

Article



Fracture Characteristics and Distribution in Slant Core from Conglomerate Hydraulic Fracturing Test Site (CHFTS) in Junggar Basin, Northwest China

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Abstract: Hydraulic fracture networks, especially fracture geometry, height growth, and proppant transport within the networks, present a critical influence on productivity evaluation and optimization of fracturing parameters. However, information about hydraulic fracture networks in post-fractured formations is seldom available. In this study, the characteristics (density and orientation) of hydraulic fractures were obtained from field observations of cores taken from conglomerate hydraulic fracturing test site (CHFTS). A large number of fractures were observed in the cores, and systematic fracture description was carried out. The fracture analysis data obtained includes fracture density, fracture depth, fracture orientation, morphology, fracture surface features, apertures, fill, fracture mechanical origin (type), etc. Our results show that 228 hydraulic fractures were intersected in a span of 293.71 m of slant core and composed of irregularly spaced single fractures and fracture swarms. One of the potential sources of the observed fracture swarms is near-wellbore tortuosity. Moreover, for regions far away from the wellbore, reservoir heterogeneity can promote complex hydraulic fracture trajectories. The hydraulic fractures were mainly cross-gravel and high-angle fractures and align with maximum horizontal stress (S_{Hmax}) \pm 15°. The fracture density, orientations, and types obtained from the core fracture description provided valuable information regarding fracture growth behavior. For the near-wellbore area with a transverse distance of less than 25 m from the hydraulically-fractured wellbore, tensile fractures were dominant. While for the area far away from the wellbore, shear fractures were dominant. Our results provide improved understanding of the spatial hydraulic fracture dimensions, proppant distribution, and mechanism of hydraulic fracture formation. The dataset acquired can also be used to calibrate numerical models and characterize hydraulic fracture geometry and proppant distribution.

Keywords: CHFTS; slant coring well; hydraulic fracture characteristics; fracture swarms; hydraulic fracture formation mechanism

1. Introduction

Tight conglomerate reservoirs are unable to obtain natural productivity due to their poor physical properties and hydraulic fracturing is thus strongly demanded. Conglomerate reservoirs are characterized by strong heterogeneity and large horizontal stress difference, which brings great challenges to the process of fracturing [1]. The primary challenge is to define artificial fracture morphology in conglomerate formations.

The artificial fracture propagation mode during the rock failure process in conglomerate reservoirs mainly comprises three types: penetrating through gravel, bypassing gravel, and embedding in gravel, but the mechanism of artificial fracture propagation is deeply understood. Former studies regarding the mechanical characteristics and fracture propagation mechanism of conglomerate reservoirs were carried out through physical experiments on surface rocks and finite element simulation based on different materials.



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Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). While these techniques provided many useful insights, the verification of results through direct the observation of hydraulic fractures is needed, and the best method of achieving this verification is to examine core intervals that have been hydraulically fractured [2].

The knowledge of the extent and density of hydraulic fracture networks in conglomerate reservoirs is generally limited. The hydraulic fracture distribution in multi-stage and multi-well operations is irregular and can be difficult to predict even with robust subsurface constraints [3]. During the stimulation of stages with multiple perforation clusters, complex interactions between fractures take place, resulting in different numbers of propagated fractures, which were usually considered greater than one but less than the number of the perforation clusters [4]. Whereas recent subsurface data from Hydraulic Fracturing Test Site-1 (HFTS1) in the Midland Basin [2,5] and Hydraulic Fracturing Test Site-2 (HFTS2) in the Delaware Basin [6,7] indicated that hydraulic fractures were not evenly distributed through the slant cores, they tended to occur in clusters, and the number of fractures was generally greater than the number of perforations [8]. Previous work in HFTS1 and HFTS2 has shown the value of cores, which were recovered from a stimulated volume, in providing information on the geometry and extent of hydraulic fractures [9,10]. The core fracture information is basic data regarding reservoir-scale simulations of hydraulic fracturing and production. Field data from the Hydraulic Fracturing Field Test (HFTS) provided upscaled parameters for calibrating the reservoir scale hydraulic fracturing model, which could accurately capture both the average length and the total aperture of the fractures in the fracture swarms [11,12]. Based on the hydraulic fracturing model calibrated to the HFTS, a fully coupled hydraulic fracturing, reservoir, and geomechanic simulator was used to perform an economic optimization of design parameters, including well spacing, landing depth, and completion design parameters [13].

