CONSTRUCTION AND INSTRUMENTATION OF A MULTI-LAYER COVER LES TERRAINS AURIFÈRES

MEND Report 2.22.4a

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CONSTRUCTION AND INSTRUMENTATION OF A MULTI-LAYER COVER

LES TERRAINS AURIFÈRES

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SUMMARY

Since January 1997, Barrick Gold Corporation's Les Terrains Aurifères (LTA) tailings site has been the subject of a detailed study - MEND Project 2.22.4 - aimed at assessing the performance of a composite cover placed on the acid-generating tailings impoundment. The full-scale composite cover was built in the winter of 1996 on the 60-hectare site. Alkaline tailings were used for the fine material layer. In addition to being the first full-scale cover of this type (e.g. oxygen barrier) in Canada (and possibly elsewhere), this project offers the added advantage of using mine tailings, a waste product.

The main objective of this report is to describe the various phases of the LTA project, from the initial conceptual design of the cover to the final construction and monitoring. The theory behind composite covers [(1)] and design methods [(2)] have already been thoroughly discussed in the literature; the present report will, therefore, be a practical field application example of this technology.

This report will describe initial concerns, the flow charts used in the decision process, the laboratory work performed as well as the fundamental properties of all the materials used for construction. Sequence of events, construction difficulties will be presented subsequently along with monitoring instruments used. Analytical results outlined in this report will allow preliminary comparison of properties observed in laboratory and in situ. Conclusions will be formulated and discussed to assess the applicability of this technology to other sites. A final monitoring report will be available in 1999.

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(1) Nicholson et al., 1989, 1991; Collin and Rasmuson, 1990; Anon, 1991; Aubertin and Chapuis, 1991; SRK, 1991; Aachib et al., 1993; 1994; Aubertin, et al., 1995.

(2) Baccini, 1988; EPA, 1989; Bagchi, 1990; Nicholson et al., 1991; Hutchison and Ellison, 1992; Daniel, 1993; Wing, 1993, 1994; Aubertin et al., 1995; Woyshner and Yanful, 1995; Ricard and al. 1997.

SOMMAIRE

Depuis janvier 1997, le site Les Terrains Aurifères (LTA) fait l'objet d'une étude détaillée dans le cadre du programme NEDEM (projet 2.22.4) dans le but d'étudier la performance de la couverture multicouche construite sur le parc à résidus potentiellement générateurs d'acide. Il s'agit d'un recouvrement multicouche construit à grande échelle (sur 60 hectares) à l'hiver 1996. La couche fine utilisée est principalement composée de résidus miniers alcalins. En plus d'être la premier recouvrement de ce type (barrière à oxygène) à être construit au Canada (et probablement ailleurs), ce projet présente l'avantage de revaloriser des résidus miniers.

L'objectif principal de ce rapport consiste à exposer les différents aspects requis pour mener le projet du stade de conception à celui de produit fini et ce, en présentant les diverses étapes réalisées lors du projet. Les aspects théoriques du fonctionnement des couvertures multicouches [(1)] ainsi que les méthodes de conception [(2)] ont déjà été traitées abondamment dans la littérature. Le présent rapport se veut plutôt un exemple pratique d'application de ce type de technologie.

Ce rapport présente la problématique initiale, le schéma décisionnel utilisé puis décrit la campagne exhaustive d'essais de laboratoire ainsi que les propriétés fondamentales des matériaux qui ont été utilisés lors de la construction. La séquence des événements et les défis de construction seront présentés par la suite, incluant une description des instruments utilisés pour le monitoring. Les résultats analytiques présentés dans ce rapport permettent une comparaison préliminaire des propriétés observées in situ avec ceux obtenus en laboratoire. Les conclusions sont élaborées autour d'une discussion sur l'applicabilité de cette technologie pour d'autres sites. Un rapport de suivi du comportement (projet 2.22.4b) sera disponible en 1999.

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(1) Nicholson et al., 1989, 1991; Collin et Rasmuson, 1990; Anon, 1991; Aubertin et Chapuis, 1991; SRK, 1991; Aachib et al., 1993; 1994; Aubertin, et al., 1995.

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1.0 INTRODUCTION

1.1 Site Description and History

The Les Terrains Aurifères (LTA) site is located approximately 8.5 km south-east of the City of Malartic, in northern Québec. An underground mine, decommissioned since 1965, a mill, and a tailings disposal facility are the main features on the property of roughly 140 hectares. The LTA property is owned by Barrick Gold Corporation.

The LTA tailings disposal facility is bordered to the east by the former Malartic Goldfield Mine tailings disposal area which is currently owned by the Québec Ministry of Natural Resources (MNR) (see Figure 1). Originally, the Malartic Goldfield tailings area covered the present LTA site. The LTA site is built over the Malartic Goldfield tailings, as shown in Figure 2. The LTA tailings facility is bordered to the west by a sand and gravel pit (west borrow pit on Figure 1) which also belongs to the MNR.

Historically, the site was selected due to its proximity to the mill (100 m to the south) and its location in a natural depression thus allowing containment without significant dyke construction. During the operating years of the Malartic Goldfield Mine (1930-1965), approximately 10 Mt of alkaline tailings were placed on the site to an average depth of 5 m.

The site was reopened in 1977, however, only the mill was operational and only half of the tailings area was used. Nearly 8.0 Mt of acid-generating tailings were produced and placed over the Malartic Goldfield alkaline tailings (see Figure 2). The average depth of the LTA tailings is 12 m. The LTA site is bordered to the north, east, and west by dykes constructed of acid-generating tailings. The site is bordered to the south by natural ground. The average height of the dykes is 15 m.

In summary, the LTA tailings impoundment contains two chemically distinct types of tailings. In effect, the bottom layer (5 m thick) contains no sulphide minerals and more than 10 % calcite ($CaCO_3$). Laboratory work showed that these tailings consumed more than 100 kg/t of acid. The LTA tailings (in fact originating from Barrick's nearby Bousquet property) are sulphidic. Extensive testing on mineralogy, acid base accounting and mineral content were carried out, and results showed that the LTA tailings contain about 6 % sulphide sulphur of which pyrite is the predominant sulphide mineral. Other sulphides present in minor amounts include pyrrhotite, chalcopyrite, sphalerite and arsenopyrite. The net acid producing potential averages about 200 kg/t as $CaCO_3$.

The tailings were maintained at neutral to alkaline pH up to closure in the fall of 1994, due to the alkaline contribution of the leaching process on the deposited tailings and associated pore water. However, these tailings have a high acid-generating potential. They were expected to become acid-generating in the near future and produce acidic runoff and seepage for hundreds of years.

1.2 Problems Requiring Assessment

Recognising the acidic potential of the tailings, there were a number of questions that needed to be answered in order to develop a cost-effective closure plan for the tailings impoundment. These questions included:

i) How much acid will be released?

ii) Over what time period?

iii) What will it cost to collect and treat?

iv) What can be done to control acid production?

v) What are the costs of alternative closure options?

Through the use of geochemical (acid generation) modelling, as a tool to obtain predictions of future water quality, it was possible to answer questions i) through v) above.

1.3 Geochemical Modelling

Acid mine drainage (AMD) prediction modelling was performed by Senes Consultant. The AMD model used is a complex model, which integrates the physical and geochemical factors controlling acid production. Some of the key input parameters required are mineralogy, oxygen diffusion coefficients, particle size distribution, and the depth of the various modelled layers. The model uses the oxygen diffusion coefficients to calculate the level of oxygen penetrating into each layer that is available to oxidize the sulphide minerals. The available surface area of sulphides that can react is calculated from the particle size distribution. The model considers the rate of sulphide oxidation based on temperature, pH, oxygen and other conditions. Both chemical and biological oxidation are considered. The geochemical reactions of sulphide minerals, their oxidation products and the buffering minerals are evaluated, and the model provides the resultant geochemistry of the pore water. Chemical processes such as dissolution, precipitation and sorption are considered. Mass balances keep track of the aqueous and solid species.

Water quality predictions were done for three distinct intervention scenarios :

1) Cover LTA tailings impoundment with a thin cover of borrow material (sand and gravel) on the reprofiled contoured tailings pond surface in order to achieve basic erosion protection/stabilization. Final surface to be vegetated. Collect acidic seepage and treat with lime;

2) Cover LTA tailings impoundment with a single cover made of alkaline tailings coming from the adjacent MNR tailings pond; final surface to be vegetated; and

3) Cover LTA tailings impoundment with a composite cover composed of a sand and gravel surface protection layer overlaying a layer of MNR alkaline tailings acting as a moisture retaining layer, and a bottom layer of sand acting as a capillary break. Final surface to be vegetated.

More details about the geochemical modelling description and assumptions can be found in McMullen et al., 1997.

As a result of the AMD modelling, the main conclusions were:

Alternative # 1: Basic surface protection. Bousquet tailings stored at LTA are strong acid generators and, if left uncovered, will soon produce acidic runoff and later, net acid seepage. Because of the occurrence of buffering minerals in and underneath the tailings, much of the seepage will not become acidic for about 60 years. Anticipated copper and zinc levels, at this stage in the seepage, have been estimated to reach a range of 40 to 50 mg/L. A basic erosion protection cover with vegetation will produce unacceptable levels of acidity and metals in both the surface runoff and seepage. As a result, untreated release of the final effluent would have a significant impact. The evaluation concluded that the construction of a treatment plant for AMD neutralization would be required in the very near future, because it is expected that some acidic seepage will initiate in the short term, in addition to the longer term requirements as described above. The closure cost assessment of the tailings area using the collect and treat scenario is inclusive of the construction of a soil cover (assume at 0.5 m) on the regraded tailings, construction of perimeter spillways and ditching, site revegetation, and collection pumping and treatment in a new treatment plant for acidic seepage.

The capital cost associated with the above, is estimated at CAN$4.28 M (1995 dollars). The net present value (NPV) of future operating costs amounts to CAN$8.3 M and CAN$5.0 M at discounted rates of 3 % and 5 % respectively. The total closure cost for this alternative has therefore a range of CAN$12.58 M to CAN$9.28 M.

Alternative #2: Single cover made of MNR tailings. The implementation of a 2 m alkaline simple cover (above Bousquet sulfide tailings) should eliminate surface acid runoff and delay acidity release in seepage for 100 to 150 years. Ultimate maximum copper and zinc levels in the seepage and ex-filtration would be in the range of 20 to 30 mg/L. Despite lower rates of acid production, a treatment plant is expected to be required, but only in 100 years when compared to Alternative #1.

The capital cost of this cover type implementation has been estimated at CAN$5.3 M. The NPV of future capital and operating costs amount to CAN$0.35 M for a total of CAN$5.65 M.

Alternative #3: Composite cover. The engineered cover would effectively eliminate any acid releases and elevated metal discharges for several hundred years. As a result of the oxygen flux barrier proposed, it has been estimated that the oxidation rates would be reduced by two orders of magnitude. This alternative would eliminate acid release for more than 400 years. Copper and zinc levels would be maintained in the seepage to less than 1 ppm. Also, this alternative would eliminate any need for treatment, and practically no noticeable downstream impact on the Piché River (final effluent) should occur.

The capital cost of the composite cover implementation has been estimated at CAN$5.2 M. Interestingly, the capital cost of this option compares to Alternative #2, as the volumes of materials to be handled are comparable. Since water quality is anticipated to be adequate, no additional future capital and operating costs for a treatment plant are anticipated for this scenario.

1.4 Risk Analysis

Without considering long-term treatment charges, the capital cost of Alternative #3 is equivalent to Alternative #2 but offers a much greater potential of obtaining a low maintenance walk-away solution. When compared to Alternative #1 (i.e. status-quo/collect and treat), the capital cost for the recommended direct tailings reclamation activities was higher by $0.9 M (a total of $5.2 M vs. $4.28 M). A sensitivity analysis was conducted comparing Alternative #3 against #1, taking into account the estimated long-term recurring treatment charges assuming that Alternative #3 might not be as successful as originally planned. Equivalent NPVs to Alternative #1 were encountered if:

1) Alternative #3 delayed the ARD process by 12 years compared to the 400 years predicted in the modelling exercise, which represented only 3 % of the expected performance period, and assuming that treatment charges at year 13 and onwards would be equivalent to those of Alternative #1.

2) Alternative #3 delayed the ARD process by 2 to 7 years considering that treatment charges, when incurred, would be reduced when compared to Alternative #1 by 50 % and discounted at 5 and 8 % respectively.

3) Considering an additional capital cost of $1.0 M to Alternative #3, it would delay the ARD process by 18 to 20 years, assuming treatment charges at 100 % of Alternative # 1 using a discount rate of 5 and 8 % respectively.

In conclusion, Alternative #3 requires no long-term treatment while Alternative #1 requires $8.3 M (discounted at 3 %) of future expenditures. Alternative #2 (which uses strictly MNR tailings), shows a relatively low NPV on future charges ($0.35 M), and was discarded because it showed no advantage over Alternative #3. In fact, it was less certain to function suitably in the very long term. The project risk (Alternative #3 versus Alternative #1) was therefore approximately $0.9 M and Alternative #3 presented much more upsides than downsides. Thus the closure alternative selected for the LTA tailings impoundment was Alternative #3. Conclusions from the above analysis demonstrated that only slight improvements over Alternative #1 are required to justify the recommendation of choosing Alternative #3. It is believed that the accuracy of the models used will most likely fall within these margins.

Also, with cover construction, all the slopes had to be reprofiled to 3H:IV. To intercept the internal pond water table seepage, toe drains had to be included for the north and west slopes.

1.5 Feasibility Study

Based on preliminary geochemical modelling, a composite cover for the tailings impoundment was recommended as the closure option.

The effectiveness of a cover is assessed by its effectiveness to reduce the oxygen flux. The oxygen flux value is a function of the oxygen diffusion value (De) of the material, and the thickness of the layer. The lesser the coefficient (or the thicker the layer), the better the cover is to reduce oxygen flux, and thus to reduce oxidation of tailings. The oxygen diffusion coefficient value is impacted mostly by the saturation of the material. The greater the saturation the smaller is the De coefficient for a given material. The efficiency of a composite cover concept thus comes from the fact that the cover acts as a moisture retention structure, hence providing a low diffusion barrier from atmospheric oxygen as well as enabling thinner layer construction (cost saving).

The preferred materials for construction of such covers are fine materials (silt, clay), because they typically yield excellent water retention properties and present low permeability. The primary objective of a composite cover is to isolate the acid-generating tailings from both oxygen and water (two necessary components in the production of acid mine drainage). The AMD modelling showed that a composite cover with a 0.8 m thick fine material layer yielding an oxygen diffusion coefficient of $1*10^{-8}$ m^2/s would inhibit acid production (Senes, 1995).

The moisture retention capability is possible because the composite cover system ensures that the low permeability (fine) material placed between two coarser material layers remains saturated almost indefinitely. Since the coarse layer does not easily retain water, its unsaturated hydraulic conductivity is low. Consequently, the fine material layer in the middle thus remains saturated, since water is attracted to this layer by greater capillary forces, and because downward flow is greatly reduced due to the low unsaturated hydraulic conductivity of the coarse layer underneath (Nicholson et al., 1989; Collin and Rasmuson, 1990; Anon, 1991; Aubertin and Chapuis, 1991; SRK, 1991; Aachib et al., 1993; 1994; Aubertin, et al., 1995a, b).

Finally, a physical-evaporation protection layer is added to the system.

In the LTA case, plenty of coarse materials were available in the west borrow pit (sand and gravel), and MNR tailings impoundment (to the east) for fine materials (Figure 1). However, the cover hydrogeological performance characteristics (its capability to remain saturated) had to be assessed.

1.6 Cover System

As mentioned previously in Section 1.5, the composite cover built over the LTA tailings impoundment consists of three layers (see Figure 3). The first layer is a 0.5 m-thick sand layer and is identified as Zone 1. This layer keeps moisture from escaping from the overlaying layer by the capillary break effect.

The second layer was a 0.8 m compacted layer of fine material with a low permeability and good water retention capacity, acting as an oxygen diffusion barrier. The MNR tailings were used for this layer, and are identified as Zone 2. Figure 1 depicts the location of the MNR tailings the borrow area for the Fall of 1995.

The third layer is a 0.3 m compacted layer of sand and gravel from the west borrow pit and is identified as Zone 3. This layer acts as a protection layer, as well as an evaporation protection layer for the underlying Zone 2 layer.

To complete such a study, many tasks had to be performed. The following sections present material characterization procedures, geotechnical and hydrogeological properties of the materials used, and performance modelling. These sections are not intended to be a cover design handbook, but rather a good starting ground for preparing a similar study for other sites.

2.0 DESCRIPTION OF SELECTED CHARACTERIZATION PROCEDURES

The characterization of the materials used in the construction of the composite cover was determined by in situ compaction testing as well as laboratory testing programs performed at l'École Polytechnique de Montréal (Mining Environment and Hydrogeology Laboratories) and the Unité de Recherche et de Service en Technologie Minérale de l'Abitibi-Témiscamingue (URSTM) in Rouyn-Noranda.

2.1 Laboratory Testing

Four types of materials were subject to laboratory testing programs at various phases of the LTA project. These include: MNR tailings (alkaline), LTA tailings (acid-generating), sand from the west borrow pit, and silt from borrow pit N° 1 (Figure 1). Samples from all materials considered were subjected to the following tests:

- sieve analysis;
- specific gravity;
- compaction;
- Atterberg limits;
- permeability;
- water retention;
- oxygen diffusion;
- particle migration; and
- freeze-thaw permeability.

2.1.1 Sieve Analysis

The grain size distribution of the MNR tailings, the LTA tailings, and the silt materials were determined using a hydrometer analysis (more precise for finer soils), while the grain size distribution of the sand was determined using a sieve analysis. ASTM D422 provides a detailed description of the testing procedure.

2.1.2 Specific Gravity (Gs)

The specific gravity of each material was obtained using a pycnometer as described in ASTM D854-91.

2.1.3 Compaction Testing

The Standard Proctor method was used for the determination of the degree of compaction. Each sample was tested using the ASTM D1557-78 A method for at least four different water contents.

2.1.4 Atterberg Limits

The Casagrande apparatus was used to determine the liquid limit (w_L) and plastic limit (w_P) of the MNR tailings, the LTA tailings, and the silt. The apparatus characteristics as well as handling instructions are described in ASTM D4318-84.

Since most of these materials did not exhibit significant plasticity, careful interpretation was required.

2.1.5 Permeability Testing

The permeability of the four types of materials was determined by the falling-head method which uses a flexible membrane triaxial cell as described in ASTM D5084-90.

The permeameter allowed testing of samples 7.25 cm in diameter and up to 15 cm high. For placement in the apparatus, a 1 kg sample of a material with approximately 10 % water content (thus approximating the optimum water content as determined by compaction testing) was prepared. The material was then placed into a split mold in 5 to 10 layers. Each layer was compacted using a 850 g compaction hammer when a high void ratio (e = 0.65 to 1.1) was needed or with a 4.5 kg compaction hammer for a lower void ratio (e = 0.5 to 0.65). Void ratios ranging from approximately 0.5 to 1.1 were therefore achievable. Once the densification was complete, the sample was saturated in the triaxial cell by the back pressure method as describe in ASTM D5084-90. Permeability testing began once the sample was saturated and inlet flow equaled outlet flow. For all permeability tests, the hydraulic conductivity was temperature corrected.

2.1.6 Moisture Retention Testing

The moisture retention testing was done in order to determine the capacity of the materials to store or release water. The water retention curves were obtained using ASTM D3152-72. More information on water retention curves (WRC) can be found in Aubertin et al. (1995b), as well as MEND (1997). The soil sample was placed on a porous plate in a Tempe pressurized cell, where it was subjected to a positive pressure while the outlet water experienced atmospheric pressure. Air was compressed into the cell and, at equilibrium, the amount of water remaining in the sample represented its water retention capacity in relation to the applied pressure. Based on results of several tests at varying pressure levels, the water retention curve (WRC) was generated. The Air Entry Value (AEV) was estimated to be the pressure yielding 90 % saturation (Ψ_{90}) in the tested materials, and this in order to simplify the analysis of the results, as described in Aubertin et al. (1998). Values for AEV are typically determined graphically, and a discussion on AEV determination is presented in Aubertin et al. (1998).

2.1.7 Oxygen Diffusion (De)

Oxygen diffusion was measured at various saturation levels. The testing procedure requires a column where the oxygen concentration at the source was decreasing with time while the one in the receiver unit was increasing proportionally. This test was performed using a transparent PVC cylinder, 10 cm in diameter and 20 cm high, to which were attached oxygen sensors.

Moisture was added until a chosen saturation level was achieved. The material was then placed in the test column and densified. Before testing, the column was purged with nitrogen to remove any oxygen from the sample. After purging, the upper reservoir (source) was opened, allowed to fill with ambient air (approximately 21 % oxygen), and then closed. The closed system allowed oxygen diffusion in the sample. Time measurements of the oxygen concentration were taken until equilibrium was reached.

The oxygen drawdown curve versus time in the upper part of the reservoir enables the calculation of the effective oxygen diffusion coefficient (De) of the material. More details about this experiment and its interpretation can be found in Aubertin et al. (1995a).

2.1.8 Particle Migration Testing

The test was performed to evaluate the compatibility of materials with respect to fine particle migration. A 29.5 cm sand layer was placed in a 15 cm diameter, 120 cm long clear Plexiglass column. A 12.2 cm layer of MNR tailings was placed in a loose state on top of the sand. Periodically, water was poured over the sample, allowing gravity flow through the two-layer system. The amount of water added gradually increased from 1 000 to 10 000 cm^3 with each cycle. Initial and final grain size distribution of the materials were analyzed, using the method described previously, to determine whether water flow through the layers modified the particle distribution. If so, this would suggest that some fine particles had migrated.

2.1.9 Freeze-Thaw Permeability Testing

The test was performed to assess the permeability of MNR tailings and the silt materials to freeze-thaw cycles. Between two constant-head permeability tests in a rigid wall permeameter (ASTM D5084-90), the sample was subjected to a freeze-thaw cycle by placing the permeameter in a freezer for 24 hours, then allowing it to thaw for 24 hours at room temperature. The variation in permeability results following freezing and thawing indicates the material's structural sensitivity to freezing.

2.2 Field Testing

Since the tailings impoundment over which the cover was to be placed was very wet and soft, the determination of levels of achievable compaction of the various materials proposed for cover construction was required. Also, the representativity of values used for the performance modelling was critical, and the combination of laboratory results as well as field results would provide those values (results discussed in Section 3.5).

This assessment was performed using two 400 m^2 in situ test cells. They were constructed on the outer slope wall of the south-east dyke and on top of the north dyke. Cell 1 consisted of an 800-mm layer of MNR tailings spread and compacted in a single lift, over a 500-mm layer of sand also compacted in a single lift. Cell 2 consisted of two 400-mm compacted lifts of MNR tailings over 500 mm of compacted sand. The materials in both test cells were densified using a smooth drum roller compactor, and the number of passes carefully recorded.

In addition, tests were performed on the test cell materials themselves, to permit comparison between in situ results and laboratory results. These activities, performed in the early fall of 1995, consisted of:

- MNR tailings sampling;
- sand and gravel (west borrow pit) sampling; and
- test cell density determination using a nucleodensometer probe.

Soils samples collected from the test cells were submitted for particle size analysis, compaction testing and water content. These tests were performed at Golder Associés's laboratory in Val d'Or, Québec, using the procedures described in Section 2.1. Since freezing conditions were present during the night, one sample was collected immediately after compaction, while another was collected the next day in order to evaluate the effect of freezing on test cell material density.

3.0 COMPOSITE COVER MATERIAL PROPERTIES

The material properties observed in the laboratory as well as in situ are described in the following sections. This description is provided along with a discussion on LTA design parameters from the feasibility study. The materials were grouped according to their basic characteristics, hydraulic properties, oxygen diffusion barrier properties, and long term stability.

3.1 Basic Characteristics

Table 1 summarizes the laboratory results obtained from École Polytechnique and URSTM. Complete results of testing on the sand from the west borrow pit, the MNR tailings, the LTA tailings, and the silt from the N° 1 silt borrow pit are outlined in Appendices A, B, C, and D respectively.

Review of the materials' basic characteristics shows that both the LTA and MNR tailings can be described as inorganic silts according to the USC classification system, while sand from the west borrow pit is described as a uniform gravely sand with little or no fines. Silt from the N° 1 silt borrow pit straddles two categories: plastic inorganic silt and plastic organic silt.

Particle size analysis allowed envelope curves, as illustrated in Figure 4, to be prepared for the MNR tailings and the sand from the west borrow pit. This figure shows that both these materials are within the limits of those observed for the field test cell cover material.

Laboratory compaction testing on MNR tailings (Golder Associés, Val d'Or) resulted in an optimum dry density of 1650 kg/m^3 and an optimum water content of 15.7 %. Density results for the two in situ test cells (early fall 1995) are listed in Table 2. The average dry density was 1560 kg/m^3 with a water content of 16.1 % which represents 94.5 % of the STD Proctor, or a void ratio of 0.768.

Even if better values were obtained, a conservative void ratio of 0.8 (92 % of the STD Proctor) was supposed to represent attainable large scale conditions of the Zone 2 material on a soft foundation for performance modelling purposes, as presented in Section 3.5. Control of the void ratio rather than the level of compaction is desirable since the void ratio is directly associated with the effectiveness of the cover to retain water and greatly affects the hydraulic properties of a material. This way, different fine materials can be used, at various compaction levels, as long as void ratio criteria is met.

3.2 Hydraulic Properties

The most important hydraulic properties of materials are those that influence the water retention of a cover and, therefore, its capacity to act as an oxygen diffusion barrier. Typically, the saturated hydraulic conductivity coefficient (commonly referred to as permeability) and the AEV are the two key parameters for cover design.

3.2.1 Saturated Hydraulic Conductivity Coefficient

During previous field work at the site (Golder Associés, 1995), permeability tests were performed in piezometers (using the Horslev method) to determine the saturated hydraulic conductivity of the soils beneath the tailings as well as of the LTA tailings.

Figures 5 to 8 depict hydraulic conductivity coefficient versus void ratio curves for the various materials tested in the laboratory, while Table 3 summarizes these results. The 1995 permeability results are summarized in Table 4 (Golder Associés, 1995).

For a void ratio of 0.8, as discussed in Section 3.1, the expected saturated hydraulic conductivity of the various materials under investigation are as follows:

- MRN tailings: $5 * 10^{-5}$ cm/s (e = 0.80);
- sand from west borrow pit: $1.21 * 10^{-1}$ cm/s (e = 0.60);
- LTA tailings: $2.5 * 10^{-5}$ cm/s (e $>$ 0.75); and
- silt from N° 1 borrow pit: $1.0 * 10^{-6}$ cm/s (e $<$ 0.75).

These values were used for modelling.

3.2.2 Water Retention Curves

Water retention curves represent the capacity of a material to retain water by capillary action in relation to the negative hydraulic head applied. Theses curves are derived from the water retention test described in Section 2.1.

Figures 9 and 10 depict the water retention versus void ratio curves for the various materials tested in the laboratory, while Table 5 summarizes these results. As mentioned, the Air Entry Value (AEV) was estimated to be the pressure yielding 90 % saturation (Ψ_{90}) in the tested materials. By using Ψ_{90} to quantify the AEV, available information in the literature can be used to compare the results and experimental uncertainties that could exist for the MNR (alkaline) tailings.

The following empirical equation is based on typical values observed at several other mine sites in Québec (Ricard, 1994; Aubertin et al., 1995b):

$$\Psi_{90} = \frac{C\ (\text{mm})^2}{e\ D_{10}\ (\text{mm})}$$ where C is a constant that varies from 4 to 10

The equation estimates the Ψ_{90} value of a fine non-plastic material (tailings) with a void ratio of 0.8 with a varying pressure of 1.0 to 2.5 m of water. When comparing the results presented in Table 5 for MNR tailings, laboratory testing seems to be concordant with the range predicted by the empirical approach.

Also in Table 5, laboratory results show that silt from borrow pit N° 1 has far better water retention capacity than the MNR tailings. For example, the silt retains 90 % of its water at a pressure head in excess of 4 m of water, while the MNR tailings retain the same amount of water at a head of approximately 1.5 to 2.5 m of water. Based on these results, the use of silt would be a good alternative to MNR tailings in areas where water retention is problematic. Although not enough volume of silt material was available to be used as the primary fine material for the cover construction in the LTA project, this material offered some advantages that are explained in Section 4.0 - Cover Construction.

3.3 Oxygen Diffusion

Figure 11 illustrates the results of the various oxygen diffusion tests performed on the MNR tailings. For quality control purposes, an empirical curve for e = 0.8 (or a porosity n = 0.44) was drawn using the Milington and Shearer (1971) model.

The results of the empirical model seem to corroborate the experimental results. The most interesting results, for design purposes, are found at a saturation level of 80 to 95 %, where oxygen diffusion drops by nearly two orders of magnitude. Results from laboratory work are concordant with those from the literature, which have also shown that, at saturation levels of at least 90 %, the effectiveness of a composite dry cover is the same as a water cover (Aachib et al., 1994).

3.4 Long-Term Stability

Particle migration and the effect of freezing and thawing on permeability were studied to evaluate the long-term stability of the composite cover.

The preliminary calculations of filter criteria between the MNR tailings and the sand indicated that typical filter criteria for dyke construction were not met. However, the hydraulic conditions of a cover system are very different from those of a dyke. Nevertheless, the column tests were performed in the hope of simulating site conditions and studying possible particle migration.

Approximately 90 to 95 litres of water was circulated through two identical columns, as described in Section 2.1.8. This represented approximately five years of precipitation for the region. For the last cycle, 10 litres of water were added, all at once, to each column. This represented a gradient eight times greater than the maximum daily precipitation ever recorded in Val d'Or, 67.8 mm.

Figures 12 and 13 illustrate the particle size distribution curves for the sand and the tailings respectively, before and after the column tests. A significant difference in particle size distribution between the sand and the tailings would have made it easy to identify an increase in fines (< 0.1 mm) in the sand if the systems were unstable. Careful study of the particle size distribution curves does not indicate that any particle migration occurred (see Appendix E for complete results). Due to the extreme conditions to which the columns were subjected to, particle migration is not expected to be a problem.

Freeze-thaw tests were performed to assess the sensitivity of the MNR tailings and the silt to structural damage caused by freeze-thaw cycling. Figures 14 and 15 present the results of these tests for the MNR tailings and the silt respectively. As can be seen in Figure 14, the MNR tailings are not sensitive to freeze-thaw cycles, which is as expected for most silty non-plastic materials.

The natural silt, which possesses significant plasticity, is potentially sensitive to damage from freeze-thaw cycles (Figure 15). As expected, after 10 freeze-thaw cycles, the average permeability of the silt increased from $1*10^{-6}$ cm/s to $5*10^{-6}$ cm/s. This, however, is not expected to be a major concern.

3.5 Performance Modelling

The performance modelling of the composite cover was based on a sensitivity analysis while considering water retention in drought periods (2 months), resistance to surface erosion, ability to withstand extreme precipitation, as well as damage potential of freeze-thaw cycles (Baccini, 1988; EPA, 1989; Bagchi, 1990; Nicholson et al., 1991; Hutchison and Ellison, 1992; Daniel, 1993; Wing, 1993, 1994; Aubertin et al., 1995a; Woyshner and Yanful, 1995, Ricard et al., 1997).

Procedures and material properties presented in Sections 2.0 and 3.0 were used for sensitivity analyses. One of the difficulties of the feasibility study was to identify parameters that could be modelled and at the same time provide clues on cover effectiveness.

During the geochemical modelling phase described earlier in Section 1.5, the effective oxygen diffusion coefficient (De) required to ensure minimal oxidation was identified to be around $1*10^{-}$

^{8} m^2/s for a 0.8 m thick fine layer (Senes, 1995). Figure 11 shows that at least 85 % saturation is required to obtain this value, and this was the target selected to analyze cover performance through hydrogeological modelling with specialized software.

Hydrogeological assessment modelling of the cover was done by Golder Associés in Pointe-Claire, Québec, in collaboration with Professor Michel Aubertin from École Polytechnique. The design was based on both laboratory and in situ testing results. Due to the complex hydraulic behaviour of a composite cover system, the optimum configuration was determined using numerical models. The water balance and various drainage and seepage parameters for the site were evaluated using the HELP and SEEP/W models. These programs were previously used in other studies (Woyshner and Yanful, 1995).

Initial results showed saturation level under 85 % in the upper part of the north dyke. Modelling also showed that water movement with the cover are essentially ruled by transient conditions, which means that quasi-stable permanent conditions are never met. To achieve proper humidity conditions anywhere on the tailings site, recharge conditions must be higher than seepage and evaporation. In the case of the north dyke, this was obtained by using hydraulic cut-offs, to reduce lateral slope seepage within the cover. According to the model, adequate humidity, even with a two-month drought period, was not related to Zone 2 layer thickness, but rather spacing of hydraulic cut-offs within the outer slope. Theses results were encouraging enough, on technical grounds, to allow the project to proceed.

The final selection of the layer thickness was done based on sensitivity analyses. For simplification purposes, the various layers of the composite cover were identified (see Figure 3) and are:

- Zone 1 (capillary break) - composed of 0.5 m of sand from the sand and gravel borrow pit to the east of the LTA tailings impoundment (Figure 1);

- Zone 2 (oxygen diffusion barrier) - composed of 0.8 m of alkaline tailings from the nearby MNR site (to the west, Figure 1); and

- Zone 3 (protection) - composed of 0.3 m of sand and gravel, also from the east sand borrow pit (Figure 1).

3.6 General Comments - Composite Cover Material Properties

As described in the previous sections, the geotechnical properties of the MNR tailings, proposed to be used as the fined grained layer in the LTA composite cover, are neither exceptional nor uncommon. The fine layer of a composite cover system, which is key to reducing oxygen flow, determines the ultimate efficiency of the cover. Nevertheless, the selected material, MNR tailings, exhibit characteristics of typical silty sand or sandy silt. In many areas, materials to be used for the fine layer are scarce. Alternative materials, such as tailings (and materials ranging from sandy silt to silty sand), could be used if they demonstrate the necessary properties and are available in sufficient quantities. They would not be expected to be as effective as silt or clay, but with proper system design, tailings could still be effective at retaining humidity with appropriate capillary break thickness selection.

This shows that to ensure optimal design of a composite cover, at least three characteristics are required:

- The value of the maximum oxygen flux allowable (obtained typically through geochemical modelling or column testing) that would provide negligible oxidation;

- The effective diffusion coefficient (De) versus saturation of the material considered for cover construction (also obtained from laboratory test). By knowing the maximum flux available, thickness calculation of the fine layer (Zone 2 in the LTA project) can be obtained using the calculation method presented in Elberling et al., 1994; and

- The water retention capacity of all the materials considered for cover construction, to enable design of capillary and hydraulic break (in certain cases, to prevent water flow within the cover) that will ensure proper saturation of the critical cover material layer.

As described, the process to properly design a composite cover can be straight forward if a good work plan is adhered to. However, many challenges awaited on the construction site. Trying to construct a composite cover on a soft and very wet tailings impoundment, which was the case in the LTA project, demanded an innovative approach. This innovative approach will be presented in the following section.

4.0 COVER CONSTRUCTION

4.1 Logistics

Construction of a composite cover on top of a tailings impoundment, such as the one proposed for LTA, requires the placement of a 1.6 m-thick soil structure on a surface of nearly 60 hectares. This work cannot be done cost effectively without the use of heavy machinery. However, circulation of any kind, especially of heavy equipment during construction, proves to be a challenge due to the elevated phreatic surface of the tailings. Any movement would raise the water level to the surface of the tailings, and trafficability would be next to impossible.

From the start of the feasibility study, it was evident that the placement of relatively thin layers requiring compaction and large-scale homogeneity on a soft foundation would be a challenge. However, the LTA tailings impoundment does offer advantages for traffic movement and subsequent construction. Since the tailings were stacked, the peripheral dykes are relatively permeable, with only one side contained by natural topography. They are generally well-drained and dry. Construction traffic in these areas is not a problem.

Due to the uncertainties surrounding construction feasibility and logistics, the project was divided into distinct phases. Phase I, scheduled to begin in late fall 1995, was the installation of test cells similar to those described in Section 2.2, with construction starting on top of south-east dyke (Figure 1), a dry area, and going inward onto the tailings impoundment (to the west) toward smoother areas. Phase II started in winter 1996 with the placement of the composite cover, and will end in the winter of 1999. This includes the construction of the cover on the whole site which ended in September 1996 and a two-year monitoring period.

4.2 Phase I - Fall 1995

The main goals of Phase I were: to verify site accessibility for construction equipment, better define the construction risks, and confirm that adequate compaction of Zone 2 material (MNR tailings) was possible. Adequate compaction is achieved when the void ratio meets the design criteria, set at 0.8.

Construction of the 2.5-hectare monitoring cell (see Figure 1) in the south-east corner of the site consisted of:

1) placement of the 0.5 m thick layer of sand (Zone 1) which would be required to prevent erosion and allow vegetative growth in the case where cover construction proved to be unfeasible; and

2) placement of the two remaining layers.

Placement of the first layer in the test area (see Photographs 1 to 7) started in late fall 1995. Due to the typical climatic conditions of this region (temperature of approximately +6°C during the day and - 5°C at night, resulting in tailings being frozen at a depth of less than 15 cm), the placement of the Zone 1 material (sand) created, as expected, traffic circulation problems, particularly toward the centre of the tailings impoundment. As shown on Photographs 4 and 5, limited infiltration (piping) of finer LTA tailings into the sand layer (0.5 m) was observed at the beginning. Compaction of the Zone 1 material was not considered critical for the cover system. The homogeneity and drainage characteristics of this layer are significantly more important to ensure a capillary break effect, and the presence of finer particles in the coarser material must be controlled. The piping effect ceased as temperature decreased and the deeper tailings froze.

During the field test work described in Section 2.2, test cells to verify compaction requirements for Zone 2 material were installed in relatively dry areas of the site, namely the north and south-east dykes. During Phase I work, a compaction value of 90 % of the STD Proctor was required on softer foundations to achieve the 0.8 void ratio target as presented in Section 3.1.

Essentially, the same procedure used for the test cells (two 0.4 m lifts versus one 0.8 m lift) was kept with compaction levels tested using a nucleodensometer (see Photograph 8). This testing was performed immediately after compaction as well as the following day to assess frost action. Results showed that a single 0.8 m thick layer of Zone 2 material undergoing four to six passes with a vibrating roller drum compactor was the best alternative. Compaction values achieved were greater than 90 % of the STD Proctor.

As noted above the main objectives of Phase I were to verify site accessibility for construction equipment, and to confirm that adequate compaction of Zone 2 (MNR tailings) was possible. Results from Phase I showed that to enable heavy equipment circulation, and to prevent piping of tailings particles into the capillary break layer (Zone 1 - coarse layer), the Zone 1 layer needed to be placed and compacted in winter, while the underlying tailings surface was frozen.

Phase I work also demonstrated that acceptable compaction levels for fine-grained materials (Zone 2) were attainable even in freezing conditions if these materials were not too wet (about 15 – 18 % water content) and were compacted immediately. Phase I work has therefore shown that composite cover construction is feasible, as long as the work is performed in winter when the tailings to be covered are frozen.

4.3 Phase II - Fall 1995 and Winter 1996

With Phase I work completed, much confidence was gained on the constructability aspects of the concept for full-scale application. Phase II was implemented, and consisted of covering the softer tailings areas first, preferably during the winter of 1995-96. A comprehensive QA/QC program was required to ensure that the required minimum standards be met. The program included:

1) snow removal prior to material placement;
2) material placement and immediate compaction (before freezing);
3) continuous compaction testing, sampling, laboratory analysis, and layer thickness verification;
4) snow and ice management at the borrow pits and work site to minimize handling of frozen materials and avoiding subsequent mixing with snow and/or ice; and
5) material management (frozen materials not used during winter construction are set aside for possible later use elsewhere during the warmer construction season).

This section describes the activities that took place at the LTA site in the fall of 1995 and winter 1996. The activities are presented in chronological order. Brief descriptions of the equipment used for the construction of the cover are also provided. The sequence of events does not include all activities performed on the site; it is focused on the actual construction of the cover system. Photographs are included for completeness.

Construction Norascon Inc. was the contractor while Golder Associés managed and supervised the field work.

4.3.1 Cover System

As mentioned previously in Section 1.5, the composite cover built over the LTA tailings impoundment consists of three layers (see Figure 3). The first layer is a 0.5 m-thick sand layer and is identified as Zone 1. This layer keeps moisture from escaping from the overlaying layer by the capillary break effect. The material is from the borrow pit located west of the LTA tailings impoundment (see Figure 1). This pit also served as a source of material used to raise dykes and to construct the toe drains. The estimated available volume of sand and gravel was 500 000 m^3. The stratigraphy of the west borrow pit is shown in Photographs 9 and 10. This layer was spread as a single lift, and compacted using the spreading equipment only.

The second layer was a 0.8 m compacted layer of fine material with a low permeability and good water retention capacity, acting as an oxygen diffusion barrier. The MNR tailings were used for this layer, and are identified as Zone 2. Figure 1 depicts the location of the MNR tailings the borrow area for the Fall of 1995. Approximately 1 Mm^3 of useable tailings was available for cover construction. Useable tailings are described as fine, unfrozen, not too wet, and within the design particle size envelope. This layer was spread as a single lift, and compacted with four to six passes of a vibrating roller drum compactor.

The third layer is a 0.3 m compacted layer of sand and gravel from the west borrow pit and is identified as Zone 3. This layer acts as a protection layer, as well as an evaporation protection layer for the underlying Zone 2 layer. This layer was spread as a single lift, and well compacted with a vibrating roller drum compactor.

4.3.2 Description of Activities

Since the LTA impoundment is actually a stack, the dykes are also composed of acid-generating materials and needed to be covered. Hence, one of the first tasks requiring some attention was the external slopes of the dykes, which were too steep to assure long-term stability. This task was not directly related to cover design layout, but had to be performed prior to cover construction.

Phase II rehabilitation work began in late fall 1995 with the profiling of the south-east dyke (see Photographs 11 to 13) that was constructed solely of tailings. The slope was reduced (maximum slope of 3H:1V) and directed away from the tailings area. The profiling work was then completed on the east, north, and west dykes. The inner slopes and crests of the dykes were also profiled to a maximum slope of 3H:1V for covering purposes.

An access road was also constructed (see Photographs 14 and 15). This road joins the west borrow pit, where Zone 1 and 3 materials are located, to the LTA tailings area via the settling pond (see Figure 1). This 7.5 m wide road was built to facilitate circulation of heavy equipment on the settling pond surface in winter. Before freezing, traffic circulation was impossible. This road was continued up to the MNR property where the Zone 2 material is located. An access ramp was constructed, using dry tailings, which led from the LTA impoundment tailings to the MNR property, crossing over the east dyke (see Figure 1).

During this period, lime was placed on the downstream slope of the peripheral dykes (see Photographs 16 and 17). This work began on the south-east dyke and then continued on the east and north dykes. Agricultural lime was spread as a precautionary step to delay any acid generation that could occur as the dyke crests were not yet covered. In total, approximately 350 tons of lime were spread on the east, south-east, and north dyke slopes and crests at a ratio of 100 t/ha.

Zone 1 material placement began on the north dyke crest, and then continued in the direction of the east and south-east dykes, as well as towards the softer areas to the south-west. The sand was excavated using a Hitachi EX-700 hydraulic shovel, loaded by a CAT 980 loader, and transported using four to six 35-ton off-road Volvo trucks. The number of machines used varied depending on work conditions and crews (day or night shift). The tailings were spread by one or two CAT7/D6 bulldozers and compacted by one or two smooth vibrating drum compactors. Since no compaction was required for Zone 1, only a road grader was used to level the Zone 1 layer in preparation for the placement of the Zone 2 layer (see Photographs 18 and 19).

With the establishment of a good working surface for Zone 1, placement of the Zone 2 MNR tailings on the south-east dyke (see Photographs 20 and 21) was started. Winter construction resulted in frozen borrow materials. The frozen tailings at the MNR site were excavated and stockpiled mainly on the outer slopes of the north dyke for future use. Frozen materials accounted for approximately 30 % of the total volume excavated. Unfrozen material from the MNR site was transported to the LTA site for placement and compaction as Zone 2 material. Even if nearly 10 Mt of alkaline tailings were present in the MNR site, only about 10 % had suitable characteristics as construction material for the composite cover. Only efficient management of these materials allowed for the completeness of the work.

Placement of Zone 1 (0.5 m-thick layer of sand) over the entire surface of the LTA tailings impoundment was completed by the end of March 1996. The only area left uncovered was the west dyke. The downstream slope of this dyke required using profiling/reprofiling (3H:1V) before placement of the cover, scheduled for the summer of 1996.

Near the end of March 1996, most of the acceptable MNR tailings identified (unfrozen and 18 % water content on average) had already been used. The moisture content of the tailings increased with depth, thus gradually reducing the attainment of adequate compaction for the cover.

A second borrow area, north-east portion of the MNR property, was used to supply Zone 2 materials (winter 1996 on Figure 1). These tailings were found to be finer and much drier (15 % water content on average). The remainder of Zone 2 construction was carried out using this material. Temporary access roads to this new borrow area on the MNR property were constructed.

Zone 3 construction (final protective layer) began as soon as the Zone 2 material was placed. Hence, a large portion of the composite cover was completed by mid-March 1996 (see Photographs 22 and 23). With a thickness of 0.3 m, this layer was spread and compacted in a single lift using spreading equipment.

Work planned for the fall 1995 - winter 1996 period was completed by the end of March 1996. During this time, the entire LTA tailings surface, with the exception of the access road and the downstream slope of the west dyke, was covered with the three-layer composite cover system. The south-east dyke was also completely covered. The east dyke was covered by Zone 1 material only, while the north dyke has Zone 1 layer completed as well as stockpiles of frozen MNR tailings (Zone 2 material).

A strict quality control program was implemented during the composite cover placement. Good compaction of the Zone 2 layer was essential for cover efficiency. The quality control program was especially important since construction was performed in difficult winter conditions, a first for this type of application.

For the MNR tailings (Zone 2), the average in situ compaction obtained using a nucleodensometer was 94.7 % of the Standard Proctor. This corresponds to an average void ratio of 0.778, which is better than the 0.8 void ratio considered in the feasibility study. The work performed during the fall 1995-winter 1996 period can therefore be considered in conformity with the design criteria.

The complete results of all compaction testing for the fall 1995-winter 1996 period are presented in Appendix G.

Table 6 provides an estimate of the volume of material put in place. Approximately 0.97 Mm^3 of materials were used in this period for the construction of the composite cover.

4.4 Phase II - Summer 1996

Construction on the LTA site was delayed in the spring of 1996 because of melting snow which made traffic circulation on the site impossible. In early July, work resumed with the removal of ponded water and debris that had accumulated in existing ditches to permit proper drainage of the site.

During winter construction, the MNR tailings were used for the Zone 2 fine layer. The spring thaw left the MNR site untrafficable. To complete Zone 2 of the composite cover, silt from the N^o 1 borrow pit was used (see Figure 1). Although material availability was limited, the silt demonstrated better water retention capabilities than the MNR tailings previously used in the winter of 1996. A 3 m-thick strip of silt was used from the borrow pit to complete the cover.

The west dyke required slope reprofiling before placement of the composite cover. This was one of the first tasks performed on the site during the summer of 1996. The outer dyke wall was given a 3H:1V slope and covered immediately by a layer of Zone 1 material (see Photographs 24 to 26) followed by the Zone 2 silt layer (see Photograph 27).

During Phase I, cover placement over the north dyke was not completed. Frozen MNR tailings (Zone 2 material) were instead stockpiled at that location. The north dyke was first reprofiled, because the spring melt created gullies on the slope walls (see Photographs 28 and 29), and stockpiled tailings were spread out and compacted. Zone 3 material was placed immediately afterwards (see Photographs 30 and 31).

The placement of the Zone 2 silt layer over both the north and west dykes was completed by mid-August 1996 and was followed by the placement of the Zone 3 layer (see Photographs 32 and 33). Due to the rain and the relatively high moisture content of the silt, the Zone 2 layer was sometimes compacted several days after allowing material to air dry. Adequate compaction was then achieved using a smooth drum vibrating compactor.

Construction materials were excavated using a Hitachi EX-700 hydraulic shovel, loaded by a CAT 980 loader, than hauled by four to six 35-ton Volvo off-road trucks. The number of trucks used varied with work conditions (day or night shift). The materials were spread over the tailing surface and the dyke slopes by one or two CAT7/D6 bulldozers and subsequently compacted by one or two smooth drum vibrating compactors.

Erosion of the dyke slopes, because of runoff, was also a problem at the east and south-east dykes. Reprofiling was necessary prior to placement of Zone 2 and Zone 3 material.

Work continued on the tailings pond where the access road was removed and replaced with the composite cover. Work began at the eastern extremity of the road and proceeded west toward the west borrow pit (see Photographs 34 to 37).

It should be noted that the LTA tailings, even in mid-summer, had a high moisture content. They were almost fully saturated and traffic circulation created a quicksand effect. As observed in Phase I under these conditions, tailings compaction using standard equipment was virtually impossible. This would create a quicksand effect which would induce piping of the LTA tailings through the Zone 1 sand layer. Hence, compaction was achieved using only the excavator bucket. Particular attention was paid to blending the remainder of the Zone 2 layer properly with the partial Zone 2 layer placed during winter construction. Since heavy equipment could not circulate on the composite cover, dismantling of the access road and placement of the cover were performed in successive 50 m long sections. This ensured continuous access to the work area via the access road. All work was completed by October 1996.

Therefore, the decision to proceed with construction of the cover on soft tailings in the winter was justified. In fact, difficulties encountered during the summer months proved that such work would have been impossible to perform during summer seasons. Furthermore, from experience, the protective Zone 3 layer must be placed as soon as possible since thawing and spring runoff can cause significant erosion, even to the point of compromising the integrity of the composite cover.

The compaction test results are presented in Appendix H. For the Zone 2 silt, the average compaction was 92 % of the Standard Proctor, which relates to a void ratio of 0.762. This is again below the target void ratio of 0.80.

Table 6 provides an estimate of the volume of material used for the composite cover construction. Approximately 100 000 m^3 of various materials were used to cover the tailings area in the summer of 1996. For both 1995 and 1996, a total of approximately 1.0 Mm^3 of material was used for cover construction.

5.0 FIELD MONITORING PROGRAM

Phase A of the monitoring program consisted in the installation of 20 monitoring stations throughout the site to adequately monitor the efficiency of the composite cover. These stations are in addition to the existing piezometers on site.

The first series of monitoring stations, identified CS96-1 to CS96-10 (top of impoundment) and PS96-1 to PS96-3 (outer slopes) was installed in June 1996. The PS96-4 to PS-96-10 (north dyke) series was installed in August 1996. The locations of the monitoring stations are shown on Figure 16. The difference in elevation between the stations is shown on Figure 17.

A typical monitoring station is illustrated in Figure 18. The oxygen probe enables the measurement of oxygen consumption, that is converted to oxygen flux through the composite cover (Photographs 38 and 39). The TDR (Time Domain Reflectometry) probes are used to evaluate the in situ moisture content of a material (Photograph 40) and the Watermark probes are used to measure capillary potential in soils (Photograph 41). A correlation between moisture content, capillary forces, and oxygen flux through the saturated layer as well as cover efficiency can be determined using these three instruments. More information on instruments characteristics can be found in MEND 1994.

Phase A monitoring stations were installed in the Zone 2 layer (MNR tailings) of the composite cover. Given the short time period between the end of construction and the first monitoring campaign results, the interpretation, which takes into consideration varying seasonal conditions, will be included in the final monitoring report due in March 1999.

6.0 CONCLUSIONS

The LTA project has increased the knowledge base of construction techniques in full-scale applications of composite covers. Initial observations on site indicate that the cover was placed in conformity with construction objectives. The design, construction, and monitoring program for the LTA soil cover provides a unique opportunity to evaluate the performance of an engineered soil cover in Canadian climate.

Several new concepts and construction techniques were developed for this project, such as the use of locally available tailings to be used for the fine layer when clays are not available. This concept could be applicable to a large number of other acid-generating sites.

The geotechnical properties of the MNR tailings used for the fine layer of the composite cover are neither particular nor uncommon. The MNR tailings exhibit characteristics that a relatively common silty sand or sandy silt may have. Often, the difficulty is not in identifying suitable locally available materials but rather in determining the required thickness of the cover layers that will ensure minimal oxidation conditions, that is the fine material at near saturation with a capillary layer.

At least three key elements are required to ensure optimal design of a composite cover:

- The value of the maximum oxygen flux allowable (obtained typically through geochemical modelling or column testing) that would provide negligible oxidation;
- The effective diffusion coefficient (De) versus saturation of the material considered for cover construction (also obtained from laboratory test). By knowing the maximum flux available, thickness calculation of the fine layer (Zone 2 in the LTA project) can be obtained using the method presented in Elberling et al., 1994.
- The water retention capacity of all the materials being considered for cover construction. This will enable the design of capillary and hydraulic breaks (in certain cases to prevent water flow within the cover) to ensure proper saturation of the fine layer in the cover system.

Furthermore, three important design parameters that effect the financial impact of the project must be considered.

The first aspect, geochemical modelling of the site specific conditions, is one of the most important parameter affecting the cost of rehabilitation. In this case study, the precise establishment of site requirements allowed the use of MNR tailings instead of other more costly materials.

The next critical parameter is knowledge and identification of available materials. Using coil covers as a closure option is cost effective when transportation costs are kept to a minimum. The LTA project confirmed that using locally available material, such as tailings, for cover construction is a viable closure option. The project also demonstrated that the results of the laboratory testing were representative of the field conditions (Aubertin et al., 1995a, b). When transportation costs are kept to a minimum, the cost of a cover system such as the one used at LTA are viable.

The final parameter in determining the total cost of construction is field conditions since cover placement requires a specified density on an often soft foundation. Innovative solutions are often required. In the LTA case, winter construction was deemed the most appropriate solution.

The final cost of the LTA composite cover, an area of almost 60 hectares, was CAN$3.9 M or $45,000/hectare/m of thickness (revegetation cost not included). The preliminary estimate of all reclamation costs (including ditches, foot drains, spillways, etc.) was approximately $93,500/hectare.

7.0 FUTURE PROJECTS

Monitoring of Phase A stations will be continued. Additional monitoring stations will be installed during Phase B. These will be carefully installed to minimize disturbance of the composite cover. TDR probes, to measure the water content, and tensiometers, to corroborate the Watermark probe readings, will be installed in the Zone 2 layer. This phase will allow a spatial distribution of results as well as the determination of an average saturation value through the entire thickness of the fine layer. These results will complement the vertical profiles of the Phase A monitoring stations. Phase B began in the spring of 1997.

To calculate the infiltration, a more detailed hydraulic balance is required. A meteorological station on site, along with the meteorological stations at the Val d'Or Airport and that of École Polytechnique at the Norebec-Manitou site (located 10 km east of Val d'Or), will provide all necessary precipitation and evaporation data. A flow measurement station will be installed at the south spillway to monitor runoff.

The impacts of surface erosion and root penetration on the effectiveness of the cover are recommended areas of research for future studies.

The final monitoring report, which will include the data and the interpretation, will be available in March 1999.

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REFERENCES

Aachib, M., Aubertin, M., Chapuis R.P. 1993. Étude en laboratoire de la performance des barrières de recouvrement constituées de rejets miniers pour limiter le drainage minier acide - Un état de la question. Rapport EPM/RT-93/32.

Aachib M., Aubertin, M., Chapuis R.P. 1994. A Laboratory Investigation of Milling Wastes Properties Used to Build Cover Systems in Column Tests. Proc. of the Int. Land Reclamation and Mine Drainage Conf. and the Third Int. Conf. on the Abatement of Acidic Drainage, Pittsburgh, PA, Bureau of Mines Special Pub. SP 06B-94, Vol. 2, pp. 128-137 (MEND Project 7.1).

Anon, 1991. The Use of Low-Permeability Covers on Acid-Forming Waste Material. A Literature Search Conducted for the Membership of AMIC, ASSMR, CLRA and REGRO (Oc.1991), 23 pages.

ASTM (American Society for Testing Material), 1995. Annual Book of ASTM Standards, seat. 4, vol. 04-08. ASTM, Philadelphia.

Aubertin, M., Chapuis, R.P., 1991. «Considérations hydrogéotechniques pour l'entrepo-sage de résidus miniers dans le nord-ouest du Québec. C.R. 2e Conf. Int. Réduction des eaux de drainages acides (MEND Project 5.6.1.)

Aubertin, M., Chapuis, R.P., Aachib, M., Bussière, B., Ricard, J.F., Tremblay, L., 1995a. Évaluation en laboratoire de barrières sèches construites à partir de résidus miniers. Projet P1622, C.D.T. École Polytechnique, novembre 1995 (Rapport NEDEM 2.22.2A).

Aubertin, M., Ricard, J.F., Chapuis, R.P. 1995b. A Study of Capillary Properties of Mine Tailings: Measurements and Modeling. Proc. 48th Can. Geoth. Conf. Vancouver, pp. 17-24.

Aubertin, M., Ricard, J.F., Chapuis, R.P. 1998. A Predictive model for the water retention curve: application to tailings from hard-rock mines. Can. Geotech. J. 35: 55-69.

Baccini, P., ed., 1988. The Landfill Reactor and Final Storage, Springler-Verlag.

Bagchi, A., 1990. Design, Construction and Monitoring of Sanitory Landfill, John Wiley and Sons.

Bussière, B., Benzaazoua, M., 1997. Valorisation des résidus miniers: Une approche intégrée (Phase II, rapport d'étape 5). URSTM, mars 1997 (Rapport NEDEM 2.22.3).

Collin M., Rasmuson, A., 1990 Mathematical Modeling of Water and Oxygen Transportation in Layered Soil Covers for Deposits of Pyritic Mine Tailings, Acid Mine Drainage: Designing for Closure. GAC-MAC Annual Meeting. pp. 311-333.

Daniel, D.E., Editor, 1993. Geotechnical Practice for Waste Disposal. Chapman & Hall.

EPA, 1989. Final Covers on Hazardous Waste Landfills and Surface Impoundments, Technical Guidance Document, EPA/530/SW/89-047.

Hutchison, I. P., et Ellison, R. D. eds., 1992. Mine Waste Management. California Mining Association.

MEND Project 2.31.1b, 1994. Engineering Design and Construction Report : Phase IV - Composite Soil Cover Acid Waste Rock Study Heath Steele Mine. November 1994.

MEND Project 2.21.3, 1997. Review of Soil Cover Technologies for Acid Mine Drainage - A Peer Review of the Waite Amulet and Heath Steele Soil Covers, July 1997.

McMullen, J., Firlotte, F.W., Knapp, R., Aubertin, M., 1997. Les Terrains Aurifères Property Site Closure and Rehabilitation Conceptual to Construction. 29th Annual CMP Operators Conference, Jan.21-23, 1997.

Millington, B.J. Sharer,, B. C. 1971. Diffusion in Aggregated Porous Media. Soils Science, vol. III, no. 6. pp 372-378.

Nicholson, R.V., Gillham, R.W., Cherry, J.A., Reardon, E.J, 1989 Reduction of Acid Generation in Mine Tailings Through the Use of Moisture-retaining Covers as Oxygen Barriers. Can. Geotech. J. Vol. 26, pp. 1-8.

Nicholson, R.V., Akindunni, F.F., Sydor, R.C. et Gilham, R.W., 1991. Saturated Tailings Covers Above the Water Table: The Physics and Criteria for Design. Deuxième Confér. Int. sur la réduction des eaux de drainage acides, pp. 443-460. (MEND Project 5.6.1).

Nicholson, R.V. et Tibble, P.A., 1996. An Oxygen Consumption Survey of the Barrick Gold Covered Tailings Impoundment, December, 19, 1996.

Ricard, J.F., 1994. Étude en laboratoire de la relation capillaire et de la conductivité hydraulique de résidus miniers. Mémoire M.Sc. A., Département de génie Minéral, École Polytechnique de Montréal, 207 pages.

Ricard, J.F., Aubertin, M., Firlotte, F.W., Knapp, R., McMullen, J., Julien, M., 1997. Design and Construction of a Dry Cover made of Tailings for the Closure of Les Terrains Aurifères Site, Québec, Canada. Proc 4th ICARD Conference, Vancouver, May-June 1997 (MEND Project 7.2).

Senes Consultants Ltd., 1995. A Review of AMD Control Strategies for Les Terrains Aurifères, Malartic, Québec. Rapport no. 31638, juillet 1995.

SRK, 1991. Guide technique préliminaire sur le drainage rocheux acide (une traduction de «Draft Acid Rock Drainage Technical Guide». 1989, BCAMD Task Force). Vol. I et II, Centre de recherches minérales, Québec

Wing, N. R., 1993. Permanent Isolation Surface Barrier: Functional Performance. Report Prepared for the U.S. Department of Energy, Westinghouse Handford Company, WHC-EP-0650.

Wing, N. R., 1994. Permanent Isolation of Surface Barrier Development Plan. Report Prepared for the U.S.. Department of Energy, Westinghouse Handford Company, WHC-EP-0673.

Woyshner, M.R., Yanful, E.K., 1995., Modeling and Field Measurements of Water Percolation Through and Experimental Soil Cover on Mine Tailings. Can. Geotech. J., 32: 601-609.

TABLE 1

SUMMARY OF LABORATORY RESULTS

ITEM	MNR TAILINGS	SAND	SILT	LTA TAILINGS
Grain size				
D_{60} (mm)	0.030	0.870	0.0095	0.030
D_{30} (mm)	0.012	0.517	0.003	0.010
D_{10} (mm)	0.005	0.300	<0.001	0.002
Cu	6.0	2.90	>9.5	15
Cc	0.96	1.02	>0.95	1.67
Specific gravity Gs	2.819	2.751	2.747	2.934
Compaction test				
Density (kg/m^3) γ_d	1650	1845	1943	1810
Optimal water content W_o	15.7%	14.2%	13.3%	15.5%
Void ratio e	0.708	0.491	0.414	0.621
Atterberg's Limits:				
Liquid limit w_ℓ	23.0	----	25.1	23.0
Plastic limit w_p	19.5	----	19.06	21.9
Plasticity index I_p	3.5	----	6.05	1.1
Soil type USC Classification	ML	SP	ML-CL	ML

TABLE 2

COMPACTION TESTS - MNR TAILINGS
EXPERIMENTAL CELLS

Description : Compaction test. South-east test cell. LTA site			
Personnel	Eric Bouchard Golder	**Compaction unit**	Smooth drum compactor
Gs	**STD Proctor Results**		
2.819	**Optimal Density (Mg/m^3)** 1.650	**Optimal water content**	15.7

Test #	Material	γ_d (kg/m^3)	W %	% Standard Proctor	Void ratio	Field notes
110	MRN	1550	17	93.9%	0.774	
111	MRN	1537	22.7	93.2%	0.789	
112	MRN	1536	19.4	93.1%	0.790	
113	MRN	1552	17.1	94.1%	0.772	
114	MRN	1481	19.3	89.8%	0.857	
115	MRN	1487	17.1	90.1%	0.849	
116	MRN	1530	13.1	92.7%	0.797	
117	MRN	1480	12.6	89.7%	0.858	
118	MRN	1555	13.1	94.2%	0.768	
119	MRN	1543	19.9	93.5%	0.782	
120	MRN	1580	10.8	95.8%	0.741	
121	MRN	1527	17.5	92.5%	0.801	
122	MRN	1539	14.5	93.3%	0.787	
123	MRN	1528	16.3	92.6%	0.800	
132	MRN	1564	17.6	94.8%	0.758	
133	MRN	1593	16.2	96.5%	0.726	
134	MRN	1535	18.6	93.0%	0.792	
135	MRN	1506	17.8	91.3%	0.826	
136	MRN	1534	14.4	93.0%	0.793	
137	MRN	1611	15.3	97.6%	0.707	
138	MRN	1510	14.7	91.5%	0.821	
139	MRN	1561	17.3	94.6%	0.762	
140	MRN	1581	16.2	95.8%	0.739	
141	MRN	1517	12.8	91.9%	0.813	
142	MRN	1623	17.6	98.4%	0.694	
143	MRN	1635	10.6	99.1%	0.682	
144	MRN	1577	18.6	95.6%	0.744	
145	MRN	1594	19.3	96.6%	0.725	
146	MRN	1658	10.9	100%	0.659	
147	MRN	1608	15.2	97.5%	0.710	
148	MRN	1519	12.7	92.1%	0.810	
149	MRN	1580	16.1	95.8%	0.741	
150	MRN	1651	10.8	100.1%	0.666	
151	MRN	1535	18.1	93.0%	0.792	
152	MRN	1521	17.7	92.2%	0.808	
153	MRN	1483	19.5	89.9%	0.854	
154	MRN	1594	18.9	96.6%	0.725	
155	MRN	1488	18.2	90.2%	0.848	
156	MRN	1610	14.3	97.6%	0.708	
157	MRN	1655	16.1	100.3%	0.662	
158	MRN	1641	12.7	99.5%	0.676	
159	MRN	1637	16.8	99.2%	0.680	
	Average	**1560**	**16.1**	**94.4%**	**0.768**	

TABLE 3

SUMMARY OF PERMEABILITY TESTING RESULTS

Void ratio	MNR tailings (cm/s)	SAND (cm/s)	SILT (cm/s)	LTA tailings (cm/s)
0.582			$2.91*10^{-6}$	
0.586		$8.57*10^{-2}$		
0.598		$1.17*10^{-1}$		
0.614		$1.55*10^{-1}$		
0.615		$1.64*10^{-1}$		
0.666			$1.05*10^{-6}$	
0.684			$1.46*10^{-6}$	
0.712	$3.06*10^{-5}$			
0.725				$9.30*10^{-6}$
0.795	$4.96*10^{-5}$			
0.824				$2.39*10^{-5}$
0.833				$1.85*10^{-5}$
0.844	$8.61*10^{-5}$			
0.919			$7.63*10^{-7}$	
1.014	$1.94*10^{-4}$			
1.028	$1.93*10^{-4}$			
1.037				$3.85*10^{-5}$

TABLE 4

SUMMARY OF IN-SITU PERMEABILITY TESTING

Location	Piezometer	Depth (feet)	Stratigraphy	Permeability (cm/s)
BH94-01	1	86.5 - 91.5	Silt	$4*10^{-6}$
BH94-02	1	50.0 - 55.5	Silty Sand	$9*10^{-5}$
BH94-03	1	49.0 - 54.0	Sandy Silt	$2*10^{-5}$
BH94-06	1	47.5 - 52.5	Silty Sand	$5*10^{-5}$
BH94-07	1	15.0 - 20.0	Silt	$8*10^{-6}$
BH94-09	1	2.0 - 12.0	MRN tailings	$8*10^{-6}$
BH93-01	1	40.0 - 50.0	Sand	$9*10^{-4}$
BH93-03	1	25.0 - 35.0	Silty Sand	$4*10^{-4}$
BH93-04	1	55.0 - 65.0	Sand	$9*10^{-3}$

TABLE 5

WATER RETENTION RESULTS SUMMARY

MATERIAL	Void ratio	AEV–Ψ_{90} m water	Ψ_r m water
MNR tailings	0.86	2.21	----
MNR tailings	0.90	2.80	----
MNR tailings	0.94	0.74	----
MNR tailings	0.94	1.36	----
Sand	0,55	----	1,04
Sand	0,64	----	0,97
Sand	0,66	----	0,97
Silt-Poly	0,56	2.81	----
Silt-Poly	0,58	4.22	25,31
Silt-URSTM	0,70	13.5	----
Silt-URSTM	0.80	> 45	----
LTA tailings	0.83	4.66	----
LTA tailings	1.08	1.10	----

AEV : Air Entry Value. Brooks and Corey (1969) method use for silt.

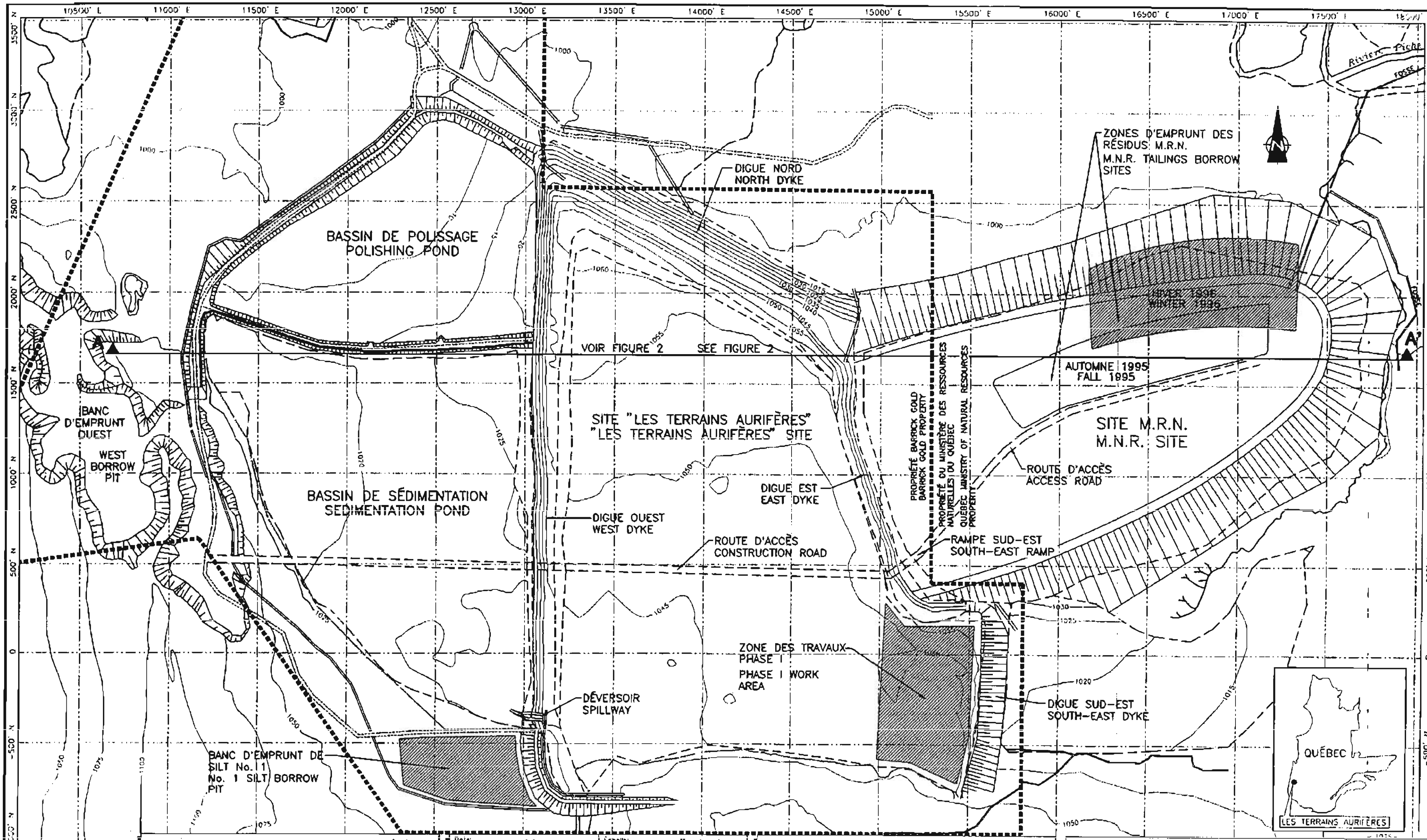
$\Psi_{90:}$ Suction Pressure at 90% saturation. method use for tailings.

$\Psi_{r:}$ Residual suction pressure (typically 5 to 10 % saturation).

TABLE 6

APPROXIMATIVE MATERIAL VOLUMES PUT IN PLACE

Item	Units	Fall 95 Winter 96	Summer 96	Total
Zone 1	m^3	323 220	28 760	351 980
		average thickness (m)		0.59
Zone 2-MNR	m^3	335 155	0	335 155
Zone 2 (MNR-frozen)	m^3	153 990	0	153 990
Zone 2 (Silt)	m^3	0	30 000	30 000
		average thickness (m)		0.87
Zone 3	m^3	153 990	34 005	187 995
		average thickness (m)		0.31
	Total	***966 355***	***92 765***	***1 059 120***



Golder Associés
63, Place Frontenac, Pointe-Claire, Qué., H9R 4Z7
Tel.: (514) 630-0990 Fax: (514) 630-1178

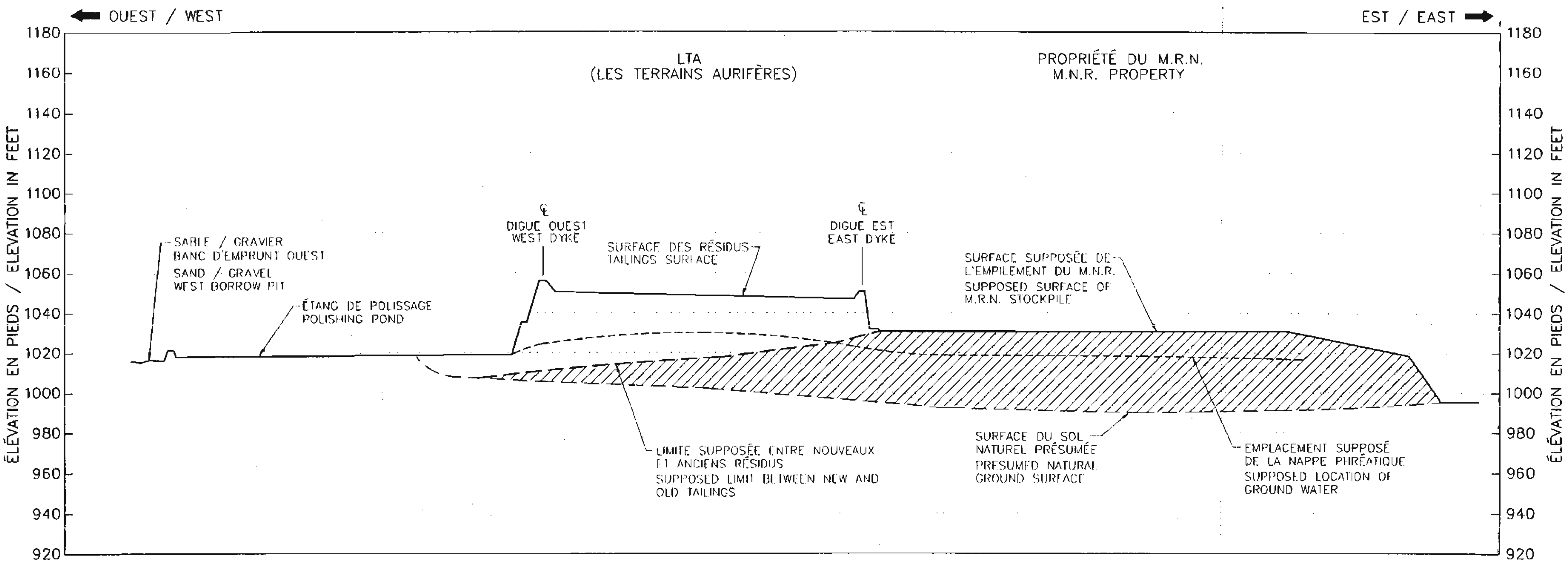
Date:	98-11-11	Échelle: Scale:	1"=500'
Dessiné par: Drawn by:	M.T.	Projeté par: Planned by:	M.K.
Vérifié par: Checked by:	J.-F.R.	Approuvé par: Approved by:	P.C.
No. de dessin: Drawing no:	9730101C	No. de projet: Project no.:	971-7301

CANMET

VUE EN PLAN DU SITE
SITE PLAN VIEW

FIGURE 1

PROPRIÉTÉ "LES TERRAINS AURIFÈRES" PROPERTY
PARC À RÉSIDUS / TAILINGS BASIN



LÉGENDE / LEGEND:

ANCIENS RÉSIDUS MINIERS M.R.N.
OLD TAILINGS M.N.R.

