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The sedimentary characteristics of near-source gravel fan delta controlled by traction flow--A case study from Baikouquan Formation in Xiazijie, Mahu Depression

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Abstract: The complex mechanism of the granite conglomerate in the Xiazijie fan of the Mabei slope has restricted the further exploration of oil and gas in the area. Based on core analysis of Xiazijie fan Baikouquan formation, combined with modern alluvial fan field investigation and understanding of domestic and foreign scholars on alluvial fan sink simulation experiment, especially in the field investigation. It is found that close to seemingly non stratified glutenite shows obvious large cross bedding on macro profile, and analyses the separation mechanism of glutenite. It is believed that the giant fan delta is mainly controlled by the traction flow, which is the main channel swing formation, the development of seasonal river deposition, temporary river and debris flow deposition rare. Based on the understanding of previous analysis on logging, grain size, heavy mineral data, it is believed that Baikouquan Xiazijie fan is near source deposition. However, the roundness of the gravel is high and does not accord with the characteristics of near-source sediments. It is believed that the glutenite is a re-cyclic sedimentation. Through the combination of tectonic, sedimentary evolution history and core analysis, analysis the cause of the proximal gravel high psephicity. The study provides a basis for finding a favorable phase.

Keywords:Mabei slope; Baikouquan formation; orientation; sorting; roundness

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I. INTRODUCE

In recent years, a major breakthrough in oil and gas exploration has been achieved in Baikouquan formation in Mabei slope.But glutenite has many characteristics, such as diverse composition, complex structure, wide range of particle size, great difference in physical properties, poor logging response, rapid lateral change and difficult plane prediction, and glutenite reservoir is usually relatively dense,It is difficult to drill well, the drilling is difficult, the exploration cost is high, and the economic benefit is low, which restricts geologists to understand them deeply and concretely. The study of the granite conglomerate in the Baikouquan Formation in this area is mainly focused on tectonic evolution and fan formation and distribution, sequence stratigraphy and subtle reservoir exploration, reservoir control factors, and application of seismic sedimentology.The deep sedimentary mechanism of glutenite has not been studied[1-9]. Some scholars have carried out fine lithofacies classification of complex sand conglomerate in this area, and established the fan delta genesis mode[10-16]. But for the gravitational orientation, sorting, roundness and gravel fan formation mechanism of understanding of the limitations,which leads to the sedimentary facies and source judgment bias, restricted the further oil and gas exploration of the gravel fans.

II. GEOLOGICAL BACKGROUND

Mahu sag is a secondary tectonic unit in the central depression of Junggar basin, and the north slope of Baikouquan Xiazijie fan group is located in north of Mahu depression(Fig. 1). The tectonic pattern of the north slope of the Mabei Formation is formed in the early Cretaceous period, showing a southeast dipping gently monoclinic shape and locally developing low amplitude anticlines and nose like structures[8, 9]. In the study area, the stratigraphic development is relatively complete, and the Carboniferous, Permian, Triassic, Jurassic and Cretaceous are developed from the bottom to the top, all regional unconformity contact between departments, the Triassic inside can be divided into internal bottom Triassic Baikouquan formation, Karamay formation and Baijiantan formation. Baikouquan interior is divided into three segments: Tlb_1, Tlb_2, Tlb_3, and the second segment are divided into $T_1b_2^2$, $T_lb_2^1$ two small layers. The target area of this research is Baikouquan formation of Maibei Xiazijie Fan.

