[PS]Using Homogenization Temperature and Trapping Pressure Of Fluid Inclusion to Doubly Constraint on Hydrocarbon Charging Times: As an Example of the Ordovician in Yubei Area, Tarim Basin*

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Abstract

Although the method of homogenization temperature (Th) of fluid inclusion projecting on burial history diagram with thermal curve to obtain hydrocarbon charging times has been widely and effectively used, some uncertainty arises on the multi-cycle superimposed basins, in which one Th can appear at two or more depths. For reducing the multiple solutions, two parameters of Th and trapping pressure (Pt) have been utilized to doubly constrain the times of hydrocarbon charging. When the Th of oil inclusion and its coeval aqueous inclusion, gas to liquid ratio of oil inclusion and chemical components of oil inclusion are known, the software VTflinc can thermodynamically model the trapping pressure of the oil inclusion. Tarim basin is a typical multi-cycle superimposed basin. Sixty-three Ordovician fluid inclusion samples from 11 wells in Yubei area were systematically measured and the burial history diagrams with thermal curves for each well were established. After the Th of aqueous inclusion and the Pt of its coeval oil inclusion were projected doubly on burial history diagram for each well, the hydrocarbon charging time would be determined. Then, we put all the charging times on the same geological age axis. Two hydrocarbon charging events occurred: the first took place from 272.2Ma to 257.5Ma (during the Late Hercynian), indicated by yellow and blue-green fluorescent oil inclusions; the second event took place from 13.1Ma to 9.9Ma (during the Late Himalaya), indicated by yellow and yellow-green fluorescent oil inclusions.

Using Homogenization Temperature And Trapping Pressure Of Fluid Inclusion To Doubly Constraint On Hydrocarbon Charging Times: As An Example Of The Ordovician In Yubei Area, Tarim Basin

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INTRODUCTION

Although the method of homogenization temperature (Th) of fluid inclusion projecting on burial history diagram with thermal curve to obtain hydrocarbon charging time has been widely and effectively used, some uncertainty arises on the multi-cycle superimposed basins, in which one Th can appear at two or more than two depths. For the purpose of reducing the multiple solutions, two parameters of Th and trapping pressure (Pt) have been utilized to doubly constrain the times of hydrocarbon charging. When the Th of oil inclusion and its coeval aqueous inclusion, gas to liquid ratio of oil inclusion and chemical components of oil inclusion are known, the trapping pressure of the oil inclusion can be thermodynamically modeled by the software VTflinc. After the Th of aqueous inclusion and the Pt of its coeval oil inclusion were projected doubly on burial history diagram for each well, the hydrocarbon charging time would be determined.

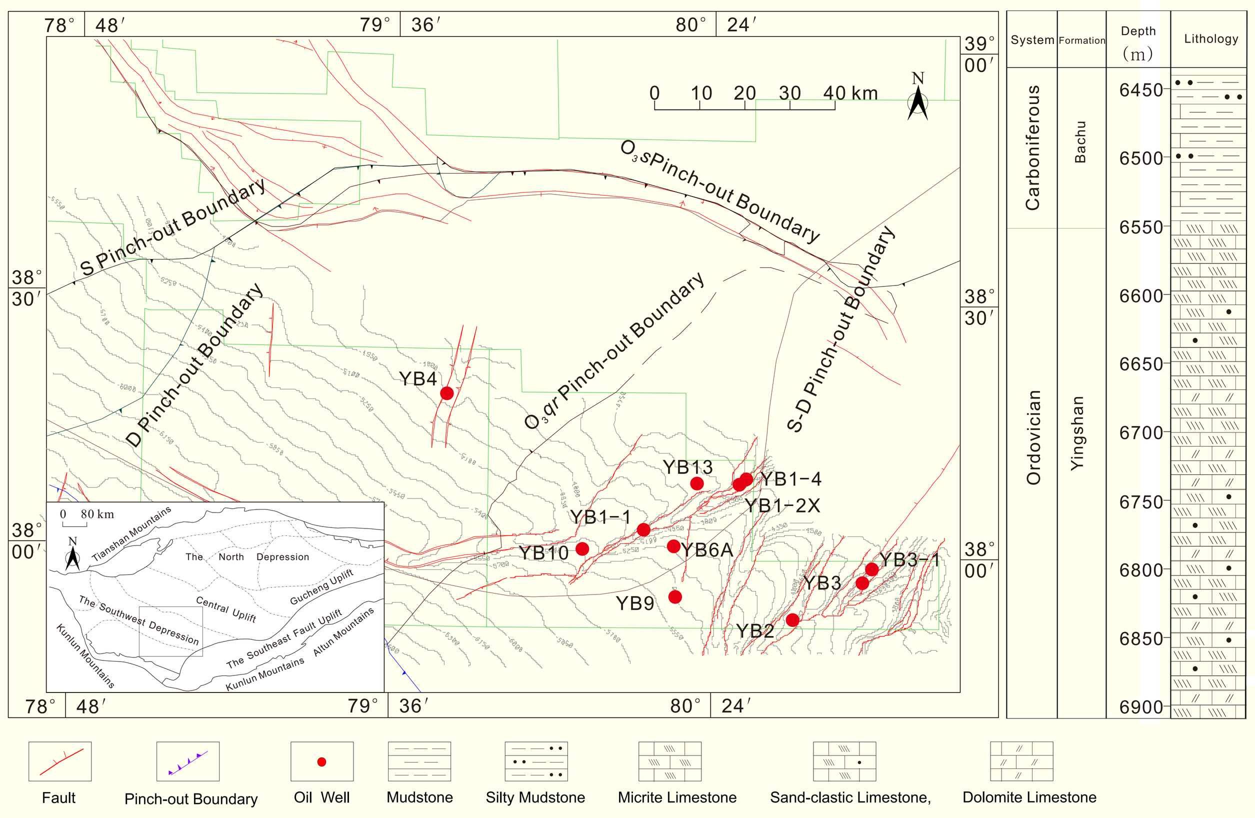

Fig. 1 The structural map showing the sampling well locations in Yubei Area Tarim Basin and the lithological column of the Ordovician in well YB9

Yubei Area is located in the southeast of the Makrit Slope, Tarim Basin. It has undergone Caledonian, Hercynian, Indosinian, Yanshan, Himalayan orogeny. The residual succession of the Ordovician consists of Yingshan Formation and Penglaiba Formation only in Yubei Area.

