Ichnofabrics from muddy shallow-water bottom current deposits, Upper Jurassic to Lower Cretaceous Vaca Muerta Formation, Argentina

Maximiliano Paz (1), M. Gabriela Mángano (1), Luis A. Buatois (1), Patricio R. Desjardins (2), Raúl Notta (2), Federico González Tomassini (3), and Noelia B. Carmona (4,5)

(1) Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5E2, Canada
(2) Shell Exploration and Production Company, 200N Dairy Ashford St, TX 77019, Houston, USA
(3) Phoenix Global Resources, Alem 855, C1001AAQ, Buenos Aires, Argentina
(4) Universidad Nacional de Río Negro, Instituto de Investigación en Paleobiología y Geología, General Roca, Argentina
(5) Instituto de Investigación en Paleobiología y Geología (IIPG), CONICET, Av. J. A. Roca 1242, 8332, General Roca, Argentina

Bottom currents induced by thermohaline-, wind-, or tide-driven circulation may occur in shallow waters (50-300 m water depths), such as in outer shelves, upper slopes and shallow sills. The Upper Jurassic-Lower Cretaceous Vaca Muerta Formation in Argentina shows drift deposits located in bottomsets and foresets of a mixed carbonate-siliciclastic, shelf-margin, subaqueous clinoform system that can be analyzed to enhance understanding of ichnofabrics associated with shallow-water bottom current sedimentation. In addition, this formation represents one of the most important unconventional reservoirs in the world, displaying high TOC levels. The drift deposits were recorded in cores from five wells (660.5 m total) located in areas that are currently explored and developed by oil and gas companies. These deposits are composed of massive, cross-bedded and parallel, low angle- and wavy-laminated crinoidal mudstone; crinoid-rich lenses; coarse mudstone laminae encased in fine mudstone; massive, parallel-, low-angle and current-ripple cross-laminated, fine to coarse mudstone; and massive, normal-graded and composite beds of calcareous, fine to coarse mudstone.

In these deposits, four ichnofabrics are recognized: *Palaeophycus heberti, Phycosiphon incertum, Nereites* isp. and Equilibrichnia-Fugichnia ichnofabrics. The *Palaeophycus heberti* ichnofabric consists of shallow-tier *Palaeophycus heberti, Planolites* isp., *Crininicaminus* isp., and rare *Palaeophycus* isp. overprinted onto a mottled background recording irregular biodeformational structures. The *Phycosiphon incertum* ichnofabric is represented by shallow-tier *Phycosiphon incertum, Nereites* isp., *Planolites* isp., *Palaeophycus* isp., and rare *Lockeia*? isp. The *Nereites* isp. ichnofabric is dominated by shallow-tier structures such as *Nereites* isp., *Phycosiphon incertum, Planolites* isp., and *Palaeophycus* isp. The Equilibrichnia-Fugichnia ichnofabric is characterized by very shallow tier *Lockeia siliquaria*, bowl-shaped structures referred to as *Lockeia*? isp., U- and V-shaped, nested vertical to highly inclined structures interpreted as equilibrium and escape structures, and rare *Skolithos*? isp.

These ichnofabrics occur in three different facies. The *Palaeophycus heberti* ichnofabric is dominant in the crinoidal mudstone facies, forming highly bioturbated intervals. The *Palaeophycus heberti, Nereites* isp. and *Phycosiphon incertum* ichnofabrics occur in the fine to coarse mudstone facies, constituting highly, moderately, and sparsely bioturbated intervals respectively. In this facies, m-thick successions display an upward decrease and then increase in bioturbation index that may be similar to the bigradational succession of contourites. The Equilibrichnia-Fugichnia ichnofabric was mostly recorded in the fine to coarse mudstone and calcareous mudstone facies and less commonly in fine to coarse

mudstone facies, forming distinctive bioturbated intervals within scarcely bioturbated, laminated mudstone successions.

Bioturbation was evidently controlled by food distribution, oxygenation, hydrodynamic energy, and water turbidity. Food was delivered at the surface or in suspension, promoting deposit-feeding (*Nereites* isp. and *Phycosiphon incertum* ichnofabrics), suspension-feeding (Equilibrichnia-Fugichnia ichnofabric), or mixed feeding (*Palaeophycus heberti* ichnofabric) strategies in the infauna, respectively. Oxygen levels increased during bottom-current activity compared with other deposits (e.g., basin and slope), yet relatively small burrow diameters indicate that dysoxic conditions were dominant. Hydrodynamic energy controlled bioturbation intensity, resulting in lower degrees of bioturbation during high-energy events. Suspension feeding strategies suggest low turbidity. The present example increases our understanding of environmental controls of shallow-water bottom currents, supporting previous suggestions that bottom-current activity increases background oxygenation of bottom waters. Moreover, it indicates that traction structures in drift deposits can be preserved when bioturbation is suppressed by high hydrodynamic energy and low oxygen conditions.