

Fluorescence intensity studies of Triassic acritarchs from the Yanchang Formation in Ordos basin, northwestern China

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Abstract Fluorescence properties of Early Cambrian acritarchs were investigated using Leica das Mikroskop (DM) microscopy with a mercury lamp. Well-preserved autofluorescence properties show a correlation between acritarchs morphology and the intensity of emitted fluorescence. In accordance with the fluorescence intensity of organic cell walls, two groups of microfossils were distinguished. Results of observation in this study, which are consistent with those of the previous foreign studies, are in good agreement with regular difference in autofluorescence intensity among paly-nomorphs reported by McPhilemy (1998). Spores and algae, including Botryococcus, have very bright fluorescence while acritarchs often show less intense fluorescence. Dark brown microfossils have been reworked, and have little or no fluorescence.

Keywords acritarchs, fluorescence, Yanchang Formation, Triassic

1971). Therefore, the well-preserved organic matter and organic-walled microfossils should be applied in the fluorescence study on fossil organic-walled algae and spores. In the exploration of oil and natural gas, the fluorescence microscopy and microphotometry have been widely used to identify different types of kerogen and degrees of organic matter maturation (Robert, 1981). The previous investigation of fluorescence focused on the coalification of spores and pollen, while paid little attention to acritarchs.

Previous fluorescence microscopy investigations of acritarchs have been carried out on marine acritarchs (Talyzina, 1998), and the fluorescence was used to distinguish different biological kinds of organic-walled microfossils; however, this paper will focus on lacustrine acritarchs. The well preserved organic-walled microfossils are recognized in Yanchang Formation of Ordos Basin, so the fluorescence study can be used on them. It is the first time to use fluorescence in distinguishing different organic-walled microfossils.

1 Introduction

Fluorescence is a typical property commonly in living and fossil organic-walled algae and spores (van Gijzel, 1967; Havinga, 1971; van Gijzel, 1971). When organic-walled algae and spores are preserved in sedimentary rocks, the autofluorescence color will gradually darkle and its intensity will gradually decrease because of the increase in temperature, pressure and oxidation and maturation level in geological processes (van Gijzel, 1967; Havinga, 1971; van Gijzel,

2 Geological settings

Ordos Basin was one part of Northern China Marine Domain during Paleozoic, and later it became a lacustrine basin in Middle and Late Triassic. During this period, clastic sediments of a lacustrine delta deposited, showing progradation towards the southwest. These sedimentary rocks, the so-called “Yanchang Formation”, became dominant Mesozoic oil source rocks in this area (Editorial Committee of Petroleum Geology of Changqing Oilfield, 1992). The Yanchang Formation includes ten oil shale sections (from sections Chang 1 to 10) (Table 1). The geological age from sections Chang 10 to 8 is middle Triassic, while sections Chang 7 to 1 are late Triassic in age on the basis of the previous studies

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Table 1 Division of the Yanchang Formation in Ordos Basin

		Stratum		Thickness (m)	Lithology	Lake evolution	
Series	Form.	Section	Oil layer				
Upper Triassic (T ₃)	Yanchang Formation (T ₂₊₃ Y)	V (T ₃ Y ₅)	Ch 1	0–240	Black and brown mudstones, light caesious siltstones, poststone interlayer with carbeneous mudstones and coal seams. The base of layer interlayer with coal seams, carbeneous mudstones and tuffs	The disappearance of Lake Basin	
		IV (T ₃ Y ₄)	Ch 2	Ch2-1	40–45	Gray and caesious fine sandstones interlayer with brown mudstones, the upper of layer interlayer with carbeneous mudstones and tuffs	The shrinkage of Lake Basin
				Ch2-2	40–45		
				Ch 2-3	45–50		
		Ch 3	Ch 3-1	35–50	Dark gray mudstones interlayer with brown siltrocks and fine sandstones, partially interlayer with coal seams, the upper of layer interlayer with tuffs, and the base of layer occasionally occur stuffs		
			Ch 3-2	40–50			
			Ch 3-3	45–50			
		III (T ₃ Y ₃)	Ch 4+5	Ch 4+5	30–50	Black mudstone, carbeneous mudstones and coal seams interlayer with thin siltstone and fine sandstones, occasionally with stuffs	The stabilization of Lake Basin
				Ch 4+5	30–50	Light gray siltstones and fine sandstones interlayer with black mudstones.	
				Ch 6	Ch 6-3	35–45	
Ch 6-2	35–45						
Ch 6-1	Ch 6-1	35–40	Dark gray mudstones and siltstoned interlayer with fine sandstones, the base of layer interlayer with stuffs				
	Ch 7	Ch 7-3	30–40	Dark gray mudstone, carbeneous mudstone and oil shale interlayer with thin siltstones, the middle and lower part of layer interlayer with stuffs			
		Ch 7-2	20–50				
Ch 7-1		15–55					
II (T ₂ Y ₂)	Ch 8	Ch 8-1	35–45	Gray and light gray arkose quartzites and arkosic arenite interlayer with brown and black mudstones	The expansion of Lake Basin		
		Ch 8-2	40–50				
		Ch 9	90–120			Gray and caesious thick arkose quartzite interlayer with dark gray and dark purple mudstones, siltstone and poststone, the base of layer interlayer with fine-gravel rocks	
Mid-Triassic (T ₂)		I (T ₂ Y ₁)	Ch 10	280			