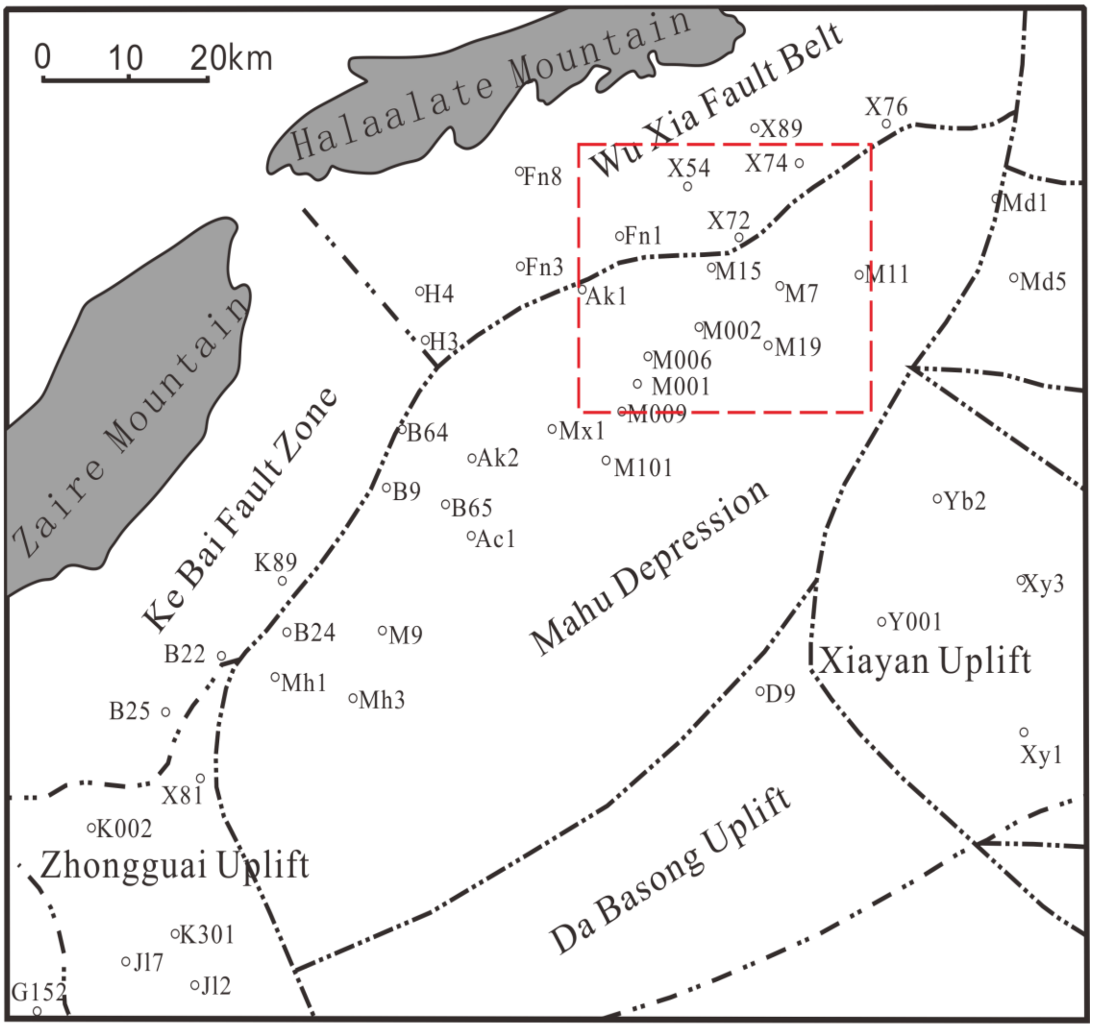

Fig. 1 Location map of the study area (the dashed line in the figure is the Xiazijie fan)

III. FAN DELTA FORMATION MECHANISM ANALYSIS

With a range of more than 50km, the Mabei Xiazijie fan has obvious inheritance for the shallow water giant fan delta in the background of gentle slope. Fan delta is an alluvial fan from the adjacent highland directly to the stagnant water. Therefore, the fan delta formation process is closely related to the formation process of the alluvial fan. Therefore, clarifying the formation mechanism of alluvial fan has a good guiding significance for the formation of fan deltas.

