analyzed for such parameters as grain size and shape, pore volume, connectivity, and permeability.

Computer graphic displays are generated using techniques developed for biomedical applications. Colored images of the reconstructed three-dimensional pore structures are photographed from many viewing angles. These multiple views are combined by a special lens-mirror optical imaging system to produce "parallax panoramagrams" which show 20° of "rotation." Panoramagrams provide high resolution, high magnification displays which can be viewed with the naked eye, without special equipment.

State-of-the-art computer graphics, research quality optics, and new image analysis techniques have been used to provide a rigorous approach to understanding pore geometry. This novel synthesis shows particular potential for the study of hitherto intractable, complex structures.

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Biostratigraphy and Phylogeny of Paleocene Radiolaria

In the radiolarian biostratigraphy of the Cenozoic Era, only the majority of Paleocene Epoch has hitherto remained unzoned. Submarine sediments recovered from DSDP Sites 208 and 327 of the southern ocean, contain rich and well-preserved radiolarians, thus providing an opportunity to fill this gap and to complete the radiolarian zonal scheme. The majority of forms, including some new taxa, are presented and discussed.

A rather diversified radiolarian fauna appears in early early Paleocene, but species belonging to the genus *Byryella* made their initial appearances only during the middle Paleocene. Throughout the Paleocene, numerous well-known Cenozoic forms made their first appearance. By using co-occurring microfossils for stratigraphic correlation, these initial appearances can be placed within the pre-existing planktonic zonation and geochronometric framework. The phylogeny of *Byryella* has been investigated throughout the Paleocene section.

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Slope and Deep-Sea Fan Facies of Miocene Castaic Formation and Lower Part of Ridge Route Formation, Ridge Basin, Southern California

The late Miocene marine Castaic Formation in Ridge basin is over 2,000 m (6,600 ft) thick and consists mostly of slope and deep-sea fan facies. The Castaic Formation is vertically transitional into the overlying Marple Canyon Sandstone Member of the Ridge Route Formation and laterally interfingers with the Violin Breccia to the southwest. The slope facies consists of poorly bedded mudstone interbedded with sandstone, conglomerate, and coquina deposits interpreted as turbidite-filled slope channels. The slope facies follows the northwest trend of the basin and occurs on the northeast, north, and southwest sides of the basin. The slope channels have laterally adjacent levee deposits. Paleocurrents in the channels are to the west-northwest and southwest-southeast, whereas paleocurrents in the levee deposits are to the northwest-southeast. Large slide blocks, slump-folded strata, and breccia beds are common in the slope facies.

Deep-sea fan deposits consist of inner and middle fan channel and interchannel facies and outer fan depositional-lobe facies. They are confined to the center of the basin, interfinger into slope facies to the southwest and northeast, and are overlain by nonmarine fan-delta complexes to the north. The channels contain thick sandstone deposits that thin and fine upward and are laterally discontinuous, whereas the adjacent interchannel deposits consist of thin-bedded sandstone and mudstone sequences which form inclined wedges of highly slump-folded strata. Depositional-lobe facies thicken and coarsen upward and consist of interbedded sandstone and mudstone which form laterally continuous deposits with minor channeling and slump folding. Paleocurrents in these deposits are to the south-southeast and suggest sediment transport down the axis of the basin from the north-northeast.

Ridge basin was a relatively shallow-marine trough about 6 km (4 mi) wide and 10 to 20 km (6 to 12 mi) long. The deep end of the basin was to the southwest and connected to the Ventura basin across the San Gabriel fault. Typical deep-sea fans did not develop in Ridge basin during Castaic Formation time; instead extensive slope deposits formed along the margins of the basin and thick but narrowly confined turbidite-filled channels and depositional lobes filled the valley or trough of this basin.

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Reservoir Facies Zonation Using Wireline Logs

Sedimentary rocks can be described an distinguished from others not only by their lithology, geometry, sedimentary structures, and fossil content but also by their overall response on the electric logs—their "electrofacies." FACIOLOG processing zones together those sections of a lithological sequence which have a comparable suite of electric log responses to give an electrofacies zonation.

Geologists have traditionally used electric logs as a basis for zonation when drawing up composite (lithological) columns. FACIOLOG processing now offers the potential of treating all the logs, including the dipmeter, on an objective and quantitative basis. The electrofacies zonation is made by cross-plotting all the log responses on a multi-dimensional set of axes and then using cluster analysis to identify locally dense areas. Each cluster represents a series of depth intervals with a similar suite of log responses (an electrofacies). The degree of similarity of the various clusters is then expressed in the form of a dendrogram, and the complete well section is displayed with each level assigned to its own particular electrofacies.

How closely does the "electrofacies zonation" correspond to the more conventional lithofacies zonation? Generally there is good agreement because electric logs, especially with new services such as the litho-density and natural gamma ray spectrometry tools, respond to the basic mineralogy of the rock matrix as well as the fluid content. FACIOLOG processing also incorporates the high resolution information from the dipmeter, which corresponds to the basic sedimentology.

Because of the usually good match between the electrofacies zonation and the lithological zonations in cored sequences (especially in siliclastic sequences), FACIOLOG processing can be used to extrapolate the results of core analysis into those sections in the well where there is no core.

A new 22 in. (56 cm) wide presentation format allows all the logs, the dipmeter curves (with GEODIP or CLUSTER tadpoles), and the electrofacies zonation itself to be used as a basis for integrating all the information acquired when a well was drilled. Lithological descriptions from cuttings and cores or other stratigraphic information can easily be integrated onto the flexible format. Presenting all the logs together and having the additional advantage of the quantitative electrofacies zonation is clearly an aid to well-to-well correlation. With data banks, specific electrofacies zones may now be automatically traced across

complete reservoirs.