METHOD

The transmitted light microscopy, micro-beam fluorescence, confocal laser scanning microscope and microthermometry measurement were employed to systematically obtain fluid inclusion petrography, such as occurrence, phase, types, abundance and fluorescent colors of oil inclusions.

Microthermometry and gas liquid ratio (*Fv*) have being widely used to reconstruct the P-T trapping conditions of petroleum inclusions(Aplin et al, 1999). Based on the functional relationship between oil inclusion component, homogenization temperature and gas liquid ratio (Fv), the oil inclusion component prediction can be proposed. When the Th of oil inclusion and its coeval aqueous inclusion, gas to liquid ratio of oil inclusion and chemical components of oil inclusion are known, the trapping pressure of the oil inclusion can be thermodynamically modeled by the software VTflinc.

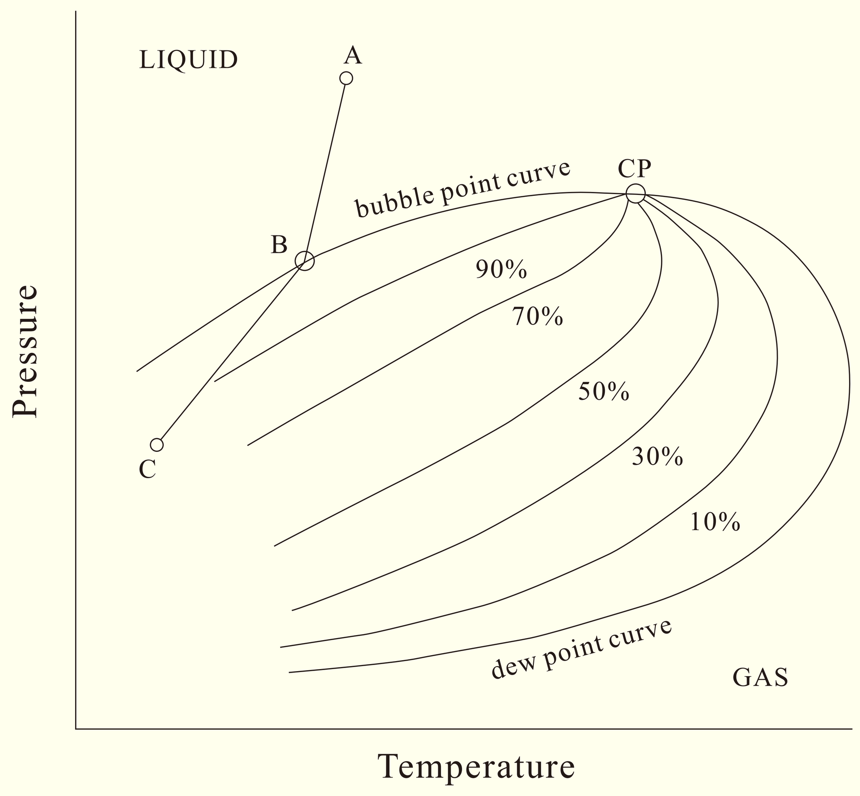

Fig. 2 PT phase diagram of a multicomponent petroleum. CP is the critical point of the fluid and the curves to the left and right of the critical point are the bubble point and dew point curves. As it is taken to surface conditions (C),the path taken by a petroleum trapped as an inclusion at point A is from A to B (bubble point or saturation temperature and pressure) along the fluid's isochore, and then through the two phase region to C. Dashed lines in the two phase region are lines of equal percent liquid and vapour(Aplin et al, 1998).

This research has observed 11wells cores and collected 63 samples to make thin sections. These thin sections were studied by microscope with plane-polarized light, cathodoluminescence, fluorescent and homogenization temperature of fluid inclusions.

SAMPLE OBSERVATION

Diagenesis Sequence

According to the observation of cores and thin sections in the Ordovician of Yubei Area, the diagenetic sequence of calcite cement and multiphase fracture can be determined.

