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Middle-Late Jurassic chronology and source-to-sink system of the Sikeshu section in the southern margin of the Junggar Basin, Xinjiang

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Abstract: With the improvement of isotopic testing technology, high-precision dating methods such as SHRIMP or LA-ICP-MS of detrital zircon have been used to analyze and infer the formation age of sedimentary basins, the source of detrital materials, and the tectonic background of the formation and widely used. The LA-ICP-MS zircon U-Pb dating method was used to study the detrital zircon in the Middle-Late Jurassic sandstone in the Sikeshu section of the southern margin of the Junggar Basin, Xinjiang. The results show that the detrital zircon ages are mainly 270~447Ma,240~440Ma,245~432Ma, and 286~360Ma. There are also several ancient zircon ages, mainly 945~1080Ma. Combined with zircon mineralogical characteristics, CL images, Th/U ratio, sandstone petrographic characteristics, and regional chronological data, the primary provenance of the Middle-Late Jurassic sandstone is mainly from the Yilinghabilga Mountains in the North Tianshan, and Carboniferous-Permian volcanic rocks, pyroclastic rocks and Carboniferous granites exposed in the Borokonu Mountains of the Central Tianshan Mountains. By comparing the age changes between the four sampling points, the change process of the North Tianshan-Middle Tianshan source-sink system is obtained. From west to east, the upper Devonian glutamate, the Middle Devonian carbonate, and the large granite bodies of the Carboniferous series constituted the early watershed. From the middle to late period of the Toutunhe Formation to the Xishanyao Formation, from east to west, the Cambrian and Silurian carbonate rocks and the large granites and other rocks formed the late water line.

Keywords: Southern margin of Junggar Basin; zircon U-Pb dating; middle-north Tianshan; source-to-sink system

1. Foreword

The four-tree area on the southern edge of the Junggar Basin in Xinjiang is an important oil production area. After years of exploration process, it is believed that the resources in the southern edge are large, and there are multiple sets of reservoirs, but multiple drilling in the depression has not achieved successful [2]. This indicates that it is very difficult to choose the exploration targets due to the complexity of the geological conditions. As one of the most stable minerals in nature, zircon is stable in physical and chemical properties, is low in ordinary lead content, rich in elements, has low ion diffusion rate, high sealing temperature, and has small thermal disturbance in the later period, so it is an ideal object for isotope dating [3]. Zircon is commonly found in granite rocks and acidic volcanic rocks, and its crystallization habit is closely related to the temperature of the magma and the symbiotic combination of minerals. Source of materials formed from the denudation area, including weathered and peeling granular sediment and dissolution material, are transported into the sedimentary area or catchment basin, and eventually deposited, a process known as the source-sink system [4]. Previous extensive chronological studies in the Central-North Tianshan region, This paper is supported by petrology, sedimentology, and zircon U-Pb dating techniques, With the source-hui system theory as the main academic guiding ideology, Drawing on and summarizing the previous research results, To solve the problems existing in the geological research of four-tree depressions, Through the survey of the medium-late Jurassic section of key sections in the area, To identify the characteristics of its related chronology, rock formation and tectonic properties, And on this basis, combining the chronology of intrusive and ejected rocks in the middle-North Tianshan region and the tectonic evolution process in this region, To explore the changing process of its

