N574: Submarine Fan Architecture from the Upper Slope to the Distal Basin Floor: Implications for Reservoir Distribution and Development *(Southwestern Karoo Basin, South Africa)*

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Format and Duration

Field - 5 Days
Moderate Physical Demand

Summary

Using world-class outcrops of submarine fan deposits representing upper slope to distal basin floor settings, participants will make multi-scale observations by integrating well-log and core data across a wide range of deep-water depositional environments. This field course visits areas of world-class 3D exposures where minimal vegetation and variable outcrop orientation enable study of virtually all areas of multiple submarine fan systems, from upper slope to distal basin-floor settings. Therefore, the depositional architecture of seismic-scale submarine fans can be placed within a 3D framework, providing the links between sedimentary processes and facies distributions of deep-water systems, their stratigraphic evolution, and resultant reservoir implications. A central theme of the course will be an exploration of the links between sedimentological processes and facies distributions within the seismic-scale depositional architecture of these submarine fans. The outcrops have been the focus of two decades of research and as such, the concepts presented are cutting-edge, and the scale of the systems visited means learnings can be exportable. The course reviews cutting-edge concepts on the sedimentary processes and stratigraphic evolution of fan systems down-system and through time, from confined net-bypass sediment transport to unconfined net-deposition, and their effects on reservoir architecture, and stacking patterns. Recognition criteria for channel-fills, levee/overbank deposits, channel-lobe transition zones, lobes, and clastic injectites will be provided. Furthermore, the detailed mapping of these systems reveals the influence of subtle and evolving seabed topography on submarine fan evolution, a critical aspect worth discussing.

Learning Outcomes

Participants will learn to:

1. Appraise the depositional processes and products of fine-grained, upper slope to basin floor submarine fan systems at various scales, including recognition criteria for different submarine fan settings.
2. Establish a range of recognition criteria for areas and periods dominated by sediment bypass, and the critically assess the use of bed types, including transitional flow deposits, in the palaeogeographic reconstruction of deep-water systems.
3. Appraise the impact and influence of mass transport complexes and clastic injectites on the reservoir architecture and properties of deep-water systems.
4. Assess the architectural styles of different channel-fill types and their stacking patterns to form channel complexes and complex sets, as well as their stratigraphic association with internal and external levee and frontal lobe deposits.
5. Construct depositional models for submarine fan lobes and lobe complexes in intra-slope and basin floor settings, their reservoir architecture, and the controls on stacking patterns.
6. Assess the mechanisms controlling fan evolution in terms of autogenic and allogenic processes to predict the segregation of grain-sizes responsible for the distribution of flow baffles, barriers, and

reservoir.
7. Evaluate the influences of subtle basin floor and slope topography, inherited and/or active, on sedimentary processes and the significance of a range of pinch-out types on stratigraphic trapping in this environment.
8. Integrate different scales of observation including basin/exploration scale and development/production scale (facies distribution, stacking patterns, bed-scale stratigraphy and hierarchy of architectural elements) within distributive deep-water systems.

Training Method

A field course examining the deep-water systems of the Laingsburg depocentre of the southwestern Karoo Basin. The proportion of field time to classroom time is approximately 90:10 percent. Field exercises include interpretation of cliff exposures on photo panels, measuring of vertical sections, outcrop to well correlations, and well prognosis. Participants are encouraged to bring some of their own data for further discussion.

Physical Demand

The physical demands for this class are MODERATE according to the RPS field course grading system. The Karoo area is a semi-desert terrain with temperatures up to 35°C. The field area lies at about 800 m above sea-level (2600 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 1-2 km (0.6-1.2 miles) most days. Transport will be on paved roads and well-maintained tracks.

Who Should Attend

This course is ideally suited for experienced geoscientists actively involved in exploration or development in deep-water clastic systems.

Course Content

The key points to be addressed include:

- Differences between channel-fill types; their stacking patterns in basin floor, base of slope and lower slope settings; relationships with levees; controls on grain-size segregation.
- Differences between lobe dimensions, geometries, and their stacking patterns in intra-slope, base-of-slope, basin-floor, and crevasse settings.
- Differentiation of thin-bedded turbidite environments, including distal (lateral and frontal lobe fringe) and lateral (levee and terrace deposits) types.

- Identification of sediment bypass dominated zones and the role of channel mouth transition zones in reservoir characterisation.
- Expression of sandbody pinch-outs in terms of sedimentary facies characteristics, reservoir potential, and sealing issues, including the role of clastic injectites.
- Stratigraphic evolution of submarine fans, and the balance of autogenic and allogenic controls on the patterns of deep-marine progradation and retrogradation.
- Impact of mass transport complexes on submarine fan architecture.
- Development of a model for grain-size, facies, and reservoir quality prediction in submarine fans deposited on a stepped basin margin.

Itinerary

Day 0: Arrival in Cape Town

Day 1

- Breakfast meeting including HSSE briefing.
- Travel from Cape Town to Laingsburg through the Cape Fold Belt region via scenic Du Toitskloof Pass.
- Stop 1: Overview stop outside Laingsburg town for stratigraphy of the Ecca Group in the Laingsburg depocentre.
- Stop 2: Walk through the stratigraphy of the Laingsburg depocentre at the Ouplaas section, from distal basin-floor and MTCs of the Vischkuil Fm. through lobe complexes of Fan A and B, to submarine slope of Fans C-E.
- Overnight Laingsburg area

Day 2: Anatomy of basin-floor lobe complexes

- Stop 1: Kranz, Fan A, lobe identification exercise, and stacking patterns from 1D data. Walk through to the stratigraphy from slope to shelf-edge.
- Stop 2: Skeiding, Fan B, stacked base-of-slope channel-fills. Lateral facies variation from stacked channel-fill to off-axis levee-overbank.
- Stop 3: Droogekloof, Fan B, Channel mouth setting and sediment waves.
- Stop 4: Jakkalsfontein. Stratigraphy of Fan A and Unit B – effects of early anticlinal basin floor topography. Fan B - medium to thin-bedded ripple-laminated succession.
- Stop 5: Waterkloof. Thin-bedded fan margin deposits of Fan A – influence of seabed topography on processes and architecture.
- Overnight Laingsburg area

Day 3

- Stop 1: Laingsburg rubbish dump: introduction to a thin-bedded succession associated with submarine channel-fills in Fan C.
- Stop 2: Architecture of channel-levee systems along the C/D ridge - facies distributions and architecture of seismic scale slope channel and internal and external levee systems - group exercise logging sections and, predicting down-dip reservoir and seal distributions over distances of 20, 40, and 60 km.
- Overnight Laingsburg area

Day 4

- Stop 1: Fans C and D distributive and channel-levee systems at Geelbek and intraslope lobes with injectites of Fan E.
- Stop 2: Fans C, D, E injectites and channel-lobe transition zone at Slagtersfontein, and the evidence for a stepped submarine slope.
- Overnight Prince Albert area

Day 5

- Stop 1: Large-scale basin margin failure and mass transport deposits with associated deposits.
- Drive to Cape Town, for departure, via the Swartberg Pass with stops to consider the Cretaceous source-to-sink sediment supply from southern Africa to the Atlantic.