# Long Term Effectiveness of Geotextiles on Subsurface Agricultural Drainage Systems

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ABSTRACT: This paper presents results of a field and laboratory examination of nine distinct geotextiles which were installed four to fifteen years ago as filters on agricultural drain pipes, in silt and sand soils. Field observations of geotextile materials have shown that in all cases but one that the fabrics were not clogged, the drains were clear of mineral sediment deposition and the filters had no tendency to tear while being sampled or hand washed. The one exception was a fibreglass geotextile of an unknown age (probably greater than 15 years) which was easily torn and was brittle upon drying. All geotextiles exhibited small amounts of particles trapped within and on the geotextiles surfaces. In some cases chemical deposits within the geotextiles and/or within the drains were observed. Iron ochre was the most predominate of drain deposits. Microscopic examination of the soil/geotextile interface established the existence of a network of soil bridges and of a large quantity of macro-pores at this interface.

## 1 INTRODUCTION

For more than a century, gravel filters have been used around drain tiles placed beneath the ground surface. Notwithstanding the following of proper design procedures, it has been observed that failure of a gravel filter to perform its function properly can still stem from one or more of several reasons, including the followings: clogging of the gravel by soil fines; particles passing through the filter to block the inside of the drain; lack of stability of the granular filter material; changes in gravel size grading along the drain line; and poor soil hydraulic conductivity surrounding the filter.

It is accepted that many large subsurface drainage development projects are needed in the arid and semi-arid regions of the world. The costs involved in such projects necessitate a firm confidence in geotextiles as functional drain filters before they will be chosen over the relatively costly granular filters. This paper presents the data on conditions of geotextile filters which had been installed on subsurface drainage systems up to 15 years ago.

## 2 FIELD DESCRIPTION

A field investigation was executed in 1991 on two sites to inspect the condition of various geotextile filters which had been installed on agricultural drainage systems. Table 1 gives a description of the fabrics.

### 2.1 Ormstown Site, Canada

This site consist of 30 parallel lateral drains of 220 m length with six replicates of five filters installed in a silt-loam soil. Four geotextiles, identified as GTX1, GTX2, GTX3 and GTX4, and one control drain with no fabric were installed in October 1983 (Bolduc, 1986; Rollin et al. 1987). Another fabric, installed in this field in 1987, identified as GTX5, was also sampled.

### 2.2 Drummond County Site, Canada

This site consists of 21 drains, 134 m in length, with four replicates of four filter fabrics, indicated as GTX6, GTX7, GTX8 and GTX9, and one granular filter (Gibson, 1978). All drains with filter as well as one control with no fabric were installed in July 1976.

Table 1: General Description of Installed Geotextiles

| Geotextile ID | Manufacturing Process | Polymer | Mass per Unit Area (g/m²) | Thickness (mm) |
|---|---|---|---|---|
| GTX1 | Slit film woven, needle punched staple fibres, side sewn | PP | 171 | 0.80 |
| GTX2 | Knitted with pile on one side | PE | 230 | --- |
| GTX3 | Nonwoven needle-punched, calendered, side sewn | PE | 200 | 0.91 |
| GTX4 | Nonwoven wet laid bonded, side sewn | PE | 119 | 0.24 |
| GTX5 | Knitted | PE | 95 | 0.89 |
| GTX6 | Nonwoven, spunbonded, glue jointed | PP | 120 | 0.33 |
| GTX7 | Nonwoven, spunbonded, glue jointed | PA | --- | --- |
| GTX8 | Nonwoven, spunbonded, glue jointed | PE | --- | --- |
| GTX9 | Knitted, yarn stocking | PA | 119 | 0.91 |

## 3 SAMPLING AND TESTING PROCEDURE

Sampling procedure is a crucial part of evaluation of filter and drain long term performance. In the reported research a special embedding technique was applied to sample undisturbed soil/geotextile specimens. After excavation close to the filtration system the sample was further isolated by carefully flaking away the surrounding soil until a soil layer of around 5 mm is left. The geotextile sample with 5 mm soil layer on top was embedded in the epoxy resin. The selected resin permits all manipulation: infiltration, drying and hardening of soil/geotextile specimens to be done without the need of dehydratation of a specimen. First, a mixture of the resin and hardener was slightly heated before being poured on the sample in the field. After pouring and preliminary hardening, a specimen was carefully cut and transported to the laboratory where the hardening process continued under controlled conditions. Cured specimens were sectioned with diamond knive. The cross section of the soil/geotextile interface was then polished prior to being analyzed under a microscope.

