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IMAGE CHARACTERISTICS OF ANNUAL LAYER IN VERY YOUNG CHINESE STALAGMITES

ABSTRACT: HOU J. & TAN M., *Image characteristics of annual layer in very young chinese stalagmites*. (IT ISSN 1724-4757, 2003).

Two kinds of micro layers, i.e., northern pattern and southern pattern have been found in Chinese stalagmites, and have been verified to be annual layers by the comparison between Thermal Ionization Mass Spectrometry U series disequilibria dating and micro layer counting. The difference in transmitted light or in fluorescent light of annual layers between the two kinds is discussed for annual layers counting chronology in reconstructing high-resolution paleoclimate in past millenniums.

KEY WORDS: Stalagmites, Annual layers, Image characteristics, China.

INTRODUCTION

The micro layers in stalagmite have acted as high-resolution paleoclimate proxy since the fluorescent band (layer) was verified to be annual band (layer) by Baker et al (Baker & *alii*, 1993). Then many researchers acknowledged the existence of annual band (or annual layer) in stalagmites and found that in other stalagmites (Shopov & *alii*, 1994; Genty & Quinif, 1996; Brook & *alii*, 1999; Tan & *alii*, 2000; Hou & *alii*, 2002). Some climate proxies have been extracted from annul layer to act as indicators of paleoclimate change (Roberts & *alii*, 1998; Holmgren & *alii*, 2001). The determination of annual layers is indispensable in these works; while some authors neither mention the methods they used to assign the annual layers nor clarify the characteristics of the annual layer in stalagmites they have studied. We have to assign each annual layer to the corresponding calendar year in different stalagmites, which is essential in quantitatively reconstructing high-resolution climate change in past millennium. The error in this determination will magnify the uncertainty in reconstruction. Stalagmite layers counting chronology has been developed on the basis of micro layer counting technique recently in order to date young stalagmite (Hou & *alii*, 2002).

Usually the column-like stalagmites are the perfect samples for paleoclimate analysis. If the stalagmite is not column like, the estimated growth trend, i.e., the deposition trend must be corrected by standardization before doing some analysis (Tan & *alii*, 2002; Proctor & *alii*, 2000), especially analysis in layer thickness.

Two kinds of micro-layers, northern pattern and southern pattern, have been found in Chinese stalagmites (Tan & *alii*, 1999a). Here we present the image characteristics of annual layers in both patterns of Chinese stalagmites for it will be useful in reconstructing high-resolution paleoclimate.

All the stalagmites mentioned in this research are still growing (i.e., the water was still dripping over the stalagmites and was depositing) when collected. And there is no coupled stalactite over the stalagmites. The stalagmites were sawn into halves along the growth axis. One half was polished and sampled for TIMS ^{230}Th dating, stable isotope analysis, and so on, another half was further cut into 1 mm thin sections for optical observation and micro layer counting.

TWO KINDS OF MICRO LAYERS

Two kinds of micro layers, northern pattern and southern pattern, have been found in Chinese stalagmites (Tan & *alii*, 1999a). The northern pattern micro layers are mainly found in stalagmites collected from caves in North China, such as those from The Water Cave situated in Benxi, Liaoning Province; Shihua Cave in Beijing; Baiyun Cave in Lincheng County, Hebei Province; Jiguan Cave and Dongshiya Cave in Luanchuan County, Henan Province; Hulu Cave in Nanjing, Jiangsu Province et al. While stalagmite with southern

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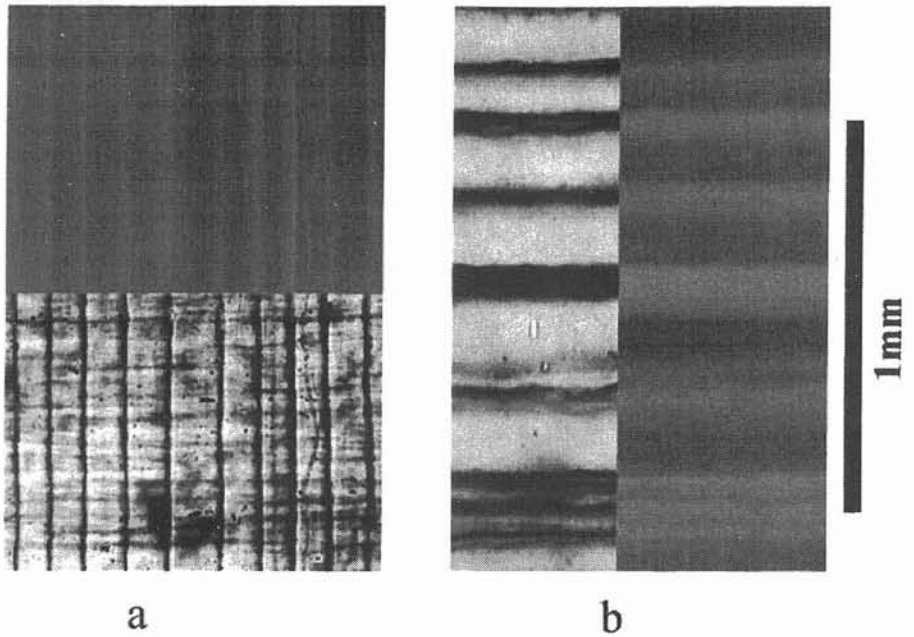

