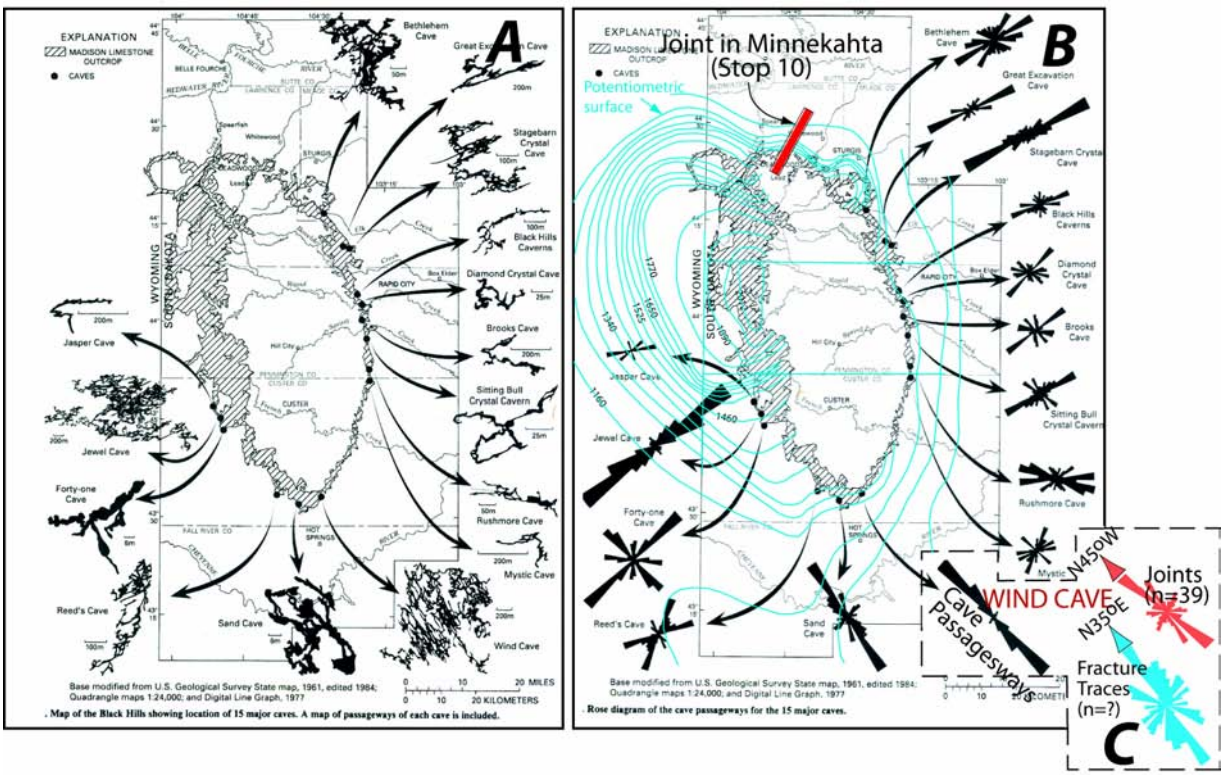

Figure 37. Fifteen major caves in the Black Hills, SD, showing passageways maps (A) and rose diagrams of cave passages (B), and comparison of trends of cave passageways, joints, and fracture traces at Wind Cave, Black Hills, SD (C). Modified from Greene and Rahn (1995). Crystal-lined joint trend in Minnekahta Limestone at Stop 10 is indicated.

The origin of the uppermost purple zone in the Opeche is worthy of investigation (*students at South Dakota School of Mines and Technology take note*). It ranges to about 15 feet in thickness and is present throughout the Black Hills. The color has been attributed to a period of weathering and erosion prior to deposition of the Minnekahta Limestone (e.g., Gries, 1996, p. 258). An alternate possible explanation is that the color is due to staining from chemical leaching in the overlying purplish Minnekahta Limestone. On the east side of the roadcut, the purple zone below the Minnekahta is well exposed and colluvium derived from the Minnekahta extends down the slope to the south (fig. 38). Under the colluvium is another purplish zone that was better exposed than at present. That zone cuts across both the upper Opeche purple zone and the underlying red beds. It is possible that this second purple zone is due to downward percolation of water through the Minnekahta colluvium, staining the underlying rocks, and post-dating the uppermost purple zone. This suggests that the uppermost purple zone in the Opeche throughout the Black Hills may also be caused by chemical alteration by ground water seeping down through the Minnekahta. The chemistry involved has not been studied, and worthy of investigation. A manganese color alteration may be ruled out because Darton (1909, p. 26) reported that manganese was not present in the Minnekahta, but we are unaware of any more recent analyses.