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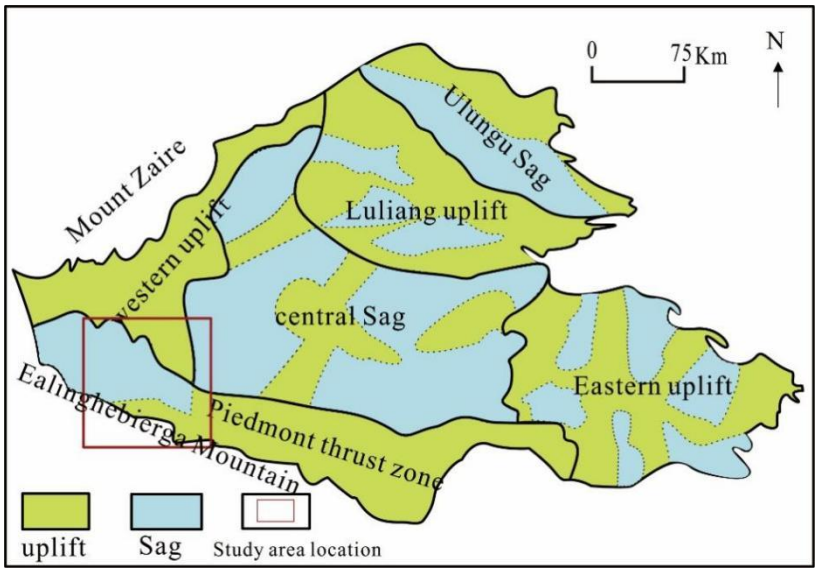
material source supply, Under the conditions that conform to the law of formation deposition, The method of inversion the supply law of source area by using the deposition law of sedimentary area, Understanding the model of single source system of four tree depression, Provide theoretical support for the basin sedimentary process and the subsequent oil and gas exploration and development.

2. Geological structure background and sampling location

The Junggar Basin is in the abdomen of the Central Asian orogenic belt, between the North China plate, Tarim plate, Siberian plate, and Kazakhstan plate, and is the convergence position of multiple plates. The study area is in the western section of the Tostan dorsal slope belt of the first row of the western southern edge of the Junggar Basin, and on the north side is the four-tree depression [5]. The north of the research area is close to the car row son bulge, the east is close to the Homatu anticline belt, and the Yilin Black Beer Mountain of the north Tianshan Mountain system relates to [6] in the south. There are multiple faults and anticline zones due to the influence of Yanshan movement and Xishan movement, and in general, two master fault zones are developed: Eka and Gultu, namely: Carindike, Goltu, High Spring, West Lake and Dushanzi. The overall structural characteristics of the four-tree sag can be summarized as: "one depression, two faults and five anticlines" [7]. (Graph 1).

Figure 1 Area Construction Background



The outcrop profiles of the four trees developed from the Jurassic to the Paleogene in the Lower Jurassic Badaowan Formation and Sanlong River Formation, the Middle Jurassic Xishan Kiln Formation and Toutunhe Formation, the Upper Jurassic Qi Ancient Formation, the Lower Cretaceous Qingshuihe Formation, and the [8] of the Shi-Oligocene Anji Haihe River Formation. On the west side of Sishu River, the line between Jurassic Tunhe Group and Xishan Kiln Group is well exposed. The Xishan Kiln Formation is a set of light gray, light gray, and white gravelly medium sandstone, fine sandstone, and dark gray mudstone mutual layer, mixed with carbonaceous shale and coal seams. Toutun River group is a set of conglomerates, fine sandstone, mixed with gray, gray-green mudstone, the top development of light gray-yellow, purple-red mudstone. The top of the Toutunhe Formation is a set of light blue-gray mudstone, mixed with light gray-white fine sandstone. Developing secondary hemite nodules and bands in the mudstone indicate that the sedimentary top surface had suffered from a long period of leaching and the infiltration of surface water. The Middle Jurassic Head Tunhe Group and Xishan Kiln Group were in contact with erosion, representing the early Yanshan movement. The bottom of igu Formation is a set of purple mudstones, bright colors, and an obvious boundary from the Xiatoutunhe Formation. Purple red mudstone is a typical deposition in the arid continental climate environment, while the semi-arid

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light blue deposition of the underlying strata, between the two, is a paleoclimatic environment conversion surface.

In this paper, the Middle Jurassic Tunhe group and Qigu group of the four tree profiles were sampled respectively. Three samples of the group numbered 20sk-03,20sk-10,20sk-15, and one sample of Qigu group numbered 20sk-26 (Figure 2). The samples are light gray with fine gravel sandstone, light gray sandstone, light gray-white coarse medium sandstone, and light gray-white fine sandstone.

