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OUTCROP ANALOGS OF UPPER MISSISSIPPIAN TO PENNSYLVANIAN CARBONATE BUILDUPS IN THE PRICASPIAN BASIN: ASTURIAS, NORTHERN SPAIN

Kenter, Jeroen A.M.[1]; Keim, Lorenz[2]; Immenhauser, Adrian[1]; Della Porta, Giovanna[1]; Clark, Michael E.[3]; Bahamonde, Juan R.[4]; Reijmer, John J.G.[5]

[1] *Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, Netherlands, kenj@geo.vu.nl;*
[2] *University of Innsbruck, Institut für Geologie & Palaeontologie, Innsbruck, Austria;*
[3] *Tengizchevroil, Tengiz, Kazakhstan;*
[4] *Departemento de Geología, Universidad de Oviedo, Jesús Arias de Velasco, s/n. 33005, Oviedo, Spain.*
[5] *GEOMAR, Wischhofstrasse 8, Kiel, Germany.*

Summary

Seismic-scale, carbonate platforms of Serpukhovian to Moscovian age in northern Spain (Fig. 1A) closely resemble those in the subsurface of the Pricaspian Basin in size, anatomy, relief, and lithofacies distribution. Outcrops in northern Spain provide unique "laboratories" that are used as analogs for subsurface buildups in the Pricaspian Basin (Tengiz and Korolev fields). This paper presents an integrated model of anatomy and lithofacies distribution of the Spanish platforms. In addition, it compares these with Mississippian to Pennsylvanian buildups in the Pricaspian subsurface.

Introduction

In NW Spain, seismic-scale cross sections are exposed in imbricate thrust sheets that were tilted 90° by thin-skinned tectonism as a result of Late Carboniferous Variscan orogeny (Figs. 1B and -C). During late Serpukhovian to Moscovian times (late Mississippian to Pennsylvanian) extensive carbonate platforms developed in Asturias. Five successive stages of platform development were observed: I) renewed flooding of the pre-existing regional Serpukhovian platform, nucleation of a low-angle ramp with automicrite deposits, aggradation and subsequent formation of a steep boundstone margin, followed by horizontal progradation (Bashkirian); II) continued progradation with several aggradational phases (Bashkirian); III) development of an extensive flat-topped shallow-water platform at the Bashkirian-Moscovian boundary followed by combined aggradation and progradation; IV) predominantly progradation followed by; V) aggradation (Moscovian). The last phase includes at least four major episodes of siliciclastic intercalations, some of which are probably associated with subaerial exposure. In other outcrops to the south, alternating siliciclastic – carbonate cycles separated by subaerial exposure surfaces are observed in the Kasimovian.

Stratal patterns

Three stratal domains are observed: 1) horizontally bedded platform, 2) clinoform bedded margin with a relief of up to 850 m and, 3) low-angle toe-of-slope where slope beds interfinger with basinal sediments (Fig. 1D). Platform strata can be traced for hundreds of meters up to more than several kilometers and are parallel except where cut by faults that generally show little displacement. The uppermost slope is indistinctively stratified and was mapped separately as a platform margin belt. The lower part of the slope shows well-bedded clinoforms with depositional dips of 26 to 30°.

Platform

In Asturias, cycles are composed of a basal interval of grain- to packstone with oncoids and lithoclasts (Cb facies) that are suggested to reflect transgressive conditions. The overlying, open marine algal bioclastic pack- to wackestone (A facies) is suggested to be deposited during subtidal conditions and to represent a period of maximum accommodation space and a restricted lagoonal environment. Near the top, fine-grained peloidal wacke- to packstone with calcispheres (B facies) and grainstone dominated by coated grains (Ca facies) are present and proposed to reflect regressive conditions. Stable isotopes and petrographic observations indicate the occurrence of subaerial exposure surfaces in B - and Ca facies.

