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Re-Discussion on the Granulometric Characteristics of Sediments and Sedimentary Environment at Altitude of 3200m in Mountain than Day of Linzhi in Southern Tibet

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Abstract: The stratum at altitude of 3278m in Mountain Than Day of Linzhi in Southern Tibet was considered to be lacustrine deposit, but this paper holds that it was aeolian deposit. Good outcrops could be seen and layers was thick. The section was observed in field investigation. In laboratory, the laser granularity instrument was used to do grain size analysis to samples. This paper analysed the grain size parameter of samples, and compared all kinds of size curves, established and extracted substitutive indexes for recording environment of monsoon climate. Meanwhile, grain size fractions that were most sensitive to monsoon change were also extracted through method of grade-standard deviation. Results showed that the eastern Tibetan had positive response to the fluctuation of ancient monsoon. Finally, the Aeolian deposit environment was further demonstrated by means of Sahu environmental discriminant formula.

Keywords: *Mountain Than Day in Southern Tibet, Aeolian deposit, Ancient monsoon*

1. Introduction

Tibetan Plateau plays an important role in Asian monsoon and global environment change because of its critical geographic position, specific rising effect and huge area effect. It is obvious that other evidences are needed on how to recognize the evolution law of these circulation systems and relationship between it and the uplift of Tibetan Plateau. The study on the activity of blown sand and the discovery of high-order lacustrine layer receives much concern all the time[1,2,3,4,5]. Heretofore, the research on the sedimentary activity of blown sand in Tibetan Plateau is weak, especially the record of the blown sand since Pleistocene is in a serious shortage, and regional climate change sequence in millennial-century scale has not been established. Aeolian formation since late early-Pleistocene is widely distributed in east edge of Tibetan Plateau. It is very important for recognizing the difference of regional climate environment, further studying the evolution process of atmospheric circulation systems and the relationship between it and uplift of Tibetan Plateau, to reveal the implicit ancient environment information of the aeolian formation[6,7,8,9,10].

Research conducted by David R. Montgomery etc. (2004) at the corner of Yalu Tsangpo River concluded that highstand lacustrine sedimentation exited at altitude of 3200[11]. They determined the sedimentary environment through macro-characteristics but lack of micro-characteristics evidences for phasing. On the basis of previous research, this paper observed the field section of Mountain Than Day and grain size analysis and test was conducted after systemic sampling. By comprehensively analyzing macro and micro characteristics, the section at the above altitude was aeolian deposit was verified.

2. Method and data

The environmental substitutive indexes chose in this research was grain size. This paper used size grading widely applied in international which was obtained by Krumbein based on Vaude-Winterhoon size grading. Its definition formula is: $\Phi=-\log_2 d$, d is diameter of particle, and the unit is mm. There was a negative correlation between Φand d, for it is convenient to do comparative calculation.

Referring to diagram calculating method, the average grain size Mz, standard deviation σ, skewness SK1, and kurtosis K were calculated for further analysis to samples. The calculation formulas are as follows:

Mz=SUMPRODUCT($B$3:$N$3,B4:N4)/100
σ=(SUMPRODUCT(($B$3:$N$3-Q7)^2,B4:N4)/100)^(1/2)
Sk1= ((SUMPRODUCT(($B$3:$N$3-O4)^3, B4:N4)/100))/P4^3
k=(SUMPRODUCT(($B$3:$N$3-P4)^4,C4:O4)/100)/P4^4

Mz reflects thickness of particles of sediments and average kinetic energy of media. It is foundation of sedimentary rhythm.

σreflects degree of sorti`ng of sediments. The larger the value, the worse the sorting. The absolute uniform sediments don’t exist, so σ is always positive.

SK1 reflects symmetrical parameters of frequency curves, which can be divided into single-peak symmetric curve, asymmetric positive skewness curve and asymmetric negative skewness curve. It can reflect symmetry degree of thickness distribution.