FIG. 1 - Northern pattern stalagmite micro layers - a) stalagmite TS9501, from Beijing Shihua Cave. Lower, observed in transmitted light; upper, in incited ultra violet; b) stalagmite TW9801, from Benxi Water Cave, Liaoning Province. Left, observed in transmitted light; right, in ultra violet.

pattern micro layers are mainly collected from caves in South China, such as Fengyuyan Cave, Ludiyan Cave in Guangxi Province; Hulu Cave in Huapin County, Yunnan Province; Dafo Cave in Zhanyi County, Yunnan Province et al.

The northern pattern micro layers mainly consist of thin opaque band and thick transparent calcite band; the latter is composed of fiber-like crystalline calcite (fig. 1), with the longitude axis of the crystal intersecting to the division of the micro layers. When incited by ultra-violet in the microscope Olympus BX-60, the thin opaque band is brighter than calcite band probably for there is much organic matter than in calcite band. The interfaces observed in transmitted light and in UV basically corre-

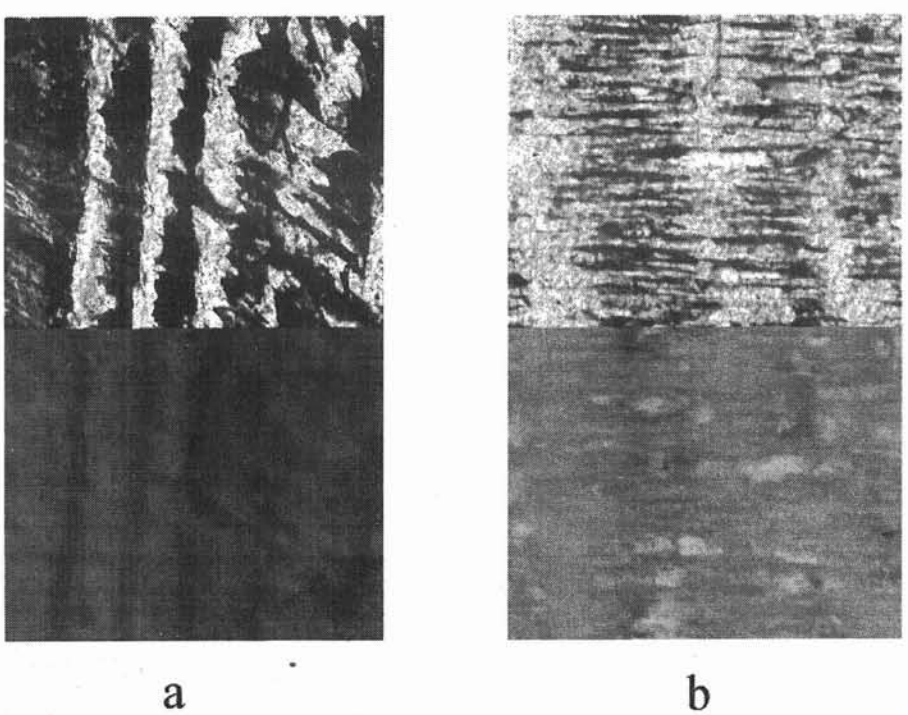

FIG. 2 - Southern pattern stalagmite micro layers - a) Stalagmite Zhch01, from Guangxi Province. Upper, observed in transmitted light; lower, in incited ultra violet; b) Stalagmite Zhch02, from Guangxi Province. Upper, observed in transmitted light; lower, in ultra violet.