on plants, fish and bivalves (Institute of Geology, Chinese Academy of Geological Sciences, 1980).

Recently, the huge Xifeng Oilfield was discovered in the southwestern part of the basin (eastern Gansu Province). The store beds of the Xifeng Oilfield are river channel sandstones of the sections Chang 8–1, while the main oil source rocks are found in deep to deepest lacustrine mudstones with high organic matter of the section Chang 7 (Fu et al., 2004).

3 Materials and methods

Samples from the sections Chang 7 and 8 of Yanchang Formation were processed. Microfossils were extracted using 45% HF, 15% concentrated HCl and filtration in distilled water to be neutral. Observation under AXIO SKOP II transmitted light microscopy and fluorescence microscopy.

Microscopy preparations were made using 502 gluewater as mounting medium to avoid background fluorescence.

Microfossils under consideration have undergone rather low thermal alteration (Robert, 1981; van Gijssel, 1981; Hayes et al., 1983; McPhilemy, 1988). The color of microfossils from the sections Chang 7 and 8 of Yanchang Formation is yellow and transparent and indicates a thermal alteration index (TAI) around I. The quiet lacustrine sedimentary environment and subsequent shales preparation left the studied microfossils extremely well preserved. Although the Ro of organic matter in the sections Chang 7 and 8 of Yanchang Formation is up to 0.9%, and the evolution of these organic matter came into maturation level; however, because of shales and hydrocarbon source rocks protection, organic microfossils in local situation are preserved very well. As a result, they have good autofluorescences.

4 Results and discussion

Investigated samples contain a diverse algae and spore assemblage, *Leiosphaeridia* sp., *Lophosphaeridium* sp., *Comasphaeridium* sp., *Botryococcus*, colonies of algae or spores, remnants of high land plant and algae. These organic-walled microfossils have very thin and transparent walls and they can be observed difficultly under transmitted light microscopy, so scanning electron microscope (SEM) is used.

Colonies of algae or spores are composed of 20–30 μm individuals, with intragranulate ornamentation on surface. Three shallow ditches can be seen between surface ornamentation under SEM. *Botryococcus* is light brown, 100 μm or larger under transmitted light microscopy; *Leiosphaeridia* sp. range from 10–50 μm , *Lophosphaeridium* sp. range from 10 to 20 μm , with strumae on surface, and process less than

1 μm ; *Comasphaeridium* sp. range from 10 to 20 μm , with filamentous process on surface, and filamentous process less than 1–2 μm .

Figure 1(a) shows *Botryococcus* and separate individuals of algae or spores under fluorescence microscopy, Fig. 1(b) shows colonies of algae or spores under SEM, Fig. 1(c) shows *Botryococcus* individual under transmitted microscopy and Fig. 1(d) shows *Botryococcus* individual under fluorescence microscopy. Figure 2(a) shows *Comasphaeridium* individual of acritarchs under transmitted microscopy, and Fig. 2(b) shows its well-developed fluorescence under fluorescence microscopy and the intensity of fluorescence varies according to specimens. Figure 2(c) shows *Comasphaeridium* sp. of acritarchs under SEM, Fig. 2(d) and (e) show *Leiosphaeridia* sp. of acritarchs under SEM, and Fig. 2(f) shows *Lophosphaeridium* sp. of acritarchs under SEM. Figure 3(a) shows the fluorescence of remnants of land higher plant under fluorescence microscopy and Fig. 3(b) shows the form of remnants of land high plants under SEM.

The fluorescence difference between microfossils and plants remnants can not be related to the state of preservation according to the following two reasons.

(1) The fluorescence of microfossils occurs along their walls, and different kinds of microfossils have different fluorescence.

