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Application of Tamarix Cone Age Layer in Studying on Environmental Change of Arid Zone

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Abstract: Tamarix cone is a kind of vegetation cones distributing in arid zone, in which there is a special internal structure consisting of the sand layer accumulated in spring and summer, and the layer of dead twigs and leaves accumulated in fall and winter form an annual deposit layer. This layer is called tamarix cone age layer. It can be utilized to estimate the age of sedimentary veins, and rebuild the sequence of environmental change.

Keywords: Arid zone, Environmental change, Tamarix cone

1. Introduction

In the region in and around Taklimakan Desert there are vegetation cones formed by shrubs with *Tamarix* and other plant species, i.e. Tamarix cones. Its height ranges from 3 to 15 m (Qong and Takamura, 1997). It was a later work to take Tamarix cone layer as a method to study environment change (Xia *et al.*, 2004, 2005). In this paper we introduce the method of Tamarix Cone Age Layer in order to perfect it further by everybody.

2. Internal structures of Tamarix Cone

Most Tamarix cones range in height from 3 to 15 m and in length from 5 to 50 m (long axis). They consist of sand layers and litter layers. The thickness of the sand and litter layers differs from part to part in a cross section. Sand layers are almost entirely composed of sand particles and excluded fallen leaves of *Tamarix* spp.; the litter layers are composed of fallen leaves and branches of *Tamarix* spp. which grow over the cone surface (Muhtar *et al*., 2002).

3. Formation of Tamarix cone age layer

During the windy season from March to July, sand materials are transported by frequent storms and accumulate around Tamarix clumps, resulting in a sand layer. During the autumn, the fallen leaves of *Tamarix* spp. form a litter layer overlying the sand layer. A formative unit is thus formed once a year. The thickness and number of formative units may have important implications for understanding the paleoclimatic conditions, evolution and ages of the cones (Muhtar *et al*., 2002).

It was discovered by investigation that in the region of Lop Nur there are many Tamarix cones with clear layers composed of sand and dead trigs and leaves of *Tamarix*. One of them has 623 clear layers. Those maybe are Tamarix Cone Age Layers.

4. Comparison Tamarix cone layer with other methods

The comparison between the counting results from Tamarix cone and the ^{14}C (AMS) as well as the archeological studies has verified the accuracy of the Tamarix cone age layer method: 1) Samples were collected from a 7-meter high Tamarix cone at downstream of Dama Creek in Cele County of Xinjiang. The Tamarix cone has 280 clear layers. The AMS analysis on the samples collected from the bottom layer (the 280th layer from the top of the cone, corresponding to 280th year) was conducted in the Carbon 14 Laboratory of Peking University. The results showed that the ^{14}C age is 290±100 years. This indicates that the two methods have similar age estimations: 2) Based on the information from the archeological studies, the ancient Andier City in Minfeng County of Xinjiang was abandoned about 1,000 years ago. In the old city gate, there is an 8-meter high Tamarix cone with 800 Tamarix cone age layers. The age layers of this cone indicate that this Tamarix cone was formed about 800 years ago, i.e. the cone was formed after the ancient city was abandoned, therefore the human activities were stopped. The above two methods have also similar age estimations.

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5. A study example of environment change by Tamarix Cone Age Layer

There is a 10-meter high Tamarix cone found on the right bank of Milan River. The age layers on the top part were clear. A total of 132 layers were counted in the field. In July, 2004, the samples were collected and laboratory analyses were conducted for investigating the environmental change in the last 132 years in this area, and the analyzed result is more satisfactory (Xia *et al*., 2005).

5.1 Analysis on the $\delta^{13}C$ values of the leaves of *Tamarix* spp.

The results show that the $\delta^{13}C$ values of the leaves of *Tamarix* spp. in the annual strata of the *Tamarix* spp. dune since 1871 fluctuate greatly, i.e. in a range of –22.379‰~–24.749‰, the average value is 23.563‰, and the fluctuation amplitude is as high as 1.778‰. According to the change of $\delta^{13}C$ values in the different periods, three periods can be divided.

(1) From the period three to the period one, the $\delta^{13}C$ values became smaller, in which the average $\delta^{13}C$ value in the period three was 1.354‰ and smaller than that in the period one, and it in the period two was 0.351‰ and smaller than that in the period one.

(2) Among these periods, the fluctuation amplitude of the $\delta^{13}C$ values in the period two was the highest and for 1.561‰, that is the $\delta^{13}C$ value was reduced from –22.379‰ during the period of 1951~1955 to –23.940‰ in 1966; the fluctuation amplitude of the $\delta^{13}C$ values in the period one was the lowest and for 0.637‰ only.

(3) The smallest $\delta^{13}C$ value occurred in the period three, and the average value was –24.332‰. In these 36 years, the $\delta^{13}C$ values were higher than the average only in 2 years; they occurred in 1990 and 1982 and were –23.796‰ and –23.642‰ respectively.

Therefore, it is related to the increase of air temperature and precipitation that the $\delta^{13}C$ values of the leaves of *Tamarix* spp. in the annual strata of *Tamarix* spp. dunes have been reduced and the sand sedimentary strata have become thinner since 1967.