Some foreign scholars have analyzed the formation of alluvial fans through field outcrop investigation and sink simulation experiments. It is considered that alluvial fan, especially giant alluvial fan, is mainly due to the periodic swing and migration of one or more main channel[17, 18], mainly controlled by traction flow.

By observing the modern sediments of the surface and shallow layers of the Poplar River alluvial Fan and the Huangyangquan fan near the modern Xiazijie street fan, and the macroscopic observation of these fans by means of the Google map. It has been found that the alluvial fan surface develops two types of channels: seasonal braided channel and temporary braided channel, and displayed on the profile is mainly for the seasonal river deposition,followed by temporary river sedimentation (Fig. 2). On the plane, a temporary channel occupies most of the surface area of the alluvial fan, seasonal river only occupies a very small area, but due to seasonal river runoff through most of the time, traffic, strongly carrying ability, strong effect on the formation of the alluvial fan and transformation, forming the formation of large thickness(Fig. 3). The temporary channel generally has no runoff, and the transport capacity of alluvial fan sediment is relatively weak, and the formation thickness is relatively thin. Therefore, it is considered that these fans are mainly controlled by traction currents, mainly seasonal channel sediments.

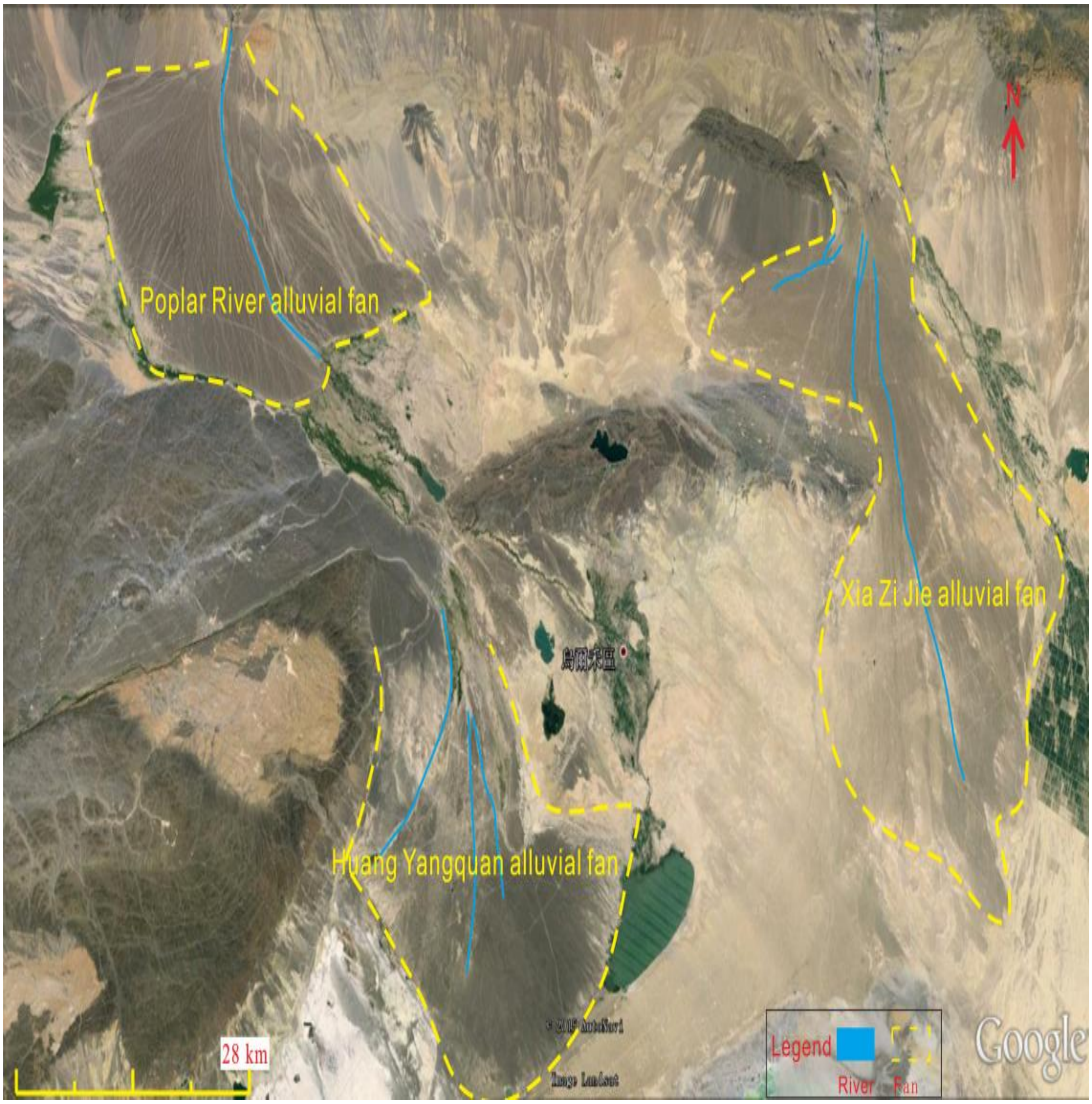

Fig. 2 Geographic location and Plane Morphology of Poplar river alluvial Fan, Huangyangquan Fan and Xiazijie Fan (according to Google Satellite Map, 2013)

These studies have shown that the giant fan delta is mainly controlled by the traction flow, but the former view that the giant fan handling mechanism is gravity flow deposition, supplemented by traction flow deposition[14-16]. The reason that the previous thought Xiazijie fan is mainly controlled by gravity flow , that is because the core observation of geological workers in the area , found that the glutenite overall showed poor sorting, directional characteristics of fuzzy, the traditional view that this structure belongs to the glutenite sedimentary characteristics of gravity flow.

