ABSTRACT

Sediment-filled wedges have been observed at two sites in northern Delaware. The wedges are located within the Pleistocene channel deposits of the Columbia Formation and are overlain by a layer of wind-blown silt. They are approximately 25 to 60 cm wide and 1 to 1.5 m in vertical extent. The origin of the sediment-filled wedges may be due to one of several mechanisms, each with its own set of requisite environmental conditions. The mode of transport for the wedge infill may also be due to one of several mechanisms, each with its own environmental implications. The origin of the sediment-filled wedges and the mode of transport for the wedge infill were explored using Chamberlain’s Method of Multiple Working Hypotheses. A detailed physical description of each wedge, along with stratigraphic and sedimentalogical information was used to eliminate any wedge-forming and sediment-transporting mechanisms that could not have resulted in the formation of the wedges in northern Delaware. The grain size of sediment samples from inside and outside one wedge from each location was analyzed using U.S. Standard Sieves. The mineralogy and surface texture of each sediment sample were analyzed using a petrographic microscope. The sedimentalogical and stratigraphic information indicates that the wedges are most likely relict frost wedges formed by thermal contraction cracking in seasonally frozen ground and filled with wind-blown Columbia sediment.

# TABLE OF CONTENTS

LIST OF TABLES............................................................................................................. ix  
LIST OF FIGURES ......................................................................................................... xi  
ABSTRACT.................................................................................................................... xiv  

Chapter  
1 INTRODUCTION .......................................................................................................1  
1.1 The Periglacial Setting.........................................................................................1  
1.2 Sediment-Filled Wedges...................................................................................2  
1.3 Origins of Sediment-Filled Wedges....................................................................3  
1.4 Explanation of Terms.........................................................................................5  

2 GEOLOGIC BACKGROUND OF SITE LOCATIONS.............................................9  
2.1 Site Locations.......................................................................................................9  
2.2 Stratigraphy of the Middletown and Kenton Sand and Gravel Pits ..............10  
  2.2.1 Sedimentology of the Columbia Formation .............................................11  
  2.2.2 Sedimentology of the Surficial Silt Deposit .............................................13  
2.3 Physical Description of the Sediment-Filled Wedges .....................................14  

3 DOCUMENTATION OF QUATERNARY COLD CLIMATE  
 INFLUENCE IN THE MID-ATLANTIC REGION ....................................................23  
3.1 Deposition of the Columbia Formation ............................................................23  
3.2 Middle- and Late-Pleistocene Cold-Climate Deposits of Delaware ................25  
3.3 Late-Wisconsin Cold-Climate Deposits .............................................................27  
3.4 Holocene Deposits ............................................................................................29  
3.5 Possible Periglacial Features in Delaware .......................................................29  

4 FIELD PROCEDURES AND LABORATORY METHODS .................................34  
4.1 Field Survey.......................................................................................................34  
4.2 Measurement and Sampling Procedures.........................................................35  
4.3 Ground-Penetrating Radar Survey ..................................................................36  
4.4 Laboratory Procedures ....................................................................................39  
  4.4.1 Grain-Size Analysis ...................................................................................40
LIST OF TABLES

2.1 Summary of sedimentary layers observed within the sand and gravel pits near Middletown and Kenton, Delaware ...............................................................22

4.1 Common grain-size scales for sediment ............................................................47

4.2 Grain-size and verbal terms for sorting classes .................................................47

4.3 Relation of Power’s verbal rounding classes to Wadell’s roundness and Folk’s Rho Scale....................................................................................................48

A.1 Results of the grain-size analysis for sample KN WI .............................................118

A.2 Results of the mineralogical analysis for sample KN WI......................................119

A.3 Results of the textural analysis for sample KN WI ................................................119

A.4 Results of the grain-size analysis for sample MT-E1 WIa ....................................121

A.5 Results of the grain-size analysis for sample MT-E1 WIc ....................................121

A.6 Results of the grain-size analysis for sample MT WI ..........................................122

A.7 Results of the mineralogical analysis for sample MT WI ......................................123

A.8 Results of the textural analysis for sample MT WI .............................................123

A.9 Results of the grain-size analysis for sample KN SC ..........................................125

A.10 Results of the mineralogical analysis for sample KN SC ....................................126
LIST OF FIGURES

1.1 Map of the mid-Atlantic region showing the locations of sediment-filled wedges (▼ indicates the location of reported relict frost wedges and field located sediment-filled wedges; ▽ indicates the location of reported ice-wedge casts)........................................................................................................................................8

2.1 Map of Northern Delaware showing the locations of the DELDOT sand and gravel pit south of Middletown and the privately owned sand and gravel pit near Kenton........................................................................................................................................16

2.2 Schematic diagram of a cross section of the DELDOT sand and gravel pit south of Middletown........................................................................................................................................17

2.3 Photograph of a sediment-filled wedge located within the DELDOT sand and gravel pit south of Middletown........................................................................................................................................18

2.4 Photograph of a sediment-filled wedge located within a privately owned sand and gravel pit near Kenton........................................................................................................................................19

2.5 Photograph of a layer of fine gravel offset by a sediment-filled wedge located within the DELDOT sand and gravel pit south of Middletown........................................................................................................................................20

2.6 Photograph of vertically oriented pebbles within a sediment-filled wedge located within the DELDOT sand and gravel pit south of Middletown........................................................................................................................................21

3.1 Generalized geologic map of named surficial sedimentary units ..................................32

3.2 Palynologically determined ages of members of the Columbia and Delaware Bay Groups........................................................................................................................................33

4.1 Schematic map of the ground penetrating survey area within the DELDOT sand and gravel pit........................................................................................................................................44

4.2 Photograph depicting the site of the ground-penetrating radar survey completed in the Middletown DELDOT sand and gravel pit on February 17, 2000........................................................................................................................................45

4.3 Ten-meter ground penetrating radar profile #6 taken directly behind the face of the southern wall of the DELDOT sand and gravel pit in Middletown ........46
5.1-8 Cumulative weight percent curves for sediment samples taken from within the sediment-filled wedges and surrounding sediments near Kenton and Middletown............................................................................................................61

6.1 Schematic diagram of a sediment-filled wedge formed by nonthermal tension cracking ..........................................................................................................................95

6.2 Schematic diagram illustrating the development of vertical stratification in desiccation cracks ..........................................................................................................................96

6.3 Schematic diagram of a sediment-filled wedge formed by wetting and drying or freezing and thawing ...........................................................................................................97

6.4 Schematic diagram illustrating the development of ice wedges in thermal contraction cracks ..........................................................................................................................98

6.5 Schematic diagram of a primary sand wedge ..........................................................................................................................99

6.6 Schematic diagram of a secondary sand wedge or ice wedge cast ..........................................................................................100

6.7 Sketch of a vertically foliated frost wedge located within the floodplain of a proglacial river in West Greenland ..........................................................................................101

A.1 Grain-size distribution for sample KN WI ..........................................................................................................................118

A.2 Grain-size distribution for sample MT WI ..................................................................................................................................122

A.3 Grain-size analysis for sample KN SC ..........................................................................................................................125

A.4 Grain-size distribution for sample MT SC ..........................................................................................................................129

A.5 Grain-size analysis for sample MT-W2 CD ..........................................................................................................................132

A.6 Grain-size distribution for sample KN UC ..........................................................................................................................134

A.7 Grain-size distribution for sample MT-E1 UC ..........................................................................................................................137

A.8 Grain-size distribution for sample KN SLT ..........................................................................................................................139

A.9 Grain-size distribution for sample MT-E1 SLT ..........................................................................................................................142