

Theme C. Applied Stratigraphy

**Sequence Stratigraphy, Seismic Stratigraphy and
Seismic Geomorphology**

Megablocks and the stratigraphic record of continental margins How large an event do they materialise?

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Three-dimensional seismic data from continental slopes often show landslide deposits that comprise large-scale megablocks, suggesting sudden catastrophic instability events. However, the true temporal and volumetric scales of such events are not well documented in the literature. This presentation reviews data from three independent projects to provide insights on the importance of large-scale instability events to stratigraphy and to petroleum systems. Based on data from three case-studies, some conclusions on the impact of these ‘megaslides’ on petroleum systems will be shown by modelling leakage tendencies across basal shear zones. Offshore Japan, a ~65 m landslide drilled during IODP Expedition 333 shows distinct degrees of erosion at their basal shear zone, whose morphology responded to the tectonic activity of underlying faults during the Quaternary. On Crete, medium-side blocks of a Miocene submarine landslide show that more than 100 metres of continental slope strata were disrupted and moved over shaley marine mudstones of a paleo-continental slope, now fully exposed. Offshore Brazil, ~400 metres blocks were left in situ when of the sudden collapse of the Espírito Santo continental slope. The data in this presentation shows that these large-scale events can cause important limitations when correlating seismic and stratigraphic units across sedimentary basins, as the erosional character of such events can be underestimated – thus implying that potential hiatuses and unconformities are not identified when interpreting older landslide successions. However, the erosional character of these large-scale landslides is mainly recorded in proximal areas, where the sudden release in vertical confining pressures has a significant impact on petroleum systems. In this presentation are presented results from fluid-flow modelling across landslide strata when of the collapse of large-scale (mega) slides.

Keywords: Submarine landslides, remnant blocks, erosion, hiatuses, confining pressures.

Seismic geometries and facies analysis of a Quaternary Tunnel glacial valley infill in the Dutch North Sea. Preliminary results

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A preliminary seismic interpretation of internal and external geometries is presented for the terminal sector of the largest Tunnel Valley of the Southern North Sea. Well log and sediment cuttings are used to constrain the interpretation of different seismo-stratigraphical units. The valley floor undulations and grooves suggest that subglacial overpressured meltwater was the dominant valley genetic process, most likely associated with several steps of ice-sheet retreat and readvances. The geometries of the TV infill could either be associated with synglacial processes (e.g. backsets) or alternatively post-glacial fluvial sediments related to the drainage of a proglacial lake developed during the Elsterian glacial maximum to the south west of the ice-sheet termination.

Keywords: tunnel valleys, overdeepening, glacial sediments, seismic stratigraphy, wells.

Facies and stratigraphic controls of the palaeokarst affecting the Lower Jurassic Coimbra Group, western-central Portugal

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An evolutionary geological/geomorphological model is proposed to explain the spatio-temporal distribution of palaeokarst affecting a Lower Jurassic shallow-marine carbonate succession (Coimbra Group; Sinemurian), outcropping in the Coimbra-Penela region (western-central Portugal), in a specific morpho-structural setting (Dolomitic Hills). Field and laboratory data allowed a detailed facies/microfacies characterization and diagenetic interpretations, with special regard to the porosity evolution. High facies/microfacies heterogeneities and contrast in porosity, becoming efficient for hydraulic circulation by meso and macro-permeability, influence and control significantly the earliest karst forming processes (i.e. inception), as well as the later degree of karstification during mesogenetic and telogenetic stages of the Coimbra Group.

Keywords: Shallow-marine carbonates, Lower Jurassic, Facies/Microfacies analysis, Dolomitization, Carbonate porosity evolution.

Sequence-Stratigraphic analysis of the Aptian deposits in the valley of the Mzymta River

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In this work, based on the example of a well drilled in the valley of the Mzymta River (Northwest-Caucasus) the possibilities of the sequence-stratigraphic method are demonstrated for the first time. This method allows us to clarify the natures of numerous repetitions in the same interval of the geological sequence (modern, ancient landslide or synsedimentary landslide, and tectonic or eustatic). In addition, the geochemical characteristics of bituminous sediments are given. The sequence that was studied in the well shows the complex polygenetic evolution of sediments since Aptian time and the oceanic anoxic event-1.

Keywords: Sequence stratigraphy, Aptian, OAE, Caucasus, Mzymta.

