DEVELOPING GLACIAL LANDFORM EDUCATIONAL MATERIALS FOR THE ICE AGE NATIONAL SCENIC TRAIL IN STRAIGHT LAKE STATE PARK, POLK COUNTY, WISCONSIN

Rebecca J. Moore, Ian F. Freeman, and Kent M. Syverson, Department of Geology, Univ. of Wisconsin, Eau Claire, WI 54702

ABSTRACT

Straight Lake State Park is the newest state park in Wisconsin (dedicated in 2005). The Ice Age National Scenic Trail was recently constructed through this park in western Wisconsin. No site-specific interpretive materials are available for park visitors. The purpose of this project is to develop glacial geologic interpretive materials for the Wisconsin DNR (WDNR).

Publications about the glacial geology of Polk County (Johnson, 2000), tunnel channels, and eskers were read in the office. One week was spent in the park area studying glacial sediments and landforms. The best locations to observe glacial sediment and landforms were selected to showcase in interpretive materials.

Straight Lake State Park contains classic examples of late Wisconsinan landforms. The Superior Lobe played a key role in developing the landforms in the park. These features include a tunnel channel, esker, hummocks, kettles, and a pitted outwash plain formed during or after the St. Croix Phase about 20,000 cal. yrs B.P.

The Straight Lake tunnel channel was eroded by a subglacial outburst flood near the ice margin. The tunnel channel trends NW-SE and is 12 km long, 0.25 to 0.75 km wide, and at least 27 m deep. After the formation of the channel, reddish-brown, supraglacial sediment of the Copper Falls Formation was deposited inside the channel via a topographic reversal process and obscured the visible channel width along the channel axis. Hummocky topography on the southwestern margin of the tunnel channel contains sandy loam diamicton.

A prominent esker rises up to 15 m above the channel floor and trends parallel to the tunnel channel axis. The esker, a subglacial stream deposit, formed after the erosion of the tunnel channel. The esker is best observed along a 1-km-long segment of the Ice Age Trail northeast of Long Lake and north of State Highway 48. There the sharp-crested, wooded esker towers above the lakes occupying the adjacent parts of the tunnel channel. The esker is present along most of the length of the tunnel channel.

Geological educational materials will be produced in consultation with the WDNR. Materials will include a trail guide, as well as multimedia presentations accessible online via smart phones. The target date for completion of the interpretive materials is May 2012.

INTRODUCTION

Straight Lake State Park is a new 2,780-acre park in Wisconsin. The Ice Age National Scenic Trail was recently constructed through this park (Fig. 1). No site-specific geologic interpretive materials are available for park visitors. The purpose of this project is to develop geologic hiking guide and geology videos for the Wisconsin DNR (WDNR).

The area is underlain by 1.1 billion year old basalt of the Midcontinental Rift (Van Schmus and Hinze, 1985; Fig. 2). Pleistocene glaciation has had the most visible and dramatic effect on the landscape. During the last part of the Wisconsin Glaciation (10,000 to 35,000 yrs ago), the park area was glaciated several times. Most recently (~20,000 years ago) the Superior Lobe covered most of Polk County during the St. Croix phase (Syverson and Colgan, 2011). During this phase and later phases, brown (7.5YR 4/4), sandy till of the Sylvan Lake Member of the Copper Falls Formation was deposited in the area (Johnson, 2000; Syverson et al., 2011; Fig. 3).

