



Some interactions of salts and clays upon diffusivity and ion movement  
by Donald Robert Christenson

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of  
MASTER OF SCIENCE in Soils  
Montana State University  
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Abstract:

The effects of clay type, electrolyte concentration and adsorbed sodium upon diffusivity and ion movement were studied. Prepared soils containing 17.6% dickite, illite or montmorillonite clay minerals were equilibrated with solutions of sodium adsorption ratios of 0, 7, 18 or 40. Calcium chloride concentrations of 0, 0.005 or 0.015 normal were applied to soil columns at a tension of 2 millibars. Diffusivities were calculated from moisture content vs distance curves. Diffusivity was increased by a factor of two or more with 0.015 N CaCl<sub>2</sub> over distilled water on all soil sodium levels except the montmorillonite soil equilibrated with SAR 40. Sodium was displaced from the first 4 centimeters of the column and was moved with the wetted front by 0.015 N CaCl<sub>2</sub>. Distilled water displaced small amounts of Na<sup>+</sup> due to hydrolysis of CaCO<sub>3</sub>.

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Soils

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Bozeman, Montana

August, 1964

## ACKNOWLEDGEMENT

The writer wishes to express his appreciation to Dr. A. H. Ferguson for suggestion of the problem. His advise and guidance were invaluable throughout the course of this study.

The writer also wishes to express appreciation to Dr. M. G. Klages, Dr. E. O. Skogley and other members of the Plant and Soil Science Department staff who have contributed time and advice.

The writer also expresses his appreciation to his wife, Carol, without whose patience and encouragement, this would not have been possible.

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## ABSTRACT

The effects of clay type, electrolyte concentration and adsorbed sodium upon diffusivity and ion movement were studied. Prepared soils containing 17.6% dickite, illite or montmorillonite clay minerals were equilibrated with solutions of sodium adsorption ratios of 0, 7, 18 or 40. Calcium chloride concentrations of 0, 0.005 or 0.015 normal were applied to soil columns at a tension of 2 millibars. Diffusivities were calculated from moisture content vs distance curves. Diffusivity was increased by a factor of two or more with 0.015 N  $\text{CaCl}_2$  over distilled water on all soil sodium levels except the montmorillonite soil equilibrated with SAR 40. Sodium was displaced from the first 4 centimeters of the column and was moved with the wetted front by 0.015 N  $\text{CaCl}_2$ . Distilled water displaced small amounts of  $\text{Na}^+$  due to hydrolysis of  $\text{CaCO}_3$ .

## INTRODUCTION

The effects of sodium salt accumulation can be seen in many arid regions of the world. When wet these soils are more impermeable to air and water than similar soils not containing sodium. When dry these soils form hard clods which are difficult to till for seed bed preparation. These physical effects reduce production.

Although Way (1850) showed that base exchange takes place in soils, it was not until 1912 that Gedroiz, as cited by Kelley (1951), showed its importance in alkali soils of dry regions. The first systematic investigation into the effects of salts on permeability was made by Gedroiz in 1924 (Kelley, 1951). He showed that the permeability of the soil is greatly reduced by replacing naturally occurring ions (chiefly  $\text{Ca}^{++}$ ) with  $\text{Na}^+$ .

Alkali soils having similar exchangeable sodium levels may vary considerably with respect to water permeability. Several soil characteristics may modify the effects of sodium.

Texture has a direct bearing on water permeability. In general, the physical properties of fine textured soils are affected more adversely at a given sodium level than those of coarse textured soils.

Clay type is an important factor in the effects of sodium on physical properties and water permeability. Soils containing expanding type clays are less permeable to water than soils containing an equal amount of non expanding type clay. It appears that this is especially true at higher exchangeable sodium percentages.

Adsorbed cations, soluble salts and electrolyte present in irrigation waters influence the effects of sodium upon permeability. High concentrations of

adsorbed calcium and magnesium reduce the effects of sodium upon infiltration (Kelley, 1951). Kelley further shows that on soils containing both soluble salts and adsorbed sodium, permeability will decrease as the soluble salts are leached due to deflocculation of the soil. High electrolyte concentrations in irrigation waters aid in maintaining permeability. Moreover, water with high sodium content may increase permeability, however, it will tend to decrease with time due to sodium adsorbing on the colloids (Kelley, 1951).

Most of the studies on water movement in soils with respect to salts have been conducted in saturated systems. It appears that very few studies have been made on the influence of salts on unsaturated flow. Furthermore, this author found no studies published on the effect of clays or the interaction of salts and clays on unsaturated water flow. A thorough understanding of how unsaturated water flow is influenced by clay type, exchangeable ions, soluble salts and water quality should be useful in irrigation and reclamation. Even under conditions where free water stands on the soil surface, as in flood irrigation, most water movement downward is thought to occur as unsaturated flow.

This study was conducted to measure the interaction of clay type, exchangeable sodium, and quality of irrigation water on unsaturated flow and ion movement.

## LITERATURE REVIEW

Diffusivity is a basic characteristic of soils which describes the tendency of a soil to conduct water in the unsaturated state (Bruce & Klute, 1956). At a given water content it may be expected to be largely influenced by pore size distribution and thus, by factors affecting pore size distribution. Clay type, aggregate stability, swelling pressures, exchangeable cations, soluble salts and quality of irrigation water might be expected to influence diffusivity.

### Theory:

Diffusion theory has been applied to the capillary movement of water in the soil. It is assumed that the capillary flow of moisture in soils is analagous to heat transmission in solids or molecular diffusion of gases. The diffusivity term in the heat flow and diffusion equation is present in a flow equation for an unsaturated porous media. This term is required for the complete treatment of transient flow systems.

The flow equation has been derived (Klute, 1952) by combining the equation of continuity,  $\frac{\partial(\rho_s \theta)}{\partial t} = -\nabla \cdot \mathbf{v}$  and Darcy's law,  $\mathbf{v} = -K\nabla\Phi$ , where;  $\rho_s$  = bulk density,  $\theta$  = moisture content,  $\mathbf{v}$  = mass flux of moisture,  $t$  = time,  $\mathbf{v}$  = volume flux of moisture,  $\Phi$  = total moisture potential and  $K$  = coefficient of aqueous conductivity. This yields the general flow equation with  $\rho$  representing fluid density:

$$\frac{\partial}{\partial t} (\rho_s \theta) = \nabla \cdot (\rho K \nabla \Phi) \quad [1]$$

If  $\theta$  may be regarded as a single valued function of the capillary potential, then the right side of equation [1] may be written for the horizontal case of flow in one dimension as:

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x} \left( D \frac{\partial \theta}{\partial x} \right) \quad [2]$$

where;  $x$  = distance. This is a nonlinear diffusion equation with a diffusivity term,  $D$ , and is impossible to solve unless one has some knowledge of the way  $D$  varies with moisture content.

Bruce and Klute (1956) applied the Boltzmann transformation,  $\lambda = \frac{1}{2} x t^{\frac{1}{2}}$ , to obtain a measure of diffusivity. By substitution of  $\lambda$ , a concentration function, into equation [2], the equation is reduced to the ordinary differential equation:

$$-\frac{\lambda}{2} \frac{d\theta}{d\lambda} = \frac{d}{d\lambda} \left( D(\theta) \frac{d\theta}{d\lambda} \right) \quad [3]$$

Upon integration in terms of  $x$  and  $t$  at constant  $t$ , equation [3] becomes:

$$D(\theta_x) = -\frac{1}{2t} \left( \frac{dx}{d\theta} \right)_{\theta_x} \theta_x \quad [4]$$

Bruce and Klute showed that equation [4] can be evaluated by:

(1) Obtaining a moisture content-distance curve from an unsaturated flow system, i.e.,  $\theta$  as a function of distance at a constant value of time,  $t$ .

(2) From the plot of  $\theta$  versus  $x$ , evaluate the integral and the derivative of equation [4] at a series of values of  $\theta_x$ .

(3) Calculate  $D$  at the values of  $\theta_x$ , used in step 2.

#### The Effects of Salts Upon Saturated Permeability

Several workers (Brooks et al., 1956; Fireman, 1944; Fireman and Bodman, 1939; Quirk and Schofield, 1955; Reeve et al., 1954) have studied the effect of exchangeable ions and/or water quality on saturated permeability. In all cases with low electrolyte concentration in the water, saturated permeability decreased as exchangeable sodium increased.

Fireman (1944) found that the permeability of a sandyloam soil was initially high to water containing 4,500 ppm. sodium chloride, but decreased with time. On the other hand, Quirk and Schofield (1955) found that waters containing greater than 14,500 ppm. sodium chloride maintained high permeability in sodium soils. Apparently the electrolyte level used by Fireman was not sufficient to depress the diffuse double layer. In the same paper, Quirk and Schofield reported that as the sodium content of the soil increased, the electrolyte concentration required to maintain a given permeability also increased. For example, when the exchangeable sodium percentage (ESP) equalled six, the electrolyte concentration required was 130 ppm. At an ESP of 35, the electrolyte concentration was 1070 ppm. This can be attributed to difficulty in depressing the diffuse double layer at the higher sodium levels.

#### The Effects of Salts Upon Aggregate Stability

Aggregate stability, as affected by salts, has an influence on the permeability of a soil. Collis-George and Smiles (1963) found that as sodium content increased, the total cation concentration in suspension that was required to maintain aggregate stability also increased. At a sodium adsorption ratio (SAR) of 10 the aggregates were dispersed when the total cation concentration was 2 me/l and flocculated at 20 me/l, while at SAR 40 the aggregates were dispersed at 10 me/l and flocculated at 40 me/l. Rowell (1963) studied the effect of total electrolyte concentration on the aggregate stability of montmorillonite at various levels of sodium and calcium. He found that at a high SAR, aggregates deflocculated at higher electrolyte concentrations than aggregates at a low SAR. For example, at SAR 2.5; ESP 54,

$\frac{3000}{200} = 15$   
 3000 10

deflocculation took place with a concentration of  $5 \times 10^{-2}$  eq/l, whereas, at SAR 0.25; ESP 12.5, deflocculation occurred at  $2 \times 10^{-5}$  eq/l. The flow of water can be expected to be reduced when deflocculation occurs.

#### The Effects of Salts Upon Swelling Pressure

Soluble salts and adsorbed ions influence swelling pressure. Swelling pressure in turn influences diffusivity. Adsorbed cations which cause a high zeta potential increase swelling pressure due to increased  $d$  spacings and distance between particles. Soluble salts, present in large concentrations depress the diffuse double layer and decrease the swelling pressure. Norrish (1954) found a linear relation between  $d$  spacing of montmorillonite and  $C^{-\frac{1}{2}}$  (concentration, g solute/l.) for LiCl, HCl, NaCl and  $\text{Na}_2\text{SO}_4$  at  $C^{-\frac{1}{2}}$  values of 2-10 over which range the  $d$  spacings varied from 40-13 Å. Warkentin and Schofield (1962) found that swelling pressures increased with decreasing sodium chloride concentrations on sodium montmorillonite in equilibrium with sodium chloride solutions. Emerson (1962) found that oriented Ca-montmorillonite flakes increased in volume as they were brought into equilibrium with successively more dilute calcium chloride solutions. However, this effect could not be reversed by increasing the concentration of calcium chloride. The observed swelling did not increase the  $d$  spacing. He concluded that this was due to the formation of tactoids by Ca-montmorillonite crystals. Swelling was due to the development of double layers within the pores of the tactoid.

#### The Effect of Clay Type on Saturated Permeability

Fireman and Bodman (1939) found greater permeability on a clay loam soil containing predominately kaolinitic clay than on another containing

predominantly montmorillonitic clay. It is interesting to note that both soils showed very similar initial permeability values to distilled water. But, as time progressed the permeability decreased more rapidly on the soil containing montmorillonitic clay than the one containing kaolinitic clay. This decrease in permeability can be attributed to the swelling of the montmorillonitic clay.

#### The Effects of Sodium and Electrolyte Concentration Upon Diffusivity

Gardner et al. (1959) measured the diffusivity of two soils with various exchangeable sodium to calcium ratios. They found that when the exchangeable sodium percentage was above 25, the diffusivity was reduced as much as one-thousand fold when the electrolyte concentration was decreased from 300 to 3 me/l. It was also found that diffusivity increased as the electrolyte concentration increased, regardless of exchangeable sodium percentage.

The data from Gardner indicate the same type of effects from adsorbed sodium and electrolyte concentration could be expected in unsaturated flow as is found in saturated flow.

*But not to  
a reduced  
state*

#### Ion Movement

Ion movement within soil columns is complex. Bower and Goertzen (1958) derived a Langmuir adsorption formula for the prediction of sodium movement in calcareous soils. Bower et al. (1957) used partial differential equations to predict ion distribution as functions of depth and volume of solution applied when two cations were present. Dutt (1962) developed a computer program for calculating the ionic composition of percolating waters.

Reclamation of sodium affected soils is usually carried out by replacing the adsorbed sodium with calcium and then leaching it from the root zone. There is an indication that distilled water, if applied in large enough quantities, will remove exchangeable sodium from saline soils. Bentley and Rost (1947) leached 10 gm. of a saline soil with 7.5 l. of distilled water. It was found that 0.55 me. (83 percent of that present) of sodium were removed. From a practical standpoint this is not feasible. First, as pointed out earlier, when soils containing soluble salts are leached with rain water, permeability decreases with time. Second, few soils, if any, have an internal drainage system capable of handling water applied at a water to soil ratio of 750:1 in a relatively short period of time. Bower and Goertzen (1958) leached approximately 40 gm. of a calcareous soil, removing 1.5 me. of sodium with 240 ml. of distilled water. It can be seen that calcium from slightly soluble sources removes sodium with greater ease than distilled water. Kelley and Brown (1934) showed that gypsum, a moderately soluble calcium salt, was effective in replacing adsorbed sodium providing the sodium sulfate formed was leached out. Kelley (1951) pointed out that saline irrigation waters were very effective in reclamation of alkali soils. The salts present in the water tend to keep the soils flocculated; hence, aiding the entry of water.

*need more  
shows just water*

*CaMgK*

One could expect that the amount and distance of movement in sodium soils would be materially influenced by the calcium concentration of the water as well as the type of calcium salts present in the soil.

## MATERIALS AND METHODS

This study was designed to use three soils prepared from sand and silt separates and one of the clay minerals, dickite, illite or montmorillonite. Subsamples of each soil were equilibrated at four different sodium levels. The SAR of the equilibrating solutions were 0, 7, 18 and 40. The soils were designated by the clay type and SAR of equilibrating solution e.g., dickite soil SAR 0, illite soil SAR 40, montmorillonite soil SAR 18, etc. Water at one of three electrolyte concentrations was used for the water movement studies and was applied at a tension of 2 millibars. The concentrations were 0, 0.005, and 0.015 N  $\text{CaCl}_2$  and had conductivities of 0, 720 and 1690, micromhos, respectively. These corresponded to salinity levels of low, medium and high, respectively (USDA Handbook #60, 1954). Each soil treatment and water application combination was duplicated.

### Soil Preparation

Soil fractions were combined to give a particle size distribution of 50% sand, 30% silt and 20% clay. The clay fraction contained 88% clay mineral and 12% soil clay.

Sand was taken from a river wash source and treated with successive portions of 10% hydrochloric acid until effervescence ceased. Particles larger than one mm. were removed by screening. Those smaller than 0.050 mm. were removed by sedimentation after dispersing with Calgon.

Silt containing some sand and clay was obtained by removing most of the clay from a calcareous silt loam surface soil. This was accomplished by treating the soil with a sodium acetate-acetic acid buffer, pH 4.8, and 30% hydrogen peroxide. Three-100 ml. portions of the buffer were added to 50 gm. portions of soil over a steam table. The soil was leached with an

additional 400 ml. of buffer. Fifty-gram portions of the acetate treated soil were treated with three successive portions of peroxide over a steam table. An additional 100 ml. of buffer were leached through the soil. Calgon was used for dispersion and a limiting size of 0.002 mm. was obtained by settling in a hydrometer jar. Dispersion and settling were repeated three times with the suspension being discarded each time.

Clay minerals were obtained from the following commercial sources: Dickite (Kaolinite) from a mine near Lewistown, Montana; Illite, No. 35, from Fithian, Illinois; and Montmorillonite, No. 19, (Bentonite) from Polkville, Mississippi. The minerals were ground to pass a one mm. sieve.

#### Soil Equilibration

Many exchange reactions in the soil are known to occur rather rapidly. Bower et al. (1952), in their procedure for measuring exchangeable cations and cation exchange capacity, used a total time of 15-20 minutes for equilibration. However, a rather wide soil to solution ratio (1:25) was used. For the equilibrations in this study, wide soil to solution ratios would not be feasible since large quantities (1400 grams) of soil were used per equilibration. On the other hand, saturation extracts are obtained with narrow soil to solution ratios and an equilibrating time of one hour (USDA Handbook #60, 1954). It was felt that sufficient time should be allowed to insure a complete reaction because the soil settled out of suspension rather rapidly. A soil to solution ratio of 1:2 was used and 24 hours were allowed for equilibration. The suspension was stirred frequently over the first 18-20 hours. Then the soil was allowed to settle to facilitate decanting of the supernatant. Equilibrating solutions were prepared from

sodium and calcium chlorides. A level of 16 me/l.  $\text{CaCl}_2$  was used in all solutions. At termination of the equilibration time, the soil was washed with distilled water to remove the excess salts. Ethyl alcohol was used to aid sedimentation by centrifuging between washings. Excess salts were considered to be removed when a negative chloride test was obtained on the supernatant of a 1:2 soil to water suspension. After the last washing, the soil was removed from the centrifuge tubes with a stream of alcohol. The soil and alcohol were then spread on a piece of paper and the alcohol was evaporated with the aid of an electric fan. When completely dry, the soil was passed through a one-mm. sieve.

Exchangeable sodium was measured on each equilibrated soil. Cation exchange capacity was also measured on duplicate samples of the soil equilibrated at SAR of zero. Methods 18 and 19, USDA Handbook #60 (1954) were used for exchangeable sodium and cation exchange capacity, respectively.

#### "Silt" Characterization

Sand and clay content were determined on the separated silt fraction. Duplicate 15 gm. samples of oven dry "silt" were placed in baffled mixing cups and 30 ml. of 2% Calgon were added. Dispersion was then completed by stirring with a high speed mixer for 10 minutes. It was not necessary to pretreat these samples as it had been done previously. The suspension was then quantitatively transferred to a hydrometer jar and diluted to one liter. Aliquots were taken to obtain limiting sizes of 0.050 and 0.002 mm. Percent sand, silt and clay were calculated from these data.

