taxonomy.

More than 250 thin sections were measured for as many as 24 variables in equatorial section and 14 variables in vertical section. Equatorial and vertical sections were analyzed using univariate and bivariate statistical analyses, cluster analysis, R-mode factor analysis, analysis of variance, and discriminant function analysis. Results show that the range of morphologic variation is large.

High correlation coefficients between some variables and the grouping of variables into factors indicate redundancy in the variable set. Future studies of this type could use fewer variables without sacrificing much information.

Morphologic differences in *Lepidocyclina (L.)* sp. forms found in this sample were not great enough to allow classification of subgroups as separate species. The differences are gradational, and the intermediate forms were impossible to classify objectively. The variation in this sample, however, has limits, and these limits are considered the range of variation of *Lepidocyclina (L.) pustulosa.*

Previous classifications based on only a few variables and individuals are inadequate considering the large degree of uncorrelated morphologic variation in some samples. The most useful classification scheme should be based on a wide range of morphologic features of the test, analyzed by statistical techniques on high-speed computers.

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Sedimentology and Development of Shallow Heavy Oil Deposit, Eastburn Field, Missouri

Eastburn field, Vernon County, Missouri, produces heavy, 21° API, crude oil at a depth of 110 ft (33 m) from a thin, 20 to 30 ft (6 to 9 m), sandstone stratigraphic trap in the Cherokee Group of Middle Pennsylvanian age. Sedimentary structures, grain-size trends, and geometry of the sandstone and the nature of associated sediments indicate the fluvial-deltaic origin of the reservoir.

Development drilling at very close spacing, 200 ft (60 m) between wells, provided information from which a sedimentologic model of the Eastburn field reservoir could be developed early in project life. From this model, strategies were proposed that guided further drilling and completion of wells, extension of the field, and placement of production facilities. Development drilling guided by the sedimentologic model resulted in tripling the known volume of the heavy oil resource, with a minimum number of dry development wells being drilled.

The reservoir sandstone is composed mostly of medium to very-fine sand-sized quartz, rock fragments, and mica, with abundant interstitial detrital silt and clay. Authigenic kaolinite clay, and calcite and siderite cements reduce reservoir quality and contribute to problems in production, such as low injectivity of steam and exhaust gases in the thermal recovery process. Identification of the permeability reducing minerals aided in design of well-stimulation treatments and contributed to increased productivity.

In a few places, where contouring of the sandstone thickness was doubtful, production performance of individual wells provided additional data to guide the geologic interpretation. This synergistic approach helped to minimize the cost and maximize the efficiency of the field development.

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Diagenetic History of Phosphoria, Tensleep, and Madison Formations, La Barge Platform, Wyoming

Petrographic and geochemical data from cores in the Wyoming Overthrust belt are used to integrate thermal maturation of the Phosphoria with timing of cementation and porosity development in the Tensleep and Madison. Vitrinite reflectance studies from the Phosphoria indicate that it contains both bitumen and kerogen and that it has already generated some hydrocarbons and retains the potential to generate more. These hydrocarbons migrated into the Tensleep during an intermediate stage of silica cementation and into the Madison prior to the last phase of dolomitization.

The observed diagenetic sequences for the underlying Tensleep and Madison, in conjunction with depositional interpretations, demonstrate that porosity generation was critically affected by both depositional environment and early diagenetic history. The Tensleep and Madison underwent dramatically different histories of cementation and porosity development. This is reflected in the present maximum of 5% porosity in the Tensleep contrasted with 20% porosity in parts of the Madison. If porosity in the Tensleep was not destroyed by early evaporitic cements, then continuous destruction of porosity by silica and dolomite cementation occurred throughout its burial history. In contrast, preliminary isotopic studies indicate porosity in the Madison was developed at temperatures of less than 35° C. These regionally correlatable porous zones in the Madison which have persisted from shallow burial to present depths of 15,000 ft (4,572 m) emphasize the potential of the Madison as a hydrocarbon reservoir both now and in the geologic past.

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Comparative Petrography of Two Upper Devonian Oil Sands of Warren County, Pennsylvania

The Glade sand and Clarendon sand are Upper Devonian shoestring sands occurring at relatively shallow depth, in most places not exceeding 1,500 ft (457 m). Both are producers of Penn Grade crude oil, having been discovered before the turn of the century. Data for this study are derived from four independent sources, namely the petrographic microscope, image analysis instruments, the X-ray diffractometer, and geophysical (nuclear and electric) log data. Special emphasis is given to grain shapes, grain sizes, primary and secondary mineral compositions (including matrix constituents), rock textures, and the relationship of permeability and porosity in thin section to geophysical data. Compositionally, the Glade and the Clarendon are very-fine to medium-grained low-rank graywackes with variable amounts of muscovite, biotite, chert, plagioclase feldspar, orthoclase feldspar, and carbonates. The Clarendon, however, is predominantly more silty throughout. Porosity in thin section is measured on the basis of its ratio to the total area of the rock being examined. Permeability, however, is described in terms of the relative interconnectivity of pore space and its tortuosity. In the end, correlation of these petrographic features with geophysical data aids in interpreting the rocks' characteristics.

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Canyons, Submarine Fans, and Older Structures of Southern Greenland Continental Margin from Seismic Surveys

Submarine fans stemming from development of canyons dur-