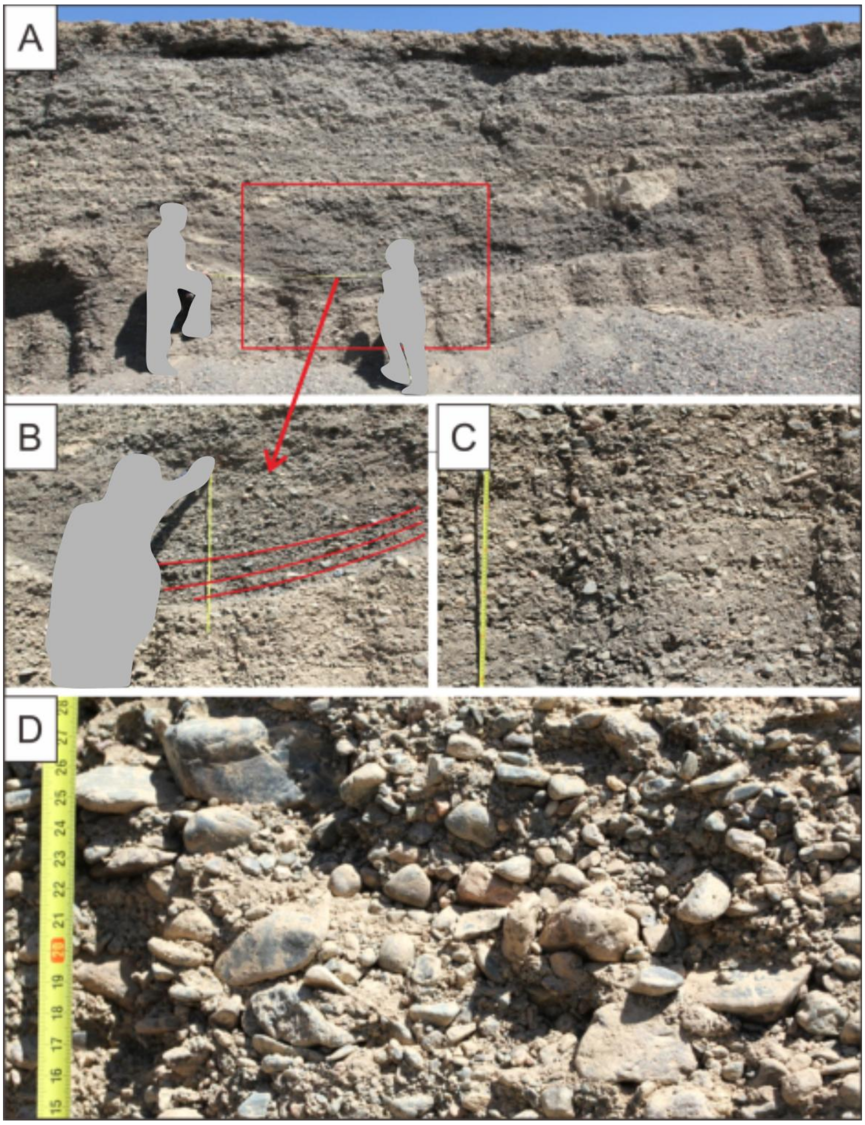

Fig. 3 Sedimentary profile of the modern Poplar River fan channel.Figure A, B for the longer distance observation, see the apparent cross bedding ; Figure C, D for the closer observation, found that the nearer the distance is, the less obvious the orientation of the gravel is, and the fuzzy orientation or disorder is arranged.

In the modern sedimentary study, it is found that the alluvial fan and sandy gravel sediments controlled by seasonal rivers show obvious stratification on the macro scale, but they are microscopic to show a messy structure, and poorly sorted (Fig. 3). This gives the core observation with great revelation, some seemingly cluttered, sorting poorly rocky structures that may be part of large cross bedding. If this can not be distinguished, it is possible to misjudge the fluvial deposits formed by the traction stream as the debris flow deposited by gravity flow.

Because the area is in the gentle slope background, the gravity flow can not be carried by long distance. If the fan deposit is controlled by gravity flow, it is obviously in contradiction with the characteristics of the wide spread of the fan. And Mabei Xiazijie fan is inherited, in Google maps show that the modern Xiazijie fan exist a number of seasonal main channel, and temporary channels occupy most of alluvial fan surface area (Fig. 2), the formation mechanism is similar with the Poplar River Fan and Huang Yangquan fan.

In conclusion, the Xiazijie fan Baikouquan formation is mainly controlled by the traction current

IV. SORTING MECHANISM AND ORIENTATION ANALYSIS

The fan is mainly controlled by the traction flow, and the seasonal channel deposits are characterized by the poor sorting. Although the author has found a large number of well sorted glutenite deposits in front of the fan delta front. But why does the traction flow make the poorly sorted glutenite deposited? There are obvious differences in sorting characteristics between seasonal channel deposits and foreset bedding deposits. What are their similarities and differences in the sorting mechanism? If it is not correctly understood, it will inevitably lead to the deviation of the sedimentary facies judgment. Therefore, it is necessary to analyze the sorting mechanism of glutenite deposits under the control of the traction flow.

Allen (1970) seems to be the first scholar to explore the traction flow sorting mechanism, which he calls the sorting process of traction flow as Avalanching[19]. Subsequently, foreign scholars have made a lot of systematic research on this sorting process, especially Kleinhans has carried on the fine characterization to the sorting mechanism of sand gravel deposition under the control of traction flow, and its research on the sorting mechanism has very good guiding significance. Combined with the tank simulation experiment ,Kleinhans consider that the sorting process of gravel foreset bedding deposits under the control of traction flow is the result of a cyclic collapse (Fig. 4)[20].

