モンゴル国バヤンホンゴル県住民の毛髪に含まれる微量成分

村尾　智[1]、Jambaldorj Uramgaa[2]、世良耕一郎[3]、後藤祥子[4]、

Baatar Tumenbayar[2]、Sainbileg Minjin[5]

[1]産業技術総合研究所　地質調査総合センター
305-8567　つくば市東1-1-1

[2] Sans Frontiere Progres
P. O. Box 46/468, Ulaanbaatar-46, Mongolia

[3]岩手医科大学サイクロトロンセンター
020-0603　岩手県滝沢市留が森348-58

[4]日本アイソトープ協会仁科記念サイクロトロンセンター
020-0603　岩手県滝沢市留が森348-58

[5] MICHIKO Foreign Language Training and Translation Center
Barmon Building, Songino khairkhan district, Ulaanbaatar, Mongolia

要旨

近年、モンゴルでは、零細及び小規模な金の採掘（ASGM）が盛んに行われているが、同国では遊牧が伝統的かつ基幹産業であるため、周辺の牧草地や居住地に与えるその影響が懸念されている。そこで、筆者らは、ASGM研究のツールとして実績があるNMCCのPIXEを用いて、バヤンホンゴル県で採掘を行う者および周辺住民の毛髪を分析した。その結果ヒ素と鉛の濃度が高いケースを見出した。ヒ素は最高17ppm、鉛は最高61ppmであった。両元素とも人体への影響が大きいので早急な対策が必要である。

Trace element distribution in hair of local people in Bayanhongor, Mongolia

Satoshi Murao[1], Jambardorj Uramgaa[2], Koichiro Sera[3], Shoko Goto[4], Baatar Tumenbayar[2] and Sainbileg Minjin[5]

[1]National Institute of Advanced Industrial Science and Technology
1-1-1 Higashi, Tsukuba 305-8567, Japan

[2]Sans Frontiere Progres
P. O. Box 46/468, Ulaanbaatar-46, Mongolia

[3]Cyclotron Research Center, Iwate Medical University
348-58 Tomegamori, Takizawa, Iwate 020-0603, Japan

[4]Nishina Memorial Cyclotron Center (NMCC), Japan Radioisotope Association
348-58 Tomegamori, Takizawa, Iwate 020-0603, Japan

[5]MICHIKO Foreign Language Training and Translation Center
Barmon Building, Songino khairkhan district, Ulaanbaatar, Mongolia

1 Introduction

In Mongolia the artisanal/small-scale gold mining (ASGM) is becoming an important livelihood for local communities and also for the jobless people. On the other hand, the nation has sustained the nomadic culture since immemorial and still heavily relies on nomadism. Thus it is a pressing need to understand whether the ASGM poses health risk to the human and animals. The information is vital to the local government and communities to protect the health, environment and livestock farming in nomadic country like Mongolia. Based on this background the authors focused on the trace element distribution of human hairs utilizing the NMCC's PIXE analysis which has contributed to the ASGM issues for many years[1-3].

2 Study area

The survey was conducted in Bayanhongor Province, one of the most productive region of gold in Mongolia. Most of the gold is produced by the ASGM with rudimentary tools and elementary technology

(Fig. 1). Some groups of miners use a common facility where they can extract gold without using mercury (Fig. 2) but many are still using amalgamation method. Mercury is often smuggled from China and Russia and it is difficult to control the illegal trade.

The authors visited a mining site in September 2015 where they do not use mercury and also a food shop near the said site. After explaining the purpose of the study to and getting the consent from the people hair samples were collected according to the NMCC's protocol[4].