NOUVEAUX RÉSIDUS MINIERS LTA
NEW TAILINGS LTA

----- NAPPE PHRÉATIQUE PRÉSUMÉ
PRESUMED GROUND WATER

ÉCHELLE/SCALE:

HORIZONTALE / HORIZONTAL: 1"=500'
VERTICALE / VERTICAL: 1"=50'

Golder Associés
63, Place Frontenac, Pointe-Claire, Qué., H9R 4Z7
Tel: (514) 630-0990 Fax: (514) 630-1178

Date:	98-11-11	Échelle: Scale:	INDIQUÉE/AS SHOWN
Dessiné par: Drawn by:	M.T.	Projeté par: Planned by:	J.-F.R.
Vérifié par: Checked by:	J.-F.R.	Approuvé par: Approved by:	M.R.J.
No. de dessin: Drawing no:	9730102C	No. de projet: Project no:	971-7301

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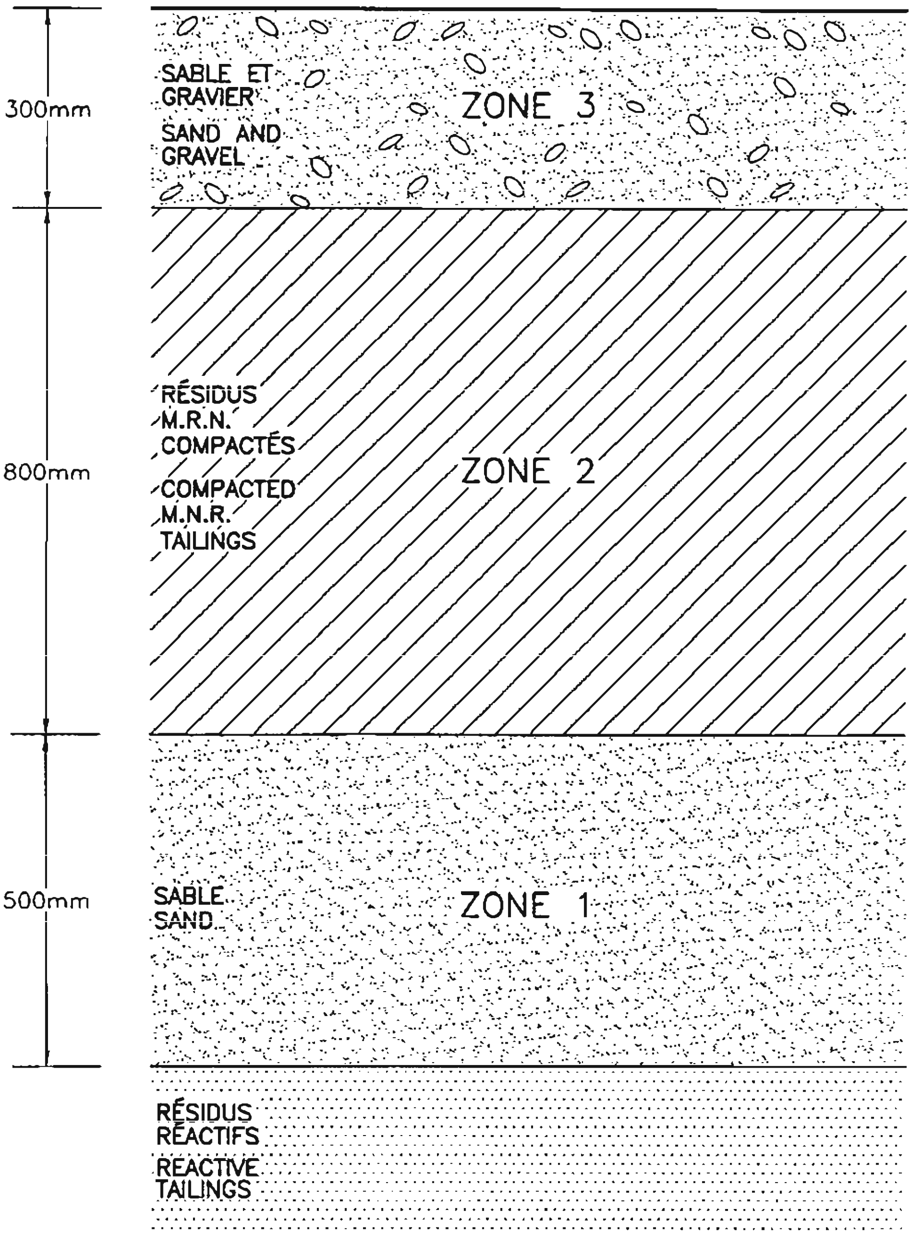
COUPE A-A' – CONDITIONS EXISTANTES
CROSS-SECTION A-A' – EXISTING CONDITIONS

FIGURE 2

PROPRIÉTÉ "LES TERRAINS AURIFÈRES" PROPERTY
PARC À RÉSIDUS / TAILINGS BASIN



Date:	98-11-11	Échelle: Scale:	AUCUNE
Dessiné par: Drawn by:	M.T.	Projeté par: Planned by:	J.-F.R.
Vérifié par: Checked by:	J.-F.R.	Approuvé par: Approved by:	P.C.
No. de dessin: Drawing no.:	9730103C	No. de projet: Project no.:	971-7301

CANMET

PROPRIÉTÉ "LES TERRAINS AURIFÈRES" PROPERTY
PARC À RÉSIDUS / TAILINGS BASIN

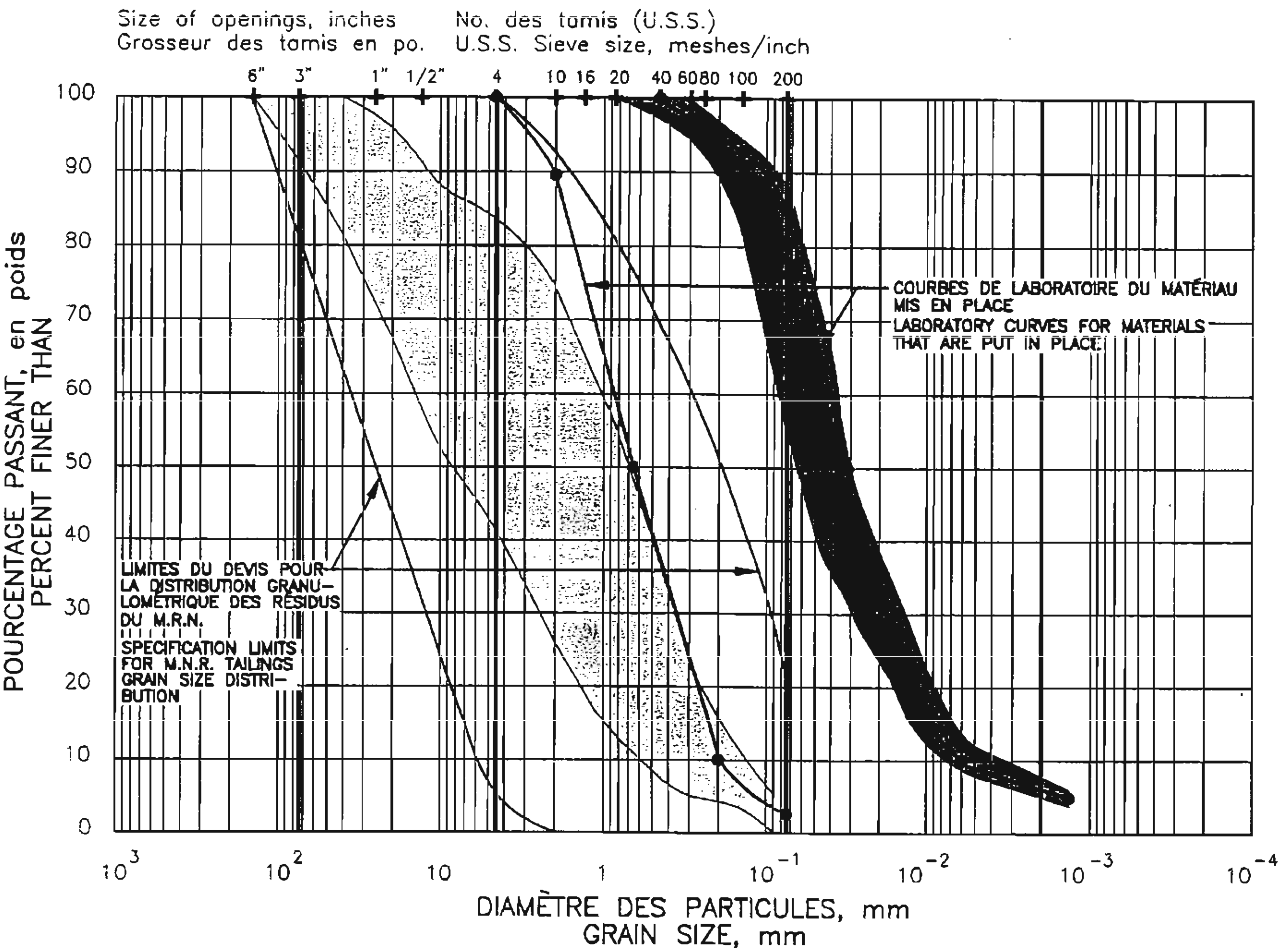
Golder Associés
63, Place Frontenac, Pointe-Claire, Qué.
H9R 4Z7
Tel.: (514) 630-0990 Fax: (514) 630-1178

STRATIGRAPHIE DU RECOUVREMENT
DRY COVER LAYOUT

FIGURE 3

COURBES GRANULOMÉTRIQUES DES MATÉRIAUX DU SITE LTA
LTA SITE MATERIAL GRAIN SIZE DISTRIBUTION

FIGURE 4



SYSTÈME UNIFIÉ DE CLASSIFICATION DES SOLS
UNIFIED SYSTEM OF SOIL CLASSIFICATION

BLOCAUX BOULDERS	CAILLOUX COBBLES	GRAVIER / GRAVEL		SABLE / SAND			SILT	ARGILE CLAY
		GROS COARSE	FIN FINE	GROS COARSE	MOYEN MEDIUM	FIN FINE		

FORAGE No. BOREHOLE No.	ÉCHANTILLON No. SAMPLE No.	PROFONDEUR (m) DEPTH (m)	DATE

LIMITES GRANULOMÉTRIQUES BANC DE SABLE ET GRAVIER
GRAIN SIZE LIMITS SAND AND GRAVEL BORROW PIT

LIMITES GRANULOMÉTRIQUES RÉSIDUS M.R.N.
GRAIN SIZE LIMITS M.N.R. TAILINGS

Date: 98-11-11
Projet / Project: 971-7301

Golder Associés

Dessiné par / Drawn by: M.T.
Projeté par / Planned by : J.F.R.

9730104C.DWG

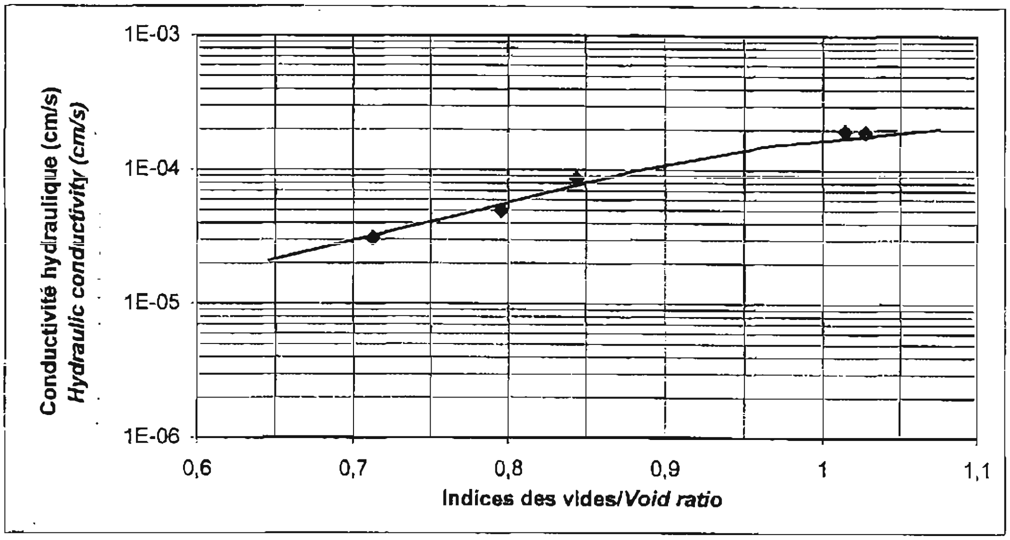


Figure 5: Conductivité hydraulique saturée - résidus MRN.
Figure 5: Saturated hydraulic conductivity - MRN tailings.

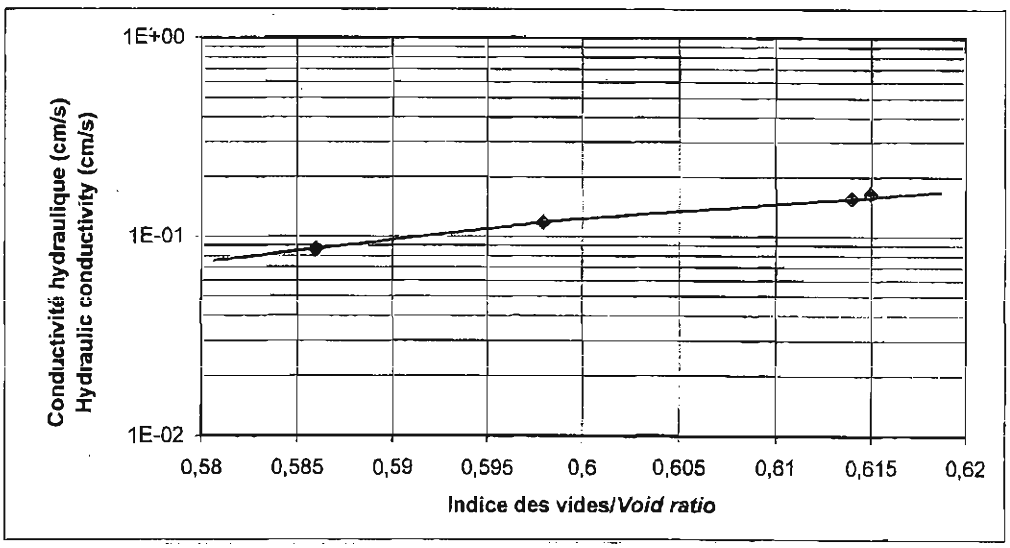


Figure 6: Conductivité hydraulique saturée - sable du banc d'emprunt.
Figure 6: Saturated hydraulic conductivity - sand from the borrow pit.

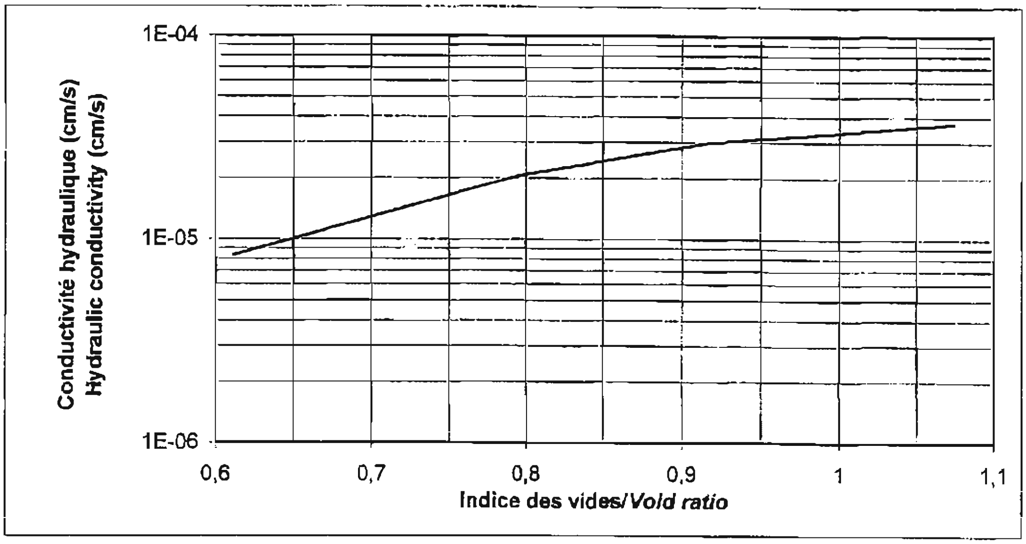


Figure 7: Conductivité hydraulique saturée - résidus LTA.
Figure 7: Saturated hydraulic conductivity - LTA tailings.

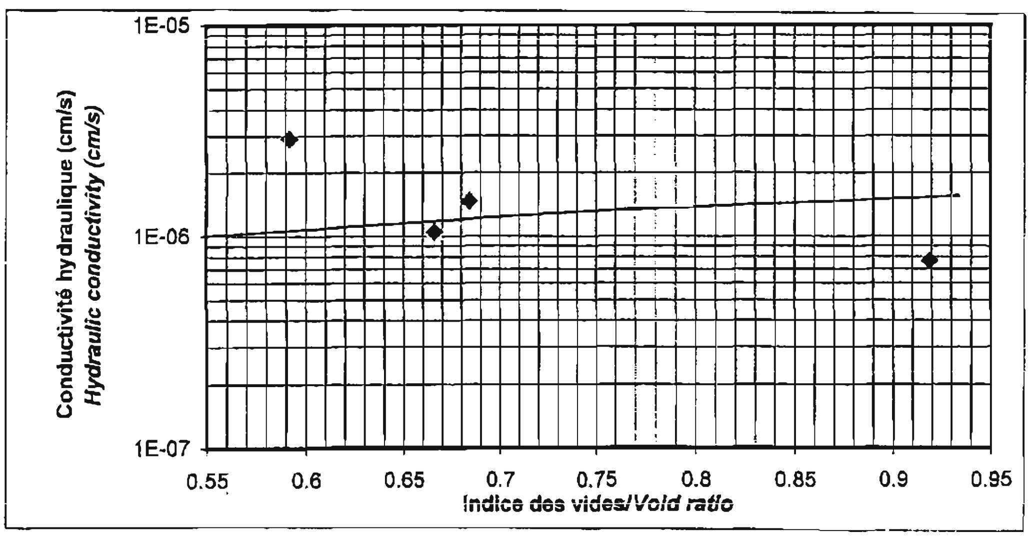


Figure 8: Conductivité hydraulique saturée - silt du banc d'emprunt.
Figure 8: Saturated hydraulic conductivity - silt from the borrow pit.

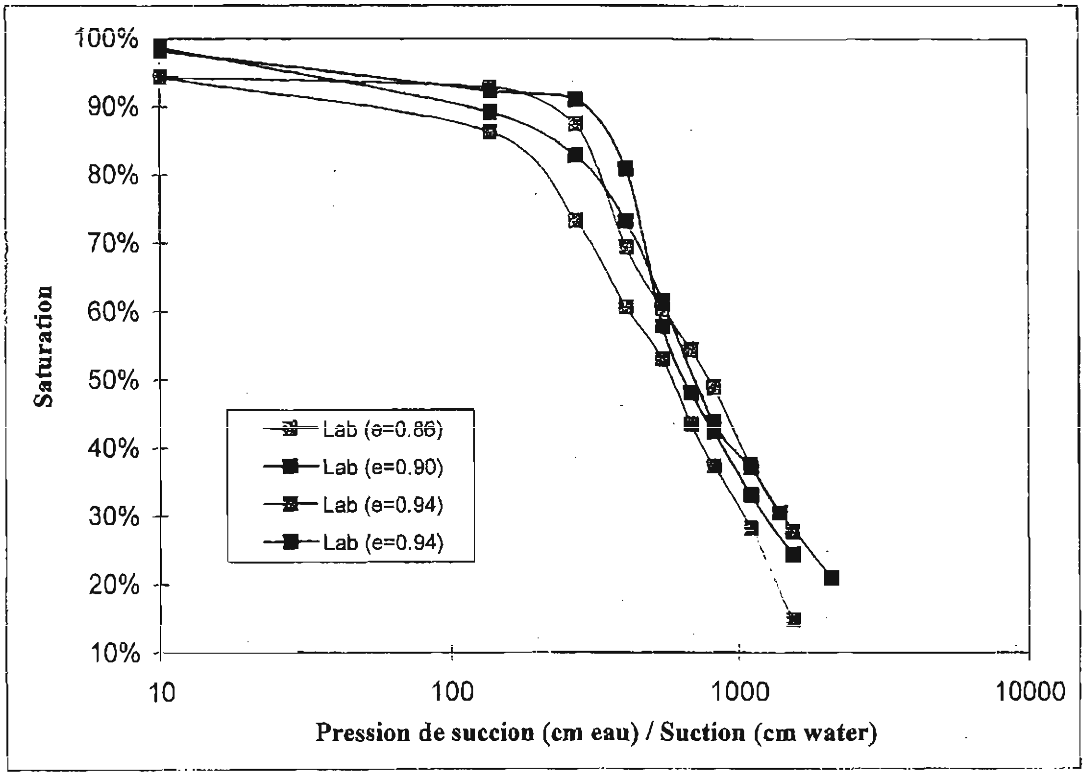


Figure 9 : Courbes caractéristiques de succion - résidus MRN
Figure 9: Water retention curves - MNR tailings.

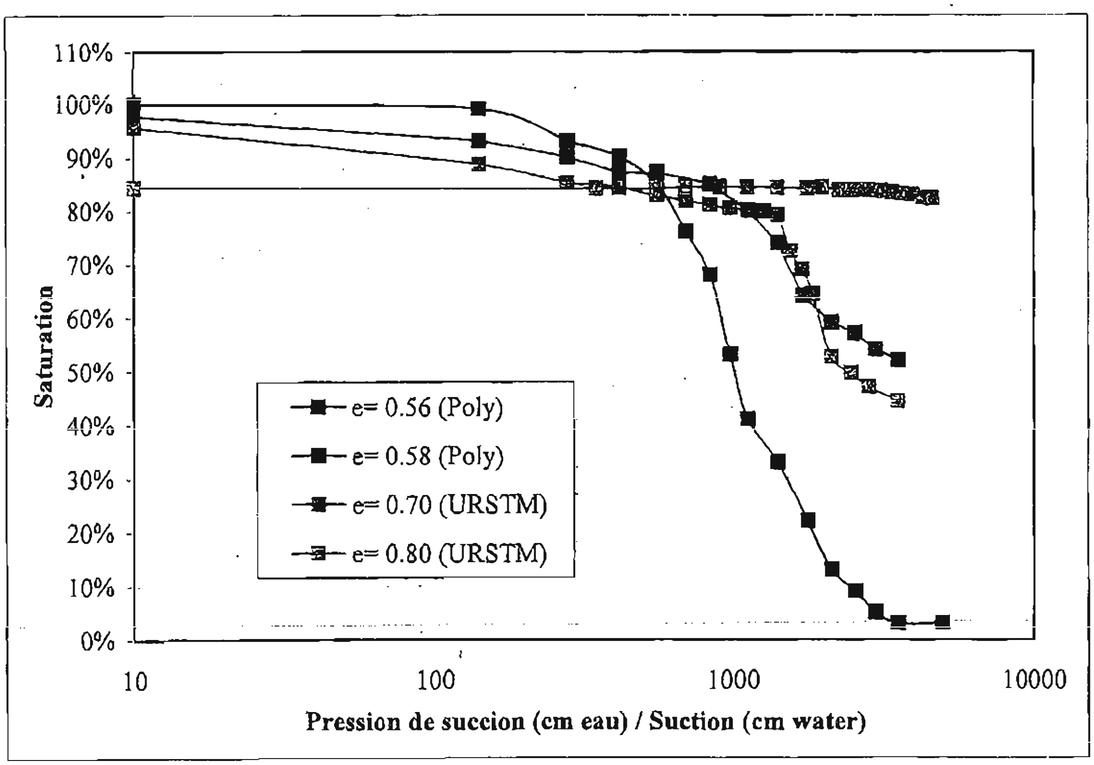


Figure 10: Courbes caractéristiques de succion du silt du banc d'emprunt no.1
Figure 10: Water retention curves of the silt from borrow pit #1.

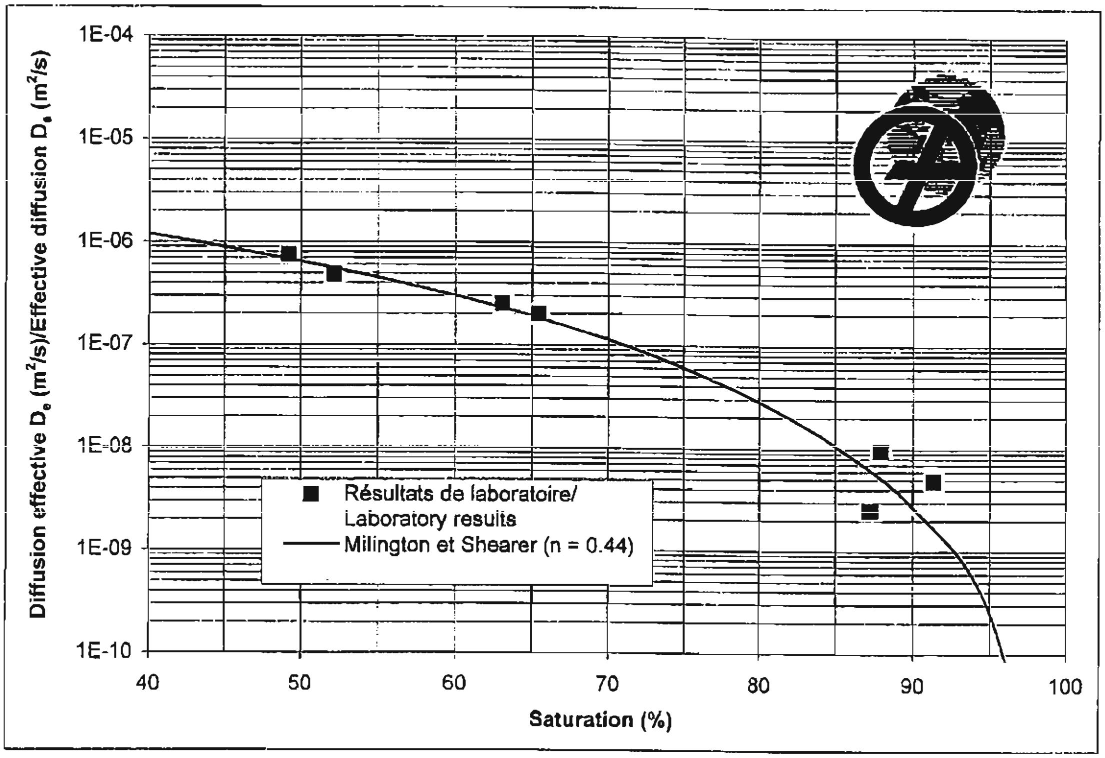
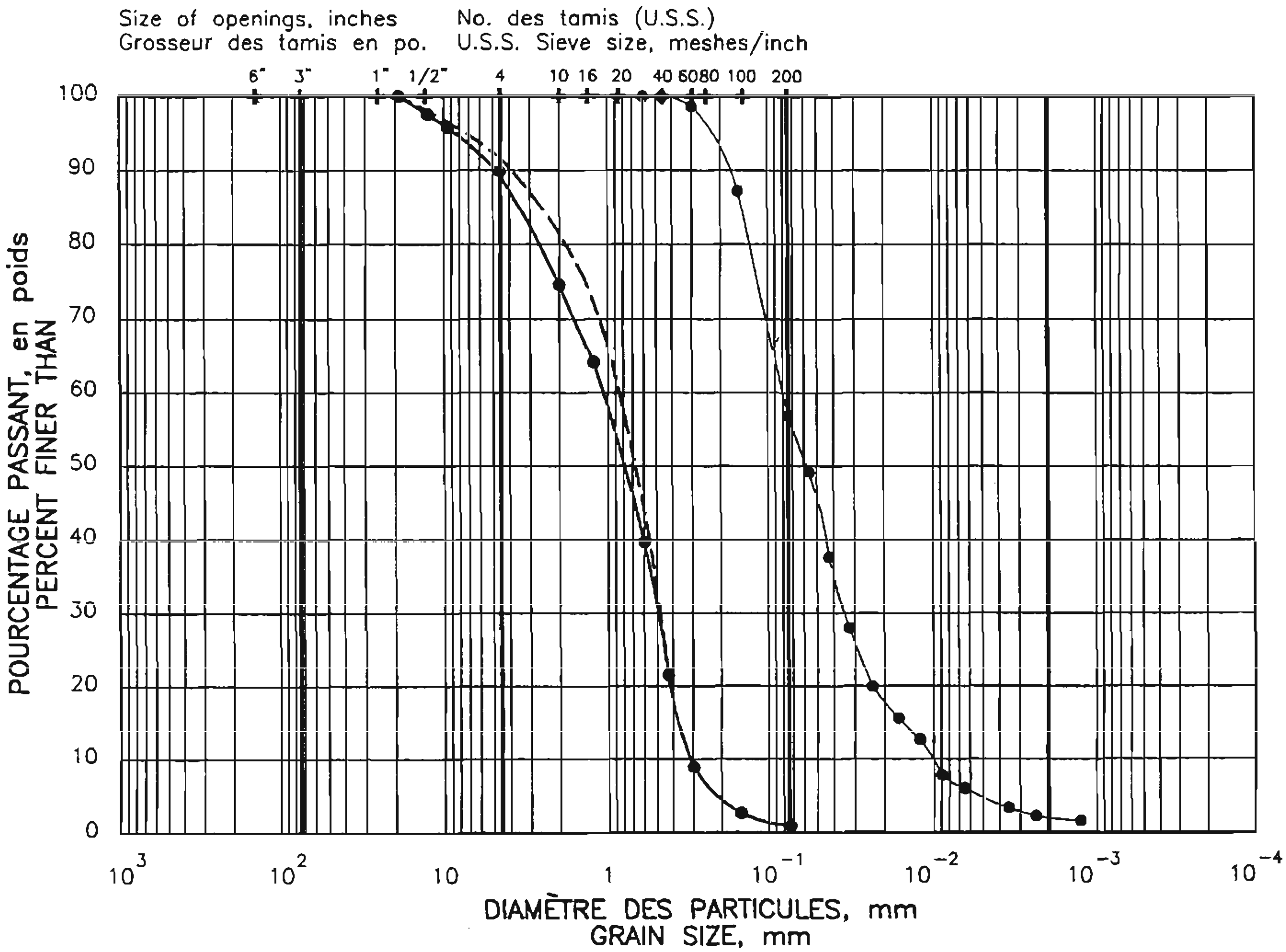


Figure 11: Valeur du coefficient de diffusion d'oxygène en fonction du degré de saturation du résidus MRN.

Figure 11: Oxygen diffusion coefficient vs saturation of the MNR tailings.

COURBES GRANULOMÉTRIQUES DES MATÉRIAUX DE LA COLONNE 1
COLUMN 1 MATERIAL GRAIN SIZE DISTRIBUTION

FIGURE 12



SYSTÈME UNIFIÉ DE CLASSIFICATION DES SOLS
UNIFIED SYSTEM OF SOIL CLASSIFICATION

BLOCAUX BOULDERS	CAILLOUX COBBLES	GRAVIER / GRAVEL		SABLE / SAND			SILT	ARGILE CLAY
		GROS COARSE	FIN FINE	GROS COARSE	MOYEN MEDIUM	FIN FINE		

FORAGE No. BOREHOLE No.	ÉCHANTILLON No. SAMPLE No.	PROFONDEUR (m) DEPTH (m)	DATE

COURBE GRANULOMÉTRIQUE – M.R.N. AU MONTAGE
GRAIN SIZE CURVE – M.N.R. AT THE SETTING

COURBE GRANULOMÉTRIQUE – GOLDER ASSOCIÉS AU MONTAGE
GRAIN SIZE CURVE – GOLDER ASSOCIÉS AT THE SETTING

COURBE GRANULOMÉTRIQUE – SABLE À L'INTERFACE APRÈS ESSAIS
GRAIN SIZE CURVE – SAND AT INTERFACE AFTER TESTS

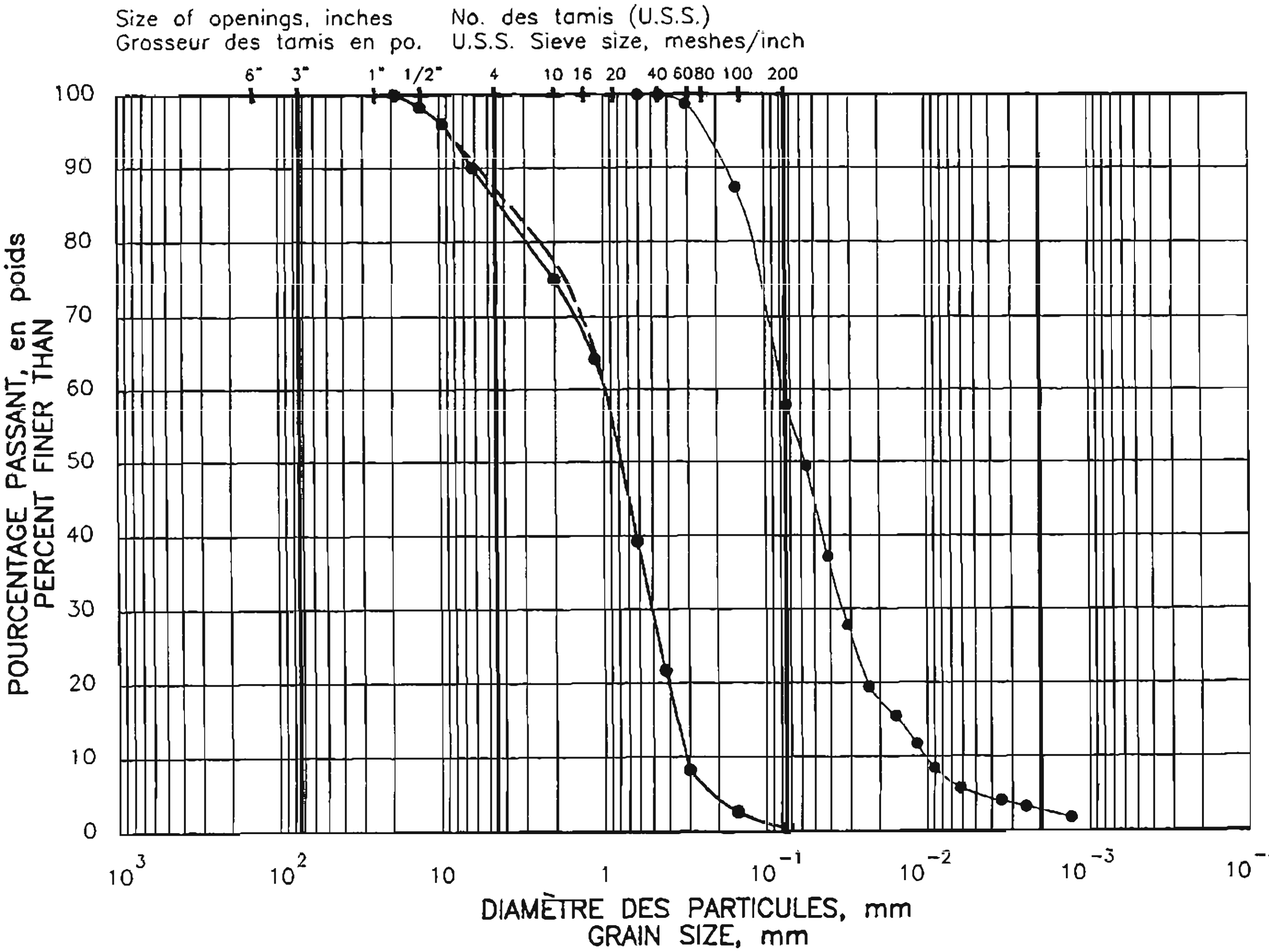
97301F12.DWG

Date: 97-03-26
Projet / Project: 971-7301

Golder Associés

Dessiné par / Drawn by: M.T.
Projeté par / Planned by : J.F.R.

COURBES GRANULOMÉTRIQUES DES MATÉRIAUX DE LA COLONNE 2 COLUMN 2 MATERIAL GRAIN SIZE DISTRIBUTION	FIGURE 13



SYSTÈME UNIFIÉ DE CLASSIFICATION DES SOLS
UNIFIED SYSTEM OF SOIL CLASSIFICATION

BLOCAUX BOULDERS	CAILLOUX COBBLES	GRAVIER / GRAVEL		SABLE / SAND			SILT	ARGILE CLAY
		GROS COARSE	FIN FINE	GROS COARSE	MOYEN MEDIUM	FIN FINE		

FORAGE No. BOREHOLE No.	ÉCHANTILLON No. SAMPLE No.	PROFONDEUR (m) DEPTH (m)	DATE

COURBE GRANULOMÉTRIQUE – M.R.N. AU MONTAGE
GRAIN SIZE CURVE – M.N.R. AT THE SETTING

COURBE GRANULOMÉTRIQUE – GOLDER ASSOCIÉS AU MONTAGE
GRAIN SIZE CURVE – GOLDER ASSOCIÉS AT THE SETTING

COURBE GRANULOMÉTRIQUE – SABLE À L'INTERFACE APRÈS ESSAIS
GRAIN SIZE CURVE – SAND AT INTERFACE AFTER TESTS

97301F13.DWG

Date: 97-03-26
Projet / Project: 971-7301

Golder Associés

Dessiné par / Drawn by: M.T.
Projeté par / Planned by : J.F.R

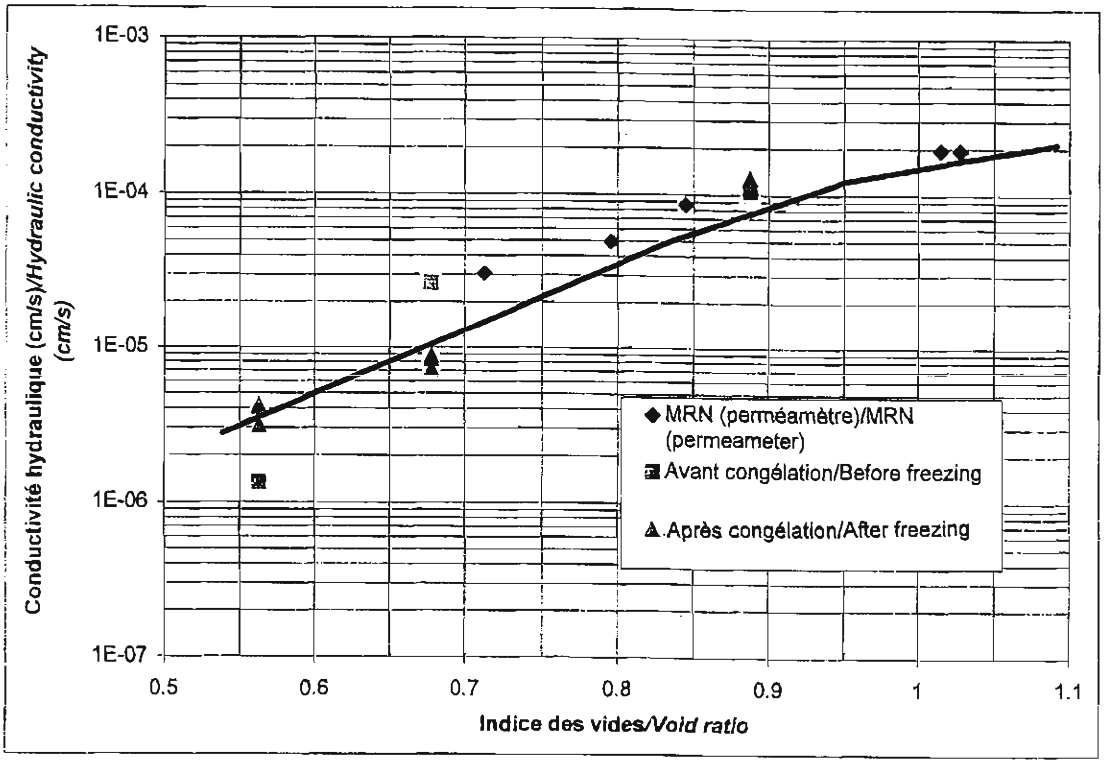


Figure 14: Conductivité hydraulique saturée du résidus MRN avec cycles de gel-dégel
Figure 14: Saturated hydraulic conductivity of the MNR tailings with freeze-thaw cycles.

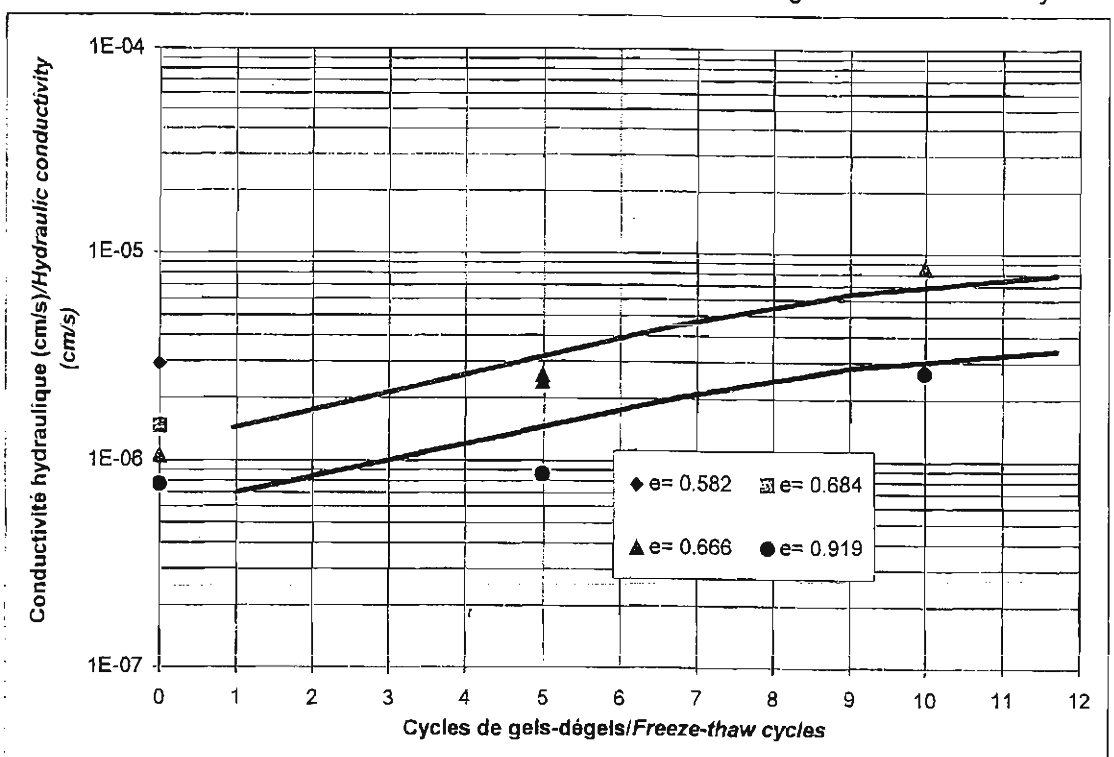
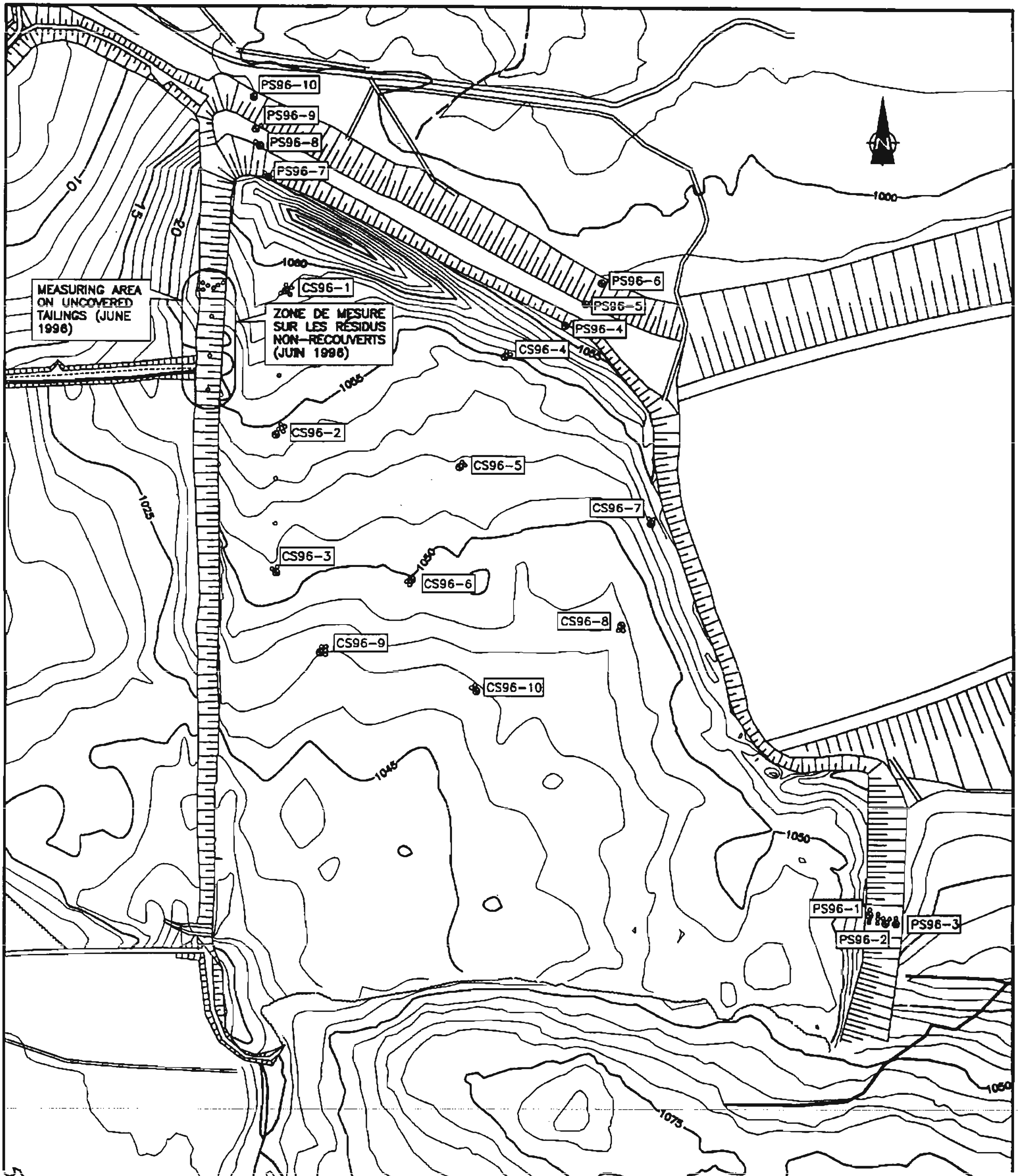


Figure 15: Conductivité hydraulique saturée du silt du banc d'emprunt.
Figure 15: Saturated hydraulic conductivity of the silt from the borrow pit.



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Dessiné par: Drawn by:	M.T.	Projeté par: Planned by:	J.-F.R.
Vérifié par: Checked by:	J.-F.R.	Approuvé par: Approved by:	P.G.
No. de dessin: Drawing no.:	97301F16	No. de projet: Project no.:	971-7301

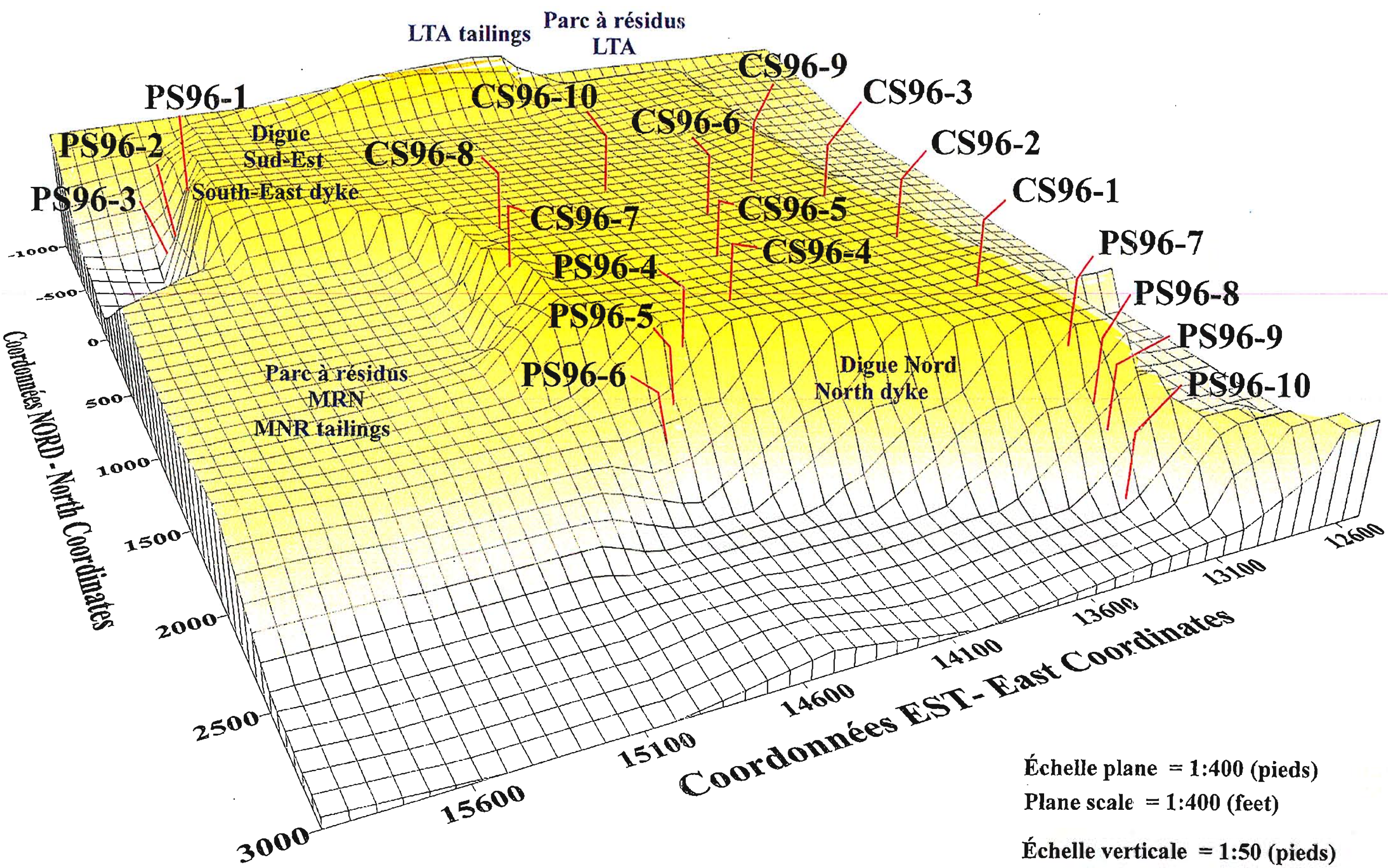
CANMET

PROPRIÉTÉ "LES TERRAINS AURIFÈRES" PROPERTY
PARC À RÉSIDUS / TAILINGS BASIN

Golder Associés
63, Place Frontenac, Pointe-Claire, Qué.
H9R 4Z7
Tel.: (514) 630-0990 Fax: (514) 630-1178

PLAN DE LOCALISATION DES STATIONS D'INSTRUMENTATION DE LA COUVERTURE
DRY COVER MONITORING STATION LOCATION PLAN

FIGURE 16



Golder Associés
63, Place Frontenac, Pointe-Claire, Qué.,
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Date: / Date:	97-03-31	Échelle: / Scale:	tel qu'indiqué / as indicated
Dessiné par: / Drawn by:	S.R.	Projet par: / Planned by:	J.F.R.
Vérifié par: / Checked by:	J.F.R.	Approuvé par: / Approved by:	P.G.
No. de dessin: / Drawing no.:	9730117	No. de projet: / Project no.:	971-7301

CANMET

Suivi de la performance de la couverture sèche à LTA
Dry cover monitoring at LTA site

FIGURE 17

Plan de localisation des stations d'instrumentation
Monitoring station location

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PHOTOGRAPH 4: Tailings infiltration through the sand layer (Zone 1).

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PHOTOGRAPH 5: Tailings infiltration through the sand layer (Zone 1).

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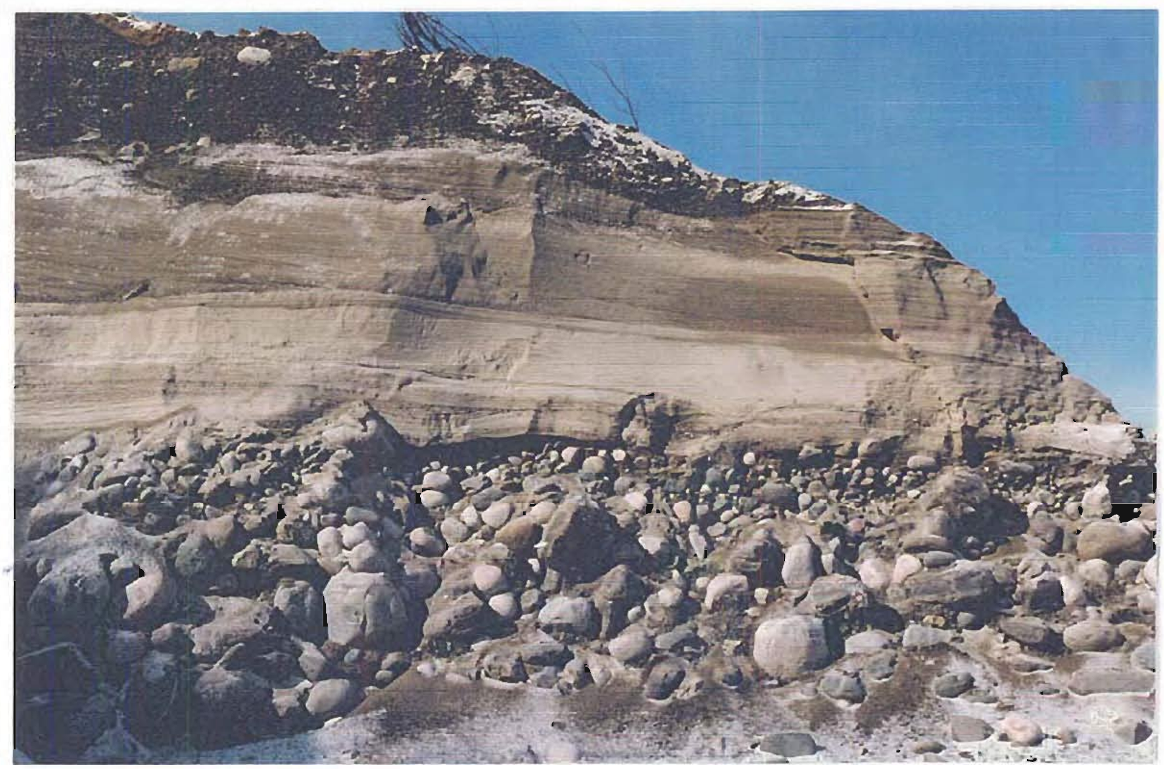

PHOTOGRAPHIE 10: Banc d'emprunt - stratification.
PHOTOGRAPH 10: Borrow pit - stratification.

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PHOTOGRAPHIE 16: Épandage de la chaux sur les parois des digues est, sud-est et nord.
PHOTOGRAPH 16: Lime spreading on the slopes of the east, south-east and north dykes.

PHOTOGRAPHIE 17: Épandage de la chaux sur les parois des digues est, sud-est et nord.
PHOTOGRAPH 17: Lime spreading on the slopes of the east, south-east and north dykes.

PHOTOGRAPHIE 18: Zone 1 - mise en place et compactage de la couche de sable et gravier.
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PHOTOGRAPHIE 19: Équipement de terrain
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PHOTOGRAPH 22: Zone 3 - placing and compacting.

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PHOTOGRAPHIE 25: Digue ouest. Mise en place et compactage de la Zone 1 (sable) de 0,5 m d'épaisseur.
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PHOTOGRAPHIE 26: Digue ouest. Mise en place et compactage de la Zone 1 (sable) de 0,5 m d'épaisseur.
PHOTOGRAPH 26: West dyke. Placing and compacting the 0,5 m thick Zone 1 (sand).

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PHOTOGRAPHIE 30: Pente de la digue nord. Mise en place de la Zone 3 (sable et gravier).
PHOTOGRAPH 30: North dyke slope. Placing the Zone 3 (sand and gravel).

PHOTOGRAPHIE 31: Pente de la digue nord. Compactage de la Zone 3 (sable et gravier).
PHOTOGRAPH 31: North dyke slope. Compacting the Zone 3 (sand and gravel).

PHOTOGRAPHIE 32: Digue ouest. Mise en place de la Zone 2 (silt) sur la Zone 1 (sable).
PHOTOGRAPH 32: West dyke. Placing the Zone 2 (silt) over the Zone 1 (sand).

PHOTOGRAPHIE 33: Digue ouest. Mise en place de la Zone 2 (silt) sur la Zone 1 (sable).
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PHOTOGRAPHIE 34: Démantèlement du chemin d'accès sur le sommet du parc à résidus.
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PHOTOGRAPHIE 35: Chemin d'accès. Mise en place de la Zone 2 (silt) sur la Zone 1 constituée du sable du chemin.
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PHOTOGRAPHIE 36: Chemin d'acces sur le sommet du parc à résidus. Mise en place de la Zone 2 (silt).
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PHOTOGRAPHIE 37: Chemin d'acces sur le sommet du parc à résidus. Construction de la couverture.
PHOTOGRAPH 37: Haul road on the top of the tailings basin. Cover construction.

PHOTOGRAPHIE 38: Mise en place d'une station de mesure de consommation d'oxygène.
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PHOTOGRAPHIE 39: Station de mesure de consommation d'oxygène.
PHOTOGRAPH 39: Oxygen consumption measurements station.

PHOTOGRAPHIE 40: Mise en place d'une sonde TDR.
PHOTOGRAPH 40: Placing a TDR probe.

PHOTOGRAPHIE 41: Mise en place d'une sonde Watermark.
PHOTOGRAPH 41: Placing a Watermark probe.

GLOSSARY

French to English Translation of technical terms used in the document

% passant	:	% passing
analyse granulométrique	:	sieve analysis
anneau	:	ring
argile	:	clay
banc d'emprunt	:	borrow pit
cellule	:	cell
charge	:	load
chocs	:	impacts
compacté	:	compacted
congélation	:	freeze
corrigée	:	corrected
couche	:	layer
débit	:	flow
dégel	:	thawing
degré de saturation	:	saturation level
densité relative des grains	:	grain density
diamètre	:	diameter
diamètre des grains	:	grain size
eau	:	water
écart type	:	standard deviation
échantillon	:	sample
entrée	:	input
épaisseur	:	thickness
essai	:	test
gel	:	freeze
gravier	:	gravel
grs - grammes	:	grams
hauteur	:	height
humide	:	humid
indice des vides	:	void ratio
indice de régression	:	regression index
lectures	:	readings
limite de liquidité	:	liquidity limit
limite de plasticité	:	plasticity limit
limites de consistance d'Atterberg	:	Atterberg's limits
longueur	:	length

GLOSSARY
(continued)

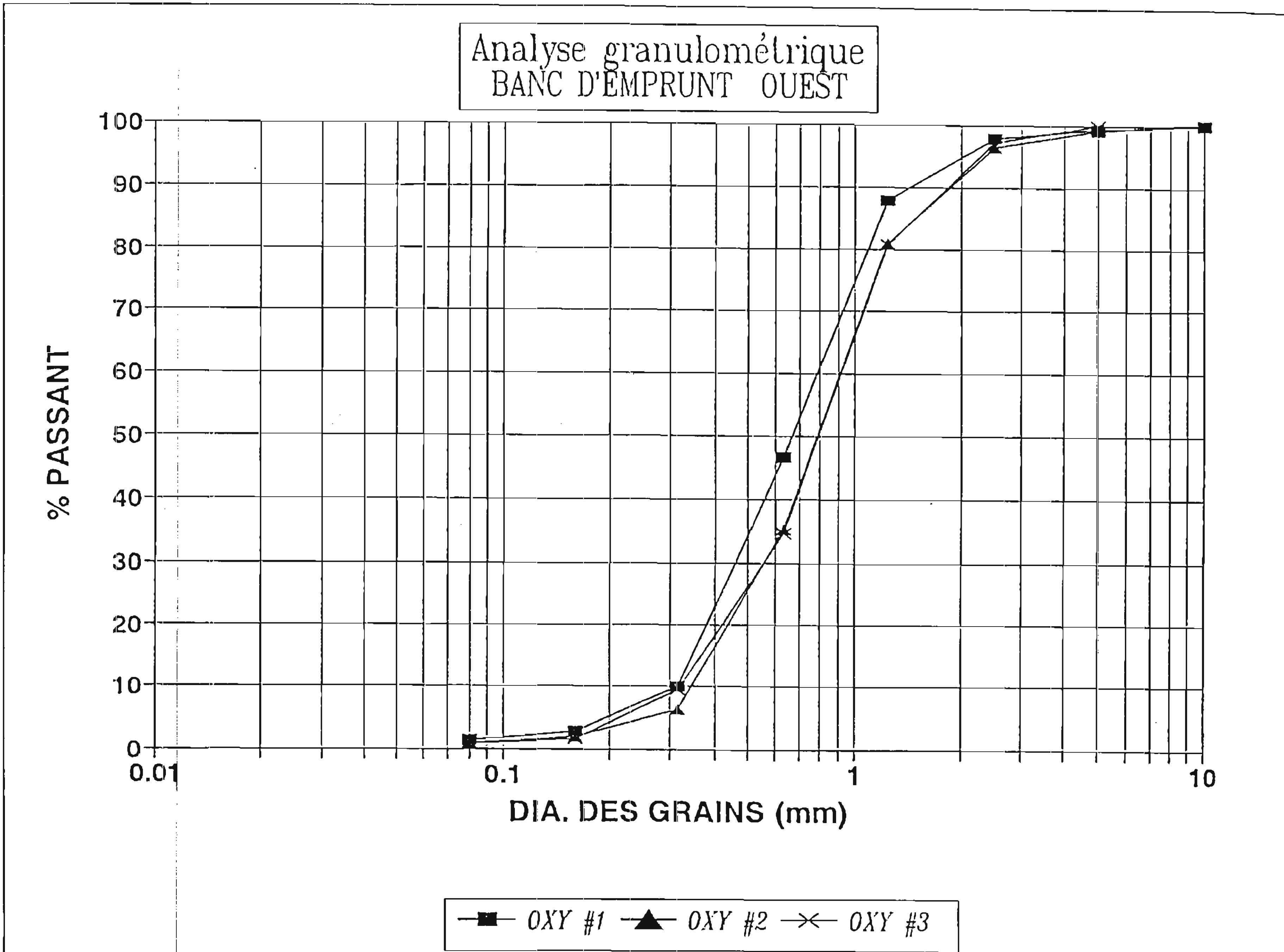
French to English Translation of technical terms used in the document

masse volumique	:	density
moule	:	mold
moyenne	:	average
nb. - nombre	:	number
pds - poids	:	mass
perméabilité	:	hydraulic conductivity
porosité	:	porosity
profondeur	:	depth
résidus	:	tailings
rétention capillaire	:	water retention
rouleau	:	drum compactor
sable	:	sand
sec	:	dry
sèche	:	dry
sol	:	soil
sortie	:	output
temps	:	time
teneur en eau	:	water content
terrain	:	field
tev - teneur en eau volumique	:	volumetric water content
trou	:	hole
valeurs	:	values

APPENDIX A

GEOTECHNICAL DATA OF THE WEST BORROW PIT

(École Polytechnique)



Analyse granulométrique
BANC D'EMPRUNT OUEST
100
90
80
70
60
50
40
30
20
10
0
% PASSANT
0.01
0.1
1
10
DIA. DES GRAINS (mm)
OXY #1
OXY #2
OXY #3

ECOLE POLYTECHNIQUE, Dépt. de Génie Minéral

DENSITE RELATIVE DES GRAINS

LOCALISATION....	GOLDER
TROU NO.........	
PROFONDEUR......	SABLE
SECTION..........	
FICHIER: GOLDER\DD\SABLE	DATE: 06-11-1995

PYCNOMETRE NO	1	3	4
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	755.38	733.38	739.35
TEMPERATURE D'ESSAI	23.4	23.3	23.3
PDS PYCNOMETRE +EAU GRS (M2T2)	675.65	665.68	665.00
TARE NO	8	9	10
PDS DE LA TARE + SOL SEC GRS. (MS)	296.39	274.58	290.27
PDS DE LA TARE	171.20	168.26	173.50
PDS DU SOL SEC GRS	125.19	106.32	116.77
MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99746	0.99748	0.99748
MASSE VOLUMIQUE DE L'EAU @ 20 °C	0.99823	0.99823	0.99823
DENSITE RELATIVE (DR)	2.754	2.753	2.753
DENSITE RELATIVE CORRIGE	2.752	2.751	2.751
MOYENNE:		2.751	

ESSAI PROCTOR

IDENTIFICATION: Sable fin Banc d'emprunt Ouest

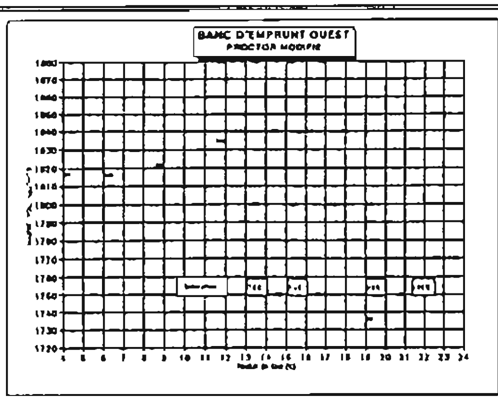
ECHANTILLONNAGE 09-95 PAR J. FRANCOIS

	1	2	3	4	5	6
MOULE SOL COMPACTE	6134.2	6169.7	6218.0	6281.9	6357.7	6300.0
MOULE	4351.7	4351.7	4351.7	4351.7	4351.7	4351.7
PDS SOL COMPACTE	1782.5	1818.0	1866.3	1930.2	2006.0	1948.3
MASSE VOL. HUMIDE	1892.9	1930.6	1981.8	2049.7	2130.2	2068.9
MASSE VOL. SECHE	1816.8	1816.1	1821.7	1834.5	1839.9	1736.0
NO TARE	14	1	6	4	3	5
MASSE T.+SOL HUM.	1949.3	2013.0	2059.7	2127.2	2555.1	2587.9
MASSE T.+SOL SEC	1877.8	1905.4	1909.1	1925.0	2235.1	2202.6
MASSE EAU	71.5	107.6	150.6	202.2	320.0	385.3
MASSE TARE	170.9	198.1	196.5	200.9	206.9	193.6
MASSE SOL SEC	1706.9	1707.3	1712.6	1724.1	2028.2	2009.0
TENEUR EN EAU %	4.2	6.3	8.8	11.7	15.8	19.2
INDICE DES VIDES:	0.514	0.515	0.510	0.500	0.495	0.585
POROSITE: %	34.0	34.0	33.8	33.3	33.1	36.9

VOL. DU MOULE: 941.7 cm^3 opt. proctor:

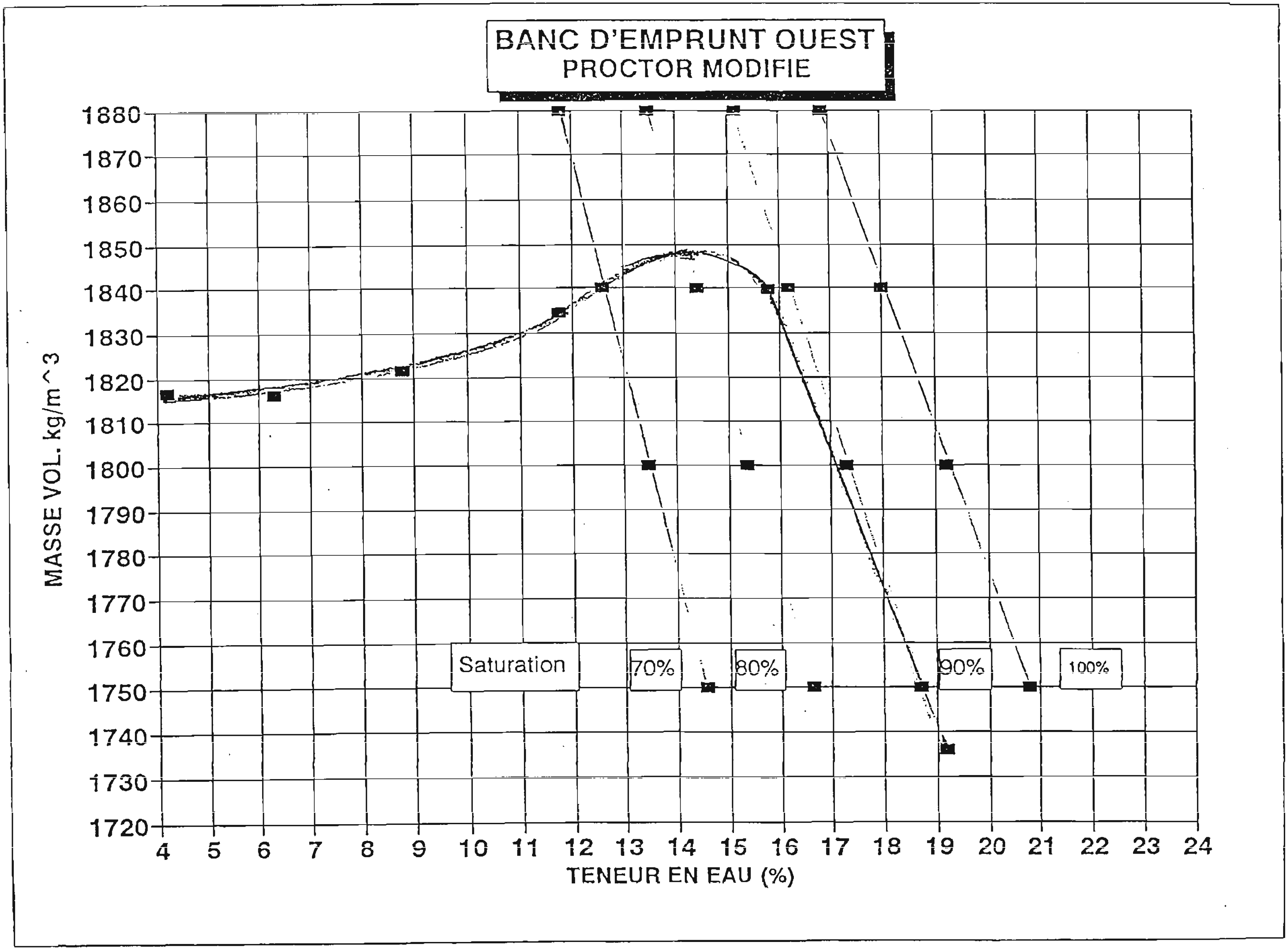
Gs: 2.751 teneur en eau opt. 14.2 % 1845.0 kg\m^3

% SAT:	22.4	33.7	47.4	64.6	87.7	90.2



DEGRE SATURATION:

MASSE VOL. Pd:		1700.0	1750.0	1800.0	1840.0	1880.0	1840.0
SAT. 100		22.47	20.79	19.21	18.00	16.84	18.00
SAT. 95		21.35	19.75	18.24	17.10	16.00	17.10
SAT. 90		20.23	18.71	17.28	16.20	15.16	16.20
SAT. 85		19.10	17.67	16.32	15.30	14.31	15.30
SAT. 80		17.98	16.63	15.36	14.40	13.47	14.40
SAT. 75		16.85	15.59	14.40	13.50	12.63	13.50
SAT. 70		15.73	14.55	13.44	12.60	11.79	12.60


BANC D'EMPRUNT OUEST
PROCTOR MODIFIE
MASSE VOL. kg/m^3
1880
1870
1860
1850
1840
1830
1820
1810
1800
1790
1780
1770
1760
1750
1740
1730
1720
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
TENEUR EN EAU (%)
Saturation
70%
80%
90%
100%

TEST DE PERMEABILITE A DIFFERENCE DE CHARGE CONSTANTE

Date du test:	13-11-1995
Nom de l'échantillon:	sable fin Banc d'emprunt Ouest
Nom du fichier:	golder\perméa\sable

GEOMETRIE (appareil #5)	
Longueur echant. (cm):	11.739
L1:	16.068
L2:	3.601
t:	0.728
Diamètre du moule: (cm)	8.125
Surface (cm):	51.849
Volume (cm ^ 3):	608.637
Dist. des m . des mano. (cm.)	7.664

FINAL	206
PDS SOL hum +TA	
PDS SOL sec + T	1270.7
TARE	234.1
SOL SEC	1036.6
Teneur en eau (%)	

MASSES (gr)		DEGRE DE SATURATION		
Tare (perméa):	2428.0	Gs du solide:	2.751	
Tare + sol sec:	3464.6	Volume des vides:	231.8	
Sol sec:	1036.6			
Tare + eau:	4094.9			
Tare+eau+sol:	4728.4	Sr initial (%):	88.7	
Sol humide:	1040.5	Sr finale (%):	90.0	
Eau dans sol:	3.9			
Mms:	1242.1	Indice des vides:	0.615	
		Masse volumique:		
		Humide (g/cm ^ 3):	1.710	
		Sèche (g/cm ^ 3):	1.703	
		OPT. PROCTOR (g/cm ^ 3):	----	
		Teneur en eau opt. (%):	----	
		% opt. Proctor:	----	
Masse finale:	4731.4	Teneur en eau compact.:	0.4	%
Masse eau initiale	205.5	Teneur en eau initiale:	19.8	%
Masse eau finale	208.5	Teneur en eau finale:	20.1	%

TEST	Charge	Vol.	Débit	Temps	Q/A?t	Gradient	T	k	k20
NO.	cm	cm3	cm ^ 3/s	s			°C	cm/s	cm/s
14-11-95									
1	1.4	47.7	1.59000	30	0.91999	0.1827	23.8	1.7E-01	1.52E-01
2	1.3	47.4	1.58000	30	0.91420	0.1722	23.8	1.8E-01	1.60E-01
3	1.2	46.7	1.45938	32	0.90070	0.1618	23.8	1.7E-01	1.58E-01
4	1.2	45.6	1.52000	30	0.87948	0.1527	23.8	1.9E-01	1.74E-01
5	1.1	43.9	1.46333	30	0.84670	0.1435	23.8	2.0E-01	1.78E-01
							k=	MOY:	1.64E-01

TEST DE PERMEABILITE A DIFFERENCE DE CHARGE CONSTANTE	
Date du test:	13-11-1995
Nom de l'échantillon:	sable fin Banc d'emprunt Ouest
Nom du fichier:	golder\perméa\sable

GEOMETRIE (appareil #1)	
Longueur echant. (cm):	12.277
L1:	15.913
L2:	2.860
t:	0.776
Diamètre du moule: (cm)	8.155
Surface (cm):	52.232
Volume (cm ^ 3):	641.241
Dist. des . des mano. (cm.)	7.229

FINAL	25
PDS SOL hum +TARE	
PDS SOL sec + T	1274.7
TARE	162.6
SOL SEC	1112.1
Teneur en eau (%)	

MASSES (gr)		DEGRE DE SATURATION		
Tare (perméa):	2231.9	Gs du solide:	2.751	
Tare + sol sec:	3344.0	Volume des vides:	237.0	
Sol sec:	1112.1			
Tare + eau:	3606.0			
Tare+eau+sol:	4293.8	Sr initial (%):	91.5	
Sol humide:	1115.0	Sr finale (%):	94.0	
Eau dans sol:	2.9			
Mms:	1329.0	Indice des vides:	0.586	
		Masse volumique:		
		Humide (g/cm ^ 3):	1.739	
		Sèche (g/cm ^ 3):	1.734	
		OPT. PROCTOR (g/cm ^ 3):	----	
		Teneur en eau opt. (%):	----	
		% opt. Proctor:	----	
Masse finale:	4299.6	Teneur en eau compact.:	0.3	%
Masse eau initiale	216.9	Teneur en eau initiale:	19.5	%
Masse eau finale	222.7	Teneur en eau finale:	20.0	%

