Determination of Formation Paleo-pressure and Evolution Process Using Gaseous Hydrocarbon Inclusions

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Introduction

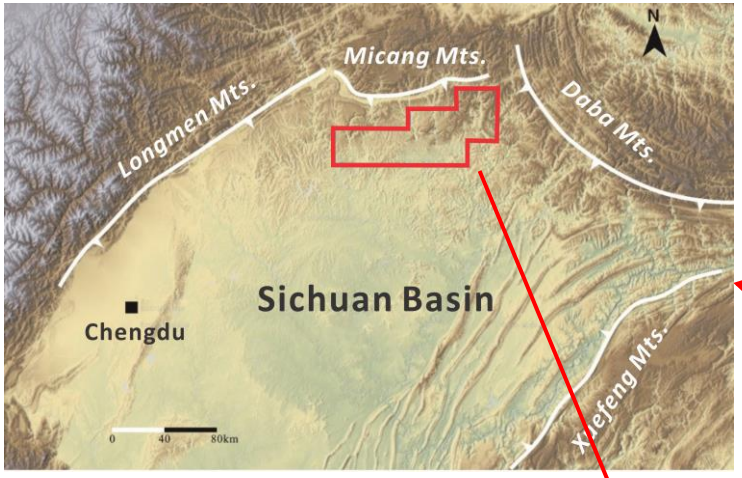
Abnormal pressures are the main mechanism for hydrocarbon migration and accumulation in both conventional and unconventional reservoirs, and they control the oil and gas distributions.

How to accurately and quantitatively reconstruct paleo-pressures has always been a tricky issue in formation pressure studies.

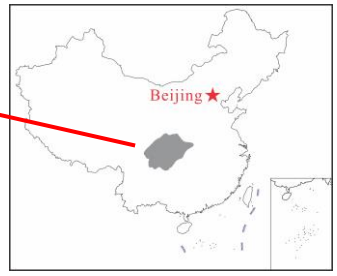
At present, the methods used to reconstruct paleo-pressures have mainly included basin simulations (Liu et al., 2019), PVT simulations (Aplin et al., 1999), PIT (Thiéty et al., 2000), and salinity-homogenization temperatures (Zhang et al., 1987), etc. Among these methods, PVT and basin simulations are widely applied. Software such as PVTsim, PIT, and PetroMod have been widely used in the reconstructions of paleo-pressures.

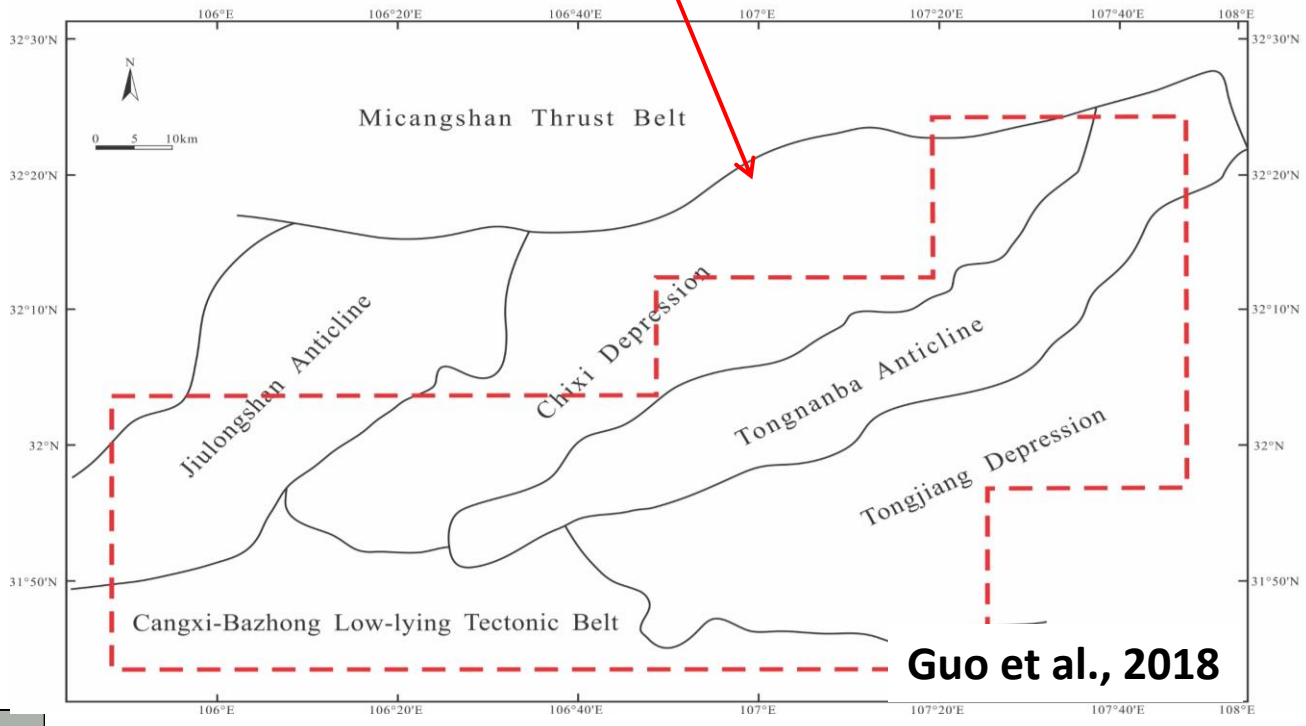
We reconstructed paleo-pressures for different periods by PVT and basin simulations in the reservoirs of the Xujiahe Formation, Sichuan Basin, China, which can be used to clarify the migration process for natural gas as well as the enrichment regularity.

