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Characteristic and Distribution of Reef Complexes on the Carbonate Platform Margin in Western Deep Water Area of the South China Sea

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The western deep water area of the South China Sea (south part of Qiongdongnan Basin), located in the area with water depth ranging from 300 to 3000 meters in the South China Sea, covers central depression, and south uplift of Qiongdongnan Basin and Changchang sag and south part of Zhujiangkou Basin (Fig. 1). Suitable sedimentary environment, hydrology conditions, temperature and relative sea level change contribute to the development of reefs in Sanya to Meishan Formation during the Miocene (Hine and Neumann, 1977; Sarg, 1988; Eberli and Ginsburg, 1989; Bachel et al., 2007; Wang et al., 2011; Zhao et al., 2012) (Fig. 1).

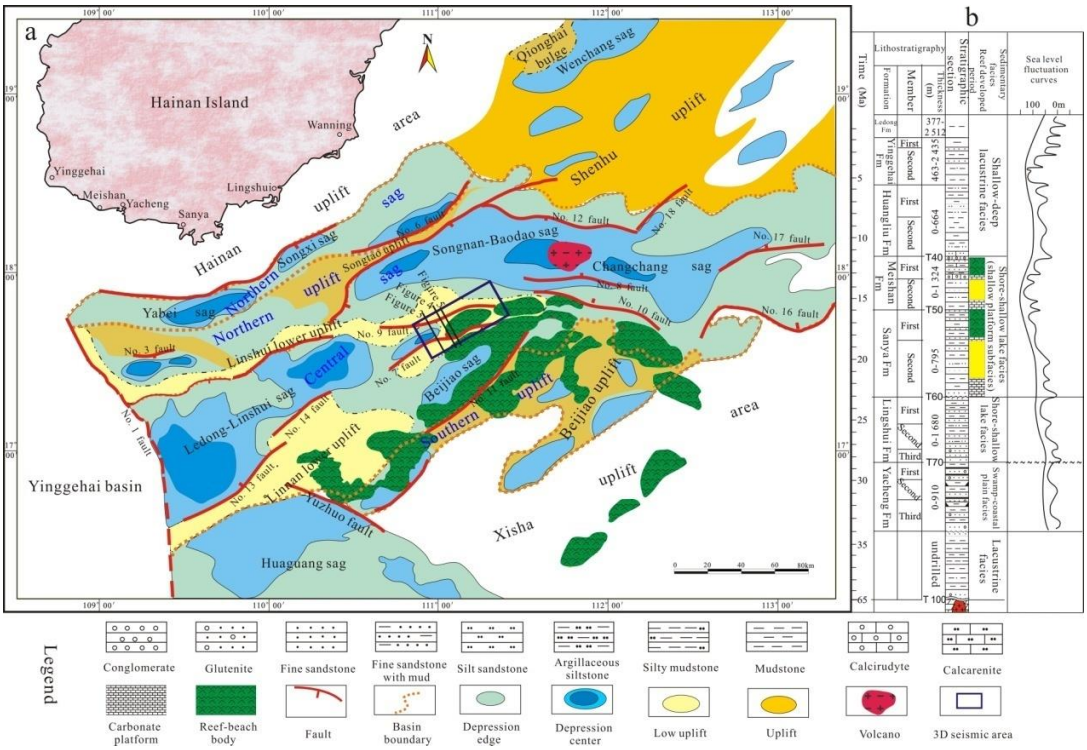

Fig.1. The distribution and geological setting of Meishan Formation reef in the western deep water area of the South China Sea. (a) The distribution of reef complexes in Meishan Formaion; (b) Stratigraphic framework and sedimentary filling pattern for Cenozoic in Qiongdongnan Basin (After Chen et al., 2012)

Based on 2D and 3D seismic data, the inner structures and evolution of reef complexes on carbonate platform margin in the western deep water area in the South China Sea were studied in detail. The result shows that fault controlling margin and ramp margin are the main platform margin types in the western deep water area in the South China Sea during the Miocene Sanya to Meishan Formation, which directly controlled the structures of reef complexes that developed on the platform margin. The fault controlling platform margin, controlled by ninth fault, seventh fault, tenth

fault, eleventh fault and Yuzhuojiao fault in the west, shows wide and gentle flat landform. The ramp margin, in contrast, characterized by gentle ramp, is not controlled by the fault. The development of reef complexes is directly related to the geomorphology of carbonate platform margin which resulted in different structure and growth process of different reef complexes.

