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CATALOGUE OF PARAMETERS OF POLARIZED LIGHT REFLECTED BY TERRESTRIAL ROCKS

by

Ye. K. Kokhan

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ABSTRACT: The author summarizes the history of studies on reflected polarized light from solid bodies. His objective in the present investigation is measurement in natural rock material of changes in degree of polarization of reflected light (of various wavelengths) depending on the phase angle. Curves were obtained for angular changes in the polarization plane and the results were compared with curves for the lunar surface. An effort was made to obtain specimens corresponding as nearly as possible to lunar types. Twelve specimens were studied (obsidian, vesicular andesite, basalt, gneissic granite, biotite granite, quartz, prismatic quartz, ocherous limonite, two varieties of tuff, and scoria) in the uncrushed state and in crushed form: $d < 0.25$ mm, 0.25 mm $< d < 1$ mm, and 1 mm $< d < 3$ mm. Grain size of the rocks was selected on conclusions concerning probable microrelief on the moon. The studies were made in the Planetary Laboratory of Leningrad State University, using the polarimeter of the Pulkovo Observatory. This polarimeter was attached to the indicating device (indicatometer) of the University. The model for the experiment was set up with a lamp to represent the sun, the specimen to represent the moon, and the polarimeter to represent the earth. All specimens were investigated with yellow and green Schott filters and without any filter. Measurements were made at various incident angles at two angles of reflection (0 and 45°). The results are tabulated. It is concluded that: 1) the angular position of the polarization plane for all terrestrial rocks depends on the phase angle, 2) the difference in angle of the polarization plane for yellow and green light is within limits of experimental error (i.e., the two coincide), 3) the angle of the polarization plane for any rock is independent of degree of crushing, 4) this angle is independent of the reflection angle at which observation is made, 5) except for prismatic quartz, all rocks have a polarization

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plane that coincides with the plane passing through the specimen, the illuminating source, and the polarimeter (at large phase angles, from 28-110°), 6) scoria and ocherous limonite exhibit the most rapid rotation of the polarization plane at low phase angles, 7) the degree of polarization is variable for different rocks (the greater the albedo, the lower the degree of polarization), 8) the degree of polarization depends on the phase angle and on the degree of crushing (high degree of polarization with coarser grain), and 9) negative polarization was observed for ocherous limonite, tuff, scoria, vesicular andesite, biotite granite, and basalt. Positive polarization changed to negative in the range of phase angles from 12 to 20°. For angle of polarization plane, ocherous limonite and scoria are most like the material on the lunar surface, but of these only limonite has a degree of polarization similar to that of the moon. "In conclusion, I express my thanks to A. V. Markov for his guidance, V. V. Sharonov for supplying the equipment for making the investigation, A. V. Khabakov for furnishing rock specimens, and L. P. Nizovtsev for his aid in setting up the equipment." Orig. art. has: 8 figures and 48 tables. English translation: 21 pages.

CATALOGUE OF PARAMETERS OF POLARIZED LIGHT REFLECTED BY TERRESTRIAL ROCKS

Ye. K. Kokhan

This paper gives tables of the variation of polarization and the position angle of the polarization plane of light reflected by terrestrial rocks as a function of phase angle and degree of pulverization of the rocks. Observations in integrated light and through yellow and green Schott filters were made with the Pulkovo Observatory electropolarimeter attached to the indicatometer of the Planetary Laboratory of Leningrad State University.

1. Historical Review

Laboratory investigations of the polarization of light reflected by solids were begun in 1852 by the physicists Laprovostaye and Desains [1]. They studied the light reflected by plates of a black matte glass, as well as plates whose surfaces were coated with black soot, platinum, white lead, and cinnabar. In 1900, Wright [2] investigated the polarization of light reflected by pressed powders. In 1903, N. A. Umov [3] demonstrated that selective depolarization occurs when polarized light is reflected from colored matte surfaces. In 1910, Salet [4] investigated the polarization of light reflected by sandstone in the direction of the incident rays. In 1860, Verdet [5] provided a theory for light polarization in the case of diffuse reflection. In 1924, S. P. Voronkov and S. I. Pokrovskiy [6] checked this theory.

In addition to the mentioned studies, work has been done on the study of the polarization of different minerals from the point of view of comparing the results with the results pertaining to the lunar surface. In 1890, Landerer [7] investigated a large number of polished volcanic rocks. In 1922, Salet [8] studied various rocks with various degrees of polishing. In 1926, N. P. Barabashev [9] published a more extensive study on the investigation of matte surfaces with different matte grains. In 1929, Lyot [10] concluded that the polarization caused by reflection of light by homogeneous powders is an extremely complex phenomenon and that a theoretical study of minerals appeared to be completely impossible. Therefore, a purely experimental approach is necessary in a search for rocks which, from the polarization point of view, have the same properties as those of the lunar surface. In 1956, Dolfus [11] demonstrated that the polarization of light reflected by solids occurs as a result of elementary phenomena of reflection, refraction, scattering, diffraction, absorption and birefringence of light reflected from the surface, on the one hand, and on the other hand, of the light penetrating into the body and emerging from it after it has experienced some of the above-mentioned phenomena. In 1958, A. V. Markov [12] studied the polarization of the fused surfaces of meteorites. His results do not confirm the hypotheses that there is a continuous fusion of the lunar surface caused by the meteorites falling on it. In 1959, N. P. Barabashev and A. T. Chekirda [13] compared observations of the moon and terrestrial rocks by means curves of the variation of polarization in dependence on the angle of incidence and reflection of light, and also on phase angle.

2. List of Investigated Rocks

Our objective in the study of the polarization properties of terrestrial rocks is to obtain curves of the variation of the position angle of the polarization plane and to compare them with lunar curves, in addition to studying the variation of polarization of reflected light at different wavelengths in dependence on the phase angle. This objective never has been formulated before. It was particularly difficult to select the necessary samples for solution of this problem. Initially, we selected rocks of different types whose presence on the moon is most probable under the volcanic hypothesis. The number of rocks was limited by the fact that in each type we investigated only the darkest and lightest samples.

Twelve samples of terrestrial rocks, kindly supplied by A. V. Khabakov and V. V. Sharonov from their collections, were investigated. The names of the samples, their sources, and the numbers of the samples mentioned in the text are given in Table 1.

The samples were investigated in both pulverized and unpulverized states, with grains whose diameter was $d < 0.25$ mm, $0.25 \text{ mm} < d < 1$ mm, and $1 \text{ mm} < d < 3$ mm.

These grains were obtained by screening at the All-Union Geological Institute. Therefore, there were 48, rather than 12 samples.

TABLE 1.

No.	Sample	Source	Sample table nos.
1	quaternary obsidian	Lesser Caucasus	2, 3, 26, 27
2	andesitic blister lava	" "	4, 5, 28, 29
3, 4	quaternary basalt	" "	6, 7, 30, 31
		Georgia, Akhalkalakskoye Plateau	8, 9, 32, 33
5	gneissous granite	Transbaykalia, Chikoy River	10, 11, 34, 35
6	biotitic granite	" "	12, 13, 36, 37
7	quartz	Ukraine, Volyn'	14, 15, 38, 39
8	columnar quartz	Eastern Transbaykalia	16, 17, 40, 41
9	ochreous limonite	Urals	18, 19, 42, 43
10	volcanic tuff, miocene	Transcarpathia	20, 21, 44
11	tuff	Georgia, Aspindza Region	22, 23, 45, 46
12	volcanic slag, very blistery		24, 25, 47, 48

The size of the rock grains was selected on the basis of the conclusions drawn by N. P. Barabashev, N. N. Sytinskaya, and V. G. Fesenkov on the probable dimensions of the lunar microrelief. N. P. Barabashev postulates [14] that the mean dimensions of the irregularities are 2-5 mm; N. N. Sytinskaya [15] believes that they are 0.1 mm - 10 cm; V. G. Fesenkov [16] visualizes the lunar surface as a combination of relatively large grains in a loose aggregate.

3. Apparatus

The observations of the polarization of light reflected by terrestrial rocks were made at the Planetary Laboratory of Leningrad State University with the polarimeter of Pulkovo Observatory [12, 17] mounted on the Leningrad State University indicatometer [18]. This apparatus reproduces a model of the relative positions of the sun, moon, and earth. The sun is a lamp, the moon is the studied sample, and the earth is the polarimeter. The corresponding circles of the indicatometer make it possible to read the phase angle when there is a change in the position of the lamp and the polarimeter. In the investigation the sample is fixed securely on a horizontal support. It is illuminated by natural light from a special lamp with a 500-V bulb that is supplied current from an a-c 220-V circuit across a SNE-200-0.75 voltage regulator. The lamp diaphragm is covered with milk glass, which imparts a natural glow to the light of the lamp. The lamp was cooled by a jet of air from a dust extractor in the space between the double walls of the lamp. The lamp was sheathed in asbestos in order to safeguard the polarimeter from heating when polarization is measured at small phase angles, that is, when the lamp and polarimeter are aligned. The underlying surface used for the sample was black velvet, since investigations revealed that this does not introduce extraneous polarization into our measurements.

4. Observation Program

All substances were investigated with yellow and green Schott filters, and also without filters. The observations were made for different angles of incidence, but for two angles of reflection: $\varepsilon = 0^o$ and $\varepsilon = 45^o$. Observations at $\varepsilon = 0^o$ correspond to observations at the center of the lunar disk, and at $\varepsilon = 45^o$ correspond to approximately ¼ of the diameter from the lunar limb. Since the observations were made in the plane of incidence, this corresponds to the location of the equator of intensity on the moon. In this case the phase angle changed from 6 to 90° when $\varepsilon = 0°$ and from 6 to 110° when $\varepsilon = 45°$, without passing through zero because of the particular design. The method for analyzing the collected data is described in [19].

The results of analyzing the degree of polarization (P%) and the position angle of the polarization plane ($\gamma°$) as a function of the phase angle $\phi°$ are given in

Tables 2-48. In these tables the names of the samples are followed by a number in parentheses which corresponds to the sequence number of the sample in Table 1; w.f., y.f., and g.f. indicate observations without a filter, with a yellow filter, and with a green filter. As a graphic example, some of the data from the tables are shown in Figures 1-6.

5. Conclusions

The following conclusions may be drawn after analysis of the polarization properties of terrestrial rocks:

1. In all terrestrial rocks the position angle γ of the polarization plane is dependent on the phase angle φ (Figure 1).

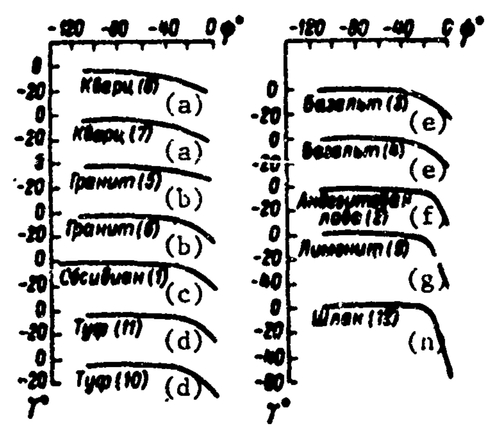

Figure 1. Variation of position angle γ of polarization plane of terrestrial rocks as a function of phase angle φ. Key: (a) quartz; (b) granite; (c) obsidian; (d) tuff, (e) basalt; (f) andesititic lava; (g) limonite; (h) slag.

