CHINESE GEOGRAPHICAL SCIENCE
Volume 5, Number 2, pp. 185-192, 1995
Science Press, Beijing, China

POSSIBLE HYDROGEOCHEMICAL PRECONDITIONS FOR KASHIN-BECK DISEASE IN TRANSBAIKALIA

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ABSTRACT: In the basin of the Amur River at the territory of Russia, in the northern regions of China and Korea the osteal-articulate disease of people and animals, well known as Kashin-Beck disease is spread. About 20 hypotheses had been suggested for explaining the disease causes, some of them are briefly introduced. The hydrogeochemical researches in Transbaikalia, Russia, showed that natural water of the endemic areas have several features in chemical composition, some of them are considered by existing hypotheses as the causes of the disease, others do not concern the possible etiologic factors of the disease for the present. The author examines these features respectively.

KEY WORDS: Kashin-Beck disease causes, endemic disease, Transbaikalia of Russia

In the basin of the Amur River at the territory of Russia, in the northern regions of China and Korea the osteal-articulate disease of people and animals, well-known as Kashin-Beck disease is spread. It also got the name of Urov endimia owing to the river Urov in Transbaikalia, in the valley of which that disease had been studied for the first time by N. I. Kashin in the middle of the last century.

The disease appears usually at childhood age and at the first period it is taking latently, without pronounced signs of pathological process. With age it is growing progressively worse and at the most serious stage it shows itself in the change of skeleton proportions. Expect of usual sharp bulges and deformation of joints it may be the so-called "bear paw", shortened extremities, etc. Sick people get tired quickly, complain of a muscular weakness, sharp reduction of efficiency, steady joint and muscular pains, cramps. The disease has a natural-nidi character, in this connection in the thirties — sixties of the current century in Transbaikalia inhabitants of the areas exposed to the disease most of all were resettled to other

places. So at present only people of elder age may have serious forms of the disease.

About 20 hypotheses had been suggested for explaining the disease causes, but the biogeochemical hypothesis of A. P. Vinogradov (1949) obtained the greatest recognition. He explained the disease by deficiency of calcium with some abundance of strontium in landscape components, including drinking waters. On these grounds the hydrogeochemical sign of unfavourable area in respect of Kashin-Beck disease is a low (under 100) ratio of Ca and Sr concentrations in waters. Other authors, supporting the biogeochemical hypothesis, consider other factors as the causes of the disease. In particular, Chinese researchers consider the organic matters of the group of humic acids, dissolved in water, which prevent directly or indirectly the sulphur exchange in a living body[1] as a possible factor of the disease. Also there were suppositions about the fluorine-lithium nature of the disease[2]. Last years a new hypothesis was suggested, it explained this disease was caused by phosphorus and manganese intoxication of the organism in consequence of redundant contents of these elements in rocks, soils, plants and waters[3-4].

Our hydrogeochemical researches of the region in Transbaikalia where the Kashin-Beck disease is spread showed that natural waters of endemic areas have some features in chemical composition. Some of them are considered by existing hypotheses as the causes of the disease, others do not concern the possible etiologic factors of the disease for the present. Let us examine these features.

Chemical and microcomponental composition of waters is formed under the influence of landscape-climate and frosty-hydrogeological conditions and the geological structure of territory.

The researched region is situated in the south eastern Transbaikalia, in a country between two rivers, Shilka and Argun, River Amur springs from their confluence. The area belongs to the mountainous-taiga and forest-steppe landscape-climate zones and it is characterized by broad development of marsh landscapes. Marshes are situated in the river valleys, gentle slopes of watersheds, and in many respects they are conditioned by permafrost. As for marshes, in their turn, they favour formation and conservation of frozen rocks. Thickness of permafrost increases in the north direction from 20—30m till 80—100m. Meltrocks are spread in the separation nature zone and in the arid slopes, closer of south exposition. Authors of the new hypothesis refer permafrost and presence of marshes to the criteria of region trouble from point of view of Kashin-Beck disease, explaning that correlation by accumulation of P and Mn compositions in soils and waters in connection with laboured outflow of soil colloids.

The territory of distribution of Kashin-Beck disease is composed of the Lower Proterozoic and Phanerozoic stratified and intrusive formations.

Lower Proterozoic metamorphic rocks such as gneisses, crystalline schists and marbles are spread in limited areas and are exposed in swells of the Pre-Cambrian basement within granite-gneiss domes, in the axial parts of watersheds.