Geological Setting

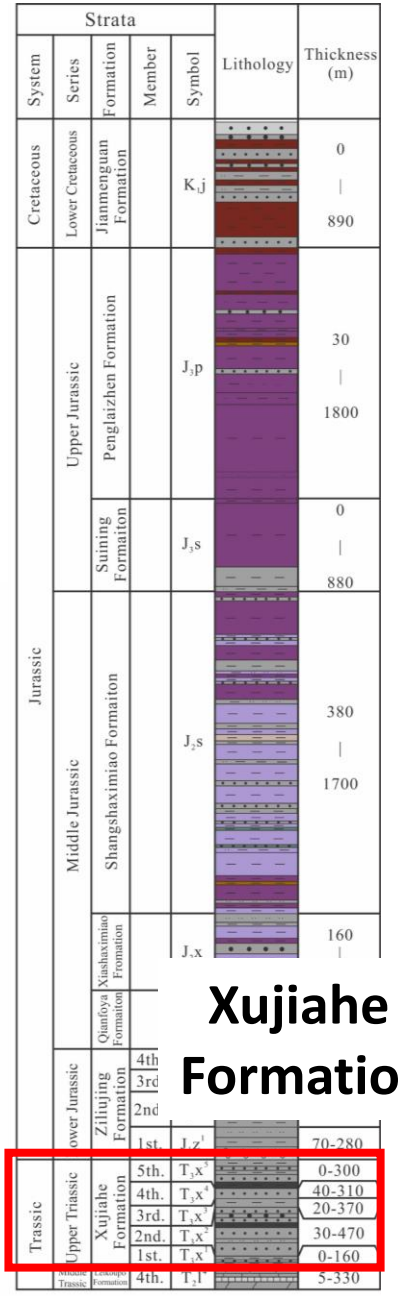


Study Area





Guo et al., 2018



Xujiahe Formation

Fig.1 Regional location, tectonic units, and continental strata in the northeast part of the Sichuan Basin.

Methods

1.Homogenization Temperatures

- Distinguish hydrocarbon inclusions and non-hydrocarbon inclusions by ZEISS AXIO Imager D1m Microscope;
- Test homogenization temperatures (Th) of fluid inclusions by Linkam THMS600.

