Pore Size Distributions by Analysis of Back-Scattered Electron and Fluorescence Images

Computerized image analysis provides direct, rapid, and highly accurate measurement of pore size in thin or plane sections. The method can be applied to a wide range of rock types and requires only conventional sample-preparation techniques. Back-scattered electron or fluorescence microscopy images of impregnated samples are scanned, converted to digital form, and stored and processed on a microcomputer. Individual picture points from a matrix of up to 600,000 elements per scan are classified as rock or pore based on gray level. Pore size is obtained by area measurements of individuals pores and by Feret's diameter, the maximum spacing between parallel tangents to a pore in up to 56 directions. The measurements are readily summarized as pore size distributions.

Cumulative porosity vs. pore diameter crossplots indicate how porosity is distributed and can be used to aid reservoir evaluation and production assessment. The crossplots can also be used to determine the amount of porosity contributed by different pore types. Individual pores, or groups of pores classified by size or shape, can be interactively identified on the image analyzer monitor, enabling the user to make a visual association of pore type with size. Rocks having a wide range of pore size can be analyzed at more than one level of magnification, and the data can be merged to form a composite pore size distribution for the sample.

Pore size distributions of carbonate rocks containing complex pore systems show changes in slope that are indicative of pore type. Other carbonates, including fine crystalline dolomites and microcrystalline limestones, show relatively uniform pore size distributions, which reflect a single pore type.

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Paleozoic Producing Sequences in Ghadames Basin of Libya, Tunisia, and Algeria: New Stratigraphic Concepts for Hydrocarbon Exploration

The Ghadames basin covers an area of more than 3 million km² in Libya, Tunisia, and Algeria. Although the basin has been productive since the mid-1950s, recent construction of a pipeline in western Libya has spurred additional exploration. The results of this increased drilling activity and the incorporation of earlier work have provided new data that indicate the following. (1) The elastic sequence underlying the Tanezzuft shales has porous and permeable fairways that may be related to the Hoggar glaciation to the south. (2) The elastic sequence overlying the Tanezzuft shales was deposited as a northerly sourced fluvial-deltaic clastic wedge, which thins and becomes less porous to the south. Only in the eastern section of the Rotliegendes were exposed to the surface by uplift and erosion.

The combined use of oxygen isotope and K/Ar dating can yield information about the diagenetic history of clastic sediments in sandstones and shales. In the Tertiary shale sequences of the United States Gulf Coast, in which the dominant detrital clay mineral is mixed-layer illite/smectite, the progressive conversion of expandable clay layers to illite layers can be monitored by the isotope systematics. Oxygen isotopes of fine-grained clay and quartz approach equilibrium with one another, raising the (as yet unrealized) possibility of an O-isotope geothermometer. Fine-grained quartz becomes isotopically zoned as detrital grains are overgrown by diagenetic quartz that forms, accompanying the smectite-to-illite transformation. The K/Ar clock of the diagenetically formed illite layers is set to zero age at the time of diagenesis (although that of existing illite layers within the crystals remains unaffected), and it is therefore possible to estimate the mean time of diagenesis in such shale sequences.

Illite is a common cement in sandstones. The time of cementation by illite can be estimated from K/Ar systematics in cases, such as that of the Permian Rotliegendes of the North Sea, where the clay-sized fraction of the original detritus was relatively free of illite or other K-bearing phases. Conditions of cementation can be inferred from oxygen isotope measurements, augmented by knowledge of the geologic/tectonic history of the sandstone. In the case of the Rotliegendes, the timing and conditions of illite cementation were relatively uniform within fault blocks but varied from block to block. Oxygen isotope measurements indicate that meteoric water components were important in illite formation at times when nearby sections of the Rotliegendes were exposed to the surface by uplift and erosion.

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Crust Type and Structure, Northern Gulf of Mexico: an Ocean Bottom Seismograph-Air Gun Seismic Transect