Hydrophobic Earth as a Means of Moisture-, Thermal-, and Electric-Insulation

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Introductory Remarks by the Chairman

During the last twenty-five years, Soil Stabilization has developed in the Western World into a definite well organized branch of Engineering Science. The first comprehensive statement of the principles and practice of this science is found in Volume VI of Jerome Alexander's "Colloid Chemistry, Theoretical and Applied," Reinhold Publishing Corporation, New York, 1946. Its development since is reflected, though not completely portrayed, in Bulletin 108 on "Soil and Soil Aggregate Stabilization" of the Highway Research Board. Little is known about the parallel development in the Soviet Union, although such development could be expected since the Russian interest in soil stabilization was well shown by the publication in 1938 of a collection of papers on soil stabilization in book form under the auspices of the Central Road Administration at Moscow. In the foreword to this book, the acting director of the Research Institute for Road Construction makes among others the following statement: "This institute and its Leningrad branch give special emphasis this year to Soil Stabilization. This problem, however, is so large and of such importance that it will hardly be possible to solve it with the means and talent available to the central institute and its branch organization. We believe that for the solution of this most important problem in road construction all scientific workers in this field must work together in close and friendly union. Only thus will it be possible to study this problem under the widely varying conditions existing in our great federation. It is necessary to organize laboratory investigations on a broad scale, and at the same time to experiment on the roads themselves with greater boldness. We road builders are still lacking in Bolshevik verve and boldness. Without large and bold experimentation, the problems of soil stabilization cannot be solved."

We are grateful to Professor Kolyasev and to Mr. Holodov for presenting an up-to-date picture of the method of approach and of the results obtained in the Soviet Union in one segment of the science of soil stabilization, namely in the water proofing of soils.

●IMMENSE ENGINEERING construction work is in full swing in the Soviet Union. Residential and industrial premises, power stations, factories, railways and highways, bridges, installations for reclamation and electrification of agriculture are erected all over the country in ever increasing numbers.

The natural base and the building materials for all these engineering works, as well as for their various constructive elements, are provided by rocks of the earth surface usually known by the name of soils.

All engineering constructions together with their natural bases (soils) are subject to the action of water, temperature, electricity and pressure. This action normally varies with time in intensity and direction. These influences shorten the life of buildings and in some cases make the ground unfit for engineering purposes.

To increase the resistance of bonded systems (concrete, stucco, bricks, plaster, etc.) against moisture, thermal and electrical forces, and to supply such resistance properties when necessary to dispersed systems like soils, ash, slag, peat, etc., a series of measures has been taken. The latter consist in changing the physicomechanical

factors of the said materials, mainly their hydrological characteristics by decreasing water absorption, filtration, swelling and wetting.

The problems of artificially decreasing wettability, water absorption and filtration of soils are treated by a comparatively new branch of physical chemistry making use of the hydrophobization methods.

The purpose of the present investigation is to elucidate some problems of the theory and practice of soil hydrophobization and to describe methods of obtaining and applying friable hydrophobic materials.

Up to the present, several methods of securing friable hydrophobic materials (hydrophobic earth) have been developed, as follows:

1. Treatment of the soil, ground, peat with surface active agents using an intermediate reagent (1a).
2. Treatment of the cinders from heat and power plant furnaces with a solution of bitumen in green oil (2).
3. Grinding the air-dried soil adding copper salt of abietic acid (copper abietate) (13).
4. Treatment of the soil with paraffin and resin vapours, vapours of silicon organic combinations, siliconates of heavy metals and salts of heavy metals of synthetic fatty acids (3).

The fundamental principle of all these methods consists in covering the hydrophilic surface with hydrophobic material.

The main point in the methods of soil and ground hydrophobization is the problem connected with the nature of building up and fixing the hydrophobic covering on the surface of the treated material particles.