Geometry and classification of submarine canyon confluences

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Confluence points are important morphological features of deepwater submarine canyons, but still poorly understood and characterised. High-quality 3D seismic data is used to investigate the confluence regions of the Miocene (C1) and Modern (C2) submarine canyons of the Rio Doce Turbidite System in the Espírito Santo Basin, on the SE Brazilian margin. Growing salt diapirs play a dominant role in the confinement of the studied canyons, as confluence points are located near slope regions with the highest degree of confinement. Continuous salt growth and interaction with evolving sedimentary systems has forced an up-slope migration of the submarine confluence areas during the Late Cenozoic. Detailed mapping and measurements of canyon thalweg reveal two distinct morphologies for both confluences. Tributaries of Canyon C1 merge at an equal junction, whereas in Canyon C2 tributaries merge at an unequal junction, with a vertical offset of 100m between them. This study also documents the presence of submarine confluence scours. In C1 a confluence scour is located at the central confluence region, whereas in C2 the scour is adjacent to the hanging tributary. Seismic attribute-based analysis of the channel fill deposits (namely maximum and RMS amplitude) highlight the predominance of sand-prone high amplitude deposits along the eastern tributary and post-confluence conduits in both canyons.

We propose a classification scheme for submarine confluences based on a combined analysis of channel geometry and the use of seismic attributes to assess sedimentary paths. Confluences may be symmetric or asymmetric based on the similarity of the angles the tributaries bear to the post-confluence channel. Left- or right-symmetric confluences define whether the dominant flow path is along the left- or right-hand tributary. Pure or secondary asymmetric confluences depend on whether the dominant pre-confluence flow takes place along the main or secondary tributary, respectively. Following these criteria, the studied canyons are classified as pure asymmetric with a predominance of high-amplitude strata in the eastern tributaries and post-confluence path.

This classification can be used to characterise the full sedimentary fill of buried canyons and channels and also of specific channel-fill events. The latter allows a detailed assessment of the lateral continuity (or lack of it) of relevant sand bodies from the main canyon conduit into the tributary systems. This has important implications for the estimation of fluid flow paths at confluence regions, and to assess which tributaries consist in the most favourable fluid accumulation compartments.

Keywords: submarine confluence, confluence classification, submarine canyons, flow paths, Espírito Santo Basin.

Sequence stratigraphy of late Quaternary deposits in the southeastern Yellow Sea of Korea

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High-resolution seismic profiles were analyzed to investigate the sequence stratigraphy of late Quaternary deposits in the southeastern Yellow Sea of Korea. Approximately 1,500 line-km data of chirp and sparker profiles were acquired. We also used deep drill cores to interpret the sedimentary sequence. High-resolution seismic profiles show the Holocene mud deposits and the complex sedimentary structure.

The late Quaternary deposits in the study area can be divided into four sedimentary units (units A, B, C, and D from the oldest to youngest) bounded by an erosional surface and internal seismic reflector: (1) incised channel fill/lowstand deltaic wedge (unit A), (2) transgressive sand ridges and sand sheets (unit B), (3) estuarine/deltaic or

shallow-water mud (unit C), (4) distal mud patch (unit D). Unit C is divided into two sedimentary sub-units by high amplitude and unconformity: (a) estuarine/deltaic mud (unit C-a), (b) redeposited mud by a sea-level rise and strong tidal current (unit C-b). The evolution of units C-a and C-b is closely related to the post glacial sea-level changes, sediment erosion, and reworking. These late Quaternary deposits have been controlled by sea-level change, tidal currents, and sediment erosion.

Keywords: high-resolution, sequence stratigraphy, late Quaternary deposit, sea-level change.

Stratigraphy by Wavelet Transform

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Wavelet (Mathematical Microscope) analysis of seismic data is made fashionable for thin bed precise subsurface imaging and interpretation. 3D seismic data interpretation for subsurface imaging of thin bed contourite systems is integral part of research work. Seismic expression of bottom current deposits from that of other related deepwater sediments (turbidites, hemipelagites, debrites, etc.), and to maximising the information that can be derived from seismic data. A wide variety of seismic facies are common in contourites, most of which are equally present in turbidite systems. Seismic facies associations that may be typical of contourites are still to be defined. Seismic characteristics also depend very closely on the methods of seismic acquisition and processing. Sediment waves and channels are very common both in contourite and turbidite systems, and not specifically diagnostic of either system. Slope deformation, sediment creep, and large-scale water-escape may cause a hummocky seismic facies that can be misinterpreted as sediment waves. The identification of hydrocarbon reservoirs from seismic data is a key issue in the oil industry. Texture Segmentation of a 3D Seismic Section with Wavelet Transform is employed for pattern recognition. Because of the segmentation, zones of different internal stratification are identified in the seismic section. This recognition is based on the comparison of the 3-D seismic data with the reference patterns extracted from the representative areas, characterized by different textures. In splicing 3-D seismic data, consistent processing is one of the key technologies because it has a great effect on imaging quality. Seismic geomorphology goal is to look for and recognize geologically or geomorphologically meaningful patterns in plan view as well as in section view. Seismic geomorphology, the extraction of geomorphic insights using predominantly 3D seismic data, is a rapidly evolving discipline that facilitates the study of the subsurface using plan view images. Methods evolved for generating horizontal and flattened slices, arbitrary traverses, wavelet attribute extractions and mapping, and rapid analysis of large complex data volumes. A geological feature must have an expression that is scientifically reasonable in multiple dimensions. Analyses of section view integrated with plan view images represents the integration of seismic stratigraphy with seismic geomorphology. Pattern recognition, involving the interpreter being able to recognize geologically significant features in plan view on 3D seismic data, is critical to the seismic geomorphological approach. In conjunction, it is also essential to cross reference plan view with section view images, thus integrating the geomorphology with the stratigraphy.