The CHFTS is in the Mahu oilfield of the Junggar basin, the slant core well is located near hydraulically fractured wells. A slant core through the stimulated volume was acquired above and below the adjoining stimulated wells, which provided direct information about hydraulic fractures. In this paper, we characterized and measured hydraulic fractures, drilling-induced fractures, and core-cutting-induced fractures in the slant core, and further classified the hydraulic fractures according to their characteristics and mechanical origin. Moreover, the hydraulic fracture density and spatial distribution were quantified based on the acquired fracture dataset. The results provide a basis for understanding hydraulic fracture characteristics and the mechanical mechanism of the conglomerate reservoir. Findings can help verify indirect diagnostic results, such as microseismic monitoring and tracer monitoring.

2. CHFTS Project Overview

2.1. Test Site

CHFTS is a field-based hydraulic fracturing research experiment performed in the Junggar basin. Figure 1 is a 3D view of the CHFTS wells. A total of eleven horizontal wells were drilled in T_1b_3 and T_1b_2 formations, in which seven wells are T_1b_3 with a well spacing of 100 m and five wells are T_1b_2 with a well spacing of 150 m. The horizontal section length of the horizontal wells are 1800 m, and the measured depths are 4597–5040 m. The horizontal wells were drilled from north to south in a three-dimensional staggered arrangement, which was approximately perpendicular to the predicted direction of maximum horizontal stress. The thickness of the T_1b_2 formation is 6–8 m, and the thickness of the T_1b_3 formation is 14–16 m. The T_1b_2 and T_1b_3 wells are separated vertically with an interlayer of approximately 13–20 m thickness. The reservoir lithology is dominated by conglomerates (gravel diameter 5–70 mm). The gravel composition is mainly pyrolith, followed by metamorphic rock. The inter-gravel is mainly filled with sand, mud, or fine gravel and the overall reservoir is highly heterogeneous.



Figure 1. Three-dimensional view of CHFTS wells. Wells in red are T_1b_3 and those in green are T_1b_2 . The slant core well is in blue, and it passes through the fracture networks of wells H8/H9 in the T_1b_3 formation and well H4 in the T_1b_2 formation.

2.2. Completion Overview

The 12 horizontal wells were divided into three factory operating well pads. The main body adopted a single segment with three clusters. The cluster spacing was 20 m. Meanwhile, three types of tests were conducted: cluster spacing (10 m/20 m/30 m), proppant concentrations (1.0–1.8 m³/m), and limited entry and temporary plugging fracturing technology.

Fracture growth is a point of concern during the completion of the adjacent horizontal wells. Thus, comprehensive monitoring data were collected, including advanced diagnostics, such as microseismic tracer data [14]. Figure 2 shows the relative position of the horizontal wells, test wells, and slant core well. A microseismic was deployed in eleven wells to help identify hydraulic fracture dimensions (H4 was microseismic monitoring well), and fluid tracers (water-based and oil-based) were placed in two wells to evaluate horizontal well profile heterogeneity.



Figure 2. Elevation view of CHFTS wells, showing the relative position of the horizontal wells, test wells, and slant core well.

2.3. Coring through the Stimulated Reservoir Volume (SRV) and the Results

The prominent task of CHFTS is to acquire a four-inch diameter whole core in close proximity to both the T_1b_3 and T_1b_2 formation wells. The well that accomplished this task was the slant core well positioned within the 2# operating well pad (horizontal wells are H8/H9/H3/H4), with an azimuth of 175.0° and an inclination of 80.3°. Figure 3 shows a perspective view of the slant core well trajectory with respect to the adjacent horizontal wells. The core well is shown as a blue line in Figure 3 and will hereafter be referred to

as S1. In the T_1b_3 formation, S1 is located between two horizontal wells as H8 and H9, near the middle of the horizontal section. The cores were drilled from the east side of H8 with a lateral distance of 18.6 m from the nearest completion stage, and sloped down to the bottom of H9 with a vertical distance of 14.6 m. In the T_1b_2 , S1 is close to H4 on the west side, the lateral distance between the cores and completion stage is in the scope of 20.3–51.8 m.



Figure 3. The slant core well trajectory with respect to the adjacent horizontal wells. (a) Vertical view; (b) side view.

The S1 trajectory enabled the collection of cores with varying lateral distances from the adjacent producing wells, providing insights into both the vertical and horizontal fracture geometries [15].

This slant core well recovered approximately 323.13 m of core, and 293.71 m of those were applied for study; a total of 48 cores, each with a length of about 6.5 m. Cores 1 to 31 are located in the T_1b_3 formation, sized approximately 194.95 m, and cores 32 to 48 are located in the T_1b_2 formation, sized approximately 98.76 m.

