Karst Features of the Hiawatha National Forest, Upper Peninsula, Michigan

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Abstract:

The Upper Peninsula of Michigan is made up in part of Silurian carbonate sequences. These carbonate sequences make up the northern edge of the Michigan Basin and part of the Niagara Escarpment, which runs from eastern New York, through Ontario, Canada, across the Upper Peninsula in Michigan, and back south through the Door Peninsula in Wisconsin. The group which makes up the largest areal extent and upon which nearly all the karst is found in the Upper Peninsula is the Engadine group, which is a dolostone of middle Silurian age.

Karst features have been mapped in this area for the last few years, including: alvar, boulder fields, caves, cliffs, fissures, ledges, outcrops, sinkholes, and springs. With the addition of this year's (2011) field data and the data from Larson et al. (2010) further karst – paleo lake level relationships can be made. Our data suggest that the karst features on the Hiawatha are related to the Algonquin (~250m) and the Nippising (~200m) high lake level stages. We believe that these surficial karst exposures are due to wave action, which eroded away the overburden leaving the bedrock and subsequent karst features exposed with the ensuing lake level drops.

We also present a model for the formation of the dolostone boulder fields on the Hiawatha that invokes the association between the boulder fields and outcrops. We suggest that the boulder fields found surrounding the outcrops are formed by the freeze-thaw cycles of northern Michigan, which bring the upper part of the bedrock to the surface in the form of boulders.

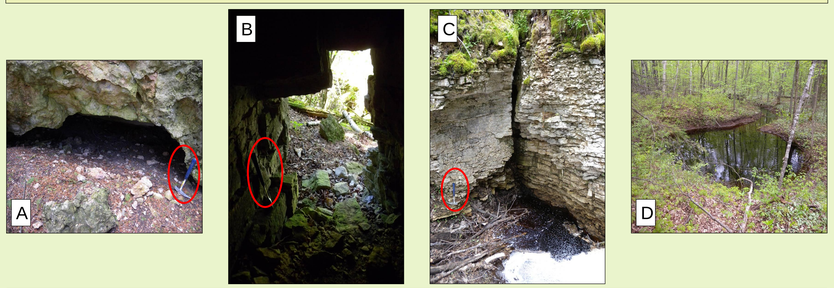

Figure 1:

A) Psuedokarst on the HNF in the Mackinac breccia, a littoral cave built into a sea stack from the Nippising stage. B) Looking out from a cave in the Niagara escarpment face, note the control of joints and bedding planes. C) A sinking stream (Biscuit Creek). D) The resurgence of the sinking stream in C (about 8 m in diameter). Note: Rock hammer is circled in the photographs.

Background:

Paleo-Lake Levels

- Algonquin – 11Kyr – 250-260m AMSL (Schaetzl et al., 2002)
- Nippising – 4.5Kyr – 185-195m AMSL (Baedke et al., 2004)

Based on carbonate cliffs and ledges and beach ridge sediments.

Definitions (NEIS, 2009):

- Alvar – flat calcareous bedrock that is exposed or covered by a thin layer of mineral soil
- Boulder Fields – an area that is ≥0.25 acres with ≥20 boulders (i.e. > 60cm diameter)
- Caves – any natural void beneath the Earth's surface that will permit human entry
- Cliffs – vertical exposure of bedrock, >2 m tall
- Fissures – gap in bedrock
- Ledges – vertical exposure of bedrock, >1 m but <2 m tall
- Outcrops – rocky and bedrock areas too complex to map as a single feature
- Sinkholes – depression in the Earth's surface, caused by dissolution

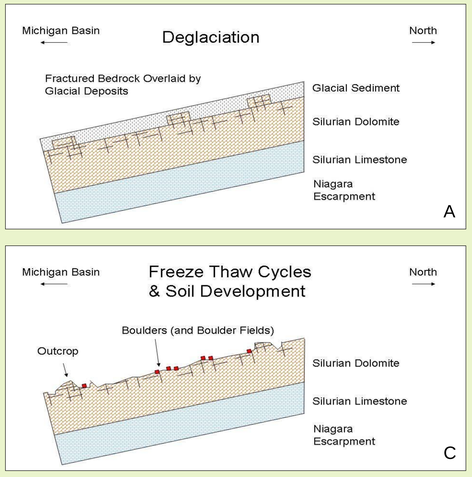

Figure 2:

The proposed mechanism for the formation of boulder fields on the HNF. The figures are not to scale, the Silurian units of the HNF make up the northern edge of the Michigan Basin, and are therefore dipping in a southerly direction. No boulder fields have been identified north of the northern edge of the Niagara Escarpment. A) The environment of the HNF immediately after deglaciation, note that the dolomite is fractured. B) Several high lake level stages were present during the Holocene which washed away any glacial till, and broke up some of the fractured dolomite. The washing of till away, and breaking of rock is focused at whatever elevation that the lake is at where wave action can be most intense. C) Lake level falls, leaving only rock exposed, which continues to break up over freeze/thaw cycles. D) Soil develops in the mid-late Holocene to present covering up some areas of bedrock. Boulder fields are typically found in association with outcrops, but are also found free standing.

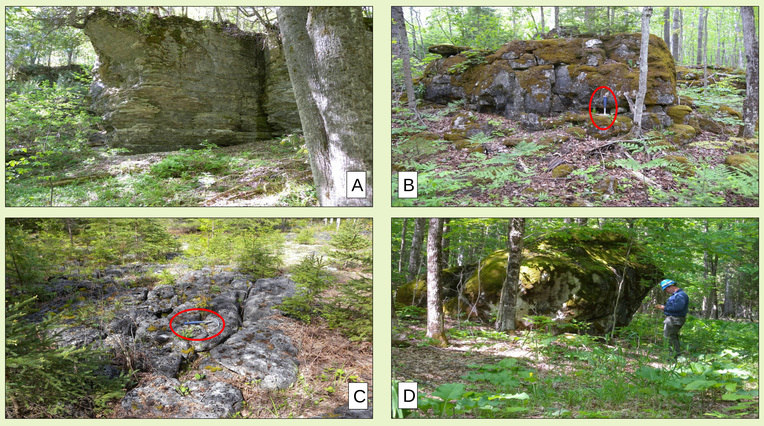

Figure 3:

A) The Niagara escarpment (a cliff by definition), the escarpment is 6 m tall at this location. B) Large outcrop which is highly fractured. C) Small outcrop which is highly fractured. D) An example of a boulder in the HNF, many are much smaller however, in high densities occasionally associated with outcrops. Note: Rock hammer is circled in the photographs.

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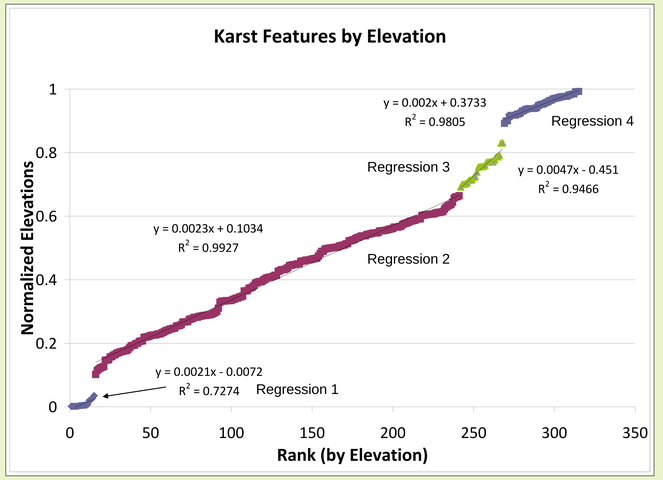

Figure 4:

The relationship between all karst features and their respective elevations. The elevations are represented on the y-axis, these data were normalized. The x-axis represents the ranking of the features by elevation. Note that there are four distinct breaks in the overall data (table 1). These regressions (populations) are all significantly different from each other using ANCOVA ($p < 0.01$) (Zar, 2010).

Table 1:

The elevation means, standard deviations, and 95% confidence intervals of the different regressions (karst feature populations) found in figure 4.

Regression	n	Mean (m)	Std. Deviation (m)	95% Lower CI (m)	95% Upper CI (m)
1	15	198.6	8.7	194.2	203.1
2	226	247.3	9.1	246.1	248.5
3	27	267.7	2.7	266.7	268.7
4	47	290.0	6.7	288.1	291.9

Conclusion

Karst features on the HNF are related to paleo lake levels. We have associated the lower two elevation populations with both the Algonquin and Nippising stages (Background & Table 1). Biases exist due to the low number of karst features in the lower class, however, based on anecdotal information many more features are present at this elevation. The highest elevation population likely represents escarpment failure as most of these features are associated with cliffs and ledges. We argue that the various karst features on the HNF are expressed as a function of paleo lake wave activity (figure 2).

References:

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