Outcrop Example of Intrastratal Slope Deformation Controlled by Depositional Architecture, Tres Pasos Formation, Magallanes Basin, Chile*

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Abstract

Sediments deposited on slopes have been shown to deform in a dominantly down-slope direction driven by the force of gravity after deposition and burial. Multidirectional gravitational spreading and contemporaneous deformation can occur over a broad range of timescales and depths from shallow-subsurface intrastratal faulting and folding to complete remobilization of material at the seafloor. Submarine slope deformation and failure has important implications for various aspects of petroleum exploration and development including: 1) evaluating potential hazards for seafloor infrastructure, 2) reservoir characterization and prediction in slope strata, and 3) interpretation of discontinuous or chaotic seismic facies associated with slope deformation. While instances of intrastratal slope deformation (e.g. creep or slip) have been documented at the microscopic and seismic scales there is a paucity of examples at the scale of centimeters to 10's of meters (reservoir scales). We present an outcrop example of syndepositional to synburial intrastratal slope deformation controlled by the distribution of turbidite deposits. Deep-marine slope deposits of the Cretaceous Tres Pasos Formation in the Magallanes Basin are exceptionally well exposed along a 3.5 km transect of the Rio Zamora at Cerro Mirador in southern Chile. Facies include: 1) thick-bedded sandstone facies (TSF; 25–200 cm beds), 2) thinly interbedded sandstone and mudstone facies (SMF; 5–30 cm beds), and 3) mudstone-prone facies (MPF; 1–10 cm beds). Facies transition significantly at the meter scale both laterally and vertically due to relative position within a composite succession of compensationally stacked, low aspect ratio sandstone-dominated bodies. Localized zones of cm- to m-scale faulting and subsidiary rotation and folding of discrete beds are bracketed by undeformed intervals that are present dominantly
in SMF facies. Fault and fracture planes are parallel to downslope paleoflow orientation. The resulting interpretation is downslope creep deformation with localized slip planes (décollements) in fine-grained interbeds of MPF. The distribution of SMF and/or MPF is interpreted to be a key control on the locations of slip and associated deformation. These results highlight important dynamics and feedbacks in slope environments between depositional architecture, intrastratal deformation, and seafloor topography.

References Cited


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Importance of Meso-Scale Gravitational Deformation

- Previous examples of gravitational deformation
  - ‘Typical’ deep-water fold-thrust belt overlying a slip plane
  - Seismic example of slip plane and gravitational deformation
  - Stratigraphic architecture controls on gravitational deformation

- Basin overview and stratigraphic framework
  - architectural elements
  - regional geometries
  - influence of mass transport deposits (MTDs)

- Intrastratal deformation: outcrop examples and interpretations

- Implications and questions to consider
Seismic-Scale Examples of Gravitational Deformation

Typical Deep-Water Fold-Thrust Belt

Maloney et al., (2010); AAPG Bulletin

Stratigraphic Architecture Influence on Gravitational Deformation

Moretti et al., (2003); Petroleum Geoscience

Seismic-Scale Slip Planes

L’Heureux et al., (2012)
Basin-Scale Stratigraphic Framework: Magallanes Basin, Chile

Section Legend:
- Sandstone
- Siltstone/mudstone
- Mass-transport

North

~100 km

South

Gap in outcrop belt (no data)
Regional Framework and Importance of MTDs

Moscardelli et al. (2006); AAPG Bulletin

Downdip thickening of MTD intervals
Intrastratal Deformation (ISD): Outcrop Example 1

- Thick-bedded, amalgamated sandstone
- Interbedded sandstone, siltstone, and mudstone
- Concordant fine-grained strata
- Mass Transport Complex (MTC)
Intrastratal Deformation (ISD): Outcrop Example 1
Intrastratal Deformation (ISD): Outcrop Example 1
Intrastratal Deformation (ISD): Outcrop Example 1

Paleoflow (n=124)

N

S

5 m

1 m
Intrastratal Deformation (ISD): Outcrop Example 1

Paleoflow (n = 124)

Imbricate

Normal Fault 1

Normal Fault 2

Reverse Fault

Legend:
- Yellow: Thick-beded, amalgamated sandstone
- Orange: Interbedded sandstone, siltstone, and mudstone
- Purple: conglomerate fine-grained shale
- Grey: Mass Transport Complex (MTC)
Intrastratal Deformation (ISD): Outcrop Example 2
Intrastratal Deformation (ISD): Outcrop Example 3
Intrastratal Deformation (ISD): Outcrop Example 4
Intrastratal Deformation (ISD): Outcrop Example 5

Imbricate segments
Conceptual Model for Buttressed Down-Slope Deformation

Slope modified by MTD topography

~ 100 m

~ 1 km
Conceptual Model for Buttressed Down-Slope Deformation

- Slip along weak layer in mud-prone strata
- Extension in response to slip and evacuation of underlying strata
- Flexure and rotation of individual beds
- Faulting of flexed beds and compression due to downslope MTD buttress
Questions to Consider

- Are these intrastratal deformational features more common in slope deposits than currently recognized?

- To what extent do these features contribute to reservoir heterogeneity (e.g., baffles/barriers to flow)?

- Can we predict the occurrence or location of sub-seismic-scale gravitational deformation based on mapping of MTDs and associated sand-prone deposits?
Thank You