Fractured sandstone karst aquifers, the St. Peter, Jordan and Hinckley Formations: Examples from Askov, Woodbury, Rochester and elsewhere.

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Hypogene Speleogenesis:

Hydrogeological and Morphogenetic Perspective

Alexander Klimchouk

National Cave and Karst Research Institute Special Paper №1 2007 Hypogene Karst

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Epigene versus Hypogene Solution Porosity



Figure 1. Epigenic and hypogenic karst in the context of basinal groundwater flow. Adopted and modified from Tóth (1999). The figure shows mainly gravity-driven flow in an idealized homogenous basin. In reality, most sedimentary sequences are highly heterogeneous, and gravity-driven flow interacts with other flow mechanisms.



Figure 2. Evolutionary types of karst and speleogenetic environments (from Klimchouk and Ford, 2000).



Hinckley Sandstone

Askov Minnesota





Subsurface Profile Sinkhole D127

Key: no vertical exaggeration

1=organic rich soil (black) 2=loess and fine sand 3=mature medium grained sand 4=clay, some gravel and sand 5=gravely sand, some clay 6=till (dark red) 7=weathered bedrock 8=bedrock and boulders 9=fracture in bedrock dashed line is limit of excavation solid vertical lines are auger holes

Karst features within the Hinckley Sandstone



Rapid Movement of Ground Water



Flow velocities in excess of miles/ month.

Multiple flow directions from single tracer inputs

Take Home Messages

It isn't what you don't know that hurts – it's what you know that isn't so.

A. Hinckley Sandstone

- 1. Quartz is soluble and karst features form in sandstone.
- Karst secondary porosity can transport ground water at velocities of <u>at least</u> miles per month in sandstone karst.

New Richmond Sandstone Shakopee Fm, Prairie du Chien Group

Altura, Minnesota, 1976





Lewiston, Minnesota 1991



Bellechester Minnesota 1992





Take Home Messages

B. New Richmond Sandstone

- 1. Don't build waste storage lagoons on top of the New Richmond Sandstone.
- The fundamental spacing of master joints is on the order of 10 meters – any construction that covers more area than that will be over one or more master joints.

Bedrock Topography Twin Cities Metro Karst Features in the St. Peter Sandstone



Bedrock Topography Minneapolis, St. Paul and central Washington Co.



34th St. Sinkhole, Minneapolis

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Take Home Messages

C. St. Peter Sandstone

1. In the Metro Area St. Peter Sandstone karst features are strongly associated with current and buried valleys.

Dancing Waters, Woodbury, Minn.

Sinkhole Locations





D42

Master Joint N61°E





D42 Excavation

Paleo Sinkhole Fill





D42 Excavation

St. Peter Sandstone heavily fractured

Old sloping fractures with stained, weathered surfaces

Fresh sloping fractures without stained, weathered surfaces

Voids in the St. Peter produced by downward slumping

Pockets of glacial sediments washed into voids in the St. Peter

Sinkhole D38 conceptual model



Excavated SW end of D38



Open sloped joints





D38 Grouting cleaned, open joints in the St. Peter benches

Back filling D38 with clayey till lifts



Take Home Messages

C. St. Peter Sandstone

- 1. In the Metro Area St. Peter Sandstone karst features are strongly associated with current and buried valleys.
- 2. An effective site investigation should start with a backhoe and a person able (and willing) to recognize evidence of karst.

Rochester Area Karst Features (in the St. Peter Sandstone)





Chateau Theater Parking Lot 2001



Chateau Theater Parking Lot 2001

Prairie Crossing - 2006







Prairie Crossing 13 April 2007



Prairie Crossing 13 April 2007



Take Home Messages

C. St. Peter Sandstone

- 1. In the Metro Area sandstone karst features are strongly associated with current and buried valleys.
- 2. An effective site investigation should start with a backhoe and a person able (and willing) to recognize evidence of karst.
- 3. Backfilling sinkholes sinkholes with transmissive materials is not an effective remediation.

CONDUITS RULE

Fractures Drool

Pores Suck