Mechanism of formation and Characteristics of deposition of Cambrian gravity flow in the eastern gucheng area, Tarim Basin

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Abstract. The Gucheng Cambrian margin and Luoxi Cambrian margin is on both sides of eastern Tarim basin. Base on the analysis of cores,thin sections and seismic data of Luoxi slope areas,this paper systematically studies the formation condition, reservoir characteristics and favorable accumulation factors of gravity flow. The gravity flow sedimentary types include debris flow, high density flow and low density flow, debris flow and high density flow reservoir is better. Hydrothermal reconstruction has active effect on reservoir. There are six phases mound-beaches develop in platform margin, reservoir characteristics are algae framework dolomite and granular dolomite. Phases of mound-beaches develop to steep slope. Seismic and geochemical data indicate that the mound-beaches are exposed with corrosion characteristics,the platform margin-slope have the requirements of geomorphologie antique and quality reservoir source.

Keywords: Eastern Gucheng; Platform margin mound-beach; Slope gravity flow.

1. Introduction

Gravity flow of carbonate rocks refers to various gravity flow deposits formed when shallow water sediments are transported from the coastal bottom slope to the deep water area under the drive of gravity [1]. Worldwide, the Cretaceous carbonate gravity flow fan (skirts) oilfield in Poza Rica, Mexico, has proven recoverable reserves of over 400 million tons [2-3]. Gravity flow of carbonate rocks is widely developed in Yangzi platform-deep water basin in southern China [4-5]. As a new exploration type in Tarim Basin, gravity flow has great research significance because of its wide distribution and large thickness. Author analyzed the outcrop, geological structure comparison and seismic response characteristics. It is proposed for the first time that gravity flow deposition is developed on the Cambrian slope in the eastern part of ancient city, and the reservoir is controlled by the original sedimentary facies and late dissolution reconstruction, forming high-quality sourcing-reservoer-cap combination with the underlying source rock and overlying mudstone cap, which is an important field for the next oil and gas exploration in Tatong.

2. Geological Setting

The Cambrian and Ordovician carbonate platform facies in the west and platform margin facies and basin facies in the east [6-8]. The sedimentary water in the platform facies area is shallow, and the edge of the platform gradually becomes stronger from the lower Cambrian gentle slope platform to the middle and Upper Cambrian platform edge, and finally forms the edge platform. Under different paleo geomorphic backgrounds, with the development of reef-bank bodies one by one in each stage, the platform margin of the Cambrian system gradually migrated to the sea, reflecting the feature that the accommodable space gradually migrated to the basin since the Middle Cambrian. The slop-basin facies area has deep sedimentary water, is an under-compensated basin, and the stratigraphic deposits are thin and mainly muddy [9-11].