The first indispensable requirement for providing the hydrophobic cover on the particles of the dispersion phase is the introduction of the corresponding hydrophobizing reagents into the treated material (soil, ground, sand or peat). Such reagents may be chemically resistant (cinders, paraffin, resin, abietates of copper, iron, aluminum) or chemically non-resistant surface active agents, such as sodium salts of carbon acid-soaps, siliconates of sodium, and potassium.

Most characteristic of all the methods developed is that of soil and ground hydrophobization by means of surface active agents using intermediate reagents, applied in the form of water solutions. We shall therefore discuss this method in detail.

The introduction of the hydrophobic reagent into the soil is followed by the phase interaction between the hydrophobizer and the treated material. The hydrophobizer introduced into the soil enters into contact with its solid phase and with the dispersion medium. In some way it is detained, i.e., absorbed, by the treated material. According to the manner in which the reagent is absorbed by the treated material, it is possible to distinguish the six following types of the ground-soil absorption power (4):

1. Mechanical absorption power;
2. Biological absorption power;
3. Chemical absorption power;
4. Chemical adsorption;
5. Physical adsorption; and
6. Physicochemical or interchange adsorption.

We shall not consider here the methods which evidently do not solve the given problem, such as the mechanical absorption power, i.e., the capacity of soils and grounds as of any porous body not to pass particles which are larger than the capillary bores of the systems, or the biological absorption power, which is connected with the activity of living organisms.

Chemical absorption power of soils, according to Gedroyz (4), is expressed in that the anions of diluted salts, which produce together with cations of the soil solution insoluble or slightly soluble salts, will leave the solution in the form of the corresponding salts. The resulting deposit will mix itself with the solid phase of the soil as a mechanical admixture.

Chemisorption is a non-reversible physicochemical process as a result of which the anions or cations, existing in the dispersion medium, are fixed on definite valence links of the mineral dispersion phase crystal grid thus forming hydrophobic combinations.

Physical adsorption is caused by the tendency of any dispersion medium to decrease its free surface energy. The reduction of the free surface energy may result from:

1. The increase of the substance concentration in the layer of dispersion medium directly adjoining the particles of the dispersed phase (positive adsorption). These phenomena are described by the Gibbs adsorption equation.

2. The coagulation of soil and other particles of colloidal dimensions into larger aggregates.

Physicochemical or interchange (reversible) adsorption consists in that the soil and ground are able to exchange a certain part of cations existing in their solid phase solution for an equivalent number of cations existing in the contacting solution. A dynamic equilibrium is always present between the cations of the solid phase of the soil and the cations of solution.

Up to the present time, the hydrophobizer fixation was preferably obtained by means of chemisorption with a preliminary orientation of the hydrophobizer molecules after Langmuir without paying attention to the processes of adhesion (5, 2).

Thus, Rebinder (5) assumes that chemical fixation of polar groups, or the chemisorption, is the most reliable type of sorption, providing a most reliable linkage and a correct orientation of the reagent hydrocarbon part. Kostrikov (6) developed a hydrophobization theory based on the equilibrium of energetically active centers of the soil mineral surfaces (O^{2-}, Ca^{2+}, CO_3^{2-}, OH^-, K^+, etc.), which are formed while the mineral is being reduced to fragments.

The way of balancing the non-compensated electric charges of the mineral surface ions by means of organic cations is preferred by this author for the following reason. The clayey part of highly dispersional soils comprises mainly the minerals of the kaolinite groups, hydromicas and montmorillonite, which in their basal planes contain a certain number of negatively charged ions O^{2-}, OH^-, etc. Thus, according to the opinion of the author, the neutralization of negative charges prevailing in the ground-colloidal system requires the application of organic cations. In this case, a typical ionic sorption will take place resulting in the reduction of the surface energy of the system.

We presume that in his considerations the author of this theory does not take into account that the surface energy results from the specific position of the phase molecules and that the mechanical destruction of the crystal cannot bring the destruction of the molecules with the building of the ion O^{2-} or OH^-. Besides, the O^{2-} ion is a strong oxidizing agent and consequently cannot remain in a free state for a long time (i. e., quietly await the introduction of hydrophobizer). The OH^- ion is univalent and, similarly to K^+, Na^+ and other ions, is unable to provide a reliable chemical linkage with the mineral and with the hydrophobizer. It should be remembered that the forces of covalent and hydrogen linkages are several times weaker than the valence forces and that they do not ensure the chemical conversion of the substances.

