CONTISLOPE—Evolution of Submarine Channel Systems on Continental Slopes*

By

Tiago M. Alves[1], Joe Cartwright[1], and Richard Davies[2]

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[1]3D Lab. School of Earth, Ocean and Planetary Sciences, Cardiff, University, United Kingdom (alvest@cardiff.ac.uk)

[2]CeREES, Department of Earth Sciences, Durham University, United Kingdom

Rationale

The investigation of geological processes on continental margins is of major interest as sediments deposited in these areas can provide a high-resolution record of past climatic changes, at the same time hosting some of the world's major hydrocarbon reservoirs. Continental margins are affected by, and hence provide a detail record of, global changes in relative sea-level, large-scale variations in oceanographic conditions and regional tectonic events. These time-dependent changes are commonly recorded on the form of major variations in slope morphology, spatial distribution of depositional systems, and overall architecture of continental margins, particularly in deep-offshore sedimentary basins where the combined effect of eustasy and regional tectonics is distinctively marked. Some of the latter processes are known to control sea-floor fluid seepage and the subsurface preservation of hydrocarbons. Thus, areas such as the Gulf of Cadiz, Brazilian margin, and Rockall trough show the effect of slope-moulding processes in subsurface fluid seepage systems, with these latter being clearly dependent on the past 4D (time vs. space) evolution of geostrophic currents and associated depositional systems. In addition, main periods of slope destabilisation and landsliding on continental margins can frequently be correlated with abrupt changes in base (sea) level associated with climatic or tectonic events (e.g., Mediterranean Sea).

To investigate and to quantify the ways depositional systems relate to the underlying structure and sea-floor geometry of continental margins are therefore crucial for the analysis and prediction of geohazards, subsurface preservation of hydrocarbon plays, and to assess the relative budget of fluid (including CO_2 and methane) expelled by continental margins into the hydrosphere. Moreover, geological studies of continental slopes are becoming increasingly important as hydrocarbon exploration is gradually, but coherently, shifting towards deep-water prospects. This is presently the case of hydrocarbon-prone areas offshore Norway, Gulf of Mexico and on the South Atlantic Margin, where most studies relate to the imperative need of evaluating the content and geometry of potential hydrocarbon fields, together with assessments of continental slope stability, in most cases within areas of significant sea-floor fluid seepage.

The CONTISLOPE project utilises a comprehensive set of 3D seismic from offshore Brazil (Espírito Santo Basin) in the investigation of 4D (spatial vs. time) changes in morphology and sedimentary facies distribution within the Rio Doce submarine canyon system. Major seismic and sedimentary facies changes are thought to be related to: a) regional salt tectonics, and; b) major eustatic variations occurring in the Cenozoic; c) regional-scale changes in palaeoceanographic conditions. Particular attention will be given to the lateral migration of stacked channel systems during the main stages of salt-diapir growth. Available 3D data sets will be complemented by existing Deep Sea Drilling Program (DSDP), Ocean Drilling Program (ODP), and Industry subsurface data.

Main hypothesis for the complex lateral and vertical stacking of submarine channels are: a) changes in accommodation space within evolving salt withdrawal basins; b) variations in the nature (and relative grain-size) of material being fed to developing submarine channels; c) changes in source-to-sink distances derived from eustatic and tectonic events. The project will try and address some of these questions, by assessing the importance of each of the latter effects on the Eocene-Miocene evolution of the Rio Doce Canyon System (Figure 1).

The secondary aim of the project relates to the interpretation of the main factors influencing the migration, escape, and preservation of hydrocarbons in such structures. Growing salt structures significantly fracture the overburden rocks generating post-depositional flow paths for any fluids accumulated in porous strata. In addition, fluid movement is promoted in adjacent salt-withdrawal basins as a result of variations in geometry and head-gradient within reservoir rocks. With salt comprising a natural barrier to fluids, it becomes crucial to understand how the stratigraphy and structure vary in relation to salt structures, so that hydrocarbon exploration can lead to significant discoveries.

Proposed Aims

Specifically, the project will be focused on the following tasks:

1) To relate the main architectural types of channels-fill deposits in the Rio Doce Canyon System – one of the hydrocarbon reservoir rocks in the Espirito Santo area - to specific periods of continental slope evolution, relating their shapes and geometries to discrete eustatic and tectonic events;
2) To investigate the role of major palaeoceanographic events in the shaping and relative development of subsurface structures, with emphasis on the role of contourite currents and related deposition/erosion on halokinesis;
3) To investigate the structural compartmentalisation of reservoir rocks in relation to the syn- and post-rift evolution of passive continental margins.

Following these principles, the CONTISLOPE project will aim at using quantitative interpretation methods applied to 3D seismic data with the purpose of analysing the tectono-stratigraphic evolution of the continental slope and associated reservoir units of the Rio Doce Canyon System, Espirito Santo Basin.

