# Organic Carbon Stable Isotopic Composition From Peat in Ruoergai Plateau, Eastern Part of Qinghai-Xizang Plateau

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Ruoergai Plateau (32°20′—34°10′, 102°15′—103°50′), 3600 m above sea level, is located in the eastern part of the Qinghai-Xizang Plateau. It is the major region in China for high-altitude peat deposition with thickness that varies from 2—3 m to over 10 m. Such thick peat deposition is one of the best ideal materials for the research on the environmental changes since the Late Glacial in the eastern part of Qinghai-Xizang Plateau, because in peat is reserved abundant information about environmental changes. The organic carbon stable isotopic curve from peat at No.2 Peatland in Hongyuan County indicates that this region had experienced frequent and drastic climatic changes since 12 ka B.P., and that the *Younger Dryas* cooling event possibly existed.

## 1 Sampling and Measurement

Samples were collected from No.2 Peatland in Hongyuan County, 3505m a.s.l. This area used to be a marsh land. Two sections, with the distance between them less than 50 m, were digged out at two different points at the same height. Section I is 4.6m thick. Its top is 26 cm-thick high-mountain meadow soil underlain by a 4.2m-thick peat layer. The bottom is a layer of fine silt and gytta with a thickness of more than 25 cm. The gytta is $^{14}C$ dated at 11.62±0.38 ka B.P. by using the organic matter in it, while the top layer is dated at 3.47±0.25 ka B.P. Section II is 5.3m thick. Its top is a peat layer underlain by the deposition of gray clay silt interbedded with peat layer, with several branches of tree and fragments of wood. The uppermost part is $^{14}C$ dated at 9.63±0.32 ka B.P. by using the branches of tree as material for dating, while the lowermost part is dated at 14.72±0.47 ka B.P. Thus a continuous section depositing from 15 ka B.P. up to now could be obtained by connecting the two above-mentioned sections.

Sixty-five samples were selected for the measurement of organic carbon $\delta^{13}C$ value, contents of organic carbon, sporo-pollen analysis and elemental analysis, etc. from the two sections at a time interval ranging from 180a to 240a. The samples from section I are mainly remains of Cyperaceae plants while those from section II are extracted from highly distintegrated peat. We can come to the conclusion after comprehensive analysis that the carbon stable isotopic fractionation of peat in these two sections remained post-depositionally intact, so the environmental implication of the $\delta^{13}C$ value proves reliable. We discuss in this report the environmental changes between 11.6 and 3.5 ka B.P.

The measurement of $\delta^{13}C$ value was conducted at Xi'an Open Laboratory of Loess and Quaternary Geology using the method described in Ref.[1]. After $CO_2$ was extracted, the $\delta^{13}C$ value was measured using a mass spectrometer (Finigen Model 251) with measurement error of $\pm 0.1$ ‰ and PDB as reference.

## 2 Results of Measurement

The $\delta^{13}C$ curve is given as below according to the results of measurement (Fig.1). It is clear that:

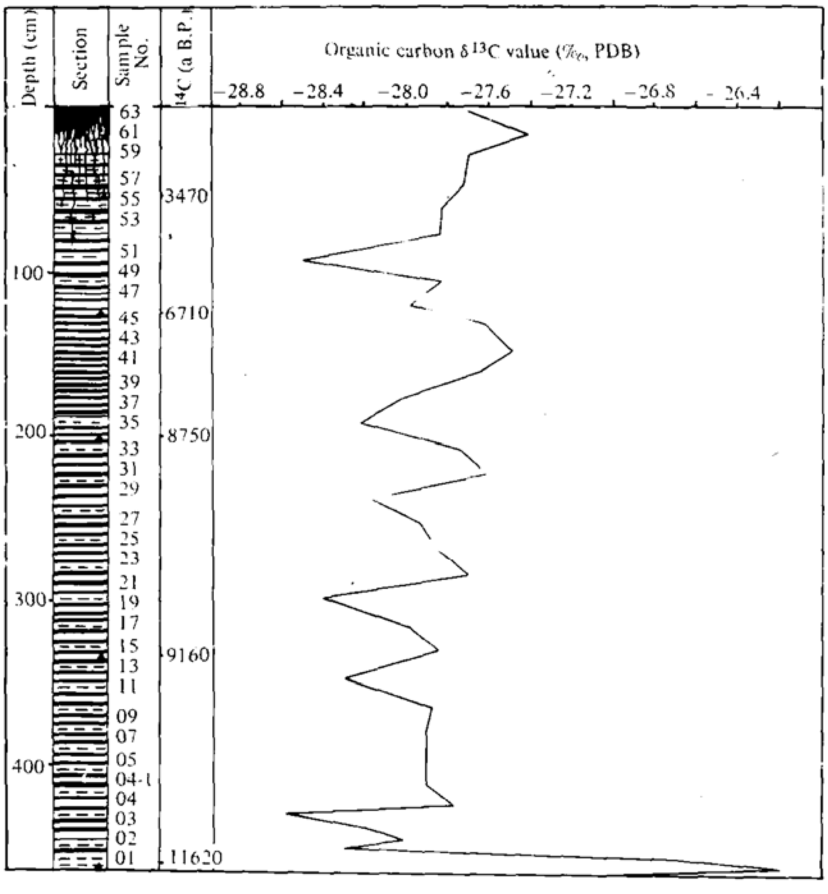


Fig.1. $\delta^{13}C$ curve of samples from No.2 Peatland in Hongyuan County.

1. The $\delta^{13}C$ value of peat at each depth is around $-28.0$‰, which is more minus than that of average lacustrine. There are two causes: (1) Cyperaceae belongs to $C_4$ plant whose $\delta^{13}C$ value is relatively low, ranging from $-12$ to $-20$ ‰ [2]. (2) In fact, the samples of organic carbon for measurement by means of the above-mentioned method is equivalent to the whole wood in tree-ring analysis. And it has been confirmed by experiments

that the $\delta^{13}C$ value of whole wood is more minus than that of $\alpha$- cellulose, but there exists good correlation between these two values, with the correlation coefficient $\gamma=0.61$[3].

2. As far as the amplitude of fluctuation is concerned, that of 11.6—10.5 ka B.P. is the biggest which is more than 2.4 ‰. After that time, the curve tends to be smooth and stable, with only small fluctuation less than 0.8 ‰.

## 3 Discussion

The peat in this area was mainly deposited by remains of Cyperaceae plants. As we know, plant grows only during growth season, when it fixes the atmospheric $CO_2$ to synthetize into its own components by means of photosynthesis. Because of carbon discrimination in plant, the light $CO_2$ which is more active is firstly assimilated; thus causes fractionation of carbon stable isotope in the course of photosynthesis. The process of fractionation is influenced by the climate condition at that time directly or indirectly, so the $\delta^{13}C$ value of peat is expected to indicate the climate state during the growth season of Cyperaceae plants. As has been noted that Cyperaceae plants belong to $C_4$ plant which grows exuberantly in summer, consequently we can turn the research on climate during growth season into that during summer season. The modern meteorological data in Ruoergai Plateau indicates that during summer season this region is under control of south-western monsoon characteristic of high temperature and rain, and influenced by the sub-tropical high pressure (STHP) as well. The photosynthetic pathway of $C_4$ plant is a utility of $C_3$ pathway and $C_4$ pathway, and the $CO_2$ fixed through $C_4$ pathway will eventually be synthetized through $C_3$ pathway, so for the simplicity of discussion it is rational to discuss the climatic influence on the carbon stable isotopic fractionation of $C_4$ plant using the fractionational mode of $C_3$ pathway[4]:

$$\delta^{13}C_p=\delta^{13}C_a-4.4-22.6\ (p_i/p_a), \tag{1}$$

where $\delta^{13}C_p$ is $\delta^{13}C$ value of cellulose while $\delta^{13}C_a$ is atmospheric one during growth season; $p_i$ and $p_a$ are the $CO_2$ concentrations in the external atmosphere and leaf intercellular spaces, respectively.

Owing to the good correlation between the $\delta^{13}C$ value of whole wood and that of cellulose, Eq.(1) could be rewritten as

$$\lambda\cdot\delta^{13}C_b=\delta^{13}C_a-4.4-22.6\ (p_i/p_a), \tag{2}$$

where $\lambda$ is the coefficient of $\delta^{13}C_b$ versus $\delta^{13}C_a$. In Eq.(2) the coefficient before the term $(p_i/p_a)$ is 22.6, far greater than that before the term $\delta^{13}C_a$ (=1), which indicates that the variation of $\delta^{13}C_b$ depends mainly upon that of the term $(p_i/p_a)$. Furthermore, there exists another correlation between $p_i$ and $p_a$:

$$p_i=p_a-A/g, \tag{3}$$

where $A$ is the rate of $CO_2$ assimilation by the plant and $g$ is the conductance of boundary layer and stomatal pores to the diffusion of $CO_2$. Various external parameters may cause the change of $A$ and $g$, thus change the value of $\delta^{13}C_b$.

