Tectonic Characteristic and Origin of Tazhong Uplift, Tarim Basin

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Abstract. This paper presents the analysis on geological characteristics of Tazhong Uplift, such as the configuration and nature of the fault structures, and the aeromagnetic anomaly, etc. The study result shows that Tazhong Uplift presents several large-scale fault belts that mainly extend in three directions: NW, approximate (approx.) EW and NNE. The NW fault belts lie in the north and northwest of the research area; the approx. EW fault belts rest in the south and southeast of the research area, whereas the NNE fault belts are mainly strike-slip faults and cut the NW fault belts into several structural segments. It is concluded that the late Caledonian and the late Hercynian period were the two major forming periods of Tazhong Uplift. In the late Caledonian period, the NW thrust faults developed in Tazhong Uplift under the tectonic compression stress from the southwest Foreland Basin. In the late Hercynian period, the subduction of Altyn Orogenic Belt influenced the central Tarim and generated the approx. EW thrust faults in the central and southern Tazhong Uplift. This subduction also forced the early-formed fault belts into an arc-shape in the central Tazhong Uplift and caused NNE strike-slip faults in the northern Tazhong Uplift. Laterally the tectonic stress decreased from the south to the north. From regional perspective, the fault belts diverge to the west and converge to the east.

Introduction

Over the years, Tazhong Uplift of Tarim Basin has been given much attention by scholars at home and abroad [1-7] and has become one of the research hotspots on Tarim Basin. From regional perspective, the major fault belts in this area are of a “brush” style, diverging to the west and converging to the east. Some fault belts also present en echelon pattern. Hence most scholars believed that this uplift was caused by rotational shear forces and has gone through a multi-stage structural evolution, i.e. embryonic forming, finalization and burial of Paleo-uplift. Through the study on the forming time of the Tazhong Uplift, the most findings support that the critically tectonic deformations occurred in the middle Caledon and the early Hercynian period [8-10], and presented the unconformity interfaces then [11]. This paper starts with the analysis on fault structures and geological characteristics and closes with the origin of Tazhong Uplift.

Geological Setting

Tectonic Background

Tarim Basin is an extremely important large-scale sedimentary basin in the grand western region of China. Tazhong Uplift sitting in the central Tarim Basin (Fig. 1) covers an area of 5×104km\textsuperscript{2} with Manjar Depression to its north, Bachu Uplift to its west, Tanggubazi Depression to its south, and Tadong Low Uplift to its east. These tectonic units depict a structural uplift extending from the east to the west and are divided by large faults (such as Tumxuk Fault Belt, No. I Tazhong Fault Belt,
Serikbuya–Mazhatage Fault Belt, etc.) with large depressions to its south and north. The early forming and consequent uplifting movements of Tazhong Uplift created the convenient migration conduits for oil and gas from the peripheral depressions as large source kitchens. Hence Tazhong Uplift is one of the most favorable exploration areas within the Tarim Basin for locating mega oil and gas fields [12-14].

Stratigraphic Features

The Stratigraphic features of Tazhong Uplift shows that a large number of marine sedimentation strata developed after multi-stage tectonic movements[15-17]; however the majority of existing strata belong to Paleozoic and the minority to Meso-Cenozoic. Unconformity interfaces presented among the different formations in the stratigraphic column and the Base Silurian is the most important one. Under this unconformity interface the paleo uplift was extensively deformed and many fault structures developed. Wherea Silurian and above were slightly deformed and substantially overlain the paleo uplift. The unconformity had led to a vertical double-layered stratification in the research area (Fig. 2) [1].

Fault Structure Characteristics

Many large fault belts developed in Tazhong Uplift (Fig. 2), for instance, No. I Tazhong Fault Belt, No. II Tazhong Fault Belt, Katake South Fault Belt, No.8 Tazhong fault belt, Tangbei fault belt, Zhong 3 Well Fault Belt, etc.
Distribution Feature

Various faults have been identified as basement-involved [18-20], but did not cut the Permian and above. From regional perspective, the fault belts present in three directions, namely NW, NNE and approx. EW direction (Fig. 1 and 3). The NW faults are mainly distributed in the north and northwest of the research area, which has similar direction and feature to that of Bachu Uplift in the west. The approx. EW faults lie mainly in the south and southeast of the research area, following the same direction as the southeast Tunguska Fault Belt and Tangnan Fault Belt. The NNE faults are strike-slip faults and spread out in the whole area, cutting the NW fault belts into several structural segments.

Figure 3. Distribution Map of Major Fault Belts in Tazhong Uplift.
(the shadow circles refer to the incision sections of the faults, see chapter 4.2 for details)

The analysis of the distribution of various fault belts concluded that the NW fault belts spread out in similar direction and space among Katake South Fault Belt, No. II Tazhong Fault Belt, and No. I Tazhong Fault Belt. The Katake South Fault Belt and the No. II Tazhong Fault Belt show an almost identical “S” curve. Similarly, the EW fault belts are represented by No. 8 Tazhong Fault Belt, No. 5 Tazhong Fault Belt and the Zhong 3 Well Fault Belt, which are also distributed in similar direction, space and change in thrust direction.