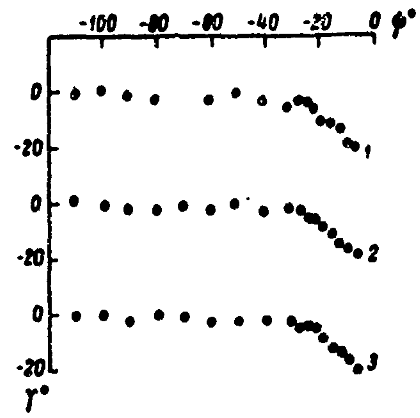

Figure 2. Variation of position angle γ of polarization plane of biotitic granite (6) as a function of phase angle φ. Grain size 0.25 mm < d < 1 mm; ε = 45°. 1 = observations without filter; 2 = with yellow filter; 3 = with green filter.

2. The difference in the position angle of the polarization plane in integrated light and in yellow and green light (Figure 2) falls in the range of our measurement errors (2-3°). This means that the polarization planes coincide.

3. The position angle of the polarization plane for each individual rock does not depend on the degree of its pulverization (Figure 3).

4. This angle is not dependent on the angle of reflection at which the observations are made (Figure 4).

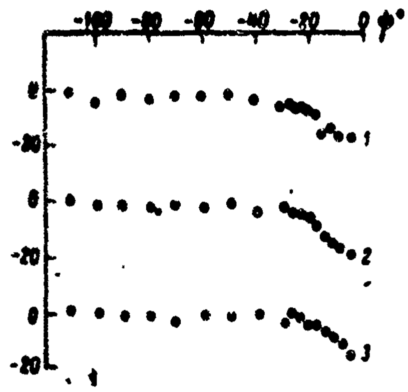

Figure 3. Variation of position angle γ of polarization plane of biotitic granite (6) in observations with yellow filter as a function of phase angle φ; ε = 45°. 1) observations of granite with grains d < 0.25 mm; 2) 0.25 mm < d < 1 mm; 3) 1 mm < d < 3 mm.

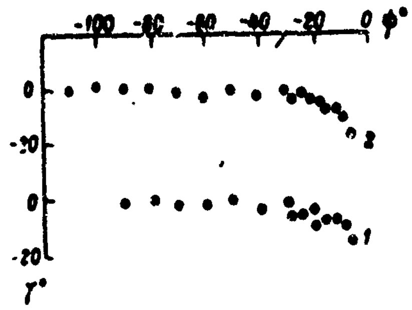

Figure 4. Variation of position angle γ of polarization plane of biotitic granite (6) in observations with green filter as a function of phase angle φ. Grain size 1 mm < d < 3 mm. 1) observations with ε = 0°; 2) observations with ε = 45°.

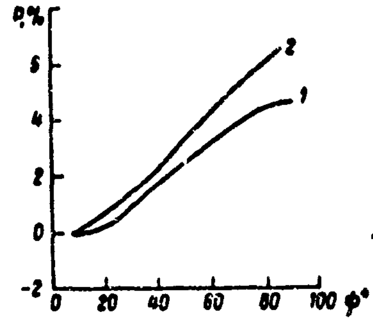

Figure 5. Variation of degree of polarization P of basalt with different albedos as a function of phase angle φ; ε = 0°; grain size d < 0.25 mm; observations without filter. 1) basalt (3), 2) basalt (4).

5. In all rocks with the exception of columnar quartz, at large phase angles (28-110°) the polarization plane coincides with the plane passing through the sample, the light source, and the polarimeter. At a phase angle of 28°, the polarization plane for all rocks begins to rotate (Figure 1). In columnar quartz there is a gradual rotation of the polarization plane for all phase angles, which obviously can be attributed to its crystalline structure.

6. The most rapid rotation of the polarization plane at small phase angles is observed in ochreous limonite and volcanic slag.

7. In contrast to the uniformity in the character of rotation of the polarization plane in terrestrial rocks, the degree of polarization varies greatly. Rocks of the same type, but with different albedo, differ in degree of polarization (Figure 5). The greater the albedo, the smaller the degree of polarization.

8. The degree of polarization depends on the phase angle; it also is dependent on the degree of pulverization of the rock (the larger the grains, the greater the degree of polarization) (Figure 6).

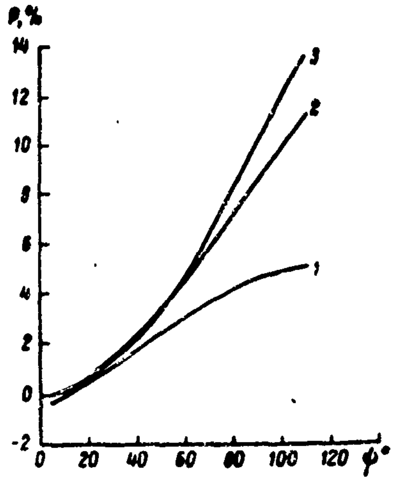

Figure 6. Polarization of biotitic granite in an observation without a filter; $\varepsilon = 45°$. 1) $d < 0.25$ mm; 2) 0.25 mm $< d < 1$ mm; 3) 1 mm $< d < 3$ mm.

9. There is negative polarization in ochreous limonite, tuff, volcanic slag, andesitic blister lava, biotitic granite, and basalt. In other rocks it cannot be observed, possibly because the observations were made at phase angles greater than 6°. The phase angle at which positive polarization becomes negative in the mentioned rocks falls in the range of 12-20°. Negative polarization does not exceed 1%.

Summary

After comparing the polarization characteristics of terrestrial rocks with the similar characteristics of the lunar surface [19], the following conclusion may be drawn: with respect to variation of the position angle of the polarization plane, the ochreous limonite and volcanic slag (see Figure 1) are most similar to the matter covering the lunar surface, but since the degree of polarization in volcanic slag is greater than the degree of polarization on the moon, preference must be given to the ochreous limonite. The degree of polarization of ochreous limonite on the average is equal to the degree of polarization of the lunar seas (Figures 7 and 8).

The curve of the variation of polarization as a function of phase angle for volcanic tuff, whose presence on the moon has been indicated by many authors, is similar to the analogous curve for the lunar continents (Figures 7 and 8), but there is no similarity in the angles of rotation of their polarization planes (Figure 1).

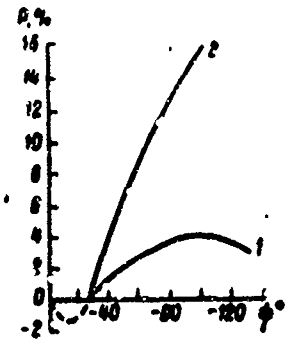

Figure 7. Polarization of continent near Cleomedes (1) and Mare Tranquillitatis (2).

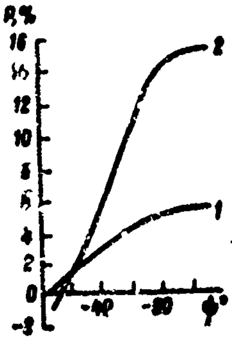

Figure 8. Polarization of tuff (1) and ochreous limonite (2).

In conclusion, I wish to express my appreciation to A. V. Markov for his guidance, V. V. Sharonov for supplying the apparatus for our investigations, A. V. Khabakov for furnishing the samples of terrestrial rocks, and L. P. Nizovtsev for his assistance in adjusting the apparatus.

TABLE 2*. QUATERNARY OBSIDIAN (1), ε = 0°

γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm			φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.		б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.
6	−12	−13	−12	—	—	—	—	—	—	30	−3	−2	−1	+2	+1	0	—	—	—
9	−12	−11	−12	—	—	—	—	—	—	40	−2	−1	0	+2	0	+1	+1	+1	+1
12	−8	−8	−9	−5	−7	−6	—	—	—	50	−3	−2	−1	0	+2	+3	+5	+3	+2
15	−8	−8	−7	−2	−3	−4	—	—	—	60	+1	0	−1	0	+1	+2	+5	+1	+4
18	−8	−7	−7	−3	−2	−3	—	—	—	70	+1	−1	0	+1	0	−1	+2	+3	+1
21	−5	−5	−6	—	−1	−2	—	—	—	80	+3	+2	0	+1	−1	0	+2	+1	+2
24	−3	−3	−3	+1	0	0	—	—	—	90	0	−1	0	+2	−1	+1	+4	+3	+1
27	−2	−1	−2	+1	+1	−1	—	—	—										

*Note: In tables 2-48 б.ф. = without filter; ж.ф. = yellow filter; з.ф. = green filter.

TABLE 3. QUATERNARY OBSIDIAN (1), ε = 45°

γ°

ψ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.
6	−21	−23	−20	−17	−19	−18	−28	−26	−23
9	−9	−13	−13	−12	−13	−12	−38	−27	−23
12	−9	−9	−10	−8	−9	−8	—	—	—
15	−10	−8	−7	−7	−6	−7	—	—	—
18	−8	−7	−8	−5	−4	−5	—	—	—
21	−5	−6	−6	−4	−5	−4	—	—	—
24	−6	−5	−3	0	−2	−1	—	—	—
27	−1	0	−2	0	0	+1	—	—	—
30	−3	−2	−1	−2	−2	−1	—	—	—
40	−4	−3	−2	—	—	—	—	—	—
50	−3	−1	−1	0	−1	0	0	—	—
60	−9	−2	−2	−2	0	−2	+1	—	—
70	−2	−1	0	+2	+2	0	+1	+1	+1
80	−1	−4	−2	—	—	—	+2	+1	+2
90	−1	−1	0	+2	+1	0	+2	+1	+1
100	0	−1	−2	+2	0	−1	+2	+2	+1
110	−1	−1	0	+1	−1	0	+2	+1	+3