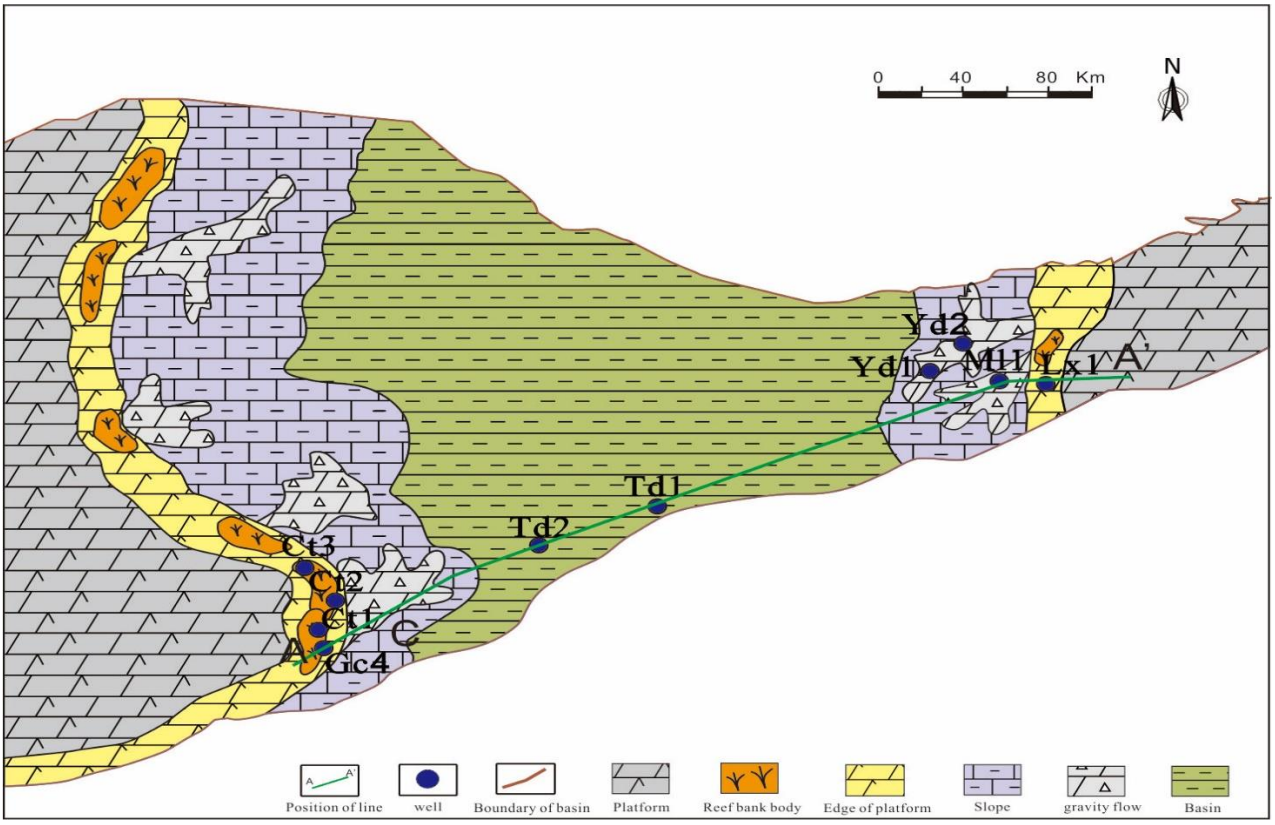


Fig 1. Upper Cambrian sedimentary facies of the eastern Tarim Basin.

3. Sedimentary reservoir characteristics of gravity flow

Gravity flow can be divided into debris flow and turbidity current according to the sediments and the latter can be further divided into high density turbidity current and low density turbidity current [12-13]. The outcrop detrital flow deposits are characterized by mixed particle size, flat underside and parallel layer arrangement of plate-strip gravel. The sandstone deposited by ultra-high density flow is thickly layered or massive, and large gravel or mudstone fragments are often found inside the sandstone. Drainage structures and liquefaction structures are common, and the particle flow with reverse grain sequence also belongs to ultra-high density flow. In the Kulluktag outcrop, there are low energy fine grain deposits in situ and coarse debris gravity flows transported from other places. The slope strata are generally 200m~800m thick, with an outcrop area of more than 300km^2. In situ deposition is mainly nodular muddy limestone and silty limestone. The gravity flow of carbonate rocks transported from other places is mainly debris flow and turbiditic rock, and the fan (kilt) pattern develops in four stages (FIG. 2). There are abundant biological fossils, many bioclasts and reef blocks, and the dissolution pores of reef beach bodies inherited from the platform margin and the residual pores of intergravel cementation develop. The lateral thickness of the low-energy channel extending 55 meters away is reduced to 3 meters, and the cumulative thickness can reach more than 50m ~ 150m.