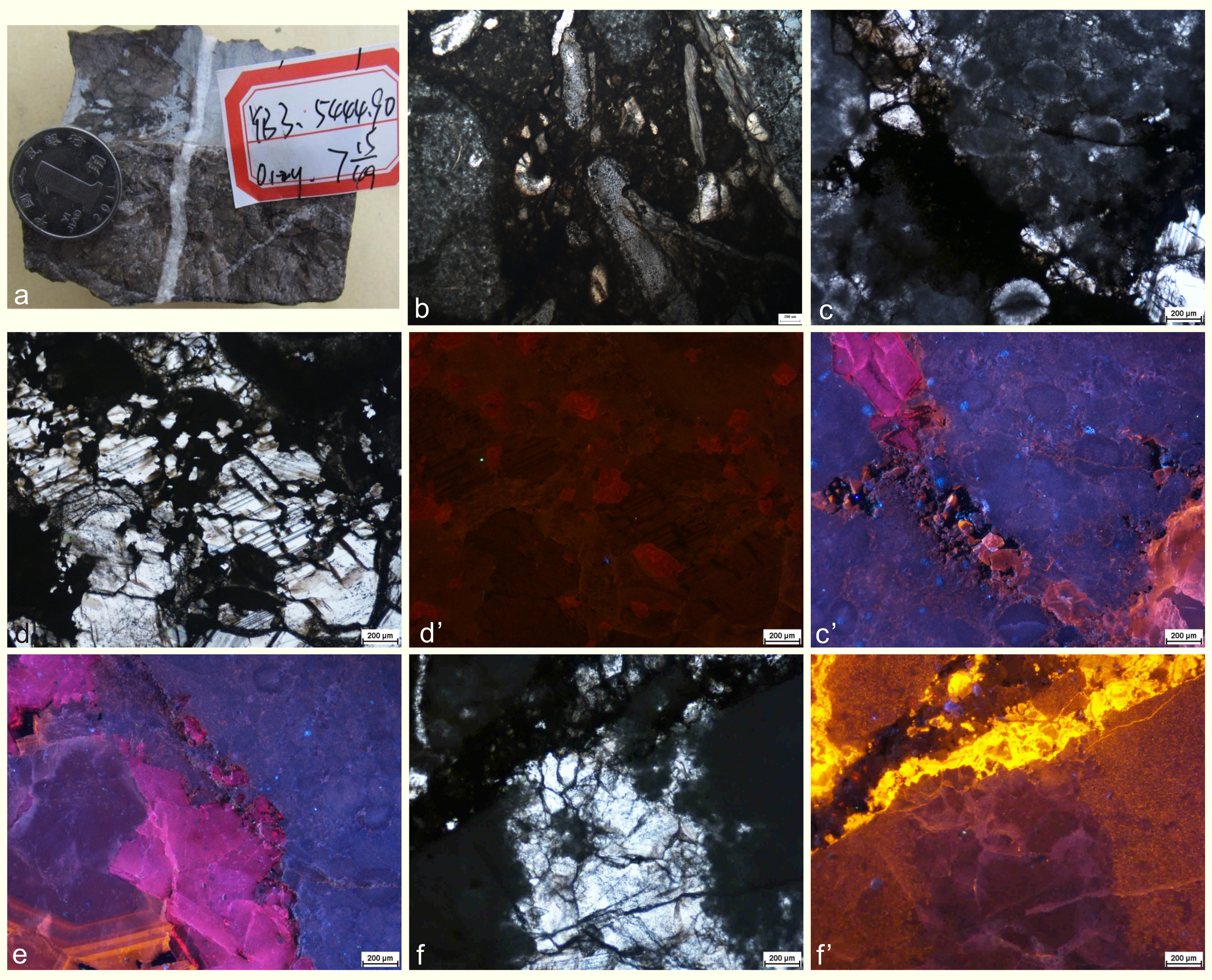

Fig. 3 Micrograph of the Ordovician cores and thin sections showing the sequences of calcite cement filling in fractures, vugs and paleocaves in Yubei Area

The results showed that there were two group of fracture at least (Fig. 3a). The early calcite veinlet filled with bitumen was cut by the late thick calcite vein. The bioclastic shell was dissolved and filled with calcite cement (Fig. 3b).There were burial dolomite along the stylolite, which was dissolved and filled with bitumen lately. The cathodoluminescence (CL) colour of the calcite cement filling in vugs is orange (Fig. 3c, c'). The CL colour of the calcite cement filling in fracture is dark purple(Fig. 3d, d').There were always two generations calcite cements filling in the vugs and paleocaves, and there were dissolved dolomite along the edge of the vugs and paleocaves (Fig. 3e). According to plane-polarized light and CL observation, the late calcite vein filled with CL colour orange calcite cement cutting the early calcite vein filled with CL colour dark purple calcite cement (Fig. 3f, f').

