Chemical composition of upper crust in eastern China*

YAN Mingcai (鄢明才), CHI Qinghua (迟清华), GU Tiexin (顾铁新)
and WANG Chunshu (王春书)
(Institute of Geophysical and Geochemical Exploration, Ministry of Geology
and Mineral Resources, Langfang 065000, China)

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Abstract In an area of 3.3×10^6 km^2 within eastern China, 28 253 rock samples were collected systematically and combined into 2 718 composite samples which were analyzed by 15 reliable methods using national preliminary certified reference materials (CRMs) for data quality monitoring. The average chemical compositions of the exposed crust, the sedimentary cover and the exposed basement as well as the upper crust for 76 chemical elements in eastern China are given.

Keywords: abundance of chemical elements, exposed crust, sedimentary cover, upper crust.

Based on extensive study of geoscience transect and data from superdeep drilling, modern geologists have made remarkable advance in understanding the structure and component of the crust. It is known that the continental crust is seemingly pieced together by lots of masses. Therefore, after the study of element abundance in the crust by applying the exposed crust model[1,2] and two-layer crustal structural model[3,4], on the basis of the new understanding of crustal structure and component, more importance is now being attached to measuring element abundance of regional crust. The crustal chemical compositions of different great tectonic units[5,6] are fairly close to the major element compositions obtained previously by different crustal models, showing that the average chemical compositions of great tectonic units or great regional crust can approximately represent the chemical composition of the global continental crust. For many years the study of element abundance of regional crust has mainly been laid particular emphasis on platform areas, such as the Canadian Shield and Russian Platform, because the samples of the middle or/and lower crust can be collected there and the crustal chemical composition can thus be understood. However, some trace element contents in platform areas are very different from that in orogenic belt. Therefore, it is appropriate to take both crustal components into account. Recently the study on the European Block model has made new advances[6]. Based on a vast amount of actual data from different tectonic units of the eastern part of China, the average chemical compositions of the exposed crust, the sedimentary cover and the exposed basement as well as abundance of the chemical elements of the upper crust in eastern China are presented in this paper.

1 Experimental

1.1 Collection and preparation of samples

Incorporated with China National Geochemical Reconnaissance and other special projects[7],

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more than 500 standard stratigraphic profiles and 800 representative igneous and metamorphic complex rock bodies were systematically collected in various tectonic units. Among them, 10 215 igneous rock samples were combined into 1 048 composite analytical samples, 10 985 sedimentary rock samples were combined into 902 composite analytical samples, and 6 704 metamorphic rock samples were conbined into 703 composite analytical samples. The sampling profile and rock bodies are shown in fig. 1. The samples were crushed by jaw-type made by crusher contamination-free corundum porcelain, and then pulverized to 200 mesh by agate ball mill.