Also, at each sampling site, a one meter length sample of drain pipe plus fabric was removed and two soil samples were taken. The first sample was extracted from the soil profile at a horizontal distance of 150 to 200 mm from the drain, and the second sample was collected from the soil layer within 5 mm of the drain pipe. Finally, soil profile characteristics, amount of sediment within the drains and the general condition of the pipe and fabric were noted. The one meter long geotextile samples were allowed to dry in the laboratory and were visually examined. Then the loose soil adhering to the surface of the fabric was shaken off and the fabric was weighed. Each fabric sample was then hand washed with warm water, dried in an oven for 20 minutes to air dryness and weighed again.

It is important to noticed that the sampling conditions were in the dry at the Ormstown location but at the Drummond County location the water table was at the top of the drain due to controlled drainage being practised at this location. Controlled drainage is practised at this location in order to irrigate the crop, and in an effort to maintain an anaerobic condition at the drain level to discourage iron ochre formation and deposition on the outside and inside of drains.

## 4 RESULTS AND DISCUSSION

### 4.1 General Condition and Performance of Fabrics

With regard to the filtering performance of the fabrics, none of the plastic drains contained more than a trace of mineral sediment. At the Ormstown location, which was in the dry, careful flaking of the soil away from the fabric revealed very clean fabric. That is, the soil did not adhere strongly to the fabric. It was noted that the soil in immediate contact with the geotextiles exhibited an abundance of macro-pores, suggesting that the soil fines had been removed from an interface zone of soil/filter. Thickness of this zone was estimated at 2 to 4 mm. The easy separation of the soil from the geotextile filter was most particularly noticeable on the GTX3 fabric. The soil surface in contact with the geotextile GTX 3 is presented in Figure 1. This pattern of macropores was not present in the soil located away from the drains.

The geotextiles were not crushed or cracked. Minor amounts of small roots on, within and under the fabric occurred at all of the Ormstown sites, but at none of the Drummond sites. The lack of roots at this last location is likely due to the artificially high water table which is maintained at this site. At the Drummond County sites the drain pipes were one half to two-thirds full of an ochre gel. The drains had however hydraulic capacity high enough to evacuate water. All of the fabrics at this site were stained a red colour. No ochre gel formation was noticed at the geotextiles.