Identifying zones with a consistent and continuous log response greatly aids manual log interpretation. It also provides a valid means of data reduction for the first passes of a computer-processed interpretation because an interpretation model may be tested by treating a limited, yet representative, number of points. Cross-plot interpretation can also be simplified by using the electrofacies type on the z-axis, and displaying averaged log values for each electrofacies.

The FACIOLOG approach is designed not to compete with conventional facies analysis but to put electric logs into a framework which the geologist can easily integrate with his own studies and thereby squeeze the maximum amount of geological information out of them.

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"Transgressive" Pore-Filling Calcite, Cretaceous of South Texas

Early marine cementation and subaerial leaching of Stuart City rudist reef facies in south Texas yielded a rock with substantial intergranular, moldic, and shelter porosity. Most of this porosity was subsequently filled with a mosaic of blocky calcite, resulting in a tight rock. A detailed study integrating transmitted light and luminescent petrography with electron microprobe and stable isotope analysis reveals that the pore filling occurred in three stages representing distinctly different diagenetic environments. All three stages are seen commonly in single syntaxial crystals, suggesting continuous crystal growth while the environments were changing.

A model consistent with the data would have the following sequence of events: (1) initiation of calcite druse on pore walls in a freshwater phreatic environment, (2) continued pore filling in the phreatic mixing zone, and (3) final pore filling in the "marine" saline phreatic zone. The sequence could have occurred during a single, transgressive submergence of the pore system.

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Role of Fluid Inclusions in Diagenesis of Metastable Marine Cements

Early diagenesis of metastable marine cements occurs through a phase of dissolution along intercrystalline boundaries which is accompanied by precipitation of low magnesium calcite (LMC) within enlarged intercrystalline pores. This LMC cement is a luminescent phase complexly intergrown with non-luminescent, corroded crystallites of the precursor fibrous marine cement. This intergrowth results in early coalescence of the multicrystalline cement, which effectively isolates metastable phases from open chemical exchange with ambient pore waters during subsequent diagenesis.

Closure of the diagenetic system during subsequent stabilization is indicated by the preservation of chemical signatures retained within final calcitized products. Multiple carbon and oxygen isotopic analyses of a single generation of marine cement, for example, define strongly covariate compositional trends that reflect varying mixtures of the luminescent and non-luminescent calcites which presently comprise the stabilized marine precursor. End-member compositions of such trends reflect the compositions of intergrown LMC and precursor marine cement, respectively. Although early coalescence provides for closure of the chemical system, it does not prevent ultimate stabilization of metastable phases to LMC. Importantly, metastable relics are not preserved in ancient marine cements.

From all available data on solid-state processes, we infer that, at diagenetic temperatures, water is a required diagenetic medium to effect transformations of aragonite and high magnesium calcite phases to LMC. If, however, water is involved in this stabilization process, how is it possible to maintain a chemically closed system? An abundance of associated fluid inclusions is characteristic of fibrous cement mosaics. Such fluids, trapped along intercrystalline boundaries during early coalescence, migrate through the metastable host. As metastable phases dissolve, driven by their solubility difference with LMC, they concomitantly precipitate LMC, which paramorphically replaces the precursor cement. Such a mechanism not only provides for the retention of overall crystal fabric, via a submicron dissolution-precipitation process, but also provides for the maintenance of chemical signatures of the dissolving, metastable precursor cements.

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Early Diagenesis of Sands and Sandstones from Middle America Trench and Trench Slope, Offshore Mexico and Guatemala

Siliciclastic sediments from the northern and southern segments of the Middle American Trench are distinctive both petrologically and diagenetically. Samples of terrigenous sands recovered in piston and DSDP cores from the continental margin of southern Mexico are primarily arkose and lithic arkose of plutonic and metamorphic provenance. Accessory constituents and diagenetic features are useful criteria for distinguishing sands from different tectonic provinces along the Mexican (northern) segment of the trench. Basal, early Miocene sandstones from the upper- and middle-slope regions (continental block) contain abundant skeletal grains and are cemented by calcite or gypsum. Early Pliocene to middle Miocene sands from the accretionary wedge are weakly lithified and contain fractured framework grains. Unlithified trench sands of Quaternary age have undergone significant pore-space reduction at very shallow burial depths.

Samples of Holocene terrigenous sands recovered in piston cores offshore from central Guatemala (southern segment) are feldspathic litharenite and litharenite of volcanic provenance. Authigenic pyrite is ubiquitous in these sands, and pore-filling phillipsite occurs locally. Partial dissolution of glass fragments, pyroxene, and plagioclase has occurred in sands from every environment sampled.

The differences observed in sands from the two segments of the Middle America Trench may also characterize siliciclastic sediments deposited along other segmented convergent margins. Within a trench segment, changes in sand composition with time could indicate intermittent volcanic activity and changes in relative sea level.

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Determination of Widths of Meander-Belt Sandstone Reservoirs from Vertical Downhole Data

Once it has been determined that a meandering fluvial model is applicable to a formation, paleohydrologic reconstructions can be applied to downhole measurements to derive sand body widths. The nonmarine part of the Mesaverde Formation in the east-central part of the Piceance Creek basin of northwestern Colorado was deposited in a predominantly meandering fluvial