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A CONTRAST ANALYSIS ON THE LOAD CHARACTER OF THE CHANGJIANG RIVER AND THE HUANGHE RIVER①

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ABSTRACT: According to the analysis of grain size, mineral composition and inclusion in quartz grain of the suspended and bed load sampled from the Changjiang (Yangtze) River and the Huanghe (Yellow) River, the authors reveal the differentiation of loads between the two rivers. In the Huanghe River the size of suspended load is coarser than that in the Changjiang River, while the bed load is on the contrary. Through heavy mineral analysis, the biotite content of the Huanghe River loads is much higher than that of the Changjiang River, and the monomorillonite content of the former is about two times higher than the latter. All those may be attributed to the effects of different material sources and hydraulic conditions on load. The analysis of inclusion in quartz grain definitely illustrates the environmental difference of material sources between the two rivers. In the meantime, it provides a new method in seeking source of river load.

KEY WORDS: grain size of load, mineral composition, inclusion in quartz grain, the Changjiang River, the Huanghe River

I. GRAIN SIZE OF LOAD

1. Grain Size of Load from the Huanghe River

The suspended load sampled from the Huanghe River mainly comprises silt whose content usually surpasses 50 percent. Most of the median sizes($M_{d\Phi}$) and average sizes(M_z) are over 5Φ (Table 1). The degree of sorting is high and the tendency of becoming well sorted from the upper reach to the lower reach exists. The bed load from the Huanghe River chiefly consists of fine sand or silty sand. The median sizes are between 3- 4Φ. The bed load is well sorted and

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the degree of sorting is becoming higher down the river except for the river mouth where the load is mixed with sand by tidal current from sea.

Table 1 Grain size of load in the Huanghe River

Load type	Samples point	Size parameter							Sand	Silt	Clay	Sediment	
		$M_{d\phi}$	QD_ϕ	Sk_ϕ	KG	M_z	M_o	σ_1					
Suspended load	Lanzhou	5.3	1.9	0.6	0.88	5.8	5.0	2.47	17	52	31	clayey	silt
	Longmem	5.0	2.25	0.75	0.78	5.93	4.0	2.85	26	42	32	clayey	silt
	Sanmen Gorge	5.3	1.6	0.6	1.0	6.13	5.0	2.56	11.4	62.6	26	clayey	silt
	Huayuankou	4.6	1.27	0.13	1.29	5.27	4.0	2.41	27.1	56.4	16.2	sandy	silt
	Lijin	5.5	1.15	0.35	1.21	6.07	5.5	2.11	5.6	72.4	22	clayey	silt
	River mouth	5.45	1.48	0.38	0.97	6.28	5.5	2.45	10.7	65.8	23.5	clayey	silt
Bed load	Lanzhou	3.2	0.65	0.1	1.42	3.35	3.5	1.19	63.8	36.2	0	silty	sand
	Longmem	2.2	0.5	0.05	1.41	2.27	2.5	0.94	89.9	10.1	0	sand	
	Sanmen Gorge	4.2	0.55	0.05	1.83	4.3	4.5	1.23	18.9	81.1	0	silt	
	Huayuankou	3.4	0.45	0.1	2.0	3.53	3.5	1.02	58.8	41.2	0	silty	sand
	Lijin	3.4	0.42	0.17	1.78	3.63	3.5	0.91	60.7	39.3	0	silty	sand
	River mouth	3.8	0.65	0.2	1.39	4.15	3.5	1.2	41.8	58.2	0	sandy	silt

Those characteristics of the Huanghe River's load are believed to be relevant to material sources and hydraulic conditions.

The Huanghe River's load originates mainly from the part of the Loess Plateau between Toudaogui and Sanmen Gorge (Ren, 1986) (Fig. 1). Exactly, coarse grains originate chiefly from the middle and lower reaches of the Wuding River, the river source area of the Baiyu Mountain and the middle and lower reaches of the tributaries between the Huangpuchuan River and Tuwei River (Qian, 1990). The sand content at the Longmen Station is distinctly high. Fine grains originate chiefly from the Weihe River and the Jinghe River (Jing, 1993). The silt contents at the Sanmen Gorge Station show a peak value.

At the downstream side of the Sanmen Gorge, the Huanghe River enters into plain area. The affluxing tributaries are fewer. The sediment recharge is greatly decreased and the flow velocity is reduced. Therefore, coarse grains gradually fall down the river and the proportion of fine load becomes higher. Moreover, the degree of sorting also becomes higher along the river. These characteristics are consistent with the analysis results.