TEST NO.	Charge cm	Vol. cm3	Débit cm ^ 3/s	Temps s	Q/A?t	Gradient	T °C	k cm/s	k20 cm/s
15-11-95									
1	3.3	67.5	2.25000	30	1.29231	0.4565	23.8	9.44E-02	8.55E-02
2	3.3	67.5	2.25000	30	1.29231	0.4496	23.8	9.58E-02	8.68E-02
3	3.2	64.2	2.14000	30	1.22913	0.4427	23.8	9.26E-02	8.39E-02
4	3.2	63.6	2.12000	30	1.21764	0.4357	23.8	9.31E-02	8.44E-02
5	3.1	65.2	2.17333	30	1.24827	0.4288	23.8	9.70E-02	8.79E-02
							k=	MOY:	8.57E-02

TEST DE PERMEABILITE A DIFFERENCE DE CHARGE CONSTANTE	
Date du test:	13-11-1995
Nom de l'échantillon:	sable fin Banc d'emprunt Ouest
Nom du fichier:	golder\perméa\sable

GEOMETRIE (appareil #7)			
		FINAL	200
Longueur echant. (cm):	12.301	PDS SOL hum +T	
L1:	16.075	PDS SOL sec + T	1331.8
L2:	3.014	TARE	236.4
t:	0.76	SOL SEC	1095.4
Diamètre du moule: (cm)	8.155	Teneur en eau (%)	·
Surface (cm):	52.232		
Volume (cm ^3):	642.521		
Dist. des . des mano. (cm.)	7.437		

MASSES (gr)		DEGRE DE SATURATION		
Tare (perméa):	2430.6	Gs du solide:	2.751	
Tare + sol sec:	3526.0	Volume des vides:	244.3	
Sol sec:	1095.4			
Tare + eau:	4121.0			
Tare+eau+sol:	4786.8	Sr initial (%):	87.1	
Sol humide:	1098.1	Sr finale (%):	91.2	
Eau dans sol:	2.7		·	
Mms:	1308.3	Indice des vides:	0.614	
		Masse volumique:		
		Humide (g/cm ^3):	1.709	
		Sèche (g/cm ^3):	1.705	
		OPT. PROCTOR (g/cm ^3):	----	
		Teneur en eau opt. (%):	----	
		% opt. Proctor:	----	
Masse finale:	4796.7	Teneur en eau compact.:	0.2	%
Masse eau initiale	212.9	Teneur en eau initiale:	19.4	%
Masse eau finale	222.8	Teneur en eau finale:	20.3	%

TEST	Charge	Vol.	Débit	Temps	Q/A?t	Gradient	T	k	k20
NO.	cm	cm3	cm ^3/s	s			°C	cm/s	cm/s
15-11-95									
1	1.3	43.3	1.44333	30	0.82899	0.1748	23.8	1.58E-01	1.43E-01
2	1.2	42.9	1.43000	30	0.82133	0.1667	23.8	1.64E-01	1.49E-01
3	1.2	41.7	1.39000	30	0.79836	0.1560	23.8	1.71E-01	1.55E-01
4	1.1	40.4	1.34667	30	0.77347	0.1452	23.8	1.78E-01	1.61E-01
5	1.0	42.3	1.28182	33	0.80985	0.1345	23.8	1.82E-01	1.65E-01
							k=	MOY:	1.55E-01

TEST DE PERMEABILITE A DIFFERENCE DE CHARGE CONSTANTE

Date du test:	13-11-1995
Nom de l'échantillon:	sable fin Banc d'emprunt Ouest
Nom du fichier:	golder\perméa\sable

GEOMETRIE (appareil #8)	
Longueur echant. (cm):	12.595
L1:	16.340
L2:	2.980
t:	0.765
Diamètre du moule: (cm)	8.155
Surface (cm):	52.232
Volume (cm ^3):	657.877
Dist. des . des mano. (cm.)	8.286

FINAL	3
PDS SOL hum +TARE	
PDS SOL sec + T	1291.8
TARE	159.2
SOL SEC	1132.6
Teneur en eau (%)	

MASSES (gr)	
Tare (perméa):	2376.6
Tare + sol sec:	3509.2
Sol sec:	1132.6
Tare + eau:	3988.5
Tare+eau+sol:	4685.8
Sol humide:	1135.9
Eau dans sol:	3.3
Mms:	1355.2
Masse finale:	4687.5
Masse eau initiale	222.6
Masse eau finale	224.3

DEGRE DE SATURATION		
Gs du solide:	2.751	
Volume des vides:	246.2	
Sr initial (%):	90.4	
Sr finale (%):	91.1	
Indice des vides:	0.598	
Masse volumique:		
Humide (g/cm ^3):	1.727	
Sèche (g/cm ^3):	1.722	
OPT. PROCTOR (g/cm ^3):	----	
Teneur en eau opt. (%):	----	
% opt. Proctor:	----	
Teneur en eau compact.:	0.3	%
Teneur en eau initiale:	19.7	%
Teneur en eau finale:	19.8	%

TEST	Charge	Vol.	Débit	Temps	Q/A?t	Gradient	T	k	k20
NO.	cm	cm3	cm ^3/s	s			°C	cm/s	cm/s
15-11-95									
1	1.7	40.1	1.33667	30	0.768	0.2052	23.8	1.25E-01	1.13E-01
2	1.7	39.7	1.32333	30	0.760	0.1991	23.8	1.27E-01	1.15E-01
3	1.6	39.0	1.30000	30	0.747	0.1931	23.8	1.29E-01	1.17E-01
4	1.6	38.0	1.26667	30	0.728	0.1871	23.8	1.30E-01	1.17E-01
5	1.5	37.8	1.26000	30	0.724	0.1810	23.8	1.33E-01	1.21E-01
							k=	MOY:	1.17E-01

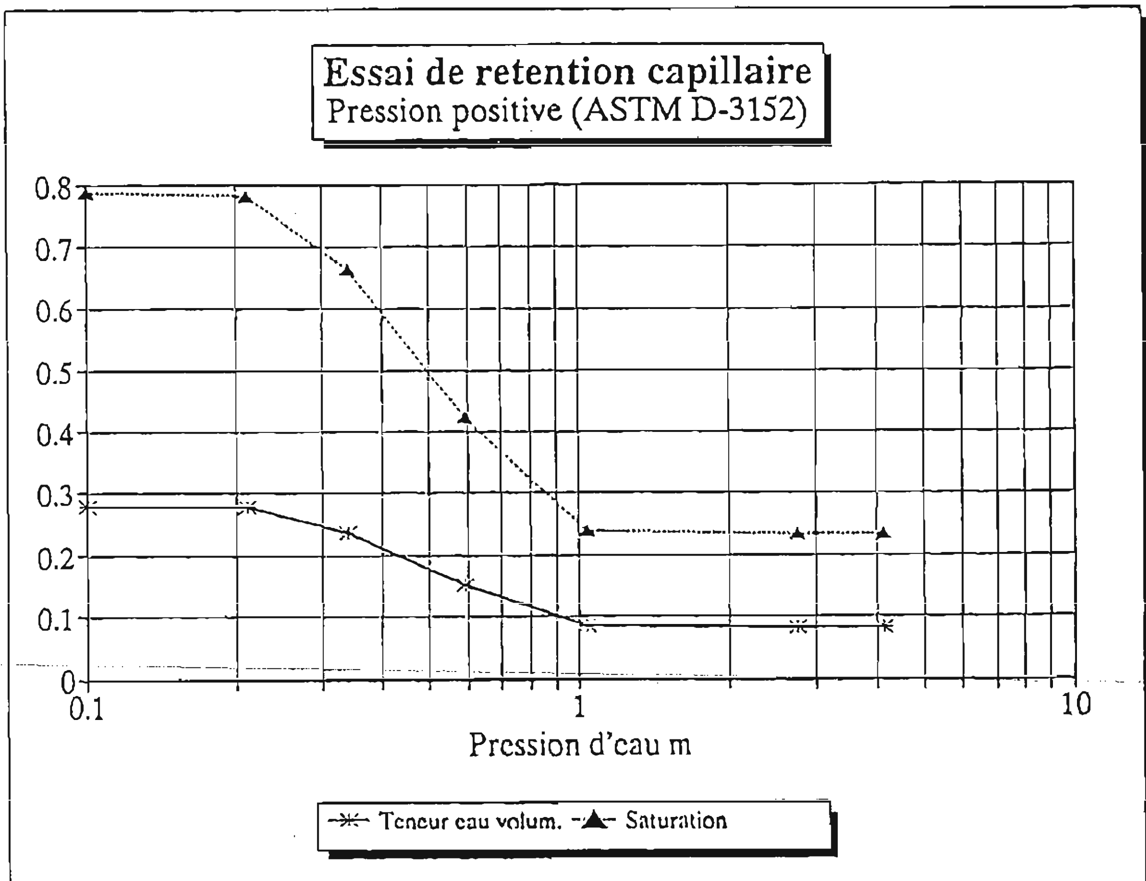
ESSAI DE RÉTENTION CAPILLAIRE

Pression positive (ASTM D-3152)

Échantill U-2	Résidus sable fin	Date montage	20 decembre 95

Dr	2.751
Volume anneau	98.99
Anneau+plaque	100.94
Masse humide initial	304.44
Masse humide finale	284.81
Tare	127.50
Tare+sol sec	303.20
Indice des vides	0.55
TEV initiale	0.28
Saturation initiale	79.15
TEV finale	0.0825
Saturation finale	23.26

kPa	Montage	m.cau	TEV	Saturation
0.0000	2003.0	0.10	0.280	0.79
2.1000	2002.8	0.21	0.278	0.78
3.4000	1998.7	0.34	0.236	0.67
5.9000	1990.2	0.59	0.150	0.42
10.3500	1983.7	1.04	0.085	0.24
27.6000	1983.5	2.76	0.083	0.23
41.4000	1983.5	4.14	0.083	0.23
55.2000	1983.5	5.52	0.083	0.23
69.0000	1983.5	6.9	0.083	0.23



ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

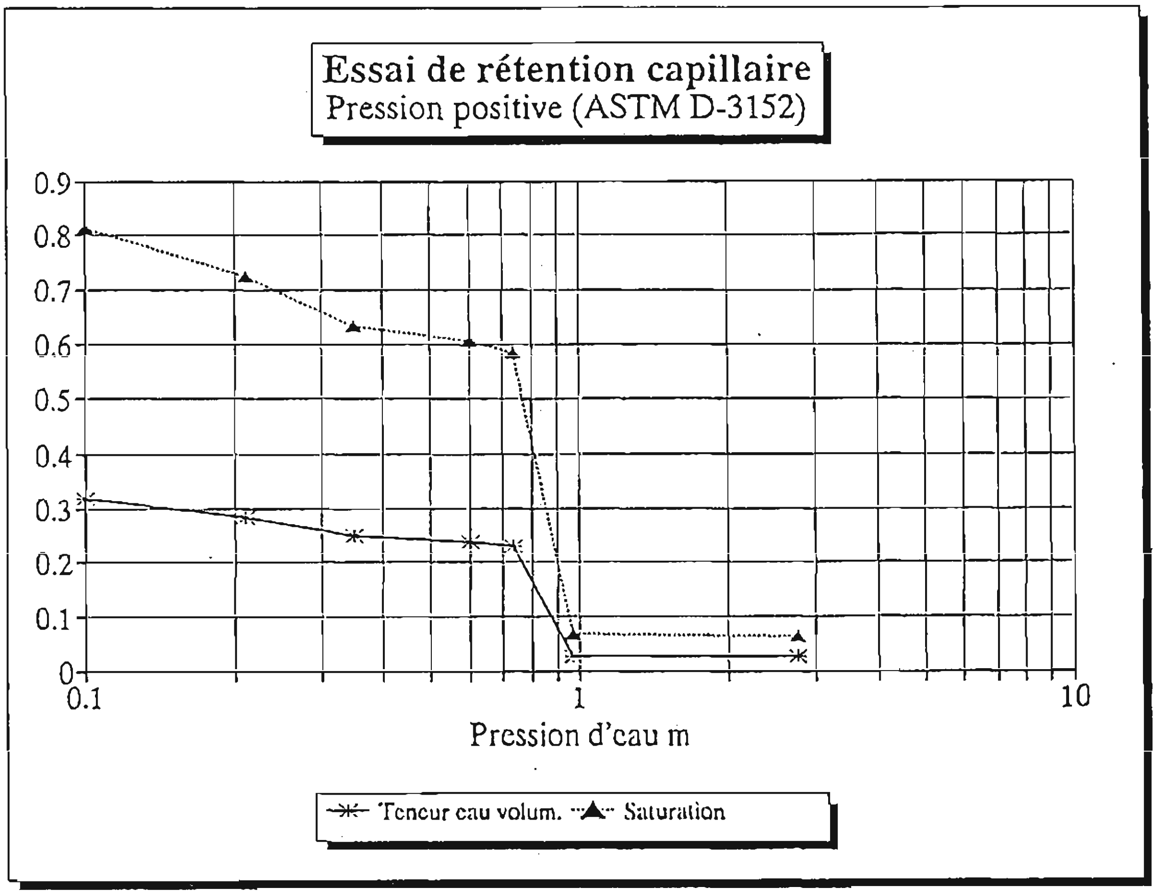
Échantill P-1	Résidus sable fin	Date montage	20 decembre 95

Dr	2.751
Volume anneau	97.63
Anneau+plaque	100.14
Masse humide initial	294.74
Masse humide finale	266.05

Tare	129.50
Tare+sol sec	293.00

Indice des vides	0.64
TEV initiale	0.32
Saturation initiale	81.42
TEV finale	0.0247
Saturation finale	6.31

kPa	Montage	m.eau	TEV	Saturation
0.0000	1898.7	0.10	0.319	0.81
2.1000	1895.2	0.21	0.283	0.72
3.5000	1891.8	0.35	0.248	0.63
6.0000	1890.7	0.60	0.237	0.61
7.4000	1889.9	0.74	0.229	0.58
9.7000	1870.1	0.97	0.026	0.07
27.6000	1870.0	2.76	0.025	0.06
41.4000	1870.0	4.14	0.025	0.06
55.2000	1870.0	5.52	0.025	0.06

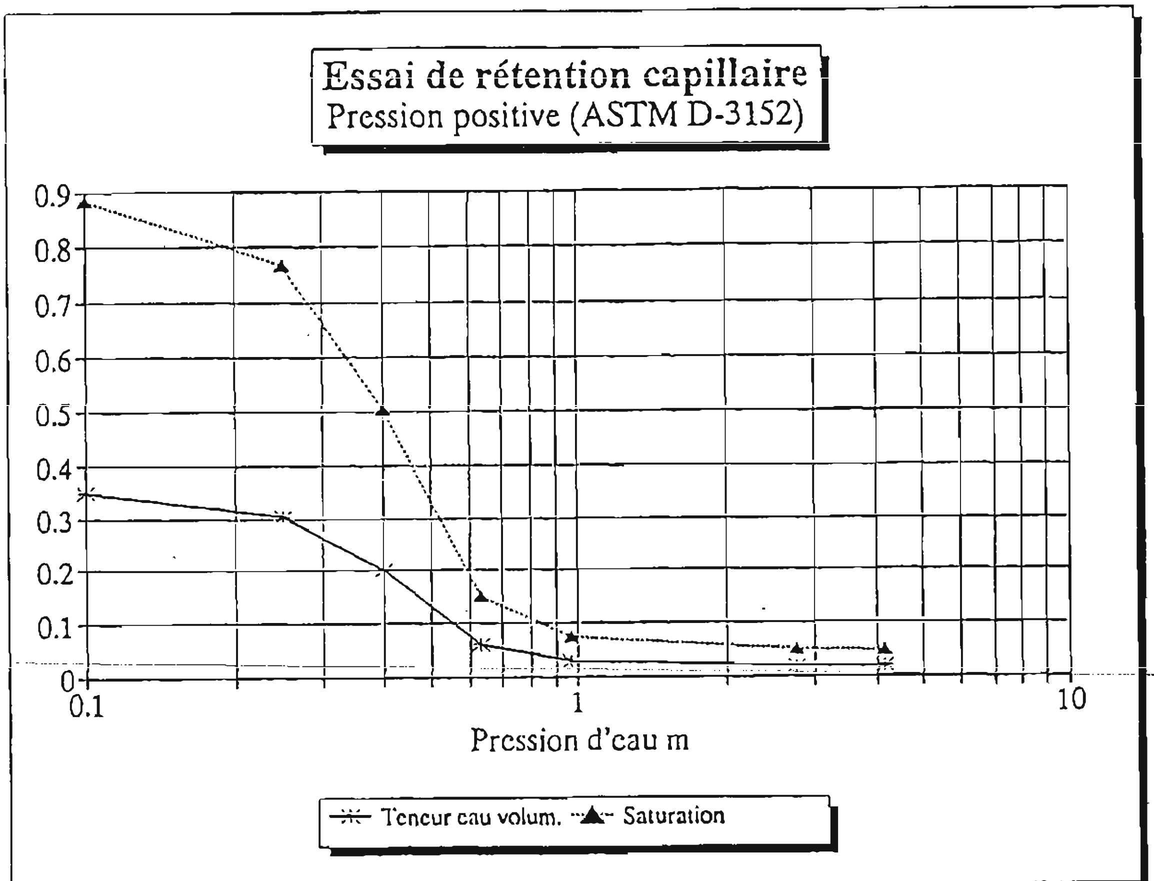


ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

Échantill P-4	Résidus sable fin	Date montage	20 decembre 95

Dr	2.751
Volume anneau	97.94
Anneau+plaque	102.44
Masse humide initial	299.20
Masse humide finale	266.05
Tare	129.70
Tare+sol sec	292.20
Indice des vides	0.66
TEV initiale	0.35
Saturation initiale	88.14
TEV finale	0.0113
Saturation finale	2.86

kPa	Montage	m.eau	TEV	Saturation
0.0000	2018.5	0.10	0.350	0.88
2.5000	2014.0	0.25	0.304	0.77
4.0000	2003.8	0.40	0.200	0.50
6.3000	1990.0	0.63	0.059	0.15
9.7000	1987.0	0.97	0.029	0.07
27.6000	1986.1	2.76	0.020	0.05
41.4000	1986.0	4.14	0.018	0.05
55.2000	1985.7	5.52	0.015	0.04
69.0000	1985.3	6.9	0.011	0.03



Laboratoire d'Hydrogéologie

École Polytechnique de Montréal

03-11-95	05-12-199	Colonne No 1		Banc d'emprunt Ouest			
Prov. Echant.:	SABLE FIN						
				DATE	HRE		%oxy
Essai No. SABLE 3		Denité des grains	2.751	NOV 95		nb/min	
Tare No.......105	128.80	Tare No.......115	127.80	07-11	11.20	0	0
Tare + sol hum.	459.10	Tare + sol hum.	660.00			0.6	20.8
sol humide	330.30	sol humide	532.20			1	18.2
Tare + sol sec	412.10	Tare + sol sec	594.30			1.5	17.4
sol sec	283.30	sol sec (ws)	466.50			2	16.8
eau dans le sol	47.00	eau dans le sol	65.70			3	16.7
						5	16.4
W i = %	16.59	W f = %	14.08			11	16.0
						18	15.6
Pds colonne vide	2030.60					28	15.2
Pds colonne + sol hum.	2507.00	température °C	22.4			57	14.4
Pds colonne + sol sec	2439.21					78	14.2
Pds sol hum.	476.40					107	13.8
Pds sol sec	408.61					145	12.7
		indice des vides:	1.047			170	12.5
Hauteur totale colonne	164.055					242	12.0
Hauteur bas	44.820	porosité:	0.511			284	11.6
Hauteur restante	119.235					350	11.3
Hauteur de la plaque	0.635						
Hauteur après compact.	61.143						
Hauteur sol humide	57.458						
		Saturation:	43.45				
Diam. de la colonne	8.215	n. air	0.29				
Surface de la colonne	53.004						
		De (m^2/s)	1.0×10^{-6}				
Volume de sol (cm ^3)	304.546	ou 3.45×10^{-6}					
Volume source (cm ^3)	327.443						
Volume res. bas (cm ^3)	237.562						
Rho hum.: gr/cm3	1.564						
Rho sec: gr/cm3	1.342						
Rho eau: gr/cm3 (20°)	0.99823						

03-11-95	05-12-199	Colonne No 2		Banc d'emprunt Ouest			
Prov. Echant.:	SABLE FIN						
				DATE	HRE		%oxy
Essai No. SABLE 2		Denité des grains	2.751	NOV 95		nb/min	
Tare No.......3	181.60	Tare No.......100	92.50	06-11	10.40	0	0
Tare + sol hum.	241.50	Tare + sol hum.	501.50			0.5	20.8
sol humide	59.90	sol humide	409.00			1	20.7
Tare + sol sec	234.10	Tare + sol sec	457.20			2	20.4
sol sec	52.50	sol sec (ws)	364.70			3	20.0
eau dans le sol	7.40	eau dans le sol	44.30			5	19.6
						12	18.6
W i = %	14.10	W f = %	12.15			20	17.5
						30	16.6
Pds colonne vide	2147.60					69	14.7
Pds colonne + sol hum.	2558.80	température °C	22.4			121	13.3
Pds colonne + sol sec	2508.00					200	13.0
Pds sol hum.	411.20					261	13.5
Pds sol sec	360.40						
		indice des vides:	0.853				
Hauteur totale colonne	165.240						
Hauteur bas	44.820	porosité:	0.460				
Hauteur restante	120.420						
Hauteur de la plaque	0.600						
Hauteur après compact.	72.988						
Hauteur sol humide	46.833						
		Saturation:	45.29				
Diam. de la colonne	8.131	n. air					
Surface de la colonne	51.925						
		$De (m^2/s)$	9.3×10^{-8}				
Volume de sol (cm ^ 3)	243.179						
Volume source (cm ^ 3)	382.105						
Volume res. bas (cm ^ 3)	232.729						
Rho hum.: gr/cm3	1.691						
Rho sec: gr/cm3	1.482						
Rho eau: gr/cm3 (20°)	0.99823						

03-11-95 06-11-199 Colonne No 1

Banc d'emprunt Ouest

Prov. Echant.: SABLE FIN

				DATE	HRE		%oxy
Essai No. SABLE 1		Denité des grains	2.751	NOV 95		nb/min	
Tare No.......105	128.80	Tare No.......3	181.40	06-11	10.30	0	0
Tare + sol hum.	466.20	Tare + sol hum.	652.40			0.5	20.8
sol humide	337.40	sol humide	471.00			1	14.2
Tare + sol sec	454.00	Tare + sol sec	639.90			1.5	13.7
sol sec	325.20	sol sec (ws)	458.50			2	13.2
eau dans le sol	12.20	eau dans le sol	12.50			3	12.4
						4	11.7
Wi = %	3.75	Wf = %	2.73			5.5	11.0

Pds colonne vide	2029.80		
Pds colonne + sol hum.	2565.90	température °C	22.4
Pds colonne + sol sec	2546.52		
Pds sol hum.	536.10		
Pds sol sec	516.72		
		indice des vides:	0.619
Hauteur totale colonne	164.055		
Hauteur bas	44.820	porosité:	0.382
Hauteur restante	119.235		
Hauteur de la plaque	0.635		
Hauteur après compact.	61.143		
Hauteur sol humide	57.458		
		Saturation:	16.61
Diam. de la colonne	8.215	n. air θ_a	0.319
Surface de la colonne	53.004		
		De (m^2/s)	$2,8 \times 10^{-6}$
Volume de sol (cm^3)	304.546		
Volume source (cm^3)	327.443		
Volume res. bas (cm^3)	237.562		
Rho hum.: gr/cm3	1.760		
Rho sec: gr/cm3	1.697		
Rho eau: gr/cm3 (20°)	0.99823		

dATE:	07-11-199	Colonne No 2					
Prov. Echant.:	SABLE FIN						
				DATE	HRE		%oxy
Essai No. SABLE 4		Denité des grai	2.751	NOV 95		nb/min	
Tare No.......20	182.30	Tare No.......	92.50	09-11	8.50	0	0
Tare + sol hum.	593.60	Tare + sol hum.	501.50			1.30	20.8
sol humide	411.30	sol humide	409.00			2	20.0
Tare + sol sec	557.20	Tare + sol sec	457.20			2.50	19.5
sol sec	374.90	sol sec (ws)	364.70			3	19.4
eau dans le sol	36.40	eau dans le sol	44.30			4.50	18.8
						9	17.7
W i = %	9.71	W f = %	12.15			11	17.2
						15	16.4
Pds colonne vide	2241.10					19	16.1
Pds colonne + sol hum.	2694.60	température °C	22.2			24.50	15.2
Pds colonne + sol sec	2654.47					31	14.7
Pds sol hum.	453.50					39	14.3
Pds sol sec	413.37					48	14.2
	167.69	indice des vides	0.879			66	14.0
Hauteur totale colonne	153.063					97	14.0
Hauteur bas	43.500	porosité:	0.468			143	14.0
Hauteur restante	109.563						
Hauteur de la plaque	0.650						
Hauteur après compact.	72.990						
Hauteur sol humide	50.550						
		Saturation:	30.28				
Diam. de la colonne	8.440	n. air	0.326				
Surface de la colonne	55.947						
		De(m^2/s)	2.0×10^{-6}				
Volume de sol (cm^3	282.811						
Volume source (cm^3	411.993						
Volume res. bas (cm^3	243.369						
Rho hum.: gr/cm3	1.604						
Rho sec: gr/cm3	1.462						
Rho eau: gr/cm3 (20°)	0.99823						

Date: 08-12-95		Colonne No 1	
Prov. Echant.:	SABLE FIN		
Essai No. SABLE 5		Denité des grains	2.751
Tare No.......107	123.80	Tare No.......110	126.80
Tare + sol hum.	533.00	Tare + sol hum.	731.40
sol humide	409.20	sol humide	604.60
Tare + sol sec	465.00	Tare + sol sec	635.20
sol sec	341.20	sol sec (ws)	508.40
eau dans le sol	68.00	eau dans le sol	96.20
W i = %	19.93	W f = %	18.92
Pds colonne vide	2124.60		
Pds colonne + sol hum.	2739.50	température °C	22.2
Pds colonne + sol sec	2637.32		
Pds sol hum.	614.90		
Pds sol sec	512.72		
		indice des vides:	0.703
Hauteur totale colonne	15.344		
Hauteur bas	4.350	porosité:	0.413
Hauteur restante	10.994		
Hauteur de la plaque	0.650		
Hauteur après compact.	4.662		
Hauteur sol humide	5.682		
		Saturation:	77.70
Diam. de la colonne	8.440	n. air	
Surface de la colonne	55.947		
		D_e (m^2/s)	5.2×10^{-7}
Volume de sol (cm^3)	317.890		
Volume source (cm^3)	297.190		
Volume res. bas (cm^3)	243.369		
Rho hum.: gr/cm3	1.934		
Rho sec: gr/cm3	1.613		
Rho eau: gr/cm3 (20°)	0.99823		

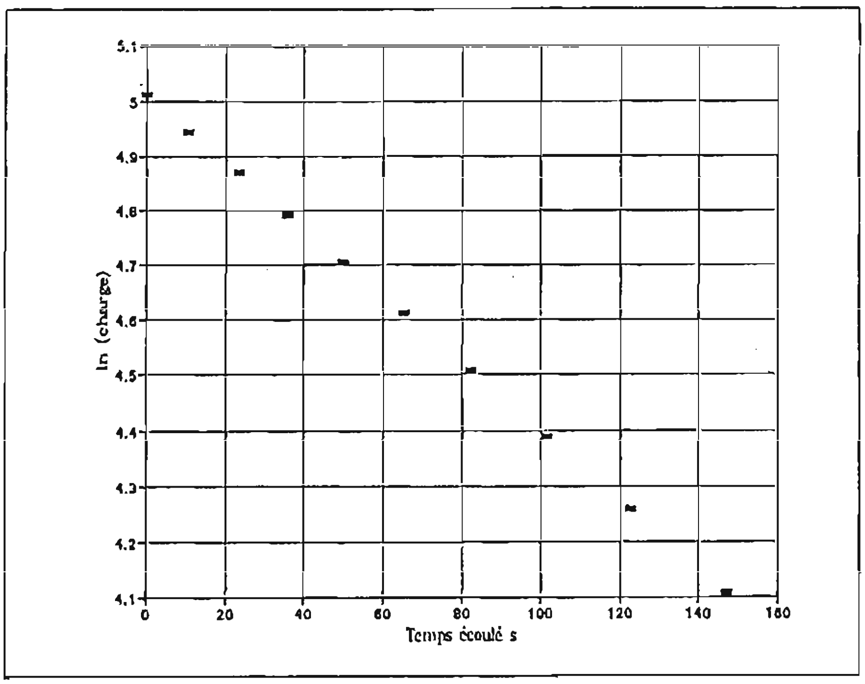
DATE	HRE		%oxy
		nb/min	
déc. 95			
14	9.05	0	0
		3	20.8
		4	20.8
		6	20.8
		10	20.8
		26	20.0
		38	19.7
		77	19.3
		355	19.0
		1350	18.8
		5674	18.2
20	8.40	7615	17.5
21		8993	16.8
22	7.30	10422	16.4
28	8.20	20532	14.2
29	8.50	21927	14.0
30	8.15	23377	13.7
31	8.25	24822	13.7
1-1-96	8.30	26267	13.4
3	7.30	29087	13.0
5	14.00	32417	12.5

FICHIER: GOLDER\TX\MRN-1 PAGE 2

DATE: 16-11-1995 Cellule No. 5 MIN. RICHESSE NATURELLE

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	160.0	10.0	0	0	150.5	0.00	-	-
0.18	155.0	15.0	1.63	1.63	140.5	10.80	2.10E-04	2.00E-04
0.39	150.0	20.0	3.25	3.25	130.5	23.40	1.93E-04	1.84E-04
0.60	145.0	25.0	4.88	4.88	120.5	36.00	2.09E-04	1.99E-04
0.83	140.0	30.1	6.50	6.53	110.4	49.80	2.09E-04	1.99E-04
1.09	135.0	34.9	8.13	8.09	100.6	65.40	1.97E-04	1.87E-04
1.37	130.0	39.9	9.75	9.72	90.6	82.20	2.06E-04	1.96E-04
1.69	125.0	44.8	11.38	11.31	80.7	101.40	1.99E-04	1.89E-04
2.04	120.0	49.8	13.00	12.94	70.7	122.40	2.08E-04	1.98E-04
2.45	115.0	54.7	14.63	14.53	60.8	147.00	2.02E-04	1.92E-04

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

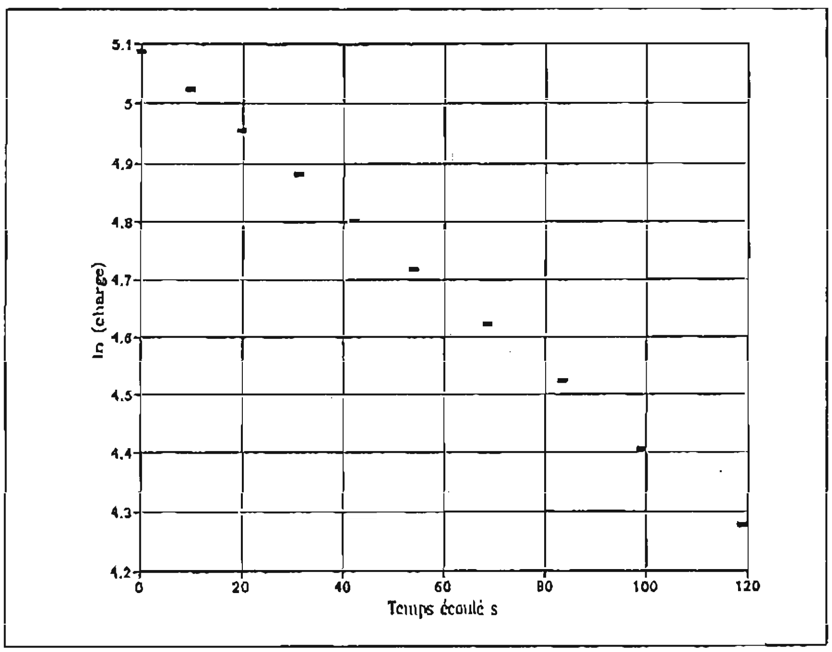


FICHIER: GOLDER\TX\MRN-1 PAGE 2

DATE: 03-10-1995 Cellule No. 3 MIN. RICHESSE NATURELLE

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	165.0	7.0	0	0	161.9	0.00	-	-
0.16	160.0	12.0	1.63	1.63	151.9	9.60	1.99E-04	1.88E-04
0.33	155.0	17.0	3.25	3.25	141.9	19.80	2.00E-04	1.89E-04
0.52	150.0	22.0	4.88	4.88	131.9	31.20	1.92E-04	1.82E-04
0.70	145.0	27.1	6.50	6.53	121.8	42.00	2.21E-04	2.09E-04
0.90	140.0	32.0	8.13	8.13	111.9	54.00	2.12E-04	2.00E-04
1.14	135.0	37.1	9.75	9.78	101.8	68.40	1.97E-04	1.86E-04
1.39	130.0	41.8	11.38	11.31	92.1	83.40	2.00E-04	1.89E-04
1.65	125.0	46.9	13.00	12.97	82.0	99.00	2.23E-04	2.11E-04
1.98	120.0	51.8	14.63	14.56	72.1	118.80	1.95E-04	1.84E-04

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

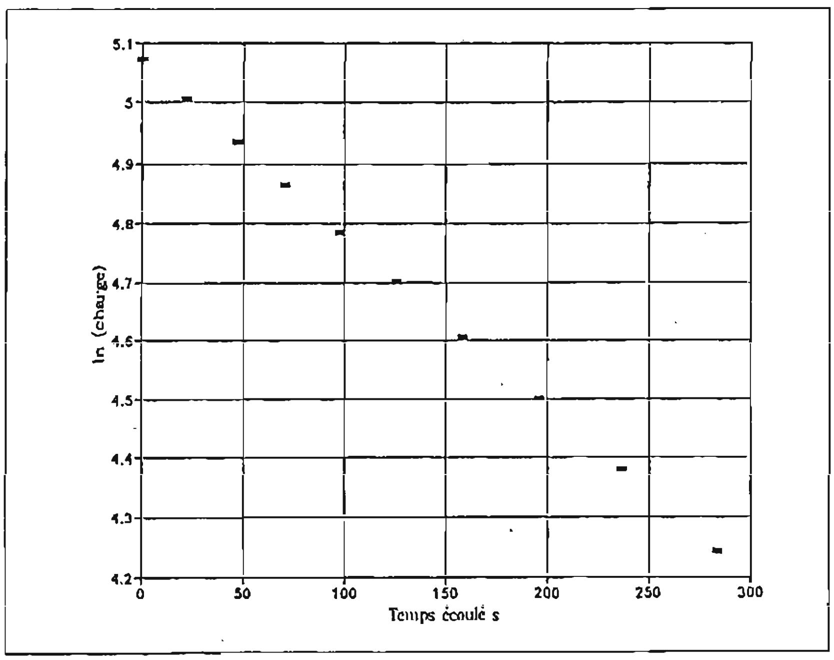


DATE: 03-10-1995 Cellule No. 2 MIN. RICHESSE NATURELLE

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	160.0	1.8	0	0	159.6	0.00	-	-
0.37	155.0	7.0	1.63	1.69	149.4	22.20	9.28E-05	8.77E-05
0.78	150.0	12.1	3.25	3.35	139.3	46.80	8.87E-05	8.39E-05
1.18	145.0	16.7	4.88	4.84	129.7	70.80	9.28E-05	8.78E-05
1.63	140.0	21.6	6.50	6.44	119.8	97.80	9.17E-05	8.67E-05
2.10	135.0	26.4	8.13	8.00	110.0	126.00	9.44E-05	8.93E-05
2.64	130.0	31.3	9.75	9.59	100.1	158.40	9.08E-05	8.59E-05
3.27	125.0	36.3	11.38	11.21	90.1	196.20	8.68E-05	8.21E-05
3.94	120.0	41.5	13.00	12.90	79.9	236.40	9.32E-05	8.81E-05
4.73	115.0	46.7	14.63	14.59	69.7	283.80	8.99E-05	8.50E-05

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral



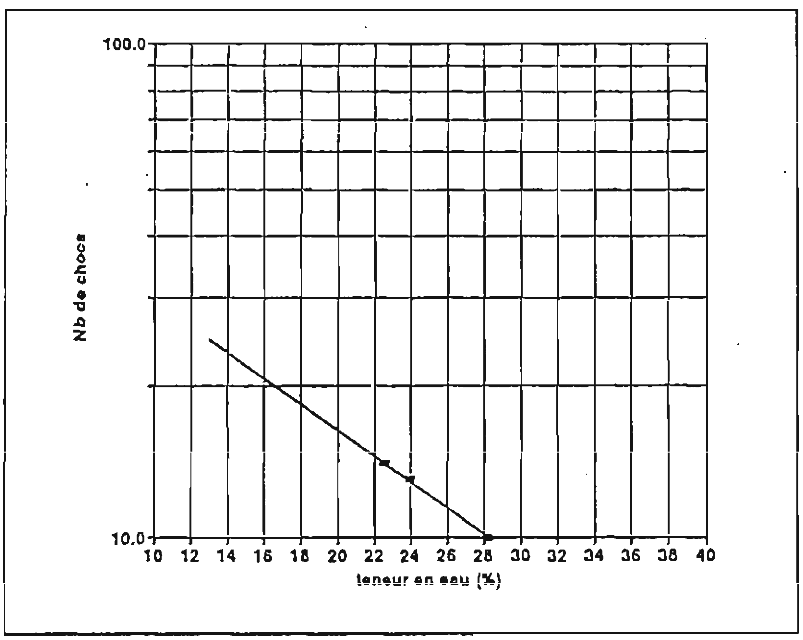
Limites de consistance d'atterberg
(ASTM D4318-84)

Échantillon: Golder ass. Résidus MRN **date:** 2 decembre 1995

	Limite de liquidité					Limite de Plasticité	
Tare	3	10	25			12	22
Wt+t	20.82	16.35	16.04			7.51	7.53
Ws+t	17.65	14.42	14.28			7.33	7.35
Ww	3.17	1.93	1.76			0.18	0.18
t	6.40	6.37	6.48			6.41	6.42
Ws	11.25	8.05	7.80			0.92	0.93
W%	28.18	23.98	22.56			19.57	19.35

Nb. Chocs	10	13	14		

LL	13.0
LP	19.5
Ip	NP



Laboratoire d'Hydrogéologie École Polytechnique de Montréal

ESSAI PROCTOR

IDENTIFICATION: MINISTERE DES RICHESSES NATURELLES

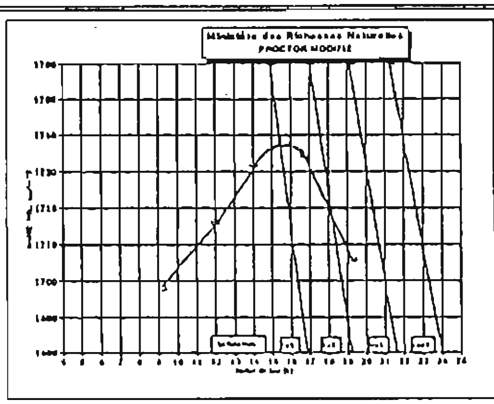
ECHANTILLONNAGE 09-95 PAR J. FRANCOIS

	1	2	3	4	5
MOULE SOL COMPACTE	6098.3	6161.8	6210.9	6258.5	6268.0
MOULE	4351.7	4351.7	4351.7	4351.7	4351.7
PDS SOL COMPACTE	1746.6	1810.1	1859.2	1906.8	1916.3
MASSE VOL. HUMIDE	1854.7	1922.2	1974.3	2024.8	2034.9
MASSE VOL. SECHE	1698.1	1715.9	1731.6	1734.3	1705.9
NO TARE	P24	16	17	20	P25
MASSE T.+SOL HUM.	1907.0	1910.9	2021.4	2112.1	2074.7
MASSE T.+SOL SEC	1760.0	1717.1	1793.9	1835.2	1765.6
MASSE EAU	147.0	193.8	227.5	276.9	309.1
MASSE TARE	166.4	104.6	171.0	182.5	162.9
MASSE SOL SEC	1593.6	1612.5	1622.9	1652.7	1602.7
TENEUR EN EAU %	9.2	12.0	14.0	16.8	19.3
INDICE DES VIDES:	0.660	0.643	0.628	0.625	0.652
POROSITE: %	39.8	39.1	38.6	38.5	39.5

VOL. DU MOULE: 941.7 cm^3 opt. proctor:

Gs: 2.819 teneur en eau opt. 15.7 % 1735.0 kg\m^3

% SAT: 39.4 52.7 62.9 75.5 83.3



DEGRE SATURATION:

MASSE VOL. Pd:		1640.0	1680.0	1720.0	1760.0	1800.0	1715.0
SAT. 100		25.50	24.05	22.67	21.34	20.08	22.84
SAT. 95		24.23	22.85	21.53	20.28	19.08	21.69
SAT. 90		22.95	21.65	20.40	19.21	18.07	20.55
SAT. 85		21.68	20.44	19.27	18.14	17.07	19.41
SAT. 80		20.40	19.24	18.13	17.08	16.07	18.27
SAT. 75		19.13	18.04	17.00	16.01	15.06	17.13
SAT. 70		17.85	16.84	15.87	14.94	14.06	15.98

ECOLE POLYTECHNIQUE, Dépt. de Génie Minéral

DENSITE RELATIVE DES GRAINS

LOCALISATION....	GOLDER
TROU NO.........	
PROFONDEUR......	MIN. RICHESSE NATURELLE
SECTION..........	
FICHIER: GOLDER\DD\SERIE1	DATE: 03-10-1995

PYCNOMETRE NO	1	3	4
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	730.83	718.20	720.83
TEMPERATURE D'ESSAI	22.0	21.8	21.8
PDS PYCNOMETRE +EAU GRS (M2T2)	675.82	665.79	665.09
TARE NO	11	21	30
PDS DE LA TARE + SOL SEC GRS. (MS)	253.93	250.27	181.11
PDS DE LA TARE	168.55	168.97	94.68
PDS DU SOL SEC GRS	85.38	81.30	86.43
MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99775	0.9978	0.9978
MASSE VOLUMIQUE DE L'EAU @ 20 °C	0.99823	0.99823	0.99823
DENSITE RELATIVE (DR)	2.811	2.814	2.816
DENSITE RELATIVE CORRIGE	2.810	2.813	2.815
MOYENNE:		2.813	

ECOLE POLYTECHNIQUE, Dépt. de Génie Minéral

DENSITE RELATIVE DES GRAINS

LOCALISATION....	GOLDER
TROU NO.........	
PROFONDEUR......	MIN. RICHESSE NATURELLE
SECTION..........	
FICHIER: GOLDER\DD\SERIE1	DATE: 06-10-1995

PYCNOMETRE NO	1	3	4
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	726.77	722.67	720.22
TEMPERATURE D'ESSAI	22.2	22.2	22.5
PDS PYCNOMETRE +EAU GRS (M2T2)	675.80	665.76	665.05
TARE NO	13	14	15
PDS DE LA TARE + SOL SEC GRS. (MS)	258.58	269.58	276.84
PDS DE LA TARE	179.77	181.44	191.41
PDS DU SOL SEC GRS	78.81	88.14	85.43
MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99771	0.99771	0.99765
MASSE VOLUMIQUE DE L'EAU @ 20 °C	0.99823	0.99823	0.99823
DENSITE RELATIVE (DR)	2.831	2.822	2.823
DENSITE RELATIVE CORRIGE	2.829	2.821	2.822
MOYENNE:		2.824	

APPENDIX B

GEOTECHNICAL DATA OF THE MNR TAILINGS

(École Polytechnique)

Date: 31-01-96		Colonne No 1	
Prov. Echant.:	SABLE FIN		
Essai N° SABLE 6		Denité des grains	2.751
Tare No.......107	125.00	Tare No.......124	121.70
Tare + sol hum.	250.00	Tare + sol hum.	685.80
sol humide	125.00	sol humide	622.80
Tare + sol sec	225.00	Tare + sol sec	635.20
sol sec	100.00	sol sec (ws)	513.50
eau dans le sol	25.00	eau dans le sol	109.30
Wi = %	25.00	Wf = %	21.29
Pds colonne vide	2123.90		
Pds colonne + sol hum.	2695.10	température °C	22.2
Pds colonne + sol sec	2580.86		
Pds sol hum.	571.20		
Pds sol sec	456.96		
		indice des vides:	0.943
Hauteur totale colonne	16.800		
Hauteur bas	4.350	porosité:	0.485
Hauteur restante	12.450		
Hauteur de la plaque	0.650		
Hauteur après compact.	6.021		
Hauteur sol humide	5.779		
		Saturation:	72.67
Diam. de la colonne	8.440	n. air	
Surface de la colonne	55.947		
		Do (m^2/s)	$7,1 \times 10^{-8}$
Volume de sol (cm^	323.317		
Volume source (cm^	373.222		
Volume res. bas (cm^3	243.369		
Rho hum.: g/cm3	1.767		
Rho sec: g/cm3	1.413		
Rho eau: g/cm3 (20°)	0.99823		

DATE	HRE	nb/min	%oxy
06-02-96	9.05	0	0
		4	20
		5	19.0
		5	18
		6	17.0
		7	16.8
		8	16.2
		15	16.2
		36	16.0
		72	14.6
		194	12.6
		344	12.5

FICHIER: GOLDER\TX\MRN-1

DATE: 03-10-1995 Cellule No. 5 MIN. RICHESSE NATURELLE

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	164.0	4.3	0	0	160.2	0.00	-	-
0.71	160.0	8.4	1.30	1.33	152.1	42.60	3.30E-05	3.12E-05
1.44	156.0	12.4	2.60	2.63	144.1	86.40	3.34E-05	3.16E-05
2.24	152.0	16.3	3.90	3.90	136.2	134.40	3.18E-05	3.01E-05
3.07	148.0	20.2	5.20	5.17	128.3	184.20	3.25E-05	3.07E-05
3.97	144.0	24.0	6.50	6.40	120.5	238.20	3.14E-05	2.97E-05
4.93	140.0	28.1	7.80	7.74	112.4	295.80	3.27E-05	3.09E-05
5.95	136.0	32.0	9.10	9.00	104.5	357.00	3.22E-05	3.05E-05
7.07	132.0	36.1	10.40	10.34	96.4	424.20	3.25E-05	3.07E-05
8.26	128.0	40.2	11.70	11.67	88.3	495.60	3.33E-05	3.15E-05

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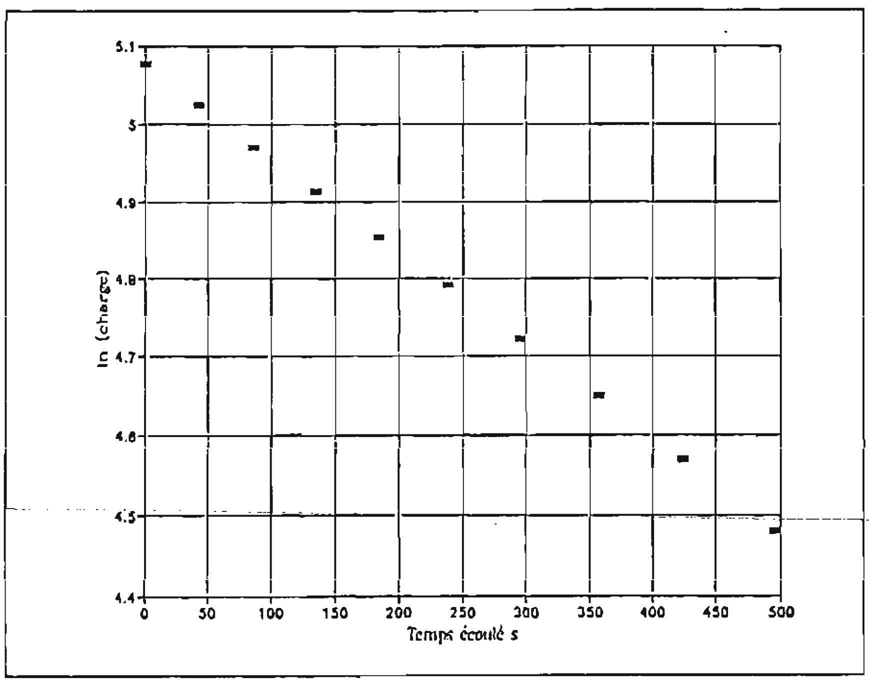


TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

Date de montage	02-10-1995	Cellule No. 7
Nom de l'échantillon:	MIN. RICHESSE NATURELLE	Burette No. 3
Nom du fichier:	GOLDER\TX\MRN-1	

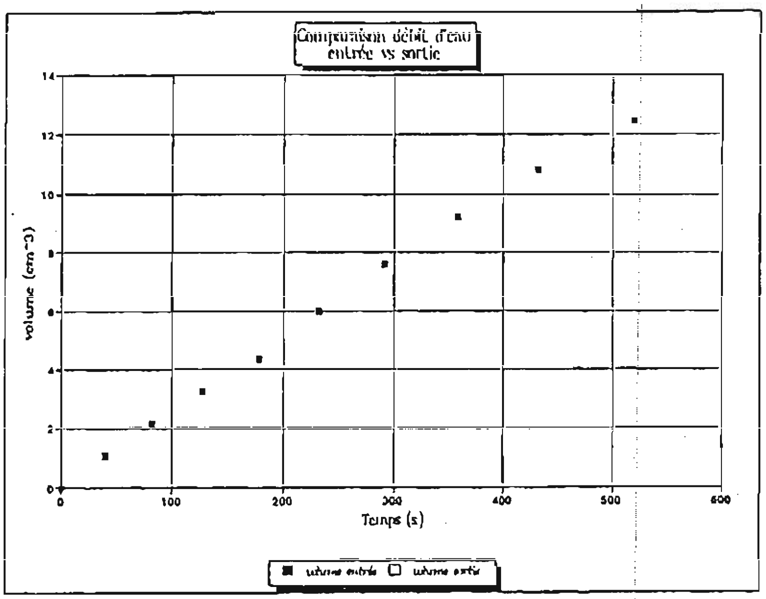
ASTM: D-5084-90

Géométrie	
épaisseur initiale (cm.)	7.766
diamètre (cm.)	7.205
surface (cm^2)	40.77
Volume (cm^3)	316.63

Masses (g)	
masse initiale humide (g)	557.0
masse finale humide (g)	630.7
masse finale sèche (g)	497.3
Gs	2.819

Conditions de l'essai			
Degré de saturation final		mas. vol. hum. g/cm3	1.759
Capt. pression (%)	94.2	mas. vol. sec. g/cm3	1.571
Par séchage (%)	95.1	Opt. Proctor g/cm3	1.735
Teneur en eau initiale (%)	12.0	teneur eau opt. (%)	15.7
Teneur en eau finale (%)	26.8	% opt. Proctor	90.5

Calibration								
o/s tête	19.80	burette utilisée		large	0	section burette	0.325
o/s base	21.50	med	1	petite	0	température	22.4



Résultat de l'essai	
Pression (psi)	
cellule:	50
in\out:	45
Indice des vides:	0.795
Cond. hydraul. cm/s.	4.96E-05
écart type	1.07E-07
ind. reg.	1.000

FICHIER: GOLDER\TX\MRN-1 PAGE 2

DATE: 03-10-1995 Cellule No. 7 MIN. RICHESSE NATURELLE

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	165.0	9.8	0	0	153.5	0.00	-	-
0.68	160.0	14.7	1.63	1.59	143.6	40.80	5.06E-05	4.78E-05
1.37	155.0	19.9	3.25	3.28	133.4	82.20	5.51E-05	5.21E-05
2.13	150.0	25.0	4.88	4.94	123.3	127.80	5.34E-05	5.05E-05
2.98	145.0	30.1	6.50	6.60	113.2	178.80	5.19E-05	4.91E-05
3.87	140.0	34.9	8.13	8.16	103.4	232.20	5.25E-05	4.96E-05
4.86	135.0	39.8	9.75	9.75	93.5	291.60	5.24E-05	4.96E-05
5.98	130.0	44.7	11.38	11.34	83.6	358.80	5.15E-05	4.88E-05
7.21	125.0	49.7	13.00	12.97	73.6	432.60	5.34E-05	5.05E-05
8.67	120.0	54.7	14.63	14.59	63.6	520.20	5.16E-05	4.88E-05

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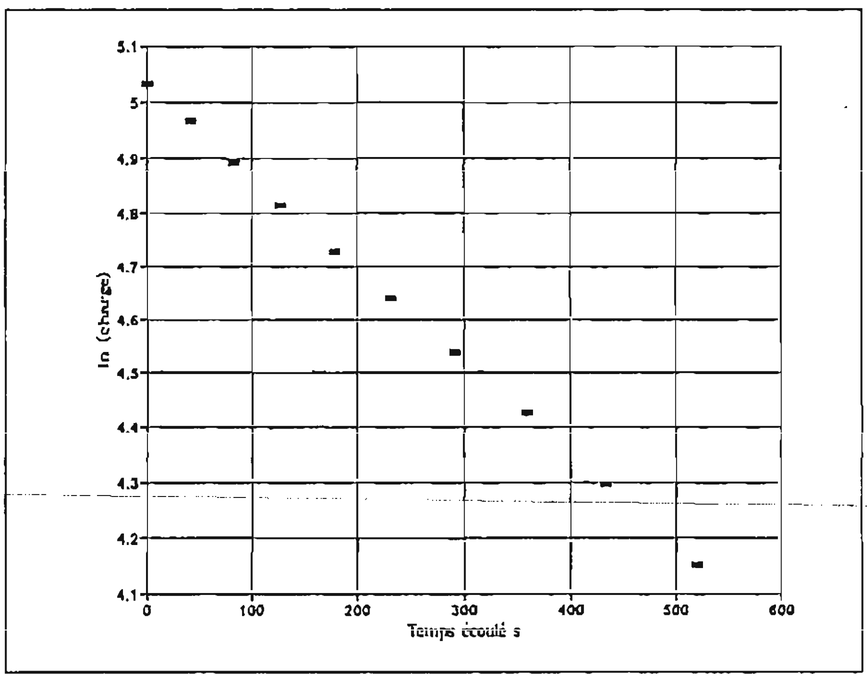


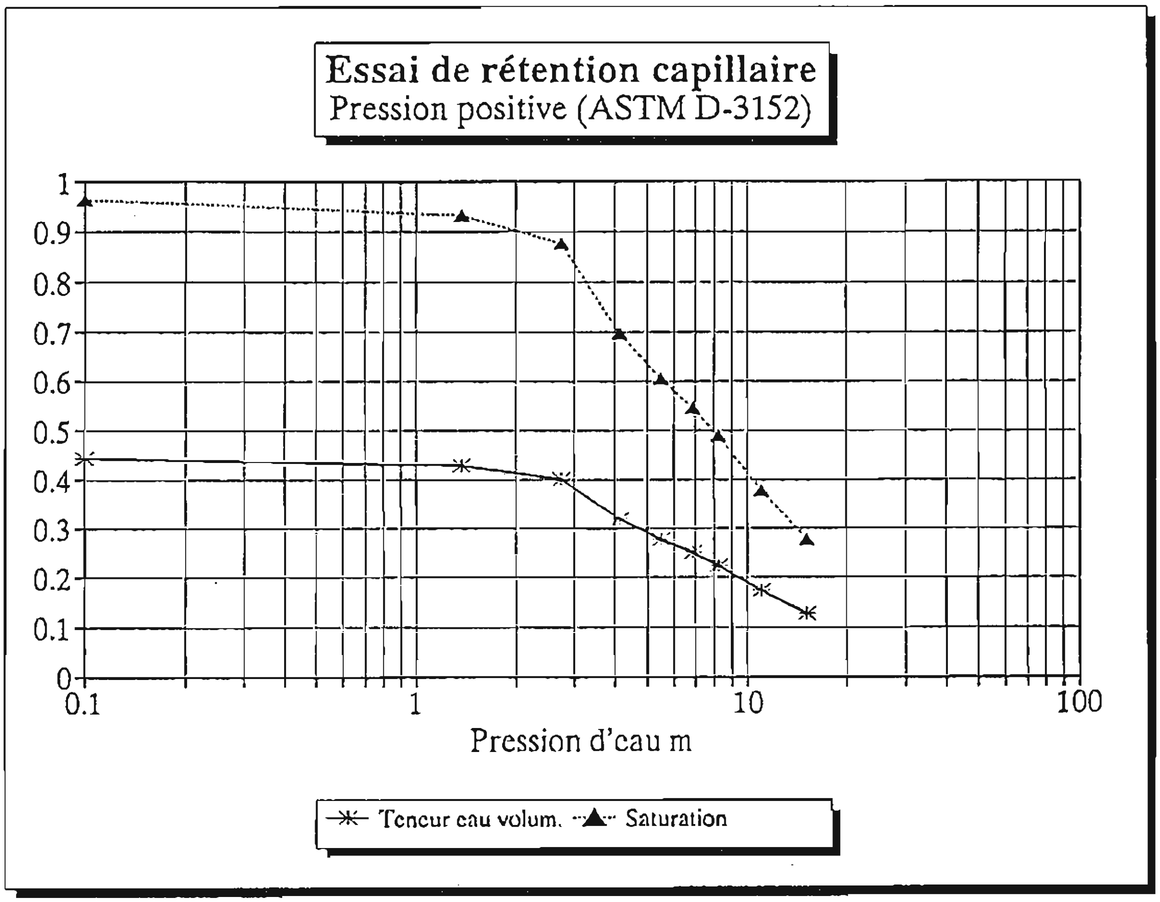
ESSAI DE RÉTENTION CAPILLAIRE

Pression positive (ASTM D-3152)

Échantillon P-4	Résidus MRN	Date montage	9 novembre '95

Dr	2.819
Volume anneau	97.94
Anneau+plaque	102.55
Masse humide initial	293.55
Masse humide finale	263.80
Tare	129.00
Tare+sol sec	277.70
Indice des vides	0.86
TEV initiale	0.43
Saturation initiale	93.60
TEV finale	0.1281
Saturation finale	27.77

kPa	Montage	m.eau	TEV	Saturation
0.0000	1862.0	0.10	0.444	0.96
1.3800	1860.6	1.38	0.429	0.93
27.6000	1858.1	2.76	0.404	0.88
41.5000	1850.0	4.14	0.321	0.70
55.2000	1845.9	5.52	0.279	0.61
70.0000	1843.2	6.90	0.252	0.55
82.8000	1840.7	8.28	0.226	0.49
110.6000	1835.6	11.04	0.174	0.38
151.8000	1831.1	15.18	0.128	0.28

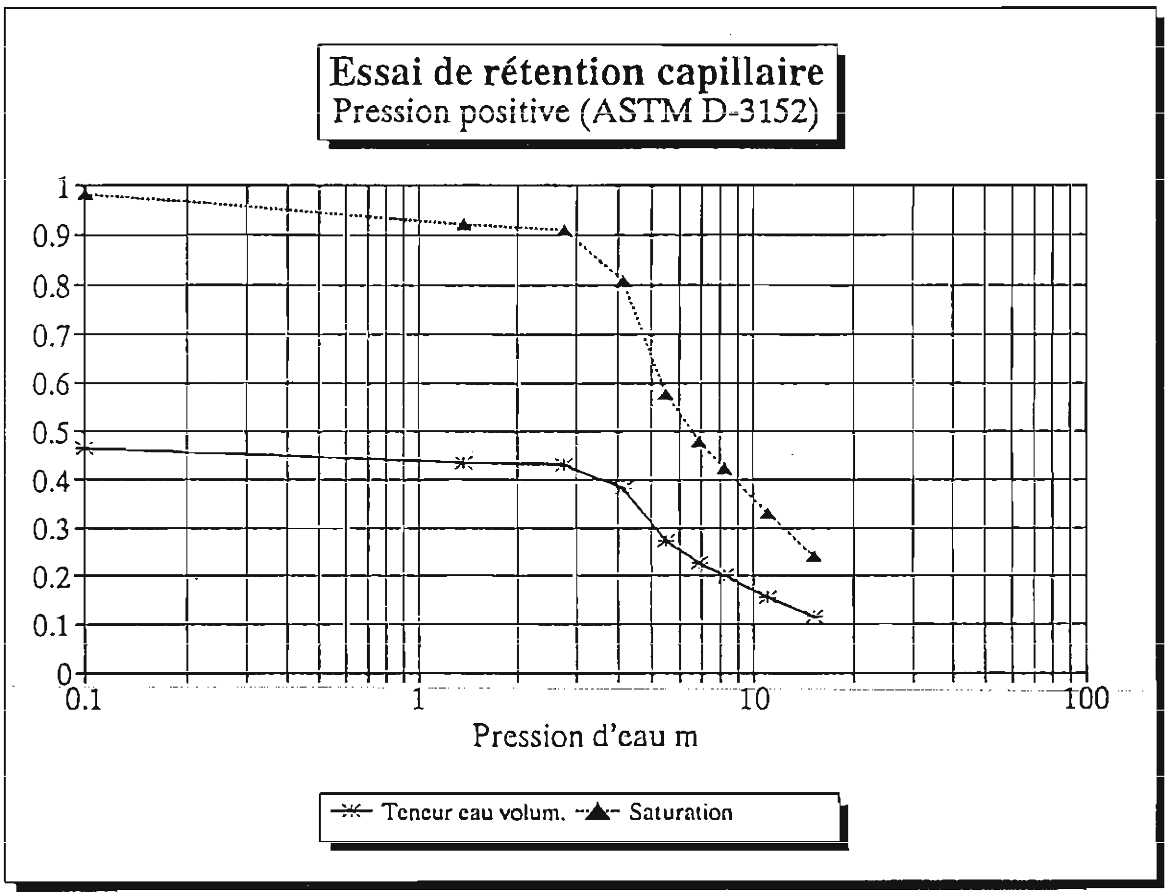


ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

Échantill	P-3 Résidus MRN	Date montage	9 novembre `95

Dr	2.819
Volume anneau	98.68
Anneau+plaque	102.85
Masse humide initial	295.07
Masse humide finale	260.46
Tare	126.60
Tare+sol sec	272.88
Indice des vides	0.90
TEV initiale	0.47
Saturation initiale	98.18
TEV finale	0.1148
Saturation finale	24.21

kPa	Montage	m.eau	TEV	Saturation
0.0000	1851.9	0.10	0.465	0.98
1.3800	1849.1	1.38	0.437	0.92
27.6000	1848.5	2.76	0.431	0.91
41.5000	1843.8	4.14	0.383	0.81
55.2000	1833.0	5.52	0.274	0.58
70.0000	1828.5	6.90	0.228	0.48
82.8000	1825.8	8.28	0.201	0.42
110.6000	1821.5	11.04	0.157	0.33
151.8000	1817.3	15.18	0.115	0.24



Laboratoire d'Hydrogéologie

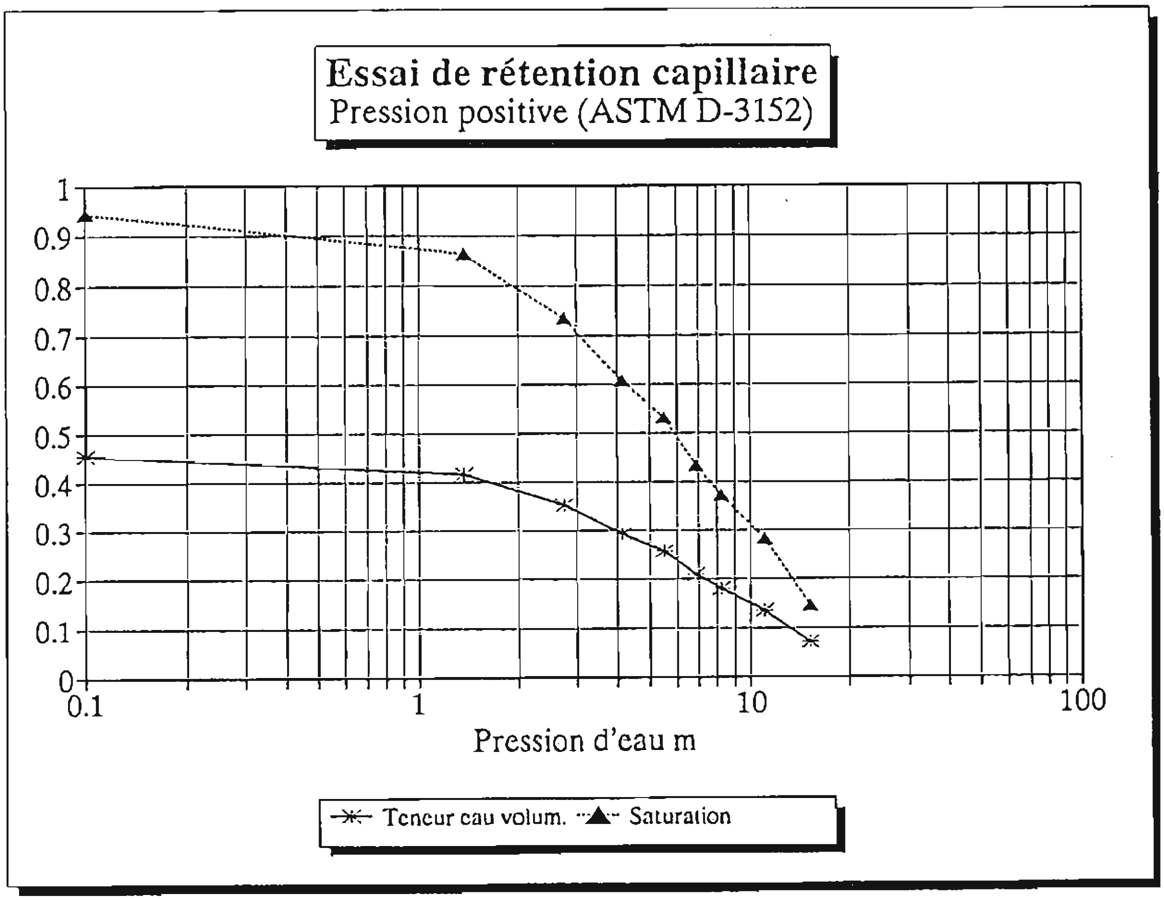
École Polytechnique de Montréal

ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

Échantill	P-1	Résidus MRN	Date montage	9 novembre `95

Dr	2.819
Volume anneau	97.63
Anneau+plaque	93.42
Masse humide initial	279.33
Masse humide finale	242.40
Tare	123.80
Tare+sol sec	265.80
Indice des vides	0.94
TEV initiale	0.45
Saturation initiale	92.92
TEV finale	0.0715
Saturation finale	14.77

kPa	Montage	m.eau	TEV	Saturation
0.0000	1882.6	0.10	0.457	0.94
1.3800	1878.8	1.38	0.418	0.86
27.6000	1872.7	2.76	0.355	0.73
41.5000	1866.7	4.14	0.294	0.61
55.2000	1863.1	5.52	0.257	0.53
70.0000	1858.6	6.90	0.211	0.44
82.8000	1855.7	8.28	0.181	0.37
110.6000	1851.4	11.04	0.137	0.28
151.8000	1845.0	15.18	0.0715	0.15



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École Polytechnique de Montréal

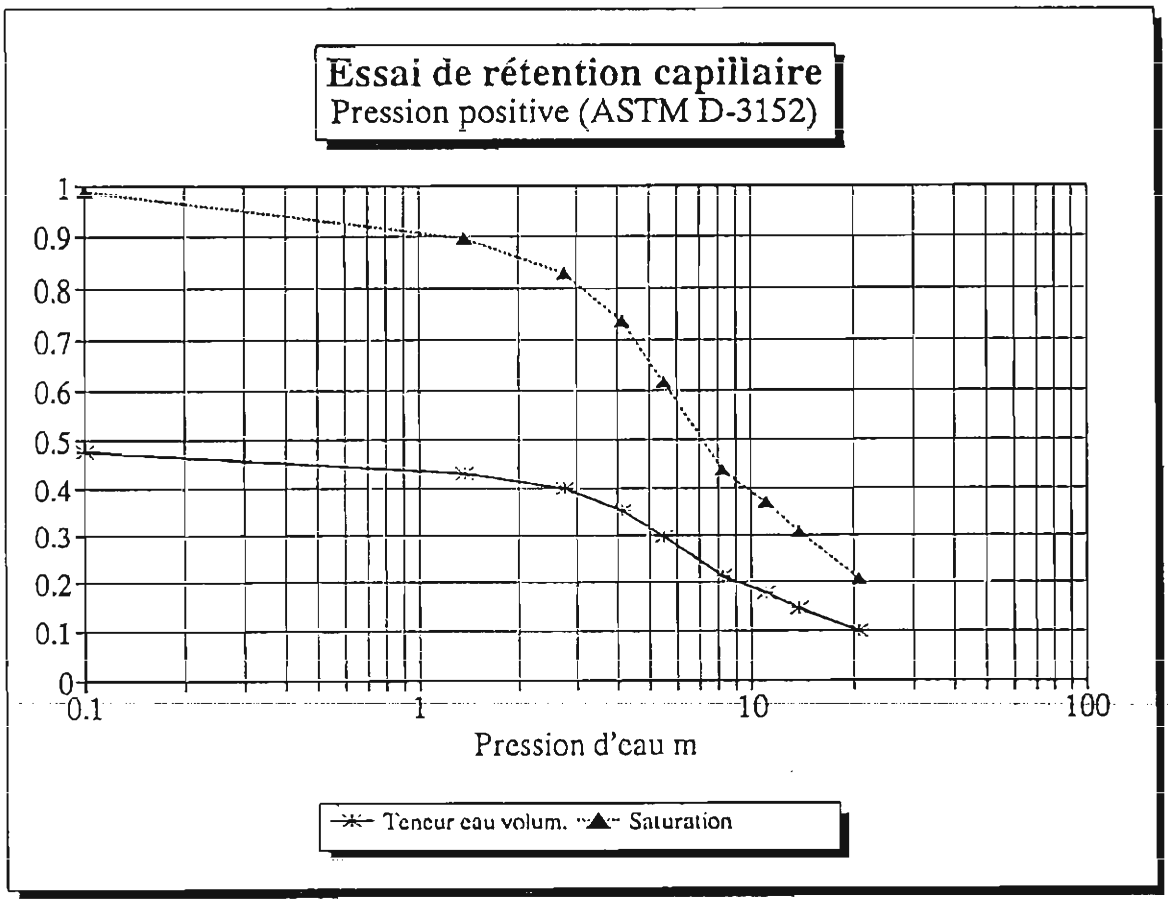
ESSAI DE RÉTENTION CAPILLAIRE

Pression positive (ASTM D-3152)

Échantill	P-3	Résidus MRN	Date montage	20 decembre 95

Dr	2.819
Volume anneau	98.68
Anneau+plaque	102.80
Masse humide initial	294.07
Masse humide finale	256.50
Tare	133.00
Tare+sol sec	276.76
Indice des vides	0.94
TEV initiale	0.48
Saturation initiale	99.64
TEV finale	0.1007
Saturation finale	20.85

kPa	Montage	m.eau	TEV	Saturation
0.0000	1849.0	0.10	0.478	0.99
1.3800	1844.5	1.38	0.432	0.89
27.6000	1841.4	2.76	0.401	0.83
41.4000	1836.9	4.14	0.355	0.73
55.2000	1831.3	5.52	0.298	0.62
82.8000	1822.8	8.28	0.212	0.44
110.4000	1819.6	11.04	0.180	0.37
138.0000	1816.5	13.80	0.148	0.31
207.0000	1811.8	20.7	0.101	0.21



Laboratoire d'Hydrogéologie

École Polytechnique de Montréal

Date:	07-11-199	Colonne No 1					
Prov. Echant.:	Min. des Richesses Naturelles						
				DATE	HRE		%oxy
Essai No. : MRN-1		Denité des grains	2.802	NOV 95		nb/min	
Tare No.......109	133.90	Tare No......13	167.70	09-11	8.58	0	0
Tare + sol hum.	623.70	Tare + sol hum.	549.00			0.5	20.8
sol humide	489.80	sol humide	381.30			1	20.7
Tare + sol sec	571.90	Tare + sol sec	510.80			2	20.4
sol sec	438.00	sol sec (ws)	343.10			3	19.6
eau dans le sol	51.80	eau dans le sol	38.20			4	19.4
						8	16.7
Wi = %	11.83	Wf = %	11.13			10	16.0
						17.5	14.2
Pds colonne vide	2034.10					24	13.4
Pds colonne + sol hum.	2565.90	température °C	22.5			32	12.8
Pds colonne + sol sec	2509.66					41	12.6
Pds sol hum.	531.80					59	12.5
Pds sol sec	475.56					90	12.5
		indice des vides:	0.631			135	12.5
Hauteur totale colonne	164.055						
Hauteur bas	44.820	porosité:	0.387				
Hauteur restante	119.235						
Hauteur de la plaque	0.635						
Hauteur après compact.	66.273						
Hauteur sol humide	52.328						
		Saturation:	52.25				
Diam. de la colonne	8.215	n. air					
Surface de la colonne	53.004	D_e (m^2/s)	4.8×10^{-7}				
Volume de sol (cm^3)	277.355						
Volume source (cm^3)	354.634						
Volume res. bas (cm^3)	237.562						
Rho hum.: gr/cm3	1.917						
Rho sec: gr/cm3	1.715						
Rho eau: gr/cm3 (20°)	0.99823						

17-11-1995	Colonne No 1 N						
Prov. Echant.:	MINIST. DES RICH. NATURELLES						
				DATE	HRE		%oxy
Essai No. MRN 2		Denité des grains	2.821	NOV 95		nb/min	
Tare No.......100	93.00	Tare No.......120	132.10	22	7.45	0	0
Tare + sol hum.	237.30	Tare + sol hum.	643.40			2	20.8
sol humide	144.30	sol humide	511.30			2.5	20.5
Tare + sol sec	216.10	Tare + sol sec	571.80			3	20.3
sol sec	123.10	sol sec (ws)	439.70			5	19.5
eau dans le sol	21.20	eau dans le sol	71.60			7	18.7
						11	17.2
W i = %	17.22	W f = %	16.28			15	16.8
						21	14.7
Pds colonne vide	2123.80					26	14.1
Pds colonne + sol hum.	2638.70	température °C	23.4			37	13.6
Pds colonne + sol sec	2563.05					45	12.9
Pds sol hum.	514.90					56	12.7
Pds sol sec	439.25					104	12.6
		indice des vides:	0.982			130	12.6
Hauteur totale colonne	15.306					175	12.6
Hauteur bas	4.498	porosité:	0.496			333	12.7
Hauteur restante	10.808						
Hauteur de la plaque	0.650						
Hauteur après compact.	4.631						
Hauteur sol humide	5.527						
		Saturation:	49.28				
Diam. de la colonne	8.440	n. air					
Surface de la colonne	55.947	De (m^2/s)	7.5×10^{-7}				
Volume de sol (cm^3	309.204						
Volume source (cm^3	295.469						
Volume res. bas (cm^3	251.649						
Rho hum.: gr/cm3	1.665						
Rho sec: gr/cm3	1.421						
Rho eau: gr/cm3 (20°)	0.99823						

				DATE	HRE		%oxy
17-11-1995		Colonne No 2 N					
Prov. Echant.:		MINIST. DES RICH. NATURELLES					
Essai No. MRN#3		Denité des grains	2.821	NOV 95		nb/min	
Tare No.......117	125.00	Tare No.......105	129.20	22	7.48	0	0
Tare + sol hum.	301.30	Tare + sol hum.	557.70			2	20.8
sol humide	176.30	sol humide	428.50			3	20.7
Tare + sol sec	275.70	Tare + sol sec	496.40			4	20.5
sol sec	150.70	sol sec (ws)	367.20			8	19.6
eau dans le sol	25.60	eau dans le sol	61.30			12	18.7
						18	17.6
W i = %	16.99	W f = %	16.69			23	17.2
						34	16.0
Pds colonne vide	2219.90					42	15.4
Pds colonne + sol sable s	2369.90	température °C	23.4			53	14.8
Pds colonne + sol hum.	2807.80					101	13.8
Pds sabel sec	150.00					127	13.7
Pds sol hum.	437.90					172	13.6
Pds sol sec	374.31	indice des vides:	0.728			207	13.5
						330	13.6
Hauteur totale colonne	13.081						
Hauteur bas	3.401	porosité:	0.421				
Hauteur restante	9.681						
Hauteur de la plaque	0.234						
Hauteur dessus du sable	2.148						
Hauteur après compact.	7.299						
Hauteur de la plaque	0.64						
Hauteur sol humide	4.106						
		Saturation:	65.53				
Diam. de la colonne	8.440	n. air					
Surface de la colonne	55.947	De (m^2/s)	2.0×10^{-7}				
		W f sable					
Volume de sol (cm ^3)	229.718	Tare No.......125	127.60				
Volume source (cm ^3)	421.448	Tare + sol hum.	263.10				
Volume res. bas (cm ^3)	190.247	sol humide	135.50				
		Tare + sol sec	261.70				
Rho hum.: gr/cm3	1.906	sol sec (ws)	134.10				
Rho sec: gr/cm3	1.629	eau dans le sol	1.40				
Rho eau: gr/cm3 (20°)	0.99823						
		W f = %	1.04				

