四川峨眉山龙门洞三叠系 SEDBA 数据库及其应用

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本文是峨眉山龙门洞三叠系 SEDBA 数据库地球化学资料在化学地层和海平面变化及层序地层学等方面的应用。化学单元组的划分完全符合岩性地层组的界限,一些化学单元则与岩性段不同。许多化学单元与沉积体系域相一致。根据碳酸盐岩的碳氧同位素分布的群聚特征(图3),结合薄片鉴定,划分了碳酸盐岩的三种沉积和浅埋藏成岩环境:T_1j^1 和 T_1j^3 段为海相正常盐度环境沉积,其他多数岩段为超盐度环境。碳氧同位素在垂向上具周期性变化(图4)。无蚀变的均匀细粒的碳酸盐岩的 $\delta^{18}O$ 有与沉积环境相应的周期性变化,其 $\delta^{18}O$ 作为海平面变化的一种地球化学响应,较好地提供了本区相对海平面变化及其与区域构造沉降速率和沉积物供应速率间相互关系的判据。认为 T_1j^3 和 T_1l^3 是两次与全球海平面上升有关的沉积,其 $\delta^{18}O$ 大幅下降与宏观的海侵沟蚀面伴随,而 T_1j^1 段的相对海平面上升则是由于区域构造沉降速率大于碎屑供应和碳酸盐生产速率而引起的,并因两种速率频繁变化造成碎屑岩-灰岩的高频韵律互层。本文还对一些层段及海进海退层序中的界面性质作了论述。

APPLICATIONS OF SEDBA TO THE TRIASSIC STRATA IN LONGMENDONG, MT. EMEI, SICHUAN, CHINA

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ABSTRACT

Applications of the geochemical data in the SEDBA of the Triassic in the Longmendong section, Mt. Emei to chemical strata and to sea-level changes and sequence stratigraphy are presented in the paper. The division of the chemical unit sets accords fully with the boundary of the lithostratigraphic groups, Some of chemical units are different from the division of lithostratigraphic members. Many of chemical units accord with the depositional system tracts. Three depositional and shallow buried diagenetic environments of the carbonates are divided based on the regional clustering features in the scatter diagram of the distribution of the $\delta^{18}O$

and $\delta^{13}C$ of carbonates; combined with thin-section identification. Deposition of T_1j^1 and T_1j^3 members occurred in normal saline environment, majority of other lithostratigraphic members deposit in hypersaline environment. There are the cyclic changes in the vertical curve change of $\delta^{18}O$ and $\delta^{13}c$. The $\delta^{18}O$ values of fine and denes carbonate rocks without alteration possess the corresponding cyclic variations related to the depositional environments. The $\delta^{18}O$ as a geochemical response to the sea-level change or eustacy, provides the criterion for the relationship of global sea-level change and the rate of regional tectonic subsidence and the rate of clastic material supply. It is believed that marine transgressions in T_1j^3 and T_2l^3 member are due to global sea-level rising; meanwhile, the smaller transgression or relative sea-level rising is ralated to the larger rate of regional tectonic subsidence than the rate of clastic material supply and carbonate production, and the rhythmic interbeds consisting of sandstones and limestone beds are also due to the frequent variations in the preceding two rates. Besides, the origin of the rocks in some members and beds, and properties of some boundary lines or interfaces have been briefly expounded in the paper.

INTRODUCTION

The Triassic Section in Longmendong is a typical locus for the research of sedimentology. Great attention has been paid to the study of this Triassic section by the geologists and sedimentologists at home and abroad, because the section is situated on the western margin of Upper Yangtze Platform, the transition zones between platform regions and geosyncline regions, and between Pacific depositional domain and Tethys depositional domain in southern China, and was formed in the important turning period in the course of geologic events.

The Longmendong section is located at the foot of famous Emei mountain, the strata are steeply distributed along the narrow valley of Emie Stream, about 2km long from the Maokou Limestone Formation (Lower Permian) to Upper Triassic Xujiahe Formation. The Lower-Middle series of Triassic 910m in thickness are believed to be one of the ideal sections for the research of the depositional facies from fluvial sediments to tidal flat and shallow shelf sediments because of the occurrence of abundant sedimentary marks and trace fossils, and thick gypsolith and gypsum—dolomite layers in T_2l^4 and T_1j^4 members. The Upper Triassic Xujiahe Formation in the Chuanzhu section is found 513m in thickness, in which the coal layers occur.