2. Grain Size of Load from the Changjiang River

The suspended load sampled from the Changjiang River mainly comprises fine silt and clay. All the median sizes ($M_{d\phi}$) and average sizes (M_z) are above 6Φ (Table 2), and the degree of sorting is a little lower. At the upstream side of the Jiangyin Station, the sand content of the bed load is over 80 percent and their median sizes and average sizes are about 2Φ. While the bed

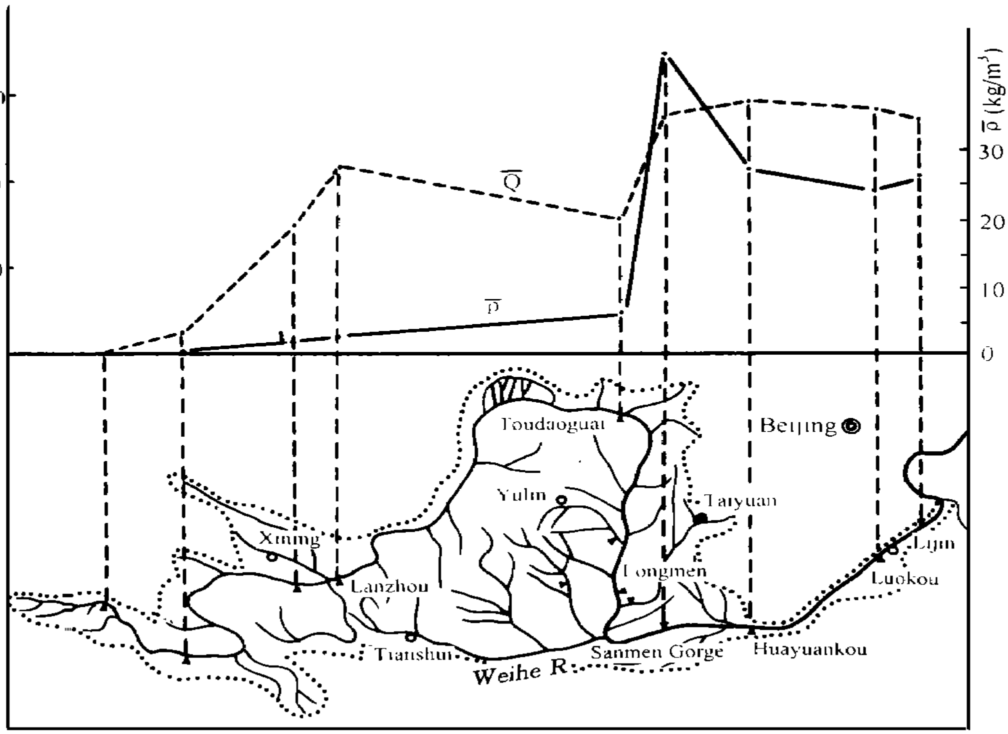

Fig. 1 Average values of water discharge and sediment concentration for nine stations along the Huanghe River (1950- 1979) (According to Ren Mei' e, 1986)

Table 2 Grain size of loads in the Changjiang River

Load type	Samples point	Size parameter							Sand	Silt	Clay	Sediment
		$M_{d\phi}$	QD_ϕ	Sk_ϕ	KG	M_z	M_o	σ_1				
Suspended load	Yichang	6.4	2.1	0.4	0.89	6.53	6.5	3.18	18.3	42.7	39	clayey silt
	Hankou	7.1	1.9	0.3	0.93	7.27	6.5	2.83	11.3	44.7	44	clayey silt
	Datong	6.5	2.25	0.75	0.77	6.67	6.5	2.9	17	39.5	43.5	silty clay
Bed load	Yichang	2.1	0.38	0.03	2.19	2.48	2.5	1.17	80.5	19.5	0	sand
	Hankou	1.9	0.38	-0.02	2.51	2.0	2.5	1.15	92.6	7.4	0	sand
	Datong	2.2	0.4	0.0	1.9	2.28	2.5	0.9	91.3	8.7	0	sand
	Nanjing	2.0	0.68	0.07	1.73	2.32	2.5	1.41	84.0	16.0	0	sand
	Jiangyin	7.6	1.75	0.25	0.89	7.73	8.5	2.3	5.5	42.0	52.5	silty clay
	River mouth	7.7	0.85	-0.1	1.78	7.47	8.5	2.25	10.5	19.5	70.0	silty clay

load at the downstream side of the Jiangyin Station mainly comprises clay whose content is above 50 percent and median sizes and average sizes over 7Φ due to the influence of tidal current.