Date: 22-11-95 Colonne No 2 N

Prov. Echant.: MINIST. DES RICH. NATURELLES

				DATE	HRE		%oxy
Essai No. MRN#4		Denité des grains	2.821	NOV 95		nb/min	
Tare no. 119	129.40	Tare.....119	129.60	22	7.48	0	0
Tare + sol hum.	246.20	Tare + sol hum.	600.40			2	20.8
sol humide	116.80	sol humide	470.80			3	20.7
Tare + sol sec	229.60	Tare + sol sec	545.40			4	20.5
sol sec	100.20	sol sec (ws)	415.80			8	19.6
eau dans le sol	16.60	eau dans le sol	55.00			12	18.7
						18	17.6
W i = %	16.57	W f = %	13.23			23	17.2
						34	16.0
Pds colonne vide	2224.90					42	15.4
Pds colonne + sol sable	2377.30	température °C	23.4			53	14.8
Pds colonne + sol hum.	2848.90					101	13.8
Pds sable sec	152.40					127	13.7
Pds sol hum.	471.60					172	13.6
Pds sol sec	404.57	indice des vides:	0.737			207	13.5
						330	13.6
Hauteur totale colonne	11.948						
Hauteur bas	3.401	porosité:	0.424				
Hauteur restante	8.547						
Hauteur de la plaque	0.640						
Hauteur dessus du sabl	9.624						
Hauteur après compact.	5.164						
Hauteur de la plaque	0.64						
Hauteur sol humide	4.461						
		Saturation:	63.14				
Diam. de la colonne	8.440	n. air					
Surface de la colonne	55.947	De (m^2/s)	2.5×10^{-7}				
		teneur en eau	sable				
Volume de sol (cm^3	249.565	Tare.....3	181.70				
Volume source (cm^3	324.688	Tare + sol hum.	327.70				
Volume res. bas (cm^3	190.247	sol humide	146.00				
		Tare + sol sec	324.50				
Rho hum.: gr/cm3	1.890	sol sec (ws)	142.80				

Date: 29-11-1995	Colonne No 1 N		
Prov. Echant.:	MINIST. DES RICH. NATURELLES		
Essai No. MRN 5		Denité des grains	2.821
Tare No.......107	123.80	Tare No.......114	127.40
Tare + sol hum.	356.70	Tare + sol hum.	607.70
sol humide	232.90	sol humide	480.30
Tare + sol sec	308.40	Tare + sol sec	508.20
sol sec	184.60	sol sec (ws)	380.80
eau dans le sol	48.30	eau dans le sol	99.50
W i = %	26.16	W f = %	26.13
Pds colonne vide	2126.30		
Pds colonne + sol hum	2611.00	température °C	23.4
Pds colonne + sol sec	2510.48		
Pds sol hum.	484.70		
Pds sol sec	384.18		
		indice des vides:	0.842
Hauteur totale colonne	15.374		
Hauteur bas	4.498	porosité:	0.457
Hauteur restante	10.876		
Hauteur de la plaque	0.650		
Hauteur après compact	5.735		
Hauteur sol humide	4.492		
		Saturation:	87.33
Diam. de la colonne	8.440	n. air	0.058
Surface de la colonne	55.947		
		De (m²/s)	2.46x10⁻⁹
Volume de sol (cm ^	251.285		
Volume source (cm ^	357.193		
Volume res. bas (cm ^	251.649		
Rho hum.: gr/cm3	1.929		
Rho sec: gr/cm3	1.529		
Rho eau: gr/cm3 (20°)	0.99823		

6.384 cm

SANS Sable

DATE	HRE		%oxy
dec 95		nb/min	
04-12-95	10.00	0	0
		3	20.8
		4	20.8
		7	20.8
		30	20.0
		65	18.9
		114	18.3
		151	17.8
		208	17.2
		337	16.2
		487	15.3
		589	14.7
		1266	13.2
		1445	13.0
		1600	12.9
		1750	12.9
		2770	12.4

Date: 29-11-1995		Colonne No 2 N					
Prov. Echant.:		MINIST. DES RICH. NATURELLES					
				DATE	HRE		%oxy
Essai No. MRN#6		Denité des grains	2.821	dec 95		nb/min	
Tare no. 107	123.80	Tare No.......126	127.80	04-12-	10.00	0	0
Tare + sol hum.	356.70	Tare + sol hum.	552.20			1.5	20.8
sol humide	232.90	sol humide	424.40			2	20.4
Tare + sol sec	308.40	Tare + sol sec	467.50			3	20.2
sol sec	184.60	sol sec (ws)	339.70			6	19.8
eau dans le sol	48.30	eau dans le sol	84.70			30	19.5
						65	19.2
Wi = %	26.16	Wf = %	24.93			113	18.8
						150	18.5
Pds colonne vide	2225.80					208	17.6
Pds colonne + sol sable se	2475.70	température °C	23.4			337	16.6
Pds colonne + sol hum.	2918.20					487	15.9
Pds sable sec	249.90					589	13.4
Pds sol hum.	442.50					1266	12.6
Pds sol sec	350.73	indice des vides:	0.835			1445	12.4
						1750	12.4
Hauteur totale colonne	15.349					2770	11.9
Hauteur bas	3.401	porosité:	0.455				
Hauteur restante	11.949						
Hauteur de la plaque	0.650						
Hauteur dessus du sable	8.721						
Hauteur après compact.	4.636						
Hauteur de la plaque	0.650						
Hauteur sol humide	4.086						
		Saturation:	88.03				
Diam. de la colonne	8.440	n. air					
Surface de la colonne	55.947	De (m^2/s)	9.4×10^{-9}				
		teneur en eau	sable				
Volume de sol (cm^3)	228.571	Tare No.......125	127.50				
Volume source (cm^3)	295.707	Tare + sol hum.	362.60				
Volume res. bas (cm^3)	190.247	sol humide	235.10				
		Tare + sol sec	360.10				
Rho hum.: gr/cm3	1.936	sol sec (ws)	232.60				
Rho sec: gr/cm3	1.534	eau dans le sol	2.50				
Rho eau: gr/cm3 (20°)	0.99823						
		Wf = %	1.07				

2 couches (en sol + plaque)

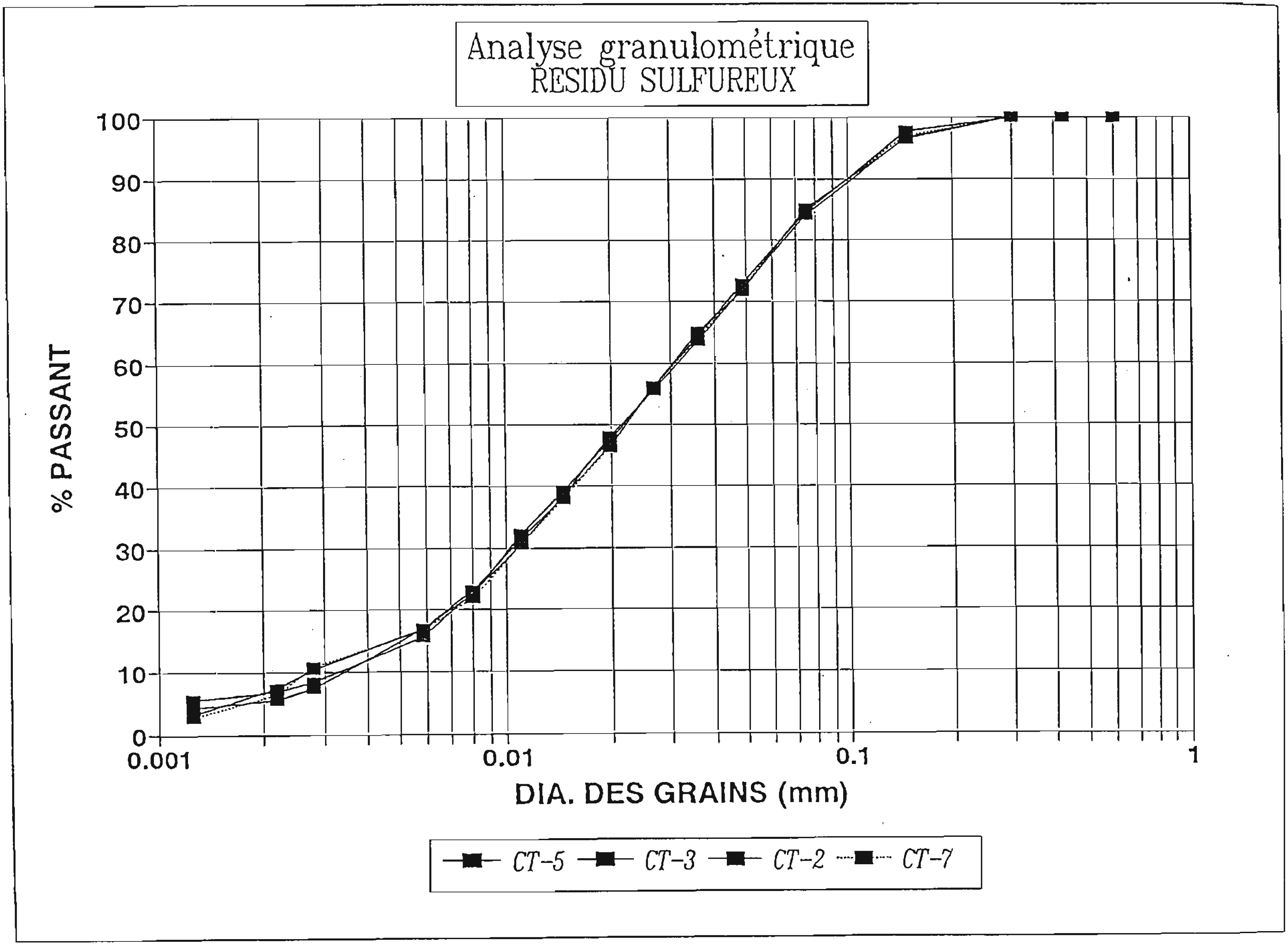
Date: 08-12-1995		Colonne No 2 N	
Prov. Echant.:	MINIST. DES RICH. NATURELLES		
Essai No. MRN#7		Denité des grains	2.821
Tare no. 107	123.80	Tare No.......11	168.60
Tare + sol hum.	356.70	Tare + sol hum.	670.40
sol humide	232.90	sol humide	501.80
Tare + sol sec	308.40	Tare + sol sec	570.20
sol sec	184.60	sol sec (ws)	401.60
eau dans le sol	48.30	eau dans le sol	100.20
Wi = %	26.16	Wf = %	24.95
Pds colonne vide	2227.20		
Pds colonne + sol sable sec	2497.10	température °C	23.4
Pds colonne + sol hum.	3018.00		
Pds sable sec	269.90		
Pds sol hum.	520.90		
Pds sol sec	412.87	indice des vides:	0.804
Hauteur totale colonne	15.361		
Hauteur bas	3.401	porosité:	0.446
Hauteur restante	11.960		
Hauteur de la plaque	0.650		
Hauteur dessus du sable	8.446		
Hauteur du sable	4.165		
Hauteur après compact.	3.717		
Hauteur de la plaque	0.650		
Hauteur sol humide	4.728		
		Saturation:	91.41
Diam. de la colonne	8.440	n. air	
Surface de la colonne	55.947	De (m^2/s)	$4,85 \times 10^{-9}$
		teneur en eau	sable
Volume de sol (cm^3)	264.531	Tare No.......9	167.30
Volume source (cm^3)	244.334	Tare + sol hum.	425.00
Volume res. bas (cm^3)	190.247	sol humide	257.70
		Tare + sol sec	422.30
Rho hum.: gr/cm3	1.969	sol sec (ws)	255.00
Rho sec: gr/cm3	1.561	eau dans le sol	2.70
Rho eau: gr/cm3 (20°)	0.99823		
		Wf = %	1.06

DATE	HRE		%oxy
dec 95		nb/min	
14	9.05	0	0
		1.2	20.8
		2	20.4
		4	20.2
		9	20.0
		25	19.6
		37	19.2
		76	18.8
		354	16.0
		1350	11.5

APPENDIX C

GEOTECHNICAL DATA OF THE LTA TAILINGS

(École Polytechnique)


Analyse granulométrique
RESIDU SULFUREUX
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
DIA. DES GRAINS (mm)
CT-5
CT-3
CT-2
CT-7

ECOLE POLYTECHNIQUE, Dépt. de Génie Minéral

DENSITE RELATIVE DES GRAINS

LOCALISATION....	GOLDER
TROU NO.........	
PROFONDEUR......	RESIDU SULFUREUX
SECTION..........	
FICHIER: GOLDER\DD\SULFURE1	DATE: 08-11-1995

PYCNOMETRE NO	1	3	4
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	750.69	740.58	746.53
TEMPERATURE D'ESSAI	23.2	23.6	22.8
PDS PYCNOMETRE +EAU GRS (M2T2)	675.68	665.65	665.03
TARE NO	7	8	12
PDS DE LA TARE + SOL SEC GRS. (MS)	287.08	287.09	294.89
PDS DE LA TARE	173.40	173.29	171.12
PDS DU SOL SEC GRS	113.68	113.80	123.77
MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99750	0.99742	0.99758
MASSE VOLUMIQUE DE L'EAU @ 20 °C	0.99823	0.99823	0.99823
DENSITE RELATIVE (DR)	2.940	2.928	2.928
DENSITE RELATIVE CORRIGE	2.938	2.925	2.926
MOYENN		2.930	

ECOLE POLYTECHNIQUE, Dépt. de Génie Minéral DENSITE RELATIVE DES GRAINS
LOCALISATION.... GOLDER
TROU NO.........
PROFONDEUR...... RESIDU SULFUREUX
SECTION..........

FICHIER: GOLDER\DD\SULFURE1	DATE: 08-11-1995

PYCNOMETRE NO	1	3	4
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	754.14	741.20	740.84
TEMPERATURE D'ESSAI	22.2	23.2	22.2
PDS PYCNOMETRE +EAU GRS (M2T2)	675.80	665.68	665.07
TARE NO	9	10	11
PDS DE LA TARE + SOL SEC GRS. (MS)	290.88	290.91	285.91
PDS DE LA TARE	172.08	176.56	171.07
PDS DU SOL SEC GRS	118.80	114.35	114.84
MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99771	0.9975	0.99771
MASSE VOLUMIQUE DE L'EAU @ 20 °C	0.99823	0.99823	0.99823
DENSITE RELATIVE (DR)	2.936	2.945	2.939
DENSITE RELATIVE CORRIGE	2.935	2.943	2.938
MOYENN		2.938	

ESSAI PROCTOR

IDENTIFICATION: Résidu Sulfureux

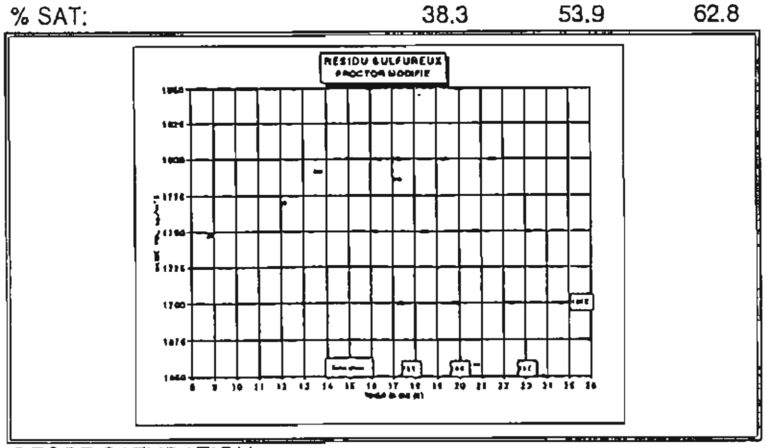
ECHANTILLONNAGE 09-95 PAR J. FRANCOIS

	1	2	3	4	5	6
MOULE SOL COMPACTE	6143.0	6220.0	6268.7	6323.6	6323.3	6236.8
MOULE	4351.7	4351.7	4351.7	4351.7	4351.7	4351.7
PDS SOL COMPACTE	1791.3	1868.3	1917.0	1971.9	1971.6	1885.1
MASSE VOL. HUMIDE	1902.2	1984.0	2035.7	2094.0	2093.7	2001.8
MASSE VOL. SECHE	1747.1	1769.9	1791.3	1800.0	1785.9	1657.9
NO TARE	5	4	3	9	1	4
MASSE T.+SOL HUM.	1977.9	2048.1	2116.1	2119.2	2176.9	2078.5
MASSE T.+SOL SEC	1832.4	1848.6	1886.9	1845.2	1886.1	1756.0
MASSE EAU	145.5	199.5	229.2	274.0	290.8	322.5
MASSE TARE	193.8	198.7	207.0	167.5	198.3	201.1
MASSE SOL SEC	1638.6	1649.9	1679.9	1677.7	1687.8	1554.9
TENEUR EN EAU %	8.9	12.1	13.6	16.3	17.2	20.7
INDICE DES VIDES:	0.679	0.658	0.638	0.630	0.643	0.770
POROSITE: %	40.5	39.7	38.9	38.7	39.1	43.5

VOL. DU MOULE: 941.7 cm^3 opt. proctor:

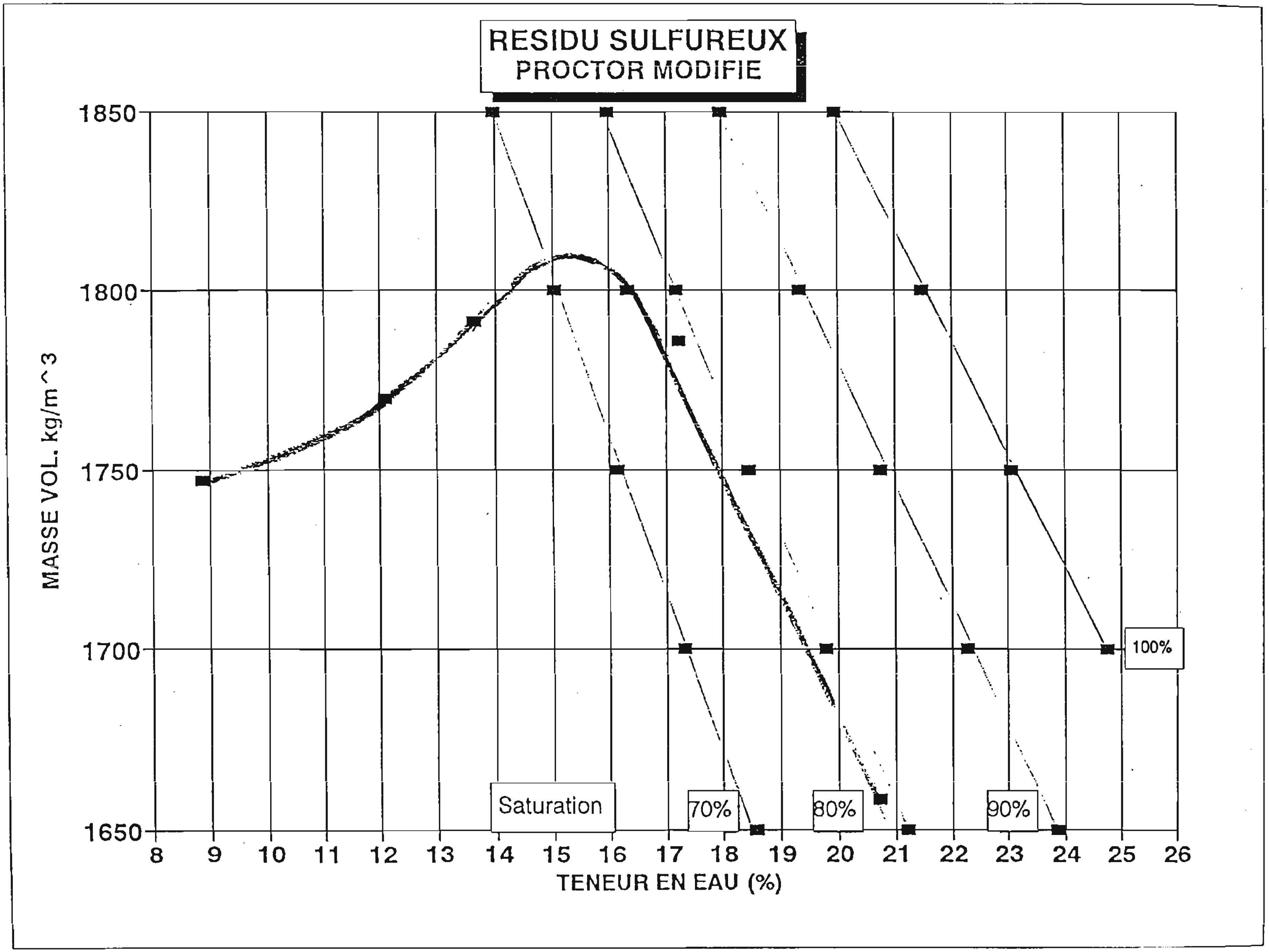
Gs: 2.934 teneur en eau opt. 15.5 % 1810.0 kg\m^3

% SAT: 38.3 53.9 62.8 76.1 78.6 79.1



DEGRE SATURATION:

MASSE VOL. Pd:		1650.0	1700.0	1750.0	1800.0	1850.0	1840.0
SAT. 100		26.52	24.74	23.06	21.47	19.97	20.26
SAT. 95		25.20	23.50	21.91	20.40	18.97	19.25
SAT. 90		23.87	22.27	20.75	19.33	17.97	18.24
SAT. 85		22.54	21.03	19.60	18.25	16.98	17.22
SAT. 80		21.22	19.79	18.45	17.16	15.98	16.21
SAT. 75		19.89	18.56	17.29	16.10	14.98	15.20
SAT. 70		18.57	17.32	16.14	15.03	13.98	14.19



RESIDU SULFUREUX
PROCTOR MODIFIE
MASSE VOL. kg/m^3
1850
1800
1750
1700
1650
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
TENEUR EN EAU (%)
Saturation
70%
80%
90%
100%

Limites de consistance d'atterberg
(ASTM D4318-84)

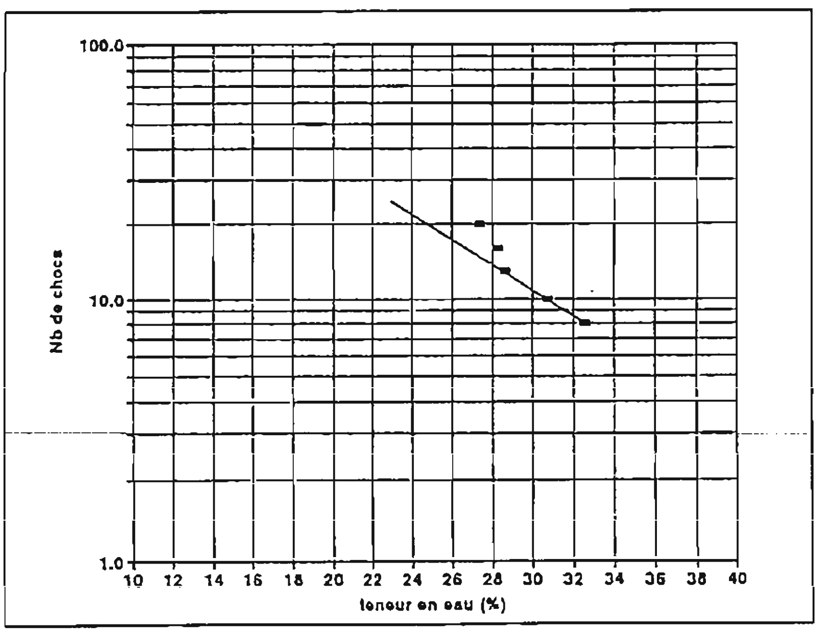
Échantillon: Golder ass.
Résidus sulfureux

date: 2 decembre 1995

	Limite de liquidité					Limite de Plasticité	
Tare	2	15	20	28	29	34	35
Wt+t	13.95	14.58	13.48	13.35	13.37	7.39	6.68
Ws+t	12.11	12.66	11.90	11.82	11.89	7.13	6.54
Ww	1.84	1.92	1.58	1.53	1.48	0.26	0.14
t	6.46	6.42	6.39	6.41	6.49	5.91	5.92
Ws	5.65	6.24	5.51	5.41	5.40	1.22	0.62
W%	32.57	30.77	28.68	28.28	27.41	21.31	22.58

Nb. Chocs	8	10	13	16	20

LL	23.0
LP	21.9
Ip	1.1
CL-ML	



Laboratoire d'Hydrogéologie

École Polytechnique de Montréal

TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

Date de montage	22-11-1995	Cellule No. 2
Nom de l'échantillon:	RESIDU SULFUREUX	Burette No. 3
Nom du fichier:	GOLDER\TX\SULFUREUX	

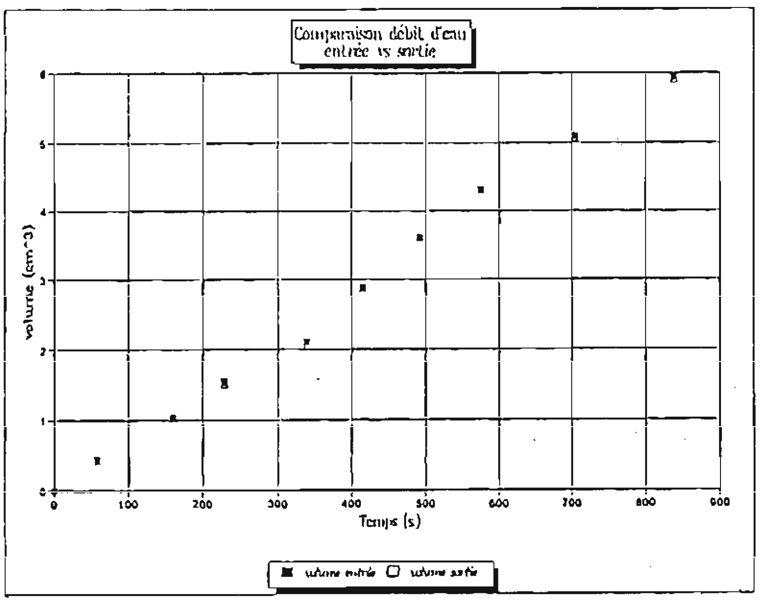
ASTM: D-5084-90

Géométrie	
épaisseur initiale (cm.)	5.977
diamètre (cm.)	7.210
surface (cm^2)	40.83
Volume (cm^3)	244.03

Masses (g)	
masse initiale humide (g)	474.0
masse finale humide (g)	517.6
masse finale sèche (g)	415.2
Gs	2.935

Conditions de l'essai			
Degré de saturation final		mas. vol. hum. g/cm3	1.942
Capt. pression (%)	93.0	mas. vol. sec. g/cm3	1.701
Par séchage (%)	99.8	Opt. Proctor g/cm3	1.810
Teneur en eau initiale (%)	14.2	teneur eau opt. (%)	15.5
Teneur en eau finale (%)	24.7	% opt. Proctor	94.0

Calibration							
o/s tête	19.80	burette utilisée		large	0	section burette	0.325
o/s base	21.50	med	1	petite	0	température	23.3



Résultat de l'essai

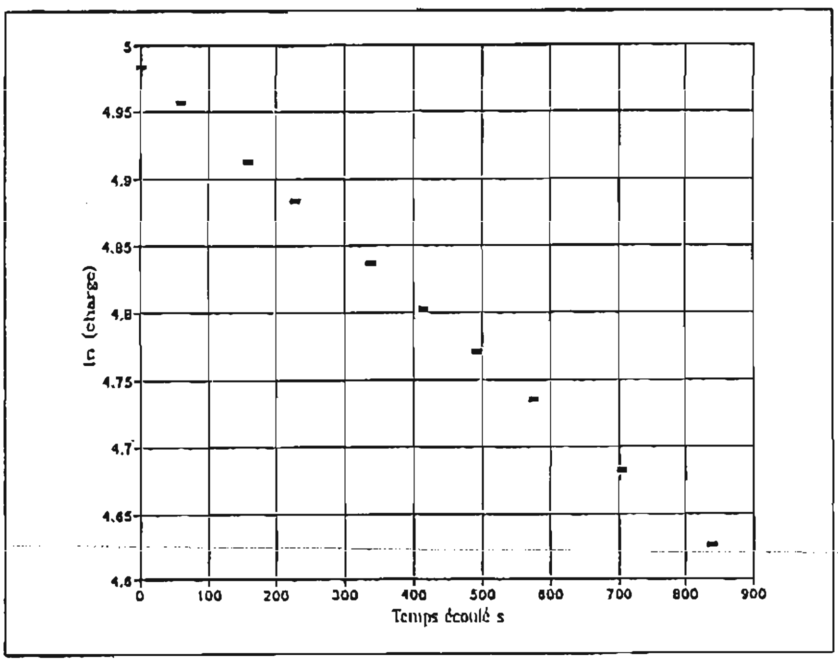
Pression (psi)	
cellule:	70
in\out:	65
Indice des vides:	0.725
Cond. hydraul. cm/s.	9.30E-06
écart type	2.93E-08
ind. reg.	1.000

FICHIER: GOLDER\TX\SULFUREUX PAGE 2

DATE: 26-11-1995 Cellule No. 2 RESIDU SULFUREUX

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	159.0	11.4	0	0	145.9	0.00	-	-
0.98	157.0	13.3	0.65	0.62	142.0	58.80	1.10E-05	1.01E-05
2.66	154.0	16.4	1.63	1.62	135.9	159.60	1.04E-05	9.57E-06
3.80	152.0	18.2	2.28	2.21	132.1	228.00	9.86E-06	9.11E-06
5.64	149.0	21.3	3.25	3.22	126.0	338.40	1.02E-05	9.41E-06
6.91	147.0	23.5	3.90	3.93	121.8	414.60	1.06E-05	9.78E-06
8.21	145.0	25.3	4.55	4.52	118.0	492.60	9.67E-06	8.93E-06
9.60	143.0	27.4	5.20	5.20	113.9	576.00	1.01E-05	9.32E-06
11.74	140.0	30.3	6.18	6.14	108.0	704.40	9.85E-06	9.10E-06
13.97	137.0	33.2	7.15	7.09	102.1	838.20	9.99E-06	9.23E-06

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral



TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

Date de montage	22-11-1995	Cellule No. 3
Nom de l'échantillon:	RESIDU SULFUREUX	Burette No. 4
Nom du fichier:	GOLDER\TX\SULFUREUX	

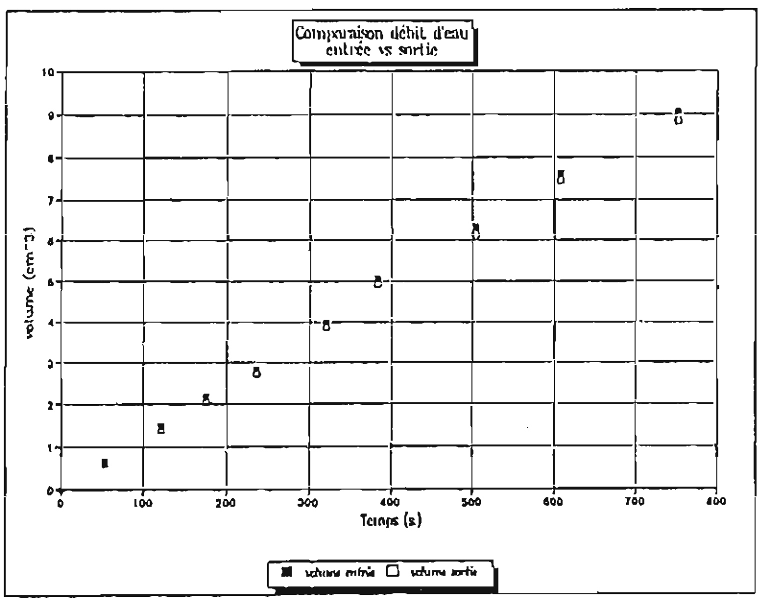
ASTM: D-5084-90

Géométrie	
épaisseur initiale (cm.)	6.236
diamètre (cm.)	7.190
surface (cm^2)	40.60
Volume (cm^3)	253.19

Masses (g)	
masse initiale humide (g)	476.7
masse finale humide (g)	520.1
masse finale sèche (g)	405.5
Gs	2.935

Conditions de l'essai			
Degré de saturation final		mas. vol. hum. g/cm3	1.883
Capt. pression (%)	93.0	mas. vol. sec. g/cm3	1.602
Par séchage (%)	99.6	Opt. Proctor g/cm3	1.810
Teneur en eau initiale (%)	17.6	teneur eau opt. (%)	15.5
Teneur en eau finale (%)	28.3	% opt. Proctor	88.5

Calibration							
o/s tête	22.30	burette utilisée		large	0	section burette	0.325
o/s base	20.90	med	1	petite	0	température	23.3



Résultat de l'essai	
Pression (psi)	
cellule:	70
in\out:	65
Indice des vides:	0.833
Cond. hydraul. cm/s.	1.85E-05
écart type	3.76E-08
ind. reg.	1.000

DATE: 26-11-1995 Cellule No. 3 RESIDU SULFUREUX

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	164.0	16.7	0	0	148.7	0.00	-	-
0.88	161.0	19.5	0.98	0.91	142.9	52.80	1.88E-05	1.74E-05
2.02	157.0	23.4	2.28	2.18	135.0	121.20	2.08E-05	1.92E-05
2.94	154.0	26.1	3.25	3.06	129.3	176.40	1.95E-05	1.80E-05
3.93	151.0	29.4	4.23	4.13	123.0	235.80	2.10E-05	1.94E-05
5.33	147.0	33.3	5.53	5.40	115.1	319.80	1.97E-05	1.82E-05
6.40	144.0	36.2	6.50	6.34	109.2	384.00	2.05E-05	1.89E-05
8.40	139.0	41.1	8.13	7.93	99.3	504.00	1.98E-05	1.83E-05
10.14	135.0	45.0	9.43	9.20	91.4	608.40	1.98E-05	1.83E-05
12.53	130.0	50.0	11.05	10.82	81.4	751.80	2.02E-05	1.86E-05

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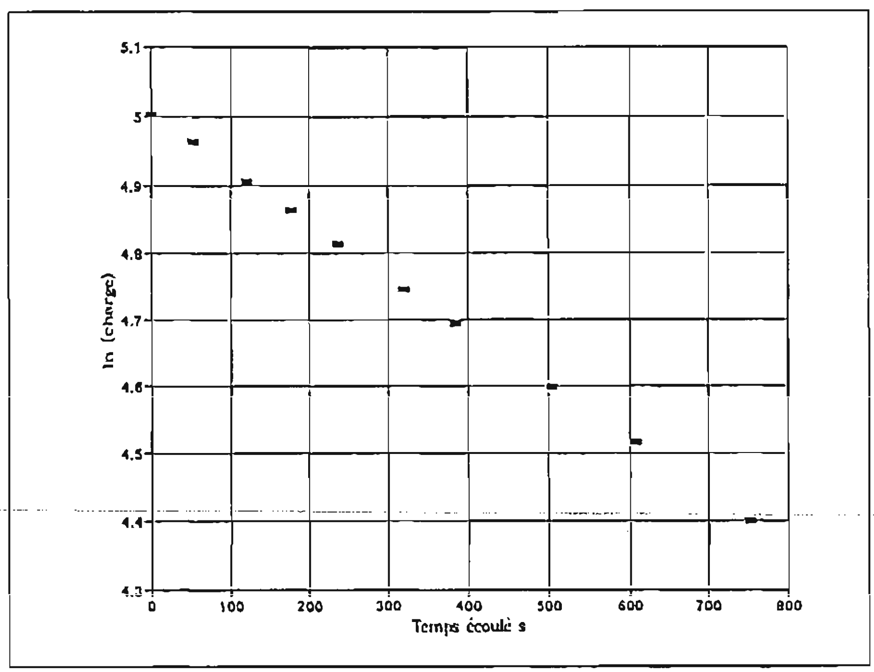


TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

Date de montage	13-11-95
Nom de l'échantillon:	RESIDU SULFUREUX
Nom du fichier:	GOLDER\TX\SULFUREUX

Cellule No. 5
Burette No. 4

ASTM: D-5084-90

Géométrie	
épaisseur initiale (cm.)	6.077
diamètre (cm.)	7.185
surface (cm^2)	40.55
Volume (cm^3)	246.40

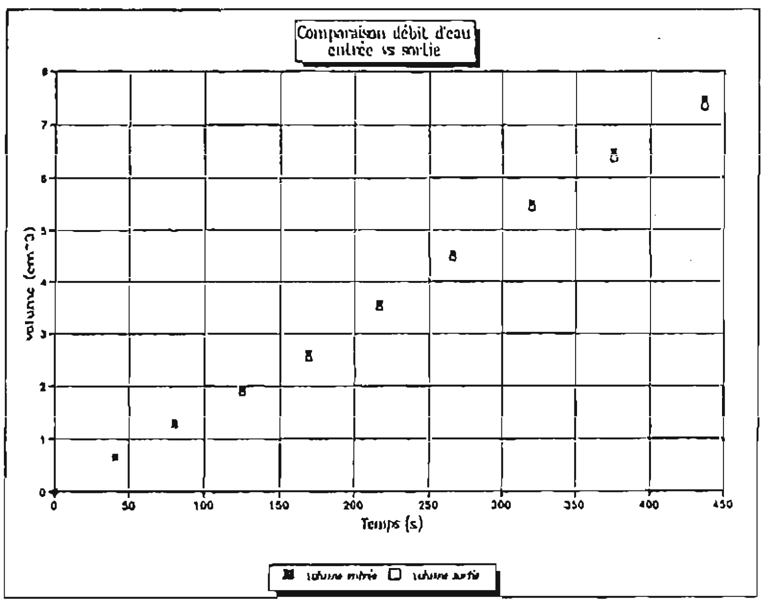
Masses (g)	
masse initiale humide (g)	447.4
masse finale humide (g)	508.5
masse finale sèche (g)	396.4
Gs	2.934

Conditions de l'essai

Degré de saturation final		mas. vol. hum. g/cm3	1.816
Capt. pression (%)	95.8	mas. vol. sec. g/cm3	1.609
Par séchage (%)	100.7	Opt. Proctor g/cm3	1.810
Teneur en eau initiale (%)	12.9	teneur eau opt. (%)	15.5
Teneur en eau finale (%)	28.3	% opt. Proctor	88.9

Calibration

o/s tête	19.50	burette utilisée		large	0	section burette	0.325
o/s base	19.00	med	1	petite	0	température	22.7



Résultat de l'essai

Pression (psi)

cellule:	70
in\out:	65
Indice des vides:	0.824
Cond. hydraul. cm/s.	2.39E-05
écart type	7.12E-08
ind. reg.	1.000

FICHIER: GOLDER\TX\SULFUREUX PAGE 2
DATE: 22-11-1995 Cellule No. 5 RESIDU SULFUREUX

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	168.0	22.2	0	0	146.3	0.00	-	-
0.68	165.0	25.2	0.98	0.98	140.3	40.80	2.50E-05	2.35E-05
1.34	162.0	28.0	1.95	1.89	134.5	80.40	2.60E-05	2.44E-05
2.08	159.0	30.9	2.93	2.83	128.6	124.80	2.46E-05	2.31E-05
2.81	156.0	34.0	3.90	3.84	122.5	168.60	2.70E-05	2.54E-05
3.61	153.0	37.0	4.88	4.81	116.5	216.60	2.55E-05	2.39E-05
4.44	150.0	39.9	5.85	5.75	110.6	266.40	2.54E-05	2.39E-05
5.33	147.0	42.8	6.83	6.70	104.7	319.80	2.50E-05	2.35E-05
6.26	144.0	45.7	7.80	7.64	98.8	375.60	2.53E-05	2.38E-05
7.28	141.0	48.7	8.78	8.61	92.8	436.80	2.49E-05	2.34E-05

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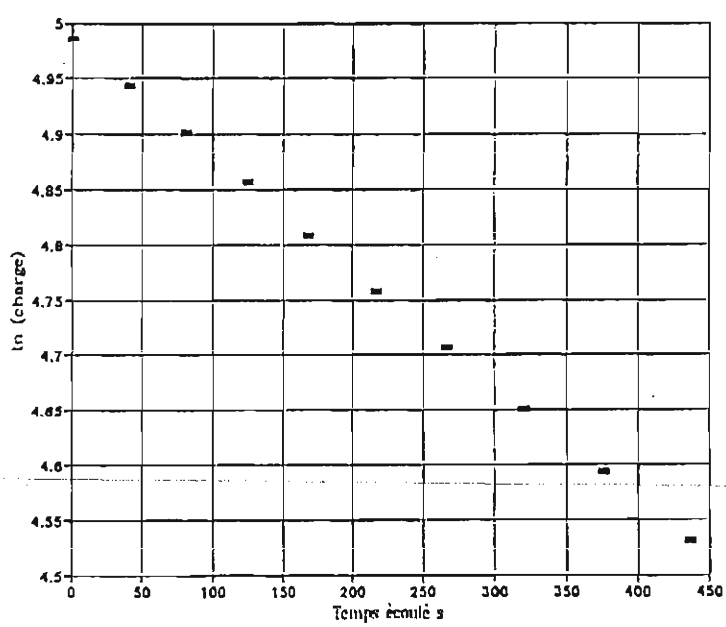


TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

Date de montage	13-11-95	Cellule No. 7
Nom de l'échantillon:	RESIDU SULFUREUX	Burette No. 3
Nom du fichier:	GOLDER\TX\SULFUREUX	

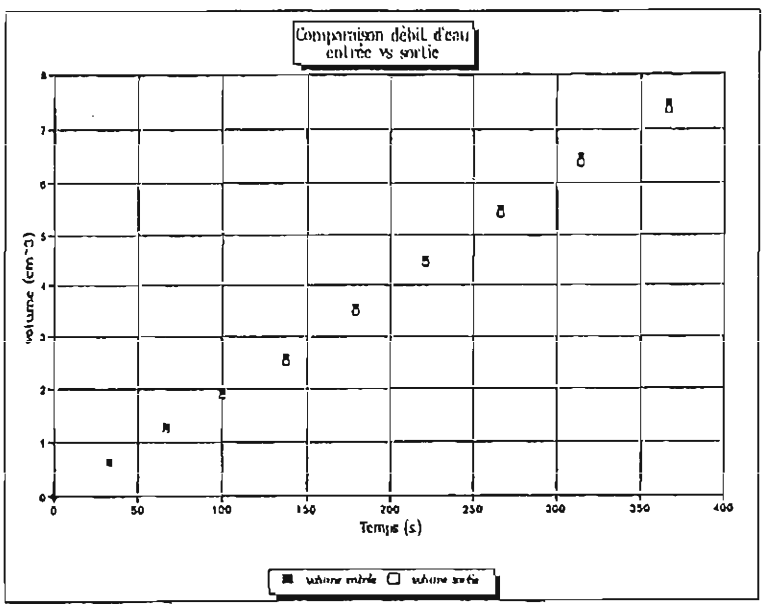
ASTM: D-5084-90

Géométrie	
épaisseur initiale (cm.)	6.834
diamètre (cm.)	7.168
surface (cm^2)	40.35
Volume (cm^3)	275.78

Masses (g)	
masse initiale humide (g)	449.2
masse finale humide (g)	526.3
masse finale sèche (g)	397.3
Gs	2.935

Conditions de l'essai			
Degré de saturation final		mas. vol. hum. g/cm3	1.629
Capt. pression (%)	93.0	mas. vol. sec. g/cm3	1.441
Par séchage (%)	93.3	Opt. Proctor g/cm3	1.810
Teneur en eau initiale (%)	13.1	teneur eau opt. (%)	15.5
Teneur en eau finale (%)	33.0	% opt. Proctor	79.6

Calibration							
o/s tête	19.80	burette utilisée		large	0	section burette	0.325
o/s base	21.50	med	1	petite	0	température	22.7



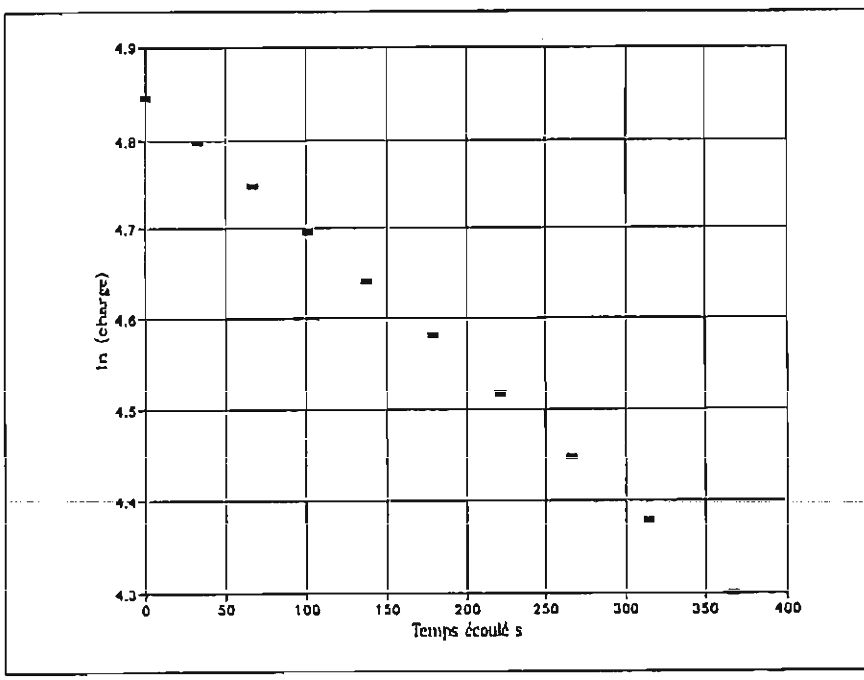
Résultat de l'essai	
Pression (psi)	
cellule	70
in\out	65
Indice des vides:	1.037
Cond. hydraul. cm/s.	3.85E-05
écart type	8.89E-08
ind. reg.	1.000

FICHIER: GOLDER\TX\SULFUREUX PAGE 2

DATE: 03-10-1995 Cellule No. 7 RESIDU SULFUREUX

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	160.0	31.1	0	0	127.2	0.00	-	-
0.55	157.0	34.0	0.98	0.94	121.3	33.00	3.96E-05	3.72E-05
1.11	154.0	36.9	1.95	1.88	115.4	66.60	4.08E-05	3.83E-05
1.67	151.0	39.8	2.93	2.83	109.5	100.20	4.30E-05	4.03E-05
2.29	148.0	42.7	3.90	3.77	103.6	137.40	4.10E-05	3.84E-05
2.98	145.0	45.7	4.88	4.75	97.6	178.80	3.97E-05	3.72E-05
3.68	142.0	48.8	5.85	5.75	91.5	220.80	4.23E-05	3.97E-05
4.44	139.0	51.8	6.83	6.73	85.5	266.40	4.09E-05	3.84E-05
5.24	136.0	54.6	7.80	7.64	79.7	314.40	4.03E-05	3.78E-05
6.12	133.0	57.6	8.78	8.61	73.7	367.20	4.08E-05	3.83E-05

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

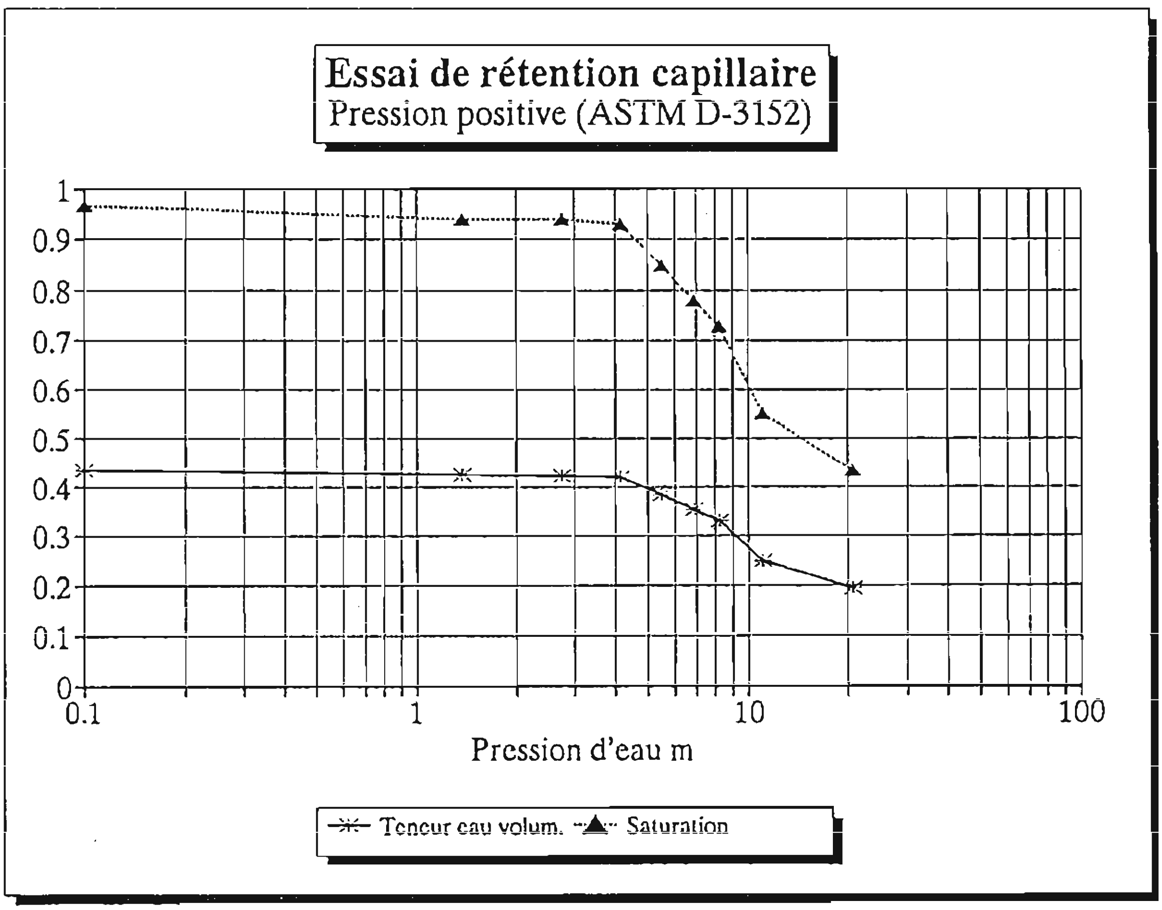


ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

Échantill	U-2	Résidus:	SULF	Date montage	9 novembre `95

Dr	2.934
Volume anneau	98.99
Anneau+plaque	101.00
Masse humide initial	302.43
Masse humide finale	279.15
Tare	119.86
Tare+sol sec	278.54
Indice des vides	0.83
TEV initiale	0.43
Saturation initiale	95.20
TEV finale	0.1967
Saturation finale	43.36

kPa	Montage	m.eau	TEV	Saturation
0.0000	1851.5	0.10	0.437	0.96
1.3800	1850.4	1.38	0.426	0.94
27.6000	1850.3	2.76	0.425	0.94
41.4000	1849.9	4.14	0.421	0.93
55.2000	1846.3	5.52	0.385	0.85
70.0000	1843.2	6.90	0.353	0.78
82.8000	1840.9	8.28	0.330	0.73
110.4000	1833.0	11.04	0.250	0.55
179.4000	1827.7	20.7	0.197	0.43



Laboratoire d'Hydrogéologie

École Polytechnique de Montréal

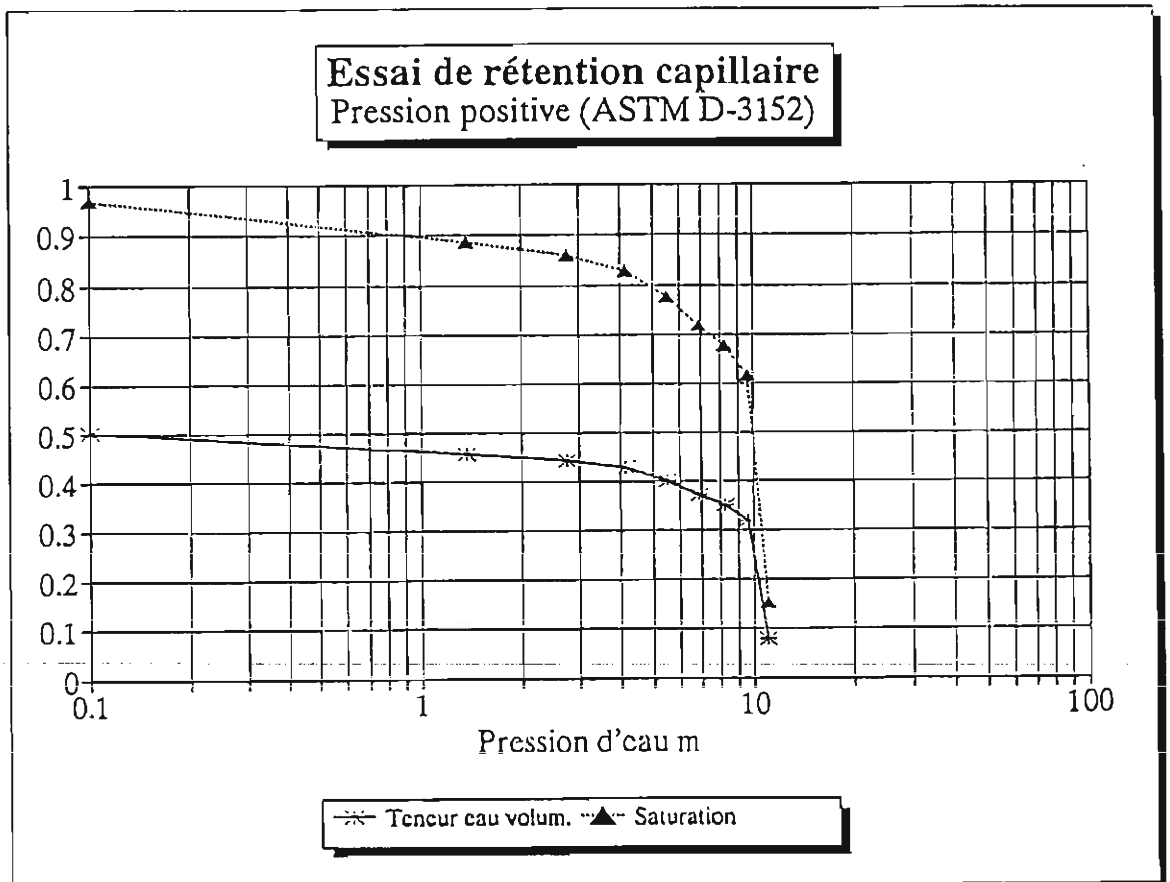
ESSAI DE RÉTENTION CAPILLAIRE

Pression positive (ASTM D-3152)

Échantill P-2 résidus: SULF		Date montage 9 novembre '95				

Dr	2.934
Volume anneau	98.32
Anneau+plaque	101.54
Masse humide initial	289.69
Masse humide finale	248.05
Tare	181.49
Tare+sol sec	320.16
Indice des vides	1.08
TEV initiale	0.50
Saturation initiale	96.91
TEV finale	0.0797
Saturation finale	15.36

kPa	Montage	m.eau	TEV	Saturation
0.0000	1885.3	0.10	0.502	0.97
1.3800	1881.1	1.38	0.459	0.88
27.6000	1879.7	2.76	0.445	0.86
41.4000	1878.3	4.14	0.431	0.83
55.2000	1875.6	5.52	0.403	0.78
70.0000	1872.7	6.90	0.374	0.72
82.8000	1870.6	8.28	0.352	0.68
96.6000	1867.4	9.66	0.320	0.62
110.4000	1843.8	11.04	0.080	0.15



Laboratoire d'Hydrogéologie

École Polytechnique de Montréal

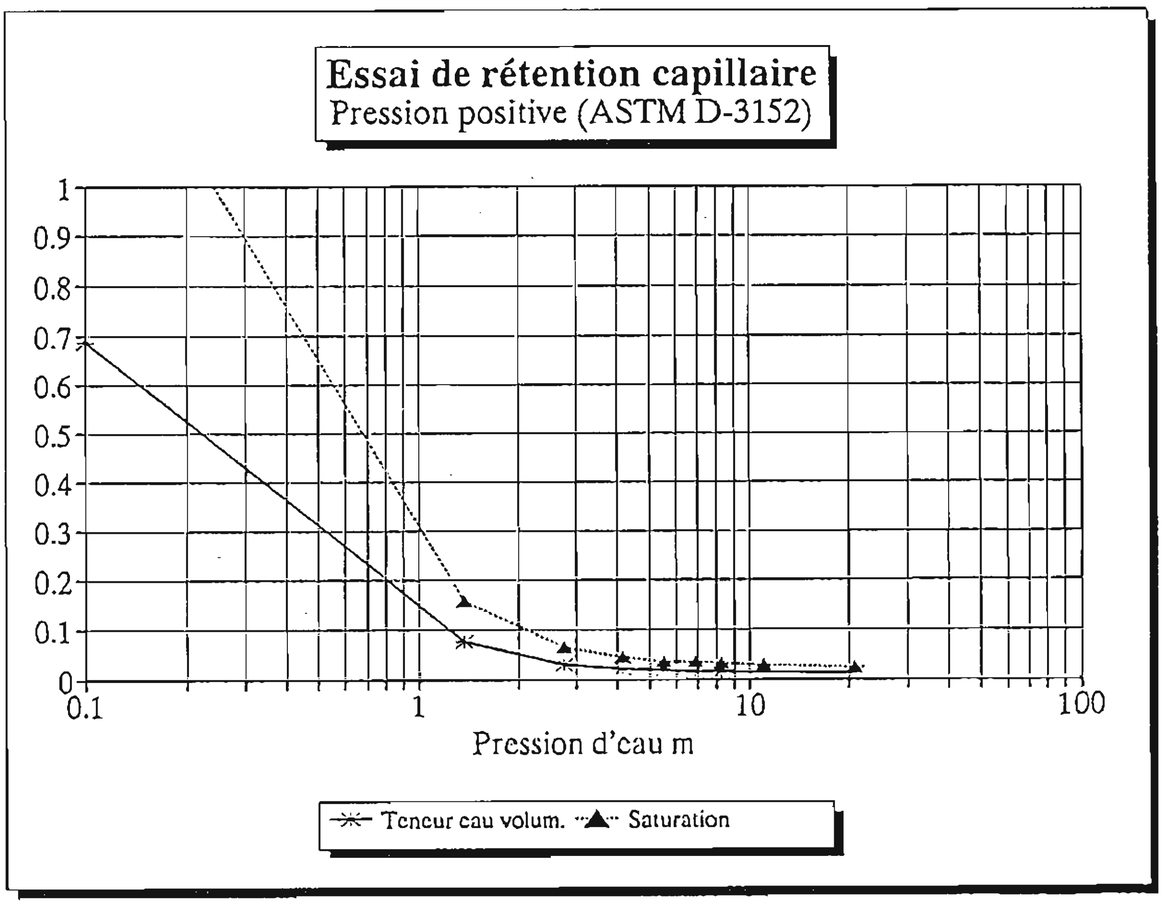
ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

Échantill	U-1	Résidus	SULF

Date montage	9 novembre `95

Dr	2.934
Volume anneau	98.99
Anneau+plaque	102.07
Masse humide initial	297.55
Masse humide finale	254.50
Tare	127.80
Tare+sol sec	279.10
Indice des vides	0.92
TEV initiale	0.45
Saturation initiale	93.16
TEV finale	0.0114
Saturation finale	2.38

kPa	Montage	m.eau	TEV	Saturation
0.0000	1847.2	0.10	0.687	1.43
1.3800	1786.7	1.38	0.076	0.16
27.6000	1782.2	2.76	0.031	0.06
41.4000	1781.3	4.14	0.022	0.04
55.2000	1780.9	5.52	0.017	0.04
70.0000	1780.8	6.90	0.016	0.03
82.8000	1780.7	8.28	0.015	0.03
110.4000	1780.5	11.04	0.013	0.03
179.4000	1780.3	20.7	0.011	0.02



Laboratoire d'Hydrogéologie

École Polytechnique de Montréal

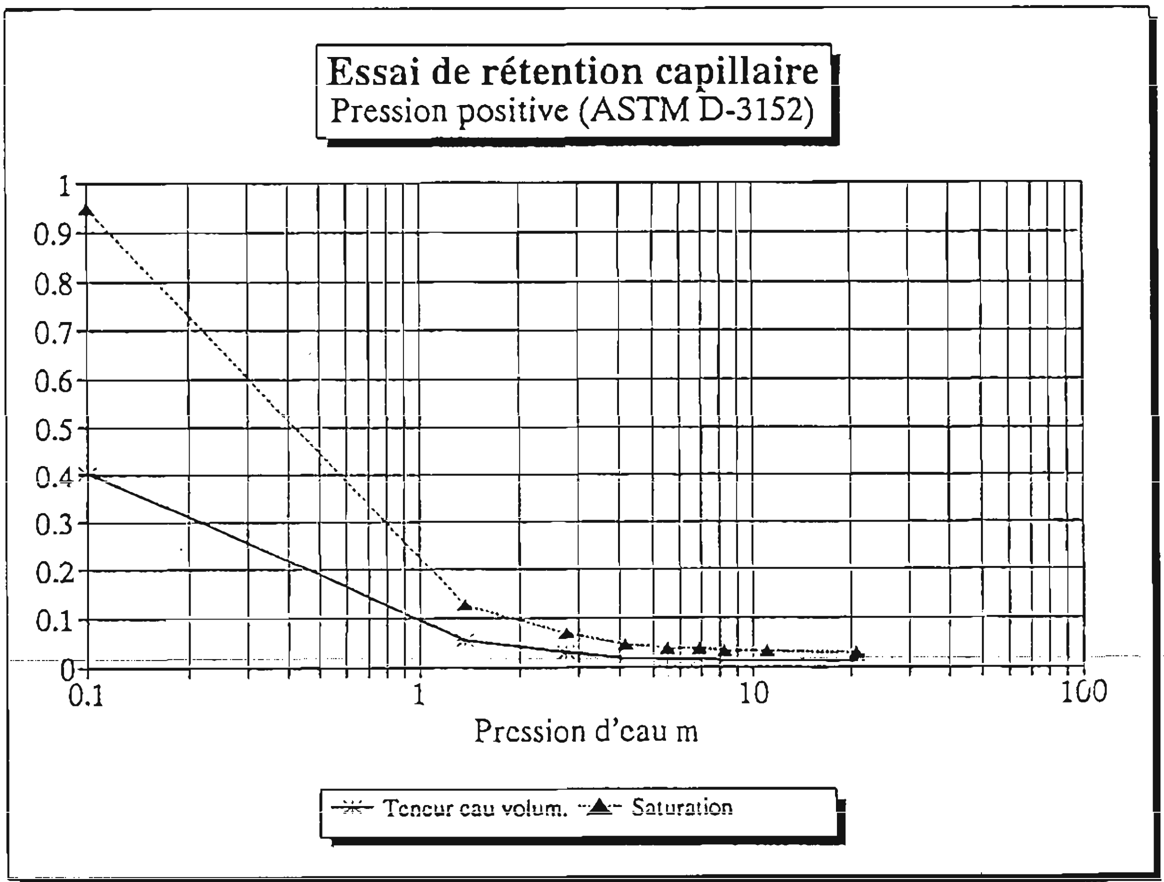
ESSAI DE RÉTENTION CAPILLAIRE
Pression positive (ASTM D-3152)

Échantill	U-3	Résidus: SULF

Date montage	9 novembre '95

Dr	2.934
Volume anneau	98.97
Anneau+plaque	97.50
Masse humide initial	303.31
Masse humide finale	264.70
Tare	127.20
Tare+sol sec	293.20
Indice des vides	0.75
TEV initiale	0.40
Saturation initiale	93.91
TEV finale	0.0121
Saturation finale	2.83

kPa	Montage	m.eau	TEV	Saturation
0.0000	1850.1	0.10	0.406	0.95
1.3800	1815.3	1.38	0.055	0.13
27.6000	1812.8	2.76	0.029	0.07
41.4000	1811.8	4.14	0.019	0.04
55.2000	1811.5	5.52	0.016	0.04
70.0000	1811.5	6.90	0.016	0.04
82.8000	1811.3	8.28	0.014	0.03
110.4000	1811.3	11.04	0.014	0.03
179.4000	1811.1	20.7	0.012	0.03



Date: 22-11-95	Colonne No 1
Prov. Echant.:	RESIDU SULFUREUX

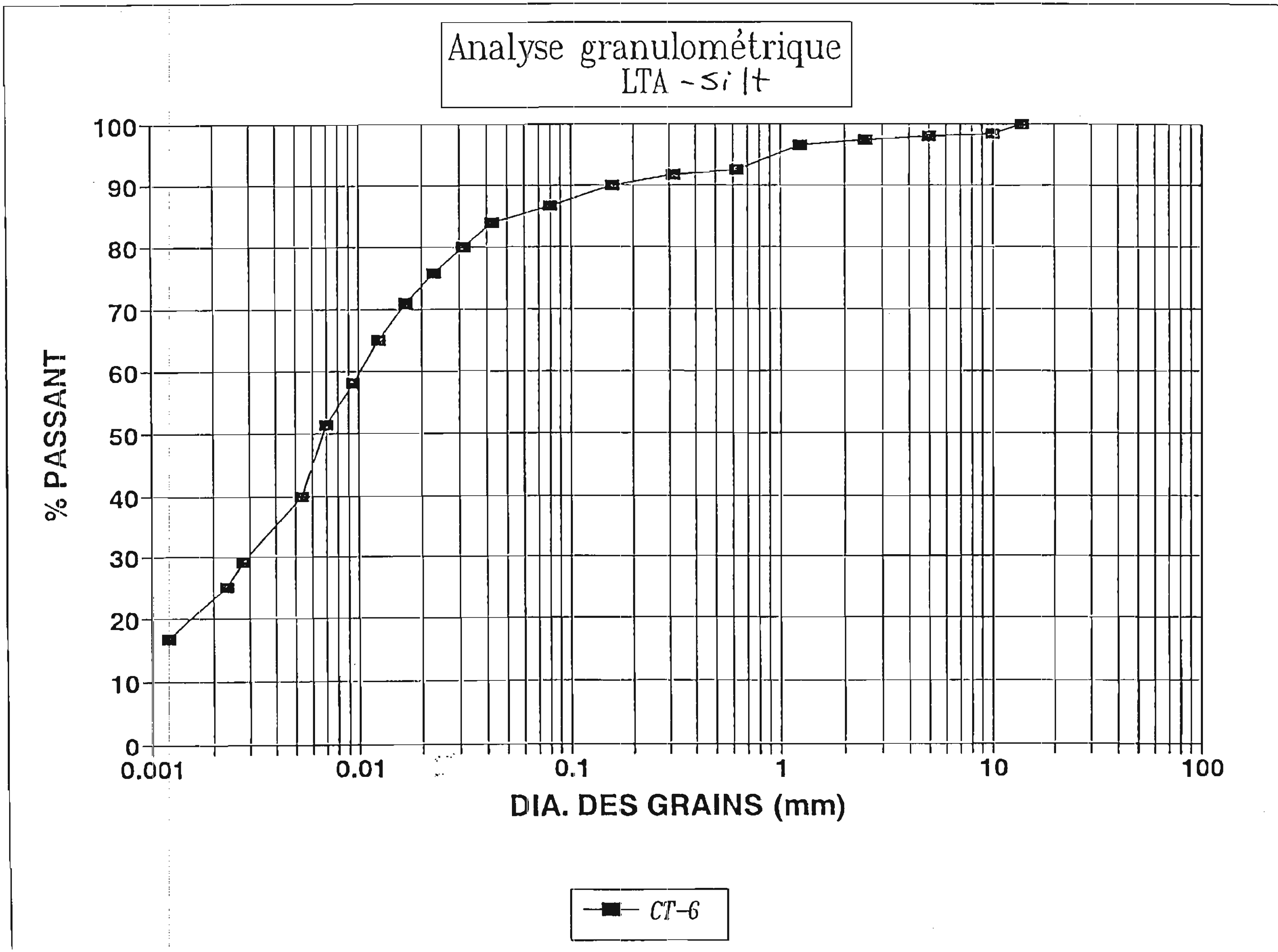
Essai No. : S-1		Denité des grains	2.934
Tare No.......114	126.90	Tare No......114	127.00
Tare + sol hum.	326.00	Tare + sol hum.	598.80
sol humide	199.10	sol humide	471.80
Tare + sol sec	300.00	Tare + sol sec	547.90
sol sec	173.10	sol sec (ws)	420.90
eau dans le sol	26.00	eau dans le sol	50.90
W i = %	15.02	W f = %	12.09
Pds colonne vide	2124.80		
Pds colonne + sol hum.	2607.70	température °C	22.5
Pds colonne + sol sec	2544.64		
Pds sol hum.	482.90		
Pds sol sec	419.84		
		indice des vides:	0.892
Hauteur totale colonne	15.374		
Hauteur bas	4.498	porosité:	0.471
Hauteur restante	10.876		
Hauteur de la plaque	0.640		
Hauteur après compact.	5.120		
Hauteur sol humide	5.116		
		Saturation:	49.23
Diam. de la colonne	8.215	n. air	
Surface de la colonne	53.004		
		D_e (m^2/s)	$6{,}1 \times 10^{-7}$
Volume de sol (cm ^3)	271.180		
Volume source (cm ^3)	305.288		
Volume res. bas (cm ^3)	238.411		
Rho hum.: gr/cm3	1.781		
Rho sec: gr/cm3	1.548		
Rho eau: gr/cm3 (20°)	0.99823		

DATE	HRE		%oxy
NOV 95		nb/min	
27	8.24	0	0
		3.5	20.8
		4	20.7
		5	20.3
		6	19.8
		9	18.7
		15	16.5
		25	14.5
		45	13.1
		75	12.7
		130	12.3
		280	11.7
		360	11.4
		500	11.2
		1800	11.2

APPENDIX D

GEOTECHNICAL DATA OF BORROW PIT #1 SILT

(École Polytechnique and URSTM)



Analyse granulométrique
LTA - silt
100
90
80
70
60
50
40
30
20
10
0
% PASSANT
0.001
0.01
0.1
1
10
100
DIA. DES GRAINS (mm)
CT-6

ECOLE POLYTECHNIQUE, *Dépt. de Génie Minéral*

DENSITE RELATIVE DES GRAINS

LOCALISATION....	GOLDER
TROU NO.........	
PROFONDEUR......	LTA - Silt
SECTION..........	
FICHIER: GOLDER\LTA\DD\SERIE1	DATE: 96-10-07

PYCNOMETRE NO	1	3	4	7
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	735.80	741.80	725.30	733.28
TEMPERATURE D'ESSAI	23.2	23.2	23.2	23.3
PDS PYCNOMETRE +EAU GRS (M2T2)	675.68	682.63	665.03	677.67
TARE NO	1	3	4	12
PDS DE LA TARE + SOL SEC GRS. (MS)	299.92	305.49	305.72	259.36
PDS DE LA TARE	205.93	212.63	210.85	171.48
PDS DU SOL SEC GRS	93.99	92.86	94.87	87.88
MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99750	0.99750	0.9975	0.99748
MASSE VOLUMIQUE DE L'EAU @ 20 °C	0.99823	0.99823	0.99823	0.99823
DENSITE RELATIVE (DR)	2.775	2.756	2.742	2.723
DENSITE RELATIVE CORRIGE	2.773	2.754	2.740	2.721
MOYENNE:			2.747	

Limite de liquidité

Golder ass.