1.2 Analysis of samples

Fifteen analytical methods were employed on 76 elements. Each analytical method and the pertaining element(s) for all samples are as follows: Instrumental neutron activation analysis (INAA): Co, Cr, Cs, Hf, Rb, Sc, Ta, Th, U, La, Ce, Nd, Sm, Eu, (Gd), Tb, Yb, and Lu; pressed powder disc X-ray fluorescence spectrometry (XRF): Ba, Cu, Ga, Mn, Nb, Ni, P, Pb, Rb, Sr, Ti, V, Y, Zn, and Zr; union of fused disc X-ray fluorescence spectrometry and chemical method: major elements (which requires the total sum of the compositions to lie within the range of 99.00%—100.70%); graphite furnace atomic absorption spectrometry (GAAS): Ag, Be, Cd, and Tl; flame atomic absorption spectrometry (FAAS): Cu, Li, Ni, Pb, Na, and K; atomic fluorescence spectrometry (AF): As, Bi, Ge, Hg, Sb, and Se; fire assay spectrography (FA) (with 10 g sample): Au, Pd, and Pt; electric arc emission spectrography (ES): B, (Be), and Sn: catalytic wave polarography (POL): Mo and W; ion chromatography (IC): Cl and S; ion selective electrode (ISE): F. Moreover, the above-mentioned 2 718 samples were taken and combined again into 150 big composite samples according to tectonic areas and rock types for the difficult analysis elements. The big composite samples were analyzed by methods described as follows. The 15 rare earth elements (REE) were analyzed by inductively coupled plasma spectrometry or ICP-masses; Pt and Rh were analyzed by POL after enrichment by FA, and Ir was analyzed by catalytic spectrophotometry (with 50 g sample); Os and Ru were analyzed by catalytic spectrophotometry after being enriched and separated by distillation method (with 10 g sample); Br and I were analyzed by flow-injection spectrophotometry; In was analyzed by GAAS; Te was analyzed by POL, N by volumetry, and U ($<0.5\times10^{-7}$) by laser fluorescence method. Trace elements with concentration less than 10^{-7} should, as a rule, be treated with a preconcentration procedure. The data qualities of analysis were monitored by 155 internationally accepted CRMs, the accuracy of analysis was evaluated by actual determinations of CRMs in comparison with their certified values, the relative errors are more than 10% for Rh and Te, 5%—10% for N, S, V, Br, Y, Ru, Cs, Tm, W, Os and Ir, and less than 5% for other elements. Similarly, the analytical precision was evaluated by the results of duplicate with 125 confidential samples, the relative deviations are less than 10% for P, Sc, Ti, Mn, Co, Zn, Ga, Rb, Sr, Y, Zr, Nb, Cs, Ba, La, Ce, Pr, Sm, Eu, Dy, Ho, Er, Tm, Lu, Hf, Pb and Th, 10%—20% for Li, Be, B, N, F, V, Cr, Ni, Cu, Ge, As, Br, Pd, Ag, Cd, Nd, Gd, Tb, Yb, Ta, Bi and U, and 20%—40% for S, Cl, Se, Ru, In, Sn, Sb, Te, Re, Ir, Pt, Au, Hg, and Tl.

1.3 Data statistical processing

All data for major elements and REE were used. As for other trace elements, the rock type was taken as the statistical unit, and the data outside $X \pm 2s$ (where X is initial arithmetic mean,

s is standard deviation) were rejected as deviated values. The arithmetic mean was adopted as the best estimate. However, the median was used as the best estimate in case the sample number was relatively small. The data for bad reliabilities were given in brackets for reference only.