K reflects swelled height of spike in size frequency curve. The controlling condition in different sedimentary environment is not the same, so the grain size distribution characteristic is different.

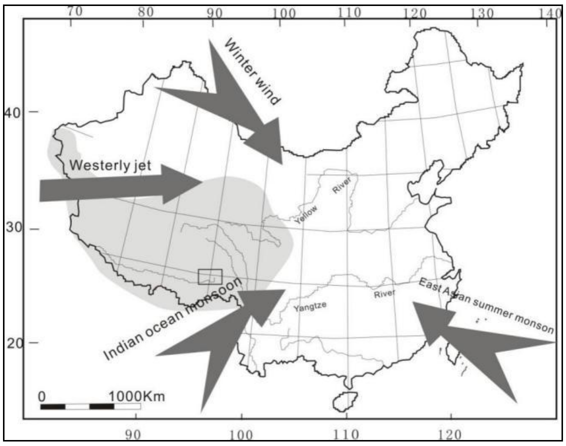

Figure 1. *Location of study area and atmospheric circulation system around the area*

Samples were taken in the scientific investigation for the topography of the dramatic turn of Yalu Tsangpo River. The section where samples were taken was at altitude of 3288m of Mountain Than Day. Because the elevation of the section is high, the strata were not affected by anthropogenic disturbance. The precise sampling position were determined by GPS. Its geographic coordinates are 29°38′448″N, 94°23′36.9″E(Figure1). Undulating loess-like aeolian sand-soil could be seen around the section. The respresentive section was over decade meters in the whole. Horizontal bedding in the section was very obvious and demarcation between layers was significantly evident. Excavation depth was 3m. Samples were taken in every 10cm to 20cm, and the corresponding numbers were 1008-01 to 1008-12 (Figure 2).

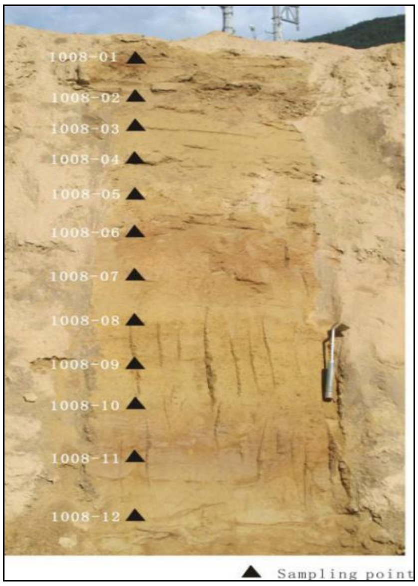

Figure 2. *Stratigraphic section of study area*

Particle size analysis experiment was done in the Key Laboratory of China University of Geosciences. The samples were pre-processed, which can remove the nonclastic sediments influencing grain size. The testing instrument used in the experiment was Mastersizer 2000 laser granularity instrument which was widely used in China and abroad for its automatization. The scale of particle size that the instrument could measure was 0.02μm—2000μm.

3. Grain size characteristics

3.1. Gradation feature

After analyzing the percentage of every size fraction of the whole section, we can see that distribution of particle size had the following characteristics

Among the particle size compositions of the section, particle size was partial to coarse fraction and fat-tail was absent. Sand was the primary material in the section. Average percent of sand was 72.24% and its distribution scale was 9.43%~59.08%. Among the sand, the maximum content was fine silt, whose average percent was 53.73% and whose distribution scale was 47.47%~59.41%. The second was coarse silt (18.48%), whose distribution scale was 9.43%~34.29%. The next was coarse clay (18.30%) and its distribution scale was 12.04~24.79%. Fine sand was the least (0.03%), distribution scale of which was 0.08 %~0.11%.

From Fig.3, we can see that fluctuation of the percentage content of coarse clay was the least and the next was fine silt. The fluctuation of coarse clay and coarse silt was approximately same. And both of them was negatively correlated with that of fine silt. In vertical profile, the difference was small.