The Triassic strata are divided into Feixianguan (T_1f), Jialingjiang (T_1j), Leikoupo (T_2l), Tianjingshan (T_2t), Kuahongdong (T_3k), Xiaotangzi (T_3x) and Xujiahe (T_3xj) Formations. The strata dominantly consist of carbonate beds except clastic rocks in T_1f and T_3x—T_3xj formations. Abundant data (Table 1) about conodont biochronostratigraphy, magnetochronostratigraphy, the chemical analyses and thin section identification of 167 pieces of samples, the carbon and oxygen stable isotopes of 46 pieces of carbonate rock samples have been stored in SEDBA. New information about sequence stratigraphy and cyclostratigraphy and basin analysis will be provided by these data through the integrated approach by the relevant computer systems. Therefore, the progress in stratigraphic and sedimentologic research requires the perfect SEDBA.

Table 1 Classification and distribution of samples and data in SEDBA for Triassic Longmendong Section in Mt. Emei (location: E103°25′, N29°35′ altitude: 550m)

Fm.	Mem.	Bed No.	Thickness (m)	Chronology			Petrology			Geochemistry & Ox. /Reduc.						
				1	2	3	4	5	6	7	8	9	10	11	12	13
T_3xj	5	253—245	85.1	45		18										
	4	244—219	107.6													
	3	218—200	125.1													
	3	199—191	107.1													
	1	190—179	87.8													
T_3x		10—9	16.34	12		10										
T_3k		—279	>5.8	15	6	5				4						
T_2t	Rem.	278	>2	6	4	2				2						
T_2l	4	276—253	211.0	126	66	14	61			6	20	6		6	6	
	3	252—219	147.8				59		1	9	18	4		4	4	2
	2	218—199	89.9				38		1	2	12	1	2	1	1	1
	1	Ⅱ11—13	28.9				13		1	2	5	1	1	2	2	
T_1j	4	198—193	78.0	207	76	28	17			3	5	1	1	1	1	
	3	192—179	76.1	7			60		2	9	16	4	3	4	4	1
	2	178—172	29.9				6		4	1	8	1	3	1	11	
	1	171—151	76.6				55		4	5	32	5	8	5	5	1
T_1f	4	34—32	32	177		1	12			1	4	1	1	1	1	
	3	31—24	58	10		3	26		4		11	2	6	2	2	
	2	23—18	35.6				23		1		7	2	3	2	2	
	1	17—1	72.4				66		6		25	5	4	5	5	
P_2	χ	01—02	>44.5	66		8	13		1		4	3	3	3	3	
	β		>30	11												
	1(?)		1													
P_1	m	$m_4—m_0$	>50													
Total				698	152	89	460	22	25	46	167	36	35	36	36	5

Note: 1. Paleomagnetism; 2. conodont; 3. mega-fossil; 4. thin sections; 5. grain size; 6. differential thermal and EM and X-ray analyses of mudstones; 7. C & O stable isotopes; 8. 24 elementary analyses; 9. lithochemistry (total analysis); 10. boron content of mudstones; 11. Fe^{3+}/Fe^{2+}; 12. S^{2-}; 13. organic matter

The statistics is made on the datasheets provided by Lu Yuanfa, Zhang Jiqing & Pan Zhongxi *et al.*

CHEMICAL STRATIGRAPHIC DIVISION OF THE TRIASSIC STRATA

The Middle—Lower Triassic strata in Longmendong could be divided into 3 chemical unit sets and 12 chemical units in the light of 2338 chemical data from 167 pieces of samples by Fisher's method (Fig. 1).