Sedimentary deposits of the Vend-Cambrian age incorporated into the Argun series cover considerable areas filling large troughs between granite-gneiss domes. The lowermost strata (Urov suite, $V-\epsilon_1$ ur) and the uppermost strata (Altachin suite, ϵ_{1-2} al) of the section are terrigene composition with prevailing aleurolites and sandstones and weak developed carbonate rocks, while in the middle part of the section (Bystrin suite, ϵ_1 bs) dolomites and limestones are sharply predominated, and terrigene rocks are subordinated.

Volcanogenic rocks dominate in the structure of Mesozoic formations. Volcanites of the Shadoron Series (J_{2-3} sd) presented by the lower, dominantly andesite-basalt and upper liparite-dacite rock masses fill small troughs and tectonic blocks elongated towards the north east in accordance with the general strike of geological structures. The Undin-Dain tuffuceous-sedimentary series (J_3 und) composed of conglomerates, sandstones, aleurolites, their tuffuceous varieties and acid tuffs and tuffites is restricted in the near-bank parts of Late Mesozoic troughs which cover about one third of the territory of the region. The given series rocks are overlapped by sedimentary volcanogenic formations of the Turgin series that incorporates the Gidarin (J_3-K_1 gdr) and Godymboy (J_3-K_1 gd) suites. The first of these suites consists of dominant volcanites, the composition of which changes successively from basis through medium and moderate-acid to acid. The second suite includes effusions of contrast and esite-basalt and liparite compositions. Terrigene sediments are weakly presented in the sections of both suites. The Turgin series rocks fill the Late Mesozoic superimposed troughs.

Among intrusive rocks, in which granitoids predominate, Early Proterozoic (γ PR_1) and carbonaceus (γ C) rocks forming large granite massives, cover the largest areas. Mesozoic granitoids form a number of small massives and stocks.

The geochemical background of the territory is characterized by higher phosphorus and boron concentrations in rocks of almost all of stratified and intrusive complexes. The maximum coefficient of the phosphorus concentration (16.7 clark) is established in effusions of basic composition in the lower strata of the Godymboy suite. Phosphorus contents reach 10.3 clark in sandstones and aleurolites of the Undin-Dain series at separate places along the left bank of the Urov River. Approximately the same level of phosphorus is established also in effusions of the lower strata of the Gidarin suite in this region. Phosphorus anomalies in rocks of this suite are less intensive in other places. Phosphorus concentrations much exceed a clark in rocks of the Shadoron series (up to 5.9 clark), Lower Proterozioc slates and carbonate deposits (5—8 times). Granitoids

are also not an exception, phosphorus contents reach 4.0 clark in granites of the Early Proterozoic and 6.7 clark in granosyenites of the Mesozoic.

Among metals, higher lead concentrations occur more often than others. The highest background of this metal is observed in effusions of the Godymboy suite and the Shadoron series (up to 5.7 and 4.6 clark, respectively). The territory is characterized by the wide development of ore mineralization, especially the lead-zinc one, also causes numerous geochemical anomalies. Manifestations of phosphorites are known in Cambrian rocks.

Rock composition has a great influence on the distribution of chemical ingredients in waters (Table 1). By degree of mineralization underground and surface waters of the researched region are fresh, their composition is almost exclusively hydrocarbonate, two-or three componens by cations, among which calcium predominates. Simulteneously with the increase of aridness of climatic conditions the total mineralization and pH value increase, the equilibrium degree of waters and contained rocks is changed.

Geochemical features of natural waters of the area of Kashin-Bec endemia based on last research results are described in our publications[5-6]. The most remarkable feature of the most of areas, striken by the disease, is the presence of hydrogeochemical phosphorus anomalies. A great amount of data of Southeastern Transbaikalia (more than 500 tests) were analysed. And on their base the value 0.1 mg/l was referred to abnormal. The maximum content of P reached 3.46 mg/l, it was determined in marsh waters in one of the most heavy nidi from the point of view of disease. In springs of drinking water, which we had tested, P concentrations did not exceed 0.24 mg/l. But not in all cases abnormal P content is typical for springs of drinking water in endemic localities. In such situations the nidi of endemia could be at the used agricultural lands, beyond the localities of constant living.

