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1 The Earth and its physical features

1.1 PHYSICAL GEOGRAPHY

1.1.1 The area of the Earth's surface

The total area of the surface of the Earth is 510 million km^2. Over 361 million km^2 or 71% of this area is occupied by the World Ocean and only 149 million km^2 or 29% is covered by land. Water and land are distributed unevenly over the globe. In the Northern Hemisphere land extends over 100 million km^2 (39% of its area), while there are 49 million km^2 in the Southern Hemisphere (19%). The area of water in the Northern Hemisphere is 155 million km^2 (61%), and in the Southern 206 million km^2 (81%).

1.1.2 The World Ocean

The World Ocean is divided into four separate oceans by the distribution of the land (Stepanov, 1983): namely the Pacific, Atlantic, Indian and Arctic Oceans, and into numerous seas, gulfs, bays and straits. The Southern Ocean is also identified but is less well defined than the others. Basic information on the oceans and seas (Korzun, 1974b) are presented in Tables 1.1 and 1.2 respectively. The volume of water in the World Ocean is about 1340 million km^3.

1.1.3 Continents and islands

During the present geological epoch the Earth's land consists of six continents: Eurasia, Africa, North America, South America, Australia and Antarctica. The borders between the separate continents are rather arbitrary. The border between Eurasia and Africa passes through the Strait of Gibraltar, along the Mediterranean Sea, Suez Canal, Red Sea, and the Straits of Bab el Mandeb. The boundary between North and South America passes through the Panama Canal. In this Monograph, Eurasia is subdivided into two parts which are considered as independent: namely Europe and Asia. The border between these continents extends from Matochkin Shar, in the north, along Pay Khoy, the Ural Mountains, Mugodzhary, along the River Emba, and the north and west coast of the Caspian Sea and Caucasus Mountains. Information on the continents and largest islands is given in Tables 1.3 and 1.4 (Terehov, 1981).

PRIMARY WATERSHEDS

Primary and secondary watersheds can be identified on the land surface. The primary watershed divides the land into two: the first carrying runoff to the Atlantic and Arctic Oceans (60% of the land area) and the second where runoff occurs to the Pacific and Indian Oceans (40%). The secondary watersheds are those surrounding the basins of the Pacific, Atlantic, Indian and Arctic Oceans and those delineating areas of internal runoff.

The primary watershed extends northwards from Cape Horn along the Andes and the Rocky Mountains to the Bering Strait, then across the eastern plateau of Asia in a westerly direction, and then it turns to run along the eastern edge of Africa to finish at the Cape of Good Hope.

The watersheds of ocean basins are located on individual continents in the following way. In Europe the watershed between the Arctic and Atlantic Oceans passes from the southwest coast of Norway along the Scandinavian Uplands, through the Manselkya Highland, and between Segozero and Onega. The watershed line between the Atlantic Ocean and the area of internal runoff to the Caspian Sea passes between Lakes Onega and Beloye Ozero, along the Valdai Hills, through the Central Russian and the Privolzhskaya Uplands, to Ergeny and the Caucasus Mountains.

In Asia the watershed between the Atlantic and Indian Oceans extends from the south end of the Suez Canal to the source of the Euphrates River. Then the watershed between the Indian Ocean and the area of internal runoff to the north passes along the Plateau of Serkhed, through the Hindu Kush, and from the southern part of Tibet to the Kukushili Mountains to meet the Pacific Ocean watershed. The main watershed of the basins with rivers flowing into the Pacific Ocean passes from Cape Dezhnev along the Chukot, Kolyma, Dzungur, Stanovy, Yablonovy and Hentey Ranges, along the highlands of the northern area of the Gobi and further along Great Khingan Mountains, Inshan, Nan Shan, Kukushili, Tanghla, Henduanshan, to Bilau.