An interval containing 8 shoaling cycles was physically traced within the inner platform. This study window is more than 2 km in length, up to 70 m in height, and some 750 m away from the platform break. The A facies shows a positive linear relationship between bed thickness and length, or lateral continuity. Bed lengths of more than 2000 m with a thickness of nearly 10 m were recorded. The C - and B facies, thicknesses ranging between 1 and 2 m, lack a clear length – thickness relationship. Their bed length ranges from several hundred meters to, in 3 out of 7 occurrences, more than 2000 m.

Margin and Flank

In Asturias, three lithofacies zones were distinguished. The upper slope, from platform break to ca. 300 m paleo-water depth, consists of clotted peloidal micrite - automicrite - with sponges and fenestellid bryozoans, and crinoid rudstone intervals. Below 300 m paleo-water depth, clast-supported lithoclastic breccia dominates the slope. Finally, below 600 to 700 m argillaceous lime mudstone beds interfinger with grain- to wackestone intervals of mostly platform top derived grains and thick intervals of upper slope-derived breccia.

The upper slope consists of an alternation of three different automicrite facies. First, accretionary - relief building - automicrite with fibrous calcite around fenestellid bryozoans and sponges, and rare crinoids. Second, structureless automicrite with scattered crinoids and fenestellid bryozoans, peloids and rare sand-sized platform-derived grains such as ooids, coated grains, foraminifers and green algae. Finally, breccia with clasts of both lithofacies and a matrix of structureless automicrite. The crinoid grain- to rudstone intervals contain brachiopods, sand-sized platform derived grains, and cm - to dm thick intervals of structureless automicrite.

We assume that, during relative sea-level lowstands, automicrite boundstone formation dominated on the upper slope. Whenever exceeding the shear strength of the substrate of loose sediment, they slid off forming breccia deposits at the mid-slope and tongues at the toe-of-slope. During relative sea-level highstands, the supply of platform-derived grains and crinoid debris prevented automicrite boundstone formation and crinoid-dominated intervals were deposited instead. Crinoid-rich sediments at the lower slope interfinger with argillaceous basin deposits during this phase and pinch out upslope. During the maximum flooding, red condensed intervals formed on the flank; those on the upper flank were preserved whereas those on the lower flank were reworked into breccias and rudstones.

Pricaspian Basin

In Tengiz, shoaling upward cycles grade upcore from open marine conditions into restricted lagoonal and sand shoal facies with numerous exposure surfaces. Though the Tengiz equivalent of the A facies is not present in all Tengiz platform cycles, the B - and C facies are usually observed near the top of the cycles. Locally, the B facies is present at the base of a cycle. The B and C facies are often tight and associated with volcanic ash layers. Pressure data suggest that these facies are concurrent with the presence of horizontally stratified impermeable layers. Local, but limited, core control in specific intervals suggests continuity of these facies among inner platform wells.

Visual inspection of most of the available Tengiz flank cores and thin sections reveals a similar facies distribution along the slope profile as that observed Asturias. Though primary porosity in both flanks is comparable, ranging from 20 to 40%, most of this was occluded by marine - and minor burial cementation, in the Asturian upper slope. In Tengiz though, a significant amount of primary porosity in voids and vugs was preserved but not connected. Preliminary observations suggest that, at least, part of the present reservoir properties in the Tengiz flank are related to post-depositional dissolution and shattering of the originally tight sediment fabric of the automicrite boundstone facies on the upper slope.

Conclusions

The relationship between lithofacies character and - distribution on the one hand and anatomy on the other has been thoroughly documented in carbonate platforms in northern Spain. These observations strongly resemble those recognized in, at least part of the succession in the Pricaspian subsurface (e.g., Tengiz and

Korolev buildups). Careful calibration and integration of the existing information on cores, thin sections and anatomy with the Spanish model offers the opportunity to develop a predictive lithofacies model for the subsurface platforms in the Pricaspian Basin.