Calcium content in abnormal waters from point of view of P is rather lower than that in the region on the average (Table 1). But often in Transbaikalia waters with lawer Ca concentrations are used for the economic-drinking objects. But with such conditions, Kashin-Beck disease does not develop. Obviously that breach of calcium-phosphorus exchange, consequence of which is the disease, can be caused not so much by Ca and P content as by their ratio. In waters of endemic localities it did not exceed 250—300 with the most low values in dozens of units, while by the background values of P it reaches some thousands of units. Low values of this ratio with the P content of 0.1 mg/l and more of it, can be considered as a forecasting hydrogeochemical criterion of unfavourable area from point of view of Kashin-Beck disease.

A. P. Vinogradov has noticed that endemia does ot reveal if villages

Table 1 Average contents of macro-and micro-components in natural waters of the Urov biogeochemical region

Index	Geological index of water-bearing rocks								Extracts	
									For effusion-sedimentary rocks	
	$\in_2$bs	$\in_{1-2al}$	V_2-$\in$ur	$\gamma\in_1$, γJ_{2-3}s	J_{2-3}šd	J_3und	J_3-K_1gdr	J_3-K_1gd	Total	Total	P≥0,1mg/l
n	26	27	24	35	33	14	8	9	286	133	31
pH	7.44	7.55	7.58	7.48	7.45	7.38	7.36	7.19	7.4	7.29	7.38
CO_2	8.2	7.2	6.3	8.7	6.3	6.3	8.0	6.3	7.4	7.1	9.4
HCO_3^-	385.0	244.7	187.9	227.9	177.7	231.5	136.7	173.2	208.0	163.0	154.9
CO_3^{2-}	6.6	1.8	0.6	3.1	1.0	10.7	1.4	3.4	2.4	2.2	10.4
SO_4^{2-}	51.3	33.1	2.2	15.4	7.6	5.0	5.9	7.9	15.7	7.3	22.5
Cl^-	5.5	4.6	0.9	6.0	1.7	3.0	2.6	5.6	3.5	3.4	6.5
F^-	0.40	0.37	0.55	0.54	0.29	0.37	0.39	0.38	0.41	0.38	0.41
Ca^{2+}	73.0	39.0	28.0	50.6	33.7	63.0	27.5	28.2	38.6	31.7	29.6
Mg^{2+}	60.1	27.9	22.2	25.4	18.4	37.2	9.4	16.2	23.0	15.4	11.6
Na^+	6.5	4.4	6.2	10.2	10.3	18.9	18.1	14.2	11.9	16.5	17.4
K^+	1.5	0.9	1.1	2.0	0.8	1.6	1.3	1.8	1.4	1.6	2.7
Sum	579	356	259	339	258	337	208	248	304	240	240
Si	4.7	4.6	3.6	2.9	5.8	11.2	8.1	11.4	6.9	9.2	12.0
Oxidab.	8.2	8.9	13.5	9.0	10.5	6.9	10.9	15.8	11.0	12.0	13.6
Ptot.	0.047	0.041	0.055	0.044	0.024	0.055	0.134	0.118	0.084	0.124	0.261
Porg.	0.032	0.028	0.035	0.033	0.024	0.007	0.071	0.050	0.046	0.060	0.107
Sr	0.37	0.18	0.15	0.40	0.46	0.52	0.22	0.21	0.31	0.25	0.21
Zn	36.4	10.2	8.0	60.9	14.7	39.0	15.4	11.4	21.3	16.6	23.5
Cu	4.0	6.7	6.6	4.5	7.6	3.3	6.9	10.2	6.8	8.0	12.9
Pb	5.4	1.1	2.8	4.7	4.2	9.1	3.0	6.0	4.2	5.3	7.4
Ni	2.1	1.4	1.6	2.9	1.7	2.7	1.5	2.0	1.9	1.9	2.1
Co	0.2	0.4	0.9	0.5	1.2	0.2	0.5	0.3	0.5	0.4	0.4
Mo	0.5	0.3	0.4	2.8	0.5	1.9	1.1	0.5	1.0	0.9	1.8
Ca/Sr	272	260	355	394	255	268	240	291	282	265	145
Ca/P	2961	2190	1682	1610	1279	4016	601	689	1297	801	238

Note: From Co_2 to Sr—mg/l; from Zn-μ_0: mg/l

are situated on carbonate rocks. He explained this fact by sufficient calcium content in waters. Really it is too higher on the carbonate rocks. For instance, the average content of Ca (on the rocks of Bystrine suite C_1 bs) was 73 mg/l (Table 1). Migration of P in such waters is limited by calcium bar. We think that is a main cause of more favourable geochemical situation in respect of Kashin-Beck endemia, since chemical elements go to final links of trophic chain (foodstuffs, drinking water) through aqueous-soluble forms. Calcium contents in waters of the region did not exceed 1.67 mg/l, that is much lower rate, adopted for drinking water (7.0 mg/l). In nidi of endemia they were less than those in the region on the whole. The received hydrogeochemical data do not confirm the calcium-strontium hypothesis. The higher Sr content in the ossa of Kashin-Beck sick people can be explained not by it's displace of Ca, but by isomorphous entry of osseous tissue to the apatite molecule in connection with the imbalance of Ca and P in the biochemical consumption.