Adam (7) has shown that the energetically active centers do not occupy more than 10 percent of the particle surface. Consequently, this theory refers only to the hydrophobization of the basal planes and at the best to the 10 percent of the energetically active part of the mineral surface which can never secure the desirable effect of hydrophobization.
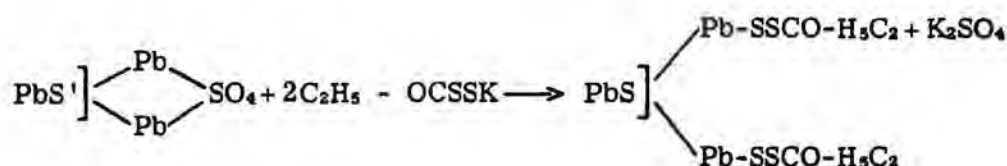
The investigations of Kostrikov (6) have proved that up to 90 percent of the hydrophobizer introduced may be extracted from the soil by means of organic solvents.

Holodov (3) has shown by his experiments that the reagents introduced in the form of water solutions, before drying up, may be almost completely washed out.

Thus, the theory of balancing the non-compensated links cannot be considered as satisfactory.

Undoubtedly, chemisorption phenomena may take place during the hydrophobization of the grounds. For instance, Shvedov (8) has proved that between the galenite mineral (PbS) and the ethyl xanthate ($C_2H_5 - OC\overline{S}SK$) a reaction of chemisorption may arise on condition of the latter's incomplete oxidation (8):

$$PbS \cdot \left[\begin{array}{c} Pb \\ Pb \end{array} \right] SO_4 + 2C_2H_5 - OCSSK \longrightarrow PbS \left] \begin{array}{c} Pb-SSCO-H_5C_2 + K_2SO_4 \\ \\ Pb-SSCO-H_5C_2 \end{array} \right.$$

However, at the same time prior to interaction the mineral had been electro-neutral and deprived of non-compensated chemical linkages.

All theories of the hydrophobic covering by chemical fixation provide adequate explanation of the occurring phenomena within one complete monomolecular layer of adsorbed molecules, which may be used in foam flotation of ores, but they do not explain the hydrophobization by means of paraffin, copper siliconates, cinders, etc. The theories do not take into consideration that the monolayers are not stable and are difficult to obtain.
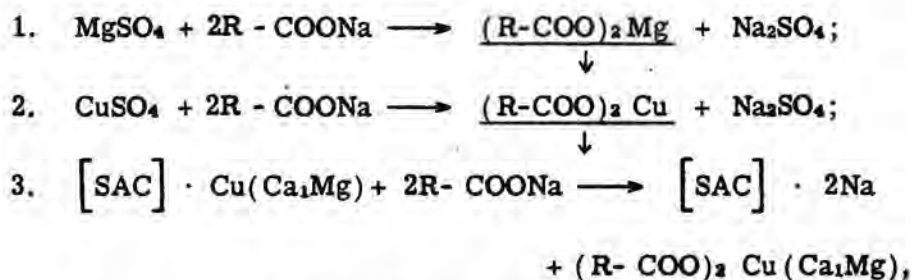
The processes of hydrophobizing soils by means of different reagents have been investigated rather thoroughly at the Soil Physics Laboratory of Leningrad Agrophysical Institute.

The most common case of hydrophobization is the hydrophobizing by means of surface active agents of the type of sodium salts of carbon acids (with the use of an intermediate reagent) of such soils, which possess interchange absorption power and whose absorbing complex is saturated with calcium, magnesium, potassium, hydrogen and other cations. (It should be noticed that the humic acid part and the zeolite part of the majority of soils are cationites.)