1. The characteristics of fault controlling platform margin reef complexes

The development of controlling fault is directly related to syndepositional fault, especially the buried drag fault. The slope, developed under the slope break, is narrow and steep with slump deposited. The platform margin developed above the slope break, which is wide and gentle, making reef complexes easily formed in this part.

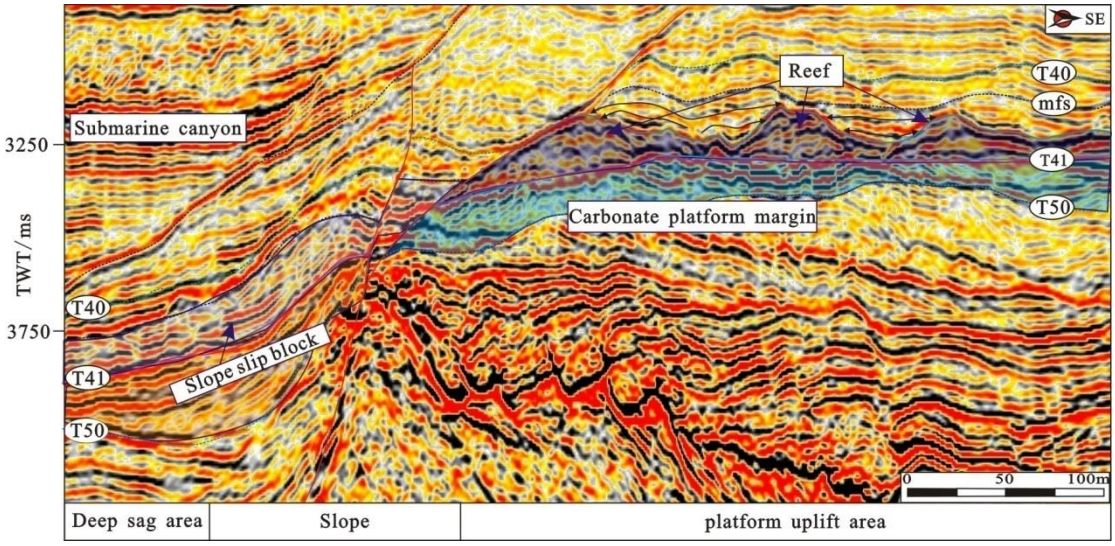

Fig.2. The structure characteristics of fault controlling platform margin in the western deep water area in the South China Sea (The location of cross section showed in Fig. 1a)

The development of reef complexes on the fault controlling platform margin is directly controlled by the structures of the platform margin. Due to dissection of fault, positive landform was formed on the upthrown fault block, on which the reef complexes developed. The reef complexes show symmetrical mound, lenticular seismic reflection. The top and bottom outline are strong reflections and can be easily identified in the seismic sections, which mean that there is significant difference of lithology and physical property between reef complexes and surrounding bed. There are chaotic and weak reflections in the interior of reef complexes. There are drape structure on the top, two-way onlap on the both sides and down concave on the bottom of the reef complexes. The gradient is almost same on the windward and leeward of the reef complexes (Fig.2, Fig.3). Reef buttress and reef canal can be recognized in the seismic sections. The reef buttress and reef canal are both symmetric. The reef buttress shows mound reflection with upper convex of the strong reflection event on the bottom, drape reflection with prograding toward the slope on the top and aggrading and prograding reflection in the interior in the seismic sections (Fig.3). Reef canal shows two-way onlap reflection, which means the reef canal formed earlier than the sediment filling in the reef canal during the period of development of reef (Fig.4).