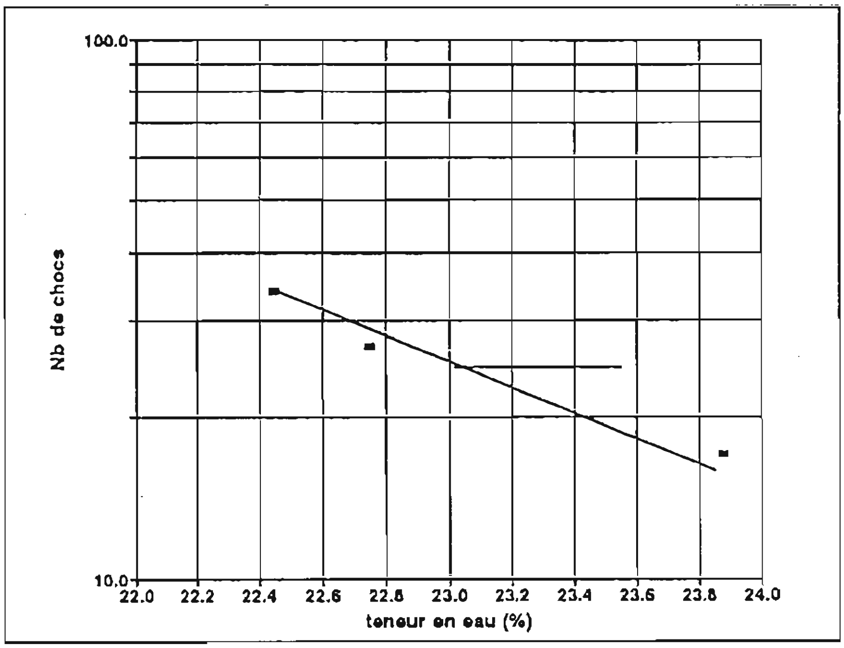
Provenance: LTA - Silt

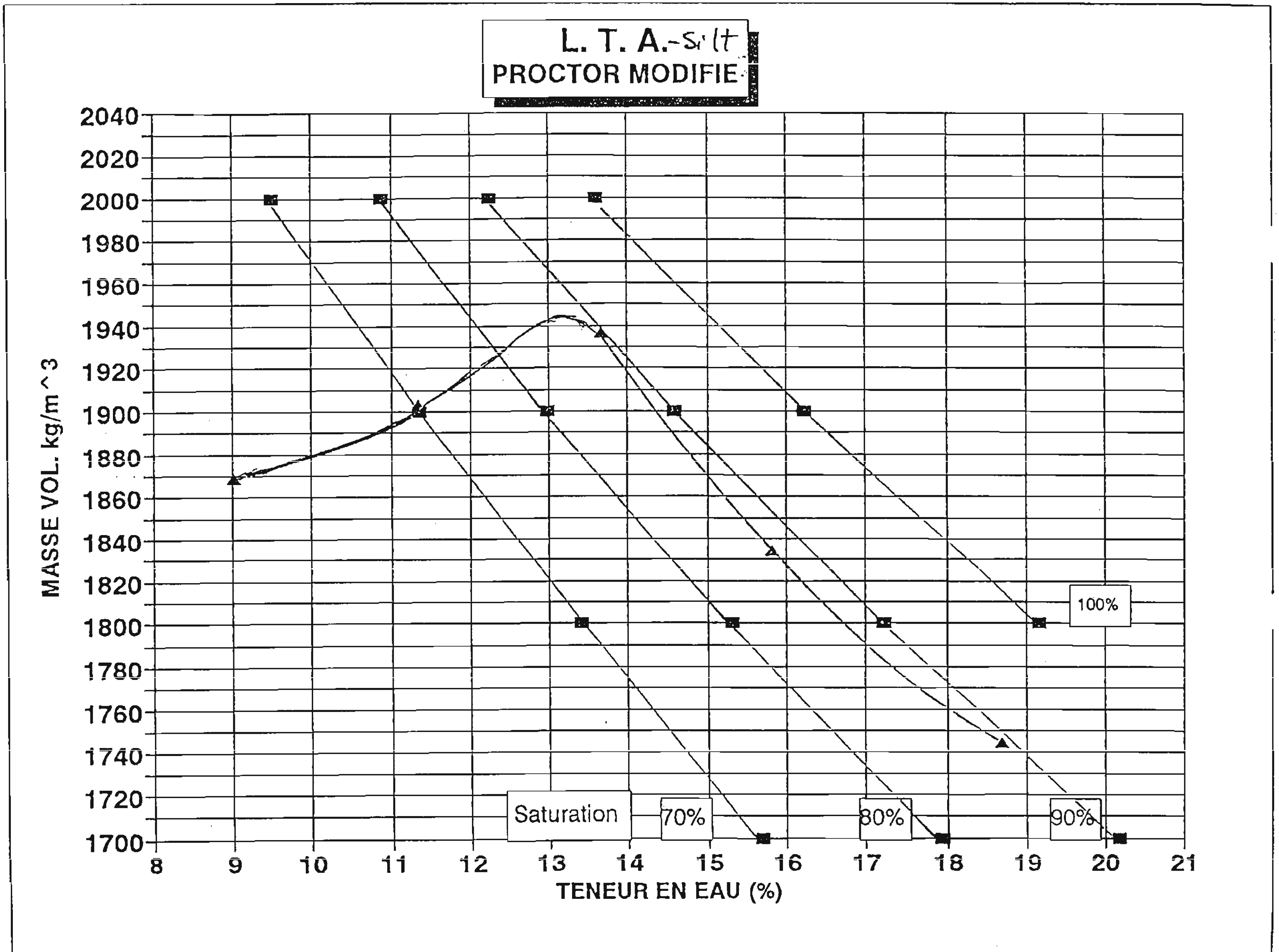
Limite de Plasticité

Tare	26	21	6			13	28
Wt+t	60.46	68.69	67.46			22.48	27.70
Ws+t	54.98	61.77	60.80			19.89	24.34
Ww	5.48	6.92	6.66			2.59	3.36
tare	32.03	31.35	31.13			6.31	6.32
Ws	22.95	30.42	29.67			13.58	18.02
W%	23.88	22.75	22.45			19.07	18.65

LL	23.0
LP	18.9
Ip	4.1

Nb. Choc	17	27	34		





L. T. A.-silt
PROCTOR MODIFIE
MASSE VOL. kg/m^3
2040
2020
2000
1980
1960
1940
1920
1900
1880
1860
1840
1820
1800
1780
1760
1740
1720
1700
8
9
10
11
12
13
14
15
16
17
18
19
20
21
TENEUR EN EAU (%)
Saturation
70%
80%
90%
100%

TEST PERMEABILITE

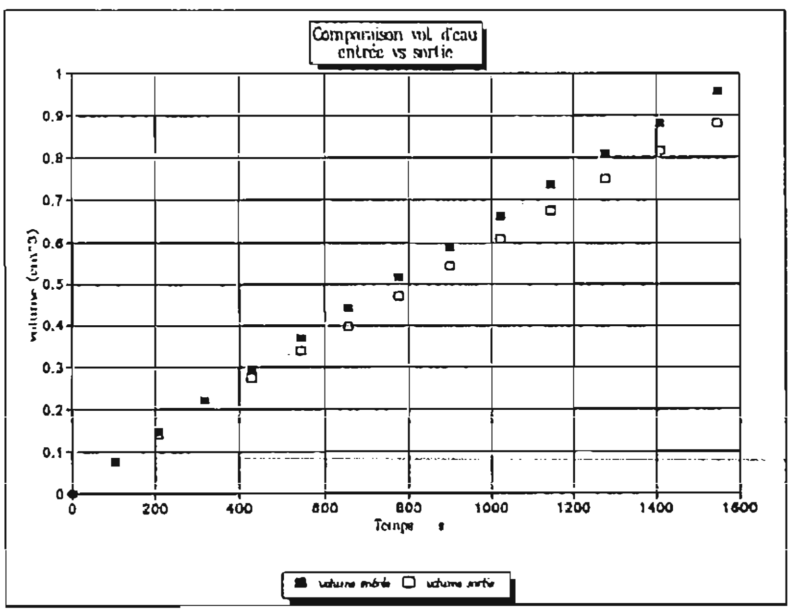
PERMEAMETRE A CHARGE VARIABLE

Date de montage	96-10-07	SANS CONGÉLATION
Nom de l'échantillon:	LTA – Silt	ETAPE 1
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1	

Géométrie	moule # 7		Masses g	
épaisseur initiale cm	10.760	16.506	masse initiale humide	1081.2
diamètre cm	8.255	5.016	masse finale humide	1171.1
surface (cm^2)	53.521		masse finale sèche	960.9
Volume (cm^3)	575.87		Gs	2.780

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.877
Par séchage (%) init.	52.3	mas. vol. sec. (g/cm3)	1.669
Par séchage (%) fin.	91.3	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.5	teneur eau opt. (%)	13.2
Teneur en eau finale	21.9	% opt. Proctor	85.9

Calibration							
o/s tête	128.20	burette utilisée		large	0	section burette	0.294
o/s base	23.30	med	0	petite	1	température	22.8

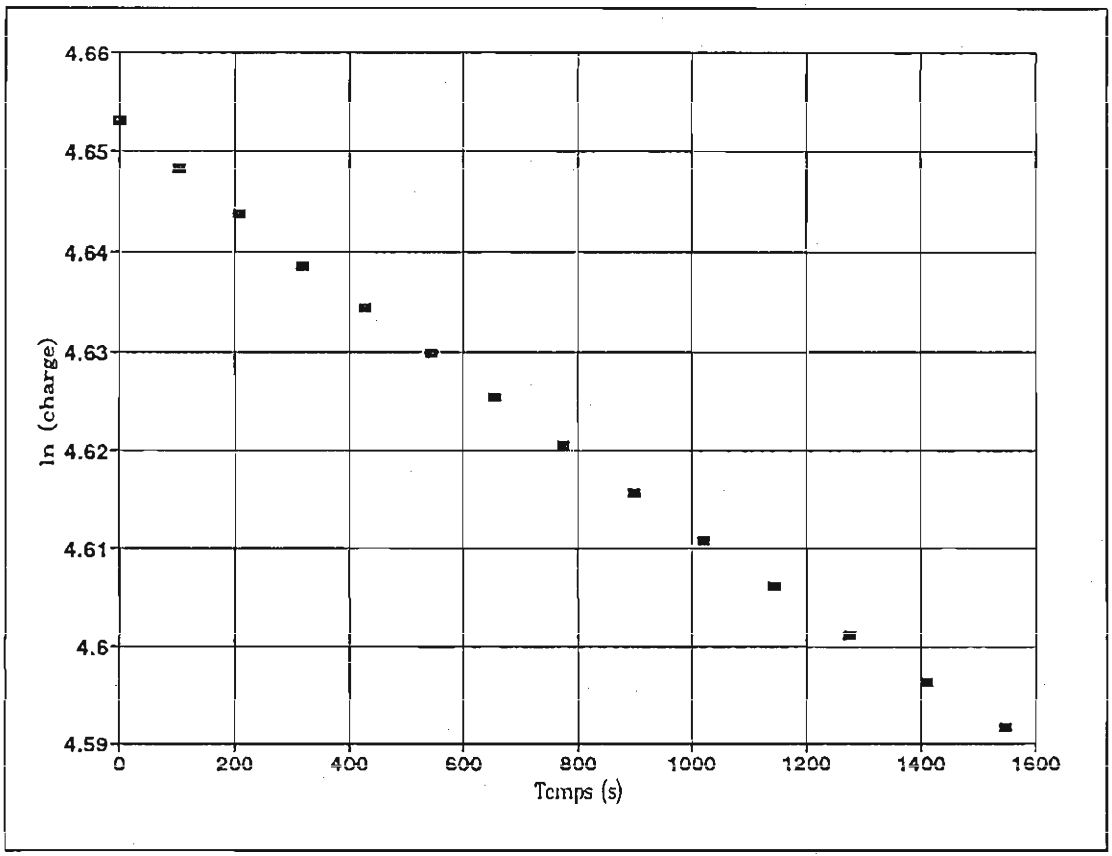


Résultat de l'essai	
charge variable	
Indice des vides	0.666
Perméabilité (cm/s)	1.05E-06
écart type	1.31E-08
ind. reg.	0.998
COMMENTAIRES	

96-10-10 LTA ETAPE 1 page 2

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	0.00	0.00	0	104.9	0.00	-	-
1.71	-0.25	0.25	0.07	0.07	104.4	102.60	1.38E-06	1.29E-06
3.47	-0.50	0.48	0.15	0.14	103.9	208.20	1.28E-06	1.19E-06
5.30	-0.75	0.75	0.22	0.22	103.4	318.00	1.36E-06	1.28E-06
7.15	-1.00	0.93	0.29	0.27	103.0	429.00	1.10E-06	1.03E-06
9.07	-1.25	1.15	0.37	0.34	102.5	544.20	1.19E-06	1.11E-06
10.92	-1.50	1.35	0.44	0.40	102.0	655.20	1.17E-06	1.10E-06
12.93	-1.75	1.60	0.51	0.47	101.5	775.80	1.20E-06	1.13E-06
14.99	-2.00	1.85	0.59	0.54	101.0	899.40	1.18E-06	1.10E-06
17.04	-2.25	2.08	0.66	0.61	100.6	1022.40	1.13E-06	1.06E-06
19.08	-2.50	2.30	0.74	0.68	100.1	1144.80	1.14E-06	1.07E-06
21.28	-2.75	2.55	0.81	0.75	99.6	1276.80	1.12E-06	1.05E-06
23.49	-3.00	2.78	0.88	0.82	99.1	1409.40	1.07E-06	9.98E-07
25.78	-3.25	3.00	0.96	0.88	98.7	1546.80	1.03E-06	9.67E-07
37.93	-4.50	4.20	1.32	1.24	96.2	2275.80	1.02E-06	9.55E-07



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

Date de montage	96-10-07	SANS CONGÉLATION
Nom de l'échantillon:	LTA - Si (T	ETAPE 1
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1	

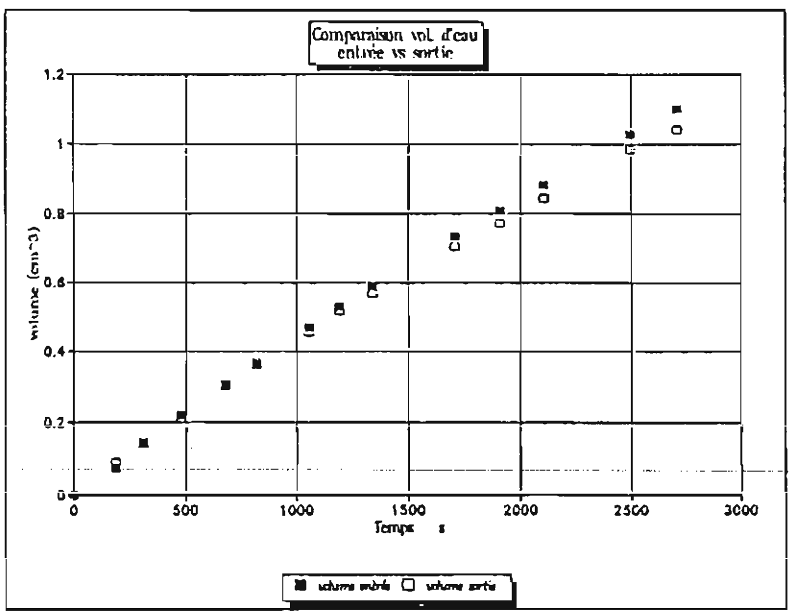
Géométrie	moule # 2		Masses g	
épaisseur initiale cm	12.466	17.378	masse initiale humide	1084.7
diamètre cm	8.255	4.182	masse finale humide	1174.0
surface (cm^2)	53.521		masse finale sèche	966.4
Volume (cm^3)	667.19		Gs	2.780

Conditions de l'essai

Degré de saturation		mas. vol. hum. (g/cm3)	1.626
Par séchage (%) init.	37.0	mas. vol. sec. (g/cm3)	1.448
Par séchage (%) fin.	65.0	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.2	teneur eau opt. (%)	13.2
Teneur en eau finale	21.5	% opt. Proctor	74.6

Calibration

o/s tête	128.50	burette utilisée		large	0	section burette	0.294
o/s base	24.80	med	0	petite	1	température	23.5



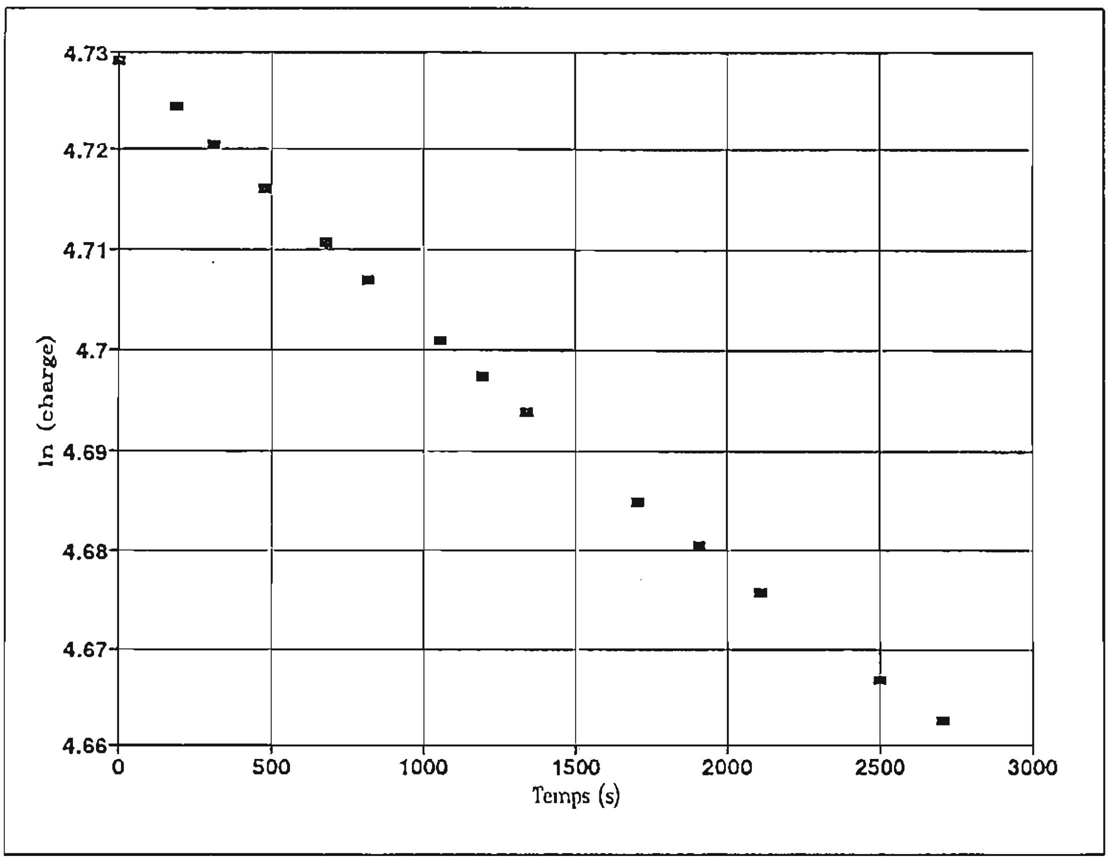
Résultat de l'essai

charge variable

Indice des vides	0.919
Perméabilité (cm/s)	7.63E-07
écart type	8.78E-09
ind. reg.	0.998

COMMENTAIRES

96-10-10	LTA			ETAPE 1			page 2	
Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	-9.50	0.00	0	113.2	0.00	-	-
3.15	-0.25	-9.20	0.07	0.09	112.7	189.00	8.83E-07	8.11E-07
5.20	-0.50	-9.03	0.15	0.14	112.2	312.00	1.05E-06	9.67E-07
7.97	-0.75	-8.78	0.22	0.21	111.7	478.20	9.20E-07	8.46E-07
11.32	-1.05	-8.48	0.31	0.30	111.1	679.20	9.18E-07	8.43E-07
13.66	-1.25	-8.28	0.37	0.36	110.7	819.60	8.80E-07	8.08E-07
17.61	-1.60	-7.95	0.47	0.46	110.1	1056.60	8.84E-07	8.12E-07
19.90	-1.80	-7.75	0.53	0.51	109.7	1194.00	9.08E-07	8.34E-07
22.31	-2.00	-7.58	0.59	0.57	109.3	1338.60	8.12E-07	7.46E-07
28.42	-2.50	-7.10	0.74	0.71	108.3	1705.20	8.37E-07	7.69E-07
31.78	-2.75	-6.88	0.81	0.77	107.8	1906.80	7.47E-07	6.86E-07
35.10	-3.00	-6.63	0.88	0.85	107.3	2106.00	7.99E-07	7.34E-07
41.63	-3.50	-6.15	1.03	0.99	106.4	2497.80	7.98E-07	7.33E-07
45.13	-3.75	-5.95	1.10	1.04	105.9	2707.80	6.92E-07	6.35E-07
48.69	-4.00	-5.70	1.18	1.12	105.4	2921.40	7.59E-07	6.97E-07



TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

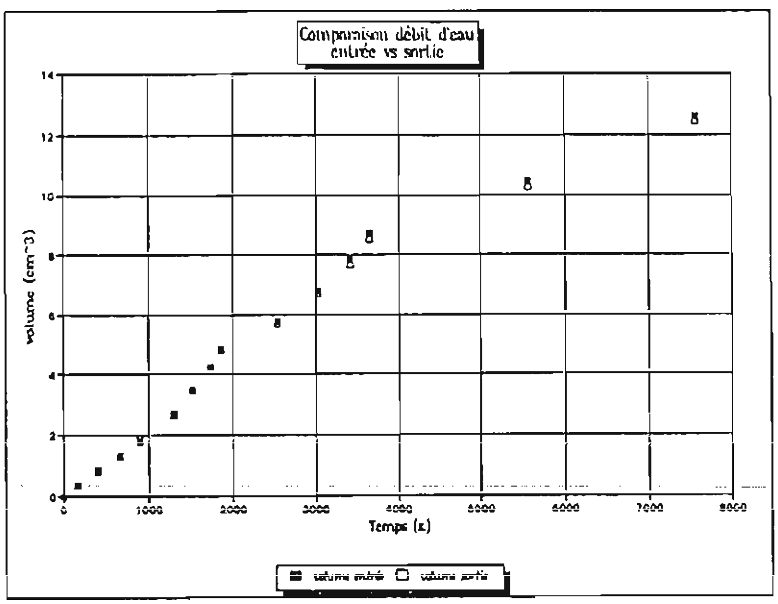
Date de montage	1996-10-08	Cellule No. 6
Nom de l'échantillon:	LTA - Silt	Burette No. 1
Nom du fichier:	GOLDER\LTA\TX\série1	

ASTM: D-5084-90

Géometrie		Masses (g)	
épaisseur initiale (cm.)	5.910	masse initiale humide (g)	462.6
diamètre (cm.)	7.165	masse finale humide (g)	499.8
surface (cm^2)	40.32	masse finale sèche (g)	413.7
Volume (cm^3)	238.29	Gs	2.747

Conditions de l'essai			
Degré de saturation final		mas. vol. hum. g/cm3	1.941
Capt. pression (%)	95.6	mas. vol. sec. g/cm3	1.736
Par séchage (%)	98.2	Opt. Proctor g/cm3	1.942
Teneur en eau initiale (%)	11.8	teneur eau opt. (%)	13.2
Teneur en eau finale (%)	20.8	% opt. Proctor	89.4

Calibration							
o/s tête	22.30	burette utilisée		large	0	section burette	0.325
o/s base	20.90	med	1	petite	0	température	22.2



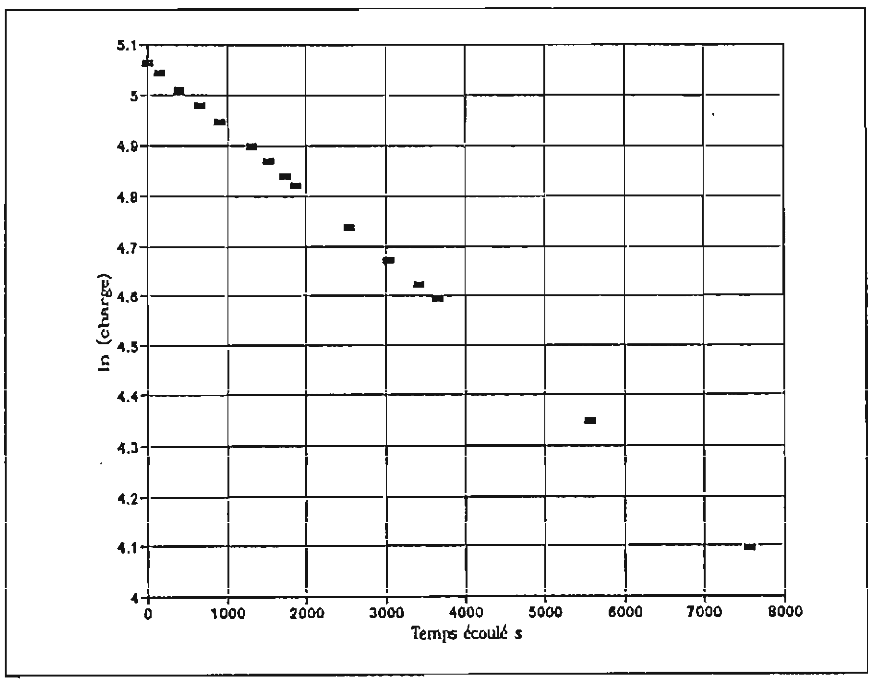
Résultat de l'essai	
Pression (psi)	
cellule:	50
in\out:	45
Indice des vides:	0.582
Cond. hydraul. cm/s.	2.91E-06
écart type	5.09E-09
ind. reg.	1.000

FICHIER: GOLDER\LTA\TX\série1 PAGE 2

DATE: 96-10-16 Cellule No. 6 LTA

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	164.0	7.3	0	0	158.1	0.00	-	-
2.75	162.5	9.0	0.49	0.55	154.9	165.00	2.95E-06	2.81E-06
6.75	160.0	11.5	1.30	1.37	149.9	405.00	3.26E-06	3.10E-06
11.00	157.8	13.7	2.01	2.08	145.5	660.00	2.78E-06	2.65E-06
14.99	155.4	16.0	2.79	2.83	140.8	899.40	3.27E-06	3.11E-06
21.75	152.0	19.3	3.90	3.90	134.1	1305.00	2.86E-06	2.72E-06
25.33	150.0	21.2	4.55	4.52	130.2	1519.80	3.27E-06	3.11E-06
28.83	148.2	23.0	5.14	5.10	126.6	1729.80	3.18E-06	3.02E-06
31.06	147.0	24.1	5.53	5.46	124.3	1863.60	3.26E-06	3.10E-06
42.26	141.8	29.0	7.21	7.05	114.2	2535.60	3.00E-06	2.86E-06
50.54	138.1	32.6	8.42	8.22	106.9	3032.40	3.17E-06	3.01E-06
56.95	135.5	35.2	9.26	9.07	101.7	3417.00	3.09E-06	2.94E-06
60.76	134.0	36.5	9.75	9.49	98.9	3645.60	2.91E-06	2.77E-06
92.80	123.4	47.5	13.20	13.07	77.3	5568.00	3.05E-06	2.90E-06
126.10	114.8	56.2	15.99	15.89	60.0	7566.00	3.02E-06	2.87E-06

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral



TEST PERMEABILITE ESSAI TRIAXIAL

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral

Date de montage	1996-10-08
Nom de l'échantillon:	LTA – S/17
Nom du fichier:	GOLDER\LTA\TX\série1

Cellule No. 5
Burette No. 1

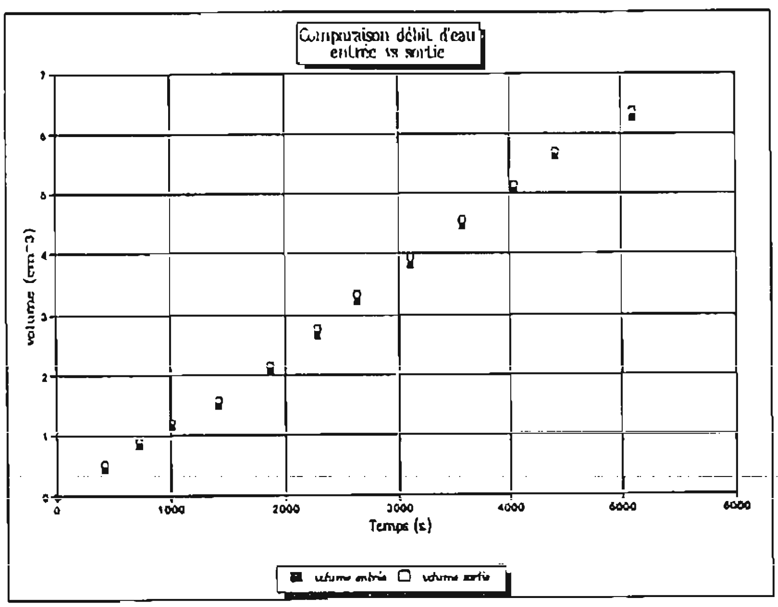
ASTM: D-5084-90

Géométrie	
épaisseur initiale (cm.)	6.158
diamètre (cm.)	7.165
surface (cm^2)	40.32
Volume (cm^3)	248.29

Masses (g)	
masse initiale humide (g)	452.6
masse finale humide (g)	498.9
masse finale sèche (g)	405.1
Gs	2.747

Conditions de l'essai			
Degré de saturation final		mas. vol. hum. g/cm3	1.823
Capt. pression (%)	91.2	mas. vol. sec g/cm3	1.632
Par séchage (%)	93.0	Opt. Proctor g/cm3	1.942
Teneur en eau initiale (%)	11.7	teneur eau opt. (%)	13.2
Teneur en eau finale (%)	23.2	% opt. Proctor	84.0

Calibration							
o/s tête	21.80	burette utilisée		large	0	section burette	0.325
o/s base	17.90	med	1	petite	0	température	22.9



Résultat de l'essai

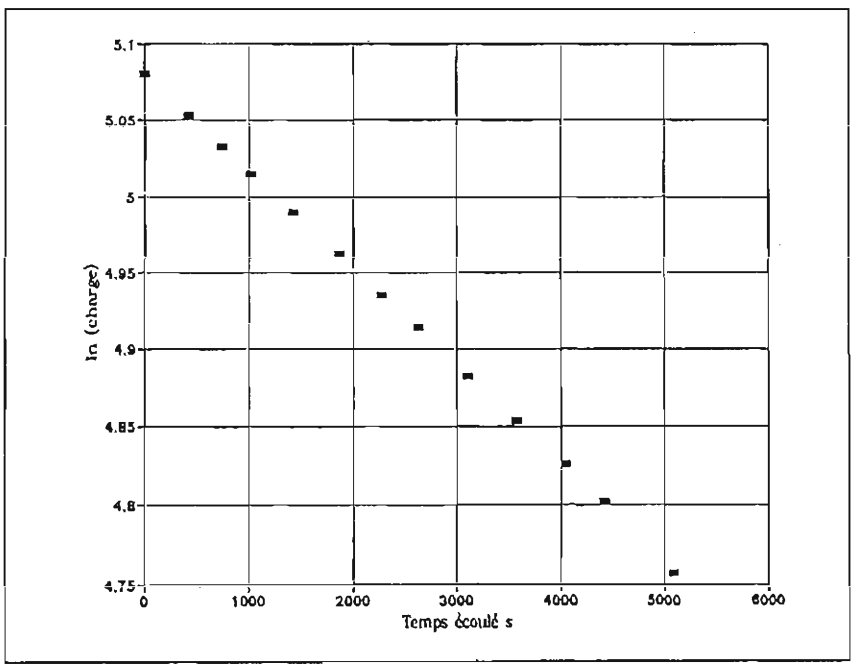
Pression (psi)	
cellule:	50
in\out:	45
Indice des vides:	0.684
Cond. hydraul. cm/s.	1.46E-06
écart type	3.61E-09
ind. reg.	1.000

FICHIER: GOLDER\LTA\TX\série1 PAGE 2

DATE: 96-10-16 Cellule No. 5 LTA

Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	161.0	4.0	0	0	160.9	0.00	-	-
7.05	159.0	6.4	0.65	0.78	156.5	423.00	1.63E-06	1.52E-06
12.24	157.3	7.8	1.20	1.24	153.4	734.40	1.59E-06	1.49E-06
16.92	156.0	9.2	1.63	1.69	150.7	1015.20	1.57E-06	1.47E-06
23.67	154.2	11.2	2.21	2.34	146.9	1420.20	1.57E-06	1.46E-06
31.13	152.2	13.1	2.86	2.96	143.0	1867.80	1.49E-06	1.39E-06
38.01	150.4	15.2	3.44	3.64	139.1	2280.60	1.66E-06	1.55E-06
43.94	148.8	16.5	3.96	4.06	136.2	2636.40	1.47E-06	1.37E-06
51.84	146.7	18.7	4.65	4.78	131.9	3110.40	1.68E-06	1.57E-06
59.60	144.8	20.5	5.26	5.36	128.2	3576.00	1.52E-06	1.42E-06
67.38	143.0	22.3	5.85	5.95	124.6	4042.80	1.51E-06	1.41E-06
73.64	141.5	23.7	6.34	6.40	121.7	4418.40	1.56E-06	1.45E-06
84.92	139.0	26.5	7.15	7.31	116.4	5095.20	1.63E-06	1.52E-06

Ecole Polytechnique de Montréal, Dépt. de Génie Minéral



ESSAI DE RÉTENTION CAPILLAIRE

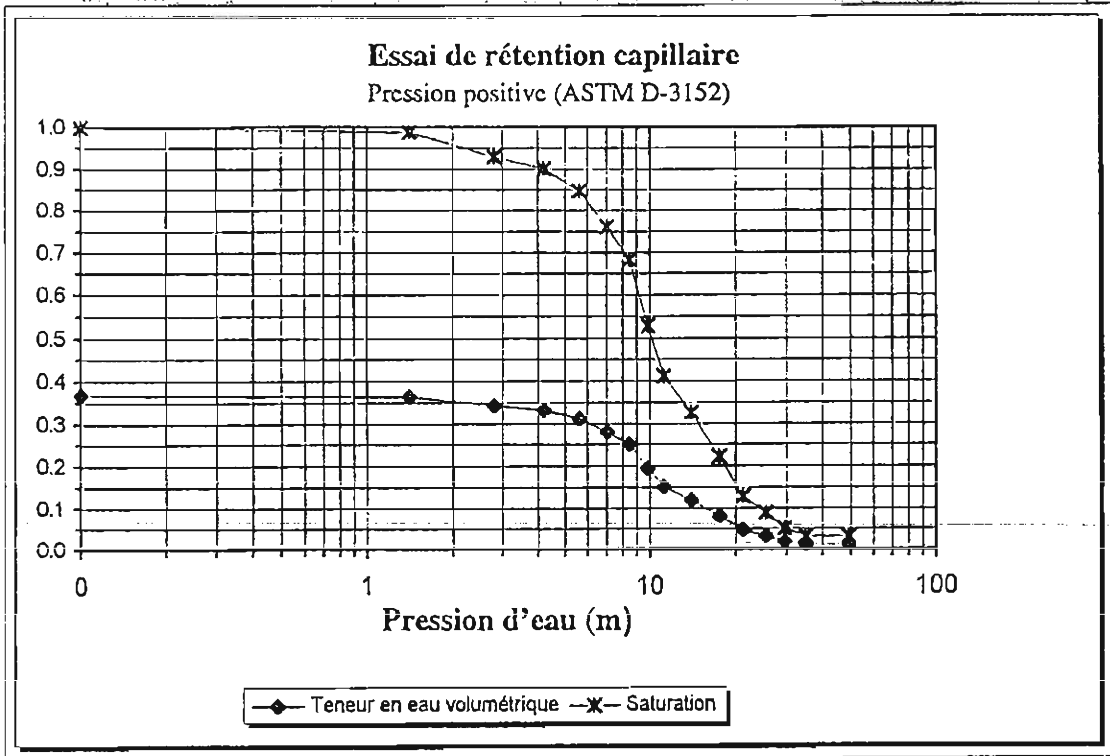
Pression positive (ASTM D-3152)

Échantillon:	LTA –Si 1t	Date:	16 octobre 1996
Numero de moule:	P-6 HP	Projet:	Golder

Dr	2.747
Vol. anneau	104.65
Anneau + plaque	100.67
Mh initial	320.90
Mh final	283.68
Tare	126.55
Tare + sol sec	308.33
Indice des vides	0.58
TEV initiale	0.37
Sr initiale	99.93
TEV finale	0.012
Sr finale	3.20

NOTES:

Psi	kPa	Montage	m. eau	TEV	Sr
0	0.00	3151.9	0.10	0.367	0.9988
2	13.79	3151.5	1.41	0.363	0.99
4	27.58	3149.2	2.81	0.341	0.93
6	41.37	3148.1	4.22	0.331	0.90
8	55.16	3146.1	5.63	0.312	0.85
10	68.95	3142.7	7.03	0.279	0.76
12	82.74	3139.7	8.44	0.251	0.68
14	96.53	3133.8	9.84	0.194	0.53
16	110.32	3129.3	11.25	0.151	0.41
20	137.90	3126.0	14.06	0.120	0.33
25	172.38	3122.0	17.58	0.082	0.22
30	206.85	3118.4	21.10	0.047	0.13
36	248.22	3116.9	25.31	0.033	0.09
42	289.59	3115.4	29.53	0.018	0.05
50	344.75	3114.7	35.16	0.012	0.03
70	482.65	3114.7	49.22	0.012	0.03



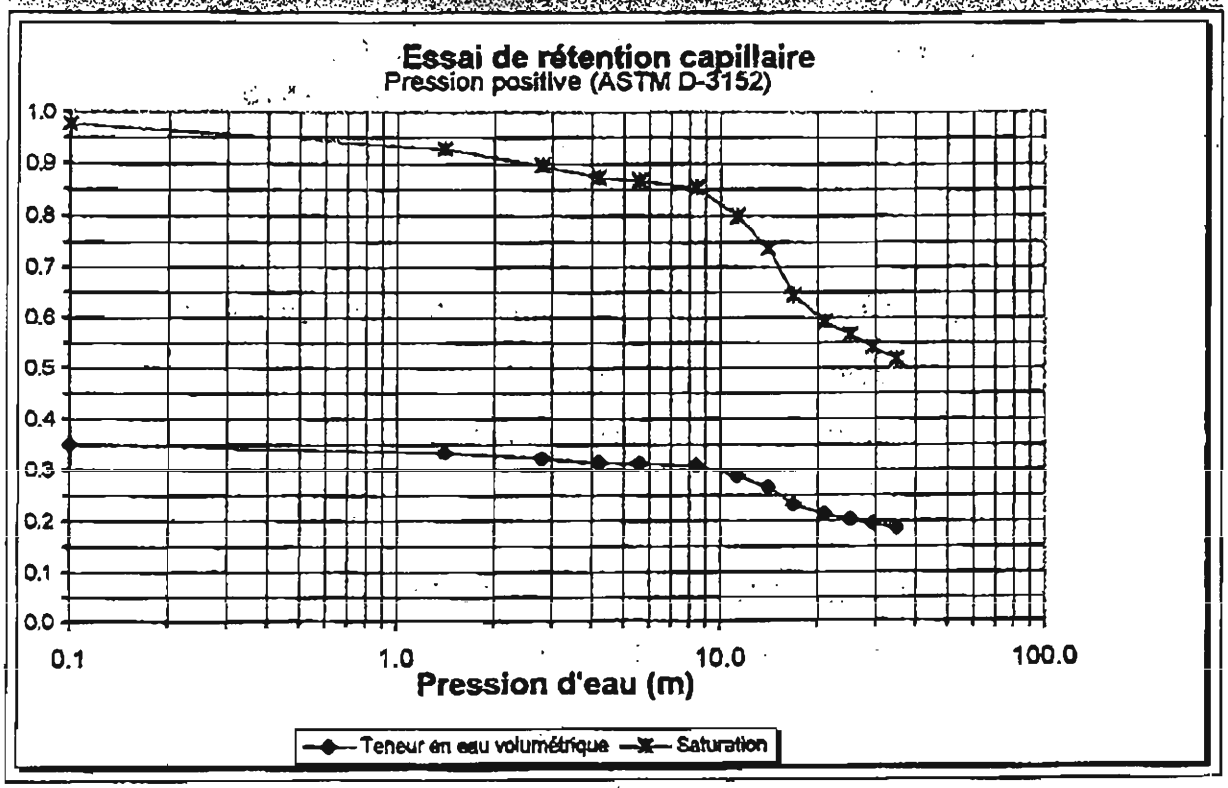
ESSAI DE RÉTENTION CAPILLAIRE

Pression positive (ASTM D-3152)

Echantillon:	LTA	**Date:**	28 janvier 1997
Numero de moule:	P-1	**Projet:**	Golder

Dr	2.747
Vol. anneau	97.12
Anneau + plaque	100.00
Mh initial	305.01
Mh final	289.01
Tare	315.58
Tare + sol sec	486.54
Indice des vides	0.56
TEV initiale	0.35
Sr initiale	97.62
TEV finale	0.186
Sr finale	51.75

Psi	kPa	Montage	m. eau	TEV	Sr
0	0.00	1928.2	0.10	0.351	0.976
2	13.79	1926.5	1.41	0.333	0.93
4	27.58	1925.4	2.81	0.322	0.90
6	41.37	1924.6	4.22	0.314	0.87
8	55.16	1924.4	5.63	0.311	0.87
12	82.74	1923.9	8.44	0.306	0.85
16	110.32	1922.0	11.25	0.287	0.80
20	137.90	1919.8	14.06	0.264	0.74
24	165.48	1916.6	16.88	0.231	0.64
30	206.85	1914.8	21.10	0.213	0.59
36	248.22	1913.9	25.31	0.203	0.57
42	289.59	1913.0	29.53	0.194	0.54
50	344.75	1912.2	35.16	0.186	0.52



RAPPORT FINAL

Essais de laboratoire sur des matériaux provenant d'un banc d'emprunt près du site minier LTA

Pour :

Golder et Associés ltée

M. Jean-François Ricard, ing., M.Sc.A.

Par :

Bruno Bussière, ing., M.Sc.A.

URSTM

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LE 18 MARS 1997

TABLE DES MATIÈRES

1. Mandat et portée de l'étude

Le mandat consiste à réaliser des essais géotechniques sur des matériaux d'origine naturelle utilisés lors de la construction d'une couverture multicouche sur le site LTA. Les essais à réaliser ont été déterminés lors d'une rencontre entre M. Jean-François Ricard de Golder et Associés ltée et l'auteur de ce document, à l'automne 96. Les résultats obtenus et présentés dans ce rapport sont valables pour les échantillons de matériaux amenés à l'UQAT par Golder et Associés ltée.

2. Nature des travaux

Les travaux réalisés dans ce projet sont les suivants :

1. détermination des teneurs en eau naturelles (5) et sélection de deux échantillons ;
2. réalisation d'analyses granulométriques et d'essais de densité relative sur les échantillons LTA-2 et LTA-4 provenant des bancs d'emprunts situés près du site minier LTA ;
3. détermination des limites de consistance des deux échantillons sélectionnés ;
4. réalisation d'essais de succion (2) sur les matériaux sélectionnés.
5. rédaction du rapport.

3. Teneurs en eau naturelles, analyses granulométriques et densité relative

Dans un premier temps, des teneurs en eau ont été réalisées sur les échantillons amenés par Golder et Associés ltée, soit les échantillons LTA-1, LTA-2, LTA-3, LTA-4 et LTA-5. À partir des teneurs en eau et des caractéristiques visuelles des matériaux, la sélection des échantillons LTA-2 et LTA-4 a été faite conjointement par l'URSTM et Golder et Associés ltée. Des analyses granulométriques ont été réalisées par la suite sur les deux échantillons sélectionnés. La méthodologie utilisée pour l'analyse granulométrique est celle proposée par la norme **ASTM D422**, soit du tamisage pour la fraction du sol dont le diamètre des grains est supérieur à 74 µm et par l'utilisation de la sédimentométrie pour la fraction plus petite que 74 µm. Pour réaliser des essais de sédimentométrie, on doit connaître la densité relative des grains solides D_r du matériau. Dans ce projet, deux essais pour la détermination de D_r ont été réalisés selon les standards établis dans la norme **NQ 2501-070**. Les principaux résultats obtenus en terme de granulométrie, de densité relative et des teneurs en eau naturelles sont présentés au tableau 1. On présente également la courbe granulométrique complète des deux matériaux en annexe.

Tableau 1 : Principaux résultats des essais de teneurs en eau naturelles, de densité relative et des analyses granulométriques.

	LTA-1	LTA-2	LTA-3	LTA-4	LTA-5
D_r	---	2,72	---	2,72	---
% passant au tamis #200	---	100	---	100	---
Teneur en eau naturelle	36,4	23,86	34,93	35,89	38,83

4. Limites de consistance

Les limites de consistance ont été déterminées au laboratoire sur les matériaux LTA-2 et LTA-4 à l'aide de l'appareil de Casagrande. La norme suivie pour la réalisation de cet essai est **ASTM D4318**. Les résultats obtenus sont présentés au tableau 2. Les résultats détaillés de l'essai sont présentés en annexe.

Tableau 2 : Principaux résultats des limites de consistance

Échantillon	w_L	w_P	I_P
LTA-2	21,90	17,96	3,94
LTA-4	30,45	20,33	10,12

5. Détermination des courbes caractéristiques de succion

La procédure d'essai utilisée pour l'obtention des courbes caractéristiques de succion est définie par la norme **ASTM D3152**. L'échantillon de sol est placé sur une plaque céramique poreuse (qui retient l'eau jusqu'à une pression de 5 bars) dans une cellule pressurisée (appelée communément Tempe Cell) où l'échantillon est soumis à une pression d'air positive tandis que l'eau de sortie subit une pression équivalente à la pression atmosphérique. La pression dans la cellule devient en équilibre avec le sol qui se draine jusqu'à équilibre. En procédant par pallier de pression et en mesurant chaque fois la quantité d'eau évacuée, on peut déterminer la courbe caractéristique de succion qui consiste en un graphique de la teneur en eau (ou la saturation) versus la pression appliquée. Dans ce projet, la valeur du AEV (Air Entry Value) est évaluée en utilisant la méthode des deux droites proposée par Fredlund et Xing (1994).

Deux essais de succion ont été réalisés dans cette étude, soit un essai sur le matériau LTA-2 et un essai sur la matériau LTA-4. Les résultats obtenus sont résumés au tableau 3, tandis que les résultats détaillés sont présentés en annexe.

Tableau 3 : Principaux résultats des essais de succion

	LTA-2	LTA-4
AEV (m d'eau)	13,5	>45
Indice des vides	0,70	0,80

6. Conclusion

En ce qui concerne les matériaux LTA-2 et LTA-4 provenant d'un banc d'emprunt situé près du parc à résidus miniers LTA, les analyses granulométriques ont montré que l'on est en présence de matériaux fins ayant 100 % passant au tamis 200 et un pourcentage élevé de particules < 2µm (environ 25 % pour LTA-2 et environ 50 % pour LTA-4). Les limites de consistance effectuées sur ces matériaux ont donné des résultats différents, avec une limite de liquidité et un indice de plasticité plus élevés pour l'échantillon LTA-4. En ce qui concerne les caractéristiques de rétention d'eau, la pression à l'entrée d'air (AEV) de l'échantillon LTA-2 a été mesurée à environ 13,5 m d'eau. La courbe mesurée a été comparée avec celle prédite par le modèle de Kovacs modifié (Aubertin et *al.*, 1997) et les résultats ont montré une excellente corrélation (voir annexe). Quant aux caractéristiques de rétention d'eau du matériau LTA-4, il a été impossible d'atteindre la pression à l'entrée d'air du matériau avec la TEMPE Cell. En effet, à des pressions inférieures à 45 m d'eau (limite de l'appareil), le matériau ne se draine pas. D'ailleurs, à partir des caractéristiques du matériau LTA-4, le modèle de Kovacs modifié prédit une pression à l'entrée d'air d'environ 100 m d'eau (voir figure en annexe). La seule conclusion que l'on peut tirer de l'essai de succion réalisé sur LTA-4 est que la pression à l'entrée d'air est supérieure à 45 m d'eau.

RÉFÉRENCES

AUBERTIN, M., RICARD, J.F. et CHAPUIS, R.P. 1996. A predictive model for the water retention curve : application to tailings from hard rock mines. Submitted to the Canadian Geotechnical Journal.

FREDLUND, D.G. et XING, A. 1994. Equations for the soil-water characteristic curve. Canadian Geotechnical Journal, 31: 521-532.

ANNEXE

DÉTERMINATION DE LA TENEUR EN EAU
NQ 2501-170

Projet: Golder	Effectuée par: Darcy Jolette
Date: 96-08-28	Provenance: Terrain Aurifère

Echantillon:	LTA-1	LTA-2	LTA-3	LTA-4	LTA-5
Pds de la tare:	12.3	12.1	12.0	12.1	12.3
Pds de la tare + sol humide:	231.5	299.7	484.8	235.1	301.2
Pds de la tare + sol sec:	173.0	244.3	362.4	176.2	220.4
Pds du sol sec:	160.7	232.2	350.4	164.1	208.1
Pds de l'eau:	58.5	55.4	122.4	58.9	80.8
Teneur en eau naturelle (W%):	36.40	23.86	34.93	35.89	38.83

Observation:

La date de prélèvement est inconnue.

DENSITE RELATIVE DES GRAINS

LOCALISATION	Terrain Aurifère
DATE	4 sept. 1996
ECHANTILLON	LTA-2

DR-1

PYNOMETRE NO	1	2
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	720,3	724,98
TEMPERATURE D'ESSAI	23,3	23,3
PDS PYCNOMETRE +EAU GRS (M2T2)	681,32	687,18
TARE NO		
PDS DE LA TARE + SOL SEC GRS. (MS)	285,19	281,54
PDS DE LA TARE	223,52	221,88
PDS DU SOL SEC GRS	61,67	59,66

MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0,99702	0,99699
MASSE VOLUMIQUE DE L'EAU @ 20 C	0,99823	0,99823

DENSITE RELATIVE (DR)	2,718	2,729
DENSITE RELATIVE CORRIGE	2,715	2,725

MOYENNE 2,72

DENSITE RELATIVE DES GRAINS

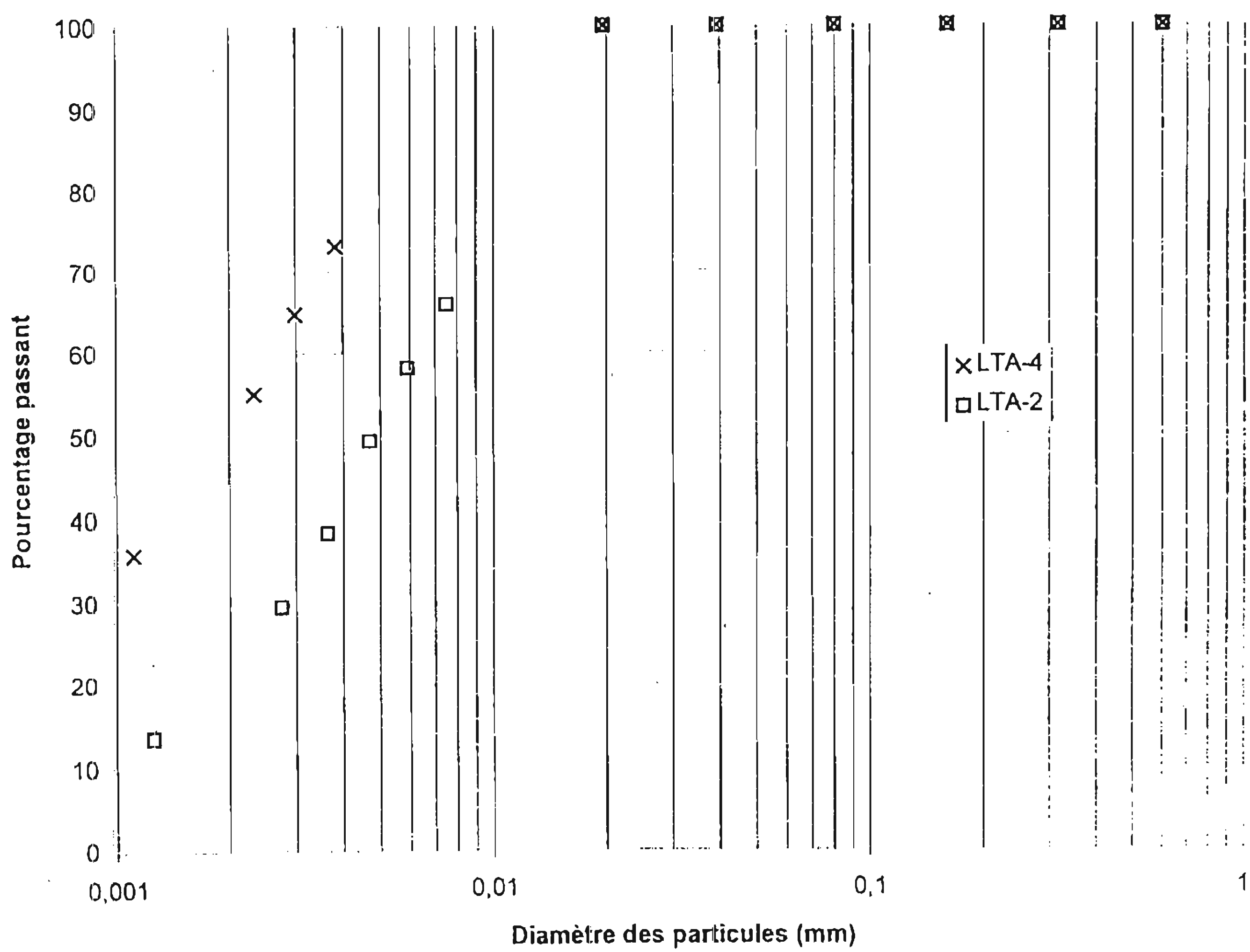
LOCALISATION	Terrain Aurifère
DATE	13-03-97
ECHANTILLON	LTA 4

PYNOMETRE NO	1	2
PDS PYCNOMETRE + EAU + SOL GRS (M3T2)	718.98	725.14
TEMPERATURE D'ESSAI	23.8	24.1
PDS PYCNOMETRE +EAU GRS (M2T2)	681.26	687.10
TARE NO	1	2
PDS DE LA TARE + SOL SEC GRS. (MS)	283.78	283.56
PDS DE LA TARE	224.16	223.52
PDS DU SOL SEC GRS	59.62	60.04

MASSE VOLUMIQUE DE L'EAU D'ESSAI (PWT2)	0.99702	0.99699
MASSE VOLUMIQUE DE L'EAU @ 20 C	0.99823	0.99823

DENSITE RELATIVE (DR)	2.723	2.729
DENSITE RELATIVE CORRIGE	2.719	2.726

MOYENNE **2.72**



Pourcentage passant
100
90
80
70
60
50
40
30
20
10
0
0,001
0,01
0,1
1
Diamètre des particules (mm)
LTA-4
LTA-2

ESSAI DE RÉTENTION CAPILLAIRE

Nom de l'échantillon:	LTA-2
Numéro du moule:	U1
Date du montage:	18/11/1996

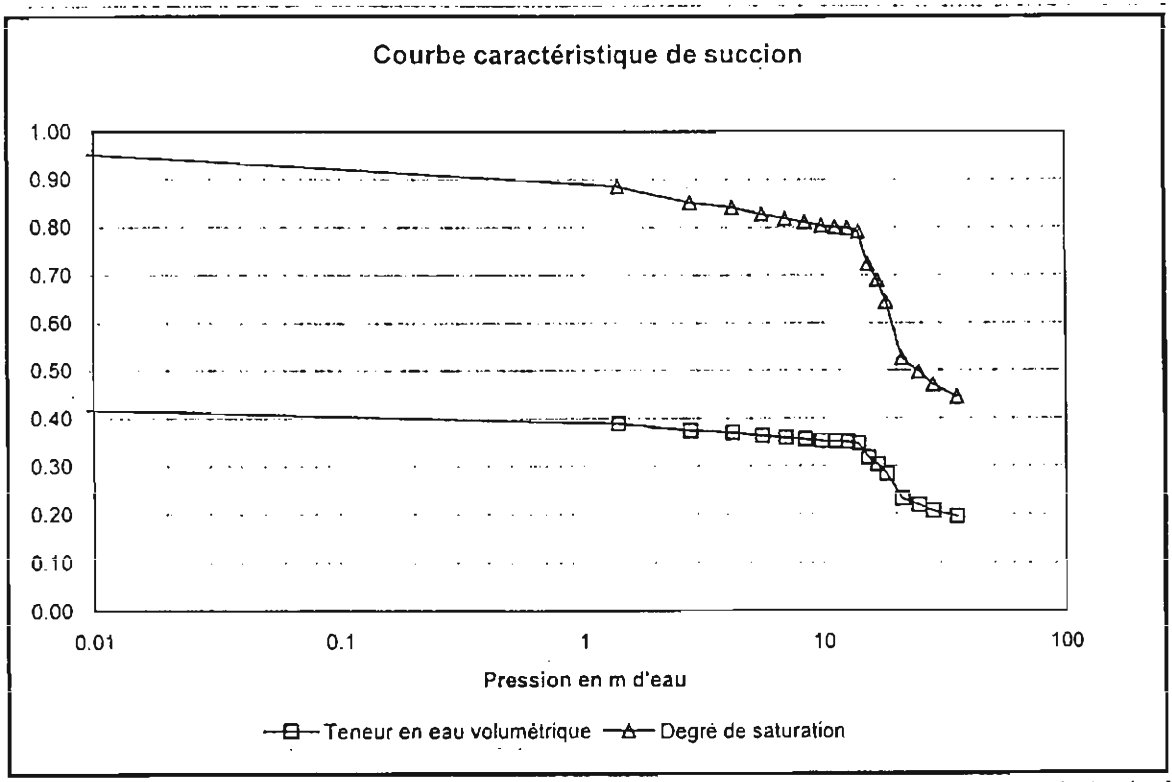
Caractéristiques de l'essai

Dr	2.72
Volume de l'anneau:	98.97
Volume du sol final	94.28
Anneau + plaque:	365.7
Masse humide initiale:	192.58
Masse humide finale:	181.69
Teneur en eau initiale	27.5%
Tare:	86.22
Tare + sol sec	237.27
Masse sec finale	151.05

Indice des vides final:	0.70
Indice des vides initial:	0.78
TEV initiale:	0.42
Saturation initiale:	95.6%
TEV finale:	0.18
Saturation finale:	44.4%

Résultats

Psi	kPa	m H2O	Montage (g)	TEV	% saturation
0	0.07	0.01	1846.8	0.42	95.6%
2	13.79	1.41	1843.9	0.39	88.6%
4	27.58	2.81	1842.5	0.37	85.2%
6	41.37	4.22	1842.1	0.37	84.3%
8	55.16	5.62	1841.5	0.36	82.8%
10	68.95	7.03	1841.1	0.36	81.8%
12	82.74	8.44	1840.8	0.36	81.1%
14	96.53	9.84	1840.5	0.35	80.4%
16	110.32	11.25	1840.4	0.35	80.1%
18	124.11	12.66	1840.3	0.35	79.9%
20	137.90	14.06	1840.0	0.35	79.2%
22	151.69	15.47	1837.2	0.32	72.4%
24	165.48	16.87	1835.8	0.30	69.0%
26	179.27	18.28	1833.9	0.28	64.4%
30	206.85	21.09	1829	0.23	52.6%
35	241.33	24.61	1827.8	0.22	49.7%
40	275.80	28.12	1826.7	0.21	47.0%
50	344.75	35.15	1825.6	0.19	44.4%



SATURATION AU PERMEAMETRE

GEOMETRIE	
Echantillon:	LTA-2
Diamètre:	8.258 cm
Hauteur :	7.20 cm
Surface:	53.634 cm^2
Volume :	386.163 cm^3
Masse initial	755.5 g.
W%	15%

MASSE	
Tare (Perméamètre sec)	1524.90 g.
Tare + sol sec	2133.60 g.
Sol sec	608.70 g.
Tare + eau	2219.00 g.
Tare + eau + sol	2588.60 g.
Sol humide	755.76 g.
Eau dans le sol	147.06 g.

DEGRE DE SATURATION	
Densité des solides	2.72
Volume des vides	162.376 cm^3
Degré de saturation	0.906
Indice des vides	0.73
Masse volumique hum.	1.957 g/cm^3
Masse volumique sec.	1.576 g/cm^3

ESSAI DE RÉTENTION CAPILLAIRE

Nom de l'échantillon:	LTA-4
Numéro du moule:	U1
Date du montage:	97-02-06

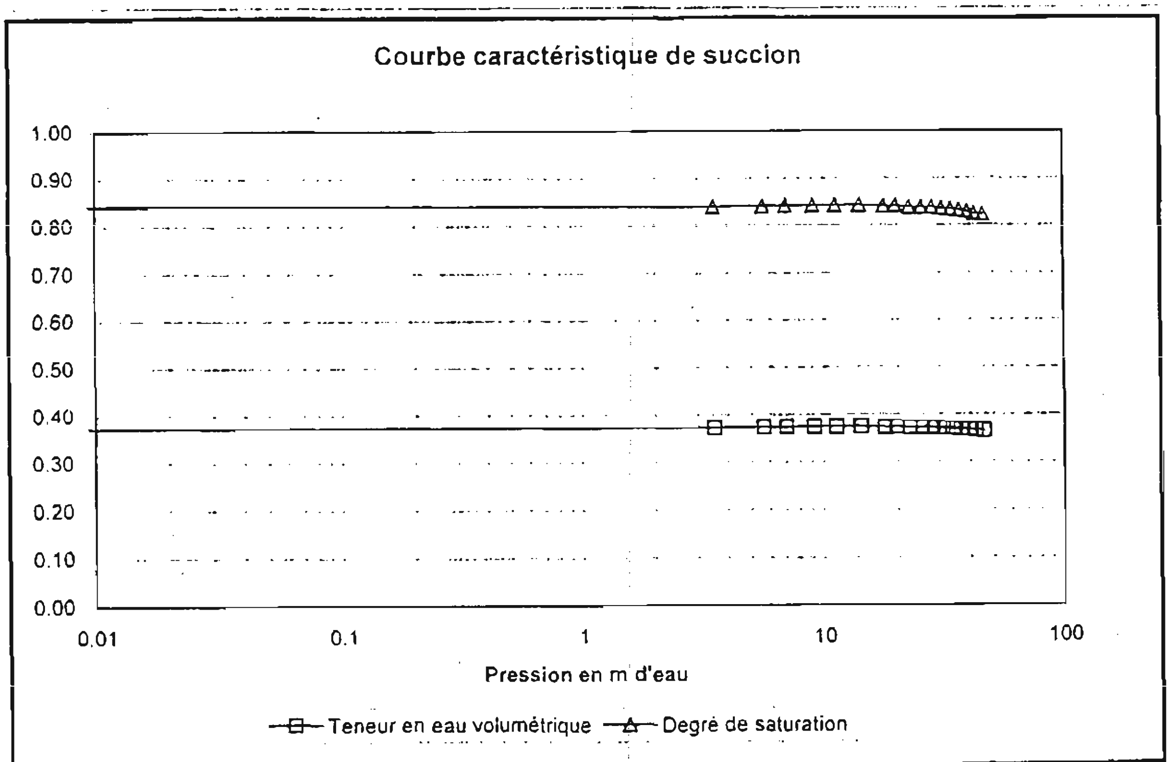
Caractéristiques de l'essai

Dr	2.72
Volume de l'anneau:	98.99
Volume du sol final	98.99
Anneau + plaque:	365.67
Masse humide initiale:	186.80
Masse humide finale:	184.15
Teneur en eau initiale	24.7%
Tare:	84.97
Tare + sol sec	234.77
Masse sec finale	149.80

Indice des vides final:	0.80
Indice des vides initial:	0.80
TEV initiale:	0.37
Saturation initiale:	84.3%
TEV finale:	0.36
Saturation finale:	82.2%

Résultats

Psi	kPa	m H2O	Montage (g)	TEV	% saturation
0	0.07	0.01	1842.3	0.37	84.3%
5	34.48	3.52	1842.2	0.37	84.0%
8	55.16	5.62	1842.2	0.37	84.0%
10	68.95	7.03	1842.3	0.37	84.3%
13	89.64	9.14	1842.3	0.37	84.3%
16	110.32	11.25	1842.3	0.37	84.3%
20	137.90	14.06	1842.3	0.37	84.3%
25	172.38	17.58	1842.2	0.37	84.0%
28	193.06	19.69	1842.3	0.37	84.3%
32	220.64	22.50	1842.1	0.37	83.8%
36	248.22	25.31	1842.1	0.37	83.8%
40	275.80	28.12	1842.1	0.37	83.8%
44	303.38	30.94	1842	0.37	83.6%
48	330.96	33.75	1841.9	0.37	83.3%
52	358.54	36.56	1841.8	0.37	83.1%
56	386.12	39.37	1841.7	0.37	82.9%
60	413.70	42.18	1841.5	0.37	82.4%
65	448.18	45.70	1841.4	0.36	82.2%



SATURATION AU PERMEAMETRE

GEOMETRIE	
Echantillon:	LTA-4
Diamètre:	8.258 cm
Hauteur :	8.15 cm
Surface:	53.634 cm²
Volume :	437.115 cm³
Masse initial	812.8 g.
W%	15%

MASSE	
Tare (Perméamètre sec)	1432.20 g.
Tare + sol sec	2138.98 g.
Sol sec	706.78 g.
Tare + eau	2229.00 g.
Tare + eau + sol	2670.10 g.
Sol humide	878.22 g.
Eau dans le sol	171.43 g.

DEGRÉ DE SATURATION	
Densité des solides	2.72
Volume des vides	177.269 cm³
Degré de saturation	0.967
Indice des vides	0.68
Masse volumique hum.	2.009 g/cm³
Masse volumique sec.	1.617 g/cm³

LABORATOIRE URSTM

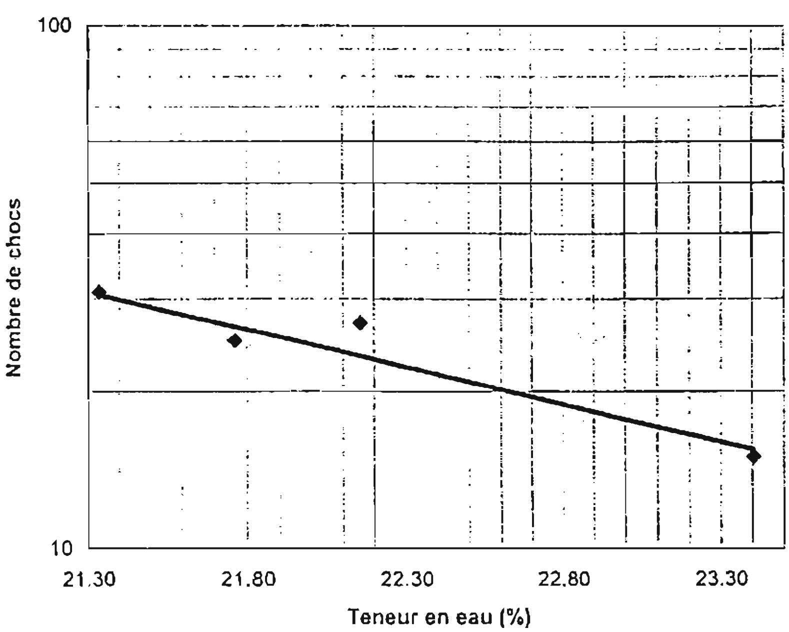
LIMITES DE CONSISTANCE D'ATTERBERG

NQ 2501-090

PROJET:	Golder	Effectué par:	Darcy Jolette
Échantillon:	LTA-2	Date de l'essai:	10-01-1997

Limites de liquidité W_L					
Capsule #	1	2	3	4	
W_T + tare (g)	36.70	36.90	33.80	31.70	
W_S + tare (g)	32.30	32.70	30.10	28.50	
W_W (g)	4.40	4.20	3.70	3.20	
Tare(g)	13.50	13.40	13.40	13.50	
W_S (g)	18.80	19.30	16.70	15.00	
W %	23.40	21.76	22.16	21.33	
Nb. de chocs	15	25	27	31	

Limites de plasticité W_P	
5	6
25.00	27.80
23.20	25.70
1.80	2.10
13.50	13.60
9.70	12.10
18.56	17.36



TENEUR EN EAU À LA RÉCEPTION	
Capsule #	X
W_T + tare (g)	299.70
W_S + tare (g)	244.30
W_W (g)	55.40
Tare(g)	12.10
W_S (g)	232.20
W %	23.86

RÉSULTATS	
W_L %	21.90
W_P %	17.96
I_P %	3.94
W_N %	23.86

OBSERVATION:

L'échantillon a été préparé selon la méthode de l'article 5.1.
La réalisation de l'essai a été effectuée par assèchement.
L'article 5.1.1 de la norme 2501-90 a été modifié car l'échantillon a été séché préalablement.

LABORATOIRE URSTM

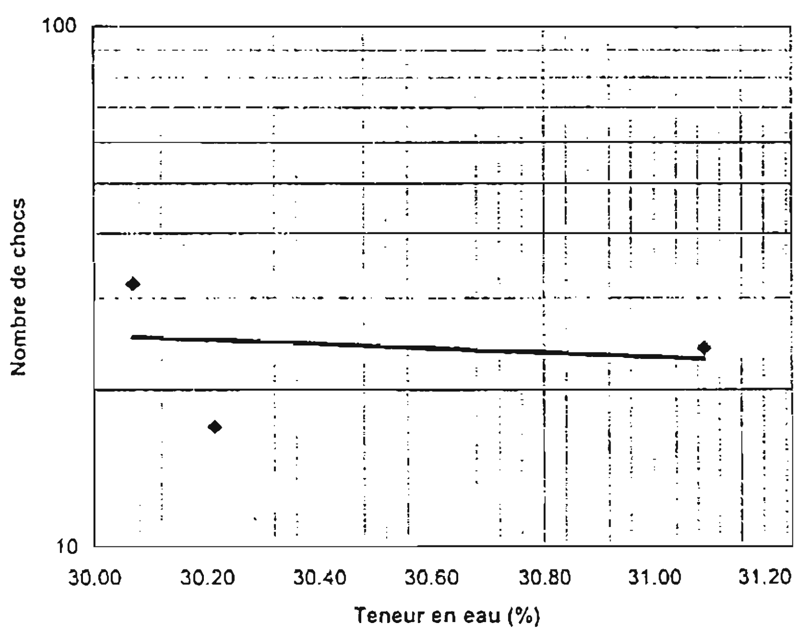
LIMITES DE CONSISTANCE D'ATTERBERG

NQ 2501-090

PROJET:	Golder	Effectué par:	Darcy Jolette
Échantillon:	LTA-4	Date de l'essai:	13-03-1997

Limites de liquidité W_L					
Capsule #	1	2	3		
W_T + tare (g)	31.14	35.64	38.19		
W_S + tare (g)	27.04	30.37	32.48		
W_W (g)	4.10	5.27	5.71		
Tare(g)	13.47	13.42	13.49		
W_S (g)	13.57	16.95	18.99		
W %	30.21	31.09	30.07		
Nb. de chocs	17	24	32		

Limites de plasticité W_P	
4	5
27.30	27.37
24.96	25.04
2.34	2.33
13.48	13.55
11.48	11.49
20.38	20.28

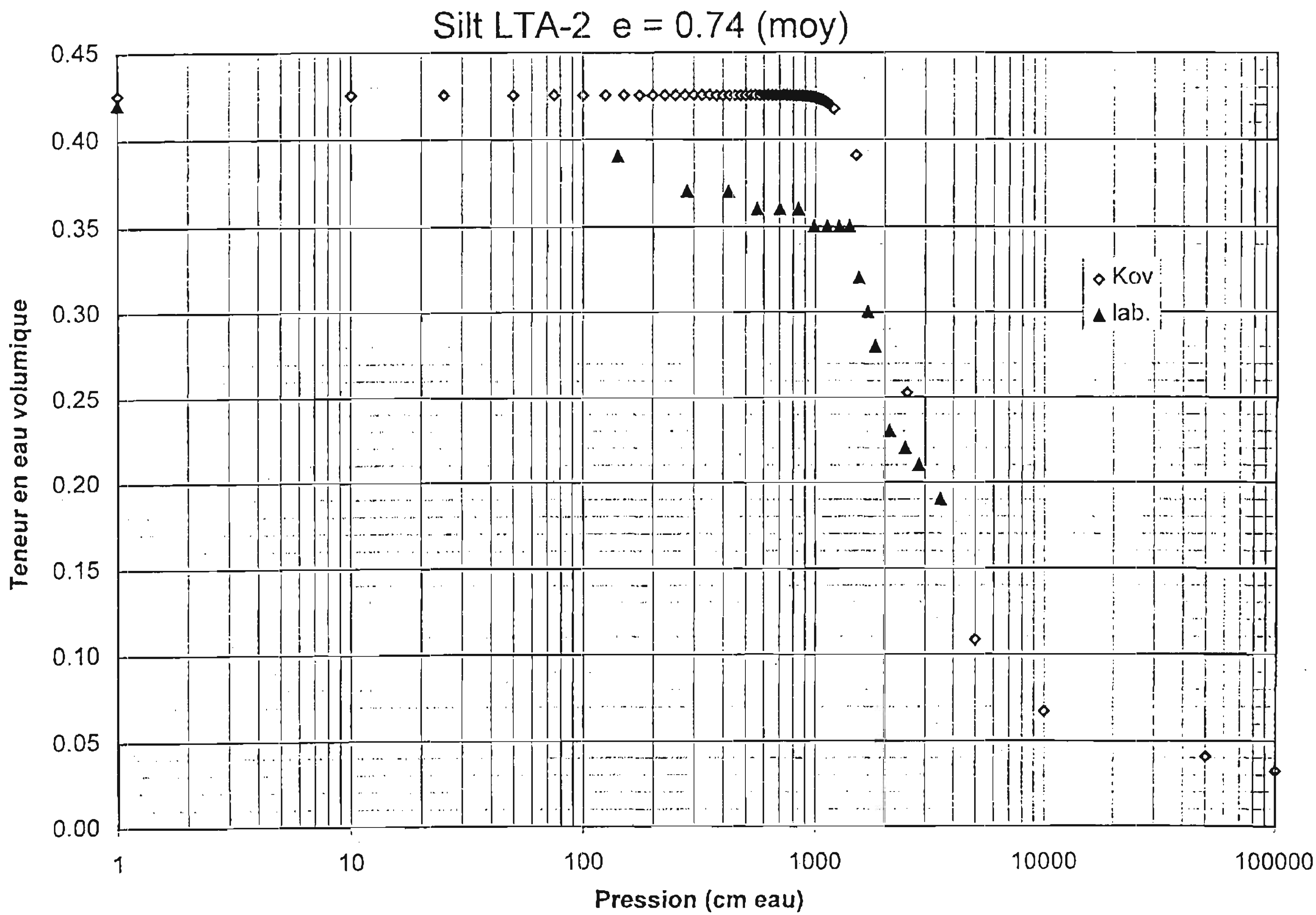


TENEUR EN EAU À LA RÉCEPTION	
Capsule #	X
W_T + tare (g)	235.10
W_S + tare (g)	176.20
W_W (g)	58.90
Tare(g)	12.10
W_S (g)	164.10
W %	35.89

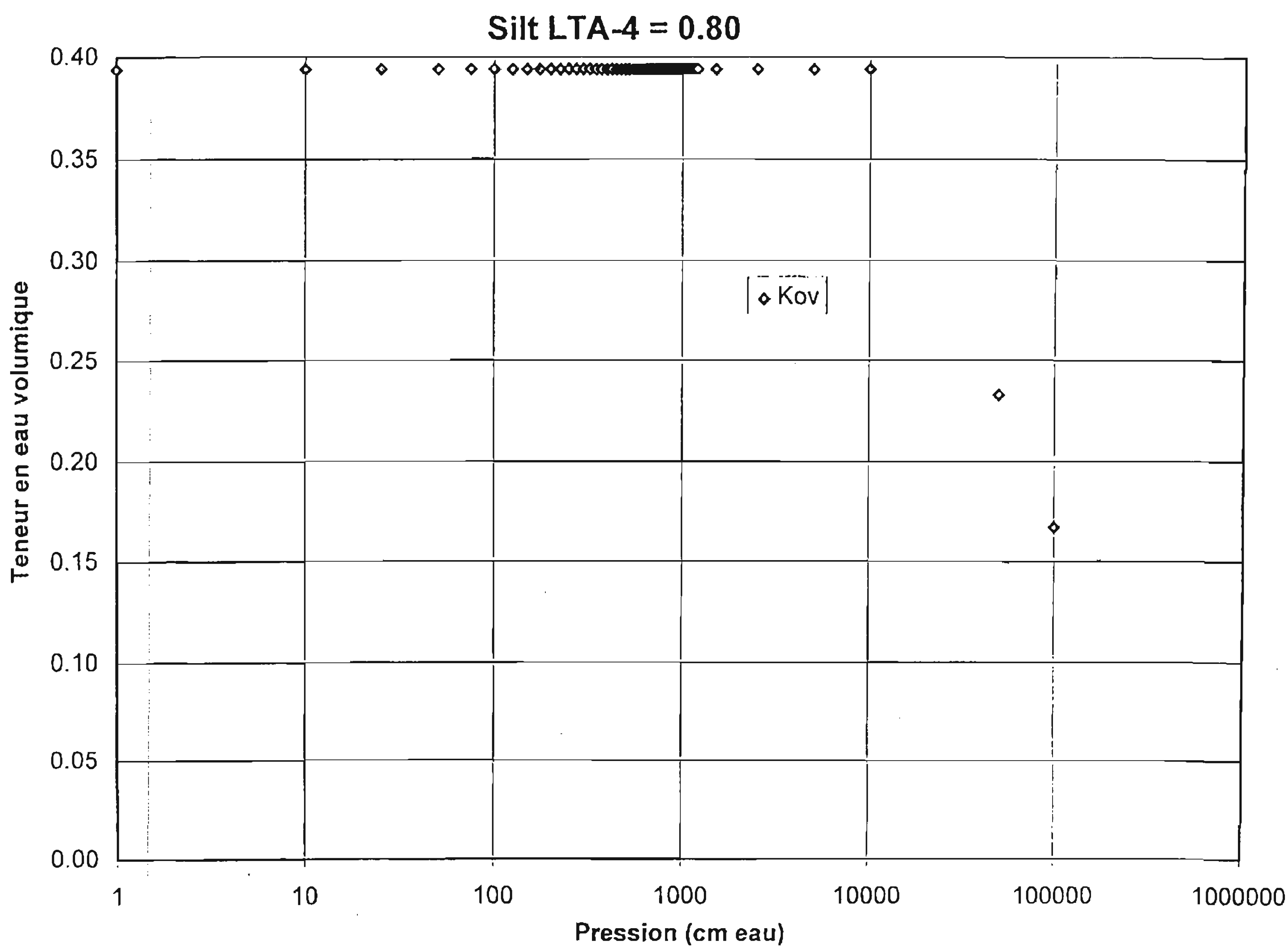
RÉSULTATS	
W_L %	30.45
W_P %	20.33
I_P %	10.12
W_N %	35.89

OBSERVATION:

L'échantillon a été préparé selon la méthode de l'article 5.1.
La réalisation de l'essai a été effectuée par assèchement.
L'article 5.1.1 de la norme 2501-90 a été modifié car l'échantillon a été séché préalablement.



Silt LTA-2 e = 0.74 (moy)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Teneur en eau volumique
1
10
100
1000
10000
100000
Pression (cm eau)
Kov
lab.


Silt LTA-4 = 0.80
Teneur en eau volumique
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Kov
1
10
100
1000
10000
100000
1000000
Pression (cm eau)

APPENDIX E

PARTICLE MIGRATION TESTS RESULTS

(École Polytechnique)

GOLDER ET ASS.

