A New Method to Rebuild Basin Thermal History

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Paleogeothermal gradient restoration is a worldwide difficulty as restoring erosion thickness. The conventional thermal quantification employs a forward technique by presuming a series of thermal process and modelling paleotemperature indicators of vitrinite reflectance and apatite fission track in combination with burial history to determine the most likely thermal history.

In this paper, by measuring inner pressure of gas inclusions and coeval homogeneous temperature in combination with burial history, a new method for reconstructing paleogeothermal gradients and heatflow values was proposed. The new method has been used to reconstruct paleo-heatflow evolution in the Xujiaweizi fault depression in the Songliao Basin.

Seitz et al. (1996) demonstrated by experiments that for a gas inclusion of single component, the peak position on the Laser Raman spectra is a function of inner gas pressure. The inner pressure of a gas inclusion therefore can be determined by a series of gas inclusions of single component.

Volcanic samples of well Weishen 5 contain three phases of fluid inclusions and they are developed in the inner side of quartz outgrowth, along the quartz outgrowth and micro-fractures across the quartz particle, respectively, whilst each phase contains both gas inclusions and aqueous inclusions. Gas inclusions in these fluid inclusions contain pure methane and their peak positions on the Laser Raman spectra are 2913.75 cm^{-1}, 2913.41 cm^{-1} and 2912.83 cm^{-1}, respectively with respect to the three phases. The corresponding homogenous temperatures are 120.75℃, 127.33℃ and 136.70℃, respectively. Under the experimental conditions of 20℃, the inner gas pressures of the three phases were therefore determined as 12.6MPa, 14.4MPa and 17.8MPa, respectively, according to the relationship between peak position and pressure of methane inclusion established by Seitz et al. (1996) (Fig. 1). Gases in the inclusion were roughly assumed as an ideal gas and charge pressures during gas accumulation were then estimated as 16.9MPa, 19.7MPa and 24.9MPa, respectively, according to the ideal gas equation. Assuming a unit of pressure coefficient during gas accumulation, the corresponding gas charging depths are 1690m, 1970m and 2490m, respectively.

The burial history of well Weishen 5 suggested that the three phases of fluid inclusions were formed at ca. 96.0Ma, 85.5Ma and 76.0Ma, which are the main source rocks in the Songliao Basin. During those periods, a large lake was developed with planktonic flourish and the surface temperature was therefore estimated to be a higher value of 10℃ than present value of 4℃. Assuming the depth of constant zone of subsurface temperature as 50m, the paleo-temperature gradients at 96.0Ma, 85.5Ma and 76.0Ma are calculated as 6.74℃/100m, 6.12℃/100m and 5.19℃/100m, respectively. And the corresponding paleo-heatflow values are 2.51HFU, 2.33HFU and 2.07HFU, respectively. it is obvious that the paleo-temperature gradients and heatflow values are higher that present values which are 4℃/100m and 1.75HFU.

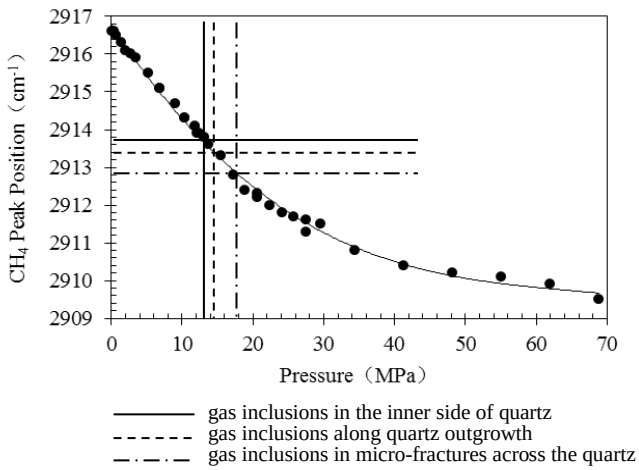

Fig1 Methane peak position vs. pressure of gas inclusions in well Weishen 5 (trend-line is after Seitz et al., 1996)

Based on fluid inclusion pressure, basin thermal history can be restored directly without forward modelling, and therefore can give out relatively precise paleo-geothermal gradients and heatflow values. Given enough fluid inclusion samples, a complete relationship of paleo-heatflow and geologic time can be achieved.

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