The degree of sorting of the Changjiang River's bed load belongs to medium-grade and gradually becomes lower down the river.

The Changjiang River's load mainly originates from the Jinsha River and the Jialing River in the upper reaches, the Hanjiang River in the middle reaches(Shi, 1986), and partly from the Taihu Lake system. The load discharge ratio at the Yichang Station is 5.14×10^8 t/a. However, the load discharge ratio greatly decreased at the downstream side of Yichang Station due to sedimentation in the Dongting Lake and the Jianghan Plain(Lin, 1984). For example, the ratio at the Datong Station becomes 4.83×10^8 t/a. The weakly changed sediment concentration in the middle and lower reaches (Fig. 2) illustrates that the grain size changes slowly along the river. This is the main reason for the lower degree of sorting of the Changjiang River's load.

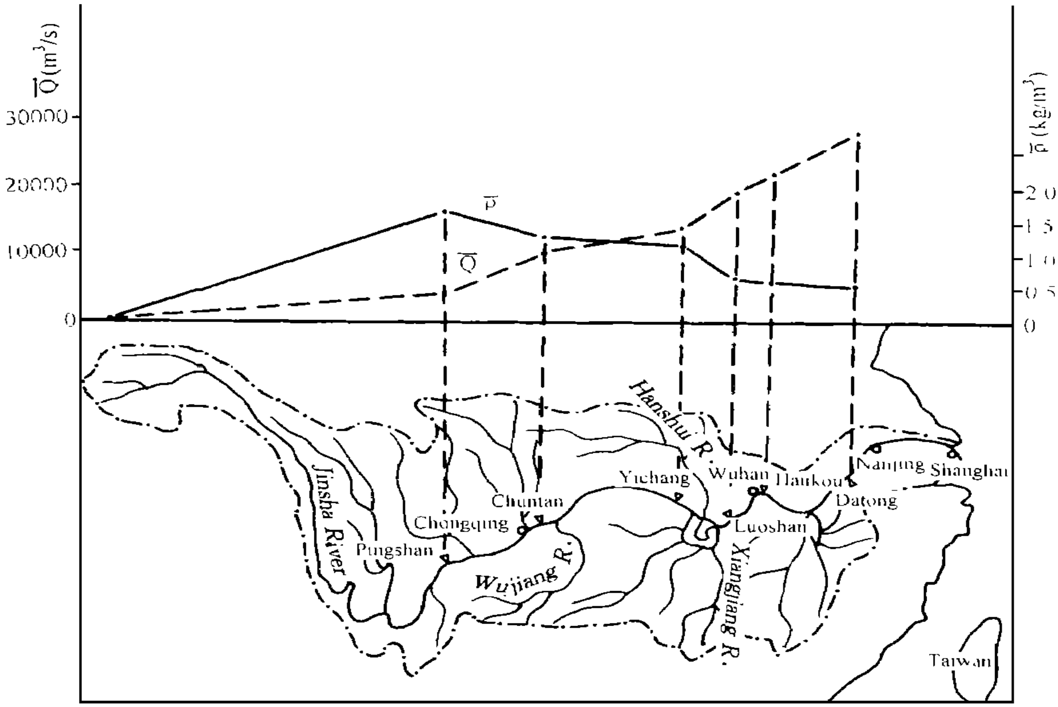

Fig. 2 30-year average values of water discharge and sediment concentration for six stations along the Changjiang River (1950–1979)

By comparison, the suspended load of the Huanghe River is substantially coarser than that of the Changjiang River while the bed load of the former is finer than that of the latter except for river mouth. The degree of sorting of the load of the Huanghe River, suspended load or bed load, has a tendency of becoming higher from upstream to downstream, but it turns out contrary to the Changjiang River. All those may be relevant to the different sediment sources and hydrodynamic conditions as well.

The high sediment concentration and stronger hydrodynamism of the Huanghe River may result in the low falling velocity of the load and the suspension of coarse grains. On the contrary, the fine suspended load in the Changjiang River may be attributed to the low sediment concentration and weak hydrodynamism. Near the mouth of the Changjiang River, broadening of river section and tidal current have made coarse grains deposit at the upstream of the tidal section and so the bed load at the mouth becomes fine instead.