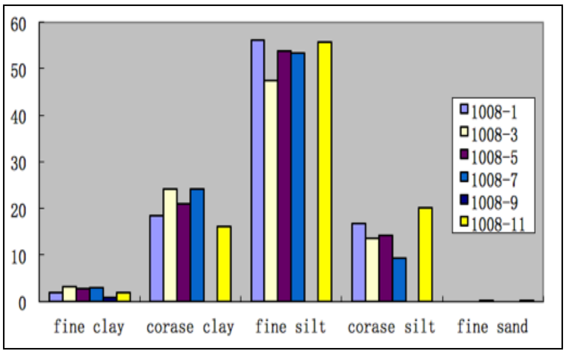

Figure 3. *Histogram of percentage of particle size*

The comprehensive function of transportation forces, transportation medium and sedimentary environment and so on, can be reflected in grain size characteristics of sediments. Cumulative frequency curves on probability were obtained and different dynamic power was distinguished by analyzing the cumulative percentage of different sedimentary grain size. The starting point of this method is forms of transportation of sediments can be divided into suspension, saltation and traction. While research for blown sand showed that movements of wind-blown sand particles could also be divided into the above three forms on the basis of the wind strength and grain size.

Cumulative frequency curves on probability were plotted based on normal probability. Φ was used as abscissa. The grading was based on size of sediments. The scale of particle size was 0.3um-1800um. Cumulative percentage was used as vertical ordinate. The probability was marked in unequal distance and center of symmetry of the ordinate was 50%. The spacing increased gradually from the center to two ends, so the coarse and the fine could be amplified and therefore their change trend would be showed clearly.

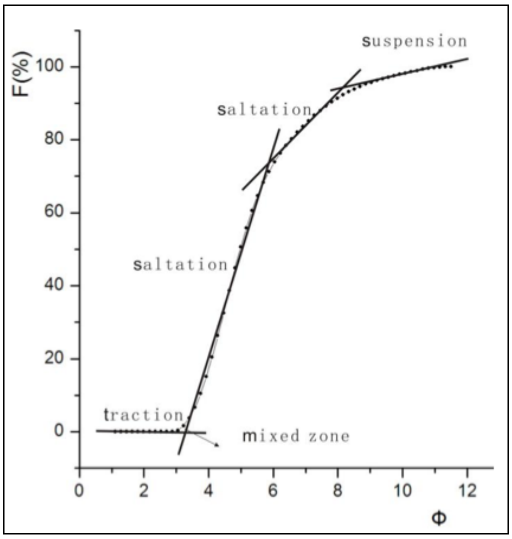

Figure 4. *Cumlatve frequency curves on probability scale of the samples in research area*

Cumulative frequency curves on probability were plotted based on normal probability. Φ was used as abscissa. The grading was based on size of sediments. The scale of particle size was 0.3um-1800um. Cumulative percentage was used as vertical ordinate. The probability was marked in unequal distance and center of symmetry of the ordinate was 50%. The spacing increased gradually from the center to two ends, so the coarse and the fine could be amplified and therefore their change trend would be showed clearly.

Cumulative frequency curves on probability for almost all samples could be divided into three or four line segments and the interval was narrow. The rate of the traction was the least. The percentage of the saltation was the most with the maximum change range. Truncation didn't exist in the middle of the saltation, that is to say, demarcation point of back-flow didn't exist. Percentage of the suspension was the second. The section (Φ) between the saltation and the suspension was about 8. Size scope of the fine was broad, so the line segment of the suspension is long(Figure4). After consulting previous research[12,13,14], combined with investigation to sample spot, test and analysis in laboratory and Cumulative frequency curves on probability, the aeolian deposit characteristics of the sampling section could be found, that is to say, the sedimentary environment is aeolian deposit.