The demarcation lines between unit sets accord fully with the boundary of biostratigraphy and Lithostratigraphy. Some of chemical units are quite different from division of

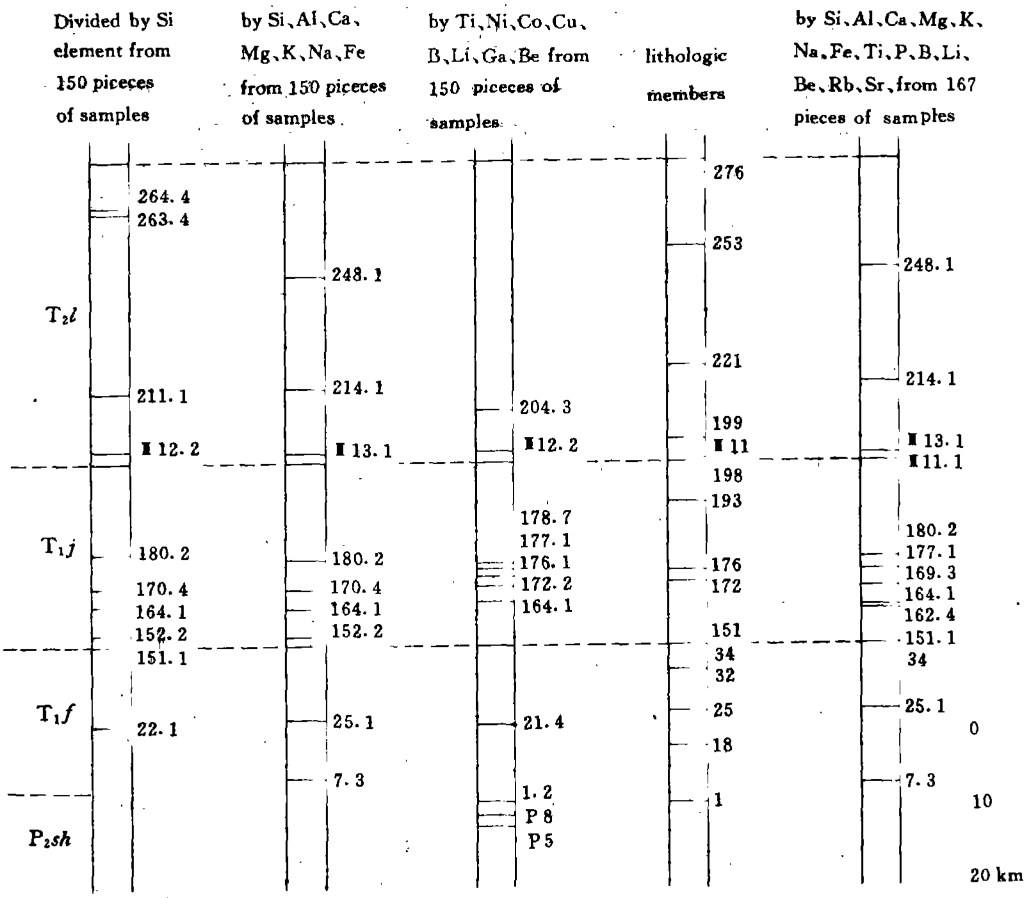

Fig. 1 Comparison of lithostratigraphic members with chemical units of Lower—Middle Triassic strata in Longmendong, Emei Mountain

lithostratigraphic members. The chemical units distinctly show the differences in compositions and the depositional environments of many depositional systems tracts. The division accords fully to that of the salinity environments based on boron contents of the mudstones, as shown in Fig. 2.

CARBON AND OXYGEN STABLE ISOTOPES OF THE CARBONATES RELATED TO THE RELATIVE SEA-LEVEL CHANGES

There is ^{18}O enrichment in the CO_2 of the atmosphere and the maximum values are suggested for the waterbody with hypersalinity, while there is ^{16}O enrichment in the ice sheets on the Earth's Poles. Therefore, the $\delta^{18}O$ values of carbonates in sedimentary stages have changed in response to global sea level, temperature and salinity, which are directly related to the climate changes and controlled by the main periods of the eccentricity, obliquity and precession of Earth. However, the $\delta^{18}O$ and $\delta^{13}C$ values of the carbonate rocks have been involved in the influence of diagenesis, epigenesis and supergenesis. Most of the $\delta^{18}O$ and $\delta^{13}C$ values should drift to negetive values under the influence of groundwater and other factors. It is believed that $\delta^{18}O$ and $\delta^{13}C$ values of fine (micrite and minimicrite) and dense carbonate rocks may represent the environments of deposition and early diagenesis in shallow buried stages. Some of 46 pieces of samples such as Nos. 278.1, 226, 197 samples containing some freshwater calcite veins may be excluded. Besides, the sampling density could only provide the framework of the environmental evolution.