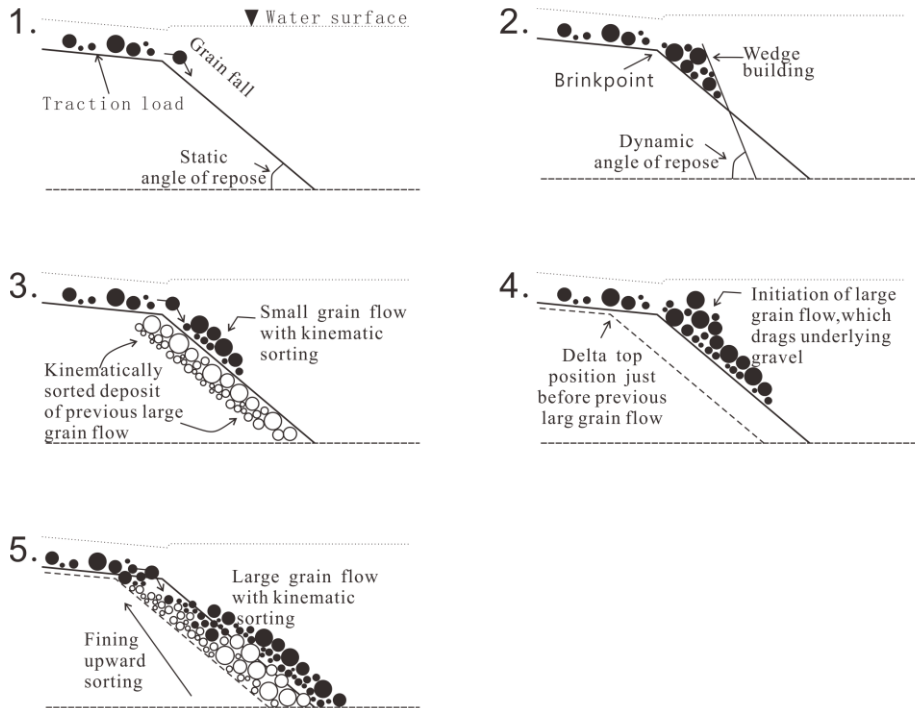

Fig. 4 Conceptual model of foreset bedding sorting under traction flow control. The whole process consists of three phases; 1 and 2 are wedge shaped particles falling out; 3 are small particle streams and are accompanied by dynamic sorting; 4 and 5 are large particle streams that drag the particles deposited prior to the top to make the particles finer.

First, the supply has just begun to deposit under brinkpoint, forming a wedge that is steeper and more than static angle of repose. This wedge eventually collapses onto the delta front surface, producing a small particle stream and accompanied by a dynamic sorting process. The smaller particles move under the large particles by means of percolation or kinematic sorting, rolling down with the large particles along the delta front surface and dragging the previously deposited pellet stream Material, forming a large particle flow, and finally deposited to the bottom of the foreset bedding. In this process, the angle of repose of large particles is often smaller than the angle of repose of small particles without regard to the shape of the particles[21], roundness and other factors,therefore, the collapse process usually gives priority to the deposition of coarser material to the bottom of the foreset bedding, resulting in bottom coarse and upper fine separation results. In this sorting process, Allen (1970) notes that the material rolling along the foreset bedding may temporarily stay in the middle position and continue to roll with the subsequent avalanches. Anyway,the final sorting results are certain.

A variety of sorting mechanisms occur during sediment transport, but most importantly, the higher the foreset bedding, the better the sediment separation[22]. This is because, in the process of avalanches, the higher and higher foreset bedding provides longer distances and more time to make the particles better separated, giving priority to drag the coarser material to the bottom. Therefore, the sink simulation found that the larger the foreset bedding height, the larger the average particle size at the bottom, the better the sorting[23]. In addition, the higher the foreset bedding, the more avalanches happen, the better the sorting. This is because the delta progradation rate is inversely proportional to its height[23], so we can measure particle flow events using the foreset height. The increasing number of avalanches resulting from the brinkpoint causes the material to fall onto the surface of the foreset, and the coarse particles are preferentially deposited along the foreset bedding to the bottom, so the more avalanches means better sorting.

