STUDY OF CLAY MINERALS AND TRACE METALS COMPOSITION OF SUSPENSIONS IN WATER COLUMN OF VANDA LAKE IN ANTARCTICA

YU Sheng-song[1], GREEN W.J[2].

(1. *Qinghai Institute of Salt Lakes, Chinese Academy of Science, Xining 810008, China*;
2. *School of Interdisciplinary Studies, Miami University, U.S.A*)

Abstract: Clay minerals in the suspension are illit, 64～67%; chlorite, 25～30%; montmorillonite, 5.9～6.6% and Kaollite rare. Clay minerals in the suspension are similar to these in the Onyx River and the lake bottom sediments. The clay mineral content in the suspensions in the upper fresh water is not clearly realated to the water depth, the clay contentis very low and no chlorite is found at depth of 65m. With the increase of water depth, distribution coefficient (Kp) of the trace metals decreases gradually. The suspension controls the vertical immigration of trace metals in the lake water. The trace metal content sequence in the suspension are: Cu>Cr>Ni>Co>Cd. In the upper 60m, trace metals are mainly bound on the silicate minerals, man ganes oxide and ion oxyhydrate particles; under 60m deep, they are mainly bound on organics and silicate minerals.

Key words: **Vanda Lake; Suspension; Clay mineral; Trace metal**

Clc number: **P**512,2 **Document code**: **A** **Article ID**: 1008－858**X**(2002)02－0010－08

1 The General Description of Vanda Lake

Vanda salt lake (77°32′S, 161°31′E) is located in the Wright Valley of the Transe Antarctic Mountains. Around the lake, it is Mesozoic and Paleozoic granites which are covered by sand and dolerite, and lamprophyre intruded. The water surface is covered by a 4－m－thick ice cover in the whole year, and the ice surface is about 123m a.s.l.. Vanda Lake is a typical dimictic lake, and the lake water can be divided into two layers, that 0－54m deep is fresh water. while that below becomes progressively brine. The Onyx River originating from the Wright Lower Glacier is the only surface discharge source of this close basin. The river discharges to the lake from eastern side of the basin during a six－week period from mid－December to early Febuary of next year with an annual discharge rate of about 2×10^9L.

Vanda Lake is a chloride evaporation salt－accumulating type salt lake. H_2S occurred at a depth of

收稿日期: 2002－02－02
基金项目: 美国科学基金项目(NSF)
作者简介: 于升松(1941－), 男, 研究员, 博士生导师。主要从事盐湖地球化学研究。

60m and the H_2S concentration increases with the water depth; 65m, 726.8μmol/l. The concentration of dissolved oxygen decreases with the increasing of weter depth, in the upper fresh water, it is 536μmol/l; and the dissolved oxygen disappeared from 57m to the bottom of the lake.

2 The Sampling, Processing and Measurement

Lake water samples were collected near the major depression toward the western end of the lake in 1986. Above 45m deep, the sampling interval is 10m; down from 45m, the interval is 1m. The samples from the Onyx River were obtained in permanent "V"—notch weir of approximately 1km upstream

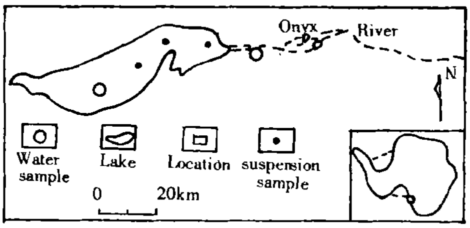


Fig. 1 Sampling Locations on Vanda Lake

from the lake (Fig. 1). At the same year, the particle traps were deployed respectively at the depth of 12m, 32m, 45m, 48m, 60m and 65m in four places alongthe east—west long axe of the lake. The particle traps were picked up in 1988. 0.2μ pore size millipore filters was used under 10 atmospheric pressure N_2 gas to obtain the suspensions. The clay grading samplesl in lake bot tom and river were collected by method of sedimentation separation. The samples of sinking particles were treated by the six—step continuous chemical extraction developed by Tessier, A. and Solomons, W. and Forstner, U.. The analyses of trace matals in the samples were performed on an IL951 graphite furnace PE3030 AAS. Clay minerals were identified on a D/max—III_BX—ray.

