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COMPOSITION AND CLASSIFICATION OF SOME PELOIDS IN THE WESTERN REGION OF MONGOLIA

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ABSTRACT

This study was focused on the analysis of the chemical and mineralogical composition of peloids from 3 lakes in the Western region of Mongolia (Khag lake in Zavkhan, Shaazgai lake in Uvs and Ikhes lake in Gobi - Altai province) and their classification in correspondence with the international standards.

The peloids studied were of a dark grey color, had a density of 1.55 g/cm^3 - 1.93 g/cm^3, and provided pH values in the range 7.17 - 8.09. They contained 21.22 % - 44.3 % of moisture, 0.19 % - 0.24 % of H_2S, 1.21 % -1.45 % of C_{org}. They were found meeting the balneological requirement, while belonging to silt sulphide muddy type according to the international classification.

The Na_2O/CaO ratio of the peloids was lower than 1.0 referring to non-swelling clay minerals.

The results of mineral analysis showed that peloids from Khag and Shaazgai lakes contain predominantly tectosilicates, while that from Lake Ikhes contained phyllosilicates, carbonates and gypsum. All peloids investigated belonged to the poly-mineral group.

Keywords: silt sulphide muddy, general characteristics, non-swelling clay.

INTRODUCTION

Peloid is a heterogeneous multiphase system consisting of a crystalline skeleton, a colloidal complex and mud mortar [1].

Maturated mud or muddy suspension of healing and/or cosmetic properties is a complex mixture of fine-grained materials, mineral water or sea water and common organic compounds from biological metabolic activity. Peloid has a therapeutic effect thanks to its biologically active substances, organo–minerals, iron, copper, aluminum, amino acids, carbohydrates, nitrogen, antibiotic substances similar to vitamins, hormones, etc. [2 - 7].

F .Guimaraes and L .Guimaraes were the first to mention the term "peloid" in 1931 at the Executive Council of ISMH (International Society of Medical Hydrology). Later in 1933 J. Lewis presented an important report proposing the general name peloid preserving its meaning [4]. It is worth noting that the first chemical analysis of peloids was performed in 1807 by the French chemist Desser [7, 8].

Peloids have a therapeutic effect. The first written instructions of using them to treat some illnesses and ailments were presented by Clergies and Doctors during the XVIII century, but their application dates back to the XII-XIV centuries. G. Dolmaa and Sh.Tserenpil, [7, 9-11], J.Oyun [12], B.Tserenkhand [13, 14] investigated the peloids found in their countries.

Mongolia is a rich source of peloids. Since 2010 a research team headed by B. Tserenkhand carries out investigations [13, 14] on the composition and classification of the peloids from the lakes of the Western provinces of Mongolia, their formation and adsorptive properties. In 2015 the team started investigating the extraction of peloids using other minerals as well as the mechanism of interaction between artificial sweat and peloids.

Peloids from Western Mongolia have been used for a long time for therapeutic and aesthetic purposes. However, they have not been analyzed so far. Main objective of this study is to classify and determine the chemical, mineralogical and physico-chemical properties of peloids from Khag, Ikhes, and Shaazgai lakes in the Western region of Mongolia.

EXPERIMENTAL

Sampling area

Khag lake is situated in Yaruu soum of Zavkhan province at the foot of Khag's ereen mountain. Its altitude is 2038 m. Being 7.4 km long and 1.5 km broad its area is 7.1 km. It is 2.8 m deep and its volume amounts to 8.8 million m^3 [15]. Ikhes lake is located in Darvi soum of Gobi - Altai province approximately 182 km north-west of Altai city. Its geographic coordinates are as follows: 50°32'11.65"N, 92°32'11.57"E it is one of the largest therapeutic mud and salty minerals lake in the province [15]. Shaazgai lake is situated in Khovd soum of Uvs province between Buraat and Buural mountains. It is a salt-water lake of an area of 4.7 km^2 [16].

Methods

The peloid samples were oven dried at 110^0C, ground and sieved. The fraction containing particles of a size < 0.074 μm was separated and kept in a dry atmosphere for a subsequent analysis. General and balneology characteristics of the peloids were determined following MNS 5849:2008 standard [7, 17].

The chemical composition of the peloids was determined by roentgen fluorescence waves disperse AXIOSmAX tool with 50kw intensity Kα бa Kγ lines. The analysis was carried out at the central geological laboratory of Mongolia.

The mineralogical analyses of the samples was performed by X-Ray diffractometer MAXimax (Rigaku) with a scanning speed of 2^0 2θ/min and Cu-Kα radiation from 5^0 to 60^0 2θ (40 kv, 30mA). It was run at the Institute of Physics and Technology, Mongolian Academy of Science (MAC).

