POROSITY OF GEOSPHERES

By G. A. MAXIMOVICH

(Communicated by A. E. Fersman, Member of the Academy, 4.VII1.1942)

By porosity, or the ratio of vacant space volume to volume of rock, is determined the depth of penetration of water and gases into the earth crust. From the data accumulated by hydrogeological and engineering geological explorations and prospecting for oil it, is possible to compute both the variation limits and the average porosity of different rocks and of geospheres composed by them.

Below are tabulated data on the porosity of rocks for different geospheres based upon a great many determinations, running into tens of thousands. In the table the figure > 2572 is referred to as a total, only because many workers did not mention the number of tests from which their data for porosity limit and for average porosity had been derived. In time the accumulation of new evidence will certainly bring precision into the figures for average porosity of the geospheres and their constituent rocks, as has been the case with Clarke numbers in geochemistry.

With reference to water, geospheres and shells making up the earth crust can be subdivided into hydrophilic and hydrophobic. Hydrophilic 1 call the geospheres that, owing to the presence of much hollow space, are collectors of subLerranean waters. Such is the pelosphere, the pedosphere, the weathering crust and the stratosphere. Contrary to this, hydrophobic shells scarcely contain any subterranean water in the liquid phase, because they are almost, entirely destitute of hollows. The metamorphosphere and the shells beneath it come under this class.

The least investigated with respect to porosity is the pelosphere. In its clayey muds porosity amounts to 90 %. It is decreased by presence of the muds, their increase in thickness ([1]) and a figure of 0.5 can be adopted as the average porosity of these muds.

Sandy muds are less porous, but the information concerning them is very scanty. For the whole pelosphere the average porosity can be put at about 0.5. Numerous data are available on the porosity of the pedosphere. According to the table, the number of determinations scarcely exceeds 50, but it is actually by far greater, since it is not mentioned how many thousands of samples of North America soils have been tested in deriving the estimates referred to in ([2]). In the lower portion of the weathering crust an average porosity of 0.45 should be assigned to loess and loess-like loams, and one of 0.35 to sands, loams and clays.

Porosity of Hocks in Different Geospheres.

Geospheres and shells		Groups	Rocks and muds	Numbers of estimates	Porosity in %			Total of estimates	Average porosity in the geosphere
					maximum	minimum	average		
Hidriphilic	Pelosphere		Glayev muds	> 18	90.0	19.83	50.0	> 18	0.5
	Pedosphere		Peat	> 4	89.0	76.0	80.0		
			Soils	> 50	65.0	43.75	55.0	> 54	0.55
	Lower portion of weathering crust (hypopedosphere)	I	Sands	>267	48.0	17.33	35.0		
			Loess, loess- like loams	>282	59.06	35.3	45.0	>968	0.45
			Loams	> 94	50.0	24.23	35 0		
			Clays	>321	55.0	18.30*	35.0		0.35
			Calcareous tuff	> 4	32.2	20.2	25.0		
			Loose sands	> 54	50.9	26.4	35.0		
			Dense sands	> 46	29. 5	11.2	25.0		0.30
			Cainozoic and Mesozoic sandstones	>683	42.0	2.231 (0.6)	20.0		
			Paleozoic sandstones	>110	26.5	1.09	10.0–12.0		
	Stratisphere		Porous limestones	> 76	34.0	0.21	5.0		
			Porous dolomites	> 9	33.0	1.5	5.0		
		II	Tableland clays	>273	54.93	17.23	40.0	>1337	
			Clays of folded regions	> 28	50.8	10.4	20.0		
		III	Dense limestones	> 7	6.9	0.2	3.0		
			Gypsum	> 4	6.0	0.1	3.0		
			Anhydrite	> 1	–	–	1.0		0.20
		IVa	Coal	> 2	–	–	4.0		
		IV	Chalk	> 33	55.0	3,28	30.0		
			Mould	> 10	49.0	20.0	35.0		
			Infusorial earth	> 1	–	–	91.6		
Hidriphobic	Metamorphosphere		Shales	> 14	10.0	0.49	4.0		0.04
			Slates	59	10.28	1.16	4.0		
			Siliceous schists	> 2	0.91	0.85	1.0		
			Marble	> 7	6.0	0.11	1.0		
			Quartzite	> 5	3.4	0.008	1.0	> 91	
			Gneiss	> 2	2.4	0.3	1.0		
			Amphibolite	> 2	1.1	0.9	1.0		0.01
	Granitosphere	1	Porphyry	> 9	6.73	0.38	2.0		
			Phonolite	> 7	3.89	1.17	2.11		
		2	Granite	> 50	1.9	0.02	1.0	75	0.01
			Svenite	> 7	2.8	0,5	1.0		
	Basaltospliere	1	Effusive rocks	> 19	6.0	0.6	2.0		
		2	Intrusive rocks	> 10	2.0	0.65	1.0	> 29	<0.01
								>2572	

