Paper Number: 1699

Characteristics of lower-order unconformity in carbonates and its significance for reservoir development: A Lower-Ordovician unconformity in Tarim Basin, NW China

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This paper presents outcrop, well log, seismic Line, petrographic data and geochemical data in order to characterise the lower-order unconformity T_7^8 within the Lower Ordovician carbonate succession in the Tarim Basin. Seven methods for recognizing unconformities, including carbon and oxygen isotopic, heavy mineral and trace element data were shown to be effective in recognizing lower-order unconformities in carbonate strata. Geochemical data indicate that the T_7^8 unconformity is associated with anomalies in profiles of stable isotope ratios, and profiles of heavy minerals and trace elements. There is a negative excursion in $\delta^{13}C$ and $\delta^{18}O$ ratios within the carbonate rocks immediately below the unconformity surface. Similarly, values of major and trace elements such as Li, K, Ti, Rb, Th, Sr, V and Ni are also significantly reduced. Conversely there is a peak in haematite and limonite contents beneath the unconformity surface. The T_7^8 unconformity has a three-layer structure: a weathered layer with abundant dissolutional pores and caves, a semi-weathered layer and an unaltered strata underneath. The T_7^8 unconformity represents a short-term exposure surface controlled both by sea-level changes and by palaeogeomorphology. The degree of erosion and weathering at the T_7^8 surface varies across the Tarim Basin may be divided into four categories: strong, medium, weak and un-exposed. Areas of intensive exposure occur mostly in the Tabei, the western Bachu, and in the Tazhong areas. Areas that experienced medium exposure intensity were developed across most of the platform facies and cover a large expanse in the middle and western parts of the basin. The lower-lying zones in central and northern parts of the platform were less exposed. Statistics on cores taken at T_7^8 unconformity interface in over 20 wells of the Tarim Basin show existence of four different types of lithologic contacts at the interface: limestone-dolomite, dolomite-dolomite, limestone-limestone and mudstone-mudstone.

The unconformity had a major influence on reservoir development in the underlying carbonate succession. Outcrop sections show there are apparent dissolutional pores and caves below the T_7^8 unconformity, which diminish in number farther beneath the unconformity. Seismic sections show a series of bead-like strong reflections below T_7^8 unconformity that are potential porous reservoir facies.

This study presents the petrographic, geochemical and geophysical characteristics of the third-order unconformity T_7^8 in the Tarim Basin, evaluates methods for the identification of third-order unconformities in carbonate successions, and analyzes their structure and distribution features to investigate their influence on the development of reservoir intervals. We attempt to clarify the third-order unconformity-related processes and the development characteristics of unconformity-controlled karst reservoirs which may be useful for future exploration in similar geological settings.

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