RESULTS AND DISCUSSION

General characteristics of the peloid studied

General characterization of the peloid studied was performed to provide its classification. The requirements of MNS 5849:2008 standard were followed. The data obtained is shown and compared to that of AvargaToson peloid [9] in Table 1.

The peloids studied are dark grey color, they have density of 1.55 $g \cdot sm^{-3}$-1.93 $g \cdot sm^{-3}$ and provide pH values in the range of 7.17 - 8.09. They contain moisture of 21.22 % - 44.3 %, H_2S of 0.19 % - 0.24 %, and C_{org} of 1.21 % - 1.45 %. It is found that they meet the balneological requirements as they belong to silt sulphide muddy type in accordance with the international classification.

Table 1. General characteristics of peloids from Western Mongolia.

General characteristics	Lake			
	Khag	Ikhes	Shaazgai	AvargaToson[a]
Colour	black, grey	black, grey	black	black
Moisture, %	44.30	21.20	30.50	37.80
Specific weight, $g \cdot sm^{-3}$	1.93	1.55	1.76	1.55
pH- test of the peloid	8.09	7.17	7.46	8.00
H_2S, %	0.24	0.19	0.19	0.27
< 0.25 mm, %	0.43	0.75	30.90	4.70
C_{org}, %	1.33	1.21	1.45	2.8
Total S, %	0.35	0.20	0.41	7.30
Total N, mg/g	5.09	5.18	4.57	-

Note: [a] refers to the mean values corresponding to AvargaToson peloid [9].

Table 2. Chemical composition of the peloids studied, %.

№	Oxide	Name of peloid				Klark [b]
		Khag	Ikhes	Shaazgai	KC-6 [a]	
1	SiO_2	70.38	31.01	63.93	41.62	66.62
2	Al_2O_3	12.57	8.96	12.52	12.82	15.4
3	Fe_2O_3	1.76	4.55	4.34	5.13	5.04
4	CaO	3.44	12.36	3.19	13.93	3.59
5	MgO	1.51	8.53	1.63	1.92	2.48
6	Na_2O	3.00	2.88	2.58	0.84	3.27
7	K_2O	2.74	0.97	2.95	2.93	2.80
8	TiO_2	0.441	0.438	8.96	0.65	0.64
9	MnO	0.059	0.111	0.095	0.19	0.10
10	P_2O_5	0.048	0.198	0.159	0.20	0.15
11	LOI	3.51	24.08	7.29	19.3	-
	Na_2O/CaO	0.87	0.23	0.8	0.06	-

Note: [a]KC6-peloid of Turkish spa [18]; [b] composition of the continental crust [19].

Table 2 shows that the peloids oxidation process takes place as expected with as a result of the corresponding physical and chemical processes and microorganisms participation.

It is evident from Table 1 that the peloid from Shaazgai lake is not suitable for direct use it is in fact a mechanical mixture, while peloids from Khag and Ihkes lakes can be directly applied.

Mineralogical and chemical composition of the peloids

The chemical analysis of the peloids investigated refers to the determination of 11 components (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, SO_2) and 32 elements (As, Ba, Bi, Ce, Co, Cr, Cs, Cu, Ga, Ge, Hf, La, Mo, Nb, Ni, Nd, Pb, Pr, Rb, Sb, Sc, Sn, Sm, Sr, Ta, Th, U, V, W, Y, Zn, Zr) .

The results obtained are compared to those of the peloid using Turkish spa [18] and other reference data [19, 20]. All values considered are listed in Tables 2 and 3.

Table 4 shows that SiO_2 content is equal to 31.01 % - 70.38 % , while that of CaO, MgO and Al_2O_3 is equal to 3.44 % - 12.36 %, 1.51 % - 8.53 %, and 8.96 V - 2.57 %, respectively. Furthermore, these peloids have to be treated as initial sediments. It is recognized that the high Na_2O/CaO ratio indicates the presence of swelling 2:1 clay minerals ($1 < Na_2O/CaO > 3$), while the low one ($Na_2O/CaO < 1$) is typical for nonswelling 2:1 clay minerals [21, 22]. The Na_2O/CaO ratio of the mud is l**ower** than 1.0, verifying that it includes non-swelling clay minerals but it higher than that found for the peloid-KC-6 of spa in Turkey [19].

The content of trace elements in the soils and healing mud is attracting the interest of the researchers in the field. Besides it has been reported [23] that the therapeutic effect of peloids is in fact determined by their elemental composition. The importance of the latter is evidenced by a number of studies. For example, Gomes and Silva (2007) pointed out that osteoporosis is determined not only by the the lack of Ca in the bone; P, Si, Mg, F, and Sr have to be present as well. It is now clear that Sr cation contributes to the stabilization of calcium phosphate (hydroxyl apatite) structure in the bone, similarly to its effect on calcium carbonate (aragonite) [23]. The human body contains about 300 mg zirconium but its physiological function is unknown [24]. The amount taken orally is about 3.5 mg per day [25].