II. MINERAL COMPOSITION

1. Light Minerals

Among the bed load of the Huanghe River and Changjiang River, the predominant light minerals are quartz and feldspar, among which calcite is universally contained, but not more than 4 percent. The contents of Both average quartz and feldspar of the Huanghe River are lower than these of the Changjiang River (Table 3). The quartz and feldspar contents of the two rivers stand high in their middle reaches and become low downstream, reflecting the influence of mass origin. Only the feldspar content at the mouth of the Changjiang River increases strikingly, reflecting the mixture of the tide-transported sand.

Table 3 Contents of main light minerals in the Huanghe River and the Changjiang River

Light minerals	Huanghe River						Changjiang River					
	H_1	H_2	H_3	H_4	H_5	H_6	C_1	C_2	C_3	C_4	C_5	C_6
Quartz	27.0	34.4	33.8	30.0	19.6	26.8	34.6	40.0	47.0	33.4	19.6	13.0
Feldspar	18.0	29.2	18.4	10.0	17.2	10.6	11.8	19.2	22.6	18.8	12.0	45.2

* H_1——Lanzhou, H_2——Longmen, H_3——Sanmen Gorge, H_4——Huayuankou, H_5——Lijing, H_6——River Mouth; C_1——Yichan, C_2——Hankou, C_3——Datong, C_4——Nanjing, C_5——Jiangying, C_6——River Mouth

2. Heavy Minerals

Twenty-four kinds of heavy minerals are identified in the samples from the Huanghe River. The average content amounts to 4.3 percent. The assemblage of hornblende-biotite-epidote-metallic mineral is its main characteristic.

Twenty-one kinds of heavy minerals are identified in the samples from the Changjiang River. The characteristic assemblage is made up of hornblende-epidote-metallic mineral. No glaucophane, monazite and chromite are found in all the samples from the Changjiang River (Table 4).

Analysis result shows that the contents of both hornblende and epidote of the two rivers are very high. The sums of hornblende and epidote contents occupy among 50 and 60 percent, and the content of those of the Changjiang River are a little higher than the Huanghe River. The metallic mineral content of the Changjiang River takes over 21% and the Huanghe

Table 4 Contents of main heavy minerals in the Huanghe River and the Changjiang River

Heavy minerals	Huanghe River						Changjiang River					
	H_1	H_2	H_3	H_4	H_5	H_6	C_1	C_2	C_3	C_4	C_5	C_6
Magnetite	6.2	6.0	0.17	0.8	0.5	0.18	23.6	5.4	13.1	2.3	few	few
Ilmenite	few	26.3	–	–	–	–	few	few	–	–	–	–
Red limonite	14.7	25.9	6.9	few	13.4	2.5	32.3	30.7	4.2	2.0	1.9	14.1
Hornblende	27.9	1.5	32.9	42.1	33.7	36.6	9.3	25.2	36.1	49.3	59.9	40.0
Epidote	4.7	8.5	39.9	28.4	6.5	5.2	14.1	24.3	35.4	33.0	11.8	30.8
Biotite	26.5	6.6	19.6	2.6	24.9	54.0	few	few	1.4	1.6	13.0	0.6
Augite	0.1	–	–	–	–	–	9.2	1.2	2.2	3.0	trace	1.2
Chlorite	few	few	0.02	–	0.3	0.24	few	0.5	2.8	2.3	9.5	1.2
Garnet	12.3	17.7	0.19	7.8	5.2	0.6	7.8	6.5	1.75	3.5	1.9	4.0
Zircon	6.6	4.4	0.15	1.0	0.6	0.17	1.8	3.2	0.7	1.2	0.06	3.4
Sphene	0.1	1.3	0.03	5.84	13.8	0.16	0.8	1.4	0.7	0.1	trace	1.5
Tourmaline	0.2	0.17	few	0.08	0.4	0.03	0.2	few	1.1	few	1.9	0.6
Apatite	0.07	0.5	0.05	0.21	0.6	0.16	0.3	0.9	0.3	1.4	trace	2.5
Rutile	0.3	0.34	0.02	0.07	0.07	0.03	0.28	0.1	few	few	trace	few
Staurolite	–	few	–	–	–	–	few	few	trace	–	–	few
Tremolite	–	–	–	–	–	0.01	0.02	–	–	–	–	–
Glaucophane	–	–	–	trace	trace	trace	–	–	–	–	–	–
Monazite	–	0.6	–	trace	–	–	–	–	–	–	–	–
Kyanite	–	–	–	few	–	–	0.02	0.14	0.1	0.1	–	few
Chromite	–	–	–	10.98	–	–	–	–	–	–	–	–
Anatase	few	trace	trace	few	trace	trace	trace	few	–	–	–	–
Leucoxene	few	0.06	0.04	0.06	few	0.03	0.2	0.1	trace	0.1	–	–
Barite	0.3	0.05	–	–	0.02	0.01	0.04	0.02	0.1	–	–	–
Pyrite	–	–	few	trace	–	trace	few	–	few	–	–	trace

