CARBONATE STRATIGRAPHY: BEDS, PARASEQUENCES AND SEQUENCES: CLIMATE AND ORBITAL-FORCING RULES

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ABSTRACT

In studies of sedimentary rocks we are striving to understand the short and long-term controls on deposition that lead to the variety of facies seen in the geological record. With the development and application of sequence stratigraphy has come the realisation that in most cases the stratigraphic record is not random, but there are patterns and trends in the nature (composition, facies, diagenesis) and thickness of sedimentary units. In addition, sedimentary cycles are widely, if not ubiquitously developed through stratigraphic successions, and do themselves vary in thickness and facies through a formation and through time.

Understanding the major controls on the stratigraphic record and the processes involved in deposition enables us to develop a degree of prediction for the occurrence of particular facies and rock-types. This could be especially significant in terms of hydrocarbon potential in frontier basins, notably in the search for source and reservoir rocks.

In the case of carbonate and carbonate-evaporite successions, recent work is showing that even at the higher-frequency scale of individual beds and bed-sets, there are regular patterns and changes in thickness. These show that controls on deposition are not random but well organised. These of course are also the constituents of lower frequency sequences on the 3rd-order (million-yr) scale. Studies of Carboniferous mid-ramp bioclastic pack-wackestones and Jurassic shallow-marine shelf oolitic-bioclastic grain-packstones from England reveal systematic variations in bed thickness. Permian lower slope carbonates show patterns in turbidite bed thickness and systematic upward changes in turbidite frequency. Metre-scale, and thicker, cycles of decreasing-increasing calciturbidite bed thickness are present. Turbidity current frequency of ~200 years can be deduced from thicknesses of interbedded background laminated facies. Allocyclicity clearly rules, even at the highest frequency, over autocyclicity.

Similar facies to these are widely developed in the pre-Mesozoic, Gondwanan successions of South America, in the Permo-Carboniferous of the Merida Andes of Venezuela and the Carboniferous of the Amazonas Basin of Brazil for example, areas of current hydrocarbon exploration. Beds, bed-sets and parasequences are typically the reservoir-unit scale of hydrocarbon-bearing carbonate formations. Close examination of carbonate facies is clearly showing that there are high-frequency controls on deposition. Consideration of the bed-thickness patterns, occurrence of clastic levels (which often define the beds and also act as permeability barriers in reservoir units), C and O isotope data and trace element contents, suggest that millennial-scale (1500-3000 year) changes in climate (arid-humid cycles), driven by orbital forcing (precession rhythm especially), are the over-riding control on carbonate deposition.