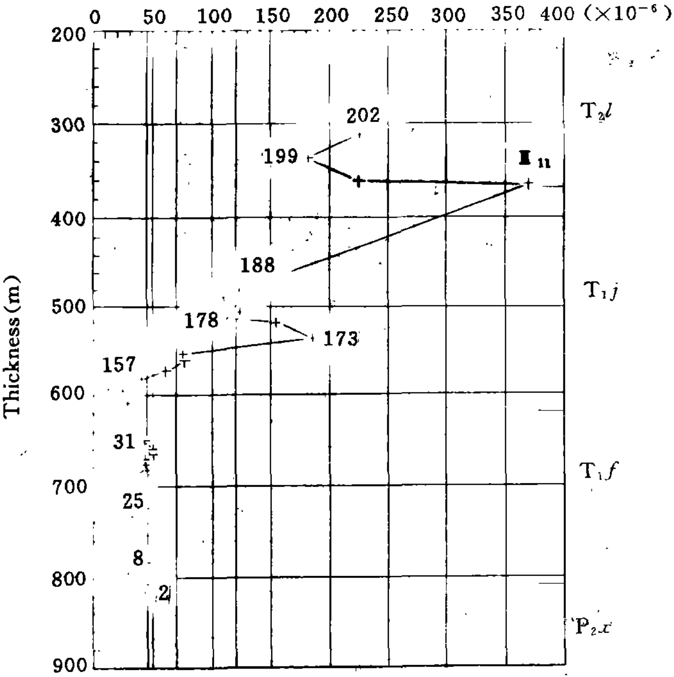

Fig. 2 Boron contents of the mudstones in Triassic Longmendong Section, Mt. Emei

Three depositional environments, i.e. hypersaliney, normal saline and freshening marine environments, could be recongnized based on the identification of the thin sections and the regional clustering in the scatter diagram shown in Fig. 3.

The division coincides also with the salinity environments in the light of the boron contents of the mudstones shown in Fig. 2. It is obvious that most of the dolomites and limestones in the section were deposited in the environments with normal and higher salinity. The T_2t (278 layer) and T_3k (279 layer) occurred in the environments of the freshening marine facies. The isotopes of beds 151 to 155 limestones provide another evidence for marine limestones accumulating upon supratidal flat due to the storm waves. T_1j^1 (151—171 layers) and T_1j^3 (178—192 layers) members deposit in the normal saline environment. T_1j^2 (172—177 layers)、T_1j^4 (193—198 layers) and T_2l^{1-4} members occurred mainly in hypersaliney environment. These salinity effect of the isotopes in higher saline environment often conceals or surpasses the importance of the depth effect of the isotopes, thus confusing the estimation of the amplitude of the eustacy or global sea-level changes.

However, there are some distinct information and evidences shown in Fig. 4 to expound relative sea-level change and some sequence boundaries.

For example, there is no evidence to prove the fluvial facies or freshened "paleoweathering crust" in the light of the $\delta^{18}O$ and $\delta^{13}C$ values of the mudstones in No. 172 layer. The bottom surface under 172 layer occurred in regressional process and hypersaliney environment, and it still is a sequence boundary.

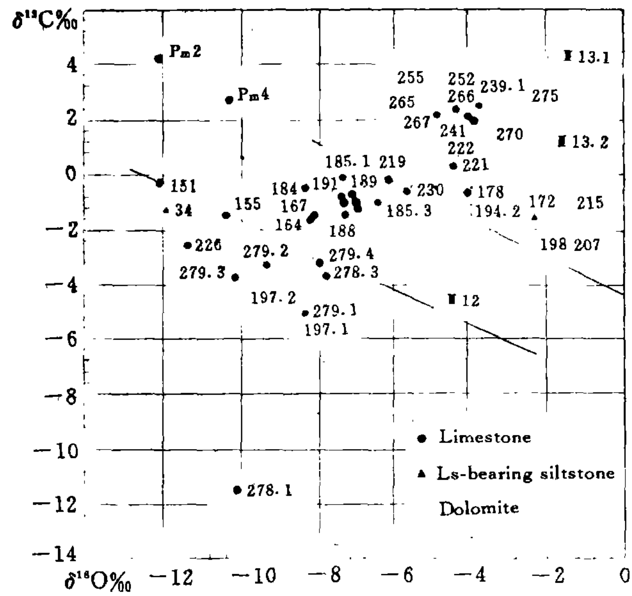

Fig. 3. Distribution of isotopes in the carbonates in the Triassic in Longmendong Section, Mt. Emei

