T. 7, R. 13, W. 3, Sask.—Section in a glaciotectonic structure. Pleistocene, 7.6 m oxidized till, 10.7 m unoxidized till, 6.1 m gravel, 3.1 m unoxidized till, 3.1 m silt and clay, 3.1 m sand, 1.8 m silt and clay, 2.4 m unoxidized till, 6.1 m oxidized till, 3.1 m sand, 1.5 m silt and clay, 2.1 m sand, 2.4 m unoxidized till, 8.5 m oxidized till, 2.7 m silt and clay, 3.7 m unoxidized till, 4.8 m oxidized till, 8.5 m silt and clay, 1.5 m sand, 2.1 m silt and clay, 2.1 m sand, 12.8 m silt and clay, 4.0 m sand, 2.4 m oxidized till, 2.4 m sand, 1.8 m oxidized till, 3.1 m unoxidized till, 1.2 m silt and clay, 1.8 m unoxidized till

●21 La Fleche test hole (Whitaker, 1965), sec. 26, T. 9, R. 5, W. 3, Sask.—Section in the Thomson Lake moraine. Pleistocene, 3.1 m oxidized till, 5.2 m sand, 1.2 m silt and clay, 13.4 m sand, 6.4 m silt and clay, 3.1 m unoxidized till, 5.5 m oxidized till, 4.0 m sand, 5.2 m unoxidized till, 1.2 m silt and clay, 12.8 m sand, 2.1 m gravel. The surface till may record a glacial readvance to the position of the Thomson Lake moraine ("phase 4" in table 1)

●22 SRC Ettington test hole (Whitaker, 1965), sec. 10, T. 11, R. 1, W. 3, Sask.—Section in the Ettington moraine ("phase 6" in table 1), 1.5 m oxidized till, 3.1 m silt and clay, 6.1 m oxidized till, 20.1 m unoxidized till, 11.6 m oxidized till, 7.3 m silt and clay, 3.1 m sand

●23 SRC Dirt Hills test hole (Christiansen and Sauer, 1997), sec. 10, T. 11, R. 25, W. 2, Sask.—Section through the Dirt Hills glaciotectonic structure. Late and middle Pleistocene Saskatoon Group, 37 m till, gravel, sand, silt, and clay; middle Pleistocene(?) Sutherland Group, 25 m unoxidized till; early Pleistocene and (or) late Pliocene Empress Group, 9 m silt, sand, and gravel; 40 m glaciotectonically transported bedrock; Sutherland Group (as above), 29 m unoxidized till; Empress Group (as above), 5 m silt, sand, and gravel; 45 m glaciotectonically transported bedrock; Sutherland Group (as above) 21 m unoxidized till; Empress Group (as above), 6 m silt, sand, and gravel; in-place bedrock

●24 Kipling test hole (Dyck and others, 1972), sec. 25, T. 13, R. 6, W. 2, Sask.—Pleistocene, 8.2 m oxidized till, 27.5 m unoxidized till, 8.5 m sand and silt, 23.8 m unoxidized till, 3.4 m pebbly sand and silt, 3.1 m oxidized till, 4.3 m pebbly sand, 0.6 m unoxidized till, 4.6 m silt, 14.6 m interbedded sand, gravel, and silt, 7.9 m clay, 75.2 m sand and silt

●25 SRC Radville test hole, sec. 12, T. 5, R. 18, W. 2, Sask.—Late Wisconsin Battleford Formation, 2.4 m oxidized till; early Wisconsin Floral Formation, 7.0 m oxidized upper till member, 1.5 m sand and gravel, 1.5 m oxidized

and unoxidized upper till member, 1.5 m interbedded till and gravel, 5.5 m oxidized and unoxidized upper till member; Illinoian Floral Formation, 5.2 m interbedded silt and sand, 3.0 m unoxidized lower till member, 11.0 m sand and silt, 6.1 m unoxidized lower till member; middle Pleistocene Dundurn Formation, 3.7 m oxidized till, 4.9 m unoxidized till; early Pleistocene Mennon Formation, 10.1 m oxidized till, 5.5 m unoxidized till, 3.7 m interbedded till, sand, and gravel, 8.5 m unoxidized till; early Pleistocene and (or) late Pliocene Empress Group, 13.7 m sand and gravel

●26 SRC Lake Alma test hole, sec. 28, T. 2, R. 17, W. 2, Sask.—Pleistocene, 9.1 m sand and gravel, 2.4 m unoxidized till, 5.5 m interbedded till and gravel, 2.4 m unoxidized till, 3.7 m gravel, 1.8 m unoxidized till, 1.8 m interbedded till and gravel, 11.6 m unoxidized till, 1.2 m silt, 2.1 m unoxidized till, 0.3 m sand, 0.9 m clay and silt, 1.2 m unoxidized till, 1.2 m silt, 23.5 m unoxidized till, 3.0 m oxidized till

●27 Marienthal, Sask.—Two test holes represented by a single symbol on map:

SRC Marienthal test hole, sec. 9, T. 1, R. 12, W. 2—Late Wisconsin Battleford Formation, 17.7 m unoxidized till; early Wisconsin Floral Formation, 4.3 m unoxidized upper till member, 2.7 m silt and sand; Illinoian Floral Formation, 21.0 m oxidized and unoxidized lower till member, 0.3 m gravel, 1.8 m interbedded till and sand; middle Pleistocene Warman Formation, 4.6 m sand and silt, 3.0 m oxidized till, 2.7 m sand and silt, 5.7 m unoxidized till; middle Pleistocene Dundurn Formation, 27.1 m unoxidized till; middle or early Pleistocene Empress Group, 3.7 m sand and gravel

SRC Marienthal test hole, sec. 4, T. 1, R. 12, W. 2—Late Wisconsin Battleford Formation, 11.0 m oxidized and unoxidized till, 0.9 m sand, 12.8 m unoxidized till, 1.2 m sand and silt, 1.2 m unoxidized till; early Wisconsin and (or) Illinoian Floral Formation, 10.4 m oxidized till, 18.0 m sand and silt, 1.5 m gravel, 3.7 m unoxidized till, 0.6 m gravel, 6.9 m sand and silt, 3.7 m unoxidized till; middle Pleistocene Dundurn Formation, 21.3 m unoxidized till, 0.3 m sand, 0.6 m sand and silt, 18.3 m unoxidized till; early Pleistocene Mennon Formation, 0.9 m silt, 4.3 m sand and gravel, 1.5 m unoxidized till, 1.2 m gravel, 1.2 m unoxidized till, 0.6 m gravel, 2.7 m unoxidized till

●28 Estevan Production Well No. 1 (Dyck and others, 1972), sec. 5, T. 4, R. 9, W. 2, Sask.—Pleistocene, 9.8 m oxidized till, 2.1 m unoxidized till, 3l.4 m bedrock (glaciotectonic raft), 23.5 m unoxidized till, 7.6 m sand and gravel, 5.8 m unoxidized till, 0.6 m gravel, 7.6 m unoxidized till, 11.9 m clay, 3.1 m interbedded sand and clay, 4.0 m sand and gravel, 12.2 m clay, sand, and gravel, 22.9 m sand and gravel

●29 SRC–1 test hole (Christiansen and Parizek, 196l), sec. 5, T. 3, R. 10, W. 2, Sask.—Pleistocene, 3.1 m oxidized till, 28.1 m unoxidized till, weathered zone in 2.4 m sand containing organic zones, 6.1 m unoxidized till, 18.6 m interbedded sand, silt, and clay that yielded a ^{14}C age of 27,750±1,200 yr B.P. (S–96; wood at 12 m depth in the unit), 3.1 m pebbly sand, 4.6 m unoxidized till, 16.5 m interbedded sand, silt, and clay, 7.6 m sand, 10.7 m interbedded sand, silt, and clay, 6.4 m gravel and sand, 2.7 m interbedded sand, silt, and clay, 2.4 m unoxidized till, 0.9 m gravel, 1.2 m kaolinitic weathered zone in till, 0.6 m pebbly sand, >0.3 m unoxidized till. If the ^{14}C age is reliable, glaciotectonic stacking is indicated

●30 SRC–2 test hole (Christiansen and Parizek, 1961), sec. 22, T. 2, R. 10, W. 2, Sask.—Pleistocene, 3.4 m oxidized till, 11.9 m unoxidized till, 0.6 m gravel, 30.5 m unoxidized till, 23.5 m interbedded gravel, sand, and till, 7.6 m unoxidized till, 4.6 m interbedded clay and till, 6.4 m interbedded sand and till, 2.7 m oxidized and unoxidized till, 11.6 m sand and gravel, 3.3 m clay and silt, 7.3 m pebbly sand, 5.2 m clay, 3.4 m sand, 0.6 m cobble and pebble gravel

●31 Alameda Eagle No. 146 test hole, sec. 1, T. 5, R. 4, W. 2, Sask.—Late Wisconsin Battleford Formation, 6.5 m oxidized till; early Wisconsin Floral Formation, 6.5 m oxidized upper till member, 38.0 m unoxidized upper till member; Illinoian Floral Formation, 4.0 m oxidized lower till member; middle Pleistocene Warman Formation, 5.0 m oxidized till; middle Pleistocene Dundurn Formation, 6.0 m unoxidized till, 8.5 m sand and gravel, 5.0 m unoxidized till, 3.0 m clay and silt, 1.5 m gravel, 4.0 m unoxidized till, 1.5 m gravel, 5.0 m unoxidized till. Preconsolidation pressure data and other engineering properties of the Floral Formation till in the test hole were published by Sauer and others (1993a,b)

●32 Oxbow test hole (Dyck and others, 1972), sec. 34, T. 2, R. 2, W. 2, Sask.—Pleistocene, 4.0 m sand and gravel, 3.4 m unoxidized till, 2.4 m sand, 0.6 m unoxidized till, 3.l m sand, 6.l m unoxidized till, 2.4 m sand and gravel, 32.6 m unoxidized till (multiple stratigraphic units?), 2.1 m sand and gravel, 53.4 m unoxidized till (multiple stratigraphic units?), 9.8 m sand and silt, 10.4 m unoxidized till, 31.1 m sand and gravel, 0.6 m silt, 0.9 m unoxidized till, 15.9 m sand and gravel

MONTANA

[Stratigraphic nomenclature of Fullerton and Colton (1986) is retained here on an informal basis, with revision of the temporal framework of the glacial deposits (see table 1). The named (informal) tills are allostratigraphic units, not lithostratigraphic units. The complex subsurface stratigraphy in the buried valley of the ancestral Missouri River in extreme northeastern Montana has not been resolved.]

●33 Loring section, sec. 28, T. 36 N., R. 30 E., Mont.—Stratotype for Loring till and reference section for Markles Point till and Perch Bay till. Late Wisconsin, 1.2 m oxidized and unoxidized Loring till; Pleistocene, 0.6 m truncated paleosol; Illinoian, 1.7 m oxidized and unoxidized Markles Point till; cobble pavement; middle Pleistocene, 3.7 m oxidized upper unit of Perch Bay till, 0.5 m paleosol (humic clay and silt), >0.3 m oxidized lower unit of Perch Bay till

●34 Anderson Ranch section, sec. 5, T. 36 N., R. 32 E., Mont.—Late Wisconsin, 2.8 m unoxidized Loring till; 3.l m covered interval; Pleistocene, 1.2 m cobble and pebble gravel (channel fill inset into older till); Illinoian, 1.2 m unoxidized Markles Point till; middle Pleistocene, 5.5 m oxidized Perch Bay till, 3.7 m unoxidized till of anomalous composition [glaciotectonic raft(?)], 1.8 m oxidized Perch Bay till

●35 South Canal site, secs. 1 and 12, T. 31 N., R. 31 E., Mont.—Composite section from walls of canal. Reference exposures for Markles Point till and Perch Bay till. Late Wisconsin, 1.2 m oxidized and unoxidized lake silt, 0.9 m oxidized and unoxidized Fort Assiniboine till; Pleistocene, 1.5 m sand and gravel replaced laterally by cobble and pebble pavement; Illinoian, 0.9 m oxidized and unoxidized Markles Point till; middle Pleistocene, paleosol in Perch Bay till replaced laterally by boulder and cobble pavement, 2.1 m oxidized upper unit of Perch Bay till, paleosol in 0.3 m sand and gravel, 2.4 m oxidized lower unit of Perch Bay till (Sturgeon Bay till of Fullerton and Colton, 1986); middle or early Pleistocene or late Pliocene, >0.3 m Wiota Gravel

●36 Glasgow Air Force Base site, sec. 17, T. 31 N., R. 40 E., Mont.—Reference exposures for Markles Point till and Perch Bay till. Composite section from abandoned gravel pits and gullies. Pleistocene, 0.9 m eolian sand and silt; Illinoian, 0.9 m oxidized Markles Point till (basal contact sharply truncates ice-wedge casts that penetrate the underlying till units); Pleistocene, 1.8 m cobble and pebble gravel, 0.5 m truncated paleosol; middle Pleistocene, 1.5 m oxidized Perch Bay till, 0.3 m silt and clay, 1.5 m oxidized Perch Bay till, 0.6 m sand and gravel, 0.4 m sand and silt, >2.8 m oxidized Perch Bay till; middle Pleistocene, early Pleistocene, and (or) late Pliocene, 1.5 m truncated soil pendants in indurated stony “calcrete” till or colluvium, 0.3 m loess. A cobble of pink granite from the Canadian Shield was extracted from near the base of the indurated till or colluvium; all

other clasts in that unit were redeposited quartzite, argillite, and chert derived from Miocene gravel exposed nearby

●37 Poplar section, sec. 1, T. 27 N., R. 50 E., Mont.—Reference section for Crazy Horse till, Markles Point till, and Archer till. Holocene and (or) late Wisconsin, 0.6 m pebbly sand and silt; late Wisconsin, 1.2 m oxidized and unoxidized Crazy Horse till; Illinoian, 2.1 m oxidized Markles Point till; middle Pleistocene, >3.1 m oxidized upper unit of Archer till

●38 MBMG drill hole 85–18 (Donovan and Bergantino, 1987), sec. 6, T. 28 N., R. 52 E., Mont.—Late Wisconsin, 0.6 m gravel, 2.5 m unoxidized Crazy Horse till; Pleistocene, 0.3 m gravel; middle Pleistocene, 5.8 m oxidized Archer till, 1.8 m oxidized and unoxidized clay and silt, 1.5 m oxidized Archer till, 6.l m oxidized and unoxidized Sprole Silt; middle or early Pleistocene, 8.2 m Wiota Gravel. The two units of Archer till may represent two glaciations

●39 MBMG drill hole 85–21–A (Donovan and Bergantino, 1987), sec. 30, T. 28 N., R. 52 E., Mont.—Holocene, 3.l m oxidized sheetwash alluvium(?); Pleistocene, 0.6 m sand and gravel; Illinoian, 2.5 m oxidized Markles Point till; Pleistocene, 0.6 m oxidized and unoxidized silt and sand; middle Pleistocene, 4.9 m oxidized Archer till, 12.2 m oxidized sand, silt, and clay, 1.8 m oxidized and unoxidized Archer till, 6.l m unoxidized clay, 1.5 m interbedded unoxidized Archer till, clay, silt, and sand, 15.9 m unoxidized Sprole Silt; middle or early Pleistocene, 2.7 m Wiota Gravel. The two units of Archer till may represent two glaciations

●40 Two drill holes (Donovan and Bergantino, 1987) represented by a single symbol on map:

MBMG drill hole 84–28A, sec. 35, T. 29 N., R. 52 E., Mont.—Late Wisconsin, 4.9 m oxidized and unoxidized Crazy Horse till; Pleistocene, 0.6 m oxidized and unoxidized clay; Illinoian, 1.8 m oxidized Markles Point till; middle Pleistocene, 5.2 m oxidized and unoxidized clay, 5.5 m unoxidized Archer till, 0.6 m unoxidized clay and silt, 2.6 m unoxidized Archer till; middle or early Pleistocene, 1.5 m Wiota Gravel

MBMG drill hole 84–30A, sec. 6, T. 28 N., R. 53 E., Mont.—Holocene and (or) late Wisconsin, 2.5 m sand; late Wisconsin, 5.3 m oxidized and unoxidized Crazy Horse till; Pleistocene, 1.5 m sand and gravel, 0.3 m peat; Illinoian, 6.4 m unoxidized Markles Point till; middle Pleistocene, 0.9 m peat, clay, and sand; 4.3 m unoxidized Archer till, 1.1 m unoxidized clay, 2.0 m unoxidized Archer till, 3.1 m sand; middle or early Pleistocene, 1.7 m Wiota Gravel