Software for the analysis and interpretation of 3D seismic data will be used to collect seismic attributes with geological significance, including: seismic coherency maps, AVO analyses, synthetic seismograms, seismic amplitude data, Vp/Vs analyses together with correlations between wireline data (gamma-ray, borehole velocities, neutron and density logs) and subsurface lithology with the purpose of characterising the physical properties of the subsurface geology.

We will focus our efforts on a continental margin where erosional (submarine canyons, landslides, and slumps) and depositional (prograding upper-slope units, filled submarine channels) processes are known to have controlled subsurface faulting and diapir growth. As most of salt structures present a complex 4D evolution, variations in their geometries and styles of propagation – dependent on local rheology and changes in local stress regimes – will be analysed in detail within the study area of offshore Brazil.

The CONTISLOPE project will be of use to the industry, particularly by reducing exploration risk in deep-water prospects through better predicting the regional distribution, architecture, and rheology of sediment bodies where hydrocarbons may occur. The project will also expect to relate the Rio Doce Canyon System with published classifications of continental slopes, concluding on their potential for fluid expulsion and retention based on morphological, rheological, and architectural analyses of key study areas in the Atlantic Ocean and Mediterranean Sea.

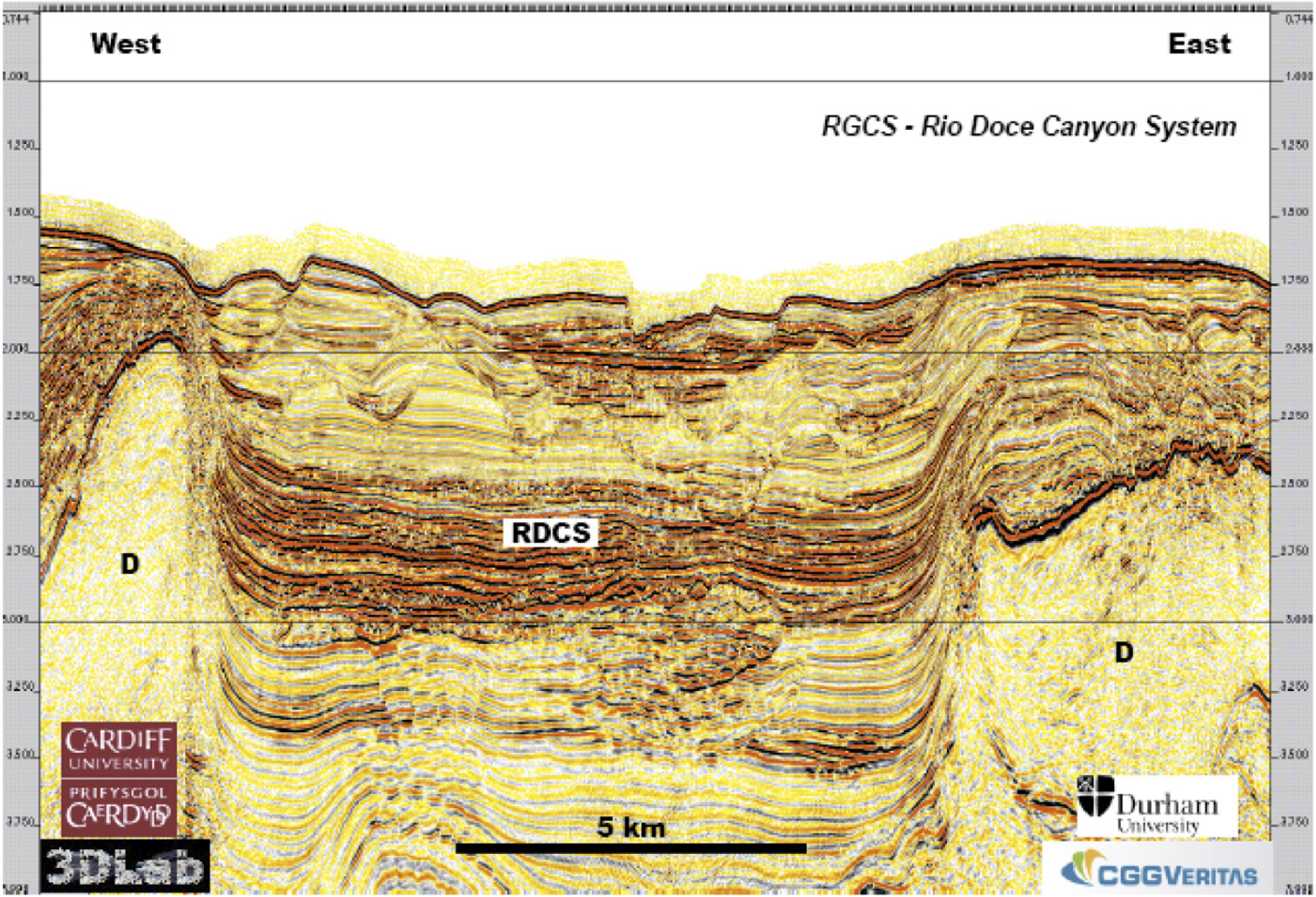

Figure 1. West-east seismic profile, Rio Doce Canyon System.