3 The Flow Volume of Suspensions in the Lake Water

The flow volume of suspensions in the lake water: water depth 12m, 119.673 $mg/cm^2 \cdot a$, 32m, 67.93 $mg/cm^2 \cdot a$, 45m, 15.82 $mg/cm^2 \cdot a$, 48m, 9.46$mg/cm^2 \cdot a$, 60m, 13.55 $mg/cm^2 \cdot a$, 65m, 30.33 $mg/cm^2 \cdot a$ (Fig. 2).

sedimentation rate ($mg/cm^2 \cdot a$)

(1) The flow volume of suspension in lake water decreases far from the Onyx River mouth; (2) In the upper fresh water, the flow volume decreases with the increase of water depth, in the lower brine, it increases with the increase of water depth; (3) The flow volume in the upper oxyen environment is larger than that in the lower reduction environment. The

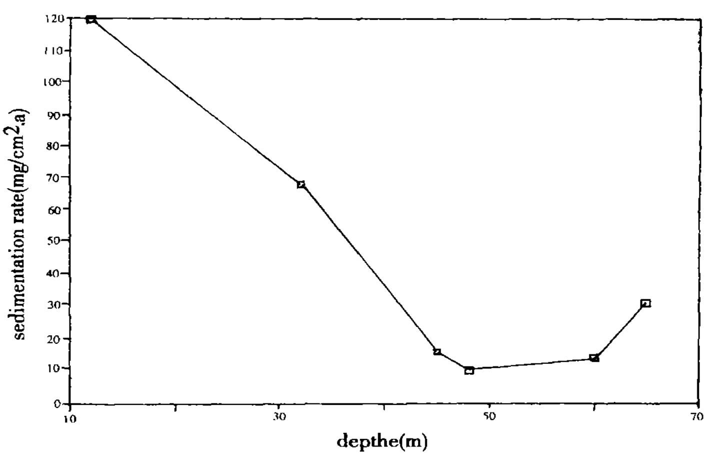


Fig. 2 Sedimentation rate in Vanda Lake

flow volume of suspension is closely related to the lake water feature, the number, discharge rate of the river, and also the feature of the surrounding soil and vegetable cover of drainage area. The flow volume of suspension in Vande Lake is smaller than that in Qinghai Lake, China.

There are four coming sources of suspensions in Vanda Lake: (1) Weathered base rocks brought by the Onyx River water; (2) Soil on the lake shore brought by strong wind to the lake or ice; (3) Dusts droped from the atmosphere; (4) Self grown sulphate and calcium carbonate and sulphate in the lake.

4 Clay Mineral Composition in the Suspension

Mineral composition in the suspension: (1) Clastic rock minerals are mainly fieldspar, quartz, pyroxene and mica; (2) Clay minerals are illit, 64~67%; chlorite, 25~30%; montmorillonite, 5.9~6.6% and Kaollite rare. Clay minerals in the suspension are similar to that in the Onyx River and the lake bottom sediments (Fig. 3). The clay mineral content in the suspensions in the upper fresh water are not clearly related to the water depth, the clay content is very low and no chlorite were found at depth of 65m.

5 Trace Metals in the Suspension

5.1 The Vertical Variation of Trace Metal Concentration in Lake Water

There is a clear regularity in the variation of trace metal concentrationsa the Vanda Lake water goes deep. The curve of the concentration can be expressed as "s", that is, with the increasing of water depth, four zones can be divided from theconcentration of trace metals in the lake water (Fig. 4). Zone Ⅰ: the trace metal concentration is the lowest, and the variation is very small, belonging to oxygenated environment fresh water with a low trace metal concentration; Zone Ⅱ: the concentration of trace metal increases sharply with water depth, and the variation is also great, belonging to the first chemocline water of higher trace metal concentration; Zone Ⅲ: the water has the highest trace metal concentration, but the lowest variation range, belonging to brines of high trace metal concentration; Zong Ⅳ: the trace metal