3. Slant Core Methods: Handling and Process for Core Description

A complete set of slant core methods was presented, as shown in Figure 4. Each of the 4-inch-diameter cores was contained within an aluminum tube. To conduct the CT scans of the core, the core was cut into segments of about 1 m length without removal from the aluminum tube, which assists in maintaining the integrity of the core. The core CT scans were utilized to compare the core description dataset to differentiate in situ fractures from fractures created while removing the core from the aluminum tube. Then, the core was removed from the aluminum tube. The methodology for extracting cores was required to maintain the condition of the core and fractures as close to their original state. A clam-shell core barrel extraction method was utilized, referred to as clam-shell methodology, via cutting the core barrel along its length on both sides to then exposing the core for study [15].



Figure 4. Workflow chart of the slant core methods: handling and process for core description.

The recovered core provides a unique opportunity to obtain a high-quality research dataset of hydraulic fracture networks in post-fractured formations. The systematic core description was conducted as follows:

The recovered core captured hundreds of fractures, which were numbered from top to bottom, denoted as "# core-segment-fracture". The fracture depth was determined by measuring the length of the core segment and the length from the fracture to the top of the core segment.

Initial fracture description was performed prior to core cleaning. Comprehensive fracture description data include fracture number, fracture depth, fracture orientation, morphology/fracture surface features, apertures, fill, fracture mechanical origin (type), etc.

Since proppant was pumped during the fracturing slurry in the adjacent horizontal wells, it was anticipated that proppant would be discovered in the collected whole core within hydraulic fractures. Following initial fracture description, sludge residue from coring operations on all fracture faces, the exterior core surface, and within the core sleeves, including drilling mud, rock cuttings, proppant, and aluminum shavings from the clamshell process, was recovered for detecting proppant [15].

A second fracture description was performed after core cleaning. Removing sludge residue on all core surfaces provided a clear view of the lithologic interface, gravel size, and gravel morphology on the fracture surface, etc. The repositioning of the core fractures to the in situ position was executed via combining the characteristics of lithologic interfaces with fractures through interpretation by FIM image logging. Considering that the core barrel had been slightly offset and twirled in the slant core wellbore during the process of coring, the core fractures repositioning assisted in correcting the fracture depth, fracture orientation, and dip angle. The fractures interpreted by FIM image logging were compared with the core fractures at the corresponding depth to identify hydraulic fractures.

Few natural fractures were observed, both filled and unfilled. Criteria was developed for distinguishing between hydraulic (tensile and shear), drilling-induced, and core cuttinginduced fractures by examining the features of all fractures, combining a CT scan of the core and FIM image logging.

4. Fracture Characteristics

4.1. Hydraulic Fracture

A total of 228 hydraulic fractures were observed in the slant core with an average fracture density of 0.78 fractures per meter. According to the characteristics of fractures formed under different mechanical conditions, hydraulic fractures were further subdivided into tensile fractures and shear fractures, of which 52 are tensile fractures and 176 are shear fractures. The tensile fractures are the principal fractures, and the shear fractures swarms are adjacent to the principal fractures.

The primary evidence used to identify the hydraulic fractures was FIM image logging, presenting broad dark bands. Moreover, CT scans of the core were utilized to eliminate core cutting-induced fractures. The fracture morphology features of the CHFTS slant

core mainly included straight, microwave, and crushed zones, as shown in Figure 5. The fracture edges are incomplete and mostly scattered with gravel. The weak plane with low cementation strength is prone to forming a crushed zone.



 (\mathbf{a})



(b)



Figure 5. Morphology features of hydraulic fractures. (a) Straight hydraulic fracture, oriented 107°, deviates slightly from the east–west direction. (b) Microwave hydraulic fracture. The fracture edge is incomplete. (c) Crushed zone with scattered gravel.

The hydraulic fracture surfaces are all rough and uneven, many have through-penetrating gravel surfaces and some have bypassing gravel surfaces. In some other cases, both through-penetrating gravel and bypassing gravel existed in a single surface, as shown in Figure 6.



(a)



(**b**)



Figure 6. Surface character of hydraulic fractures. (a) Through-penetrating gravel surfaces, planar surface with split gravel. (b) Bypassing gravel surfaces, uneven surface with raised unbroken gravel. (c) Bypassing gravel and through-penetrating gravel occur in a single surface.

