Untersuchungsräumen aus den gleichen Haupt-Lithologien: Karbonate mit unterschiedlich hohen Tongehalten. Größere Trends im Log entsprechen weitgehend Schwankungen des Tongehaltes und sind damit gut vergleichbar. Im Gegensatz dazu sind die Lithologien im Keuper heterogener. Während im Germanischen Becken kaum Karbonate vorkommen, fehlen in den Kössener Schichten Sandsteine. Zudem ist die mangelhafte biostratigraphische Datierung der verglichenen Logs für eine hochauflösende Korrelation äußerst problematisch. Eine zumindest grobe Korrelation auf biostratigraphischer Basis ist aber die Grundlage jeder GR-Korrelation. Erst wenn verläßliche korrelierbare biostratigraphische Daten vorliegen, besteht die Chance für eine verläßliche hochauflösende GR-Korrelation von Germanischem und Alpinem Rät.

Diversität von onkoidischen Krusten im Einflußbereich eines Schwammbiostroms im Kimmeridge des Keltiberikums SE-Spaniens (Prov. Valencia)

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Die Kimmeridge-Sedimente des Keltiberikums SE-Spaniens wurden in einer flachen Meeresstraße (Cuenca de la Iberica) abgelagert, die vom Westrand der Tethys die iberische Halbinsel von SE nach NW durchzog. Im Randbereich dieses Epikontinentalmeeres entstanden in einem niedrigenergetischen Flachmeermilieu (Lagune) skelettale Biostrome mit Patchreefcharakter aus Chaetetiden, Stromatoporen und einer niedrigdiversen Korallenfauna. Am Rande dieser Biokonstruktionen und über weite Räume mit ihnen verzahnend entwickelte sich eine ausgedehnte Onkoidfazies, die hinsichtlich der Diversität der inkrustierenden Organismen, der Größen und Formen der Onkoide sowie der steuernden palökologischen Faktoren untersucht wurde.

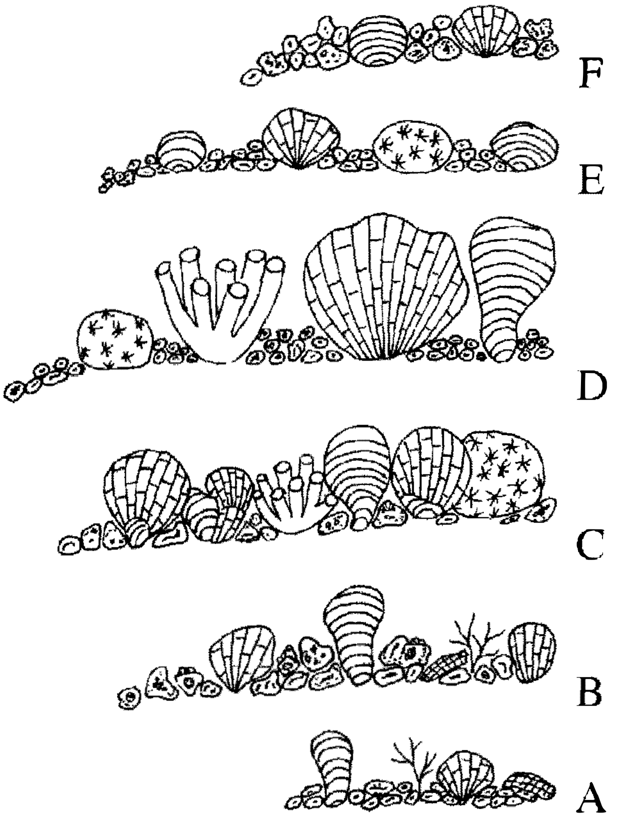

Abb. 1: Entwicklung der Onkoidfazies in Zusammenschau mit der Riffentwicklung. Nähere Erklärung im Text.

Im Initialstadium (A) des rezifalen Wachstums, das geprägt wurde durch Stromatoporen, Chaetetiden sowie microsolenide und dendroide Korallen, entwickelten sich bis zu 10 mm große Onkoide mit vorwiegend mikritischen (spongiostromaten) Krusten unter der Beteiligung nubeculariider Foraminiferen. Daneben treten Girvanellenonkoide mit *Koskinobullina socialis*, *Cayeuxia* sp. und Bryozoen der Formgattung "*Berenicea*" auf. Auch Chaetetiden sind zumeist im äußeren Teil an der Krustenentwicklung beteiligt. Während die spongiostromaten Onkoide überwiegend runde Formen zeigen, neigen die etwas höherdiversen Girvanellenonkoide zu eher lobaten Formen.

