PSTiming and Mechanism of Calcites in Fractures of Middle Ordovician of Northern Tarim Basin, Northwest China*

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Abstract

Absolute radiometric dating has huge potential to better understand diagenetic processes and evolution of carbonate platforms and has been applied to young strata successfully. Furthermore, recent development of U-Pb dating by laser ablation applied directly on thin sections makes it possible to date older carbonates. Middle Ordovician in the Northern Tarim Basin experienced multiple stages of tectonic movement and related karstification, and six types of vugs and fractures were recognized, including vugs, horizontal fractures, tectonic fractures, dissolved fractures, irregular fractures, and faults, filled with calcite partially or completely. Based on the analysis of petrographic sequences of the calcites, laser-based U-Pb dating was conducted, and additionally C, O, and Sr isotopes and REE were analyzed to verify the results of dating and corresponding diagenetic environment.

U-Pb dating revealed that calcite in vugs formed at 344 ±20 Ma during early Hercynian; magacalcite in fault precipitated during 316.8 to 251.8 Ma of Late Hercynian; calcite in irregular fractures formed at 118 ±26 Ma of Yanshanian, perfectly corresponding to the three tectonic episodes exerted important influences on the region. The diagenetic environments revealed by conventional C, O, Sr and REE analysis are consistent with the corresponding geological settings. Calcite in vugs, showing relatively positive C and negative O, similar 87Sr/86Sr to host rock, and obviously negative Ce anomalies, interpreted as the products of meteoric karstification related to the uplift of Tabei Uplift during Early Hercynian. The calcites in faults and tectonic fractures (including irregular fractures) showing obviously negative O, 87Sr/86Sr similar to seawater values of the Cambrian, and REE pattern different from either meteoric or hydrothermal environments, revealing the features of burial formation fluids probably related to the activities of strike-slip faults induced by Late Hercynian and Yanshanian tectonic movements. The consistence of petrographic sequence, dating results, diagenetic environments, and fluids properties revealed the reliability of laser-based U-Pb dating on the Paleozoic calcite. Furthermore, considering the close relationship of megacalcite and tectonic fractures to reservoirs, it is proposed that the main reservoirs were formed by strike-slip faults during Late Hercynian and probably are just empty spaces in the fault and fractures, instead of previously thought karstification related to unconformity.

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1. Introduction

Absolute radiometric dating could provide the valuable information to better understand diagenetic processes and evolution of carbonate platforms (Godeau et al., 2018). U-Pb dating of carbonates has been applied to nearly the full range of the geologic time scale （Rasbury and Cole, 2009), especially in younger strata (Uysal et al., 2007, 2009; Godeau et al.，2018).

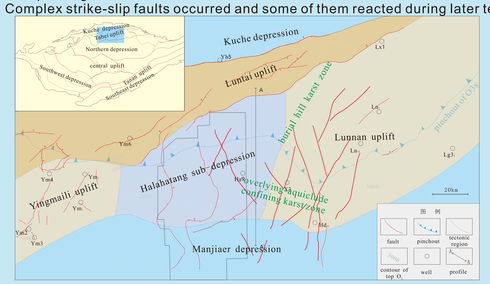
However, because of either low uranium or high common lead content, or because of the impossibility of microsampling a single (monogeneration) diagenetic cement of interest，it is very difficult to realize the U/Pb dating of old carbonate by using conventional solution method. Recent development of U-Pb dating of carbonates by laser ablation–inductively coupled plasma–mass spectrometry (LA-ICP-MS) applied directly on thin sections or slabs opened a wealth of possibilities with which to date calcite-cemented fossils (Li et al., 2014), calcite-filled veins (Coogan et al., 2017; Roberts and Walker, 2016; Nuriel et al., 2017)，paleosols (Methner et al., 2016) or calcite cement in microporous carbonate (Godeau et al., 2018), because it offers the possibility to capture a more extended range of U/Pb variability (thereby providing a greater spread of U/Pb ratios to generate isochrons), as well as rapid data acquisition and large sample throughput.

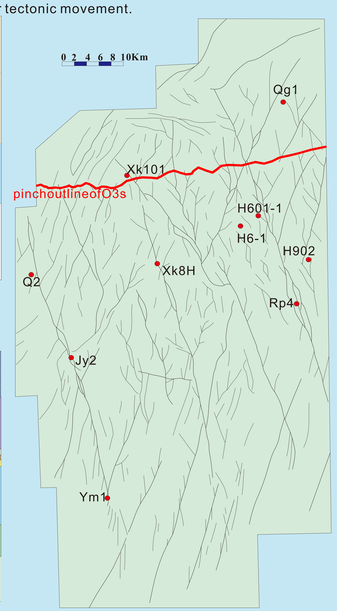
large oilfield was discoveried and exploited in middle Ordovician of Halahatang area in the south slope of Tabei uplift with the proven reserves of 0.3 billion ton oil , and the main reservoir spaces are fracture-cavern systems, proved by frequent bit drop and loss of circulation. The fracture-cavern systems appear to distribute mainly 50 m below the top of O2 as well as be related to fault system.Thus, a controversy exists whether the reservoir spaces are formed by dis-/un-conformity-related karstification or by activities of strike-slip faults, which is further complicated by the multiple tectonic movements suffered in this region.