Soil clay was characterized by determining a swelling factor, cation exchange capacity and specific surface on a fraction of the "silt" less

than 0.002 mm. limiting diameter. It appears that a standard method for determining a swelling factor for clays and clay minerals has not been adopted. The methods reviewed measure the suitability of materials for ditch and dike sealing purposes. It is pointed out by Shen <sup>1/</sup> that most procedures for swelling measurements are arbitrary in nature. A swelling measurement procedure is described by him as a quick test to determine if further testing of a material would be worth while. This amounts to placing the material in a jar, adding "soft" water and observing wetting time and swelling volume. Expanding on this approach, the following procedure was used. Ten grams of soil clay were shaken by hand in 100 ml. of distilled water containing 5 me. of NaCl. The suspension was then washed through a 300 mesh sieve into a 250 ml. graduated cylinder and brought to 200 ml. Five ml. increments of N NaCl were added until flocculation occurred. The volume of clay after 12 hours of settling, divided by ten, was considered to be the factor of swelling. This factor was compared to that of the three clay minerals, obtained in a similar manner.

Cation exchange capacity of the soil clay was determined using sodium acetate as outlined by Method #19, USDA Handbook #60 (1954). This value was compared to those generally accepted for clay minerals, i.e., 8, 30 and 100 me/100g for kaolinitic, illitic and montmorillonitic minerals, respectively (Lyon et al., 1952).

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<sup>1</sup>Shen, R. T. Evaluation Procedures of Sediment Material for Canal Sealing. Colorado State University, Fort Collins, Colorado. Mimeo CER58RTS4. January 1958.

Specific surface was estimated by the orthophenanthroline method developed by Lawrie (1961).

#### Column Preparation

A common method of packing soil columns is to tamp small, weighed increments of soil into the column. This frequently results in layering and heterogeneity of particle size distribution. Non-uniform packing has been an attributing factor for discrepancies in soil water diffusivity data (Bruce and Klute, 1956; Gardner and Mayhugh, 1958; Ferguson and Gardner, 1963). Vibration techniques have been shown to minimize layering (Rosenberg, 1959 and 1960). Jackson et al. (1962) have described a packer which minimizes layering and particle size separations. In addition, their data show uniformity within columns as well as reproducibility between columns. The packer consists of three main parts: a motorized tremie, a vibrator block assembly, and an angle iron frame work uniting the two. The vibrator block is driven by a vibrator motor and restrained by adjustable bolts. The tremie is connected to the driving motor by a threaded rod held in the vertical position by a half-nut. Opening the half-nut the tremie can be raised and lowered. When the nut is closed, the tremie is raised by the driving motor. Soil is delivered to the tremie by means of a funnel and stainless steel tube. The column is clamped to the vibrating block. The tremie assembly is lowered into the column for packing. The vibrator motor is turned on to pack the soil during delivery. The machine used was modified from Jackson's to incorporate a stationary driving motor and to accomodate a rectangular column.

Preliminary columns showed a heterogeneity within and between columns. After considerable effort it was found that by setting the clearance between the restraining bolts and the vibrator block at 0.020 inches and vibrating the column an additional 15 minutes with a 180 gm. weight resting on the soil, apparent uniformity and reproducibility was achieved. The term "apparent" is used because when the wet column was segmented and bulk density determined, there was considerable variation within a column as well as between columns. On the other hand, a plot of the rate of advancement of the wetted front as a function of the square root of time yielded a straight line. Using this as a criterion for measuring uniformity (Nielsen et al., 1962) it was found that columns were uniform and reproducible.

The column (Fig. 1) was made of plexiglass sections fastened together with metal rods. It was constructed so as to facilitate ease of sectioning. Two extensions were used for one end of the column. One (packing extension), with an opening the same diameter as that of the column, was used during packing. The other (applicator extension), with an opening slightly larger than the column, was used to hold the water applicator with a fritted glass disc the same diameter as the column. The packing extension was removed after packing in such a manner so as to leave a smooth exposed soil surface. The applicator extension was fastened to the column. The applicator was moved against the soil allowing water flow.

Average bulk densities were determined by packing five columns, removing and weighing the soil. Densities for the soils were 1.34, 1.39 and 1.32 gm/cc. for dickite, illite and montmorillonite soils, respectively.

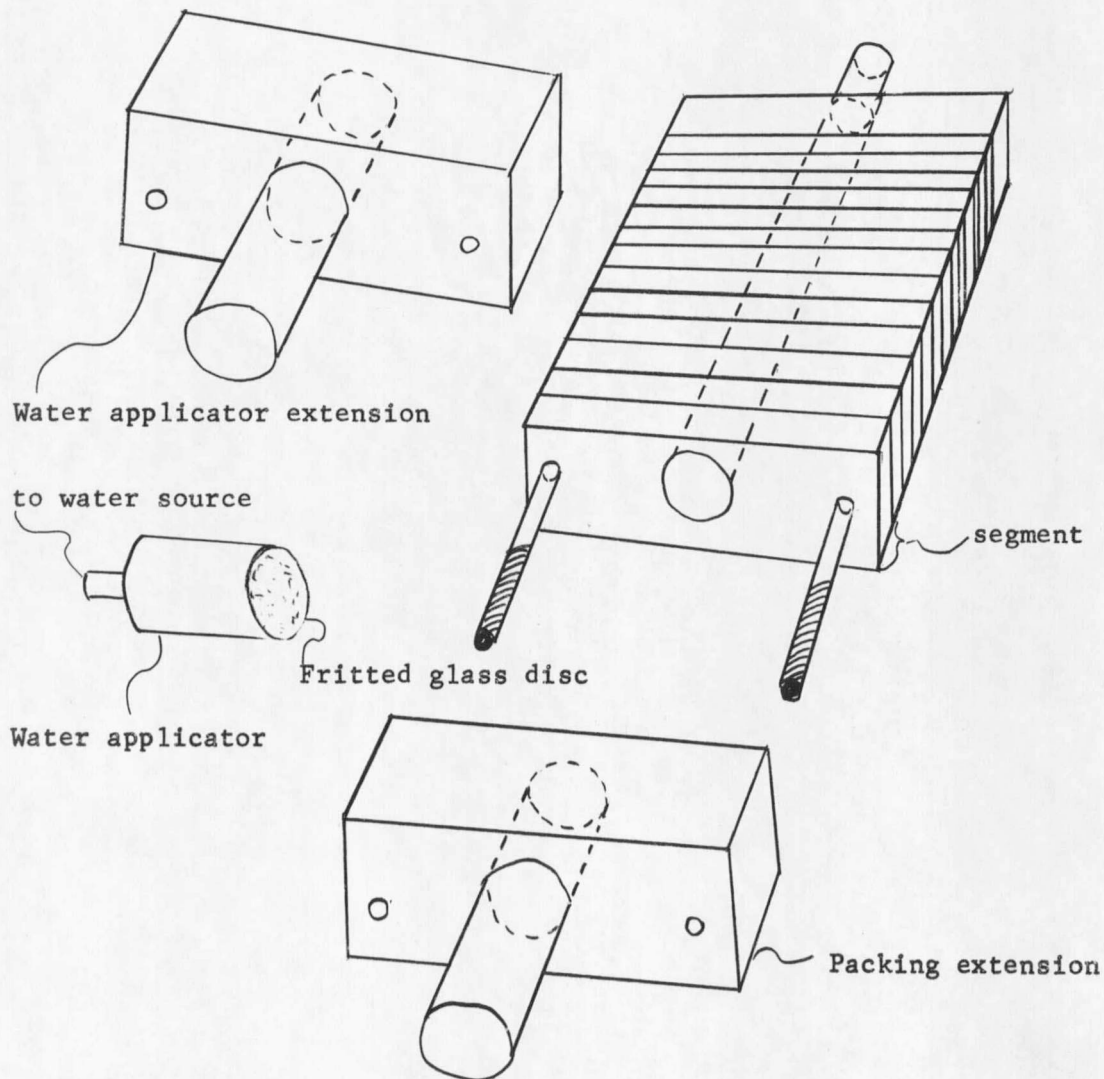


Figure 1. Plexiglass column showing the packing extension, water applicator extension and water applicator.

Box and Taylor (1962) showed that the matric potential of soils varied only slightly between bulk densities of 1.1 and 1.5 gm/cc. Accordingly, differences in matric potential due to variation in bulk densities were expected to be negligible.

#### Measurements and Analysis on the Columns

Nielsen et al. (1962) have shown that water applied at a tension of 2 millibars yields a linear relation between a plot of  $x$  (distance to wetted front) as a function of  $t^{1/2}$  (time). A system similar to that used by Nielsen was used for water application. Time ( $t$ ), distance ( $x$ ) of the wetted front from the water source, and quantity of water ( $Q$ ) were measured periodically during the run. This was accomplished by recording the desired measurements at the point when the wetted front reached a dividing line between segments. The runs were conducted at  $19^{\circ} \pm 1^{\circ}$  C. The runs were allowed to proceed until the wetted front reached 20.9 cm. (22 segments). At termination of each run the column was sampled every 1.9 cm. (2 segments).

Moisture percentage was determined gravimetrically on each segment by determining air dry moisture percent of the sample and then determining oven dry moisture percent of a subsample. Percent by volume was calculated using the average densities reported above.

Each segment was analyzed to trace ion movement. A 1:5 soil to water ratio extraction is described in Method #3(c) USDA Handbook #60 (1954). In this procedure the suspension is shaken for 15 minutes and allowed to stand one hour with a terminal shaking of five minutes. In this study, it was found that equilibrium could be reached by shaking the samples for 15

minutes. At termination of shaking, 0.5 ml. of 0.3% Superfloc 16 and Aerofloc 3171, <sup>1</sup>/<sub>2</sub> was used to flocculate the organic matter and soil. Sodium was determined flame photometrically on a Model B Beckman Spectrophometer. Calcium was determined by the versenate titration as outlined in Method #7, USDA Handbook #60 (1954). It was not necessary to pretreat the soil extract with aqua regia since the organic coloring was removed by the flocculating agent. Calcium was reported from the versenate titration since only negligible amounts of magnesium were considered to be present.

Moisture percentages were plotted as a function of distance and diffusivity measurements were made as outlined by Bruce and Klute (1956).

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<sup>1</sup>The American Cyanamid Company, New York 20, New York.

## RESULTS AND DISCUSSION

Two sodium levels (SAR 0 and 40) and two water electrolyte levels (0 and 0.015 N  $\text{CaCl}_2$ ) were chosen to be discussed because these data demonstrated the general nature of the measurements and analysis. The other two sodium levels (SAR 7 and 18) gave results intermediate to the above sodium levels at all water electrolyte levels. Likewise, results from the 0.005 N  $\text{CaCl}_2$  water electrolyte level were intermediate to the above electrolyte levels at all sodium levels.

### Silt Characterization

Table I shows the data obtained for characterization of the silt and its contained clay.

Table I. Data characterizing the silt separate and its contained clay.

Measurement or analysis	Silt	Clay
Cation exchange capacity	21.2 me/100g	70.0 me/100g
Swelling factor	-	6
Specific surface	-	240 $\text{m}^2/\text{g}$
Particle size distribution	18.7% sand 75.2% silt 6.1% clay	

Lawrie (1961) reported a specific surface of 290  $\text{m}^2/\text{g}$  and 770  $\text{m}^2/\text{g}$  for illite and Wyoming bentonite, respectively, as estimated by orthophenathroline adsorption. It would appear that the value for the soil clay closely agrees with that of illite. However, during the initial separation of the clay from the soil the finer fractions were discarded which would decrease the specific surface and cation exchange capacity.

A montmorillonite clay generally has a cation exchange capacity of about 100 me/100g (Lyon, et al., 1954). On the basis of the swelling measurements discussed earlier, the following swelling factors were determined for the clay minerals: montmorillonite = 7, illite = 2.5 and dickite = 1.5. From the above considerations, one could say that the soil clay is montmorillonitic in nature.

The cation exchange capacity of the silt was greater than one would expect for pure silt. However, since the clay was not completely removed a greater cation exchange capacity could be expected.

#### Soil Equilibration with Sodium

Table II shows the exchangeable sodium percentages and cation exchange capacity for the soils used in this study.

Table II. Exchangeable sodium percentages and cation exchange capacity of the 3 artificial soils.

Clay mineral base	SAR Equilibrating Solution				me/100g
	0	7	18	40	
	--Exchangeable Sodium Percentage--				
Dickite	5.0	12.7	16.8	20.3	9.9
Illite	4.8	5.1	10.7	12.2	12.5
Montmorillonite	5.5	7.1	9.6	13.6	31.2

These levels were not as high as desired or expected from consideration of equilibrium relations between soluble and exchangeable cations (USDA Handbook #60, 1954). Equilibrating solutions were prepared according to the equation:

$$ESP = \frac{100}{1 + (-0.0126 + 0.01475SAR)}$$

[ 5 ]

The desired ESP values were in the neighborhood of 0, 8, 21 and 37 which were expected by equilibration with solutions at SAR levels of 0, 7, 18 and 40, respectively. Three factors contributed to not attaining the desired sodium levels and to differences between clays. First, the differences between the dickite soil and the other two soils can be attributed to the fact that clay particles having a high cation exchange capacity adsorb calcium relative to sodium more readily than clay particles having a low cation exchange capacity. Work by Marshall (1948) bears this out. Equation  $\bar{5}$  was obtained from data of 59 soils and represents an average over a broad range of soil minerals. Secondly, the SAR of the equilibrating solution changes as the exchange reaction proceeds, which in turn changes the equilibrium. Divalent ions initially on the exchange complex would cause a greater shift in equilibrium than monovalent ions. Third, hydrolysis of calcium carbonate released calcium to solution which in turn replaced adsorbed sodium. Considering that it is possible to dissolve up to 26 me/l of  $\text{CaCO}_3$  and that the soil was washed four to five times with 2.0 - 2.5 liters of water, it can be seen that a considerable amount of sodium could have been replaced by calcium.

It appears that the method used for equilibration was a bad choice. Sodium hexametaphosphate is generally thought to coat lime particles, reducing their solubility (Tyner, 1939). Possibly, by first saturating the soil with sodium hexametaphosphate, the lime would be sufficiently insoluble to reduce hydrolysis. The soil then could have been brought to the desired calcium level by assuming that nearly all the calcium added in solution would be adsorbed.

### Effects of Salts on Termination Time

In general, the time required for the wetted front to reach termination distance (20.9 cm. from the water source) was decreased by 0.015 N CaCl<sub>2</sub> as compared to distilled water. This effect was most pronounced at the high sodium level. Table III presents the average time required for the wetted

Table III. Average time for the Wetted Front to Reach Termination Distance (20.9 cm. from the water source)

Clay Base	Sodium level*	Electrolyte Concentration of Water	
		0 N CaCl <sub>2</sub>	0.015 N CaCl <sub>2</sub>
		Minutes	
Dickite	SAR 0	379**	278
Dickite	SAR 40	608	372
Illite	SAR 0	633	453
Illite	SAR 40	998	440
Montmorillonite	SAR 0	538	393
Montmorillonite	SAR 40	1490**	607**

\* SAR of the equilibrating solution  
\*\* one run

front to reach termination. The effects of sodium on termination time are less with the dickite soil than with the montmorillonite soil. This was due to the swelling of the montmorillonite mineral. However, the increase in time for the illite soil SAR 40 over SAR 0 was not greater than the increase in time for the dickite soil at the same SAR levels. This was due to the lower ESP (Table II) of the illite soil than of the dickite soil equilibrated at SAR 40. When comparing the increase in termination time of the

montmorillonite soil SAR 40 over SAR 0 to the same increase of the illite soil, it can be seen that at approximately equal levels of sodium (12.2% for illite, 13.6% for montmorillonite) the effects due to sodium were much greater with montmorillonite. Again this was due to the greater amount of swelling of the montmorillonite mineral.

Effect of Swelling on Movement of the Wetted Front

To obtain a quantitative measure of the effect of sodium level and electrolyte concentration upon swelling of the artificial soils, the soils were packed in glass tubes to a depth of approximately 3 cm. Distilled water or 0.015 N  $\text{CaCl}_2$  was applied from a blotter to wet the soils by capillarity. Increase in volume of the soil was measured with a cathetometer. Data are presented in Table IV. The swelling factors for the clay minerals, as determined in this way, were as follows: dickite = 1.31, illite = 1.47 and montmorillonite = 2.01. These values were not as great as those reported earlier. The previous values were obtained from a sodium saturated system. The above values were measured on the natural clays, which were probably nearly saturated with divalent ions.

Table IV. Swelling factor of the artificial soils as measured by increase in volume of samples wet by capillarity.

SAR of Equilibrating Solution	Dickite Soil		Illite Soil		Montmorillonite Soil	
	Electrolyte Concentration of the Water (me/ml $\text{CaCl}_2$ )					
	0	0.015	0	0.015	0	0.015
0	1.05	1.10	1.10	1.17	1.24	1.25
40	1.09	1.12	1.13	1.13	1.27	1.25

Differences in swelling due to sodium status of the soil and electrolyte content of the water for a particular soil are probably within experimental error. Differences between soils were not as great as had been expected. Sand and silt particles probably created pore spaces within the system which absorbed the swelling clay. The swelling exhibited by the dickite soil was attributed to the montmorillonite clay contained in the silt and interparticle swelling of the dickite mineral. Actually one is interested in the effect of swelling upon pore size. This could possibly have been obtained by measuring swelling pressure of compacted samples of soil. However, the equipment for this measurement was not readily available. These data, had they been available, would probably have been useful in explaining the effect of salts and swelling upon movement of the wetted front.

Preliminary runs were conducted with distilled water on the silt separate and the dickite soil SAR 0. It was found, when the logarithm of distance of the wetted front from the water source was plotted as a function of the logarithm of time, that a linear relationship held between 2 and 26 cm. from the water source. The plot, logarithm of quantity of water absorbed as a function of logarithm of time, also showed a linear relationship between 2 and 26 cm. Accordingly, it was assumed that any deviation from the linear would be caused by swelling. Thus, when swelling began to influence water movement, a nonlinear plot would result.