The sorting mechanism of river sediments is similar to that of the foreset bedding, and will not be repeated here. It should be noted that river sediment separation effect is closely related to dune height, however, compared with the previous layer height, the formation of the river dune height is often smaller, therefore, relatively poor sorting.

Therefore, the fan delta foreset glutenite separation is better, because the foreset height is larger, better separation of gravel sediments, and can clearly see the multilevel normal grading, this is foreset several avalanches and separation of the evidence (Fig. 5). Seasonal braided channel sorting is poor, this is because the dune height relative to the fan delta foreset height is often smaller and smaller height showed poor sorting, which is a reason of seasonal river sedimentary micro weak directional , because of poor sorting means directional fuzzy. And the part also found a good orientation of the glutenite, the reason is that the glutenite bed surface is easy to form a movable protective layer surface, that is, imbricate structure.

Therefore, the seasonal braided river deposits show obvious stratification on the macro scale, but they show disorder structure, poor sorting and partly imbricate structure on the micro level.

Fig. 5 M001 well core photographs (3486.00-3491.07m) showing multiple positive grain sequences.

V. NEAR-SOURCE HIGH-ROUNDNESS ANALYSIS

Comprehensive understanding of previous logging, grain size, heavy mineral data analysis, it is shown that the Xiazijie Fan Baikouquan Formation is near source sedimentary. However, a large number of high-roundness gravels in the study area do not meet the typical near-source sedimentary characteristics, and some people think that the fan is far-source deposition, which is the main reason why the fan distribution range is not clear. Therefore, it is important to recognize the formation mechanism of gravel high degree of roundness.

The sediment is transported from the mountain to the basin. In the process of deposition, the particles will be rounded by friction, collision and dissolution. It can be seen that the sedimentary environment and hydrodynamic characteristics of gravel deposition are important reasons for its high roundness. For the warm and humid paleoclimate environment, wet and rainy, frequent floods, hydrodynamic stability, the particles are eroded and modified for a long time, and the gravel often has higher roundness. But Xiazijie fan Baikouquan formation historical period, in the semi arid climate, drought, flood burst, mainly seasonal rivers, temporary rivers comprehensive result of channel stability, particle erosion time is short, weak, difficult to form high gravel roundness. In the course of transport, besides the influence of the stability of the river, the roundness of the gravel will be affected by the following factors.

(1) the type of fluid, compared to the traction flow, gravity flow has a poor stability, and a short particle transformation time, which is difficult to form a pebble with high roundness. But the gravity flow deposits in this area also have better roundness (Fig. 6).

(2) the composition of gravel, compared to the tuff, mudstone and other plastic particles,high hardness, high

content of siliceous granite, siliceous gravel is not easy to be rounded, but the area of granite, siliceous gravel also has good roundness (Fig. 6).
(3) gravel size, usually the smaller particle size of gravel is not easy to be rounded, mainly due to the small particles and other particles hard to collision and friction, and gravel transport rate faster, by the water erosion time Short, thus further weakening its degree of grinding round, but in the area even if the fine gravel also has a good roundness (Fig. 6).