●41 MBMG drill hole 83–1 (Donovan and Bergantino, 1987), sec. 1, T. 29 N., R. 53 E., Mont.—Section in a buried glaciotectonic structure. Pleistocene, 2.4 m oxidized till, 3.7 m oxidized till (different till), 6.7 m unoxidized till, 7.0 m unoxidized sand, 0.6 m Wiota Gravel, 4.l m bedrock, 3.2 m unoxidized till, 2.1 m unoxidized clay, 1.2 m bedrock or sand, 12.8 m bedrock, 12.8 m unoxidized till

●42 MBMG drill hole 83–4A (Donovan and Bergantino, 1987), sec. 16, T. 30 N., R. 55 E., Mont.—Section in a buried glaciotectonic structure. Pleistocene, 5.5 m sand, 0.3 m "coal" (bedrock?), 3.4 m sand, 3.1 m gravel and sand, 4.6 m oxidized sand. 3.7 m oxidized till, 0.9 m "coal" (bedrock?), 2.l m sand, 1.5 m gravel and sand, 2.4 m sand, 4.3 m bedrock, 8.8 m sand and gravel, 5.6 m bedrock, 3.8 m gravel

●43 USGS Medicine Lake test hole (Swenson, 1955), sec. 28, T. 31 N., R. 56 E., Mont.—Section in a buried glaciotectonic structure. Pleistocene, 1.5 m gravel, 15.8 m oxidized and unoxidized till, 3.7 m sand and clay, 2.7 m unoxidized till, 3.3 m bedrock, 1.5 m oxidized till, 24.1 m unoxidized clay, 4.3 m unoxidized till, 0.9 m boulder gravel, 18.0 m unoxidized till, 2.4 m boulder gravel, 5.8 m interbedded unoxidized till and gravel, 20.7 m bedrock, 4.0 m oxidized and unoxidized till

●44 Kisler Butte section, sec. 10, T. 34 N, R. 54 E., Mont.—Reference section for Crazy Horse till, Kisler Butte till, and Archer till. Holocene and (or) late Wisconsin, 0.3 m eolian sand and silt; late Wisconsin, 1.8 m oxidized

and unoxidized Crazy Horse till; Illinoian, 0.9 m oxidized Kisler Butte till, pavement of cobbles and boulders, 1.4 m oxidized and unoxidized Kisler Butte till; middle Pleistocene, cobble and boulder pavement; 0.8 m oxidized lacustrine sand and silt, 1.8 m gravel, 3.7 m oxidized Archer till, 1.8 m gravel

NORTH DAKOTA

[Formal stratigraphic nomenclature from stratigraphic sections farther east (Ulmer and Sackreiter, 1973; Hobbs and Bluemle, 1987) has not been extended to the region north of the Missouri River in the North Dakota portion of the Regina 4° x 6° quadrangle. The complex subsurface stratigraphy in the buried valleys of the ancestral Missouri, Yellowstone, and Little Missouri Rivers (recorded in many of the stratigraphic sections) has not been resolved. Most of the test-hole sections probably are more complex than is indicated in the logs. The complexity of the subsurface stratigraphy indicates that till units of middle Pleistocene and early Pleistocene age, identified in adjacent Saskatchewan, also are present in northwestern North Dakota.]

●45 USGS test hole 3026 (Armstrong, 1965), sec. 2, T. 160 N., R. 103 W., N. Dak.—Pleistocene, 10.7 m oxidized and unoxidized till, 8.2 m unoxidized till, 3.0 m gravel, 3.0 m unoxidized clay, 12.2 m sand and gravel, 5.5 m unoxidized till, 4.9 m unoxidized silt, clay, and sand, 2.1 m unoxidized till, 7.9 m organic(?) silt, 13.4 m unoxidized till, 42.7 m unoxidized silt, clay, and sand, 0.7 m gravel, 2.7 m unoxidized silt and clay, 0.9 m Wiota Gravel

●46 USGS test hole 3005 (Armstrong, 1965), sec. 18, T. 160 N., R. 102 W., N. Dak.—Holocene or Pleistocene, 1.8 m gravel; Pleistocene, 2.4 m oxidized till, 2.1 m oxidized and unoxidized till, 3.7 m unoxidized till, 3.4 m gravel, 4.3 m unoxidized silt and clay, 6.7 m unoxidized sand and silt, 0.9 m boulders, 0.9 m unoxidized silt, 4.3 m unoxidized till, 0.7 m sand, 1.2 m organic(?) silt (slough or swamp deposit?), 0.7 m sand and gravel, 19.8 m unoxidized till, 4.0 m unoxidized silt and clay, 0.1 m sand and gravel, 11.9 m organic(?) silt, 6.7 m Wiota Gravel

●47 USGS test hole 3028 (Armstrong, 1965), sec. 3, T. 160 N., R. 102 W., N. Dak.—Pleistocene, 7.9 m oxidized till, 4.3 m unoxidized till, 18.9 m unoxidized till (different till), 1.2 m gravel, 8.5 m unoxidized till, 5.5 m oxidized and unoxidized till, 0.6 m gravel, 40.6 m unoxidized till (multiple stratigraphic units?), 0.9 m gravel and sand containing wood fragments, 5.5 m unoxidized silt, 13.4 m bedrock (glaciotectonic raft), 5.2 m sand and silt, 3.7 m Wiota Gravel

●48 USGS test hole 2248 (Armstrong, 1965), sec. 9, T. 161 N., R. 102 W., N. Dak.—Section in glaciotectonic structure. Holocene or Pleistocene, 1.2 m gravel; Pleistocene, 9.4 m oxidized till, 135.6 m bedrock (glaciotectonic raft), 1.5 m gravel, 15.6 m unoxidized clay, bedrock, and till

●49 USGS test hole 3004 (Armstrong, 1965), sec. 35, T. 161 N., R. 101 W., N. Dak.—Holocene or Pleistocene, 3.1 m gravel and sand; Pleistocene, 6.1 m unoxidized till, 1.5 m oxidized till, 5.5 m unoxidized till, 8.2 m silt and clay containing organic zones, 0.3 m gravel, 0.6 m bedrock (glaciotectonic raft), 2.7 m unoxidized till

●50 USGS Fortuna test hole 3075 (Armstrong, 1965), sec. 35, T. 163 N., R. 101 W., N. Dak.—Pleistocene, 9.8 m oxidized till, 4.6 m unoxidized till, 7.6 m sand, 1.2 m unoxidized till, 4.3 m sand and silt, 3.0 m interbedded unoxidized till, gravel, and sand, 18.3 m interbedded unoxidized sand, silt, and clay, 9.1 m unoxidized clay and silt, 4.0 m unoxidized till, 2.7 m sand and gravel, 0.7 m unoxidized till, 7.6 m sand, 28.0 m unoxidized till (multiple stratigraphic units?), 2.7 m sand, 89.0 m unoxidized till (multiple stratigraphic units?)

●51 USGS Colgan test hole 3076 (Armstrong, 1965), sec. 13, T. 163 N., R. 100 W., N. Dak.—Pleistocene, 13.7 m oxidized and unoxidized till, 8.5 m unoxidized till, 2.1 m gravel and sand, 18.3 m unoxidized till, 4.5 m gravel and sand, 7.6 m unoxidized till, 13.1 m interbedded unoxidized till, gravel, and sand, 50.9 m unoxidized till (multiple stratigraphic units?)

●52 Two test holes (Armstrong, 1965) represented by a single symbol on map:

USGS test hole 3019, sec. 4, T. 163 N., R. 97 W., N. Dak.—Holocene or Pleistocene, 0.6 m gravel; Pleistocene, 1.2 m oxidized till, 0.7 m gravel and sand, 1.2 m oxidized and unoxidized till, 10.3 m unoxidized till, 4.0 m oxidized and unoxidized till, 1.5 m gravel and sand, 22.9 m oxidized and unoxidized till, 9.4 m unoxidized till (different till?), 3.7 m gravel, 0.7 m unoxidized till, 0.7 m unoxidized silt and sand, 1.8 m gravel and sand

USGS test hole 3024, sec. 3, T. 163 N., R. 97 W., N. Dak.—Holocene or Pleistocene, 6.1 m gravel, 3.1 m unoxidized silt; Pleistocene, 5.8 m unoxidized till, 8.8 m oxidized till, 6.7 m oxidized and unoxidized till, 0.6 m gravel, 12.2 m oxidized till, 2.1 m oxidized silt, 2.7 m gravel, 6.7 m oxidized and unoxidized till, 3.1 m oxidized silt, 0.6 m oxidized till, 0.1 m gravel, 2.4 m oxidized till, 23.5 m unoxidized till, 21.4 m unoxidized sand and silt, 8.8 m unoxidized till, 1.8 m gravel

●53 USGS Crosby test hole 3017 (Armstrong, 1965), sec. 30, T. 163 N., R. 97 W., N. Dak.—Holocene or Pleistocene, 3.7 m gravel; Pleistocene, 0.3 m oxidized till, 3.4 m unoxidized till, 1.2 m sand, gravel, and clay, 6.7 m unoxidized till, 18.3 m oxidized and unoxidized till, 6.1 m unoxidized clay, 4.9 m unoxidized till, 4.3 m sand, 3.l m organic silt, 9.2 m unoxidized till

●54 Two test holes (Armstrong, 1965) represented by a single symbol on map:

NDWC test hole 1530, sec. 19, T. 162 N., R. 97 W., N. Dak.—Pleistocene, 5.8 m oxidized till, 9.4 m oxidized till (different till), 6.1 m unoxidized till, 2.4 m silt and sand, 0.6 m gravel, 2.4 m silt or sand, 4.3 m unoxidized till, 3.7 m gravel, 5.8 m unoxidized till, 4.9 m gravel, 4.3 m unoxidized till, 62.4 m unoxidized till (different till; multiple stratigraphic units?), 5.5 m gravel and sand, 1.8 m indurated boulder gravel

USGS Test hole 3089, sec. 25, T. 162 N., R. 98 W., N. Dak.—Holocene and (or) Pleistocene, 9.1 m oxidized silt and sand; Pleistocene, 9.8 m oxidized till, 15.8 m unoxidized till, 4.9 m sand, 10.1 m unoxidized till, 20.4 m unoxidized silt, 3.0 m unoxidized till, 6.1 m gravel, 46.0 m unoxidized till (multiple stratigraphic units?), 13.l m unoxidized silt and sand

●55 USGS test hole 3033 (Armstrong, 1965), sec. 33, T. 161 N., R. 99 W., N. Dak.—Pleistocene, 2.7 m oxidized till, 1.5 m oxidized gravel, 4.6 m unoxidized till, 2.4 m oxidized till, 2.1 m interbedded till, sand, and gravel, 35.7 m till, silt, and sand, 8.5 m unoxidized till, 9.2 m unoxidized silt, 6.7 m unoxidized sand, 20.7 m clay, silt, and sand containing fragments of wood, 39.7 m bedrock(glaciotectonic raft), 17.1 m till, 3.7 m unoxidized silt, sand, and clay

●56 USGS test hole 3016 (Armstrong, 1965), sec. 3, T. 160 N., R. 99 W., N. Dak.—Holocene and (or) Pleistocene, 0.9 m silt; Pleistocene, 2.1 m oxidized till, 4.0 m oxidized and unoxidized till (different till), 3.1 m unoxidized silt and sand, 9.8 m unoxidized till, 6.1 m bedrock (glaciotectonic raft), 1.5 m unoxidized till, 16.8 m sand, 13.7 m unoxidized till, 16.2 m unoxidized sand and silt, 2.1 m sand and gravel, 3.4 m unoxidized silt and sand, 2.7 m sand and gravel, 9.5 m unoxidized till, 19.5 m gravel, 1.2 m bedrock (glaciotectonic raft), 6.4 m gravel, 3.4 m unoxidized till, 3.1 m gravel, 9.5 m clay, 14.3 m gravel, 16.8 m unoxidized till and blocks of bedrock, 1.5 m gravel, 1.2 m silt

●57 Appam test hole (Armstrong, 1967), sec. 23, T. 159 N., R. 100 W., N. Dak.—Pleistocene, 11.6 m oxidized and unoxidized till, 9.2 m gravel, 1.5 m oxidized and unoxidized till, 25.3 m unoxidized till, 3.4 m unoxidized clay, 2.7 m unoxidized till, 17.1 m gravel, 18.0 m unoxidized till, 3.4 m unoxidized clay, 19.5 m unoxidized till

●58 USGS test hole 3002 (Armstrong, 1965), sec. 13, T. 160 N., R. 97 W., N. Dak.—Holocene and (or) Pleistocene, 13.1 m oxidized and unoxidized sand and silt; 1.8 m unoxidized till, 2.1 m unoxidized silt, 6.1 m sand and gravel, 8.2 m unoxidized till, 0.9 m gravel, 2.1 m unoxidized till, 2.1 m organic silt containing mollusc tests, 5.2 m

oxidized till (middle Pleistocene Medicine Hill Fm?)

●59 USGS Wildrose test hole 3003 (Armstrong, 1965), sec. 36, T. 160 N., R. 97 W., N. Dak.—Holocene and (or) Pleistocene, 9.8 m oxidized and unoxidized clay, silt, and sand; Pleistocene, 13.4 m unoxidized till, 6.1 m gravel, 7.0 m unoxidized till, 0.6 m gravel, 5.5 m unoxidized till, 0.6 m unoxidized silt, 0.9 m gravel, 1.2 m unoxidized till, 0.3 m gravel, 4.9 m unoxidized till, 0.3 m gravel, 23.2 m unoxidized till, 13.4 m unoxidized sand and silt, 1.8 m "Wiota gravel." The clast composition of the "Wiota gravel" in the buried Yellowstone River valley differs from that of the Wiota Gravel in the buried Missouri River valley (Howard, 1960). The "Wiota gravel" here is the Cartwright Gravel of Howard (1960)

●60 Test hole (Armstrong, 1967), sec 7, T. 158 N., R. 98 W., N. Dak.—Pleistocene, 12.5 m oxidized and unoxidized till, 4.3 m unoxidized till, 14.0 m sand and clay, 4.6 m unoxidized till, 3.4 m unoxidized silt, 1.5 m oxidized clay, 13.7 m oxidized till (middle Pleistocene Medicine Hill Formation?), 9.4 m unoxidized till, 3.4 m interbedded till and gravel, 4.3 m gravel and sand, 5.2 m unoxidized clay, 7.3 m sand and gravel, 5.5 m unoxidized till, 7.3 m gravel

●61 Test hole 3304 (Armstrong, 1967), sec. 22, T. 158 N., R. 97 W., N. Dak.—Holocene or Pleistocene, 1.5 m gravel; Pleistocene, 2.7 m oxidized till, 12.8 m oxidized till (different till), 4.6 m unoxidized sand, 3.7 m unoxidized till, 8.8 m interbedded unoxidized till and gravel, 14.9 m unoxidized till, 4.0 m sand and gravel

●62 Test hole (Armstrong, 1967), sec. 3, T. 157 N., R. 97 W., N. Dak.—Holocene or Pleistocene, 0.6 m sand; Pleistocene, 3.7 m oxidized till, 3.0 m oxidized till (different till), 4.6 m unoxidized clay, 1.5 m unoxidized sand, 2.1 m oxidized till, 8.5 m unoxidized clay, 19.2 m unoxidized till, 12.8 m sand

●63 Test hole (Armstrong, 1967), sec. 21, T. 157 N., R. 97 W., N. Dak.—Pleistocene, 6.4 m oxidized and unoxidized till, 5.5 m unoxidized silt, 3.0 m unoxidized clay, 17.7 m oxidized and unoxidized till, 0.9 m gravel, 5.8 m unoxidized till, 0.9 m gravel, 1.8 m unoxidized till, 21.0 m sand and gravel

●64 NDSWC well T48W (North Dakota State Water Conservation Commission, unpub. data, 1996), sec. 1, T. 155 N., R. 97 W., N. Dak.—Pleistocene, 1.8 m oxidized till, 9.4 m oxidized till (different till), 7.9 m sand and gravel, 1.5 m oxidized till, 1.5 m gravel, 3.0 m oxidized till, 5.5 m gravel and sand

●65 Two test holes (Armstrong, 1969) represented by a single symbol on map:

NDSWC Columbus test hole, sec. 19, T. 163 N., R. 93 W., N. Dak.—Pleistocene, 3.4 m oxidized till, 28.4 m unoxidized till (multiple stratigraphic units?), 0.6 m sand, 8.2 m unoxidized till, 55.2 m unoxidized clay, silt, and sand, 11.0 m unoxidized till, 1.5 m gravel, 7.3 m unoxidized till, 20.7 m oxidized and unoxidized till