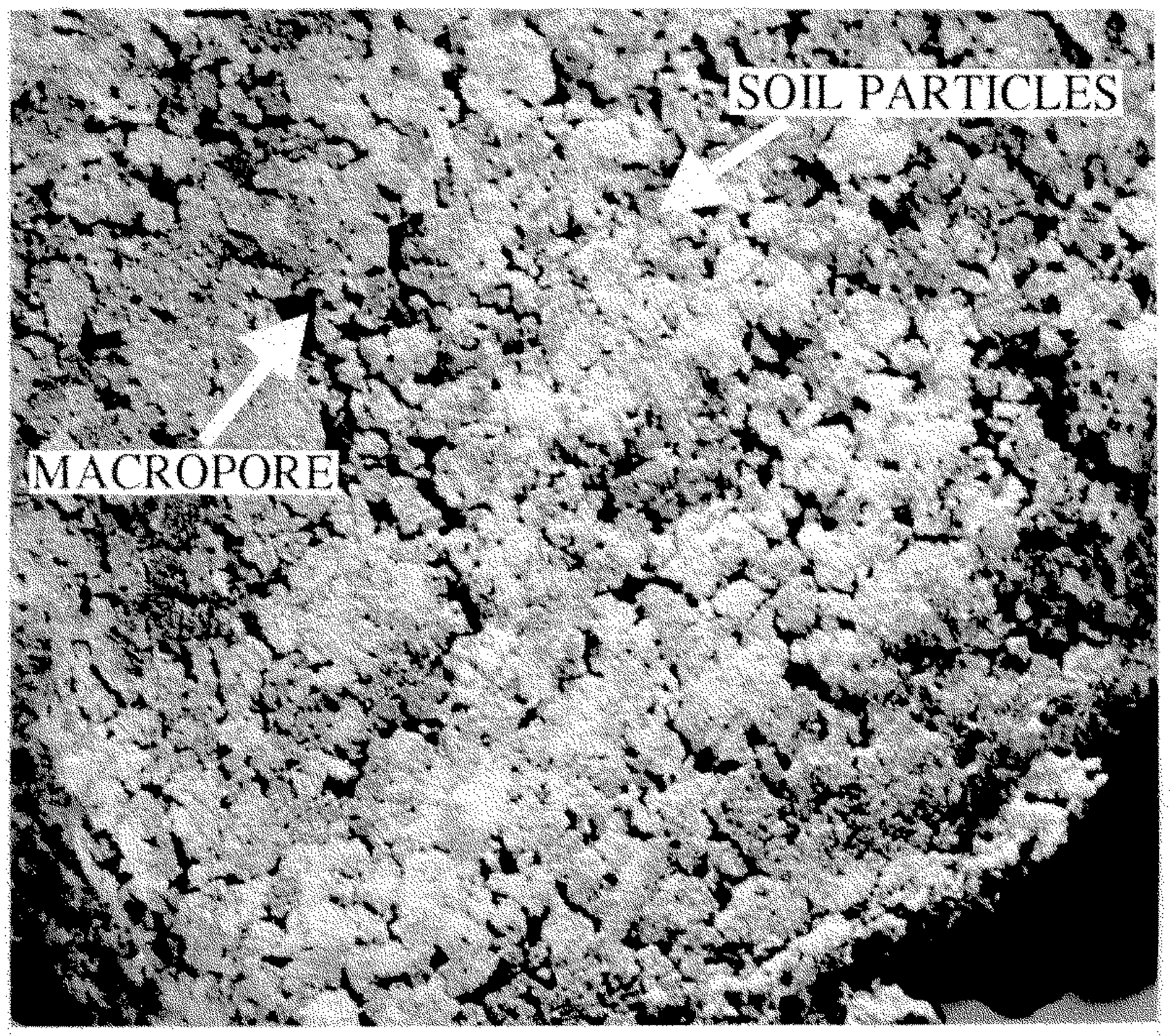



Figure 1: View of the soil surface in immediate contact with the GTX3 geotextile filter at the Ormstown location (actual size)

4.2 Microscopic Evaluation of Undisturbed Soil / Geotextile Interface

Cross sections of specimens GTX3 and GTX8 from the Ormstown and Drummond locations are shown on micrographs in Figures 2 and 3.

Note that the bulk of fabric pore space is free of soil particles. Also, the bridging of the soil and development of macro-pores at the soil to fabric interface is noticed. This bridging zone is found on soil particle agglomerations, and not on single soil particles. This zone forms a natural granular filter of transient filtration properties (pore sizes and permeability) between the undisturbed base soil and the geotextile fabric.

4.3 Soil Conditions

Figure 4 presents the gradation analyses of the soil samples extracted from the soil profile at a distance of 150 to 200 mm from the drain ("Base") and from the soil layer within 5 mm of the drain pipe ("Adjacent"). The hydrometer method was used for these analyses.

It is evident that the samples adjacent to the fabric contained more clay then the original base soil (as