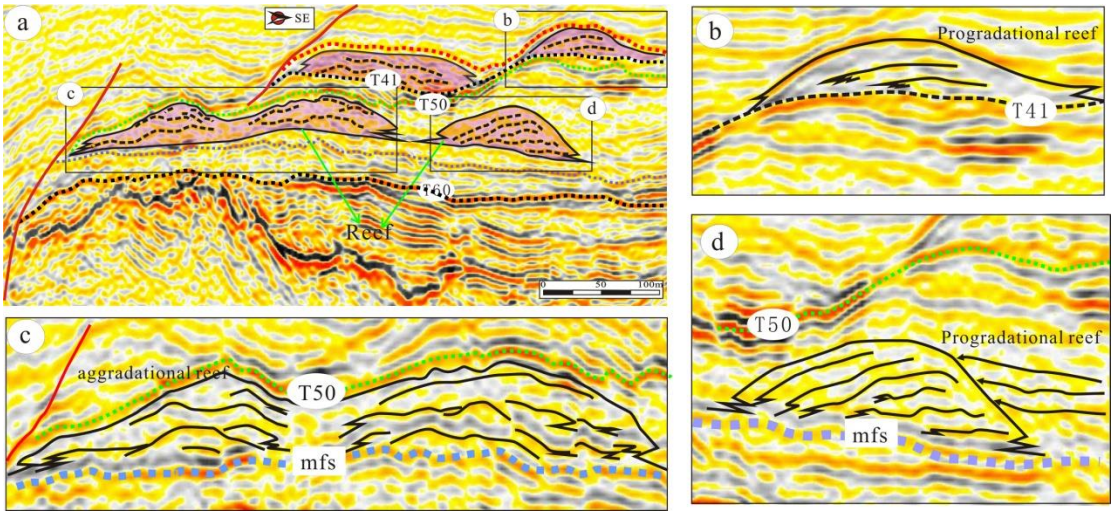

Fig.3. The seismic reflection features of reef complexes on the fault controlling platform margin in the western deep water area in the South China Sea. (a) The seismic section showing reef complexes developed during the Meishan Formation and Sanya Formation (See fig. 1a for the seismic section location); (b) The seismic section showing progradational units developed within the reef complex; (c) The seismic section showing aggradational units developed within the reef complexes; (d) The seismic section showing progradational units developed within the reef complexes.

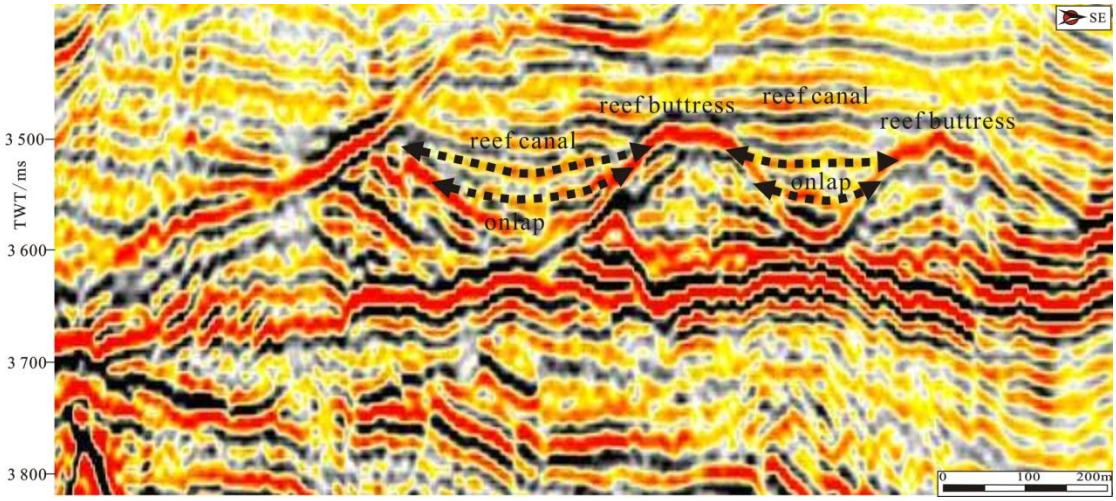

Fig.4. The characteristics of reef buttress and reef canal on the fault controlling platform margin in the western deep water area in the South China Sea (See fig. 1a for the seismic section location).

2 The characteristics of ramp margin reef complexes

Ramp margin, characterized by no obvious slope break, is a gentle slope. With the rise of sea level, reef complexes formed along the ramp. This kinds of platform margin and reef complexes developed in the northeast part of the south uplift which located in the tectonic transition zone among the buried brush arc like fault systems. Because early deep seated fault disappeared in the ramp margin, there is no slump developed in the slope toward the basin(Fig.5).

The development of reef complexes on the ramp margin is only controlled by ramp morphology. The reef complexes are centralized on the ramp and retrograde

toward southeast along the ramp. This kind of reef complexes shows multiple asymmetric mound seismic reflection and characterized by stacking patterns migrating toward the highland. The mound seismic reflection of the reef complexes differed from the surrounding beds. Windward side of reef (fore reef) is steep while the leeward side of reef (back reef) is gentle. There is chaotic or blank seismic reflection in the interior of reef complexes with no obvious layer developed. The internal stacking patterns show retrogradation and faint progradation. Two-way onlap happens between the adjacent reef mounds (Fig.6).