The difference is clearly revealed in the ratio of mineral and organic forms of P in waters. By background values the organic form predominates. In abnormal tests the role of mineral phosphorus appreciably increases, in selections on J_3 and J_3-K_1, gd and on effusive-sedimentary rocks on the whole (Table 1), it predominates. If a new hypothesis is true, evidently the mineral phosphorus makes that main form, which represents the cause of the disease.

In any case the biological researches revealed, by means of P, the excess of highest rate in blood serum and higher secretions with urine of Kashin-Beck sick people and experimental animals[7].

In the examining region hydrogeochemical anomalies of phosphorus, as most of disease nidi, are related to mesozoic effusives of average and main composition. Presence of such rocks can be the criterion of prognosis of area trouble from the point of view of Kashin-Beck disease.

We have data that manganese contents in waters of endemic areas have not exceeded 0.28 mg/l, while the permissible rate for economic-drinking waters is 0.1 mg/l. But even such concentrations can meet with water a considerable quota of daily physiological requirements for people in that chemical element, equal to 2—4 mg. Judge by value of oxidizement, waters of endemic areas do not differ from waters of nonendemic ones in content of organic matters. This fact casts doubt on the hypothesis about connection of Kashin-Beck disease and entering of organic matters dissolved in water into the human organism. The supposition of Kashin-Beck disease as consequence of fluorine-drinking intoxication also is not confirmed by hydrogeochemical data. Fluorine content in waters in general is lower than optimum (0.5 mg/l), and lithium concentrations on the effusive-sedimentary rocks are minimum (less than 1.0 mg/l) and they do not reach the level typical for

such landscape-climate conditions.

Waters abnormal by phosphorus also have other features of macro-and microcomponental composition. In particular they are distinguished by the most high silicon content (12.0 mg/l) by selection on the average and till 24—28 mg/l in seperate tests. It is well-known that abundance of silicon and deficiency of iodine and coablt causes breach of calcium-phosphorus exchange[8]. Transbaikalia is notable for great deficiency of iodine in fresh underground and surface waters. In the examining region according to some tests content of iodine in waters does not exceed 1.6 mg/l, while sufficient content for drinking waters is 5.0 mg/l[9]. Concentrations of cobalt in waters abnormal by P and S are also law.

Low content of magnesium in waters, which has been determined in endemic area still by Vinogradov A. P., also has influence on the calcium-phosphorus exchange. By abnormal selection it is twice below the average in the region.

Among the rest of macrocomponents it is necessary to mark higher content of Na in abnormal selection than in the area on the average. Use of poor mineralized waters, where Na predominates in cation composition, characteristic for endemic areas, is also may be the cause of osteal-articulate diseases. This fact according to Votschenko A. V.[10], for instance, explains the development of osteoporosis (loosening of ossa) and flat-footedness of children, who have been born and lived for a long time in the regions of Baikal-Amur main line building in the North Transbaikalia, where waters of such cation composition are used for water-supply.

Abnormal selection on heavy metals is marked by Cu, Mo and Pb concentrations which exceed average concentrations in the region. Among these metals Mo has a great role in disease of goat, and increased contents of Pb are found out in ossa of Kashin-Beck sick people.

Thus, the area of spreading of Kashin-Beck disease is marked by hydrogeochemical anomalies of phosphorus, which in many cases are connected with nidi of disease by space. This fact and also data of Mn distribution in waters confirm the biogeochemical validity of phosphate-mangenese hypothesis.

There is no abundance of strontium in waters and other components of landscape, though content of calcium in waters is decreased in endemic areas, it differs little from other areas of Transbaikalia where there is no Kashin-Beck disease. Consequently calcium-strontium hypothesis is not confirmed by modern geochemical data. At the same time natural waters of disease area have a series of supplemantary features of macro-and microcomponental composition, which reflect the total geochemical situation of locality. These features are disregarded by existing hypotheses of Kashin-Beck disease, but they can be supplemantary factors of disease and they must be taken into account when basing and controlling of its hypotheses.

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