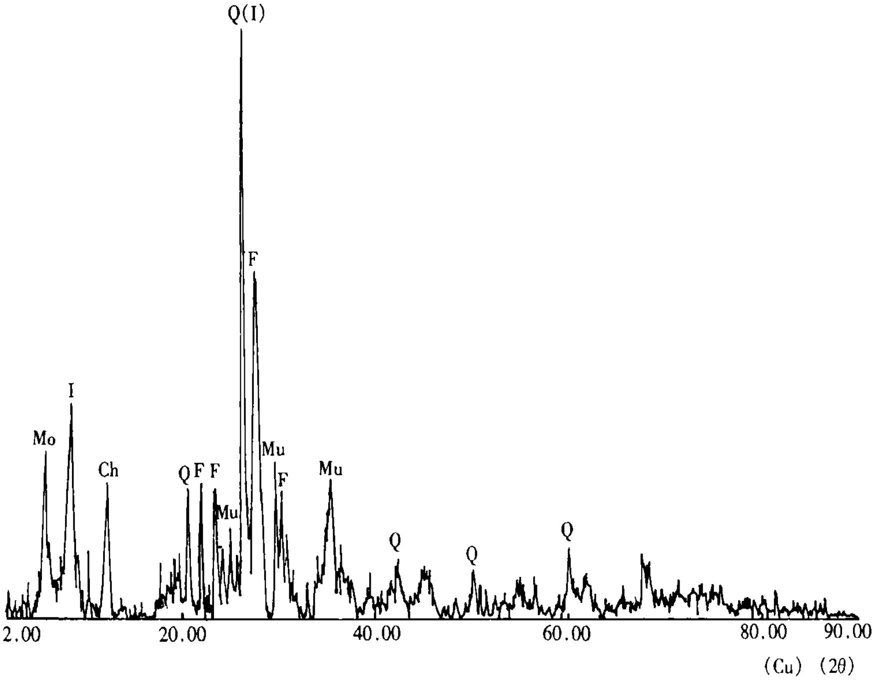


Fig. 3(a) X-ray analyses of sediment in Onyx river

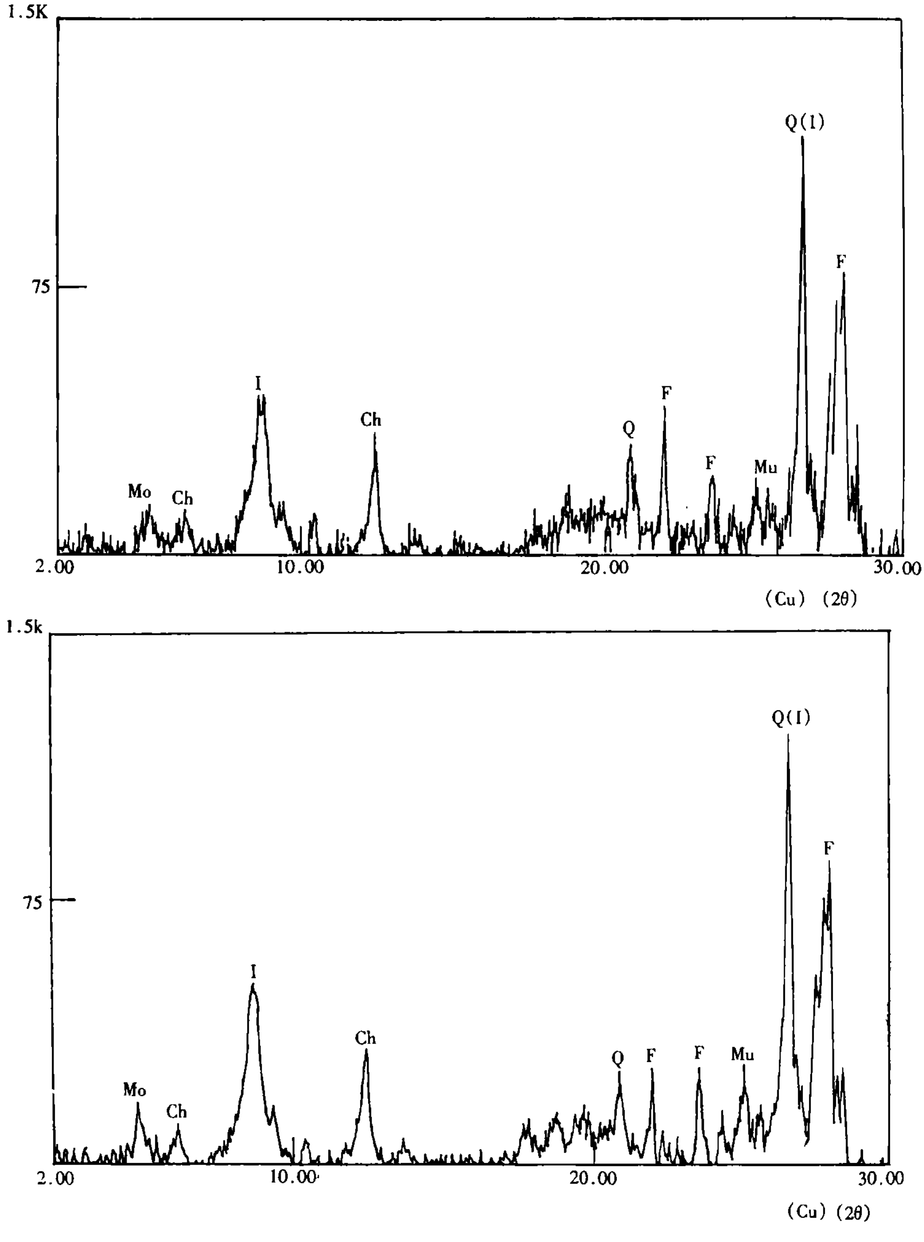
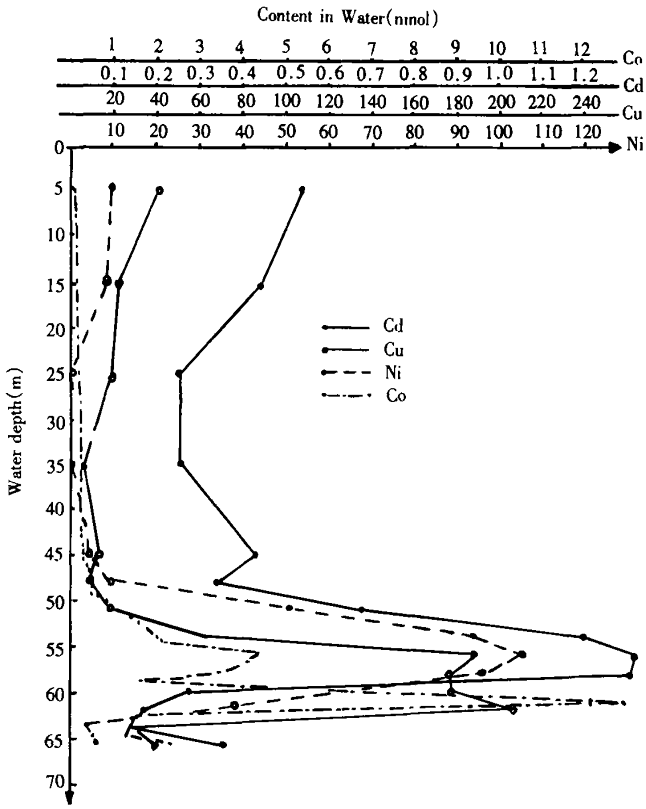


Fig. 3(b)　X-ray analyses of suspension in Vanda Lake water (upper, 12m, lower, 32m)
Mo—montmorillonit, Ch—chlorite, I—illit, Q—Quartz, F—Fieldspar, Mu—Mica.