(2) Under transmitted light microscopy, the different microfossils with various levels of fluorescence have the same state of preservation.

The investigated acritarchs and spores cell walls show well-preserved autofluorescence and the level of fluorescence changes for different kinds of kerogens was found. These microfossils can be divided into the following three kinds according to the fluorescence property.

(1) Colonies of spores or algae and *Botryococcus* have high intensity of fluorescence. It can be found that they have

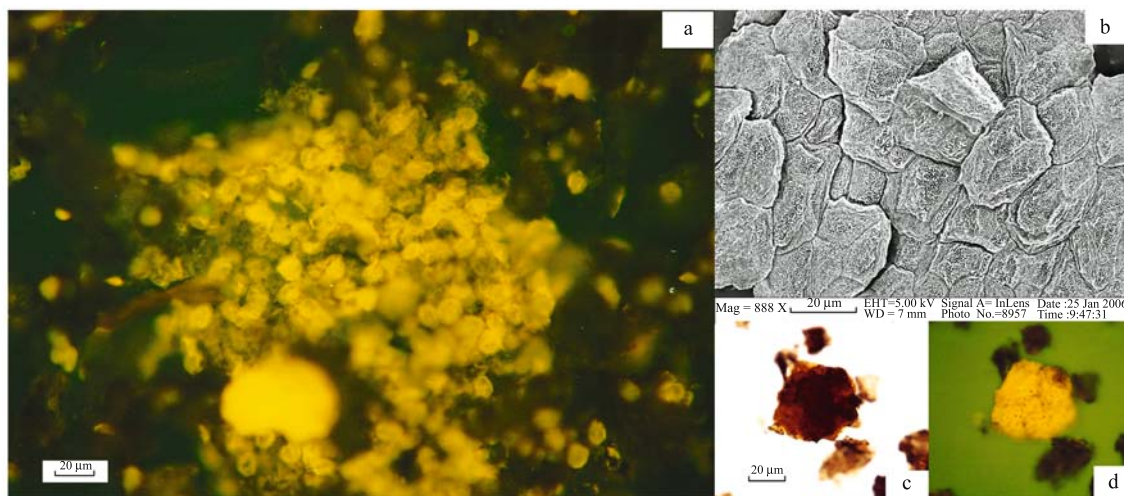


Fig. 1 Form and fluorescence show of Acritarchs (*Leiosphaeridia*) and *Botryococcus*

(a) *Botryococcus* and separate individuals of *Leiosphaeridia* under fluorescence microscopy (with highest fluorescence); (b) colonies of fresh algae under SEM (with brain surface texture ornament and shallow groove); (c) *Botryococcus* under transmitted light microscopy; (d) *Botryococcus* under fluorescence microscopy