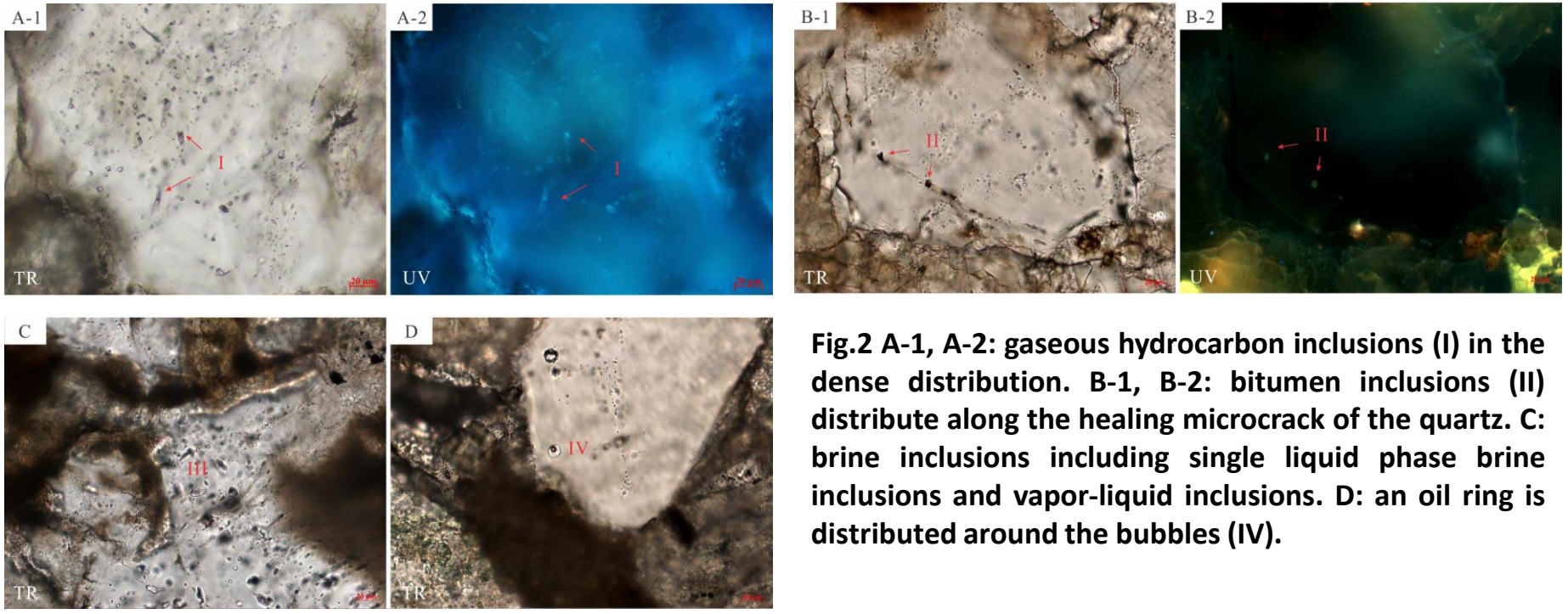


Fig.2 A-1, A-2: gaseous hydrocarbon inclusions (I) in the dense distribution. B-1, B-2: bitumen inclusions (II) distribute along the healing microcrack of the quartz. C: brine inclusions including single liquid phase brine inclusions and vapor-liquid inclusions. D: an oil ring is distributed around the bubbles (IV).

Methods

2.Components and Vapor-liquid Ratios

- Test components of fluid inclusion by laser Raman spectroscopy;
- Calculate the areas of inclusions and bubbles at different slice depths by CorelDRAW and microscope;
- Fit functions between the inclusion areas and slice depths, and between the bubble areas and slice depths by OriginLab;
- Obtian vapor-liquid ratios (Fv) of fluid inclusions.