3.2. Grain size parameter characteristics

The average Mz of the whole section was 5.43, the corresponding size of which was fine silt. Based on Mz, we could see that the whole section show characteristics of the fine and the coarse interbed. Amplitude of Mz was 1.5Mz, which could reflect average kinetic energy of transportation medium, or could be determined kinetic energy of blown-sand transportation. For lakes, fine sediments were primary and they mainly focused on silt and clay fraction[15,16] (Figure 5).

The average σ of the whole section was 1.69, which reflected degree of sorting and the scattered and centralized feature of grains of the section. Average σ was consistent with average Mz, which could show bad sorting of the whole section. Sorting was decided by transportation medium in some extent. Both of the later sedimentary weathering of samples and mixture of surrounding weathering clastic materials could make sorting of samples get worse.

The average SK1 of the whole section was 1.08 and all SK1 was positive, that is to say, skewness was positive skew. Generally, lacustrine was mainly negative skew and Aeolian sand was mainly positive with few negative skew. Based on this feature, samples were more likely products of wind.

The average K of the whole section was 0.64, which reflected the concentration degree of grain-size population. Kurtosis of whole section was wide, which showed that sedimentary particle size distribution was a wide kurtosis frequency curve. By analyzing grain size parameters, we could see that samples of research section had characteristics of Aeolian sand, but not lacustrine.

Table 1: *Characteristics of grain size of samples*

parameters / sample number	**average Mz**	**Sorting coefficient σ**	**skewness Sk1**	**Kurtosis k**
1008-1	5.41709	1.644231	1.142507	0.694858
1008-2	5.240255	1.60144	1.37834	0.860688
1008-3	5.85794	1.881773	0.694669	0.369157
1008-4	5.233345	1.586015	1.303014	0.821565
1008-5	5.60544	1.751383	0.941396	0.537516
1008-6	5.31011	1.632731	1.137785	0.69686
1008-7	5.863925	1.73573	0.906044	0.521996
1008-8	5.79223	1.805449	0.716833	0.397038
1008-9	5.40287	1.74973	1.030636	0.589026

1008-10	4.81012	1.601151	1.364909	0.852455
1008-11	5.25468	1.663147	1.110628	0.667787
1008-12	5.142415	1.630644	1.288676	0.790286

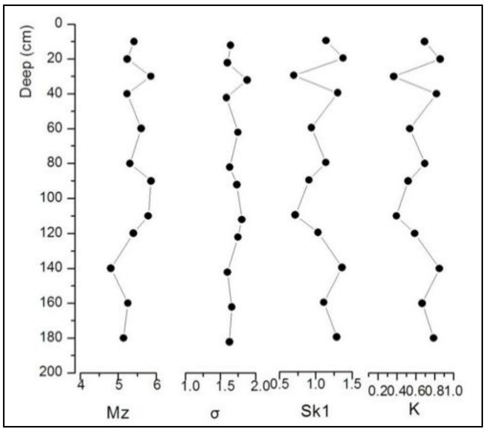

Figure 5. *Distribution of grain size parameters of the section*

4. Discussion and conclusion

For the research of ancient environment evolution law and reconstruction geologic climate and its environmental substitute information, the usual methods adopted internationally are the tree ring, ice core, loess soil sequence, lakes, sporopollen, deep sea sediment core, plant opal, historical document records and grain size analysis etc. Grain size analysis is the one widely applied.

Grain size analysis discusses the multi - component separation of grain size from different sources by calculating different size indexes, based on the mathematical methods such as Weibull distribution function fitting, element model constructing, grain size - standard deviation and constituent parts analyzing, etc[17,18].

Grain size - standard deviation was used to analyze grain size component of the whole section in this essay. The frequency distribution curve shows that, the curve change trend is alike on the whole, which shows the characteristic of single peak with high peak value, roughly consistent distribution, well-concentrated grain size. This demonstrates that the sedimentary environment of the whole section was influenced by a relatively stable transportation force and medium. Samples of the section can be used in the study of high resolution climate evolution.