TABLE 4. ANDESITIC BLISTER LAVA (2), ε = 0°

γ°

ψ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.
6	−26	−27	−25	−31	−30	−31	−31	−27	−29
9	−13	−18	−17	−25	−25	−24	−20	−20	−20
12	−14	−15	−13	−20	−20	−20	−15	−15	−15
15	−8	−10	−11	−15	−15	−16	−15	−12	−11
18	−8	−7	−8	−6	−6	−5	−15	−8	−8
21	−6	−6	−6	−2	−1	−2	+1	−1	−2
24	−4	−3	−3	−1	−1	0	+1	0	+1
27	−1	−1	−2	−3	−2	−2	−1	−1	0
30	−4	−2	−1	−1	0	−1	−1	0	+1
40	−3	−3	−3	—	—	—	+2	0	+1
50	−2	−2	−2	—	—	—	+2	+2	+1
60	−2	−1	−2	—	—	—	+2	+1	+2
70	−2	−2	−2	—	—	—	0	0	+1
80	−2	0	−2	—	—	—	+2	+2	+2
90	0	−1	−2	—	—	—	+1	+1	+1

TABLE 5. ANDESITIC BLISTER LAVA (2), ε = 45°

γ°

ψ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.
6	—	—	—	−34	−35	−33	−32	−33	−31
9	−14	−18	−18	−26	−26	−26	−22	−23	−22
12	−14	−14	−15	−14	−14	−15	−15	−16	−15
15	−7	−9	−7	−6	−7	−6	−5	−7	−7
18	−5	−5	−6	−3	−4	−3	−7	−6	−5
21	−3	−4	−3	−1	−2	−1	−2	−2	−2
24	−3	−3	−3	0	−1	0	+1	0	+1
27	−3	−2	−3	−2	−1	−2	−2	−1	−2
30	−3	−3	−3	+1	0	+1	+1	0	+1
40	−2	−3	−2	0	+1	0	+1	+1	+1
50	+1	0	−1	−1	—	—	0	0	0
60	−1	+1	−1	+1	0	0	+1	+1	0
70	−1	0	−1	−1	−1	−1	+1	0	+1
80	+1	0	+1	+1	0	+1	0	0	0
90	0	+1	0	−1	−1	−1	+1	+1	+1
100	+1	0	+1	+1	+1	0	+1	+1	−1
110	−1	−1	0	+1	+1	0	+1	+1	0

TABLE 6. QUATERNARY BASALT (3), ε = 0°

γ°

ψ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.
6	−11	−12	−17	−18	−18	−17	−20	−19	−20
9	−14	−16	−15	−17	−17	−16	−22	−21	−20
12	−13	−12	−13	−15	−15	−13	−15	−15	−15
15	−6	−7	−6	−16	−14	−13	−9	−11	−10
18	−5	−7	−7	−12	−12	−12	−7	−7	−8
21	−5	−6	−5	−9	−8	−9	−5	−6	−4
24	−5	−5	−5	−2	−3	−2	−4	−2	−3
27	−6	−4	−5	−3	−2	−3	−1	−2	−1
30	−6	−5	−4	−4	−3	−2	−4	−3	−2
40	−6	−3	−4	−3	−1	−2	−2	−1	0
50	−2	−2	−5	−1	0	−1	0	0	−1
60	−3	−2	−1	0	−1	+2	+2	+1	0
70	−1	−1	0	0	+1	0	0	−1	0
80	−2	0	−2	+1	−1	0	+1	−21	−1
90	−4	−2	−1	−1	0	−1	0	0	0

TABLE 7. QUATERNARY BASALT (3), ε = 45°

γ°

ψ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.
6	−15	−14	−15	−16	−16	−16	−23	−20	−23
9	−14	−14	−14	−18	−17	−18	−19	−19	−19
12	−14	−13	−13	−11	−12	−11	−12	−16	−15
15	−10	−10	−11	−8	−8	−9	−11	−11	−11
18	−8	−4	−9	−8	−7	−8	−9	−8	−9
21	−11	−6	−7	−5	−4	−4	−5	−3	−5

TABLE 8. QUATERNARY BASALT (4), ε = 0°

γ°

ψ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.	б. ф.	н. ф.	з. ф.
6	−18	−19	−16	−28	−25	−26	−28	−27	−28
9	−16	−17	−14	−20	−22	−20	−20	−21	−23
12	−17	−17	−14	−18	−19	−17	−16	−16	−17
15	−15	−12	−12	−12	−11	−10	−10	−11	−10
18	−9	−9	−10	−4	−5	−4	−6	−7	−8
21	−8	−6	−8	−6	−5	−4	−2	−3	−2

TABLE 7. (Continued)

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.
24	−7	−5	−4	−2	−2	−2	0	−1	−1
27	−7	−4	−3	−2	−1	−1	0	−2	−1
30	−8	−4	−5	−2	0	−2	−2	−2	−2
40	−3	−4	−3	+1	0	−1	−3	−1	−3
50	−2	−2	−2	−2	−1	0	0	−2	0
60	−2	−2	−2	−1	−1	−1	0	−1	0
70	−2	−1	−1	−1	0	−1	+1	0	+1
80	−3	−1	−2	0	−1	0	−1	+1	+1
90	−3	−3	−2	0	0	0		−1	0
100	−3	−1	0	+1	+1	−1	+.	+1	0
110	−2	0	−1	0	0	−1	+3	0	+1

TABLE 8. (Continued)

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.
24	−2	−5	−4	−5	−3	−5	−2	−3	−3
27	−7	−6	−5	−1	−1	−2	−2	−2	−3
30	−4	−3	−4	−2	0	−2	−2	−1	−2
40	−3	−2	−3	0	−1	0	0	−2	−1
50	−2	−1	−2	+1	+1	+1	−2	0	−2
60	−4	−4	−1	0	−1	0	+1	−1	0
70	0	−1	0	+1	+1	+1	−2	−1	−1
80	0	0	−1	−1	0	0	−1	0	0
90	+1	+1	0	+2	+1	−1	+1	+1	−1

TABLE 9. QUATERNARY BASALT (4), ε = 45°

γ°

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.
6	−13	−19	−19	−21	−20	−18	−24	−25	−25
9	−16	−17	−16	−17	−18	−16	−17	−18	−17
12	−16	−15	−16	−14	−14	−15	−17	−16	−17
15	−14	−13	−14	−11	−11	−12	−12	−13	−11
18	− 8	−12	−10	− 7	− 8	− 7	−10	−11	− 9
21	−11	−10	−11	− 6	− 6	− 5	− 5	− 5	− 5
24	− 9	− 8	− 9	− 2	− 1	− 3	− 2	− 2	− 1
27	− 6	− 7	− 6	− 1	0	− 1	0	0	− 2
30	− 3	− 3	− 2	− 2	− 1	− 2	0	0	− 1
40	− 3	− 2	− 3	+ 1	+ 1	0	0	0	0
50	− 2	− 1	0	− 2	− 2	− 1	− 1	− 1	− 1
60	− 2	− 2	− 1	0	0	− 1	− 2	− 2	− 1
70	− 1	0	− 1	− 2	− 2	0	0	− 1	0
80	− 2	− 1	− 2	0	0	0	+ 1	+ 1	0
90	− 2	− 2	− 1	0	− 1	− 1	+ 2	+ 1	+ 1
100	− 2	0	− 2	− 1	+ 1	0	0	− 1	0
110	− 2	0	0	− 2	− 2	− 1	0	− 1	− 1

TABLE 10. GNEISSOUS GRANITE (5), ε = 0°

γ°

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.
6	−14	−18	−13	.	−12	−15	−12	− 10	−11
9	−13	−11	−11	−15	−11	−16	−12	− 12	−
12	−15	−11	− 9	−11	− 8	− 9	− 8	− 9	−
15	−13	−13	−13	− 6	− 8	− 8	− 9	− 9	− 7
18	− 9	−13	− 6	− 8	− 9	−10	−10	− 9	− 5
21	−13	− 6	− 6	−10	−10	−10	− 6	− 2	− 7
24	−11	−11	− 6	−10	−10	−10	− 3	− 4	−
27	− 9	− 5	−	− 5	−10	− 9	− 4	− 1	−
30	− 9	− 6	− 6	− 6	− 4	−	− 4	− 4	− 4
40	− 6	− 6	− 7	− 6	− 6	− 7	− 2	− 1	− 4
50	− 7	− 3	− 7	− 7	− 4	0	− 2	0	− 1
60	− 4	− 3	− 4	− 4	− 4	− 4	0	− 2	− 1
70	− 3	− 1	− 4	− 1	− 1	− 3	0	0	− 2
80	− 1	− 3	− 2	+ 1	− 4	0	0	+ 2	+ 2
90	−	− 2	−	−	−	−	+ 2	+ 2	−

TABLE 11. GNEISSOUS GRANITE (5), ε = 45°

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.	б. ф.	м. ф.	а. ф.
6	−16	−14	−15	−12	−16	−16	−14	−13	−14
9	−14	−15	−11	−16	−13	− 6	−14	−14	− 8
12	−15	−15	−15	− 8	−12	− 7	−14	−10	− 8
15	−11	−11	−11	−10	−14	−11	−11	− 8	−12
18	−14	−12	−16	−13	−13	− 3	−10	− 8	−12
21	−11	−12	− 7	−10	−10	− 3	− 8	− 7	− 3
24	− 8	−10	−12	− 7	− 8	− 4	− 9	− 8	− 9
27	−11	−11	− 9	− 7	− 6	− 7	− 6	− 4	− 1
30	−10	− 8	− 9	− 6	− 7	− 8	− 7	− 7	− 2
40	− 9	− 7	− 8	− 7	− 4	− 3	− 4	− 4	0
50	− 7	− 5	− 3	− 6	− 4	− 2	− 4	− 2	− 1
60	− 3	− 5	− 1	− 4	− 4	0	− 1	− 2	+ 3
70	− 6	− 4	− 5	− 3	− 4	− 2	− 4	0	+ 1
80	− 4	− 4	− 2	− 2	− 2	0	− 3	− 2	− 3
90	− 3	− 3	− 4	− 3	0	− 1	− 2	− 2	+ 1
100	− 4	− 4	− 4	0	− 2	− 2	− 3	− 2	+ 1
110	− 3	−	− 6	0	− 2	− 1	− 1	−	− 1

TABLE 12. BIOTITIC GRANITE (6), ε = 0°
γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-19	-17	-14	-19	-14	-12	-13	-13	-14
9	-18	-13	-13	-12	-13	-13	-10	-8	-9
12	-12	-13	-13	-16	-15	-14	-9	-9	-7
15	-7	-8	-10	-7	-6	-7	-8	-10	-7
18	-9	-9	-5	-4	-3	-3	-11	-8	-8
21	-9	-7	-7	-6	-10	-4	-4	-5	-3
24	-5	-9	-9	—	—	—	-6	-6	-4
27	-6	-5	-5	-4	-5	-5	-5	-6	-5
30	-6	-7	-5	-6	-6	-4	-3	-3	-1
40	-8	-6	-4	-5	-3	-2	-4	-4	-2
50	-4	-6	-4	-2	-2	-1	-4	-3	0
60	-1	-1	+1	0	-2	0	0	-5	0
70	-4	-1	+1	-2	0	+3	-4	-2	-1
80	-1	-2	-2	-3	+1	-2	+3	0	+1
90	-3	0	0	-2	0	0	+2	0	0

