prepare plotted maps at a work station that can easily be fitted into an average size office.

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Sedimentary Fabrics of Debris Flow-Dominated, Stream-Modified Alluvial Fan, Saline Valley, California

Although depositional sequences in alluvial-fan deposits may reflect tectonic activity, they are difficult to distinguish from those produced by changes of climate or by local aggradation. This presentation deals with an alluvial fan depositional style that occurs in arid conditions in which rare, large-scale debris flows are modified by more frequent, but small-scale, stream floods. Recognition of this type of deposition in an alluvial-fan succession could indicate change of climate and aggradational sequences may be seen by changes in its fabric.

A small alluvial fan in Saline valley, California, was described from apex to toe to determine the types of fabrics produced and their relative distributions. Debris flows produce levees and lobes which appear as 1 to 3 m high mounds of poorly sorted, matrix-supported conglomerates. These mounds become lower, less regularly distributed downfan and disappear before the fan toe. The tops and outer edges of levees and lobes have the largest boulders, which are tightly packed in a near-vertical, imbricatelike pattern. Fan-toe debris-flow fabric is 1 to 10-cm thick pebbly mud sheets with irregular lines of isolated cobbles. The small streams are deeply incised between levees at the fan apex, shallow and anastomosing around levees and lobes at mid-fan, and braided at the fan toe. Deep channels are floored by step patterns produced by partly or completely exhumed debris-flow boulders with fine gravel or sand deposited on the upstream side. Shallow channels have two major fabrics: (1) 5 to 20-cm high hummocks of poorly sorted, muddy gravel surrounded by fine gravel and sand with better sorting, and (2) muddy, moderately well-sorted gravel in which the long axes are horizontal and oriented parallel with flow. The braided channels at the fan toe are dominated by horizontally discontinuous lamination and abundant mud intraclasts. Wind-blown sand commonly accumulates in channels, preserving mud curls and mud drapes from the last flood.

All fabrics observed in the small fan in Saline valley were also seen in larger fans there and in several other Mojave basins. These fabrics were also found in some Triassic alluvial-fan deposits in New Jersey.

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Detection and Characterization of Reservoir Rock, Deep Basin Gas Area, Western Canada

Major gas reserves have been discovered in the past 6 years in Cretaceous sandstones and conglomerates at depths of 3,000 to 10,000 ft (915 to 3,045 m) within Alberta and British Columbia, Canada. Discovery of these new reserves resulted from a joint geologic and petroleum engineering effort which used rock-fluid data from cuttings, cores, well logs, and drill-stem and production tests. A key element in the exploration search is the rapid detection and characterization of reservoir-rock properties from well cuttings, especially of the low-permeability rocks.

Rock studies of over 10,000 ft (3,045 m) of conventional cores integrated with petrophysical studies of well logs and core analyses, which were compared with drill-stem and production tests in over 200 wells, provide the basis for establishing reservoir-rock potential. Porous rocks are subdivided into three categories: type I, capable of gas production without natural and/or artificial fracturing (subdivided on basis of air permeability), type II, capable of gas production when interbedded with type I rocks or with natural and/or artificial fracturing, and type III, too tight to produce at commercial rates even with natural or artificial fracturing.

Criteria to identify a rock's reservoir potential from well cuttings or conventional and sidewall cores are based on examination of dry, freshly broken fragments with a binocular microscope. Estimates of the following parameters form the basis of establishing a rock's reservoir potential: (1) size, (2) volume and distribution of visible pores, (3) particle size and distribution, (4) type and amount of cements and pore-filling material, and (5) degree of consolidation. Geologists and engineers can make rapid, accurate estimates of reservoir-rock potential of unknown porous intervals with the help of several visual aids. These include plastic trays of cuttings-size rock chips crushed from conventional cores of known rock and pore types, porosity, and permeability; colored photographs of freshly broken rock surfaces; and thin-section microphotographs and scanning electron photomicrographs of rock chips and their pore casts.

The methods and procedures described continue to be used in Western Canada and the United States for delineation of exploration opportunities, identification of bypassed pays in old wells, for well-log interpretation, and in evaluating intervals for completion.

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Productivity Gradients for Paleo-Oceans: A New Application of Isotopes of C-13 and O-18

Based on the coincident relationship between the $\delta^{13}C$ and $\delta^{18}O$ of modern ocean water, above the $O_2$ minimum, I have constructed a series of ocean-specific models designed to calculate open-ocean values of $PO_4$ for paleo-oceans. Inherent in these models are the assumptions that the $\delta^{18}O$ and $\delta^{13}C$ of ocean water vary as functions of temperature and dissolved $O_2$ (or AOU), respectively. In the Atlantic, for example, the derived model is:

$$PO_4 = 4.95 - 2.54\,[\log 16.9 - 4.206(\delta^{18}O_c - \delta^{18}O_w) + (\delta^{18}O_c - \delta^{18}O_w)^2] - 0.32\,[O_2 \text{ saturation} - (e^{7.15} - 3.45\,\delta^{13}C_w/43.5)].$$

Above the $O_2$ minimum, foraminiferally derived values of $\delta^{13}C$ and $\delta^{18}O$ can be used to calculate $PO_4$ concentrations at the levels at which the tests were secreted, resulting in a restratification of the $PO_4$ concentration with depth for paleo-oceans. A more powerful application of these models is the construction of productivity ($\Delta PO_4$) gradients using average concentrations of $PO_4$ obtained from the sedimented tests of surface (0 to 50 m) and deep-dwelling (below 150 m) planktonic Foraminifera. The higher the value of $\Delta PO_4$, the greater the productivity. Preliminary results for the Sargasso Sea suggest that plots of $\Delta PO_4$ values are very effective in delineating water masses, and possibly strong surface currents. Calculated $\Delta PO_4$ gradients are in agreement with observed $\Delta PO_4$ gradients. Calculated concentrations of $PO_4$ with depth in the Atlantic compare well with observed trends. Concentrations of $PO_4$, derived from Holocene planktonic Foraminifera from the Indian Ocean, are noticeably similar to observed $PO_4$ concentrations in the overlying water in which the tests were secreted. These results, although preliminary, suggest that $\Delta PO_4$ gradients can be calculated and used to delineate water masses for paleo-oceans throughout the Cenozoic.