Keywords: Stratigraphy, Seismic Stratigraphy with Seismic Geomorphology, Wavelet analysis.

Sequence stratigraphy of sedimentary basins in Europe, northern Africa and the Middle East: implications for rates and periodicities of early Late Cretaceous sea-level changes

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The Cenomanian–Turonian (C–T, early Late Cretaceous, ~100–90 ma) interval of generally rising and high sea-level stands was characterized by large and rapid sea-level falls of hitherto unknown reasons. An interplate sequence stratigraphic study of selected Cenomanian–Turonian basins on different tectonic plates (Europe, northern Africa, Middle East) demonstrated the contemporaneity of the resulting sedimentary unconformities and intervening depositional sequences. The study also showed a regular temporal recurrence of unconformities in a ~1.2 myr-mode with an amplification of the magnitude of every second event (~2.4 myr), suggesting that early Late Cretaceous 3rd-order sequences developed by low-frequency modulations of the Milankovitch oscillations. As high-frequency sequences (controlled by the ca. 400-kyr-long eccentricity cycle) are components of the depositional sequences, our study thus perfectly integrates cyclo-, high-frequency and depositional sequence stratigraphic approaches.

Keywords: Cenomanian–Turonian; interplate correlation; sea-level; 3rd-order sequences; quantification.

Sequence Stratigraphy of the Cambrian and Ordovician Series in the Illizi Basin (Algeria)

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The Cambro-Ordovician sediments of the South East Saharan platform show a facies evolution from continent to platform rather than platform to basin; that is the reason why the faciological stratigraphy (HOMEWOOD *et al.*, 1992) is applied.

The genetic sequences, are limited at their bases and tops by MFS (Maximum Flooding Surfaces); these surfaces mark transition between retrogradation and progradation; therefore, they are the best isochrone surfaces and easy to identify.

The "Infra Tassilian Surface "or" Panafrican Surface" marking the contact between the basement and the sedimentary facies is absolutely flat and no alteration horizon is visible, the sediments are anisometric and cleaned, with conglomerates containing rounded, gravelly and sandy quartz grains; KAZI TANI (2000) considers it as a marine abrasion surface.

Evidence exists for eight third order cycles and the key surfaces (MFS), which define them, have been dated by biostratigraphy.

Correlations have been done between the Tassilis outcrops series and wells; new oil stratigraphic traps and argillaceous seal rocks have been found.

In this study we have noticed that the flooding surfaces, between two MFS, present two important characters in the formation of the stratigraphic traps

- Formation of pinch out reservoirs;
- Argillaceous facies very widespread constituting the cover of the trap.

Thus the flooding surfaces appear a new way to develop the exploration of oil in this region.

Keywords: Cambro-Ordovician, genetic sequences, flooding surfaces, correlations, stratigraphic traps, south eastern Sahara.

The Mesozoic platform megasequences in the Eastern part of the Russian Plate

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On the basis of results from sequence and chronostratigraphic investigations of the Middle Jurassic – Lower Cretaceous deposits of the eastern part of the Russian Plate, five megasequences were identified: the Upper Bajocian – Callovian, Oxfordian – Berriasian, Valanginian, Upper Hauterivian – Aptian, and Albian megasequences. These were formed under stable tectonic-eustatic conditions (without long breaks in sedimentation). The megasequences are characterized by peculiar sediment composition: mineral assemblages are specific to individual horizons, units, or the entire megasequence, and they include specific complex of solid mineral resources.

Keywords: sequence stratigraphy, chronostratigraphy, megasequences, solid mineral resources.