# 1. Introduction

For almost two hundred and seventy five years it has been suggested that some lowland sediments may reflect processes occurring within glaciers (Scheuchzer, 1723, quoted in translation by North, 1943). Large scale features, such as diamict beds, uniform clast orientations, folds, and shears have been explained as the result of either glacial deposition and deformation, and have given us much information on the processes obscured under ice masses. The research in this thesis aims to refine the interpretation of glaciogenic structures, but at a much smaller scale.

The study of small scale (µm to cm size) structures in glacial sediments began in the 1950s. This followed the development of resin-impregnation techniques to produce soil thin sections. Plastic resin is drawn into the sediments by a vacuum, and allowed to harden. The material is then sawn up, set on glass slides, polished, and examined under an optical or electron microscope. As with soil science and hard rock geology, it was discovered that glacial sediments that appear homogeneous on a larger scale display complex depositional and deformational structures under a microscope. It was quickly realised that such structures reflect the mode of the sediments formation. However, it was only after advances in other soft sediment fields that it was recently realised the structures will also have affected the materials bulk properties. These property changes may have affected the glacial dynamics. It is hoped that the results of this Ph.D. research add to the understanding of how specific microstructures both reflect and affect the conditions in which they are produced.

The principle aim of this Ph.D. research is to examine the place of microscopic structures in the response of glaciogenic sediments to the ice and surrounding conditions. However, it is also hoped that this research indicates a number of new ways of using micromorphological data, as well as utilising recently developed techniques, such as dynamic permeability testing in triaxial rigs. Larger scale information is only rarely brought into this discussion, principally to explain the background to each region studied, and also, occasionally, to enlarge upon, or back up, interpretations derived from the micromorphology.

## The structure of this thesis.

*Chapter Two* introduces previous studies of microscopic structures from glacial sediments and reviews their conclusions. These conclusions largely centre upon how the microstructures may have been produced, and how this production reflects the environments they formed in.

*Chapter Three* introduces work from other studies of sediment microstructures, continuing the theme of the origin of the structures, but also examining work that looks at how microstructures may have gone on to affect the response of the sediment to stress and fluid throughflow after their formation. This information will be used throughout this thesis, and also reveals a number of conclusions pertinent to other glacial studies.

*Chapter Four* examines a deposit in North Wales, using the information reviewed in the previous chapters to analyse the simplest case of glaciogenic sediment development; the passive response of sediments to changing conditions. The development of the sediment's micromorphology is used to form a chronology of events which the material has experienced, and to indicate how conditions changed during these events in a qualitative manner. The changes in the material are not thought to have fed back to change the local glacial dynamics.

*Chapter Five* determines new information on the development of a suite of micromorphological structures which reflect a situation where the ice and subglacial bed are actively affecting one another; the ploughing and lodgement of a clast. Here the micromorphology is still largely a passive reflection of conditions, however, a more complex analysis is undertaken which allows us to quantify the rheology of the sediment using the micromorphology.

*Chapter Six* examines the active response of till to glacial stress and hydraulic conditions using laboratory tests. The problems with moving from laboratory tests to a generalised till rheology are discussed, and a model of till rheology for specific areas of deforming sediments is developed. The areas of this model which are uncertain are outlined in preparation for their examination in Chapter Seven.

*Chapter Seven* looks at the micromorphology of the test samples, and indicates how the development of micromorphological features in the till contributes to the bulk responses seen in the laboratory tests. The micromorphology of the test samples also shows how a number of the 'classic' glaciogenic microstructures develop.

*Chapter Eight* examines the active and passive response of glacial sediments from a number of field sites using information from the previous chapters. The information from these sediments is used to build up a picture of the basal conditions of the Late Devensian glacier responsible for their development.

*Chapter Nine* draws together the most important results of the previous chapters and outlines the directions future work will follow.

Thus, it is hoped that this thesis provides information on the active and passive interaction between the microstructure of sediments and their surrounding conditions, and indicates the wealth of information locked in the small scale structure of glaciogenic materials.