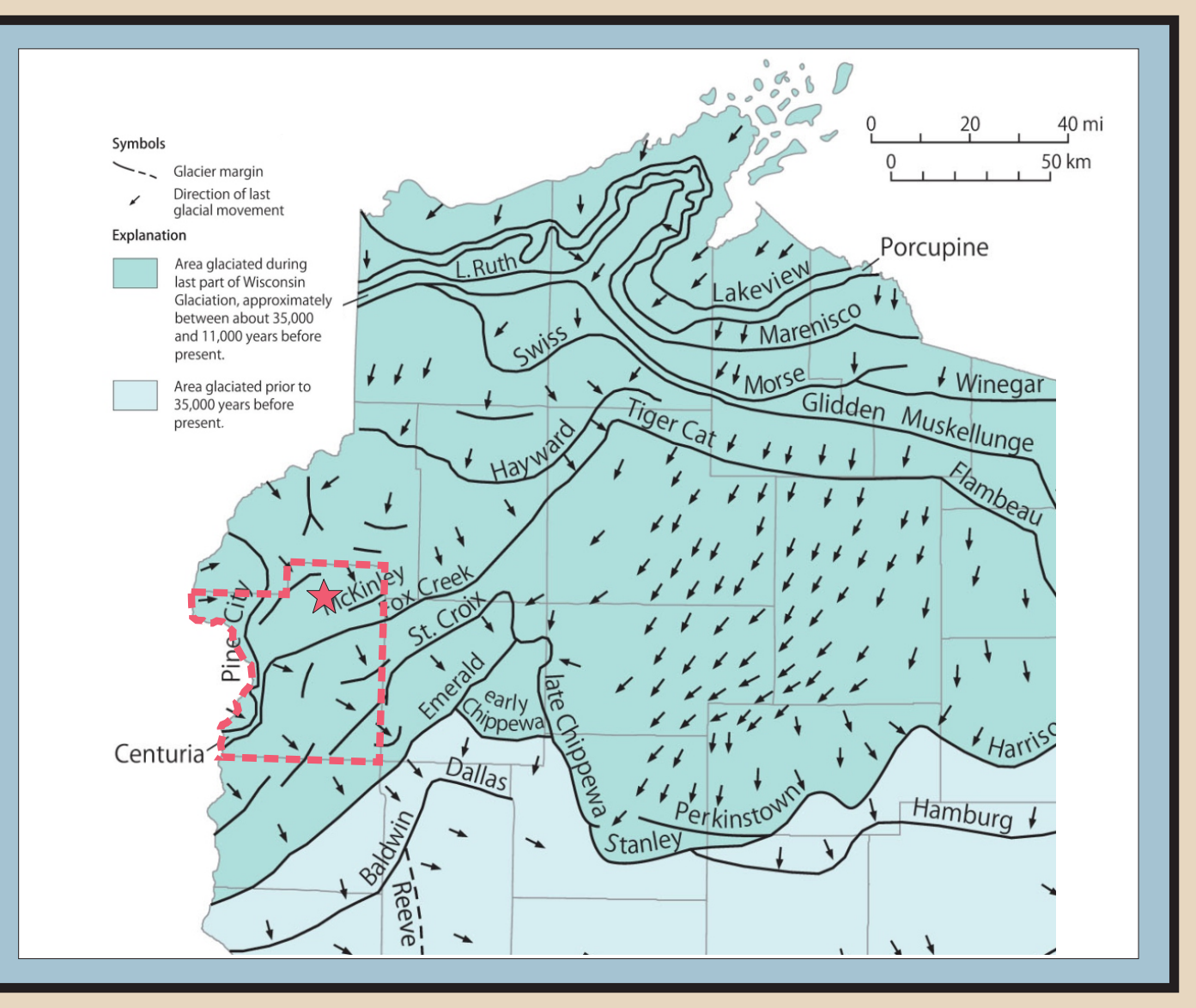

Figure 1. Location of Straight Lake State Park (red star) in Polk County, Wisconsin (outlined in red dashed line). Lines and names represent phases of the last part of the Wisconsin Glaciation. Modified from Syverson et al. (2011).

METHODS

- Read publications about the glacial geology of Polk County (Johnson, 2000), tunnel channels, and eskers in the office.
- Spent two weeks in the park area studying glacial sediments and mapping glacial landforms (summer 2011).
- Selected the best locations to showcase glacial sediment and landforms in interpretive materials. Selection criteria involved finding the most prominent, accessible, and geologically significant features to tell the complete geological history of the park area.
- Took photos and video footage of selected locations to highlight the geologic history of the area.
- Prepared text, figures, and videos in conjunction with the WDNR to use in educational materials for the park.
- Use iMovie to create a series of informational videos of the geology of the state park.

RESULTS

Several locations along the trail were chosen to showcase in a hiking guide for the park and surrounding areas. Five stops are along the trail within the state park boundaries, and three other stops are located on the trail segment between 270th Ave. and State Highway 48 (Fig. 4).