USGS Columbus test hole, sec. 20, T. 163 N, R. 93 W. N. Dak.—Pleistocene, 9.6 m oxidized till, 3.0 m gravel, 2.4 m oxidized clay and silt, 5.5 m gravel, 15.6 m unoxidized till, 4.9 m unoxidized silt, 1.5 m gravel, 1.8 m silt and sand, 4.9 m sand, 11.3 m unoxidized till, 0.9 m gravel, 7.9 m unoxidized clay, 1.2 m gravel, 2.1 m clay and sand, 2.1 m sand and boulders, 2.7 m gravel, 7.3 m unoxidized till, 5.5 m unoxidized till containing inclusions of organic material, 16.8 m unoxidized organic clay (swamp deposit?) (also see "Important Stratigraphic Sections," #80), 7.9 m sand and pebbly sand, 1.2 m unoxidized clay, silt, and sand, 11.3 m gravel, 4.3 m sand, 14.9 m gravel

●66 USGS Portal test hole (Armstrong, 1969), sec. 14, T. 163 N., R. 92 W., N. Dak.—Pleistocene, 2.4 m oxidized till, 15.2 m oxidized and unoxidized till, 12.2 m unoxidized till, 2.4 m unoxidized silt and clay, 18.3 m unoxidized till, 21.6 m unoxidized clay and silt containing lenses of sand and gravel, 12.8 m unoxidized till, 3.4 m unoxidized clay, 14.0 m unoxidized till, 2.4 m gravel, 7.6 m unoxidized till

●67 USGS Portal test hole (Armstrong, 1969), sec. 4, T. 163 N., R. 91 W., N. Dak.—Pleistocene, 0.9 m oxidized till, 5.8 m oxidized till, 0.9 m unoxidized organic clay and silt (slough or marsh deposit), 2.1 m oxidized sand, 8.5 m unoxidized till, 9.1 m unoxidized till, 22.3 m unoxidized till, 6.4 m unoxidized till (four different tills), 1.5 m gravel, 1.8 m unoxidized clay, silt, and sand, 1.2 m gravel, 14.3 m unoxidized till, 7.0 m unoxidized sand, 1.8 m unoxidized silt, 24.7 m unoxidized till, 4.9 m gravelly sand, 11.0 m sandy clay and clay containing lenses of sand and gravel, 2.1 m oxidized and unoxidized sand, 1.2 m sandy clay, 3.4 m unoxidized till, 1.5 m cobbles and boulders

●68 USGS Flaxton test hole (Armstrong, 1969), sec. 30, T. 163 N., R. 90 W., N. Dak.—Pleistocene, 4.9 m oxidized till, 3.4 m oxidized till (two different tills), 21.0 m unoxidized till, 1.8 m gravel, 2.1 m unoxidized till, 0.9 m gravel, 3.7 m unoxidized silt, sand, and clay, 1.8 m cobble gravel, 6.7 m unoxidized till, 1.5 m unoxidized sand, 12.2 m unoxidized till

●69 USGS test hole (Armstrong, 1969), sec. 10, T. 161 N., R. 93 W., N. Dak.—Pleistocene, 2.1 m oxidized till, 3.4 m oxidized till (two different tills), 0.9 m gravel, 3.7 m oxidized till, 13.4 m unoxidized till, 16.2 m gravel, 11.9 m unoxidized till, 1.5 m gravel, 15.2 m unoxidized till

●70 USGS test hole (Armstrong, 1969), sec. 35, T. 161 N., R. 92 W., N. Dak.—Holocene or Pleistocene, 9.6 m gravel; Pleistocene, 6.1 m unoxidized till, 0.6 m gravel, 1.8 m unoxidized till, 0.9 m gravel, 2.7 m unoxidized till, 3.0 m gravel, 10.4 m sand, 6.1 m oxidized till, 1.8 m unoxidized clay, 2.1 m unoxidized till, 0.9 m gravel

●71 NDSWC Petella test hole (Armstrong, 1969), sec. 8, T. 162 N., R. 89 W., N. Dak.—Holocene or Pleistocene, 0.9 m sandy clay; Pleistocene, 3.0 m oxidized till, 7.3 m unoxidized till, 3.7 m gravel, 52.1 m unoxidized till (multiple stratigraphic units?), 3.4 m unoxidized sand, 6.7 m unoxidized till, 3.4 m oxidized till, 22.0 m unoxidized till, 2.4 m oxidized till, 19.8 m oxidized and unoxidized till

●72 USGS test hole (Armstrong, 1969), sec. 36, T. 163 N, R. 89 W., N. Dak.—Holocene or Pleistocene, 3.0 m sand; Pleistocene, 5.8 m oxidized till, 3.7 m oxidized and unoxidized till (different till), 2.1 m unoxidized sand, 5.5 m unoxidized till, 3.7 m sand and gravel, 58.8 m unoxidized till (multiple stratigraphic units?), 1.5 m gravel, 11.3 m unoxidized till, 1.2 m sand, 7.6 m unoxidized till, 2.4 m unoxidized clay, 4.9 m unoxidized, interbedded silt and clay, 7.3 m unoxidized silt and sand

●73 USGS test hole (Armstrong, 1969), sec. 25, T. 162 N., R. 89 W., N. Dak.—Pleistocene, 10.1 m oxidized and unoxidized till, 0.6 m gravel, 5.5 m oxidized till, 6.7 m unoxidized till, 3.4 m bedrock (glaciotectonic raft), 4.0 m unoxidized till, 1.2 m gravel, 0.9 m sand, 4.6 m unoxidized till

●74 NDSWC test hole (Armstrong, 1969), sec. 31, T. 162 N., R. 88 W., N. Dak.—Holocene or Pleistocene, 0.6 m oxidized and unoxidized sandy clay; Pleistocene, 2.1 m oxidized till, 3.7 m sand, 18.9 m unoxidized till, 3.4 m oxidized till, 11.6 m unoxidized till, 0.9 m gravel, 6.7 m unoxidized till, 7.6 m gravel and boulders, 6.7 m oxidized till, 29.0 m unoxidized till

●75 USGS Bowbells test hole (Armstrong, 1969), sec. 13, T. 161 N., R. 90 W., N. Dak.—Holocene or Pleistocene, 2.4 m silt; Pleistocene, 3.0 m sand and gravel, 4.3 m oxidized and unoxidized clay and silt, 2.7 m unoxidized till, 2.1 m gravel, 2.7 m unoxidized clay and silt containing lenses of gravel, 2.4 m unoxidized till, 2.4 m sand, 14.9 m alternating beds of gravel and unoxidized clay (some or all of the clay may be till), 12.2 m alternating beds of sand and clay, 4.9 m alternating beds of gravel and clay, 4.6 m alternating beds of sand and clay, 9.6 m alternating beds of silt and sand containing carbonaceous material, 17.5 m unoxidized till, 3.0 m unoxidized clay, 6.1 m alternating beds of unoxidized sand and silt, 3.7 m sand, 5.5 m gravel, 2.7 m unoxidized clay, 1.2 m sand, 1.8 m lignite and 11.0 m other bedrock

(glaciotectonic raft), 18.9 m sand and (or) silt, 2.1 m clay, 9.6 m sand and (or) silt, 1.8 m gravel, 1.5 m sand, 0.9 m clay, 1.5 m sand

●76 NDSWC Bowbells test hole (Armstrong, 1969), sec. 16, T. 161 N., R. 89 W., N. Dak.—Holocene or Pleistocene, 1.2 m oxidized clay; Pleistocene, 5.2 m oxidized till, 3.7 m sand, 0.6 m sand and gravel, 7.6 m unoxidized till, 1.2 m gravel, 4.6 m unoxidized till, 4.6 m sand and gravel, 1.5 m unoxidized till, 2.7 m sand and gravel, >21.3 m unoxidized till (multiple stratigraphic units?)

●77 Two test holes (Pettyjohn, 1968) represented by a single symbol on map:

USGS Kenmare test hole 3335, sec. 19, T. 160 N., R. 88 W., N. Dak.—Pleistocene, 10.1 m oxidized (and unoxidized?) till, 2.1 m sand, 1.8 m oxidized till, 30.8 m unoxidized till (multiple stratigraphic units?), 22.9 m unoxidized till and interbedded till and gravel, 7.0 m interbedded unoxidized till and sand, 1.5 m sand, 1.5 m unoxidized till, 2.1 m sand, 0.9 m unoxidized till, 2.4 m sand, 7.9 m unoxidized till, 3.4 m sand, 10.1 m interbedded gravel and clay, 3.4 m unoxidized till, 2.8 m gravel, 4.9 m oxidized till, 9.5 m oxidized till (different till?), 7.0 m unoxidized till

USGS test hole 3341, sec. 19, T. 160 N., R. 88 E., N. Dak.—Holocene or Pleistocene, 2.1 m sand; Pleistocene, 3.0 m oxidized till, 20.1 m unoxidized till, 1.2 m gravel, 9.1 m sand, 1.8 m oxidized till, 4.9 m sand and gravel, 10.1 m unoxidized till, 3.0 m gravel, 19.8 m unoxidized till, 6.1 m sand, 0.6 m silt and clay, 3.0 m sand, >12.5 m gravel and boulders

●78 USGS test hole (Armstrong, 1969), sec. 13, T. 160 N., R. 91 W., N. Dak.—Pleistocene, 1.2 m oxidized till, 5.8 m oxidized silty clay and sandy clay, 7.0 m oxidized till, 6.4 m unoxidized till, 4.3 m sand, 8.8 m unoxidized till, 1.2 m sand, 14.9 m unoxidized till, 2.7 m sand, 7.0 m unoxidized till, 14.3 m sand and gravel, 5.5 m unoxidized silty clay and sandy clay, 1.2 m sand, 1.5 m unoxidized silty clay, 8.5 m unoxidized till, 3.4 m gravel, 1.2 m marl(?), 10.4 m gravelly sand, 4.0 m gravel, boulder at base

●79 USGS Powers Lake test hole (Armstrong, 1969), sec. 2, T. 158 N., R. 93 W., N. Dak.—Holocene and (or) Pleistocene, 1.2 m oxidized silt; Pleistocene, 4.9 m oxidized till, 5.5 m oxidized till (different till), 4.0 m gravel, 3.4 m truncated calcic paleosol(?) in oxidized till (also see "Important Stratigraphic Sections," #82), 8.5 m unoxidized till, 5.2 m unoxidized silt and sand, 1.8 m unoxidized silt and clay, 1.5 m gravel

●80 USGS Cottonwood Lake test hole (Armstrong, 1969), sec. 16, T. 157 N., R. 92 W., N. Dak.—Holocene or Pleistocene, 6.1 m oxidized clayey, gravelly silt, 3.0 m gravel; Pleistocene, 26.8 m unoxidized till (multiple stratigraphic units?), 28.4 m organic clay that has a strong odor (swamp deposit) (also see "Important Stratigraphic Sections," #65), 26.5 m unoxidized till (multiple stratigraphic units?), 2.4 m bedrock inclusions and unoxidized till, 4.9 m unoxidized till

●81 USGS Stanley test hole (Armstrong, 1969), sec. 23, T. 156 N., R. 92 W., N. Dak.—Pleistocene, 9.1 m oxidized till, 1.2 m sand, 5.2 m gravel, 1.5 m unoxidized till, 3.4 m gravel, 2.1 m oxidized and unoxidized till, 1.5 m oxidized sand containing carbonaceous zones, 1.5 m humic clay paleosol containing fragments of wood (also see "Important Stratigraphic Sections," #83), 4.9 m unoxidized till, 2.1 m oxidized till, 11.0 m oxidized and unoxidized till

●82 Three test holes (Armstrong, 1969) represented by a single symbol on map:

USGS test hole, sec. 5, T. 156 N., R. 91 W., N. Dak.—Pleistocene, 7.9 m oxidized and unoxidized till, 3.7 m oxidized till, 3.7 m oxidized till (different till), 13.7 m unoxidized till, 5.5 m truncated calcic paleosol(?) in oxidized till (also see "Important Stratigraphic Sections," #79), 7.0 m unoxidized till, 0.6 m bedrock (glaciotectonic raft), 15.9 m unoxidized till

USGS test hole, sec. 5, T. 156 N., R. 91 W., N. Dak.—Pleistocene, 3.7 m oxidized till, 3.4 m unoxidized till, 10.7 m unoxidized interbedded silt and

sandy clay, 5.5 m unoxidized till, 2.1 m unoxidized sand, 10.4 m unoxidized till, 3.4 m unoxidized silty clay, 17.1 m unoxidized till, 5.5 m gravel, 47.0 m unoxidized till (multiple stratigraphic units?)

USGS testhole, sec. 10, T. 156 N., R. 91 W., N. Dak.—Pleistocene, 1.8 m oxidized till, 14.3 m oxidized silt and sand, 5.5 m unoxidized sand, silt, and clay, 2.1 m unoxidized clay, 8.9 m unoxidized clay, silt, and sand, 1.8 m sand, 5.2 m gravel, 3.7 m unoxidized till, 34.5 m unoxidized till (multiple stratigraphic units?), 11.0 m unoxidized till, 3.4 m unoxidized sand, 1.5 m unoxidized till, 3.0 m sand and gravel

●83 USGS test hole (Armstrong, 1969), sec. 3, T. 155 N., R. 90 W., N. Dak.—Pleistocene, 2.7 m oxidized till, 10.7 m oxidized till, 51.5 m unoxidized till containing a horizon of peaty clay, roots, and small fragments of wood (a paleosol between two till units) (also see "Important Stratigraphic Sections," #81), 2.1 m sand

●84 USGS test hole (Armstrong, 1969), sec. 15, T. 154 N., R. 89 W., N. Dak.—Pleistocene, 11.3 m oxidized till, 3.0 m unoxidized till, 1.5 m gravel, 2.1 m unoxidized till, 1.5 m bedrock (glaciotectonic raft), 1.8 m unoxidized sand, 2.7 m gravel

●85 USGS test hole (Armstrong, 1969), sec. 7, T. 153 N., R. 70 W., N. Dak.—Pleistocene, 4.3 m oxidized till, 5.2 m oxidized till, 2.1 m gravel, 6.1 m oxidized till, 7.6 m unoxidized till, 1.5 m gravel, 8.6 m bedrock (glaciotectonic raft), 28.1 m unoxidized till (multiple stratigraphic units?)

SOURCES OF INFORMATION

[Also see "Supplementary References"]

MONTANA

Alden, W.C., 1924, Physiographic development of the northern Great Plains: Geological Society of America Bulletin, v. 35, p. 385–424.

Alden, W.C., 1932, Physiography and glacial geology of eastern Montana and adjacent areas: U.S. Geological Survey Professional Paper 174, 133 p.

Bauer, C.M., 1915, A sketch of the late Tertiary history of the upper Missouri River: Journal of Geology, v. 23, p. 52–58.

Bergantino, R.N., 1984, Topographic map of the bedrock surface, northeastern Montana, northwestern North Dakota, and southeastern Saskatchewan: Montana Bureau of Mines and Geology Open-File Report MBMG 151, scale 1:250,000.

Bretz, J.H., 1943, Keewatin end moraines in Alberta, Canada: Geological Society of America Bulletin, v. 54, p. 31–52.

Christiansen, E.A., 1979, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas: Canadian Journal of Earth Sciences, v. 16, p. 913–938.

Clayton, Lee, and Moran, S.R., 1982, Chronology of late Wisconsinan glaciation in middle North America: Quaternary Science Reviews, v. 1, p. 55–82.

Collier, A.J., 1919, Geology of northeastern Montana: U.S. Geological Survey Professional Paper 120–B, p. 17–39.

Collier, A.J., and Thom, W.T., Jr., 1918, The Flaxville gravel and its relation to other terrace gravels of the northern Great Plains: U.S. Geological Survey Professional Paper 108–J, p. 179–184.

Colton, R.B., 1951, Geology of the Oswego quadrangle, Montana: U.S. Geological Survey Open-File Report 101, 45 p.

Colton, R.B., 1955, Geology of the Wolf Point quadrangle, Montana: U.S. Geological Survey Geologic Quadrangle Map GQ–67, scale 1:62,500.

Colton, R.B., 1958, Ice-crack moraines in northwestern North Dakota and northeastern Montana, in Guidebook, Ninth Annual Field Conference, Mid-Western Friends of the Pleistocene: North Dakota Geological Survey Miscellaneous Series 10, p. 99–107.

Colton, R.B., 1962, Geology of the Otter Creek quadrangle, Montana: U.S. Geological Survey Bulletin 1111–G, p. 237–288.

Colton, R.B., 1963a, Geologic map of the Brockton quadrangle, Roosevelt and Richland Counties, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–362, scale 1:62,500.

Colton, R.B., 1963b, Geologic map of the Chelsea quadrangle, Roosevelt and McCone Counties, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–363, scale 1:62,500.

Colton, R.B., 1963c, Geologic map of the Cuskers quadrangle, Roosevelt County, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–364, scale 1:62,500.