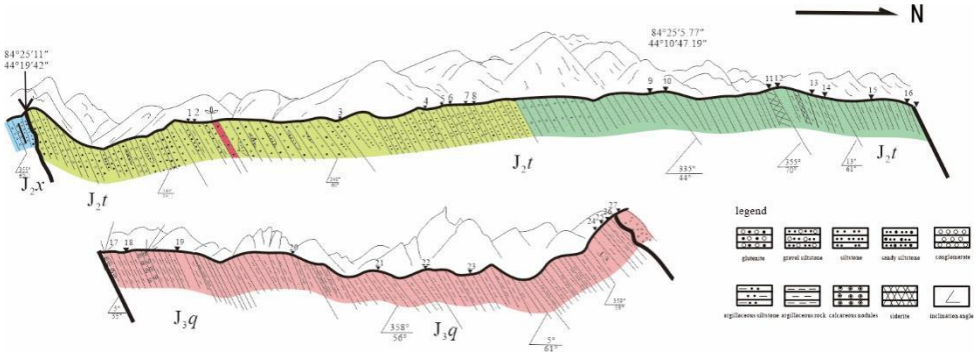

Figure 2: Middle-Late Jurassic stratum profile and sampling location

3. Sample test methods and results

3.1 Sample test method

At Northwestern University, the state key laboratory of mainland dynamics to complete sample selection, selected for complete crystal, good crystallinity of zircon particles based on epoxy sample target, and polished to the zircon exposed maximum cross-section, based on transparent, reflected light application with Gatan MonoCL3 + cathode fluorescence detector electron SEM complete zircon cathode luminous image, and select the zircon laser stripping microregion [9].

The U-Pb age determination and single mineral trace element analysis of the zircon were completed at the Provincial Key Laboratory of Continental Dynamics of Shandong University of Science and Technology. Using Hewlett-Packard Agilient7500a ICP-MS with ShieldTorch and ComPex102ArF laser from Lambda Physik of Germany and Micro Las GeoLas200M optics on-line, trace element and U-Th-Pb isotope determination acquired [9] simultaneously at one point. The laser spot beam diameter is 32 μ m, the partially narrow edge beam spot diameter is 24 μ m, and the laser denudation depth is 20 μ m. The gas was used as the gas of the denuded material in the experiment. The sampling method is single point denudation, data collection is a mass method (peak jumping), zircon 91500 as the external standard material, element content is NIST610 as the external standard, and 29Si as the internal standard element (SiO2 content in zircon is 32.8%). Add 91500 test samples twice for every 5 points, add NIST610s once per 10 test points, and two [10] s for 91500 test samples. Single-particle zircon U-Pb in situ test analysis of data processing using the ICPMSDatacal12.0 procedure the isotopic ratio of the sample as well as the element content was calculated.

3.2 Chronological characteristics of crushed zircon

A total of 353 zircons were selected, and 222 effective test sites were obtained. In the sample, the zircon particle size is mainly 100~200 μ m, and the shape difference is small. Most of the zircon is self-shaped, but slightly broken, and some of the zircon is semi-automatism-shaped, showing the overall structural characteristics of the crushed zircon (Figure 3). Through the cathode luminous image (CL chart), it can be found that the zircon develops as a whole shock ring band, and the crystal is in the shape of a square column and a square double cone. Its Th / U value is greater than 0.1, and the Th / U of some zircon can even reach about 2.3, indicating that these zircons are all magmatic zircons. In the zircon U-Pb harmonic diagram, there is no age data deviation from the

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harmonic line, and the age of the zircon is above the harmonic line, thus indicating that the credibility of the data is high (Figure 4).