Basalt Outcrops

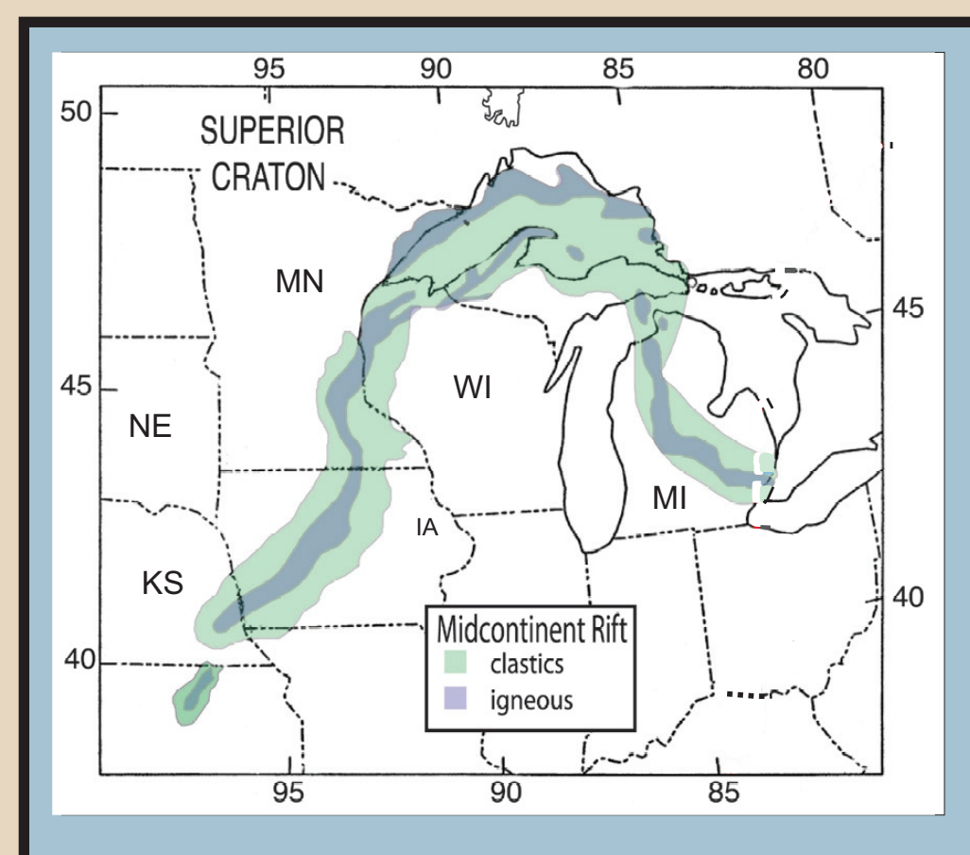

Figure 2. Map depicting the location and extent of the Midcontinent Rift System. The Straight Lake State Park study area is located on eastern side of the rift. Modified from Stein et al. (2011).

Outcrops of amygdaloidal basalt are exposed along the Ice Age Trail in the park area, especially north of 280th Ave. (Stop 2, Fig. 4). Outcrops are up to 20 m in diameter. Many of the outcrops display flat tops or elongate shapes resulting from glacial abrasion. Vesicles in the basalt are elongate, up to 1 cm long, and the amygdules contain several minerals crystallized from hot fluids.

The basalt formed in the Midcontinent Rift (Fig. 2). The continent started to split apart (rift) during the Precambrian Era 1.1 billion years ago. Basaltic lava erupted through fissures parallel to the rift system that extended over 1500 km from Lake Superior to Oklahoma (Van Schmus and Hinze, 1985). The rift was created by stresses forcing the continent apart. If the rift had been successful, a new ocean would have been created. Rather, the rift subsided as it filled with several kilometers of basaltic lava flows, conglomerate, sandstone, and shale. The rifting stopped before an ocean formed, and later the opposite sides of the rift converged and forced blocks of basalt upward.