The cyclic changes in $\delta^{18}O$ values in Fig. 4 reflect the environmental changes (oscillation) in the Longmendong section. There are two trends in the variation of the $\delta^{18}O$ values during the marine transgression. The $\delta^{18}O$ values decrease significantly with rapid marine transgression, as in the case of Beds 178 and 218 with the ravinement surface (i. e. transgressional erosional surface). This may be related to the global sea-level changes or eustacy; contrarily, the $\delta^{18}O$ values increase and the $\delta^{13}C$ values decrease in response to the oscillation and small scale of the transgression from supratidal to intertidal zones in Beds 151 to 171 in T_1j^1 member. This relative transgression may be caused by the higher subsidence rates of the regional tectonics than the rates of the clastic sediment supply and carbonate production, and the higher salinity at the late early Olenic (T_1j). Besides, The depositional depths in the transgression in T_2l^3 member may be greater than that in T_1j^3 member according to the facies analysis, but the $\delta^{18}O$ values in T_2l^3 limestones are distinctly higher than those in T_1j^3 member, the higher salinity in T_2l^3

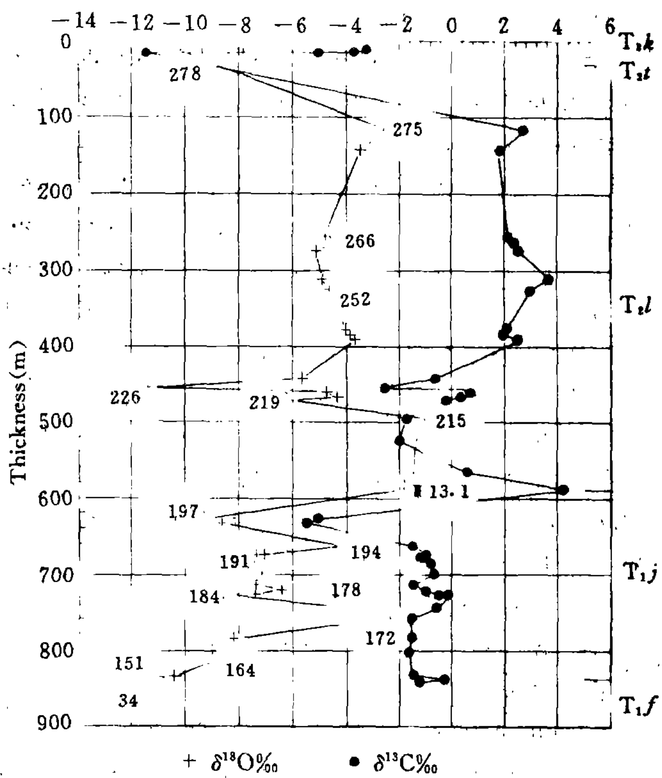

Fig. 4. Curve of carbon and oxygen isotopes of the carbonates in Triassic Longmendong Section, Mt. Emei

member may be a main factor.

REFERENCES

Lu Yuanfa, Huang Huiqiong and Ye Zhiliang, 1986. Chemical stratigraphy and sedimentary geochemistry of Middle and Lower Series of Triassic in Longmendong, Mt. Emei, Sichuan. Bulletin of the Chengdu Institute of Geology and Mineral Resources, No. 7.

Milliman, J. D., 1974. Recent sedimentary carbonates: Part 1, Marine carbonates. Springer-Verlag Ber'in. Heidelberg. New York.

Wilgus, C. K., Posamentier, H. H., Ross, C. A., Kendall, C. G. St. C., 1988. Sea-level changes: An integrated approach.

Wu Yingling, Zhu Zhongfa *et al.*, 1989. Lithofacies-paleogeography and environment control of sedimentary deposifs of the Early and Middle Triassic in the Upper Yangtze Area. Chongqing Publishing House.

Zhang Jiqing, 1982. Rock types and the analysis of their sedimentary facies of the Lower and Middle Triassic Section in Longmendong, Emei, Sichuan, Bulletin of the Chengdu Institute of Geology and Mineral Resources, No. 3.