



The Selectively Extractive Sr/Ba Ratio and Discrimination between Marine and Terrestrial Sedimentary Environments in Terrigenous Clastic Sediments

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Abstract: Discrimination between marine and terrestrial sedimentary environment is one of the main task of the sedimentology. The Sr/Ba ratio is one of the geochemical discriminant indicators of the terrestrial or marine sedimentary environment. Differences of supergene geochemical behavior of Sr and Ba in the marine and terrestrial sedimentary environment make that the terrigenous clastic sediments is relatively rich in Ba and poor in Sr in terrestrial sedimentary environment and is relatively rich in Sr and poor in Ba in marine sedimentary environment, which generates that the Sr/Ba ratio of terrigenous clastic sediments is less than 1.0 in terrestrial sedimentary environment and is more than 1.0 in marine sedimentary environment (Liu Y.J., et al, 1984). In fact, although some scientists use the Sr/Ba ratio to study sedimentary environment, this method usually is ineffective, and it can not be used independently up till now. Therefore, some people doubt the feasibility of discrimination of Marine and terrestrial sedimentary environment by the Sr/Ba ratio (Wang A.H., 1996).

The theoretical reliability of this index is only based on the inference of the differentiation in the geochemical behavior of the strontium & barium in delta area. So far, no one has done the experimental verification. In order to verify the above inference, we obtained 14 artificial deltaic sediments in different salinity by mixing the river water collected from the flood period of the lower reaches of the Yangtze River and the normal sea water collected from the East China Sea in the east of the Yangtze River Estuary in different proportions. Some new understandings have been obtained by Sequential extraction of strontium and barium in these artificial deltaic sediments. Firstly, the total amount of barium is 435~530 mg/kg, of which the largest amount is in silicate (also known as residue, 74.1 to 90.1% of the total), followed by exchangeable (3.06% ~ 16.3%), and a small amount of Fe-Mn oxide (3.46% to 4.49%), bound to carbonates (2.22% to 4.94%) and bound to organic and reducing materials (0.52% ~ 0.62%). The total amount of strontium is 109~141 mg/kg, of which 60.2% to 73.0% are in silicate, obviously lower than the percentage of the barium in silicate; the percentage of the exchangeable is 20.4% to 32.6%, and the proportion is obviously higher than the exchangeable barium; in addition, followed by a small amount of Fe-Mn oxide (3.15% to 4.02%) and bound to carbonate (2.52%~3.97%) and organic and reducing materials (0.38%~0.56%). Secondly, We found that the

varied regularity of the content of strontium and barium with the increases of salinity: the exchangeable barium decreased with the increase of salinity (mainly at lower salinities), and Ba bound to carbonate decreases with increases in salinity, Fe-Mn oxide and the organic and reduction materials is almost changed with salinity, while the concentration of exchangeable Sr slightly increases with increasing salinity, the content of Sr of other fractions show very little change with increasing salinity; the content of barium or Strontium in residue has no obvious regularity with salinity. Thirdly, only the exchangeable Sr/Ba ratio has a good linear correlation with the change of salinity, and the minimum is 0.36 from river water, the maximum is 2.41 when salinity is about 31.2‰; the Sr/Ba ratio in the carbonate fraction is relatively small, with minimum and maximum values of 0.16 and 0.46, respectively, and the Sr/Ba ratio tends to slightly increase with salinity increases when salinity is less than 6.55‰, the other Sr/Ba ratio all did not change obviously with salinity (Fig. 1), so only the exchangeable Sr/Ba ratio and the Sr/Ba ratio bound to carbonate can be used to distinguish between marine and terrestrial sedimentary environment. We can only selectively extract exchangeable and bound to carbonate strontium and barium from sediments by dilute acetic acid to distinguish between marine and continental sedimentary environments.

The results show that the ratio (expressed as Sr/Ba-HAc) of strontium to barium extracted by dilute acetic acid and the ratio (expressed as Sr/Ba-NH₄Ac) of strontium to barium extracted by 1M ammonium acetate from the artificial sediments of the Yangtze River Delta has a good linear relationship with salinity (Fig.2). The ratio Sr/Ba-HAc and the ratio Sr/Ba-NH₄Ac is less than 1 at salinities less than 5‰, but the maximum values of the Sr/Ba-HAc ratio and the Sr/Ba-NH₄Ac ratio are 2.40 and 2.69 respectively when salinity is 31.2‰. The linear equations of the quadratic curves of the two selective extraction methods are respectively :

Salinity(‰) = 6.5147X²-3.2126X+1.3531 (for selective extraction by 10%HAc X=Sr/Ba-HAc R² = 0.9913)