On the basis of the fact that the climate had experienced frequent fluctuations of cooling and warming since the Late Glacial, we try to take a preliminary analysis of Eqs. (2) and (3):

1. During cooling periods, climate becomes worse, which is not favorable for the growth of plant and consequently shortens the growth season and weakens photosynthetic intensity. These changes make the concentration of atmospheric $CO_2$ above the peatland decline (similar to that above forest during winter season), thus increase the value of $p_a$ and the value of $(p_i/p_a)$; finally the $\delta^{13}C_b$ value becomes greater as the result. This period appears at the peak of the curve.

2. During warming periods, this region is probably characterized in summer by strengthening of two different synoptic processes—south-western monsoon and sub-tropical high pressure (STHP), but the strengthening of them ought not to be synchronous. So there exist two situations as below: firstly, when south-western monsoon predominates over the other, temperature and precipitation are increased though it becomes more cloudy at the same time, thus lessening the solar radiation through the clouds. In order to admit more radiation, the value of $g$ rises and so does the $CO_2$ concentration in cellulose intercellular space which means that $p_i$ value rises. In the mean time, because of exuberance of plant growth and intensity of photosynthesis, the concentration of atmospheric $CO_2$ above the peatland decreases which means decrease in the $p_a$ value. As the result of $p_i$'s increase and $p_a$'s decrease, the value of $(p_i/p_a)$ rises, thus lessening the value of $\delta^{13}C_b$. This period appears at the gulley of the curve. Secondly, when sub-tropical high pressure predominates over the other, the temperature rises while the climate gets more arid and less cloudy, so the radiation through the clouds gets intensified. In order not to be hurt by the intensified radiation and to reduce evaporation, plant would shrink or close part of its pores, thus decreasing the value of $g$ and the value of $p_i$. But its multitude of decrease is not so great as that of $p_a$, so the multitude of $\delta^{13}C_b$'s decrease is smaller than that in the first situation. This period appears in the transitional part of the curve.

We also selected some samples to conduct sporo-pollen analysis in order to check the above discussion. The results prove that they are in close agreement with one another (a series of theses on this are expected to be published soon).

## 4 Conclusion

The $\delta^{13}C$ curve of Ruoergai Plateau indicates that this region had suffered several short and drastic climatic changes since 11.6 ka B.P.

1. As shown in the curve, during the period of 11.5—11.1 ka B. P. before the Holocene, the $\delta^{13}C$ value declines with the amplitude up to 2.0‰, which indicates a short

and drastic cooling event. Now a question arises: Is it equivalent to the so-called *Younger Dryas* cooling event in Northern Europe which started from 11.0 ka B.P. and ended in 10.6ka B.P.? We think yes. There are two reasons for it: precision of $^{14}C$ dating is not up to the requirement at present; this region is located at high altitude in mid-latitude part of the Earth, which is sensitive to climatic change, and is under control of south-western monsoon. On this point, it is different from Northern Europe which is influenced by the northern Atlantic warming current. So the climatic changes in these two different regions may not always be synchronous. Zhu drew the conclusion after studying Chinese climatic changes since 5 ka B.P. that the cooling periods seemed always to shift westward from East Asia to Europe in the history[5]. Is it possible that the climatic fluctuations before 5 ka B.P. also has a similar trend? However, Zhu drew this conclusion choosing winter temperatures as the index while we choose summer temperature in this report.

2. According to the $\delta^{13}C$ curve, the climatic fluctuation since 11.0 ka. B. P. could be divided into a series of warming and cooling events which include the obvious warming ones between 9.3 ka B. P. and 9.0 ka B.P., arround 8.3 ka B.P. and 5.3 ka B.P. and the obvious cooling ones between 10.0 ka B.P. and 9.4 ka B.P., arround 6.1 ka B.P. and 4.6 ka B.P.

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