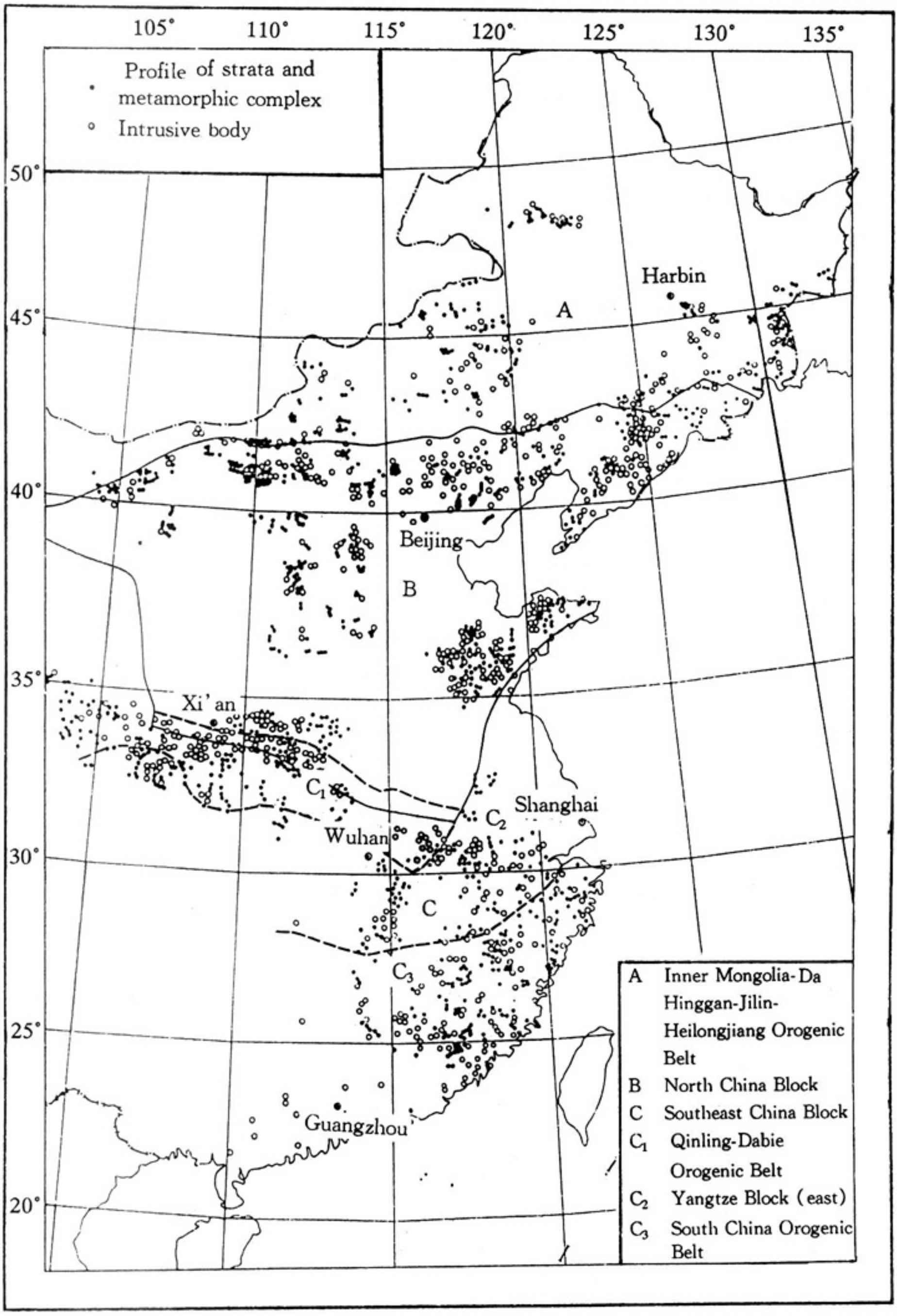

Fig. 1

2 Average chemical compositions of exposed crust, sedimentary cover and exposed basement in eastern China

2.1 Calculation methods

For the exposed crust except those covered by loose sediments, the weighted average of element contents based on exposed area of all rocks or geologic bodies was adopted. The areas of geological bodies were obtained from 1:500 000 geological map and the weights for various rocks in strata were given by the overall average of standard profiles. The ratios of main rock types in exposed rocks in eastern China are listed in table 1.

Table 1 Distribution of main rock types of exposed rocks in eastern China (%, by area)

Region	EC	A	B	C	D	E
Granitoid	22.1	31.5	19.1	12.7	9.2	24.9
Acid volcanic rock	11.0	18.5	1.9	6.6	3.7	20.6
Dioritoid	1.5	0.9	2.4	2.4	0.84	1.0
Andesite	6.5	12.6	4.7	3.2	0.5	4.0
Diabase and gabbro	0.34	0.15	0.35	1.1	0.4	0.06
Basalt	5.2	6.6	7.0	5.8	0.4	2.0
Ultramafic rock	(0.1)	(0.1)	(0.06)	(0.2)	(0.01)	
Clastic rock	23.1	16.6	21.7	22.1	34.6	31.8
Argillaceous rock	15.1	11.0	14.7	18.5	30.4	11.3
Carbonate rock	9.4	1.3	14.6	20.2	19.0	1.1
Gneiss	3.7	0.72	8.6	7.0	0.6	0.3
Leptite	0.9		3.0			3.0
Granulite	0.5		1.7			

EC, Eastern China; A, Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt; B, North China Block; C, Qinling-Dabie Orogenic Belt; D, Yangtze Block (east); E, South China Orogenic Belt.

For the sedimentary cover, volumes of the sedimentary cover for each tectonic division were obtained first by the product of the overall thickness and the paleogeographic area of strata of various ages. Then, the value for the sedimentary cover of each tectonic unit was given by the weighted volume for each tectonic division. Finally, the sedimentary cover in eastern China was obtained by the weighted volume of the sedimentary cover for each tectonic unit.

For the exposed basement, values were given by the weighted exposed area of metamorphic strata and intrusive rocks, mainly granites.

2.2 Average chemical compositions

Average chemical compositions of the exposed crust, the sedimentary cover and the exposed basement in eastern China are listed in table 2.