Table 1 Comparision of Concentration of Trace Metatls Between Lake water and Sinking Particles

Depth(m) / Items			12	32	45	60	65
Specific gravity of water			0.999	0.999	0.999	1.04	1.07
Cr	sinking particles	Q	120×10^{-3}	67×10^{-3}	14×10^{-3}	8×10^{-3}	30×10^{-3}
		C_1	54.3	44.9	53	13.2	7.4
		T	6.5	3.0	0.74	0.11	0.22
	lake water	C_2	5.1×10^{-5}	4.4×10^{-5}	9.2×10^{-5}	7.2×10^{-4}	4.2×10^{-4}
		$\log C_2$	−4.3	−4.4	−4.0	−3.1	−3.4
	coefficient	$P(=C_1/C_2)$	1.1×10^{6}	1.0×10^{6}	5.8×10^{5}	1.8×10^{4}	1.76×10^{4}
		$\log P$	6.0	6.0	5.8	4.3	4.2
Cu	sinking particles	Q	120×10^{-3}	67×10^{-3}	14×10^{-3}	8×10^{-3}	30×10^{-3}
		C_1	119.3	118.7	142.8	49.6	17.6
		T	14.3	8.0	2.0	0.36	0.53
	lake water	C_2	1.4×10^{-3}	3.9×10^{-4}	8.1×10^{-4}	1.1×10^{-2}	4.3×10^{-3}
		$\log C_2$	−2.9	−3.4	−3.1	−2.0	−2.4
	coefficient	$P(=C_1/C_2)$	8.5×10^{4}	3×10^{5}	1.8×10^{5}	4.5×10^{3}	4.1×10^{3}
		$\log P$	4.9	5.5	5.3	3.7	3.6
Ni	sinking particles	Q	120×10^{-3}	67×10^{-3}	14×10^{-3}	8×10^{-3}	30×10^{-3}
		C_1	53.4	50.2	59.8	13.4	6.7
		T	6.4	3.4	0.84	0.11	0.20
	lake water	C_2	5.3×10^{-4}	2.0×10^{-5}	2.8×10^{-4}	3.4×10^{-3}	2.7×10^{-4}
		$\log C_2$	−3.3	−4.7	−3.6	−2.5	−3.6
	coefficient	$P(=C_1/C_2)$	1.0×10^{5}	1.7×10^{5}	2.1×10^{5}	3.9×10^{3}	2.5×10^{4}
		$\log P$	5.0	5.2	5.3	3.6	4.4
Co	sinking particles	Q	120×10^{-3}	67×10^{-3}	14×10^{-3}	8×10^{-3}	30×10^{-3}
		C_1	23.9	19.4	19.8	4.3	2.4
		T	2.87	1.30	0.28	0.03	0.07
	lake water	C_2	3.1×10^{-6}	1.5×10^{-5}	1.5×10^{-5}	3.2×10^{-4}	7.2×10^{-5}
		$\log C_2$	−5.5	−4.8	−4.8	−3.5	−4.1
	coefficient	$P(=C_1/C_2)$	7.7×10^{6}	1.3×10^{6}	1.3×10^{6}	1.3×10^{5}	3.3×10^{4}
		$\log P$	6.9	6.1	6.1	5.1	4.5
Cd	sinking particles	Q	120×10^{-3}	67×10^{-3}	14×10^{-3}	8×10^{-3}	30×10^{-3}
		C_1	1.43	1.51	1.83	0.37	0.36
		T	0.17	0.10	2.6×10^{-2}	3×10^{-3}	10.8×10^{-3}
	lake water	C_2	1.7×10^{-4}	1.0×10^{-4}	2.6×10^{-5}	2.9×10^{-6}	1×10^{-5}
		$\log C_2$	−3.8	−4.0	−4.6	−5.5	−5.0
	coefficient	$P(=C_1/C_2)$	8.4×10^{3}	1.5×10^{4}	7×10^{4}	1.3×10^{5}	3.6×10^{4}
		$\log P$	3.9	4.2	4.9	5.1	4.6

Note: Q, Sinking particle flow of lake water($g/cm^2\cdot a$). C_1, C_2, the element concentration of sinking particles and lake water($\mu g/L$). T, total concentration of sinking particles($\mu g/cm^2\cdot a$)



