Natural fractures and stress state analysis from Nankai Trough wells' logging data

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This study is aimed at estimating the stress state of the rocks surrounding the wells drilled during the IODP Nankai Trough Seismogenic Zone Experiment. The cases when the standard methods of stress estimation don't provide reliable information are especially considered.

Wellbore logging data is one of the major sources of information regarding the stress state of the upper layers of the Earth's crust. Among all the methods of estimating stresses from well logging the borehole breakout analysis provides the majority of reliable results. Also, acoustic methods of from stress-induced polarization of wells data may also be used.

Nevertheless, there are some cases when the standard methods don't provide reliable information: the acoustic methods may be used only in case when the difference between horizontal stresses' values is considerable, while the borehole analysis may only be carried out when the breakouts are observed at depths of stress estimation. Thus, alternative methods are to be applied.

One of such alternative approaches is based on the critically stressed fracture analysis. The main concept in this approach is determination of the parameters controlling the stress state (e.g. the horizontal stresses' values divided by vertical stress magnitude) from the information on which fractures in the wellbore vicinity are critically stressed at the actual stress field. We recently used this approach to estimate stress state in Nankai Trough area –the acoustic logging data was used to estimate the number of critically stressed fractures among all the fractures observed on resistivity imagers. It was assumed that the critically stressed fractures tend to have influence on the local behavior of dynamic elastic moduli logs.

The recent experimental results provided a solid basis for establishing a numerical relationship between effective elastic moduli of the medium and the number of critically stressed fractures existing in it. It was proved that the existence of a local extremum in a certain effective elastic modulus curve in the vicinity of a fracture makes it possible to estimate the probability of this fracture to be critically stressed. Thus the stress state may be estimated using the developed fracture analysis approach.

This was carried out for the wells of NanTroSEIZE expeditions for the depths, where the fractures were observed through the imager and the acoustic logging data was present at the same time. The resultant estimations were visualized by the stress polygon –a sample result is shown at fig. 1, where the purple curve confines all possible horizontal stresses' magnitudes at the depth of 2200 mbsf for hole C0002P. Although the breakouts provided information on stresses values above 2163 mbsf, the stress polygons were obtained from fracture analysis for a range of depths between 2175 and 2875 mbsf.

We have to mention that there are flaws in this approach: it is useless for non-fractured rocks and it only provides possible values of combinations of horizontal stresses –applied individually it cannot provide data on both horizontal stresses independently.

Nevertheless, the wells considered in this study were characterized by extra data. For example, the C0002P hole is characterized by data from two leak-off tests and other data on minimum horizontal stress. Usage of the simplest assumption of linear minimum horizontal stress profile makes it possible to reconstruct possible horizontal stresses' profiles from the obtained stress polygons. This reconstruction is shown at fig. 2: the borders of maximum horizontal stress magnitude (SH) are shown in green.
This approach was used for the wells with necessary data available. We believe that it can provide extra information regarding the stress state in the Nankai Trough area if used alongside with other methods of stress analysis.

Keywords: Nankai Trough, In-situ stress, Geomechanics, Critically stressed fractures

Fig. 1

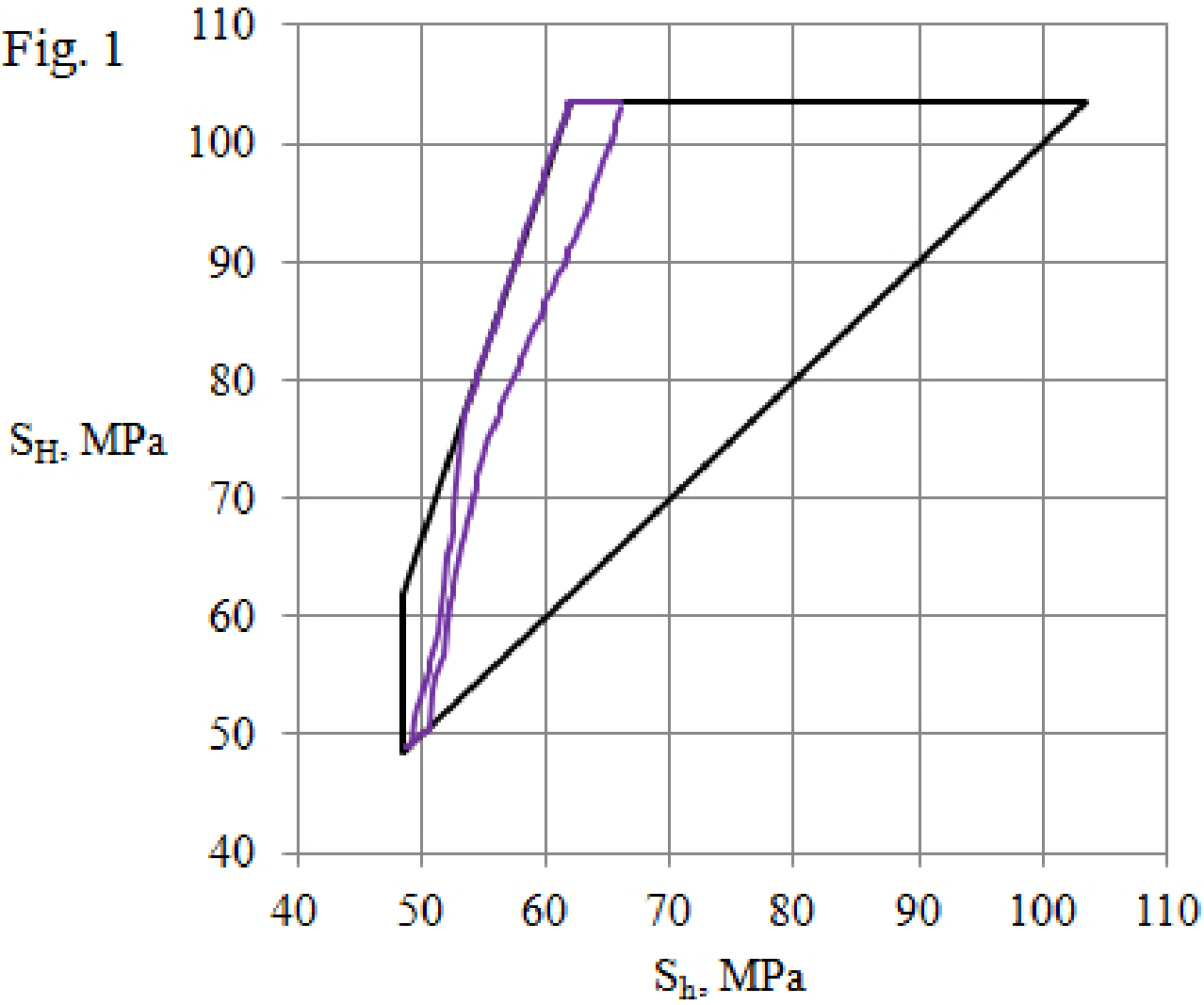

Fig. 2