The annual measurement data of crushed zircon sampled from tunhe Group and Xishan Kiln Group were distributed in the Neoproterozoic to Early Jurassic. Sample 20sk-03 yielded a 302Ma main age peak, 275Ma with 330Ma, and two secondary age peaks. Sample 20sk-10 yielded two main age peaks: 200Ma and 350Ma, and four secondary age peaks: 300Ma, 250Ma, 400Ma, and 450Ma. Sample 20sk-15 yielded 180Ma with 360Ma, two main peaks of age, 280Ma, 320Ma, 580Ma, and 880Ma. Sample 20sk-26 yielded a 300Ma primary age peak, a 330Ma secondary age peak, and a maximum age of 1050Ma (Figure 4).

By comparing the chip zircon U-Pb age spectrum of four sandstone samples, each sample has 270~447Ma, 240~440Ma, 245-432 M a, 286 ~ 360Ma. The corresponding peak ages are 302 Ma, 350Ma, 360 M a, 360 M and 300Ma, indicating that the source are consistent and mostly derived from the Carboniferous. However, compared to the sample 20sk-03 and 20sk-15, they also have similar intervals of 170 to 191 M and 170 to 196 M a, and the peak age of both samples is 180Ma. This shows that there is a certain gap between different samples, but there are rules to follow. It shows that in the sedimentary period of Toutunhe Group, the source gradually increased. In the sedimentary period of Qiqihar Group, the supply of materials in the new era gradually decreased, and the source in the older era still exists.

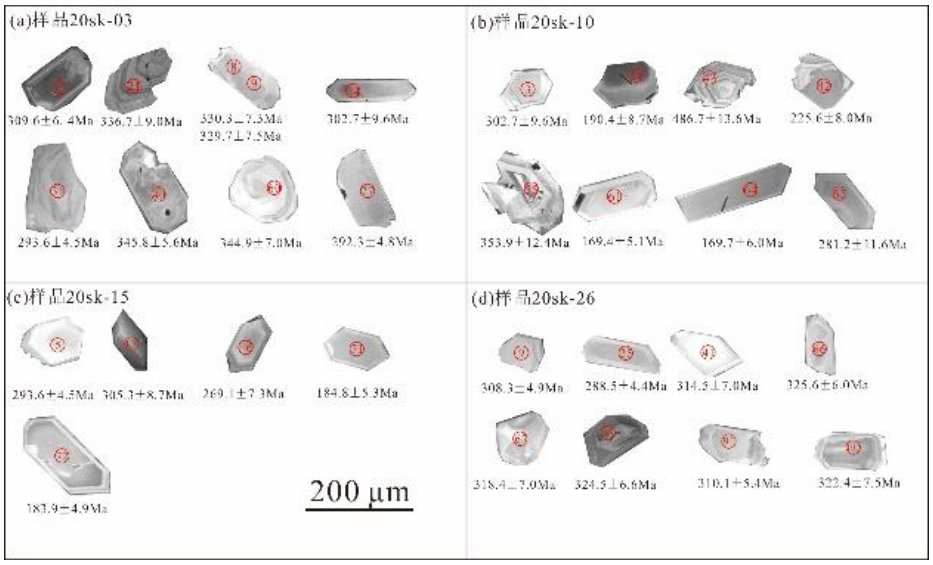

Figure 3 Representative CL diagram of zircon in the four tree profiles of the middle-late Jurassic sandstone samples in the Junggar Basin

4. Composition of the source area and the magma evolution

4.1 Composition of the material source region

In the previous study of the southern edge of the junggar basin, a detailed sediment study shows that the early-middle Jurassic of the southern margin of the junggar basin is mainly from south to north, the tianshan region becomes the main southern source of the basin, and the tianshan source system on the southern margin of the junggar basin deposition has absolute control [11]. With the collision of Lhasa plot and Eurasian plate during the Late Jurassic-Early Cretaceous, the tectonic strengthened, and the mountains began to uplift [12].