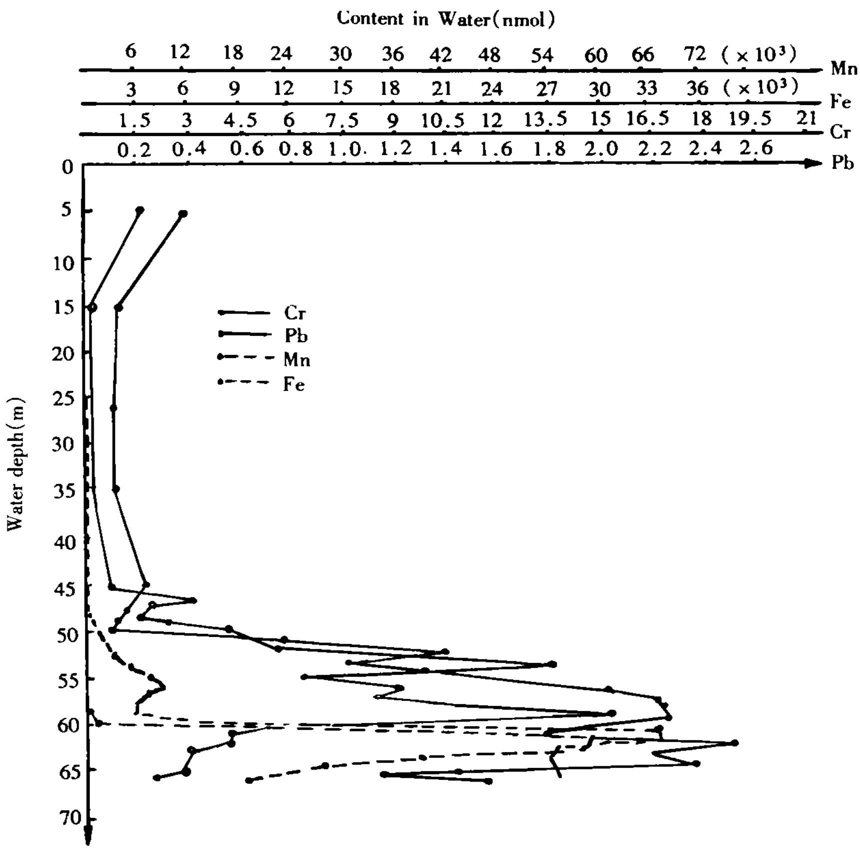


Fig. 4(a) The vertical variation of Cu, Co, Ni, Cd concent, in Vanda Lake water (lower).

The vertical variation of Fe, Mn, Pb, Cr concent in Vanda Lake water (upper).

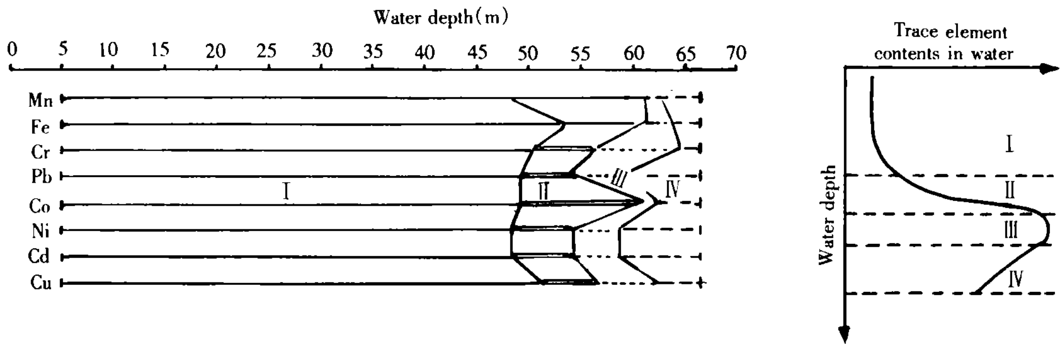


Fig.4(b) The zones of the vertical variation of trace metal concent, in Vanda Lake water

concentration decreases greatly with water depth, and the variation range becomes large, belonging to the second chemocline reduced environment brine of middle trace metal content, In general, (1)the trace metal concentration is low in the upper fresh water and lower brines, and higher in the middle lake waterlayer; (2)for the content of all trace metals in water, although there is a small difference in the distribution of water of the four zones, the general tendency is the same; (3) the water depth distribution of Zone Ⅰ is largest, the water layer is up to 54m thick, zones Ⅱ, Ⅲ, Ⅳ distributions are relatively small.