Parallel zur lateralen Entfaltung des Riffkörpers (B) entwickelte sich eine leicht höhere Vielfalt der Korallen mit cerioiden, plocoiden, thamnasterioiden und phaceloiden Formen; die Diversität der onkoidischen Krusten steigt an: Die Girvanellenonkoide treten in den Vordergrund, zu den bereits erwähnten inkrustierenden Organismen kommen *Bacinella irregularis*, *Lithocodium aggregatum* und *Marinella lugeoni* hinzu. Die Onkoide erreichen Durchmesser bis zu 25 mm, es entwickelten sich Mehrfachonkoide und zum Teil stark nichtkonzentrische bis lobate Formen.

Die maximale Entfaltung der Rifforganismen zeigt sich in zwei Phasen: Eine dichtere Konzentration der Organismen (C) wirkt sich nicht auf die Onkoidfazies aus. Mit der absoluten Größenzunahme der Stromatoporen, Chaetetiden und Korallen (D) geht eine Reduzierung der Größe der Onkoide auf maximal 15 mm einher, verbunden mit einem Diversitätsrückgang hinsichtlich der inkrustierenden Organismen. Es dominieren spongiostromate Cortices unter Beteiligung nubeculariider Foraminiferen, Chaetetiden und Bryozoen. Die Form dieser Onkoide ist vorwiegend konzentrisch zu den Kernen.

Die Rückzugsphase der riffbildenden Organismen (E) wurde eingeleitet durch leicht erhöhten terrestrischen Sedimenteintrag bei zunehmendem Energieniveau. Die in dieser Phase gebildeten Onkoide gleichen sowohl in Zusammensetzung als auch Größe denen der maximalen Riffphase. In spongiostromaten Cortices treten eisenhaltige Lagen auf.

In einer zweiten Rückzugsphase des Biostroms (F) nimmt die Diversität in den onkoidischen Krusten wieder zu, dabei dominiert *Bacinella irregularis*. Außer-dem sind *Lithocodium aggregatum*, *Girvanella* sp. und Chaetetiden an den Krusten beteiligt. Daneben treten in alternierenden Lagen spongiostromate Onkoide unter Einschluß eisenhaltiger Cortices. Die Bildung von Mehrfach-onkoiden ist in dieser Fazies häufig.

Modern 3D-Seismic Interpretation – Principles and Applications

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3D reflection seismology differs from 2D profiling by the fact that data are gathered over a surface and not along a line. The data are processed into a cube, subdivided into bins formed by inlines and crosslines. Therefore, interpretation of 3D seismic data can be achieved over volumes.

Seismic attributes are different ways of looking at the seismic data usually represented in amplitude. They are various mathematical operations done on the seismic data. Volume attributes e.g. are calculated over a certain volume (e.g. between top and base reservoir) and displayed as an attribute map showing the lateral distribution of the computed attribute in a 2D map view. A large number of attributes exists, like Integrated Seismic Amplitude (integrates the amplitude of a seismic trace over a volume), Integrated Reflection Strength (integrates the reflection strength of a seismic trace), Reflection Heterogeneity (measures the trace length) or Integrated Instantaneous Frequency (integrates the instantaneous frequency of a trace) and many others. These different attributes can help the interpreter as they can highlight various features of the data that would not be visible otherwise.

It is known that the attribute response of one single attribute is guided simultaneously by fluids, facies, pressure etc. Furthermore, different attributes show different sensitivities to fluid, facies, etc. Thus, the key question in attribute analysis is to find out which attributes show the desired feature. Hence, to find out the fluid or facies distribution within a reservoir it is necessary to combine several attributes and to filter out the desired information. The method of using seismic data and to "read" from them fluid or facies information is an inversion process. SeisClass is such an inversion tool supplying additional model constraints to assist exploration geophysicists, reservoir engineers and project management in generating realistic earth models. The use of SeisClass maximises the use of information derived directly from seismic reflection data. The basic function of SeisClass is to discriminate statistically or non-statistically between "classes" (e.g. oil-water, sand-shale), these classes being based upon seismic attributes or other input data. SeisClass produces class maps, each different class being related to a distinct reservoir property. The inversion of the seismic response of a reservoir into classes showing the distribution of certain reservoir properties is called Reservoir Classification.

Two main classification modes exist in SeisClass: Unsupervised Classification (based on natural clustering techniques) and Supervised Classification (based on learning strategies or training data input). For supervised classification the clustering algorithm has to be supplemented by a learning strategy based on training data. The training data can, for instance, be picked around well-locations or based on prior geological knowledge. A training data element is a vector that contains attribute values coming from the same location (cell or bin) for all attribute grids used in the classification. Different statistical and neural network algorithms have been implemented in the classification module.

