SHORT COURSE
Applied Ichnology: The Use of Trace Fossils in Sequence Stratigraphy,Exploration and Production Geology

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Ichnology is the interdisciplinary subject that brings together sedimentologists, paleontologists, stratigraphers, and geochemists to unravel the post-depositional history of sedimentary rocks with respect to the lasting effects that the activities of small animals and plants have on sediment properties and stratification. The subject focuses on trace fossils (sedimentary structures that directly reflect organism activity such as burrows, borings, trails, tracks and fecal pellets), bioturbation (sediment-mixing and disruption of original stratification by burrowers) and bioerosion (excavation and breakdown of hard substrates by boring animals and plants).

Modern sedimentary geologists should be able to recognize biologically produced fabrics, textures and sedimentary structures, because they are extremely prominent in the sedimentary record. Interpretation of such post depositional biogenic features can aid the geologists immensely in solving major problems of paleoecology, paleoenvironmental reconstruction, basin analysis, diagenesis, and so on.

This short course focuses on the sedimentologic implications of ichnology, especially as they apply to paleoenvironmental analysis in the broad sense. The theme of the course will be geologic problem-solving in the realm of ichnology, and practical applications and conceptual models will be emphasized. Included will be a thorough introduction to the fundamentals of the science, such as recognition, classification and preservation of biogenic structures. The major portion of the course, however, will cover the application of basic principles and new advances in ichnology to solving geologic problems in the areas of sedimentology. Included will be such topics as general models of bioturbation, animal-sediment relationships, paleoenvironmental interpretations based on trace fossil associations, sedimentologic implications of biogenic textures and fabrics, and the influence of bioturbation on early diagenic processes, such as differential cementation and selective mineralization, and the implications of burrowing on fluid flow pathways in hydrocarbon bearing reservoirs.

The course will also include selected case histories, using core examples, to illustrate the significance of trace fossils in paleoenvironmental analysis. Special attention will be focused on the recognition of trace fossils in core and their implications in subsurface geology.

Audience: This course is designed for the professional geologist, geophysicist or engineer interested in learning how to apply fundamental concepts of clastic sedimentology, ichnology and sequence stratigraphy to successful hydrocarbon exploration and reservoir characterization.

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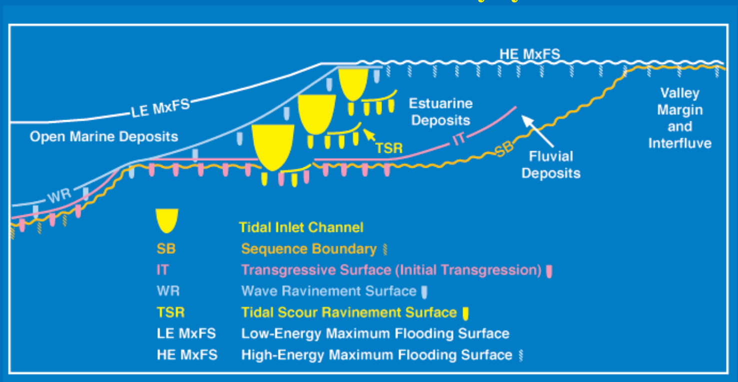
COURSE OBJECTIVES: A combined lecture presentation and core workshop course providing a detailed overview of the recognition and application of Sedimentology and Ichnology (i.e. physical and biogenic sedimentary structures), to the interpretation of depositional environments in whole diameter cores and subsequent delineation of reservoir geometries, exploration trends and sequence stratigraphic surfaces.

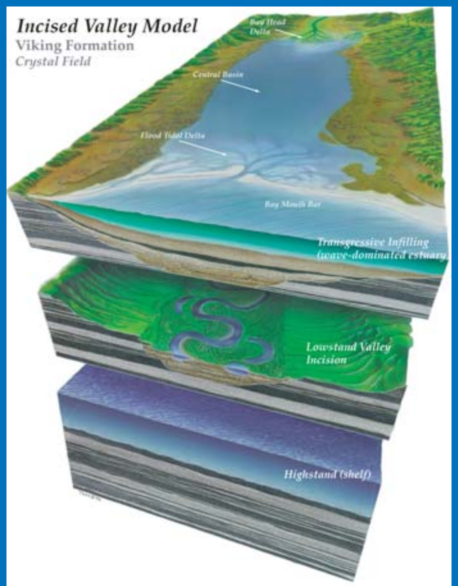
The Determination of Ichnofacies

Recognition of Trace Fossils in Core

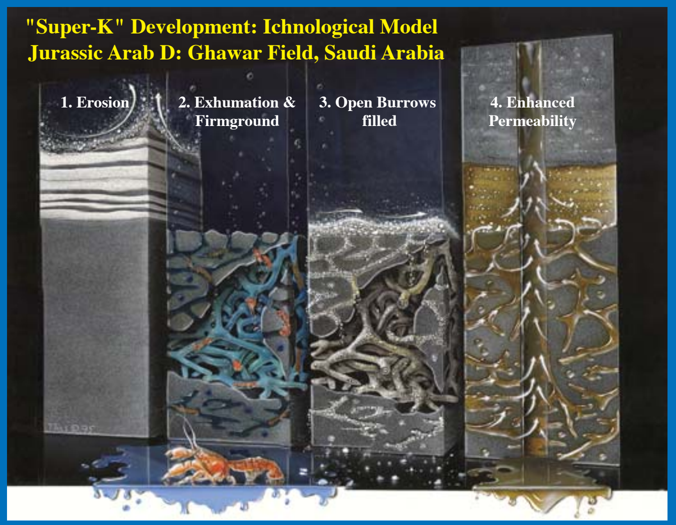
Glossifungites demarcated surfaces associated with incised valley systems