Figures 2 and 3 show log-log plots of distance of the wetted front from the water source as a function of time for the dickite soil SAR 0 and 40, respectively. The linearity of the plots indicate that the effects of swelling are not influencing the movement of the wetted front. One could expect this

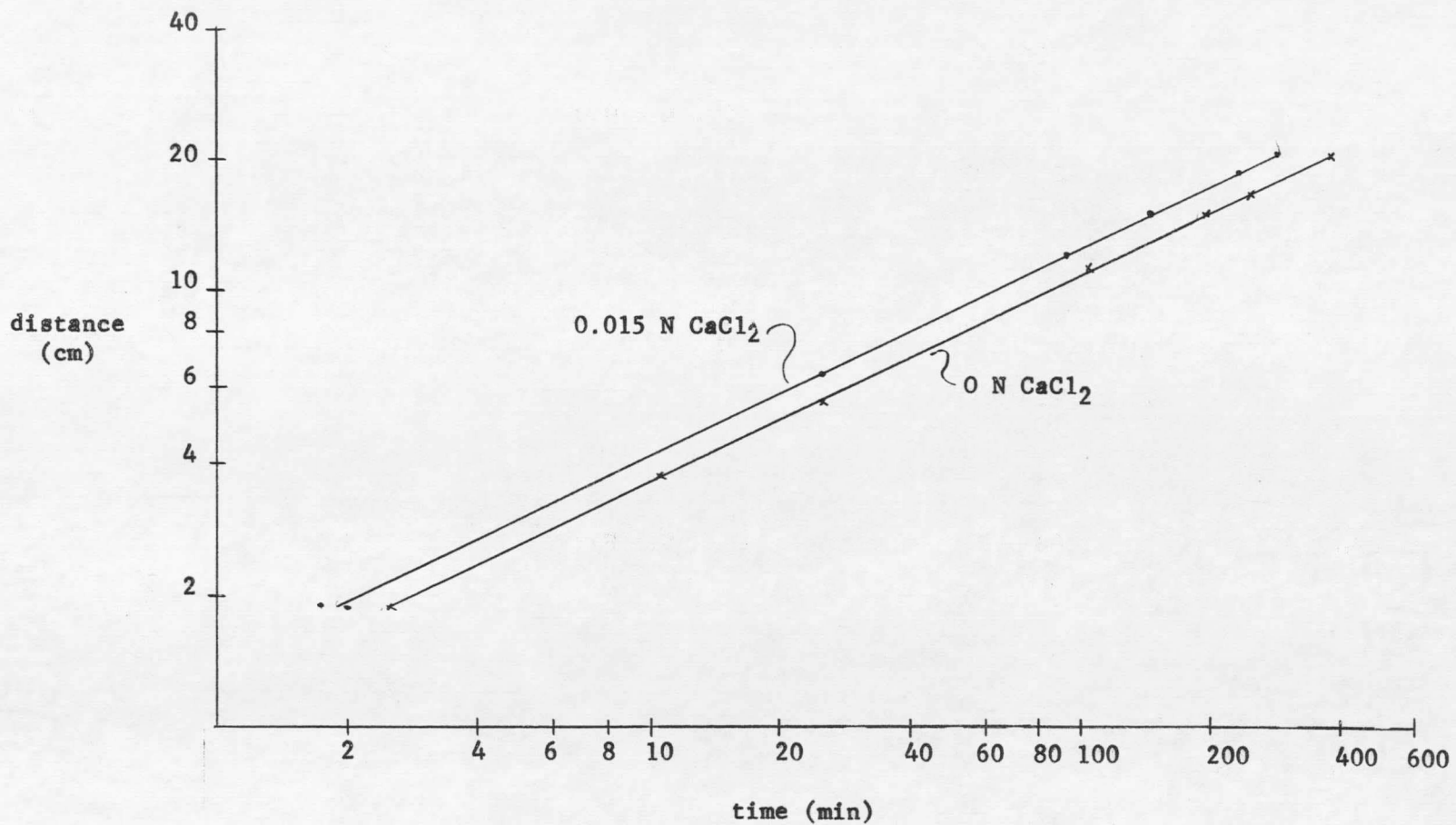


Figure 2. Distance of the wetted front from the water source as a function of time for the dickite soil SAR 0 with two water electrolyte concentrations.

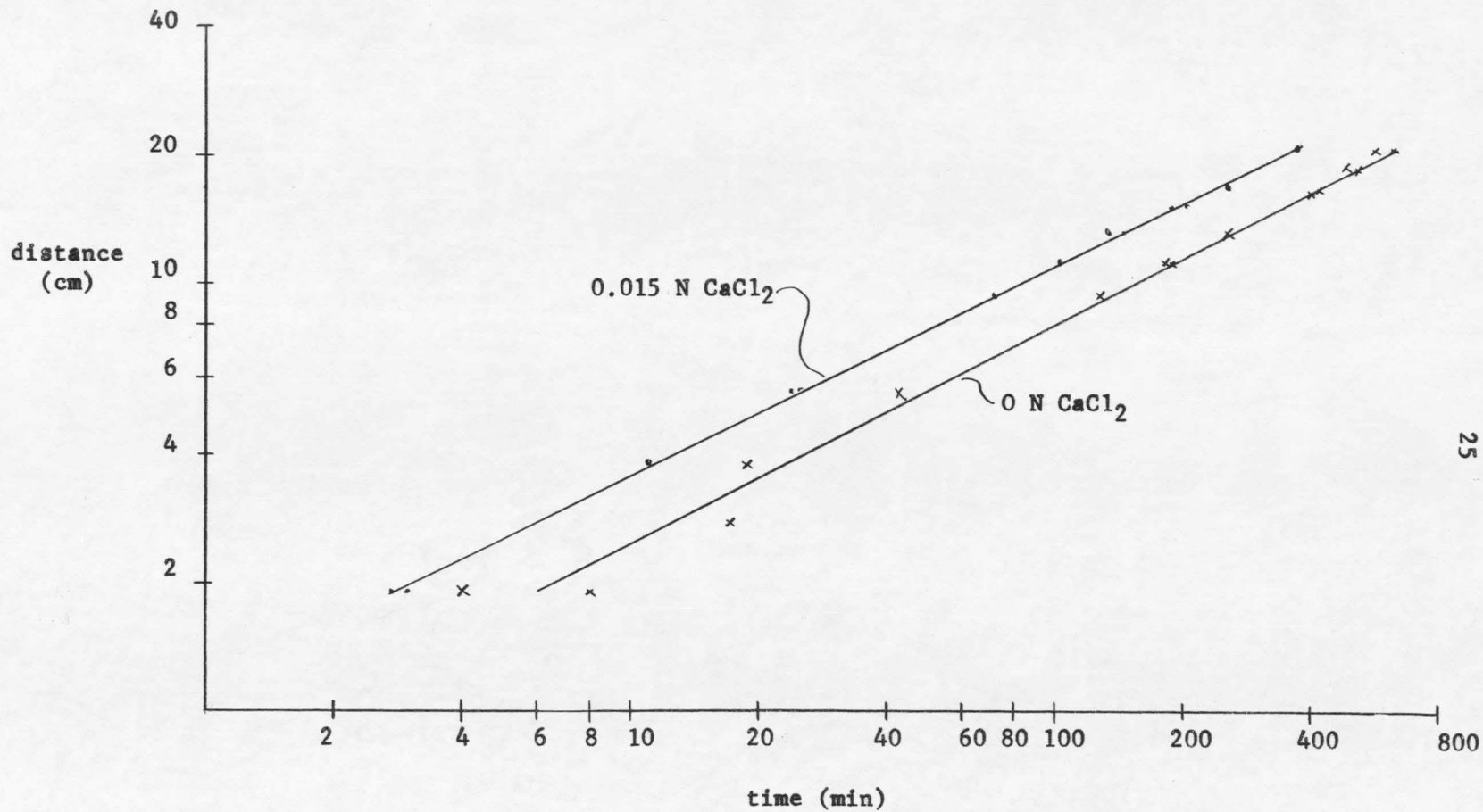


Figure 3. Distance of the wetted front from the water source as a function of time for the dickite soil SAR 40 with two water electrolyte concentrations.

since dickite is a nonexpanding clay mineral. A linear relationship also resulted from a log-log plot of quantity of water absorbed as a function of time, except for a slight deviation with the dickite soil SAR 40 and distilled water. This would indicate that swelling was influencing water absorption at this sodium level when distilled water was applied. The interparticle swelling of the dickite clay mineral and the swelling of the montmorillonitic clay in the silt probably caused this effect. Data for these measurements are presented in Tables XIX and XXII of the appendix.

It appears that swelling did not influence the movement of the wetted front on the illite soil SAR 0 (Figure 4). However, the log-log plot of quantity of water absorbed as a function of time indicates that water absorption was affected by swelling when distilled water was applied (Figure 5). The dotted line shows the expected plot had swelling not occurred. The linear plot for 0.015 N  $\text{CaCl}_2$  indicates that swelling was reduced so as not to influence water absorption.

It is indicated (Figure 6) that swelling affected movement of the wetted front to a greater degree with 0.015 N  $\text{CaCl}_2$  than with distilled water. This is the opposite effect from what would have been expected. On the other hand, the log-log plot of quantity of water absorbed as a function of time (Figure 7) shows that swelling was greatest with distilled water. It should be noted that 0.015 N  $\text{CaCl}_2$  reduced the effect of swelling on water absorption, but did not eliminate it completely. This electrolyte concentration was evidently not sufficient to completely depress the diffuse double layer.

The montmorillonite soil was affected to a greater degree than were the other soils. Figure 8 shows a log-log plot of distance of the wetted front from the water source as a function of time for the montmorillonite soil SAR 0.

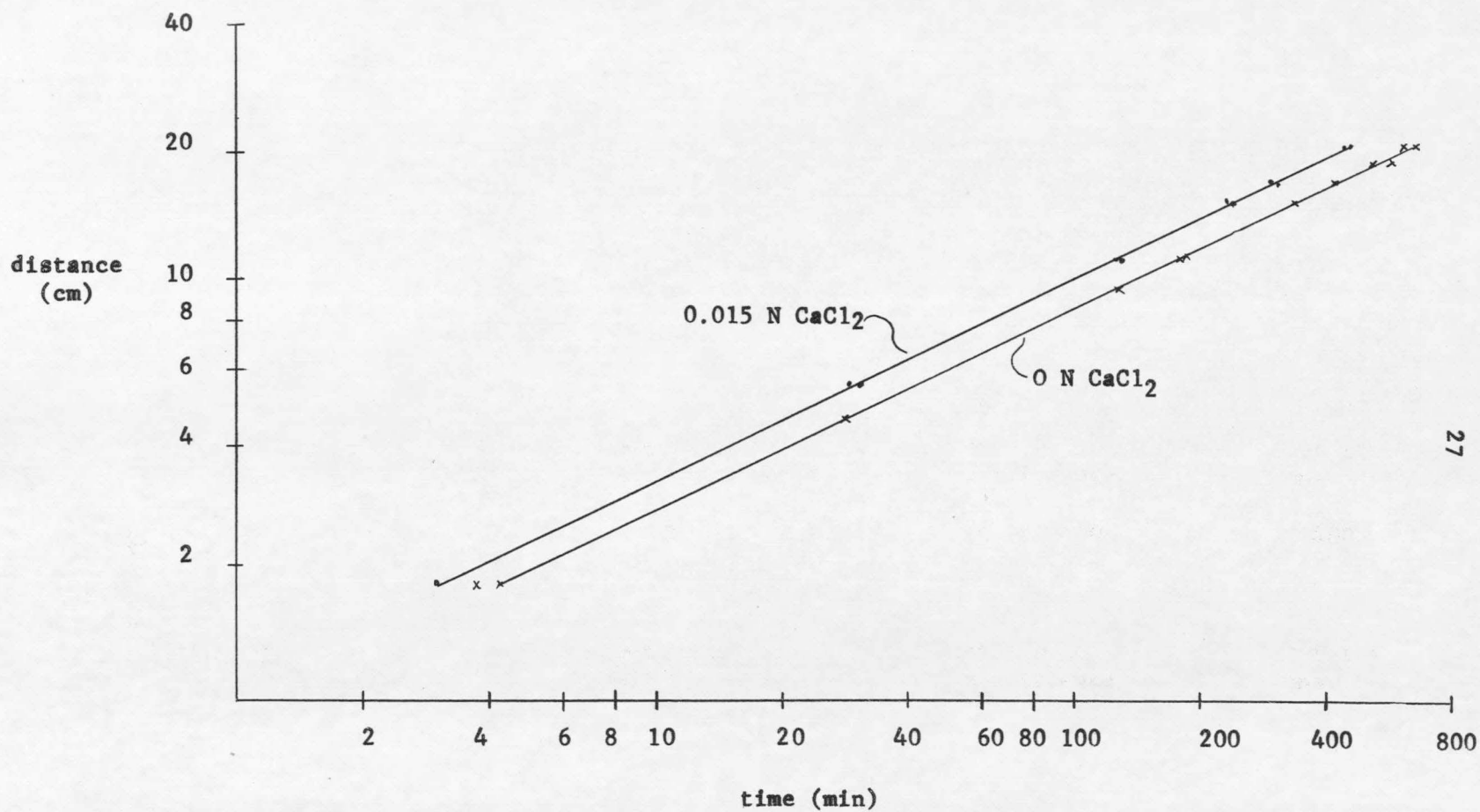


Figure 4. Distance of the wetted front from the water source as a function of time for the illite soil SAR 0 with two water electrolyte concentrations.

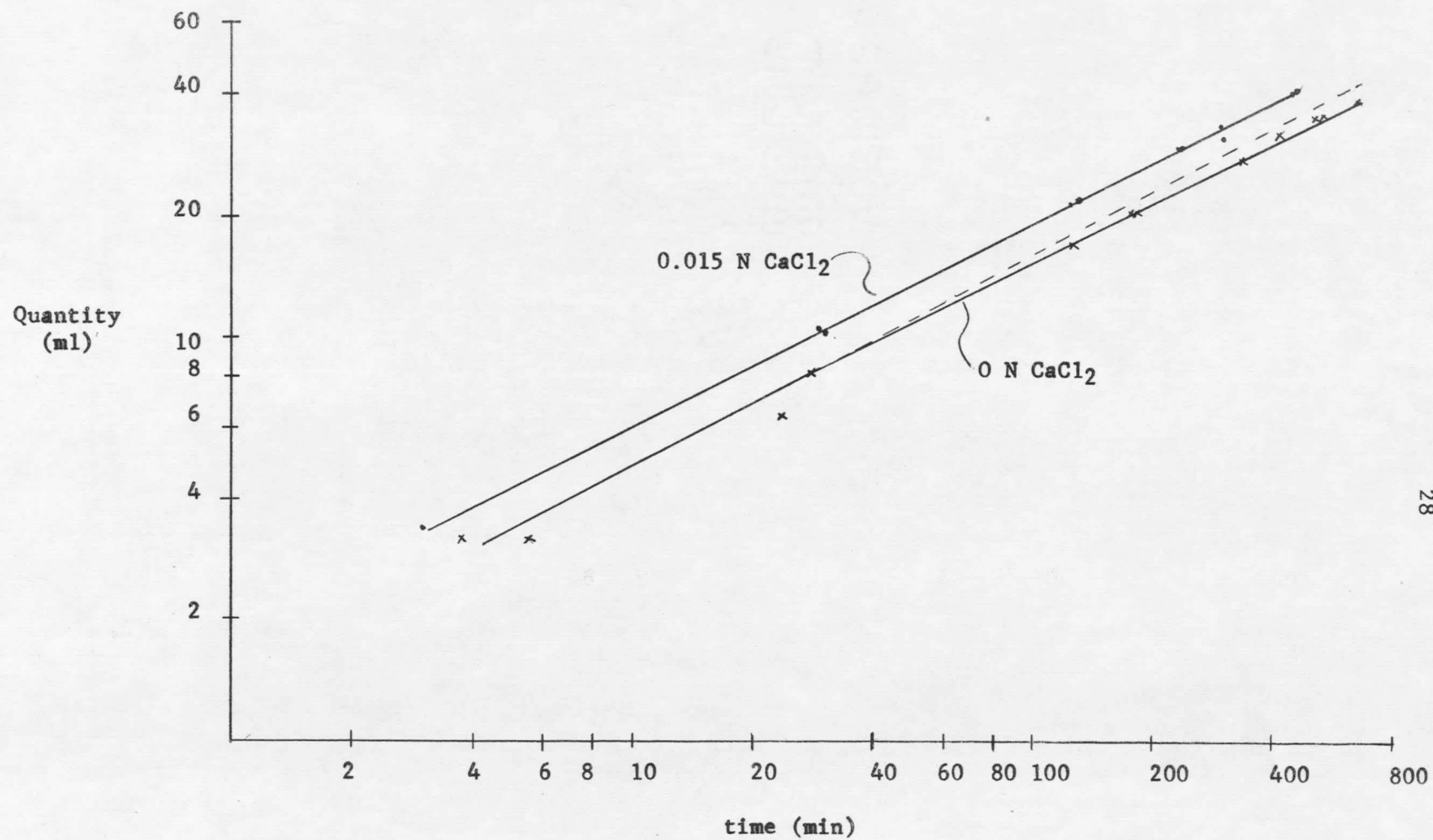


Figure 5. Quantity of water absorbed by the soil as a function of time for the illite soil SAR 0 with two water electrolyte concentrations. The dotted line is the expected plot had swelling not occurred.

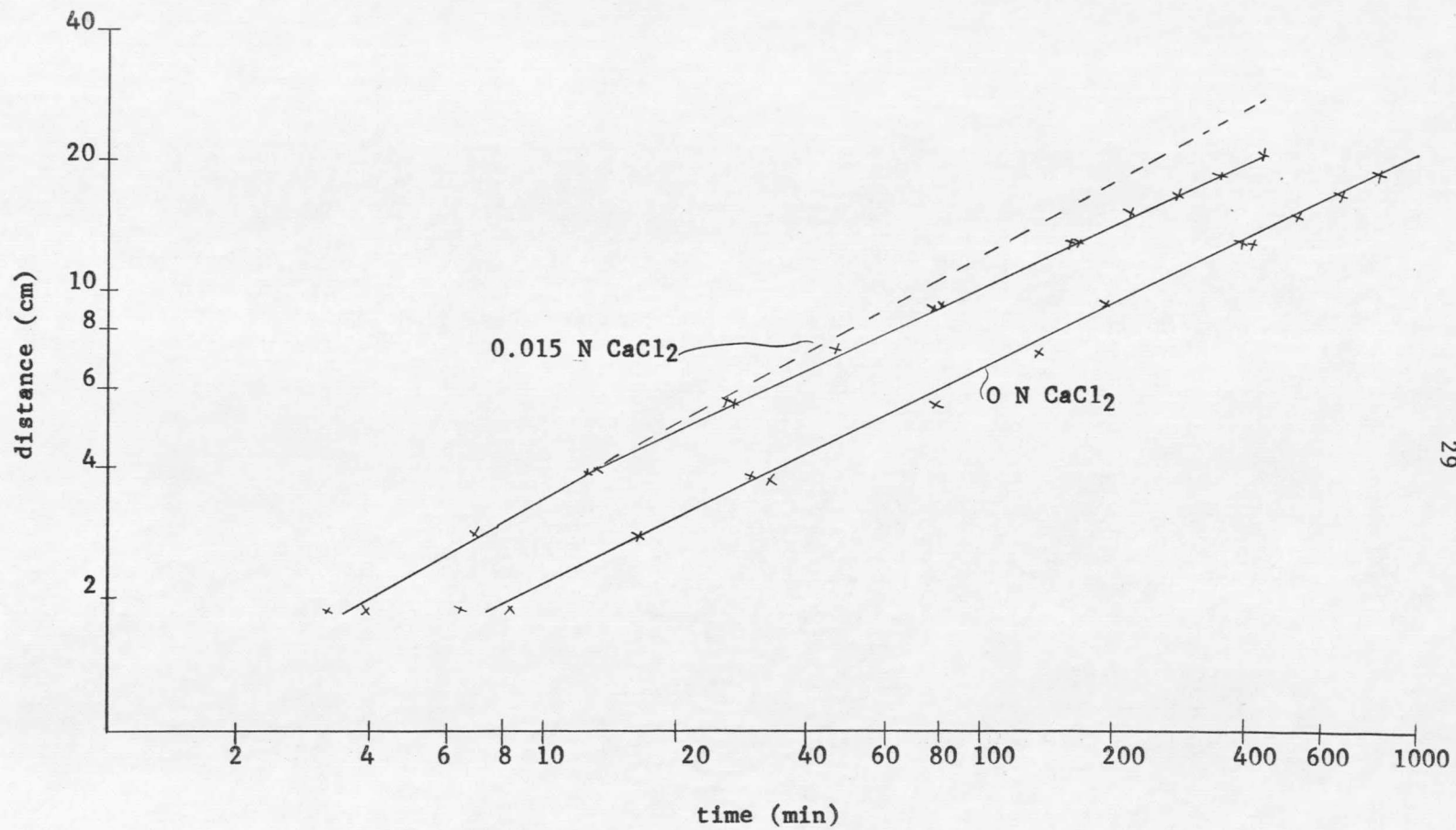


Figure 6. Distance of the wetted front from the water source as a function of time for the illite soil SAR 40 with two water electrolyte concentrations. The dotted line is the expected plot had swelling not occurred.