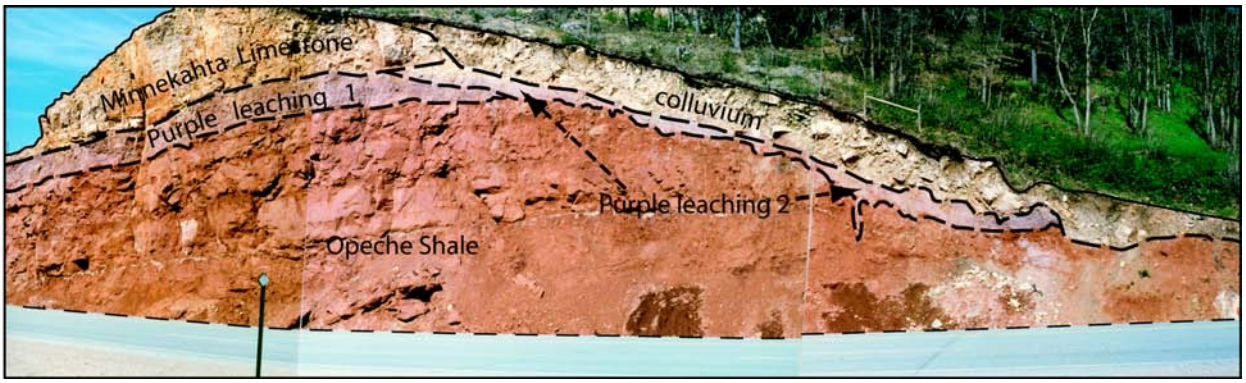

Figure 38. Exposure of the Minnekahta Limestone and upper Opeche Shale on the east side of US 85 at stop 10 showing two purple leach zones in the Opeche.

Turn around heading north on US 85 and retrace route back to I-90.

128.3 2.9 Turn right on I-90 east.

129.3 1.0 Circular hill to right is the Elkhorn dome, rimmed by a circular dip slope of the Minnekahta Limestone and cored by the Minnelusa Formation. Uplift is presumably due to intrusion of a Tertiary laccolith at depth. We are riding on a narrow part of the "red racetrack" underlain by red beds of the Spearfish Formation and with moderately dipping Sundance and Inyan Kara rocks on the left and the Minnekahta to Minnelusa on the right.

133.5 4.2 Turn right on exit 23 towards Whitewood.

133.9 0.4 Stop sign, turn left on Rte 34 west.

134.5 0.6 Turn right on Weyrich Lane.

134.7 0.2 Park in lot of Weyrich Gravel and Service. Walk to top of hill along dirt road.

STOP 11: PROPOSED WHITEWOOD SEWAGE LAGOON AND ARTIFICIAL WETLAND
Leader: Arden Davis

A sewage lagoon and artificial wetland were proposed for the City of Whitewood, South Dakota, at the site of this stop. The geology and hydrology of the proposed wastewater treatment site are similar to that of the failed sewage lagoon site near Spearfish, SD, where two lagoons were built on alluvium above a thick, widespread layer of gypsum in the Gypsum Spring Formation. The lagoons near Spearfish started leaking within a year of their completion; the southern lagoon was abandoned soon after construction, and the northern lagoon could not provide sufficient retention time for proper treatment of sewage (Rahn and Davis, 1996).

At the site of the proposed Whitewood sewage lagoon and artificial wetland (the present stop), surface investigation of the area showed numerous gypsum outcrops, several sinkholes, and a cave entrance nearby (figures 39 and 40). Exposures of thick gypsum in the Gypsum Spring Member were identified within the proposed wetland cells. Sinkholes as deep as 10 meters below the land surface were mapped within 30 m of

the proposed wetland (Figures 41 and 42). Subsequent drilling within a proposed wetland cell showed a 9-meter thickness of gypsum. South of the wetland cells, the proposed site of the sewage lagoon was covered by alluvium, but later drilling also showed massive gypsum beneath that site (Davis and Rahn, 1997).

The Lawrence County Commission tabled the proposed Whitewood wetland project, although not without controversy. Eventually the entire site was abandoned as a potential wastewater disposal facility.