While introducing into such ground a solution, e. g., of copper sulphate, the following reactions of the cation interchange will take place between the soil absorbing complex (SAC) and the soil solution:

$$\left[SAC \right] \cdot Ca\,Mg + 2CuSO_4 \rightleftharpoons SAC \cdot 2Cu \xrightarrow{+CaSO_4 \downarrow} + MgSO_4$$
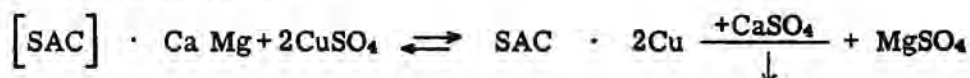
While introducing soap solution into a soil which had been treated with copper sulphate, the following reactions will occur:

1. $MgSO_4 + 2R - COONa \longrightarrow \underset{\downarrow}{(R-COO)_2 Mg} + Na_2SO_4$;

2. $CuSO_4 + 2R - COONa \longrightarrow \underset{\downarrow}{(R-COO)_2 Cu} + Na_2SO_4$;

3. $\left[SAC \right] \cdot Cu(Ca_1Mg) + 2R- COONa \longrightarrow \left[SAC \right] \cdot 2Na$

$$+ (R- COO)_2 Cu (Ca_1Mg),$$

where R is the hydrophobic radical.

Thus, out of the soil solution will precipitate copper, calcium, magnesium and other waterproof soaps. (A chemical absorption of reagents, after Gedroyz (4), will take place.) The deposit will be in the form of a mechanical admixture to the soil. It should be noticed that the reactions involved in the formation of the waterproofing soap proceed mainly stoichometrically.

The investigations of Kolyasev, Jutchenkov, Holodov and others have shown that for obtaining the proper effect of hydrophobicity the soil particles should be completely covered with hydrophobizer.

Practically, the uniform distribution of hydrophobizer on the surface of particles is provided by mechanically mixing the treated material with the introduced reagents until a homogenous mass is obtained. Consequently, the mixing of the soil with the reagents introduced is the second necessary technological requirement.

In the process of mixing the soil with the deposit of the waterproof soap the latter is adsorbed by the surface of the particles as a result of molecular interaction (physical

adsorption, case 2). It is to be assumed that the adsorption of the amorphous deposit of the waterproof soap does not depend on Gibbs' adsorption equation.

To ensure the hydrophobic effect after having introduced and mixed the soil with the reagents it is necessary to eliminate the hydrate films from the surface of the hydrophobizer and the soil particles. Practically, this is achieved by means of drying the material.

In the process of drying only humidity is removed from the treated soil, while all the products of the interchange between the salts of the soil and the soap solution, as well as the products of the interchange between the soap solution and the soil absorbing complex, remain in the treated material either as a mechanical admixture or in adsorbed state as a result of physical adsorption (e. g., calcium soap), or in the interchange state in the soil absorbing complex (e. g., sodium).

While removing the hydrate films from the surface of the particles during the process of drying, the force of interaction between the particles of the ground and and the soap (adhesion) will grow as the distance between them decreases and, finally, a direct contact will appear between the hydrophobizer and the mineral. This statement has been proved by the experiments of Krotova (9). While removing the hydrate films from the surface a "drying adhesion" of the hydrophobizer takes place. Consequently, thorough drying of the treated soil is the third necessary technological requirement, ensuring, on one hand, a more reliable fixation of the hydrophobizer and, on the other hand, the removal of hydrate films from the surface of the hydrophobic covering. The presence of hydrate films would permit rewetting of the ground.

As shown in Table I, the medium thickness of the hydrophobic covering, which prevents the ground from being wetted, is about 60-70 m μ and does not depend upon the length of the applied reagent molecules.

(The length of molecules from C_{16} - C_{18} is assumed to be 24 Å, while the length of molecules from C_7 - C_8 is assumed to equal 12 Å.)