Pitted Outwash Plains

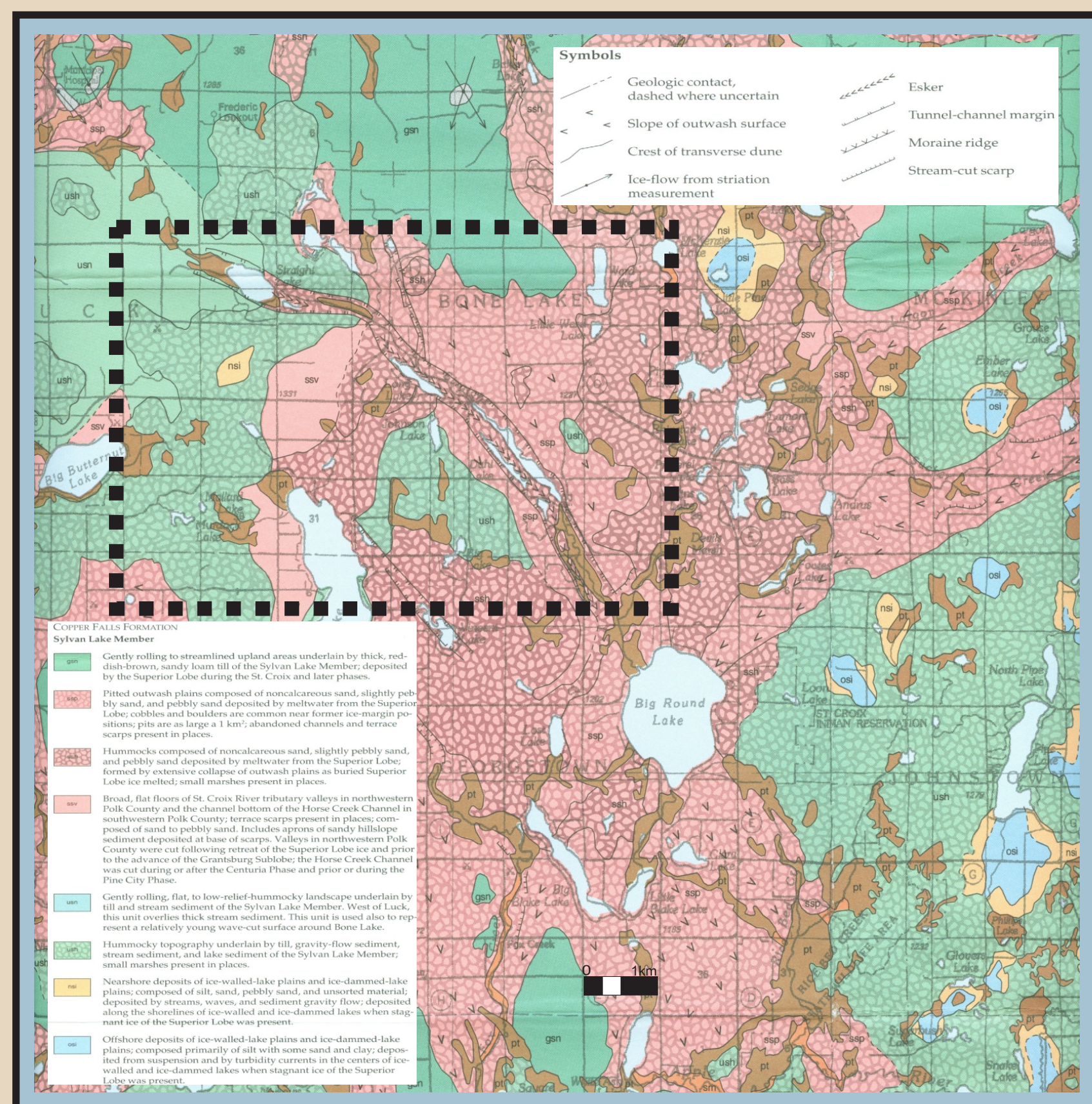

Figure 3. Part of the Pleistocene geology map for the park area (from Johnson, 2000). The dominant sediment in area is Sylvan Lake Member of Copper Falls Formation, predominantly underlying hummocky stream sediment (ssh) and pitted outwash plains (ssp).

The trail crosses a pitted outwash plain located northeast of the tunnel channel and south of 270th Ave., as well as south of the tunnel channel and Big Round Lake (Stop 6, Fig. 4; Johnson, 2000; Mickelson et al., 2011). The plain contains numerous kettles. The trail passes through one particularly prominent kettle about 20 m in diameter and about 5 m deep, and provides an unrestricted view of the kettle and the relatively flat-topped pitted outwash plain surface.

This pitted outwash plain formed as the margin of the Superior Lobe retreated to the northwest. Meltwater deposited stream sediment of the Sylvan Lake Member over blocks of glacial ice (Johnson, 2000). The plain probably formed after the McKinley phase and after the tunnel channel and esker. However, the pitted outwash plain sediment did not fill the tunnel channel. The deep tunnel channel must have been filled with ice during sediment deposition or else the channel would have filled with stream sediment. Later, buried ice blocks melted, and the overlying stream sediment collapsed to form the pitted outwash plain.

Farming is common on the pitted outwash plain because of its rather flat surface; this allows kettles to stand out in an otherwise flat surface.