The strata of the Southern Tianshan Mountains are mainly Silurian-Devonian, and the Carboniferous and Permian strata are exposed less [13]. Due to the northern margin of Narati, the Southern Tianshan Mountains cannot become the source area. The Middle Tianshan Mountains contain many Carboniferous strata, among which the intrusive rocks are also from the Carboniferous period and are also found in the Precambrian base exposure. The Luodoto-Silurian shallow metamorphic sand and mudstones in the lower Paleozoic are not covered with Devonian

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middle-acidic volcanic-sedimentary rocks, which generally constitute the Calidong tectonic layer and are not covered by the Hercynian tectonic layer. The Hercynian tectonic mainly includes middle Devonian-lower carboniferous limestone, dolomite, acidic volcanic-sedimentary strata in upper Carboniferous, Permian continental volcanic rock, and clastic rock construction [14]. The northern Tianshan Mountains are mainly exposed to the Devonian-Carboniferous Formation, and the Permian strata appear in the north of the Northern Tianshan Mountains

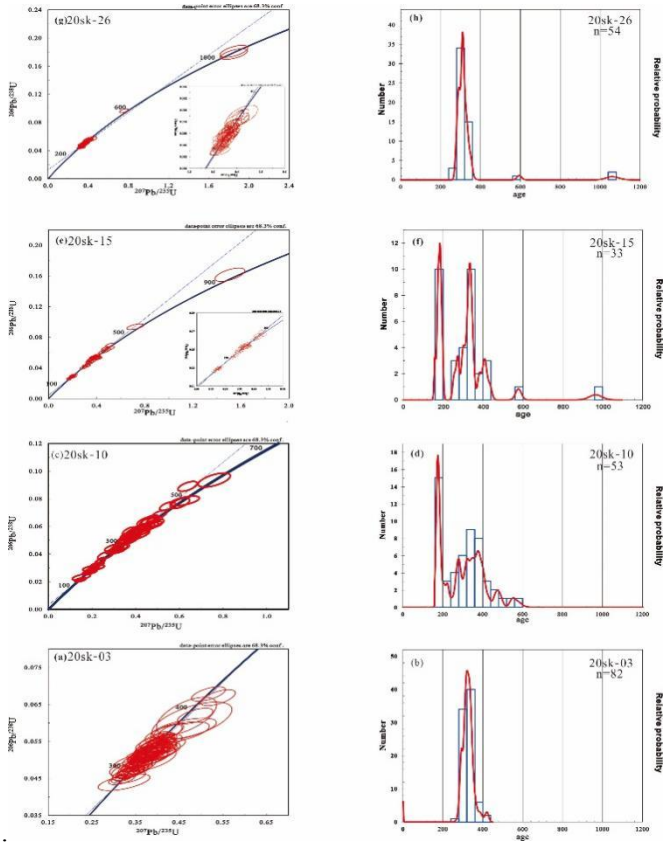

Figure 420sk-0 samples of sandstone 3 (a, b), 20sk-10 (c, d), 20sk-15 (e, f), 20sk-26 (g, h) debris zircon U-Pb age and histograms

There are data on isotopes and chronology in the North Tianshan orogen belt, and the average age of the Carboniferous invasive rocks in the West Tianshan orogenic belt is 308.2Ma+5.4Ma. The main rock types of Salsala and Aluson bodies are dilong granite, and the U-Pb age of zircon is 303Ma and 298Ma, respectively, which are early carboniat-early Permian intrusions. The age of the phanerozoic bedrock zircon in the western North Tianshan Mountains is concentrated from 307 to 347 M a, and the Precambrian age is 798Ma. In previous studies, the age of formation of the oblique long granite mass in a snake-green intermixed rock zone was 324Ma and 325Ma in SHRIMP.

Zircon U-Pb dating of black, Jinghe, Jordan, and pier in the Northwest Tianshan Mountains occurred in the Early Permian (282 ± 2Ma, 2Ma, 2Ma), 289 ± 2 M a), the 305 ± (2Ma, 298 ± 2Ma, 293 ± 2Ma) (311 ± 4Ma) and the Georma in the Late Carboniferous (338 ± 2Ma). The above age comparison shows that the source area of the four tree profiles is relatively stable, and the North Tianshan Mountains serve as the source area. However, due to the influence of tectonics and orogeny, the sources at different times, that is, the change process of the source-sink system of the four tree profiles in the middle-late Jurassic.