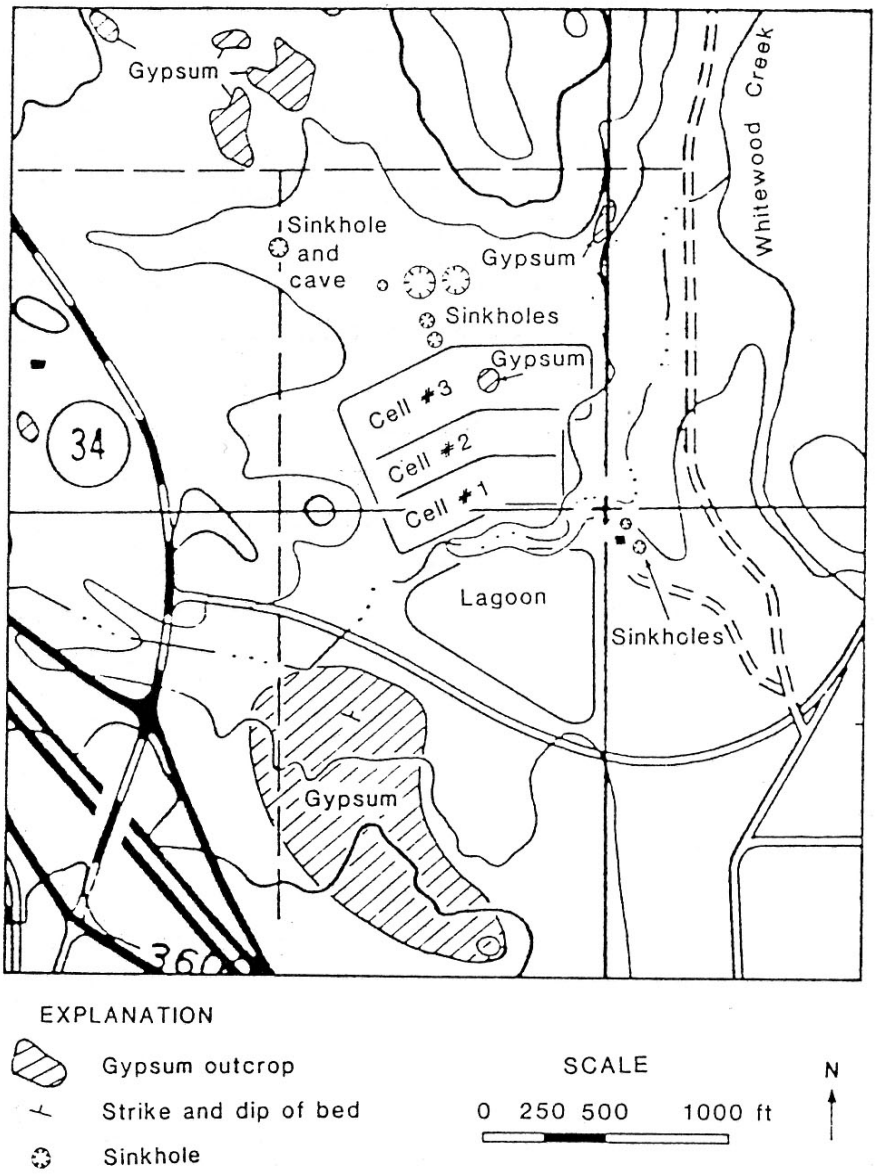

Figure 39. Map of proposed Whitewood sewage lagoon and artificial wetland, showing sinkholes, gypsum outcrops, and cave (from Davis and Rahn, 1997).