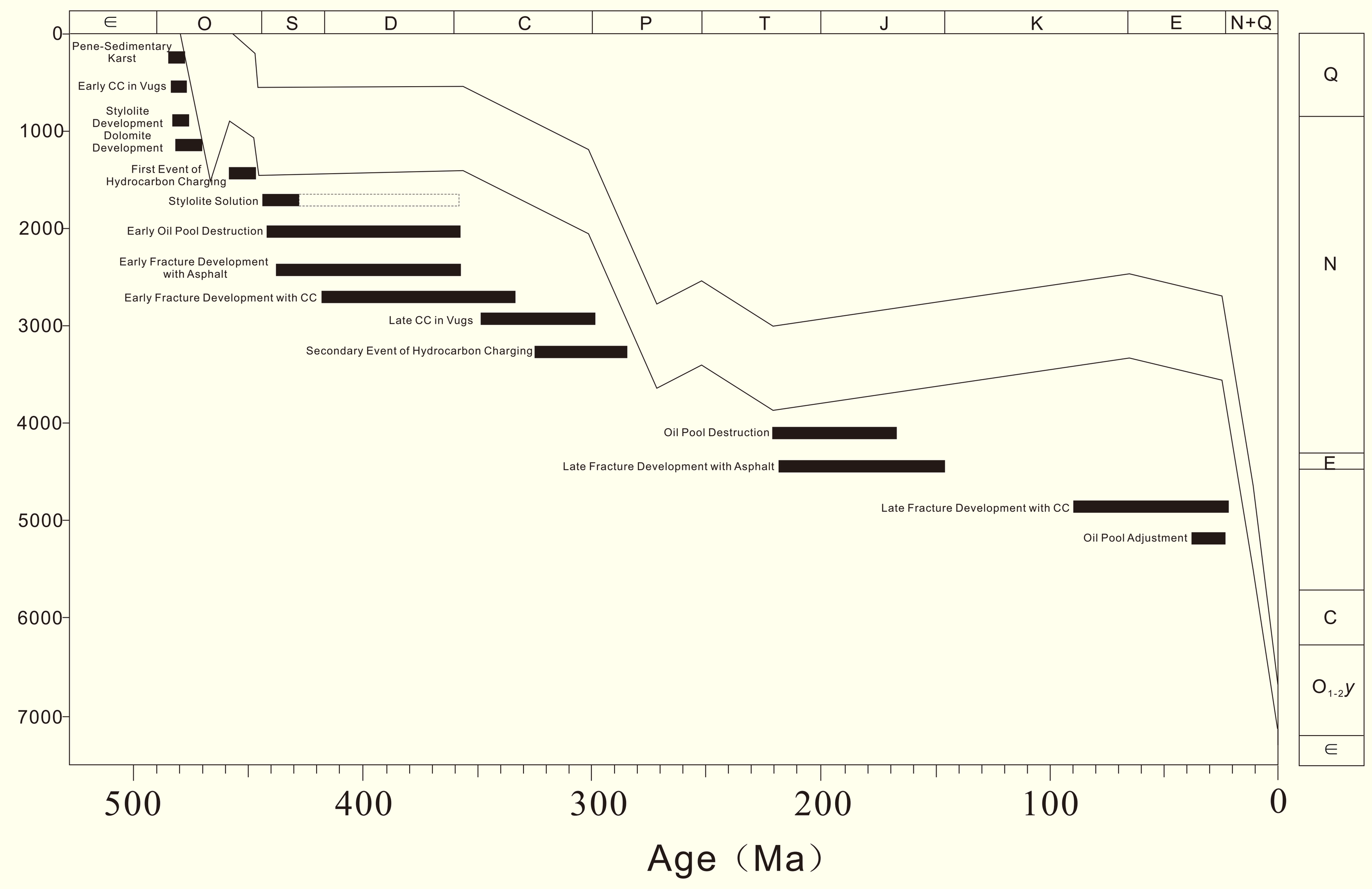

Fig. 4 Schematic diagram of the period of the paleo-fluid and diagenesis sequence in the burial history of Yubei Area

In summary, the diagenetic sequence of the Ordovician of Yubei Area was as follow: since mid-Caledonian, the shell was dissolved and filled with calcite cement in the later burial process. The stylolite developed and then associated dolomitization along the stylolite. At the late Caledonian, the first event of hydrocarbon charging took place. The secondary oil inclusions were trapped in the calcite cement filling the casting vugs of shell, and the dolomites along the stylolite trapped the primary oil inclusions. Due to the late Caledonian and early Hercynian tectonic uplifting, the charged hydrocarbon was breathed, but recorded by the oil inclusions in the early calcite veinlets and bitumen. During the Mid-Hercynian, the formation gradually subsided and the stylolite was dissolved to vugs or paleocaves. The second event of hydrocarbon charging took place in late Hercynian. During Indosinian and Yanshan, the oil reservoir underwent destory again by the tectonic uplifting, and the late fractures were filled with calcite cement. Quick sedimentation adjusted the paleo-reservoir in Himalayan(Fig. 4).