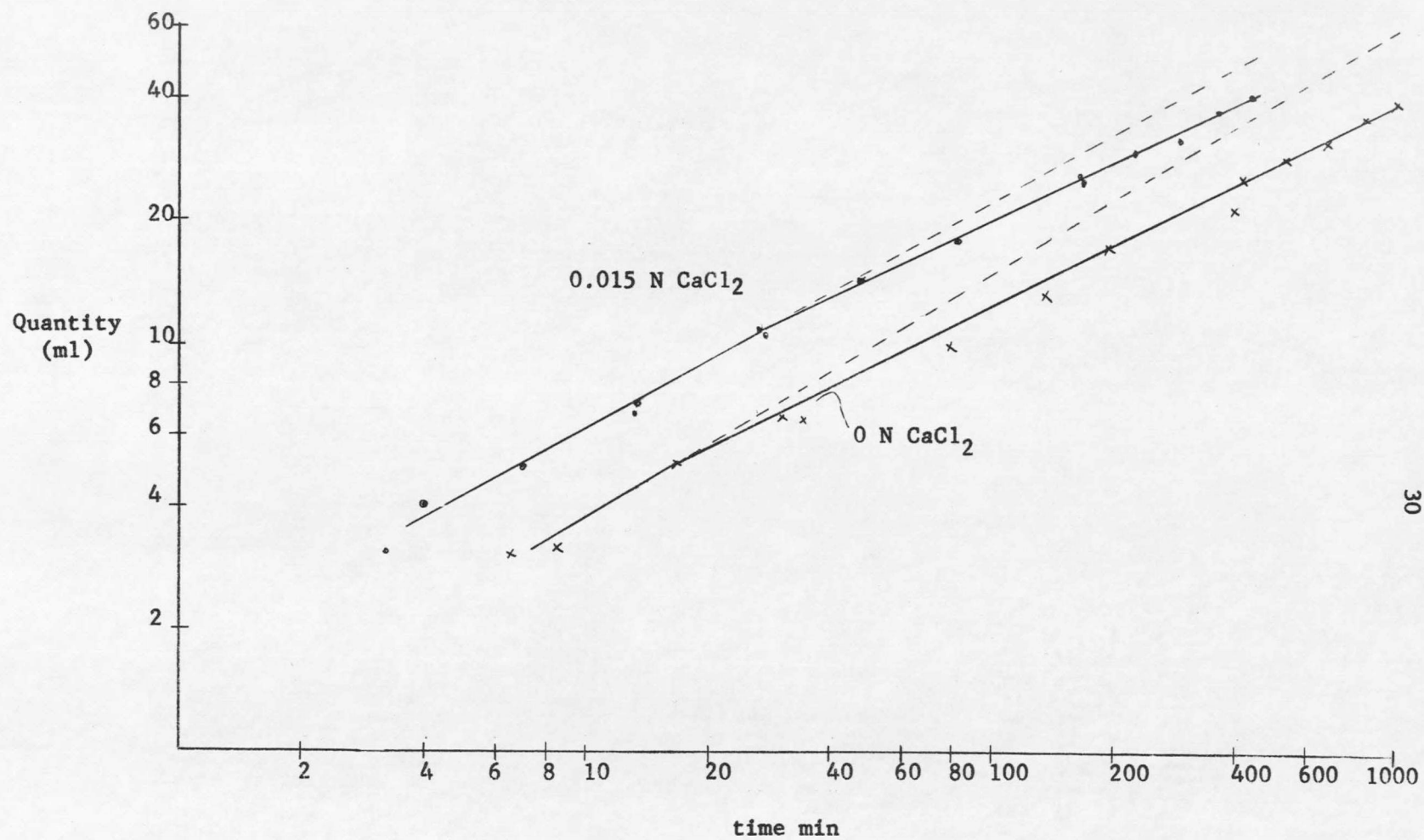


Figure 7. Quantity of water absorbed by the soil as a function of time for the illite soil SAR 40 with two water electrolyte concentrations. The dotted line is the expected plot had swelling not occurred.

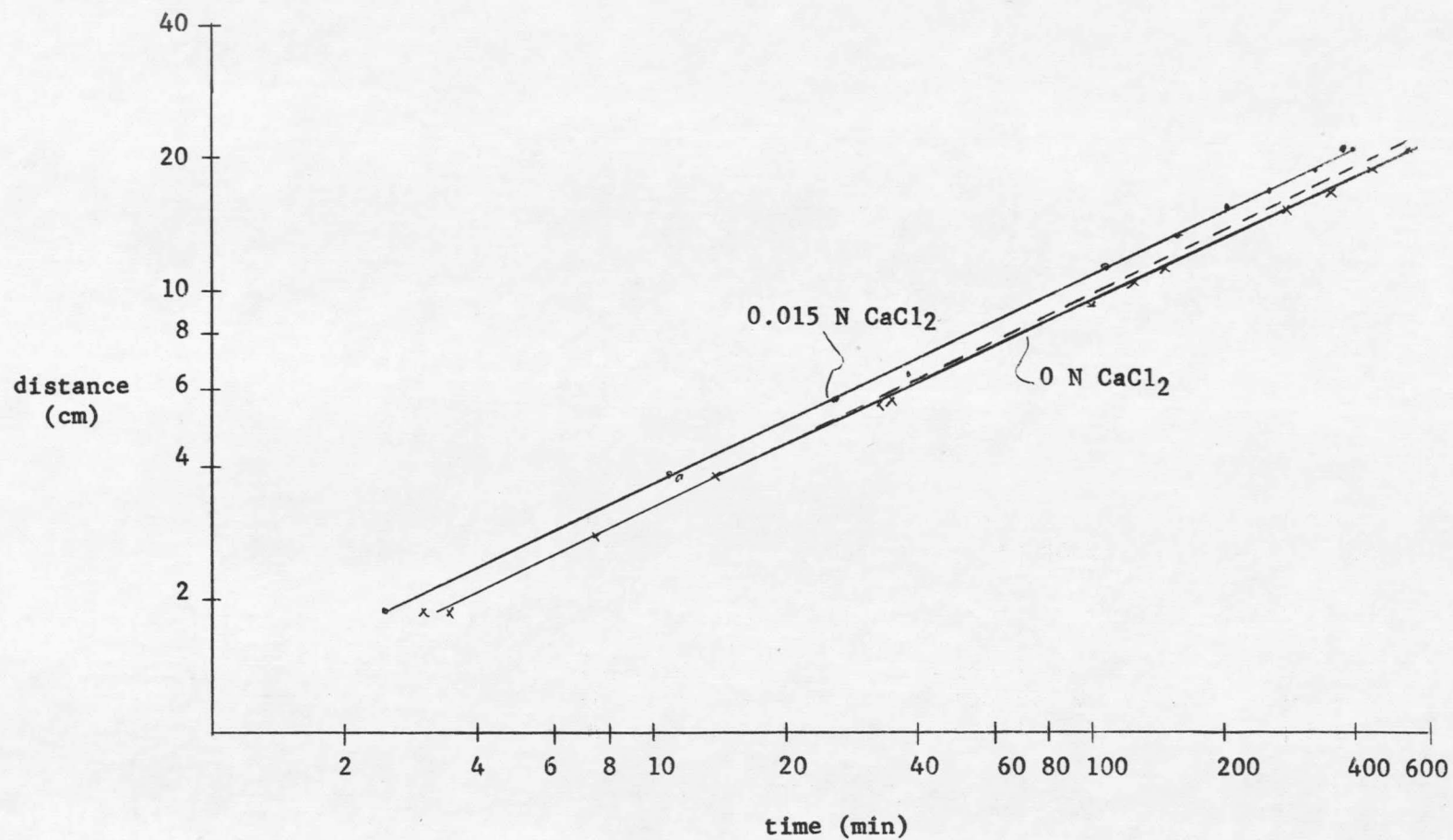


Figure 8. Distance of the wetted front from the water source as a function of time for the montmorillonite soil SAR 0 with the two water electrolyte concentrations. The dotted line is the expected plot had swelling not occurred.

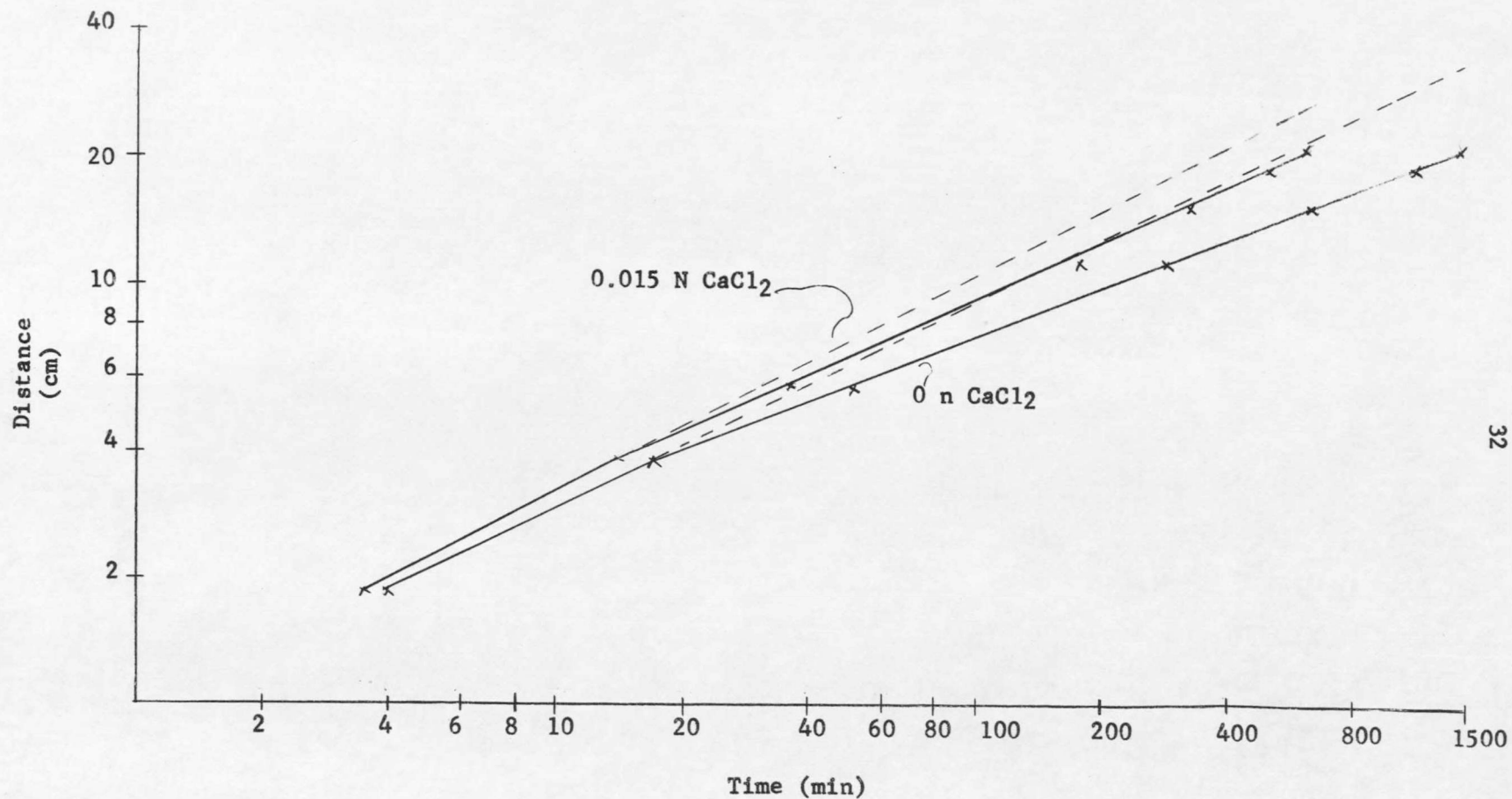


Figure 9. Distance of the wetted front from the water source as a function of time for the montmorillonite soil SAR 40 with two water electrolyte concentrations. The dotted line is the expected plot had swelling not occurred.

It can be seen from the dotted line showing the expected linear plot, that with distilled water swelling influenced water movement as time progressed. However, with 0.015 N  $\text{CaCl}_2$  the swelling influence was eliminated, as shown by the resulting linear plot. Figure 9 presents the same plot for the montmorillonite soil SAR 40. Swelling influenced movement of the wetted front to a very large degree with distilled water. The 0.015 N  $\text{CaCl}_2$  application reduced the effect of swelling on movement of the wetted front, but did not eliminate it completely. The electrolyte concentration was not sufficient to completely depress the diffuse double layer. Water absorption was affected by swelling similarly to movement of the wetted front on the montmorillonite SAR 0 and 40. The log-log plot for quantity of water absorbed as a function of time was linear for the montmorillonite SAR 0 with 0.015 N  $\text{CaCl}_2$ . It was nonlinear for the other treatments discussed above. Data are presented in Tables XXVI and XXX of the appendix.

The influence of swelling was more easily suppressed at lower sodium levels on the montmorillonite soil. Detailed data are presented in Tables XXVII through XXX of the appendix. Log-log plots of these data indicate that 0.005 N  $\text{CaCl}_2$  eliminated the effects of swelling on movement of the wetted front with the montmorillonite soil SAR 0 and 7. With the montmorillonite soil SAR 18, 0.015 N  $\text{CaCl}_2$  was required to reduce this effect. Figure 9 shows that 0.015 N  $\text{CaCl}_2$  did not reduce the effect of swelling on movement of the wetted front an appreciable amount with the montmorillonite soil SAR 40.

Swelling began to influence movement of the wetted front after 20-30 minutes. Most investigators (Norrish, 1954; Rowell, 1963 and others) allowed 24-48 hours for equilibrium in swelling studies. In view of this, it would be hasty to say that this would be the extent to which swelling influences movement of the wetted front.

### Diffusivity

Diffusivity was calculated from the equation

$$D(\theta)_x = -\frac{1}{2t} \left( \frac{dx}{d\theta} \right)_x \int_{\theta_i}^{\theta_x} x d\theta$$

which was shown earlier (Bruce and Klute, 1956). The integral was evaluated by determining the area under the curve of a plot of water content,  $\theta$ , as a function of distance,  $x$ . The differential was evaluated utilizing a glass prism as described by Swartzendruber and Olson (1963). Detailed data for diffusivity are presented in Tables XLIII through XLVIII in the appendix. It should be noted that slight irregularities (greater diffusivity at a particular value of  $\theta$  than at a greater value of  $\theta$ ) in diffusivity are present at higher moisture contents. This was attributed to errors in drawing of the moisture content - distance curves (Figure 10) and to measurement of the tangent,  $\frac{d\theta}{dx}$ . A small error in measuring the tangent would create a sizeable error in the cotangent,  $\frac{dx}{d\theta}$ , thus an error in diffusivity.

Table V presents diffusivity values at several moisture contents. Figures 11, 12 and 13 present plots of logarithm of diffusivity as a function of moisture content.

Diffusivity in the dickite soil was increased by use of 0.015 N  $\text{CaCl}_2$  rather than distilled water at both sodium levels. Choosing a value of 40% moisture (Table V), one can see that 0.015 N  $\text{CaCl}_2$  increased diffusivity by

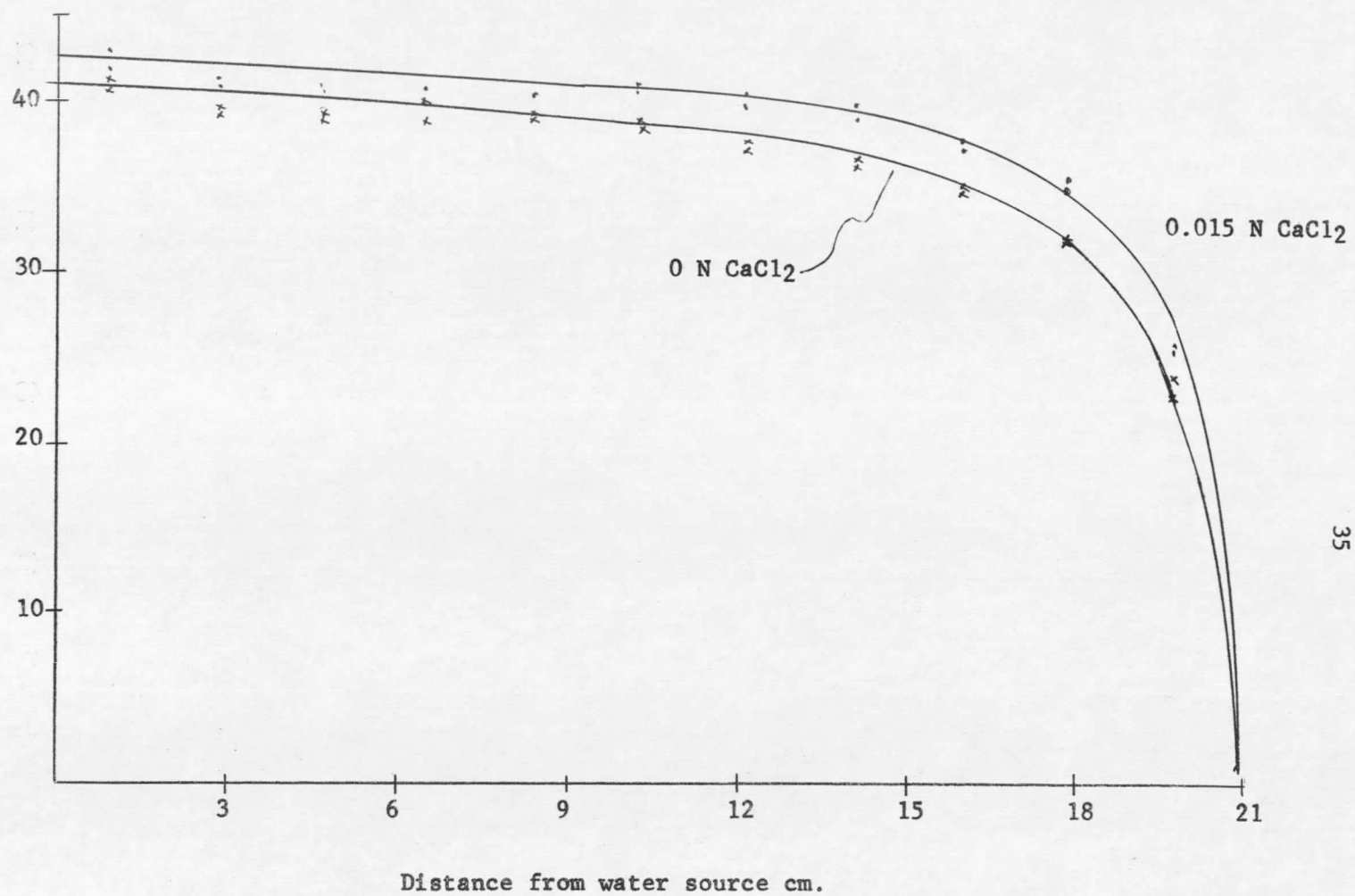


Figure 10. Moisture content as a function of distance from the water source for the illite soil SAR 0 with two water electrolyte concentrations.