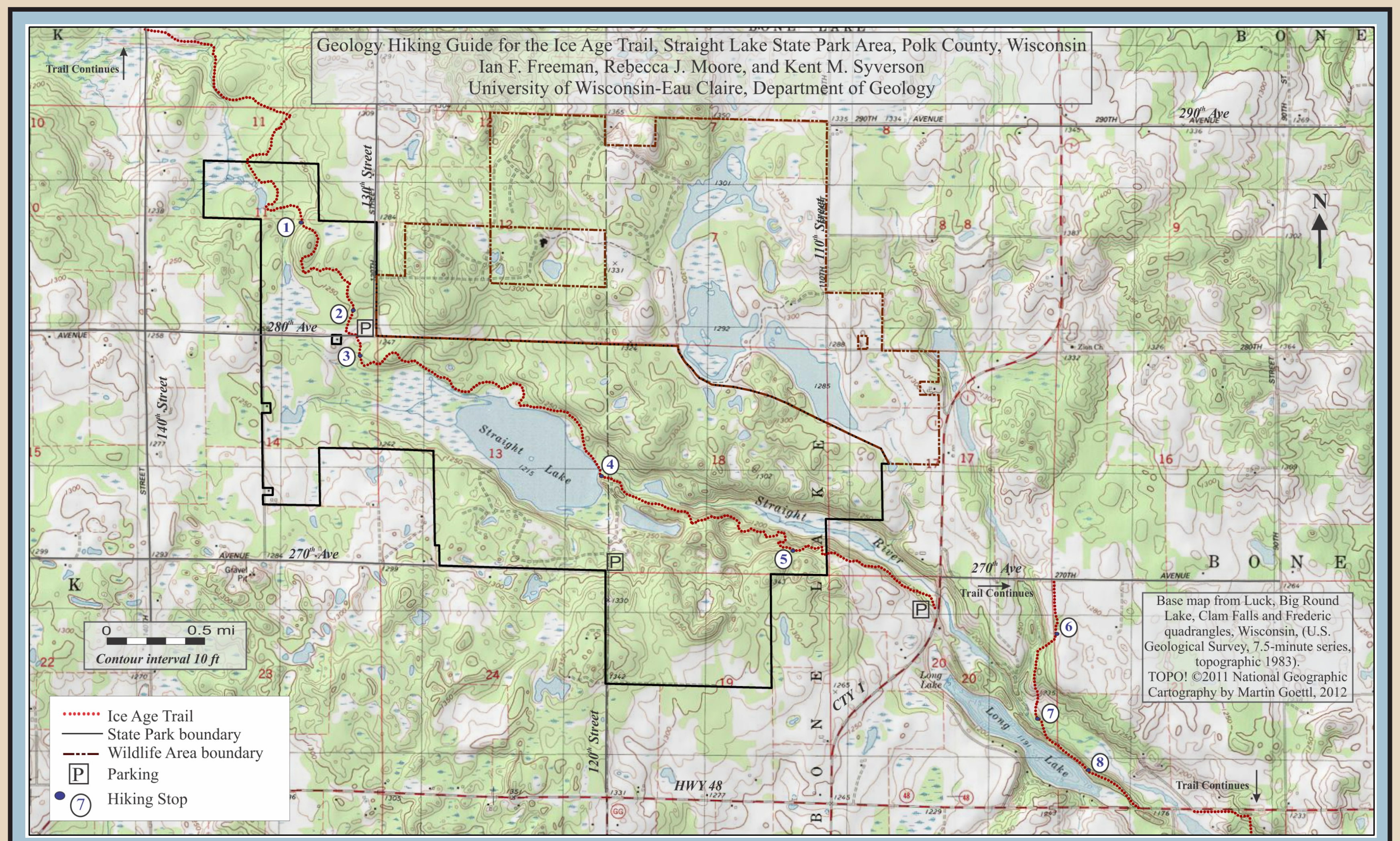

Figure 4. Geology hiking guide for the park region. The back side of the map contains explanations of the geologic features observed in the park. This guide is intended to be published in an 8.5 x 14 inch format.

Tunnel Channel and Till

Johnson (2000) recognized that Straight Lake is located in a tunnel channel. A spectacular view of the greatest width of the tunnel channel can be seen at the south end of Straight Lake along the trail (Stop 4, Fig. 4). The tunnel channel extends 12 km from 280th Ave. southeast to Big Round Lake (Fig. 3). According to Johnson (2000), the tunnel channel terminates near the McKinley phase ice-margin position and starts ~2 km northwest of the Luck phase ice-margin position. The exact timing of tunnel channel formation is uncertain.

A tunnel channel forms as meltwater is stored in a subglacial reservoir (O'Cofaigh, 1996). Pressurized water bursts toward the margin during an outburst flood event and erodes a tunnel channel (Hooke and Jennings, 2006). In the park region, the flood event eroded a tunnel channel at least 27 m deep and 0.25 to 0.75 km wide beneath the ice (Fig. 5). Sediment eroded from the channel was transported to the ice margin, where the water deposited material in a pitted outwash plain south of Big Round Lake.

A poorly-exposed diamicton outcrop is visible south of the trail and a few meters east of Straight Lake (Stop 4, Fig. 4). This outcrop contains the Sylvan Lake Member of the Copper Falls Formation (Johnson, 2000; Syverson et al., 2011). Sylvan Lake Member diamicton in the park area is a brown (7.5YR 4/4) sandy loam. This supraglacial sediment draping the esker (see Esker section) was deposited after the tunnel channel formed (see Hummocky Topography section).

