Stratigraphy and Geochemistry of the Organic-Rich Toolebuc Formation, Upper Albian, Eromanga and Carpenteria Basins, Australia*

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Abstract

The Toolebuc Formation is a widespread, organic-rich rock that covers the northern and central parts of the Eromanga Basin in interior Queensland, Australia (Figure 1). It is late Albian in age.

The Toolebuc unconformably overlies the Middle Albian Wallumbilla Formation (Figure 2), a silty organic-lean mudstone deposited basinward of marginal-marine to shelfal sandstones to the south (Figure 1). The content of carbonate and organic carbon increases abruptly at the base of the Toolebuc.

The Toolebuc thins and laps out along this depositional basin margin in the southern Eromanga Basin (Figure 1). It thins by onlap onto the southern and eastern margins of the basin, as well as onto topographic highs within the basin, most notably at Julia Creek.

The top of the Toolebuc is gradational with silty organic-lean mudstones of the Allaru Formation (Figure 2). This transition from carbonate-rich to quartz-rich mudstones occurs over a span of 3-5 meters. The Allaru is also Late Albian in age.

Stratigraphy and Geochemistry

The Toolebuc consists of 1 to 3 basinally restricted sequences, each marked by an abrupt increase in organic carbon at the base, which in most cases gradually decreases upwards. These sequences can be regionally correlated, as shown in Figure 3. The base of each sequence of the Toolebuc is unconformable and laps onto the underlying strata.

An organic-rich claystone occurs at the base of the Toolebuc in 4 cores. The claystone is laminated and contains an average of 18% $CaCO_3$ as lime mud in the matrix. It is present where the Toolebuc is thickest and reaches a maximum thickness of 14.1 meters in BMR Croydon 1. The average TOC is 6.6% and the average HI is 491 mg HC/g TOC, and both are constant or slightly increase upwards. The underlying Wallumbilla mudstones have an average TOC of 1.8%, average HI of 82 mg HC/g TOC, and 5% $CaCO_3$.

Overlying the basal claystone is laminated organic-rich chalk with an average content of 57% $CaCO_3$. Thickness varies greatly, from 2.7-14.4 meters, due to onlap of lower beds onto the underlying claystone or older Wallumbilla, and it is absent in the southeast Eromanga Basin. TOC and HI are uniform across the basins, averaging 10.6% and 591 mg HC/g TOC. TOC slightly decreases upwards from the base in several cores, but HI remains fairly constant.

The upper Toolebuc sequence is the most widespread. This upper sequence is 4.0-13.3 meters thick. In most cores it consists of interlayered bivalve-shell limestone and organic-rich chalky mudstone with an average of 56% $CaCO_3$. It changes facies to claystones that have an average of 28% $CaCO_3$ in south and southeast Eromanga Basin, where older sequences are absent. TOC and HI are uniform across the basins, averaging 7.4% and 534 mg HC/g TOC. Both TOC and HI decrease upwards in most cores, especially at the top 2-5 meters of the formation, due to an increase in terriginous organic matter and detrital sediments transitional with the Allaru mudstones, which have an average TOC of 1.6%, average HI of 73, and 8% $CaCO_3$.

The composition of organic matter varies vertically within the Toolebuc, as determined by organic-geochemical analyses of solvent extracts (Figure 4). The organic matter is marine, with high HI values and no oleanane, except for the uppermost mudstones that grade into the Allaru mudstones that have low HI values and oleanane present. The lower part of each sequence tends to have been most reducing (highest gammacerane contents) and contains the most bacterial input (highest percentage of C35 pentacyclic terpanes).

Conclusion

The Toolebuc was deposited during a sea-level low and is underlain and overlain by highstand siliciclastics. There are no systematic variations in organic content across the basin. The high content of marine organic matter was formed by increased productivity and preservation in a wide, shallow and somewhat restricted sea.