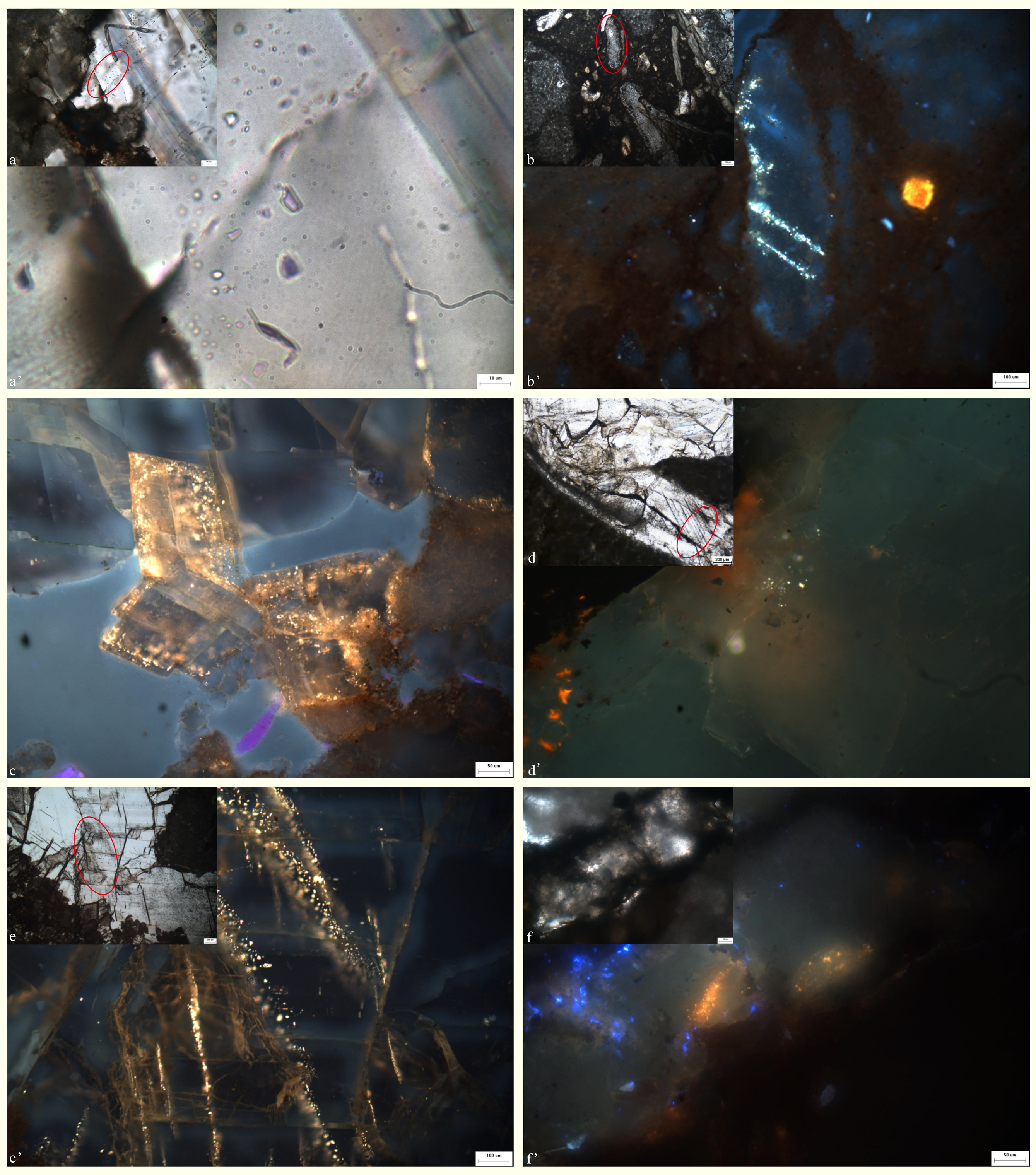

Fig. 5 Fluorescent micrograph of oil inclusions in the Ordovician of Yubei Area

Fluorescent Spectrums

The fluorescence parameters of oil inclusion include fluorescent colour, the peak wavelength of individual oil inclusion and QF535. There is a negative correlation between the maturity of the oil and the peak wavelength or QF535.The analysis of fluorescent spectrums characteristics of oil inclusion in the Ordovician of Yubei Area shows that there are yellow, yellow-green, green and blue-green of fluorescence colours(Fig. 5, 6, 7).

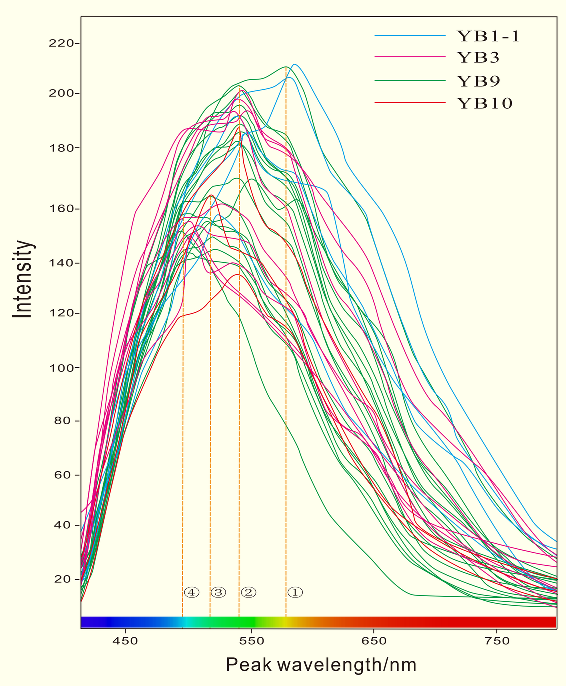

Fig. 6 Fluorescent spectrums of individual oil inclusions in the Ordovician of Yubei Area

Microthermometry

In this research, pertofacies observation of fluid inclusions shows the occurence and the generation of the host mineral, and then measure the homogenization temperature of oil inclusions and its coeval aqueous inclusion in different host minerals, different generations, and different occurrence(Fig. 8).

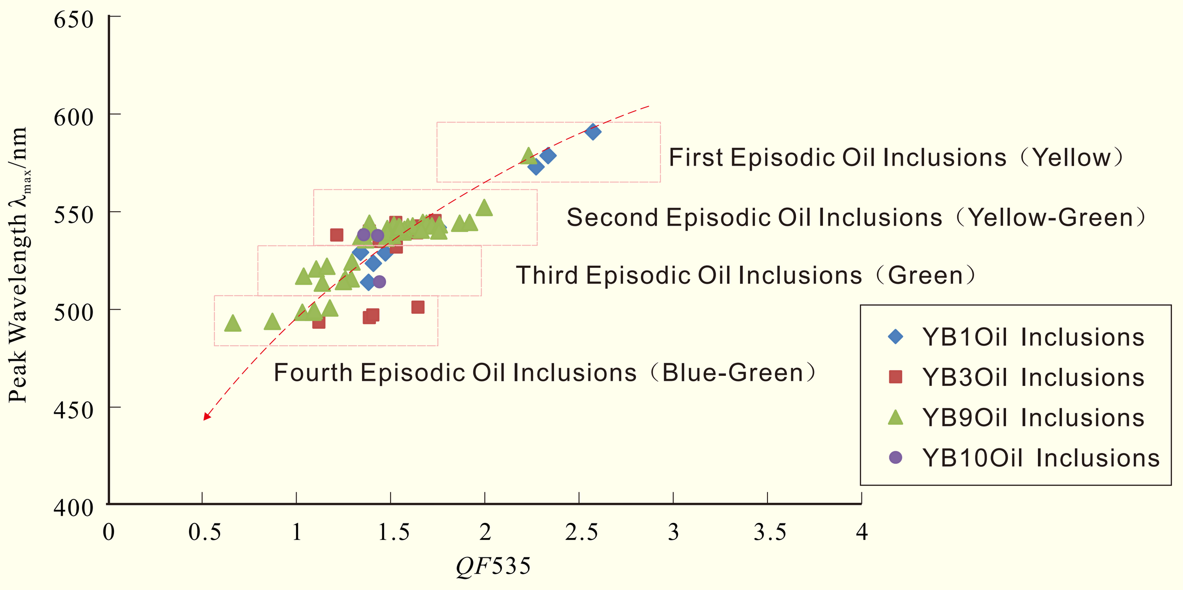

Fig. 7 Plot of relationship between *QF*535 and λ_{max} of individual oil inclusions in the Ordovician of Yubei Area