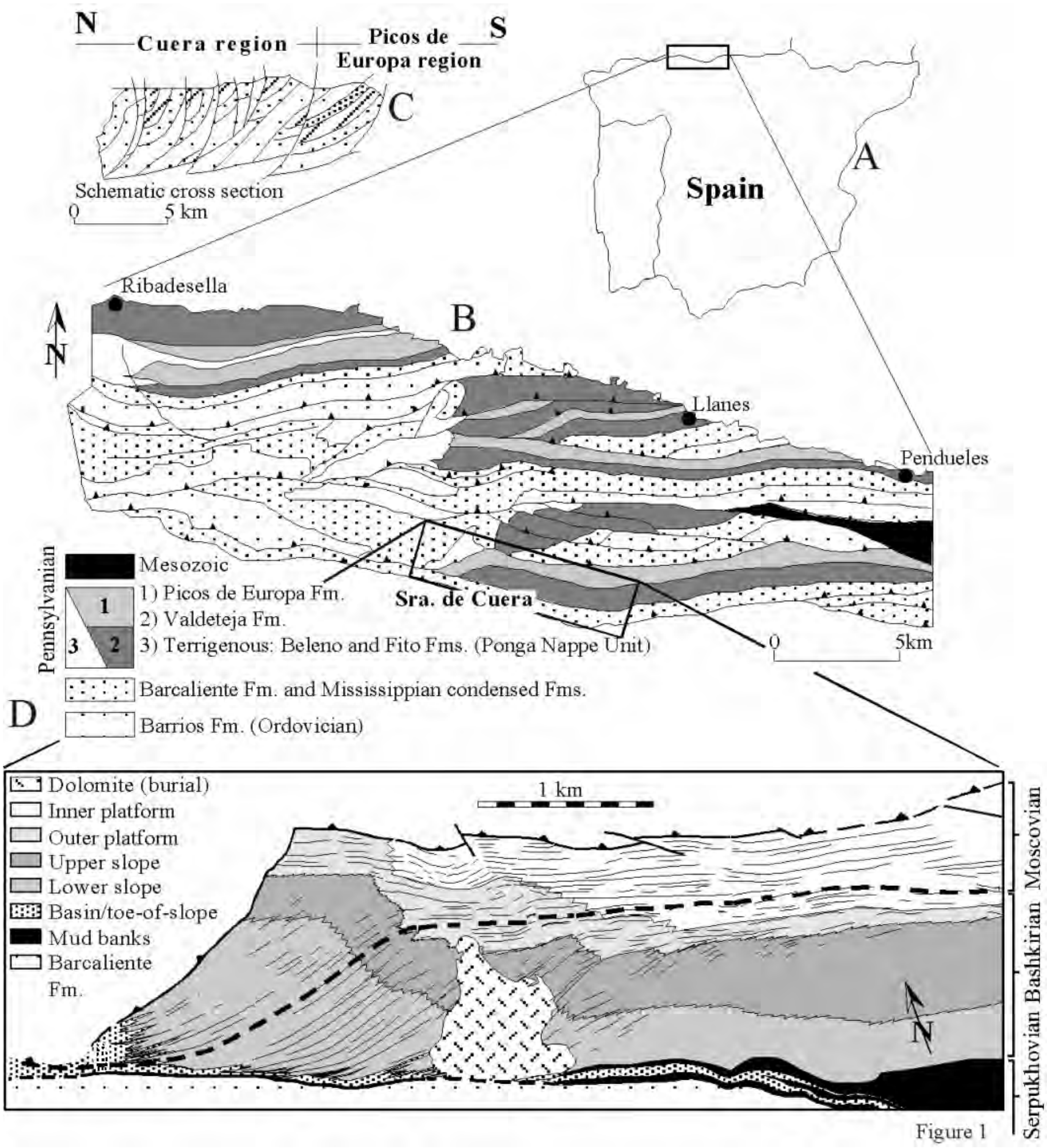

Figure 1