Table V. Diffusivity as a function of moisture content for the 3 artificial soils. The values were obtained from Figures 11, 12 and 13.

Percent Moisture (by volume)	Dickite Soil				Illite Soil				Montmorillonite Soil			
					SAR of Equilibrating Solution							
	0		40		0		40		0		40	
	Electrolyte Concentration of the Water (me/ml CaCl <sub>2</sub> )											
	0	0.015	0	0.015	0	0.015	0	0.015	0	0.015	0	0.015
	cm <sup>2</sup> /min											
30	0.18	0.21	0.12	0.65	-	-	-	-	-	-	-	-
35	2.65	0.71	1.30	1.95	0.30	0.23	0.31	0.17	-	-	-	-
40	12.0	38.0	5.20	11.0	9.20	5.20	1.30	1.95	0.10	0.10	-	-
41	-	-	-	-	14.9	11.0	-	-	-	-	-	-
45	-	-	-	-	-	-	3.00	8.20	0.15	0.24	0.14	0.15
50	-	-	-	-	-	-	-	-	1.14	6.00	0.71	0.80
51.4	-	-	-	-	-	-	-	-	3.80	13.5	-	-
54.4	-	-	-	-	-	-	-	-	-	-	9.80	11.8

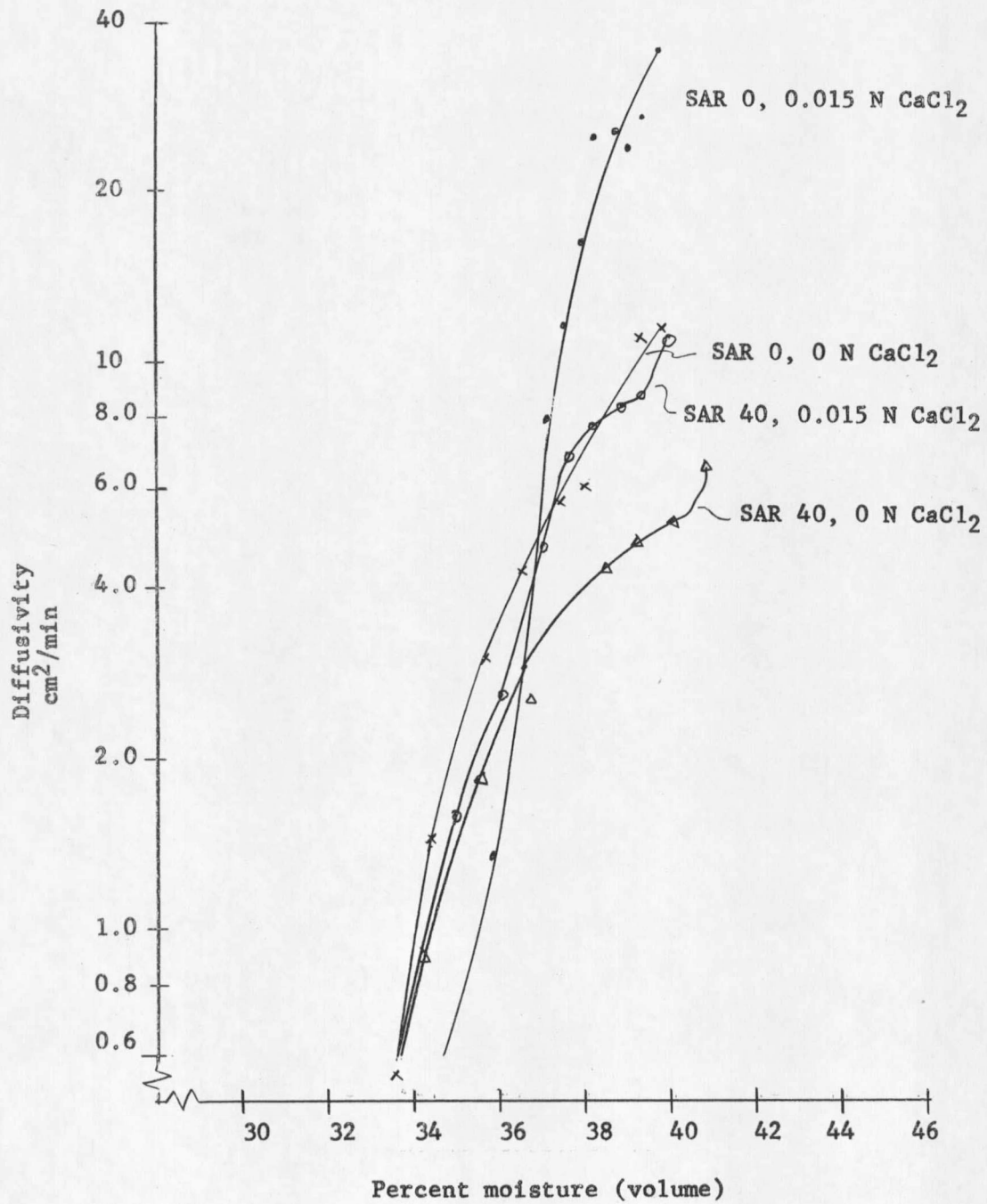


Figure 11. Diffusivity as a function of moisture content for the dickite soil. The SAR of the equilibrating solution and the water electrolyte concentration are shown with the respective lines.

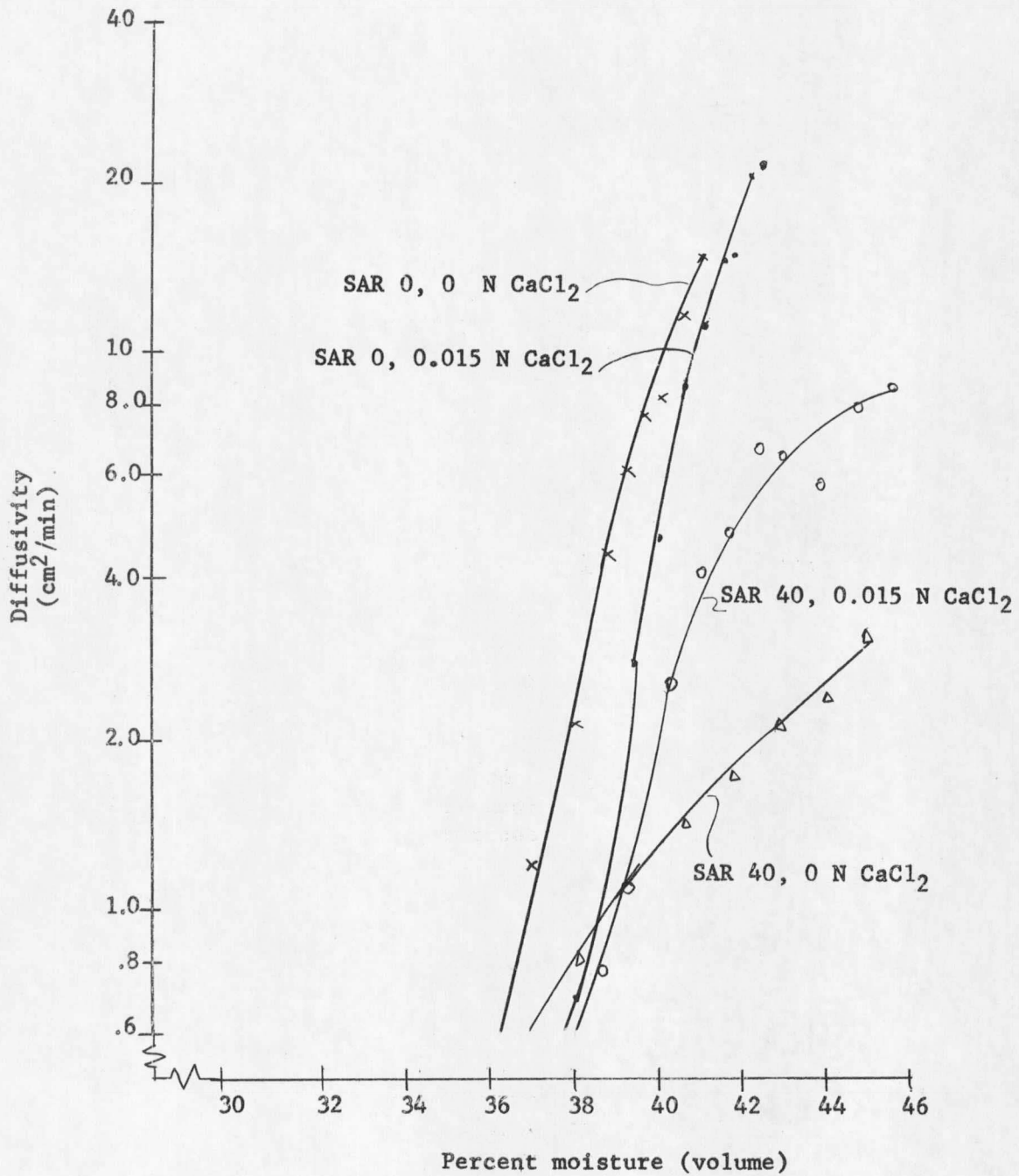


Figure 12. Diffusivity as a function of moisture content for the illite soil. The SAR of the equilibrating solution and the water electrolyte concentration are shown with the respective lines.

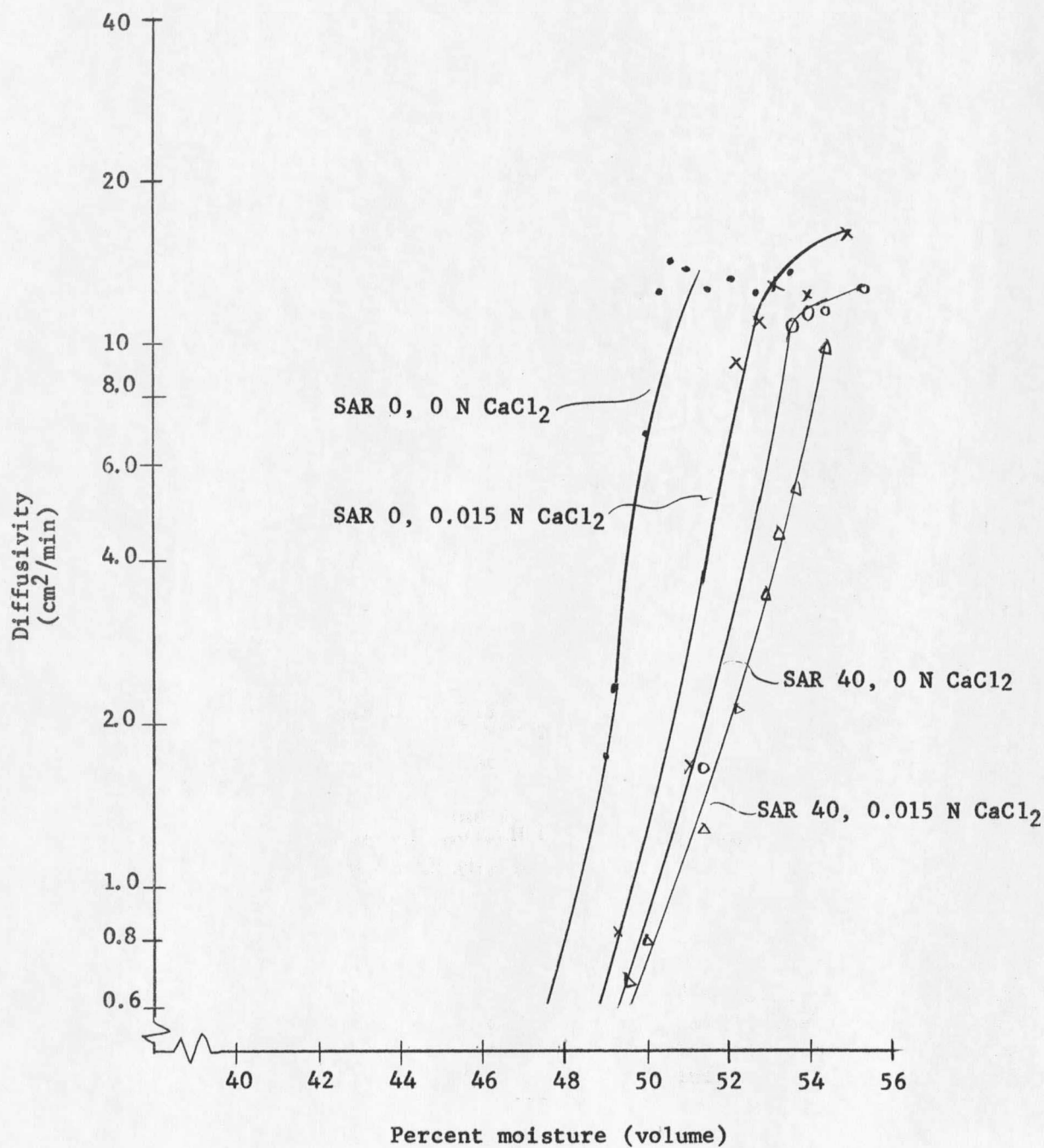


Figure 13. Diffusivity as a function of moisture content for the montmorillonite soil. The SAR of the equilibrating solution and the water electrolyte concentration are shown with the respective lines.

a factor of 2.1 with the dickite soil SAR 40 and by a factor of 3.2 on the dickite soil SAR 0. It is apparent that the diffuse double layer was more easily depressed on the dickite soil SAR 0. The higher value of diffusivity for distilled water than for 0.015 N  $\text{CaCl}_2$  with the dickite soil SAR 0 at 35% moisture is attributed to experimental error. The dickite soil SAR 40 at both electrolyte levels demonstrated a marked increase in diffusivity at the highest moisture content (Figure 11). Figure 14 shows that sodium has been removed from or reduced in the first two cm. of the column, which allowed the increase in diffusivity due to flocculation by calcium.

Illite soil SAR 40 demonstrated the same type of diffusivity pattern as did the dickite soil SAR 40. A 2.7 fold increase in diffusivity was observed with 0.015 N  $\text{CaCl}_2$  over distilled water at 45% moisture.

It appears that distilled water produced an increase in diffusivity over 0.015 N  $\text{CaCl}_2$  with the illite soil SAR 0 (Figure 12). Figure 10 presents the moisture content-distance curve for this soil. These curves were estimated from the plotted points. Several curves could have been drawn for each set of points and still fit fairly well. This would present the possibility of several different slopes at a particular point. As pointed out earlier, small deviations in the slope of the curve cause large deviations in the contangent to that curve. This in turn would change the magnitude of the diffusivity. It was felt that the diffusivity of this soil was increased by the electrolyte. But, due to estimations in drawing the moisture distribution curve and determining diffusivity it was not readily shown.

With the montmorillonite soil SAR 0, 0.015 N  $\text{CaCl}_2$  increased diffusivity over distilled water. At 51.4% moisture, the increase was by a factor of 3.6. It appears that the diffuse double layer and swelling were depressed sufficiently to allow the greater flow of water. The increase in diffusivity with the montmorillonite soil SAR 40 with 0.015 N  $\text{CaCl}_2$  was not as great as that shown with the other soils. The 0.015 N  $\text{CaCl}_2$  did not depress the diffuse double layer and swelling sufficiently to allow the greater water flow.

#### Ion Movement

Sodium movement with the dickite soil was increased by 0.015 N  $\text{CaCl}_2$  at both sodium levels (Figure 14). This is evidenced by the amount of sodium removed near the water source and the concentration within 4 cm. of the termination point (20.9 cm. from the water source). With the dickite soil SAR 0, the calcium electrolyte removed the water soluble sodium within 6 cm. of the water source; whereas, distilled water removed only half of the sodium within the first 6 cm. The same pattern of sodium movement is demonstrated with the dickite soil SAR 40, however, the content is greater than with SAR 0. The sodium content between 4 to 6 cm. and 17 cm. from the water source was the same as that initially present in the soil. In all four cases, the displaced sodium accumulated within 5 cm. of the wetted front. Evidently the ions were carried by the wetted front. Distilled water removed soluble calcium from the soils and moved it with the wetted front. The concentration of calcium in the first 4-6 cm. of the 0.015 N  $\text{CaCl}_2$  treatment was due to a replenishing from the water source.