ESSAI DE MIGRATION DES PARTICULES

COLONNE no. 1

Pds filtre init.		24.7	24.7	date	heure	min.	QTE eau	tare + eau	eau net	QTE eau	QTE eau	Diff. entre
Pds filtre finale						total	cc Ajouté			cc Sortie	cc Entrée	eau in/out
				27-11-95	10:30	0	1300	321	0	0	1300	1300
HAUTEUR INIT. SABLE	49.7	Gs	2.819		11:30	60	1000	421	110	110	2300	2190
DIAM. DE LA COLONNE	15.2				12:42	132	1000	1407	986	1096	3300	2204
		teneur en eau auxil.			16:30	360	1000	2424	1017	2113	4300	2187
Pds des couches de sabl	998	Tare	121	28-11-95	14:20	2690	1000	3642	1218	3331	5300	1969
	999	Pds sol hum. + tare	631.6		20:00	3030	1000	1285	964	4295	6300	2005
	1002	Pds sol sec + tare	615.8	29-11-95	7:30	3030		OUBLIE VALVE FERMEE		4295	6300	2005
	1000	Pds tare	123.0		10:00	3030	1000	2083	798	5093	7300	2207
	1004				17:30	3630	1000	3378	1295	6388	8300	1912
	1000	teneur en eau	3.2	30-11-95	7:45	4485	1000	1384	1063	7451	9300	1849
	1005				13:35	4835	1000	2282	1219	8670	10300	1630
	1008			01-12-95	8:00	5940	1000	3358	1078	9748	11300	1554
	1001			02-12-95	8:20	7400	1000	1355	1034	10780	12300	1520
	540				12:20	7640	1000	2308	953	11733	13300	1567
				03-12-95	8:20	8840	1000	3476	1168	12901	14300	1399
Total du sable humide	9557	Total du sable sec	9138.5		10:40	8980	1000	1202	881	13782	15300	1518
		teneur en eau init.	4.6	04-12-95	7:30	10230	1000	2292	1090	14872	16300	1428
Hauteur finale	19.5				11.05	10445	1000	3111	819	15691	17300	1609
Hauteur du sable	30.2	Total du sable hum.			18.00	10860	1000	1373	1052	16743	18300	1557
Volume	5480.1	final	10273.0		20.00	10980	1000	2260	907	17650	19300	1650
Pds Unit. hum.	1.744	teneur en eau finale	12.4	05-12-95	7.00	11640	1000	3474	1194	18844	20300	1456
Pds unitaire sec	1.668			06-12-95	8.15	11715	1000	1230	909	19753	21300	1547
Indice des vides	0.687				14.45	12105	1000	2222	992	20745	22300	1555
Porosité	0.407			07-12-95	9.30	13230	2000	3308	1086	21831	24300	2469
					13.45	13485	2000	2265	1944	23775	26300	2525
				08-12-95	7.30	14550	2000	2391	2070	25845	28300	2455
		teneur en eau auxil.			10.00	14700	2000	4084	1693	27538	30300	2762
Pds des couches de résid	1014	Tare	101		14.10	14830	2000	2412	2091	29629	32300	2671
	996	Pds sol hum. + tare	476.3	11-12-95	8.00	19180	2000	4608	2196	31825	34300	2475
	1016	Pds sol sec + tare	421.6		14.50	19590	2000	2232	1911	33736	36300	2564
	501	Pds tare	128.0	12-12-95	8.40	20580	2000	4260	2028	35764	38300	2536
		teneur en eau	18.6		14.50	20950	2000	2106	1785	37549	40300	2751
				13-12-95	7.20	21940	2000	4273	2167	39716	42300	2584
Total du résidu humide	3527	Total du résidu sec	2962.1		11.05	22165	2000	2000	1679	41395	44300	2905
		teneur en eau init.	19.1		13.30	22310	2000	3995	1995	43390	46300	2910
Hauteur finale	7.3	Total du résidu hum.		14-12-95	9.00	23480	2000	2733	2412	45802	48300	2498
Hauteur des residus	12.2	final	3752.1		11.30	23630	2000	4475	1742	47544	50300	2756
Volume	2213.8	teneur en eau finale	26.7		15.05	23845	2000	2315	1994	49538	52300	2762
Pds Unit. hum.	1.593			15-12-95	9.15	24935	4000	4318	3997	53535	56300	2765
Pds unitaire sec	1.338			18-12-95	8.00	29180	4000	4268	3947	57482	60300	2818
Indice des vides	1.103				10.20	29320	4000	3735	3414	60895	64300	3404
Porosité	0.525				14.30	29570	4000	4865	4544	65440	68300	2860
				19-12-95	7.30	30590	4000	4333	4012	69452	72300	2848
					11.35	30835	4000	4321	4000	73452	76300	2848
				20-12-95	8.30	32090	4000	4314	3993	77445	80300	2855
				03-01-96	9.00	32090	10000			77445	90300	
				04-01-96	8.00	33470		8819	8819	86264	90300	4036

GOLDER & ASS. ESSAI DE PERCOLATION

COLONNE no. 1

TENEUR EN EAU SABLE

13 et 14 CONJOINT
INTERFACE

A PARTIR DU FOND

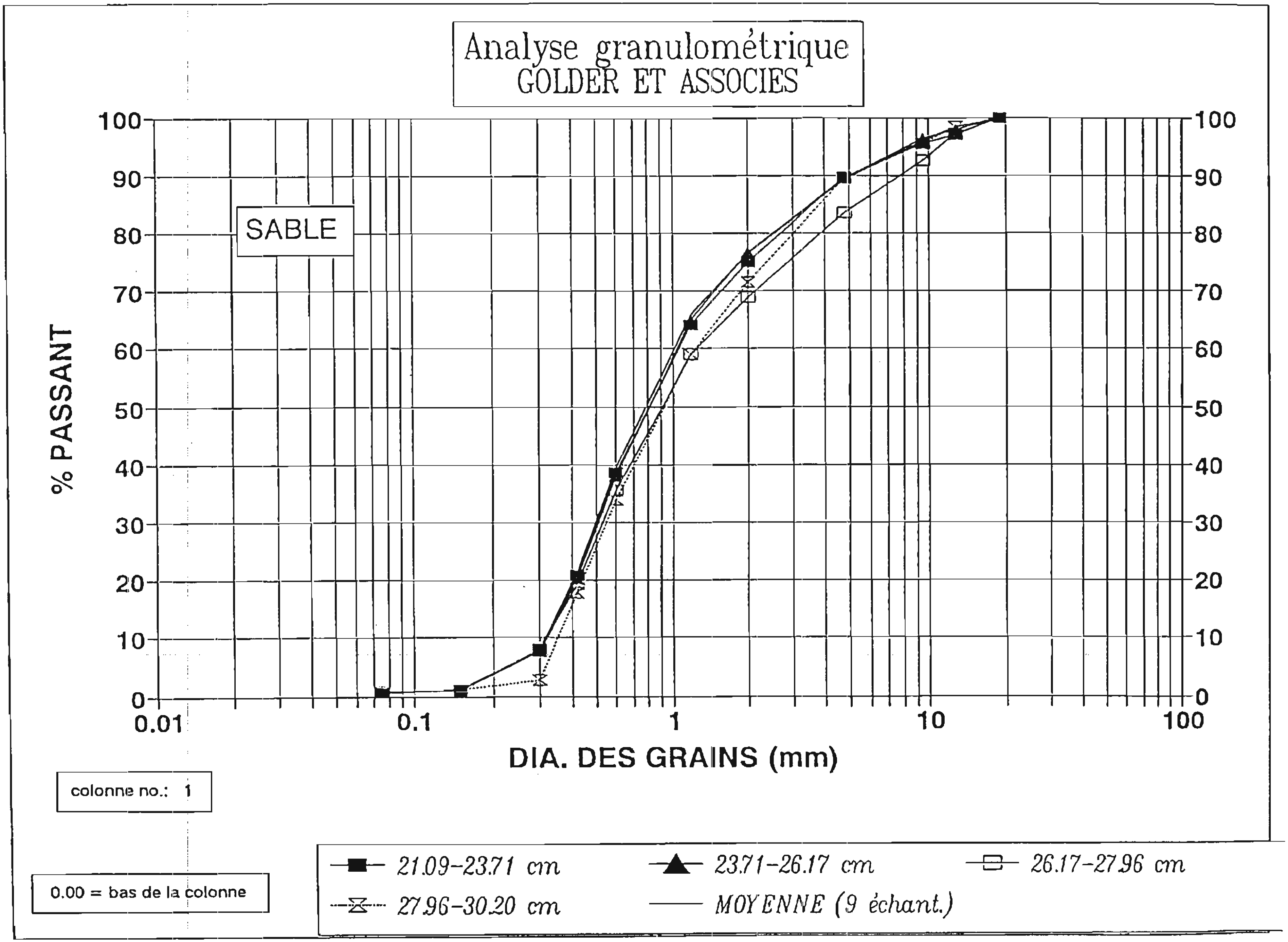
HAUTEUR ESTIME									
TARE no.	P25	P58	20	16	111	122	30	14	13
PDS HUM. + TARE	2548.6	1697.0	1496.8	1139.8	1265.1	958.7	879.2	741.9	884.4
PDS SEC + TARE	2208.5	1474.9	1318.0	1003.4	1161.7	911.6	839.8	712.3	846.6
PDS TARE	162.7	213.5	182.6	104.6	120.8	120.2	94.9	171.1	167.9
PDS SOL SEC	2045.8	1261.4	1135.4	898.8	1040.9	791.4	744.9	541.2	678.7
TENEUR EN EAU (%)	16.6	17.6	15.7	15.2	9.9	6.0	5.3	5.5	5.6
HAUTEUR EN cm.	6.76	10.93	14.68	17.65	21.09	23.71	26.17	27.96	30.20

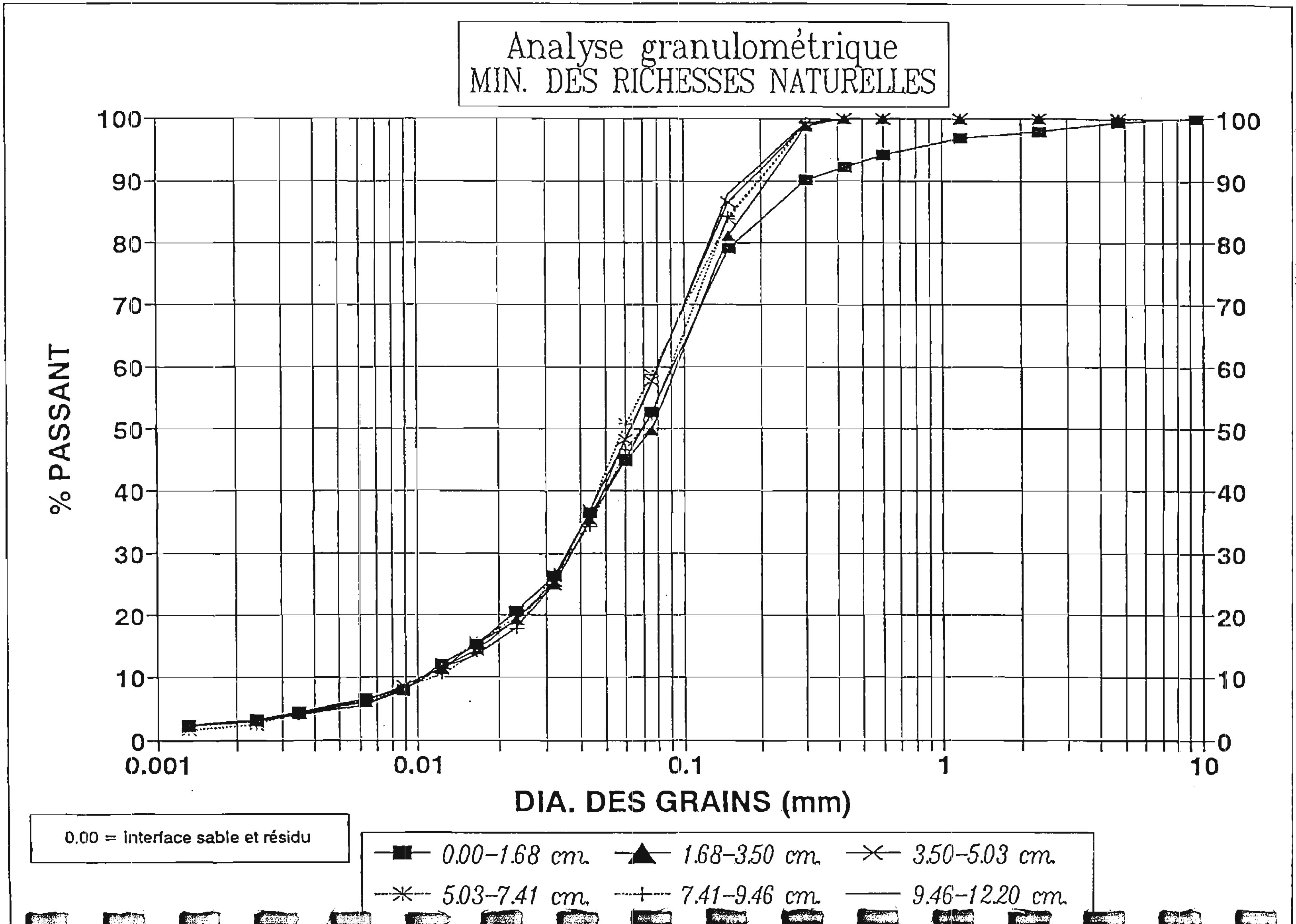
TAMIS (mm) GRANULOMETRIE

19.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.700	28.2	6.9	6.4	10.3	22.0	22.9	15.0	14.8	11.2
9.500	75.8	29.2	41.9	28.9	46.4	36.4	27.3	40.1	30.8
4.750	175.0	104.5	117.6	91.2	115.2	80.7	78.2	89.2	70.5
2.000	33.8	52.3	39.9	52.0	48.7	51.5	49.6	51.9	47.0
1.180	71.7	98.7	81.9	102.0	92.1	90.5	96.2	87.2	79.1
0.595	179.1	214.9	187.1	222.6	204.3	178.7	200.7	170.3	143.4
0.420	256.0	293.0	264.1	306.6	284.6	241.2	270.1	228.1	185.2
0.300	312.8	349.6	320.1	366.3	348.1	286.3	318.6	270.0	224.0
0.150	342.3	379.9	350.5	398.1	381.4	310.4	344.0	292.3	227.8
0.075	344.7	383.4	352.8	400.5	384.1	312.2	345.9	293.9	229.0
Masse Utilisée	347.7	384.8	356.4	403.8	387.0	314.4	348.2	296.6	231.1

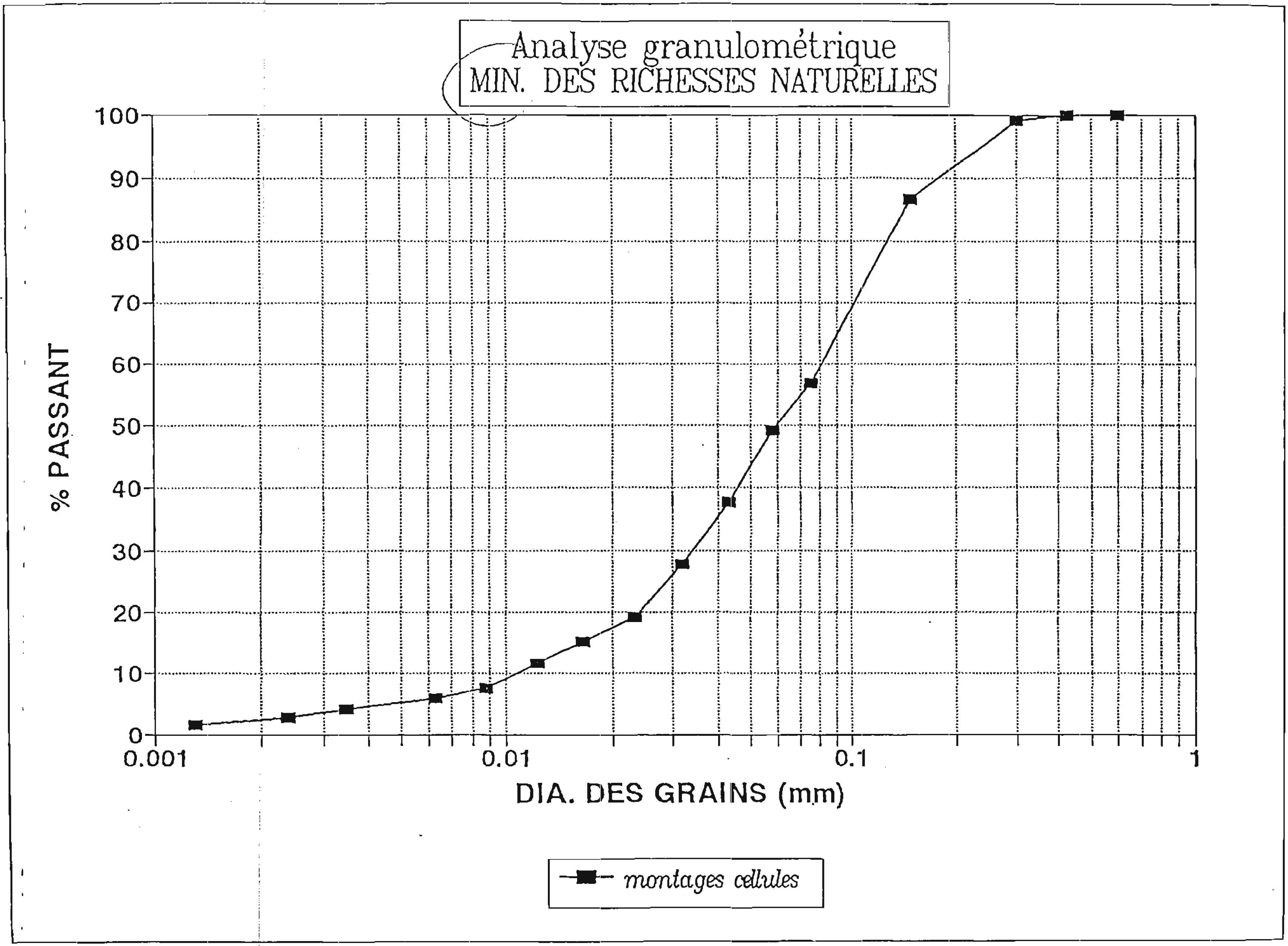
% PASSANT

										MOYENNE
19.000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12.700	98.6	99.5	99.4	98.9	97.9	97.1	98.0	97.3	98.3	98.3
9.500	96.3	97.7	96.3	96.8	95.5	95.4	96.3	92.6	95.5	95.8
4.750	91.4	91.7	89.6	89.9	88.9	89.8	89.5	83.5	89.6	89.3
2.000	82.6	79.3	79.6	78.3	77.7	75.1	76.8	68.9	71.4	76.6
1.180	72.6	68.2	69.0	67.2	67.8	64.0	64.8	59.0	58.9	65.7
0.595	44.3	40.5	42.6	40.3	42.0	38.8	37.9	35.6	34.0	39.6
0.420	24.1	21.9	23.2	21.6	23.5	20.9	20.1	19.3	17.8	21.4
0.300	9.2	8.4	9.1	8.3	8.9	8.0	7.6	7.5	2.8	7.8
0.150	1.4	1.2	1.5	1.3	1.3	1.1	1.1	1.2	1.3	1.3
0.075	0.8	0.3	0.9	0.7	0.7	0.6	0.6	0.8	0.8	0.7

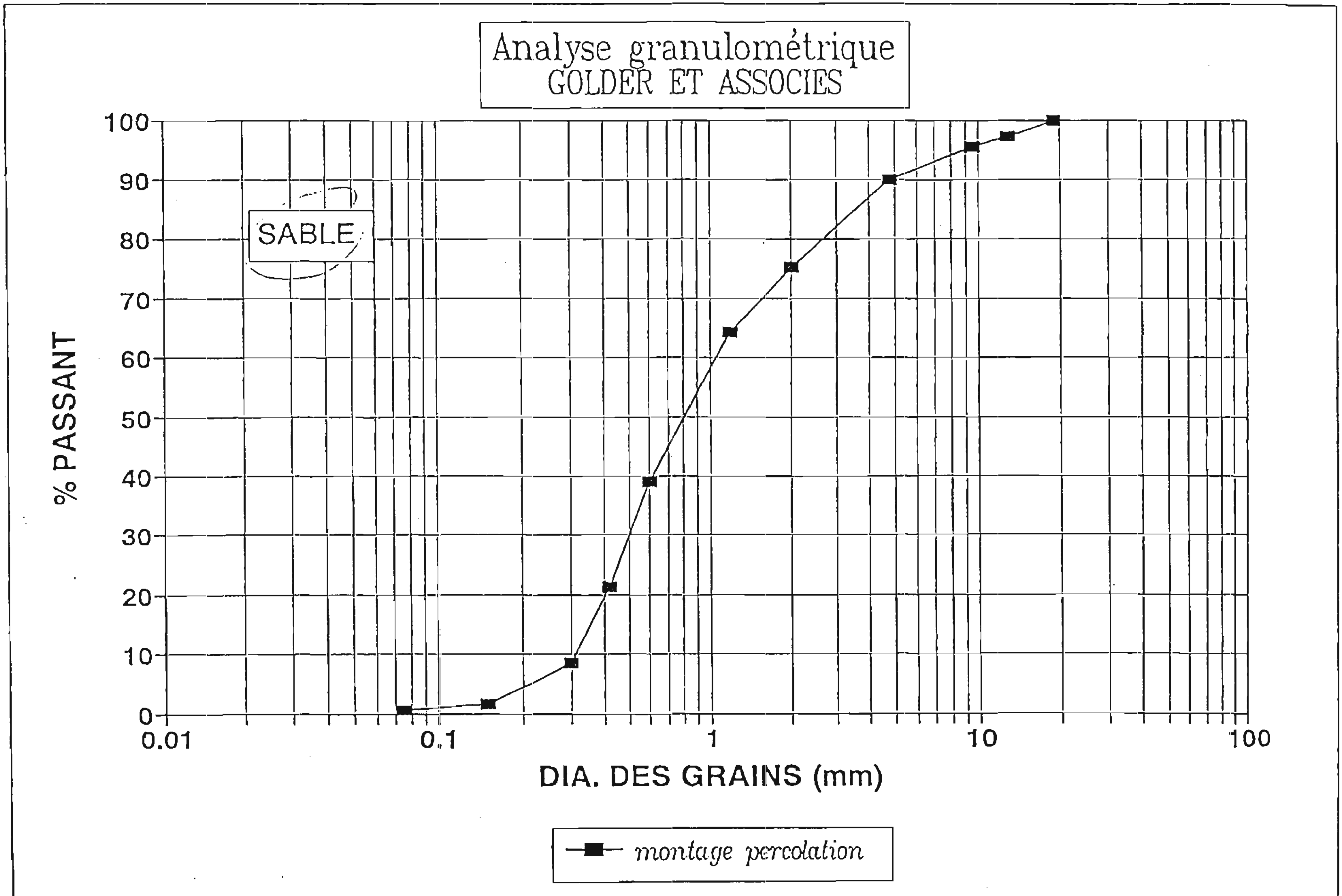

Analyse granulométrique
GOLDER ET ASSOCIES
SABLE
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
DIA. DES GRAINS (mm)
colonne no.: 1
0.00 = bas de la colonne
21.09-23.71 cm
23.71-26.17 cm
26.17-27.96 cm
27.96-30.20 cm
MOYENNE (9 échant.)

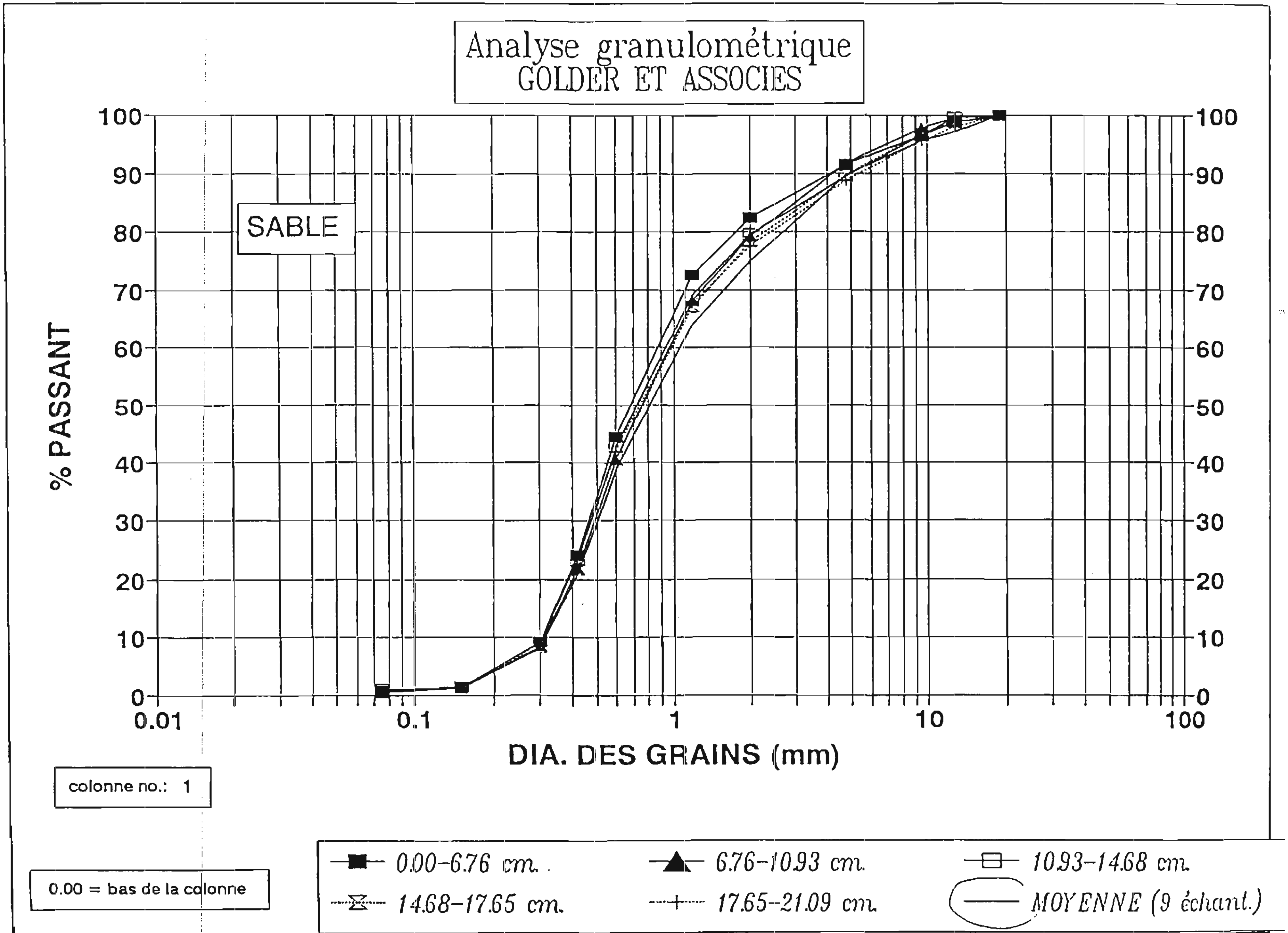


Analyse granulométrique
MIN. DES RICHESSES NATURELLES
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
DIA. DES GRAINS (mm)
0.00 = Interface sable et résidu
0.00-1.68 cm.
1.68-3.50 cm.
3.50-5.03 cm.
5.03-7.41 cm.
7.41-9.46 cm.
9.46-12.20 cm.



Analyse granulométrique
MIN. DES RICHESSES NATURELLES
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
DIA. DES GRAINS (mm)
montages cellules


Analyse granulométrique
GOLDER ET ASSOCIES
SABLE
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
DIA. DES GRAINS (mm)
montage percolation



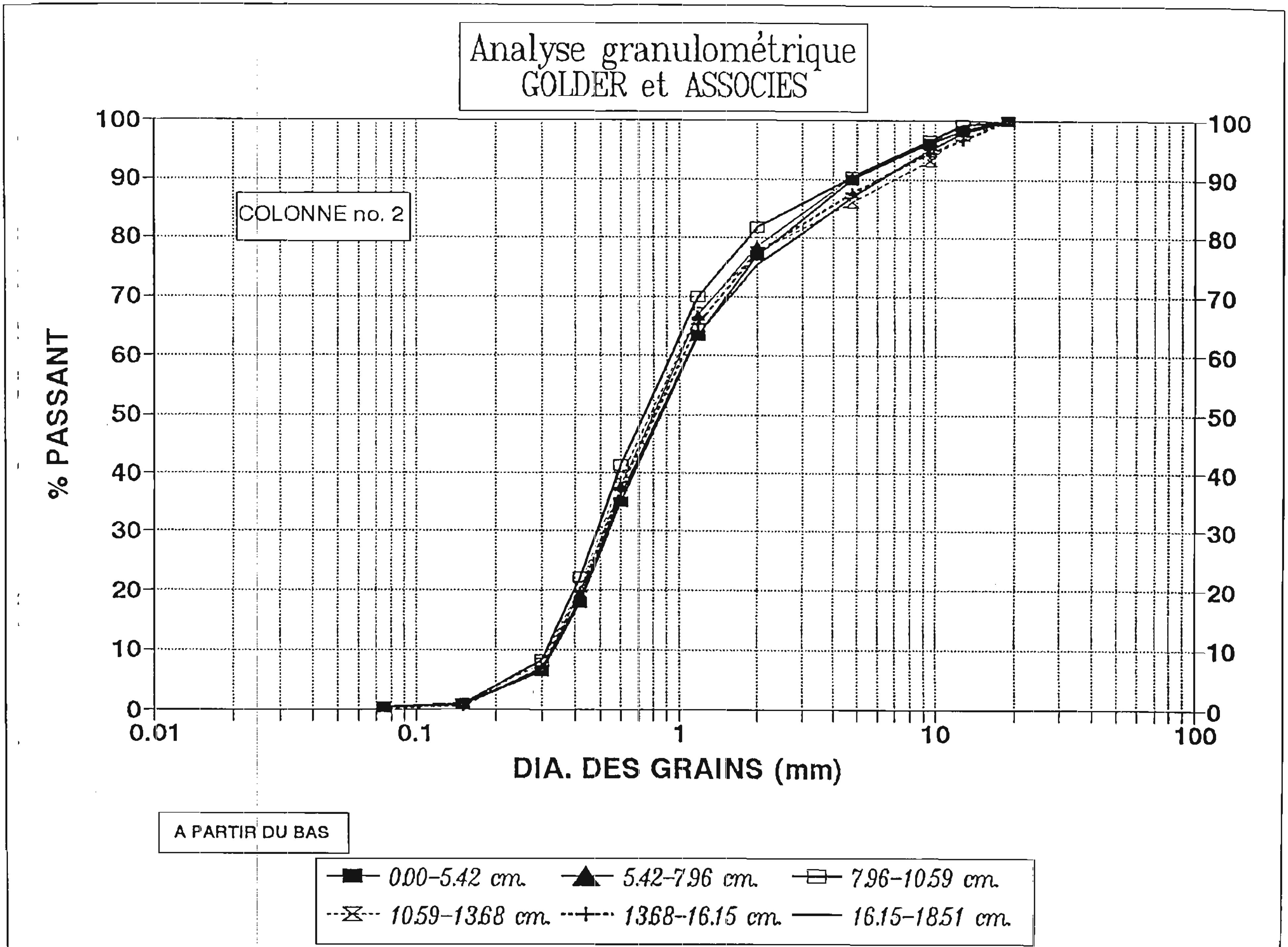
Analyse granulométrique
GOLDER ET ASSOCIES
SABLE
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
DIA. DES GRAINS (mm)
colonne no.: 1
0.00 = bas de la colonne
0.00-6.76 cm.
6.76-10.93 cm.
10.93-14.68 cm.
14.68-17.65 cm.
17.65-21.09 cm.
MOYENNE (9 échant.)

GOLDER ET ASS.

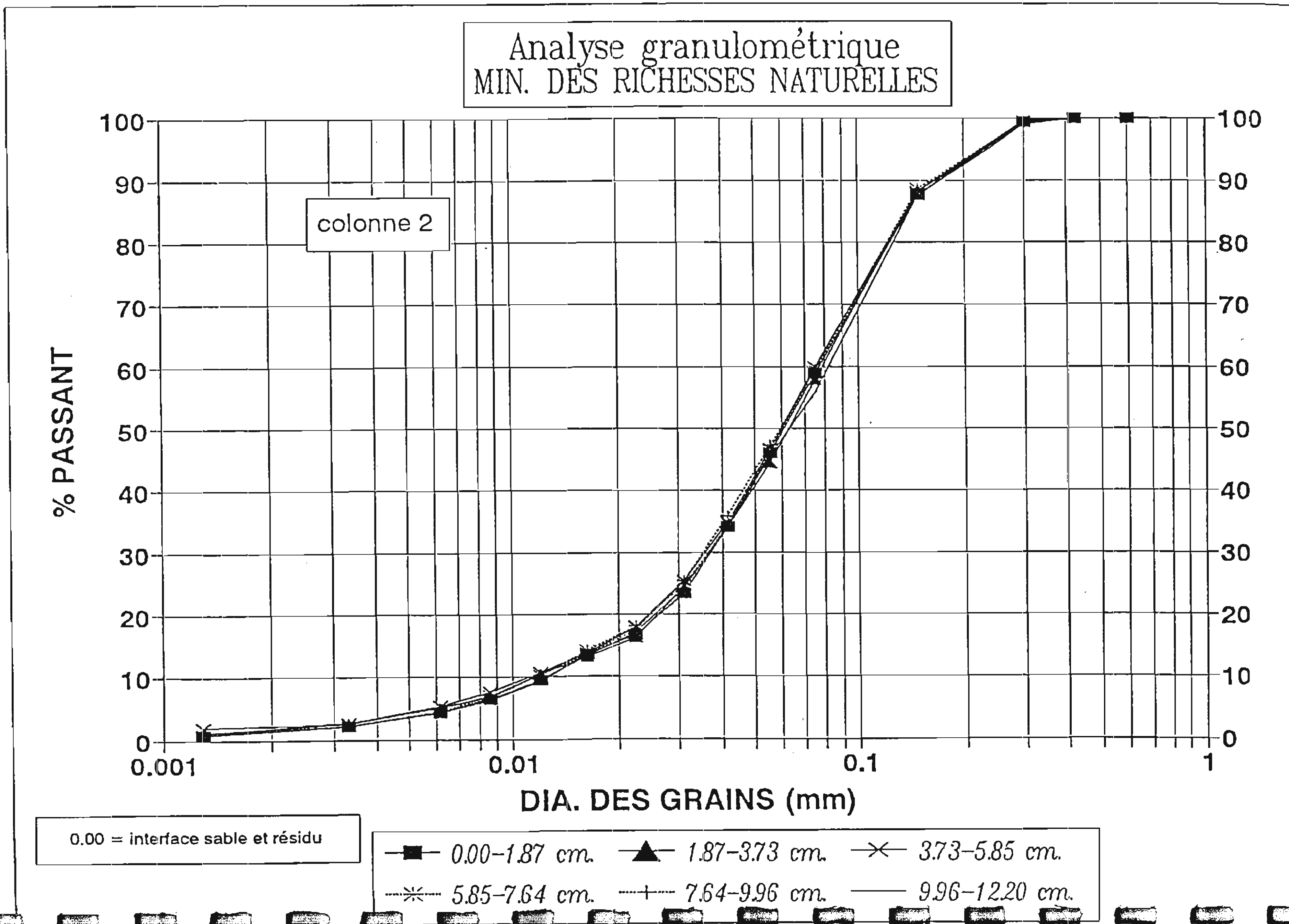
ESSAI DE MIGRATION DES PARTICULES

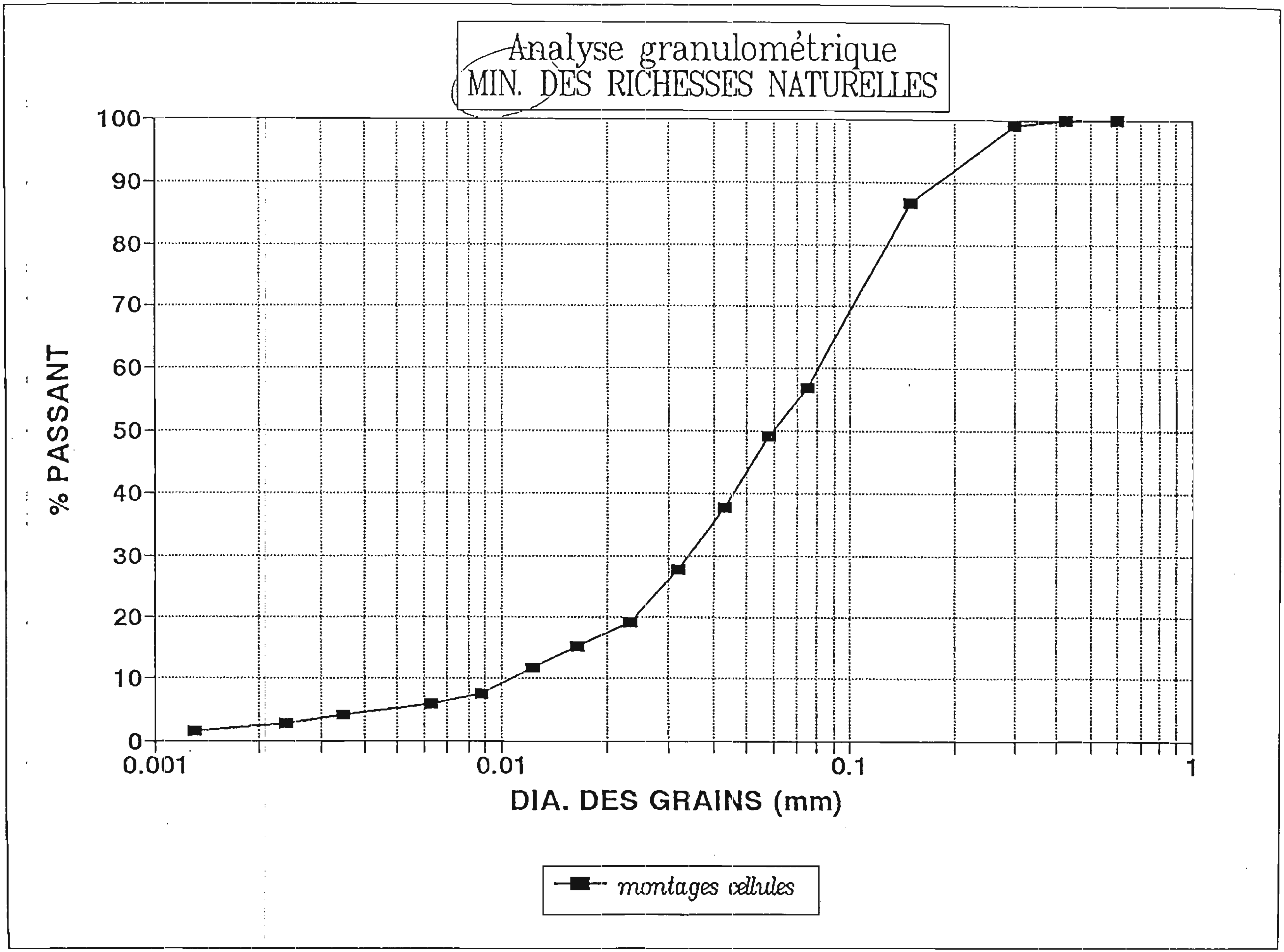
COLONNE no. 2

Pds filtre init.		26.1	26.1	date	heure	min.	QTE eau	tare + eau	eau net	QTE eau	QTE eau	Diff. entre
Pds filtre finale						total	cc Ajouté			cc Sortie	cc Entrée	eau in/out
				27-11-95	10:30	0	1300			0	1300	1300
HAUTEUR INIT. SABLE	49.4	Gs	2.819		11:30	60	1000			100	2300	2200
DIAM. DE LA COLONNE	15.2				12:42	132	1000	1422	1101	1101	3300	2199
		teneur en eau			16:30	360	1000	2424	1002	2103	4300	2197
PDS DES COUCHES	999	Tare	104	28-11-95	14:20	2690	1000	3412	988	3091	5300	2209
DE SABLE	1002	Pds sol hum. + tare	710.7		20:00	3030	1000	1337	1016	4107	6300	2193
	1001	Pds sol sec + tare	695.2	29-11-95	7:30	3030	OUBLIE VALVE FERMEE			4107	6300	2193
	1001	Pds tare	124.6		10:00	3180	1000	2292	955	5062	7300	2238
	1002				17:30	3630	1000	3306	1014	6076	8300	2224
	999	teneur en eau	2.7	30-11-95	7:45	4485	1000	1455	1134	7210	9300	2090
	1003				13:35	4835	1000	2298	843	8053	10300	2247
	1002			01-12-95	8:00	5940	1000	3417	1119	9172	11300	2128
	1004			02-12-95	8:20	7400	1000	1506	1185	10357	12300	1943
	560				12:20	7640	1000	2135	629	10986	13300	2314
				03-12-95	8:20	8840	1000	3431	1296	12282	14300	2018
TOTAL DU SABLE	9573	Total du sable sec	9067.0		10:40	8960	1000	1016	695	12977	15300	2323
		teneur en eau init.	5.6	04-12-95	7:30	10230	1000	2298	1282	14259	16300	2041
Hauteur finale	19.9				11.05	10445	1000	2994	696	14955	17300	2345
Hauteur du sable	29.5	Total du sable hum.			18.00	10860	1000	1414	1093	16048	18300	2252
Volume	5353.0	final	9655.2		20.00	10980	1000	2416	1002	17050	19300	2250
Pds Unit. hum.	1.788	teneur en eau finale	6.5	05-12-95	7.00	11640	1000	3606	1190	18240	20300	2060
Pds unitaire sec	1.741			06-12-95	8.15	11715	1000	1447	1126	19366	21300	1934
Indice des vides	0.616				14.45	12105	1000	2138	1817	21183	22300	1117
Porosité	0.381			07-12-95	9.30	13230	2000	3473	1335	22518	24300	1782
					13.45	13485	2000	1892	1571	24089	26300	2211
				08-12-95	7.30	14550	2000	2544	2223	26312	28300	1988
		teneur en eau			10.00	14700	2000	4228	1684	27996	30300	2304
PDS DES COUCHES	1005	TARE	108		14.10	14830	2000	2143	1822	29818	32300	2482
DE RESIDU	1004	Pds sol hum. + tare	653.4	11-12-95	8.00	19180	2000	4134	1991	31809	34300	2491
	1006	Pds sol sec + tare	569.8		14.50	19590	2000	2350	2029	33838	36300	2462
	503	Pds tare	123.9	12-12-95	8.40	20580	2000	4400	2050	35888	38300	2412
					14.50	20950	2000	2290	1969	37857	40300	2443
		teneur en eau	18.7	13-12-95	7.20	21940	2000	4139	1849	39706	42300	2594
TOTAL DU RESIDU	3523				11.05	22165	2000	2471	2150	41856	44300	2444
		Total du résidu sec	3020.9		13.30	22310	2000	4135	1664	43520	46300	2780
Hauteur finale	7.7	teneur en eau init.	16.6	14-12-95	9.00	23480	2000	2548	2327	45847	48300	2453
Hauteur des résidus	12.2	Total du residu hum.			11.30	23630	2000	4288	1640	47487	50300	2813
Volume	2213.8	final	4068.3		15.05	23845	2000	2410	2089	49576	52300	2724
Pds Unit. hum.	1.591	teneur en eau finale	34.7	15-12-95	9.15	24935	4000	4610	4289	53865	56300	2435
Pds unitaire sec	1.340			18-12-95	8.00	29180	4000	4289	3968	57833	60300	2467
Indice des vides	1.100				10.20	29320	4000	2930	2609	60442	64300	3858
Porosité	0.524				14.30	29570	4000	5230	4909	65351	68300	2949
				19-12-95	7.30	30590	4000	4646	4325	69676	72300	2624
					11.35	30835	4000	4013	3692	73368	76300	2932
					11.35	30835	4000	4203	3882	77250	80300	3050
				20-12-95	8.30	32090	4000	4703	4382	81632	84300	2668
				03-01-96	9.00	32090	10000	9884	8815	90447	94300	3853
				04-01-96	8.00	33470		177	177	90624	94300	3676

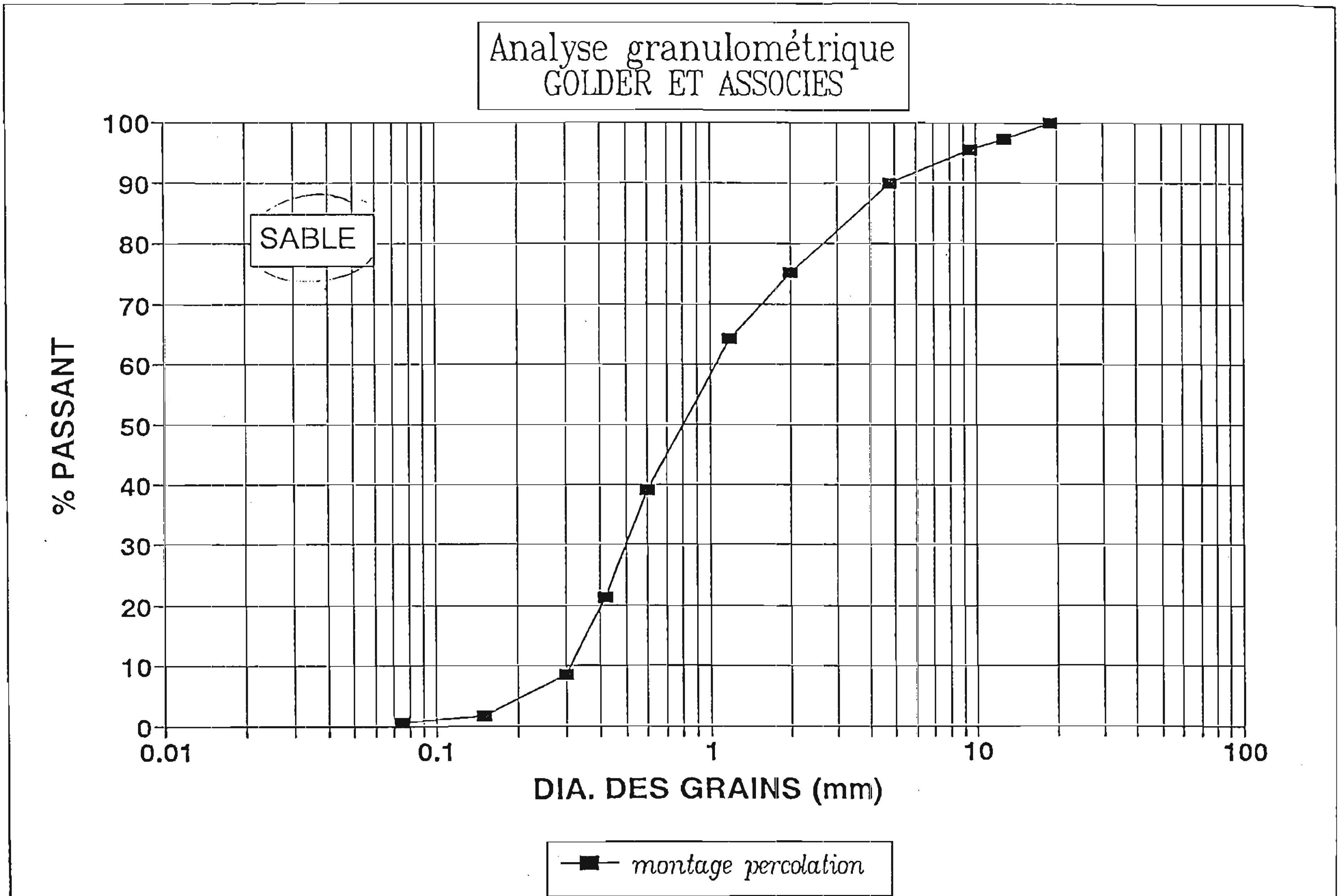


Analyse granulométrique
GOLDER et ASSOCIES
COLONNE no. 2
% PASSANT
DIA. DES GRAINS (mm)
A PARTIR DU BAS
0.00-5.42 cm.
5.42-7.96 cm.
7.96-10.59 cm.
10.59-13.68 cm.
13.68-16.15 cm.
16.15-18.51 cm.

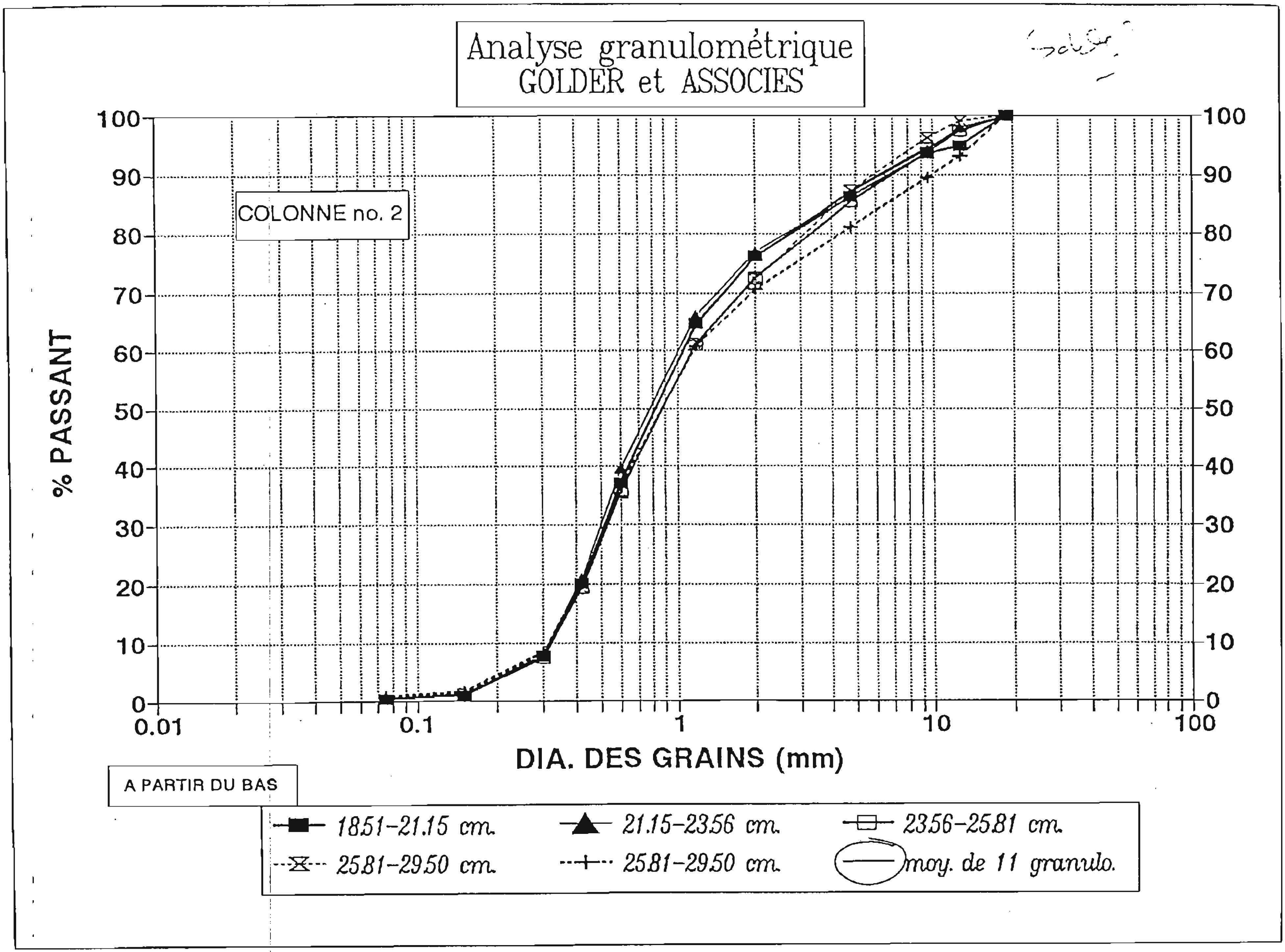

Analyse granulométrique
MIN. DES RICHESSES NATURELLES
colonne 2
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
DIA. DES GRAINS (mm)
0.00 = interface sable et résidu
0.00-1.87 cm.
1.87-3.73 cm.
3.73-5.85 cm.
5.85-7.64 cm.
7.64-9.96 cm.
9.96-12.20 cm.


Analyse granulométrique
MIN. DES RICHESSES NATURELLES
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
DIA. DES GRAINS (mm)
montages cellules

2



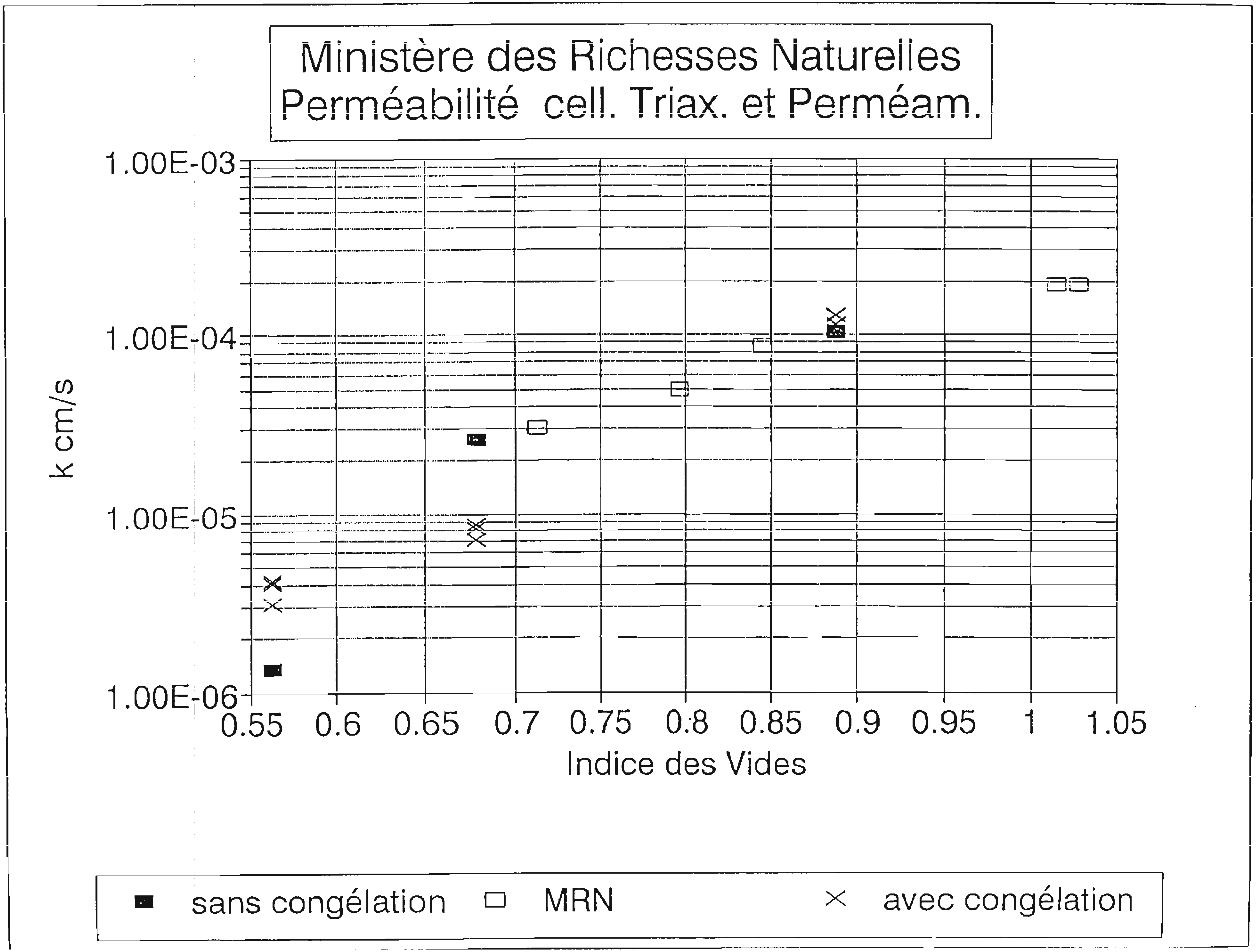
Analyse granulométrique
GOLDER ET ASSOCIES
SABLE
% PASSANT
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
DIA. DES GRAINS (mm)
montage percolation


Analyse granulométrique
GOLDER et ASSOCIES
COLONNE no. 2
% PASSANT
DIA. DES GRAINS (mm)
A PARTIR DU BAS
18.51-21.15 cm.
21.15-23.56 cm.
23.56-25.81 cm.
25.81-29.50 cm.
25.81-29.50 cm.
moy. de 11 granulo.

APPENDIX F

PERMEABILITY TESTS RESULTS WITH FREEZE-THAW CYCLES FOR MNR TAILINGS AND SILT

(École Polytechnique)


Ministère des Richesses Naturelles
Perméabilité cell. Triax. et Perméam.
1.00E-03
1.00E-04
1.00E-05
1.00E-06
k cm/s
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
Indice des Vides
sans congélation
MRN
avec congélation

TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

Date de montage	26-02-96	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	1er essai avant congélation
Nom du fichier:	GOLDER\PERMEA\CONGELATION3	

Géométrie	(moule #1)	
épaisseur initiale cm	6.989	15.997
diamètre cm	8.440	8.288
surface (cm^2)	55.947	
Volume (cm^3)	391.03	

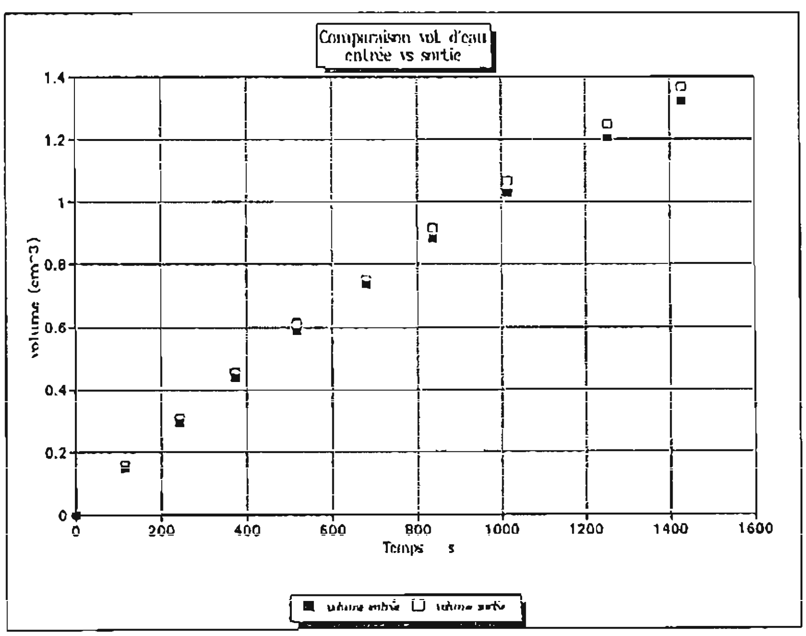
Masses g	
masse initiale humide	809.4
masse finale humide	846.0
masse finale sèche	705.2
Gs	2.819

Conditions de l'essai

Degré de saturation			
Par séchage (%) init.	74.0	mas. vol. hum. (g/cm3)	2.070
Par séchage (%) fin.	100.0	mas. vol. sec. (g/cm3)	1.803
Teneur en eau initiale	14.8	Opt. Proctor (g/cm3)	1.735
Teneur en eau finale	20.0	teneur eau opt. (%)	15.7
		% opt. Proctor	103.9

Calibration

o/s tête	89.20	burette utilisée		large	0	section burette	0.294
o/s base	17.80	med	1	petite	0	température	24.5



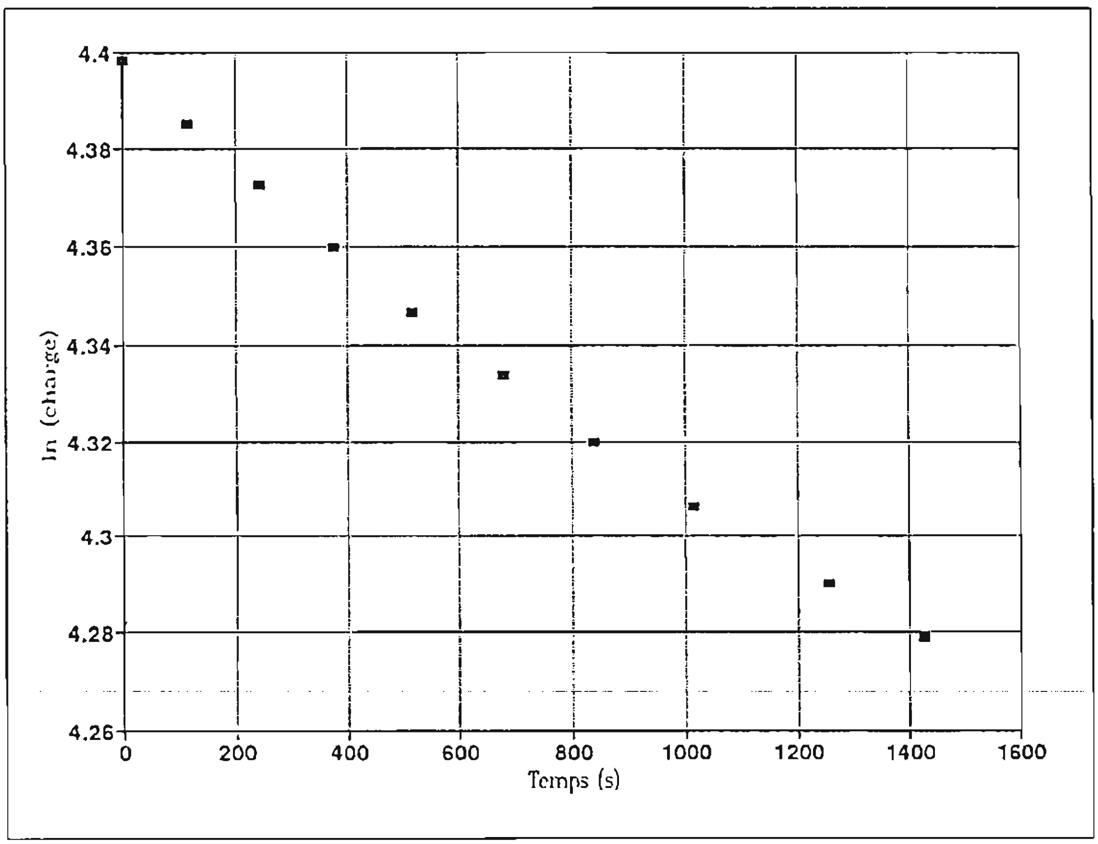
Résultat de l'essai

charge variable

Indice des vides:	0.563
Perméabilité (cm/s)	1.33E-06
écart type	3.44E-08
ind. reg.	0.995

COMMENTAIRES

27-02-1996		GOLDER MIN. RICHESSES NATURELLES					page 2	
	Lectures							
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-9.90	0	0	81.3	0.00	-	-
1.91	-0.5	-9.36	0.15	0.16	80.3	114.60	2.06E-06	1.85E-06
4.03	-1.0	-8.85	0.29	0.31	79.3	241.80	1.94E-06	1.74E-06
6.23	-1.5	-8.35	0.44	0.46	78.3	373.80	1.88E-06	1.68E-06
8.63	-2.0	-7.82	0.59	0.61	77.2	517.80	1.83E-06	1.63E-06
11.33	-2.5	-7.35	0.74	0.75	76.3	679.80	1.73E-06	1.55E-06
13.97	-3.0	-6.78	0.88	0.92	75.2	838.20	1.72E-06	1.53E-06
16.93	-3.5	-6.27	1.03	1.07	74.2	1015.80	1.66E-06	1.48E-06
20.91	-4.1	-5.66	1.21	1.25	73.0	1254.60	1.58E-06	1.42E-06
23.77	-4.5	-5.25	1.32	1.37	72.2	1426.20	1.54E-06	1.38E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

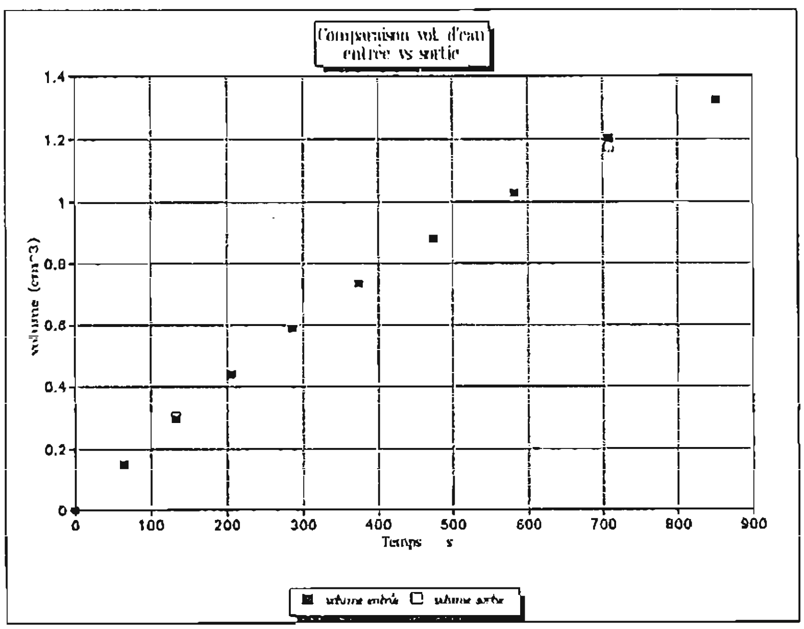
Date de montage	26-02-96
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE
Nom du fichier:	GOLDER\PERMEA\CONGELATION3

Géométrie	(moule #1)	
épaisseur initiale cm	6.989	15.997
diamètre cm	8.440	8.288
surface (cm^2)	55.947	
Volume (cm^3)	391.03	

Masses g	
masse initiale humide	809.4
masse finale humide	846.0
masse finale sèche	705.2
Gs	2.819

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	2.070
Par séchage (%) init.	74.0	mas. vol. sec. (g/cm3)	1.803
Par séchage (%) fin.	100.0	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	14.8	teneur eau opt. (%)	15.7
Teneur en eau finale	20.0	% opt. Proctor	103.9

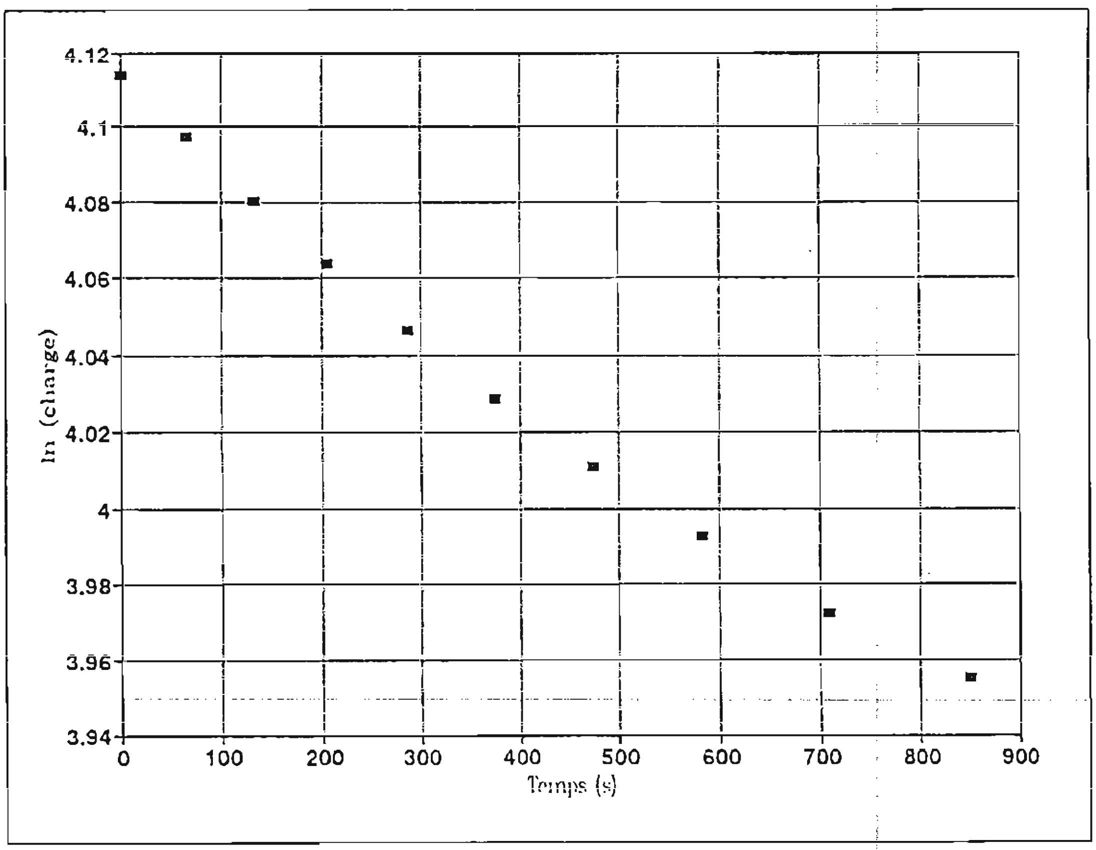
Calibration							
o/s tête	70.40	burette utilisée		large	0	section burette	0.294
o/s base	19.00	med	0	petite	1	température	23.5



Résultat de l'essai	
charge variable	
Indice des vides:	0.563
Perméabilité (cm/s)	3.08E-06
écart. type	1.17E-07
ind. reg.	0.990
COMMENTAIRES	

Lectures — 2ième essai de perméabilité après 5 cycles de congélation

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-9.80	0	0	61.2	0.00	-	-
1.09	-0.5	-9.28	0.15	0.15	60.2	65.40	4.72E-06	4.34E-06
2.21	-1.0	-8.76	0.29	0.31	59.2	132.60	4.70E-06	4.32E-06
3.42	-1.5	-8.30	0.44	0.44	58.2	205.20	4.50E-06	4.13E-06
4.78	-2.0	-7.80	0.59	0.59	57.2	286.80	4.33E-06	3.98E-06
6.24	-2.5	-7.30	0.74	0.74	56.2	374.40	4.18E-06	3.84E-06
7.90	-3.0	-6.80	0.88	0.88	55.2	474.00	4.00E-06	3.67E-06
9.70	-3.5	-6.30	1.03	1.03	54.2	582.00	3.83E-06	3.52E-06
11.80	-4.1	-5.80	1.21	1.18	53.1	708.00	3.68E-06	3.38E-06
14.18	-4.5	-5.30	1.32	1.32	52.2	850.80	3.43E-06	3.16E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

Date de montage	26-02-96
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE
Nom du fichier:	GOLDER\PERMEA\CONGELATION3

Géométrie	(moule #1)	
épaisseur initiale cm	6.989	15.997
diamètre cm	8.440	8.288
surface (cm^2)	55.947	
Volume (cm^3)	391.03	

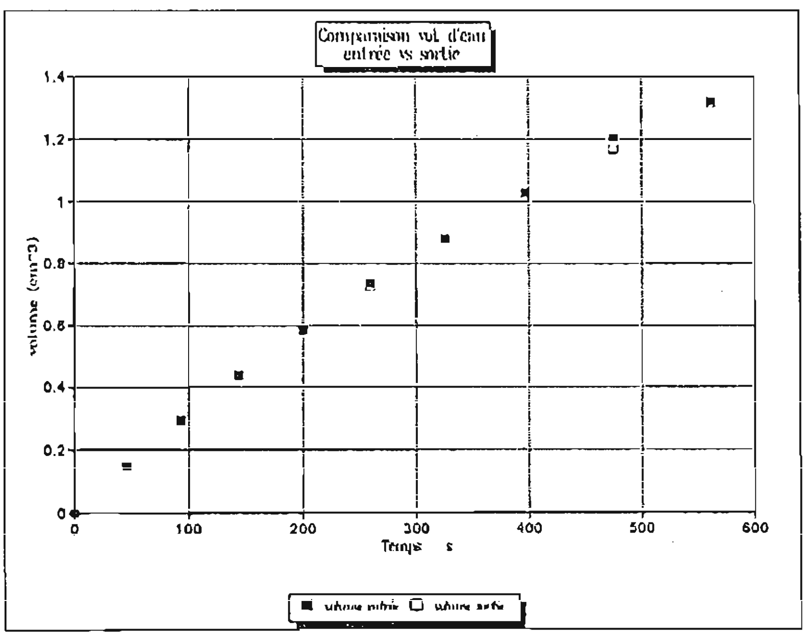
Masses g	
masse initiale humide	809.4
masse finale humide	846.0
masse finale sèche	705.2
Gs	2.819

Conditions de l'essai

Degré de saturation			
Par séchage (%) init.	74.0	mas. vol. hum. (g/cm3)	2.070
Par séchage (%) fin.	100.0	mas. vol. sec. (g/cm3)	1.803
Teneur en eau initiale	14.8	Opt. Proctor (g/cm3)	1.735
Teneur en eau finale	20.0	teneur eau opt. (%)	15.7
		% opt. Proctor	103.9

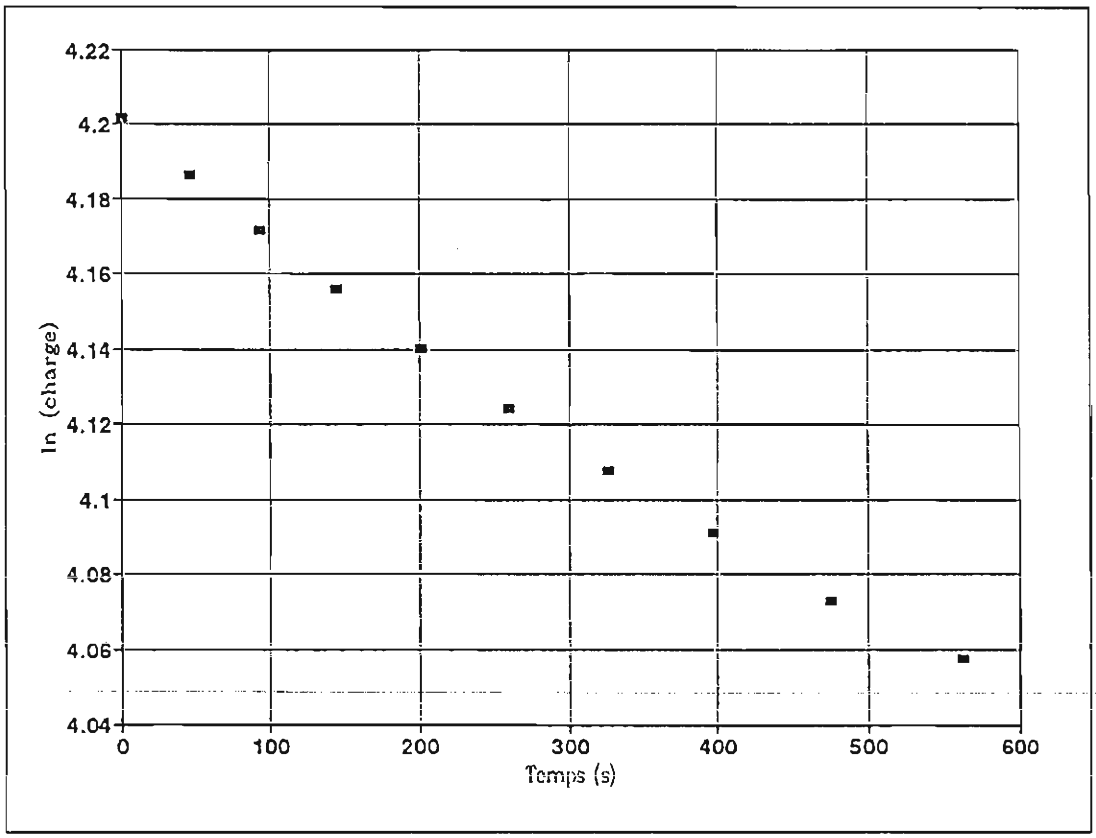
Calibration

o/s tête	75.10	burette utilisée		large	0	section burette	0.294
o/s base	15.90	med	0	petite	1	température	24