Figure 7 shows the filling materials in hydraulic fractures. Hydraulic fractures in the core are completely open with large apertures and the fracture surfaces are filled with materials, including mud, mud sediment, and proppant.



(a)

Figure 7. Cont.



(b)



Figure 7. Filling materials in hydraulic fracture. (**a**) A film of dried mud on the surface. (**b**) Thick drilling mud sediment in the fracture. (**c**) Proppant attached to the fracture surface.

All fractures are high-angle, largely in the east–west direction, oriented at $70^{\circ}-110^{\circ}$, and align with the maximum horizontal stress ($\pm 15^{\circ}$). Difference in the morphology of the created fractures was commonly observed in cores, and the orientations of certain through-penetrating gravel fractures deviate slightly from the main direction (Figure 5a). Changes of those kind are evidence for the formation of complex fracture networks.

Hydraulic fractures are unevenly distributed along the coring wellbore, and they occurred in both single and clusters [6]. Doublets and fracture swarms are quite common. For example, doublets (Figure 8a), triplets (Figure 8b), a 5-fracture swarm (Figure 8c), and even a 9-fracture swarm (Figure 8d) were extant.



 (\mathbf{a})

Figure 8. Cont.



Figure 8. Fracture swarms in the slant core. (a) Doublets; (b) triplets; (c) 5-fracture swarm; (d) 9-fracture swarm.

The characteristics of hydraulic fractures are controlled by the dynamic geostress field. In the near-wellbore area, under the condition of low stress difference and high pore pressure, tensile failure mainly occurs, and the tensile fractures extend along the weak-cemented planes or gravel edge with large effective apertures. Proppant enters the wedge-shaped fractures and forms the propped fractures. In the area far from the wellbore, under the conditions of high dynamic stress difference at the fracture tip, shear failure mainly occurs, and the shear fracture extends along the through-penetrating gravel fracture surface or forms a crushed zone. The shear displacement leads to a certain volume expansion of the fracture and forms a self-supported fracture.

According to fracture characteristics under different mechanical states, hydraulic fractures were subdivided into tensile fractures and shear fractures. Tensile fracture damage along the weak cementation surfaces of gravel and matrix under tensile stress forms graveledge fractures. Thus, tensile fractures are mostly microwave in morphology, with a large aperture; they have uneven surfaces, mainly have bypassing gravel surfaces, shown as Figure 9.



Figure 9. Tensile fracture is microwave in morphology and has a bypassing gravel surface.

Shear fractures are created by an induced stress field with the growth of the principal hydraulic fractures along natural weak planes. These shear fractures can also be formed by shear failure or the bifurcation and splitting of principal fractures during propagation. Thus, shear fractures are mainly straight and crushed zones in morphology. These fractures mainly have small apertures and through-penetrating gravel surfaces. Where shear fractures occur, fracture orientations change slightly and fracture swarms and crushed zones are common. Figure 10 shows conjugate shear fracture and crushed zone in the slant core. Conjugate shear fractures were observed in cores, forming scissor-shaped fracture planes. Moreover, crushed zones are prone to forming when shear slip occurs at the weak-cemented planes; some of these occur close to fracture swarms.



Figure 10. Cont.



Figure 10. Conjugate shear fracture and crushed zone in a slant core. (**a**) Scissor-shaped conjugate shear fracture is straight in morphology and has through-penetrating gravel surface. (**b**) Crushed zone, which forms when shear slip occurs at the weak-cemented planes.

4.2. Drilling-Induced Fractures and Core Cutting-Induced Fractures

Both drilling-induced and core cutting-induced fractures were present, with characteristics different from hydraulic fractures. Drilling-induced fractures have complete morphology, many are twisted and serrated, and have bypassing gravel surfaces with uneven drilling mud attached (Figure 11).



Figure 11. Drilling-induced fracture in slant core with irregular twisted fracture morphology. Fracture surface comprises bypassing gravel with drilling mud attached.

Core cutting-induced fractures were mostly formed near the two ends of the core segment; they are highly closed and serrated and display a fresh surface with no drilling mud (Figure 12).



Figure 12. Core cutting-induced fracture in a slant core. Fracture morphology is highly closed and serrated. Fracture surface is fresh with no drilling mud.

4.3. Proppant Observation

Obvious quartz particles were observed in two fractures, which was consistent with the sand used in fracturing in terms of particle size, roundness, and uniformity. The quartz particle was identified as proppant, as shown in Figure 13. The two fractures lie in the T_1b_3 formation. A thin layer of proppant appeared as patches on the fracture surface with mud attached, indicating that drilling mud flowed into the hydraulic fracture during coring. In Figure 13, the proppant is the light-grey signal in the CT scan. The bright signal in the fractures and matrix is likely pyrite [2].



