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Oriented Core: Its Use, Error, and Uncertainty[1]

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ABSTRACT

Error analysis of oriented-core data indicates that: (1) the error in the coring and surveying procedure is ± 5°; (2) the error inherent to the mechanical goniometer is ± 2¾°; (3) the reproducibility error in using the goniometer is ± 2° for one analyst and ±4° for multiple analysts; and (4) the uncertainty in interpolating and manipulating sets of orientation data may be quite large. Overall error in oriented core procedures should be considered ± 11°.

A simple set of guidelines can be used to determine the most accurately oriented zones within the core. The guidelines are based on the physical character of the core, orientation scribes, and patterns displayed by plotting the azimuth of the orientation groove versus depth. Approximately 26% of oriented core analyzed fits the guidelines of most accurately oriented core.

INTRODUCTION

Cores are taken to solve exploration and production problems. Current analysis techniques have resulted in an increasing percentage of oriented core. Data from oriented cores are of great benefit in defining directional reservoir properties (such as permeability) and in detailed modeling of very anisotropic reservoirs. Whereas oriented core is important in reservoir description and modeling, it is expensive. At present, little documentation exists concerning the accuracy of orientation data and determination of zones of best orientation data.

The objective of this paper is to provide a background on retrieval of orientation data from oriented cores and the accuracy of the data. In addition, this paper provides guidelines for determining where the best orientation data exist within the core.

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The data and conclusions presented here were derived from a single orientation study performed by the writers. The opinions presented are ours and not necessarily those of Amoco or the various service companies cited.

DISCUSSION

Oriented core is used to facilitate measurements of directional rock properties to answer questions in sedimentary petrology, structural geology, geophysics, and reservoir engineering (Davison and Haszeldine, 1984). In general, microfabric, macrofabric, anisotropy, or current stress and strain state data may be measured. These are discussed in the following sections.

Oriented cores can provide significant data in sedimentary petrology and petrofabrics. The orientation and abundance of microfractures, twinning, translations, and deformation lamellae may be used to infer past deformational stress and strain fields and, therefore, determine the position, intensity, and sequence of structural deformation (Friedman, 1964; Groshong, 1975; Ramsay and Huber, 1983). The statistical orientation of crystallographic axes, long-grain axes, and shortening due to suturing or pressure solution can be used to interpret diagenesis or petrogenesis (Carver, 1971).

All of these microscopic techniques are based on oriented thin-section analysis. They require individual, accurately oriented samples, although the entire core may not be accurately oriented.

The most common measurements from oriented cores are macrofabric. These include attitude of bedding and cross-bedding (including ripples, etc), fractures, flow textures, and stylolites (Pettijohn et al, 1973). The importance of most macrofabric data lies in the determination of structural geometry, sedimentary textures, depositional environment, and their combined effect on reservoir properties. Unlike the microfabric data, these data generally require more samples of the core to make a sufficient number of measurements; therefore, greater percentages of the core must be reasonably accurately oriented.

Anisotropy is the condition in which a material has physical properties or characteristics that vary in different directions. For example, a rock is anisotropic with respect to permeability if its permeability measured perpendicular to bedding is different than that measured parallel to bedding. Properties such as permeability, sonic velocity, and strength are generally anisotropic in sedimentary reservoir rocks.

If a reservoir is anisotropic with respect to permeability, for example, it is very important to know the orientations of the maximum, minimum, and intermediate values and the degree of inhomogeneity. Physical property measurements may be made on core samples and related to reservoir orientations by use of core-orientation data. Because anisotropic properties are variable and generally add to produce an overall reservoir response (such as in fluid flow or seismic response), these data generally require slightly less accurate orientation data than the data acquired for microfabric analysis.