TABLE 13. BIOTITIC GRANITE (6), ε = 45°
γ°

φ°	d < 0.25 mm			0.25 mm · d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-13	-17	-14	-20	-19	-20	-13	-15	-15
9	-18	-16	-13	-19	-17	-17	-10	-11	-10
12	-13	-14	-10	-14	-15	-13	-9	-9	-8
15	-14	-15	-12	-12	-12	-13	-7	-7	-7
18	-8	-8	-10	-10	9	-9	-6	-4	-5
21	-8	-6	-7	-6	6	-5	-4	-4	-4
24	-8	-6	-6	-4	-4	-4	0	-1	-2
27	-8	-5	-5	-3	-3	-4	—	0	-3
30	-6	-6	-6	-5	-2	-3	-4	-3	0
40	-5	-4	-3	-4	-4	-2	-3	-1	-2
50	-4	-2	-4	0	0	-2	-2	-2	0
60	-4	-3	-2	-3	-2	-3	-3	-1	-3
70	-4	-2	-3	—	0	-1	-2	-3	-1
80	-6	-4	-1	-2	-2	0	+1	-1	0
90	-4	-2	-2	-1	-1	-2	-1	-1	0
100	-4	-4	-3	+1	-1	0	-1	+1	+1
110	-3	-1	-2	0	+1	0	+1	+1	0

TABLE 14. QUARTZ (7), ε 0°
γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-13	-14	-5	-13	-14	-16	-17	-13	-10
9	-15	-14	-11	-13	-10	—	-14	-13	-10
12	-12	-9	-14	-15	-14	-9	-17	-9	-10
15	-13	-12	-7	-12	-6	-3	-9	-9	-6
18	-11	-6	-10	-6	-7	-5	-10	-10	-10
21	-8	-9	-6	-7	-9	-6	-8	-8	-3
24	-13	-13	-7	-9	-11	-11	-8	-6	-6
27	-11	-8	-7	-7	-9	-10	-6	-4	-5
30	-7	-10	-8	-10	-11	-4	-4	-4	-3
40	-8	-9	-4	-7	-6	-6	-2	0	-3
50	-7	-7	-7	-6	-8	-3	-3	0	0
60	-4	-7	0	-5	-5	-4	-3	-1	0
70	-4	-5	-5	-4	-4	-5	-2	-1	-1
80	-4	-1	-1	-5	-9	-5	-1	-1	+1
90	-1	-1	+2	-3	-4	-4	-1	-1	—

TABLE 15. QUARTZ (7), ε = 0°
γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-20	-15	-24	—	—	—	-20	-21	—
9	-20	-15	-12	-22	-19	—	-18	-21	—
12	-17	-16	-20	-19	-19	—	-18	-21	—
15	-16	-16	-8	-13	-15	—	-11	-9	—
18	-12	-17	-13	-16	-16	—	-9	-13	—
21	-16	-11	-13	-11	-11	—	-5	-13	—
24	-17	-13	-13	-15	-12	—	-9	-7	—
27	-13	-16	-11	-9	-9	—	-5	-6	—
30	-10	-13	-15	-9	-10	—	-7	-7	—
40	-7	-10	-10	-9	-9	—	-6	-7	—
50	-8	-6	-8	-4	-6	—	-5	-5	—
60	-6	-8	-6	-5	-5	—	-4	-3	—
70	-5	-4	-2	-1	-2	—	-3	-3	—
80	-6	-4	-1	-2	-2	—	-2	-2	—
90	-5	-3	-2	-3	-3	—	-3	-3	—
100	-3	-3	-3	-2	-2	—	-2	-1	—
110	-3	-4	-2	-1	-3	—	0	-1	—

TABLE 16. COLUMNAR QUARTZ (8), ε = 0°

γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	−13	−15	−11	−12	−13	−13	−15	−10	−12
9	−11	−11	− 6	− 9	−10	−10	−15	−11	−10
12	−14	−12	−11	−14	−12	− 8	−10	−16	−10
15	−12	−11	− 9	− 7	− 6	− 8	−14	−10	− 9
18	−12	−14	−11	− 7	−10	− 7	−14	−14	− 8
21	− 9	−10	− 4	−10	− 7	− 6	−13	−10	− 9
24	−12	−9	−9	−8	− 9	−7	−12	−8	−9
27	−8	−8	−3	−8	− 7	−8	− 6	−6	−8
30	−10	−8	−5	−9	−11	−6	− 8	−8	−7
40	− 9	−5	−5	−6	− 5	−5	− 6	−6	−7
50	− 7	−6	−4	−5	− 6	−2	− 7	−6	−2
60	− 5	−6	−5	−6	− 3	−6	− 4	−5	+1
70	− 4	−5	−4	−4	− 4	−4	− 5	−4	−2
80	− 4	−5	−4	−2	− 3	−5	− 1	−3	+1
90	− 2	−6	−	−3	− 2	−2	+ 1	+3	+6

TABLE 17. COLUMNAR QUARTZ (8), ε = 45°

γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	−19	−17	−11	−15	−12	−11	−14	−15	−
9	−19	−21	−12	−13	−14	−10	−15	− 9	−10
12	−16	−12	−11	−14	−14	−11	−12	−16	− 7
15	−16	−15	−17	−14	−15	− 9	−16	−17	−11
18	−16	−12	−18	−14	−10	− 9	−16	−12	−15
21	−16	−11	− 6	−16	−11	− 9	−12	−12	−10
24	−14	−11	− 5	−11	−12	−12	− 9	−11	−12
27	−12	−14	−10	−12	− 6	−	−10	−11	− 6
30	−12	− 9	− 8	−12	−10	−10	−12	−13	−12
40	− 9	−11	− 8	−10	−10	− 4	−12	−11	− 9
50	− 8	− 7	0	− 9	− 7	− 4	− 8	− 7	−11
60	− 4	− 8	− 1	− 6	− 6	− 9	− 8	− 6	− 4
70	− 7	− 6	− 7	− 3	− 7	− 5	− 5	− 6	− 2
80	− 2	− 4	− 4	− 3	− 3	− 5	− 4	− 5	− 2
90	− 2	− 3	− 5	− 2	− 4	− 2	− 2	− 4	− 2
100	− 3	− 5	− 1	− 3	− 1	0	− 2	− 3	− 2
110	− 2	− 5	− 4	+ 1	+ 1	− 2	−	−	−

TABLE 18. OCHREOUS LIMONITE (9), ε = 0°

γ°

φ°	d < 0.25 mm			0.25 mm < d < 3 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	−28	−30	−	−36	−38	−	−34	−35	−
9	−38	−38	−	−37	−37	−	−35	−34	−
12	−35	−36	−	−	−	−	−29	−29	−
15	−15	−15	−	−32	−29	−	−	−	−
18	− 6	− 7	−	−11	−12	−	−14	−15	−
21	− 3	− 2	−	− 4	− 5	−	−11	−11	−
24	− 4	− 3	−	− 3	− 2	−	− 4	− 4	−
27	− 2	− 2	−	+ 1	0	−	− 4	− 3	−
30	− 2	0	−	0	+ 1	−	− 1	− 1	−
40	0	− 1	−	+ 3	+ 2	−	0	− 1	−
50	+ 1	0	−	+ 3	+ 3	−	+ 1	0	−
60	+ 4	+ 2	−	+ 3	+ 3	−	+ 2	+ 2	−
70	+ 4	+ 3	−	+ 4	+ 2	−	+ 1	+ 1	−
80	+ 5	+ 3	−	+ 5	+ 4	−	+ 2	+ 1	−
90	+ 3	+ 2	−	+ 6	+ 5	−	+ 2	+ 2	−

TABLE 19. OCHREOUS LIMONITE (9), ε = 45°

γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	−43	−43	−	−41	−43	−	−	−	−
9	−31	−32	−	−39	−99	−	−32	−33	−
12	−27	−27	−	−33	−32	−	−24	−24	−
15	−28	−26	−	−13	−15	−	−19	−18	−
18	− 9	−10	−	− 9	− 8	−	−14	−15	−
21	− 6	− 6	−	− 1	− 2	−	− 5	− 8	−
24	− 3	− 3	−	− 1	− 2	−	− 6	− 6	−
27	+ 2	− 1	−	− 5	− 3	−	− 1	− 2	−
30	0	0	−	+ 1	0	−	+ 1	0	−
40	+ 2	+ 1	−	+ 2	+ 1	−	+ 2	+ 1	−
50	+ 1	+ 1	−	− 2	− 1	−	+ 2	+ 2	−
60	+ 1	+ 2	−	+ 2	+ 2	−	+ 2	+ 1	−
70	0	+ 1	−	+ 2	+ 2	−	+ 2	+ 2	−
80	+ 1	0	−	+ 3	+ 3	−	+ 1	+ 2	−
90	+ 3	+ 1	−	+ 3	+ 3	−	+ 4	+ 4	−
100	+ 4	+ 2	−	+ 3	+ 3	−	+ 2	+ 2	−
110	+ 4	+ 2	−	+ 5	+ 4	−	+ 4	+ 3	−

TABLE 20. MIOCENE VOLCANIC TUFF (10), ε = 0°
γ°

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-23	-23	-19	-20	-23	-23	-24	-24	-21
9	-19	-13	-13	-18	-19	-20	-23	-21	-20
12	-14	-15	-14	-15	-16	-17	-15	-17	-16
15	-14	-14	-12	-15	-15	-15	-11	-11	-13
18	-13	-11	-10	-7	6	-8	-8	-8	-9
21	-8	-9	-7	-9	8	-8	-6	-5	-6
24	-8	-8	-6	-7	7	-5	-6	-6	-6
27	-8	-7	-5	-4	5	-4	-8	-6	-4
30	-6	-4	-3	-5	5	-3	-6	-4	-5
40	-3	-1	-2	-3	-3	-2	-2	-1	-2
50	-4	-3	-1	-2	-2	0	-2	-3	-1
60	-2	-2	0	-4	-4	-3	-2	-2	0
70	-2	-1	-2	-4	-4	-4	0	-3	+4
80	-3	-4	-4	0	-1	0	-2	0	-2
90	0	-2	-1	0	-2	-2	0	-1	0