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Table 1.1. *Major hydrological and morphometric characteristics of the World Ocean*

Ocean	Total area (with islands), $km^2 \times 10^6$	Area of water surface, $km^2 \times 10^6$	Area of catchment, $km^2 \times 10^6$	Water volume		Depth, m	
				$km^3 \times 10^6$	%	Average	Maximum
Pacific	182.6	178.7	24.9	707.1	53.4	3957	11 034
Atlantic	92.7	91.7	50.7	330.1	24.6	3602	9 219
Indian	77.0	76.2	20.9	284.6	21.0	3736	7 450
Arctic	18.5	14.7	22.5	16.7	1.0	1131	5 220
World Ocean	370.8	361.3	119.0	1338.5	100	3704	11 034

Table 1.2. *Major morphometric characteristics of seas*

Sea	Area, $km^2 \times 10^3$	Volume, km^3	Sea	Area, $km^2 \times 10^3$	Volume, km^3
		Pacific Ocean			
Coral Sea	4791	11 470	Java Sea	480	22
South China Sea	3447	3 929	Sulawesi Sea	435	1586
Bering Sea	2344	3 796	Sulu Sea	348	553
Sea of Okhotsk	1617	1 317	Molucca Sea	291	554
Sea of Japan	1070	1 630	Seram Sea	187	227
East China Sea	752	263	Flores Sea	121	222
Yellow Sea	417	17	Bali Sea	119	49
Banda Sea	695	2 129	Savu Sea	105	178
		Atlantic Ocean			
Caribbean Sea	2754	6 860	North Sea	554	52
Mediterranean Sea	2505	3 754	Baltic Sea	448	20
Gulf of Mexico	1543	2 332	Black Sea	431	555
Hudson Bay	819	92	Sea of Azov	40	0.4
Baffin Bay	689	593	Sea of Marmara	11	4.0
		Indian Ocean			
Arabian Sea	3683	10 070	Timor Sea	615	250
Bay of Bengal	2172	5 616	Andaman Sea	602	660
Arafura Sea	1037	204	Red Sea	450	251
		Arctic Ocean			
Barents Sea	1470	268	Kara Sea	903	101
Norway Sea	1547	2 408	Laptev Sea	678	363
Greenland Sea	1205	1 740	Chukchi Sea	590	45
East Siberian Sea	926	61	Beaufort Sea	476	478
			White Sea	91	4.4

The watershed of the rivers draining to the Arctic Ocean in Asia passes from the northern end of land in the Strait of Matochkin Shar, along the Pay Khoy Range and the Ural Mountains, to the interfluvial area of Tobol, Turgay, Ishim, and to the Kazakh area of low hills, onwards to the ranges of Tarbagatay, Mongolian Altai, Tank Ola, Hangay and Hentey, and then it extends along the watershed of rivers draining to the Pacific Ocean.

In Africa the watershed between the basins of Atlantic and Indian Oceans passes from the Gulf of Suez along the peaks of mountains situated besides the Red Sea, along the eastern part of the Abyssinian Highlands, to the east of Lake Victoria between Lake Tanganyika and Lake Nyasa, along the Muchinga Mountains, between the Rivers Congo and Zambezi, Cubango and Cunene, westwards and southwards of Lake Etosha, along

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Table 1.3. *Morphometric characteristics of continents*

Continent	Area with islands, $km^2 \times 10^6$	Area of islands, $km^2 \times 10^6$	Altitude above sea level, m		
			Average	Maximum	Minimum
Europe	10.5	0.7	300	5642	−28
Asia	43.5	2.7	950	8848	−392
Africa	30.1	0.6	750	5895	−150
North America	24.2	4.1	700	6193	−85
South America	17.8	0.1	580	7014	−35
Australia and Oceania	8.9	1.3	350	5029	−12
Antarctica	14.0	0.058	2040	5140	–

Damaraland, across the hills of the southwest and the southern borders of the Kalahari Desert, through the Drakensberg Mountains to Cape Agulhas.

In North America the watershed between the Arctic Ocean and the Pacific and Atlantic Oceans passes from Cape Prince of Wales along the Brooks Range, through the Richardson Mountains, Seluin, and Rocky Mountains, along the uplands between the Mississippi and Nelson Rivers, northwards of Lake Superior and Lake Huron and along the Labrador Peninsula. The watershed between the Atlantic and Pacific Oceans passes along the Rocky Mountains, around the upper parts of the Mississippi and South Saskatchewan, along the Isthmus of Tehuantepec and to the Panama Canal.

In South America the watershed separating runoff to the Atlantic and Pacific Oceans starts at the Panama Canal and passes along the Andes, through the Strait of Magellan along Tierra del Fuego to its southern tip.