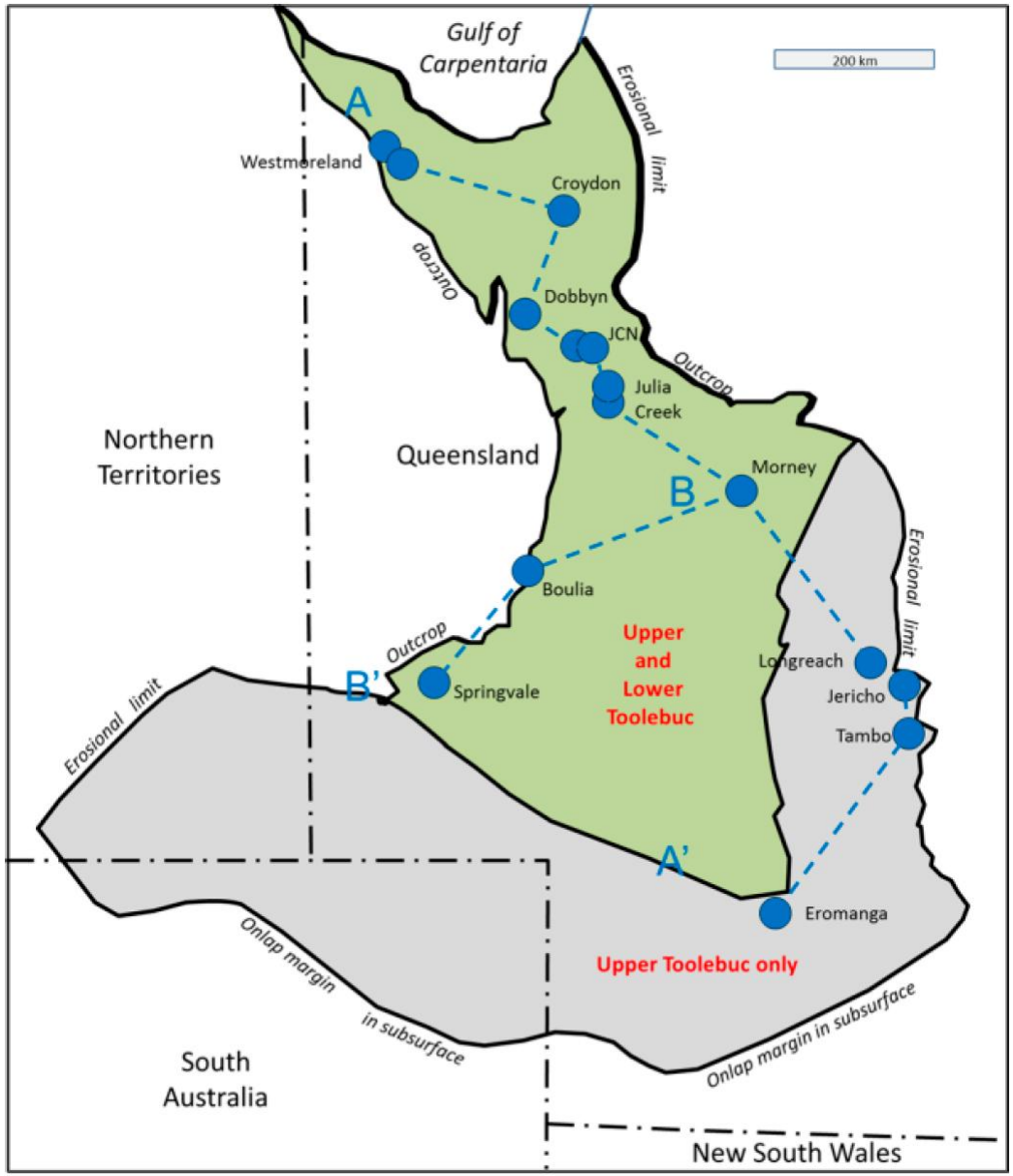

Figure 1. Distribution of Upper and Lower Toolebuc Formation and boreholes studied.