Colton, R.B., 1963d, Geologic map of the Hay Creek quadrangle, Roosevelt County, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–365, scale 1:62,500.

Colton, R.B., 1963e, Geologic map of the Oswego quadrangle, Valley, Roosevelt, and McCone Counties, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–366, scale 1:62,500.

Colton, R.B., 1963f, Geologic map of the Poplar quadrangle, Roosevelt, Richland, and McCone Counties, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–367, scale 1:62,500.

Colton, R.B., 1963g, Geologic map of the Porcupine Valley quadrangle, Valley County, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–368, scale 1:62,500.

Colton, R.B., 1963h, Geologic map of the Spring Creek quadrangle, Valley County, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–369, scale 1:62,500.

Colton, R.B., 1963i, Geologic map of the Todd Lakes quadrangle, Valley and Roosevelt Counties, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–370, scale 1:62,500.

Colton, R.B., 1963j, Geologic map of the Tule Valley quadrangle, Roosevelt County, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–371, scale 1:62,500.

Colton, R.B., 1964, Geologic map of the south half of the Baylor, Larslan, West Fork, Police

Creek, Kahle, and Lundville quadrangles, Valley, Roosevelt, and Daniels Counties, Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–361, scale 1:62,500.

Colton, R.B., 1979a, Geologic map of the Bainville SW quadrangle, Roosevelt and Richland Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–1110, scale 1:24,000.

Colton, R.B., 1979b, Geologic map of the Three Buttes quadrangle, Richland and Roosevelt Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–1111, scale 1:24,000.

Colton, R.B., 1979c, Geologic map of the Bainville SE quadrangle, Roosevelt and Richland Counties, Montana, and Williams County, North Dakota: U.S. Geological Survey Miscellaneous Field Studies Map MF–1112, scale 1:24,000.

Colton, R.B., 1979d, Geologic map of the Dugout Creek quadrangle, Richland and Roosevelt Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–1113, scale 1:24,000.

Colton, R.B., 1982a, Geologic map of the Twomile Creek quadrangle, Richland and Roosevelt Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–1413, scale 1:24,000.

Colton, R.B., 1982b, Geologic map of the Cedar Coulee quadrangle, Roosevelt and Richland Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–1414, scale 1:24,000.

Colton, R.B., and Bateman, A.F., Jr., 1956a, The Brockton-Froid fault zone in northeastern Montana [abs.]: Geological Society of America Bulletin, v. 67, no. 12, pt. 2, p. 1792.

Colton, R.B., and Bateman, A.F., Jr., 1956b, Geologic and structure contour map of the Fort Peck Indian Reservation and vicinity, Montana: U.S. Geological Survey Miscellaneous Geological Investigations Map I–225, scale 1:125,000.

Colton, R.B., and Jensen, F.S., 1953, Crevasse fillings on the glaciated plains, northeastern Montana [abs.]: Geological Society of America Bulletin, v. 64, no. 12, pt. 2, p. 1542–1543.

Colton, R.B., Lemke, R.W., and Lindvall, R. M., 1961, Glacial map of Montana east of the Rocky Mountains: U.S. Geological Survey Geologic Investigations Map I–327, scale 1:500,000.

Colton, R.B., Naeser, N.D., and Naeser, C.W., 1986, Drainage changes in eastern Montana and western North Dakota during late Cenozoic time: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 347.

Colton, R.B., Whitaker, S.T., and Ehler, W.C., 1982, Reconnaissance geologic map of the Miller Coulee quadrangle, Valley County, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–1404, scale 1:24,000.

Colton, R.B., Whitaker, S.T., and Ehler, W.C., 1989a, Geologic map of the Glasgow 1° x 30′ quadrangle, Valley and McCone Counties, Montana: U.S. Geological Survey Open-File Report 89–17l, 13 p.

Colton, R.B., Whitaker, S.T., and Ehler, W.C., 1989b, Geologic map of the Opheim 1° × 30′ quadrangle, Valley and Daniels Counties, Montana: U.S. Geological Survey Open-File Report 89–319, 10 p.

Colton, R.B., Whitaker, S.T., Ehler, W.C., and Fuller, H.K., 1978, Preliminary photogeologic map of the Four Buttes, Scobey, and Flaxville quadrangles, Daniels County, Montana: U.S. Geological Survey Open-File Report 78–898, scale 1:50,000.

Crone, A.J., and Wheeler, R.L., 2000, Data for Quaternary faults, liquefaction features, and possible tectonic features in the Central and Eastern United States, east of the Rocky Mountains: U.S. Geological Survey Open-File Report 00–260, 332 p. (available at http://pubs.usgs.gov/of/2000/ofr-00-0260/; accessed August 27, 2004).

DeYoung, William, Youngs, F.O., and Glassey, T.W., 1932, Soil survey of the Milk River area, Montana: U.S. Department of Agriculture, Bureau of Chemistry and Soils, Series 1928, no. 22, 35 p.

Donovan, J.J., and Bergantino, R.N., 1987, Groundwater resources of the Fort Peck Indian Reservation, with emphasis on aquifers of the preglacial Missouri River valley: Montana Bureau of Mines and Geology Open-File Report MBMG 178, 41 p.

Edwards, G.J., 1951, A preliminary report on the electrical resistivity survey at Medicine

Lake, Montana: U.S. Geological Survey Circular 97, 16 p.
Feltis, R.D., 1979, Water resources of shallow aquifers in the upper Poplar River basin, northeastern Montana: U.S. Geological Survey Water-Resources Investigations WRI–79–5l, 23 p.
Fullerton, D.S., and Colton, R.B., 1986, Stratigraphy and correlation of the glacial deposits on the Montana Plains, *in* Richmond, G.M., and Fullerton, D.S., eds., Quaternary glaciations in the United States of America: Quaternary Science Reviews, v. 5, p. 69–82.
Fullerton, D.S., Colton, R.B., and Bush, C.A., 2004a, Limits of mountain and continental glaciations east of the Continental Divide in northern Montana and northwestern North Dakota, U.S.A., *in* Ehlers, Jurgen, and Gibbard, P.L., eds., Major Quaternary glaciations–Extent, timing, and global synchroneity. Volume 2, North America: Amsterdam, Elsevier, p. 123–143.
Fullerton, D.S., Colton, R.B., Bush, C.A., and Straub, A.W., 2004b, Map showing spatial and temporal relations of mountain and continental glaciations on the Northern Plains, primarily in northern Montana and northwestern North Dakota: U.S. Geological Survey Scientific Investigations Map 2843, 36 p, scale 1:1,000,000.
Giesecker, L.F., Morris, E.R., Strahorn, A.T., and Manifold, C.B., 1933, Soil survey (reconnaissance) of the Northern Plains of Montana: U.S. Department of Agriculture, Bureau of Chemistry and Soils, Series 1929, no. 21, 74 p.
Gott, G.B., Witkind, I.J., Hansen, W.R., Lindvall, R.M., Prouty, C.E., Smith, J.H., Basile, R.E., and Kaye, C.A., 1959, Geologic map of the Smoke Creek–Medicine Lake–Grenora area, Montana and North Dakota, *in* Witkind, I.J., Quaternary geology of the Smoke Creek–Medicine Lake–Grenora area, Montana and North Dakota: U.S. Geological Survey Bulletin 1073, 2 sheets, scale 1:62,500.
Hopkins, W.B., and Tilstra, J.R., 1966, Availability of ground water from the alluvium along the Missouri River in northeastern Montana: U.S. Geological Survey Hydrologic Investigations Atlas HA–224, 13 p.
Howard, A.D., 1956, Till-pebble isopleth maps of parts of Montana and North Dakota: Geological Society of America Bulletin, v. 67, p. 1191–1206.
Howard, A.D., 1958, Drainage evolution in northeastern Montana and northwestern North Dakota: Geological Society of America Bulletin, v. 69, p. 575–588.
Howard, A.D., 1960, Cenozoic history of northeastern Montana and northwestern North Dakota, with emphasis on the Pleistocene: U.S. Geological Survey Professional Paper 326, 107 p.
Izett, G.A., and Wilcox, R.E., 1982, Map showing localities and inferred distributions of the Huckleberry Ridge, Mesa Falls, and Lava Creek ash beds (Pearlette family ash beds) of Pliocene and Pleistocene age in the Western United States and southern Canada: U.S. Geological Survey Miscellaneous Investigations Series I–1325, scale 1:4,000,000.
Jensen, F.S., 1951a, Preliminary report on the geology of the Frazer quadrangle, Montana: U.S. Geological Survey Open-File Report 51–37, 29 p.
Jensen, F.S., 1951b, The geology of the Nashua quadrangle, Montana: Baltimore, Md., Johns Hopkins University, Ph.D. dissertation, 86 p.
Jensen, F.S., 1951c, Bedrock deformation of late Quaternary age at Tiger Butte, northeastern Montana [abs.]: Geological Society of America Bulletin, v. 62, no. 12, p. 1452.
Jensen, F.S., 1952, Preliminary report on the geology of the Nashua quadrangle, Montana: U.S. Geological Survey Open-File Report 52–82, 37 p.
Jensen, F.S., 1953, Preliminary geologic map of the Glasgow quadrangle, Montana: U.S. Geological Survey Open-File Report 53–137, scale 1:62,500.
Jensen, F.S., and Varnes, H.D., 1964, Geology of the Fort Peck area, Garfield, McCone, and Valley Counties, Montana: U.S. Geological Survey Professional Paper 414–F, p. F1–F49.
Lemke, R.W., Laird, W.M., Tipton, M.J., and Lindvall, R.M., 1965, Quaternary geology of the northern Great Plains, *in* Wright, H.E., Jr., and Frey, D.G., eds., The Quaternary of the United States: Princeton, N.J., Princeton University Press, p. 15–27.
Levings, G.W., 1986, Preliminary appraisal of ground water in and near the ancestral Missouri River valley, northeastern Montana:

U.S. Geological Survey Water-Resources Investigations Report 86–4138, 41 p.
Mathewes, W.H., 1974, Surface profiles of the Laurentide ice sheet in its marginal areas: Journal of Glaciology, v. 13, no. 97, p. 37–43.
Mickelson, D.M., Clayton, Lee, Fullerton, D.S., and Borns, H.W., Jr., 1983, The late Wisconsin glacial record of the Laurentide ice sheet in the United States, *in* Porter, S.C., ed., Late-Quaternary environments of the United States; Volume 1, The late Pleistocene: Minneapolis, University of Minnesota Press, p. 3–37.
Montagne, Clifford, Munn, L.C., Nielsen, G.A., Rogers, J.W., and Hunter, H.E., 1982, Soils of Montana: Montana Agricultural Experiment Station Bulletin 744, 95 p.
Moran, S.R., and Clayton, Lee, 1984, Chronology of late Wisconsinan glaciation in middle North America–Reply to the comments of R.W. Klassen: Quaternary Science Reviews, v. 3, no. 2/3, p. i–vi.
Patton, T.W., 1987, Quaternary and Tertiary geology of the Turner–Hogeland Plateau, north-central Montana: Bozeman, Montana College of Mineral Science and Technology, M.S. thesis, 175 p.
Prichard, G.E., and Landis, E.R., 1975, Coal resources and Cenozoic geology of the Girard coal field, Richland County, Montana: U.S. Geological Survey Bulletin 1310, 89 p.
Simonson, G.H., Rogers, J.W., Brownfield, S.H., Richardson, R.E., and Nielsen, G.A., 1978, General soil map of Montana: Montana Agricultural Experiment Station Miscellaneous Publication 16, scale 1:1,000,000.
Soller, D.R., 1993, Preliminary map showing the thickness and character of Quaternary sediments in the United States east of the Rocky Mountains: U.S. Geological Survey Open-File Report 93–543, scale 1:3,500,000.
Soller, D.R., 1994, Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains–Northern Plains states (west of 102° West Longitude): U.S. Geological Survey Miscellaneous Investigations Series Map I–1970–D, scale 1:1,000,000.
Swenson, F.A., 1955, Geology and groundwater resources of the Missouri River valley in northeastern Montana (*with a section on* The quality of ground water *by* W.H. Durum): U.S. Geological Survey Water-Supply Paper 1263, 128 p.
Thomas, G.E., 1974, Lineament-block tectonics—Williston–Blood Creek Basin: American Association of Petroleum Geologists Bulletin, v. 58, p. 1182–1191.
U.S. Department of Agriculture, published soils maps of individual counties.
Veseth, Roger, and Montagne, Clifford, 1980, Geologic parent materials of Montana soils: Montana Agricultural Experiment Station Bulletin 721, 117 p.
Vorhis, R.C., 1950, Progress report on the ground-water hydrology of the Medicine Lake–Grenora area, Missouri–Souris Irrigation Project, Montana and North Dakota: U.S. Geological Survey Open-File Report 50–53, 88 p.
Whitaker, S.T., 1980, The Flaxville Formation in the Scobey-Opheim area, northeastern Montana: Boulder, University of Colorado, M.S. thesis, 164 p.
Wild, J.R., 2003, A model for landform genesis in north-central Montana, USA: Calgary, Alberta, University of Calgary, M.S. thesis, 205 p.
Witkind, I.J., 1959, Quaternary geology of the Smoke Creek–Medicine Lake–Grenora area, Montana and North Dakota: U.S. Geological Survey Bulletin 1073, 80 p.
Unpublished soils maps of Phillips County, Mont., provided by Robert Lund, Montana Geospatial Center.

NORTH DAKOTA

Aber, J.S., Croot, D.G., and Fenton, M.M., 1989, Glaciotectonic landforms and structures: Dordrecht, Kluwer Academic Publishers, 200 p.
Alden, W.C., 1924, Physiographic development of the northern Great Plains: Geological Society of America Bulletin, v. 35, p. 385–424.
Alden, W.C., 1932, Physiography and glacial geology of eastern Montana and adjacent areas: U.S. Geological Survey Professional Paper 174, 133 p.

Alpha, A.G., l935, Geology and ground water resources of Burke, Divide, Mountrail, and Williams Counties in North Dakota: Grand Forks, University of North Dakota, M.S. thesis, 62 p.

Armstrong, C.A., 1965, Geology and ground water resources of Divide County, North Dakota; Part II, ground water basic data: North Dakota Geological Survey Bulletin 45, pt. 2, 112 p.

Armstrong, C.A., 1967, Geology and ground water resources, Williams County, North Dakota; Part II, Ground water basic data: North Dakota Geological Survey Bulletin 48, pt. 2, 132 p.

Armstrong, C.A., 1969, Geology and ground water resources of Burke and Mountrail Counties; Part II, Ground water basic data: North Dakota Geological Survey Bulletin 55, pt. 2, 282 p.

Bergantino, R.N., 1984, Topographic map of the bedrock surface, northeastern Montana, northwestern North Dakota, and southeastern Saskatchewan: Montana Bureau of Mines and Geology Open-File Report MBMG 151, scale 1:250,000.

Bluemle, J.P., 1971a, Topographic map of bedrock surface of North Dakota (preliminary map): North Dakota Geological Survey Miscellaneous Map 12, scale 1:500,000.

Bluemle, J.P., 1971b, Depth to bedrock in North Dakota (preliminary map): North Dakota Geological Survey Miscellaneous Map 13, scale 1:500,000.

Bluemle, J.P., 1972, Pleistocene drainage development in North Dakota: Geological Society of America Bulletin, v. 83, p. 2189–2193.

Bluemle, J.P., 1977, Geologic highway map of North Dakota: North Dakota Geological Survey Miscellaneous Map 19, scale 1:1,000,000.

Bluemle, J.P., 1983, Geologic and topographic bedrock map of North Dakota: North Dakota Geological Survey Miscellaneous Map 25, scale 1:670,000.

Bluemle, J.P., 1988a, Geologic highway map of North Dakota: North Dakota Geological Survey Miscellaneous Map 29, scale 1:1,000,000.

Bluemle, J.P., 1988b, North Dakota clinker: North Dakota Geological Survey Newsletter, December 1988, p. 29–34.

Bluemle, J.P., 1989, Geology of Renville and Ward Counties, North Dakota: North Dakota Geological Survey Bulletin 50, pt. 1, 62 p.

Bluemle, J.P., 1991, The origin of the Missouri River valley in North Dakota: North Dakota Geological Survey Newsletter, June 1991, p. 43–51.

Bluemle, J.P., 2000, The face of North Dakota, third edition: North Dakota Geological Survey Educational Series 26, 210 p.

Bluemle, J.P., no date, Unpublished map showing glaciotectonic deposits in the Williston 1° × 2° quadrangle, North Dakota, scale 1:250,000.

Bluemle, J.P., and Clayton, Lee, 1984, Large scale glacial thrusting and related processes in North Dakota: Boreas, v. 13, p. 279–299.

Boettger, W.M., 1986, Origin and stratigraphy of Holocene sediments in the Souris and Des Lacs Valleys: Grand Forks, University of North Dakota, M.A. thesis, 186 p.