In Australia the watershed between the basins of Pacific and Indian Oceans passes from Cape York along the Great Dividing Range to South East Point (Cape Otway).

Excluding the areas of internal runoff, the Arctic Ocean takes 15% of the runoff from the total land area of the globe, the Atlantic 34%, the Pacific 17% and the Indian Ocean 14%.

RIVERS

Depending on the size of the basin they drain, the length and volume of the flowing water, rivers are usually subdivided into very large, large, medium, small and very small. Table 1.5 presents information on the morphology of the principal river basins of the earth.

The largest river in the world is the Amazon with a catchment area of 6915 thousand km^2, and length 6280 km. Its total annual runoff amounts to about 15% of the total runoff of all the world's rivers. Among very large rivers are the Congo (catchment area 3680 thousand km^2 and length 4370 km) and Mississippi (2980 thousand km^2 and 4700 km). Over the world as a whole there are 20 rivers with catchment areas between 3 million to 1 million km^2 and 89 rivers with basin areas from 1 million km^2 to 100 000 km^2. Most rivers are amongst the medium, small and very small categories. About 80% of the land surface drains to the World Ocean, while the area of internal runoff where the rivers do not reach the ocean accounts for 20% of the land surface. Most of the world's largest rivers drain to the ocean.

In Europe the area of internal runoff consists of the Caspian Sea basin, which includes the basins of Volga, Ural, and Kura Rivers. In Asia the area of internal runoff is larger and includes: the basin of the Aral Sea (Amu Darya, Syr Darya Rivers) the basin of Lake Balkhash (Ili River) and many rivers flowing into small lakes or disappearing in arid areas (Tedzhen, Murgab, Sary-Su, Turgay, Irgiz and Nura Rivers). There are also the deserts of Alashan, Gobi, and Takla-Makan in Central Asia, while parts of Asia Minor and most of the Arabian Peninsula have areas of internal runoff. There are several closed basins situated in the interfluvial area of the Indus and Ganges.

Almost one-third of Africa drains internally. These are the Sakhara, Libyan, Nubian, Kalahari, and Namib Deserts and semi-deserts, together with the basins of Lakes Chad, Rukwa and Turkana.

In North America the Great Basin (including Great Salt Lake), the deserts of the Mexican Plateau, the Colorado Plateau and the right bank of the Rio Grande have no outlets to the ocean, while in South America the internal runoff areas include the basins of the Lakes Titicaca–Poopo, the Puna de Atakama Desert, the semi-desert plateau of Patagonia and other territories.

In Australia Lakes Eyre, Amadeus, Torrens and Frome are closed, as well as the Great Sandy Desert, Gibson Desert and Great Victoria Desert. Little is known about drainage on the Antarctic continent.

The total area of internal runoff (Korzun, 1974b) amounts to 30.2 million km^2, including Europe 2.2 million km^2, Asia 12.3 million km^2, Africa 9.6 million km^2, Australia 3.9 million km^2, South America 1.4 million km^2 and North America 0.88 million km^2.

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Table 1.4. *Principal islands of more than 10 000 km² in area*

Island	Area, km² × 10³	Island	Area, km² × 10³
Europe		*North America*	
Great Britain	230.0	Greenland	2176.0
Iceland	103.0	Baffin Island	519.0
Ireland	84.4	Victoria Island	213.8
Novaya Zemlya Islands	81.3	Ellesmere Island	202.7
Spitsbergen Islands	62.1	Cuba	105.0
Sicily	25.4	Newfoundland	111.0
Sardinia	23.8	Haiti	77.2
Franz Josef Land	16.1	Banks Island	69.9
Asia		Devon Island	56.4
Kalimantan	735.7	Southampton Island	44.1
Sumatra	435.0	Melville Island	42.1
Honshu	223.4	Alexander Archipelago	36.8
Sulawesi	179.4	Axel Heiberg Island	34.4
Java	126.5	Prince of Wales Island	33.3
Luzon	105.6	Vancouver Island	32.1
Mindanao	95.6	Somerset Island	24.3
Hokkaido	77.7	Aleutian Islands	17.7
Sakhalin	76.4	Prince Patrick Island	15.8
Sri Lanka	65.6	The Bahamas	11.4
Kyushu	42.6	Jamaica	11.1
Novosibirsk Islands	38.4	Queen Charlotte Islands	10.3
Severnaya Zemlya Islands	37.6	Cape Breton	10.3
Taiwan	35.9	*South America*	
Hainan	33.7	Tierra del Fuego	48.0
Timor	33.6	Falkland Islands (Islas Malvinas)	12.0
Shikoku	18.8		
Seram	18.2	*Australia and Oceania*	
Halmahera	18.0	New Guinea	829.3
Kuril Islands	15.6	New Zealand	265.3
Sumbawa	15.5	Tasmania	68.4
Flores	15.2	Solomon Islands	40.4
Palawan	11.8	New Britain	36.6
Bangka	11.6	Fiji Islands	18.2
Sumba	11.2	Hawaii	16.7
Africa		New Caledonia	16.7
Madagascar	587.0	New Hebrides	14.8
		Bougainville Island	10.0
		Antarctica	
		Alexander I Land	43.2