Figure 13. Proppant attached to the hydraulic fracture surface. In the CT scan, proppant is the light-grey signal, and the bright signal is likely pyrite. The characteristic was also observed in Ref. [2].

Moreover, sandy mud deposits were observed in multiple fractures. The drilling mud, mud deposits, and proppant particles were collected from parted fractures for further analyses, regarding whether it contained proppant. However, a large level of sand pack was not found in the core hydraulic fractures. The possible reason for this is that the fracture surfaces were separated during the coring process and drilling mud flowed into the hydraulic fracture. The proppant could not adhere to the fracture surface and was washed away by drilling mud. Therefore, drilling mud and cutting samples were collected during the coring operation to detect and quantify the spatial distribution of proppant along the cored interval.

5. Core Fracture Visualization and Analysis

A total of 371 fractures were recorded in the slant core, and these fractures were systematically described and classified. A total of 228 hydraulic fractures were identified, including 52 tensile fractures and 176 shear fractures. One of the potential sources of the observed fracture swarms is near-wellbore tortuosity [16]. Moreover, for regions far away from the wellbore, reservoir heterogeneity can promote complex hydraulic fracture trajectories and form fracture swarms. The variations of rock mechanical properties and in situ stress may lead to variable fracture-front speeds and potential fracture splitting and segmentation [17,18].

The data (type, orientation, and measured depth of fractures) from the core description were used to visualize fracture orientations/types along the core wellbores and the perforation clusters of the infield-scale in three-dimensional space, especially the relative locations of fractures to the fracturing wells/stages/clusters [8]. After filtering other types of fractures (fractures induced by drilling and core cutting), only the hydraulic fractures were visualized as lines with their orientations at their corresponding measured depths. The tensile fractures are in blue, and the shear fractures are in red. To better understand the spatial location of fractures relative to their initiation points (perforation clusters), the adjacent perforation clusters were also visualized by disks with different colors for each treatment stage.

Figure 14 shows a perspective view of hydraulic fractures along the core wellbore and the adjacent perforation clusters. The completion interval length is 60 m. Wells H8, H9, and H4 have two clusters, three clusters, and six clusters in each interval, respectively. The cores 1~31 are located in the T_1b_3 formation, in which the cores 1~8 are closest to the stages 2 to 4 of the well H8, and the cores 9~31 are closest to the stages 3 to 5 of the well H9. The cores 32~48 are located in the T_1b_2 formation, closest to stage 4 and stage 5 of well H4.



Figure 14. Perspective view of hydraulic fractures along the core wellbore and perforation clusters in the infield-scale in three-dimensional space.

Hydraulic fractures were observed in cores within the 100 m space between wells H8 and H9, indicating that fractures extended laterally over a distance of 50 m. Vertically, the distribution range of hydraulic fractures is 20.2 m above the adjacent well and 9.8 m below it. It can be inferred that the fractures extended over 30 m in a vertical direction, realizing the full coverage of hydraulic fracture network in the reservoir.

5.1. Presentation of Fractures in Cores 1-31

Cores 1-31 are located between H8 and H9 in the T_1b_3 formation. Figure 15 shows the perspective view of the hydraulic fractures in cores 1-31. Cores 1-8 are close to the two perforating clusters from stage 3 and the heel-side perforating clusters from stage 2 of well H8. Fractures observed in cores 1-8 are mainly from these clusters, and the fractures and clusters have a lateral distance of 21.4–45.1 m and a vertical distance in the range of 20.2 m above to 9.8 m below the clusters. The length of cores 1-8 is 50.0 m. The number of hydraulic fractures is 57, including 8 tensile fractures and 49 shear fractures.



Figure 15. Perspective view of fractures in cores 1-31 from the southwest.

Cores 9-31 are close to the two toe-side perforating clusters from stage 5, three perforating clusters from stage 4, and the heel-side perforating clusters from stage 3 of the well H9. Fractures observed in cores 9-31 are mainly from these clusters, and the fractures and clusters have a lateral distance of 3.5–44.7 m, and the vertical distance is in the range of 0.8 m above to 14.5 m below the clusters. The length of the cores 9-31 is 144.95 m. The number of hydraulic fractures is 79, including 15 tensile fractures and 64 shear fractures.