According to the experimental data the rate of applying the hydrophobizer expressed in percent of the soil weight (C) may be determined by the following equation:

$$C = K \cdot S_S \cdot h \cdot \rho \ 100\%,$$

where K is a factor depending on the relation of kinetic specific surface to the static one. For soil with a specific surface up to 1 m^2/g, "K" may be taken as 1.

S_S - specific surface of the soil in cm^2/g.

ρ - specific weight of hydrophobizer.

h - thickness of hydrophobic covering in cm.

TABLE 1

THICKNESS OF HYDROPHOBIC COVERING (hÅ) AT MINIMUM DOSAGE OF
REAGENTS (C%) ENSURING THE HYDROPHOBICITY OF TREATED SOILS

Kind of Soil	Specific Surface (Ss m/g)	Dosage of Reagent in Percent of Soil Weight (C%)	Thickness of Hydrophobic Cover (hÅ)	Hydrophobizer	Cation	Number of Molecular Layers (n)
Sand	0.02	0.12	600-650	Fatty soap	Cu	25 - 27
Sand	0.07	0.50	800-900	Fatty soap C_{16} - C_{18}	Fe	33 - 37
Light loam	0.20	1.00	500-600	Naphtha soap	Fe	21 - 25
Medium loam	0.31	2.00	600-700	Resin soap	Cu	25 - 30
Medium loam	0.31	2.00	700-720	Synthetic fatty acids C_7-C_8	Cu	60 - 70
Clay	0.99	3.00	300-400	Resin soap	Cu	13 - 17

Thus, the hydrophobic covering obtained on the soil particle surfaces may be considered as a volume system of hydrophobic films, having the character of an independent phase, and according to Schwartz and Perry (10) being nothing else than a layer of hydrophobic color on a mineral surface.

Hence the hydrophobicity of the particle surface will be determined by the hydrophobicity of the reagent combination, which consequently enables us to foretell the degree of hydrophobization that will be achieved by treatment.

The general requirements to be fulfilled by the hydrophobizing reagents may be formulated as follows:

1. Absence of wettability and solubility in water;
2. Considerable adhesion to the mineral surface; and
3. Easy and uniform distribution in soil mass.

The first sign of hydrophobicity is a great reduction of the water holding power of the material, increase of drying rate, and decrease of equilibrium humidites. Figure 1 shows the drying rate of thin layers of the original and the hydrophobized soil, the soil having a specific surface of $S_S = 900$ cm^2/g.

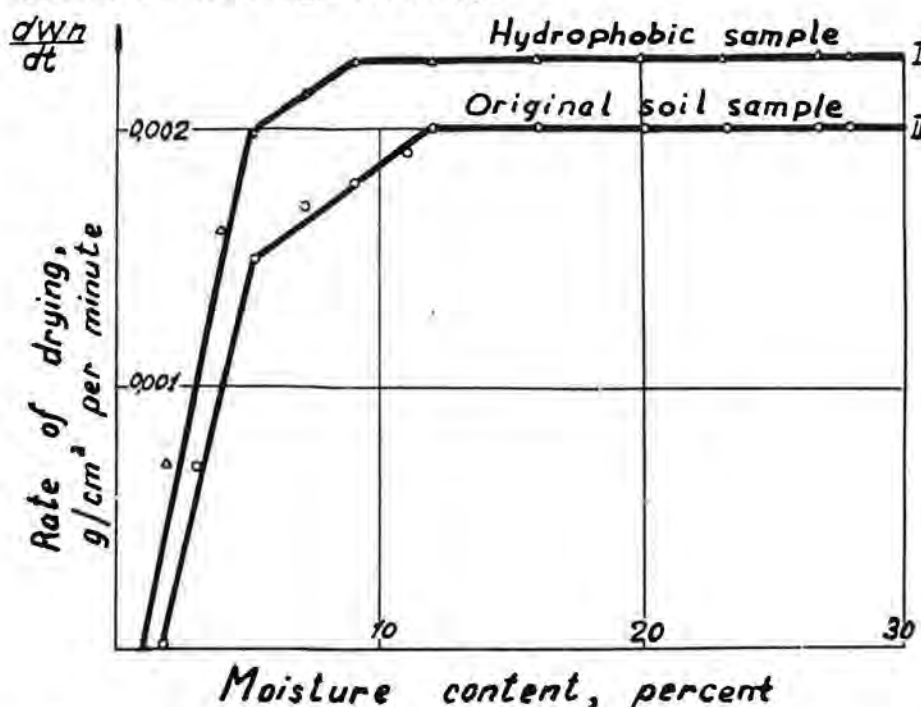Figure 1. Rate of drying a natural soil and its hydrophobic modification (sandy-loam, Ss = 900 cm^2/g). Drying conditions: t^o = 22 C, W = 0.3 percent. Equilibrium moisture of the soil: original—1.60 percent; hydrophobic—0.93 percent.