5.2 Trace Metals in the Suspensions of Lake Water

The geochemical activities of trace metals in the suspensions: (1) With the increase of water depth, trace metal content (C_1) decrease gradually, while the trace metal content in lake water increase, from 54~60m, because of the dissolution of salid particles, the trace metal content in the lake water increases greatly, under 60m deep, the trace metal content in lake water decrease dur to the formation of trace metal sulphate, but it is still higher than that in the upper water. With the increase of water depth, distribution coefficient (Kp) decrease gradually (Tab. 1). The suspension controls the vertical immigration of trace metals in the lake water; (2)The trace metal content sequence in the suspension are: Cu>Cr>Ni>Co>Cd. In the upper 60m, trace metals are mainly bound on the silicate minerals, manganes oxide and ion oxyhydrate particles; under 60m deep, they are mainly bound on organics and silicate minerals; (3)Residence time of trace metals in the lake water: Cr>Cu>Cd>Ni>Co.

References

[1] Green, W.J.& Confield, D.E. Geochemistry of the Onyx river and its role in the chemical evolution of Lake Vanda [J]. Geochimica et Cosmochimica Acta, 1984, 48: 2460.

[2] Murray, J.W., Berry Spell & Barbara Paul. Trace Metals in Sea Water[M]. 1981, 643-648.

[3] Truesdell A.H.& Jones, B.F. [J]Jour. Research U.S. Geol. Survey, 1974, 2(2): 233.

[4] Green, W.J., Canfield, D.E., Fred Lee, G.& Anne Jones, R. Mn, Fe, Cu and Cd distributions and residence time in closed basin lake Vanda [J]. Hydrobiologia, 1986, 134: 240.

[5] Yu shengsong. The hydrochemical features of salt lakes in Qaidam basin [J]. Oceanologia et Limnologia Sinica, 1984, 15: 383-403.

[6] Yu shengsong, Green, W.J. Trace metals in Vanda lake in Antarctica [J]. Science in China (Series B), 1992, 35, 1399-1404.

南极洲万达盐湖水的悬浮物中的粘土矿物和痕量金属组成的研究

于升松[1]， W.J.格林[2]

(1.中国科学院青海盐湖研究所,青海 西宁 810008;2.美国迈阿密大学,边缘科学系)

摘要:南极洲万达盐湖水中悬浮物的流量:水深12m,119.673mg/cm^2•a;32m,67.93mg/cm^2•a;45m,15.82mg/cm^2•a;48m,9.46mg/cm^2•a;60m,13.55mg/cm^2•a;65m,30.33mg/cm^2•a。

湖水悬浮物中粘土矿物主要为伊利石,含量64～67%,次为绿泥石,含量25～30%,蒙脱石仅含5.9～6.6%,而高岭石含量极低。

湖水悬浮物中痕量金属的含量:水深12m,Cr 54.3μg/g、Cu 119.3μg/g、Ni 53.4μg/g、Co 23.9μg/g、Cd 1.43μg/g;32m,Cr 44.9μg/g、Cu 118.7μg/g、Ni 50.2μg/g、Co 19.4μg/g、Cd 1.51μg/g;45m,Cr 53μg/g、Cu 142.8μg/g、Ni 59.8μg/g、Co 19.8μg/g、Cd 1.83μg/g;60m,Cr 13.2μg/g、Cu 49.6μg/g、Ni 13.4μg/g;Co 4.3μg/g、Cd 0.37μg/g;65m,Cr 7.4μg/g、Cu 17.6μg/g、Ni 6.7μg/g、Co 2.4μg/g、Cd 0.36μg/g。

悬浮物中痕量金属含量高低顺序:Cu>Cr>Ni>Co>Cd。

在水深60m以上,悬浮物中痕量金属主要被束缚在硅酸盐、锰的氧化物及铁的氢氧化物悬浮物颗粒上,在水深60m以下,则主要被束缚在硅酸盐矿物及有机质颗粒上。

关键词:万达湖;悬浮物;粘土矿物;痕量金属