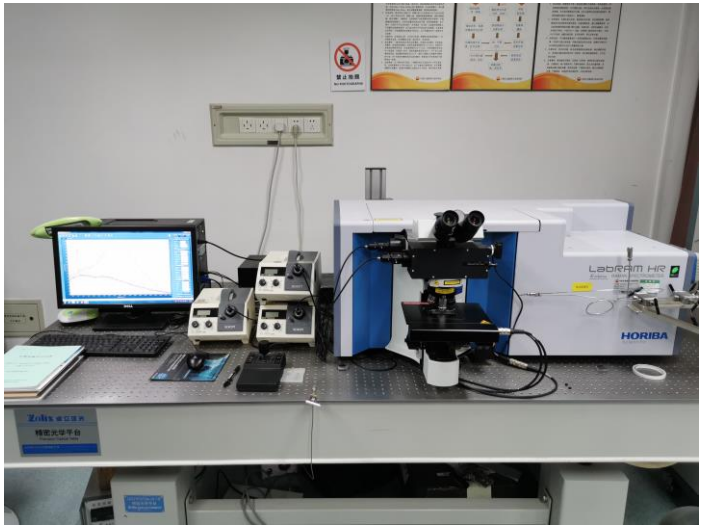


Fig.3 LabRAM HR Confocal Laser Raman Spectrometer

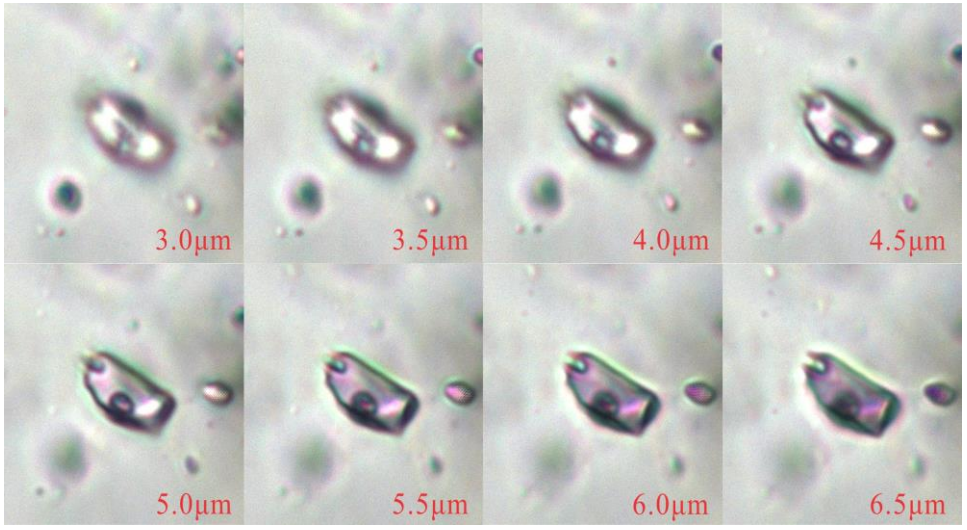


Fig.4 Images of inclusions at different slice depths

Methods

3. PVT and Basin Simulations

- Calculate trapping pressure by PVTsim (Th, Fv, and components are necessary) ;
- Construct paleo-pressure and its evolution by PetroMod;
- Current measured formation pressure, and the reconstructed paleo-pressure simulated by PVT simulations were considered as the correct data to ensure the accuracy of the results.

Fig.5 Software for PVT and basin simulations

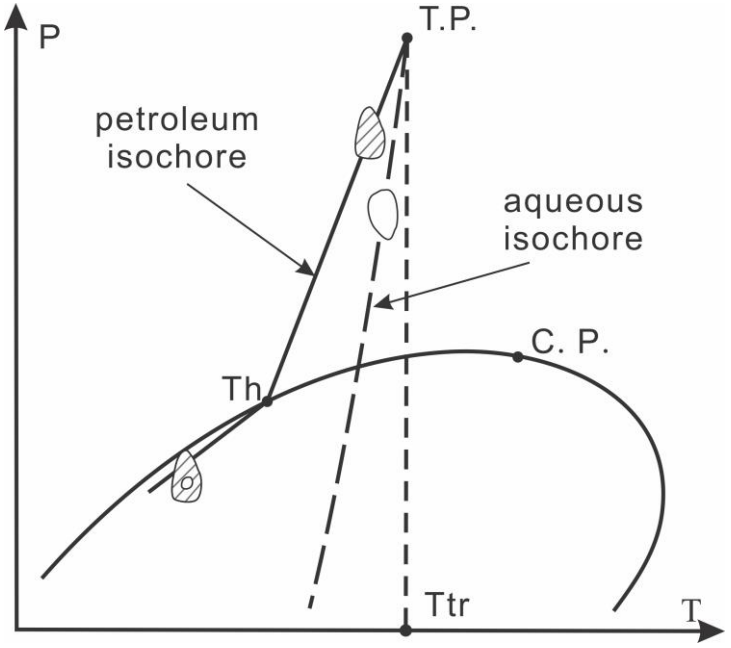


Fig.6 Determination of Trapping Pressure
(Modified according to Liu et al., 2003)