As shown in Figure 1, the drying rate for the hydrophobic soil (curve 1) during the period of constant drying rate is somewhat higher than for the original soil. The duration of the constant drying rate period for the original sample is 3 percent less than for the treated sample.

The first period of falling rate of drying for the hydrophobic sample is shorter than for the original soil. The second critical point both for the original soil and for the hydrophobic sample is at a humidity of 5 percent. The equilibrium humidity, set at the parameters shown in the diagram, equals 1.60 percent for the original soil sample and 0.93 percent for the hydrophobic sample. According to the curves it is found that the hydrophobic sample completed its drying in 280 minutes, while the sample of the original soil continued it for 330 minutes.

Table 2 shows the equilibrium humidities for different soils treated with different hydrophobizers. As shown in Table 2, the equilibrium humidity for the hydrophobic soil equals 34-58 percent of the equilibrium humidity of the initial material.

The treatment of soil by one of the previously discussed methods, according to the scheme:

TABLE 2

EQUILIBRIUM HUMIDITIES OF ORIGINAL AND HYDROPHOBIC SOILS OVER 84 PERCENT SULPHURIC ACID

Kind of Soil	Specific Surface (S_S m^2/g)	Hydrophobizer	Cation	Equilibrium Humidity in Percent of the Absolutely Dry Soil Weight		$\dfrac{W_1}{W_2} \cdot 100\%$
				Initial (W_1)	Hydrophobic (W_2)	
Sand	0.02	Fatty Soap $C_{16} - C_{18}$	Cu	0.39	0.13	34
Sand	0.07	Resin Soap	Fe	0.69	0.39	56
Loam	0.14	Naphtha Soap	Fe	1.37	0.66	48
Loam	0.20	Fatty Soap $C_{18} - C_{18}$	Fe	1.60	0.99	58
Loam	0.30	Resin Soap	Cu	2.27	1.26	55

1. Introduction of one or two interacting hydrophobizers into the soil;
2. Uniform distribution of hydrophobizer by means of mixing;
3. Drying of treated material;
4. Grinding in a mill;
5. Sifting through a sieve with holes of diameters between 0.5 and 0.25 mm, provides a dry powder whose particles are not wetted by water. This sort of powder has been named "hydrophobic earth" (1a).

Hydrophobic earth is a singular kind of material combining in itself both unwettability and friability. It possesses considerable porosity and has an interconnected capillary pore space.

The unwettability of the particle surfaces ensures to the hydrophobic earth some additional properties: capillary rise of water does not occur in the hydrophobic earth for a considerable length of time and the earth is capable of withstanding various hydrostatic pressures. Therefore, the hydrophobic earth like other kinds of hydroinsulation may be used for protecting engineering works from the action of water and from water filtration through the enclosing constructions.

The numerical value of the anticapillary pressure in the hydrophobic earth depends both on the mechanical properties of the initial material and on the reagents used.

The experimental determination of the hydrostatic pressures which the hydrophobic earths are able to withstand, was carried out by means of glass tubes (dia 1.8 cm). The tube walls were paraffined at one end. The paraffined end of the tube was bound with gauze and filtering paper. The hydrophobic earth filled the tube to a height of 3 cm. Through all the experiments densification of the earth was accomplished by means of a rod which transmitted a pressure of one kg/cm^2.