Salinity(‰) = 6.221X²-7.7224X+4.1191 (for selective extraction by 1MNH₄Ac X=Sr/Ba-NH₄Ac R² = 0.973)

It should be pointed out that the Sr/Ba ratio extracted by acetic acid contains exchangeable and bound to carbonate strontium and barium (Chen, L.Y. et al., 2014). Because of the weak biological participation in synthetic sediments, the geochemical

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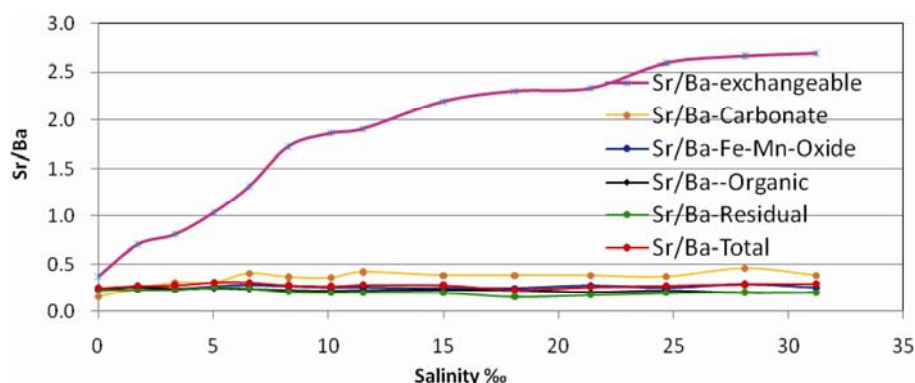


Fig. 1. The Sr/Ba ratio changes with salinity in different occurrence modes for the artificial sediments

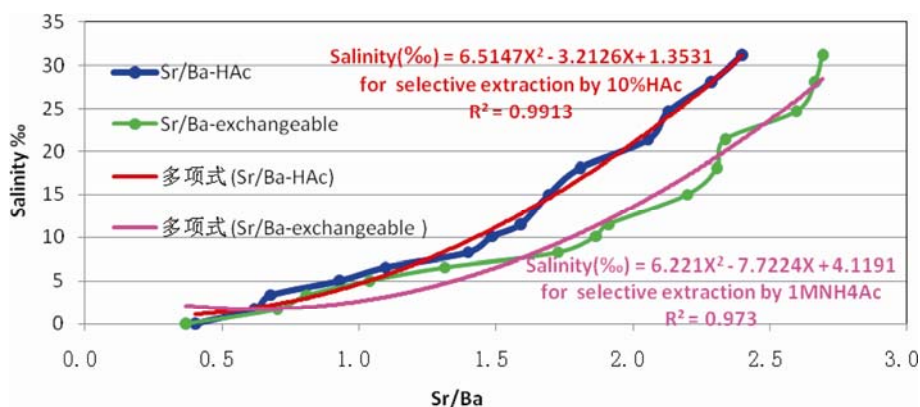


Fig. 2. Relationship between salinity and the Sr/Ba ratio by different extraction in artificial sediments

behavior of strontium & barium bound to carbonate in nature can not be fully reflected. Therefore, the linear equation of Sr/Ba-HAc ratio extracted by dilute acetic acid does not necessarily conform to the actual situation of nature.

Therefore, it can be found that the Sr/Ba ratio is completely applicable to discriminant between the Marine and terrestrial sedimentary environment of terrigenous clastic sediments, but it must be only sedimentogenic strontium and barium of extracted by selective extraction. It is unreasonable in theory to distinguish marine and continental sedimentary environment by traditional total amount analysis method, but it is not feasible in practice (Chen, Z.Y., 1997).

Key word: the Sr/Ba ratio, selectively extraction, marine or terrestrial environments, sedimentary environments discrimination, terrigenous Clastic Sediments

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References

- Chen, L.Y., Li, C.Y., and Chen, D.F., 2014. Dissolution method of authigenic calcites in marls for rare earth elements analysis. *Geochimica*, 43(6):647-654(in Chinese with English abstract).
- Chen, Z.Y., Chen, Z.L., and Zhang, W.G., 1997. Quaternary Stratigraphy and Trace-Element Indices of the Yangtze Delta, Eastern China, with Special Reference to Marine Transgressions. *Quaternary Research*, 47:181-191.
- Liu, Y.J., Cao, L.M., Li, Z.L., Wang, H.N., Chu, T.Q., and Zhang, J.R., 1984. Element Geochemistry. Beijing: Science Press, 283–372 (in Chinese).
- Wang, A.H., 1996. Discriminant effect of sedimentary environment by the Sr/Ba ratio of different existing forms. *Acta Sedimentologica Sinica*, 14: 168–173(in Chinese with English abstract).

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