TABLE 21. MIOCENE VOLCANIC TUFF (10), ε = 45°
γ°

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-23	-21	-20	-28	-27	-25	-25	-26	-
9	-13	-19	-15	-19	-28	-19	-20	-19	-
12	-12	-14	-13	-15	-16	-17	-19	-17	-
15	-10	-10	-9	-13	-12	-13	-12	-13	-
18	-10	-8	-7	-11	-10	-9	-8	-9	-
21	-13	-8	-9	-11	-11	-8	-8	-7	-
24	-8	-7	-8	-8	-7	-6	-	-7	-
27	-7	-4	-4	-4	-4	-5	-7	-5	-
30	-4	-3	-4	-8	-6	-5	-7	-6	-
40	-4	-2	-3	-6	-4	-3	-2	-3	-
50	-6	-4	-4	-4	-2	-1	-4	-1	-
60	-2	-3	0	-4	-4	-2	-3	0	-
70	-4	-3	+1	-4	-3	-1	-1	-2	-
80	-2	-2	-3	-3	-1	0	-1	0	-
90	-4	-4	-2	-4	-2	-1	0	-1	-
100	-4	-3	0	-4	-3	-2	0	-1	-
110	-2	-3	-4	-3	-1	0	0	0	-

TABLE 22. TUFF (11), ε = 0°
γ°

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-21	-19	-17	-18	-18	-15	-26	-27	-28
9	-17	-17	-9	-22	-19	-18	-16	-16	-14
12	-9	-9	-12	-19	-12	-	-14	-16	-16
15	-9	-9	-12	-12	-11	-11	-12	-11	-11
18	-9	-7	-9	-7	-8	-4	-4	-6	-9
21	-6	-3	-4	-6	-4	-2	-6	-4	-8
24	-6	-4	-	-8	-5	-7	-2	-3	-5
27	-4	-4	-6	-2	-1	-6	-4	-9	-2
30	-4	-3	-2	-3	-3	+2	-4	-4	-4
40	-4	-3	-3	-1	-2	0	-4	-4	-2
50	-4	-3	-2	-3	-2	+2	-6	-1	-
60	-2	-3	-4	0	+2	+1	-2	-4	-3
70	-4	-1	-1	+1	0	+1	-3	-2	-2
80	-2	-3	-1	-	-	-	0	-2	+1
90	-4	-1	-1	-	-	-	-1	0	-

TABLE 23. TUFF (11), ε = 45°
γ°

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	-23	-19	-22	-23	-20	-18	-25	-23	-23
9	-14	-14	-16	-14	-12	-13	-25	-17	-25
12	-11	-12	-9	-12	-12	-8	-12	-13	-13
15	-9	-13	-9	-12	-9	-9	-13	-10	-14
18	-8	-5	-4	-8	-9	-10	-9	-4	-
21	-8	-5	-10	-5	-9	-3	-10	-3	-1
24	-	-	-	-4	-5	-	-6	-3	-8
27	-7	-5	-2	-8	-9	-6	-5	-4	-3
30	-4	-	-3	-4	-6	-4	-7	-3	-4
40	-5	-6	-5	-5	-2	-	-3	-3	0
50	-2	-3	-3	-3	0	-	-2	+2	0
60	-3	-1	-3	-1	-1	-1	-1	0	0
70	-4	-3	0	-3	-2	-	0	+2	+2
80	-2	-3	-5	-3	-1	-	0	0	+2
90	-2	-2	-	+2	0	-	+2	0	+4
100	0	-1	-2	+2	+1	-	+1	0	+2
110	-2	-3	-	0	-1	-	0	+3	+1

TABLE 24. VOLCANIC SLAG (12), ε = 0°
γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	—	—	—	−44	−43	—	−41	−41	—
9	—	—	—	−43	−40	—	−41	−35	—
13	—	—	—	−38	−33	—	−40	−30	—
15	—	—	—	−11	−15	—	−25	−25	—
18	—	—	—	−10	−10	—	−6	−7	—
21	—	—	—	−2	−4	—	−6	−5	—
24	0	−1	—	−2	−2	—	−2	−2	—
27	+1	0	—	0	+1	—	+1	0	—
30	−3	−2	—	+2	+1	—	+4	+2	—
40	+4	+2	—	+2	+2	—	+5	+3	—
50	+4	+3	—	+3	+2	—	+4	+3	—
60	+3	+3	—	+3	−3	—	+4	+4	—
70	+4	+3	—	+5	+5	—	+6	+4	—
80	+4	+4	—	+5	+4	—	+3	+3	—
90	+3	+3	—	—	—	—	+3	+3	—

TABLE 25. VOLCANIC SLAG (12), ε = 45°
γ°

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	−44	−44	—	−56	−55	—	−51	−52	—
9	−44	−40	—	−44	−43	—	−47	−45	—
12	−35	−35	—	−48	−38	—	−39	−40	—
15	−15	−17	—	−19	−20	—	−24	−22	—
18	−8	−9	—	−10	−10	—	0	−4	—
21	0	−2	—	−2	−3	—	0	−1	—
24	0	0	—	−1	−2	—	−1	0	—
27	+2	+1	—	−2	−2	—	+2	+1	—
30	+3	+3	—	0	0	—	0	+1	—
40	+2	+2	—	+2	+1	—	+4	+2	—
50	+2	+2	—	+1	+1	—	0	+2	—
60	+3	+2	—	+2	+2	—	+2	+1	—
70	+2	+3	—	+2	+2	—	+2	0	—
80	+3	+3	—	+2	+2	—	+2	+2	—
90	+3	+2	—	+2	+3	—	+2	+2	—
100	+3	+2	—	+4	+3	—	+2	+3	—
110	+1	+2	—	+2	+2	—	+3	+3	—

TABLE 26. QUATERNARY OBSIDIAN (1), ε = 0°
P%

φ°	Не раздробленный (a)		d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0	0.7	0.2	0.1	—	0.4	0	0.5	−0.4	0	—
9	0.2	0	0.2	0.5	—	0.4	0	0.5	0	0	—
12	0.8	0.9	0.2	0.2	—	0.4	0.6	0.9	0	0	—
15	0.7	1.2	0.5	0.4	—	0.6	0.7	2.5	0.5	0.4	1.3
18	2.1	2.0	0.4	0.8	—	1.1	2.1	2.6	0.5	0.4	1.4
21	3.6	2.8	0.9	0.7	—	2.2	3.6	3.0	2.1	1.9	1.6
24	4.0	4.2	0.7	0.9	—	3.2	2.9	3.0	3.6	2.3	1.3
27	5.6	5.2	1.2	1.2	—	3.9	—	3.2	3.8	4.2	1.6
30	6.9	7.0	1.9	1.9	—	4.6	7.2	—	3.5	5.2	4.3
40	12.8	12.4	2.9	2.7	—	7.0	8.5	6.5	9.5	8.1	7.1
50	16.5	15.0	3.9	4.2	—	12.4	11.0	6.9	12.8	12.6	8.7
60	19.6	21.5	5.4	4.8	—	16.1	14.9	9.9	20.8	16.8	16.2
70	29.2	28.0	6.6	6.2	—	18.8	18.8	—	23.2	23.6	19.0
80	28.0	—	7.8	6.9	—	21.0	21.9	16.4	—	—	—
90	—	—	—	7.4	—	—	23.8	—	—	—	—

TABLE 27. QUATERNARY OBSIDIAN (1), ε = 45°
P%

φ°	d < 0.25 mm			0.25 mm < d < 1 mm			1 mm < d < 3 mm		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0	−0.5	0	0	0.2	—	0.2	0	—
9	0.1	−0.2	0	0	0	—	0.2	—	—
12	0.4	0	0	0.4	0.3	0.8	0.2	0	—
15	0.3	0.6	0.3	1.3	1.0	0.8	0.2	0.7	—
18	0.6	0.6	1.0	2.4	1.7	1.1	0.9	0.7	—
21	0.7	1.2	1.0	1.9	2.3	1.1	1.5	1.7	—
24	1.4	1.2	1.1	3.8	3.7	3.4	2.1	2.4	—
27	1.2	1.6	1.7	3.8	5.0	3.2	4.4	4.3	—
30	2.0	2.0	1.7	5.1	5.0	3.2	5.2	3.5	—
40	2.2	2.8	2.4	6.8	7.1	7.3	8.1	7.6	—
50	3.9	3.9	3.6	12.1	12.4	11.0	14.8	13.8	—
60	5.2	5.2	5.8	18.6	16.6	19.0	19.6	20.8	—
70	6.4	6.6	5.8	24.4	23.2	22.4	27.2	26.1	—
80	7.8	8.1	8.0	28.6	26.9	28.8	34.4	34.7	—
90	8.8	9.1	9.6	31.8	31.2	29.9	41.0	39.8	—
100	10.0	9.4	9.4	38.3	36.4	—	46.0	45.5	—
110	10.1	9.2	9.1	39.4	38.4	33.5	51.4	55.4	—

Key: (a) not pulverized

TABLE 28. ANDESITIC BLISTER LAVA (2), $\varepsilon = 0°$ P%

φ°	Не раздроб-лённый (a) б. ф.	Не раздроб-лённый (a) ж. ф.	d < 0.25 мм б. ф.	d < 0.25 мм ж. ф.	d < 0.25 мм з. ф.	1 мм < d < 3 мм б. ф.	1 мм < d < 3 мм ж. ф.	1 мм < d < 3 мм з. ф.
6	—	—	−0.6	0.3	—	−0.3	−1.2	−1.7
9	0	0	−0.5	0	0	−0.1	−0.6	−1.4
12	0	0	0	0.5	0	0	0	−0.3
15	0.2	0.4	0.4	0.8	0.5	0.5	0.7	0
18	0.3	0.5	1.0	0.3	0.6	0.9	0.4	0.3
21	0.9	0.5	1.1	1.2	1.4	1.3	2.3	1.7
24	1.5	1.4	1.5	1.5	0.7	2.5	2.0	3.7
27	1.9	2.2	1.8	1.2	1.6	2.6	2.6	3.0
30	2.8	1.9	1.9	1.9	1.6	3.1	3.7	3.7
40	6.3	4.4	2.8	3.7	2.8	6.4	6.4	6.2
50	8.0	7.3	4.3	5.1	4.3	9.1	9.8	6.7
60	11.9	12.1	6.2	6.0	5.0	12.1	9.7	—
70	13.3	13.5	6.8	6.3	—	15.7	14.3	10.8
80	17.6	18.5	8.2	7.1	8.1	15.7	16.0	—
90	19.6	22.4	8.1	6.3	—	—	—	—