Results and Discussions

1.Paleo-pressure Reconstruction

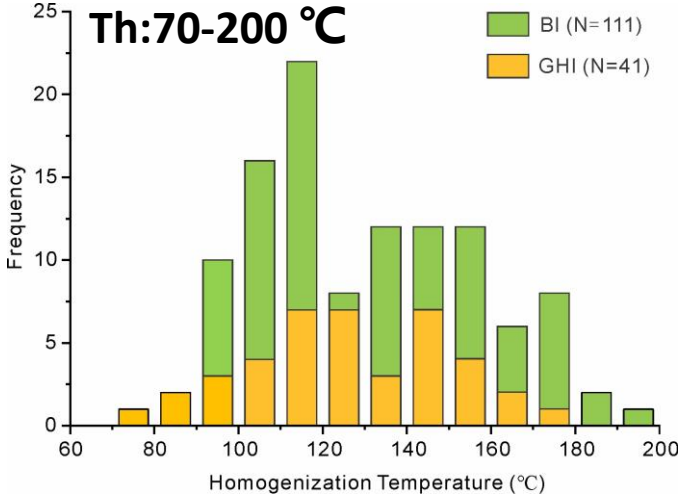


Fig.7 Homogenization temperatures of inclusions

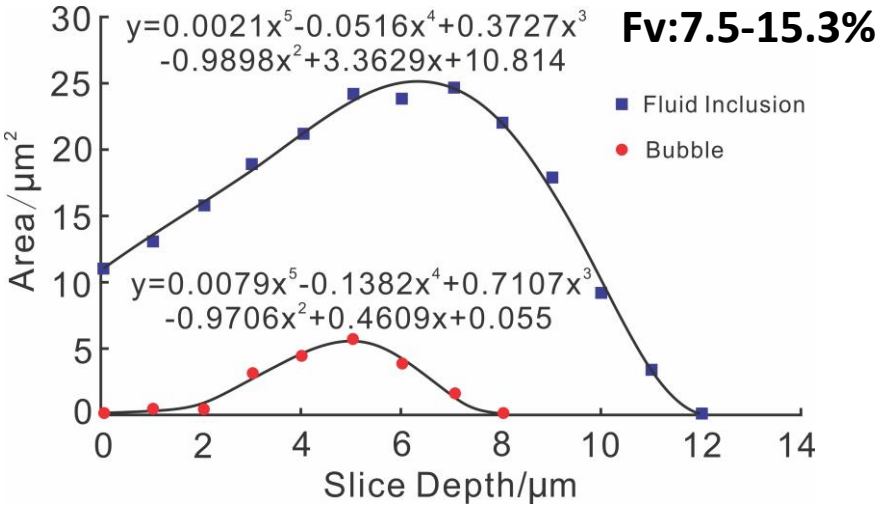


Fig.8 Fitted functions of inclusion slices at different depths (Zhou et al., 2011)

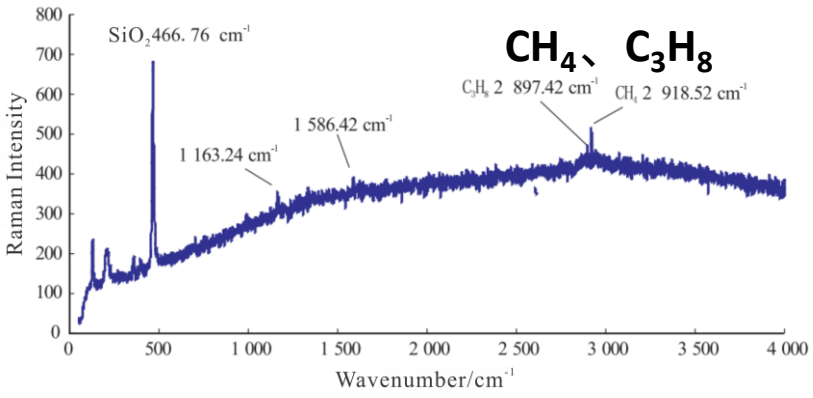


Fig.9 Laser Raman spectra of inclusions (Zhang et al., 2015)