4.2 Source and exchange system

The analysis method of source-sink system was first proposed in modern sedimentary research and mainly applied to solve the problem of river and sea deposition. “Source" represents the denotative area and the denotative material, and "hui" represents the sedimentary area and the

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sedimentary material, which summarizes the process of the denotative material being eroded and transported in the sedimentary area. This study area is a single close sediment deposition, and the transport channel is relatively invisible, when the emergence of the watershed controls the sediment supply in the sediment area with a relatively stable tectonic movement (Figure 6).

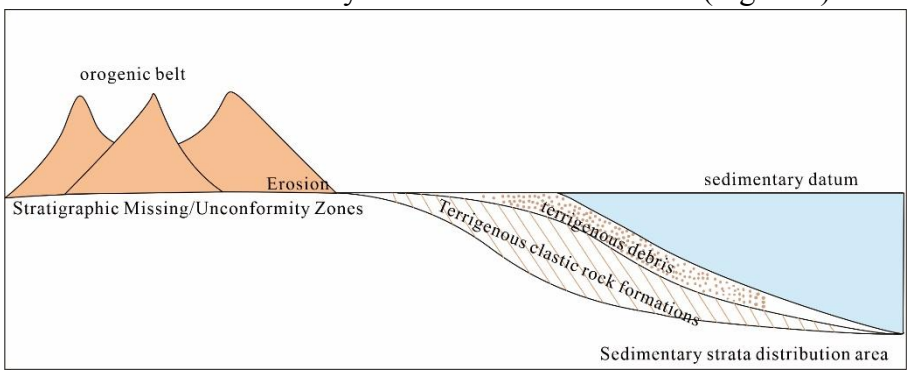

Figure 6 Model of a single close object source sink system

In the long-term denudation areas, the difference of lithology or the influence in faults also often causes asymmetry on both sides of the watershed. The bedrock type in the source area will affect the catchment unit elements and their deposition response relationship. The bedrock types of continental basins mainly include clastic, carbonate, metamorphic, and magmatic (granite), and others [15].

From the zircon age-spectrum analysis, we can conclude that the 20sk-03 sample debris zircon date stratigraphic distribution reflects that its source is mainly derived from carboniferous-Permian volcanic rocks, pyroclastic rocks, and Carboniferous granite, Followed by the volcanic and pyroclastic rocks of the Devonian and Late Silurian, there are no crushed zircon, It indicates that the main sources in this period were the sedimentary strata from the Hercynian tectonic spiral and the intrusive rocks, While the older sedimentary strata of the eastern Garrison, Jinning and Luliang tectonic spiral cycles and the intrusive rocks have not yet become the source, Located on the other side of the diversion line (Figure 7a). The clastic zircon dating stratigraphic distribution of the 20sk-10 samples and 20sk-15 samples was significantly changed from the 20sk-03, although still dominated by carboniferous-Permian volcanic rocks, pyroclastic rocks, and carboniferous granite, the Mesozoic sources from early Jurassic to Triassic, as well as the sedimentary strata and intrusive rocks of the Garrison and Jinning structural cycles, appeared. It indicates that the source area has changed significantly, with the diversion line moving southward to the older strata, with higher mountains and further denudation sources (Figure 7b). It shows that the continuous denudation of this period causes the overall gentle landform of the Tianshan area, and the material from the Middle Tianshan area can be transported into the basin from long distances. The previous work on fission tracks and ancient landform reconstruction of the Tianshan orogenic belt and the peripheral edge of the Junggar Basin also showed that the northern Tianshan region began to uplift during this period. Late Jurassic ancient sedimentary period inherited the early source system, sample 20sk-26 debris zircon strata distribution is still in cupriferous - Permian volcanic, pyroclastic, and carboniferous granite, although the lack of inching and Gary zircon, but the presence of Jinning and older luliang clastic zircon, indicating that the dividing line is still in the Tianshan area, may only because of the printing period and Gary east magmatic activity, less zircon contained (Figure 7c).