TABLE 29. ANDESITIC BLISTER LAVA (2), $\varepsilon = 45°$ P%

φ°	d < 0.25 мм б. ф.	d < 0.25 мм ж. ф.	d < 0.25 мм з. ф.	0.25 мм < d < 1 мм б. ф.	0.25 мм < d < 1 мм ж. ф.	0.25 мм < d < 1 мм з. ф.	1 мм < d < 3 мм б. ф.	1 мм < d < 3 мм ж. ф.	1 мм < d < 3 мм з. ф.
6	0	0	0	0	0.4	—	0.4	0	0.4
9	0.4	0	0	0.1	0	0	0.3	0	0.4
12	0.6	0.8	0	0.4	0.9	0.5	0.6	1.2	0.5
15	0.5	0.5	0.1	0.4	1.0	0.6	0.7	0.6	0.5
18	1.1	0.5	0	1.1	0.6	0.6	1.3	1.3	0.5
21	1.3	1.9	—	1.8	2.0	0.8	1.7	2.3	0.5
24	1.3	1.9	—	2.5	3.0	2.0	2.1	2.0	0.6
27	1.5	1.9	0.9	3.0	3.1	—	3.1	2.9	—
30	2.1	2.2	0.9	3.7	2.8	5.4	4.2	4.0	—
40	3.5	3.9	3.5	6.0	6.2	4.0	6.0	5.8	2.5
50	4.6	4.4	4.5	8.7	9.3	—	8.6	8.6	4.5
60	6.0	6.2	—	13.0	11.7	12.9	11.5	13.3	8.3
70	7.5	7.3	7.3	16.0	15.8	20.0	14.7	17.0	12.9
80	7.4	8.3	8.4	18.8	16.8	15.9	16.0	15.2	15.°
90	9.0	8.9	8.3	21.0	20.4	21.2	18.2	19.9	18.4
100	9.6	9.0	9.1	22.6	24.0	19.2	22.2	20.0	20.4
110	10.0	—	—	23.2	23.6	21.8	22.0	22.7	19.2

Key: (a) not pulverized

TABLE 30. QUATERNARY BASALT (3), $\varepsilon = 0°$ P%

φ°	Не раздроб-лённый (a) б. ф.	Не раздроб-лённый (a) ж. ф.	d < 0.25 мм б. ф.	d < 0.25 мм ж. ф.	d < 0.25 мм з. ф.	0.25 мм < d < 1 мм б. ф.	0.25 мм < d < 1 мм ж. ф.	0.25 мм < d < 1 мм з. ф.	1 мм < d < 3 мм б. ф.	1 мм < d < 3 мм ж. ф.	1 мм < d < 3 мм з. ф.
6	0	0	0.3	0.3	..	0.2	0.5	—	—	0	—
9	0	0.4	0.3	0.5		0.3	0.8	—	0	0	0.4
12	0.2	0.2	0.5	0.4		[illegible]	0.8	—	0.4	0.5	0.5
15	0.1	0.5	0.5	0.4	—	0.7	0.2	—	0.5	0.3	0.7
18	0.6	0.6	0.5	0.8	—	—	0.8	—	0.7	0.9	0.8
21	0.7	1.7	0.6	0.6	—	1.6	0.9	—	0.8	0.5	1.7
24	1.9	1.2	0.9	1.1	—	1.7	1.9	—	1.5	1.4	1.7
27	1.7	1.5	1.4	1.3	—	2.0	1.4	—	2.0	1.6	2.0
30	1.6	1.9	1.3	1.4	—	2.6	1.7	—	2.9	2.3	2.0
40	3.7	3.9	2.3	1.8	—	3.7	3.4	—	3.4	3.1	4.6
50	6.5	6.2	3.1	2.5	—	5.7	5.5	—	5.1	4.7	4.3
60	8.3	8.2	3.4	4.0	—	7.7	7.0	—	7.7	7.1	7.2
70	11.8	11.0	4.5	5.1	..	9.4	9.6	—	9.4	8.8	—
80	15.0	15.2	—	5.0	..	11.9	11.4	—	10.1	10.4	11.5
90	17.2	18.4	5.0	4.7	—		—	—	17.4	13.3	14.3

TABLE 31. QUATERNARY BASALT (3), $\varepsilon = 45°$ P%

φ°	d < 0.25 мм б. ф.	d < 0.25 мм ж. ф.	d < 0.25 мм з. ф.	0.25 мм < d < 1 мм б. ф.	0.25 мм < d < 1 мм ж. ф.	0.25 мм < d < 1 мм з. ф.	1 мм < d < 3 мм б. ф.	1 мм < d < 3 мм ж. ф.	1 мм < d < 3 мм з. ф.
6	0	0.1	0	0.4	0	0.5	0.2	0.7	0
9	0.1	0	0	0.3	0	—	0.2	0	0
12	0.5	0.3	0	—	—	0.7	0.4	0.6	0
15	0.2	0.6	0.1	0.5	0.1	0.8	—	0.6	0
18	0.3	0.3	0.3	0.8	0.7	0.8	0.7	—	0.7
21	0.9	0.3	0.6	1.2	1.3	0.9	1.2	1.2	0
24	0.4	0.9	0.6	1.2	1.0	0.8	1.2	1.3	0.7
27	1.0	1.5	0.7	1.6	1.4	0.8	1.2	1.5	1.7
30	1.3	1.1	0.7	2.1	2.3	1.8	2.5	2.0	3.6
40	2.1	2.0	1.3	3.8	4.1	2.1	3.6	3.5	4.0
50	3.1	2.6	1.9	6.0	5.4	4.3	5.5	4.9	5.4
60	3.7	3.7	3.3	8.2	7.7	5.7	7.7	7.8	5.8
70	4.7	4.3	3.5	9.4	8.8	—	10.0	9.1	—
80	—	4.9	4.3	11.1	10.1	8.6	12.1	10.6	8.6
90	5.6	5.5	5.0	12.6	12.5	—	12.8	13.0	12.3
100	5.6	5.9	4.6	14.6	14.0	12.0	14.0	—	12.2
110	6.1	5.5	4.1	15.7	13.7	12.7	14.7	14.4	12.6

Key: (a) not pulverized

TABLE 32. QUATERNARY BASALT (4), ε = 0°

P%

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0.3	0.2	0	0.4	0.2	—	0.1	0.2	0.9
9	0.2	0	0.7	0.2	0	0.2	0.9	0	1.0
12	0.2	0.4	0.7	0.3	0	1.5	0.7	1.1	1.2
15	0.6	0.3	0.2	0.3	0.8	1.7	0.8	1.2	1.3
18	0.4	0.5	0.2	1.2	0.9	1.8	1.2	0.5	2.6
21	1.1	0.4	0.9	2.0	1.2	1.8	1.4	1.7	1.5
24	1.0	0.9	0.9	2.0	1.5	2.8	1.9	1.9	1.5
27	—	0.7	1.9	2.8	2.0	3.4	2.0	2.4	1.6
30	1.1	1.3	2.0	2.9	3.6	4.9	3.0	2.6	3.1
40	2.5	2.4	2.3	4.9	5.9	4.5	5.0	4.8	3.8
50	3.2	3.2	2.9	7.8	7.7	6.2	7.5	6.8	6.2
60	4.5	4.6	5.0	9.6	9.6	12.2	9.9	9.6	10.1
70	5.3	5.3	6.5	12.4	13.3	14.4	12.3	12.7	13.3
80	6.3	5.7	8.3	15.8	16.1	15.0	14.6	14.6	13.3
90	—	6.1	—	17.9	19.2	15.9	19.0	17.2	—

TABLE 33. QUATERNARY BASALT (4), ε = 45°

P%

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	−0.3	−0.2	0.3	0	0.4	0.1	−0.1	0	0
9	−0.2	−0.2	0.3	0	0.1	0.1	−0.1	−0.6	0
12	−0.6	−0.2	0.3	0.3	0.5	0.2	−0.2	−0.7	0
15	−0.2	0.2	0.4	0.6	0.9	0.2	0	−0.7	0.2
18	0	0.5	0.4	0.9	0.6	1.4	0.7	−0.4	0.2
21	0.7	0.7	0.4	1.5	1.4	1.4	1.0	1.6	1.3
24	0.7	0.7	1.2	1.6	2.2	1.6	1.9	1.6	1.4
27	1.2	1.2	1.1	2.2	2.2	2.9	2.4	1.7	1.4
30	1.4	1.7	1.1	3.1	2.8	2.9	2.3	2.2	2.4
40	2.7	2.5	1.9	5.3	4.8	3.1	4.6	4.1	4.6
50	3.5	3.5	2.0	7.4	7.5	5.1	6.6	7.2	7.6
60	4.9	4.9	2.9	10.0	9.8	7.5	9.4	9.0	7.6
70	5.6	5.9	3.9	12.7	12.0	10.5	12.8	11.2	9.8
80	6.5	6.3	5.1	16.0	15.6	14.4	14.5	14.2	9.0
90	7.0	7.1	6.4	17.2	16.8	15.7	17.1	16.6	15.0
100	7.4	7.3	6.1	20.3	20.2	17.0	18.5	18.4	11.0
110	8.1	6.7	6.5	—	21.2	20.2	20.4	19.0	11.2

TABLE 34. GNEISSOUS GRANITE (5), ε = 0°

P%

ψ°	Не раздробленной (a)		d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0.2	−0.4	0	0.2	−0.7	0.1	0.5	−1.2	0.2	0.2	—
9	0.4	−0.6	0.1	0.2	—	0.2	0.5	−0.9	0.1	0.4	0.3
12	0.4	−0.2	0.2	0.5	−0.8	0.4	0.6	−0.6	0.3	0.1	0.4
15	0.6	−0.2	0.3	0.1	−0.5	0.6	0.9	−0.2	0.2	0.2	0.5
18	0.5	0.4	0.4	0.4	−0.2	0.4	0.6	0.6	0.5	0.4	0.5
21	0.8	0.6	0.4	0.5	0.2	0.7	0.6	0.6	0.8	0.8	0.5
24	0.9	1.0	0.7	0.7	0.8	0.8	1.0	0.3	0.8	0.9	0.6
27	1.2	1.2	0.8	0.7	—	1.0	1.1	1.1	1.2	0.8	0.6
30	1.8	1.1	0.9	1.2	1.2	1.1	1.2	1.2	0.9	0.8	1.6
40	2.2	2.1	1.4	1.6	1.9	1.8	1.9	1.4	1.7	1.9	1.9
50	3.6	3.5	2.1	1.8	2.5	3.1	2.6	2.3	2.8	2.7	2.4
60	5.0	4.6	2.8	2.7	2.8	3.6	3.7	4.4	3.7	3.6	4.0
70	6.6	6.5	3.6	3.0	2.9	4.3	4.4	4.3	4.7	4.8	3.8
80	8.9	8.0	4.3	4.1	3.8	5.7	5.1	5.8	6.4	5.7	5.2
90	11.5	—	5.5	4.9	—	8.1	6.7	7.3	6.5	—	—