Bretz, J.H., 1943, Keewatin end moraines in Alberta, Canada: Geological Society of America Bulletin, v. 54, p. 31–52.

Brostuen, E.A., 1977, Physical data for land-use planning, Divide, McKenzie, and Williams Counties, North Dakota: North Dakota Geological Survey Report of Investigation 62, 17 p.

Carlson, C.G., 1985, Geology of McKenzie County, North Dakota: North Dakota Geological Survey Bulletin 80, pt. 1, 48 p.

Christiansen, E.A., 1979, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas: Canadian Journal of Earth Sciences, v. 16, p. 913–938.

Christiansen, E.A., 1980, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas—Reply: Canadian Journal of Earth Sciences, v. 17, p. 541.

Clayton, Lee, 1966, Notes on Pleistocene stratigraphy of North Dakota: North Dakota Geological Survey Report of Investigation 44, 25 p.

Clayton, Lee, 1967, Stagnant-glacier features of the Missouri Coteau in North Dakota, *in* Clayton, Lee, and Freers. T.F., eds., Glacial geology of the Missouri Coteau and adjacent areas: North Dakota Geological Survey Miscellaneous Series 30, p. 25–46.

Clayton, Lee, 1972, Geology of Mountrail County, North Dakota: North Dakota Geological Survey Bulletin 55, pt. 4, 77 p.

Clayton, Lee, and Moran, S.R., 1982, Chronology of late Wisconsinan glaciation in middle North America: Quaternary Science Reviews, v. 1, p. 55–82.

Clayton, Lee, Moran, S.R., and Bickley, W.B., 1976, Stratigraphy, origin, and climatic implications of late Quaternary upland silt in North Dakota: North Dakota Geological Survey Miscellaneous Series 54, 15 p.

Clayton, Lee, Moran, S.R., and Bluemle, J.P., 1980, Explanatory text to accompany the geologic map of North Dakota: North Dakota Geological Survey Report of Investigation 69, 93 p.

Clayton, Lee, Moran, S.R., Bluemle, J.P., and Carlson, C.G., 1980, Geologic map of North Dakota: U.S. Geological Survey, scale 1:500,000.

Clayton, Lee, Teller, J.T., and Attig, J.W., 1985, Surging of the southwestern part of the Laurentide ice sheet: Boreas, v. 14, p. 235–241.

Colton, R.B., 1958, Ice-crack moraines in northwestern North Dakota and northeastern Montana, *in* Guidebook, Ninth Annual Field Conference, Mid-Western Friends of the Pleistocene: North Dakota Geological Survey Miscellaneous Series 10, p. 99–107.

Colton, R.B., and Lemke, R.W., 1957, Unpublished glacial map of North Dakota, scale 1:1,000,000.

Colton, R.B., Lemke, R.W., and Lindvall, R.M., 1963, Preliminary glacial map of North Dakota: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–331, scale 1:500,000.

Dove, L.P., 1922, Clinkertill, a new metamorphic rock: Science, v. 56, p. 338.

Freers, T.F., 1970, Geology and ground water resources, Williams County, North Dakota; Part I, Geology: North Dakota Geological Survey Bulletin 48, pt. 1, 55 p.

Freers, T.F., 1973, Geology of Burke County, North Dakota: North Dakota Geological Survey Bulletin 55, pt. 1, 32 p.

Fullerton, D.S., Colton, R.B., and Bush, C.A., 2004a, Limits of mountain and continental glaciations east of the Continental Divide in northern Montana and northwestern North Dakota, U.S.A., *in* Ehlers, Jurgen, and Gibbard, P.L., eds., Major Quaternary glaciations–Extent, timing, and global synchroneity. Volume 2, North America: Amsterdam, Elsevier, p. 123–143.

Fullerton, D.S., Colton, R.B., Bush, C.A., and Straub, A.W., 2004b, Map showing spatial and temporal relations of mountain and continental glaciations on the Northern Plains, primarily in northern Montana and northwestern North Dakota: U.S. Geological Survey Scientific Investigations Map 2843, 36 p., scale 1:1,000,000.

Fulton, Clark, 1976, The glacial geology of McKenzie County, North Dakota: Grand Forks, University of North Dakota, M.S. thesis, 100 p.

Gott, G.B., Witkind, I.J., Hansen, W.R., Lindvall, R.M., Prouty, C.E., Smith, J.H., Basile, R.E., and Kaye, C.A., 1959, Geologic map of the Smoke Creek–Medicine Lake–Grenora area, Montana and North Dakota, *in* Witkind, I.J., Quaternary geology of the Smoke Creek–Medicine Lake–Grenora area, Montana and North Dakota: U.S. Geological Survey Bulletin 1073, 2 sheets, scale 1:62,500.

Hansen, D.E., 1967, Geology and ground water resources of Divide County, North Dakota; Part I, Geology: North Dakota Geological Survey Bulletin 45, pt. 1,100 p.

Hobbs, H.C., and Bluemle, J.P., 1987, Geology of Ramsey County, North Dakota: North Dakota Geological Survey Bulletin 71, pt. 1, 69 p.

Howard, A.D., 1956, Till-pebble isopleth maps of parts of Montana and North Dakota: Geological Society of America Bulletin, v. 67, p. 1199–1206.

Howard, A.D., l958, Drainage evolution in northeastern Montana and northwestern North Dakota: Geological Society of America Bulletin, v. 69, p. 575–588.

Howard, A.D., 1960, Cenozoic history of northeastern Montana and northwestern North Dakota, with emphasis on the Pleistocene: U.S. Geological Survey Professional Paper 326, 107 p.

Kehew, A.E., 1982, Catastrophic flood hypothesis for the origin of the Souris spillway, Saskatchewan and North Dakota: Geological Society of America Bulletin, v. 93, p. 1051–1058.

Kehew, A.E., and Clayton, Lee, 1983, Late Wisconsinan floods and development of the Souris-Pembina spillway system in

Saskatchewan, North Dakota, and Manitoba, *in* Teller, J.T., and Clayton, Lee, eds., Glacial Lake Agassiz: Geological Association of Canada Special Paper 26, p. 187–209.

Kehew, A.E., and Lord, M.L., 1986, Origin and large-scale erosional features of glacial-lake spillways in the northern Great Plains: Geological Society of America Bulletin, v. 97, p. 162–177.

Kehew, A.E., and Lord, M.L., 1987, Glacial-lake outbursts along the mid-continent margins of the Laurentide ice sheet, *in* Mayer, L., and Nash, D., eds., Catastrophic flooding: Boston, Allen and Unwin, p. 95–120.

Kehew, A.E., and Teller, J.T., 1994, History of late glacial runoff along the southern margin of the Laurentide ice sheet: Quaternary Science Reviews, v. 13, p. 859–877.

Klassen, R.W., 1883, Chronology of late Wisconsinan glaciation in middle North America—A discussion: Quaternary Science Reviews, v. 1, no. 4, p. xxiii–xxvii.

Lemke, R.W., 1960, Geology of the Souris River area, North Dakota: U.S. Geological Survey Professional Paper 352, 138 p.

Lemke, R.W., and Kaye, C.A., 1953, Geology of the Bowbells quadrangle, North Dakota: U.S. Geological Survey Geologic Quadrangle Map GQ–26, scale 1:62,500.

Lemke, R.W., Laird, W.M., Tipton, M.J., and Lindvall, R.M., 1965, Quaternary geology of the northern Great Plains, *in* Wright, H.E., Jr., and Frey, D.G., eds., The Quaternary of the United States: Princeton, N.J., Princeton University Press, p. 15–27.

Leonard, A.G., 1916a, Pleistocene drainage changes in western North Dakota: Geological Society of America Bulletin, v. 27, p. 295–304.

Leonard, A.G., 1916b, The pre-Wisconsin drift of North Dakota: Journal of Geology, v. 24, p. 521–532.

Lord, M.L., 1984, Paleohydraulics of Pleistocene drainage development of the Souris, Des Lacs, and Moose Mountain spillways, Saskatchewan and North Dakota: Grand Forks, University of North Dakota, M.S. thesis, 162 p.

Lord, M.L., 1988, Glacial Lake Souris–The history and sedimentology of a lake inundated by discharges from a glacial-lake outburst: Grand Forks, University of North Dakota, Ph.D. dissertation, 200 p.

Lord, M.L., and Kehew, A.E., 1987, Sedimentology and paleohydrology of glacial-lake outburst deposits in southeastern Saskatchewan and northwestern North Dakota: Geological Society of America Bulletin, v. 99, p. 663–673.

Mickelson, D.M., Clayton, Lee, Fullerton, D.S., and Borns, H.W., Jr., 1983, The Laurentide ice sheet in the United States, *in* Porter, S.C., ed., Late-Quaternary environments of the United States; Volume 1, The late Pleistocene: Minneapolis, University of Minnesota Press, p. 3–37.

Moran, S.R., Arndt, B.M., Bluemle, J.P., Camara, Michael, Clayton, Lee, Fenton, M.M., Harris, K.L., Hobbs, H.C., Keatinge, R., Sackreiter, D.K., Salomon, N.L., and Teller, J., 1976, Quaternary stratigraphy and history of North Dakota, southern Manitoba, and northwestern Minnesota, *in* Mahaney, W.C., ed., Quaternary stratigraphy of North America: Stroudsburg, Penn., Dowden, Hutchinson, and Ross, p. 133–158.

Moran, S.R., and Clayton, Lee, 1984, Chronology of late Wisconsinan glaciation in middle North America–Reply to the comments of R.W. Klassen: Quaternary Science Reviews, v. 3, no. 2/3, p. i–vi.

Moran, S.R., Clayton, Lee, Hooke, R.L., Fenton, M.M., and Andriashek, L.D., 1980, Glacier-bed landforms of the prairie region of North America: Journal of Glaciology, v. 25, no. 93, p. 457–476.

Moran, S.R., Clayton, Lee, Scott, M,W., and Brophy, J.A., 1973, Catalog of North Dakota radiocarbon dates: North Dakota Geological Survey Miscellaneous Series 53, 51 p.

Murphy, E.C., 2001, Geology of Dunn County: North Dakota Geological Survey Bulletin 68, pt. 1, 36 p.

Paulson, Q.F., and Powell, J.E., 1962, Geology and ground water resources of Tioga and Hofflund Flats areas, Williams and Mountrail Counties, North Dakota: North Dakota Water Conservation Commission, North Dakota Ground Water Studies 43, 65 p.

Pettyjohn, W.A., 1968, Geology and ground water resources of Renville and Ward Counties; Part II–Ground water basic data: North Dakota Geological Survey Bulletin 50, pt. 2, 302 p.

Salomon, N.L., 1974, Geology of northwestern McKenzie County, North Dakota: Grand Forks, University of North Dakota, senior thesis, 36 p.

Salomon, N.L., 1976, Late Cenozoic drainage evolution in northwestern McKenzie County, North Dakota: North Dakota Academy of Science Proceedings, v. 28, pt. 2, p. 44–49.

Sigsby, R.J., 1966, "Scoria" of North Dakota: Grand Forks, University of North Dakota, Ph.D. dissertation, 218 p.

Soller, D.R., 1993, Preliminary map showing the thickness and character of Quaternary sediments in the United States east of the Rocky Mountains: U.S. Geological Survey Open-File Report 93–543, scale 1:3,500,000.

Soller, D.R., 1994, Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains–Northern Plains states (west of 102° West Longitude): U.S. Geological Survey Miscellaneous Investigations Series Map I-1970-D, scale 1:1,000,000.

Spencer, J.M., 1981, Geologic map and lignite resources of the Cussicks Spring quadrangle, Williams County, North Dakota: U.S. Geological Survey Coal Investigations Map C–89, 2 sheets, scale 1:24,000.

Teller, J.T., Moran, S.R., and Clayton, Lee, 1980, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas—Discussion: Canadian Journal of Earth Sciences, v. 17, p. 539–541.

Todd, J.E., 1914, The Pleistocene history of the Missouri River: Science, v. 39, p. 263–274.

Todd, J.E., 1923, Glacial diversion of the Missouri River: Pan-American Geologist, v. 39, p. 169–184.

Todd, J.E., 1926, Is the channel of the Missouri River through North Dakota of Tertiary origin?: Geological Society of America Bulletin, v. 34, p. 469–493.

Townsend, R.C., 1950, Deformation of Fort Union Formation near Lignite, North Dakota: American Association of Petroleum Geologists Bulletin, v. 34, p. 1552–1564.

Townsend, R.C., 1954a, Geology of the Noonan quadrangle, North Dakota: U.S. Geological Survey Geologic Quadrangle Map GQ–44, scale 1:62,500.

Townsend, R.C., 1954b, Geology of the Crosby quadrangle, North Dakota: U.S. Geological Survey Geologic Quadragle Map GQ–46, scale 1:62,500.

Townsend, R.C., 1954c, Geology of the Portal quadrangle, North Dakota: U.S. Geological Survey Geologic Quadrangle Map GQ–47, scale 1:62,500.

Townsend, R.C., and Jenke, A.L., 195la, General geology and engineering geology of Rival No. 1 quadrangle, North Dakota: U.S. Geological Survey Open-File Report, scale 1:48,000.

Townsend, R.C., and Jenke, A.L., 1951b, General geology and engineering geology of Rival No. 2 quadrangle, North Dakota: U.S. Geological Survey Open-File Report, scale 1:48,000.

Townsend, R.C., and Jenke, A.L., 1951c, The problem of the origin of the Max moraine of North Dakota and Canada: American Journal of Science, v. 249, p. 842–858.

Trimble, D.E., no date, Unpublished map showing landslide deposits in the Williston 1° × 2° quadrangle, North Dakota, scale 1:250,000.

Ulmer, J.H., and Sackreiter, D.K., 1973, Late Cenozoic stratigraphy of the Lake Sakakawea bluffs north and west of Riverdale, North Dakota: North Dakota Geological Survey Report of Investigation 51, 1 plate.

U.S. Department of Agriculture, published soils maps of individual counties.

Vorhis, R.C., 1950, Progress report on the ground-water hydrology of the Medicine Lake–Grenora area, Missouri–Souris Irrigation Project, Montana and North Dakota: U.S. Geological Survey Open-File Report 50–53, 88 p.

Waring, G.A., 1949, Statistical data on glacial boulders: Science, v. 109, p. 283–284.

Waring, G.A., and LaRocque, G.A., Jr., 1947, Progress report, ground-water hydrology, lower Missouri–Souris area, North Dakota: U.S. Geological Survey Open-File Report, 144 p.

Witkind, I.J., 1959, Geology of the Smoke Creek–Medicine Lake–Grenora area, Montana and North Dakota: U.S. Geological Survey Bulletin 1073, 80 p.

SASKATCHEWAN

Aber, J.S., 1988, Ice-shoved hills of Saskatchewan compared with Mississippi delta mudlumps–Implications for glaciotectonic models, *in* Croot, D.G.,

ed., Glaciotectonics–Forms and processes: Rotterdam, A.A. Balkema, p. 1–9.

Aber, J.S., 1989, Spectrum of constructional glaciotectonic landforms, *in* Goldthwait, R.P., and Matsch, C.L., eds., Genetic classification of glaciogenic deposits: Rotterdam, A.A. Balkema, p. 281–292.

Aber, J.S., 1993a, Geomorphic and structural genesis of the Dirt Hills and Cactus Hills, southern Saskatchewan, *in* Aber, J.S. ed., Glaciotectonics and mapping glacial deposits: Regina, Sask., University of Regina, Canadian Plains Research Center, p. 9–35.

Aber, J.S., 1993b, Glaciotectonic landforms and structures, *in* Sauchyn, D.J., ed., Quaternary and late Tertiary landscapes of southern Saskatchewan and adjacent areas: Regina, Sask., University of Regina, Canadian Plains Research Center, p. 20–26.

Aber, J.S., Croot, D.G., and Fenton, M.M., 1989, Glaciotectonic landforms and structures: Boston, Kluwer Academic Publishers, 200 p.

Acton, D.F., 1979, Unpublished generalized soil landscape maps of southwestern Saskatchewan, University of Saskatchewan, Saskatchewan Institute of Pedology, scale 1:250,000.

Ayers, K.W., Acton, D.F., and Ellis, J.G., 1985, The soils of the Swift Current map area, 72J, Saskatchewan: Saskatchewan Institute of Pedology Publication S6 (Extension Publication 308), 226 p.

Barendregt, R.W., 1984, Correlation of Quaternary chronologies using paleomagnetism–Examples from southern Alberta and Saskatchewan, *in* Mahaney, W.C., ed., Correlation of Quaternary chronologies: Norwich, United Kingdom, Geo Books, p. 59–71.

