Sedimentological sand grain orientation in oil-producing U1 layer Kazan oil-gas-condensate field (Tomsk Oblast)

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Abstract. The paper describes the results in identifying the prevalent directions of elongated quartz grains being the major oil-producing layer component in sand reservoirs. Studying the orientation of quartz to its grain shapes in paleogeographical oriented core samples made it possible to identify the hydrodynamic reservoir regimes and facies type. The spatial confinement of pore spaces and cataclasis fractures in grain material to the prevalent elongated quartz grain directions was defined.

1. Introduction
Kazan oil-gas-condensate field is located in the central east of Western Siberia lowland within Tomsk Oblast. The cross-section embraces sand- argillaceous sediments of Mesozoic-Cenozoic sedimentary mantle embedded in metamorphically altered Palaeozoic folded basement rocks. Geologically, Upper Jurassic U1 Vasugan suite is the major oil-gas producing layer which can be observed in all well logs. It occupies a significant area of the Kazan complex.

2. Research methods
The research target includes core samples from oil-producing rocks of U1 layer, Kazan field wells. The general core sample interpretation embraced more than 130 meters. Paleomagnetically-oriented 25 rock samples were selected from two field wells. Paleomagnetic method involves the direction reconstruction of specific rock samples on the paleogeographic pole. The standard orientation method for viscous components was applied in determining the orientation of the core sample itself. Elongated quartz grains, base rock-forming components in investigated terrigenous reservoirs, were measured in preliminary prepared oriented thin sections. Generation of oriented sedimentation structures of quartz grains could determine the sedimentation facies conditions of sedimentary rocks and trace the development of pore spaces relative to debris in these rocks.

3. Results and discussion
U_1 layer sediments embrace medium/fine-grained sandstones and aleurolite-clay rocks. The lithological and mineral petrographic features of above-mentioned rocks were previously studied [1].

Macrofacies classification of Jurassic sediments [2] was applied to identify the facies environments in investigated sediments. Upper Jurassic terrigenous layer material could have accumulated in open active shallow-water basins and/or within off-coast areas [3].

Clastic material accumulates within shallow waters, which, in its turn, migrates with longshore currents from outboard coast towards its back land. In this case, well-sorted rocks with low-inclined and cross-bedding and banded structure develop. Simultaneously, homogeneous horizontally-bedded sediments accumulate mainly in distant coastlines, predominately in coastal-marine environments bounded by river lowlands.

Morphological analysis included the measurement of elongated grains in oriented thin sections relevant to specified direction (paleogeographic north pole). This involved the measurement of strike azimuth of elongated quartz grains. The minimum number of accurate and precise quartz grain orientation measurements in a rock embrace 100-150 grains in one thin section. The measurement of elongated grain orientation in photomicrographic thin sections was also conducted. Obtained photomicrographic data was processed in ArcGIS and Grapher 9 programs. Plotted rose diagrams defined the prevailing development direction of elongated quartz grains in a rock. Comparably, in both cases, the rose diagrams reflected that the microscopic measurement of thin sections and photomicrographic processing were practically identical.

The proposed computerized measurement method and calculations of grain orientation simplify the processing of enormous numerical data.

The measurement procedure and further calculation is as follows:

1. Oriented thin sections are photographed, processed and produced photos are glued into one photo via CorelDRAWX5. When photographing thin sections under the polarized POLAM 312 microscope, a line was selected on the thin section orienting to north paleogeographic direction; and along this line a series overlapping photos were compiled.

The photos were glued together via CorelDraw to produce a continuous image and this, in its turn, makes it more convenient to perform TIF file in ArcMap.

2. Prevailing elongated quartz grain orientation directions were drawn up in ArcMap (figure 1, A). Produced TIF file was uploaded in ArcMap, then the file shape was designed, coordinates of which were imported from the uploaded image. The direction of elongated quartz grains was drawn up and saved in the produced file shape.

3. According to designated directions the grain azimuths were recalculated in ArcInfo. To measure the linear grain orientation in ArcInfo and to calculate the azimuth of produced lines relative to the north direction, the results of half a circumference at an angle of 0 to 180^{o} were processed. After statistic processing produced results were imported into circular diagram.

4. Rose diagrams of identified azimuths to visualize the produced data were plotted in StereoSN and Grapher 9 (Figure 1, B).

Grapher 9 was used to visualize and compare the elongated quartz grain orientation with other petrostructural data (optical axis). Based on produced data rose diagrams and prevalent elongated quartz grain line were plotted.

Based on the morphological analysis of sandstones the most common orientation types of quartz grains were classified (Figure 2).

Type I (predominate)- orientation in two directions of elongated clastic quartz material, where one is dominating. Biomodal orientation of clastics can be found in coastal (inward) zones of water basins affected by wave actions and/or sediment reworking by two currents sorting the grains in different directions. For example, backwash, including wind-induced and longshore currents, approaches the land at an angle and most grains are oriented either subnormal or subparallel to the coastline. In this case, distinct orientation of clastic material is predominate.