TABLE 35. GNEISSOUS GRANITE (5), ε = 45°

P%

ψ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0.1	0.2	0.2	0	0.3	0.8	0.2	0.1	0.4
9	0.2	0.2	0	0.3	0.3	0.4	0	0	0.1
12	0	0.3	0.3	0	0.1	0.4	0.3	0.2	0.1
15	0.3	0.3	1.0	0	0.3	0.8	0.2	0.3	0.1
18	0.3	0.4	0.3	0.3	0.2	1.2	0.2	0.4	0
21	0.5	0.4	1.0	0.6	0.6	1.2	0.5	0.6	0.1
24	0.5	0.9	1.0	0.8	0.3	1.6	0.8	0.8	0.9
27	0.6	0.9	0.6	1.2	1.2	1.6	0.8	1.1	1.4
30	0.8	0.9	1.4	0.8	1.1	1.3	1.2	0.8	1.4
40	1.2	1.5	1.1	1.4	1.5	1.6	1.7	1.6	1.9
50	1.8	1.4	—	2.0	2.2	2.5	2.7	2.4	2.0
60	2.5	2.5	2.4	2.8	3.0	2.9	3.4	3.7	2.8
70	3.1	3.0	3.0	3.9	4.2	4.2	4.4	4.6	4.7
80	3.7	3.7	3.7	4.9	4.9	4.9	5.7	5.7	6.3
90	4.2	4.0	4.2	5.2	5.9	5.8	6.7	6.7	5.8
100	5.0	4.7	—	7.4	7.0	7.4	7.6	7.6	7.5
110	5.0	5.5	5.6	7.5	7.1	7.6	8.7	7.9	8.2

Key: (a) not pulverized

TABLE 36. BIOTITIC GRANITE (6), ε = 0°
P%

φ°	Не раздробленный (a)		d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0.4	0.3	-0.3	0.2	0.5	0.1	0	0.4	0.2	0.5	—
9	0.2	0.2	-0.2	0.4	0.6	0.3	0.6	0.4	0.3	0.4	0.4
12	0.3	0.4	0	0.3	0.3	0.7	0.5	0.9	0.2	0.8	0.9
15	0.6	0.5	0.1	0.4	0.7	0.5	0.6	0.9	0.5	0.6	0.5
18	1.0	0.8	0.3	0.8	0.4	0.7	1.1	1.0	1.0	0.8	0.5
21	1.1	1.0	-0.6	0.5	1.2	0.6	1.0	1.0	0.8	1.1	1.1
24	1.4	1.4	0.7	0.9	1.2	0.7	1.2	1.0	1.0	—	—
27	1.7	2.0	0.8	1.2	1.3	1.6	1.6	2.2	1.2	1.4	1.7
30	2.0	1.7	1.2	1.2	1.5	1.6	1.9	1.7	1.4	1.3	1.9
40	3.5	3.4	1.5	1.3	1.8	2.3	2.4	2.6	2.5	2.4	2.6
50	5.3	5.5	2.3	2.4	3.0	3.6	3.3	3.8	3.8	3.6	4.3
60	6.7	7.0	3.1	2.8	3.0	5.0	5.3	4.8	5.1	4.9	5.1
70	9.5	7.7	3.4	3.8	3.8	6.3	5.8	7.7	6.4	6.3	6.9
80	10.1	9.3	4.8	4.2	5.5	7.1	7.0	—	7.9	7.4	—
90	—	—	—	6.5	5.9	—	—	—	8.1	—	8.1

TABLE 37. BIOTITIC GRANITE (6), ε = 45°
P%

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0.3	0.2	0.1	0.3	−0.5	0.5	0.1	0	0
9	0.2	0.3	0.1	0	−0.5	0	0.2	0.4	0
12	0.1	0.6	0.5	0.4	−0.3	0.5	0.2	0	0
15	0.2	0.3	0.2	0.5	+0.3	0	0.3	0.3	0.5
18	0.4	0.3	0.2	0.5	0.5	0.5	0.4	0.8	0
21	0.5	0.6	0.2	0.9	0.6	0.5	0.5	0.8	0.5
24	0.7	0.8	0.2	1.0	1.0	1.0	0.5	0.8	0.5
27	0.9	0.7	—	1.2	1.2	1.1	1.0	0.7	1.1
30	1.1	0.9	0.6	1.8	1.5	1.6	1.7	1.6	1.6
40	1.4	1.5	1.4	2.9	2.2	2.7	[illegible]	2.2	2.3
50	2.4	2.0	2.6	3.6	3.7	2.7	3.2	3.7	3.5
60	2.9	2.7	3.1	4.4	4.6	4.1	4.5	4.8	4.3
70	3.5	3.7	3.4	5.8	6.0	4.9	6.0	6.1	5.4
80	4.5	4.5	4.8	7.9	8.3	8.3	6.4	7.7	6.0
90	4.4	5.1	—	8.7	8.6	8.6	10.2	9.6	8.1
100	5.2	5.1	4.3	10.2	10.2	10.8	12.1	11.1	12.0
110	5.2	4.9	—	11.5	10.9	—	13.8	12.5	12.4

Key: (a) not pulverized

TABLE 38. QUARTZ (7), ε = 0°
P%

φ°	Не раздробленный (a)		d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	—	—	0.4	0.2	0	0	0.1	0.4	0	0.3	−0.9
9	0.6	0.7	0.2	0.2	0.4	0.2	0	0.5	0.2	0.2	−0.9
12	1.2	1.2	0.2	0.4	0.2	0.1	0.1	—	0.3	0.4	−0.9
15	1.9	1.9	0.3	0.3	0.4	0.1	0.4	—	0.3	0.6	−0.5
18	2.9	2.5	0.2	0.3	0.2	0.4	0.7	0.9	0.5	0.6	−0.1
21	4.1	3.7	0.3	0.4	0.5	0.4	0.5	1.3	0.7	0.8	0.5
24	6.1	5.4	0.3	0.6	0.7	0.4	0.6	1.3	0.9	1.0	1.1
27	7.2	6.5	0.4	0.6	1.0	0.8	0.7	1.4	1.2	0.9	1.6
30	8.0	8.3	0.6	0.5	0.6	0.8	0.6	1.1	1.3	1.4	1.2
40	10.5	9.7	1.1	1.0	1.0	1.3	1.5	2.1	2.5	2.7	3.0
50	—	—	1.3	1.4	1.3	2.1	2.2	2.8	3.4	3.5	4.5
60	—	—	1.9	2.0	1.9	—	3.3	3.5	5.0	4.8	5.4
70	—	—	2.9	2.7	2.6	3.9	3.5	3.7	6.3	6.2	7.3
80	—	—	3.2	3.5	3.7	5.2	5.3	5.7	7.5	6.8	7.5
90	—	—	4.7	5.0	5.4	5.1	5.7	6.4	8.2	6.9	—

TABLE 39. QUARTZ (7), ε = 45°
P%

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.	б. ф.	м. ф.	з. ф.
6	0.2	0.3	−0.6	−0.2	0.3	0	−0.2	0.1	0
9	0.2	0.3	−0.1	−0.3	0.4	0	−0.1	0.4	0
12	0.2	0.3	−0.6	0	0.3	0	0.3	0.4	0
15	0.3	0.2	0	−0.2	0.5	0	0.4	0.5	0.5
18	0.4	0.3	−0.1	−0.2	0.4	0	0.5	0.7	0.5
21	0.5	0.6	−0.1	−0.1	0.6	0.3	0.7	0.7	0.5
24	0.5	0.5	0.5	0.2	0.5	0.7	1.1	1.0	1.0
27	0.5	0.7	0.7	0.4	0.8	0.3	1.1	1.2	1.0
30	0.6	0.8	0.7	0.7	0.9	0.6	1.5	1.5	2.0
40	0.9	1.0	1.1	1.3	1.3	1.5	2.2	2.4	1.9
50	1.4	1.3	1.3	1.7	2.0	2.2	3.4	3.6	3.5
60	1.7	1.9	2.0	2.7	2.9	2.9	5.5	5.2	4.3
70	2.3	2.0	2.0	4.3	4.6	4.5	7.6	7.5	7.6
80	3.3	2.7	3.1	5.3	5.7	6.0	9.6	9.3	9.6
90	3.6	3.9	4.1	7.3	8.3	7.6	12.3	12.3	12.4
100	5.1	4.9	4.9	9.5	10.3	10.8	15.4	15.5	14.4
110	5.3	5.1	5.4	12.1	12.3	12.5	20.1	19.8	20.0

Key: (a) not pulverized

TABLE 40. COLUMNAR QUARTZ (8), $\varepsilon = 0°$

P%

φ°	Не раздроб-ленный (a)		d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	б. ф.	м. ф.	в. ф.	б. ф.	м. ф.	в. ф.	б. ф.	м. ф.	в. ф.
6	0.1	0.1	0	0.2	[illegible]	0.3	0.3	0	0.2	0	0.2
9	0.1	0.1	0.5	0.3	[illegible]	0.3	0.1	0.1	0.1	0.3	0.2
12	0.2	0	0.2	0	[illegible]	0.2	0.1	0.3	0.2	0.3	0.3
15	0.2	0.1	0.4	0.2	[illegible]	0.2	0	0	0.4	0.2	0.2
18	0.2	0.2	0.4	0.1	[illegible]	0.2	0.2	0.4	0.4	0.5	0.2
21	0.3	0.2	0.4	0.6	[illegible]	0.2	0.3	0.4	0.4	0.4	0.3
24	0.5	0.3	0.4	0.4	[illegible]	0.5	0.3	0.5	0.6	0.7	0.7
27	0.4	0.4	0.5	0.3		0.4	0.1	0.2	0.7	0.6	0.5
30	0.8	0.9	0.5	0.3		0.5	0.5	0.6	0.6	0.6	0.6
40	0.9	0.8	1.0	0.8	[illegible]	1.0	0.9	0.8	0.8	0.8	0.7
50	1.4	1.2	1.4	0.7	[illegible]	1.4	1.2	1.2	1.6	1.6	1.0
60	1.9	1.6	1.8	1.5	[illegible]	1.8	1.8	1.7	1.8	1.9	2.0
70	2.3	2.5	2.3	1.7	[illegible]	2.6	2.4	2.5	3.0	2.2	2.3
80	2.0	1.2	2.7	2.6	[illegible]	3.5	3.2	4.2	3.8	3.3	3.5
90	—	—	3.3	1.5	—	5.2	4.9	4.0	4.7	5.4	4.0