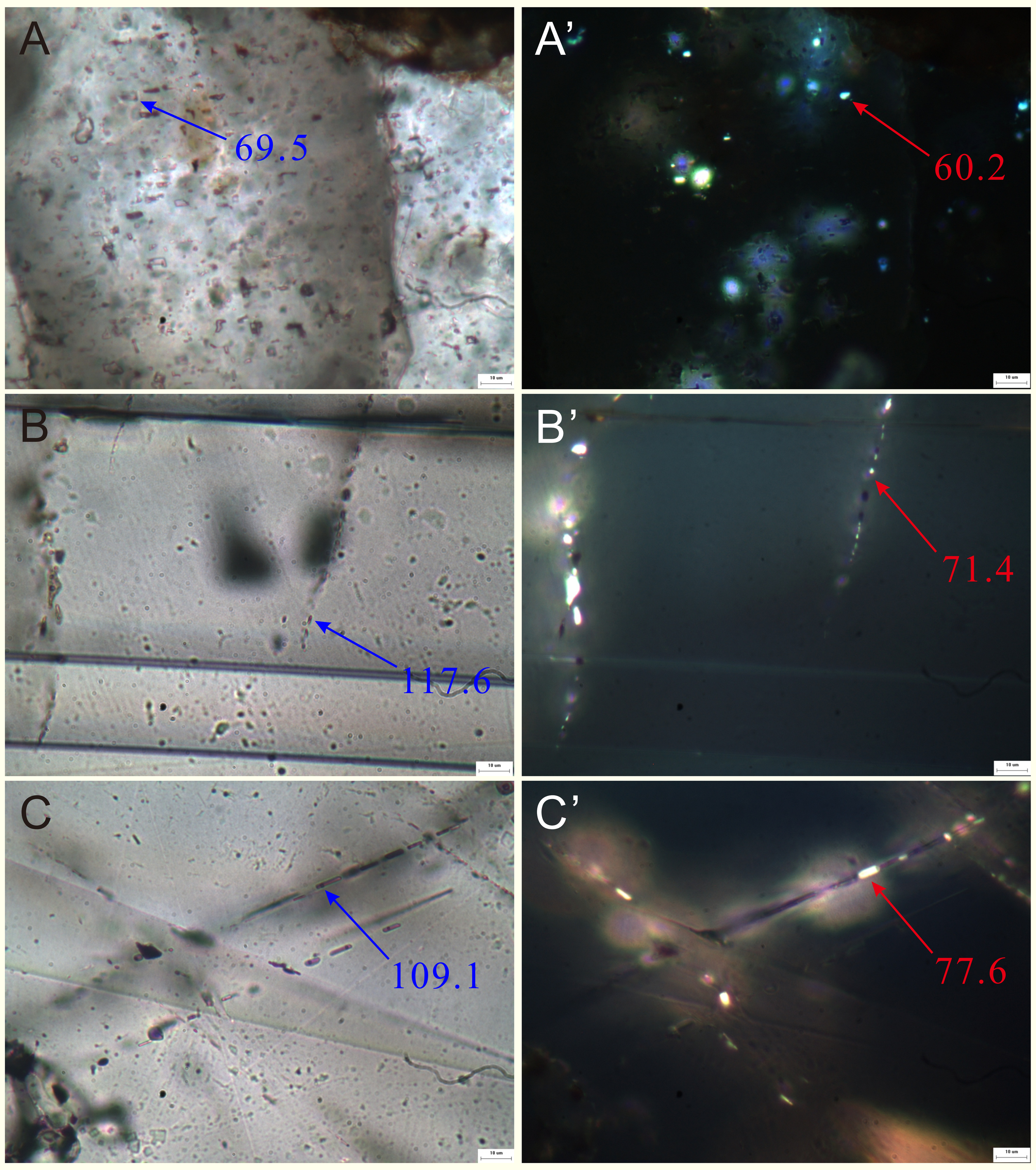

Fig. 8 Occurences, fluorescence colors and homogenization temperature of oil inclusions and its coeval aqueous inclusions in the Ordovician of Yubei Area

Gas to Liquid Ratio

3D model of individual oil inclusion taken with Confocal Laser Scanning Microscope can get the volume of oil inclusion(Fig. 9), and measure the diameter of gas bubble in the transmission light, work out the volume of gas bubble with formula for sphere, then get the gas/liquid ratio(Table. 1).

