A New Example of Retrograde Solubility Model for Carbonate Rocks

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Objective

The dissolution and precipitation of carbonate during burial diagenetic process controls the reservoir property in deep buried strata. The geological process related with it has become a research focus during recent years. The most important dissolution fluids to carbonates are probably H2S and CO2 as byproducts of sulfate reduction in deep-buried setting with sulfate minerals, but carbonates are more soluble in relatively low temperature, which is the so-called retrograde solubility. Several geological processes can result in the decrease of temperature, including the upward migration of thermal fluids and tectonic uplift. The Ordovician strata in the Tahe oilfield of the Tarim Basin have experienced continuous burial since the Caledon-Hercynian ancient karstification, and the present depth is the deepest during geological history. Therefore, according to retrograde solubility model, with the increasing of formation temperature, the carbonate mainly precipitates but not dissolved. This burial process is a destructive diagenesis for reservoir. The study of this model will provide theoretical guidance for carbonate exploration.

Methods

The samples were mainly collected from the wells S65, S72 and S77 which penetrated the Ordovician strata. Based on thin section analysis, the work determined the structure and mineral composition to determine the sedimentary and diagenetic characteristics. The calcite in vein of carbonate near unconformity was extracted and grinded into powder with microdrill for C-O isotope, homogenization of fluid inclusion and cathode luminescence analysis to determine the diagenesis property. The matrix was also grinded into powder for comparative study.

Results

The calcite in pores and veins has low δ18O (Fig. 1a), with average value less than -11%, which is much lower than surrounding matrix (-8% on average). This reveals that the calcite in pores and veins may precipitate in high temperature. Besides, fluid inclusions are well developed in the calcite in pores and veins (Fig. 1b), with high inclusion homogenization temperature of 110–160°C, corresponding to the formation temperature of the Tahe Oilfield after the Caledon–Hercynian karstification. This shows that the calcite in pores and veins related with ancient karstification was precipitated during different periods of burial process. Cathode luminescence analysis reveals that the calcite in pores and veins shows very weak luminescence, which is quite different from the strong luminescence of calcite cement precipitated under a karst environment. This further proves that some calcites in pores and veins are precipitated in burial environment. The diagenetic fluid is not meteoric water.

Conclusions

It reveals that the reservoir was mainly formed by the carbonate karstification in Caledon-Hercynian period, which controls the dissolution and precipitation of carbonate. However, the reservoir space is not well preserved, some of which is filled by secondary calcite. The remaining reservoir space is only small part of the original space. We believe that some of the spaces are filled in the karstification period. This kind of precipitation is accompanied by dissolution. A great part of reservoir space is filled in following deep buried process after karstification. This is consistent with the burial history of the Tahe region. According to retrograde solubility model, the carbonate was mainly precipitated with the buried strata and increasing strata temperature. This precipitation is a kind of destruction diagenesis to the reservoir.

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Fig. 1. Thin section and core sample from the Ordovician carbonate rocks in the Tahe Oilfield of the Tarim Basin. (a), C-O isotope comparison between calcite in vein and surrounding matrix, S77 well, 5448.01m, Yingshan Formation, 11.51m from unconformity, 4mm of short edge of photo; (b), Dolomite filled in cavity with well idiomorphic crystal, TSI well, sample 4-3/21, lower Qiaqitoge Formation in Cambrian, 6.66cm of core diameter.

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