Résultat de l'essai	
charge variable	
Indice des vides:	0.563
Perméabilité (cm/s)	4.03E-06
écart type	1.21E-07
ind. reg.	0.994
COMMENTAIRES	

10-05-96			GOLDER MIN. RICHESSES NATURELLES				page 2	
Lectures			3ième essai de perméabilité après 10 cycles de congélation					
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-10.00	0	0	66.8	0.00	-	-
0.77	-0.5	-9.50	0.15	0.15	65.8	46.20	6.00E-06	5.44E-06
1.56	-1.0	-9.01	0.29	0.29	64.8	93.60	5.94E-06	5.38E-06
2.41	-1.5	-8.52	0.44	0.44	63.8	144.60	5.80E-06	5.26E-06
3.34	-2.0	-8.02	0.59	0.58	62.8	200.40	5.63E-06	5.11E-06
4.32	-2.5	-7.53	0.74	0.73	61.8	259.20	5.48E-06	4.97E-06
5.44	-3.0	-7.01	0.88	0.88	60.8	326.40	5.29E-06	4.79E-06
6.62	-3.5	-6.52	1.03	1.02	59.8	397.20	5.10E-06	4.63E-06
7.92	-4.1	-6.03	1.21	1.17	58.7	475.20	4.98E-06	4.51E-06
9.37	-4.5	-5.53	1.32	1.31	57.8	562.20	4.71E-06	4.27E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

Date de montage	26-02-96
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE
Nom du fichier:	GOLDER\PERMEA\CONGELATION3

Géométrie	(moule #1)
épaisseur initiale cm	6.989
diamètre cm	8.440
surface (cm^2)	55.947
Volume (cm^3)	391.03

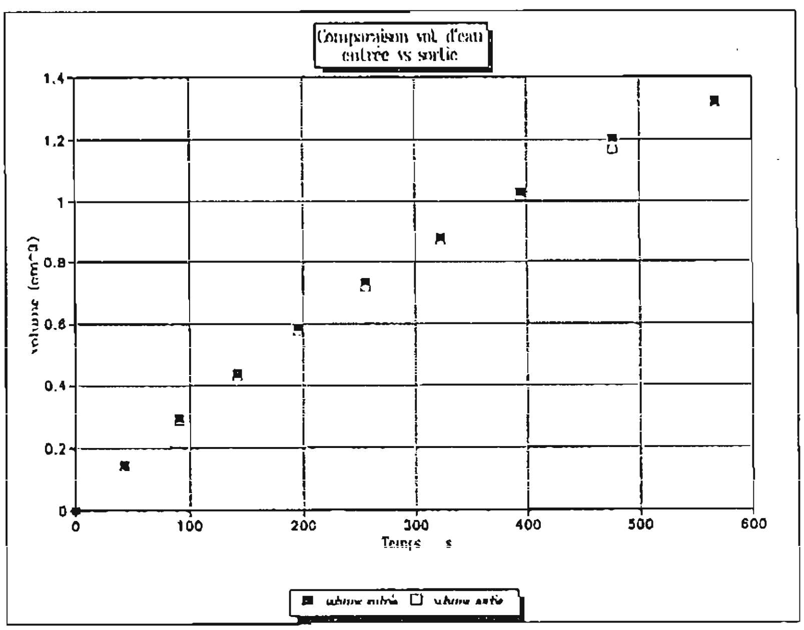
15.997

8.288

Masses g	
masse initiale humide	809.4
masse finale humide	846.0
masse finale sèche	705.2
Gs	2.819

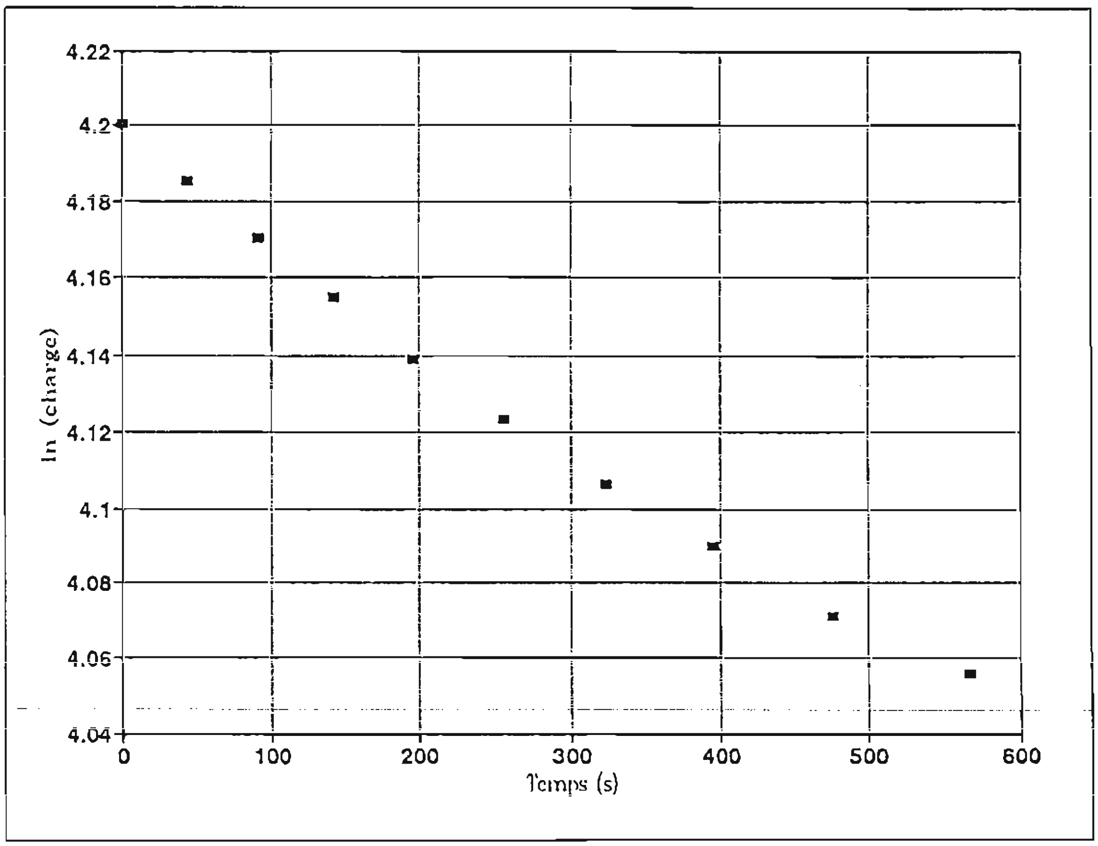
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	2.070
Par séchage (%) init.	74.0	mas. vol. sec. (g/cm3)	1.803
Par séchage (%) fin.	100.0	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	14.8	teneur eau opt. (%)	15.7
Teneur en eau finale	20.0	% opt. Proctor	103.9

Calibration							
o/s tête	74.90	burette utilisée		large	0	section burette	0.294
o/s base	18.10	med	0	petite	1	température	24



Résultat de l'essai	
charge variable	
Indice des vides	0.563
Perméabilité (cm/s)	4.16E-06
écart type	1.35E-07
ind. reg.	0.993
COMMENTAIRES	

29-05-96	GOLDER MIN. RICHESSES NATURELLES						page 2	
Lectures	4ième essai de perméabilité après 15 cycles de congélatio							
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-9.90	0	0	66.7	0.00	-	-
0.73	-0.5	-9.42	0.15	0.14	65.7	43.80	6.21E-06	5.63E-06
1.52	-1.0	-8.93	0.29	0.29	64.7	91.20	6.04E-06	5.47E-06
2.38	-1.5	-8.45	0.44	0.43	63.8	142.80	5.82E-06	5.28E-06
3.27	-2.0	-7.95	0.59	0.57	62.8	196.20	5.72E-06	5.18E-06
4.26	-2.5	-7.46	0.74	0.72	61.8	255.60	5.53E-06	5.01E-06
5.39	-3.0	-6.94	0.88	0.87	60.7	323.40	5.32E-06	4.82E-06
6.58	-3.5	-6.44	1.03	1.02	59.7	394.80	5.13E-06	4.65E-06
7.94	-4.1	-5.93	1.21	1.17	58.6	476.40	4.97E-06	4.51E-06
9.45	-4.5	-5.43	1.32	1.31	57.7	567.00	4.68E-06	4.24E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

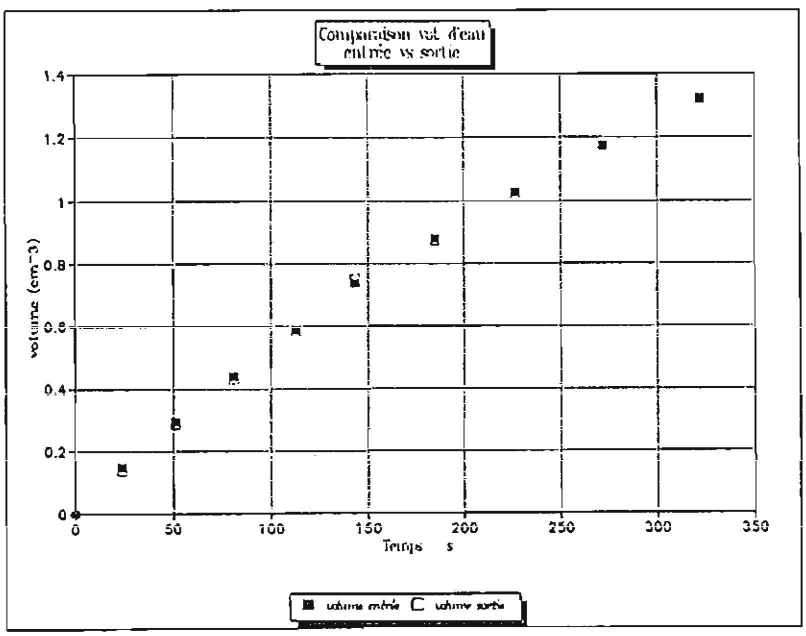
Date de montage	26-02-96
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE
Nom du fichier:	GOLDER\PERMEA\CONGELATION2

Géométrie	(moule #4)	
épaisseur initiale cm	8.154	16.591
diamètre cm	8.440	7.707
surface (cm^2)	55.947	
Volume (cm^3)	456.16	

Masses g	
masse initiale humide	836.6
masse finale humide	951.4
masse finale sèche	766.4
Gs	2.819

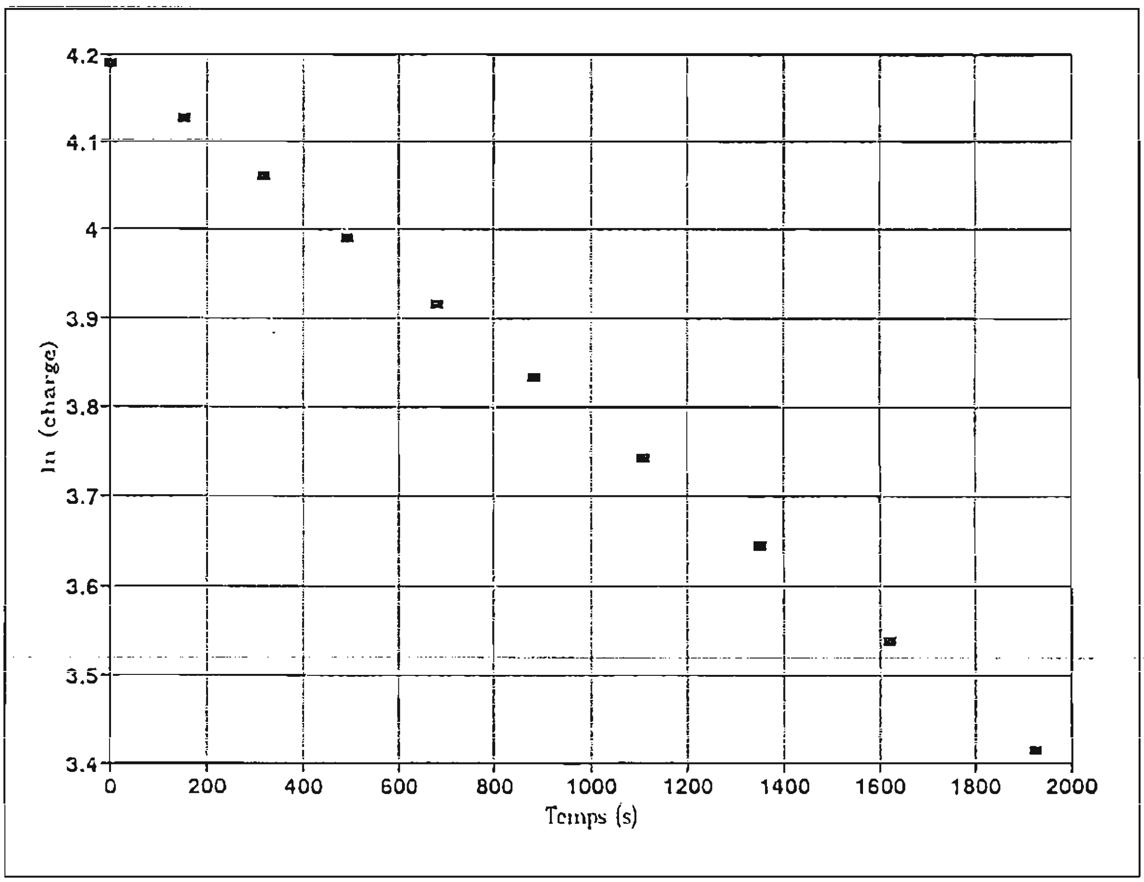
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.834
Par séchage (%) init.	38.1	mas. vol. sec. (g/cm3)	1.680
Par séchage (%) fin.	100.4	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	9.2	teneur eau opt. (%)	15.7
Teneur en eau finale	24.1	% opt. Proctor	96.8

Calibration								
o/s tête	76.00	burette utilisée		large	0	section burette	0.294
o/s base	20.60	med	0	petite	1	température	24



Résultat de l'essai	
charge variable	
Indice des vides	0.678
Perméabilité (cm/s)	8.71E-06
écart type	3.05E-07
ind. reg.	0.991
COMMENTAIRES	

27-02-96		GOLDER MIN. RICHESSES NATURELLES					page 2	
Lectures		1er essai de perméabilité: avant congélation						
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	0.3	0	0	66.0	0.00	-	-
2.50	-2.0	2.3	2.00	2.00	62.0	150.00	3.04E-05	2.72E-05
5.24	-4.0	4.2	4.00	3.90	58.1	314.40	2.95E-05	2.64E-05
8.20	-6.0	6.2	6.00	5.90	54.1	492.00	2.94E-05	2.63E-05
11.32	-8.0	8.1	8.00	7.80	50.2	679.20	2.94E-05	2.63E-05
14.75	-10.0	10.1	10.00	9.80	46.2	885.00	2.94E-05	2.63E-05
18.44	-12.0	12.1	12.00	11.80	42.2	1106.40	2.95E-05	2.63E-05
22.53	-14.0	14.0	14.00	13.70	38.3	1351.80	2.93E-05	2.62E-05
27.00	-16.0	15.9	16.00	15.60	34.4	1620.00	2.93E-05	2.62E-05
32.09	-18.0	17.9	18.00	17.60	30.4	1925.40	2.93E-05	2.62E-05



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

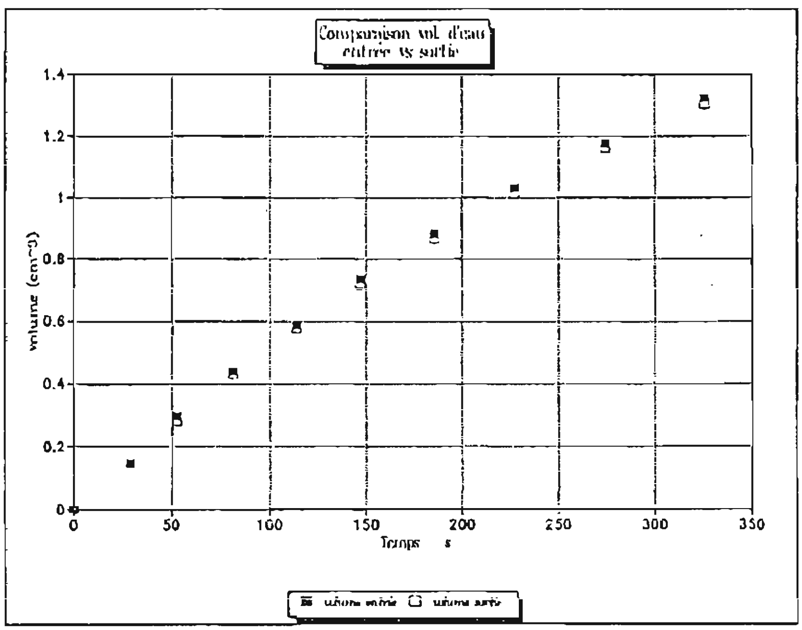
Date de montage	26-02-96
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE
Nom du fichier:	GOLDER\PERMEA\CONGELATION2

Géométrie	(moule #4)	
épaisseur initiale cm	8.154	16.591
diamètre cm	8.440	7.707
surface (cm^2)	55.947	
Volume (cm^3)	456.16	

Masses g	
masse initiale humide	836.6
masse finale humide	951.4
masse finale sèche	766.4
Gs	2.819

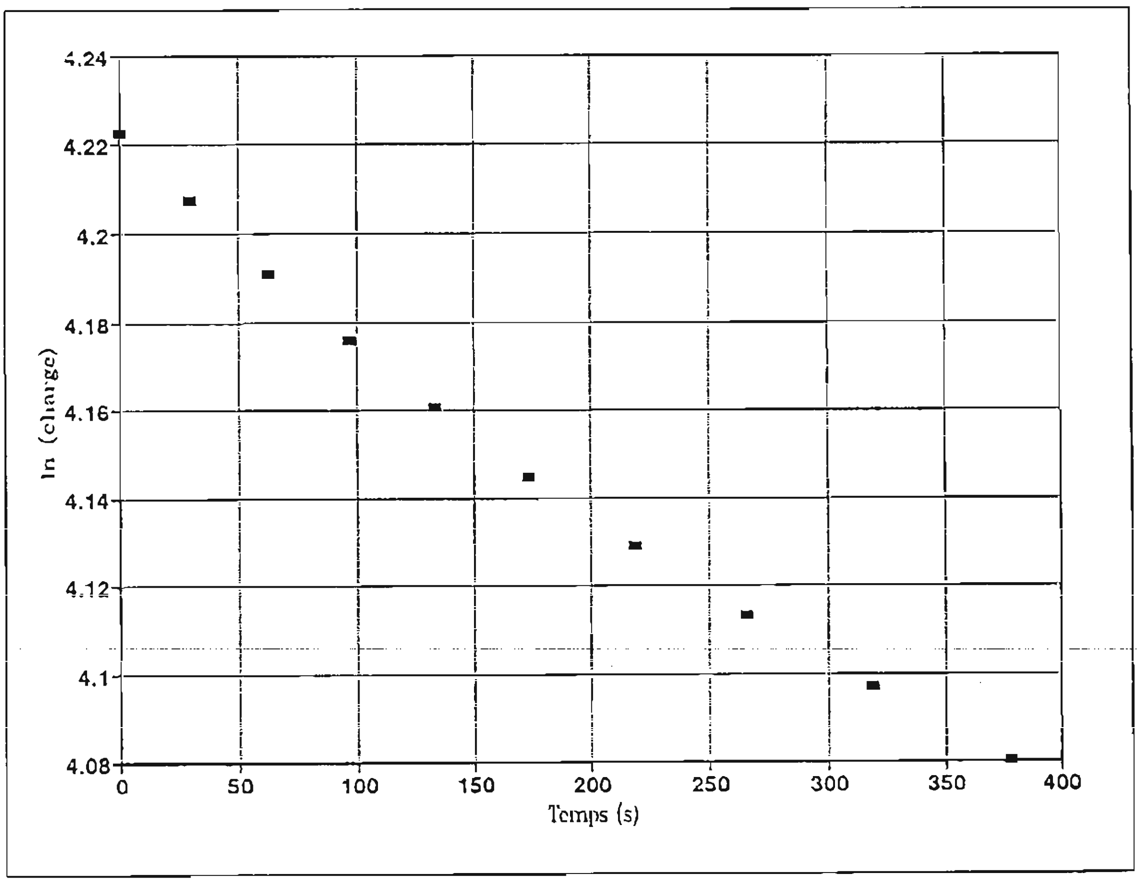
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.834
Par séchage (%) init.	38.1	mas. vol. sec. (g/cm3)	1.680
Par séchage (%) fin.	100.4	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	9.2	teneur eau opt. (%)	15.7
Teneur en eau finale	24.1	% opt. Proctor	96.8

Calibration								
o/s tête	76.20	burette utilisée		large	0	section burette	0.294
o/s base	17.60	med	0	petite	1	température	23.5



Résultat de l'essai	
charge variable	
Indice des vides	0.678
Perméabilité (cm/s)	8.28E-06
écart type	2.95E-07
ind. reg.	0.991
COMMENTAIRES	

18-04-96	GOLDER MIN. RICHESSES NATURELLES						page 2	
Lectures	2ième essai de perméab. après 5 cycles de congélation							
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-9.60	0	0	68.2	0.00	-	-
0.50	-0.5	-9.10	0.15	0.15	67.2	30.00	1.06E-05	9.70E-06
1.04	-1.0	-8.50	0.29	0.32	66.1	62.40	1.07E-05	9.87E-06
1.61	-1.5	-8.00	0.44	0.47	65.1	96.60	1.03E-05	9.48E-06
2.22	-2.0	-7.50	0.59	0.62	64.1	133.20	9.98E-06	9.17E-06
2.89	-2.5	-7.02	0.74	0.76	63.1	173.40	9.57E-06	8.79E-06
3.65	-3.0	-6.52	0.88	0.91	62.1	219.00	9.14E-06	8.40E-06
4.43	-3.5	-6.04	1.03	1.05	61.1	265.80	8.81E-06	8.10E-06
5.31	-4.0	-5.55	1.18	1.19	60.2	318.60	8.45E-06	7.76E-06
6.30	-4.5	-5.06	1.32	1.34	59.2	378.00	8.06E-06	7.41E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

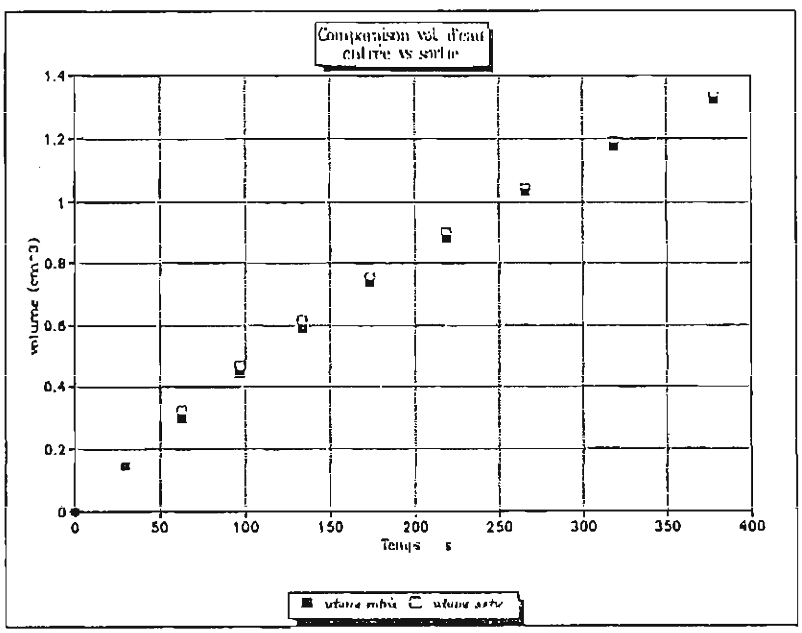
Date de montage	26-02-96
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE
Nom du fichier:	GOLDER\PERMEA\CONGELATION2

Géomètrie	(moule #4)	
épaisseur initiale cm	8.154	16.591
diamètre cm	8.440	7.707
surface (cm^2)	55.947	
Volume (cm^3)	456.16	

Masses g	
masse initiale humide	836.6
masse finale humide	951.4
masse finale sèche	766.4
Gs	2.819

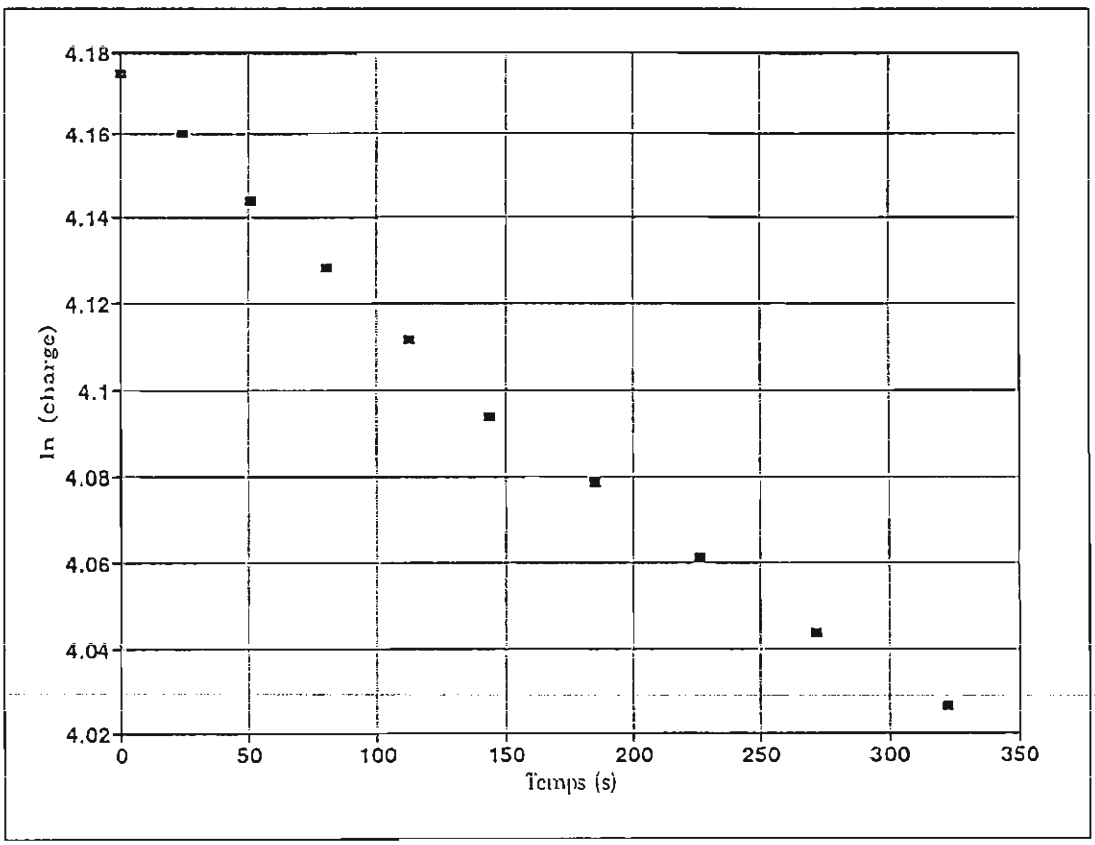
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.834
Par séchage (%) init.	38.1	mas. vol. sec. (g/cm3)	1.680
Par séchage (%) fin.	100.4	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	9.2	teneur eau opt. (%)	15.7
Teneur en eau finale	24.1	% opt. Proctor	96.8

Calibration							
o/s tête	76.20	burette utilisée		large	0	section burette	0.294
o/s base	17.60	med	0	petite	1	température	23.5



Résultat de l'essai	
charge variable	
Indice des vides:	0.678
Perméabilité (cm/s)	7.17E-06
écart type	2.44E-07
ind. reg.	0.992
COMMENTAIRES	

10-05-96	GOLDER MIN. RICHESSES NATURELLES						page 2	
Lectures	3ième essai de perméab. après 10 cycles de congélation							
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-9.63	0	0	65.0	0.00	-	-
0.40	-0.5	-9.18	0.15	0.13	64.1	24.00	1.31E-05	1.19E-05
0.85	-1.0	-8.66	0.29	0.29	63.1	51.00	1.29E-05	1.17E-05
1.35	-1.5	-8.17	0.44	0.43	62.1	81.00	1.23E-05	1.12E-05
1.88	-2.0	-7.66	0.59	0.58	61.1	112.80	1.20E-05	1.08E-05
2.39	-2.5	-7.07	0.74	0.75	60.0	143.40	1.21E-05	1.10E-05
3.08	-3.0	-6.66	0.88	0.87	59.1	184.80	1.12E-05	1.01E-05
3.77	-3.5	-6.15	1.03	1.02	58.1	226.20	1.08E-05	9.75E-06
4.53	-4.0	-5.64	1.18	1.17	57.0	271.80	1.03E-05	9.37E-06
5.37	-4.5	-5.15	1.32	1.32	56.1	322.20	9.88E-06	8.96E-06



TEST PERMEABILITE

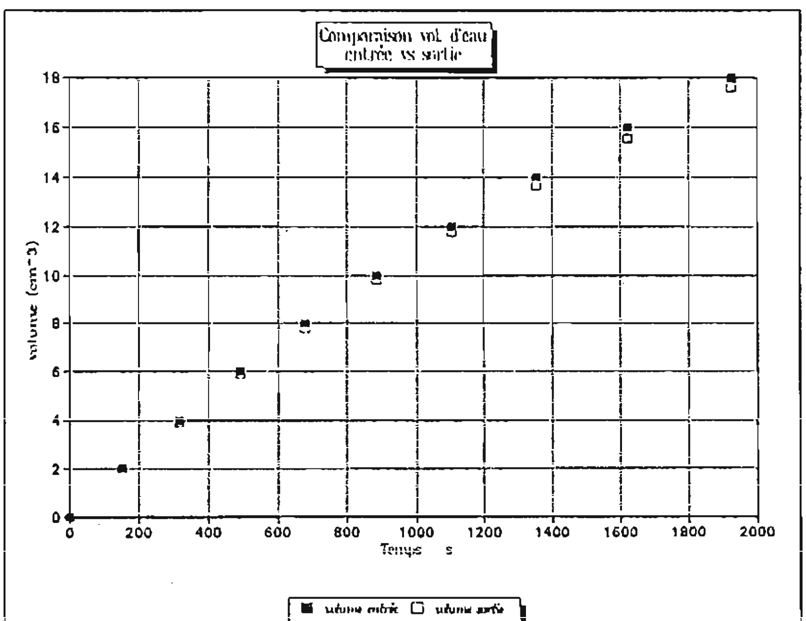
PERMEAMETRE A CHARGE VARIABLE

Date de montage	26-02-96	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	2ième essai sans congélation
Nom du fichier:	GOLDER\PERMEA\CONGELATION2	

Géométrie	(moule #4)		Masses g	
épaisseur initiale cm	8.154	16.591	masse initiale humide	836.6
diamètre cm	8.440	7.707	masse finale humide	951.4
surface (cm^2)	55.947		masse finale sèche	766.4
Volume (cm^3)	456.16		Gs	2.819

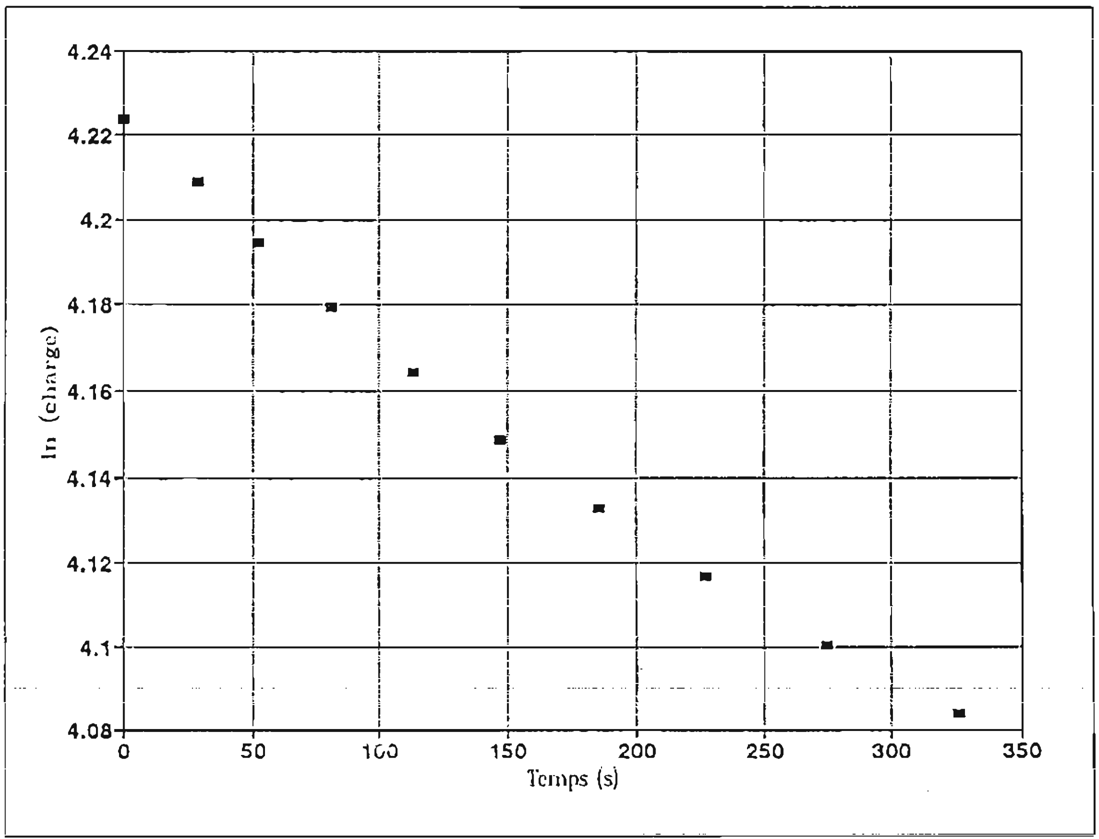
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.834
Par séchage (%) init.	38.1	mas. vol. sec. (g/cm3)	1.680
Par séchage (%) fin.	100.4	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	9.2	teneur eau opt. (%)	15.7
Teneur en eau finale	24.1	% opt. Proctor	96.8

Calibration							
o/s tête	93.20	burette utilisée		large	0	section burette	1.00
o/s base	26.90	med	1	petite	0	température	24.5



Résultat de l'essai	
charge variable	
Indice des vides	0.678
Perméabilité (cm/s)	2.62E-05
écart type	2.75E-08
ind. reg.	1.000
COMMENTAIRES	

18-04-96		GOLDER	MIN. RICHESSES NATURELLES				page 2	
Lectures			4ième essai de perméab. après 15 cycles de congélation					
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-9.70	0	0	68.3	0.00	-	-
0.48	-0.5	-9.20	0.15	0.15	67.3	28.80	1.10E-05	1.01E-05
0.87	-1.0	-8.74	0.29	0.28	66.3	52.20	1.20E-05	1.10E-05
1.36	-1.5	-8.24	0.44	0.43	65.3	81.60	1.16E-05	1.07E-05
1.89	-2.0	-7.75	0.59	0.57	64.4	113.40	1.13E-05	1.03E-05
2.45	-2.5	-7.26	0.74	0.72	63.4	147.00	1.09E-05	1.01E-05
3.09	-3.0	-6.76	0.88	0.86	62.4	185.40	1.05E-05	9.66E-06
3.78	-3.5	-6.26	1.03	1.01	61.4	226.80	1.01E-05	9.30E-06
4.57	-4.0	-5.76	1.18	1.16	60.4	274.20	9.66E-06	8.87E-06
5.43	-4.5	-5.27	1.32	1.30	59.4	325.80	9.22E-06	8.47E-06



TEST PERMEABILITE

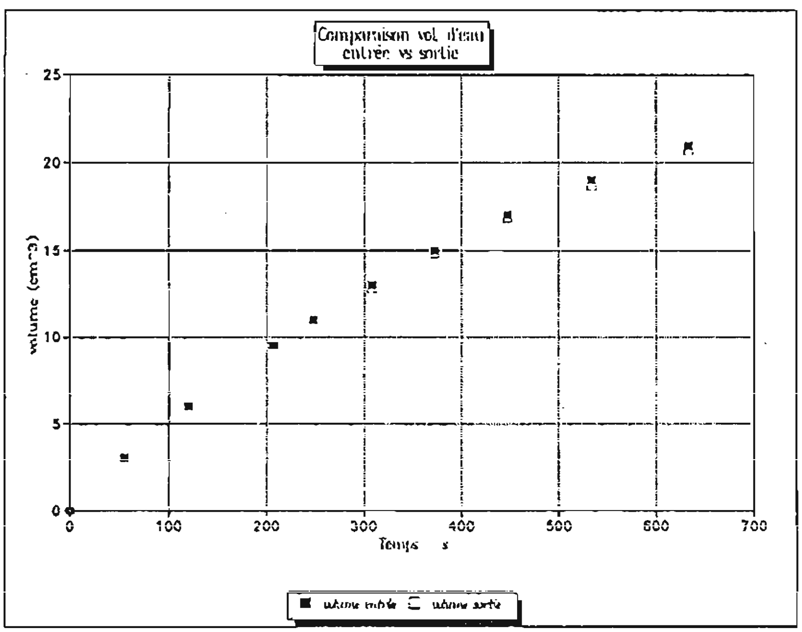
PERMEAMETRE A CHARGE VARIABLE

Date de montage	30-01-1996	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	1er essai sans congélat.
Nom du fichier:	GOLDER\PERMEA\CONGELATION	

Géométrie	(moule #4)		Masses g	
épaisseur initiale cm	7.357	15.815	masse initiale humide	668.8
diamètre cm	8.440	7.738	masse finale humide	807.4
surface (cm^2)	55.947		masse finale sèche	614.7
Volume (cm^3)	411.60		Gs	2.819

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.625
Par séchage (%) init.	28.0	mas. vol. sec. (g/cm3)	1.493
Par séchage (%) fin.	99.6	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	8.8	teneur eau opt. (%)	15.7
Teneur en eau finale	31.3	% opt. Proctor	86.1

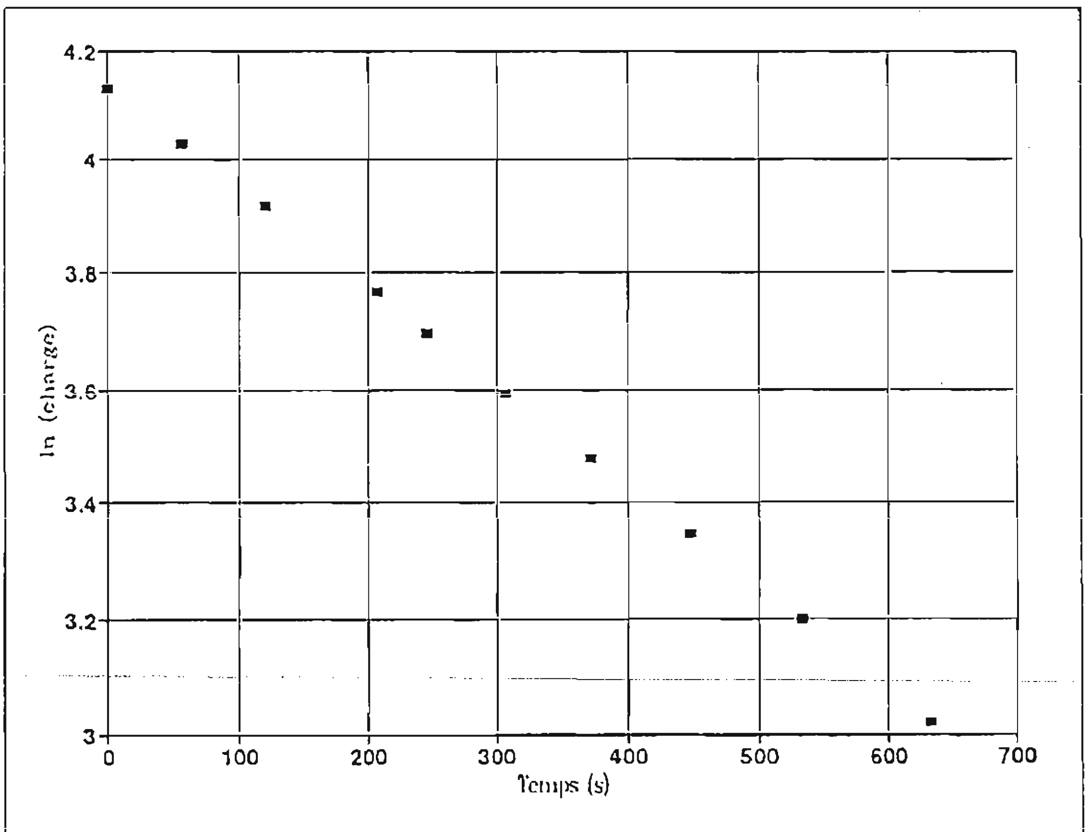
Calibration							
o/s tête	84.00	burette utilisée		large	0	section burette	1.00
o/s base	20.80	med	1	petite	0	température	24



Résultat de l'essai	
charge variable	
Indice des vides:	0.888
Perméabilité (cm/s)	1.04E-04
écart type	1.91E-07
ind. reg.	1.000

COMMENTAIRES

30-01-96		GOLDER MIN. RICHESSES NATURELLES					page 2	
	Lectures							
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	1.0	0	0	62.2	0.00	-	-
0.93	-3.0	4.0	3.00	3.00	56.2	56.00	1.19E-04	1.08E-04
2.00	-6.0	7.0	6.00	6.00	50.2	120.00	1.17E-04	1.06E-04
3.45	-9.5	10.5	9.50	9.50	43.2	207.00	1.16E-04	1.05E-04
4.12	-11.0	11.9	11.00	10.90	40.3	247.00	1.16E-04	1.05E-04
5.12	-13.0	13.8	13.00	12.80	36.4	307.00	1.15E-04	1.04E-04
6.20	-15.0	15.8	15.00	14.80	32.4	372.00	1.15E-04	1.04E-04
7.45	-17.0	17.8	17.00	16.80	28.4	447.00	1.15E-04	1.05E-04
8.88	-19.0	19.7	19.00	18.70	24.5	533.00	1.15E-04	1.04E-04
10.55	-21.0	21.7	21.00	20.70	20.5	633.00	1.15E-04	1.05E-04



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

Date de montage	30-01-1996	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	2ième cycle de congélat
Nom du fichier:	GOLDER\PERMEA\CONGELATION	

Géométrie	(moule #4)	
épaisseur initiale cm	7.357	15.815
diamètre cm	8.440	7.738
surface (cm^2)	55.947	
Volume (cm^3)	411.60	

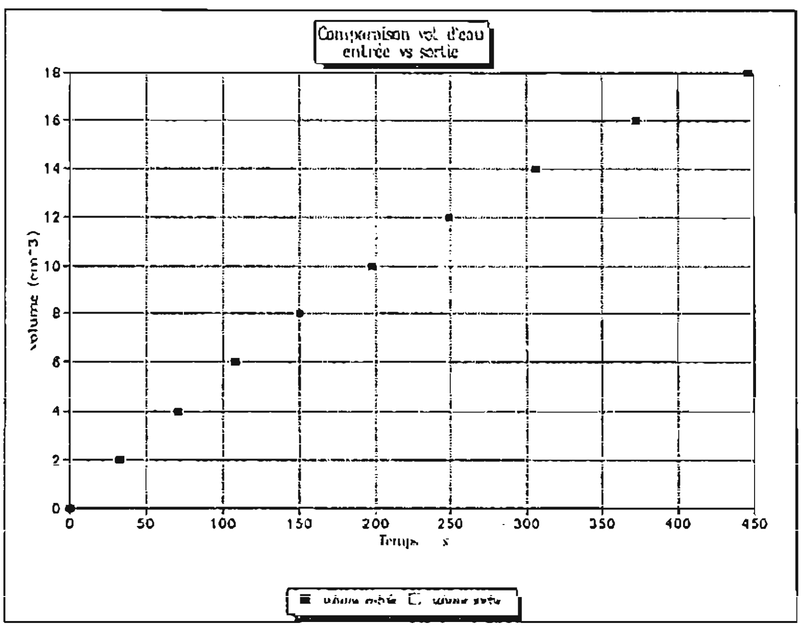
Masses g	
masse initiale humide	668.8
masse finale humide	807.4
masse finale sèche	614.7
Gs	2.819

Conditions de l'essai

Degré de saturation		mas. vol. hum. (g/cm3)	1.625
Par séchage (%) init.	28.0	mas. vol. sec. (g/cm3)	1.493
Par séchage (%) fin.	99.6	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	8.8	teneur eau opt. (%)	15.7
Teneur en eau finale	31.3	% opt. Proctor	86.1

Calibration

o/s tête	84.00	burette utilisée		large	0	section burette	1.00
o/s base	17.40	med	1	petite	0	température	23.9
	22						



Résultat de l'essai

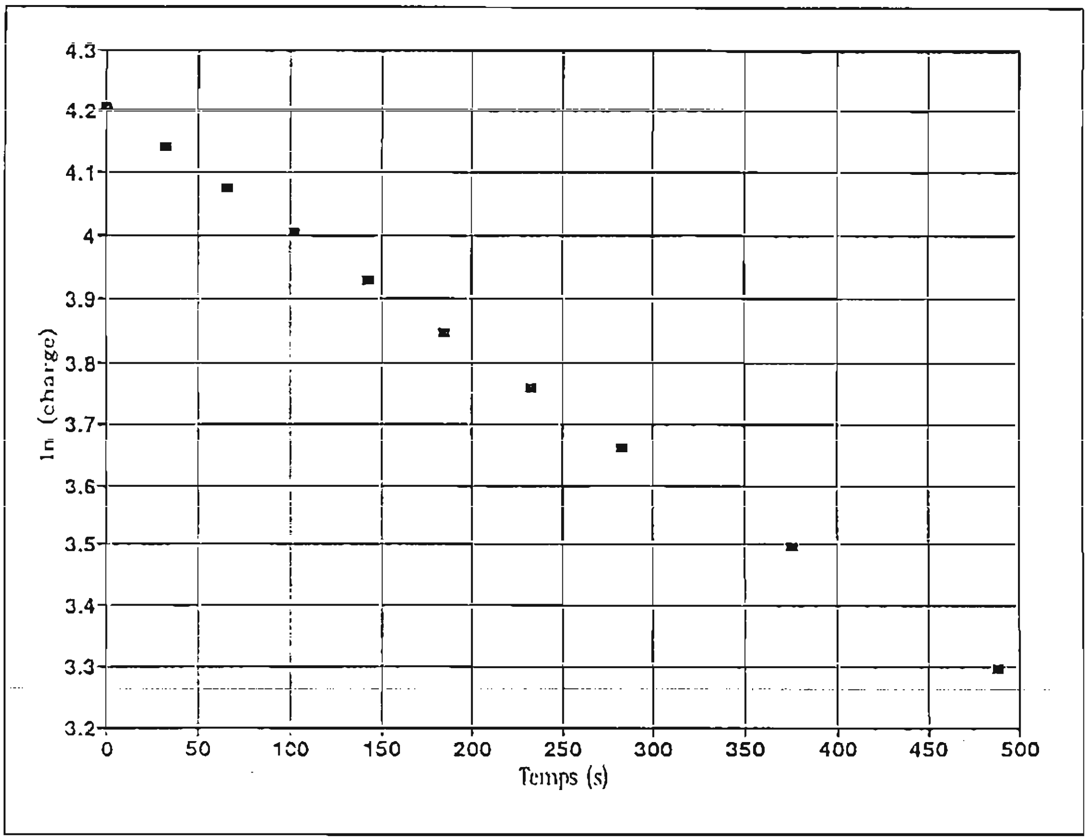
charge variable

Indice des vides	0.888
Perméabilité (cm/s)	1.14E-04
écart type	4.12E-07
ind. reg.	1.000

COMMENTAIRES

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-0.4	0	0	67.0	0.00	-	-
0.53	-2.0	1.7	2.00	2.10	62.9	32.00	1.30E-04	1.19E-04
1.10	-4.0	3.7	4.00	4.10	58.9	66.00	1.28E-04	1.17E-04
1.70	-6.0	5.7	6.00	6.10	54.9	102.00	1.28E-04	1.17E-04
2.38	-8.0	7.7	8.00	8.10	50.9	143.00	1.26E-04	1.15E-04
3.08	-10.0	9.7	10.00	10.10	46.9	185.00	1.27E-04	1.16E-04
3.88	-12.0	11.7	12.00	12.10	42.9	233.00	1.26E-04	1.15E-04
4.72	-14.0	13.7	14.00	14.10	38.9	283.00	1.26E-04	1.15E-04
6.25	-17.0	16.6	17.00	17.00	33.0	375.00	1.24E-04	1.13E-04
8.13	-20.0	19.6	20.00	20.00	27.0	488.00	1.22E-04	1.12E-04



TEST PERMEABILITE

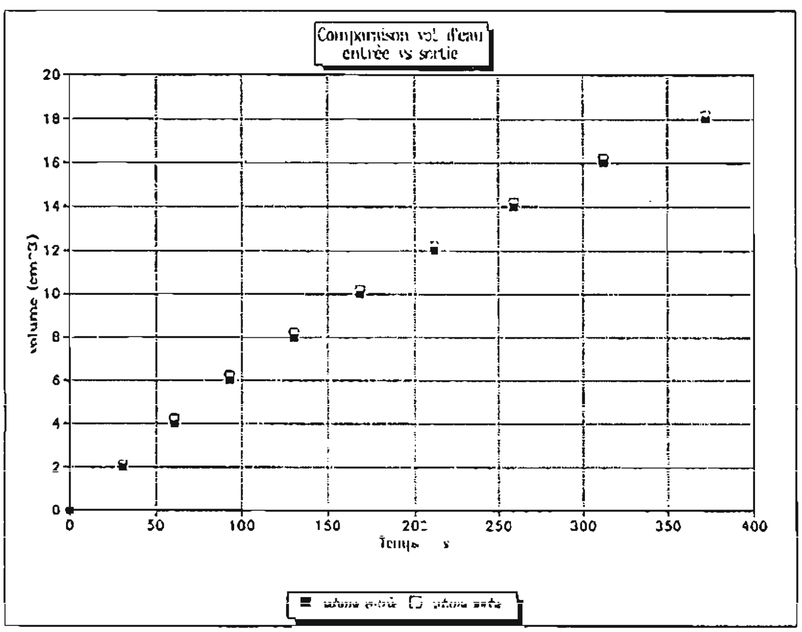
PERMEAMETRE A CHARGE VARIABLE

Date de montage	30-01-1996	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	4ième cycle de congélat
Nom du fichier:	GOLDER\PERMEA\CONGELATION	

Géométrie (moule #4)			Masses g	
épaisseur initiale cm	7.357	15.815	masse initiale humide	668.8
diamètre cm	8.440	7.738	masse finale humide	807.4
surface (cm^2)	55.947		masse finale sèche	614.7
Volume (cm^3)	411.60		Gs	2.819

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.625
Par séchage (%) init.	28.0	mas. vol. sec. (g/cm3)	1.493
Par séchage (%) fin.	99.6	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	8.8	teneur eau opt. (%)	15.7
Teneur en eau finale	31.3	% opt. Proctor	86.1

Calibration							
o/s tête	84.00	burette utilisée		large	0	section burette	1.00
o/s base	17.80	med	1	petite	0	température	23.7

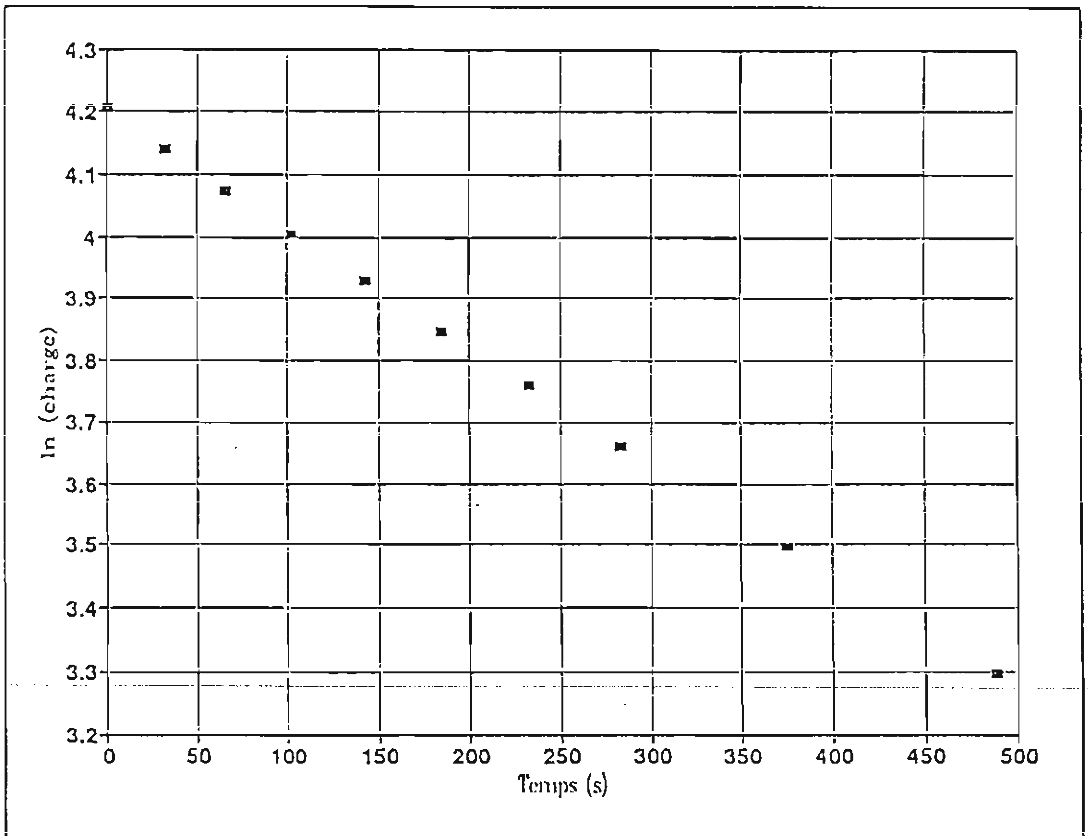


Résultat de l'essai	
charge variable	
Indice des vides	0.888
Perméabilité (cm/s)	1.27E-04
écart type	5.01E-07
ind. reg.	1.000
COMMENTAIRES	

05-02-96	GOLDER MIN. RICHESSES NATURELLES	page 2

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-0.4	0	0	67.0	0.00	-	-
0.53	-2.0	1.7	2.00	2.10	62.9	32.00	1.30E-04	1.19E-04
1.10	-4.0	3.7	4.00	4.10	58.9	66.00	1.28E-04	1.17E-04
1.70	-6.0	5.7	6.00	6.10	54.9	102.00	1.28E-04	1.17E-04
2.38	-8.0	7.7	8.00	8.10	50.9	143.00	1.26E-04	1.15E-04
3.08	-10.0	9.7	10.00	10.10	46.9	185.00	1.27E-04	1.16E-04
3.88	-12.0	11.7	12.00	12.10	42.9	233.00	1.26E-04	1.15E-04
4.72	-14.0	13.7	14.00	14.10	38.9	283.00	1.26E-04	1.15E-04
6.25	-17.0	16.6	17.00	17.00	33.0	375.00	1.24E-04	1.13E-04
8.13	-20.0	19.6	20.00	20.00	27.0	488.00	1.22E-04	1.12E-04



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

Date de montage	30-01-1996	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	3 ième cycle de congéla
Nom du fichier:	GOLDER\PERMEA\CONGELATION	

Géométrie	(moule #4)	
épaisseur initiale cm	7.357	15.815
diamètre cm	8.440	7.738
surface (cm^2)	55.947	
Volume (cm^3)	411.60	

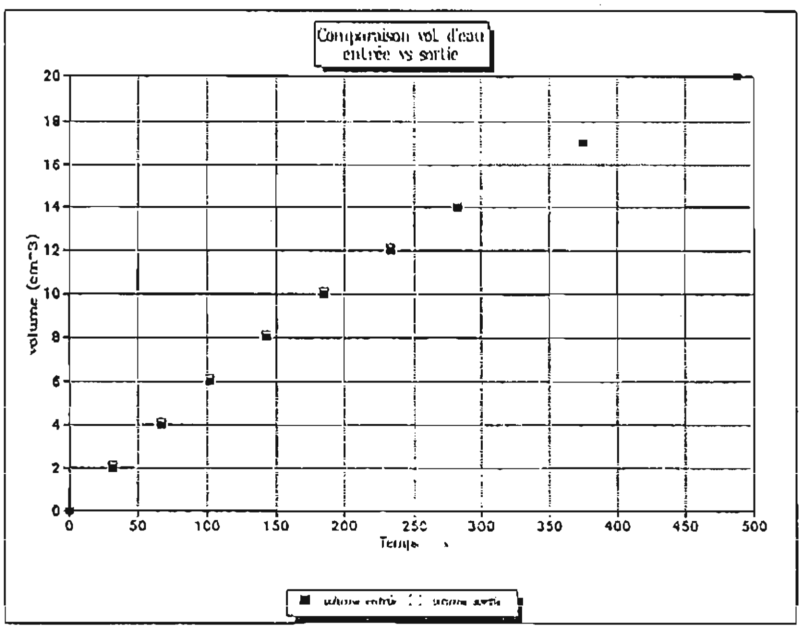
Masses g	
masse initiale humide	668.8
masse finale humide	807.4
masse finale sèche	614.7
Gs	2.819

Conditions de l'essai

Degré de saturation		mas. vol. hum. (g/cm3)	1.625
Par séchage (%) init.	28.0	mas. vol. sec. (g/cm3)	1.493
Par séchage (%) fin.	99.6	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	8.8	teneur eau opt. (%)	15.7
Teneur en eau finale	31.3	% opt. Proctor	86.1

Calibration

o/s tête	84.00	burette utilisée		large	0	section burette	1.00
o/s base	17.40	med	1	petite	0	température	23.7



Résultat de l'essai

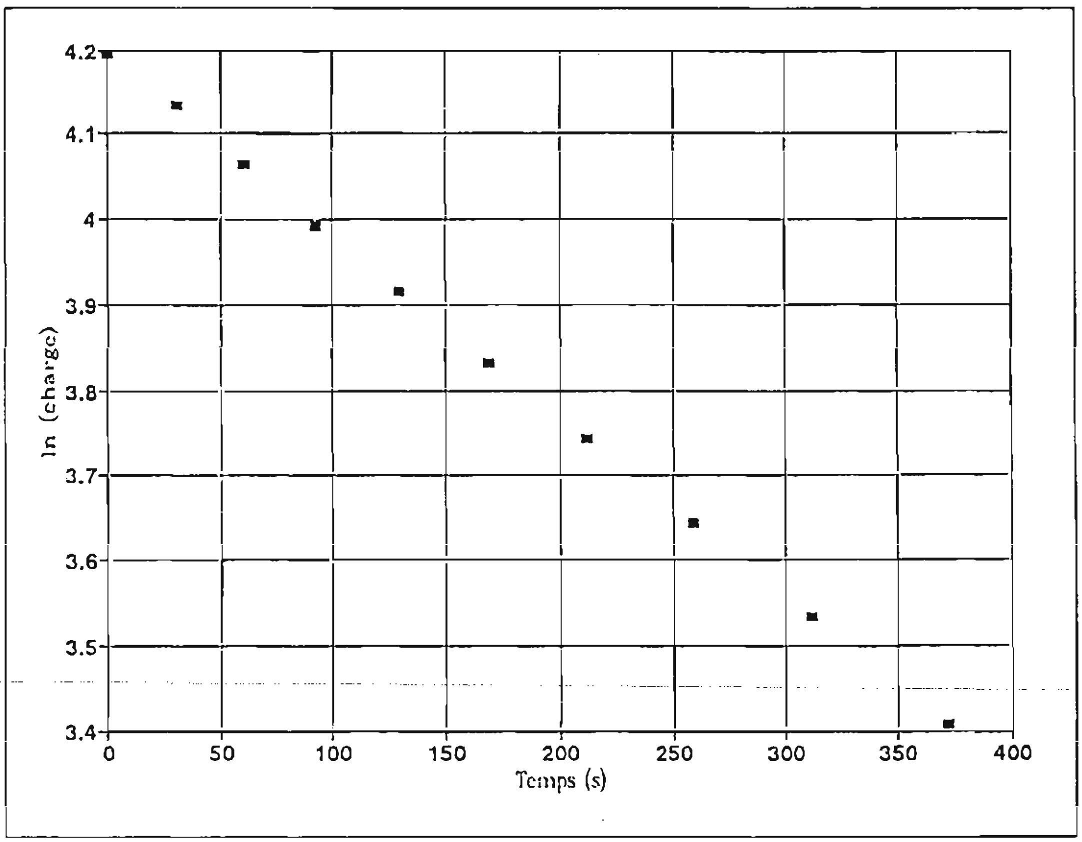
charge variable

Indice des vides	0.888
Perméabilité (cm/s)	1.12E-04
écart type	7.49E-07
ind. reg.	1.000

COMMENTAIRES

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	-0.2	0	0	66.4	0.00	-	-
0.52	-2.0	1.9	2.00	2.10	62.3	31.00	1.35E-04	1.24E-04
1.00	-4.0	4.0	4.00	4.20	58.2	60.00	1.44E-04	1.32E-04
1.55	-6.0	6.0	6.00	6.20	54.2	93.00	1.44E-04	1.31E-04
2.17	-8.0	8.0	8.00	8.20	50.2	130.00	1.41E-04	1.29E-04
2.82	-10.0	10.0	10.00	10.20	46.2	169.00	1.41E-04	1.29E-04
3.53	-12.0	12.0	12.00	12.20	42.2	212.00	1.41E-04	1.28E-04
4.32	-14.0	14.0	14.00	14.20	38.2	259.00	1.40E-04	1.28E-04
5.20	-16.0	16.0	16.00	16.20	34.2	312.00	1.40E-04	1.28E-04
6.20	-18.0	18.0	18.00	18.20	30.2	372.00	1.39E-04	1.27E-04



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

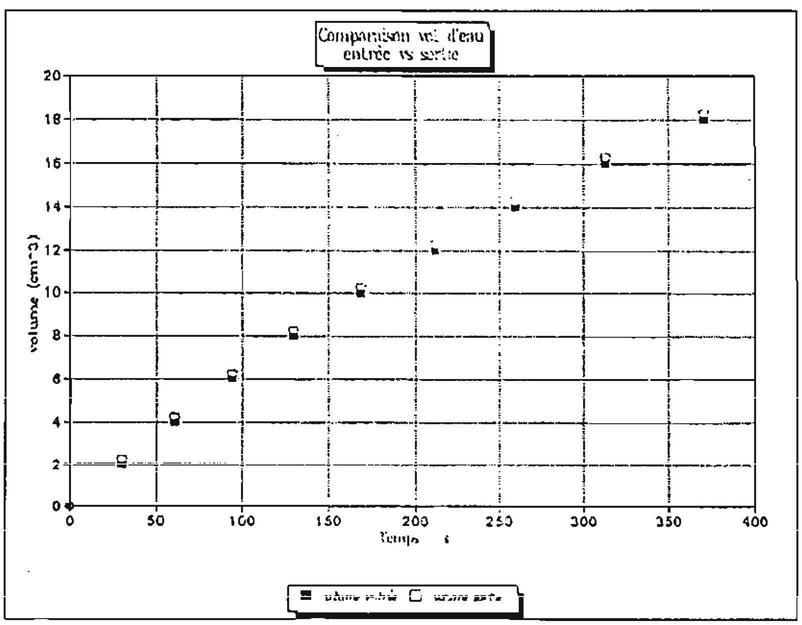
Date de montage	30-01-1996	
Nom de l'échantillon:	GOLDER MIN. RICHESSES NATURELLE	5ième cycle de congélat
Nom du fichier:	GOLDER\PERMEA\CONGELATION	

Géométrie	(moule #1)	
épaisseur initiale cm	7.357	15.815
diamètre cm	8.440	7.738
surface (cm^2)	55.947	
Volume (cm^3)	411.60	

Masses g	
masse initiale humide	668.8
masse finale humide	807.4
masse finale sèche	614.7
Gs	2.819

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.625
Par séchage (%) init.	28.0	mas. vol. sec. (g/cm3)	1.493
Par séchage (%) fin.	99.6	Opt. Proctor (g/cm3)	1.735
Teneur en eau initiale	8.8	teneur eau opt. (%)	15.7
Teneur en eau finale	31.3	% opt. Proctor	86.1

Calibration							
o/s tête	84.00	burette utilisée		large	0	section burette	1.00
o/s base	17.80	med	1	petite	0	température	23.7

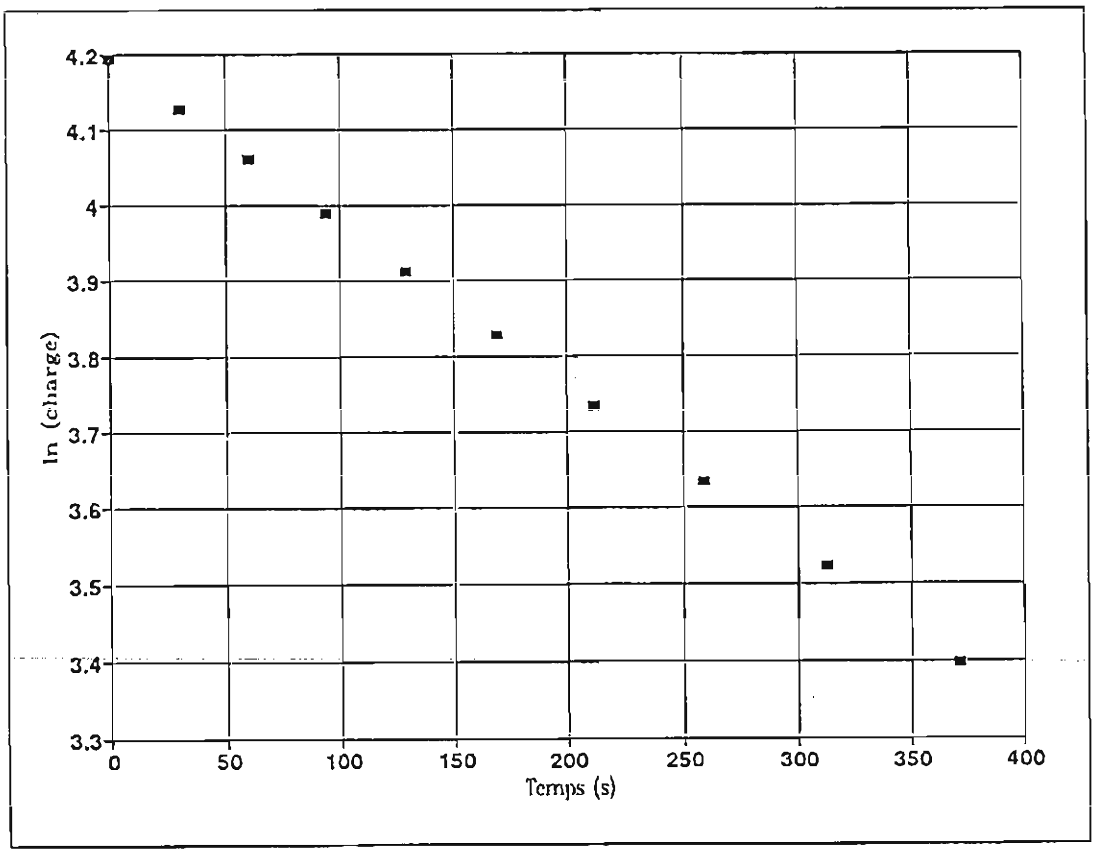


Résultat de l'essai	
charge variable	
Indice des vides	0.888
Perméabilité (cm/s)	1.28E-04
écart type	2.88E-07
ind. reg.	1.000
COMMENTAIRES	
5ième cycle de congélation	

12-02-96 GOLDER MIN. RICHESSES NATURELLES page 2

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.0	0.0	0	0	66.2	0.00	-	-
0.50	-2.0	2.2	2.00	2.20	62.0	30.00	1.44E-04	1.31E-04
1.00	-4.0	4.2	4.00	4.20	58.0	60.00	1.45E-04	1.32E-04
1.57	-6.0	6.2	6.00	6.20	54.0	94.00	1.42E-04	1.30E-04
2.15	-8.0	8.2	8.00	8.20	50.0	129.00	1.43E-04	1.31E-04
2.82	-10.0	10.2	10.00	10.20	46.0	169.00	1.42E-04	1.29E-04
3.53	-12.0	12.3	12.00	12.30	41.9	212.00	1.42E-04	1.30E-04
4.32	-14.0	14.3	14.00	14.30	37.9	259.00	1.42E-04	1.29E-04
5.22	-16.0	16.3	16.00	16.30	33.9	313.00	1.41E-04	1.28E-04
6.18	-18.0	18.3	18.00	18.30	29.9	371.00	1.41E-04	1.29E-04



TEST PERMEABILITE

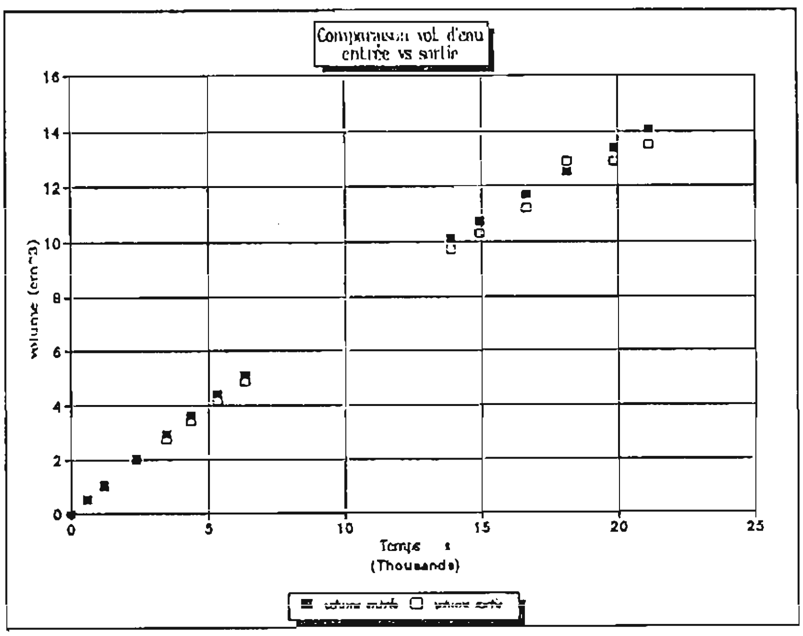
PERMEAMETRE A CHARGE VARIABLE

Date de montage	96-10-07	ETAPE 2
Nom de l'échantillon:	LTA - Silt	après 5 cycles de gel
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1	et dégel

Géométrie	moule # 2		Masses g	
épaisseur initiale cm	12.466	17.378	masse initiale humide	1084.7
diamètre cm	8.255	4.182	masse finale humide	1174.0
surface (cm^2)	53.521		masse finale sèche	966.4
Volume (cm^3)	667.19		Gs	2.780

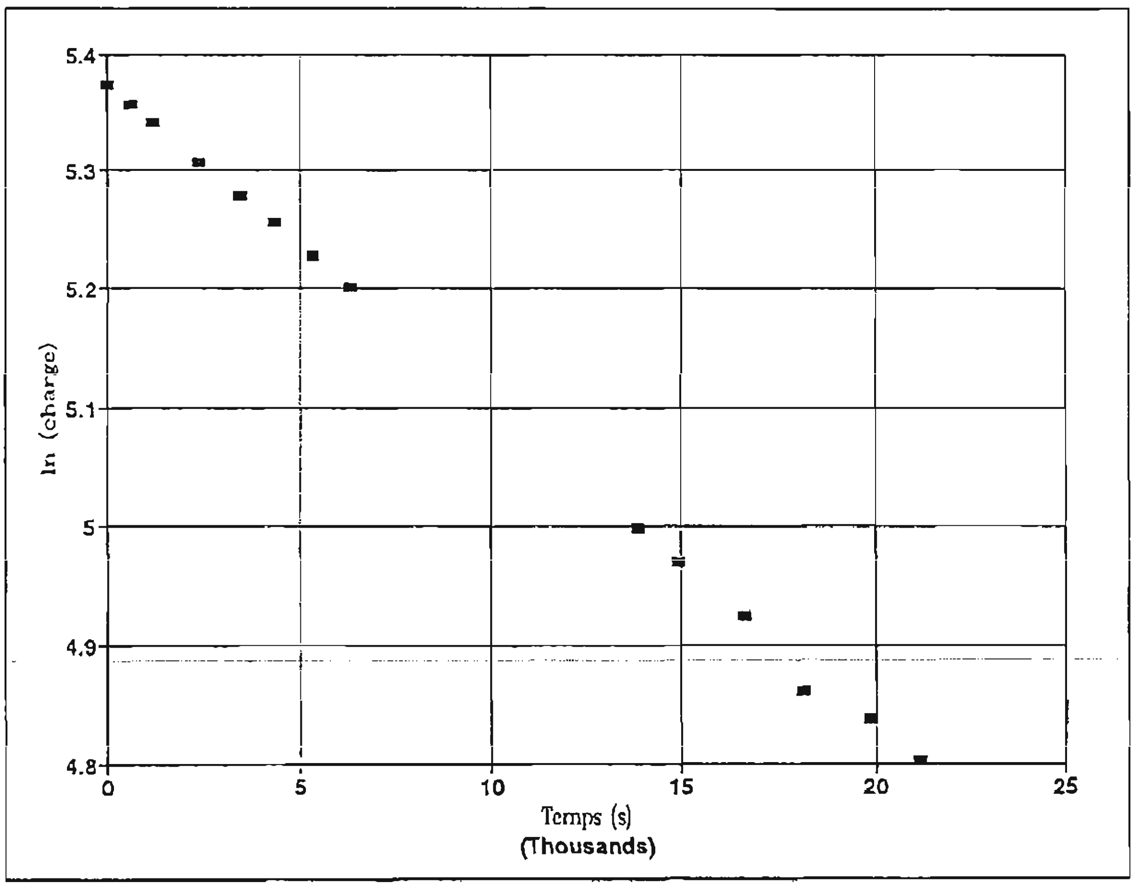
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.626
Par séchage (%) init.	37.0	mas. vol. sec. (g/cm3)	1.448
Par séchage (%) fin.	65.0	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.2	teneur eau opt. (%)	13.2
Teneur en eau finale	21.5	% opt. Proctor	74.6

Calibration							
o/s tête	247.00	burette utilisée		large	0	section burette	0.294
o/s base	27.50	med	0	petite	1	température	23.5



Résultat de l'essai	
charge variable	
Indice des vides:	0.919
Perméabilité (cm/s)	8.56E-07
écart type	7.22E-09
ind. reg.	0.999
COMMENTAIRES	

96-10-25	LTA			ETAPE 2			page 2	
Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	4.00	0.00	0	215.5	0.00	-	-
10.09	-1.80	5.70	0.53	0.50	212.0	605.40	9.26E-07	8.51E-07
20.05	-3.60	7.40	1.06	1.00	208.5	1203.00	9.54E-07	8.77E-07
39.80	-7.00	10.70	2.06	1.97	201.8	2388.00	9.44E-07	8.67E-07
57.80	-10.00	13.40	2.94	2.76	196.1	3468.00	9.09E-07	8.35E-07
72.32	-12.30	15.70	3.62	3.44	191.5	4339.20	9.33E-07	8.57E-07
88.90	-15.00	18.20	4.41	4.18	186.3	5334.00	9.48E-07	8.71E-07
105.54	-17.40	20.60	5.12	4.88	181.5	6332.40	8.96E-07	8.23E-07
231.00	-34.40	37.00	10.12	9.71	148.1	13860.00	9.25E-07	8.50E-07
248.75	-36.50	39.00	10.74	10.29	144.0	14925.00	9.03E-07	8.30E-07
276.80	-39.80	42.10	11.71	11.21	137.6	16608.00	9.25E-07	8.50E-07
302.10	-42.50	47.80	12.50	12.88	129.2	18126.00	1.42E-06	1.31E-06
330.66	-45.50	47.80	13.38	12.88	126.2	19839.60	4.70E-07	4.31E-07
352.30	-47.80	49.90	14.06	13.50	121.8	21138.00	9.36E-07	8.60E-07



