N107: Turbidite Facies Architecture, Reservoir Applications and Predictive Stratigraphy *(Karoo, South Africa)*

Format and Duration

Field - 6 Days
High Physical Demand

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Summary

This field class examines the links between depositional processes, facies distribution, reservoir architecture and stratigraphic evolution of the deepwater complexes of the southwestern Karoo Basin, South Africa. The differences in morphology, stacking patterns and stratigraphic fills of channels from basin floor to shelf margin/fluvial systems are investigated. The course reviews the evolution down fan from net-bypass to net-deposition, confined/unconfined transport and deposition and the development and distribution of depositional elements (channel, lobes and levee/overbank deposits).

Learning Outcomes

Participants will learn to:

1. Appraise the depositional processes and products of fine-grained, basin floor to slope turbidite systems at various scales.
2. Predict the development and distribution of facies and facies associations of deepwater fan systems in slope through basin floor settings.
3. Evaluate the architectural styles of different channel types, channel complexes and complex sets in basin floor, base-of-slope and lower slope settings, as well as their association with frontal splay and levee/overbank deposition.
4. Evaluate the significance of linked debrite deposits in the palaeogeographic reconstruction of deepwater deposits.
5. Compose depositional models illustrating reservoir architecture and quality in highly confined to unconfined depositional settings and predict flow barriers related to different orders of depositional cyclicity.
6. Predict the vertical and lateral stacking patterns and internal architecture of sheet sandstones as related to relict depositional topography and volume of flows.
7. Evaluate the significance of fan pinch-out lithologies in terms of reservoir potential and sealing aspects.
8. Assess mechanisms of fan evolution in terms of high-frequency sandy growth phases, periods of starvation and its bearing on the distribution of reservoir and non-reservoir facies.
9. Evaluate the influences of basin floor and slope topography on facies distribution.
10. Integrate different scales of observation including basin/exploration scale (sequence expression on the basin floor and sequence stacking) and development/ production scale (facies distribution, stacking patterns, bed-scale stratigraphy and hierarchy of architectural elements) within distributive deepwater systems.

Training Method

A six-day field course visiting the Tanqua and Laingsburg subabsins of the Karoo. The proportion of field time to classroom time is approximately 90:10. Field exercises include interpretation of cliff exposures on photo panels and measuring of vertical sections and are aimed at developing a sense for scale, i.e. from seismic to core and log scale, and an understanding of vertical stacking patterns and architectural style of depositional elements. Participants are also encouraged to bring some of their own data for further

discussion.

Physical Demand

The physical demands for this class are HIGH according to the Nautilus Training Alliance field course grading system. The Karoo area is a semi-desert terrain with temperatures up to 35°C. The field area lies at about 450 m above sea-level (1500 ft) which can lead to unexpected fatigue or shortness of breath for some participants. Access to outcrops is relatively easy but with extensive walking in places, often across scrubby, rocky and steep ground. There will be walks of up to 2 km (1.2 miles) most days.

The longest walk on the class is approximately. 6 km (4 miles) with an ascent of 700 m (2300 ft). This day is particularly strenuous with participants being away from the vehicles for 6/7 hours. As part of this day there is a point at which participants may choose to take an optional, circular hike to summit Skoorsteenberg 1250 m (4100 ft). Participants should be realistic about their fitness levels if attempting this hike.

Who Should Attend

Geoscientists actively involved in exploration and development in deepwater clastic systems. This class will appeal to those working in a range of disciplines including geologists, geophysicists, quantitative seismic interpreters and reservoir engineers.

Prerequisites and Linking Courses

It is assumed that participants will have knowledge of the fundamental processes and terminology of deepwater sedimentology before attending the class. This can be gained at Basic Application Competence Level on N155 (Introduction to Clastic Depositional Systems: a Pertroleum Perspective) and N156 (Clastic Depositional Systems in a Basinal Framework: Exploration and Reservoir Implications, Pyrenees, Spain). Nautilus offers a wide range of additional deepwater field classes, at Skilled Application Competence Level, including those focusing on sedimentology (N009, N102), topography (N112, N252) and structural control (N028, N218). Please see the Nautilus Training Alliance website for detailed descriptions of these and other deepwater courses.

Course Content

The excursion will visit areas of world class 3D exposures where minimal vegetation and variable outcrop orientation enable virtually all areas of a fan system and the architecture of stacked fans to be examined in a 3D sense.

A central theme of the course will be to explore the link between depositional processes, sequence stratigraphic framework, facies distribution, and resultant architecture in a generic sense. As such, the ideas presented are exportable worldwide.

