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Microcomputer Stratigraphic Applications

With the advent of large-capacity computer files, interactive languages for retrieval of large data bases, and low-cost effective microcomputers, the approach to stratigraphic analysis has been dramatically improved. In terms of immediate payoff, the computer assumes the role of retriever and data presenter, while the geologist concentrates on analysis of retrieved data. The biggest benefit of these new approaches is a measurable increase in productivity for the geologist.

Through use of the computer, gathering and interpretive data from sample logs are greatly facilitated. With the computer, logs are encoded electronically for access by the geologist via a computer terminal, and analysis of the data is accomplished interactively. The process obviates the need for the time-consuming process of locating the appropriate logs, hanging them for analysis, and researching each log to locate appropriate intervals for correlation and interpretation. Recent studies indicate that through computerized approaches, time required for these steps is vastly diminished, and resulting productivity is 40-80% greater than with conventional manual methods.

A by-product of this approach results from the data being created in a form that lends itself to graphic presentation upon demand by the geologist. This avoids the time-consuming delays inherent in interrelating with the computing department for mapping requests to ensure that the results of the analysis are as expected. With the computer, many kinds of maps become practical to produce from the terminal, including base maps, cross sections, and lithofacies, structures, and isopach maps.

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Evolution of a Carbonate-Siliciclastic Platform: Middle to Upper Cambrian of Western Newfoundland

Middle to Upper Cambrian platform deposits of the Port au Port Peninsula in western Newfoundland are characterized by three large-scale, 100-250-m (330-820-ft) thick, sedimentary cycles or Grand Cycles. The lower half of each cycle consists of recessive-weathering, thinly interbedded lime mudstone, shales, and argillaceous dolostones. These sediments grade into a resistant-weathering, upper half-cycle of thick-bedded ooid and skeletal grainstones and laminated dolostones. Meter-scale, shallowing-upward cycles are developed throughout the Grand Cycles and are generally punctuated by stromatolite and thrombolite mounds and storm-derived deposits, such as flat-pebble conglomerates.

The Port au Port sequence records cyclic migrations of a wide muddy tidal flat on the inner platform (recessive half cycle) and a peritidal carbonate sand shoal complex on the outer platform (resistant half cycle). These large-scale cycles are the products of environmental variations resulting from a complex interplay of differential rates of eustatic sea level change and basin subsidence.

Grand Cycles are characteristic of stable, mixed carbonate-siliciclastic shelf environments. These cycles provide a framework for depositional and diagenetic models of many Cambrian shelf deposits, such as the Cambrian of the Great basin and the Canadian Cordillera. The Grand Cycles of the Port au Port Peninsula are the first to be studied in detail from the Appalachian orogene and provide additional insight into early Paleozoic shelf evolution.

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Strike-Slip Deformation, Basin Formation, and Sedimentation: A Summary

Basins in which subsidence accompanied strike-slip deformation are known from the Proterozoic to Holocene. They occur in virtually all plate-tectonic settings (transform, convergent, and divergent plate margins, and plate interiors), and they are underlain in different places by crustal types ranging from continental to oceanic. In transform (wrench) systems, basins develop where fault strands splay, bend, or overstep in a divergent sense, and where plate motion is obliquely divergent to the strike of individual faults. Basins also develop between fault blocks rotating about vertical axes, and at some convergent splays, bends, and oversteps as a result of crustal loading. Basins formed by overall crustal extension (e.g., grabens) and by crustal loading (e.g., foredeeps) may terminate against strike-slip faults.

Basins associated with strike-slip deformation are filled with a wide range of sedimentary facies, deposited in nonmarine to deep marine environments. The principal controls on sedimentation are crustal type and thickness, plate-tectonic setting, amounts and rates of subsidence, relative sea level, topographic relief, and climate. Abrupt facies changes and discontinuities are relatively common. Subsidence rates are generally high, but there is significant variation within individual basins and from one basin to another. The type and degree of associated volcanic activity at any locality are related to tectonic setting and the amount of lithospheric extension. Heat-flow history is extremely variable, even within a single basin; consequently, the level of maturation of petroleum source rocks is notoriously difficult to predict in these types of basins.

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Synthetic Stratigraphy of Epicontinental Seas: A Carbonate Sedimentation Model and its Applications in Sea Level Studies

Carbonates from the central parts of epicontinental seas are ideal strata for detailed study of eustatic sea level change. On the basis of sedimentation model in which carbonate accumulation rate is directly proportional to water depth, we developed synthetic stratigraphies for sea level histories expected for post-glacial transgression and for constant and sinusoidally fluctuating ocean ridge volume increase. These histories give distinctly different trends for water depth as a function of stratigraphic position in the sections' bathymetric curves. In general, water depth is proportional to the rate of sea level rise. Depth-dependent sedimentation leads to a time lag between sea level fluctuation and corresponding depth fluctuation which, as examples show, can approach $10^6$ years for depth fluctuations of even a few meters—a fundamental consideration for reconstructing sea level curves, time-correlating sections by bathymetric curves, and relating water depth on continents to ocean ridge volume.

Bathymetric curves based on gradient analysis of fossil assemblages (coenocorrelation curves) for American Middle Ordovician sections approximate patterns expected for sinusoidally increasing sea level. The model's predictions are tested in an "artificial experiment" that takes advantage of differential subsidence between the craton's middle and its edge to make a difference in the bathymetric histories of sections that otherwise record the same sea level history. The depth dependence in sedimentation was that above wave base net accumulation per year was very roughly $3 \times 10^{-6}$ of the water depth.

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Seismic Stratigraphy on a Micro Budget

Formerly, computer-aided stratigraphic analysis of seismic data was available only to those with access to large mainframe computers. Now, microcomputers are capable of performing many of the necessary operations at a cost within the means of most earth scientists. The critical restraints beyond the standard micro are graphics input and display devices, and software designed to operate within the capacity of the microcomputer.

For a brief period Tandy Corporation marketed an inexpensive digitizer under its Radio Shack trademark. A seismic stratigraphic analysis system has been developed using this device and a 48K Radio Shack microcomputer. This system has the capacity to enter well log curves and seismic traces at the digitizer, convert log curves to time dimension by integration or interpolation, compute synthetic seismograms and time logs, and do synthetic modeling, wavelet estimation, and inversion of seismic and synthetic traces.

The system allows great flexibility, as each process is designed as a stand-alone, interactive program, and data files are in identical format. Thus almost any order of operation may be chosen, and modeling may be in either depth or time. Display is to a pen plotter or dot-matrix printer-plotter. The plot routines allow flexibility in the number, order, spacing, and scale of the curves displayed.