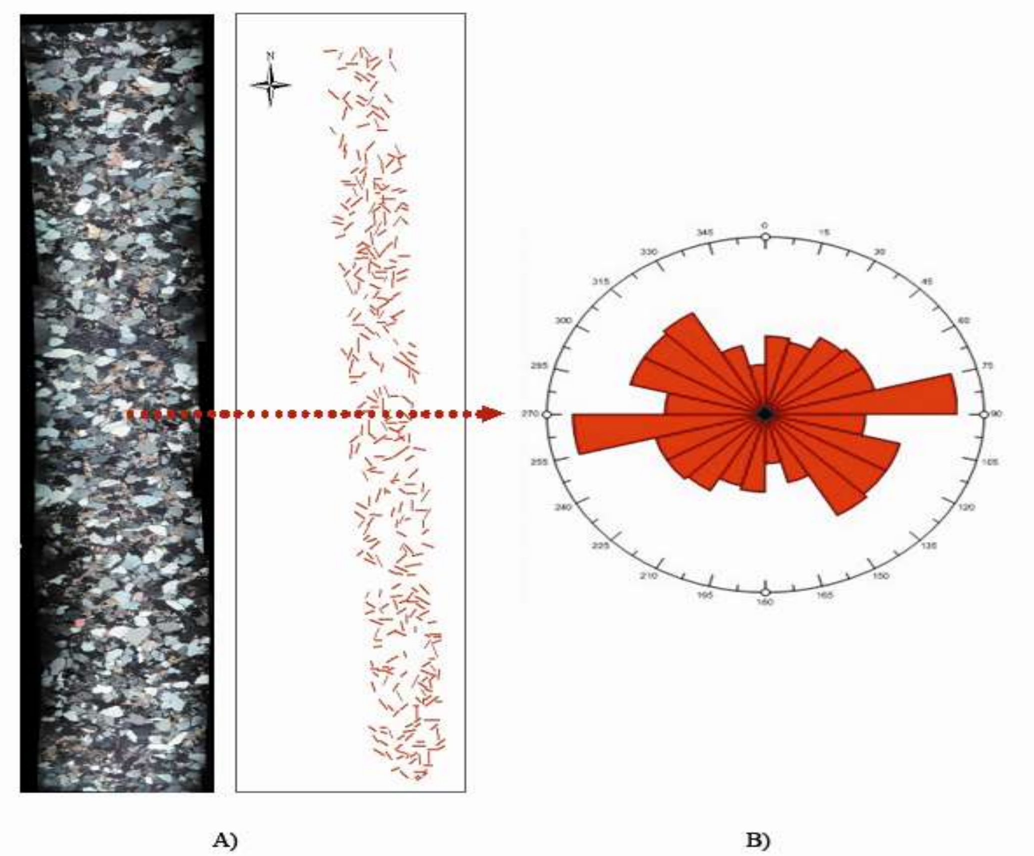

Figure 1. A) Prevalent orientation directions of quartz grains via ArcMap by photomicrographic oriented thin section (sample 2); B) Rose diagrams of prevailing orientation directions of quartz grains plotted in Grapher 9 (sample 2).

Type 2 (less common) – one maximum longitudinal grain orientation and insignificant cross orientation of elongated quartz. This orientation can occur in rapid stream flows where grain point end is downward to the current. In this case, the prevalent quartz clastic arrangement is accordant to the current.

Type 3 (insignificant) - polymodal development of elongated grains in rocks. Such orientation could occur in sediment detachment, similar to turbidite type. In non-compacted sediments with significant plastic clay matter terrigenous grains could be mixed and turned under conditions of external factors.

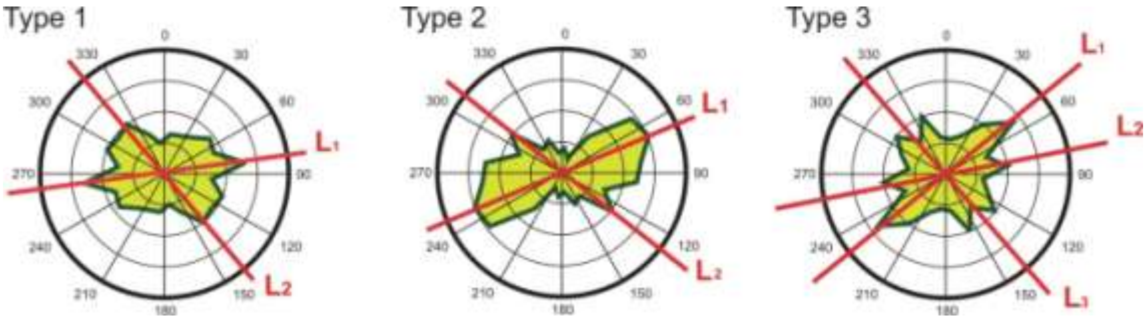

Figure 2. Rose diagrams of oriented elongated quartz grains in sandstones of U_1 Kazan field. L_1, L_2, L_3 – prevalent directions of elongated quartz grains in rocks.

4. Conclusion

Analysis of elongated quartz grain orientation in studied sedimentary rocks reflected two predominately distinct orientation directions of these elongated grains being close to N-E and N-W. Facies and dynamic conditions of sedimentation is governed by the shelf water environment, i.e. wave behavior and shoreline currents. Wave velocity is moderate to strong. Morphological quartz analysis data identified the location of the coastline within the field, i.e north-east. The development of pores and pore channels in sandstones coincides with the orientation of elongated quartz grains. There is also an insignificant number of cataclasis cracks in terrigenous sandstones involving simultaneous development of additional breaking directions in the grains. This prevalent quartz orientation in N-E and N-W directions can be found in rocks of Tomsk Oblast oilfield [3]. In this case, maximum porosity values can be found along these predominately oriented elongated grains.

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