LAKES

Lakes are widespread on all continents. There are about 15 million of them, and the total water surface area is about 2 million km² or 1.5% of the land area (excluding the Antarctic). Most of the lakes are small and very small. Across the world there are 88 large lakes with a water surface area exceeding 1000 km². Of these lakes 28 are located in Asia, 13 in Europe, 16 in Africa, 22 in North America, 5 in South America and 4 in Australia. The number of lakes with a surface area greater than 10 000 km² is 19; 1 in Europe (Lake Ladoga), 4 in Asia (Aral, Baikal, Balkhash, Tonle Sap), 4 in Africa (Victoria, Nyasa, Chad, Turkana), 8 in North America (Superior, Huron, Michigan, Great Bear Lake, Great Slave Lake,

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Table 1.5. *Major morphometric characteristics of principal world rivers*

River	Area of catchment, $km^2 \times 10^3$	Length, km	River	Area of catchment, $km^2 \times 10^3$	Length, km
		Europe			
Volga	1380	3700	Douro	95	938
Danube	817	2850	Daugava	88	1020
Dnieper	504	2200	Garonne	56	650
Don	422	1870	Ebro	87	928
North Dvina	357	1302	Tagus	81	1010
Pechora	322	1809	Seine	79	776
Neva	281	74	Mezen	78	966
Rhine	252	1320	Po	75	652
Ural	236	2534	Dniester	72	1352
Vistula	198	1092	Guadiana	72	801
Elbe	148	1165	South Bug	64	792
Loire	120	1010	Kuban	61	907
Odra	119	907	Guadalquivir	57	680
Rhône	98	812	Onega	57	416
Neman	98	937			
		Asia			
Ob	2990	3650	Salween	325	2820
Yenisey	2580	3490	Godavari	313	1465
Lena	2490	4410	Huai He	270	1000
Amur	1855	2820	Krishna	259	1401
Yangtze	1808	6300	Helmand	250	1150
Ganges with	1746	5425	Yana	238	872
Brahmaputra			Liao He	229	1390
and Meghna			Olenek	219	2270
Amu Darya	1100	1415	Anadyr	191	1150
Indus	960	3180	Kura	188	1360
Mekong	795	4500	Pyasina	182	818
Huang He	752	5464	Chao Phraya	160	1200
Shatt al Arab	750	2900	Taz	150	1400
(Tigris and			Songka (Red)	145	1185
Euphrates)			Mahanadi	142	851
Kolyma	647	2130	Ili	140	1000
Xi Jiang	454	2214	Taimyra	124	754
Tarim	446	2000	Kerulen	120	1264
Syr Darya	440	2210	Pur	112	389
Irrawaddy	410	2300	Anabar	100	939
Khatanga	364	1634	Narmada	99	1312
Indigirka	360	1726			
		Africa			
Congo	3680	4370	Ogowe	203	850
Nile	2870	6670	Gambia	180	1200
Niger	2090	4160	Rufiji	178	1400
Zambezi	1330	2660	Cuanza	149	630
Orange	1020	1860	Ruvuma	145	800
Chari	880	1400	Qui Hon	137	830
Okowango	785	1800	Sanaga	135	860

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Table 1.5. (*cont.*)