2.2.1 Exposed crust. Carbonate rocks are easily decomposed in supergenesis, namely, CaO, MgO and CO_2 are mostly run off, and silicate components remain. Therefore, it is suitable that the study of geology, geochemical exploration, agriculture, and environment mainly on stream sediments, soil and silicate rocks should deal with the average chemical compositions of the exposed crust excluding carbonate rocks. Carbonate rocks are the important part of the sedimentary cover, of which the average chemical composition is required in contrasting the composition with the nature for the regional sedimentary cover. The studies of environment and agriculture deeply concerned by people involve also the geologic and geochemical processes on the surface. Average chemical composition of regional exposed crust has important actual significance for the quantitative study and scientific correlation on environment and agriculture. For the use of various

Table 2 Average chemical compositions of exposed crust, sedimentary cover and exposed basement in eastern China

	Exposed crust		Sedimentary cover	Exposed basement		Exposed crust		Sedimentary cover	Exposed basement
	A	B				A	B		
SiO_2	68.44	61.71	54.81	67.80	P	550	515	520	490
Al_2O_3	14.30	12.84	11.27	14.14	Pb	19	18	16	20
Fe_2O_3	2.42	2.19	2.40	1.66	Pd	0.28	0.27	0.33	0.34
FeO	1.82	1.66	1.50	1.94	Pt	0.26	0.25	0.25	0.35
MgO	1.50	2.15	2.59	1.71	Rb	112	101	78	120
CaO	1.72	6.18	10.82	2.60	Re	(0.40)	(0.42)		
Na_2O	2.88	2.56	1.76	3.38	Rh	23	21		
K_2O	3.37	3.04	2.36	3.44	Ru	28	27		
H_2O^+	2.11	1.97	2.36	1.45	S	140	170	200	160
CO_2	–	4.06	8.93	0.94	Sb	0.34	0.33	0.43	0.22
Ag	0.060	0.060	0.056	0.060	Sc	9.9	8.9	9.4	8.5
As	4.4	4.3	5.9	2.6	Se	0.062	0.063	0.085	0.045
Au	0.85	0.81	0.87	0.77	Sn	2.1	1.9	1.8	2.1
B	21	20	31	12	Sr	223	232	218	250
Ba	636	577	514	630	Ta	1.03	0.93	0.82	1.06
Be	2.3	2.1	1.56	2.6	Te	(8)	(8)		
Bi	0.18	0.17	0.17	0.19	Th	11	10	8.4	12.3
Br	(0.25)	(0.3)			Ti	3 190	2 880	3 040	2 595
Cd	0.080	0.085	0.10	0.066	Tl	0.65	0.59	0.47	0.70
Cl	66	71	74	63	U	2.3	2.2	2.0	2.3
Co	10	9.1	9.5	9.0	V	69	63	67	54
Cr	46	42	44	36	W	0.97	0.91	1.01	0.83
Cs	4.6	4.1	3.9	3.9	Zn	68	63	63	57
Cu	17	15	17	14	Zr	200	179	178	160
F	485	470	480	460	Y	21	19	17	20
Ga	19	17	15	18	La	40	36	32	34.5
Ge	1.3	1.2	1.2	1.2	Ce	76	69	61	66
Hf	5.7	5.1	4.8	4.9	Pr	8.6	8.0		
Hg	12	13	15	9.4	Nd	34	31	28	28
I	(0.12)	(0.14)			Sm	6.0	5.5	5.0	5.0
In	(0.05)	(0.048)			Eu	1.20	1.10	1.09	0.99
Ir	17	16			Gd	4.8	4.4	4.4	4.6
Li	23	21	23	20	Tb	0.81	0.74	0.70	0.73
Mn	580	560	580	500	Dy	5.0	4.5		
Mo	0.62	0.62	0.64	0.57	Ho	1.03	0.98		
N	155	150			Er	2.9	2.7		
Nb	15	14	13	13	Tm	0.42	0.39		
Ni	25	22	21	19	Yb	2.6	2.4	2.2	2.4
Os	46	47			Lu	0.37	0.34	0.32	0.38

A, Excluding carbonate rocks; B, including carbonate rocks; content units: major elements: %; Au, Hg, Pd, Pt and Te: 10^{-9}; Ir, Os, Rh and Ru: 10^{-12}; other elements: 10^{-6}.

