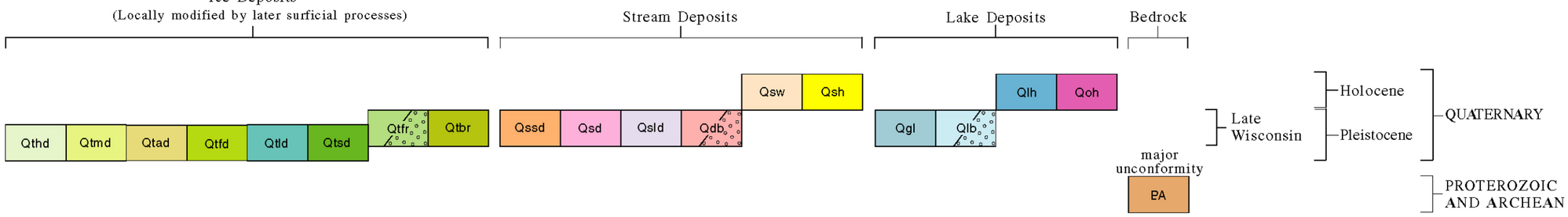
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

HOLOCENE AND LATE PLEISTOCENE

Qoh — **Organic deposits**—Peat and sediment deposited in marshes and shallow lakes. Typically found in depressions interpreted to have formed through melting of buried glacial ice and along former glacial stream channels. Some deposits have been drained.

Qlh — **Lake sediment**—Clay, silt, marl, and some organic material. The basins are commonly shallow (less than 10 feet deep), and the sediment may be thin; some basins have been drained.

Qsh — **Stream sediment**—Stratified layers of silt, clay, and sand; some organic material. The sediment is coarser in the Minnesota River channel. Commonly located along glacial stream channels, where it may bury and incorporate coarser glacial stream sediment. The unit is not shown in narrow channels, although it is present to some extent wherever a modern stream flows. The unit includes the steep side slopes of channels, especially along the Minnesota River, where very little stream sediment is preserved. Rather, older units are exposed in bluffs, and colluvial sediment covers less steep slopes.

Qsw — **Stream sediment of Glacial River Warren**—Stratified sand and gravel; commonly forms bars that protrude above Holocene stream sediment (map unit Qsh) in the River Warren gorge (Fig. 2). The unit is predominantly found where the river reworked existing deposits of sand and gravel. Glacial River Warren was mostly an erosive stream and created erosional (strath) terraces that have boulder lags at the surface.

PLEISTOCENE

DEPOSITS OF THE BIG STONE PHASE OF THE RED RIVER LOBE (LATE WISCONSIN)

Qtbr — **Till of the Big Stone moraine**—Till that contains lenses of sorted sediment and blocks of incorporated clayey lake sediment. Till texture and lithology are highly variable. Texture of the till matrix is loam to clay; yellow-brown where oxidized, gray where unoxidized. Clast rock types include carbonate, crystalline rock, shale (from none to 50 percent of the coarse sand fraction), and some lignite.

The unit is a complex of tills that were deposited along ice fronts that advanced into glacial Lake Benson (Figs. 1b and 2). The first advance to this position was probably of the Des Moines lobe, but the later advances were of the Red River lobe. Although the Red River lobe followed a path similar to that of the Des Moines lobe, its clast content and pattern of retreat indicate it originated in a different part of the ice sheet (directly north rather than north–northwest of the study area; Figs. 1a and 1b). The unit includes areas where lobate bodies of till, interpreted as flow tills, extend from the position of the former ice front (along the Big Stone moraine) into glacial Lake Benson (shown on map by fan symbol). Arcuate ridge crests mark the eastern extent of the moraine (crest line of moraine symbol; see Description of Map Symbols); they may be small push moraines. Elsewhere, the moraine has an irregular, extremely pitted surface, and the till contains many boulders. Pits are interpreted to have formed by burial and subsequent melting of small blocks of ice, possibly lake ice. Boulders are interpreted to have been incorporated locally from nearby granite outcrops. Linear depressions trending south and southeast through the moraine are interpreted to represent collapsed drainageways that eroded through or beneath debris-laden ice.

Qtfr — **Till with stream-modified surface**—Till modified by flowing water; fluvially eroded and streamlined in places. Till texture, lithology, and color are as above (till of the Big Stone moraine; map unit Qtbr). Locally overlain by thin lag of sand and gravel or covered by silt and clay. Channel scars are common; channels may localize organic deposits (map unit Qoh), lakes, and modern streams and flood waters. Stipple indicates areas that collapsed after stream modification, probably from meltout of buried ice; the resulting topography is irregular.