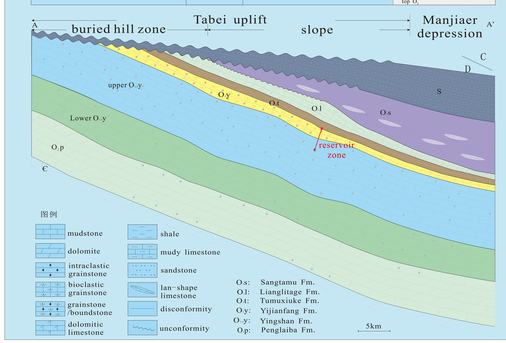
In this study, laser-based U-Pb dating, established in CNPC KEY LABORATORY OF CARBONATE RESERVOIR, has been successfully used to decipher the tectonic history and the reservoir-forming date.

2. Geological settings

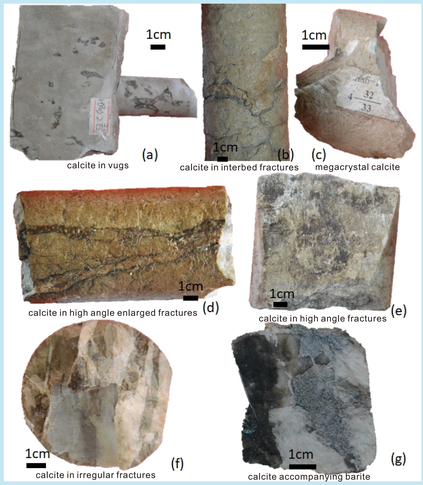
Halahatang area is located at the slope of Tabei uplift.
Multiple disconformities and unconformities above the middle Ordovician (the reservoir zone).
Multiple stages of tectonic movement involved after the middle Ordovician.
Complex strike-slip faults occurred and some of them reacted during later tectonic movement.







3. Calcites and their geochemistry features



(a) calcite in vugs

(b) calcite in interbed fractures

(c)megacrystal calcite

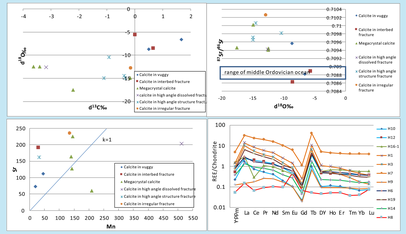
(d) calcite in high angle enlarged fractures

(e) calcite in high angle fractures

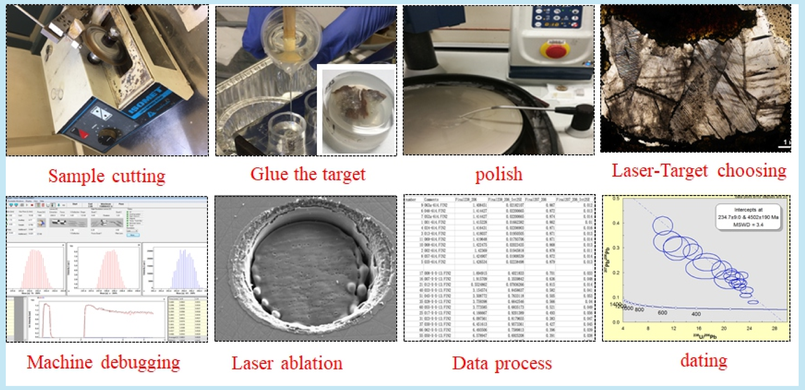
(f) calcite in irregular fractures

(g) calcite accompanying barite

closely related to bit drops and/or loss of circulation, within 20 m



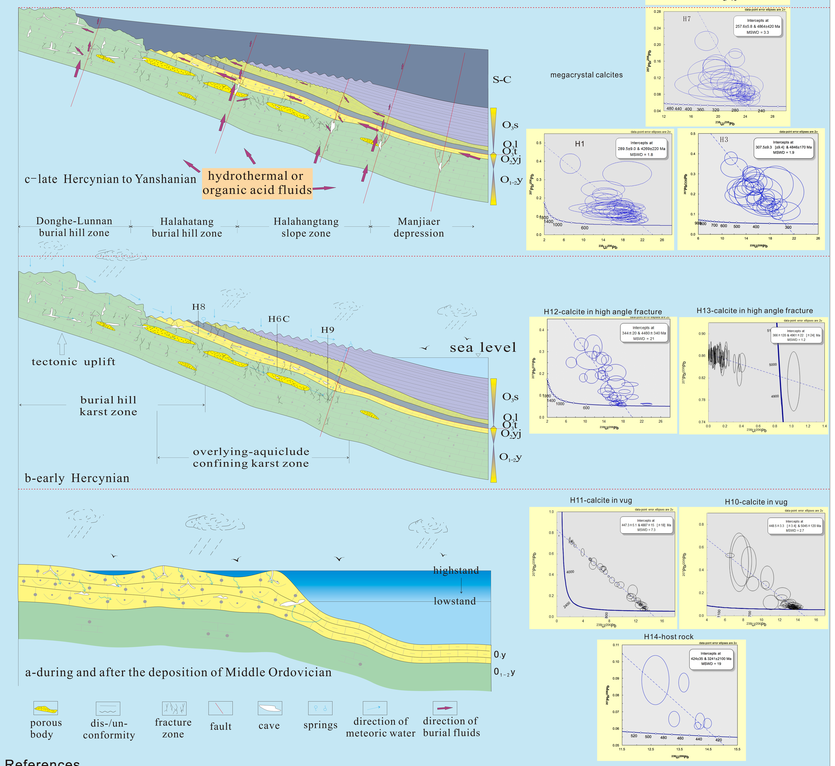
4. laser-based U-Pb dating workflow



5. Results and Conclusions

At least four stages of modification have been recognized, including the meteoric dissolution during the end of deposition and early hercynian, and fault related modification during late Hercynian and Yanshanian.

Fault related modification probably made the biggest contribution to the reservoir spaces.



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