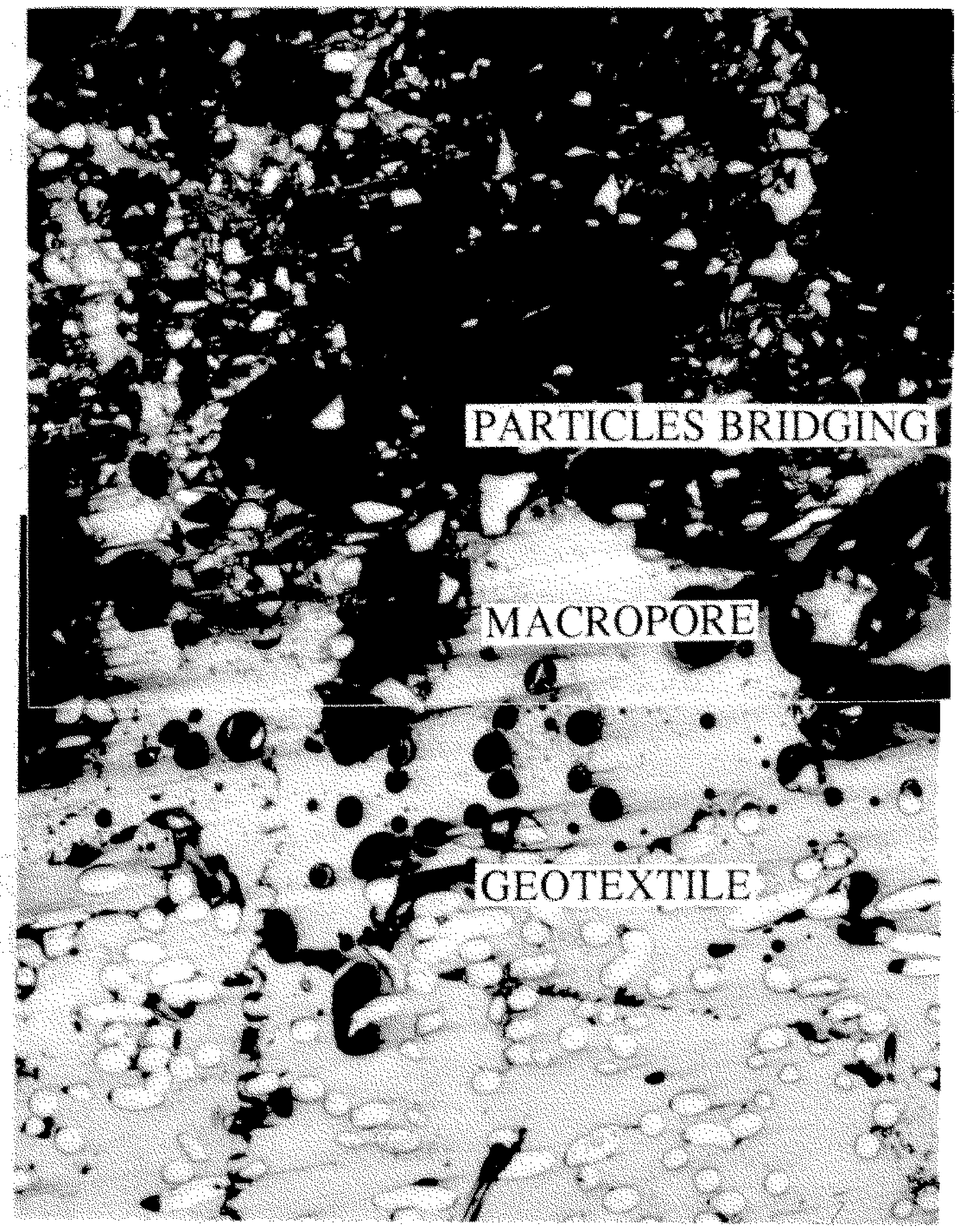



Figure 2: Micrograph of undisturbed cross-section of soil/GTX3 filter from Ormstown location

