The Origin of Sediment-Filled Wedges in Northern Delaware and their Paleoclimatic Significance

By: Mary D. Lemcke
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I. Introduction

   a. Geologic Background of Site Locations
   b. Quaternary Cold Climate Influence in Mid-Atlantic Region

II. Field and Laboratory Methods

   a. Field Survey and Sampling Procedures
   b. Laboratory Procedures

III. Data Analysis

IV. Origin of Delaware’s Sediment-Filled Wedges

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   b. Physical Properties of Various Sediment-Filled Wedges

V. Conclusions and Recommendations for Future Research
You may be asking yourselves…

What on earth is a “sediment-filled wedge”? and Why would anyone want to study “sediment-filled wedges”? 
Geologic Map of Delaware

Tbd: Beaverdam Formation
Qcl: Columbia Formation
Qo: Omar Formation
Qlh: Lynch Heights Formation
Qsc: Scotts Corners Formation
Qn: Nanticoke Deposits
Qst: Staytonville Unit

(Groot and Jordan, 1999)
Why are sediment-filled wedges significant?

or more specifically…

Why are sediment-filled wedges significant in Delaware?
<table>
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<tr>
<th>TIME DIVISIONS</th>
<th>AGE (Ma)</th>
<th>ISOPOE STAGES</th>
<th>ESTIMATED M.A.T.</th>
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vc = very cold; c = cold; ct = cool-temperate; t = temperate; wt = warm-temperate; w = warm; m = moist.
Field Procedures:

- Gravel pits were identified on USGS topographic maps and inspected for sediment-filled wedges.

- The depth to the top, width, and length of each wedge and was measured.

- Measurements were taken along the pit wall to determine the depth to any distinct layers within the surrounding sediments.

- Sediment samples were taken from the silt cap, stratified and unstratified portions of the Columbia Formation, and from inside one wedge at each site.

Laboratory Procedures:

- Grain-Size Distribution

- Mineralogy and Texture
Data Analysis

Columbia Formation:
- Grain size, mineralogical, and textural data support the fluvial nature of the Columbia Formation.
- Grain size data differ for stratified and unstratified layers of the Columbia Formation while mineralogical and textural data are very similar.

Silt Cap:
- The silt deposit differs from the other layers in grain size, mineralogy, and texture.

Sediment-filled Wedges:
- Based on grain size, mineralogical, and textural data from inside and outside of the sediment-filled wedges, the wedge infill appears to wind-blown Columbia sediments.
- They do not contain any sediment from the overlying layer of wind-blown silt and most likely formed before the silt cap was deposited.
Theory of Multiple Working Hypotheses (Chamberlain, 1897)

- Chamberlain (1897) advocated a method of multiple working hypotheses (MWH) as a device to determine a “best” explanation by eliminating other possibilities.

- In the present context, this approach allows for exploration of every cracking mechanism that could have produced the wedges, and all modes of sediment transport that resulted in the infilling of each wedge.
Ice-Wedge Cast or Secondary Sand Wedge

Wyoming
Primary Sand Wedge

- Form by thermal contraction cracking
- Require the presence of permafrost
- Similar to ice wedges in size and shape
- Infill consists of vertically stratified sediment
- Adjacent strata are upwardly deformed along the wedge
- Form polygons
Frost Wedges

- Form by thermal contraction cracking
- Require intense seasonal freezing but the presence of permafrost is not necessary
- Commonly form in sand and gravel
- Very narrow and usually less than 1.5 m in vertical extent
- Infill consists of vertically stratified sediment with the largest grains at the top
- Adjacent strata are deformed downward along the edge of the wedge
- Form polygons
Nonthermal Tension Crack

- Result from stresses developed in response to non-temperature dependent processes
- Small and narrow
- Linear features that rarely form polygons
- Form in fine-grained floodplain deposits
- Adjacent sediment is not deformed along the edge of the wedge
- Infill consists of collapse material and adjacent layers continue into crack
- Infill may contain organics near the center
Kettle Cracks

- Occur in conjunction with kame and kettle topography.
- Tend to curve with increasing depth.
- May form poorly organized polygons.
- Form within outwash plain deposits.
- Adjacent strata slightly offset.
- Infill consists of fine- to medium-grained outwash sediment.
Desiccation Cracks

- Calcite-Filled Cracks
- Lenticular Cracks

Vertically Foliated Cracks

Desiccation cracking in floodplain mudstone → Sediment infilling → Reopening of crack in crack margin

Vertical stratification in infilling sediments → Repetition
Alteration Processes

Wetting and Drying
• Expansion of clay soils within a pre-existing wedge during the wet season causes the wedges to expand
• Contraction of clay during the dry season causes the wedge to contract and reopen

Freezing and Thawing
• Expansion of thawing wedge sediments during a warm period causes the wedge to expand
• Contraction of freezing sediment during cold period causes wedge to contract and reopen
Seismic and Small-Scale Ground Movements

• Loading – underground movement of liquified sediment.

• Diapirism – upward movement of minerals into domed or folded geologic units.

• Sedimentary Dikes – seismic activity causes liquified sediment to move into sedimentary layers from above and below.

• Small Faults - open at or near the ground surface due to seismic activity may fill with sand that falls in from above or is injected into the crack from below.
Groundwater Movements

Soil Fingers
- 10’s of cm deep but may be up to 2 m
- Form at the base of the B-horizon
- Form within coarse, calcareous sediments
- Located within relatively flat areas
- May form linear, circular, or irregular surface patterns
- Layers are drawn downward into the wedge structure
- Grain size decreases with increasing depth within the wedge

Sand-Filled Fissures
- Water escape structures
- Vertically stratified infill
- Infill consists of collapsed host material
- Adjacent strata is upturned along the edge of the fissure
Delaware’s sediment-filled wedges are not…

- Delaware’s sediment-filled wedges are not ice wedge casts or relict sand wedges and the associated extreme climatic conditions cannot be assumed for Northern Delaware.

- Delaware’s sediment-filled wedges are not nonthermal tension cracks or kettle cracks.

- They did not form as the result of desiccation cracking or altered by wetting and drying and the associated moisture conditions cannot be assumed for Northern Delaware.

- They are not the result of the seismic processes of loading and diapirism, nor are they sedimentary dikes.

- They were not formed by groundwater mechanisms such as sediment-filled fissures or soil fingers.
Delaware’s sediment-filled wedges may be...

- The sediment-filled wedges in Northern Delaware are very similar to frost wedges in seasonally frozen ground.

…but at this stage we can not rule out…

- Small faults formed in response to seismic activity.

- Alteration by freezing and thawing processes.
Future Research

• A more accurate age for the sediment-filled wedges would provide us with more specific information about the environment in which the wedges formed.

• A more accurate age can be determined using thermoluminescence or optically stimulated luminescence dating.
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