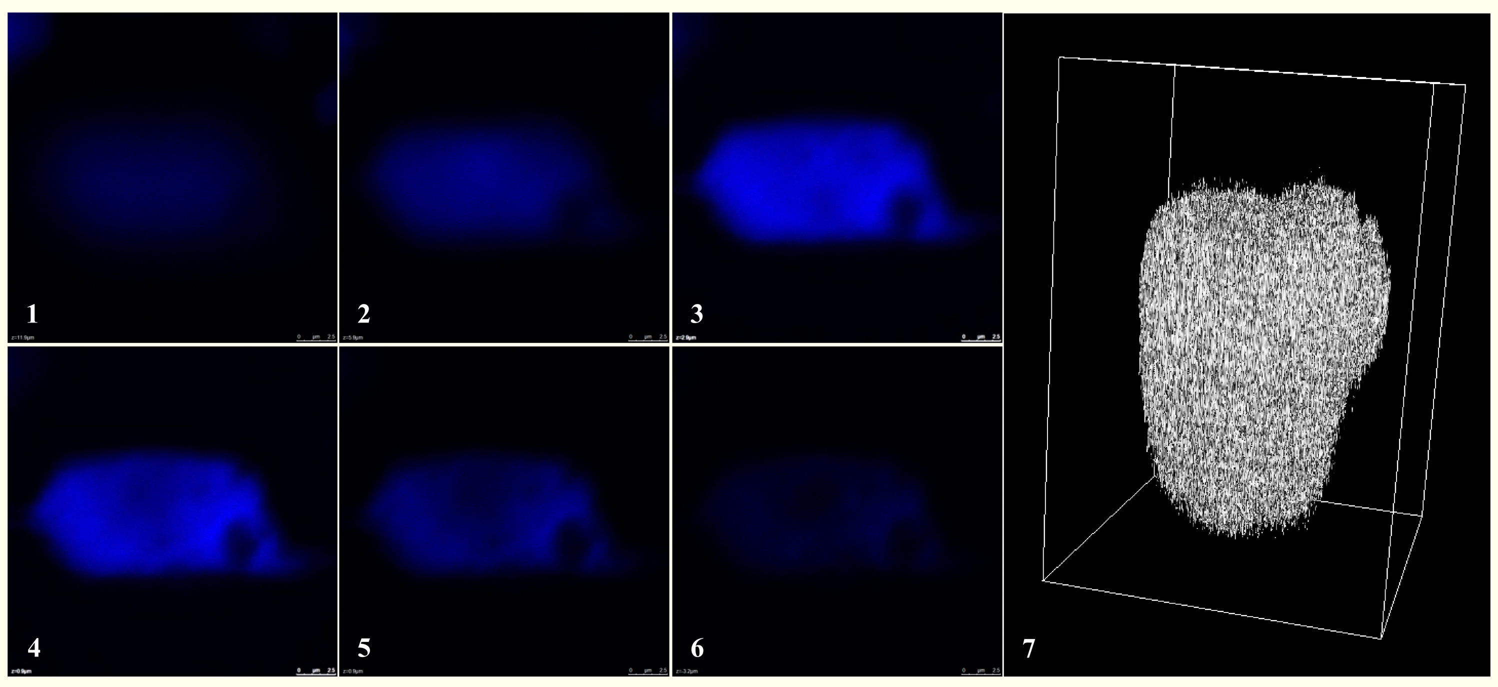

Fig. 9 3D model of individual oil inclusion taken with Confocal Laser Scanning Microscope

Table 1 Component prediction of oil inclusion in the Ordovician of Yubei Area

Well	Depth (m)	Fluorescence Colour	Gas Liquid Ratio (%)	Th of Oil inclusion (℃)	C_1 (%)	C_{7+} (%)
YB1-1	5984.50	Yellow-Green	5.0	79.5	29.70	44.54
YB1-1	5984.50	Yellow-Green	10.0	80.5	44.56	27.34
YB1-1	5985.50	Yellow-Green	5.0	80.1	29.41	44.87
YB3	5444.90	Yellow-Green	8.0	72.8	42.61	29.61
YB3	5450.00	Yellow-Green	8.0	86.4	38.82	34.16
YB9	6561.70	Bule-Green	2.0	60.2	12.54	63.36
YB9	6846.00	Yellow-Green	3.0	77.6	13.10	62.64
YB9	6846.90	Yellow	4.0	80.6	21.67	53.02
YB9	6847.20	Yellow	1.8	54.6	14.44	61.00
YB9	6847.20	Yellow-Green	1.5	71.4	2.35	92.82
YB9	6847.20	Yellow	1.5	59.6	5.44	75.59
YB9	6883.10	Yellow	2.0	60.2	12.54	63.36
YB9	6883.10	Yellow-Green	3.0	74.5	19.81	54.99
YB9	6883.25	Yellow	4.0	77.6	23.56	51.04
YB10	6634.00	Yellow-Green	2.0	63.8	9.64	67.38
YB10	6634.20	Yellow-Green	5.0	83.9	27.45	46.95
YB10	6634.00	Bule-Green	2.5	64.0	16.82	58.26

Chronology of Hydrocarbon Charging

Burial history projected with homogenization temperatures of fluid inclusions determines the chronology of hydrocarbon charging.(1)Project the Th of the coeval aqueous inclusions on the burial history to obtain hydrocarbon charging time. (2)Put the charging time on the same timeline to the influence of depth. (3)Determine the age of the events of hydrocarbon charging(Fig. 10).