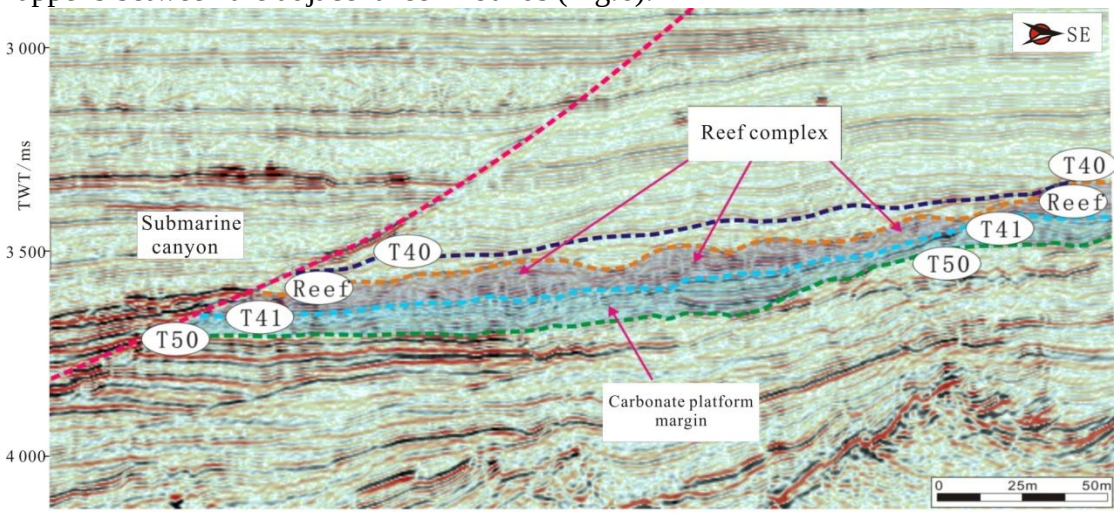

Fig.5. The structure characteristics of ramp margin in the western deep water area in the South China Sea (See fig. 2a for the seismic section location)

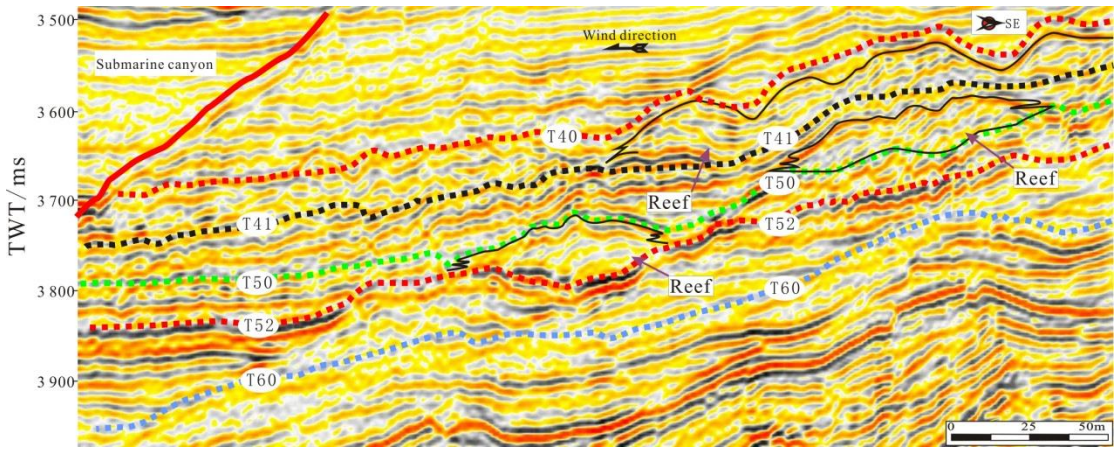

Fig.6. Seismic reflection characteristics of reef complexes on the ramp margin in the western deep water area in the South China Sea (See fig. 2a for the seismic section location).

In addition, There is significant difference between reef complexes on the fault controlling platform margin and on the ramp margin. The growth patterns of reef complexes on the fault controlling platform margin are keep-up and quick step style with no obvious migration. The reef complexes on the ramp margin are catch-up reefs with significant migration which is mainly controlled by the relationship between sea level change (subsidence rate) and reef growth rate.

During the Sanya to Meishan Formation, the evolution of reef complexes shows organic bank developed in the early time and reef complexes developed in the late

time. However, the distribution and growth of reef complexes varied in different period. This study can applied to the exploration and prediction of carbonate platform margin reef complexes in the other area which is similar to the study area.