A new approach to determining stress state in the crust on the basis of well data using borehole imagers

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The study is devoted to the inverse problem of the stress state in the crust determination via the opportunities provided by drilling (it was developed for oil wells drilling). In particular, the proposed study introduces a methodic to define the maximum horizontal stress magnitude at the well’s vicinity with high precision using the log data having the other stress state parameters known.
The basic concept of the introduced method is the relationship between the stress state of the medium and the distribution of the cracks in the material. Knowing the six independent parameters of the stress state in the medium, one is able to determine the probable spatial distribution of cracks in this material. An attempt to find a solution of the inverse problem is introduced here: in case one knows the spatial distribution of cracks in the medium it is likely to define the processes which induced these cracks and define the stress state of the area.
In case of drilling such processes might be divided into two groups: the first is closely connected to the tectonic stress state in the wide area, while the second group contains the stress alteration during the drilling process. The second group is easier to analyze as there are developed approaches to define the stress alteration. Thus once one knows the spatial distribution of cracks near the drilled well and has the drilling process analyzed, it becomes possible to get some basic information regarding the tectonic stress.
There are special logging methods known as borehole images which are sufficient to define the spatial distribution of the cracks near the wellbore. For a typical well there might be up to several thousand cracks with such information provided. Using the various types of images allows defining, which cracks are active (in terms of oil engineering it means that oil can penetrate through them). This factor plays a key role in the methodic as it was stated by the researchers of the same problem: the active cracks are in correlation with the friction properties of the medium: in fact it appears that the active cracks should all be in the area bounded by the Mohr-Coulomb failure criterion curve if using the Mohr circle.
Every crack is represented by a point at the Mohr stress diagram. Its position is determined by three principal components of the stress tensor and three angles determining its orientation relative to the stress tensor principal axes. Assuming that two principal stresses and all directions are known one can adjust the last variable (maximum horizontal stress magnitude) to move the point representing a crack. Adjusting the horizontal stresses for all cracks simultaneously (keeping in mind the general rules of continuity, equilibrium and rheology) leads to an array of points’ sets representing the cracks at a normalized Mohr stress diagram. The set where all the active cracks are bounded by the Mohr-Coulomb failure criterion might be the preferable one with the maximum horizontal stress magnitude being defined. Using such a methodic allows determining the stress state near the wellbore with the lowered uncertainty (compared to other methods). The next step is to define the tectonic stresses on the basis of the stress state near the wellbore.
This methodic was successfully applied for several datasets for real oil production wells and the determined stress states were comparable with the geomechanical models for these wells and were characterized by lowered uncertainty. The methods of adjusting the maximum horizontal stress in a proper way for all the cracks and the way of considering the medium rheology are to be developed further but the mathematical models standing for these points in case of elastic medium are already

developed.

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