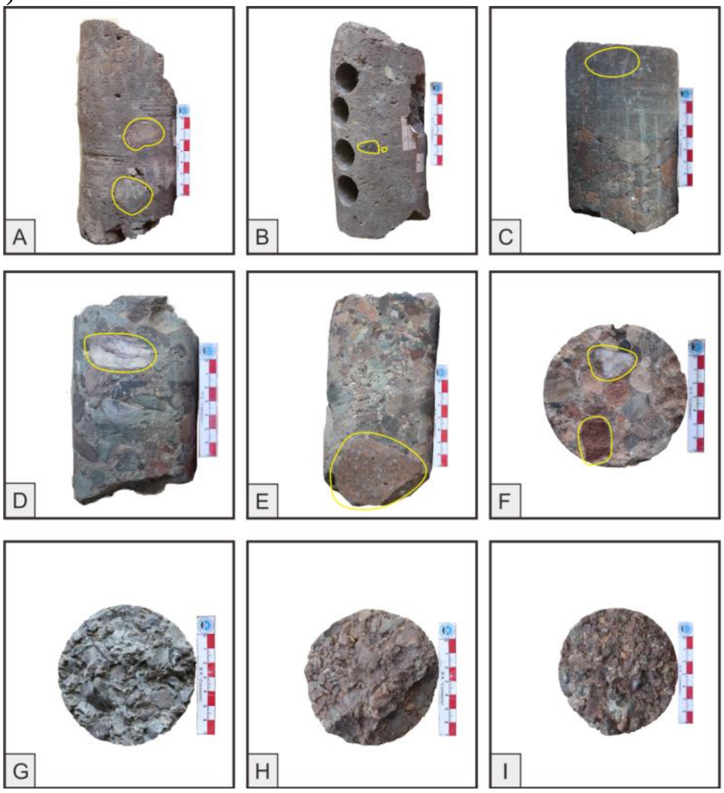

Fig. 6 A-C. Mud flow deposits, round gravel (A.M002 wells, 3505.1m; B.M133 3303.5m; C.X95, 2805.1m); D-E. Glutenite, containing a circle circle shaped granite and siliceous rock gravel (D.M001 wells, wells E.M004, 3538.9m; 3471.6m; M5; 3445.5m; wells) G-I. Grit, containing a circle - round gravel (G.M5 3516.8m; X81 wells, wells, 2557.4 wells; I.X81, 2557.8m)

Based on the analysis, the near source characteristics and semi-arid paleoclimate environment in this area are not conducive to the formation of high - roundness gravel. Based on the analysis of previous achievements, modern sedimentation and core data, combined with the regional tectonic evolution and sedimentary background, it is considered that the glutenite is a re-cyclic sedimentation. In the Early Carboniferous, the northwestern margin of the Junggar basin is in the shallow and semi-deep-sea environment. The sediments are mainly volcanic rocks formed by shallow sea volcanic eruption and some normal shallow marine deposits; With the influence of tectonic movement of Late Carboniferous, the distribution of sea and land in the basin has changed, and seawater invaded from the southeast to the northwest of the Junggar Basin. The HalaAlat mountain became the sea and land transfer area. Early Permian, the northern Junggar Basin uplift to further expand the seawater all quit, forming a deeper lacustrine sedimentary environment. The corresponding relationship between the gravel composition shows that the Xiazijie fan Baikouquan formation mainly derived from the Late Carboniferous-Early Permian sediments in the HalaAlat mountainous area. The debris material in the source area are washed and washed by sea water for a long time in the coastal sedimentary environment,forming a high degree of roundness of the gravel. This type of re-transport sedimentary high roundness gravel is also common in modern alluvial fans on the northern edge of the Junggar Basin. Of course, a small amount of secondary angular gravel is present in the fan. A small amount of angular gravel existing in the near source area of this area belongs to the newly disintegrated products in the piedmont zone, while a small amount of angular gravel existing in the far source area may be caused by the fragmentation of the brittle gravel during the transport.

In conclusion, the structure and sedimentary environment of gravel formation period is the basic reason for its high grinding roundness.

VI. CONCLUSION

1)Mabei slope of Xiazijie fan Baikouquan formation is mainly affected by the traction current.It is due to one or more of the main channel of periodic swing and migration of sedimentary formation, development of seasonal rivers, temporary fluvial deposition, rare debris flow deposits.
2)Season of sandy braided river deposition, close seemingly no bedding, shows the large-scale cross bedding in the macro profile, which gives the core observation with great inspiration, some seemingly messy rock fabric, may be part of a large cross bedding.
3)Particle separation process in gravel fan delta by traction control is a continuous collapse of the results, and is highly related to the quality and sorting of fan delta and braided river sand, height of the larger, better sorting.
4)Fan deltas in this area belong to near source deposits, and high abrasion round gravels are recycled gravels.

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