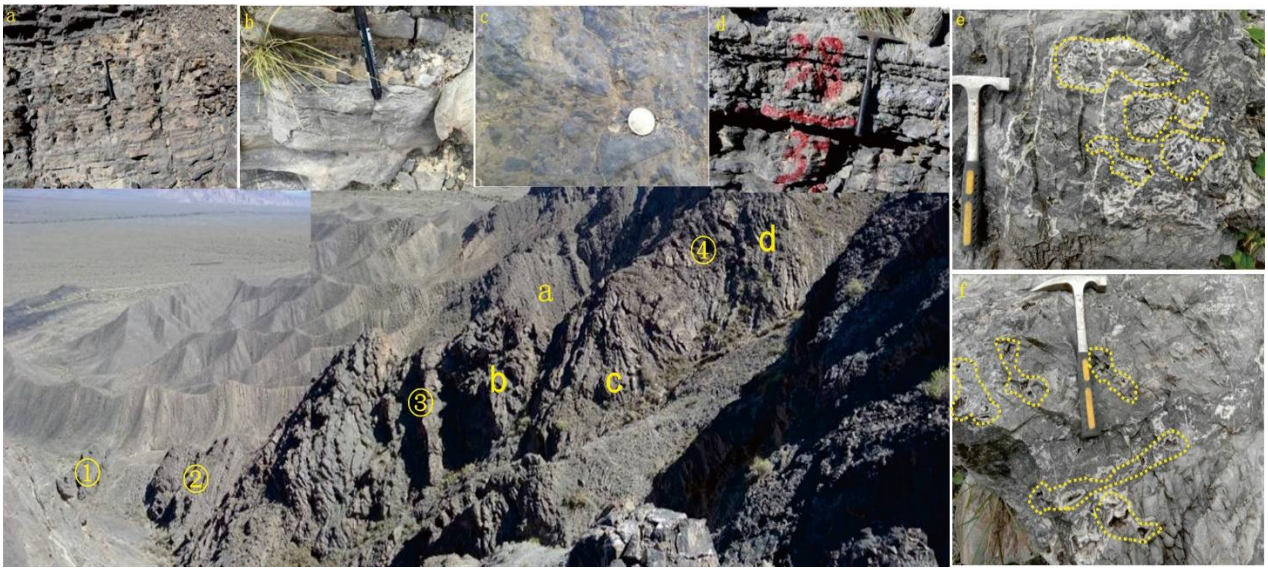


Fig 2. Sedimentary characteristics of gravity flow in kuruketage.
(a) Thin layer micrite limestone.(b) Flow of debris.(c) Turbidite rock.
(d) Marillaceous limestone. (e) Dissolution pores between breccia.(f) Reef beach body holes.

The coarse clastic sediments transported from the shallow water platform were intermingled with the dark marl with low energy deposits in situ deep water, and the thickness of the drilled cores accounted for up to 30% of the total formation thickness. A large number of clastic gravity flow deposits were found in the Middle and Upper Cambrian of ML1, YD2 and YD1, and the remote redeposition of these coarse debris was mainly sand-grade turbidite with a small amount of gravel clastic flow deposits. The clastic flow mainly developed breccia or gravel dolomite, with breccia of approximately 2×4cm. Part of the breccia was cemented by sparry calcite, and part was filled with calcite powder and sand, with a few intergranular dissolved pores and super-large dissolved pores. The high density turbidite lithology is mainly medium-coarse-grained dolomite, with dark parallel bedding in A+B member of Bauma sequence and positive grain sequence. The low-density flow mainly develops granular dolomite and fine-silty dolomite, with parallel bedding in B and C members of the Bauma sequence, with a thickness of 20cm~40cm, and a few intergranular dissolution pores.

4. Mechanism of gravity flow formation

4.1. Ancient geomorphology

3D seismic data reveal that the Gucheng area was carbonate gentle slope deposition in the Early Cambrian, which evolved into a rimmed platform in the Middle and Late Cambrian, and platform types showed a dynamic evolution process. The fourth to sixth reef-flat bodies developed in the Upper Cambrian, and the edge rimmed platform gradually became stronger, and finally formed the rimmed platform. The reef-bank body belonging to the 4th to 6th stage of the Upper Cambrian is the main provenological basis for the formation of the slope gravity flow. As shown in the front figure, the Angle between the edge of the ancient city platform and the slope foot can reach 9° to 19°. Compared with the Angle between the Rossi platform edge and the slope foot of 7° to 20°, the lower slope of the ancient city platform edge has the paleo-geomorphic conditions for the development of gravity flow (FIG. 3)