DEPOSITS OF THE ALTAMONT, MARSHALL, GARY, ANTELOPE AND YOUNGER PHASES OF THE DES MOINES LOBE (LATE WISCONSIN)

Qlb — **Lake sediment of glacial Lake Benson**—Silt, clay, and some fine sand; rhythmically laminated in places. Upper part of unit is commonly a massive silt. The thickest, most continuous lake sediment is found in the northeastern quadrant of the former lake, where the lake may have survived longer after the southern part of the basin was drained. A discontinuous distribution of lake sediment in lake margins, ice-supported inlets and outlets, and a lack of clear shoreline features indicate that the lake was confined by stagnant ice. Minor linear ridges and small channels in the basin are interpreted to have formed beneath stagnating ice. Stipple indicates areas of collapsed lake sediment, which is interpreted as originating from meltout of buried ice; the resulting topography is irregular.

Qdb — **Delta sediment of glacial Lake Benson**—Sand, gravel, and silt deposited by streams entering glacial Lake Benson. The largest deltas formed at the mouths of the Pomme de Terre and Chippewa Rivers. Minor deltas are located (1) on the northeastern side of the basin where the East Branch Chippewa River entered it (Swift Falls delta; Fig. 2); (2) at a higher elevation south of the East Branch Chippewa River where some small streams entered during a higher stage of the lake (within the Kerkhoven washed-till plain; Fig. 2); and (3) where Tenmile Creek entered the southwest part of the basin (Boyd delta; Fig. 2). Stipple indicates collapsed delta sediment, areas where a delta apparently formed on a buried glacier and possibly on lake ice; the resulting topography is irregular.

Qtsd — **Subglacial till**—Dense, homogeneous till of the Marshall, Antelope, and younger phases of the Des Moines lobe. Texture of till matrix is loam to clay loam. Clast rock types include carbonate, crystalline rock, shale (average proportion for Marshall phase, 20–30 percent, for Antelope phase, 30–50 percent), and some lignite. Till surface has low relief. Locally overlain by thin (about 10–20-feet thick), discontinuous, supraglacial and englacial sorted sediment and till that typically form linear ridges. The sediment is interpreted to have been localized by crevasses in stagnant ice.

Qtld — **Till with lake-modified surface**—Till that has at its surface a discontinuous, silty, clayey cap or a coarser, near-shore sediment. Till of all phases of the Des Moines lobe and the Big Stone phase of the Red River lobe, and, possibly, older glacial sediment are affected. Till texture, color, and clast lithology are similar to surrounding unit. The till surface has low relief. Erosion may have removed fine sediment, leaving a lag of clasts at the surface. Shorelines are locally marked by very low escarpments, beach ridges, or deltas (sediment of map unit Qdb).

Qtfd — **Till with stream-modified surface**—Till modified by flowing water; fluvially eroded and streamlined in places. Till of all phases of the Des Moines lobe and, locally, older glacial sediment are included in this unit. Matrix texture, color, and clast lithology are similar to the original till unit before erosion. Locally overlain by a thin lag of sand and gravel or covered with silt and clay. Channel scars are common. Channels may localize organic deposits (map unit Qoh), lakes, and modern streams and flood waters. After stream modification, channels may have collapsed from meltout of buried ice.

Qtad — **Till of the Antelope moraine**—Till that forms a low, broad ridge. Matrix texture is loam to clay loam; yellow brown where oxidized, gray where unoxidized. Clast rock types include carbonate, crystalline rock, a moderate to large proportion of shale (30–50 percent), and some lignite. The Antelope-phase ice margin is otherwise indicated by deposits of ice-marginal and ice-supported streams (Antelope Hills and Big Tom hills ice-supported-stream ridges; map unit Qssd; see also Fig. 2).

Qtmd — **Till modified by slope processes**—Till along the slope of the Coteau des Prairies (a glacial erosional scarp); modified by slope wash, mass movement, and ice-marginal streams. Matrix texture is loam to clay loam; yellow-brown where oxidized, gray where unoxidized. Clast rock types include carbonate, crystalline rock, a low to moderate proportion of shale (10–20 percent), and some lignite. In the map area, this part of the Coteau slope was exposed after the Gary phase of the Des Moines lobe, but older units, including pre–Late Wisconsin units, may be exposed locally.

Qthd — **Hummocky till**—Till that has an irregular surface expression and contains discontinuous lenses of clay, silt, sand, and gravel. Clast rock types include carbonate, crystalline rock, a low to moderate proportion of shale (10–20 percent), and some lignite. Unit is interpreted to have been deposited during the Altamont and Gary phases of the Des Moines lobe on and beneath stagnant, wasting ice, and it may have been subject to repeated mass movement during deposition. Unit includes small areas of supraglacial lake and stream sediment. Much of the relief is inherited in the northeast corner of the map area: the till there buries an older moraine of an ice advance from the northeast, and the till texture reflects the more sandy till of the underlying Alexandria moraine (Alexandria highlands; Fig. 2).

