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Abstract

Ponded, structurally confined submarine fan systems are common features near earth’s continental margins. These systems often form significant hydrocarbon reservoirs, and they can occur in a wide variety of tectonic settings, including salt-withdrawal mini-basins, extensional-contractional systems (e.g., Mississippi fan fold-belt, and offshore Nigeria), transtensional regions, foreland basins, and fore-arc basins. The Eocene Guaso turbidite system crops out in the Ainsa Basin, a piggyback basin within the South Pyrenean foreland basin system. Outcrops of the Guaso I (GI), a fourth-order cycle within the Guaso turbidite system, reveal a structurally confined, distributive submarine fan.

GI outcrops provide a rare opportunity to document stratigraphic architecture, as well as proximal-to-distal changes in gross thickness, net-sand thickness, lithofacies associations, and reservoir quality for a structurally confined submarine fan. The strata in the proximal slope depositional setting are dominated by mass-transport-deposits (MTDs), sandy debrites, mud-filled channels, and occasional pebble- or sandstone-filled channels. Net-sand values are relatively low (< 10 m) in this area, and gross thickness increases downslope. The medial slope setting contains bedded mudstones, as well as sandstone-filled channels and levees. Net-sand and gross thickness values are higher than in the proximal slope setting. Near the basin’s depocenter, the GI is comprised of mudstone overlain by a thin MTD, which is in turn overlain by ~ 80 m of vertically connected sandstone (with some minor siltstones). The vertical succession of this dominantly sandstone package is: (1) basal lobes; (2) distributary channels and lobes; (3) interbedded very-fine-sandstones and siltstones. This region has the highest net-sand and gross thickness (~150 m) values of the entire system. Near the distal and lateral fan margins, there are minor sandstone-filled channels and thin, tabular sandstone beds intercalated with laminated mudstone. This depositional region has the lowest net-sand values (1-3 m) of the entire GI system.
Stratigraphic stacking patterns document that the GI fan increased in depositional area through time. As depositional area increased, successive lobes and channels increased in the degree of compensational stacking. Data collected in this study can be used to predict architectural and facies patterns in ponded strata of structurally confined turbidite systems in the subsurface.

Selected References


Structural Setting

Geologic Setting

- These reservoirs are most commonly characterized with seismic, well, and/or conventional data. Each of these datasets, however, has limitations in either detail or spatial extent.
- Detailed stratigraphic field studies in analogous deepwater basins, such as the Anza basin, will yield critical quantitative data regarding styles of longitudinal, lateral, and temporal variations in reservoir architecture.
- Structurally confined turbidite systems are prolific hydrocarbon reservoirs around the world, from the Gulf of Mexico to southern California to offshore West Africa.
- Paleogeographic reconstruction using above correlations and paleocurrent data.
- We correlated measured sections, and interpreted time-significant surfaces within the Guaso I cycle. We used these correlations to construct stratigraphic cross-sections.
- Field mapping of cycle-bounding condensed sections, sandstone bodies, and mass-transport deposits (MTDs, i.e. slumps, slides, debris-flow deposits) was conducted.
- We define cycles based on condensed sections, not speculative sequence boundaries.
- Measured 30 sections (1,980 m total); 429 paleocurrent measurements in the Guaso I cycle. We used these correlations to construct stratigraphic cross-sections.
- We used the thickness and net-sandstone values to create isopach maps (gross-thickness and net-sandstone).
- Paleogeographic reconstruction using above correlations and paleocurrent data.

Examples of structurally confined deepwater basins:

- Basin I, Ainsa basin, southern Spanish Pyrenees

Introduction

Data/methods

- Previous Work

Previous Work

- Subcliffe and Pickering (2009) interpreted the Guaso as a structurally confined, delta-fed, low-gradient deepwater clastic depositional system.
- Pickering and Bayliss (2009) interpreted that the Guaso system was sourced from the south, between the two growth anticlines.
- In our present study, we offer a different interpretation for the Guaso (specifically, Guaso I) turbidite system.

Ainza basin, southern Spanish Pyrenees

- In the early Eocene, the Ainza basin developed as a foredeep south and west of the Montsec thrust sheet in the South Pyrenean foreland basin system (Fernandez et al., 2004).
- As thrusting propagated toward the foreland in the middle Eocene, the Ainza basin evolved into a piggyback basin (Fernandez et al., 2004; Hoffman, 2009).
- The entire Guaso system was deposited in ~ 800 ka (Pickering and Bayliss, 2009).

Regional Stratigraphic Framework

- The Ainza basin is currently expressed as the Buil syncline.
- This basin is bounded by the Mediano and Boltana anticlines, to the east and west, respectively. These structures were active in the middle Eocene during the deposition of the basin’s deepwater clastic systems.
- The Guaso I turbidite system is sourced from the south, west of the two growth anticlines.
- The Guaso I turbidite system is proximal to the Ainza basin (Hoffman, 2009).

Geologic Setting

- The Ainza basin is a structurally confined, ponded, delta-fed submarine fan (specifically, Guaso I) turbidite system.
The Guaso I system is an out-of-grade system. There are erosional channels and pervasive mass-transport deposits on the slope, and the depocenter (location of highest gross-thickness value) is on the basin floor. Maximum sandstone content is near the depocenter. Effective subsidence was highest in the early stages (T0-T2) of Guaso I deposition. Later stages exhibit decreased accommodation relative to sediment supply.

Depositional area and degree of compositional stacking increased through time. The system evolved from primarily aggradational (element- and complex-scale) near the depocenter to a more distributive depositional pattern (at Rio Ena) as the area increased.

This study also documents an erosive “basal” sandstone complex at the T0-T1 boundary in the absence of other data. Caution should always be applied to sequence boundary interpretations in the subsurface or in the field, especially when there are only 2-dimensional data available.

Conclusions

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