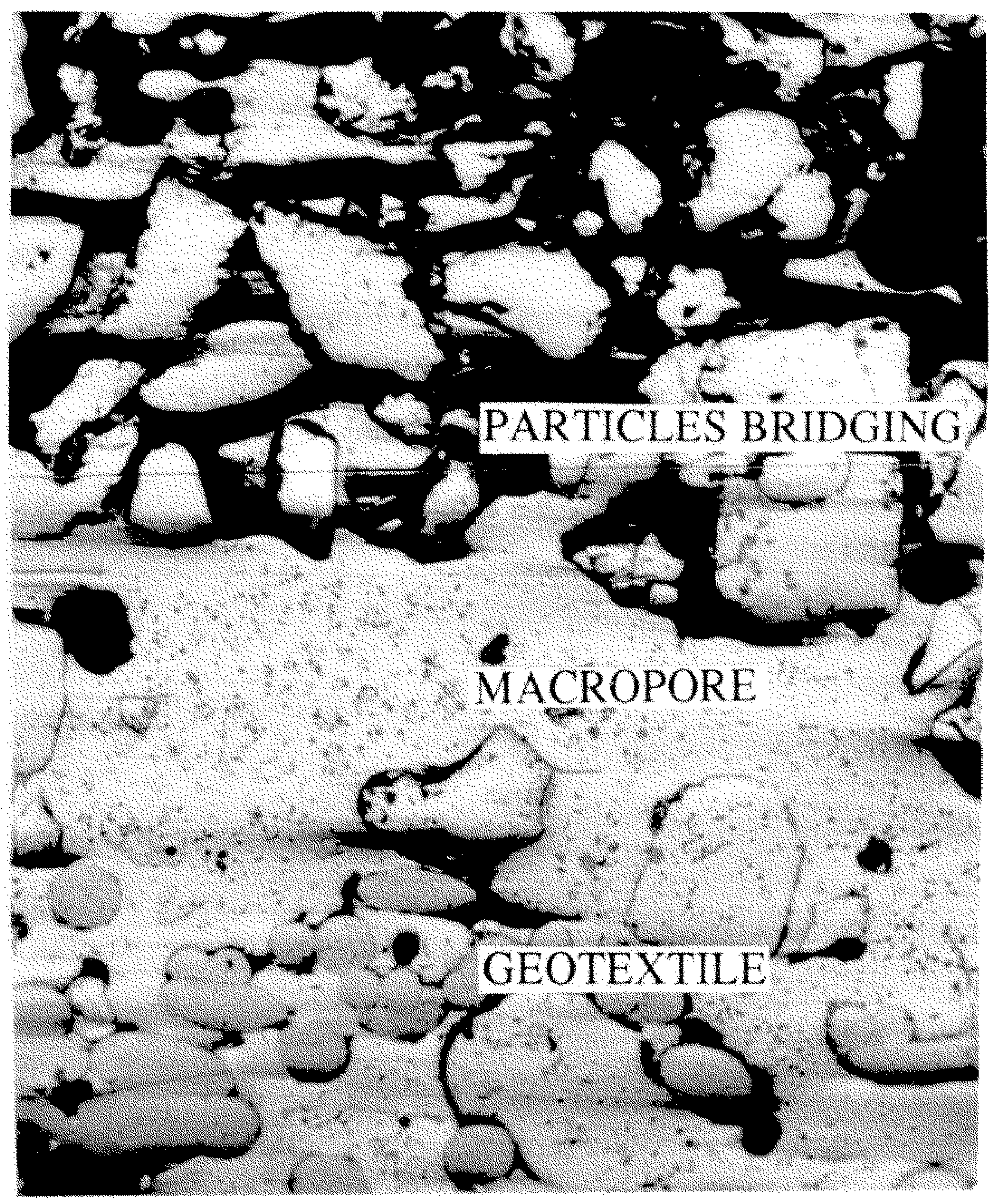