River	Area of catchment, $km^2 \times 10^3$	Length, km	River	Area of catchment, $km^2 \times 10^3$	Length, km
Juba	750	1600	Savi	107	680
Senegal	441	1430	Bandoma	97	780
Limpopo	440	1600	Wad Dra	95	1150
Volta	394	1600	Tana	91	720
		North America			
Mississippi	2980	3780	Koksoak	133	1300
Mackenzie	1787	5472	Rio Grande de Santiago	125	960
Nelson	1132	2574			
St. Lawrence	1026	3057	Brazos	118	2060
Yukon	850	2897	Mobile	116	1250
Columbia	668	1953	Colorado	110	1390
Colorado	637	2333	Mus	108	–
Rio Bravo del Norte	570	2880	Hais	108	–
			Goalzas	106	–
Churchill	298	1609	Severn	101	976
Fraser	233	1370	Fort George	98	–
Telon	142	–	Saguenay	90	–
Albany	134	975	Panuko	84	–
		South America			
Amazon	6915	6280	Chubut	138	850
La Plata	3100	4700	Rio Negro	130	1000
Orinoco	1000	2740	Rio Dose	81	600
São Francisco	600	2800	Rio Colorado	65	1000
Parnaíba	325	1450	Paraíba	59	800
Magdalena	260	1530	Atrata	32	644
Essequibo	155	970	Bío Bío	24	380
		Australia			
Murray	1072	3490	Gascoyne	79	770
Cooper Creek	285	2000	Victoria	77	570
Diamantina	115	896	Mitchell	69	520
Fitzroy	143	960	Murchison	68	700
Burdekin	131	680	Fly	64	1040
Flinders	108	930	Fortescue	55	670
Ashburton	82.0	640	Kluta	22	338
Sepik	81.0	1120			

Erie, Winnipeg, Ontario), 1 in South America (Maracaibo), and 1 in Australia (Lake Eyre).

Most lakes are situated in the Northern Hemisphere and are located in glaciated areas (there are many small lakes in the tundra). Many lakes of Europe (e.g. Ladoga and Onega) are situated in large basins, often grabens where the northern sides were eroded by ice. Tectonic depressions, glacial erosion and moraine dams form many lakes in Sweden: Vanern, Vattern, Malaren, for example. There are many lakes formed by glacial dams in the northwest of Russia, and in Finland, Poland, Germany and Canada. A large group of lakes in the south of Finland (e.g. Lakes Saimaa and Paijanne) are divided from the Gulf of Finland by a huge dam made of a double ridge of terminal moraines, known as Salpa-Uselka. The chain of large lakes in North America (Lake Winnipeg, Lake of the Woods, and the Great Lakes: Superior, Huron, Michigan, Erie and Ontario) lie behind morainic

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deposits left by the receeding ice, which covered the whole of the north of the North America continent. A group of alpine lakes (Lake Geneva, Lake Maggiore and Lake Garda) are located in the glacially eroded basins at the foot of the Alps.

A number of lakes are located in deep tectonic depressions in mountain areas such as Baikal (1741 m), Khubsugul (267 m), Issyk Kul (702 m), Nyasa (706 m), and Titicaca (281 m). In the mountain systems of the Tien Shan, the Pamirs and the Altai there are many lakes formed from the blocking of river valleys with rock fragments during earthquakes. Among them are Lake Teletskoye in the Altai Mountains, and Lake Sarezskoye in the Pamirs in the Murghab River valley (this lake was formed in 1911 as a result of the Usoisky River being blocked).

The lakes in high mountain areas are often situated on plateaux surfaces and are mainly of a tectonic origin. Among the large lakes are Lakes Victoria (altitude 1136 m above sea level) and Tanganyika (773 m) in Africa; Titicaca (3812 m) in South America; Kara Kul (3954 m) and Chatyr Kul (3486 m) on the Pamirs, and Issyk Kul (1609 m) on the Tien Shan in Asia. One of the highest lakes is Lake Horpatso, situated in Tibet at an altitude of 5400 m.

The Caspian Sea (−27 m), and the Dead Sea (−392 m) are situated in deep depressions below sea level. The Caspian Sea and a number of other large lakes (Lakes Balkhash, Balaton etc.) are relics of former more extensive water bodies that appeared after the recession of the ice sheets.