Two case studies will be presented to demonstrate the successful application of attribute analysis and classification during different phases of oilfield development.

Case study one is a carbonate field during the early exploration phase with seismic data being the only information source available. The issue was to map the distribution of carbonate mounds which are the main reservoir. Volume attributes were computed on a chaos cube and a variance cube. The chaos cube and the variance cube are different approaches to measure the lateral continuity of a seismic signal. They were applied because carbonate mounds show a different seismic texture than lagoonal sediments. K-Means Classification (an unsupervised classification method), which is based on the natural clustering of attribute data, was successful in quickly (several hours) mapping the distribution of carbonate mounds. Manual mapping (Inline by Inline) of the mounds would have taken several weeks. This way of reservoir mapping is very quick and, additionally, helps to construct paleogeographic models and play concepts very early during the exploration phase.

The challenge of the second case study was to map the distribution of channel sands encased in a shale/coal sequence of a fluvial depositional environment. The mapping of sand channels was important for field development and well planning. Production wells had to be placed at locations where an optimum vertical connectivity of sand channels occurred. Input data were shear wave data (converted waves) aquired as 4C data (ocean bottom cable method), so volume attributes were computed on a S-wave data set. In this case study a lot of well information was available. Lithologic information based on wells was used to train the inversion tool. Hence, a neural network classification method (supervised classification) was applied to invert for the classes sand vs. shale/coal. Afterwards drilled horizontal wells confirmed the prediction of the distribution of sand.

Carbonate depositional systems – from factories to sequences

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Limestones and dolomites make up less than 25 % of the sediment mass of the Earth but they merit special attention: they contain nearly 50 % of the known reserves of oil and gas, host some of the largest aquifers in the world and play a significant role in the carbon cycle of the our planet. This presentation revolves around the production of carbonate material and the ordering of carbonate sediments into depositional sequences. Recent progress in both areas has been very significant and undoubtedly will improve the subsurface prediction of carbonate rocks – a central task in petroleum geology and hydrogeology.

Carbonate precipitation in the ocean proceeds in three basic modes – abiotic, biotically induced, i.e. triggered by organisms, and biotically controlled, i.e. fully determined by organisms (LOWENSTAM & WEINER 1989). The three modes combine in a variety of ways to produce carbonate sediment. When viewed on the scale of formations and global facies belts, three carbonate production systems, or "**factories**", emerge (REITNER & NEUWEILER 1995, JAMES 1997, SCHLAGER in press): (1) the tropical shallow-water factory, dominated by biotically controlled (mainly autotrophic) and abiotic precipitates; (2) the cool-water factory, dominated by biotically controlled (mainly heterotrophic) precipitates; and (3) the mud-mound factory, dominated by abiotic and biotically induced (mainly microbial) precipitates.

Sedimentation rates and growth potential of all three factories decrease as the time span of observation increases. This scaling trend has real physical meaning and is related to the episodic nature of sedimentation and the pervasive distribution of hiatuses in the record. The growth potential can be estimated from the maximum observed rates of aggradation (SCHLAGER 1999). The tropical system shows the highest rates - 10^4 m/yr at 10^3 yr, decreasing to 10^2 m/yr at 10^7 yr. The maximum rates of the cool-water system amount to only 25 % of the tropical standard in the domain of 10^6-10^8 yr. Only the short-term rates of cool-water carbonates occasionally equal those of the tropical factory because of extensive reworking and local trapping of sediment. The growth rates of the mud-mound system significantly exceed cool-water rates and rival those of the tropical factory. However, the mud-mound system exports less sediment than its tropical counterpart and is, therefore, somewhat less productive.

Sediment accumulations of the three factories differ in composition, geometry and facies patterns and some of these differences appear prominently in seismic data. The characteristic accumulation of the tropical factory is the flat-topped platform with a rim of reefs or sand shoals. Cool-water carbonates lack rim-building capability and tend to produce seaward-sloping shelves similar to siliciclastic systems. The typical accumulation of the mud-mound factory are convex-up mounds that normally form on gentle slopes in tens to hundreds of meters of water depth.

Carbonate sequence stratigraphy. The standard model of sequence stratigraphy is based on siliciclastic systems. Carbonates share many of the basic trends but also deviate from the standard model in several respects. These differences are most apparent on tropical carbonates.

Accumulation geometries and of tropical carbonates that build close to sea level, are governed by two rates: if we call A the