Relationships between Fracture Patterns, Geodynamics and Mechanical Stratigraphy in Carbonates (South-East Basin, France)*

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Search and Discovery Article #120071 (2012)*
Posted December 31, 2012

*Adapted from extended abstract prepared in conjunction with poster presentation at AAPG Hedberg Conference, Fundamental Controls on Flow in Carbonates, July 8-13, 2012, Saint-Cyr Sur Mer, Provence, France, AAPG©2012

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Abstract

We aim at improving the understanding of fracture genesis in layered carbonate sedimentary sequences, focusing on field analysis of Jurassic to Maastrichtian age carbonates of Provence (France). Fracture patterns of nine outcrops were characterized in 3D: 6 of Urgonian, 1 of Tithonian and 2 of Campanian-Late Maastrichtian ages. Seven sites are located in relatively weakly deformed areas away from larges fault and fold zones where strain partitioning and stress localization effects may take place. Two sites are located in fold flanks for relative dating and for comparison with the sites in the weakly deformed areas. Patterns and detailed fracture attributes were compared to host rock sedimentary facies, porosity and P-wave velocities. Fracture chronology was determined with crosscutting relationships and compared to burial/uplift history reconstructed from subsidence curves and from a regional structural analysis.

Our results show that fractures are clustered in two perpendicular joint sets whatever the host rock age (Figure 1). We observe an average spacing of 20cm and no control of strike, age, facies, or bed thickness on fracture size. There is no mechanical stratigraphy (Figure 1). The fracture sequence compared to subsidence curves indicates that fractures occurred before tectonic inversion, during early and rapid burial, whatever the host rock age and facies. The abundance of burial stylolites does not correlate with maximum burial depth but with fracture frequency, host rock porosity and P-wave velocity (Figure 2).

We conclude that the studied carbonates had early brittle properties controlled by their geographic position rather than by depositional facies types and undergone early diagenesis. The porosity loss/gain and the mechanical differentiation in carbonates of Provence could have been acquired during very early burial and diagenesis and have preserved through time.

This study also demonstrates that regional fracturing is not necessarily driven by large-scale structural events as it is often assumed in fractured reservoir modeling.