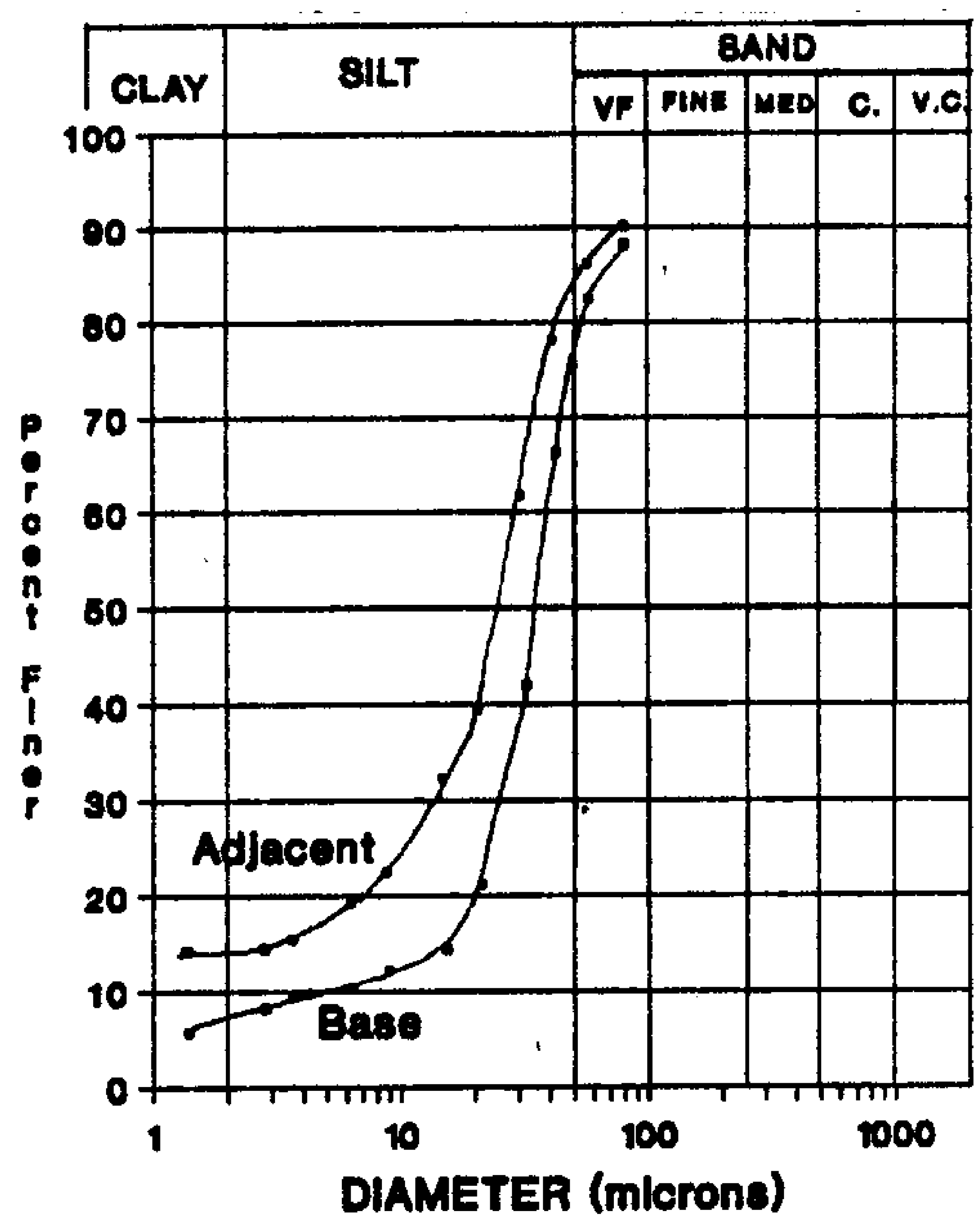