The results of some experiments are shown in Table 3.

As shown in Table 3 the anticapillary pressure in finely dispersed hydrophobic earth is approximately 1.25 m and probably may be increased. The anticapillary pressure has been estimated according to the formula of Deriagin (11).

$$\Delta \rho = \frac{\sigma \cdot \text{Cos } \Theta \cdot \text{So}}{\delta},$$

where:

$\Delta \rho$ - anticapillary pressure in centimeters of water;

σ - surface tension of liquid in erg/cm^2;

Θ - marginal angle of wetting;

So - specific surface of porous body in cm^2/cm^3;

δ - porosity equal to the ratio of specific and volume weights to specific weight.

It has been assumed that the marginal angle of wetting was Θ = 106 deg (paraffin).

According to Table 3, such theoretical evaluation is not justified, because not only the hydrophobizer, but also the cation included in the latter, as well as the mechanical properties, influence the marginal angle to a considerable extent. Thus, it was ascertained that the lead abietates are the most hydrophobic, while the abietates of aluminum, copper and iron are less hydrophobic and the abietates of calcium, magnesium and especially silver are the least hydrophobic agents.

The experimental definition of marginal angles of wetting in dispersion mediums was carried out according to the following formula:

$$\text{Cos } \Theta = 2.5 \, \frac{(\Delta \, 1)^2}{\tau} \, \frac{\eta}{\sigma} \, \frac{So}{\delta} \, ,$$

where:

Θ - marginal angle of wetting;

2.5 - empirical factor;

1 - path followed by the liquid during capillary impregnation, in cm;

τ - time in seconds;

TABLE 3

ANTICAPILLARY PRESSURE IN HYDROPHOBIC POWDERS

Kind of Material	Specific Surface (S_S m²/g)	Hydrophobizer	Cation	Anticapillary Pressure In Water Column (cm)	
				Experimental Data[1]	Evaluation Data Θ = 106 deg
Sand	0.02	Naphtha Soap	Fe	7	12
	0.02	Dimethyl-oxysilan	-	19	12
	0.02	Wood Tar	Cu	11	12
	0.02	Resin Soap	Cu	15	12
Clay	0.99	Resin Soap	Cu	125	400
Ash From the Heat and Power Plant Furnaces	0.40	Dimethyl-oxysilan	-	80	160
	0.40	Resin Soap	Cu	60	160
Sandy Loam	0.07	Fatty Soap	Fe	35	32
	0.07	Dimethyl-oxysilan	-	40	32
Loam	0.30	Resin Soap	Cu	70	125
	0.30	Dimethyl-oxysilan	-	85	125
	0.20	Resin Soap	Cu	50	88
	0.20	Dimethyl-oxysilan	-	60	88
	0.20	Naphtha Soap	Cu	36	88
	0.20	Naphtha Soap	Fe	30	88

[1] A slight increase of the anticapillary pressure shown in this column brings squirting of water through the pores.

η - viscosity in poises;

σ - surface tension of liquid in dynes;

S_0 - specific surface in cm^2/cm^3 of the body;

δ - porosity $\dfrac{g - d}{g}$ (g - specific weight   d - volume weight)

Marginal angles of wetting (Θ) versus specific surface (S_s) values are shown in Figure 2.

As shown by the diagrams, in the process of the material passing from a massive piece to a coarsely ground state the marginal angle of wetting grows, then reaches its maximum and with the further grinding of the particles starts to minimize. The maximum angles of wetting in the above-mentioned experiments correspond to the specific surface of $2 \cdot 10^3 \, cm^2/g$. This relation is observed when the hydrophobic material is impregnated by petroleum. Consequently, the most favorable soils for hydrophobization are those the mechanical properties of which correspond to the specific surface of $(1-3) \cdot 10 \, cm^2/g$.

In connection with the change of the hydrocharacteristics of soil under the influence of hydrophobization, its thermal and electric characteristics are also changed.