Barendregt, R.W., 1995, Paleomagnetic dating methods, *in* Rutter, N.W., and Catto, N.R., eds., Dating methods for Quaternary deposits: Geological Association of Canada Geotext 2, p. 29–49.

Barendregt. R.W., and Irving, Edward, 1998, Changes in the extent of North American ice sheets during the late Cenozoic: Canadian Journal of Earth Sciences, v. 35, p. 504–509.

Barendregt, R.W., Irving, Edward, Christiansen, E.A., Sauer, E.K., and Schreiner, B.T., 1998, Stratigraphy and paleomagnetism of late Pliocene and Pleistocene sediments in the Wellsch Valley and Swift Current Creek areas, southwestern Saskatchewan, Canada: Canadian Journal of Earth Sciences, v. 35, p. 1347–1361.

Barendregt, R.W., Thomas, F.F., Irving, Edward, Baker, Judith, Stalker, A.M., and Churcher, C.S., 1991, Stratigraphy and paleomagnetism of the Jaw Face section, Wellsch Valley site, Saskatchewan: Canadian Journal of Earth Sciences, v. 28, p. 1353–1364.

Bergantino, R.N., 1984, Topographic map of the bedrock surface, northeastern Montana, northwestern North Dakota, and southeastern Saskatchewan: Montana Bureau of Mines and Geology Open-File Report MBMG 151, scale 1:250,000.

Bretz, J.H., 1943, Keewatin end moraines in Alberta, Canada: Geological Society of America Bulletin, v. 54, p. 31–52.

Byers, A.R., 1959, Deformation of the Whitemud and Eastend Formations near Claybank, Saskatchewan: Royal Society of Canada Transactions, v. 53, ser. 3, sect. 4, p. 1–11.

Campbell, J.E., 1987a, Surficial geology of the Regina area (72–I), Saskatchewan: Saskatchewan Research Council Sedimentary Processes Map, scale 1:250,000.

Campbell, J.E., 1987b, Surficial geology of the Swift Current area (72–J), Saskatchewan: Saskatchewan Research Council Sedimentary Processes Map, scale 1:250,000.

Cherry, J.A., 1966, Geology of the Yorkton area, Saskatchewan: Urbana, University of Illinois, Ph.D. dissertation, 118 p.

Cherry, J.A., and Whitaker, S.H., 1969, Geology and groundwater resources of the Yorkton area (62–M, N), Saskatchewan: Saskatchewan Research Council Geology Division Map 9, scale 1:250,000.

Christiansen, E.A., 1956, Glacial geology of the Moose Mountain area, Saskatchewan: Saskatchewan Department of Mineral Resources Report 21, 35 p.

Christiansen, E.A., 1959, Glacial geology of the Swift Current area, Saskatchewan: Saskatchewan Department of Mineral Resources Report 32, 62 p.

Christiansen, E.A., 1960, Geology and groundwater resources of the Qu'Appelle area, Saskatchewan: Saskatchewan Research Council Geology Division Report 1, 53 p.

Christiansen, E.A., 196l, Geology and ground-water resources of the Regina area,

Saskatchewan: Saskatchewan Research Council Geology Division Report 2, 72 p.
Christiansen, E.A., 1965, Preglacial valleys in southern Saskatchewan: Saskatchewan Research Council Geology Division Map 3, scale 1:1,520,640.
Christiansen, E.A., 1968a, A thin till in west-central Saskatchewan: Canadian Journal of Earth Sciences, v. 5, p. 329–336.
Christiansen, E.A., 1968b, Pleistocene stratigraphy of the Saskatoon area, Saskatchewan, Canada: Canadian Journal of Earth Sciences, v. 5, p. 1167–1173.
Christiansen, E.A., 1969a, Pleistocene stratigraphy of the Swift Current Creek, Prelate Ferry, Empress, and Medicine Hat sections: Friends of the Pleistocene, Midwest Section, 19th Field Conference, 24 p.
Christiansen, E.A., 1969b, Geology of the Saskatoon site: Napao, v. 1, p. 28–31.
Christiansen, E.A., 1970, Geology and groundwater resources of the Wynyard area (72–P), Saskatchewan: Saskatchewan Research Council Geology Division Map 10, scale 1:250,000.
Christiansen, E.A., 1971a, Geology and groundwater resources of the Melville area (62–K, L), Saskatchewan: Saskatchewan Research Council Geology Division Map 12, scale 1:250,000.
Christiansen, E.A., 1971b, Geology and groundwater resources of the Regina area (72–I): Saskatchewan Research Council Geology Division Map 13, scale 1:250,000.
Christiansen, E.A., 1971c, Tills of southern Saskatchewan, Canada, *in* Goldthwait, R.P., ed., Till, a symposium: Columbus, Ohio State University Press, p. 167–183.
Christiansen, E.A., 1971d, Geology of the Crater Lake collapse structure in southeastern Saskatchewan: Canadian Journal of Earth Sciences, v. 8, p. 1505–1513.
Christiansen, E.A., 1972a, Stratigraphy of the Fort Qu'Appelle vertebrate fossil locality, Saskatchewan: Canadian Journal of Earth Sciences, v. 9, p. 212–218.
Christiansen, E.A., 1972b, Southern Saskatchewan, *in* Rutter, N.W., and Christiansen, E.A., eds., Quaternary geology and geomorphology between Winnipeg and the Rocky Mountains: International Geological Congress, Guidebook, 24th session, Montreal, Quebec, Excursion C–22, p. 24–3l.
Christiansen, E.A., ed., 1972c, Guidebook on geology and its application to engineering practice in the Qu'Appelle Valley area: Regina Geotechnical Group and Saskatchewan Geological Society Field Trip Guidebook, 55 p.
Christiansen, E.A., ed., 1973, Quaternary geology and its application to engineering practice in the Saskatoon-Regina-Watrous area, Saskatchewan: Geological Association of Canada Guidebook for Field Trip C, 81 p.
Christiansen, E.A., 1979a, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas: Canadian Journal of Earth Sciences, v. 16, p. 913–938.
Christiansen, E.A., 1979b, Geology of the Regina–Moose Jaw region, Saskatchewan: Regina, Saskatchewan Municipal Affairs Regional Studies Program, Part A, Report 16–003, 67 p.
Christiansen, E.A., 1980, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas–Reply: Canadian Journal of Earth Sciences, v. 17, p. 541.
Christiansen, E.A., 1991, Quaternary stratigraphy of southern Saskatchewan, Canada, unpublished manuscript, 46 p.
Christiansen, E.A., 1992, Pleistocene stratigraphy of the Saskatoon area, Saskatchewan, Canada–An update: Canadian Journal of Earth Sciences, v. 29, p. 1767–1778.
Christiansen, E.A., Gendzwill, D.J., and Meneley, W.A., 1982, Howe Lake–A hydrodynamic blowout structure: Canadian Journal of Earth Sciences, v. 19, p. 1122–1139.
Christiansen, E.A., and Meneley, W.A., 1971, Geology and groundwater resources of the Rosetown area (72–O): Saskatchewan Research Council Geology Division Map 14, scale 1:250,000.
Christiansen, E.A., and Parizek, R.R., 196l, A summary of studies completed to date of the groundwater geology and hydrology of the buried Missouri and Yellowstone Valleys near Estevan: Saskatchewan Research Council Geology Division Circular 1, 31 p.
Christiansen, E.A., and Sauer, E.K., 1988, Age of the Frenchman Valley and associated drift south of the Cypress Hills, Saskatchewan, Canada: Canadian Journal of Earth Sciences, v. 25, p. 1703–1708.

Christiansen, E.A., and Sauer, E.K., 1997, The Dirt Hills structure–An ice-thrust feature in southern Saskatchewan, Canada: Canadian Journal of Earth Sciences, v. 34, p. 76–85.

Christiansen, E.A., and Sauer, E.K., 1998, Géotechnique of Saskatoon and surrounding area, Saskatchewan, Canada, *in* Karrow, P.F., and White, O.L., eds., Urban geology of the Canadian Cities: Geological Association of Canada Special Paper 42, p. 117–145.

Christiansen, E.A., and Sauer, E.K., 2001, Stratigraphy and structure of a late Wisconsinan salt collapse in the Saskatoon Low, south of Saskatoon, Saskatchewan–An update: Canadian Journal of Earth Sciences, v. 38, p. 1601–1613.

Christiansen, E.A., and Sauer, E.K., 2002, Stratigraphy and structure of Pleistocene collapse in the Regina Low, Saskatchewan: Canadian Journal of Earth Sciences, v. 39, p. 1411–1423.

Christiansen, E.A., and Whitaker, S.H., 1976, Glacial thrusting of drift and bedrock, *in* Legget, R.F., ed., Glacial till: Royal Society of Canada Special Publication 12, p. 121–130.

Churcher, C.S., and Stalker, A.M., 1972, Geology and vertebrate paleontology of the Wellsch Valley site, Saskatchewan, unpublished manuscript, 114 p.

Churcher, C.S., and Stalker, A.M., 1988, Geology and vertebrate paleontology of the Wellsch Valley site, Saskatchewan, unpublished manuscript.

Clayton, Lee, and Moran, S.R., 1982, Chronology of late Wisconsinan glaciation in middle North America: Quaternary Science Reviews, v. 1, p. 55–82.

Clayton, Lee, Teller, J.T., and Attig, J.W., 1985, Surging of the southwestern part of the Laurentide ice sheet: Boreas, v. 14, p. 235–241.

David, P.P., 1964, Surficial geology and groundwater resources if the Prelate area (72–K), Saskatchewan: Montreal, Que., McGill University, Ph.D. dissertation, 329 p.

David, P.P., 1966, The late-Wisconsin Prelate Ferry paleosol of Saskatchewan: Canadian Journal of Earth Sciences, v. 3, p. 685–696.

David, P.P., 1969, A reappraisal of the Prelate Ferry paleosol: Friends of the Pleistocene, Midwest Section, 19th Field Conference, 34 p.

David, P.P., 1977, Sand dune occurrences of Canada—A theme and resource inventory study of eolian landforms in Canada: Canada Department of Indian and Northern Affairs, National Parks Branch, Contract 74–230, Report, 183 p.

David, P.P., 1987, The Prelate Ferry paleosol—A new date: Geological Association of Canada and Mineralogical Association of Canada, Program with Abstracts, v. 12, p. 36.

Delorme, L.D., 1962, A stratigraphic study of the Regina basin, Saskatchewan: Edmonton, University of Alberta, M.S. thesis, 118 p.

Dyck, J.H., Keys, W.S., and Meneley, W.A., 1972, Application of geophysical logging to groundwater studies in southeastern Saskatchewan: Canadian Journal of Earth Sciences, v. 9, p. 78–94.

Ellis, J.G., Acton, D.F., and Clayton, J.S., 1965, The soils of the Regina map area (72–I), Saskatchewan: Saskatoon, University of Saskatchewan, Saskatchewan Institute of Pedology Publication S1 (Extension Publication 176), 133 p.

Ellis, J.G., Acton, D.F., and Moss, H.C., 1967, The soils of the Willow Bunch map area, Saskatchewan: Saskatoon, University of Saskatchewan, Saskatchewan Institute of Pedology Publication S2 (Extension Publication 200), 98 p.

Ellis, J.G., Acton, D.F., and Moss, H.C., 1968, The soils of the Rosetown map area (72–O), Saskatchewan: Saskatoon, University of Saskatchewan Institute of Pedology Publication S3 (Extension Publication 202), 160 p.

Foster, J.H., and Stalker, A.M., 1976, Paleomagnetic stratigraphy of the Wellsch Valley site, Saskatchewan: Geological Survey of Canada Paper 76–1C, p. 191–193.

Fraser, F.J., McLearn, F.H., Russell, L.S., Warren, P.S., and Wickenden, R.T.D., 1935, Geology of southern Saskatchewan: Geological Survey of Canada Memoir 176, 137 p.

Fullerton, D.S., Colton, R.B., and Bush, C.A., 2004a, Limits of mountain and continental glaciations east of the Continental Divide in northern Montana and northwestern North Dakota, U.S.A., *in* Ehlers, Jurgen, and Gibbard, P.L., eds., Major Quaternary glaciations–Extent, timing, and global

synchroneity: Amsterdam, Elsevier, p. 123–143.

Fullerton, D.S., Colton, R.B., Bush, C.A., and Straub, A.W., 2004b, Map showing spatial and temporal relations of mountain and continental glaciations on the Northern Plains, primarily in northern Montana and northwestern North Dakota: U.S. Geological Survey Scientific Investigations Map 2843, 36 p., scale 1:1,000,000.

Greer, J.E., and Christiansen, E.A., 1963, Geology and groundwater resources of the Wynyard area (72–P), Saskatchewan: Saskatchewan Research Council Geology Division Report 3, 55 p.

Izett, G.A., and Wilcox, R.E., 1982, Map showing localities and inferred distributions of the Huckleberry Ridge, Mesa Falls, and Lava Creek ash beds (Pearlette family ash beds) of Pliocene and Pleistocene age in the Western United States and Southern Canada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1325, scale 1:4,000,000.

Johnston, W.A., and Wickenden, R.T.D., 1930, Glacial Lake Regina, Saskatchewan, Canada: Royal Society of Canada Transactions, series 3, v. 24, sect. 4, p. 41–49.

Johnston, W.A., and Wickenden, R.T.D., 1931, Moraines and glacial lakes in southern Saskatchewan and southern Alberta, Canada: Royal Society of Canada Transactions, series 3, v. 25, sect. 4, p. 29–44.

Johnston, W.A., Wickenden, R.T.D., and Wier, J.D., 1948, Preliminary map, surface deposits, southern Saskatchewan: Geological Survey of Canada Paper 48–18, scale 1:375,000.

Kehew, A.E., 1982, Catastrophic flood hypothesis for the origin of the Souris spillway, Saskatchewan and North Dakota: Geological Society of America Bulletin, v. 93, p. 105l–1058.

Kehew, A.E., and Clayton, Lee, 1983, Late Wisconsinan floods and development of the Souris-Pembina spillway system in Saskatchewan, North Dakota, and Manitoba, *in* Teller, J.T., and Clayton, Lee, eds., Glacial Lake Agassiz: Geological Association of Canada Special Paper 26, p. 187–209.

Kehew, A.E., and Lord, M.L., 1986, Origin and large-scale erosional features of glacial-lake spillways in the northern Great Plains: Geological Society of America Bulletin, v. 97, p. 162–177.

Kehew, A.E., and Lord, M.L., 1987, Glacial-lake outbursts along the mid-continent margins of the Laurentide ice sheet, *in* Mayer, L., and Nash, D., eds., Catastrophic flooding: Boston, Allen and Unwin, p. 95–120.

Kehew, A.E., and Lord, M.L., 1989, Glacial-lake spillways of the central interior plains, Canada–U.S.A.: Canadian Geographer, v. 33, p. 274–277.

Kehew, A.E., and Teller, J.T., 1994a, Glacial-lake spillway incision and deposition of a coarse-grained fan near Watrous, Saskatchewan: Canadian Journal of Earth Sciences, v. 31, p. 544–553.

Kehew, A.E., and Teller, J.T., 1994b, History of late glacial runoff along the southern margin of the Laurentide ice sheet: Quaternary Science Reviews, v. 13, p. 859–877.

Khan, Ehsanullah, 1970, Biostratigraphy and paleontology of a Sangamon deposit at Fort Qu'Appelle, Saskatchewan: National Museums of Canada, National Museum of Natural Sciences Publications in Paleontology, no. 5, 82 p.

Klassen, R.W., 1972, Wisconsin events and the Assiniboine and Qu'Appelle Valleys of Manitoba and Saskatchewan: Canadian Journal of Earth Sciences, v. 9, p. 544–560.

Klassen, R.W., 1975, Quaternary geology and geomorphology of Assiniboine and Qu'Appelle Valleys of Manitoba and Saskatchewan: Geological Survey of Canada Bulletin 228, 61 p.

Klassen, R.W., 1983a, Assiniboine delta and the Assiniboine–Qu'Appelle valley system–Implications concerning the history of Lake Agassiz in southwestern Manitoba, *in* Teller, J.T., and Clayton, Lee, eds., Glacial Lake Agassiz: Geological Association of Canada Special Paper 26, p. 211–299.

Klassen, R.W., 1983b, Chronology of late Wisconsinan glaciation in middle North America—A discussion: Quaternary Science Reviews, v. 1, no. 4, p. xxiii–xxvii.

Klassen, R.W., 1984, Dating methods applicable to late glacial deposits of the Lake Agassiz basin, Manitoba, *in* Mahaney, W.C., ed., Quaternary dating methods: New York, Elsevier, p. 375–388.