5.2 Analysis on the sand layers

If the change of the general atmospheric circulation in the past 132 years is neglected, the sand properties in this region are mainly affected by the properties of underlying surface.

The 4-year sedimentary thickness of the selected *Tamarix* spp. dune varies in a range of 6.3~8.1 cm, it can be 5.4 cm in minimum and 18.9 cm in maximum in very few years, and it is 10.01 cm in average. They reveal that the sedimentary thickness of sand strata became generally thinner from 1871 to 2002. The sedimentary sand strata were thick when the climate was dry, the precipitation and moisture content in soils were reduced, and the ground surface was easy to be eroded, contrarily, the sedimentary sand strata were thin. Thus, it is considered that the climate in Lop Nur Lake region has changed from dry type to the relatively humid type since recent 132 years.

If the range of vein thickness is divided into 4 groups according to the same space, the ones with sedimentary thickness in a range of 5.85~8.14 cm is classified as Grade one, that means the wind power was weak, the situation of underlying surface was fine, and the sand transport power was low, these reveal that the climate in the Lop Nur region was relatively humid during such periods; the ones with sedimentary thickness in a range of 8.14~10.43 cm is Grade two, that means the wind power was weak of middle and the climate was relatively humid during this period; the ones with sedimentary thickness in a range of 10.43~12.72 cm is Grade three, that means the wind power was strong of middle and the climate was relatively dry; the ones with sedimentary thickness in a range of 12.72~15.01 cm is Grade four, that means the wind power was strong, the climate was dry, the ground surface was arid, and it was extremely dry during these periods. In which the sedimentary rate was high during the periods of 1871~1886, 1899~1906 and 1911~1926, especially it was up to 15.01 cm during the period of 1911~1926. Moreover, the absence of Grade two reveals that the environment in this region may be changed suddenly.

5.3 Environmental evolutions in the Lop Nur Lake region from 1871 to 2002

According to the fluctuation curves of the sand stratum thickness and of the $\delta^{13}C$ values of the leaves of *Tamarix* spp. in the annual sand dune strata, the climatic fluctuation in Lop Nur Lake region from 1871 to 2002 could be divided into 3 main periods.

In the first period (1871~1926), the average $\delta^{13}C$ value was –22.979‰, and the average thickness of sand strata was 15.2 cm. During this period, the average $\delta^{13}C$ value was the highest and the sand strata were the thickest in the whole study period, which reveal that the climate was cold and dry and the wind sand action was violent at that time.

In the second period (1927~1966), the average $\delta^{13}C$ value was –23.239‰, the average thickness of sand strata was 8.0 cm, and the climate was little cold and dry. Moreover, the $\delta^{13}C$ values and the thickness of sand strata reveal that the climatic fluctuation was high during this period, and it was relatively warm in the earlier stage (1927~1950) but relatively cold in the later stage (1951~1966). Such climate change was possibly related to the dried-up of the lower reaches of the Tarim River and the Karahoson Lake and the great change of the surface vegetation and surface radiation caused by the restoration of stream flow in the lower reaches of the Tarim River in 1952, thus, the climate in the Lop Nur Lake region was significantly changed.

In the third period (1967~2002), the average $\delta^{13}C$ value was –24.221‰, and the average thickness of sand strata was 8.2 cm. The average $\delta^{13}C$ value during this period was the smallest in the whole study period, and the thickness of sand strata was similar to that in the second period. These reveal that it was warm with more precipitation during this period, in which the air temperature was slightly dropped during the period of 1979~1990, which accorded with the low temperature in China in the 1980's (Ren, 1991), meanwhile, the high $\delta^{13}C$ values of the leaves of *Tamarix* spp. in the annual strata of *Tamarix* spp. dunes may be possibly related to that the local climate became dry due to the complete dried-up of the lower reaches of the Tarim River and the Taitema Lake from 1972 and the reduction of areas of the oases.

6. Discussion

(1) Establishing age series of stratum is one of the most important ways to rebuild the paleo-geographical environment. But different methods require different testing materials and are applicable to different ranges of geological age. In the areas existing desert with strong windy and sandy actions, it is more difficult to find the dating material for those methods mentioned above. In the south margin of Taklimakan Desert and surrounding Lop Nur Lake the unique Tamarix cone provides a new way for estimating the geological age. Like the tree ring, the structure of the Tamarix cone has the clear age layers.

(2) Although the study of Tamarix Cone Age Layer has received primarily success, but: 1) the studied Tamarix cone layer is modern vegetation sanddune only with clear Tamarix Cone Age Layer of about 100 years, the time of them is very short: 2) the location of studied Tamarix cone is near to river bed, it is difficult to distinguish the impact of river flood on the environment information of Tamarix Cone Age Layer: 3) there are a few environment information analysis, and not to compare on the typical characteristic of environment indication information. Thus, there are some aspects on Tamarix Cone Age Layer need to be studied further such as the method universality popularizing from Tamarix Cone Age Layer to other vegetation cone age layer, the feasibility from Lop Nur Lake region to other regions, and possibility from modern Tamarix Cone Age Layer to older one's, as well as the correct environment information discrimination, and so on.

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