Table 1. Basic Elements of Important Faults in Tazhong Uplift.

<table>
<thead>
<tr>
<th>No.</th>
<th>Fault Name</th>
<th>Character</th>
<th>Dipping Direction</th>
<th>Dipping Angle</th>
<th>Through Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No. I Tazhong Fault Belt</td>
<td>Thrust</td>
<td>SW</td>
<td>20-30°</td>
<td>AnZ- ∈₁₂</td>
</tr>
<tr>
<td>2</td>
<td>No. 10 Tazhong Fault Belt</td>
<td>Thrust</td>
<td>NW</td>
<td>45-60°</td>
<td>AnZ-D₁</td>
</tr>
<tr>
<td>3</td>
<td>No. II Tazhong Fault Belt</td>
<td>Thrust</td>
<td>NW, SE</td>
<td>45-60°</td>
<td>AnZ-D₁</td>
</tr>
<tr>
<td>4</td>
<td>Katake South Fault Belt</td>
<td>Thrust</td>
<td>NW</td>
<td>30-50°</td>
<td>AnZ-O₂,₃</td>
</tr>
<tr>
<td>5</td>
<td>No. 8 Tazhong Fault Belt</td>
<td>Thrust</td>
<td>SSE</td>
<td>25-40°</td>
<td>AnZ-C</td>
</tr>
<tr>
<td>6</td>
<td>Tangbei Fault Belt</td>
<td>Thrust</td>
<td>S</td>
<td>30-40°</td>
<td>AnZ-C</td>
</tr>
<tr>
<td>7</td>
<td>Zhong 3 Well Fault Belt</td>
<td>Thrust</td>
<td>SSE</td>
<td>30-40°</td>
<td>AnZ-O₂,₃</td>
</tr>
<tr>
<td>8</td>
<td>No. 5 Tazhong Fault Belt</td>
<td>Thrust</td>
<td>SSW</td>
<td>30-60°</td>
<td>∈₂-P</td>
</tr>
</tbody>
</table>

Dissection Relationship

The distribution map of fault belts in Tazhong Uplift (Fig. 3) evidently shows that dissection occurred at the joint point (incision section) of two fault belts with different orientations. The NW fault belts represented by Katake South Fault Belt, No. II Tazhong Fault Belt and No. I Tazhong Fault Belt were incised and reformed by the EW fault belts represented by No. 8 Tazhong Fault Belt, No. 5 Tazhong Fault Belt and Zhong 3 Well Fault Belt.
Deformation Pattern

**Section AA’ (Fig. 4).** The section AA’ refers to the west of Tazhong Uplift and cross through No. I Tazhong Fault Belt, No. II Tazhong Fault Belt, No. 10 Tazhong Fault Belt and Katake South Fault Belt. No. I Tazhong Fault Belt is a large-scale low-angle thrust fault belt and dissects the Lower-Middle Cambrian. No. II Tazhong Fault Belt, No. 10 Tazhong Fault Belt and Katake South Fault Belt were formed as the reversed thrusts from the hanging wall of No. I Tazhong Fault Belt at the same time. The fault dissection analysis and the unconformity interfaces demonstrated that these fault belts mainly formed in the late Caledon Tectonic Movement.

![Figure 4. Structural Section AA’ of Tazhong Uplift (location see figure 3).](image)

**Section BB’ (Fig. 5).** The section BB’ refers to the central Tazhong Uplift and cross through No. I Tazhong Fault Belt, No. II Tazhong Fault Belt, Katake South Fault Belt, No. 8 Tazhong Fault Belt and the Zhong 3 Well Fault Belt. As illustrated above, No. I Tazhong Fault Belt, No. II Tazhong Fault Belt and Katake South Fault Belt mainly formed in the late Caledon Tectonic Movement, and the latter two are the reversed thrust faults of the former one. No. 8 Tazhong Fault Belt and Zhong 3 Well Fault Belt formed after the Caledon Tectonic Movement because they cut and reformed the earlier fault belts, for example, the upper section of Katake South Fault Belt was destroyed by No. 8 Tazhong Fault Belt.

![Figure 5. Structural Section BB’ of Tazhong Uplift (location see figure 3).](image)

**Section CC’ (Fig. 6).** The section CC’ refers to the east of Tazhong Uplift and cross through No. I Tazhong Fault Belt and No. 5 Tazhong Fault Belt. The interrelationship between strata and faults, and the degree of structural deformation of the overlying strata support that No. I Tazhong Fault Belt formed in the late Caledon Tectonic Movement, and No. 5 Tazhong Fault Belt was originated in the late Hercynian Tectonic Movement and finalized in the Indo-Sinian Orogenic episode.
Discussion

The Role of Deep Structure on the Deformation Style

The aeromagnetic data analysis shows that the basement of Tazhong Uplift could be divided into three anomaly areas (Fig. 7). The area I and III behaved as positive anomaly, and area II as negative anomaly. Area I and II were divided by No. I Tazhong Fault Belt. It means that this fault belt created a large and deep basement-involved structure, which led to distinct aeromagnetic anomaly in the hanging and foot wall. Area II gives a negative anomaly between No. I Tazhong Fault Belt and Katake South Fault Belt. It suggests that the Paleozoic Erathem (that is the strata above Devonian System) in area II has a stable sedimentary thickness and slight structural deformation. Area III is situated to the south of No. 8 Tazhong Fault Belt and No. 5 Tazhong Fault Belt with a positive anomaly. It reflects a shallower basement and further suggests that the structural deformation from the late-stage thrust nappe has raised the magnetic basement.