The key points to be addressed in studying the western Karoo deepwater deposits include:

- Comparison of unconfined versus confined fan deposition.
- Sequence stratigraphic concepts in deepwater systems including relative base-level controls on sediment supply to the basin, depositional signature of superimposed high-frequency and low-frequency cyclicity, and prediction of flow barriers related to different orders of depositional cyclicity.
- Channel types and their evolution down-fan from erosional/bypass to erosional/depositional to depositional to pinch-out channels at the far basinward limit. Differences between channels in basin floor, base of slope and lower slope settings. Channel-fill/overbank relationships.
- Sheet sandstones and differentiation between distal (down-fan) and lateral (overbank/interchannel) types.
- Stratigraphic significance in fan pinch-out areas in terms of facies characteristics, reservoir potential and sealing issues.
- Mechanisms of fan growth in terms of high-frequency sandy growth phases, separated by fan-wide starvation zones ('flooding surfaces').
- Development of a model for lithology and reservoir quality prediction in fans deposited on a simple basin floor.
- The opportunity to see the stratigraphic fill for the Tanqua subbasin from the deepwater fans, through the slope and shelf margin to shallow marine and fluvial systems. The deepwater elements form the focus of the course itinerary.

Approximate Itinerary

Day 0
Arrival in Cape Town.

Day 1
Breakfast meeting including course and driver safety briefing.
Travel from Cape Town to Inverdoorn Game Reserve. Drive through Cape Fold Belt region via scenic Bains Kloof Pass.
Course introductory talk before dinner.
Overnight - Inverdoorn

Day 2:
Stop 1: Ongeluks River channel complex, base of slope setting, most proximal outcrops of Fan 3. Prediction of facies down-dip and marginally away from the channel complex. Team exercise on photo panels prior to investigating the outcrops.
Stop 2: Fan 5. Pienaarsfontein SE Berg. Ripple cross-laminated fan margin/overbank type facies lateral to Klein Hanklip channel complexes, lower slope setting.
Stop 3: Fan 5. Kleine Hanklip. Lower slope channel complexes and interchannel slope deposition. Architectural style of laterally and vertically stacked channel-fills exposed in dip and strike sections. Team exercise on photo panel interpretation to focus on channel architecture and stacking patterns.
-Overnight Inverdoorn

Day 3:
Stop 4: Kleine Rietfontein. Large-scale architectural styles of Fans 1, 2 and 3, channel fills within Fan 4, thin-bedded overbank facies, associated crevasse channel fills. Comparison of Fan 3 facies assemblage with Ongeluks River section. Prediction of facies towards the fan axis of Fan 3.
Stop 5: Kanaalkop channel-fill. Channel-fill/overbank relationship in Fan 3. Internal facies and reservoir characteristics of Fan 2.
Stop 6: Los Kop. Pinch out characteristics of Fan 2, broad "channel-fills" near fan axis of Fan 3. Architectural styles of axial "channel-fills" and their lateral changes from axis to off-axis. Team exercise on photo panels.
Stops 7-9: Fan 3 eastern margin and Fan 4. Sedimentary characteristics and internal architecture of sheet-like lobes, interfan sections, reservoir implications.
-Overnight Inverdoorn

Day 4:
Stop 10: Klipfontein area. Group climbs through Fans 3, 4 and 5 and throught the slope succession above Fan 5 (optional) i.e. experiencing a complete exposure from basin floor to shoreface.
Examine depostional characteristics and architectural style of Fan 3 (distal pinch-out area), Fan 4 (mid-outer fan sheets and transitional elements) and Fan 5 (base of slope, high aspect ratio channelised). Transition to shelf/prodelta/delta front deposits overlying Fan 5.
-Overnight Inverdoorn

Day 5:
Depart Inverdoorn, drive to Laingsburg.
Overview stop outside Laingsburg town for stratigraphy of the Ecca Group in the Laingsburg subbasin.
Stop 1: Grootkloof area. High resolution basin floor fan stratigraphy (Fan A).
-Overnight Matjiesfontein

Day 6:
Stop 2: Skeiding, Fan B, stacked base-of-slope channel fill deposits. Lateral facies variation from stacked channel-fill to off-axis levee-overbank.
Stop 3: Paardefontein, Fan B architecture - 10 km down-dip from Skeiding.
Stop 4: Architecture of erosive slope setting channel fills along C/D ridge.
Stop 5: Paardefontein, Fan B architecture - 15 km down-dip from Skeiding.
Stop 6: Jakkalsfontein. Stratigraphy of Fan A and Fan B - controlled by early anticlinal basin floor topography? Fan B - medium to thin-bedded ripple-laminated succession.
Stop 7: Waterkloof. Thin-bedded fan margin deposits of Fan B - result of basin floor control on facies distribution?
-Overnight Matjiesfontein

Day 7:
Depart from Matjiesfontein. Travel N1 via Hex River Valley and Worcester to Cape Town.