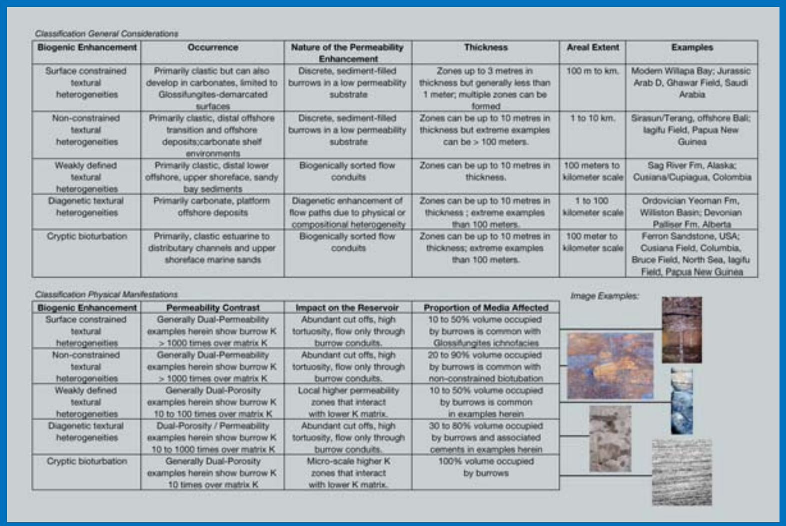


Recognition of Sequence Stratigraphic Surfaces



Paleoenvironmental Interpretation





Classification General Considerations

Biogenic Enhancement	Occurrence	Nature of the Permeability Enhancement	Thickness	Areal Extent	Examples
Surface constrained textural heterogeneities	Primarily clastic but can also develop in carbonates, limited to Glossifungites-demarcated surfaces	Discrete, sediment-filled burrows in a low permeability substrate	Zones up to 3 metres in thickness but generally less than 1 meter; multiple zones can be formed	100 m to km.	Modern Willapa Bay; Jurassic Arab D, Ghawar Field, Saudi Arabia
Non-constrained textural heterogeneities	Primarily clastic, distal offshore transition and offshore deposits;carbonate shelf environments	Discrete, sediment-filled burrows in a low permeability substrate	Zones can be up to 10 metres in thickness but extreme examples can be > 100 meters.	1 to 10 km.	Sirasun/Terang, offshore Bali; Iagifu Field, Papua New Guinea
Weakly defined textural heterogeneities	Primarily clastic, distal lower offshore, upper shoreface, sandy bay sediments	Biogenically sorted flow conduits	Zones can be up to 10 metres in thickness.	100 meters to kilometer scale	Sag River Fm, Alaska; Cusiana/Cupiagua, Colombia
Diagenetic textural heterogeneities	Primarily carbonate, platform offshore deposits	Diagenetic enhancement of flow paths due to physical or compositional heterogeneity	Zones can be up to 10 metres in thickness ; extreme examples than 100 meters.	1 to 100 kilometer scale	Ordovician Yeoman Fm, Williston Basin; Devonian Palliser Fm, Alberta
Cryptic bioturbation	Primarily, clastic estuarine to distributary channels and upper shoreface marine sands	Biogenically sorted flow conduits	Zones can be up to 10 metres in thickness; extreme examples than 100 meters.	100 meter to kilometer scale	Ferron Sandstone, USA; Cusiana Field, Columbia, Bruce Field, North Sea, Iagifu Field, Papua New Guinea

Classification Physical Manifestations

Biogenic Enhancement	Permeability Contrast	Impact on the Reservoir	Proportion of Media Affected
Surface constrained textural heterogeneities	Generally Dual-Permeability examples herein show burrow K > 1000 times over matrix K	Abundant cut offs, high tortuosity, flow only through burrow conduits.	10 to 50% volume occupied by burrows is common with Glossifungites ichnofacies
Non-constrained textural heterogeneities	Generally Dual-Permeability examples herein show burrow K > 1000 times over matrix K	Abundant cut offs, high tortuosity, flow only through burrow conduits.	20 to 90% volume occupied by burrows is common with non-constrained biotubation
Weakly defined textural heterogeneities	Generally Dual-Porosity examples herein show burrow K 10 to 100 times over matrix K	Local higher permeability zones that interact with lower K matrix.	10 to 50% volume occupied by burrows is common in examples herein
Diagenetic textural heterogeneities	Dual-Porosity / Permeability examples herein show burrow K 10 to 1000 times over matrix K	Abundant cut offs, high tortuosity, flow only through burrow conduits.	30 to 80% volume occupied by burrows and associated cements in examples herein
Cryptic bioturbation	Generally Dual-Porosity examples herein show burrow K 10 times over matrix K	Micro-scale higher K zones that interact with lower K matrix.	100% volume occupied by burrows

Image Examples:

Enhanced Porosity-Permeability Trends in Bioturbated Media