The content of elements is related to C_{org}. In fact the elements present are divided into four groups [1] in accordance with their biological effect: (i) elements with a pronounced pharmacological effect (Fe, Co, J, Br) and B, optionally; (ii) elements involved in the enzymatic processes in the body (J, Fe, Cu, Mo, Zn, Co, Mn) as well as Ni, Ba, Sr, Cd possibly; (iii) elements which are toxic to humans (As, Pb, Hg, V and F); (iv) elements whose biological role is not yet elucidated (Ti, Zr, Jr, Cs, and many others). Table 3 shows a significant presence of biogen element of importance in the peloids studied.

Some mud samples contain high levels of elements (Table 4) including Sr and Zr when compared to other references [19, 20]. However, these elements contents

Table 3. Elemental composition of the peloids studied, μg·kg.⁻

№	Micro element	Name of peloid				Clark of elements	
		Khag	Ihkes	Shaazgai	KC-6[a]	In the continental crust[b]	In the deep-water clay[c]
1	As	<5	<5	13	62.6	4.8	=
2	Ba	543	331	362	1153	624	2300
3	Bi	<5	<5	<5	0.4	0.16	=
4	Ce	32	-	93	=	63	350
5	Co	<5	19	7	15.2	17.3	74
6	Cr	27	88	55	73.3	92	90
7	Cs	<30	<15	<30	14.8	4.9	6.0
8	Cu	13	65	26	30.3	28	250
9	Ga	12	13	19	17.1	17.5	=
10	Ge	<3	<3	<3	=	1.4	=
11	Hf	<15	<15	<15	7.2	5.3	4.1
12	La	<30	-	66	=	31	120
13	Mo	<5	<5	<5	0.7	1.1	27
14	Nb	9	<3	22	25.8	12	14
15	Nd	<50	-	<50	=	27	225
16	Ni	12	46	23	40	47	140
17	Pb	11	9	29	32.3	17	80
18	Pr	<30	<30	<30	=	7.1	33
19	Rb	81	-	141	146	84	110
20	Sb	<40	-	<40	0.4	0.4	1.0
21	Sc	<10	12	<10	10	14	19
22	Sm	<30	<30	<30	=	4.7	38
23	Sn	<20	<20	<20	=	2.1	1.5
24	***Sr***	***397***	***1777***	***202***	***1540.4***	***320***	***180***
25	Ta	<10	<10	<10	1.4	0.9	0.05
26	Th	6	13	21	28.0	10.5	7.0
27	U	<5	<5	24	5.5	2.7	80
28	V	29	83	60	95	97	120
29	W	<8	<8	25	3.6	1.9	=
30	Y	20	17	76	24.2	21	90
31	Zn	28	63	124	50	67	=
32	***Zr***	***189***	***71***	***367***	***274.5***	***193***	***150***

Note: [a]KC6- peloid of Turkish spa [18]; [b] composition of the continental crust [19]; [c]refers to the deep-water clay mean value [20].

are lower than those of KC-6 peloid in Turkey.

We determined total content of minerals in the peloids from the three lakes by X-ray diffraction analysis. The mineralogical analysis results are shown in Figs. 1-3 and Table 4. The results of mineral analysis show that the peloid from Khag and Shaazgai lakes contain predominantly tectosilicates, while that from Lake Ikhes contains phyllosilicates, carbonates, halite and gypsum. The peloids studied belong to the polymineral group.

There is a difference between the lake's mud relating to physico–chemical maturated conditions and features of chemical elements transformation. Moreover, we can see that mineralogical content of some lakes originate from various geological conditions.

Table 4. Mineralogical composition of the peloids investigated, % .

Mineral class[a]	Mineral name		Group	Mineral formula	content of mineral, %		
					1	2	3
Silicates	Tecto-silicates	Albite	Feldspar	$Na_2AlSi_4O_8$	20	9.8	43.3
		Anorthoclase		$(Na,K)(Si_3Al)O_8$	15.8		4.4
		Quartz	Quartz	SiO_2	58.9	11.9	42.1
	Phyllo-silicates	Muscovite	Mica	$KAl_2\ (Si_3Al)O_{10}(OH)_2$		18.7	
		Kaolinite	Clay minerals	$Al_2Si_2O_5(OH)_2$		1.2	
Carbonates	Calcite		Calcite	$CaCO_3$	1.3	7.6	10.2
	Kutnohorite		Dolomite	$Ca(Mn,Mg)(CO_3)_2$			
	Ankerite			$CaMg_{0.32}Fe_{0.68}(CO_3)_2$		5.4	
Sulfates	Gypsum		Sulfate	$CaSO_4 \cdot 2H_2O$		22.4	
Chloride	Halite		Chlorite	NaCl		23.1	
Vanadite	Milanovanadite		Vanadite	$CaV_4O_{10}(H_2O)_5$	4.1		
				$\sum$	100	100	100