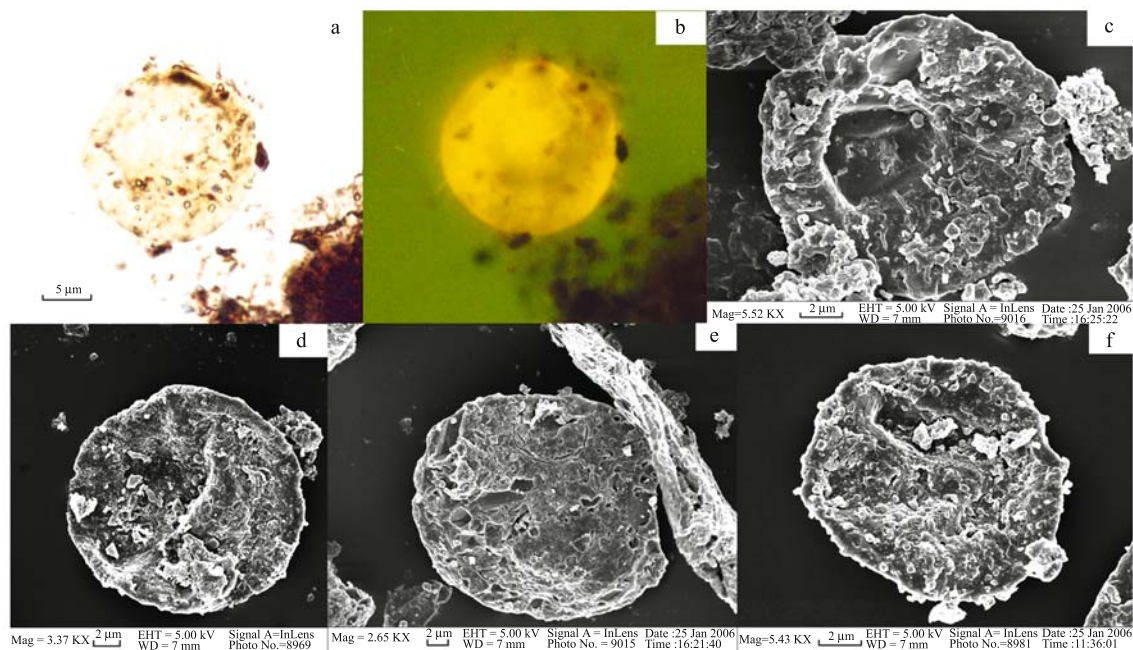


Fig. 2 Acritarchs from the Yanchang Formation, with moderate fluorescence compare with *Botryococcus* (a) *Comasphaeridium* sp. under transmitted light microscopy; (b) *Comasphaeridium* sp. under fluorescence microscopy; (c) *Comasphaeridium* sp. under SEM; (d), (e) *Leiosphaeridia* sp. under SEM; (f) *Lophosphaeridium* sp. under SEM

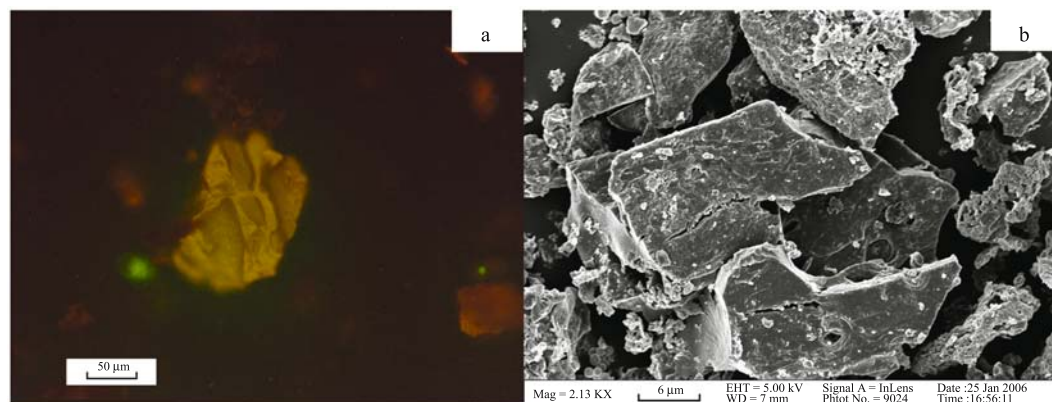


Fig. 3 Form and fluorescence show of high plant remnant (a) High plant remnant under fluorescence microscopy, with low fluorescence compared to other organic matters; (b) high plant remnant in Yanchang Formation under SEM

high and yellow fluorescence, and the high fluorescence makes us not to identify their walls. An example is shown in Fig. 1.

(2) Acritarchs have well-developed fluorescence, especially acritarchs with different ornamentation. For example in Picture 2, when observing the *Comasphaeridium* sp., it can be found that even process on the walls of *Comasphaeridium* sp. also have well-developed fluorescence, just like their walls. The same fluorescence between the process and walls of *Comasphaeridium* sp. indicates that they have same chemical composition.

(3) Materials which have weakly developed fluorescence include remnants of high land plants and degraded

microfossils. The fluorescence of degrade microfossils will decrease with the maturation rise.

Under the observation, the results are consistent with the previous studies (McPhilemy, 1988; Talyzina, 1998). Observations in this study are in good agreement with regular differences in autofluorescence intensity among palynomorphs reported by McPhilemy (1988). McPhilemy noticed that early Carboniferous spores, cuticle and algae, including the prasinophycean *Tasmanites* sp., have very bright fluorescence while acritarchs often show less intense fluorescence. Dark brown microfossils have been reworked, and have little or no fluorescence.

The authors considered that a quantitative study can be performed with fluorescence cell distributary equipment in

the future by the different fluorescence characteristic of microfossils. It will be helpful for the system and classification studies of microfossils, and the separation of microfossils also will be actualized by fluorescence cell distributary equipment (Talyzina et al., 2000). Accordingly the means can meet the requirement of the experimental technique of biomarkers analysis and TEM studies in the studies on microfossils (Talyzina et al., 2000; Meng et al., 2005).

5 Conclusions

This paper showed that colonies of algae or spores and *Botryococcus* have very high fluorescence intensity, and lacustrine acritarchs have well-developed fluorescence. However, the kerogen of land high plants and degraded microfossils has weak fluorescence.

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