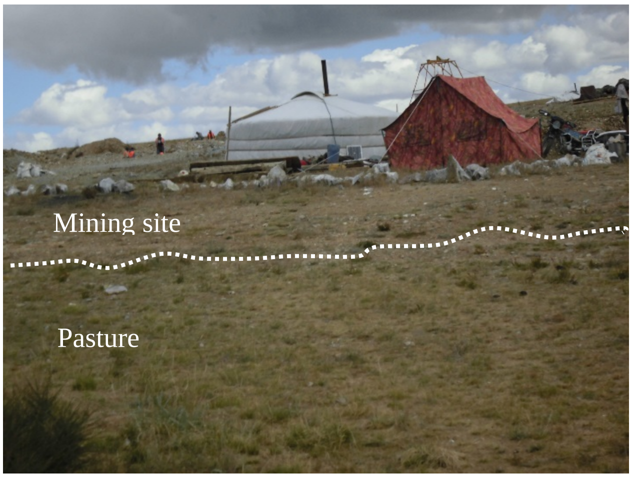

Fig. 1 Typical condition of ASGM in Mongolia

Fig. 2 An example of common ore dressing plant

3 Hair analysis

Seven male Ninjas, a female Ninja, a male herder, a female harder and a female cook donated the scalp hair to the authors. A strands of hair from each person was fixed on the sample holder, cleaned with aceton and then set in the vacuum chamber. The targets were bombarded with a 2.9 MeV proton beam extracted from a small-sized cyclotron at NMCC, and the emitted X-rays were simultaneously measured with two Si(Li) detectors. X-ray absorbers were used for the No. 1 detector. 500-μm-thick Mylar film was used for the food, while 300-μm Mylar was used for the hair samples.

According to the analysis the range of arsenic is from the detection limit (about 1ppm) to 17ppm and of mercury from the detection limit (about ppm) to 12ppm. Lead showed a range up to 61ppm (Table 1).

4 Discussion

The study showed that mercury contamination is not serious in the area but attention should be paid to the arsenic and lead poisoning (Table 1).

Arsenic anomaly was noticed both for three Ninjas and a herder. Long-term exposure to arsenic in drinking water can cause cancer in the skin, lungs, bladder and kidney. It can also cause other skin changes such as thickening and pigmentation. Exposure to arsenic in the workplace by inhalation can also cause lung cancer. Additional survey is a pressing need in the prevention of arsenic poisoning in Bayanhongor.

High level of lead is of the other concern because, even at low levels, lead can cause problems like learning disabilities, behavior problems, decreased intelligence, speech problems, decreased attention span, brain or nerve damage, poor coordination, kidney damage, decreased growth, and hearing loss.

No information is available in Bayanhongor at present for the control of health risk arising from arsenic and lead. Possible sources of the elements are ground water like reported in another area[5], ore dust from mining site and dust from the surface expression of rocks[6]. A further study should be necessary to verify the exact cause of the high level of arsenic and lead in this region.