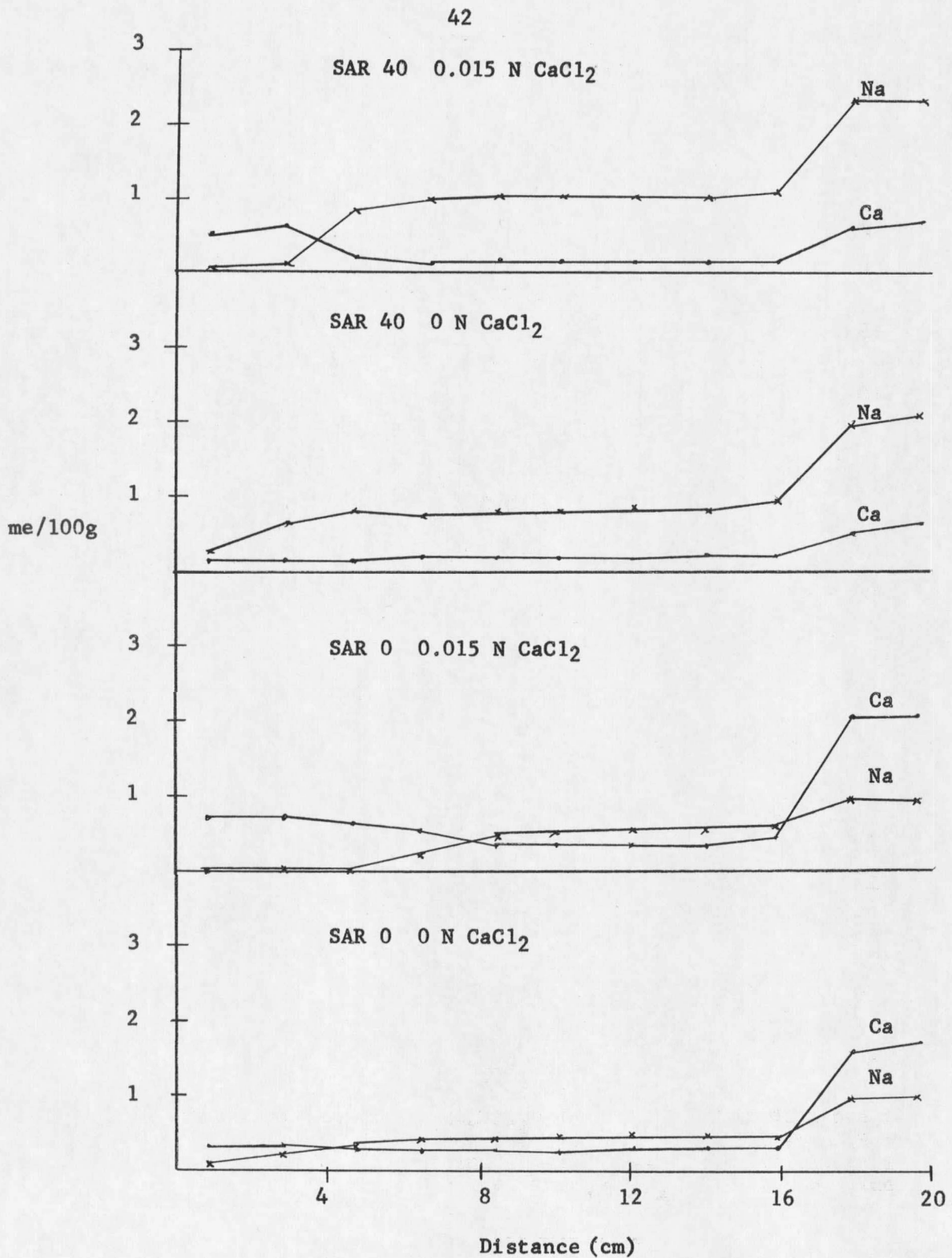


Figure 14. Ion concentration as a function of distance from the water source for the dickite soil. The SAR of the equilibrating solution and the water electrolyte concentration are shown with the respective lines.

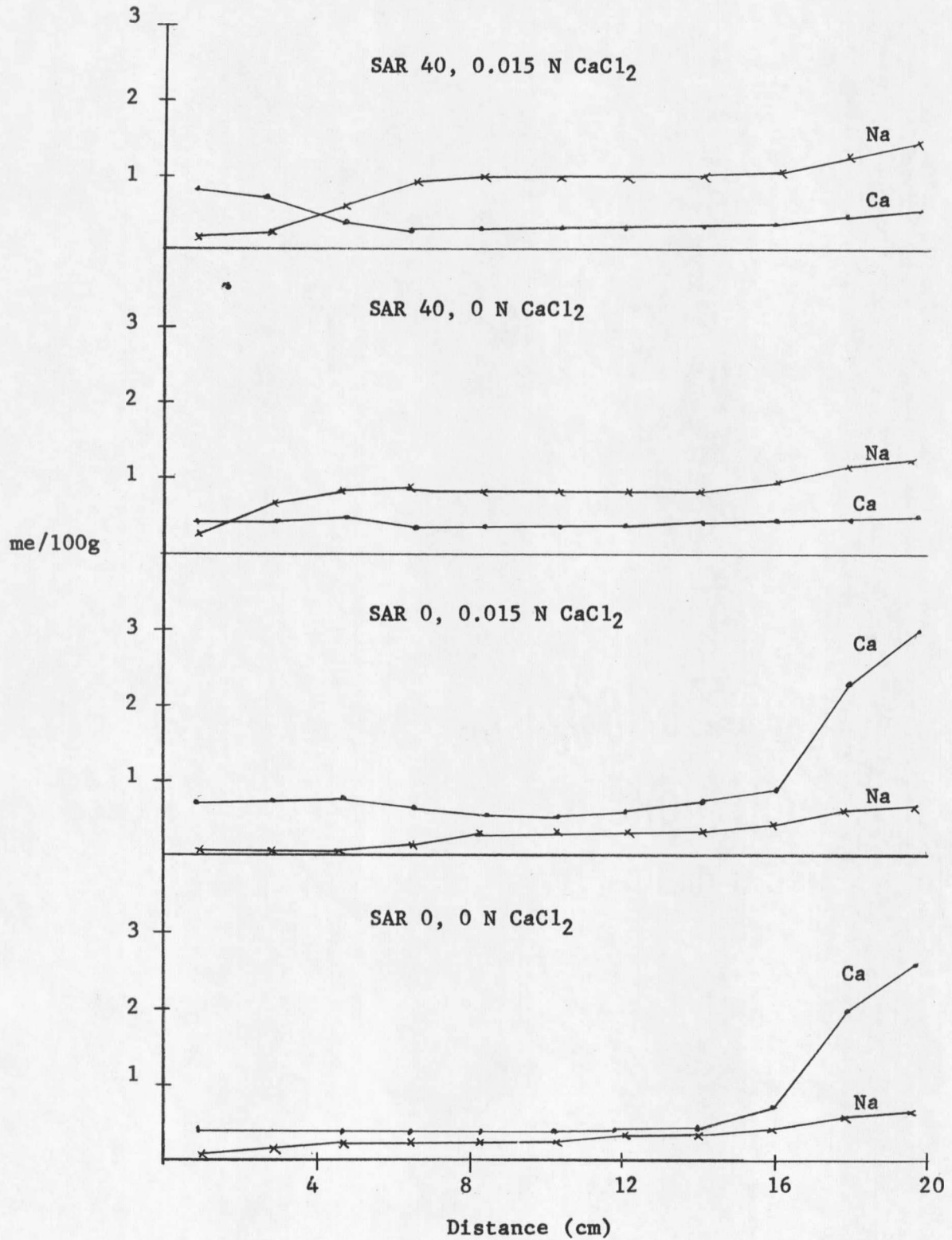


Figure 15. Ion concentration as a function of distance from the water source for the illite soil. The SAR of the equilibrating solution and the water electrolyte concentration are shown with the respective lines.

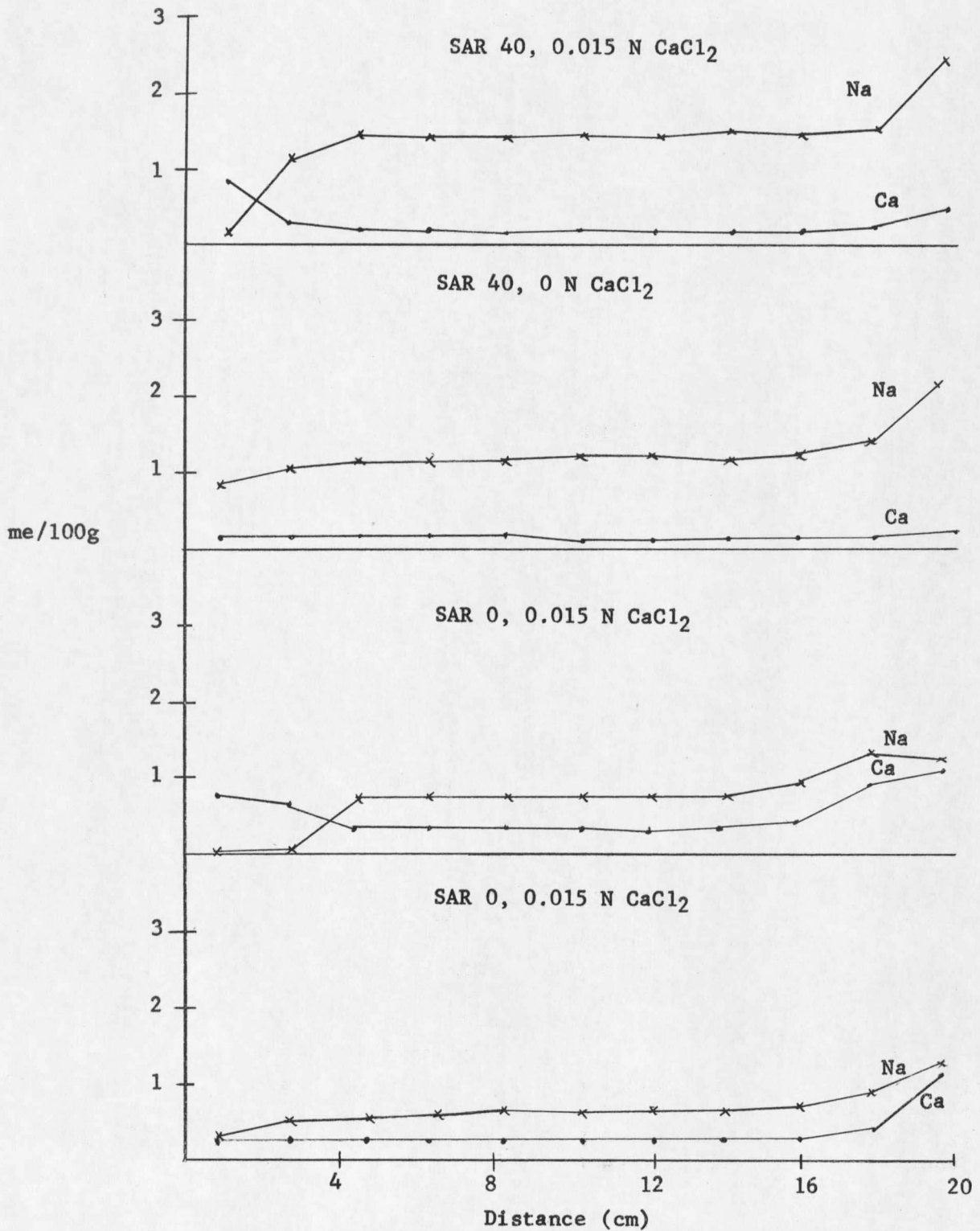


Figure 16. Ion concentration as a function of distance from the water source for the montmorillonite soil. The SAR of the equilibrating soil and the water electrolyte concentration are shown with the respective lines.

Calcium from 0.015 N  $\text{CaCl}_2$  was adsorbed by the SAR 40 treatment, replacing the displaced sodium. This would account for the lower calcium content at the wetted front with the dickite soil SAR 40 than SAR 0.

In general, the above discussion could apply to the ion movement for both the illite and montmorillonite soils (Figures 15 and 16). However, due to the preferential adsorption of calcium over sodium by these clay minerals, less calcium was moved with the wetted front. The calcium concentration increased 6 fold at the wetted front over the soluble level with the dickite soil SAR 40 and 0.015 N  $\text{CaCl}_2$ . It was increased 2 fold with the illite and montmorillonite soils with same sodium level and electrolyte concentrations. A similar relationship held for distilled water and the high sodium level. There was a 4 fold increase of calcium at the wetted front with the dickite soil, whereas, the illite and montmorillonite soils presented no increase. With the low sodium level there was more calcium movement with the illite and dickite soils than with the montmorillonite soil.

## SUMMARY AND CONCLUSIONS

Prepared soils containing 17.6% dickite, illite or montmorillonite clay minerals were equilibrated with solutions with sodium adsorption ratios of 0, 7, 18 or 40. Calcium chloride concentrations of 0, 0.005 or 0.015 normal were applied to soil columns at a tension of 2 millibars. Moisture and ion distribution were measured on 1.9 cm. segments of the soil column.

Diffusivity was increased by a factor of two or more by 0.015 N  $\text{CaCl}_2$  over distilled water with the illite and dickite soils equilibrated with a solution of SAR 0 and SAR 40, and with the montmorillonite soil SAR 0. This electrolyte concentration did not depress the diffuse double layer or reduce swelling sufficiently with the montmorillonite soil SAR 40 to increase diffusivity by an appreciable amount. Diffusivity was greater at a particular moisture content for the dickite soil than for the illite soil and greater for the illite soil than for the montmorillonite soil.

Swelling began to affect movement of the wetted front 20-30 minutes after the water was applied. An electrolyte concentration of 0.015 N  $\text{CaCl}_2$  was effective in reducing the swelling to a negligible amount on illite and montmorillonite soils equilibrated with a solution at SAR 0. This concentration failed to reduce the effect of swelling more than slightly on these soils equilibrated with a solution at SAR 40.

A general pattern of ion movement occurred at all soil treatments. Sodium was displaced from the first 4-6 cm. of the column and moved within 2-4 cm. of the wetted front. The ion content in the remainder of the column changed only slightly from the present in the soil initially.

From a reclamation standpoint, the dickite soil was more easily reclaimed than the illite and montmorillonite soils due to the greater diffusivity obtained with the dickite soil. The calcium electrolyte (0.015 N) was more effective in removing sodium than distilled water.

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APPENDIX

Table VI.--Soluble cations initially present in soils.

Clay Base	SAR of Equilibrating Solution							
	0		7		18		40	
	Sodium	Calcium	Sodium	Calcium	Sodium	Calcium	Sodium	Calcium
	mē/100 gm							
Dickite	0.35	0.32	0.51	0.27	0.70	0.29	0.88	0.22
Illite	0.23	0.64	0.28	0.36	0.52	0.54	0.82	0.30
Montmorillonite	0.62	0.30	0.78	0.20	1.02	0.31	1.15	0.35

Table VII.--Ion concentration (me/100 gm) in Dickite SAR 0 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	----	0.10	----	0.32	0.00	0.00	0.54	0.47	0.00	0.00	0.70	0.66
2	----	0.20	----	0.32	0.00	0.00	0.43	0.54	0.00	0.00	0.66	0.70
3	----	0.30	----	0.28	0.20	0.20	0.35	0.51	0.00	0.00	0.58	0.66
4	----	0.40	----	0.28	0.30	0.30	0.28	0.35	0.20	0.15	0.49	0.53
5	----	0.40	----	0.28	0.35	0.35	0.32	0.28	0.45	0.45	0.33	0.33
6	----	0.45	----	0.28	0.35	0.35	0.28	0.28	0.45	0.55	0.32	0.32
7	----	0.45	----	0.24	0.35	0.35	0.32	0.31	0.50	0.50	0.32	0.35
8	----	0.45	----	0.28	0.40	0.35	0.32	0.31	0.55	0.50	0.32	0.28
9	----	0.45	----	0.28	0.45	0.45	0.32	0.31	0.55	0.60	0.32	0.47
10	----	0.95	----	1.56	1.00	0.85	1.81	1.37	0.95	0.95	2.19	1.84
11	----	0.95	----	1.68	0.95	0.90	1.68	2.02	0.95	0.95	2.23	1.56

Table VIII.--Ion concentration (me/100 gm) in Dickite SAR 7 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	0.20	0.35	0.28	0.30	0.00	0.05	0.39	0.52	0.00	0.00	0.76	0.72
2	0.55	0.65	0.24	0.20	0.15	0.05	0.20	0.36	0.05	0.05	0.68	0.68
3	0.55	0.75	0.18	0.24	0.45	0.40	0.24	0.28	0.15	0.15	0.60	0.52
4	0.70	0.80	0.24	0.17	0.50	0.60	0.16	0.28	0.70	0.60	0.28	0.28
5	0.75	0.85	0.23	0.24	0.50	0.65	0.20	0.20	0.75	0.65	0.24	0.28
6	0.75	0.90	0.26	0.20	0.50	0.70	0.20	0.24	0.75	0.70	0.28	0.24
7	0.75	0.90	0.24	0.17	0.50	0.65	0.20	0.24	0.85	0.70	0.24	0.24
8	0.75	0.90	0.18	0.20	0.50	0.70	0.16	0.20	0.85	0.75	0.24	0.24
9	0.80	0.90	0.22	0.14	0.55	0.85	0.20	0.24	0.85	0.85	0.24	0.28
10	1.00	1.10	0.26	0.24	0.85	0.65	0.32	0.24	1.10	0.95	0.44	0.36
11	1.00	1.25	0.29	0.40	0.85	1.30	0.28	0.40	1.05	1.15	0.36	0.52

Table IX .--Ion concentration (me/100 gm) in Dickite SAR 18 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	0.35	0.35	0.25	0.20	0.10	0.10	0.37	0.71	0.10	0.05	0.82	0.70
2	0.55	0.60	0.22	0.20	0.35	0.35	0.32	0.37	0.10	0.15	0.62	0.90
3	0.65	0.65	0.24	0.18	0.65	0.70	0.19	0.30	0.25	0.20	0.70	0.66
4	0.70	0.75	0.30	0.24	0.70	0.75	0.30	0.27	0.75	0.70	0.39	0.35
5	0.75	0.75	0.24	0.26	0.75	0.75	0.28	0.24	0.85	0.90	0.24	0.28
6	0.75	0.75	0.20	0.28	0.75	0.75	0.25	0.24	0.90	0.90	0.24	0.28
7	0.80	0.80	0.24	0.24	0.75	0.75	0.27	0.34	0.90	0.90	0.24	0.28
8	0.80	0.80	0.20	0.24	0.75	0.80	0.27	0.27	0.90	0.95	0.24	0.24
9	0.75	0.80	0.20	0.24	0.80	0.90	0.27	0.30	0.90	0.95	0.24	0.28
10	1.05	0.80	0.40	0.28	1.05	1.05	0.38	0.32	1.20	1.30	0.54	0.54
11	1.10	1.20	0.44	0.48	1.20	1.20	0.57	0.60	1.20	1.20	0.54	0.54

Table X .--Ion concentration (me/100 gm) in Dickite SAR 40 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
me/100 gm												
1	0.45	0.10	0.15	0.16	0.10	0.10	0.32	0.41	0.05	0.05	0.48	0.51
2	0.75	0.60	0.13	0.16	0.75	0.70	0.17	0.18	0.15	0.10	0.64	0.54
3	0.80	0.85	0.13	0.16	0.80	0.80	0.15	0.15	0.90	0.80	0.18	0.20
4	0.90	0.60	0.18	0.20	0.85	0.90	0.15	0.15	1.00	0.95	0.17	0.16
5	0.85	0.70	0.15	0.20	1.00	0.90	0.15	0.18	1.10	1.00	0.17	0.16
6	0.90	0.70	0.15	0.20	0.95	0.90	0.15	0.15	1.05	0.95	0.15	0.20
7	0.90	0.70	0.15	0.16	0.95	0.95	0.15	0.15	1.10	0.95	0.18	0.16
8	0.85	0.80	0.15	0.16	0.90	0.95	0.18	0.17	1.10	0.95	0.15	0.16
9	1.00	0.85	0.18	0.20	0.95	1.00	0.15	0.17	1.15	1.00	0.15	0.16
10	2.10	1.85	0.41	0.58	2.10	2.10	0.56	0.47	2.45	2.30	0.75	0.47
11	2.45	1.80	0.74	0.62	2.15	2.35	0.60	0.78	2.40	2.30	0.71	0.78