Numerous small lakes are formed by wind action (aeolian lakes) in the hot, dry climate of the steppes such as in Western Siberia and Kazakhstan. In regions where limestone, dolomite and gypsum formations dominate the geology, there are karstic lakes, and in areas of permafrost there are thermokarstic lakes. These form when buried ice melts. Lakes of volcanic origin are frequent in Kamchatka, in the Kuril Islands, in the Armenian Highlands, in Middle and Central Asia, and in New Zealand.

Table 1.6 shows the morphological characteristics of the largest lakes. The total volume of water stored in the world's lakes is 176 400 km^3; salt lakes account for 85 400 km^3 and fresh lakes for 91 000 km^3. The largest volume of saline waters (91% of the total volume) is found in a single water body – the Caspian Sea.

In Asia, the volume of salt lakes is only 3% of the volume of the world total; the volume of fresh waters in Asia is almost 10 times greater than the salt lakes, because of Lake Baikal which holds 27% of the total volume of the world's freshwater lakes.

In Africa all the large lakes are fresh. Lake Chad situated on the edge of the Sahara, although highly mineralized, is not related to the salt lakes. In North America among the salt lakes is the Great Salt Lake, while in South America Lake Poopo and Lake Titicaca are not salt lakes, but their water cannot be used for drinking.

RESERVOIRS

During the twentieth century the numbers of reservoirs increased markedly. They are used for public water supply, irrigation, hydropower generation and for other purposes. By the late 1980s, Avakyan *et al*. (1987) estimated there were about 30 000 reservoirs across the world with a volume of greater than 1 million m^3. There were 2500 reservoirs with a capacity larger than 100 million m^3, accounting for more than 90% (or 5750 km^3) of both the total volume and the total surface area of all the world's reservoirs. According to the estimates available, the total volume of such reservoirs now exceeds 5750 km^3, and the total surface area is about 400 000 km^2.

The large reservoirs constructed during the twentieth century since 1950 have substantially transformed the volume and pattern of fresh water stored on the land surface. They also allowed the development and maintenance of a large number of inter-basin transfer systems (Vugeinsky, 1991).

Of the world's reservoirs, most are valley reservoirs, which are created by damming the river channel. The biggest valley reservoir in the world in terms of volume is the Bratskoye Reservoir on the River Angara (169.3 km^3), and in terms of water surface area the Volta on the Volta River (8480 km^2). Since 1950, cascades of reservoirs have been constructed on many large rivers such as the Nile, Yenisei, Colorado, Euphrates, Huang He, Zambezi, Volga, Parana, Mississippi and Missouri.

Reservoirs have also been built by constructing a dam to raise the water level of an existing lake, for example, in Finland, in the northwest of the European part of Russian, and in East Africa. The largest reservoir of this type is Lake Victoria, where the dam at the Owen Falls harnesses a storage of 204.8 km^3 and a surface area of 68 800 km^2.

Along with these two types of reservoirs there are also ones filled in natural depressions by diverting water from a river or by pumping. The largest reservoir in the world of this type is Wadi-Tartar in Iraq having a volume of 72.8 km^3 and a surface area of 2000 km^2.

Reservoirs differ widely in their usage. Hydropower reservoirs are numerous in Africa and South America. In Asia and Latin America there are reservoirs that are used primarily for irrigation.

Besides the above usage, many reservoirs on the planet are made for public water supply. In addition there are the reservoirs constructed for navigation, flood protection, fisheries, recreation, timber rafting, and for a variety of different needs. In recent decades multi-purpose reservoirs have been constructed in many parts of the world.

The greatest proportion of the world total volume of stored water is made up from the reservoirs of the USA, Russia, Canada, India and China. Information on reservoirs with a capacity of more than 20 km^3 is given in Table 1.7.