* Underestimated by 5–10 %.

The rocks of the stralisphere fall into four main groups. The first is formed by ultra-capillary and capillary collectors of gravitational waters. It includes sands, sandstones, also limestones and dolomites. Loose sands of this group are as porous on the average, as the sands of the weathering crust. The porosity of dense sands is 0.25. Gainozoic and Mesozoic sandstones have an average porosity of 0.20; Paleozoic, 0.1–0.12. The latter are less porous not merely because they are in a higher degree metamorphic and cemented, but also because the samples were taken from finer grained sandstones lying further away from the former shore-line. The coarser sandstones in the folded regions are either transformed into the quartzite of the metamorphosphere or denudated.

Porous limestones and dolomites show an average porosity of 5°/$_0$. They present oolite, cavernous, breccia-like and similar varieties.

In the second group of rocks of the stralisphere belong the ultra-capillary collectors of water. These are clayey rocks. From the available data distinction with regard to porosity can be made in a preliminary way between the clays of table-lands and those of folded regions. For the former tile average is 40 %; for the latter, 20 %.

In the table-lands the clays are more porous, because they were less influenced by the pressure. These data, however, must be verified on a more abundant material.

The third group of the stralisphere rocks are dense rocks, the limestone gypsum, anhydrite and salt. Their porosity is low; 3 % in the case of dense limestone or gypsum; 1 % in the case of anhydrite. Their hydrophilic nature is expressed in their yielding to the action of water penetrating into their fissures, whereby hollows are formed.

Finally, the fourth group is made up by different organogenic rocks. Of them coal exhibits a low porosity. Considerable porosity is shown by chalk and infusorial earth.

The metamorphosphere, composed by the transformed rocks of the stratisphere, is the uppermost of the hydrophobic shells. Here the pores have nearly vanished under the action of pressure, and their water either entered into the composition of hydrous minerals or moved upwards along the fissures. The available determinations of porosity refer largely to those rocks of the metamorphosphere which are in the zone of weathering. For them the average data are 4 and 1 %, according to the zone of the meta- morphism. It will be evident that the role of liquid phase water in the metamorphosphere is quite insignificant.

The porosity of rocks in the granitosphere and basaltosphere is on the average 2 % for effusives; 1 % for intrusives.

To sum up, the porosity of geosphere varies from 0.5–0.55 in the pelo- arid pedosphere down to 0.01 arid less in the granite- and basaltosphere. The porosity of surface geospheres is one of the geophysical characteristics. It is determined by the position of the geosphere in the earth crust and depends upon the thermodynamic conditions. This accounts for the decrease of the average porosity in the direction from the pedosphere to the core.

Department of Dynamic Geology.
State University. Molotov.

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[1]A thy, Bull. Am. Ass. Petrol. Geol., 14 (1930). [2] M. L. Fuller, U. S. Geol. Survey, Water Supply Paper, 160 (1906).

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Porosity of Rocks in Different Geospheres

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