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

Format and Duration
Field - 5 Days
High Physical Demand

Instructor(s): De Ville Wickens and Dave Hodgson

Summary

This field course demonstrates the down-fan evolution from net-bypass to net-deposition, confined to unconfined transport and deposition, and the development and distribution of depositional elements such as channels, lobes, and levee/overbank deposits. It further integrates the different scales of observation, namely the basin scale (exploration/seismic) and production scale (facies distribution, stacking patterns, bed-scale stratigraphy, and hierarchy of architectural elements) within distributive deep-water systems.

Business impact: Participants on this field class will examine the **links between depositional processes, facies distribution, reservoir architecture, and stratigraphic evolution** of deep-water fan complexes. The Tanqua sub-basin of the western Karoo Basin offers world-class 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.

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 deep-water 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 deep-water deposits.
5. Compose depositional models illustrating reservoir architecture and quality in highly confined to unconfined depositional settings and predict flow barriers and baffles 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 deep-water systems.

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Training Method

A field course visiting the Tanqua sub-basin of the western Karoo, South Africa. Field exercises include delineation and interpretation of depositional elements on photo panels of cliff exposures and measuring and correlation of vertical sections; 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 form part of creating a depositional framework for deep-water sedimentation. Participants are encouraged to bring some of their own data for further discussion.

Physical Demand

The physical demand for this course is HIGH according to the RPS field course grading system. The Tanqua Karoo area is a semi-desert terrain with temperatures up to 38°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 extend the hike up to the summit of Skoorsteenberg 1250 m (4100 ft). Participants should be realistic about their fitness levels before attempting this hike.

Who Should Attend

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

Course Content

The key points to be addressed in studying the western Karoo deep-water deposits include:

- Comparison of unconfined versus confined fan deposition.
- Sequence stratigraphic concepts in deep-water 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/pinch-out at the far basinward limit. Differences between channel-fills in basin floor, base of slope and lower slope settings and their relationship to overbank development.
- 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.

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- 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 (unconfined?) basin floor.
- The opportunity to see the stratigraphic fill for the Tanqua sub-basin from the basin floor and deep-water fans, through the slope and shelf margin to shallow marine and fluvial systems. The deep-water elements form the focus of the course itinerary.

Approximate Itinerary

Day 0 - Arrival in Cape Town

Day 1

- Breakfast meeting - summary of course itinerary, logistics, and HSSE 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: Ongeluk 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: 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 Ongeluk River section. Prediction of facies towards the fan axis of Fan 3.
- Stop 3: Kanaalkop channel-fill. Channel-fill/overbank relationship in Fan 3. Internal facies and reservoir characteristics of Fan 2.
- Overnight Inverdoorn

Day 3

- Stop 4: Los Kop. Pinch out characteristics of Fan 2. Architectural styles and lateral changes from axis to off-axis of transitional elements (broad "channel-fills") near fan axis of Fan 3. Team exercise on photo panels.
- Stops 5-7: Fan 3 eastern margin and Fan 4. Sedimentary characteristics and internal architecture of sheet-like lobes complexes, interfan sections, reservoir implications.
- Overnight Inverdoorn

Day 4

- Stop 8: Klipfontein area. Group climbs through Fans 3, 4 and 5 and through the slope succession

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- above Fan 5 (optional) i.e. experiencing a complete exposure from basin floor to shoreface.
- Examine depositional 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 prodelta/delta front deposits overlying Fan 5.
- Overnight Inverdoorn

Day 5

- Stop 9: Groot Hangklip, Kleine Hangklip: Fan 5 slope channels overlain by shelf-edge deltas, and abrupt oblique up-dip pinchout of Fans 3 and 4. 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.
- Stop 10: Blaukop, Juxtaposition of channels and lobes, and comparison to basin-floor lobe architecture
- Depart from the field. Travel NI via Hex River Valley and Worcester to Cape Town for return flights.