* The meanings are the same as those in Table 3

River only 2 percent. The biotite content of the Huanghe River reaches to 23.36 percent, but that of the Changjiang River is very low. The above-mentioned assemblage characteristic reflects the different environmental feature of mass source of the two rivers and different hydrodynamic functions at different river section(Lu, 1987).

III. X-RAY DIFFRACTION ANALYSIS

After colloid abstracting, X-ray diffraction analysis of clay mineral is done. The quasi-quantitative content estimation shows the dominant clay mineral of the samples from the Huanghe River and the Changjiang River is illite. The average illite content is 75 percent and the content of the Changjiang River is higher than that of the Huanghe River. The curves (Fig. 3) show that the crystallinity of illite from the Changjiang River stands better than the Huanghe River. The characteristic peaks of 10Å are all very high and narrow, and the feature peaks of 5Å, 4.5Å and 3.3Å are also obvious. The contents of secondary chlonite and montmorillonite of the two rivers are almost the same. The content of montmorillonite of the Huanghe River averages 6 percent, being 3 percent higher than the Changjiang River. The authors believe that the arid and semiarid Loess Plateau makes the montmorillonite to be the characteristic clay mineral corresponding to the neutral-to-alkaline environment of the Huanghe River and while the wetter and warmer climate of the Changjiang River system brings to the lower content of montorillonite.

IV. INCLUSION IN QUARTZ GRAIN

1. Inclusion Characteristic of the Huanghe River

The quartz grains from the load of the Huanghe River are relatively well rounded but their transparence are poor due to former wind transportation. Inclusions can be seen only in about one-third of those quartz grains through microscope by 630 times of magnification. Those inclusions are irregularly shaped and their scales are small, generally with a diameter of 6 μm. The main inclusions are liquid ones and the gas-liquid ratio(GLR) is small. There are also pure liquid inclusions and coexisting of liquid and pure liquid inclusions. In addition, carbon dioxide inclusions are universally seen. Secondary inclusions are not developed. Fibrous solid impurity can be found in some quartz grains. This metamorphic evidence indicates that the source environment of the quartz grains of the Huanghe River contains epithermal ore vein accompanied by metamorphic process.

2. Inclusion Characteristic of the Changjiang River

Conversely, the quartz grains from the load of the Changjiang River are poorly rounded and their transparence is good. Inclusion can be seen in almost all the quartz grains. Those inclusions are irregularly or regularly shaped and their scales are a little larger, generally with a diameter of 2–8 μm, individually up to 20 μm. Liquid inclusion is also the main type. There are also coexisting of liquid and pure liquid inclusions. The gas-liquid ratio (of inclusion of the Changjiang River) is higher than that of the Huanghe River, reflecting that the source environment of the quartz grains of the Changjiang River contains hydrothermal ore vein with a higher metallogenic temperature accompanied by magnetism. Secondary inclusions found in some quartz grains indicate the ore vein is affected by compression or tensional stress after its formation.

V. CONCLUSION

1) The load of the Huanghe River originate mainly from the Loess Plateau. The Huanghe