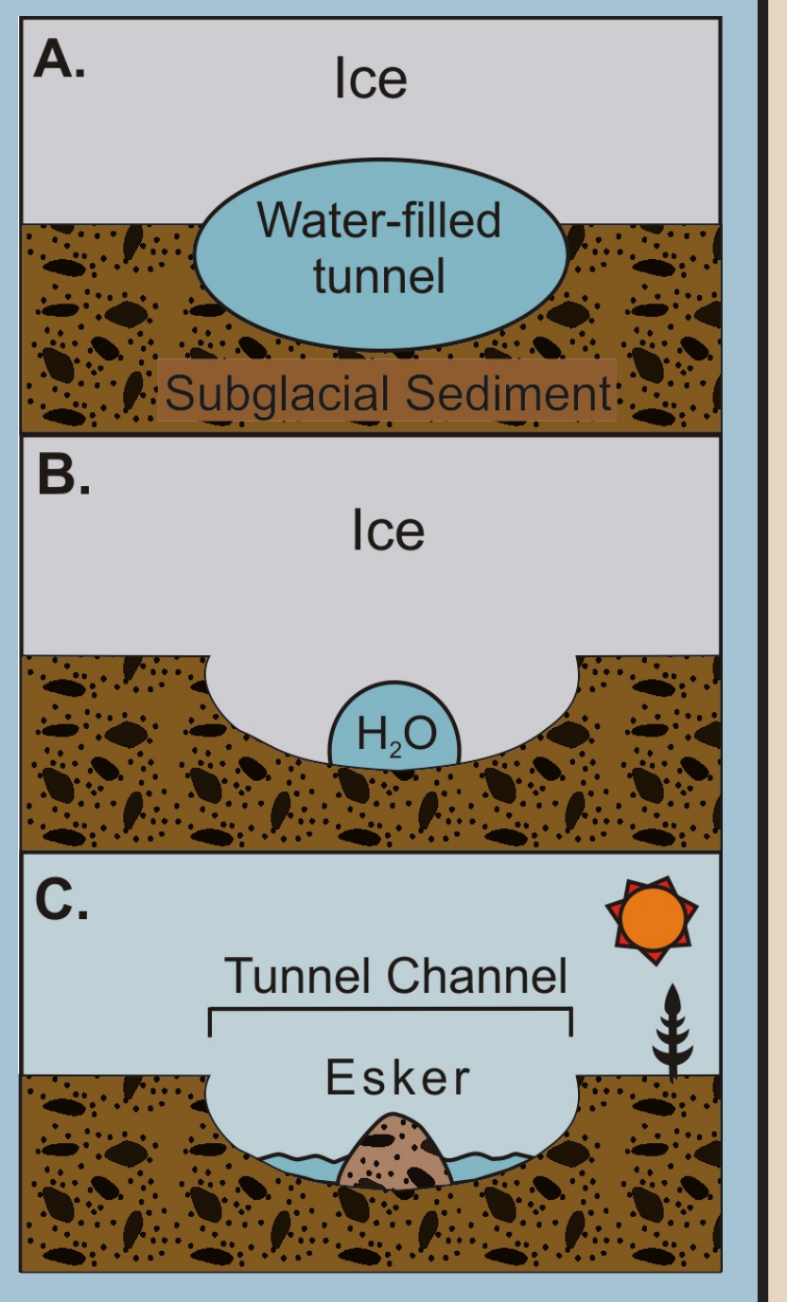

Figure 5. A) Subglacial water flows rapidly toward the ice margin and erodes a tunnel channel in the underlying sediment and/or bedrock. B) Water discharge decreases so ice flows into the tunnel channel. As water discharge decreases, sediment is deposited in the small conduit to form an esker. C) Ice melts to leave a tunnel channel and esker. Lakes and marshes commonly are present in the base of the tunnel channel.

Esker

In the Straight Lake area, a spectacular example of an esker is present in the bottom of the tunnel channel (northeast of Long Lake and directly north of State Highway 48, Stop 8, Figs. 3, 4). Here the trail traverses the crest of the 15-m-high esker. The esker is quite continuous for 7 km along the axis of the tunnel channel. This is a classic example of a sharp-crested esker, which is a sinuous ridge typically deposited by subglacial meltwater (Shreve, 1985). Eskers are common features in glaciated areas, appearing alone or in systems.

Sometime after meltwater eroded the Straight Lake tunnel channel, water flowed toward the southeast through the tunnel channel lowland, but with a lower velocity and discharge than during the outburst flood. Unlike the earlier outburst flood, this water-flow event deposited sediment in the conduit (Fig. 5B). Water washed most silt and clay out of the sediment and left behind sand and gravel in a ridge (the esker, Fig. 5C). No sediment outcrops were observed in this esker segment along the Ice Age Trail.

Hummocky Topography

Hummocky topography is common in the park and the surrounding area. The best example is seen on the trail between Straight Lake and Cty Hwy I (Stop 5, Fig. 4). Kettles and hummocks are formed through the topographic reversal process (Fig. 6). Sediment accumulates on the ice surface near the ice margin. Variable sediment thicknesses cause differential melting and relief on the ice surface (Johnson et al., 1995). Ultimately this leads to the formation of hummocks and kettles. This topography is most common on the part of the trail where supraglacial sediment slumped into the tunnel channel. The slumped sediment reduces the width of the visible tunnel channel to 0.25 km from its maximum width of 0.75 km.