purposes, in the meantime, two kinds of average chemical compositions of the exposed crust are listed in this paper. The average chemical composition of the exposed crust in eastern China is equivalent to that of monzogranite. The contents of most elements are between those in the sedimentary cover and exposed crust. Because the strata and intrusive bodies of Mesozoic Era had a considerable ratio in the exposed crust, which were affected by the movement of Pacific Ocean Plate, and crustal movement was strong in eastern China, the sedimentary environment was changed from marine facies to continental facies, in which clastic rocks and argillaceous rocks occupied a dominant position. Acidic magmatic activity was widespread. On the other hand, the influence of carbonate rocks and quartz-rich sandstone in Proterozoic Eon and Paleozoic Era is relatively small, which causes the high contents of Cs, Nb, Zr, Hf, and REE in the exposed crust. The chemical compositions of the exposed crust in various regions have an obvious difference. In the North China Block and the Qinling-Dabie Orogenic Belt, the contents of alkaline earth metal elements are high, in which the average chemical compositions are equivalent to those of granitic-granodioritic, whereas, the average chemical compositions of the Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt and the South China Orogenic Belt tend to be more acidic.

2.2.2 Sedimentary cover and exposed basement. The chemical compositions have an obvious difference between them. In the sedimentary cover, Fe and Al contents are low, CO_2, CaO, As, Sb, Hg, and Se rich, Na poor, and oxidation index high, which reflect the geochemical characteristics of recirculation of crust materials. Average chemical composition of the exposed basement is equivalent to that of granitic, in which contents of alkaline elements are rich, Si, Al, and oxidation index low, lithophile elements and large ion radius elements such as Be, U, Th, Rb, Pb, Tl and REE high. This shows the geochemical characteristics of main endogenitic geologic process, and represents the overall chemical composition of the upper-middle part of the upper crust. In the chemical compositions an obvious difference also exists between the sedimentary cover and the exposed basement of various regions. High grade metamorphic terrains are widespread in the exposed basements of the North China Block and the Qinling-Dabie Orogenic Belt, of which the chemical compositions are equivalent to that of granodioritic. However, granites in the exposed basements of the Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt and the South China Orogenic Belt are dominant and more acidic. The chemical composition of the sedimentary cover has an obvious inheritance on basements, such as the North China Block and the South China Orogenic Belt, i.e. the chemical compositions of the sedimentary cover and the exposed basement have similar characteristics in the same region (table 3). It is shown that the chemical composition of the sedimentary cover has inheritance to that of the basement.

Table 3 Comparison of part elements contents between sedimentary cover and exposed basement in North China Block (NC) and South China Orogenic Belt (SC) (10^{-6})

Element		Be	Bi	Cs	Pb	Rb	Sb	Sn	Sr	Ta	Th	U	W	La	Lu
Sedimentary	NC	1.4	0.15	2.8	16	73	0.25	1.7	259	0.90	7.6	1.7	0.96	34	0.27
cover	SC	2.1	0.26	7.4	24	132	0.46	2.4	112	1.1	14	3.0	1.75	48	0.46
Exposed	NC	1.8	0.12	2.0	18	100	0.14	1.3	360	0.73	9.5	1.3	0.53	35	0.27
basement	SC	3.3	0.35	6.0	28	185	0.27	3.4	130	1.7	19	4.3	1.7	46	0.56

For the chemical compositions of various tectonic units see *The Chemical Compositions of Crust and Rocks in the Eastern Part of China* (in Chinese), Beijing: Science Press, 1997.

3 Chemical composition of upper crust in eastern China

Based on the basic geotectonic pattern and regional geochemical characteristics of the eastern part of China[8], taking Yinshan Mountains and Qinling Mountains as the boundary, the eastern part of China is divided into the Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt, the North China Block and the Southeast China Block (including the South Qinling Orogenic Belt, the Yangtze Block (east) and the South China Orogenic Belt). The chemical compositions of the three tectonic regions and the eastern part of China are listed in table 4.