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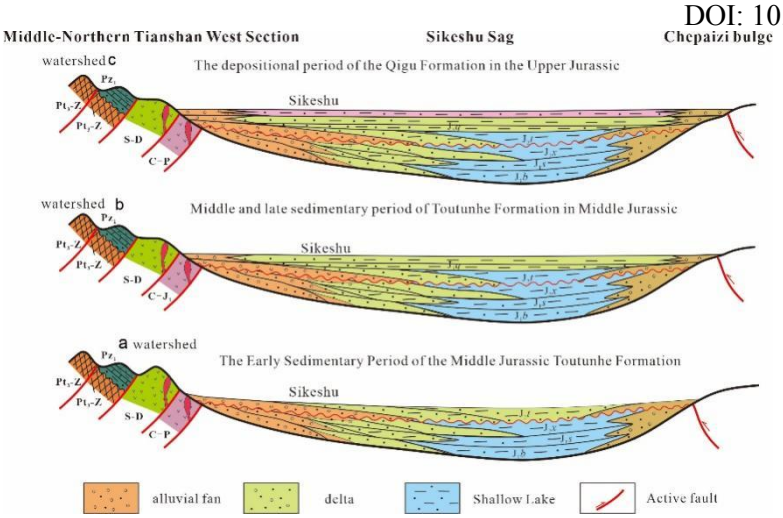

Figure 7 Section view of the watershed control source supply mode

From west to east of the upper Devonian conglomerate, central Devoice carbonate and carboniferous of large granite bodies are difficult to weathering rock, weathering resistance, can constitute the positive landform plateau, constitute the early water line, the north slope of the Devonian and carboniferous-Permian volcanic rocks, sedimentary debris rocks, carbonate rocks, and granite became the earliest main sediment source in the basin area.

To the middle and late tun river group, with the strengthening of denudation and tectonic uplift of continuous activity, diversion to the south, from east to west, in turn by the Cambrian, Silurian carbonate and reflect the late watershed, the north slope of the Neoproterozoic, early Paleozoic and late Paleozoic volcanic rocks, clastic rocks and granite became the main sediment source of the basin area.

5. Conclusion

(1) Using LA-ICP-MS U-Pb dating method, the results showed that the 4 samples were 270-447 M a, 240 and 240-440 M a. Based on previous sedimentary studies, the main source areas were volcanic rocks, pyroclastic rocks, and Carboniferous granite of the Sino-North Tianshan Mountains.

(2) The source-sink deposition pattern of the four trees' s depression can be divided into three stages. In the early sedimentary stage of the Toutun River Formation, its source was mainly from the Carboniferous period, and the early-middle Jurassic age level of the North Tianshan Mountains was not exposed and did not become the source area. Currently, the northern edge of the north Tianshan Mountains serves as the main source area. In the late sedimentary stage of the Toutun River Formation, the early-middle Jurassic area of the North Tianshan region began to be exposed, and the Cambrian strata emerged. At this time, the source area should be the mixture of North Tianshan and Middle Tianshan Mountain as the source. During the sedimentary period of the Qiqihar Formation, the newer source area of the North Tianshan Mountains may be completely denuded and cannot be used as the supply source, while the Borconu area of Central Tianshan Mountains served as the main supply source.

(3) From west to east, the upper Devonian conglomerate, the middle Devonian carbonate rock, and the large granite body of the carboniferous system are difficult to weathering rocks, strong weathering resistance, can constitute a positive geomorphic plateau, and constitute the early diversion line. From the middle and late periods of the Toutunhe Formation to the Xishan Kiln Formation, the late watershed was formed by the Cambrian and Silurian carbonate rocks and the large granite and other unweathered rocks.

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