Klassen, R.W., 1989, Quaternary geology of the southern Canadian Interior Plains, *in* ch. 2 of Fulton, R.J., ed., Quaternary geology of Canada and Greenland: Geological Survey of Canada, Geology of Canada, no. 1 (also Geological Society of America, The geology of North America, v. K–1), p. 138–172.

Klassen, R.W., 1992a, Surficial geology and drift thickness, Wood Mountain, Saskatchewan: Geological Survey of Canada Map 1802A, scale 1:250,000.

Klassen, R.W., 1992b, Nature, origin, and age relationships of landscape complexes in southwestern Saskatchewan: Géographie Physique et Quaternaire, v. 46, p. 36l–388.

Klassen, R.W., 1994, Late Wisconsinan and Holocene history of southwestern Saskatchewan: Canadian Journal of Earth Sciences, v. 31, p. 1822–1837.

Klassen, R.W., 2001, Textural and carbonate analyses of tills in the Cypress Lake and Wood Mountain areas, Saskatchewan: Geological Survey of Canada Open File D4006, 1 diskette, IBM format.

Klassen, R.W., 2002, Surficial geology of the Cypress Lake and Wood Mountain map areas, southwestern Saskatchewan: Geological Survey of Canada Bulletin 562, 60 p.

Klassen, R.W., and Hughes, David, 2000, Diamict fill in sub-glacial channels, Poplar River Strip Mine, southern Saskatchewan: Quaternary International, v. 68–71, p. 111–115.

Kugler, Marianne, and St-Onge, Denis, 1973, Composantes du mouvement de rebondissement isostatique d'après des données de remblaiements alluviaux (Exemple de la Rivière Saskatchewan Sud): Canadian Journal of Earth Sciences, v. 10, p. 551–556.

Kupsch, W.O., 1962, Ice-thrust ridges of western Canada: Journal of Geology, v. 70, p. 582–594.

Kupsch, W.O., 1964, Bedrock surface and preglacial topography of the Regina-Wynyard region, southern Saskatchewan: Bismarck, North Dakota, Conrad Publishing Company, Third Williston Basin Symposium, p. 274–283.

Lammers, G.E., 1968, A note on the Saskatoon site, Saskatoon, Saskatchewan, and its contained paleofauna: Napao, v. 1, p. 32–33.

Lissey, Alan, 1962, Groundwater resources of the Regina area, Saskatchewan: City of Regina Engineering Department, Hydrology Division Report 1, 52 p.

Lord, M.L., 1984, Paleohydraulics of Pleistocene drainage development of the Souris, Des Lacs, and Moose Mountain spillways, Saskatchewan and North Dakota: Grand Forks, University of North Dakota, M.S. thesis, 162 p.

Lord, M.L., 1988, Glacial Lake Souris–The history and sedimentology of a lake inundated by discharges from a glacial-lake outburst: Grand Forks, University of North Dakota, Ph.D. dissertation, 200 p.

Lord, M.L., and Kehew, A.E., 1987, Sedimentology and paleohydrology of glacial-lake outburst deposits in southeastern Saskatchewan and northwestern North Dakota: Geological Society of America Bulletin, v. 99, p. 663–673.

Lord, M.L., and Schwartz, R.K., 2003, An array of large-scale erosional bedforms—A detailed record of a glacial outburst flow architecture and spillway evolution: Geological Society of America Abstracts with Programs, v. 35, no. 6, p. 334.

Maathuis, Harm, and van der Kamp, Garth, 1988, Comprehensive evaluation of the groundwater resources in the Regina area: Saskatchewan Research Council, SRC Technical Report 209, 152 p.

Mahaney, W.C., and Stalker, A.M., 1988, Stratigraphy of the North Cliff section, Wellsch Valley site, Saskatchewan: Canadian Journal of Earth Sciences, v. 25, p. 206–214.

Mathewes, W.H., 1974, Surface profiles of the Laurentide ice sheet in its marginal areas: Journal of Glaciology, v. 13, no. 97, p. 37–43.

McCallum, K.J., and Wittenberg, Jurgen, 1962, University of Saskatchewan radiocarbon dates III: Radiocarbon, v. 4, p. 71–80.

McCallum, K.J., and Wittenberg, Jurgen, 1968, University of Saskatchewan radiocarbon dates V: Radiocarbon, v. 10, p. 365–378.

McConnell, R.G., 1885, Report on the Cypress Hills, Wood Mountain, and adjacent country: Geological Survey of Canada Annual Report 1, pt. C, p. C1–C85.

Meneley, R.A., 1956, Pleistocene stratigraphy of the Saskatchewan Landing area: Saskatoon, University of Saskatchewan, B.S. thesis, 34 p.

Meneley, W.A., 1972, Ketepwa fluting field, *in* Christiansen, E.A., ed., Guidebook on geology and its application to engineering practice in the Qu'Appelle Valley area: Regina Geotechnical Group and Saskatchewan Geological Society Field Trip Guidebook, p. 17–20.

Meneley, W.A., Christiansen, E.A., and Kupsch, W.O., 1957, Preglacial Missouri River in Saskatchewan: Journal of Geology, v. 65, p. 441–447.

Mitchell, John, Moss, H.C., and Clayton, J.S., 1947, Soil survey of southern Saskatchewan from Township 1 to 48 inclusive: Saskatoon, University of Saskatchewan, College of Agriculture, Soil Survey Report 12, 259 p.

Mollard, J.D., 1979, Terrain base data map, Regina–Moose Jaw region, Saskatchewan: Regina, Saskatchewan Urban Affairs Regional Studies Program, scale 1:250,000.

Mollard, Jack, Kozicki, Paul, and Adelman, Tim, 1998, Some geological, ground water, geotechnical and geoenvironmental characteristics of the Regina area, Saskatchewan, Canada, *in* Karrow, P.F., and White, O.L., eds., Urban geology of Canadian cities: Geological Association of Canada Special Paper 42, p. 147–170.

Moran, S.R., and Clayton, Lee, 1984, Chronology of late Wisconsinan glaciation in middle North America—Reply to the comments of R.W. Klassen: Quaternary Science Reviews, v. 3, no. 2/3, p. i–vi.

Moran, S.R., Clayton, Lee, Hooke, R.L., Fenton, M.M., and Andriashek, L.D., 1980, Glacier-bed landforms of the prairie region of North America: Journal of Glaciology, v. 25, no. 93, p. 457–476.

Parizek, R.R., 1961, Glacial geology of the Willow Bunch Lake area, Saskatchewan: Urbana, University of Illinois, Ph.D. dissertation, 206 p.

Parizek, R.R., 1964, Geology of the Willow Bunch Lake area (72–H), Saskatchewan: Saskatchewan Research Council Geology Division Report 4, 46 p.

Parizek, R.R., 1969, Glacial ice-contact rings and ridges, *in* Schumm, S.A., and Bradley, W.C., eds., United States contributions to Quaternary research: Geological Society of America Special Paper 123, p. 49–102.

Pohorecky, Z.H., and Wilson, James, 1968, Preliminary archaeological report on the Saskatoon site: Napao, v. 1, p. 35–70.

Quigley, R.M., 1980, Geology, mineralogy, and geochemistry of Canadian soft soils–A geotechnical perspective: Canadian Geotechnical Journal, v. 17, p. 261–285.

Russell, L.S., 1950, The Tertiary gravels of Saskatchewan: Royal Society of Canada Transactions, 3rd ser., v. 24, sec. 4, p. 51–59.

Rutherford, A.A., Wittenberg, Jurgen, and Gordon, B.C., 1984, University of Saskatchewan radiocarbon dates X: Radiocarbon, v. 26, p. 241–292.

Rutherford, A.A., Wittenberg, Jurgen, and McCallum, K.J., 1975, University of Saskatchewan radiocarbon dates VI (sic): Radiocarbon, v. 17, p. 328–353.

Rutherford, A.A., Wittenberg, Jurgen, and Wilmeth, R., 1979, University of Saskatchewan radiocarbon dates VIII: Radiocarbon, v. 21, p. 48–94.

Saskatchewan Research Council, 1986a, Surficial geology of the Melville area (62–K, L), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.

Saskatchewan Research Council, 1986b, Surficial geology of the Yorkton area (62–M, N), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.

Saskatchewan Research Council, 1986c, Surficial geology of the Rosetown area (72–O), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.

Saskatchewan Research Council, 1987, Surficial geology of the Wynyard area (72–P), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.

Saskatchewan Soil Survey Staff, 1997, The soils of the Weyburn and Saskatchewan portion of the Virden map areas 62E and 62F, Saskatchewan: Saskatoon, University of Saskatchewan, Saskatchewan Centre for Soil Research, 128 p.

Sauer, E.K., 1974, Geotechnical implications of Pleistocene deposits in southern Saskatchewan: Canadian Geotechnical Journal, v. 11, p. 359–373.

Sauer, E.K., 1978, The engineering significance of glacier ice-thrusting: Canadian Geotechnical Journal, v. 15, p. 457–472.
Sauer, E.K., 1979, A slope failure at Lebret, Saskatchewan, Canada: Canadian Geotechnical Journal, v. 16, p. 242–250.
Sauer, E.K., and Christiansen, E.A., 1991, Preconsolidation pressures in the Battleford Formation, southern Saskatchewan, Canada: Canadian Journal of Earth Sciences, v. 28, p. 1613–1623.
Sauer, E.K., Egeland, A.K., and Christiansen, E.A., 1993a, Compression characteristics and index properties of tills and intertill clays in southern Saskatchewan, Canada: Canadian Geotechnical Journal, v. 30, p. 257–275.
Sauer, E.K., Egeland, A.K., and Christiansen, E.A., 1993b, Preconsolidation of tills and intertill clays by glacial loading in southern Saskatchewan, Canada: Canadian Journal of Earth Sciences, v. 30, p. 420–433.
Schreiner, B.T., 1990, Lithostratigraphic correlation of Saskatchewan tills—A mirror image of Cretaceous bedrock: Saskatchewan Research Council Publication R1210–3–E–90, v. 1, p. 1–114, v. 2, p. 115–286 (also, 1990, Saskatoon, University of Saskatchewan, Ph.D. dissertation).
Schwarcz, H.P., and Zymela, Steve, 1985, ESR dating of Pleistocene teeth from Alberta, Canada, *in* Ikeya, M., and Miki, T., eds., ESR dating and dosimetry: Tokyo, Ionics Publications Company, Limited, p. 325–333.
Scott, J.S., 1960, Surficial geology of the Elbow-Outlook area, Saskatchewan: Urbana, University of Illinois, Ph.D. dissertation, 40 p.
Scott, J.S., 196l, Surficial geology of the Elbow map-area, Saskatchewan: Geological Survey of Canada Paper 61–15, 10 p.
Scott, J.S., 1971, Surficial geology of the Rosetown map-area, Saskatchewan: Geological Survey of Canada Bulletin 190, 40 p.
Simpson, M.A., 1987a, Surficial geology of the Weyburn area (62–E, F), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.
Simpson, M.A., 1987b, Surficial geology of the Willow Bunch area (72–H), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.
Simpson, M.A., 1987c, Surficial geology of the Wood Mountain area (72–G), Saskatchewan: Saskatchewan Research Council Sedimentary Resources Map, scale 1:250,000.
Skwara, Terri, and Walker, E.G., 1989, Extinct muskox and other additions to the late Pleistocene Riddell local fauna, Saskatoon, Canada: Canadian Journal of Earth Sciences, v. 26, p. 881–893.
SkwaraWoolf, Terri, 1980, Mammals of the Riddell local fauna (Floral Formation, Pleistocene, late Rancholabrean), Saskatoon, Canada: Saskatchewan Museum of Natural History Contributions, no. 2, 129 p.
SkwaraWoolf, Terri, 1981, Biostratigraphy and paleoecology of Pleistocene deposits (Riddell Member, Floral Formation, late Rancholabrean), Saskatoon, Canada: Canadian Journal of Earth Sciences, v. 18, p. 311–322.
Souster, W.E., 1973, Characteristics of thin loess deposits in the Swift Current map area (72–J): Saskatoon, University of Saskatchewan, M.S. thesis, 125 p.
Souster, W.E., St. Arnaud, R.J., and Huang, P.M., 1977, Variation in physical properties and mineral composition of thin loess deposits in the Swift Current area of Saskatchewan: Soil Science Society of America Journal, v. 41, p. 594–60l.
Stalker, A.M., 1976, Quaternary stratigraphy of the southwestern Canadian Prairies, *in* Mahaney, W.C., ed., Quaternary stratigraphy of North America: Stroudsburg, Penn., Dowden, Hutchinson and Ross, p. 381–408.
Stalker, A.M., and Churcher, C.S., 1972, Glacial stratigraphy of the southwestern Canadian Prairies; the Laurentide record: International Geological Congress, 24th session, Montreal, Quebec, Section 12, p. 110–119.
Stalker, A.M., and Vincent, J.-S., 1993, Quaternary, *in* Stott, D.F., and Aitken, J.D., eds., Sedimentary cover of the craton in Canada: Geological Survey of Canada, Geology of Canada, no. 5 (also Geological Society of America, The geology of North America, v. D–1), p. 466–482.
Teller, J.T., 1993, Quaternary geology of the eastern Canadian Prairies, Winnipeg to Moose Jaw: International Geological Correlation Program Project 253, Termination of the Pleistocene, Field Guide, pt. 1, 68 p.

Teller, J.T., 1995, History and drainage of large ice-dammed lakes along the Laurentide sheet: Quaternary International, v. 28, p. 83–92.

Teller, J.T., Moran, S.R., and Clayton, Lee, 1980, The Wisconsinan deglaciation of southern Saskatchewan and adjacent areas–Discussion: Canadian Journal of Earth Sciences, v. 17, p. 539–541.

Townsend, R.C., and Jenke, A.L., 1951, The problem of the origin of the Max moraine of North Dakota and Canada: American Journal of Science, v. 249, p. 842–858.

Vonhof, J.A., 1965, Tertiary gravels and sands in southern Saskatchewan: Saskatoon, University of Saskatchewan, M.S. thesis, 99 p.

Vonhof, J.A., 1969, Tertiary gravels and sands in the Canadian Great Plains: Saskatoon, University of Saskatchewan, Ph.D. dissertation, 279 p.

Westgate, J.A., 1973, Mineralogical and chemical data bearing on the correlation of the Wascana Creek ash in southern Saskatchewan, *in* Christiansen, E.A., ed., Quaternary geology and its application to engineering practice in the Saskatoon-Regina-Watrous area, Saskatchewan: Geological Association of Canada, Guidebook for Field Trip C, p. 54–63.

Westgate, J.A., Briggs, N.D., Stalker, A.M., and Churcher, C.S., 1978, Fission-track age of glass from tephra beds associated with Quaternary vertebrate assemblages in the southern Canadian Plains: Geological Society of America Abstracts with Programs, v. 10, no. 7, p. 514–515.

Westgate, J.A., Christiansen, E.A., and Boellstorff, J.D., 1977, Wascana Creek ash (middle Pleistocene) in southern Saskatchewan–Characterization, source, fission track age, paleomagnetism, and stratigraphic significance: Canadian Journal of Earth Sciences, v. 14, p. 357–374.

Westgate, J.A., and Gorton, M.P., 1981, Correlation techniques in tephra studies *in* Self, Stephen, and Sparks, R.S.J., eds., Tephra studies: Dordrecht, D. Reidel, p. 73–94.

Whitaker, S.H., 1965, Geology of the Wood Mountain area (72–G), Saskatchewan: Urbana, University of Illinois, Ph.D. dissertation, 95 p.

Whitaker, S.H., 1967, Geology and ground water resources of the Wood Mountain area (72–G), Saskatchewan: Saskatchewan Research Council Geology Division Map 5, scale 1:250,000.

Whitaker, S.H., 1970, Geology and groundwater resources of the Swift Current area (72–J), Saskatchewan: Saskatchewan Research Council Geology Division Map 11, scale 1:250,000.

Whitaker, S.H., 1974a, Geology and groundwater resources of the Willow Bunch area (72–H), Saskatchewan: Saskatchewan Research Council Geology Division Map 20, scale 1:250,000.

Whitaker, S.H., 1974b, Geology and groundwater resources of the Weyburn area (62–E, F), Saskatchewan: Saskatchewan Research Council Geology Division Map 21, scale 1:250,000.

Whitaker, S.H., and Christiansen, E.A., 1972, The Empress Group in southern Saskatchewan: Canadian Journal of Earth Sciences, v. 9, p. 353–360.

Wickenden, R.T.D., 193l, An area of little or no drift in southern Saskatchewan: Royal Society of Canada Transactions, series 3, v. 25, sect. 4, p. 45–47.

Williams, M.Y., 1929, The physiography of the southwestern plains of Canada: Royal Society of Canada Transactions, ser. 3, sect. 4, p. 61–79.

Williams, M.Y., and Dyer, W.S., 1930, Geology of southern Alberta and Saskatchewan: Geological Survey of Canada Memoir 163, 160 p.