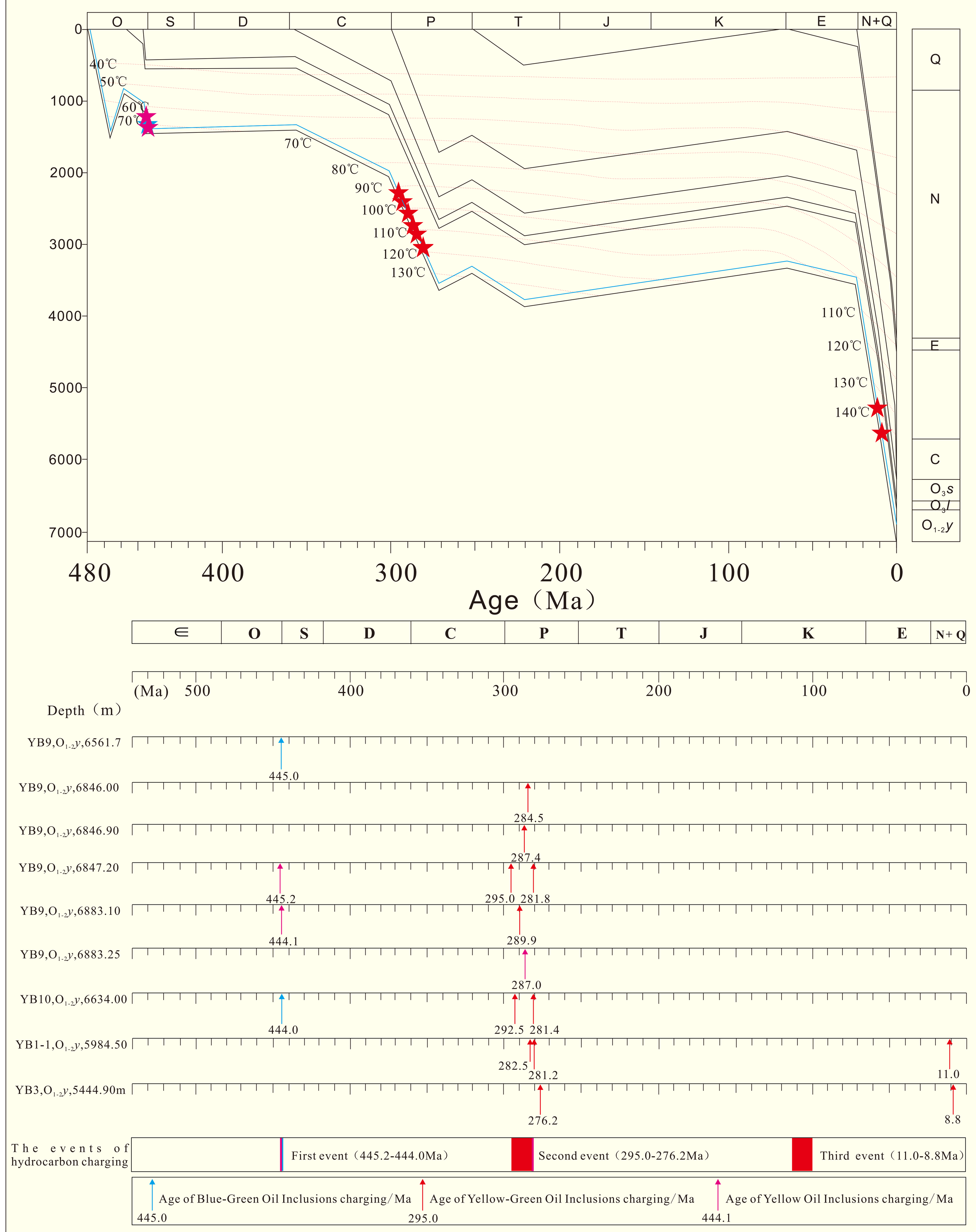

Fig. 10 Schematic diagram of burial curve projected with homogenization temperatures of fluid inclusions in the Ordovician of Yubei Area

Trapping pressure of fluid inclusions determines the chronology of hydrocarbon charging.(1)Calculate Pt by software VTFlinc. (2) Calculate the trapping depth under hydrostatic pressure (3) Project the depth on the burial history to obtain hydrocarbon charging time. (4) Determine the age of the events of hydrocarbon charging(Table. 2)

Table 2 Data of homogenization temperatures and trapping pressure of fluid inclusions constrainting on chronology of hydrocarbon charging

Well	Depth (m)	Host mineral	Th of coeval aqueous inclusion (℃)	Age by Th (Ma)	Pt(MPa)	Trapping Depth (m)	Age by Pt (Ma)
YB1-1	5984.50	Calcite cement in paleocaves	96.8	281.2	22.78	2324.32	282.0
YB1-1	5984.50	Calcite cement in fractures	128.5	11.0	46.02	4695.49	14.8
YB1-1	5985.50	Intergranular calcite cement	98.5	282.5	23.24	2371.69	281.8
YB3	5444.90	Calcite cement in fractures	118.4	8.8	44.12	4502.20	9.7
YB3	5450.00	Intergranular calcite cement	95.8	276.2	23.70	2418.59	274.7
YB9	6561.70	Intergranular calcite cement	69.5	445.0	11.05	1127.83	447.1
YB9	6846.00	Calcite cement in paleocaves	111.5	284.5	26.17	2670.39	287.6
YB9	6846.90	Calcite cement in paleocaves	112.7	287.4	27.65	2821.38	284.4
YB9	6847.20	Calcite cement in paleocaves	65.4	445.2	12.67	1292.60	444.2
YB9	6847.20	Calcite cement in paleocaves	117.6	281.8	32.43	3308.97	277.0
YB9	6847.20	Calcite cement in paleocaves	92.2	295.0	25.02	2553.46	290.3
YB9	6883.10	Calcite cement in paleocaves	71.2	444.1	12.18	1242.53	445.4
YB9	6883.10	Calcite cement in paleocaves	101.7	289.9	28.44	2902.01	282.6
YB9	6883.25	Calcite cement in paleocaves	109.1	287.0	28.13	2870.76	282.9
YB10	6634.00	Intergranular calcite cement	96.0	292.5	25.25	2576.78	289.5
YB10	6634.20	Intergranular calcite cement	118.0	281.4	30.84	3146.68	281.4
YB10	6634.00	Intergranular calcite cement	71.3	444.0	11.27	1149.54	446.3

CONCLUSION

Based on diagenesis sequence, homogenization temperatures and trapping pressure of fluid inclusions and burial history, there were three events of hydrocarbon charging in the Ordovician of Yubei Area:

(1)the first event took place from 445.2Ma to 444.0Ma (during the Late Caledonian), indicated by yellow and blue-green fluorescent oil inclusions;

(2)the secondary event from 295.0Ma to 276.2Ma (during the Late Hercynian), indicated by yellow and yellow-green fluorescent oil inclusions;

(3)the third event from 11.0Ma to 8.8Ma (during the Late Himalaya), indicated by yellow and yellow-green fluorescent oil inclusions.

ACKNOWLEDGEMENT

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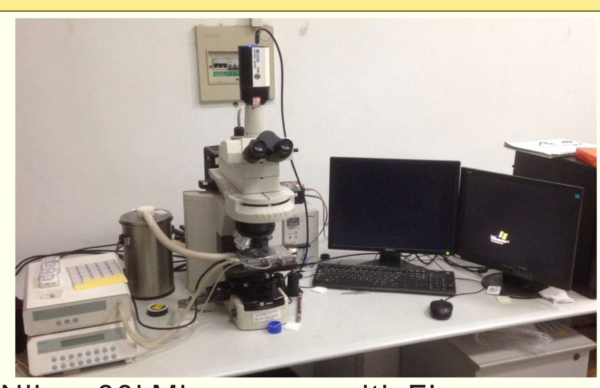
LABORATORY

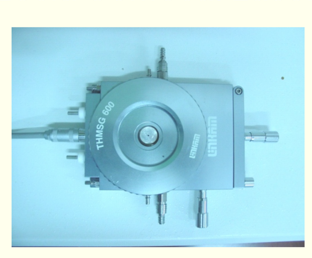


Nikon 80i Microscope with Fluorescence

Lecia Confocal Laser Scanning Microscope

Cathodoluminescence

Spectrum Analyzer



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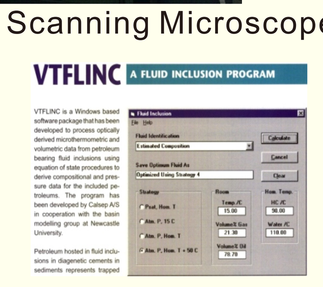

Software VTFlinc