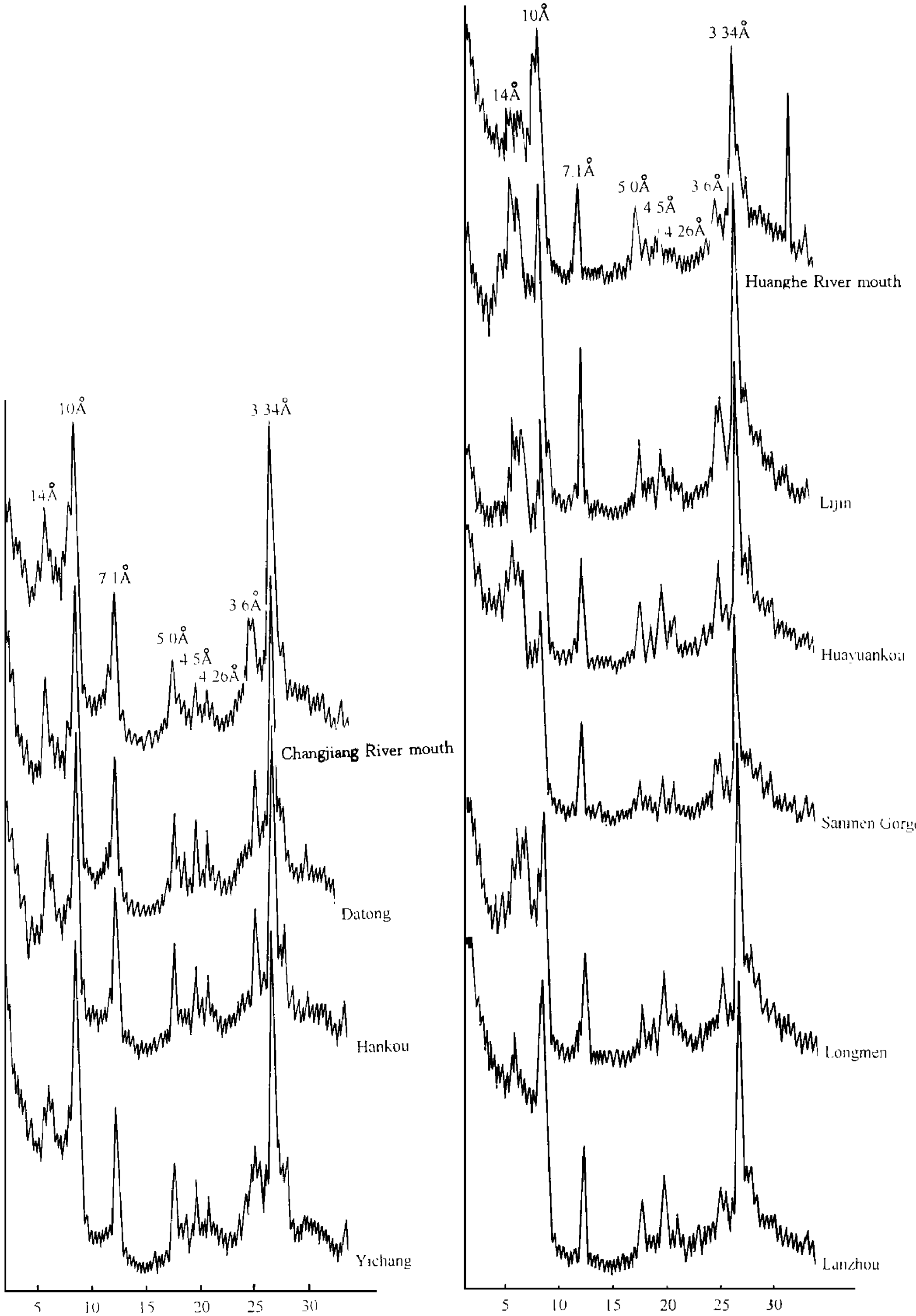

Fig. 3 X-ray diffraction's characters of clay minerals in the load of the Changjiang River and the Huanghe River

River's suspended load is chiefly composed of silt and the bed load is composed of fine sand. The heavy mineral assemblage is characterized by hornblende-biotite-epidote-metallic mineral. The montmorillonite content of the Huanghe River is higher than that of the Changjiang River. Through inclusion analysis, the source of quartz grains of the Huanghe River is believed to be epithermal ore veins accompanied by metamorphic process.

2) The load of the Changjiang River originate mainly from the upstream of Yichang, partly from the Hanjiang River, Boyang Lake and Taihu Lake system. The suspended load is mainly composed of fine silt and clayey matter and the bed load is composed of sand. The heavy mineral assemblage is characterized by hornblende-epidote-metallic mineral. The crystallinity of illite of the Changjiang River is better than that of the Huanghe River. Inclusion analysis indicates that the source of quartz grains of the Changjiang River may be hydrothermal ore vein accompanied by magnetism and affected by compression or tensional stress.

3) Inclusion analysis can be used to distinguish quartz grains with different genetic types. Therefore, it provides a method in seeking source of river load.

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