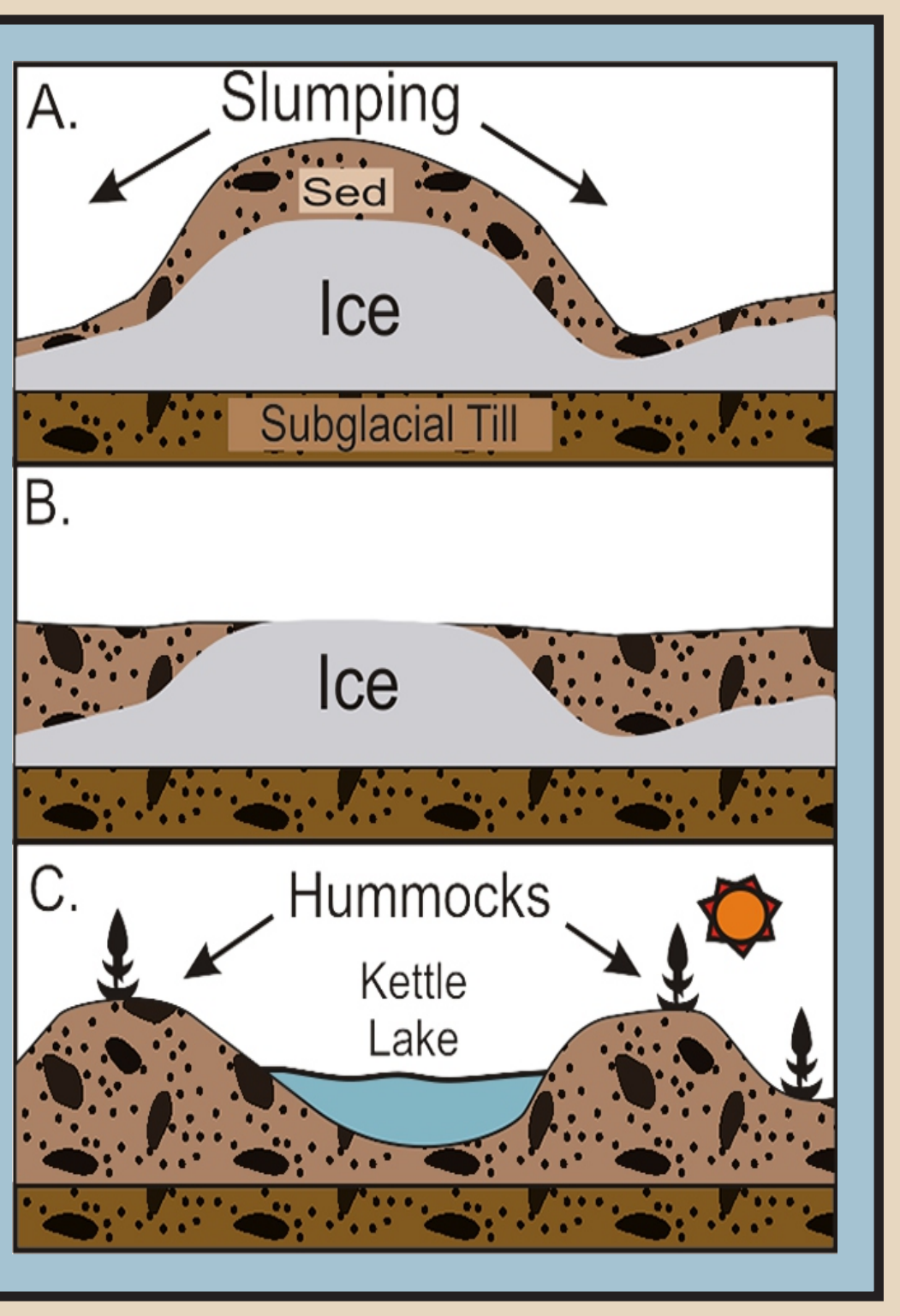

Figure 6. The process of topographic reversal. A) Ice melts more slowly beneath thick sediment and relief develops on the ice surface. Sediments slump off the high area into the surrounding low areas. B) Ice in the center is uncovered and melts. C) The end result is a low area (a kettle) marking the place that was once a high area on the ice surface. The hummocks (hills) mark former low areas on the ice surface. Thus, the resulting land surface is a mirror image of the original topography. Modified from Syverson et al. (1995).

Glacial Erratic Boulder

Figure 7. Glacial erratic boulder. An erratic 0.25 km south of the 280th Ave. segment of the trail in the state park. Meter stick shown for scale.