Note:[a] classification of minerals [26], 1-peloid from Khag lake, 2- peloid from Ikhes lake, 3- peloid from Shaazgai lake

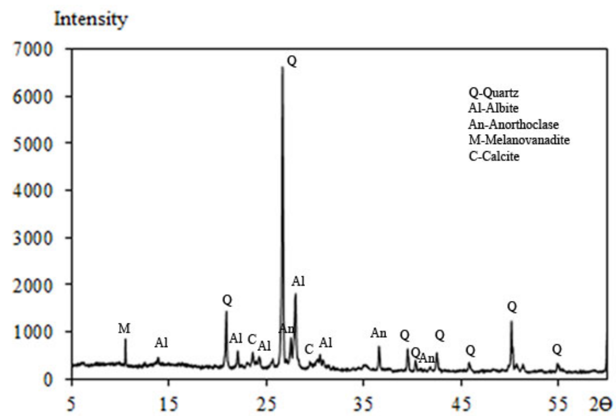

Fig 1. XRD pattern of the peloid from Khag lake.

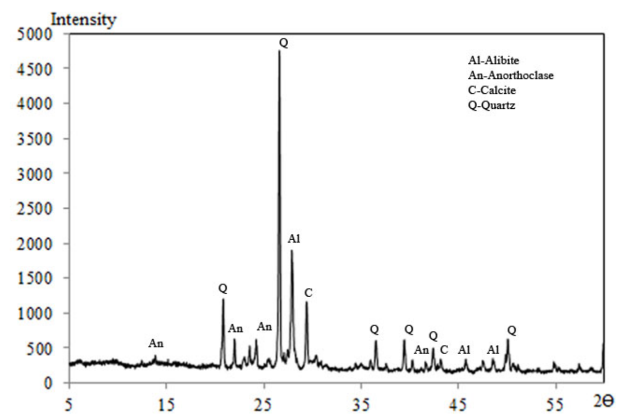

Fig 2. XRD pattern of the peloid from Shaazgai lake.

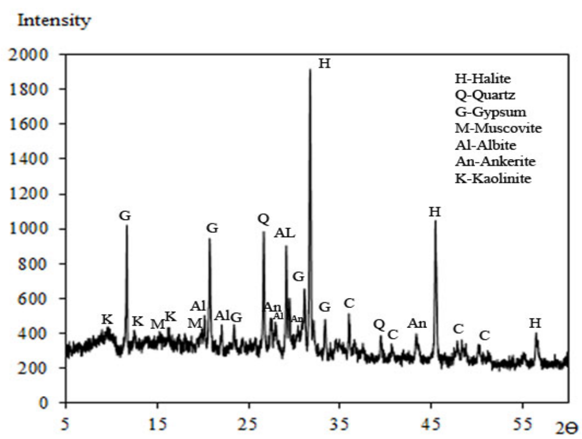

Fig 3. XRD pattern of the peloid from Ikhes lake.

CONCLUSIONS

The peloids studied are of a dark grey color, have a density of 1.55 g/cm^3 - 1.93 g/cm^{3,} and provid pH values in the range 7.17 - 8.09. They contain 21.22 % - 44.3 % of moisture, 0.19 % - 0.24 % of H_2S, 1.21 % - 1.45 % of C_{org}. They are found meeting the balneological requirement, while belonging to silt sulphide muddy type according to the international classification.

The peloids from Khag and Shaazai lakes contain predominantly tectosilicates and phyllosilicates, while that from Lake Ikhes contains mainly phyllosilicates, carbonates and gypsum. According to the mineralogical compositions, the peloids belong to the poly-mineral group. Furthermore, the peloids mineralogical content from some lakes refers to origination under various geological conditions.

The major elements of the peloids are related to their mineralogical composition. The peloids from Khag and Shaazgai lake contain predominantly tectosilicates, which accounts for SiO_2 present. They contain also albite and anorthoclase which determine MgO presence. The peloid from Lake Ihkes contains mainly carbonates (calcite and ankerite) and gypsum, which are responsible for CaO and MgO presence.

The Na_2O/CaO ratio of all peloids investigated is lower than 1.0, which is an evidence of non-swelling clay minerals presence. The chemical analysis data shows that these peloids are Ca-Mg type. The content of Al_2O_3, Fe_2O_3 and Na_2O in all samples is lower than that of the continental crust, while the content of SiO_2, CaO, MgO, K_2O, TiO_2, MnO and P_2O_5 is higher in some samples. The general characteristics and the composition of the peloids studied are in in correspondence with those of the balneological requirements.

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