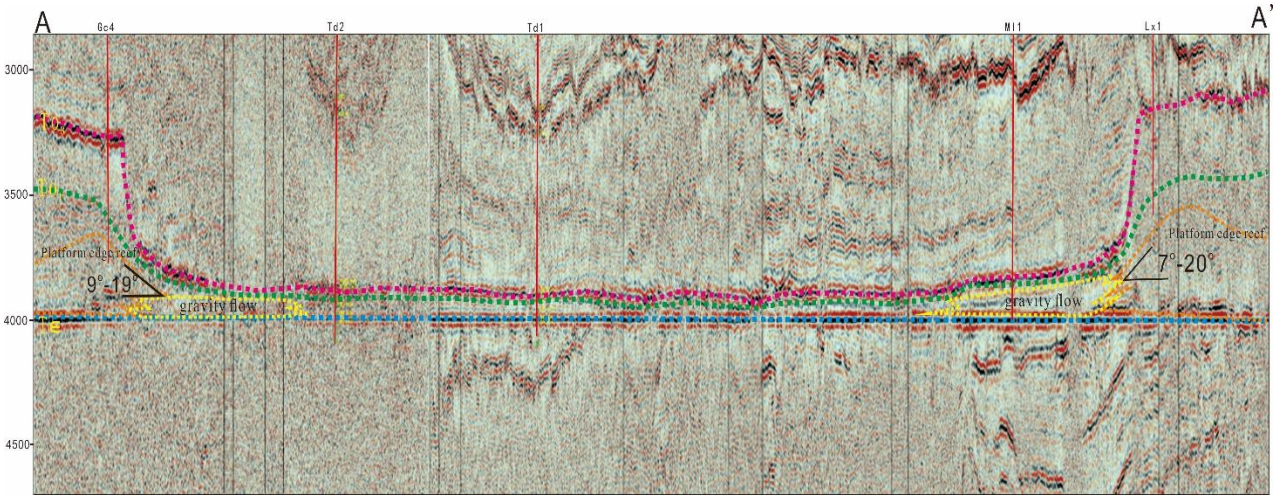
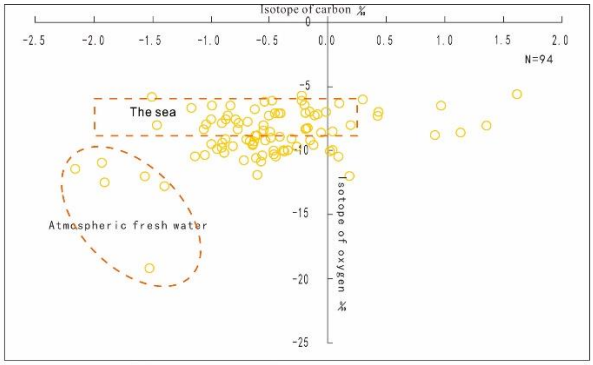


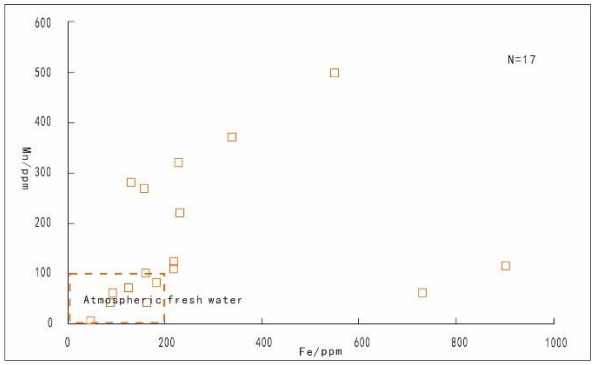
Fig 3. Seismic stratigraphic structure profile in Gucheng-Luoxi platform margin of the eastern Tarim Basin.