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Table 1.6. *Major morphometric characteristics of principal world lakes*

Lake	Area, km^2	Maximum depth, m	Volume, km^3	Country
Europe				
Caspian Sea[a]	378 000	1025	78200	Russia, Kazakhstan, Azerbaijan, Iran, Turkmenistan
Ladoga	18 135	230	908	Russia
Onega	9 890	120	295	Russia
Vänern	5 648	106	153	Sweden
Chudsko-Pskovskoye	3 558	15.3	25.2	Russia, Estonia
Vättern	1 856	122	74	Sweden
Suur-Saimaa	1 800	58	36.0	Finland
Mälaren	1 140	61	14.3	Sweden
Päijänne	1 116	95	18.1	Finland
Inari	1 116	92	15.9	Finland
Ilmen	982	4	12	Russia
Balaton	593	12	1.9	Hungary
Geneva	584	310	88.9	Switzerland, France
Bodensee	539	252	48.5	Germany, Austria, Switzerland
Hjamaren	484	22	2.9	Sweden
Storsjon	464	74	7.38	Sweden
Asia				
Aral Sea[a,b]	64 100	68	1020	Kazakhstan, Uzbekistan
Baikal	31 500	1741	23000	Russia
Balkhash[a]	18 200	25	106	Kazakhstan
Tonle Sap	10 100[c]	12	40	Cambodia
Issyk Kul[a]	6 280	702/668	1730	Kirghizia
Dongting Hu	6 000[d]	10	–	China
Rezaieh (Urmia)[a]	5 800	16	45	Iran
Zaisan	5 510	10	53.0	Kazakhstan
Taimyr	4 560	26	13	Russia
Koko Nor[a]	4 220	38	–	China
Khanka	4 190	11	18.5	Russia, China
Van[a]	3 760	145	–	Turkey
Lop Nor	3 500	5	(5)	China
Ubsu Nur[a]	3 350	–	–	Mongolia
Khubsugul	2 770	207	381	Mongolia
Poyang Hu	2 700	20	–	China
Alakol[a]	2 650	54	58.6	Kazakhstan
Chany[a]	2 500	10	4.3	Kazakhstan
Tuz[a]	2 500	–	–	Turkey
Nam Co[a]	2 460	–	–	China
Tai Hu	2 210	–	–	China
Kara-Us-Nur	1 760	–	–	Mongolia
Tengiz[a]	1 590	8	–	Kazakhstan
Sevan	1 360	86	58.5	Armenia
Toba	1 110	529	1258	Indonesia
Marka Kul	454	27		Kazakhstan
Kara Kul	380	238	–	Kirghizia
Teletskoye	245	128	40	Russia

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Table 1.6. (*cont.*)

Lake	Area, km^2	Maximum depth, m	Volume, km^3	Country
Africa				
Victoria	68 800	84	2 750	Tanzania, Kenya, Uganda
Tanganyika	32 000	1471	17 800	Tanzania, Zaire, Zambia, Rwanda, Burundi
Nyasa	30 900	706	7 725	Malawi, Mozambique, Tanzania
Chad	10 000–25 000[e]	10–11	72	Chad, Niger, Nigeria
Turkana	8 660	73	–	Kenya
Albert	5 300	58	280	Uganda, Zaire
Mweru	5 100	15	32.0	Zambia, Zaire
Bangweulu	4 920[f]	5	5.0	Zambia
Rukwa	4 500	–	–	Tanzania
Tana	3 150	14	28.0	Ethiopia
Kiwu	2 370	496	569	Zaire, Rwanda
Edward	2 325	112	78.2	Zaire, Uganda
Leopold II	2 325	6	–	Zaire
Katnit	1 270	60	14	Nigeria
Abaya	1 160	13	8.20	Ethiopia
Shirwa	1 040	2.6	45.0	Malawi
Tumba	765	–	–	Zaire
Faguibini	620	14	3.72	Mali
Gabel-Aulia	600	12	–	Sudan
Chamo	551	13	–	Ethiopia
Upemba	530	3	0.90	Zaire
Zwoi	434	7	1.10	Ethiopia
Shalla	409	266	37	Ethiopia
North America				
Superior	84 500	406	11 600	Canada, USA
Huron	63 500	229	3 580	Canada, USA
Michigan	58 000	281	4 680	USA
Great Bear Lake	31 400	137	1 010	Canada
Great Slave Lake	28 600	156	1 070	Canada
Erie	25 800	64	545	Canada, USA
Winnipeg	24 400	19	127	Canada
Ontario	19 300	236	1 710	Canada, USA
Nicaragua	8 030	70	108	Nicaragua
Athabasca	7 940	60	110	Canada
Reindeer Lake	6 640	–	–	Canada
Winnipegosis	5 360	12	16	Canada
Manitoba	4 700	28	17	Canada
Great Salt Lake[a]	4 660	14	19	USA
Lake of the Woods	4 410	21	–	Canada, USA
Dubawnt	3 830	–	–	Canada
Mistassini	2 190	120	–	Canada
Managua	1 490	26	7.97	Nicaragua
Saint Clair	1 200	7	5.3	Canada
Small Slave Lake	1 190	3	–	Canada
Chapala	1 080	10	10.0	Mexico