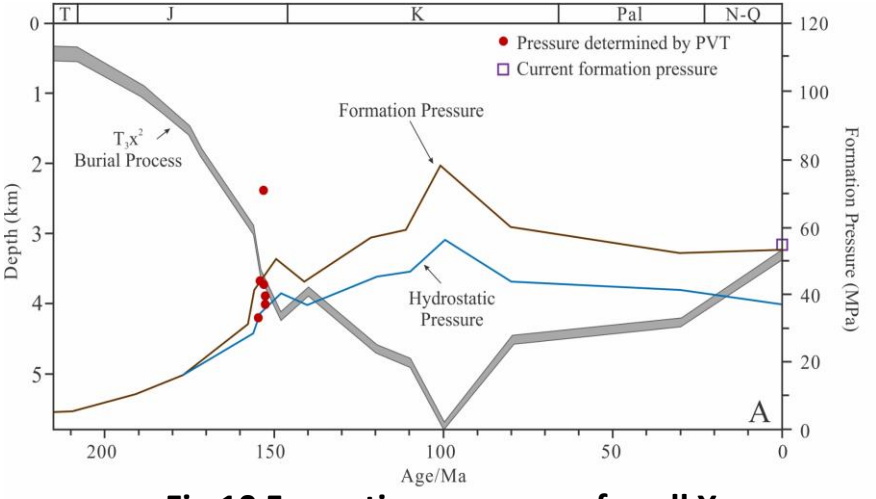


Fig.10 Formation pressure of well X

Results and Discussions

2.Paleo-pressure Evolution

- Overpressure began to develop in the Middle Jurassic period.
- Formation pressure increased rapidly due to hydrocarbon generation taking place from the Middle Jurassic period to the early Cretaceous period.
- Formation pressure has gradually decreased due to tectonic uplift and erosion since the early Late Cretaceous period.
- Formation pressure has increased again in local areas due to tectonic compression form the Oligocene period to the present.

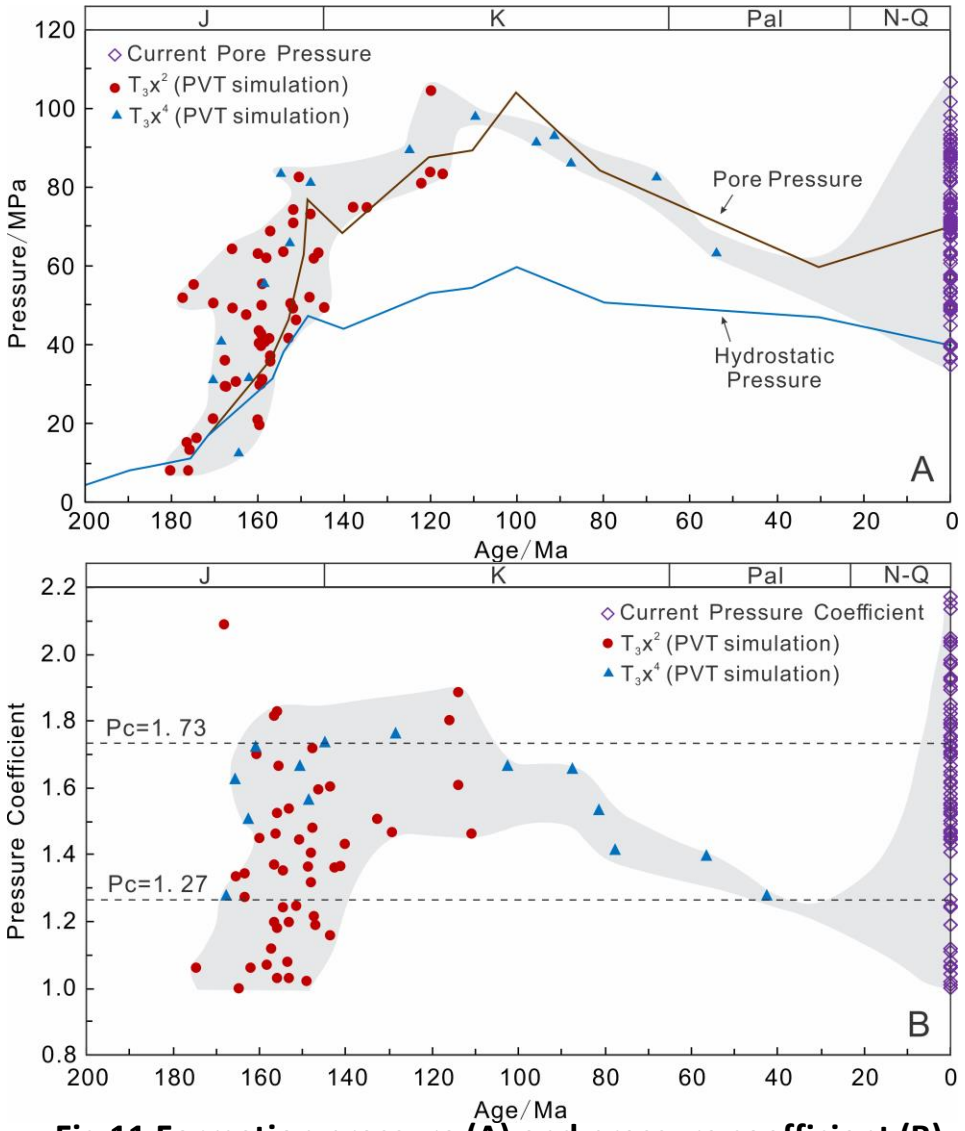


Fig.11 Formation pressure (A) and pressure coefficient (B) evolutionof the Xujiahe Formation in the Northeast Portion of the Sichuan Basin

Thanks

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