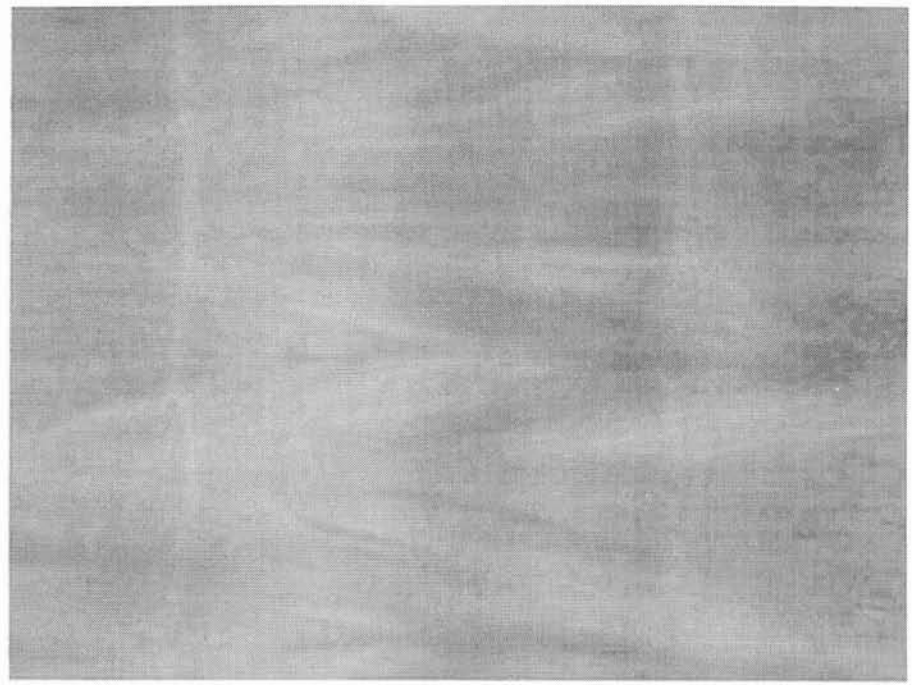

FIG. 3 - Southern pattern micro layers in stalagmite JBF9901, collected from Bianfu Cave, Yunnan Province. Observed by in low magnification stereomicroscope.

spond one by one, and the phenomenon is called bi-optical (Tan & *alii*, 1999b).

While the stalagmites collected from south China mainly consist of aragonite, a few of them is transparent, some of them are translucent, some opaque. The southern pattern micro layers are composed of thick opaque band and thin transparent band when observed in transmit light. While observed in UV, the opaque band of some stalagmites are brighter than the transparent band (fig. 2a), while in some other stalagmites, the transparent band are brighter than the opaque band (fig. 2b). We do not know why these happen yet. Observed by naked eyes or in low magnification stereomicroscope, the micro layers in opaque stalagmites could be seen clearly (fig. 3). The micro layers are composed of thin protuberant ridges and wide shallow groves.

All the annual layers are verified by the comparison between high resolution Thermal Ionization Mass Spectrometry ^{230}Th dating and layer counting (Hou & *alii*, 2002; Tan & *alii*, 2000), the results of some stalagmites are displayed in fig. 4. The comparison shows that the stalagmites are continuously deposited, and that the layers we counted are annual layers.

IMAGE CHARACTERISTICS OF THE ANNUAL LAYERS

The northern pattern and southern pattern annual layers differ in image characteristics when the thin sections of stalagmites are observed either in transmitted light or in ultra violet. The difference between them is discussed in detail as follows.

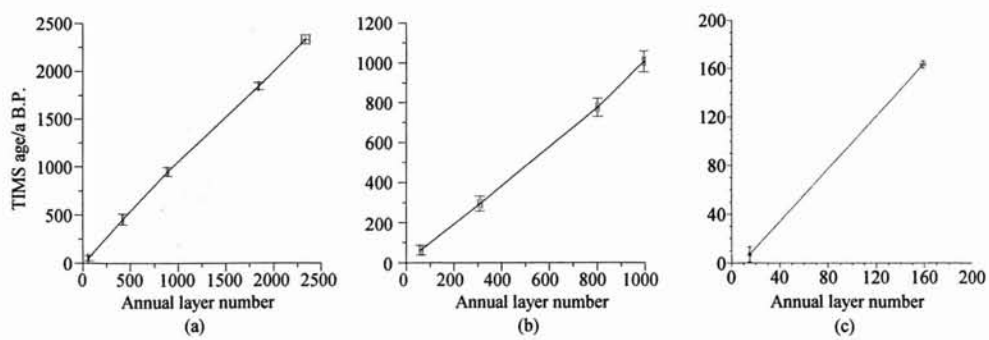

FIG. 4 - Comparison between TIMS ^{230}Th dating and annual layers counting of three young Chinese stalagmites - a) TS9701, Beijing Shihua Cave; b) LS9602, Beijing Shihua Cave; c) JBF9901, Bianfu Cave, Jiuxiang, Yunnan Province. TIMS dating and annual layer counting of three stalagmite show that the layer counting is effective in dating young stalagmites.

1. *Northern pattern annual layers*

The northern pattern stalagmites layers are easily observed in transmit light for calcite, the major component of stalagmites collected in northern China is transparent. The significant features of the northern pattern annual layers are their carving-like dark layer and convex bright layer under microscope, and the light line will move come and back when the focal distance is adjusted (see fig. 5).