An erratic is a rock with a different composition than the underlying bedrock. Erratics range in size from pebbles to large boulders. Numerous erratics of different sizes are found in the park area. Their composition reflects the diverse geologic provinces the glacier flowed across. Orange rhyolite, pink granite, and black, coarse-grained gabbro erratics are quite different than the basalt bedrock in the area (see Basalt Outcrops section). The largest erratic along this part of the trail is 0.25 km south of 280th Ave.(Stop 3, Figs. 4, 7). This boulder is about 4 m in diameter and is composed of diorite.

The Superior Lobe flowed out of the Superior basin. Thus, most erratics in the park region come from rock units >160 km to the north along the shores of Lake Superior. The park area is especially rich in erratics because the area was not extensively farmed and the erratics were not moved.

Lag Valley

A meltwater lag valley is located along the northernmost segment of the trail in the park (Stop 1, Fig. 4). This valley contains boulders ranging from 0.5 to 1.5 m in diameter. The lag boulders are primarily basalt, but a few granite and felsite boulders are observed as well. Most of the boulders are rounded from glacial and fluvial transport; however, some are angular because they eroded from a large basalt outcrop along the trail only a few meters southeast of the valley. The boulders fill a valley 10 meters across, about 100 meters long, and a shallow stream flows through open spaces between the boulders ~1 m below the surface.

At the eastern end of the valley is a perched wetland. This wetland is located on a bedrock high. As the glacier wasted in the park region, energetic meltwater flowed through this valley, removed the sand, silt, and clay from between the boulders, and left this boulder lag in the valley.

FUTURE WORK

Work continues with the WDNR to develop a set of educational materials for the park area. The interpretive hiking guide for the Ice Age Trail (Fig. 4) is in its final form and is under review by the WDNR and glacial geologists. In addition, a series of brief videos are currently being produced to discuss the geologic features and the history of the area. The videos will be uploaded to the internet and be accessible within the park via smart phones.

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BIBLIOGRAPHY

Bennett, M.R., and Glasser, N.F., 2009, Glacial geology ice sheets and landforms [2nd edition]: Hoboken, NJ, Wiley-Blackwell, 377 p.
Hooke, R. Leb., and Jennings, C.E., 2006, On the formation of the tunnel valleys of the southern Laurentide ice sheet: Quaternary Science Reviews, v. 25, p. 1364-1372.
Mickelson, D.M., Johnson, M.D., and Syverson, K.M., 2011, Geology of the Ice Age National Scenic Trail, in Miller, J.D., Hudak, G.J., Wittkop, C., and McLaughlin, P.I., eds., Archean to Anthropocene: Field Guides to the Geology of the Mid-Continent of North America: Geological Society of America Field Guide 24, p. 285–297.
Johnson, M.D., Mickelson, D.M., Clayton, L., and Attig, J.W., 1995, Composition and genesis of glacial hummocks, western Wisconsin, USA: Boreas, v. 24, p. 97-116.
Johnson, M.D., 2000, Pleistocene geology of Polk County, Wisconsin: Wisconsin Geological and Natural History Survey Bulletin, v. 92, 70 p.
O'Cofaigh, C., 1996, Tunnel valley genesis: Progress in Physical Geography, v. 20, p. 1-19.
Shreve, R.L., 1985, Esker characteristics in terms of glacier physics, Katahdin esker system, Maine: Geological Society of America Bulletin, v. 96, p. 639-646.
Stein, S. and thirteen others, 2011, Learning from failure: The SPREE Mid-Continent Rift Experiment: GSA Today, v. 21, no. 9, p. 5-7, doi:10.1130/G120A.1.
Syverson, K.M. and nine others, 1995, Hiking field trip guide for glacial landforms in the Chippewa Moraine Ice Age National Scientific Reserve, Wisconsin: Unpublished field guide available through the WGNHS.
Syverson, K.M., and Colgan, P.M., 2011, The Quaternary of Wisconsin: An updated review of stratigraphy, glacial history, and landforms, in Ehlers, J., Gibbard, P.L., and Hughes, P.D., eds., Quaternary Glaciations -- Extent and Chronology, Part IV – a closer look: Developments in Quaternary Science, v. 15, Amsterdam, Elsevier Publishing, p. 537-552.
Syverson, K.M., Clayton, L., Attig, J.W., and Mickelson, D.M., 2011, Lexicon of Pleistocene Stratigraphic Units of Wisconsin: Wisconsin Geological and Natural History Survey Technical Report 1, 180 p.
Van Schmus, W.R., and Hinze, W.J., 1985, The Midcontinent Rift System: Annual Review of Earth Planetary Science, v. 13, p. 345-383.