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Mechanism of Early Post-Rift Normal Faults in the Central Songliao Basin, Northeast China

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In the Songliao basin, a network of normal faults, characterized by relative variability in strike and smallness in length, was widely produced in sediments accumulated during the early post rifting (Gong et al., 2006). Based on the appearance of the angular unconformity and the corresponding period's volcano activity, the development of the normal faults were considered previously by the extensional tectonic (Liu et al., 1996; Hu, 1995). In terms of the abnormal pressure between T_3 and T_1, Mei et al. (1996) described that the normal faults may come into being through the evolution of the hydrofractures. But the two viewpoints cannot explain the variability in strike and a mass of the normal faults cannot be explained by weak regional extension, neither. What is the mechanism of the normal faults occurred during the early post rifting? In order to do more research on the mechanism of the normal faults, we use 3-D high-resolution seismic data from the Taipintun block in the Daqing oilfield (Fig. 1). We measured the extensional strain in NW-SE and E-W direction in the different layers in the block. Calculated extensional strain is 0.059 4±0.020 9 in these rocks , and turns markedly smaller in the above and the below layers (Table 1 and Fig. 2). This is inconsistent with the generally monotonous increase of extensional strain in rift basin with buried depth, implying that the simple regional extension should not account for this abnormal phenomenon.

The network of normal faults widely produced in sediments accumulated during the early post rifting in Songliao basin was similar with the regional-scale polygonal fault systems in north sea. It was argued that the apparent extension is by lay-parallel volumetric contraction (Dewhurst et al., 1999; Cartwright and Dewhurst, 1998; Cartwright and Lonergan, 1996). This was believed to occur in response to fluid expulsion from the mudrocks during early compaction. Despite North sea was deep sea facies, the Songliao basin had similar sedimentary systems involving rapidly deposited, fine-grained sediments, where continuous dewatering and compaction was prevented by low matrix permeabilities. We considered that the network of normal faults may be assumed to be representative of a volumetric contraction during the compaction of mud rocks. Three main possible mechanisms for such layer-parallel shortening are hydrocarbon generation, transformation from smectite to illite (Lu et al., 2004), and lateral compaction, among which the last is considered the most important mechanism in this case.

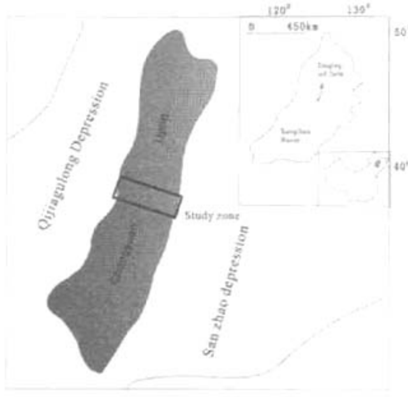

Figure 1. Location of the study area.

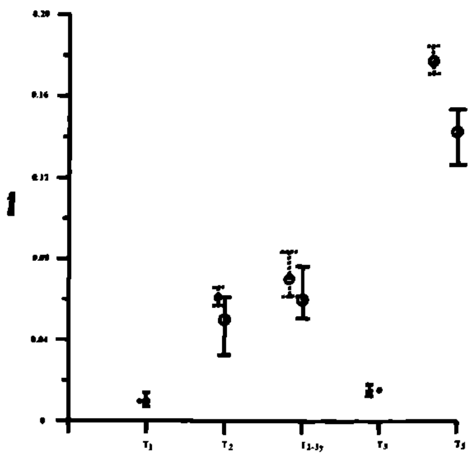

Figure 2. The range of extensional strain and its average value measured in NW-SE and E-W directed scan lines in the different layers.

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Table 1 Extensional strain measured along the scan lines in the seismic reflection layers in the study area

Reflection layers			T_1	T_2	$T_{2\text{-}3y}$	T_3	T_5
Strain	NW directed line	Line 1	0.0139	0.0319	0.0514	0.0142	0.1263
		Line 2	0.0069	0.0610	0.0765	0.0169	0.1539
		Line 3	0.0078	0.0549	0.0503	0.0144	0.1474
		Average	0.0095	0.0493	0.0594	0.0152	0.1425
		Mean square error	0.0054	0.0217	0.0209	0.0203	0.0021
	E-W directed line	Line 4	0.0081	0.0540	0.0641	0.0109	0.1848
		Line 5	0.0104	0.0581	0.0838	0.0139	0.1781
		Line 6	0.0099	0.0661	0.0574	0.0185	0.1694
		Average	0.0095	0.0594	0.0684	0.0144	0.1774
		Mean square error	0.0017	0.0087	0.0194	0.0054	0.0109

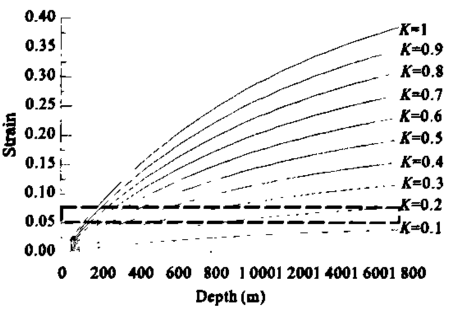

Figure 3. Relationship between lateral shortening ratio and burial depthfor variable ratio of horizontal to and vertical shortening in contraction. A dashed rectangle represents the range of measured extensional strain and of buried depth for seismic reflection layer $T_{2\text{-}3}y$.

This studies described above clearly demonstrate that calculated extensional strain is 0.059 4±0.020 9 in these rocks, and turns markedly smaller in the above and the below layers. Tectonic extension and hydrofractures cannot explain this abnormal strain. It is possible that volumetric contraction during the compaction of mudrocks leads to the development of the normal faults and corresponding high extensional strain. With regard to tectonic extension, the results showed that the ratio of lateral shortening with longitudinal shortening is not less than 0.13 (Fig. 3). The percent of the strain caused by volumetric contraction is more than 76% and did by tectonic extension is less than 24%. In addition, volumetric contraction may shrink the length of the layer, but the basic theory of the balanced cross-section method is based on that the length of tha layer is constant during structural evolution. Volumetric contraction challenges the theory of the balanced cross-section method. Because of this reason, the results using the balanced cross-section method to study the structural evolution should be made some modifications. Otherwise we may make a wrong result. Nevertheless, the preferred orientation of these normal faults indicated the influence of tectonic stress, although it was relatively slight, on their propagation.

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