It is rare that the layer divisions are perpendicular to the stalagmite thin section with 1mm thickness, so the image of the interface of layers moves come and back if we move the thin section up and down, i.e., when the focal distance is adjusted (fig. 6). But, the deposition of calcite probably includes some impurities, which may produce the indistinct divisions in stalagmites. It is thought that impurity yields the sub-layer or multi-year layer in stalagmites.

2. *Southern pattern stalagmite layers*

Some of southern pattern micro layers could be observed in transmitted light, while some other could not, which should be observed in reflected light in low magnification stereomicroscope or by naked eyes. When observed in transmitted light in microscope, the southern pattern annual layers are divided by very thin bright band. Sometimes the bright line is not clear enough, and is penetrated through by fiber-like crystalline calcite; probably that is not the division of annual layers. When some samples are observed in reflected light in low magnification stereomicroscope, the southern pattern annual layers are stereo, with an annuals layer consisting of a thin protuberant ridge and a wide shallow grove.

The southern pattern micro layers of a stalagmite were observed and counted either in transmitted light or in reflected light, the results show that both methods are effective in counting annual layers after compared with TIMS-^{230}Th dating.

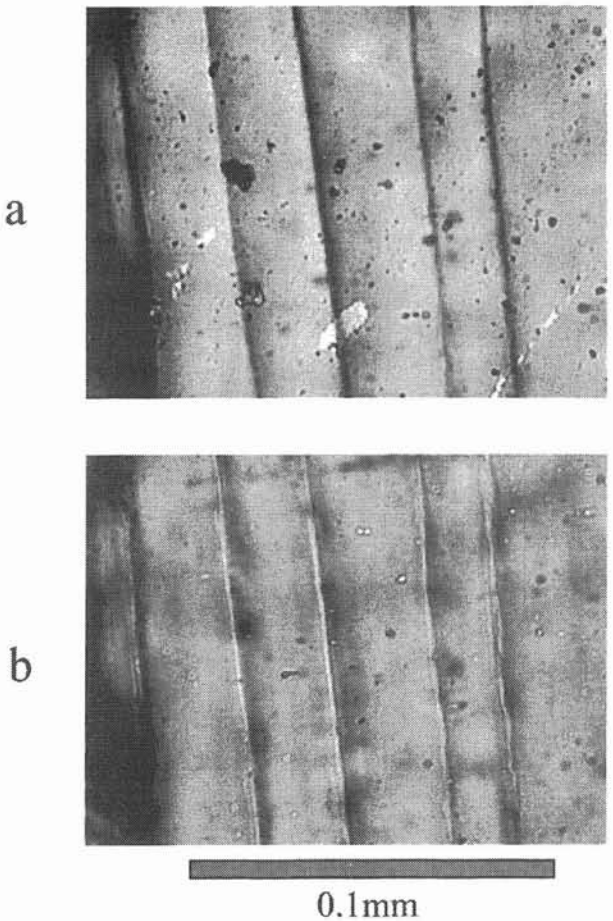

FIG. 5 - Image characteristics of northern pattern annual layer in different focal plane observed in transmitted light - a) the carving-like dark division; b) the convex bright layer.

CONCLUSION AND DISCUSSION

From the above discussion, we could know the characteristics of annual layers in Chinese stalagmites are clearly determined. The annual layer counting can be an effective method to date young continuously deposited stalagmites. And the chronology obtained by annual layers counting can be corresponding to calendar age, which could decrease the uncertainties in age determination, one major problem in reconstructing past climate change.

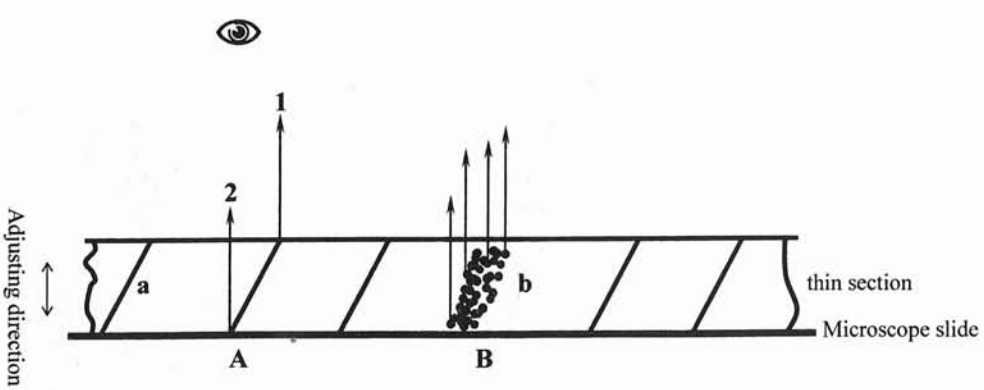

FIG. 6 - Sketch map showing formations of different images in the stalagmite thin section - a) layer interface; b) impurities. A) divisions of annual layers; B) pseudo division of annual layers, which probably mislead us to count them into true annual layers.

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