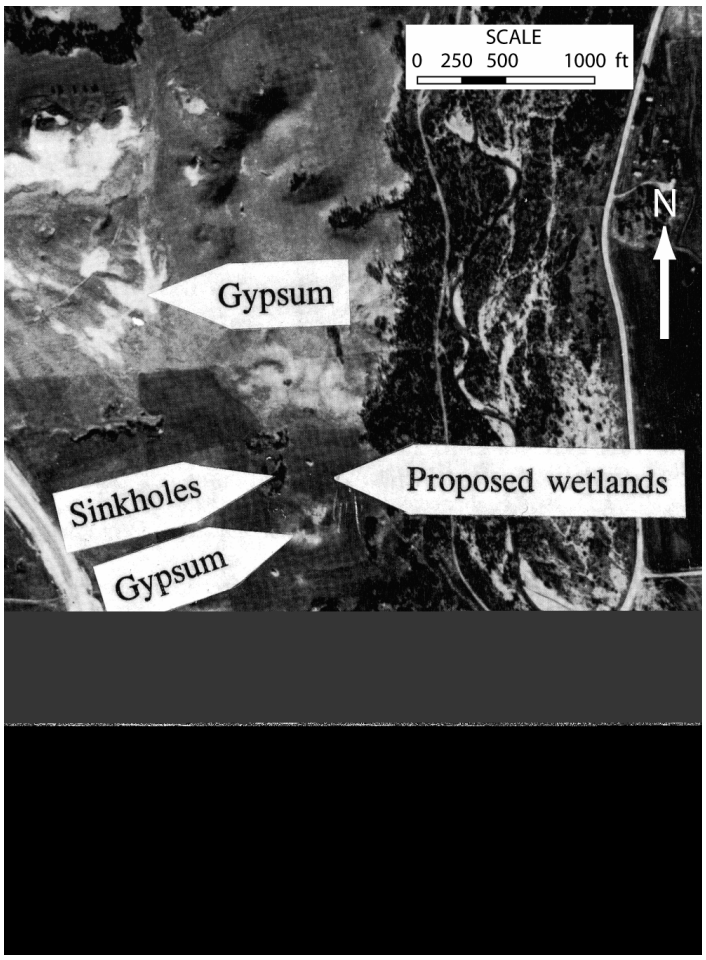

Figure 40. Aerial photograph of proposed Whitewood site (from Davis and Rahn, 1997).

Figure 41. Recently developed sinkhole approximately 100 meters north of proposed wetland cell. Note that the area was being fenced for the safety of cattle and horses (from Davis and Rahn, 1997).

Figure 42. Large sinkhole about 60 meters north of proposed wetland cell. Land surface elevation where person is standing is about 10 meters lower than the elevation at the edge of the sinkhole (from Davis and Rahn, 1997).

Retrace route back to I-90.

135.0 0.3 Turn left on Rte 34 east.

135.6 0.6 Turn left on I-90 East.

137.8 2.2 Gypsum Spring gypsum overlies the Spearfish on left. Bear Butte, an exhumed Tertiary laccolith, may be seen in the far distance poking through hills to left.

138.8 1.0 Gypsum caps red beds, both units of the Gypsum Spring Formation to right. Overlain by greenish shale of the Stockade Beaver Member of the Sundance Formation, and overlies red beds of the Spearfish Formation.

150.9 2.1 Hummocky topography typical of landslide on the slope of the hogback on left.

151.6 0.7 Sturgis, Exit 30. Every year during August a multitude of motorcyclists invade the Black Hills for the famous Sturgis Bike Rally. In 2004 there were 515,000 participants, generating 706 tons of garbage, with 133 marriage licenses issued, four deaths, 16 felony drug arrests, 405 jailed, 340 emergency hospital visits, and $1,100,000 taxes collected (From The Official City of Sturgis Rally Website).

156.2 4.6 Exit 34, Black Hills National Cemetery, one of several, including Arlington National Cemetery near Washington DC.

157.2 1.0 In 1963 a roadcut on I-90 triggered a landslide that was stabilized by removing material equal to the amount removed at the toe of the slide (Rahn, 1986, p. 173).

159.2 2.0 Landslide topography on slope ahead to left.

152.6 3.4 Rest area.

153.3 0.7 Gypsum caps Spearfish red beds on left. Minnekahta, Opeche, and Minnelusa rocks dip towards us on right.

159.6 6.3 Exit 48. Stagbarn Canyon Road. Excellent exposure of upper Sundance, Morrison, and lower Lakota Formations along the road up the hill to left.

164.7 5.1 Enter Pennington County.

168.1 3.4 Cut through the Dakota hogback held up by Lower Cretaceous sandstone and underlain by Jurassic sandstone and shale.

168.6 0.5 Turn right onto I-190 South.

169.8 1.2 Turn right on exit 1C towards the Civic Center.

169.9 0.1 Stop Sign. Turn left towards Civic Center.

170.0 0.1 Bear left towards Civic Center passing under I-190.

170.2 0.2 Stop sign. Continue straight.

170.5 0.3 Traffic light. Turn right on 5th Street.

170.7 0.2 Turn right into Holiday Inn. End of trip.

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