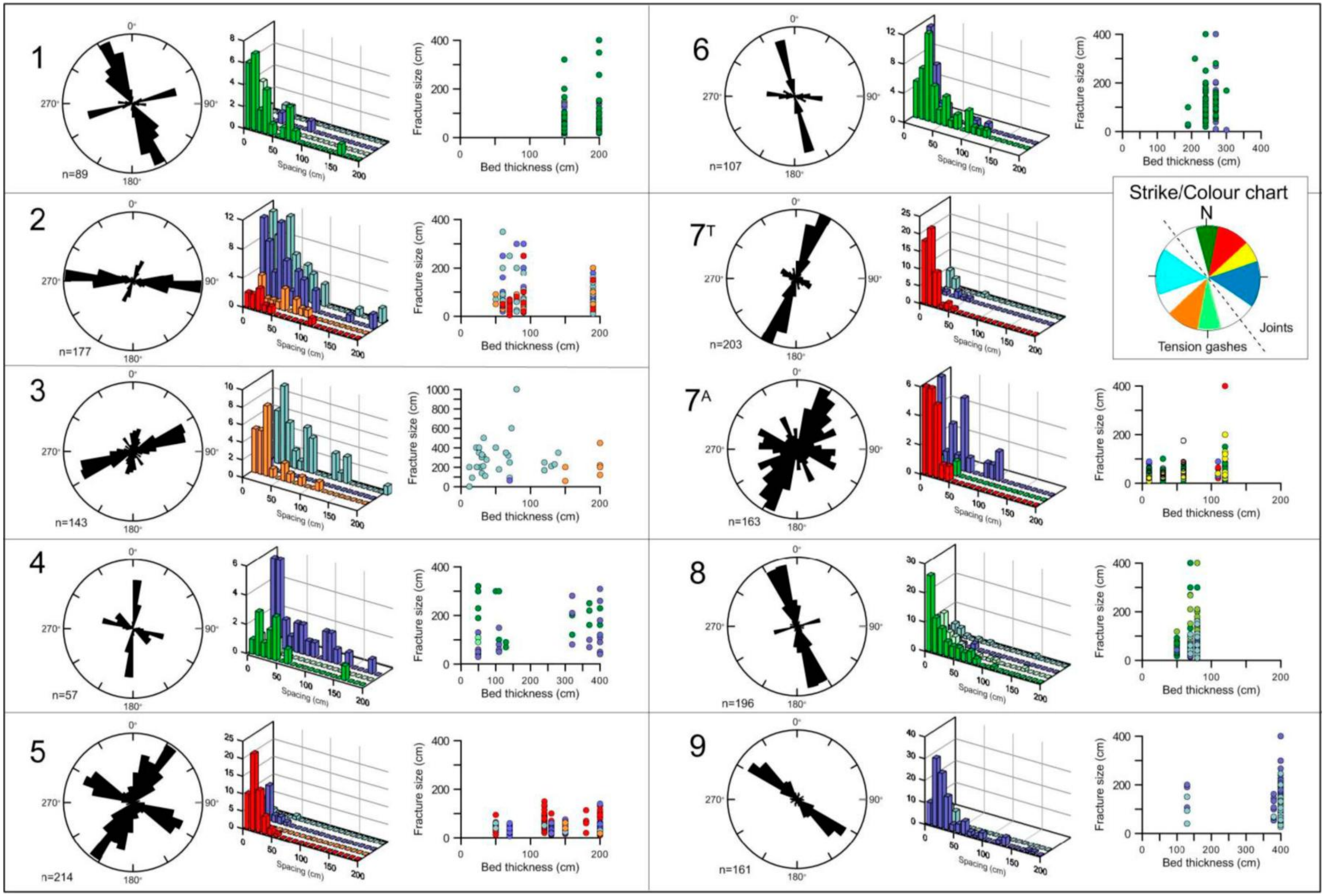

Figure 1. Structural and geometrical analysis of fractures, including joints and veins. Numbers 1 to 9 refer to outcrops 1 to 9 located in figure 1 (7A for Rustrel Antennes; 7T for Rustrel Tunnel). From left to right column: rose diagrams: joints and veins strikes; histograms: fracture spacing; cross-plots: fracture size compare to bed thickness. Colour chart on the figure with dark colours for joints and light colours for veins.

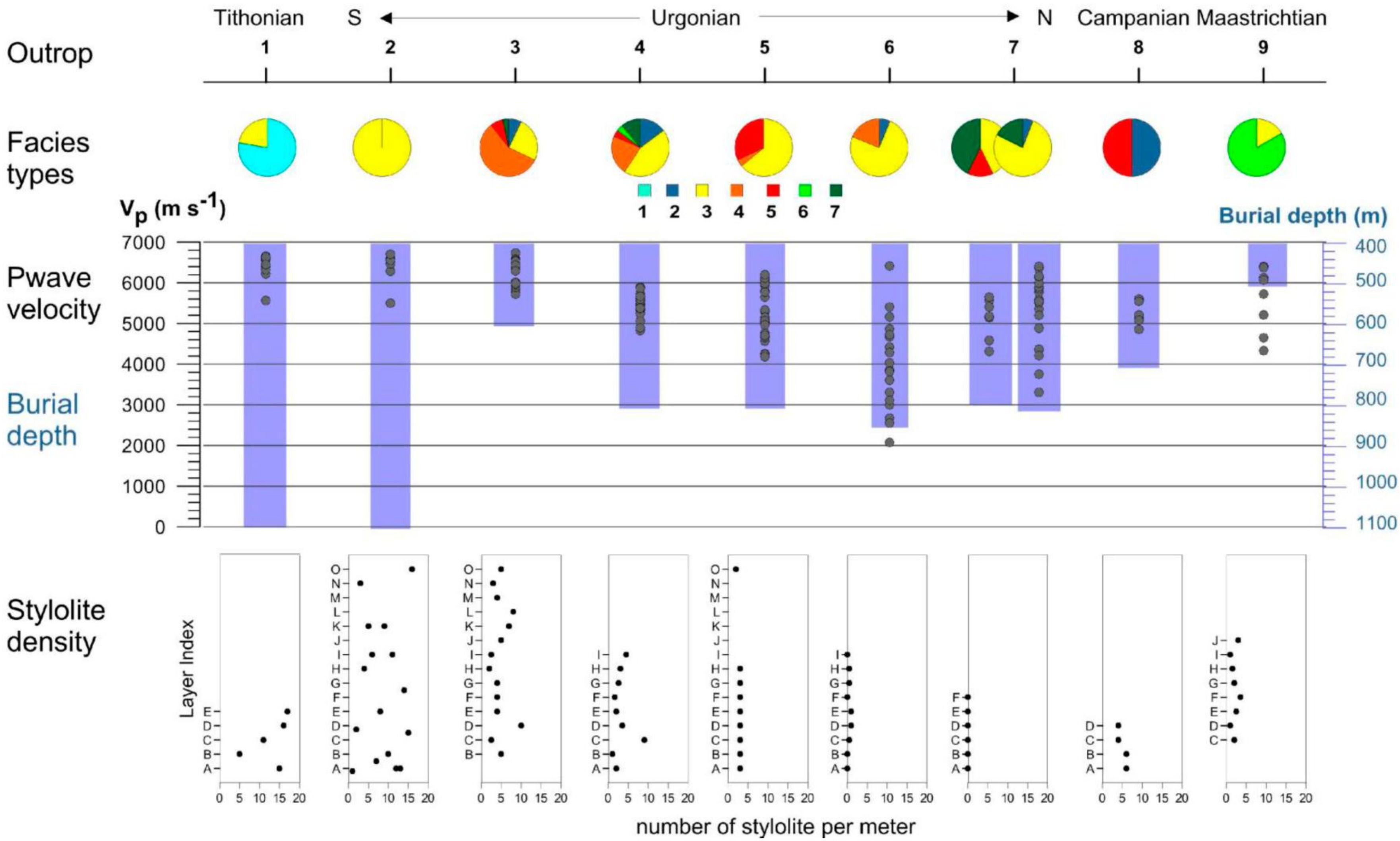

Figure 2. Comparison between (from top to bottom) facies, P wave velocity, maximum burial depth and density of burial stylolites per meter in outcrops 1 to 9 (from left to right). Facies: mixed Dunham and Folk type facies (1) mudstone, (2) wackestone, (3) pelsparite, (4) bio-pelsparite, (5) oosparite, (6) intraclastic pelsparite and (7) biosparite with >20% fauna. See the text for explanations.