Table 4 Chemical compositions of upper crust in eastern China

Region	EC	NC	IMJH	SEC	Region	EC	NC	IMJH	SEC
SiO_2	63.27	61.77	64.69	65.52	P	600	590	610	575
Al_2O_3	14.15	13.61	15.12	14.00	Pb	18	17	16	23
Fe_2O_3	2.07	2.36	1.64	1.96	Pd	(0.4)	0.43	(0.3)	0.45
FeO	2.33	2.18	2.62	2.31	Pt	(0.4)	0.45	(0.3)	0.4
MgO	2.31	2.73	1.91	1.96	Rb	95	92	92	115
CaO	4.78	5.60	3.95	3.60	Re	(0.45)	(0.5)		
Na_2O	3.14	2.96	3.65	2.70	Rh	(20)	26		
K_2O	2.95	3.06	2.76	3.05	Ru	(25)	31		
H_2O^+	1.65	1.55	1.52	2.03	S	160	200	90	240
CO_2	2.35	3.17	1.10	1.72	Sb	0.22	0.18	0.26	0.29
Ag	0.056	0.055	0.056	0.056	Sc	10	10.6	11	11
As	2.8	1.9	4.2	3.0	Se	0.050	0.060	0.040	0.06
Au	0.77	0.74	0.8	0.75	Sn	1.8	1.5	1.8	2.5
B	16	17	11	20	Sr	300	330	300	220
Ba	640	740	505	630	Ta	0.85	0.8	0.8	1.1
Be	1.9	1.6	2.3	1.9	Te	(5)	(6)		
Bi	0.16	0.13	0.15	0.21	Th	9.5	8.6	9.5	12
Br	(0.25)	(0.3)			Ti	3 070	3 000	3 200	3 360
Cd	0.075	0.072	0.075	0.076	Tl	0.55	0.50	0.57	0.63
Cl	93	125	91	72	U	1.8	1.5	2.0	2.6
Co	12	12	10	11	V	70	68	73	73
Cr	44	52	35	40	W	0.8	0.9	0.5	1.2
Cs	3.3	2.2	4.0	5.0	Zn	63	60	63	69
Cu	17	18	13	19	Zr	170	162	165	182
F	480	540	370	570	Y	18	17	18	22
Ga	18	18	18	18	La	33	35	26	40
Ge	1.25	1.2	1.25	1.3	Ge	64	67	53	73
Hf	4.8	4.5	5.0	5.4	Pr	7.3	7.2	5.9	8.5
Hg	9	8	9	9.5	Nd	28	29	23	33
I	(0.15)	(0.15)			Sm	5.0	4.8	4.7	6.2
In	(0.04)	(0.04)			Eu	1.12	1.10	1.08	1.26
Ir	(13)	17			Gd	4.4	4.0	4.2	5.5
Li	20	16	22	25	Tb	0.67	0.61	0.68	0.86
Mn	600	580	700	560	Dy	4.0	3.3	3.8	5.0
Mo	0.6	0.6	0.5	0.6	Ho	0.80	0.67	0.82	1.0
N	100	90			Er	2.3	1.9	2.6	2.9
Nb	13	12	11	16	Tm	0.34	0.30	0.40	0.45
Ni	21	24	16	21	Yb	2.2	1.9	2.5	2.8
Os	(35)	50			Lu	0.33	0.29	0.39	0.44

EC, Eastern China; NC, North China Block; IMJH, Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt; SEC, Southeastern China Block. Content units: major elements: %; Au, Hg, Pd, Pt and Te: 10^{-9}; Ir, Os, Rh and Ru: 10^{-12}; other elements: 10^{-6}.

The crust consists of the sedimentary cover and the basement. The calculation methods are as follows:

(i) North China Block. On the basis of the systematic geochemical study of the sedimentary cover and 16 main metamorphic facies belts[9], with reference to the data of metamorphic geology and geoscience transect, the average thickness of the sedimentary cover is 3 km ($V_p<6.0$ km/s by seismology), which is obtained by the weighted average of volumes estimated from the integrated stratigraphic thickness of various ages and the paleogeographic area since Mesoproterozoic Era. Of the volumes clastic rocks make up about 36%, argillaceous rocks 26%, carbonate rocks 24% and volcanic rocks 14%. The thickness of the basement is assumed to be 12 km (V_p =6.0—6.3 km/s), which was obtained by weighted average of exposed areas of various rocks. Of the areas, metamorphic rocks make up 60%, granite 35% and diorite 5%. Abundance of the chemical elements of the upper crust was finally evaluated according to the weighted averages of the thickness of the sedimentary cover and the basement.

