ON THE DEVELOPMENT OF A WIRELINE TOOL FOR IN SITU STRESS MEASUREMENT BY HYDRAULIC FRACTURING

by

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ABSTRACT

The present paper is a preliminary progress report of a DOE program at Terra Tek, Inc. to develop a wireline tool for in situ stress measurements by hydraulic fracturing. In addition, a laboratory and analytical study are underway to determine the feasibility of in situ stress measurement through the casing (via perforation). This program could fill the gap that currently exists in the commercial application of in situ stress determination as a design tool for MHF stimulation of tight formations. The paper will be split in two parts. The first part discusses the aspects of the wireline tool, while the second part deals with the measurements of in situ stress through casing perforations.

The degree to which adjacent rock layers will impede vertical hydraulic fracture propagation, in a pay zone, is strongly dependent upon the difference in minimum in situ stresses between layers, the contrast between their elastic moduli and the bond quality of their interface. The results of various fracture containment case studies performed by Terra Tek suggest that elastic properties contrasts, large enough to insure minimal vertical fracture growth during MHF, are a fairly rare occurrence. On the other hand, advances in analytical capabilities indicate that the effect of the in situ stress on vertical fracture growth is a significant factor. The in situ stress state affects not only the containment problem, but also the geometry of the fracture. Present findings suggest that the in situ stress contrasts may be a more active element in the containment problem. They also suggest that knowledge of in situ stresses offer an avenue to better design of fracture treatments and control of fracture growth. The techniques of measuring in situ stress variations within a gas reservoir must be developed into a routine test before significant advances in fracturing treatment design concepts can be made.

Techniques of measuring stress in geologic materials can be divided into two main categories, stress/strain relief methods and hydraulic fracturing. Hydraulic fracturing holds the most promise for use in deep boreholes because of its operational simplicity. It also has interpretative advantages (for fracture containment studies) in that it measures the minimum principal component of stress directly. Terra Tek has coducted such measurements in production gas wells that were candidates for MHF treatments as part of DOE "Demonstration Programs." The two most common factors used to decide upon including hydrofracturing measurements of in situ stress into a design program are hole safety and testing cost. Moreover, based on Terra Tek experience to date the greatest difficulties in providing good stress measurements are:

Note: Copies of this report are available from the authors.

(1) Washed out hole making packer seating difficult or impossible.
(2) Limited pressure across packers; this is a problem in holes not filled with mud (i.e., air drilled Devonian shale wells).
(3) Sluffing holes.

These concerns can be overcome provided in situ stress measurements can be made using a wireline tool. The current program at Terra Tek is aimed at the design/fabrication and prototype testing of a cable-operated packer system for determining in situ stress at depth. The prime reason for the tool is to gather data in an inexpensive manner, satisfactory to gas well operators for the design of massive hydraulic fractures (MHF). Tool design is based on using available "off the shelf" components such as packers, pumps, etc. Control system design and development is considered an integral part of the proposed work. A further advantage can be gained if the in situ stress measurements can be performed through perforations. The second part of the paper deals with this subject.

The laboratory study is an attempt to perform simulated hydraulic fracturing measurements in blocks of rock subjected to a biaxial stress state. These measurements will be designed to test the possibility of performing in situ stress measurements through perforations in well casing. The tests will be performed in a large load frame utilizing stainless steel flatjacks to apply the loads.

Stress states on the block will be on the order of 5,000 psi applied to a three-foot cubic sample. Simulated wellbore diameter will be on the order of 1 inch diameter, and the grout will be simulated with epoxy. Several factors will be evaluated:

(1) Orientation of the perforation with respect to the minimum horizontal stress.
(2) The use of several perforations at the same horizon.
(3) Pumping rate.
(4) Grout thickness.
(5) Formation thickness.

In particular, data obtained in evaluating (1) thru (3) will be used to assess determination of fracture orientation.