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

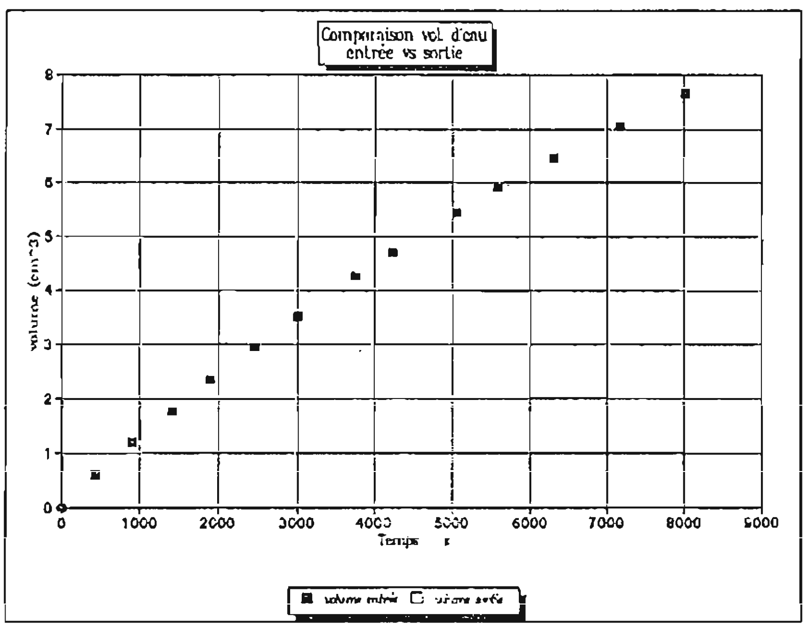
Date de montage	96-10-07	ETAPE 3
Nom de l'échantillon:	LTA -Silt	après 10 cycles de gel
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1	et dégel

Géométrie	moule # 2	
épaisseur initiale cm	12.466	17.378
diamètre cm	8.255	4.182
surface (cm^2)	53.521	
Volume (cm^3)	667.19	

Masses g	
masse initiale humide	1084.7
masse finale humide	1174.0
masse finale sèche	966.4
Gs	2.780

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.626
Par séchage (%) init.	37.0	mas. vol. sec. (g/cm3)	1.448
Par séchage (%) fin.	65.0	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.2	teneur eau opt. (%)	13.2
Teneur en eau finale	21.5	% opt. Proctor	74.6

Calibration							
o/s tête	133.20	burette utilisée		large	0	section burette	0.294
o/s base	24.80	med	0	petite	1	température	23.5

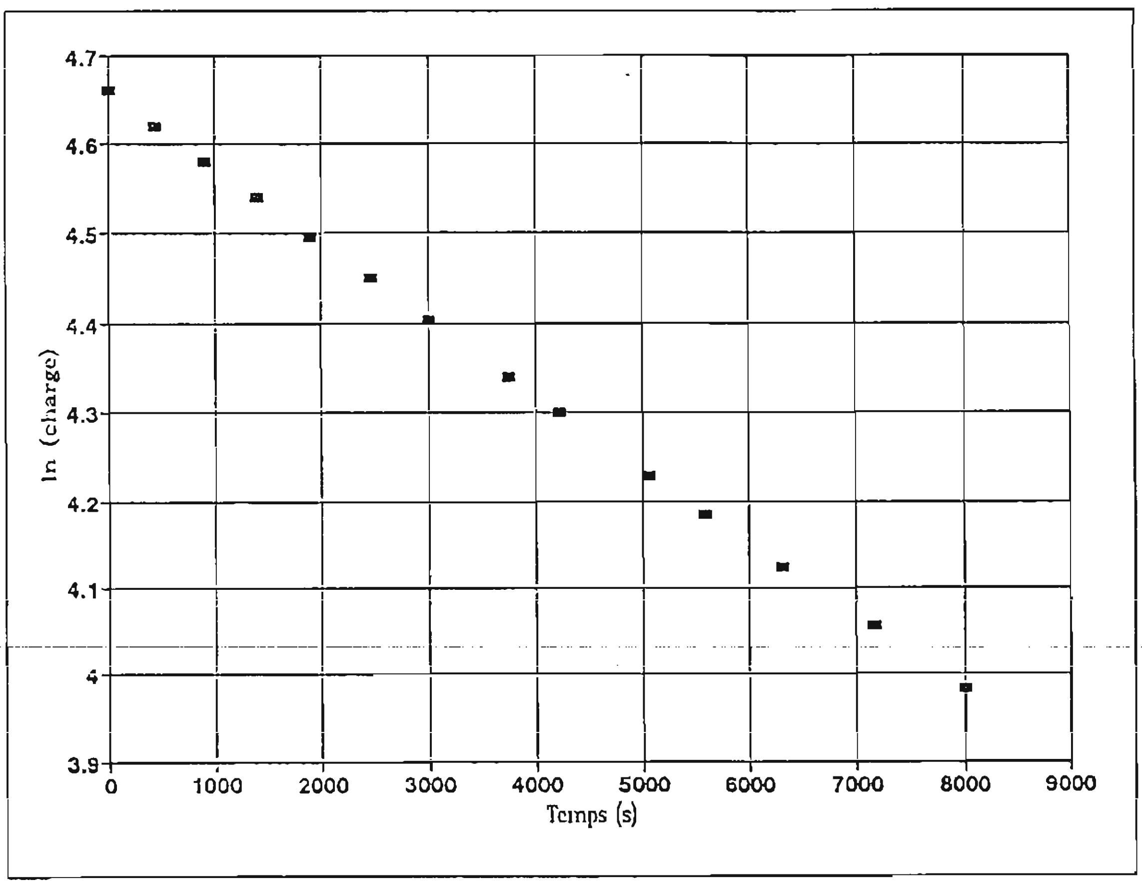


Résultat de l'essai	
charge variable	
Indice des vides:	0.919
Perméabilité (cm/s)	2.66E-06
écart type	4.06E-09
ind. reg.	1.000
COMMENTAIRES	
CONGÉLATION SANS RESSORT	

96-11-11 LTA ETAPE 3 page 2

Lectures

Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	2.70	0.00	0	105.7	0.00	-	-
7.29	-2.00	4.80	0.59	0.62	101.6	437.40	3.10E-06	2.85E-06
15.20	-4.00	6.80	1.18	1.21	97.6	912.00	2.90E-06	2.66E-06
23.26	-6.00	8.70	1.76	1.76	93.7	1395.60	2.89E-06	2.65E-06
31.55	-8.00	10.70	2.35	2.35	89.7	1893.00	3.00E-06	2.76E-06
41.00	-10.00	12.70	2.94	2.94	85.7	2460.00	2.76E-06	2.53E-06
50.12	-12.00	14.60	3.53	3.50	81.8	3007.20	2.92E-06	2.68E-06
62.47	-14.50	17.20	4.26	4.26	76.7	3748.20	2.98E-06	2.73E-06
70.40	-16.00	18.70	4.71	4.71	73.7	4224.00	2.87E-06	2.64E-06
84.35	-18.50	21.20	5.44	5.44	68.7	5061.00	2.87E-06	2.64E-06
93.22	-20.00	22.70	5.88	5.88	65.7	5593.20	2.87E-06	2.64E-06
105.30	-22.00	24.60	6.47	6.44	61.8	6318.00	2.89E-06	2.66E-06
119.43	-24.00	26.70	7.06	7.06	57.7	7165.80	2.77E-06	2.55E-06
133.41	-26.00	28.80	7.65	7.68	53.6	8004.60	3.01E-06	2.77E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

ÉTAPE 2

2 ième essai après 5 cycles de gel et dégel

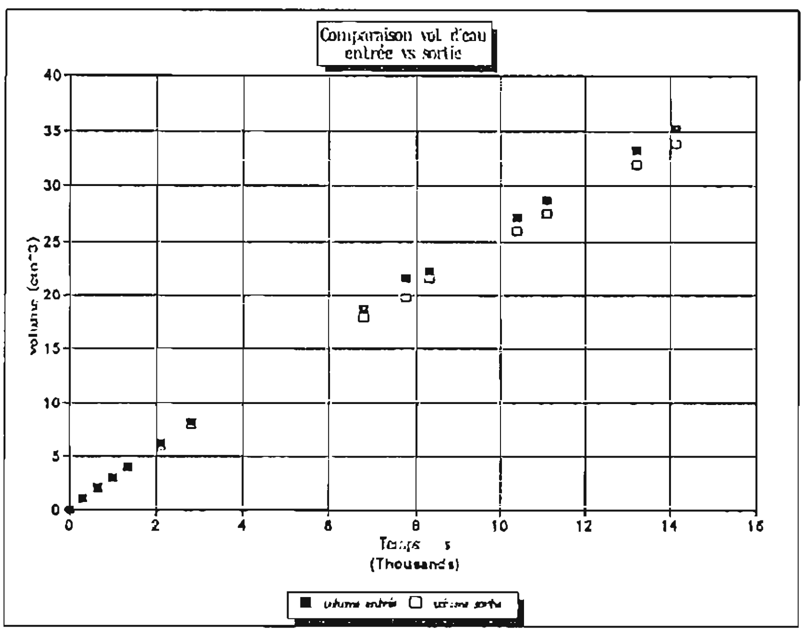
Date de montage	96-10-07
Nom de l'échantillon:	LTA - Silt
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1

Géométrie	(moule # 7	
épaisseur initiale cm	10.760	16.506
diamètre cm	8.255	5.016
surface (cm^2)	53.521	
Volume (cm^3)	575.87	

Masses g	
masse initiale humide	1081.2
masse finale humide	1171.1
masse finale sèche	960.9
Gs	2.780

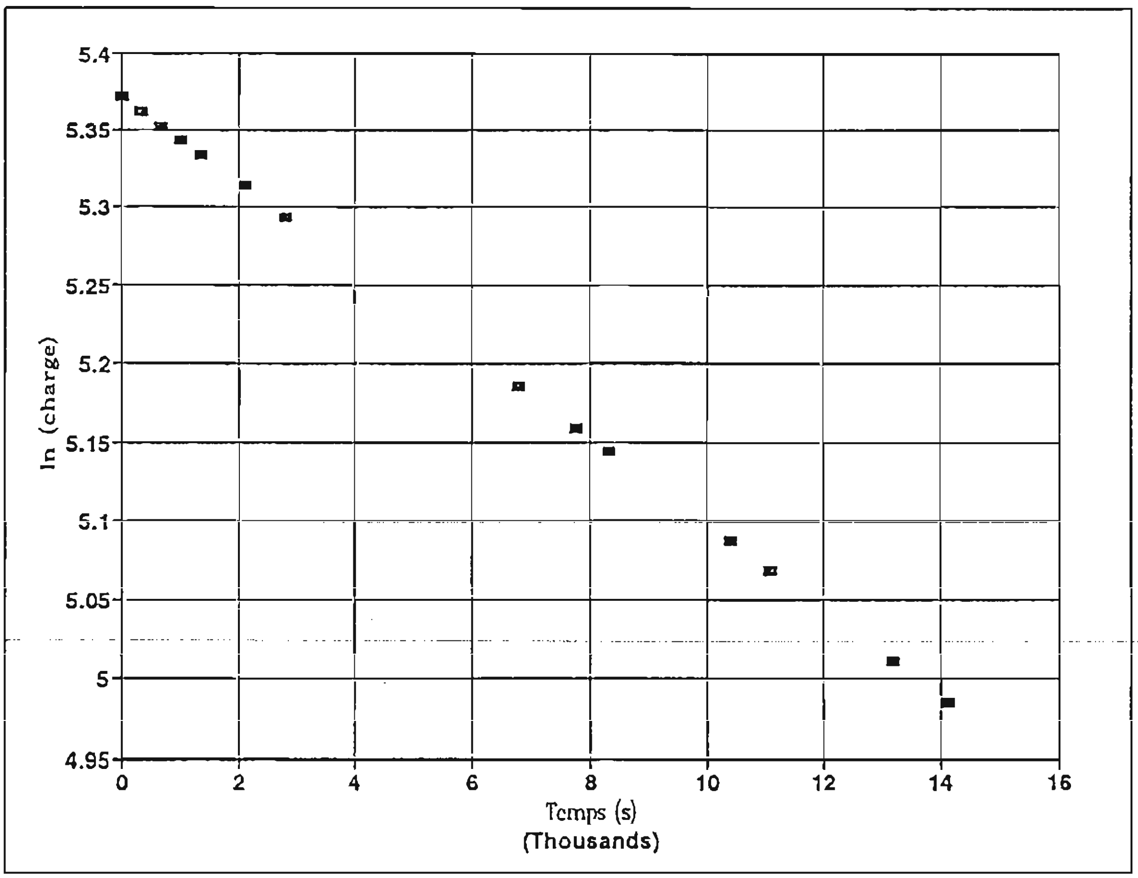
Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.877
Par séchage (%) init.	52.3	mas. vol. sec. (g/cm3)	1.669
Par séchage (%) fin.	91.3	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.5	teneur eau opt. (%)	13.2
Teneur en eau finale	21.9	% opt. Proctor	85.9

Calibration							
o/s tête	249.10	burette utilisée		large	0	section burette	1.000
o/s base	32.50	med	0	petite	1	température	22.8



Résultat de l'essai	
charge variable	
Indice des vides:	0.666
Perméabilité (cm/s)	2.56E-06
écart type	1.85E-09
ind. reg.	1.000
COMMENTAIRES	

96-10-23	SILT ARGILEUX						page 2	
Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	1.40	0.00	0	215.2	0.00	-	-
5.35	-1.00	2.50	1.00	1.10	213.1	321.00	3.07E-06	2.87E-06
11.00	-2.00	3.50	2.00	2.10	211.1	660.00	2.80E-06	2.62E-06
16.61	-3.00	4.40	3.00	3.00	209.2	996.60	2.70E-06	2.53E-06
22.47	-4.00	5.40	4.00	4.00	207.2	1348.20	2.75E-06	2.57E-06
35.07	-6.20	7.40	6.20	6.00	203.0	2104.20	2.72E-06	2.55E-06
46.75	-8.20	9.40	8.20	8.00	199.0	2805.00	2.85E-06	2.67E-06
113.20	-18.70	19.30	18.70	17.90	178.6	6792.00	2.73E-06	2.55E-06
129.50	-21.50	21.10	21.50	19.70	174.0	7770.00	2.68E-06	2.51E-06
138.60	-22.20	22.90	22.20	21.50	171.5	8316.00	2.66E-06	2.49E-06
173.20	-27.20	27.40	27.20	26.00	162.0	10392.00	2.76E-06	2.58E-06
184.89	-28.70	29.00	28.70	27.60	158.9	11093.40	2.77E-06	2.59E-06
219.60	-33.20	33.30	33.20	31.90	150.1	13188.00	2.73E-06	2.56E-06
235.40	-35.20	35.20	35.20	33.80	146.2	14124.00	2.83E-06	2.65E-06
248.44	-36.70	36.70	36.70	35.30	143.2	14906.40	2.66E-06	2.49E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

ÉTAPE 3

3 ième essai après 5 cycles de gel et dégel sans ressort

Date de montage	96-10-07
Nom de l'échantillon:	LTA - Si +
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1

Géométrie	(moule # 7	
épaisseur initiale cm	10.760	16.506
diamètre cm	8.255	5.016
surface (cm^2)	53.521	
Volume (cm^3)	575.87	

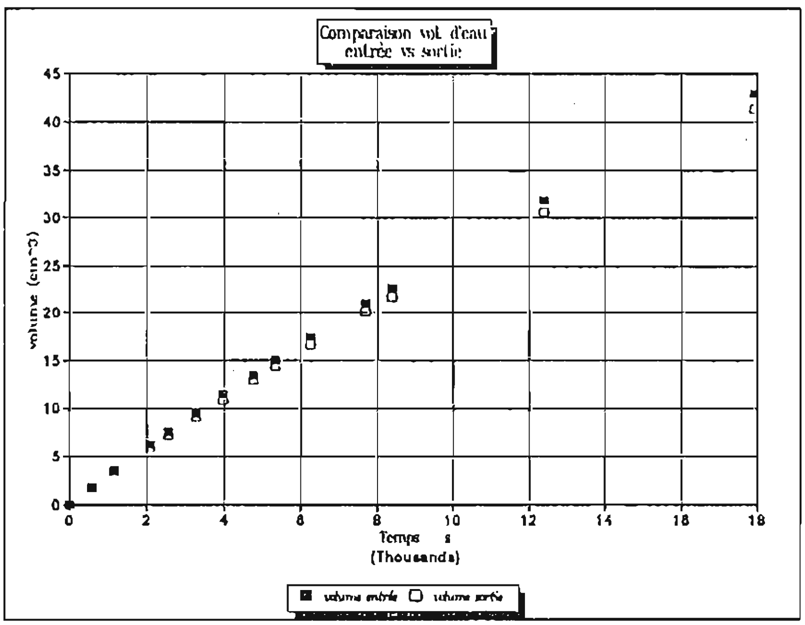
Masses g	
masse initiale humide	1081.2
masse finale humide	1171.1
masse finale sèche	960.9
Gs	2.780

Conditions de l'essai

Degré de saturation		mas. vol. hum. (g/cm3)	1.877
Par séchage (%) init.	52.3	mas. vol. sec. (g/cm3)	1.669
Par séchage (%) fin.	91.3	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.5	teneur eau opt. (%)	13.2
Teneur en eau finale	21.9	% opt. Proctor	85.9

Calibration

o/s tête	249.10	burette utilisée		large	0	section burette	1.000
o/s base	19.90	med	0	petite	1	température	23.5



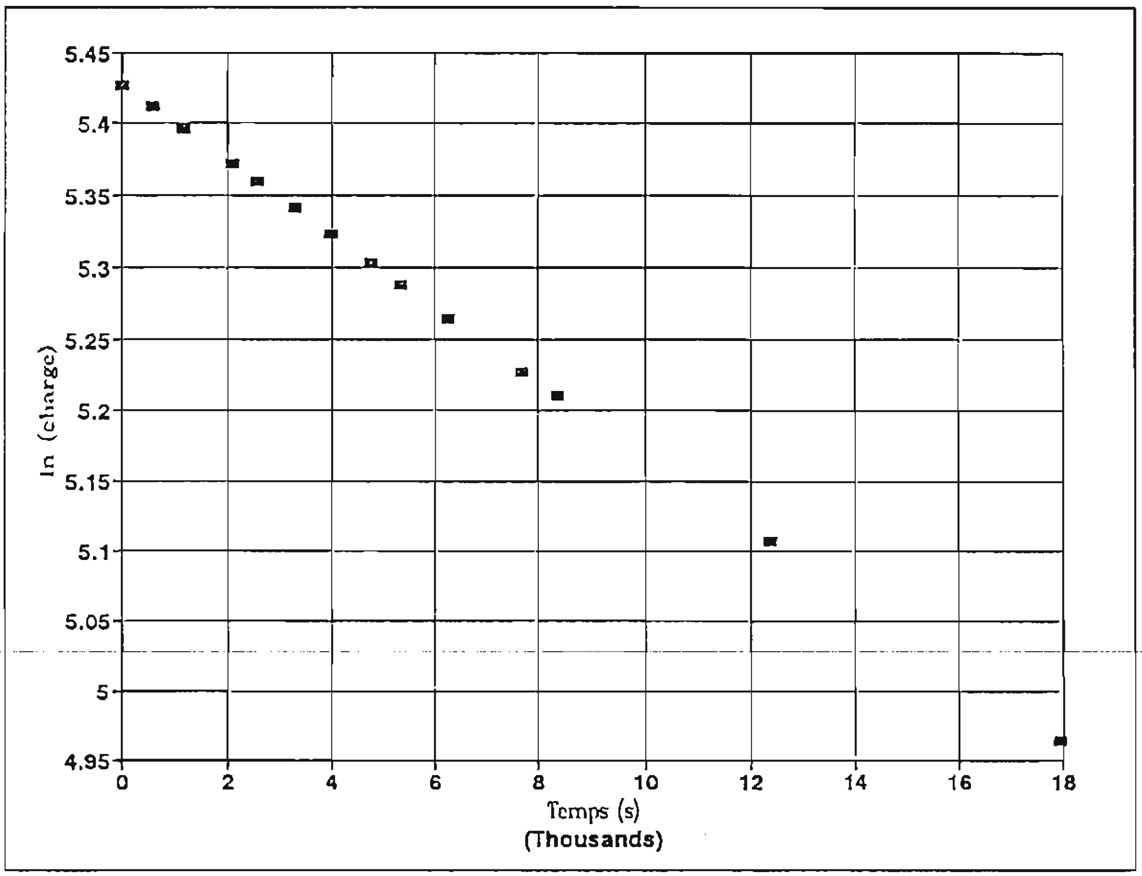
Résultat de l'essai

charge variable

Indice des vides:	0.666
Perméabilité (cm/s)	2.38E-06
écart type	1.91E-09
ind. reg.	1.000

COMMENTAIRES

96-10-24	SILT ARGILEUX						page 2	
Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	1.70	0.00	0	227.5	0.00	-	-
9.62	-1.80	3.40	1.80	1.70	224.0	577.20	2.70E-06	2.48E-06
19.50	-3.50	5.10	3.50	3.40	220.6	1170.00	2.59E-06	2.38E-06
34.89	-6.20	7.60	6.20	5.90	215.4	2093.40	2.60E-06	2.39E-06
42.70	-7.60	8.90	7.60	7.20	212.7	2562.00	2.71E-06	2.49E-06
54.80	-9.50	10.80	9.50	9.10	208.9	3288.00	2.50E-06	2.29E-06
66.20	-11.50	12.60	11.50	10.90	205.1	3972.00	2.70E-06	2.48E-06
79.20	-13.50	14.60	13.50	12.90	201.1	4752.00	2.54E-06	2.33E-06
89.00	-15.00	16.10	15.00	14.40	198.1	5340.00	2.57E-06	2.36E-06
104.20	-17.40	18.40	17.40	16.70	193.4	6252.00	2.65E-06	2.43E-06
128.00	-21.00	21.80	21.00	20.10	186.4	7680.00	2.60E-06	2.38E-06
139.50	-22.60	23.40	22.60	21.70	183.2	8370.00	2.52E-06	2.32E-06
206.30	-31.80	32.30	31.80	30.60	165.1	12378.00	2.61E-06	2.40E-06
299.20	-43.00	43.10	43.00	41.40	143.1	17952.00	2.58E-06	2.37E-06
332.35	-46.60	46.50	46.60	44.80	136.1	19941.00	2.53E-06	2.33E-06



TEST PERMEABILITE

PERMEAMETRE A CHARGE VARIABLE

étape 4
4 ième essai après 10 cycles de gel et dégel

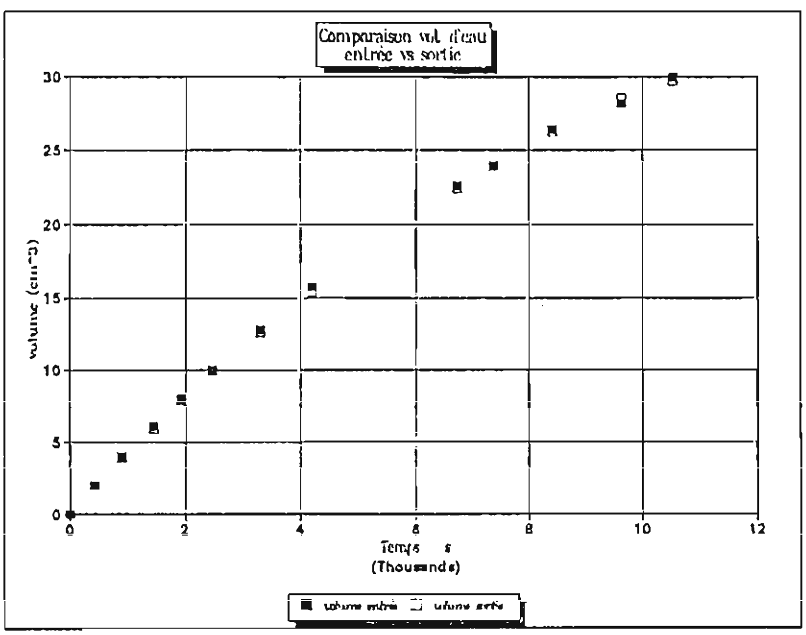
Date de montage	96-10-07
Nom de l'échantillon:	LTA - Silt
Nom du fichier:	GOLDER\LTA\CONGEL\SERIE1

Géométrie	(moule # 7	
épaisseur initiale cm	10.760	16.506
diamètre cm	8.255	5.016
surface (cm^2)	53.521	
Volume (cm^3)	575.87	

Masses g	
masse initiale humide	1081.2
masse finale humide	1171.1
masse finale sèche	960.9
Gs	2.780

Conditions de l'essai			
Degré de saturation		mas. vol. hum. (g/cm3)	1.877
Par séchage (%) init.	52.3	mas. vol. sec. (g/cm3)	1.669
Par séchage (%) fin.	91.3	Opt. Proctor (g/cm3)	1.942
Teneur en eau initiale	12.5	teneur eau opt. (%)	13.2
Teneur en eau finale	21.9	% opt. Proctor	85.9

Calibration							
o/s tête	133.30	burette utilisée		large	0	section burette	1.000
o/s base	29.30	med	0	petite	1	température	23.3

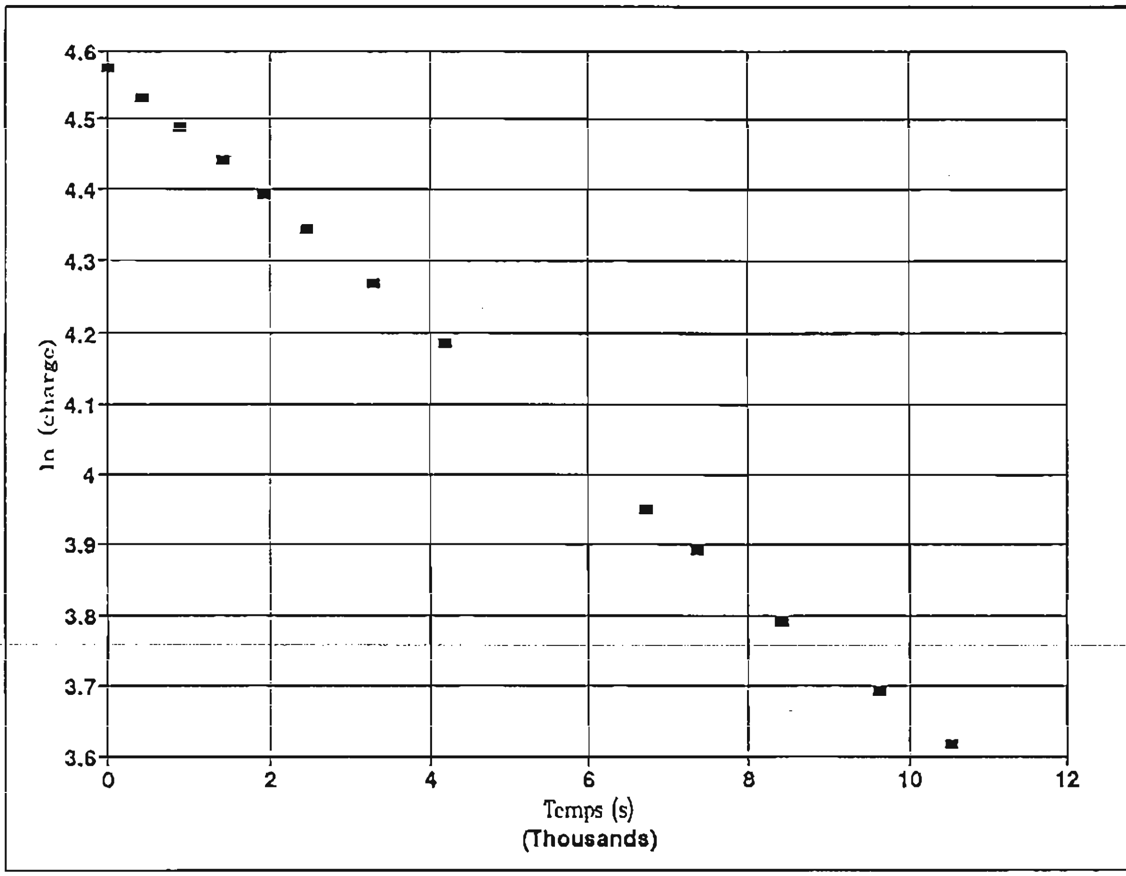


Résultat de l'essai	
charge variable	
Indice des vides	0.666
Perméabilité (cm/s)	8.51E-06
écart type	3.76E-08
ind. reg.	1.000

COMMENTAIRES

Sans ressort durant la congélation

96-11-11	LTA			étape 4			page 2	
Lectures								
Temps Min	hauteur tête	hauteur base	Volume entrée	Volume Sortie	charge cm	diff s	K cm/s	K20 cm/s
0.00	0.00	7.10	0.00	0	96.9	0.00	-	-
7.24	-2.00	9.10	2.00	2.00	92.9	434.40	9.75E-06	9.01E-06
15.10	-4.00	11.00	4.00	3.90	89.0	906.00	9.14E-06	8.44E-06
24.10	-6.10	13.00	6.10	5.90	84.9	1446.00	8.78E-06	8.11E-06
32.18	-8.00	15.00	8.00	7.90	81.0	1930.80	9.75E-06	9.01E-06
41.18	-10.00	17.00	10.00	9.90	77.0	2470.80	9.43E-06	8.71E-06
55.05	-12.80	19.70	12.80	12.60	71.5	3303.00	8.95E-06	8.27E-06
70.02	-15.70	22.50	15.70	15.40	65.8	4201.20	9.30E-06	8.59E-06
112.15	-22.60	29.50	22.60	22.40	51.9	6729.00	9.44E-06	8.72E-06
123.02	-24.00	31.00	24.00	23.90	49.0	7381.20	8.86E-06	8.19E-06
140.23	-26.40	33.30	26.40	26.20	44.3	8413.80	9.82E-06	9.07E-06
160.44	-28.20	35.70	28.20	28.60	40.1	9626.40	8.26E-06	7.63E-06
175.45	-30.00	36.80	30.00	29.70	37.2	10527.00	8.38E-06	7.74E-06



APPENDIX G

IN SITU COMPACTION MONITORING RESULTS
(FALL 95- WINTER 96)

(Golder Associés)

TABLEAU A - 1

Rapport des essais de calcul de densité - Sable et gravier

Projet	Barrick - Finalisation - LTA	**no. projet**	951-7156
Description	Sable et gravier - site LTA		
Personnel	Eric Bouchard (Golder)	**Compacteur**	rouleau

		Résultats du Proctor standard		**Résultats du Proctor modifié**
Gs	2,751	**Densité optimale (Mg/m3)**	1,958	**Densité optimale (Mg/m3)**
		Teneur en eau optimale	6,5	**Teneur en eau optimale**

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
1	0,5	1920	3,2	98,1%	0,433	12 décembre 1996
2	0,5	1928	5,9	98,5%	0,427	
3	0,5	1554	3,1	79,4%	0,770	
4	0,5	1905	4,1	97,3%	0,444	
5	0,5	1880	3,4	96,0%	0,463	
6	0,5	1799	3,2	91,9%	0,529	
7	0,5	1876	5,1	95,8%	0,466	
8	0,5	1901	4,3	97,1%	0,447	
9	0,5	1615	4,1	82,5%	0,703	
10	0,5	1879	6,1	96,0%	0,464	

TABLEAU A - 1

Rapport des essais de calcul de densité - Sable et gravier

Projet	Barrick - Finalisation - LTA	**no. projet**	951-7156
Description	Sable et gravier - site LTA		
Personnel	Eric Bouchard (Golder)	**Compacteur**	rouleau

Gs	2,751	**Résultats du Proctor standard**		**Résultats du Proctor modifié**	
		Densité optimale (Mg/m3)	1,958	**Densité optimale (Mg/m3)**	
		Teneur en eau optimale	6,5	**Teneur en eau optimale**	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
1	0,5	1920	3,2	98,1%	0,433	12 décembre 1996
2	0,5	1928	5,9	98,5%	0,427	
3	0,5	1554	3,1	79,4%	0,770	
4	0,5	1905	4,1	97,3%	0,444	
5	0,5	1880	3,4	96,0%	0,463	
6	0,5	1799	3,2	91,9%	0,529	
7	0,5	1876	5,1	95,8%	0,466	
8	0,5	1901	4,3	97,1%	0,447	
9	0,5	1615	4,1	82,5%	0,703	
10	0,5	1879	6,1	96,0%	0,464	

Rapport des essais de calcul de densité - Sable et gravier

Projet	Barrick - Finalisation - LTA	no. projet	951-7156
Description	Sable et gravier - site LTA		
Personnel	Eric Bouchard (Golder)	Compacteur	rouleau

Gs	2,751	Résultats du Proctor standard	Résultats du Proctor modifié
		Densité optimale (Mg/m3) 2,05	Densité optimale (Mg/m3)
		Teneur en eau optimale 6,5	Teneur en eau optimale

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
11	0,5	1887	4,2	92,0%	0,458	8 janvier 1996
12	0,5	1975	3,5	96,3%	0,393	
13	0,5	2031	2,9	99,1%	0,355	
14	0,5	1857	5,4	90,6%	0,481	
15	0,5	1971	3,1	96,1%	0,396	
16	0,5	1898	3,5	92,6%	0,449	
17	0,5	2010	3,8	98,0%	0,369	
18	0,5	1857	4,1	90,6%	0,481	
19	0,5	1888	2,8	92,1%	0,457	
20	0,5	1910	4,5	93,2%	0,440	
21	0,5	1925	3,8	93,9%	0,429	
22	0,5	1979	4	96,5%	0,390	
23	0,5	2013	4,1	98,2%	0,367	
24	0,5	1920	3,2	93,7%	0,433	
25	0,5	1905	4,1	92,9%	0,444	
26	0,5	2006	4,2	97,9%	0,371	
27	0,5	2020	3,8	98,5%	0,362	
28	0,5	1989	3,4	97,0%	0,383	
29	0,5	1990	3,8	97,1%	0,382	
30	0,5	2015	3,3	98,3%	0,365	
47	0,5	1879	4	91,7%	0,464	9 janvier 1996
48	0,5	1820	4,1	88,8%	0,512	
49	0,5	1966	3,8	95,9%	0,399	
50	0,5	1975	3,2	96,3%	0,393	
51	0,5	1864	6,1	90,9%	0,476	
52	0,5	1960	3,8	95,6%	0,404	
53	0,5	1879	5,4	91,7%	0,464	
54	0,5	1910	6,1	93,2%	0,440	
55	0,5	1918	3,2	93,6%	0,434	
56	0,5	1898	4	92,6%	0,449	
57	0,5	1357	6,7	66,2%	1,027	
58	0,5	1690	6,1	82,4%	0,628	
59	0,5	1606	5,2	78,3%	0,713	
60	0,5	1570	5,6	76,6%	0,752	
61	0,5	1473	4,6	71,9%	0,868	
62	0,5	1713	5,7	83,6%	0,606	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
63	0,5	1795	5,8	87,6%	0,533	
64	0,5	1651	5	80,5%	0,666	10 janvier 1996
65	0,5	1773	2,2	86,5%	0,552	
66	0,5	2017	5,5	98,4%	0,364	
67	0,5	2021	4,8	98,6%	0,361	
68	0,5	2005	2,5	97,8%	0,372	
69	0,5	1993	3,9	97,2%	0,380	11 janvier 1996
70	0,5	1927	3,4	94,0%	0,428	
71	0,5	1928	3	94,0%	0,427	
72	0,5	2055	5,3	100,2%	0,339	
73	0,5	2052	5,1	100,1%	0,341	
74	0,5	2097	2,9	102,3%	0,312	
75	0,5	2045	5,3	99,8%	0,345	
76	0,5	2061	3,7	100,5%	0,335	
77	0,5	2030	3,2	99,0%	0,355	
78						
79	0,5	1998	3,8	97,5%	0,377	
80	0,5	1993	3,9	97,2%	0,380	
81	0,5	1959	3,3	95,6%	0,404	
82	0,5	1986	2,6	96,9%	0,385	
83	0,5	1898	3,3	92,6%	0,449	
84	0,5	1964	3	95,8%	0,401	
85	0,5	1996	2,2	97,4%	0,378	
86	0,5	2072	1,8	101,1%	0,328	12 janvier 1996
87	0,5	2030	4,3	99,0%	0,355	
88	0,5	2022	2,5	98,6%	0,361	
89	0,5	2234	3,6	109,0%	0,231	
90	0,5	2027	2,3	98,9%	0,357	
91	0,5	2091	4,8	102,0%	0,316	
92	0,5	2081	3,2	101,5%	0,322	
93	0,5	2020	3,2	98,5%	0,362	
94	0,5	2035	4,3	99,3%	0,352	
95	0,5	2070	2,1	101,0%	0,329	
96	0,5	2055	3	100,2%	0,339	
97	0,5	2097	2,8	102,3%	0,312	
98	0,5	2045	3,9	99,8%	0,345	
99	0,5	2082	3	101,6%	0,321	

TABLEAU B - 1

Rapport des essais de calcul de densité - Résidus MRN

Projet	Barrick - Finalisation - LTA	no. projet	951-7156
Description	Cellules d'essai de compaction - matériaux MRN - site LTA		
Personnel	Eric Bouchard (Golder)	Compacteur	rouleau

Gs	2,819	Résultats du Proctor standard		Résultats du Proctor modifié	
		Densité optimale (Mg/m3)	1,714	Densité optimale (Mg/m3)	
		Teneur en eau optimale	15,5	Teneur en eau optimale	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
1	0,8	1572	23,5	91,7%	0,793	6 décembre - Cellule 1
2	0,8	1505	33,2	87,8%	0,873	Couche de 0.8 m d'épaisseur
3	0,8	1549	23,3	90,4%	0,820	5 passage du rouleau
4	0,8	1476	22,5	86,1%	0,910	
5	0,8	1560	23,8	91,0%	0,807	
6	0,8	1525	25,2	89,0%	0,849	
7	0,8	1480	23,5	86,3%	0,905	
8	0,8	1551	17,1	90,5%	0,818	
9	0,8	1562	17,5	91,1%	0,805	
10	0,8	1486	21,3	86,7%	0,897	
11a	0,8	1563	19,7	91,2%	0,804	même place - 4 passages
12a	0,8	1593	19,8	92,9%	0,770	même place - 5 passages
13a	0,8	1511	22,5	88,2%	0,866	même place - 6 passages
14	0,4	1463	27,6	85,4%	0,927	6 décembre - Cellule 2
15	0,4	1453	28,6	84,8%	0,940	Couche de 0.4 m d'épaisseur
16	0,4	1515	27,5	88,4%	0,861	Après le 4eme passage, l'eau
17	0,4	1465	27,8	85,5%	0,924	remonte, compaction moins bonne
18	0,8	1385	24,9	80,8%	1,035	7 décembre - Cellule 1
19	0,8	1445	22,8	84,3%	0,951	0.05 m de gel, compaction
20	0,8	1384	21,5	80,7%	1,037	moins bonne
21	0,4	1437	22	83,8%	0,962	7 décembre - Cellule 2
22	0,4	1397	26	81,5%	1,018	0.05 m de gel, compaction
23	0,4	1391	25,1	81,2%	1,027	

TABLEAU B - 2

Rapport des essais de calcul de densité - Résidus MRN

Projet	Barrick - Finalisation - LTA	**no. projet**	951-715
Description	Zone sud -est - matériaux MRN - site LTA		
Personnel	Eric Bouchard (Golder)	**Compacteur**	rouleau

Gs	2,819	**Résultats du Proctor standard**		**Résultats du Proctor modifié**
		Densité optimale (Mg/m3)	1,714	**Densité optimale (Mg/m3)**
		Teneur en eau optimale	15,5	**Teneur en eau optimale**

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
15a	0,8	1524	18,5	88,9%	0,850	13 décembre 1996
16a	0,8	1548	15,4	90,3%	0,821	
17a	0,8	1492	20	87,0%	0,889	
18a	0,8	1600	15,3	93,3%	0,762	
19a	0,8	1435	21,4	83,7%	0,964	
20a	0,8	1490	18,1	86,9%	0,892	
21a	0,8	1535	19,1	89,6%	0,836	
22a	0,8	1601	16,1	93,4%	0,761	
23a	0,8	1590	14,1	92,8%	0,773	
24	0,8	1505	18,4	87,8%	0,873	
25	0,8	1499	15,4	87,5%	0,881	
26	0,8	1475	17,1	86,1%	0,911	
27	0,8	1456	24,1	84,9%	0,936	
28	0,8	1490	17,6	86,9%	0,892	
29	0,8	1253	20	73,1%	1,250	
30	0,8	1426	24,9	83,2%	0,977	
31	0,8	1435	16	83,7%	0,964	
32	0,8	1495	17,5	87,2%	0,886	
33	0,8	1481	16,2	86,4%	0,903	
34	0,8	1505	20	87,8%	0,873	
35	0,8	1422	18,7	83,0%	0,982	
36	0,8	1439	24,1	84,0%	0,959	
37	0,8	1597	15,6	93,2%	0,765	
38	0,8	1542	19,9	90,0%	0,828	
39	0,8	1505	19,8	87,8%	0,873	
39a	0,8	1583	17,7	92,4%	0,781	
40	0,8	1528	27,8	89,1%	0,845	15 décembre 1996
41	0,8	1605	20,2	93,6%	0,756	
42	0,8	1646	19,8	96,0%	0,713	
43	0,8	1416	33,3	82,6%	0,991	
44	0,8	1625	21,1	94,8%	0,735	
45	0,8	1576	21,5	91,9%	0,789	
46	0,8	1586	22,1	92,5%	0,777	

Rapport des essais de calcul de densité - Résidus MRN

Projet	Barrick - Finalisation - LTA	no. projet	951-7156
Description	Matériaux MRN - site LTA		
Personnel	Eric Bouchard (Golder)	Compacteur	rouleau

		Résultats du Proctor standard		Résultats du Proctor modifié	
Gs	2,819	Densité optimale (Mg/m3)	1,65	Densité optimale (Mg/m3)	
		Teneur en eau optimale	20 %	Teneur en eau optimale	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
100	0,15	1514	15,6	91,8%	0,862	15 janvier 1996
101	0,15	1412	18,4	85,6%	0,996	
102	0,15	1562	16,2	94,7%	0,805	
103	0,15	1573	18,8	95,3%	0,792	
104	0,15	1596	15,8	96,7%	0,766	
105	0,15	1472	17,1	89,2%	0,915	
106	0,15	1596	14,8	96,7%	0,766	
107	0,15	1509	13,1	91,5%	0,868	
108	0,15	1534	15,8	93,0%	0,838	
109	0,15	1451	13,4	87,9%	0,943	
110	0,15	1550	17	93,9%	0,819	16 janvier 1996
111	0,15	1537	22,7	93,2%	0,834	
112	0,15	1536	19,4	93,1%	0,835	
113	0,15	1552	17,1	94,1%	0,816	
114	0,15	1481	19,3	89,8%	0,903	
115	0,15	1487	17,1	90,1%	0,896	
116	0,15	1530	13,1	92,7%	0,842	
117	0,15	1480	12,6	89,7%	0,905	
118	0,15	1555	13,1	94,2%	0,813	
119	0,15	1543	19,8	93,5%	0,827	
120	0,15	1580	18,8	95,8%	0,784	
121	0,15	1527	17,5	92,5%	0,846	
122	0,15	1539	14,5	93,3%	0,832	
123	0,15	1528	16,3	92,6%	0,845	
124	0,15	1401	30,2	84,9%	1,012	16 janvier 1996
125	0,15	1376	21,5	83,4%	1,049	Taux d'humidité très haut
126	0,15	1499	22	90,8%	0,881	Compaction moins bonne
127	0,15	1359	20,2	82,4%	1,074	
128	0,15	1525	18,9	92,4%	0,849	
129	0,15	1522	15,4	92,2%	0,852	
130	0,15	1317	28,8	79,8%	1,140	
131	0,15	1472	19,8	89,2%	0,915	
132	0,15	1546	17,6	93,7%	0,823	17 janvier 1996
133	0,15	1593	16,2	96,5%	0,770	
134	0,15	1535	18,6	93,0%	0,836	
135	0,15	1506	17,8	91,3%	0,872	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
230	0,15	1597	14,7	96,8%	0,765	
231	0,15	1556	16,3	94,3%	0,812	
232	0,15	1602	13,3	97,1%	0,760	
233	0,15	1656	16,6	100,4%	0,702	
234	0,15	1621	10,7	98,2%	0,739	
235	0,15	1490	23,5	90,3%	0,892	
236	0,15	1644	12,5	99,6%	0,715	
237	0,15	1514	11,8	91,8%	0,862	30 janvier 1996
238	0,15	1581	16,8	95,8%	0,783	
239	0,15	1436	27,2	87,0%	0,963	
240	0,15	1476	13,1	89,5%	0,910	
241	0,15	1554	13,8	94,2%	0,814	
242	0,15	1547	9	93,8%	0,822	
243	0,15	1586	11,5	96,1%	0,777	
244	0,15	1465	16,4	88,8%	0,924	
245	0,15	1609	11,9	97,5%	0,752	
246	0,15	1589	13,2	96,3%	0,774	31 janvier 1996
247	0,15	1508	17,4	91,4%	0,869	
248	0,15	1554	13,3	94,2%	0,814	
249	0,15	1490	21,5	90,3%	0,892	
250	0,15	1489	17,8	90,2%	0,893	
251	0,15	1515	16,9	91,8%	0,861	
252	0,15	1473	18,3	89,3%	0,914	2 février 1996
253	0,15	1579	17,2	95,7%	0,785	
254	0,15	1521	19,1	92,2%	0,853	
255	0,15	1587	17,3	96,2%	0,776	
256	0,15	1435	17,1	87,0%	0,964	
257	0,15	1508	20,3	91,4%	0,869	
258	0,15	1492	25,5	90,4%	0,889	5 février 1996
259	0,15	1422	29,4	86,2%	0,982	
260	0,15	1602	18,7	97,1%	0,760	
261	0,15	1524	23,3	92,4%	0,850	
262	0,15	1482	23,9	89,8%	0,902	
263	0,15	1490	26,6	90,3%	0,892	
264	0,15	1364	29,1	82,7%	1,067	
265	0,15	1592	20,5	96,5%	0,771	
266	0,15	1596	19,8	96,7%	0,766	
267	0,15	1562	16,8	94,7%	0,805	
268	0,15	1572	20	95,3%	0,793	6 février 1996
269	0,15	1505	17,2	91,2%	0,873	
270	0,15	1466	21,9	88,8%	0,923	
271	0,15	1484	24	89,9%	0,900	
272	0,15	1505	18,1	91,2%	0,873	
273	0,15	1555	19	94,2%	0,813	
274	0,15	1570	17	95,2%	0,796	
275	0,15	1569	16,2	95,1%	0,797	
276	0,15	1578	16,9	95,6%	0,786	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
183	0,15	1619	16,5	98,1%	0,741	
184	0,15	1490	18,3	90,3%	0,892	
185	0,15	1518	17,7	92,0%	0,857	
186	0,15	1516	18,6	91,9%	0,859	
187	0,15	1600	13,2	97,0%	0,762	
188	0,15	1616	20	97,9%	0,744	
189	0,15	1610	13,8	97,6%	0,751	
190	0,15	1622	18,1	98,3%	0,738	
191	0,15	1585	14,6	96,1%	0,779	
192	nd	nd	nd			
193	0,15	1605	14,1	97,3%	0,756	
194	0,15	1568	10,3	95,0%	0,798	
195	0,15	1587	10,5	96,2%	0,776	
196	0,15	1447	16,6	87,7%	0,948	
197	0,15	1571	12,6	95,2%	0,794	
198	0,15	1521	19,6	92,2%	0,853	
199	0,15	1468	14,5	89,0%	0,920	24 janvier 1996
200	0,15	1541	17,9	93,4%	0,829	
201	0,15	1520	15,9	92,1%	0,855	
202	0,15	1417	18,1	85,9%	0,989	
203	0,15	1417	18,3	85,9%	0,989	
204	0,15	1553	14,3	94,1%	0,815	
205	0,15	1590	9,2	96,4%	0,773	
206	0,15	1523	16,4	92,3%	0,851	
207	0,15	1538	24	93,2%	0,833	25 janvier 1996
208	0,15	1456	11,4	88,2%	0,936	
209	0,15	1559	15,6	94,5%	0,808	
210	0,15	1527	10,5	92,5%	0,846	
211	0,15	1506	20	91,3%	0,872	
212	0,15	1561	16,6	94,6%	0,806	
213	0,15	1486	12,9	90,1%	0,897	
214	0,15	1448	23,1	87,8%	0,947	
215	0,15	1554	13,3	94,2%	0,814	
216	0,15	1522	17,3	92,2%	0,852	
217	0,15	1459	19,3	88,4%	0,932	
218	0,15	1562	19,5	94,7%	0,805	
219	0,15	1523	18,7	92,3%	0,851	
220	0,15	1581	12,2	95,8%	0,783	
221	0,15	1548	13,1	93,8%	0,821	
222	0,15	1470	12,9	89,1%	0,918	
223	0,15	1409	25,4	85,4%	1,001	
224	0,15	1471	11,8	89,2%	0,916	
225	0,15	1376	18,3	83,4%	1,049	
226	0,15	1532	22,2	92,8%	0,840	
227	0,15	1565	14,4	94,8%	0,801	26 janvier 1996
228	0,15	1523	13,3	92,3%	0,851	
229	0,15	1544	11,2	93,6%	0,826	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
136	0,15	1534	14,4	93,0%	0,838	
137	0,15	1611	15,3	97,6%	0,750	
138	0,15	1510	14,7	91,5%	0,867	
139	0,15	1561	17,3	94,6%	0,806	
140	0,15	1581	16,2	95,8%	0,783	
141	0,15	1517	12,8	91,9%	0,858	
142	0,15	1623	17,6	98,4%	0,737	
143	0,15	1655	10,6	100,3%	0,703	
144	0,15	1577	18,6	95,6%	0,788	
145	0,15	1594	19,3	96,6%	0,769	
146	0,15	1658	10,9	100,5%	0,700	
147	0,15	1608	15,2	97,5%	0,753	
148	0,15	1519	12,7	92,1%	0,856	
149	0,15	1580	16,1	95,8%	0,784	
150	0,15	1651	10,8	100,1%	0,707	
151	0,15	1535	18,1	93,0%	0,836	
152	0,15	1521	17,7	92,2%	0,853	
153	0,15	1483	19,5	89,9%	0,901	
154	0,15	1594	18,9	96,6%	0,769	
155	0,15	1488	18,2	90,2%	0,894	
156	0,15	1610	14,3	97,6%	0,751	
157	0,15	1655	16,1	100,3%	0,703	
158	0,15	1641	12,7	99,5%	0,718	
159	0,15	1637	16,8	99,2%	0,722	
160	0,15	1514	14,3	91,8%	0,862	18 janvier 1996
161	0,15	1581	21,7	95,8%	0,783	
162	0,15	1638	20,6	99,3%	0,721	
163	0,15	1637	21,8	99,2%	0,722	
164	0,15	1669	20,5	101,2%	0,689	
165	0,15	1593	19,2	96,5%	0,770	
166	0,15	1601	18,4	97,0%	0,761	
167	0,15	1667	18,5	101,0%	0,691	
168	0,15	1597	20,2	96,8%	0,765	
169	0,15	1592	21,2	96,5%	0,771	
170	0,15	1649	20,4	99,9%	0,710	
171	0,15	1672	20,1	101,3%	0,686	
172	0,15	1564	19,2	94,8%	0,802	22 janvier 1996
173	0,15	1531	12,7	92,8%	0,841	
174	0,15	1623	19,7	98,4%	0,737	
175	0,15	1666	14,2	101,0%	0,692	
176	0,15	1593	16,1	96,5%	0,770	
177	0,15	1658	15,3	100,5%	0,700	
178	0,15	1653	8,5	100,2%	0,705	
179	0,15	1632	16,5	98,9%	0,727	
180	0,15	1560	21,1	94,5%	0,807	
181	0,15	1626	18,8	98,5%	0,734	
182	0,15	1575	13,6	95,5%	0,790	23 janvier 1996

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
277	0,15	1508	23,3	91,4%	0,869	
278	0,15	1441	22,8	87,3%	0,956	
279	0,15	1499	19,6	90,8%	0,881	
280	0,15	1526	21,6	92,5%	0,847	
281	0,15	1416	27,4	85,8%	0,991	
282	0,15	1619	19,1	98,1%	0,741	8 février 1996
283	0,15	1614	14,1	97,8%	0,747	
284	0,15	1576	19,4	95,5%	0,789	
285	0,15	1597	22	96,8%	0,765	
286	0,15	1577	19,8	95,6%	0,788	
287	0,15	1607	20,1	97,4%	0,754	
288	0,15	1528	26,9	92,6%	0,845	
289	0,15	1589	22,5	96,3%	0,774	
290	0,15	1582	22,7	95,9%	0,782	
291	0,15	1668	20,2	101,1%	0,690	
292	0,15	1637	21,7	99,2%	0,722	
293	0,15	1606	23,4	97,3%	0,755	
294	0,15	1643	20,5	99,6%	0,716	
295	0,15	1625	19,8	98,5%	0,735	
296	0,15	1605	20,2	97,3%	0,756	
297	0,15	1590	19,1	96,4%	0,773	
298	0,15	1608	20,4	97,5%	0,753	
299	0,15	1530	19,8	92,7%	0,842	
300	0,15	1580	23,1	95,8%	0,784	
301	0,15	1612	23	97,7%	0,749	
302	0,15	1584	17	96,0%	0,780	
303	0,15	1515	23,9	91,8%	0,861	
304	0,15	1574	16	95,4%	0,791	
305	0,15	1488	29,4	90,2%	0,894	
306	0,15	1538	14,1	93,2%	0,833	
307	0,15	1563	16,3	94,7%	0,804	
308	0,15	1617	22,1	98,0%	0,743	
309	0,15	1638	14,1	99,3%	0,721	
310	0,15	1606	14,8	97,3%	0,755	
311	0,15	1557	24,1	94,4%	0,811	
312	0,15	1545	25	93,6%	0,825	
313	0,15	1337	22,3	81,0%	1,108	
314	0,15	1660	19,9	100,6%	0,698	
315	0,15	1669	21,4	101,2%	0,689	
316	0,15	1625	19,8	98,5%	0,735	
317	0,15	1578	19,1	95,6%	0,786	
318	0,15	1584	22,9	96,0%	0,780	
319	0,15	1527	17,5	92,5%	0,846	
320	0,15	1537	19,4	93,2%	0,834	
321	0,15	1502	26,7	91,0%	0,877	
322	0,15	1636	18,8	99,2%	0,723	
323	0,15	1619	22,4	98,1%	0,741	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
324	0,15	1630	15,7	98,8%	0,729	
325	0,15	1630	15,1	98,8%	0,729	
326	0,15	1545	18,9	93,6%	0,825	
327	0,15	1574	14,7	95,4%	0,791	
328	0,15	1532	12,5	92,8%	0,840	
329	0,15	1609	13,6	97,5%	0,752	
330	0,15	1534	11,8	93,0%	0,838	13 février 1996
331	0,15	1559	14,3	94,5%	0,808	
332	0,15	1571	10	95,2%	0,794	
333	0,15	1666	13,2	101,0%	0,692	
334	0,15	1645	13	99,7%	0,714	
335	0,15	1608	16,2	97,5%	0,753	
336	0,15	1570	13,6	95,2%	0,796	
337	0,15	1511	12,8	91,6%	0,866	
338	0,15	1615	13,8	97,9%	0,746	
339	0,15	1581	16,2	95,8%	0,783	
340	0,15	1655	12,3	100,3%	0,703	
341	0,15	1721	13	104,3%	0,638	
342	0,15	1640	13,3	99,4%	0,719	
343	0,15	1595	12,8	96,7%	0,767	
344	0,15	1565	13,1	94,8%	0,801	
345	0,15	1580	14,1	95,8%	0,784	
346	0,15	1640	13,4	99,4%	0,719	
347	0,15	1620	13	98,2%	0,740	
348	0,15	1605	12,7	97,3%	0,756	
349	0,15	1667	13,9	101,0%	0,691	
350	0,15	1652	9,4	100,1%	0,706	
351	0,15	1534	13	93,0%	0,838	
352	0,15	1564	13,8	94,8%	0,802	
353	0,15	1526	11,7	92,5%	0,847	
354	0,15	1598	11,5	96,8%	0,764	
355	0,15	1563	8,7	94,7%	0,804	
356	0,15	1556	13,5	94,3%	0,812	
357	0,15	1726	15,9	104,6%	0,633	14 février 1996
358	0,15	1596	16,3	96,7%	0,766	
359	0,15	1646	17,1	99,8%	0,713	
360	0,15	1692	15,6	102,5%	0,666	
361	0,15	1784	16,4	108,1%	0,580	
362	0,15	1672	12,4	101,3%	0,686	
363	0,15	1553	21,4	94,1%	0,815	
364	0,15	1630	15,5	98,8%	0,729	
365	0,15	1716	17,7	104,0%	0,643	
366	0,15	1625	15,8	98,5%	0,735	
367	0,15	1565	16,4	94,8%	0,801	
368	0,15	1710	17,9	103,6%	0,649	
369	0,15	1650	16,1	100,0%	0,708	
370	0,15	1641	16	99,5%	0,718	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
371	0,15	1570	15,1	95,2%	0,796	
372	0,15	1595	15,8	96,7%	0,767	
373	0,15	1610	16,1	97,6%	0,751	
374	0,15	1548	16,3	93,8%	0,821	15 février 1996
375	0,15	1558	13,6	94,4%	0,809	
376	0,15	1512	16,4	91,6%	0,864	Les essais ont été faits
377	0,15	1566	19,8	94,9%	0,800	12 heures après
378	0,15	1546	16,2	93,7%	0,823	l'emplacement
379	0,15	1576	14,5	95,5%	0,789	
380	0,15	1580	15,1	95,8%	0,784	
381	0,15	1560	16,2	94,5%	0,807	
382	0,15	1678	10,4	101,7%	0,680	15 février 1996
383	0,15	1639	12,4	99,3%	0,720	
384	0,15	1537	11,8	93,2%	0,834	
385	0,15	1559	8,9	94,5%	0,808	
386	0,15	1580	11,6	95,8%	0,784	
387	0,15	1660	11,1	100,6%	0,698	
388	0,15	1752	15	106,2%	0,609	
389	0,15	1806	13,5	109,5%	0,561	
390	0,15	1755	13,9	106,4%	0,606	
391	0,15	1683	11,5	102,0%	0,675	
392	0,15	1721	13,4	104,3%	0,638	
393	0,15	1619	12,1	98,1%	0,741	
394	0,15	1740	16,5	105,5%	0,620	
395	0,15	1636	12,9	99,2%	0,723	
396	0,15	1713	13,7	103,8%	0,646	
397	0,15	1553	15,7	94,1%	0,815	
398	0,15	1556	15,3	94,3%	0,812	
399	0,15	1668	14	101,1%	0,690	
400	0,15	1704	13,4	103,3%	0,654	
401	0,15	1653	19	100,2%	0,705	
402	0,15	1727	16,9	104,7%	0,632	
403	0,15	1776	16,7	107,6%	0,587	
404	0,15	1709	19,3	103,6%	0,650	
405	0,15	1726	14,6	104,6%	0,633	
406	0,15	1627	15	98,6%	0,733	
407	0,15	1715	12,5	103,9%	0,644	
408	0,15	1702	17,2	103,2%	0,656	
409	0,15	1670	15	101,2%	0,688	
410	0,15	1645	18,9	99,7%	0,714	
411	0,15	1681	16	101,9%	0,677	
412	0,15	1675	17,1	101,5%	0,683	
413	0,15	1580	15,4	95,8%	0,784	
414	0,15	1620	15,4	98,2%	0,740	
415	0,15	1578	18,2	95,6%	0,786	
416	0,15	1507	13,5	91,3%	0,871	
417	0,15	1517	14,3	91,9%	0,858	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
418	0,15	1564	17	94,8%	0,802	
419	0,15	1524	11,7	92,4%	0,850	
420	0,15	1511	11,7	91,6%	0,866	
421	0,15	1656	12,3	100,4%	0,702	
422	0,15	1564	14,9	94,8%	0,802	
423	0,15	1711	12,4	103,7%	0,648	16 février 1996
424	0,15	1632	11,3	98,9%	0,727	
425	0,15	1702	11,2	103,2%	0,656	
426	0,15	1752	10,9	106,2%	0,609	
427	0,15	1681	12,9	101,9%	0,677	
428	0,15	1700	9,5	103,0%	0,658	
429	0,15	1670	10,1	101,2%	0,688	
430	0,15	1695	11	102,7%	0,663	
431	0,15	1660	12,3	100,6%	0,698	
432	0,15	1721	11	104,3%	0,638	
433	0,15	1704	9,5	103,3%	0,654	
434	0,15	1677	14,9	101,6%	0,681	
435	0,15	1738	12,2	105,3%	0,622	
436	0,15	1791	13,6	108,5%	0,574	
437	0,15	1751	13,6	106,1%	0,610	
438	0,15	1735	19	105,2%	0,625	
439	0,15	1678	16,6	101,7%	0,680	
440	0,15	1723	10,4	104,4%	0,636	
441	0,15	1697	16,8	102,8%	0,661	
442	0,15	1620	17,7	98,2%	0,740	
443	0,15	1636	15	99,2%	0,723	
444	0,15	1605	13	97,3%	0,756	
445	0,15	1724	13,9	104,5%	0,635	
446	0,15	1721	14	104,3%	0,638	
447	0,15	1726	18,5	104,6%	0,633	
448	0,15	1710	18,1	103,6%	0,649	
449	0,15	1720	17,2	104,2%	0,639	
450	0,15	1796	13,3	108,8%	0,570	
451	0,15	1687	12,7	102,2%	0,671	
452	0,15	1717	13,6	104,1%	0,642	
453	0,15	1684	18,2	102,1%	0,674	
454	0,15	1698	16,3	102,9%	0,660	
455	0,15	1780	16,9	107,9%	0,584	
456	0,15	1678	16,3	101,7%	0,680	
457	0,15	1715	15,2	103,9%	0,644	

Rapport des essais de calcul de densité - Résidus MRN

Projet	Barrick - Finalisation - LTA	**no. projet**	951-7156
Description	Matériaux MRN - site LTA		
Personnel	Eric Bouchard (Golder)	**Compacteur**	rouleau

		Résultats du Proctor standard		**Résultats du Proctor modifié**	
Gs	2,819	**Densité optimale (Mg/m3)**	1,718	**Densité optimale (Mg/m3)**	
		Teneur en eau optimale	17%	**Teneur en eau optimale**	

Test no.	**Couche** m	γ_d kg/m3	**w** %	**% du Proctor standard**	**Indice vides**	**notes de terrain**
458	0,15	1583	22,2	92,1%	0,781	20 février 1996
459	0,15	1734	14,1	100,9%	0,626	
460	0,15	1734	17,4	100,9%	0,626	
461	0,15	1654	15,4	96,3%	0,704	
462	0,15	1682	16	97,9%	0,676	
463	0,15	1725	19,1	100,4%	0,634	
464	0,15	1630	18,9	94,9%	0,729	
465	0,15	1645	18,6	95,8%	0,714	
466	0,15	1674	12,6	97,4%	0,684	
467	0,15	1703	12,6	99,1%	0,655	
468	0,15	1731	15,9	100,8%	0,629	
469	0,15	1708	12,3	99,4%	0,650	
470	0,15	1710	18,1	99,5%	0,649	
471	0,15	1651	17,1	96,1%	0,707	
472	0,15	1675	16	97,5%	0,683	
473	0,15	1609	15,3	93,7%	0,752	
474	0,15	1670	17,5	97,2%	0,688	
475	0,15	1668	13,3	97,1%	0,690	
476	0,15	1667	21,9	97,0%	0,691	
477	0,15	1705	15,7	99,2%	0,653	
478	0,15	1657	14,5	96,4%	0,701	
479	0,15	1676	19,9	97,6%	0,682	
480	0,15	1683	20,3	98,0%	0,675	
481	0,15	1690	18,6	98,4%	0,668	
482	0,15	1661	21,6	96,7%	0,697	
483	0,15	1668	21,2	97,1%	0,690	
484	nd	nd	nd			
485	0,15	1565	21,1	91,1%	0,801	21 février 1996
486	0,15	1597	19,1	93,0%	0,765	
487	0,15	1559	18,6	90,7%	0,808	Les essais ont été faits
488	0,15	1610	17,9	93,7%	0,751	12 heures après
489	0,15	1593	17,8	92,7%	0,770	l'emplacement
490	0,15	1584	22	92,2%	0,780	
491	0,15	1620	22,2	94,3%	0,740	
492	0,15	1535	23,2	89,3%	0,836	
493	0,15	1639	21,6	95,4%	0,720	21 février 1996

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
494	0,15	1622	17,7	94,4%	0,738	
495	0,15	1628	17,1	94,8%	0,732	
496	0,15	1586	18,3	92,3%	0,777	
497	0,15	1644	20	95,7%	0,715	
498	0,15	1591	23,1	92,6%	0,772	
499	0,15	1527	21,7	88,9%	0,846	
500	0,15	1601	22,7	93,2%	0,761	
501	0,15	1620	20,1	94,3%	0,740	
502	0,15	1610	20,5	93,7%	0,751	
503	0,15	1585	23,1	92,3%	0,779	
504	0,15	1579	22,2	91,9%	0,785	
505	0,15	1611	21,5	93,8%	0,750	
506	0,15	1630	20	94,9%	0,729	
507	0,15	1684	17,8	98,0%	0,674	22 février 1996
508	0,15	1466	23,9	85,3%	0,923	
509	0,15	1441	26,5	83,9%	0,956	Les essais ont été faits
510	0,15	1539	14,5	89,6%	0,832	12 heures après
511	0,15	1656	18,6	96,4%	0,702	l'emplacement
512	0,15	1564	13,7	91,0%	0,802	
513	0,15	1605	17,3	93,4%	0,756	
514	0,15	1578	18,3	91,9%	0,786	
515	0,15	1534	19,1	89,3%	0,838	
516	0,15	1525	15,3	88,8%	0,849	
517	0,15	1479	25,5	86,1%	0,906	
518	0,15	1426	23,5	83,0%	0,977	
519	0,15	1594	15,5	92,8%	0,769	23 février 1996
520	0,15	1653	14,6	96,2%	0,705	
521	0,15	1678	16,9	97,7%	0,680	
522	0,15	1552	25,2	90,3%	0,816	
523	0,15	1646	21,4	95,8%	0,713	
524	0,15	1633	13,2	95,1%	0,726	
525	0,15	1708	14,4	99,4%	0,650	
526	0,15	1609	20,9	93,7%	0,752	
527	0,15	1568	25,6	91,3%	0,798	
528	0,15	1533	17,1	89,2%	0,839	
529	0,15	1593	17,8	92,7%	0,770	
530	0,15	1591	24,4	92,6%	0,772	
531	0,15	1606	17,7	93,5%	0,755	
532	0,15	1610	17,5	93,7%	0,751	
533	0,15	1667	17,2	97,0%	0,691	
534	0,15	1605	17,7	93,4%	0,756	
535	0,15	1657	16,8	96,4%	0,701	
536	0,15	1616	14,6	94,1%	0,744	
537	0,15	1595	15,8	92,8%	0,767	
538	0,15	1568	18,2	91,3%	0,798	
539	0,15	1591	19,6	92,6%	0,772	27 février 1996
540	0,15	1532	21,1	89,2%	0,840	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
541	0,15	1530	24,2	89,1%	0,842	
542	0,15	1450	18,9	84,4%	0,944	
543	0,15	1507	20,3	87,7%	0,871	
544	0,15	1528	16,1	88,9%	0,845	
545	0,15	1539	13,9	89,6%	0,832	
546	0,15	1503	21,4	87,5%	0,876	
547	0,15	1543	20,6	89,8%	0,827	
548	0,15	1698	18,4	98,8%	0,660	
549	0,15	1553	18,3	90,4%	0,815	
550	0,15	1631	13	94,9%	0,728	
551	0,15	1582	23,6	92,1%	0,782	
552	0,15	1613	13,2	93,9%	0,748	
543a	0,15	1631	13	94,9%	0,728	
544a	0,15	1582	23,6	92,1%	0,782	
545a	0,15	1613	13,2	93,9%	0,748	
546a	0,15	1661	17,6	96,7%	0,697	
547a	0,15	1654	14,8	96,3%	0,704	
548a	0,15	1598	22	93,0%	0,764	
549a	0,15	1600	19,3	93,1%	0,762	
550a	0,15	1458	23,5	84,9%	0,933	28 février 1996
551a	0,15	1519	22,4	88,4%	0,856	
552a	0,15	1446	29,3	84,2%	0,950	
553	0,15	1488	19,2	86,6%	0,894	
554	0,15	1456	23,2	84,7%	0,936	
555	0,15	1456	26,9	84,7%	0,936	
556	0,15	1565	20,1	91,1%	0,801	
557	0,15	1587	19,1	92,4%	0,776	
558	0,15	1610	17,9	93,7%	0,751	
559	0,15	1622	17,1	94,4%	0,738	
560	0,15	1591	23,1	92,6%	0,772	
561	0,15	1594	15,5	92,8%	0,769	
562	0,15	1608	19,1	93,6%	0,753	
563	0,15	1568	21,1	91,3%	0,798	
564	0,15	1553	20,6	90,4%	0,815	
565	0,15	1506	22,9	87,7%	0,872	
566	0,15	1563	22,7	91,0%	0,804	
567	0,15	1555	19,6	90,5%	0,813	
568	0,15	1641	16,8	95,5%	0,718	1 mars 1996
569	0,15	1655	16,2	96,3%	0,703	
570	0,15	1678	15,9	97,7%	0,680	
571	0,15	1667	15,7	97,0%	0,691	
572	0,15	1698	17,1	98,8%	0,660	
573	0,15	1761	13,6	102,5%	0,601	
574	0,15	1618	19,1	94,2%	0,742	
575	0,15	1553	22,3	90,4%	0,815	
576	0,15	1552	17,3	90,3%	0,816	
577	0,15	1610	16,1	93,7%	0,751	

Test no.	Couche m	γ_d kg/m3	w %	% du Proctor standard	Indice vides	notes de terrain
578	0,15	1640	16,3	95,5%	0,719	
579	0,15	1622	16,1	94,4%	0,738	
580	0,15	1690	16,9	98,4%	0,668	
581	0,15	1685	17,1	98,1%	0,673	
582	0,15	1608	17,6	93,6%	0,753	
583	0,15	1671	15,5	97,3%	0,687	
584	0,15	1655	14,1	96,3%	0,703	
585	0,15	1677	13,6	97,6%	0,681	
586	0,15	1715	14,5	99,8%	0,644	
587	0,15	1689	16,1	98,3%	0,669	
588	0,15	1720	16,5	100,1%	0,639	
589	0,15	1621	16,3	94,4%	0,739	
590	0,15	1701	17,1	99,0%	0,657	
591	0,15	1633	15,9	95,1%	0,726	
592	0,15	1846	14,2	107,5%	0,527	5 mars 1996
593	0,15	1616	11,6	94,1%	0,744	
594	0,15	1735	14,4	101,0%	0,625	
595	0,15	1554	15,8	90,5%	0,814	
596	0,15	1744	14,9	101,5%	0,616	
597	0,15	1758	15	102,3%	0,604	
598	0,15	1759	14,2	102,4%	0,603	
599	0,15	1796	10,4	104,5%	0,570	
600	0,15	1712	12	99,7%	0,647	
601	0,15	1618	15,2	94,2%	0,742	
602	0,15	1719	14,8	100,1%	0,640	
603	0,15	1728	15,6	100,6%	0,631	
604	0,15	1731	14	100,8%	0,629	

APPENDIX H

IN SITU COMPACTION MONITORING RESULTS
(SUMMER 96)

(Golder Associés)

TABLEAU A-1
Résultats des analyses de compactage sur place
Sable et gravier

Projet	Barrick/Construction/LTA		no. du projet	951-7156
Dr	2.751	Résultats du Proctor standard		
		Densité optimale, kg/m3		2010
		Teneur en eau optimale		6.5

No. de test Test no.	Couche m	γ_d kg/m³	w %	% du Proctor standard	Indice des vides	Remarques
1	0.5	2047	5	102%	0.344	Poids volumique
2	0.5	2009	6.5	100%	0.369	Proctor = 2010 kg/m³
3	0.5	2087	5.5	104%	0.318	
4	0.5	1939	8.3	96%	0.419	
5	0.5	2062	6.1	103%	0.334	
6	0.5	1967	7.8	98%	0.399	
7	0.5	2020	8.8	100%	0.362	
8	0.5	1984	5.4	99%	0.387	
9	0.5	2055	7.4	102%	0.339	
10	0.5	2026	4.6	101%	0.358	
11	0.5	2044	4.5	102%	0.346	
12	0.5	1998	4.3	99%	0.377	
13	0.5	2145	3.4	107%	0.283	
14	0.5	2058	4.2	102%	0.337	
15	0.5	2023	4.4	101%	0.360	
16	0.5	2055	5.2	102%	0.339	
17	0.5	2104	4.3	105%	0.308	
18	0.5	2049	3.4	102%	0.343	
19	0.5	1987	3.3	99%	0.384	
20	0.5	1956	4.2	97%	0.406	
21	0.5	2096	3.1	104%	0.313	
22	0.5	1983	3.3	99%	0.387	
23	0.5	1965	3.9	98%	0.400	
24	0.5	2081	3.6	104%	0.322	
25	0.5	2130	5.7	106%	0.292	
26	0.5	2082	4.8	104%	0.321	
27	0.5	2007	5	100%	0.371	
28	0.5	2121	4.6	106%	0.297	
29	0.5	2045	4.2	102%	0.345	
30	0.5	2038	4.2	101%	0.350	
31	0.5	1997	5.3	99%	0.378	
32	0.5	2106	4	105%	0.306	
33	0.5	2073	6.9	103%	0.327	
34	0.5	1996	4.3	99%	0.378	
35	0.5	2095	3.7	104%	0.313	
			Valeurs moyennes	102%	0.349	

TABLEAU B-1
Résultats des analyses de compactage sur place
Silt

Projet	Barrick/Construction/LTA	no. du projet	951-7156
Dr 2.819		Résultats du Proctor standard	
		Densité optimale, kg/m3	1742
		Teneur en eau optimale	11.45

No. de test Test no.	Couche m	γ_d kg/m³	w %	% du Proctor standard	Indice des vides	Remarques
1	0.8	1540	21.3	88%	0.831	
2	0.8	1612	22.7	93%	0.749	
3	0.8	1617	12.5	93%	0.743	
4	0.8	1674	13.6	96%	0.684	
5	0.8	1597	20.1	92%	0.765	
6	0.8	1596	11.8	92%	0.766	
7	0.8	1626	9.8	93%	0.734	
8	0.8	1638	10.2	94%	0.721	
9	0.8	1673	12.9	96%	0.685	
10	0.8	1689	11.8	97%	0.669	
11	0.8	1530	25.9	88%	0.842	
12	0.8	1539	24.4	88%	0.832	
13	0.8	1513	27.5	87%	0.863	
14	0.8	1577	21.7	91%	0.788	
15	0.8	1622	12.2	93%	0.738	
16	0.8	1582	10.1	91%	0.782	
17	0.8	1640	21.4	94%	0.719	
18	0.8	1602	20.7	92%	0.760	
19	0.8	1679	17.6	96%	0.679	
20	0.8	1671	18.8	96%	0.687	
21	0.8	1688	14.7	97%	0.670	
22	0.8	1662	17.3	95%	0.696	
23	0.8	1513	18.4	87%	0.863	
24	0.8	1526	15.3	88%	0.847	
25	0.8	1474	16.4	85%	0.912	
26	0.8	1611	12.9	92%	0.750	
27	0.8	1573	17.3	90%	0.792	
			Valeurs moyennes	92%	0.762	