Stratigraphic architecture of deep-water channel complexes: Outcrop analogue insight for base of slope deposits, Tres Pasos Formation, Chilean Patagonia

Ryan V. Macauley and Stephen M. Hubbard

Department of Geoscience, University of Calgary, 2500 University Dr NW
Calgary, Alberta, Canada T2N 1N4
rvmacaul@ucalgary.ca

Abstract

Sedimentologists have examined turbidite deposits in great detail, in part because they commonly exhibit excellent reservoir properties and comprise large-scale sedimentary bodies, which consequently makes them important hydrocarbon exploration targets. Seismic reflection studies have provided significant insight into deep-water sedimentation, particularly when identifying gross-scale architectural characteristics and stages of depositional system evolution. Sedimentological detail irresolvable in seismic data is critical to understanding turbidite reservoir architecture but is difficult to acquire for deeply buried deposits, making outcrop analogues particularly useful. The Cretaceous Tres Pasos Formation of southern Chile is composed primarily of mudstone- and siltstone- dominated strata that represent a prograding continental slope system characterized by > 800 m of bathymetric relief (Figure 1A; Hubbard et al, 2010). It encompasses slope clinoform deposits as well as associated coarse clastic base of slope deposits, which represent an appropriate reservoir analogue for numerous hydrocarbon accumulations currently being explored for along Canada's continental margins. Outcrops like that of the Tres Pasos Formation represent an important means for acquiring the deep-water facies and architectural data necessary to build realistic reservoir models. This study attempts to capture the stratigraphic complexity of sandstone-rich, base of slope deposits found in proximity to the channel-lobe transition.

Architectural analysis was completed on an outcrop belt 3.5 km long and ~350 m thick. Numerous gullies cross-cut stratigraphy at high angles and provide excellent 2-D and 3-D exposures. The database collected consists of over 2500 m of measured stratigraphic section, numerous photomosaics, and ~3000 high-resolution GPS measurements used to map stratigraphic surfaces in 3-D. Channelform bodies 15-40 m thick characterize the stratigraphy, with erosive bases frequently draped by siltstone-dominated deposits (1.5-10 m thick) attributed to sedimentation from largely bypassing sediment gravity flows. Internally, these channel complexes are composed of stacked, smaller channelform elements, with axial portions consisting of amalgamated sandstone sedimentation units 0.2-3 m thick. These units are typically structureless, high-concentration turbidity current deposits with common mudstone conglomerate or very coarse sandstone to granular basal lags. Channel fills are characterized by a rapid transition from axial facies with 90-100% sandstone, to thinly interbedded marginal facies with < 30% sandstone. This facies transition typically takes place over < 20 m, which is a much shorter distance than is commonly expected. Understanding these architectural relationships will add important insight into the prediction of reservoir distribution and quality from 1-D well penetrations.

The overall stratigraphic architecture records punctuated periods of channel incision and subsequent sedimentary bypass followed by depositional stages where channels are in-filled by

collapsing, high-concentration turbidity-currents at the base of slope break. The outcrop belt is characterized by an average net:gross ratio approaching 0.7; however, it is possible that widespread silty bypass deposits would provide barriers to vertical and lateral fluid flow throughout the stratigraphic interval (Figure 1B). The spatial arrangement of low-permeability margin and drape facies mapped in the Tres Pasos Formation provides insight into reservoir architecture of continental slope units and particularly to those deposits in the channel-lobe transition zone.