The Effect of Tectonic Evolution on the Current Structure Frame

Given the analysis on the configuration, nature and the aeromagnetic anomaly of the fault structures in Tazhong Uplift, it is believed that Tazhong Uplift is the result of the superimposition of tectonic movements. Various fault belts diverge to the west and converge to the east.

**Early Stage Faulting Characteristics.** Before the sedimentation of Devonian System (that is the final stage of Caledonian Tectonia Movement), Tazhong Uplift mainly developed the NW thrust-slip faults, shown as multi-type back thrust fault blocks on profiles. The primary thrust direction to SW was driven by the compressive stress from the Foreland Basin in the southwest Tarim. This area is indeed as part of the front uplift of the Foreland Basin [21, 22]. NW thrust fault belts spread out in the whole area of Tazhong Uplift, that include No. I Tazhong Fault Belt, No. 10 Tazhong Fault Belt, No.
II Tazhong Fault Belt, Katake South Fault Belt (Fig. 7, Table 2). These structures look almost straight on the surface.

**Late Stage Deformation Characteristics.** Due to the closure of Altyn Ocean Basin and the strike-slip subduction of Altyn Orogenic Zone in the southeast of Tarim Basin in the late Hercynian and Indo-Sinian Tectonic Movement [23-25], Tazhong Uplift sustained a strong subduction that affected the whole area. In the south and southeast of the research area, the EW thrust fault belts were formed and extended from the east to the west. This thrust fault belt with thrust direction to the south protruded to the north thus formed a curved feature in the plane. They cut and adjusted the NW thrust fault belts formed in early stage. The central Tazhong Uplift witnessed an arc-shape bend on the early-formed faults; whereas the east part of No. II Tazhong Fault Belt changed its thrust direction from previous SW to current NE, accompanied by NNE strike-slip faults. In the north of Tazhong Uplift, various NNE strike-slip faults formed, and they cut the early-formed faults into several structure segments [8]. It demonstrates a weakening of the tectonic stress from the south to the north (Table 2, Fig. 8).

<table>
<thead>
<tr>
<th>Forming Stage</th>
<th>Geological Period</th>
<th>Orientation</th>
<th>Developed Area</th>
<th>Typical Fault</th>
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</thead>
<tbody>
<tr>
<td>Late stage</td>
<td>K-Q</td>
<td>Approx. EW (thrust fault)</td>
<td>central and south of Tazhong Uplift for thrust faults northwest of Tazhong Uplift for strike-slip faults</td>
<td>No. 8 Tazhong Fault Belt, Tangbei Fault Belt, Zhong 3 Well Fault Belt, No. 5 Tazhong Fault Belt</td>
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<tr>
<td></td>
<td>J</td>
<td>NW</td>
<td>whole Tazhong Uplift, especially in NW</td>
<td>No. I Tazhong Fault Belt, No. 10 Tazhong Fault Belt, No. II Tazhong Fault Belt Katake South Fault Belt</td>
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<tr>
<td>Early stage</td>
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Summary

The Fault Belts Extend in Three Directions

Tazhong Uplift presents several large fault belts that mainly extend in three directions: NW, EW and NNE. The NW fault belts lie in the north and northwest of the research area, spreading out in similar direction and at similar space. The EW fault belts rest in the south and southeast of the research area and show the similar orientation, space and change in thrust direction. The NNE fault belts are mainly strike-slip faults cutting the NW fault belts into several structure segments.

Tazhong Uplift Formed in Two Stages

First forming stage occurred in the late Caledonian Tectonic Movement, when NW thrust faults developed and spread out in the whole Tazhong Uplift which include No. I Tazhong Fault Belts, No. II Tazhong Fault Belts, Katake South Fault Belts, and all these fault belts are nearly straight on the surface.

In the late Hercynian period, the Altyn Orogeny influenced the whole Tazhong Uplift and generated the EW thrust fault belts in the central and southern Tazhong Uplift. The new-formed fault belts cut and adjusted the early-formed NW thrust fault belts. In central Tazhong Uplift, the early-formed fault belts were bend into an arc-shape and the thrust direction of some faults was changed to NE. In the north of Tazhong Uplift, it caused many NNE strike-slip faults. Laterally the
tectonic stress decreased from the south to the north. From regional perspective, various fault belts diverge to the west and converge to the east.

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