Table XI ---Ion concentration (me/100 gm) in Illite SAR 0 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	0.05	0.00	0.43	0.33	0.00	0.00	0.51	0.47	0.00	0.00	0.74	0.74
2	0.25	0.05	0.43	0.33	0.00	0.00	0.47	0.51	0.00	0.00	0.74	0.74
3	0.25	0.15	0.39	0.37	0.15	0.15	0.39	0.39	0.05	0.00	0.82	0.70
4	0.30	0.10	0.35	0.41	0.20	0.25	0.32	0.43	0.15	0.15	0.66	0.62
5	0.30	0.15	0.39	0.29	0.20	0.25	0.39	0.35	0.35	0.25	0.58	0.54
6	0.35	0.15	0.35	0.33	0.25	0.25	0.39	0.35	0.35	0.30	0.58	0.54
7	0.30	0.15	0.39	0.33	0.25	0.25	0.39	0.39	0.35	0.30	0.62	0.58
8	0.35	0.20	0.39	0.33	0.30	0.30	0.35	0.43	0.35	0.30	0.82	0.58
9	0.50	0.20	0.90	0.54	0.35	0.40	0.62	0.82	0.45	0.35	0.94	0.84
10	0.65	0.45	2.00	1.89	0.55	0.60	2.07	1.96	0.65	0.55	2.34	2.15
11	0.75	0.55	2.66	2.42	0.55	0.60	2.54	2.27	0.70	0.55	2.98	2.90

Table XIII.--Ion concentration (me/100 gm) in Illite SAR 7 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	0.05	0.05	0.40	0.54	0.00	0.00	0.51	0.47	0.00	0.00	0.76	0.72
2	0.20	0.30	0.37	0.40	0.00	0.05	0.32	0.51	0.00	0.00	0.68	0.72
3	0.25	0.45	0.34	0.40	0.20	0.15	0.62	0.35	0.05	0.05	0.66	0.68
4	0.35	0.45	0.31	0.36	0.25	0.25	0.51	0.39	0.20	0.15	----	0.60
5	0.35	0.45	0.34	0.43	0.25	0.25	0.39	0.35	0.35	0.35	0.54	0.52
6	0.35	0.45	0.25	0.43	0.25	0.25	0.35	0.39	0.35	0.35	0.52	0.48
7	0.40	0.50	0.34	0.40	0.25	0.30	0.39	0.39	0.35	0.35	0.48	0.48
8	0.45	0.50	0.37	0.43	0.25	0.30	0.39	0.35	0.35	0.35	0.48	0.42
9	0.65	0.65	0.46	0.72	0.35	0.30	0.47	0.35	0.45	0.40	0.70	0.64
10	0.85	0.90	1.08	1.34	0.45	0.40	0.82	0.74	0.50	0.45	0.94	0.92
11	0.95	1.00	1.64	1.75	0.45	----	0.86	----	0.50	0.45	1.04	1.08

Table XIII.--Ion concentration (me/100 gm) in Illite SAR 18 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
me/100 gm												
1	----	0.05	----	0.31	0.05	----	0.54	----	0.05	0.10	0.60	0.82
2	----	0.25	----	0.31	0.15	0.25	0.57	0.60	0.05	0.10	0.62	0.75
3	----	0.30	----	0.37	0.40	----	0.41	----	0.10	0.15	0.62	0.66
4	----	0.30	----	0.31	0.45	0.45	0.36	0.33	0.30	0.45	0.50	0.56
5	----	0.60	----	0.31	0.45	0.55	0.38	0.32	0.50	0.60	0.37	0.57
6	----	0.35	----	0.31	0.40	0.55	0.38	0.35	0.55	0.55	0.40	0.54
7	----	0.35	----	0.31	0.45	----	0.41	----	----	0.60	----	0.54
8	----	0.35	----	0.31	0.45	0.55	0.43	0.32	0.55	0.60	0.40	0.68
9	----	0.40	----	0.31	0.55	----	0.46	----	0.55	0.65	0.44	0.46
10	----	0.55	----	0.46	0.70	0.60	0.80	0.54	0.70	0.80	0.78	1.18
11	----	0.85	----	0.78	0.70	0.70	1.00	0.58	1.25	1.25	0.90	1.07

Table XIV.--Ion concentration (me/100 gm) in Illite SAR 40 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	0.15	0.30	0.32	0.34	0.10	0.10	0.45	0.41	0.10	0.10	0.78	0.86
2	0.60	0.75	0.24	0.38	0.60	0.70	0.38	0.44	0.15	0.15	0.69	0.70
3	0.65	0.95	0.28	0.38	0.90	0.90	0.26	0.31	0.65	0.55	0.43	0.47
4	0.70	0.95	0.20	0.31	0.90	0.95	0.26	0.44	0.95	0.90	0.22	0.32
5	0.65	0.95	0.24	0.27	0.95	1.00	0.26	0.30	1.00	1.00	0.26	0.32
6	0.65	0.95	0.28	0.24	0.90	0.95	0.26	0.30	1.00	0.95	0.26	0.35
7	0.70	0.95	0.20	0.24	0.95	1.00	0.22	0.31	1.10	0.95	0.26	0.32
8	0.70	0.95	0.24	0.34	0.95	1.05	0.22	0.54	1.05	1.05	0.30	0.32
9	0.75	1.00	0.28	0.31	0.90	1.05	0.22	0.62	1.10	1.00	0.26	0.39
10	1.00	1.20	0.32	0.34	1.20	1.40	0.30	0.17	1.35	1.30	0.52	0.43
11	1.05	1.40	0.43	0.44	1.30	1.40	0.43	0.54	1.55	1.30	0.52	0.54

Table XV .--Ion concentration (me/100 gm) in Montmorillonite SAR 0 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
me/100 gm												
1	0.40	0.20	0.36	0.20	0.00	0.00	0.54	0.51	0.00	0.00	0.78	0.86
2	0.65	0.40	0.28	0.24	0.50	0.45	0.29	0.24	0.05	0.00	0.78	0.54
3	0.70	0.45	0.36	0.24	0.55	0.55	0.24	0.24	0.70	0.75	0.32	0.35
4	0.75	0.50	0.28	0.24	0.60	0.60	0.24	0.24	0.80	0.75	0.32	0.35
5	0.75	0.50	0.32	0.24	0.60	0.60	0.29	0.28	0.75	0.75	0.28	0.37
6	0.80	0.45	0.32	0.20	0.60	0.60	0.22	0.20	0.80	0.75	----	0.29
7	0.80	0.50	0.32	0.24	0.65	0.60	0.35	0.28	0.80	0.70	0.32	0.37
8	0.80	0.50	0.32	0.24	0.60	0.60	0.24	0.24	0.80	0.70	0.35	0.33
9	0.85	0.55	0.25	0.24	0.65	0.65	0.29	0.28	0.90	0.95	0.32	0.50
10	0.85	0.85	0.22	0.54	1.10	1.05	0.90	0.78	1.40	1.20	1.25	0.70
11	1.40	1.15	0.86	1.60	1.30	1.25	1.36	1.37	1.15	1.35	1.36	1.93

Table XVI.--Ion concentration (me/100 gm) in Montmorillonite SAR 7 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
me/100 gm												
1	0.55	0.55	0.18	0.25	0.30	0.15	0.28	0.39	0.00	0.00	0.74	0.80
2	0.75	0.75	0.28	0.18	0.75	0.75	0.12	0.20	0.30	0.35	0.51	0.43
3	0.85	0.85	0.25	0.22	0.75	0.85	0.20	0.20	0.90	0.95	0.16	0.24
4	0.90	0.85	0.22	0.18	0.80	0.80	0.16	0.16	0.90	0.95	0.24	0.20
5	0.90	0.90	0.28	0.25	0.80	0.85	0.16	0.20	0.95	0.95	0.20	0.24
6	0.90	0.90	0.22	0.22	0.85	0.85	0.24	0.20	0.95	0.95	0.24	0.20
7	0.90	0.95	0.18	0.22	0.80	0.85	0.16	0.20	0.95	0.95	0.24	0.20
8	0.90	1.00	0.25	0.28	0.80	0.85	0.16	0.20	0.95	1.00	0.20	0.20
9	0.95	1.00	0.28	0.25	0.85	0.90	0.20	0.20	0.95	1.05	0.20	0.24
10	1.00	0.95	0.22	0.25	0.95	1.00	0.20	0.24	1.15	1.35	0.32	0.35
11	1.45	1.70	0.39	0.60	1.60	1.65	0.58	0.54	1.75	1.65	0.78	0.66

Table XVII.--Ion concentration (me/100 gm) in Montmorillonite SAR 18 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Sodium		Calcium		Sodium		Calcium		Sodium		Calcium	
	1	2	1	2	1	2	1	2	1	2	1	2
	me/100 gm											
1	0.60	0.60	0.16	0.16	0.40	0.60	0.28	0.14	0.15	0.15	0.78	0.87
2	0.80	0.75	0.32	0.24	0.70	1.00	0.24	0.17	1.05	1.10	0.24	0.32
3	0.90	0.85	0.28	0.24	0.80	1.10	0.20	0.12	1.35	1.40	0.20	0.31
4	1.00	0.85	0.20	0.51	0.75	1.15	0.24	0.08	1.40	1.40	0.24	0.34
5	0.95	0.95	0.23	0.32	1.45	1.55	0.24	0.12	1.40	1.40	0.28	0.31
6	0.95	0.95	0.23	0.24	1.00	1.20	0.20	0.12	1.50	1.45	0.28	0.28
7	1.05	1.00	0.22	0.24	1.00	1.20	0.24	0.12	1.40	1.40	0.28	0.28
8	1.05	1.00	0.23	0.26	1.10	1.15	0.20	0.14	1.55	1.45	0.41	0.29
9	1.05	1.10	0.47	0.26	1.20	1.20	0.24	0.14	1.55	1.50	0.28	0.22
10	1.40	1.30	0.35	0.28	1.90	1.55	0.35	0.12	2.10	2.10	0.38	0.44
11	1.75	1.95	0.32	0.35	2.05	1.65	0.35	0.12	2.30	2.25	0.60	0.62

Table XVIII.--Ion concentration (me/100 gm) in Montmorillonite SAR 40 as a function of distance from the water source.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	Sodium	Calcium	Sodium	Calcium	Sodium	Calcium
	me/100 gm					
1	0.86	0.15	0.38	0.56	0.15	0.82
2	1.02	0.18	1.10	0.24	1.20	0.28
3	1.16	0.18	1.32	0.18	1.45	0.20
4	1.16	0.18	1.33	0.18	1.40	0.20
5	1.16	0.18	1.32	0.20	1.40	0.16
6	1.20	0.14	1.34	0.16	1.40	0.16
7	1.18	0.14	1.34	0.15	1.40	0.16
8	1.15	0.14	1.34	0.15	1.50	0.16
9	1.21	0.14	1.36	0.13	1.45	0.12
10	1.41	0.14	1.48	0.16	1.55	0.16
11	2.20	0.21	2.36	0.28	2.45	0.45

Table XIX .--Time (min) and quantity (ml) of water as a function of distance from the water source for Dickite SAR 0. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
1	2	1	2	1	2	1	2	1	2	1	2	
1	-	2.5	-	3.1	2.3	2.8	3.4	3.2	2.0	1.8	3.2	3.2
2	-	10.5	-	6.5	11	-	6.6	-	-	-	-	-
3	-	25	-	10.0	20	-	10.2	-	-	-	-	-
3.5	-	-	-	-	-	-	-	-	25	25	12.1	12.0
5	-	-	-	-	-	69	-	17.4	-	-	-	-
6	-	104	-	20.5	86	-	21.0	-	-	-	-	-
6.5	-	-	-	-	-	-	-	-	93	92	23.2	23.3
7	-	-	-	-	-	137	-	24.9	-	-	-	-
8	-	194	-	27.8	158	-	29.3	-	143	142	28.4	28.9
9	-	247	-	31.2	-	228	-	32.4	-	-	-	-
10	-	-	-	-	251	282	35.5	36.3	229	228	35.8	36.2
11	-	379	-	38.4	304	342	39.2	40.1	281	276	39.8	39.8

Table XX --Time (min) and quantity (ml) of water as a function of distance from the water source for Dickite SAR 7. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	4.2	6	2.8	2.6	3.0	3.5	3.2	2.6	2.5	3.0	3.4	2.2
2	19	23	6.6	6.6	-	-	-	-	-	-	-	-
3	-	46	-	10.0	-	-	-	-	-	-	-	-
3.5	-	-	-	-	35	36	12.8	11.9	-	-	-	-
4	133	-	16.4	-	-	-	-	-	37	41	13.4	13.7
5	-	120	-	16.8	-	-	-	-	-	-	-	-
6	-	170	-	20.2	96	96	21.0	20.9	-	-	-	-
7	265	228	23.3	24.0	-	-	-	-	-	-	-	-
8	349	300	26.6	27.2	178	178	28.8	28.9	157	161	28.4	28.4
9	434	-	30.0	-	-	-	-	-	-	-	-	-
10	536	-	33.8	-	277	277	36.0	36.4	249	253	35.4	35.7
11	646	553	37.2	37.6	332	332	37.2	39.9	304	311	39.0	39.7

Table XXI .--Time (min) and quantity (ml) of water as a function of distance from the water source for Dickite SAR 18. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
1	2	1	2	1	2	1	2	1	2	1	2	
1	4.8	4.2	3.1	3.0	3.2	3.8	3.2	3.2	2.5	2.7	3.4	3.0
2	22	20	6.4	6.4	12	-	6.5	-	10	11	6.9	6.8
3	-	42	-	9.6	27	28	10.0	10.0	22	23	10.4	10.2
5	116	109	16.6	16.6	-	-	-	-	-	-	-	-
6	165	-	20.1	-	110	111	20.3	20.8	90	-	21.1	-
7	225	214	23.8	23.6	-	-	-	-	-	132	-	24.8
8	-	279	-	29.1	205	204	27.8	28.3	167	-	28.6	-
9	371	-	30.6	-	-	261	-	31.8	-	224	-	32.1
10	455	438	34.1	34.0	-	-	-	-	272	-	36.0	-
11	552	539	36.6	39.8	399	393	38.4	38.9	324	340	39.7	39.4

Table XXII--Time (min) and quantity (ml) of water as a function of distance from the water source for Dickite SAR 40. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
1	2	1	2	1	2	1	2	1	2	1	2	
1	8.0	4.0	3.2	3.0	3.2	3.0	3.3	3.1	2.8	3.0	3.2	3.2
2	-	18	-	6.4	12	12	6.6	6.6	-	11	-	6.4
3	-	43	-	9.8	29	-	10.2	-	24	25	10.0	10.0
4	-	-	-	-	-	49	-	12.8	-	-	-	-
5	-	128	-	16.5	-	-	-	-	-	71	-	17.0
6	189	185	21.0	19.9	-	-	-	-	101	-	20.7	-
7	252	-	24.7	-	-	-	-	-	-	143	-	24.1
8	-	-	-	-	-	-	-	-	202	190	28.2	27.9
9	400	425	31.4	30.8	292	-	31.2	-	251	-	32.0	-
10	489	520	35.1	34.2	364	371	34.9	35.6	-	-	-	-
11	588	629	38.4	38.0	504	466	38.6	39.0	374	370	39.0	38.4

Table XXIII.--Time (min) and quantity (ml) of water as a function of distance from the water source for Illite SAR 0. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
1	2	1	2	1	2	1	2	1	2	1	2	
1	8.5	4.2	2.8	3.2	3.8	4.0	3.3	3.2	3.0	3.8	3.4	3.2
2	24	-	6.5	-	-	-	-	-	-	-	-	-
2.5	-	28	-	8.3	-	-	-	-	-	-	-	-
3	-	-	-	-	32	32	10.4	10.4	29	31	10.6	10.4
5	128	-	17.2	-	-	-	-	-	-	-	-	-
6	183	179	20.8	20.8	137	133	21.4	21.4	125	130	21.8	22.0
8	-	332	-	28.0	255	252	29.1	29.1	232	236	29.6	29.6
9	416	-	32.2	-	-	-	-	-	299	300	33.4	31.4
10	510	534	35.9	35.5	409	394	36.3	37.0	-	-	-	-
11	613	652	39.8	39.1	500	475	40.2	40.4	452	454	41.0	41.0

Table XXIV.--Time (min) and quantity (ml) of water as a function of distance from the water source for Illite SAR 7. Numbers 1 and 2 are duplicate columns.

Seg- ment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	4.5	4.8	3.4	3.2	3.0	4.0	3.4	1.9	2.8	2.8	3.6	3.1
2	16	16	6.6	6.6	-	-	-	-	-	-	-	-
3	-	35	-	10.0	-	34	-	10.8	-	-	-	-
3.5	-	-	-	-	35	-	12.2	-	-	-	-	-
4	-	-	-	-	-	-	-	-	41	41	14.6	14.1
5	105	100	19.4	17.0	-	-	-	-	-	-	-	-
6	153	148	21.0	20.7	106	-	21.8	-	-	-	-	-
7	215	207	24.6	24.4	-	-	-	-	-	-	-	-
8	-	276	-	28.0	-	-	-	-	177	182	29.8	29.2
9	-	356	-	31.7	253	265	32.9	33.5	-	-	-	-
10	455	446	35.4	35.1	-	-	-	-	280	-	37.6	-
11	560	551	39.4	39.0	385	398	40.4	41.0	341	351	41.2	40.7

Table XXV ---Time (min) and quantity (ml) of water as a function of distance from the water source for Illite SAR 18. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	-	4.0	-	3.6	2.5	3.0	3.2	2.2	3.0	3.0	3.0	3.2
1.5	-	8.5	-	5.5	6.0	6.0	5.0	5.0	6.5	6.0	5.0	4.8
2	-	15	-	7.2	11	11	7.0	6.8	11	11	6.8	5.6
3	-	34	-	10.8	25	25	10.4	10.6	25	24	10.6	10.0
4.5	-	-	-	-	-	-	-	-	-	56	-	15.4
5	-	-	-	-	74	-	17.9	-	-	-	-	-
6	-	-	-	-	-	108	-	19.6	101	-	21.6	-
7	-	-	-	-	152	152	25.5	25.6	-	-	-	-
8	-	-	-	-	199	-	27.2	-	205	-	29.2	-
8.5	-	-	-	-	-	-	-	-	-	215	-	30.8
9	-	-	-	-	-	255	-	32.7	-	-	-	-
10	-	-	-	-	-	-	-	-	-	296	-	36.2
11	-	486	-	42.2	391	391	40.6	40.4	365	361	40.4	40.2

Table XXVI ---Time (min) and quantity (ml) of water as a function of distance from the water source for Illite SAR 40. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	6.5	8.5	3.2	3.2	3.8	3.8	3.2	3.4	3.2	4.0	3.2	4.0
2	30	34	6.6	6.6	16	16	6.8	7.0	12	12	6.8	7.2
3	-	79	-	10.0	37	36	10.6	10.6	28	26	10.5	10.8
4	-	136	-	13.4	-	-	-	-	-	47	-	14.4
5	195	-	17.2	-	105	104	17.8	17.8	81	78	18.0	18.2
7	393	419	21.4	25.4	-	219	-	25.4	167	164	25.4	25.8
8	-	534	-	28.6	-	289	-	29.2	223	222	29.3	29.6
9	667	-	31.6	-	380	-	33.0	-	-	288	-	31.3
10	-	828	-	36.0	477	-	35.0	-	360	-	37.2	-
11	997	999	38.2	39.6	579	578	40.8	40.6	439	440	40.1	40.9

Table XXVII --Time (min) and quantity (ml) of water as a function of distance from the water source for Montmorillonite SAR 0. Numbers 1 and 2 are duplicate columns.