Figure 3: Micrograph of undisturbed cross-section of soil/GTX8 filter from Drummond location

a)




b)

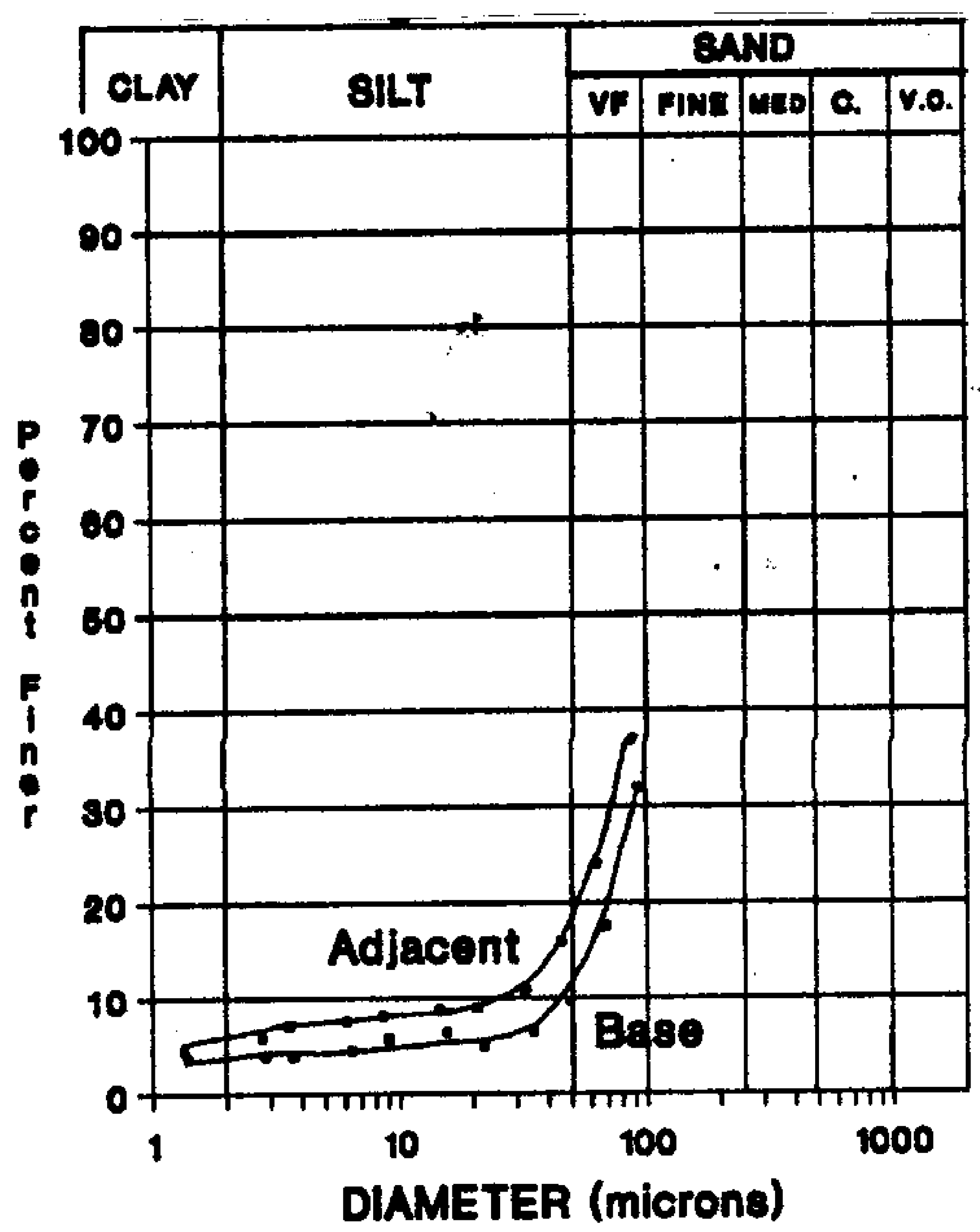



Figure 4: Gradation of soils sampled adjacent to and at 150 mm from the fabric
a) soil/GTX 3 system
b) soil/GTX 9 system

represented by the samples taken at a distance of 150 mm from the fabric surface). The data means were calculated for both adjacent soil and soil at 150 mm from the drains. A Student t-Test of these means showed no significant difference at the 5% confidence level. The obtained data suggests however a trend of more clay adjacent to the fabric. In contrary, the visual evidence of a network of macro-pores (Figure 1) indicates clearly an interface filter formation. It is believed that this network is a result of all free soil particle sizes moving, after drain installation, into the geotextile filter with some of the clayey and silty particles being trapped within soil particle agglomerations (Figures 2 and 3). Thus the formation of a more porous soil, a "natural soil filter" in the immediate vicinity of the geotextile and more clayey particles being measured in soil samples extracted from the interface layer. This feature was common to all drains at both the Ormstown and Drummond locations.

## 5 CONCLUSION

After eight to fifteen years in silty soils, all geotextiles investigated were found to be efficient in retaining soil particles without restricting water flow. The geotextiles were not clogged and the drains were clear of mineral sediment deposition.

The one exception was a fibreglass fabric of unknown origin, over fifteen years in the soil, which tore easily and was brittle upon drying.

A natural interim soil filter was developed at the soil/geotextile interface as a result of a complex phenomenon of moving silt and clay particles in the drain vicinity. The occurrence of macro-pores at the interface is a result of washing all free particles into the drains and leaving aggregates of clayey and silty particles in the remaining adjacent soil.

## REFERENCES

Rollin, A.L., Broughton, R.S. & Bolduc, G.F. (1987) Thin Synthetics Envelope Materials for Subsurface Drainage Tubes, *Geotextiles & Geomembranes*, Vol.5, pp.99-122

Bolduc, G.F. (1988) Développement de géotextiles pour utilisation en drainage souterrain dans les soils limoneux, Ph.D. Thesis, Université de Montréal, École Polytechnique, Montréal, Canada.

Gibson, W. (1978) A field evaluation of some subsurface drain envelopes, M.Sc.Thesis, Dept. of Agricultural Engineering, McGill University, Montréal, Québec.