Thus, according to the investigational data of Kolyasev and Levin (12) the heat conductivity factor of hydrophobic earths in air-dried condition is

$$0.17 - 0.36 \; \frac{K. \; cal}{m. \; hour. \; degrees} \; , \; i.e.$$

4 to 6 times lower than the heat conductivity of concrete and 3 to 4 times lower than the heat conductivity of brick, being approximately equal to the conductivity of wood.

The investigations of Kolyasev, Levin and Holodov prove that the specific electric resistance of hydrophobic earth in an air-dried state is $(5-9) \cdot 10^8$ to $(1.2-3) \cdot 10^9$ ohm/cm and approaches such insulating materials as asbestos and marble.

Consequently, hydrophobic earth may be used as a combined "hydro-thermo-electro" insulating material. In particular, the hydrophobic earth has been used by us for the electrically heated hot beds of the "screen grid type" and has proved itself to be a reliable hydro-thermo-electric insulator.

Experiments which we had conducted with the hydroinsulation of flat roofs on buildings proved the stability of hydrophobic earth against the variations of the atmospheric temperature and humidity regimes.
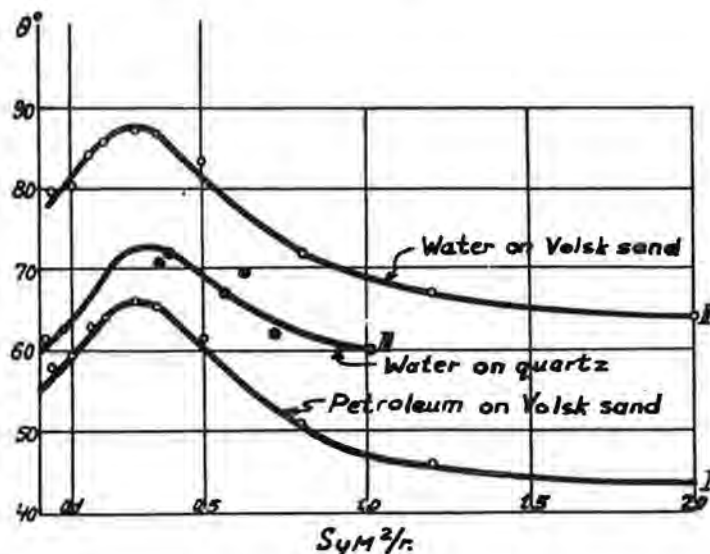

Figure 2. Alteration of Kinetic angle of wetting versus specific surface value.

The application of hydrophobic earth as an antifiltration barrier in irrigation channels has been successful (13).

The investigations of Selkyn (14) have shown that the use of a waterproof layer of hydrophobic earth, the formulae and technology of which had been worked out by the Agrophysical Institute (Kolyasev and others), minimizes the frost heaving of soil fourteen times as compared to the noninsulated soils.

The possibility of preparing hydrophobic earth as a building material out of unstable soils results in more economical construction. Thus, hydrophobic earth is employed to suppress the heaving of railway beds built under severe hydrological conditions (high ground water level, heaving ground), especially, if the use of coarse-grained material (sand, gravel, etc.) is connected with considerable expense.

SUMMARY

1. A brief survey is presented of possible mechanisms for providing and fixing hydrophobizers on the surface of minerals. The fundamental process of hydrophobization is considered as an adhesion process with the building up of an independent phase on the surface of the minerals.

2. For the purpose of hydrophobization any substances may be used with a sufficient degree of adhesion to the mineral, which are neither wetted by water nor soluble in the latter.

3. The main requirements for the hydrophobization are: a) the uniform distribution of reagent on the mineral surface; b) the building of a volume film resisting the hydrostatic pressures; c) the elimination of hydrate films from the mineral surface and from the hydrophobic covering.

4. The possibility is shown of using the hydrophobic earth as a combined thermo-hydro-electric insulator as well as a separate thermo- and hydro-insulating material.

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