A Laboratory Study of the Effects of Confining Pressure on Fracture Flow and Storage Capacity in Carbonate Rocks

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A laboratory study was made to develop means to predict the effects of increased net overburden pressures on fracture capacity. Both fabricated cores and reservoir core samples containing natural fractures were investigated. Response to confining pressure increase was found significant and similar for both types of fracture systems. A linear relationship was found between the cube root of permeability and the logarithm of confining pressure.

Introduction

Natural fracture systems are the principal source of flow capacity of many reservoirs and contribute materally to the storage capacity of some. Consequently, changes in fracture capacity would be expected to have an important influence on reservoir performance. Almost nothing, however, has previously performance. Almost nothing, however, has previously been done to study the effects of a changing net overburden on fractures, although a great deal has been published on the influence of fixed capacity fractures on reservoir behavior, the flow capacity of fixed fractures, hydraulic fracturing, the effect of hydraulically induced fractures on reservoir and well performances, and the parting of fractures. A performances, and the parting of fractures. A number of studies of rock mechanical properties have also been made, dealing with how the properties are influenced by pressure and how they contribute to fracture induction, propagation, and orientation. Much work was related closely enough to this research to offer valuable guidance, especially the work on fractures in granite by Snow and that on the behavior of rocks under stress by the Texas A and M U. Tectonophysics Center. Some work had been done by the Russians in which fracture compressibility values were calculated from production data.

Theory and Experimental Procedure

The experimental work was started using fabricated cores with ideal planar fractures and was ultimately extended in complexity to the use of reservoir cores containing networks of natural fractures. The first cores were molded from Portland cement and from plaster of Paris. Later, fabricated cores were plaster of Paris. Later, fabricated cores were machined from rocks. Lastly, naturally fractured rocks were tested. Cylindrical samples 2 to 3 1/2 in. in diameter X 4 to 6 in. long were tested in a type of Hassler core holder (schematically illustrated in Fig. 1) that had floating end plates to permit uniform triaxial compressive loading. Compressive loading of up to 20,000 psi was exerted using oil as a hydraulic fluid in the annulus. Pore pressure was essentially atmospheric. Permeabilities at various levels of compressive loading were determined in a conventional manner by measuring flow rates and pressure differentials of air flowed through the cores. Turbulent flow was avoided by maintaining sufficiently low flow rates. Fracture porosity was not determined directly because system volume changes due to sleeve intrusion overshadowed fracture volume changes; total fracture volume in many of the cores was less than 0.1 ml. Apparent fracture porosities were computed from the permeability data by a method discussed in a later section.

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