A study on combination of ground P-wave and well S-wave in microseismic fracture monitoring

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There are many kinds of microseismic fracture monitoring（MFM）methods, MFM results also have their own characteristics, but they cannot accurately and completely reflectthe height, length, width and the spatial distribution of fractures. The MFM source locations are significantly important in oil and gas well layouts, and the optimized fracturing construction increases oil and gas production. The current popular MFM methods are mainly ground monitoring and well monitoring, respectively. The ground monitoring method has a higher resolution in the horizontal distribution of fractures than in the vertical direction. The well monitoring method has a good effect on the vertical direction of the fractures, but it cannot clearly reflect the process of fractures in the horizontal direction. Therefore, a combination of two methods - well combined with ground MFM method (Fig. 1) will be able to clearly monitor the length, height, width and development of fractures.

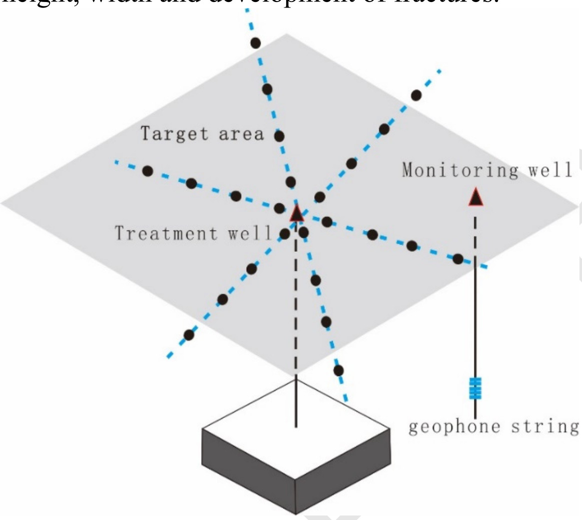

Figure 1. Schematic diagram of well combined with ground microseismic fracture monitoring; Triangle: well; circle: geophone array

The ground part of the geophone station should be displayed above the target area and with a symmetrical arrangement, generally with a star-shaped array. It is most important to keep the maximum offset at any point in the monitoring target area, and the seismic rays in the seismic wave propagation region receive as much as possible at different angles and increase the viewing angle. The detectors sould be buried underground about 1 m depth or deeper, which can greatly reduce the surface noise interference. The minimum frequency signal route interval should be at least one wavelength from the deepest source to the nearest geophone station and the farthest geophone station. The minimum array is x and the source depth is d. The relative relationship is as follows:

$$x = \sqrt{(d+\lambda)^2 - d^2}$$

In the well part, it is necessary to select a monitoring well in the periphery of the treatment well and display the underground geophone strings in the monitoring well. In order to make better use of the three components data and better resolution of the P, S wave and the depth of the geophones string in the later data processing, the underground geophone string and fracturing wells need to have a certain angle to increase the monitoring perspective. When adding three-component microseismic geophones in the well, this may be able to greatly improve source positioning accuracy in the vertical direction.

The S wave in the well, combined with the ground P wave data, and the similarity between the frequency characteristics, the amplitude feature and the phase feature have been used. The frequency of the P-wave (bandwidth 20-50 Hz) on the ground is relatively high compared to its S-wave, and the frequency of the S-wave (bandwidth 30-100 Hz) in the well is relatively low compared to its P-wave. After proper filtering, the energy characteristics of the well S-wave data and the ground P-wave data are similar. According to the normalized feature, the stack energy of the S-wave in the well and the ground P-wave are not deformed. In this way we can locate the position of the microseismic source.

During the twelfth five-year-plan, 11 wells combined with ground MFM have been completed in Shanxi Province. Figure 2. shows the 4-D display of the combined MFM method.

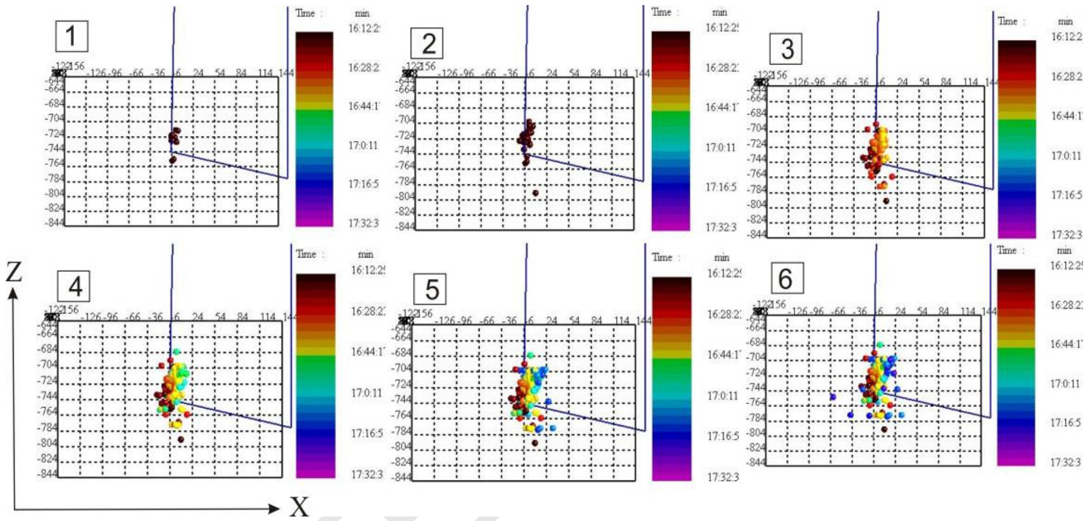

Figure 2. Fracture monitoring side view (Z-X). Serial number indicates development at a time scale. Vertical axis Z: refers to the up, up positive; horizontal axis Y: refers to the East, right positive; The color of the ball indicates different time.

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References

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