Table 1 Trace element distribution of human hair in Bayanhongor

Upper row: values in ppm; lower row: one sigma

#	MGHH-	MGHH-2	MGHH-	MGHH-4	MGHH-	MGHH-	MGHH-7	MGHH-8	MGHH-9
Sex	F	M	F	M	M	M	M	M	M
Run #	22759	22760	22769	22770	22771	22772	22773	22774	22775
S	39326	45215	44227	48228	44850	44759	40051	46587	44362
	1721	2094	3155	2868	3533	2885	1516	3087	1447
Cl	3207	1672	1109	2127	4494	1419	4657	3905	5211
	150	86	89	136	358	101	187	266	208
K	1074	558	481	210	784	185	2347	1693	23124
	60	38	46	30	70	27	103	122	783
Ca	1468	1056	156	783	379	622	766	630	1733
	47	34	7.9	61	14	53	27	22	68
Ti	59	50	44	7.0	8.6	22	15	9.2	169
	3.0	2.6	2.9	2.1	2.1	2.6	2.4	2.0	14
Mn	9.0	4.9	nd	nd	7.3	nd	26	12	21
	1.1	0.9			1.0		1.5	1.0	6.8
Fe	202	106	78	86	115	87	299	122	457
	6.9	3.8	3.3	3.4	4	3.6	10	4.4	18
Ni	4.0	2.2	nd	nd	2.9	nd	nd	nd	nd
	0.8	0.7			0.7				
Cu	28	27	18	15	20	16	21	15	20
	1.5	1.3	1.2	1.0	1.2	1.1	1.3	1.0	2.4
Zn	484	321	279	276	159	229	240	237	353
	16	10	9.6	9.3	5.7	8.1	8.4	8.0	14
Ga	4.9	3.0	1.7	2.8	2.2	2.4	1.6	2.3	5.2
	0.7	0.6	0.6	0.6	0.5	0.6	0.6	0.5	1.8
As	nd	nd	1.6	nd	3.0	nd	16	4.3	17
			0.7		0.8		1.5	0.9	2.8
Br	9.2	7.6		4.9	9.0	22	7.5	7.3	7.2
	1.3	1.0		0.9	1.1	1.9	1.2	1.0	2.4
Sr	11	8.1	nd	nd	nd	nd	6.6	nd	nd
	1.9	1.4					1.7		
Hg	12	5.5	4.4	5.8	nd	4.9	nd	8.7	nd
	2.2	1.7	1.8	1.7		1.9		1.7	
Pb	23	11	nd	4.3	15	6.6	10	12	nd
	3.0	2.1		1.9	2.6	2.4	4.2	2.6	

Table 1 (Continued)

#2	MGHH-10(scalp	MGHH-10(3cm	MGHH-11(scalp	MGHH-12(3-4.5cm	MGHH-13(6-7.5cm	MGHH-13(9-10.5cm	MGHH-13(12-13.5cm	MGHH-13(16-16.5cm
Sex	M	M	F	F	F	F	F	F
Run #	22776	22785	22786	22787	22788	22789	22790	22791
S	36489	47741	44372	43370	46306	36203	36927	31233
	1777	3089	2648	2419	2267	1615	1429	2342
Cl	3802	2829	3941	2664	1665	1044	1422	1636
	191	194	243	156	94	56	61	149
K	3634	725	1329	967	1226	921	1020	1031
	184	63	90	64	74	51	46	108
Ca	911	801	759	705	1160	1106	1119	1300
	30	30	27	25	40	36	35	42
Ti	37	4.4	20	24	19	18	14	13
	2.6	2.8	2.8	2.3	3.2	2.1	1.5	2.0
Mn	15	28	6.3	7.7	12	13	16	21
	1.2	1.9	1.2	1.0	1.6	1.0	0.9	1.2
Fe	408	76	121	58	72	57	51	67
	13	3.8	4.9	2.7	3.5	2.5	1.9	2.7
Ni	nd	nd	nd	nd	3.4	nd	nd	nd
					1.1			
Cu	20	24	16	15	26	16	16	17
	1.2	1.7	1.3	1.1	1.7	1.0	0.8	1.0
Zn	284	219	251	199	358	230	247	267
	10	8.5	9.1	7.0	12.0	7.8	7.9	8.9
Ga	3.2	4.2	1.8	1.9	4.3	1.6	2.2	1.5
	0.7	0.9	0.7	0.6	0.9	0.5	0.4	0.5
As	nd	4.9	nd	nd	nd	nd	nd	nd
		1.9						
Br	18	16	15	16	18	nd	9.8	11
	1.6	2.1	1.8	1.5	2.0		0.9	1.2
Sr	7.1	nd	nd	5.6	19	15	22	26
	1.5			1.5	3.0	1.9	1.7	2.6
Hg	6.4	nd	nd	nd	6.6	4.5	3.9	nd
	2.1				2.6	1.6	1.2	
Pb	8.1	61	nd	3.9	8.4	8.4	7.3	4.1
	2.3	6.1		1.8	2.8	2.0	1.5	1.6

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