Seg- ment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	3.5	3.0	4.2	3.9	2.8	2.8	4.2	4.0	2.5	2.5	4.2	4.0
2	14	-	8.2	-	-	-	-	-	11	11.5	8.0	8.0
3	33	35	13.4	12.0	28	28	12.4	12.4	26	-	12.1	-
3.5	-	-	-	-	-	-	-	-	-	38	-	14.0
5	100	-	20.9	-	-	-	-	-	-	-	-	-
5.5	-	127	-	22.2	123	122	25.4	24.8	-	-	-	-
6	148	-	25.1	-	-	-	-	-	109	-	24.6	-
7	-	-	-	-	-	-	-	-	-	158	-	28.6
8	-	279	-	32.8	222	229	33.2	33.4	201	-	33.2	-
9	355	-	38.3	-	-	291	-	37.8	257	-	39.6	-
10	442	438	42.7	41.1	350	-	41.8	-	-	328	-	41.8
11	542	534	47.5	45.6	428	442	46.2	46.6	389	398	46.2	46.2

Table XXVIII.--Time (min) and quantity (ml) of water as a function of distance from the water source for Montmorillonite SAR 7. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	6.5	5.5	3.8	3.6	2.8	2.5	4.0	3.8	2.5	2.5	4.2	4.0
2	22	20	8.0	5.6	-	-	-	-	-	-	-	-
3	-	46	-	11.7	28	27	12.8	13.4	-	-	-	-
4	83	-	16.0	-	-	-	-	-	-	50	-	16.2
4.5	-	-	-	-	-	-	-	-	55	64	18.6	18.3
5	135	135	20.4	19.9	-	-	-	-	68	-	20.6	-
6	192	196	24.5	23.9	118	122	24.4	24.8	-	-	-	-
7	-	270	-	28.3	-	-	-	-	-	-	-	-
8	-	-	-	-	223	228	33.2	33.5	189	-	33.4	-
9	430	444	37.2	36.8	-	-	-	-	-	-	-	-
10	590	549	41.8	41.2	358	-	41.6	-	-	-	-	-
11	661	661	45.6	45.8	437	448	46.0	47.0	382	407	46.8	46.3

Table XXIX.--Time (min) and quantity (ml) of water as a function of distance from the water source for Montmorillonite SAR 18. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water											
	0 N CaCl <sub>2</sub>				0.005 N CaCl <sub>2</sub>				0.015 N CaCl <sub>2</sub>			
	Time		Quantity		Time		Quantity		Time		Quantity	
	1	2	1	2	1	2	1	2	1	2	1	2
1	3.8	4.0	4.0	4.0	3.2	3.2	4.2	4.2	2.5	3.0	4.0	4.0
2	20	22	8.4	8.0	14	14	8.4	8.1	12	12	8.2	8.0
3	46	52	12.4	12.1	33	34	12.4	12.0	28	30	12.2	12.0
5	138	155	20.9	20.3	104	-	20.8	-	85	89	20.4	20.2
6	203	230	25.2	24.9	-	161	-	24.6	-	-	-	-
7	-	-	-	-	-	227	-	28.8	176	190	29.0	28.7
8	379	-	34.2	-	287	-	33.8	-	233	-	33.2	-
9	486	541	38.8	37.8	-	-	-	-	-	328	-	37.2
10	605	-	43.2	-	459	487	42.2	41.6	372	404	41.8	41.6
11	740	819	46.8	46.4	562	600	46.6	46.2	456	492	46.2	45.6

Table XXX .--Time (min) and quantity (ml) of water as a function of distance from the water source for Montmorillonite SAR 40.

	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	Time	Quantity	Time	Quantity	Time	Quantity
1	4.0	4.2	3.8	4.1	3.5	4.3
2	17	8.3	17	8.4	14	8.0
3	51	12.5	44	12.7	36	12.2
6	285	24.5	210	25.0	170	25.3
8	640	34.1	440	34.1	321	34.4
10	1140	42.8	740	42.6	501	43.2
11	1490	47.3	910	47.5	607	47.3

TableXXXI.--Moisture content in Dickite SAR 0 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Seg- ment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	----	39.7	41.0	37.3	39.4	39.8
2	----	37.3	38.5	36.9	39.1	39.1
3	----	36.2	39.0	36.6	36.4	38.6
4	----	36.9	37.1	37.7	37.4	41.3
5	----	37.4	38.7	37.5	37.7	37.7
6	----	37.4	38.4	37.0	37.9	38.8
7	----	35.6	37.1	36.9	36.6	37.5
8	----	34.0	36.0	36.3	36.9	37.5
9	----	32.2	34.3	34.3	35.5	36.3
10	----	29.2	31.0	31.4	33.4	32.4
11	----	20.1	20.5	24.9	25.6	24.9

TableXXXII.--Moisture content in Dickite SAR 7 as a function of distance from the water source.

Seg- ment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	39.8	39.8	38.5	39.2	41.9	42.3
2	39.0	38.4	38.3	39.5	39.8	39.4
3	38.8	37.5	37.1	38.5	39.8	38.1
4	38.3	37.2	36.4	37.5	39.5	37.9
5	37.5	36.8	35.6	38.6	37.5	38.6
6	35.8	35.5	35.3	36.7	39.0	39.0
7	35.2	34.0	36.3	36.6	37.5	37.5
8	33.9	32.2	36.2	36.6	37.0	38.1
9	31.7	30.5	34.4	28.1	35.6	35.4
10	28.5	27.5	31.5	41.1	31.9	32.3
11	----	20.1	22.1	27.9	22.9	25.2

TableXXXIII.--Moisture content in Dickite SAR 18 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	39.9	39.5	39.9	39.6	41.7	40.5
2	37.8	38.1	38.5	38.7	39.3	39.7
3	38.4	38.3	38.7	38.3	39.1	38.9
4	38.3	37.9	38.4	38.0	39.5	38.3
5	39.8	37.4	38.3	37.8	38.9	38.8
6	37.0	36.3	38.1	37.9	39.5	39.5
7	35.9	34.8	37.1	36.6	37.5	38.8
8	33.6	32.7	34.9	35.5	37.1	37.5
9	31.3	30.3	32.9	33.2	34.6	35.7
10	29.2	28.9	31.2	33.6	32.9	34.6
11	20.7	21.7	22.7	21.1	22.7	23.8

TableXXXIV.--Moisture content in Dickite SAR 40 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	41.7	40.1	40.6	41.0	39.8	38.6
2	41.4	38.2	38.1	38.2	38.3	37.7
3	38.9	38.3	37.7	37.5	37.9	37.1
4	38.6	37.9	37.7	36.7	37.4	36.6
5	38.6	36.2	36.6	36.9	37.5	37.5
6	37.3	35.5	35.9	36.4	37.3	36.4
7	35.6	34.4	35.8	35.6	36.4	38.1
8	33.1	33.5	34.0	34.8	35.0	33.1
9	32.2	31.4	32.4	32.8	32.4	31.8
10	29.5	29.2	29.9	30.4	30.0	30.2
11	19.8	18.2	20.0	15.5	22.2	21.2

Table XXXV.--Moisture content in Illite SAR 0 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	41.1	40.7	41.4	41.8	41.8	43.0
2	39.1	39.6	38.6	39.3	40.9	41.3
3	39.0	39.2	38.6	39.8	40.7	40.6
4	38.9	40.0	38.4	39.6	40.7	39.9
5	39.2	39.1	38.6	39.8	40.3	40.3
6	38.9	38.4	38.1	39.8	40.9	40.7
7	37.7	37.1	38.9	38.9	39.9	40.4
8	36.6	36.3	38.4	38.8	39.8	39.9
9	35.0	34.9	37.1	37.0	37.1	37.8
10	31.9	32.2	33.9	33.5	35.4	34.8
11	24.0	22.8	24.6	23.9	25.6	25.9

Table XXXVI.--Moisture content in Illite SAR 7 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	42.7	41.9	42.0	44.3	44.1	43.0
2	40.6	38.9	41.0	41.7	41.1	42.1
3	40.7	39.9	40.4	42.3	40.4	41.3
4	40.3	40.4	42.3	42.3	40.9	40.4
5	40.8	39.7	42.1	41.7	41.7	40.7
6	38.7	38.4	41.0	41.0	41.1	40.7
7	37.7	37.8	42.8	39.2	40.4	40.9
8	32.2	35.9	39.5	38.1	39.5	40.9
9	32.1	33.7	37.9	37.0	38.5	38.5
10	30.2	30.5	34.6	33.9	36.3	36.4
11	22.7	24.0	22.3	23.5	25.9	25.2

Table XXXVI--Moisture content in Illite SAR 18 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	----	44.0	42.1	----	----	40.6
2	----	43.0	40.8	----	----	38.3
3	----	41.8	40.2	----	----	39.1
4	----	41.2	41.3	----	----	40.5
5	----	41.6	41.1	----	----	41.1
6	----	42.1	41.2	----	----	40.0
7	----	41.3	40.2	----	----	39.7
8	----	40.3	38.2	----	----	39.3
9	----	39.5	39.2	----	----	35.9
10	----	35.8	34.2	----	----	34.5
11	----	27.5	23.4	----	----	22.4

Table XXXVII--Moisture content in Illite SAR 40 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	43.6	46.0	43.0	45.6	45.0	45.5
2	42.4	43.9	43.0	41.1	42.5	42.7
3	42.5	42.3	42.1	42.3	42.3	40.9
4	41.4	43.2	41.1	41.7	42.3	40.4
5	40.9	41.6	41.3	41.1	41.4	40.7
6	38.6	40.3	40.3	40.7	41.0	40.4
7	37.4	37.8	40.6	39.3	41.8	40.2
8	35.7	36.6	36.7	37.4	40.6	41.1
9	33.6	34.2	35.4	36.1	39.2	38.5
10	30.7	31.0	32.9	34.3	35.6	34.6
11	21.8	21.0	22.0	22.4	23.8	23.5

Table XXXIX.--Moisture content in Montmorillonite SAR 0 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	59.2	51.3	51.9	54.3	54.0	52.1
2	57.2	50.2	51.0	50.6	49.6	49.2
3	55.3	50.2	50.3	49.6	48.7	48.7
4	55.3	50.3	49.9	49.9	47.9	49.4
5	55.0	50.2	50.6	49.6	48.4	49.4
6	55.4	50.4	50.4	50.3	49.2	49.6
7	55.3	49.6	51.5	50.8	50.3	49.5
8	52.6	47.8	51.5	51.1	49.8	50.3
9	51.1	47.5	49.9	49.6	49.4	48.7
10	47.7	44.5	47.4	46.6	47.0	46.3
11	39.2	34.8	37.8	37.1	37.4	36.8

Table XL.--Moisture content in Montmorillonite SAR 7 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	55.0	52.9	55.2	53.2	54.5	49.8
2	52.1	50.2	51.0	50.2	49.4	48.3
3	53.1	50.5	51.0	51.1	48.4	48.4
4	53.8	51.8	51.2	51.0	50.3	50.0
5	53.6	50.5	51.3	50.7	50.7	50.6
6	51.3	49.1	52.0	50.6	50.2	49.9
7	50.7	49.5	51.3	51.0	49.8	48.6
8	49.9	48.6	49.8	49.5	48.8	48.6
9	48.6	46.7	47.0	49.0	48.7	46.7
10	46.3	43.9	44.6	45.7	45.1	45.5
11	42.3	36.4	36.0	40.3	41.3	35.8

Table XLI.--Moisture content in Montmorillonite SAR 18 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water					
	0 N CaCl <sub>2</sub>		0.005 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
	1	2	1	2	1	2
	% by volume					
1	56.2	53.6	53.7	52.0	52.8	52.0
2	52.3	50.4	49.4	47.4	47.1	47.3
3	52.9	50.3	49.8	47.7	48.0	47.9
4	49.5	52.0	50.5	48.3	48.4	48.3
5	51.3	52.8	50.6	49.2	49.8	48.6
6	52.5	52.8	50.3	50.0	50.8	53.0
7	52.9	51.2	48.6	49.5	51.0	50.4
8	52.8	49.3	49.0	51.5	49.4	48.6
9	51.3	47.2	47.5	47.7	47.8	46.7
10	47.8	44.5	44.7	45.4	44.6	43.2
11	37.2	34.2	34.0	35.8	35.9	34.5

Table XLII.--Moisture content in Montmorillonite SAR 40 as a function of distance from the water source. Numbers 1 and 2 are duplicate columns.

Segment	Electrolyte Concentration of Water		
	0 N CaCl <sub>2</sub>	0.005 N CaCl <sub>2</sub>	0.015 N CaCl <sub>2</sub>
	% by volume		
1	52.8	51.3	51.1
2	52.0	47.9	49.8
3	51.2	47.8	51.1
4	52.0	47.8	52.3
5	51.5	48.0	52.7
6	51.7	48.5	53.2
7	49.8	47.0	52.4
8	48.2	47.0	51.1
9	46.1	46.1	49.5
10	42.8	43.8	46.6
11	36.3	33.7	38.1

Table XLIII--Diffusivity as a function of moisture content for Dickite SAR, 0.

Electrolyte Concentration of Water			
0 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
Moisture	Diffusivity	Moisture	Diffusivity
% by volume	cm <sup>2</sup> /min	% by volume	cm <sup>2</sup> /min
17.3	0.0054	23.0	0.13
28.7	0.15	32.6	0.28
33.5	0.56	35.9	1.34
34.4	1.46	37.2	7.81
35.7	3.01	37.5	11.6
36.5	4.30	37.9	16.1
37.4	5.70	38.2	25.0
38.0	6.04	38.7	25.3
38.8	8.96	39.0	24.0
39.3	11.0	39.3	27.1
39.8	11.5	39.7	35.9

Table XLIV.--Diffusivity as a function of moisture content for Dickite SAR 40.

Electrolyte Concentration of Water			
0 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
Moisture	Diffusivity	Moisture	Diffusivity
% by volume	cm <sup>2</sup> /min	% by volume	cm <sup>2</sup> /min
16.6	0.0039	19.2	0.0058
28.8	0.089	29.6	0.15
32.2	0.24	31.0	0.54
34.2	0.89	34.9	1.58
35.6	1.83	36.1	2.58
36.7	2.55	36.9	4.74
37.7	3.28	37.6	6.80
38.5	4.32	38.2	7.85
39.2	4.80	38.8	8.42
40.0	5.08	39.3	8.61
40.8	6.64	39.9	10.8

Table XLV --Diffusivity as a function of moisture content for Illite  
SAR 0.

Electrolyte Concentration of Water			
0 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
Moisture	Diffusivity	Moisture	Diffusivity
% by volume	cm <sup>2</sup> /min	% by volume	cm <sup>2</sup> /min
20.1	0.0045	23.0	0.0062
31.8	0.011	34.7	0.18
35.3	0.45	38.0	0.69
37.0	1.20	39.4	2.77
38.0	2.16	40.0	4.63
38.8	4.37	40.7	8.62
39.3	6.06	41.1	11.3
39.7	7.87	41.5	14.7
40.1	8.32	41.8	14.9
40.6	11.8	42.2	21.9
41.0	14.8	42.5	21.5

Table XLVI --Diffusivity as a function of moisture content for Illite  
SAR 40.

Electrolyte Concentration of Water			
0 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
Moisture	Diffusivity	Moisture	Diffusivity
% by volume	cm <sup>2</sup> /min	% by volume	cm <sup>2</sup> /min
18.8	0.00048	20.9	0.0045
30.5	0.060	34.7	0.15
34.3	0.22	38.6	0.78
36.5	0.45	40.2	2.45
38.1	0.82	41.0	3.99
39.4	1.10	41.7	4.72
40.6	1.41	42.4	6.85
41.8	1.72	43.0	6.41
42.9	2.10	43.8	5.70
44.0	2.38	44.7	7.98
45.0	3.08	45.6	8.62

Table XLVII.--Diffusivity as a function of moisture content for Montmorillonite SAR 0.

Electrolyte Concentration of Water			
0 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
Moisture	Diffusivity	Moisture	Diffusivity
% by volume	cm <sup>2</sup> /min	% by volume	cm <sup>2</sup> /min
34.1	0.0077	34.0	0.0087
46.0	0.22	46.6	0.41
49.3	0.82	49.3	2.33
51.1	1.65	50.0	6.84
52.2	9.24	50.3	12.4
52.7	11.0	50.6	14.1
53.1	12.9	51.0	13.8
53.5	14.4	51.5	12.7
53.9	12.4	52.1	13.0
54.4	12.0	52.8	12.4
54.9	15.7	53.5	13.2

Table XLVIII.--Diffusivity as a function of moisture content for Montmorillonite SAR 40.

Electrolyte Concentration of Water			
0 N CaCl <sub>2</sub>		0.015 N CaCl <sub>2</sub>	
Moisture	Diffusivity	Moisture	Diffusivity
% by volume	cm <sup>2</sup> /min	% by volume	cm <sup>2</sup> /min
34.4	0.0043	32.6	0.0047
42.7	0.059	45.8	0.16
46.1	0.21	49.5	0.67
48.4	0.41	51.4	1.66
50.0	0.80	52.5	4.09
51.4	1.28	53.1	6.75
52.3	2.21	53.6	10.8
52.9	3.45	54.0	11.2
53.3	4.46	54.4	11.8
53.7	5.40	54.9	12.3
54.0	9.82	55.4	12.6

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