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Table 1.6. (*cont.*)

Lake	Area, km^2	Maximum depth, m	Volume, km^3	Country
South America				
Maracaibo	13 300	35	–	Venezuela
Titikaka	8 372	281	893	Peru, Bolivia
Poopo[a]	2 530	3	2	Bolivia
Buenos Aires	2 400	–	–	Argentina, Chile
Argentino	1 400	300	–	Argentina
Valencia	350	39	6.3	Venezuela
Australia				
Eyre	15 000	20		
Amadeus[a]	8 000	–	–	
Torrens	5 800	–	–	
Gairdner	4 780	–	–	
Georgi	145	3	0.3	
Taupo	611	164	60	New Zealand

[a] Salt lake.
[b] Area of the Aral Sea water surface is given before reducing its level.
[c] With low levels 3000 km^2, with high levels 30 000 km^2.
[d] With low levels 4000 km^2, with high levels 12 000 km^2.
[e] With low levels 7000–10 000, with high levels 18 000–25 000 km^2.
[f] With low levels 4000 km^2, with high levels 15 000 km^2.

1.2 THE HYDROSPHERE

1.2.1 The origins of water on the Earth

The hydrosphere[1] surrounding the Earth includes liquid, solid and gaseous forms of water. The hydrological cycle transports this water about the Earth exchanging energy and moving materials as part of the process. The hydrosphere unity is determined by not only its continuity but also the constant water exchange between all its elements. The hydrosphere includes all types of natural waters – oceans, seas, rivers, lakes and glaciers, underground, atmospheric and biologically combined waters. The lower limit of the hydrosphere is assumed to be at the level of Mokhorovichich surface, and the upper limit practically coincides with the upper atmospheric limit (Blyutgen, 1972). Sea, lake, river, glacier, underground and atmospheric waters are all interrelated and water moves from one situation to another as the hydrological cycle progresses (Glushkov, 1929; Vernadsky, 1967).

The Earth's hydrosphere is one of the oldest mantles of this planet and it appeared between 3.5 and 4 billion years ago (Klige *et al*., 1998). It developed together with and in close relationship to the lithosphere, the atmosphere, and then with life itself. Up to the present the mechanisms of the origin of water on the Earth have not been completely explained (Kotwicki, 1991). However, the degasification theory seems to be the most likely explanation (Rubey, 1951; Vinogradov, 1959; Artyushkov, 1970; Condie, 1989). According to this theory the basic mass of the hydrosphere formed as a result of the processes of melting and degassing the Earth's mantle and it was determined by geophysical processes operating at depth.

The mechanism is assumed to be that water vapour, the carbon compounds CO_2, CO and CH, ammonia, sulphur and its compounds H_2S and SO, acid halides HCl, HF, HBr, boric acid, hydrogen, argon and some other gases came to the Earth's surface during lava degassification (Monin and Shishkov, 1979; Holland, 1989). The largest part of the volcanic gases condensed and was transformed into water, forming the hydrosphere.

Acid vapours HCl, HF, HBr, ammonia, sulphur and its compounds, and a considerable part of the CO_2 dissolved in drops of condensed water and fell as acid rain to the Earth's surface. These acid flows ran to low places (oceanic depressions) on the Earth's primary surface, at the same time reacting with underlying rocks and taking out of them the equivalent amount of alkali and alkali earths. Oceanic water appeared to be saline from the very beginning, and land waters fresh as a result of the leaching occurring in

1 There are different interpretations of term "hydrosphere" and viewpoints on its origin (Hydrosphere, 1960; Belousov *et al*., 1972; Chebotarev, 1978; Monin and Shishkov, 1979; L'vovich, 1986; Kotwicki, 1991; Hydrosphere, 1993a, b).

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