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Spectral analysis of passive DAS data for monitoring of an undermined massif at a salt deposit

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Solicited talk

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In the undermined territory of the Verkhnekamskoye field, the issue of monitoring the stability of the undermined areas is acute. Distributed acoustic sensors (DAS) are a recent cutting-edge technology in seismic research. It is based on the registration of scattered light in optical fiber cable. Optical fiber registration systems are extensively studied worldwide as they allow for addressing a wide range of seismic and acoustic tasks. In addition to classical active seismic surveys, the DAS system can also be used in passive observations.

Passive seismic observations were conducted at the Verkhnekamskoye salt deposit. A borehole-deployed cable line of an DAS was tested. The registration system includes a sensor cable and an interrogator that generates, registers and analyzes optical signals. DAS works by detecting Rayleigh backscattering of light, which is caused by tiny imperfections in an optical fiber that cause light scattering. The DAS system can register axial deformation or deformation velocity within a wide dynamic range (>100 dB) with an accuracy of tens of picometers on the gauge length [1].

The aim of the research is to monitor the condition of near-well rocks by analyzing the spectrum of recorded acoustic noise [2]. Observations were conducted in four geophysical wells to a depth of 195 meters. The optical fiber line is looped, forming a single contour, enabling recording along the entire line using a single interrogator [3].

The passive observation records comprise seismic traces recorded at 1-meter intervals along the optical line. The sampling frequency is 1000 Hz, with a total recording time of 8 hours per trace. For each trace, the total spectrum is calculated using Fourier transformation, enabling the construction of a map of spectral density along the receiver line. Based on this distribution, energy spectrum curves were calculated in 7 frequency ranges: 0-20 Hz, 20-40 Hz, 40-60 Hz, 60-80 Hz, 80-100 Hz, 100-200 Hz, and 200-300 Hz, as well as the full energy of the spectrum.

Presumably, the primary contribution to the recorded wavefield is attributed to Lamb-Stoneley waves propagating along the borehole, as well as Stoneley waves propagating along sub-horizontal lithological boundaries.

The calculated energy curves are compared with acoustic logging data and lithology of well sections. The energy values of acoustic noise correlate with seismic-geological boundaries, distinguished by the P-wave velocity curve obtained from acoustic logging data and lithological data. The proposed method for assessing the state of a rock mass, based on the correlation of acoustic impedance with the energy of passive noise, allows to expand the capabilities of monitoring the stability of an undermined rock mass.

The correlation between changes in the energy of passive noises in wells and the acoustic impedance of rock mass boundaries opens up possibilities for monitoring the condition of near-well space with passive measurements using DAS technology.

References

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