4.2. Ancient environment

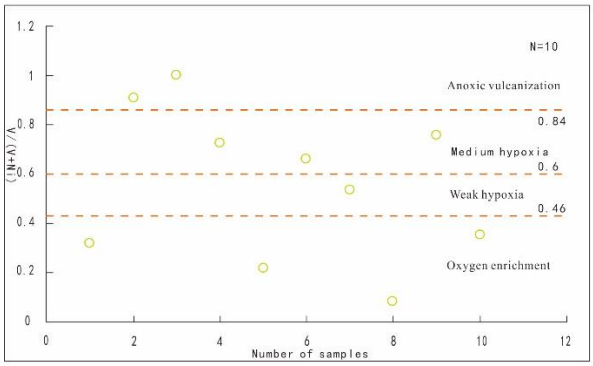
Based on the principles of petro stratigraphy and chemical stratigraphy, integrated logging curves and seismic reflection characteristics, the identification marks of Cambrian sequence stratigraphic interface in Gucheng area are summarized. Generally, the water at the sequence interface is shallow and the strata are easily exposed. When the sea level drops and the sedimentary strata are exposed, the sedimentary interruption will be caused and the sedimentary discontinuity surface will be formed. The abrupt change of sedimentary environment, lithology and lithofacies combination will occur above and below the interface. The low value of uranium free GR and the high value of Th/U (>7) at the sequence interface reflect the characteristics of low argillaceous content and weathering residue of oxidative exposure. The transformation of KTH from high value to low value and the transformation of LLD/LLS curve from high value to low value reflect the decrease of carbonate mud content. The geochemical data also indicate the process of water-rock reaction in atmospheric freshwater of rereef shoal body. The change of sea level often causes the change of carbon isotope value. The distribution range of δ13C value of Marine carbonate sediments is -5‰ ~ 5‰ (PDB), and the change of δ13C value is positively correlated with the change of sea level, and the negative bias of δ13C reflects the decrease of sea level. Through the comprehensive analysis of more than 100 data points of carbon and oxygen isotopes, V and Ni elements, it is determined that the reef beach body has exposed dissolution conditions. The analysis of 17 sampling points of MN-Fe and 41 sampling points of strontium isotopes shows that the reef beach body has experienced freshwater environment (Figure 4). The seismic profile also shows significant unconformity cutting characteristics of the top surface of the platform edge reef beach body. These information comprehensively reflects that the Upper Cambrian platform margin reef beach body experienced the exposed oxidation of the paleoenvironment.



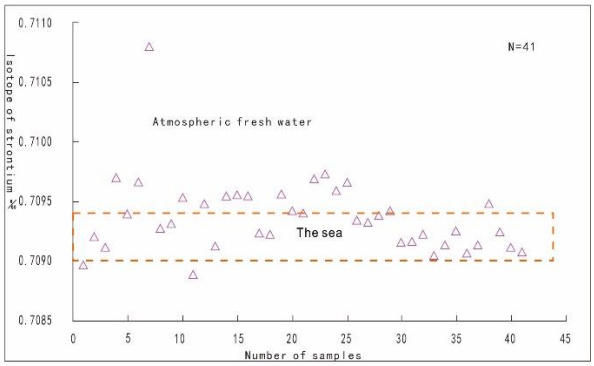
Scatter plot of carbon and oxygen isotopes



Scatter plot of Fe-Mn



Scatter plot of V/(V+Ni)



Scatter plot of strontium

Fig 4. Geochemical characteristics of platform margin mound-beach in Gucheng.

4.3. Formation of reservoir

Under the background of carbonate platform edge-type platform, the sea level is constantly rising and falling, and the top of reef beach body is near the wave base, which is easy to form residual granular dolomite, and it is a high-quality reservoir. Dissolution and fracture are important constructive diagenesis. The former forms the main reservoir Spaces such as ingrain dissolution pore, intergranular dissolution pore, super-large dissolution pore and karst cave, while the latter ranges from micro-fine fractures at the microscopic scale to high-angle fractures at the core scale, and some of them are dissolved along the fractures. The coring and microscopic observation show that the reservoir space of platform margin reef-bank body can be divided into two types, one is large-scale karst fractures, breccia pores, structural fractures, etc., and the gaps are more than a few centimeters (FIG.5[a], [b], [c]).



Fig 5. Reservoir space of mound-beach in Gucheng platform margin.
(a) CT3, 7123.14 m, algal lattice dolomite, dissolution cavity, high Angle fracture dissolution expansion. (b) CT3, 7372.00 m, porphyry dolomite, dissolution cavity development. (c) CT1, 7253m, light gray brecciform dolomite, triangular cavity developed between breccibres, with high Angle fine fractures accompanied by dissolution pores.

5. Conlusions

Carbonate gravity flow deposits are developed in the Rossi slope of the eastern Tarim Basin, which are dominated by clastic flow and reservoir dissolution pores, which have typical hydrothermal dissolution characteristics. The Gucheng platform edge developed six stages of reef bank uplift, granular dolomite reservoir development, with typical exposed dissolution characteristics, has the paleo-geomorphic conditions and material basis for the formation of slope gravity flow.

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