Wolfe, Brent, 1993, Geological history of glacial Lake Assiniboine, Saskatchewan: Winnipeg, University of Manitoba, M.S. thesis, 391 p.

Wolfe, Brent, and Teller, J.T., 1995, Sedimentation in ice-dammed glacial Lake Assiniboine, Saskatchewan, and catastrophic drainage down the Assiniboine Valley: Géographie Physique et Quaternaire, v. 49, p. 25l–263.

Zymela, Steve, 1986, ESR dating of Pleistocene deposits: Hamilton, Ont., McMaster University, B.S. thesis, 118 p.

Zymela, Steve, Schwarcz, H.P., Grün, Rainer, Stalker, A.M., and Churcher, C.S., 1988, ESR dating of Pleistocene fossil teeth from Alberta and Saskatchewan: Canadian Journal of Earth Sciences, v. 25, p. 235–245.

SUPPLEMENTAL REFERENCES FOR FIGURES AND TABLES NOT LISTED IN "SOURCES OF INFORMATION"

Aguirre, Emiliano, and Pasini, Giancarlo, 1985, The Pliocene-Pleistocene boundary: Episodes, v. 8, p. 116–120.

Andrews, J.T., and Fulton, R.J., 1987, Inception, growth, and decay of the Laurentide ice sheet: Episodes, v. 10, p. 13–15.

Bard, Edouard, Arnold, Maurice, Fairbanks, R.G., and Hamelin, Bruno, l993, ^{230}Th–^{234}U and ^{14}C ages obtained by mass spectrometry on corals: Radiocarbon, v. 35, no. l, p. 191–199.

Bard, Edouard, Arnold, Maurice, Hamelin, Bruno, Tisnerat-Laborde, Nadine, and Cabioch, Guy, 1998, Radiocarbon calibration by means of mass-spectrometric ^{230}Th/^{234}U and ^{14}C ages of corals–An updated database including samples from Barbados, Mururoa, and Tahiti: Radiocarbon, v. 40, p. 1085–1092.

Bard, Edouard, Hamelin, Bruno, Fairbanks, R.G., and Zindler, Alan, 1990a, Calibration of the ^{14}C timescale over the past 30,000 years using mass spectrometric U-Th ages from Barbados corals: Nature, v. 345, p. 405–410.

Bard, Edouard, Hamelin, Bruno, Fairbanks, R.G., Zindler, Alan, Mathieu, Guy, and Arnold, Maurice, 1990b, U/Th and ^{14}C ages of corals from Barbados and their use for calibrating the ^{14}C time scale beyond 9000 years B.P.: Nuclear Instruments and Methods in Physics Research, v. B52, p. 461–468.

Bassinot, F.C., Labeyrie, L.D., Vincent, Edith, Quidelleur, Xavier, Shackleton, N.J., and Lancelot, Yves, 1994, The astronomical theory of climate change and the age of the Brunhes-Matuyama magnetic reversal: Earth and Planetary Science Letters, v. 126, p. 91–108.

Berger, W.H., Yasuda, M.K., Bickert, Torsten, Wefer, Gerold, and Takayama, Toshiaki, 1994, Quaternary time scale for the Ontong Java Plateau–Milankovitch template for Ocean Drilling Program site 806: Geology, v. 22, p. 463–467.

Berggren, W.A., Hilgen, F.J., Langereis, C.G., Kent, D.V., Obradovich, J.D., Raffi, Isabella, Raymo, M.E., and Shackleton, N.J., 1995, Late Neogene chronology–New perspectives in high-resolution stratigraphy: Geological Society of America Bulletin, v. 107, p. 1272–1287.

Berggren, W.A., Kent, D.V., Swisher, C.C., III, Aubry, Marie-Pierre, and Hardenbol, Jan, eds., 1995, Geochronology, time scales, and global stratigraphic correlation: Society for Sedimentary Geology (SEPM) Special Publication 54, p. 1272–1284.

Chen, Jiajie, Farell, J.W., Murray, D.W., and Prell, W.L., 1995, Timescale and paleoceanographic implications of a 3.6 m.y. oxygen isotope record from the northeast Indian Ocean (Ocean Drilling Program site 758): Paleoceanography, v. 10, p. 21–47.

Clark, P.U., Licciardi, J.M., MacAyeal, D.R., and Jenson, J.W., 1996, Numerical reconstruction of a soft-bedded Laurentide ice sheet during the last glacial maximum: Geology, v. 24, p. 679–682.

Clark, P.U., Licciardi, J.M., MacAyeal, D.R., and Jenson, J.W., 1997, Numerical reconstruction of a soft-bedded Laurentide ice sheet during the last glacial maximum–Reply: Geology, v. 25, p. 380–381.

Dyke, A.S., Dredge, L.A., and Vincent, Jean-Serge, 1982, Configuration and dynamics of the Laurentide ice sheet during the late Wisconsin glacial maximum: Géographie Physique et Quaternaire, v. 36, p. 5–14.

Dyke, A.S., and Prest, V.K., 1987a, Paleogeography of northern North America 18,000–5,000 years ago: Geological Survey of Canada Map 1703A, 3 sheets, scale 1:12,500,000.

Dyke, A.S., and Prest, V.K., 1987b, Late Wisconsinan and Holocene history of the Laurentide ice sheet: Géographie Physique et Quaternaire, v. 41, p. 237–263.

Fenton, M.M., Moran, S.R., Teller, J.T., and Clayton, Lee, 1983, Quaternary stratigraphy and history in the southern part of the Lake Agassiz basin, *in* Teller, J.T., and Clayton, Lee, eds., Glacial Lake Agassiz: Geological Association of Canada Special Paper 26, p. 49–74.

Fisher, D.A., Reeh, Niels, and Langley, K., 1985, Objective reconstructions of the late Wisconsinan Laurentide ice sheet and the significance of deformable beds: Géographie Physique et Quaternaire, v. 39, p. 229–238.

Fullerton, D.S., Bluemle, J.P., Clayton, Lee, Steece, F.V., Tipton, M.J., Bretz, Richard,

and Goebel, J.E., compilers, 1995, Quaternary geologic map of the Dakotas 4° × 6° quadrangle, United States: U.S. Geological Survey Miscellaneous Investigations Series Map I–1420 (NL–14), 9 p., map scale 1:1,000,000.

Fullerton, D.S., Ringrose, S.M., Clayton, Lee, Schreiner, B.T., and Goebel, J.E., compilers, 2000, Quaternary geologic map of the Winnipeg 4° x 6° quadrangle, United States and Canada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1420 (NM–14), 16 p., map scale 1:1,000,000.

Gansecki, C.A., Mahood, G.A., and McWilliams, M., 1998, New ages for the climatic eruptions at Yellowstone–Single-crystal $^{40}Ar/^{39}Ar$ dating identifies contamination: Geology, v. 26, p. 343–346.

Hilgen, F.J., 1991, Astronomical calibration of Gauss to Matuyama sapropels in the Mediterranean and implication for the geomagnetic polarity time scale: Earth and Planetary Science Letters, v. 104, p. 226–244.

Hilgen, F.J., 1994, An astronomically calibrated (polarity) time scale for the Pliocene-Pleistocene—A brief review, *in* de Boer, P.L., and Smith, D.G., eds., Orbital forcing and cyclic sequences: International Association of Sedimentary Geologists Special Publication 19, p. 109–116.

Hilgen, F.J., Lourens, L.J., Berger, A., and Loutre, M.F., 1993, Evaluation of the astronomically calibrated time scale for the late Pliocene and earliest Pleistocene: Paleoceanography, v. 8, p. 549–565.

Hughes, Terrence, 1985, The great Cenozoic ice sheet: Palaeogeography, Palaeoclimatology, and Palaeoecology, v. 50, p. 9–43.

Hughes, Terrence, 1987, Ice dynamics and deglaciation models when ice sheets collapsed, *in* Ruddiman, W.F., and Wright, H.E., Jr., eds., North America and adjacent oceans during the last deglaciation: Geological Society of America, The geology of North America, v. K–3, p. 183–220.

Izett, G.A., 1981, Volcanic ashbeds–Recorders of upper Cenozoic silicic pyroclastic volcanism in the Western United States: Journal of Geophysical Research, v. 86, no. B11, p. 10200–10222.

Izett, G.A., and Obradovich, J.D., 1992, $^{40}Ar/^{39}Ar$ dating of the Jaramillo normal subchron and the Matuyama and Brunhes geomagnetic boundary: U.S. Geological Survey Open-File Report 92–699, 16 p.

Izett, G.A., and Obradovich, J.D., 1994, $^{40}Ar/^{39}Ar$ age constraints for the Jaramillo normal subchron and the Matuyama-Brunhes geomagnetic boundary: Journal of Geophysical Research, v. 99, no. B2, p. 2925–2934.

Izett, G.A., Pierce, K.L., Naeser, N.D., and Jaworowski, Cheryl, 1992, Isotopic dating of Lava Creek B tephra in terrace deposits along the Wind River, Wyoming—Implications for post 0.6 Ma uplift of the Yellowstone hotspot: Geological Society of America Abstracts with Programs, v. 24, no. 7, p. A102.

Johnston, W.A., 1935, Western extension of Patrician glaciation: Pan-American Geologist, v. 68, p. 13–18.

Lanphere, M.A., Champion, D.E., Christiansen, R.L., Izett, G.A., and Obradovich, J.D., 2002, Revised ages for tuffs of the Yellowstone Plateau volcanic field—Assignment of the Huckleberry Ridge Tuff to a new geomagnetic polarity event: Geological Society of America Bulletin, v. 114, p. 559–568.

Lanphere, M.A., Champion, D.E., Clynne, M.A., and Muffler, L.J.P., 1999, Revised age of the Rockland tephra, northern California–Implications for climate and stratigraphic reconstructions in the western United States: Geology, v. 27, p. 135–138.

Lourens, L.J., Antonarakou, A., Hilgen, F.J., van Hoof, A.A.M., Vernaud-Grazzini, C., and Zachariasse, W.J., 1996, Evaluation of the Plio-Pleistocene astronomical timescale: Paleoceanography, v. 11, p. 391–413.

Lourens, L.J., Hilgen, F.J., Raffi, Isabella, and Vergnaud-Grazzini, C., 1996, Early Pleistocene chronology of the Vrica section (Calabria, Italy): Paleoceanography, v. 11, p. 797–812.

Lowdon, J.A., Robertson, I.M., and Blake, W., Jr., 1971, Geological Survey of Canada radiocarbon dates XI: Radiocarbon, v. 13, p. 255–324.

Martinson, D.G., Pisias, N.G., Hays, J.D., Imbrie, John, Moore, T.C., Jr., and Shackleton, N.J., 1987, Age dating and the orbital theory of the ice ages–Development of a high-resolution 0 to 300,000-year chronostratigraphy: Quaternary Research, v. 27, p. 1–29.

Mauz, Barbara, 1998, The onset of the Quaternary—A review of new findings in the Pliocene-Pleistocene chronostratigraphy: Quaternary Science Reviews, v. 17, p. 357–364.

Obradovich, J.D., 1992, Geochronology of the late Cenozoic volcanism of Yellowstone National Park and adjoining areas, Wyoming and Idaho: U.S. Geological Survey Open-File Report 92–408, 45 p.

Obradovich, J.D., and Izett, G.A., 1991, $^{40}Ar/^{39}Ar$ ages of upper Cenozoic Yellowstone Group tuffs: Geological Society of America Abstracts with Programs, v. 23, no. 2, p. 84.

Partridge, T.C., 1997, Reassessment of the position of the Plio-Pleistocene boundary–Is there a case for lowering it to the Gauss-Matuyama palaeomagnetic reversal?: Quaternary International, v. 40, p. 5–10.

Preston, R.S., Person, Elaine, and Deevey, E.S., 1955, Yale natural radiocarbon measurements II: Science, v. 122, p. 954–960.

Pringle, M.S., Coe, R.S., and Singer, B.S., 1995, Misidentified polarity transitions from Maui and Jaramillo Creek—The need for complete stratigraphic and geochronologic control [abs.]: EOS (American Geophysical Union Transactions), v. 76, no. 46, supplement, p. F176.

Renne, P.R., Deino, A.L., Walter, R.C., Turrin, B.D., Swisher, C.C., III, Becker, T.A., Curtis, G.H., Sharp, W.D., and Jaouni, Abdur-Rahim, 1994, Intercalibration of astronomical and radioisotopic time: Geology, v. 22, p. 783–786.

Rieck, H.J., Sarna-Wojcicki, A.M., Meyer, C.E., and Adam, D.P., 1992, Magnetostratigraphy and tephrochronology of an upper Pliocene to Holocene record in lake sediments at Tulelake, northern California: Geological Society of America Bulletin, v. 104, p. 409–428.

Sarna-Wojcicki, A.M., Meyer, C.E., Bowman, H.R., Hall, N.T., Russell, P.C., Woodward, M.J., and Slate, J.L., 1985, Correlation of the Rockland ash bed, a 400,000-year-old stratigraphic marker in northern California and western Nevada, and implications for middle Pleistocene paleogeography of central California: Quaternary Research, v. 23, p. 236–257.

Sarna-Wojcicki, A.M., Morrison, S.D., Meyer, C.E., and Hillhouse, J.W., 1987, Correlation of upper Cenozoic tephra layers between sediments of the western United States and eastern Pacific Ocean and comparison with biostratigraphic and magnetostratigraphic data: Geological Society of America Bulletin, v. 98, p. 207–223.

Shackleton, N.J., Berger, Andre, and Peltier, W.R., 1990, An alternative astronomical calibration of the lower Pleistocene timescale based on ODP site 677: Royal Society of Edinborough, Transactions, Earth Sciences, v. 81, p. 251–261.

Shilts, W.W., 1980, Flow patterns in the central North American ice sheet: Nature, v. 286, p. 213–218.

Shilts, W.W., 1982, Quaternary evolution of the Hudson/James Bay region: Le naturaliste Canadien, v. 109, p. 309–332.

Shilts, W.W., 1985, Geological models for the configuration, history and style of disintegration of the Laurentide ice sheet, *in* Woldenberg, M.J., ed., Models in geomorphology: Boston, Allen, and Unwin, p. 73–91.

Suc, Jean-Pierre, Bertini, Adele, Leroy, S.A.G., and Suballyova, Danica, 1997, Towards the lowering of the Pliocene/Pleistocene boundary to the Gauss-Matuyama reversal: Quaternary International, v. 40, p. 37–42.

Tauxe, Lisa, Deino, A.D., Behrensmeyer, A.K., and Potts, Richard, 1992, Pinning down the Brunhes/Matuyama and upper Jaramillo boundaries—A reconciliation of orbital and isotopic time scales: Earth and Planetary Science Letters, v. 109, p. 561–572.

Tauxe, Lisa, Herbert, Timothy, Shackleton, N.J., and Kok, Y.S., 1996, Astronomical calibration of the Matuyama-Brunhes boundary—Consequences for magnetic remanence acquisition in marine carbonates and the Asian loess sequences: Earth and Planetary Science Letters, v. 140, p. 133–146.

Teller, J.T., 1976, Lake Agassiz deposits in the main offshore basin of southern Manitoba: Canadian Journal of Earth Sciences, v. 13, p. 27–43.

Teller, J.T., 1985, Glacial Lake Agassiz and its influence on the Great Lakes, *in* Karrow, P.F., and Calkin, P.E., eds, Quaternary evolution of the Great Lakes: Geological Association of Canada Special Paper 30, p. 1–16.

Teller, J.T., 1989, Importance of the Rossendale site in establishing a deglacial chronology along the southwestern margin of the Laurentide ice sheet: Quaternary Research, v. 32, p. 12–23.

Teller, J.T., 1995, History and drainage of large ice-dammed lakes along the Laurentide ice sheet: Quaternary International, v. 28, p. 83–92.

Teller, J.T., and Fenton, M.M., 1980, Late Wisconsin glacial stratigraphy and history of southeastern Manitoba: Canadian Journal of Earth Sciences, v. 17, p. 19–35.

Tyrrell, J.B., 1914, The Patrician glacier south of Hudson Bay: International Geological Congress, 12th Session, Toronto, 1913, Compte Rendu, p. 523–534.

Veillette, J.J., Dyke, A.S., and Roy, M., 1999, Ice-flow evolution of the Labrador sector of the Laurentide ice sheet—A review, with new evidence from northern Quebec: Quaternary Science Reviews, v. 18, p. 993–1019.

Westgate, J.A., Easterbrook, D.J., Naeser, N.D., and Carson, R.J., 1987, Lake Tapps Tephra—An early Pleistocene stratigraphic marker in the Puget Lowland, Washington: Quaternary Research, v. 28, p. 340–355.