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MEASUREMENT OF PORE COMPRESSIBILITY CHARACTERISTICS IN ROCK EXHIBITING "PORE COLLAPSE" AND VOLUMETRIC CREEP

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ABSTRACT

This paper presents data showing the importance of creep measurements when determining the compressibility characteristics of reservoir rocks that undergo volumetric yield (often referred to as "pore collapse"). Rocks exhibiting pore collapse under hydrostatic loading are characterized by volumetric strains that are predominantly elastic prior to yield and plastic afterwards. Limestones, chalks, and diatomite reservoir rocks have been shown to exhibit pore collapse and high degrees of volumetric creep. Reservoir calculations involving pore compressibility, especially reservoir compaction and subsidence calculations, are often very sensitive to the stress level at which pore collapse is assumed to initiate. This is because there is usually an order of magnitude difference in the compressibility between the elastic (pre-yield) and inelastic (post-yield) regions.

It has been shown by others that materials that exhibit volumetric creep under constant stress can be characterized by a family of compaction curves (porosity or void ratio vs. confining stress) corresponding to different loading rates, from laboratory test rates to reservoir depletion rates. Standard loading rates used in laboratory pore compressibility tests (typically 500 psi/hr) do not allow time for creep to occur and can predict pore collapse stresses that are up to several thousand psi too high, depending on the creep rate of the material and the rate at which the reservoir is depleted. If this overestimated collapse stress is a significant portion of the estimated total pressure drop in the reservoir, pore volume change calculations will result in substantial underpredictions of reservoir compaction.

Test results are presented for two reservoir materials exhibiting pore collapse and substantial volumetric creep behavior. A method for measuring creep is discussed, and it is shown that the creep is generally linear on a log(time) plot. A method is proposed for estimating the correct or "field" compaction curve based on extrapolation of the laboratory data to reservoir depletion rates. Examples are given that illustrate the degree to which reservoir compaction is underestimated using standard, non-creep-corrected laboratory compressibility data.