TABLE 41. COLUMNAR QUARTZ (8), $\varepsilon = 45°$

P%

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	м. ф.	в. ф.	б. ф.	м. ф.	в. ф.	б. ф.	м. ф.	в. ф.
6	0.2	0.3	0	0.3	0.3	0.6	0	0.2	0.3
9	0	0.2	0.2	0.2	0.3	0.3	−0.1	0.1	0.5
12	0.4	0.2	0.4	0.1	0.3	0	−0.7	0.3	0.1
15	0.1	0.3	0.2	0.1	0.2	0.5	−0.3	0.1	0
18	0.3	0.5	0.5	0.2	0.6	0.4	−0.4	0.1	0.3
21	0.4	0.4	0.3	0.3	0.4	0.4	−0.2	0.4	0.2
24	0.3	0.4	0.3	0.5	0.4	0.5	−0.1	0.4	0.4
27	0.4	0.4	0.6	0.4	0.2	0.7	+0.3	0.4	0.7
30	0.7	0.6	0.8	0.5	0.6	1.0	0.4	0.5	0.6
40	0.9	1.0	1.4	0.8	0.7	0.7	1.1	1.0	0.3
50	1.1	1.2	1.1	1.4	1.3	0.8	1.5	1.5	1.1
60	2.0	1.6	1.5	1.9	1.7	1.5	2.1	1.8	1.6
70	2.3	2.4	2.1	2.4	2.2	2.4	2.4	2.5	2.4
80	3.1	3.3	3.2	3.1	3.0	2.6	3.3	3.5	3.1
90	4.2	3.9	4.3	3.8	4.0	3.2	4.8	4.8	4.1
100	4.8	4.9	5.0	4.7	4.4	4.4	5.3	5.2	5.6
110	5.4	6.6	5.4	6.4	6.2	5.4	6.5	5.3	5.8

Key: (a) not pulverized

TABLE 42. OCHREOUS LIMONITE (9), $\varepsilon = 0°$

P%

φ°	Не раздроб-ленный (a)		P < 0.25 мм		1 мм < P < 0.25 мм		1 мм < P < 3 мм	
	б. ф.	м. ф.	б. ф.	м. ф.	б. ф.	м. ф.	б. ф.	м. ф.
6	0.3	0.3	−0.7	−0.2	−0.9	−0.6	−0.4	−0.4
9	0.2	0.4	−0.3	−0.5	−0.7	−0.4	−0.3	−0.4
12	0.3	0.4	−0.1	0	−0.1	0	−0.3	−0.2
15	0.4	0.6	−0.1	0	0.3	0.2	−0.1	0
18	0.5	—	0.2	0.3	0.6	0.5	−0.1	0
21	0.6	1.0	0.5	0.8	0.7	0.6	0.5	0.3
24	1.5	1.7	0.9	0.8	1.9	1.7	1.4	1.1
27	1.8	2.0	2.3	1.7	2.3	2.2	2.2	2.4
30	1.9	1.6	3.3	2.8	2.4	2.7	2.7	2.2
40	4.1	4.2	4.4	4.4	4.1	4.1	4.4	4.9
50	6.5	6.2	6.6	6.6	7.4	6.4	7.2	7.0
60	9.1	8.8	9.6	8.1	10.2	7.1	8.6	9.0
70	12.8	10.5	13.9	11.5	13.6	10.4	11.3	11.3
80	13.6	11.7	14.3	14.4	15.6	13.9	15.0	13.3
90	—	13.9	—	—	—	—	—	—

TABLE 43. OCHREOUS LIMONITE (9), $\varepsilon = 45°$

P%

φ°	d < 25 мм		0.25 мм < d < 1 мм		1 мм < d < 3 мм	
	б. ф.	м. ф.	б. ф.	м. ф.	б. ф.	м. ф.
6	0	0.1	0.2	−0.4	0	0.1
9	0.3	0.2	0.4	−0.2	0	0.2
12	0.1	0	0.3	0	0.1	0
15	0.1	0.3	0.6	0.5	0.1	0.3
18	0.7	0.3	1.0	0.5	0.4	0.3
21	1.0	0.7	1.6	2.4	1.3	1.0
24	1.7	1.8	1.7	1.5	2.2	1.0
27	2.7	2.7	2.3	2.6	2.3	2.6
30	2.8	3.2	2.7	3.0	2.7	3.1
40	5.2	4.4	5.2	4.5	4.9	4.4
50	7.4	7.4	5.9	7.2	7.7	7.4
60	8.7	10.4	10.1	9.0	9.3	9.3
70	11.9	11.4	13.1	11.8	11.3	12.4
80	13.7	12.1	13.9	13.4	12.8	13.9
90	14.4	13.9	16.1	13.9	16.1	15.0
100	14.7	14.6	13.0	15.1	17.6	—

Key: (a) not pulverized

TABLE 44. MIOCENE VOLCANIC TUFF (20) P% (without filter)

φ°	(a) Не раздробленный	d < 0.25 мм		0.25 мм < d < 1 мм		1 мм < d < 3 мм	
	ε = 0°	ε = 0°	ε = 45°	ε = 0°	ε = 45°	ε = 0°	ε = 45°
6	0.2	—	0	0.4	0	−0.3	0
9	0	0.2	0.1	0.2	0.1	−0.1	0
12	0.2	0.1	0.1	0.3	0.2	0	0
15	0.6	0.5	0.3	0.5	0.3	0.4	0.1
18	0.4	0.2	0.5	0.5	0.6	0.6	0.4
21	0.6	0.5	0.5	0.8	0.6	0.9	0.7
24	1.0	1.0	0.7	1.2	1.0	0.8	0.6
27	1.5	0.8	0.9	1.3	1.1	1.3	1.1
30	—	1.1	1.0	1.5	1.5	1.5	[illegible]
40	2.7	1.7	1.6	2.3	2.3	2.6	[illegible]
50	3.7	2.6	2.3	3.6	3.0	3.6	[illegible]
60	5.6	3.3	2.6	5.1	4.2	4.9	4.7
70	8.6	3.7	3.6	5.5	4.9	5.4	[illegible]
80	10.4	4.5	4.1	6.3	6.2	6.4	6.2
90	12.1	—	4.2	6.9	[illegible]	7.3	7.0
100	—	—	4.4	—	7.1	—	7.1
110	—	—	4.1	—	6.5	—	6.9

Key: (a) not pulverized

TABLE 45. TUFF (11), ε = 0° P%

φ°	(a) Не раздробленный		d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	ж. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.
6	0.2	0.4	−0.1	−0.4	0.1	−0.4	−0.2	0.4	−0.3	−0.7	−0.4
9	0.2	0.3	−0.1	−0.1	0.1	0	0	0.5	0	−0.4	−0.4
12	0.3	0.4	0	−0.3	0.6	0	−0.2	0.2	0.2	0	0
15	0.4	0.4	0.2	−0.1	0.2	0.3	0	0.4	0.4	0.5	0.5
18	0.7	0.6	0.7	0.5	0.5	0.3	0.2	0.4	0.8	0.7	0.9
21	0.8	0.8	0.6	0.8	0.8	0.5	0.4	1.0	0.8	1.1	0.7
24	1.0	1.0	0.5	0.7	1.0	0.8	0.4	0.6	1.1	0.9	1.2
27	1.0	1.2	0.7	1.1	0.8	0.9	0.8	1.4	1.6	1.6	1.3
30	1.4	1.4	1.1	1.2	1.8	2.3	0.9	1.1	1.5	1.6	1.8
40	2.4	1.9	2.0	2.2	2.6	2.3	1.4	2.1	2.6	2.4	2.5
50	2.8	2.9	2.4	2.5	2.8	3.0	2.7	2.6	3.7	3.5	3.5
60	3.5	3.8	3.2	3.8	3.0	4.1	3.8	3.5	4.2	4.8	4.7
70	4.1	4.6	4.1	4.1	3.8	5.0	4.5	4.1	5.8	5.3	6.2
80	5.0	4.6	5.2	4.4	3.9	5.3	5.1	4.7	5.9	6.6	6.9
90	—	—	6.0	—	3.8	5.5	—	—	—	—	—

Key: (a) not pulverized

TABLE 46. TUFF (11), ε = 45° P%

φ°	d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.
6	0.1	0.2	0.8	0	0.4	0.4	0	0	0.7
9	0	0.4	0	0.2	0.2	0	0.1	0.4	0.4
12	0.2	0.2	0.6	0.1	0.4	0	0.4	0.3	0.7
15	0.3	0.3	0.6	0.3	0.4	0.8	0.2	0.7	0.4
18	0.3	0.5	0.6	0.5	0.6	1.6	0.6	0.9	0.4
21	0.6	1.0	1.0	0.8	0.9	1.7	0.9	0.8	1.7

TABLE 47. VOLCANIC SLAG VERY BLISTERED (12), ε = 0° P%

φ°	(a) Не раздробленный		d < 0.25 мм			0.25 мм < d < 1 мм			1 мм < d < 3 мм		
	б. ф.	ж. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.	б. ф.	ж. ф.	з. ф.
6	−0.4	−0.3	−0.7	−0.7	—	−1.6	−0.4	—	−0.1	−0.3	—
9	−0.2	−0.2	−1.0	−0.4	—	−1.0	−1.0	—	−0.2	0	0.3
12	0	0	−0.6	−0.1	—	−1.1	−0.4	—	−0.3	0	0.5
15	0.4	0.5	−0.2	−0.1	—	−0.3	−0.3	—	0	0	0.6
18	0.7	1.0	0	−0.1	—	−0.4	−0.6	—	0.4	0	0.6
21	1.0	1.4	0.7	0.8	—	0.4	0.1	—	1.0	0.8	0.6

Key: (a) not pulverized

TABLE 48. VOLCANIC SLAG
VERY BLISTERED (12), $\varepsilon = 45°$
P%

$\varphi°$	$d < 0.25$ mm			0.25 mm $< d < 1$ mm			1 mm $< d < 3$ mm		
	б. ф.	м. ф.	р. ф.	б. ф.	м. ф.	р. ф.	б. ф.	м. ф.	р. ф.
6	0.1	0	—	0.3	—	—	−0.7	0.6	—
9	0.5	0.4	—	0.4	0.1	—	−0.4	0.1	—
12	0.6	0.4	—	0.4	0.2	—	0	0.2	—
15	0.9	1.3	1.3	0.5	0.8	—	0.1	0.2	—
18	1.7	1.4	0.9	1.0	0.8	1.9	—	0.8	—
21	1.7	1.9	1.4	2.0	1.5	2.0	1.1	1.5	0.8
24	2.2	3.4	1.4	2.2	2.2	2.2	2.2	1.6	1.4
27	3.7	2.1	3.3	3.3	2.4	2.2	3.2	2.4	2.5
30	4.5	3.7	3.4	4.0	4.0	3.4	4.2	3.3	2.3
40	6.3	6.2	6.0	6.8	7.5	5.5	7.3	6.3	5.8
50	9.0	8.4	6.6	11.2	10.5	8.7	11.2	9.9	15.6
60	12.3	11.7	9.1	16.1	17.1	13.9	16.2	13.9	17.8
70	15.4	15.2	13.9	19.6	19.7	19.6	22.3	19.6	25.9
80	18.2	16.0	17.2	25.1	25.3	—	26.3	25.0	—
90	18.6	19.0	17.2	—	26.4	—	29.5	28.4	32.9
100	20.4	18.5	22.2	33.0	31.8	—	34.0	35.8	32.9
110	20.8	19.2	—	29.9	35.8	—	37.8	31.3	—

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