Qsd — **Stream sediment**—Sand and gravel deposited by meltwater issuing from stagnating or receding ice of the Altamont and younger phases of the Des Moines lobe. Includes sediment of contemporaneous nonglacial streams, as well as younger and finer glacial and postglacial stream sediment. Broadly arcuate streams delimit former ice-margin positions (Marshall phase, Antelope phase, and possibly younger phases).

Qssd — **Stream sediment formerly supported by ice**—Ridges of sand and gravel deposited by streams; some glacial sediment was deposited by gravity flow into channels. Interpreted to have been deposited in channels that were walled, supported, or enclosed by ice (eskers in the broadest definition of the term). Melting of ice may have led to local disruption of bedding. A significant amount of unsorted, glacial sediment may overlie the sorted sediment. Areas of this unit too small to delineate at the map scale are indicated by a line symbol (minor linear ridges; see Description of Map Symbols).

Qsld — **Stream sediment overlain by lake sediment**—Similar to stream sediment (map unit Qsd) but buried by thin layers (generally less than 10 feet thick) of clay, silt, fine sand, and organic deposits. Streams flowing down the Coteau des Prairies slope deposited fans (for example, Canby fan; Fig. 2) that blocked streams flowing southeast between the base of the slope and the ice margin. The unit is also present where glacial streams backed up owing to some other type of constriction.

Qgl — **Sediment of ice-walled glacial lakes**—Lake sediment in a high topographic position. Deposited in pools in stagnant ice. Fine sediment (clay and silt) may be rhythmically bedded near former lake centers; minor amounts of sand and gravel are present along former lake rims. Unit commonly contains thick, till-like, debris-flow deposits. Forms flat-topped circular uplands within hummocky till terrain in the southwest and northeast corners of map area.

PROTEROZOIC AND ARCHEAN

PA — **Gneiss and granite, undivided**—Archean quartzofeldspathic gneiss; granitoid intrusions and low-grade greenstone belts. Exposed mostly along the bottom of the Glacial River Warren channel (present-day Minnesota River Valley), where overlying glacial sediment and weathered rock (saprolith) have been eroded. Saprolith is still preserved in some protected locations. The smoothly undulating rock surface is interpreted to have formed through chemical weathering while the rock was buried by thick regolith. Glacial and fluvial erosion selectively stripped away the regolith but has made only the minor modifications to the rock surface of striae, crescentic fractures, polish, and potholes.

DESCRIPTION OF MAP SYMBOLS

Geologic contact—Approximately located; established from aerial photographs, geomorphology, and examination of surficial material and soil maps.

Scarp—Ticks point down scarp; established from aerial photographs and topographic maps. Where paired, interpreted as former drainageway. Not indicated where scarp coincides with stream-related unit. In places, drainageways contain organic material, lake sediment, and stream sediment; the deposits are commonly too small in area, too thin, or too discontinuous to map. Former drainageways may locally control the direction of present-day surface and near-surface water flow, especially flood waters. Scarps shown on the Kerkhoven washed-till plain (Fig. 2) are interpreted as having been lake cut and therefore represent former shorelines.

Deep, broad, irregular trough—Interpreted as collapsed subglacial channel (tunnel valley) or buried valley. Some troughs now contain long narrow lakes, such as Lake Hendricks in the extreme southwest corner of the map area.

Fan-shaped sloping hill at mouth of channel—Interpreted to be an alluvial fan (for example, Canby fan; Fig. 2) or a delta into a lake (Boyd delta; Fig. 2) composed of sand, gravel, and silt. Where shown on till of the Big Stone moraine (map unit Qtbr), the symbol indicates a fan-shaped lobe of till (not sorted sediment) that flowed into the lake basin.

Crest line of moraine.

Minor linear ridges—Discontinuous ridges that are generally less than 15 feet high. Visible in areas of thin supraglacial debris. Texture varies from till that is slightly coarser than is found in surrounding area to sand and gravel. Chaotic and collapsed deposits. Interpreted to be sediment localized by low areas, such as crevasses and supraglacial stream channels, in the disintegrating glacier and along the ice margin.

Steep-sided mound of sorted sediment (kame)—Stream sediment deposited on, beneath, or along wasting ice that subsequently collapsed as the ice melted.

Circular depression—Small, generally circular pit that may contain water, lake sediment, or peat, depending on the local water-table elevation. Interpreted to have formed through melting of buried chunks of ice. Very common in certain parts of the Big Stone moraine.

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