No hydraulic fractures were observed in cores 20–22, in which the core lithology is reddish-brown silty mudstone. This indicates that argillaceous rocks are not conducive to fracture propagation. In addition, cores 20–22 are close to the middle perforation cluster from stage 4 of well H9. The lack of fractures in the middle perforation cluster seems to

indicate that the growth of the middle fractures, lagging behind the two outside fractures, is suppressed. A significant proportion of the literature attributes this uneven distribution mainly to the stress shadow phenomenon [4].

5.2. Presentation of Fractures in Cores 32-48

Cores 32–48 are located on the west side of well H4 in the T_1b_2 formation, close to the six perforating clusters from stage 4 and the three toe-side perforating clusters from stage 5 of well H4. Figure 16 shows them in a side view from the west. The lateral distance between the cores and the clusters is 19.8–51.5 m, and the vertical distance is in the range of 8.8 m above to 2.3 m below the clusters. The length of cores 32–48 is 98.76 m, and the number of hydraulic fractures is 92, including 24 tensile fractures and 68 shear fractures.



Figure 16. Side view of fractures in cores 32–48. The viewpoint is from the west.

As in previous cores, the large number of fractures observed in cores seems to indicate that tensile fractures are formed in the near-wellbore area and the extension of tensile fractures induces a large number of shear fractures in the area far from the wellbore.

Based on hydraulic fracture distribution data along the coring wellbore, a statistical analysis was conducted to better understand the spatial distribution of hydraulic fractures. Hydraulic fractures were considered to be derived from adjacent wells with the closest horizontal distance. Thus the spatial corresponding relationship between the hydraulic fractures distribution in cores and adjacent wells was established.

Figure 17 presents the relationship between hydraulic fracture density in the cores and the lateral distance from the horizontal well. Figure 17a shows that the hydraulic fracture density decreases with the increase of distance in the area far from the wellbore for well H8. The coring trajectory starts about 19 m away from H8, suggesting that cores in near-wellbore area were not drilled. In Figure 17b,c, the hydraulic fracture density is small in the near-wellbore area, where the lateral distances from wells H9 and H4 are in the range of <10 m and <25 m, respectively. In particular, for well H9, the hydraulic fracture density decreases with the increase of distance in the area far from the wellbore with a lateral distance range of >10 m.

As a general trend, the fracture density of the near-wellbore area is lower than that of the far-wellbore area. For the near-wellbore area, one of the potential sources of the dense fractures is near-wellbore tortuosity, which can propagate in parallel even in the presence of strong stress shadowing [16]. Meanwhile, for regions far away from the wellbore, reservoir heterogeneity can promote complex hydraulic fracture trajectories [17,18]. During fracture propagation, the local net pressure of fracture front decreases gradually, which results in decreasing fracture density in the area far from the wellbore. The near-wellbore area can be considered to have a lateral distance of less than 25 m from the horizontal wellbore.



Figure 17. The relationship between the hydraulic fracture density in cores and lateral distance from the horizontal well. (**a**) H8; (**b**) H9; (**c**) H4.

6. Conclusions

(1) Hydraulic fracturing formed planar fracture swarms. The conglomerate hydraulic fractures have varied morphology; mainly straight with through-penetrating gravel surfaces. Fracture swarms are quite common. Fracture density along the coring wellbore is 0.78 fractures per meter, and hydraulic fractures are largely in the east–west direction, oriented at 70° – 110° . Obvious proppant particles were observed in two fractures.

(2) For regions far away from the wellbore, a large number of additional fractures were created by the growth of principal fractures. These additional fractures may be shear failures along the natural weak plane created by the induced stress field or the bifurcation and splitting of principal fractures during propagation.

(3) In the near-wellbore area, tensile fractures are mainly formed, and the fracture density of the near-wellbore area is lower than that of the far-wellbore area. In the far-wellbore area, shear fractures are mainly formed, and the hydraulic fracture density decreases with the increase of distance. The near-wellbore area can be considered to have a lateral distance of less than 25 m from the horizontal wellbore. **Author Contributions:** Conceptualization, S.S. and X.M.; methodology, R.Z.; software, R.Z.; validation, L.C., Y.X. and T.W.; formal analysis, R.Z.; investigation, R.Z.; resources, S.S.; data curation, Y.X.; writing—original draft preparation, R.Z.; writing—review and editing, X.M.; visualization, R.Z.; supervision, L.C.; project administration, Y.X. and T.W. All authors have read and agreed to the published version of the manuscript.

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