Sequence Stratigraphy and Characterization of Carbonate Reservoirs

by **Charles Kerans and Scott Tinker**, 1999, SEPM Short Course No. 40 , ISBN # 1-56576-040-9, $48.00, and 130p.

Review by **Christopher G. Kendall**

This volume consists of five chapters which provide an introduction to the link between sequence stratigraphy and the characterization of carbonate reservoirs. This book contains an elaborate set of notes which support an SEPM course taught by the authors. It is beautifully illustrated in color and sharply printed on glossy paper in bold clear type giving it the look and feel of a book which has had some money invested in its publication. The book is aimed at scientists who have an interest in improving their understanding of and working with the principles of sequence stratigraphy in order to better describe carbonate reservoirs. The text explains how the different properties of carbonate reservoirs including petrophysics, geostatistics, geophysics and reservoir simulation can be linked to a stratigraphic framework derived from an understanding of sequence stratigraphy.

After a short preface, which gives a sense of the intent of the authors, the text launches into an introduction which explains the objectives of the SEPM course. Which are to follow an interpretive process which coordinates sequence stratigraphy with carbonate reservoir quality. This process begins with the 1-D analysis of data, then a consideration of 2-D, followed by a 3-D analysis of the former information.

The first chapter begins by describing the concepts of sequence stratigraphy in terms of those generalized by Sloss, Vail, and the group of Exxon sequence stratigraphers that Vail worked with. These concepts tie the relationship between sea level, subsidence and rates of sedimentation along with the development of the now famous Exxon "seaslug" model. The chapter goes on to explain the difference between high stand, low stand, and transgressive system tracts, the relationship between the sequence model, the lithostratigraphically based reservoir model, and the chronostratrigraphically based reservoir model. This chapter also provides an introduction to the ever increasing complex terminology of sequence stratigraphy and explains how, when working with both with logs, seismic, and outcrops, one goes about identifying stratigraphic sequences in the rocks being studied. This chapter not only considers the sequence stratigraphic system tracts but relates them to depositional systems as well. It provides a critical examination of Walther's Law and it's relationship to the different orders of sequence that can be identified, including first, second, third, and fourth, and fifth order sequences or cycles. The origins of these different types of cycles are explained in terms of classic models of tectonically driven vs. glacial variations in eustasy.

Chapter Two deals with stratigraphic analysis. It explains how a regional analysis should be made of the data before the reservoir can be properly understood. There is a description of how one goes about describing cores from the perspective of sequence stratigraphy and reservoir quality. It starts with preparing the core, analyzing the material one sees in it, and the description
of lithofacies, texture, lithology, cycles, cements, and depositional settings. The text explains how one breaks out different cycle hierarchies within a well, outcrop, or seismic. Once the geologist has gained an understanding of the general depositional setting of the sediments that make up the core the authors advise trying to establish a more detailed picture of the various depositional settings. They explain how vertical lithofacies relationships can be extended laterally and thus enable an understanding of relationships between sea level, subsidence, and the preservation of individual characteristic sedimentary features. The chapter ends with an introduction to petrophysical analysis and includes a discussion of both porosity and permeability from the perspective of their relationship to lithology and their study

with the use of different tools including borehole image logs and the data recovered from gamma ray neutron porosity, and deep induction logs etc.

Chapter Three deals with 2-D correlation and stratigraphic analysis. It explains how to construct cross sections, how to select datums, and how a cross section should be oriented. It describes the use of well logs scales; the spacing one should use; the use of fixed or "mobile" logs; making "strike" maps, recording core, lithology, and lithofacies data along with production and other data types. There is a discussion of stratal 2-D isopach mapping, the identification of stratal geometry, using both seismic, well, and outcrop data with an explanation of how the stratal geometries vary within the different system tracts, and how one can correlate different cycles of hierarchical surfaces. It explains how one should test these interpretations with Walther's Law and tie them to lithofacies interpretation, facies tract delineation and facies tract offsets.

Chapter four deals with 3-D analysis and model construction. It again begins from the initial stratigraphic framework and then ties 2-D structural mapping, and non-stratigraphic maps to the development of a 3-D framework. It shows how various models can be constructed from the stratigraphic data and tied to the rock properties or the reservoir properties of the sediments involved. Both the log, core and seismic data, and the development of reservoir simulation models use a combination of sequence stratigraphic interpretations and reservoir petrophysics.

This elegant book is a flawed masterpiece; this is because although the illustrations, writing style and presentation are extremely clear, the exercises that are presented to the SEPM class are not included with the notebook, making it a little difficult for the reader to practice the interpretations that are suggested to them. Nevertheless, this book provides many insights and ideas on how to develop sequence stratigraphic models and relate them to reservoir models of the carbonates. It shows that the initial over simple models of the "seaslug" model when transferred to carbonates aren't necessarily perfect. However, the book does establish that with careful and complete description of the data available to the interpreter, much more sophisticated models of the depositional setting and so reservoir geometry can be established. This kind of approach leads to a most effective means of communication between the geologist and the engineer with the result that both parties should be able to start talking the same language. This elegant book could not have been written some five or six years ago, but now it is clear that the use of the sequence stratigraphic models helps the interpretation of depositional systems and this is beginning to drive a new understanding of reservoir geology, be it for clastic or carbonate rocks. Not everyone is going to agree with all of Tinker's and Kerans's philosophies but these authors have provided a fine framework from which one can build one's own approach to interpreting the geological data associated with carbonate reservoirs. This is an extremely sophisticated book which will be not only of use to the novitiate graduate student, making initial sequence stratigraphic interpretations and characterizations of carbonates, but will appeal to the mature scientist who is working in the realm of production. This book also represents a Rosetta Stone for earth scientists linking the language of the reservoir engineer and the carbonate stratigrapher. A great book and SEPM and the authors ought to be congratulated on a very fine sophisticated, clear exposition on an extremely complex subject that is fraught with emotional as well as scientific problems. All models are models and of course the authors are going to be accused of forcing their model too far, but careful examination of the data in the book will demonstrate to the reader that the sequence stratigraphic approach to the interpretation of carbonate rocks is valid and a powerful tool for interpreting reservoirs in these sediments.