For further research of the relationship between sedimentary environment and particle size constituent, the standard deviation was got in Excel. Because the particle size of ＞250um only account for 0 percent, according to the highest and lowest point that the standard deviation corresponds to, all the grain size can be divided into two standard deviation areas, namely two groups: 0.24um-4.0um and 4.0um-250um.

As was shown in Fig. 6, the change trend of the first group is larger than that of the second group which follows in a similar pattern. So it was presumed that the sensitivity of the second group is higher.

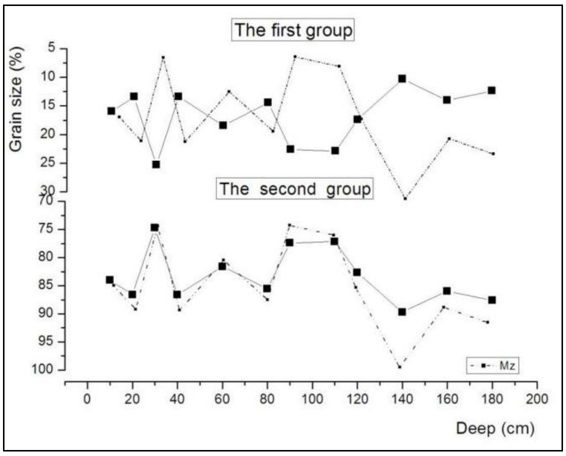

Figure 6. *Mean particle size curves of the samples in the section*

Therefore, we chose the second group as the climate sensitivity grain size, corresponding to silt, which is one of the monsoon sensitive factor. The reason for the increase of the particle size of deposits probably is the relative particle size of the sand removed by summer monsoon increased and the climate was dry.

Normally, it is difficult to distinguish the aeolian deposit and lacustrine deposit outcrops in field, but the aeolian deposit has cross – bedding with a significant depth. The wind – deposit sand is red, with medium to small particle size and good sorting and rounding, and little mud in it.
From the above analysis, we can see that this section is a typical aeolian accumulation. So far, the aeolian records of over 4000 meters above sea level on and around Qinghai-Tibetan Plateau are relatively rare, and there is a lot of controversy, which may be related to late destroying or the inhibition caused by the extremely drought[19,20].

The environment discrimination formula can be used to. compute for further distinguish of sedimentary environment.

In 1964, based on Fawke's grain size parameter, Sahu B.K used the deposit sediment analytical results of depositional environments, such as modern aeolian dunes, shallow sea, beach, delta region, river, turbidity, a empirical formula was obtained according to linear diverse discrimination formula. This formula can be used to distinguish the deposit sediments such as dunes, shallow sea, beach, river and turbidite. The discrimination formulas are as follows:

Yeolian, beach $=-3.5688Mz+3.7016\sigma^2-2.0766SK1+3.1135K$ *(Y＜-2.7411is the eolian, Y＞-2.7411 is the beach)*

Y shallow sea. beach$=15.6534Mz+65.70916\sigma2+18.1071SK1+18.5034$

K (Y＜65.3650 is the beach, Y＞-65.3650 is the shallow sea)

Y shallow sea. river=0.2825Mz-8.7604σ2-4.8922SK1+0.0842K (Y＜-7.4190 is the river, Y＞-7.4190 is the shallow sea＝

Yriver. turbidity=0.7125Mz-0.40306σ^2*+6.7322K1+5.2927K (Y＜9.8433 is the turbidity, Y＞9.8433 is the river)*

On the basis of the observation of sampling point in field, by separate substitution of grain size parameters of the whole section into the formula above, calculations shows that, the minimum of Y was -10.03, the maximum was -7.85, the average was -8.97. According to the explanation of Sadhu formula, when the Y of unknown samples is less than -2.7411, the sedimentary environment is aeolian deposit.

5. Acknowledgement

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