References

Hubbard, S.M., Fildani, A., Romans, B.W., Covault, J.A., and McHargue, T., 2010, High-relief slope clinoform development: insights from outcrop, Magallanes Basin, Chile: Journal of Sedimentary Research, in press

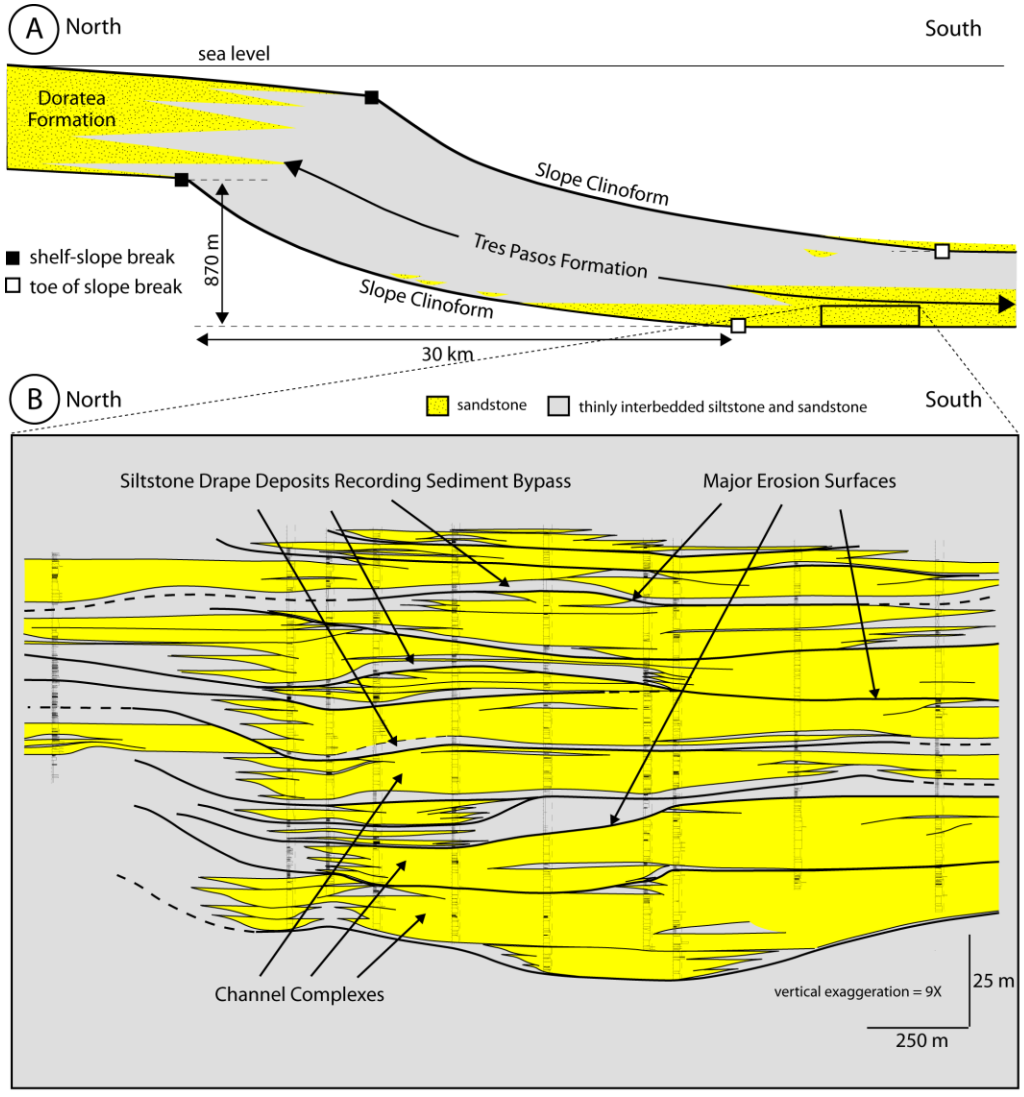

Figure 1 – Regional context and stratigraphy of the Tres Pasos Formation. (A) Schematic cross-section of the Cretaceous slope geometry mapped in the study area, showing prograding clinoforms characterized by >800 m of bathymetric relief (modified from Hubbard et al, 2010). (B) Stratigraphic cross section through the channel deposit-dominated outcrop belt located at the base of slope, showing the channel stacking patterns, erosional surfaces and architectural complexity observed at the channel-lobe transition zone.