(ii) Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt and Southeast China Block. The exposed basements of them are lacking in high grade metamorphic geologic bodies of deep source, those of the middle-upper part of the upper crust. Therefore, by consulting the geophysical data the ratios of the deep source metamorphic rocks and magmatic rocks were properly increased when the basement was calculated. The chemical compositions of the upper crust are as follows. On the basis of geophysical data of the Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt[10,11]1), thickness of the sedimentary cover is assumed to be 2 km ($V_p<5.0$ km/s) and the basement 12 km(V_p 6.0 km/s). The basement consists of 40% rocks of the exposed basement (including Precambrian metamorphic rocks and intrusive rocks dominated by granite, their ratio was obtained by the actual exposed areas), 20% granodiorite, 15% tonalite, 20% diorite and 5% basic rocks. Based on the geophysical data of the Southeast China Block[10,12,13], thickness of the sedimentary cover (consisting of Phanerozoic Eon strata) is assumed to be 2 km ($V_p<6.0$ km/s) and the basement 10 km (V_p 6.0 km/s). The basement consists of 50% rocks of the exposed basement, 35% intermediate-acidic intrusive rocks and TTG gneisses, and 15% intermediate-basic rocks.

(iii) Abundance of the chemical elements of the upper crust in eastern China. This is obtained by the weighted average of the volumes of the upper crust of the North China Block, the Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt and the Southeast China Block. The average chemical compositions of the three tectonic regions and the eastern part of China are all equivalent to those of granodioritic, but their geochemical characteristics are not the same. The North China Block is enriched in Fe, Mg, Ca, Cr, Ni, Co, Cu and platinum group elements (PGE), depleted in Al, Li, Rb, Cs, U, Th, Zr, Hf, Ti, Mn, V and HREE, and has high oxidation index (Fe_2O_3/FeO = 1.12) in the upper crustal composition. The Inner Mongolia-Da Hinggan-Jilin-Heilongjiang Orogenic Belt is enriched in Al, As, Be, Li, Mn, Ti, V and HREE, depleted in Cu, Ni, F, Se, Ba, PGE and LREE, and has high Na_2O/K_2O ratio (1.32) and low

1) Chi Xiaoguo, Liu Yongxiang, Li Shuanglin *et al.*, Study for geochemistry and physical property of rock on Manzhouli-Suifenhe global geoscience transect, China, *Scientific Report of Changchun University of Earth Science* (in Chinese), 1995.

oxidation index ($Fe_2O_3/FeO = 0.63$) and low La/Yb. The original basement is inferred to be stable landmass according to the Na-rich composition, and the orogenic belt is the split product afterwards. The Southeast China Block is enriched in Si, K, Rb, Cs, Nb, Ta, U, Th, W, Sn, Sb, Bi and REE, depleted in Fe, Mg and Ca, and has low Na_2O/K_2O ratio. It is shown that the main part of the upper crust in this region is the differentiates of the later period according to the characteristics of high K and incompatible elements. The main part of the upper crust formed in post-Archean Eon when thermal state of the mantle-crust obviously changed. Taking the Qinling-Dabie Orogenic Belt as the boundary of the upper crust in eastern China, the north part is enriched in Na, with low Rb/Sr ratio and REE, and the south part in Si, K, LREE and incompatible elements, with high Rb/Sr ratio. It reflects that in the geochemical characteristics of the upper crust between the north and the south part of eastern China there exists a remarkable difference with the Qinling-Dabie Orogenic Belt as the boundary.

4 Conclusions

(1) The abundance of the chemical elements of the upper crust and the average chemical compositions of the exposed crust, the sedimentary cover and the exposed basement in the eastern part of China obtained by the actual data in this paper will have extensive use in geology, environment and agriculture, which also provide important conditions for the quantitative geochemical study.

(2) Regional crust of the eastern part of China comprises the continental crust of various properties, striding across the north and the south huge plates——paleoEurasia and Gondwana continents. On the basis of the actual integrated data of regional geology, geochemistry, geophysics and geoscience transect, the values of the most major elements in abundance of the chemical elements of the upper crust lie at the medians of the values in literature. This demonstrates the reliabilities of the values.

(3) New analytical techniques have been used in this study, samples were severely analyzed under data quality monitoring. Elements up to 76 were given, consisting mostly of the natural elements apart from the inert gas elements. Accuracies of the most trace elements have been obviously improved and are better than the values in literature. The reliable values of the elements which are difficult to determine at present in the world especially Au, Os, Ir, Pt, Ru, Rh, Pd and Hg have been obtained. This is a new important development in this study of the crustal abundance of the chemical elements.

(4) The comparability and representativity of the values among elements in this paper should be superior to those derived from literature compilation, because the same analytical methods have been applied to a large number of representative samples.

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