Characteristics and origin of carbonate cements in eastern slope of Fukang Sag, Junggar Basin

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Abstract: The Permian clastic reservoirs has undergone large tectonic uplift and subsidence and are dominited litharenite and feldspathic litharenite. Volcanic lithic fragments dominate the detrital grains and are mainly composed of tuff clasts, andesite clasts, and felsite clasts in eastern slope of Fukang Sag, Junggar Basin. Carbonate cements are ubiquitous and reduce the reservoir properties. The characteristics and origin of the carbonte cements were deduced using data from the casting of thin sections, scanning electron microscopy, fluorescence, cathodoluminescence obervation, electron probe microanalysis, micro-drilling and O, C stable isotope microanalysis and aqueous fluid inclusions microthermometry.

Two distinct episodes of carbonate cements were identified, including sparry calcite and ferroan calcite. Calcites with red dyeing and orange-red luminescence generally developed along the side of pores and were dissolved partially. Ferroan calcites with purple dyeing and dark red luminescence generally developed in the center of the pores. The hydrocarbon inclusions were captured in calcites and ferroan calcites. Microthermometry of aqueous fluid inclusions indicated the calcites were precipitated at 119.9-132.7℃ (247.8-270.9 °F) which were higher than the normal burial temperatures. After micro-drilling for the areas of pure calcites or ferroan calcites, the $\delta^{13}C_{(V\text{-}PDB)}$ values range from -19.4‰ to -18.42‰ and $\delta^{18}O_{(V\text{-}PDB)}$ values range from -18.08‰ to -17.2‰ for calcites. For ferroan calcites, the characteristics of oxygen isotopes are similar, but the carbon isotopes are quite different. The $\delta^{13}C_{(V\text{-}PDB)}$ values range from -6.00‰ to -5.94‰ and $\delta^{18}O_{(V\text{-}PDB)}$ values range from -15.85‰ and -15.59‰ for ferroan calcites developing in deep burial depth. The $\delta^{13}C_{(V\text{-}PDB)}$ values range from +22.10‰ to +22.16‰ and $\delta^{18}O_{(V\text{-}PDB)}$ values range from -15.49‰ and -15.27‰ for ferroan calcites developing in shallow burial depth. Electron probe microanalysis shows that the ferroan calcites have more enrichment of Fe, Mn, Cr, and Mg than the calcites. Compared to the ferroan calcites with a negative $\delta^{13}C_{(V\text{-}PDB)}$, the ferrocalcites with a positive $\delta^{13}C_{(V\text{-}PDB)}$ are richer in Fe.

The calcium source of carbonate cements is mainly from the hydration of abundant volcanic materials. The unusual formation temperatures, C-depleted carbon isotopes and hydrocarbon inclusions indicated the calcites were precipitated after oil emplacement and impacted by the hydrothermal fluid during the large tectonic uplift, but not impacted by the biodegradation of crude oil. The decarboxylation of organic matters would provide the carbon source for calcites. After the large tectonic uplift, the biodegradation of crude oil in shallow burial depth would be conducted. The ferroan calcites enriched in ^{13}C were impacted by the CO_2 from the biodegradation of crude oil. During these processes, Fe^{3+} oxides were reduced and the generated Fe^{2+} were released into the interstitial solutions and extra increase the content of iron in ferroan calcites.

Keywords: carbonate cements; hydrothermal fluid; biodegradation