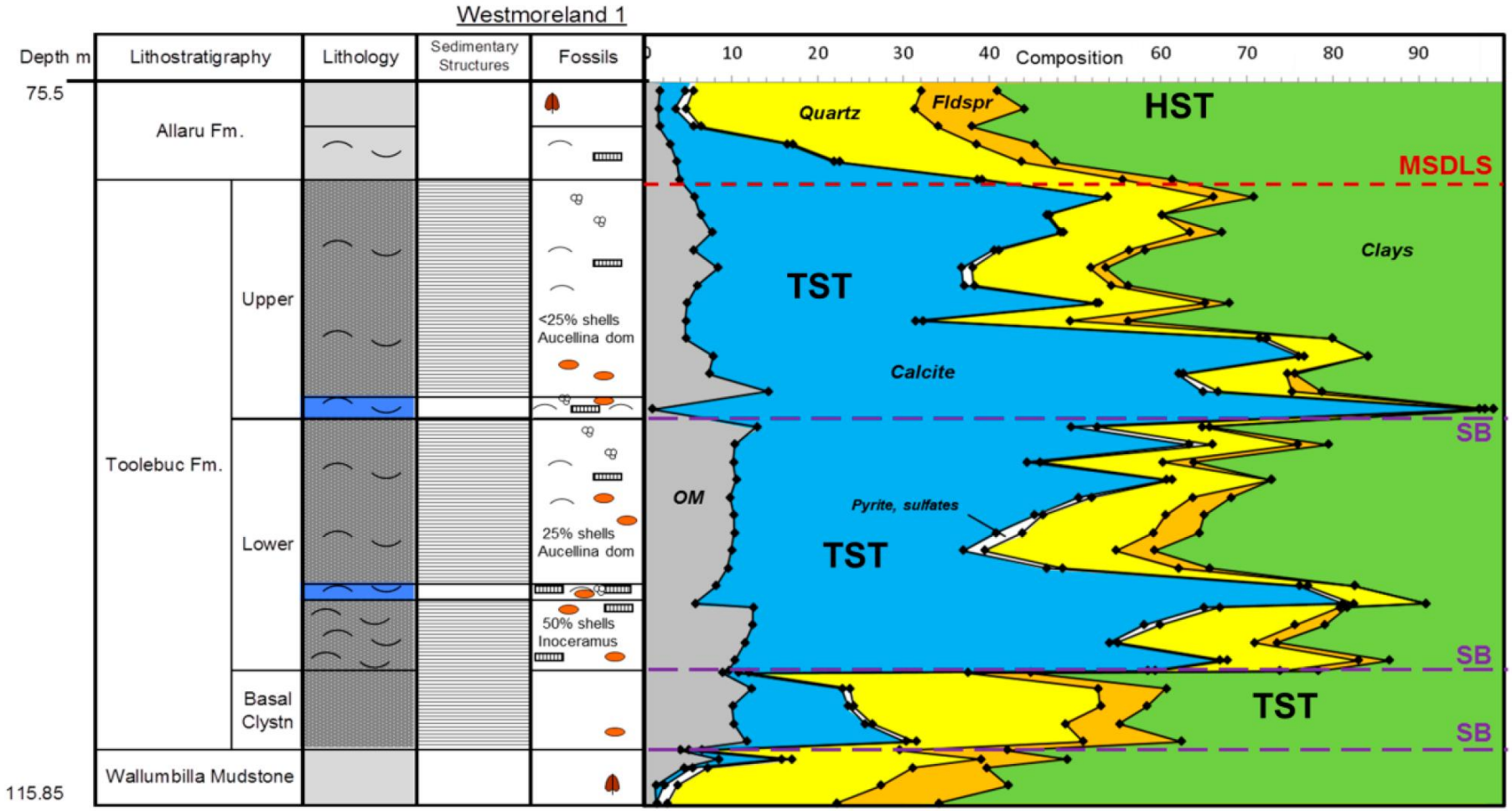

Figure 2. Lithology and composition of Toolebuc Formation in Westmoreland 1 borehole.

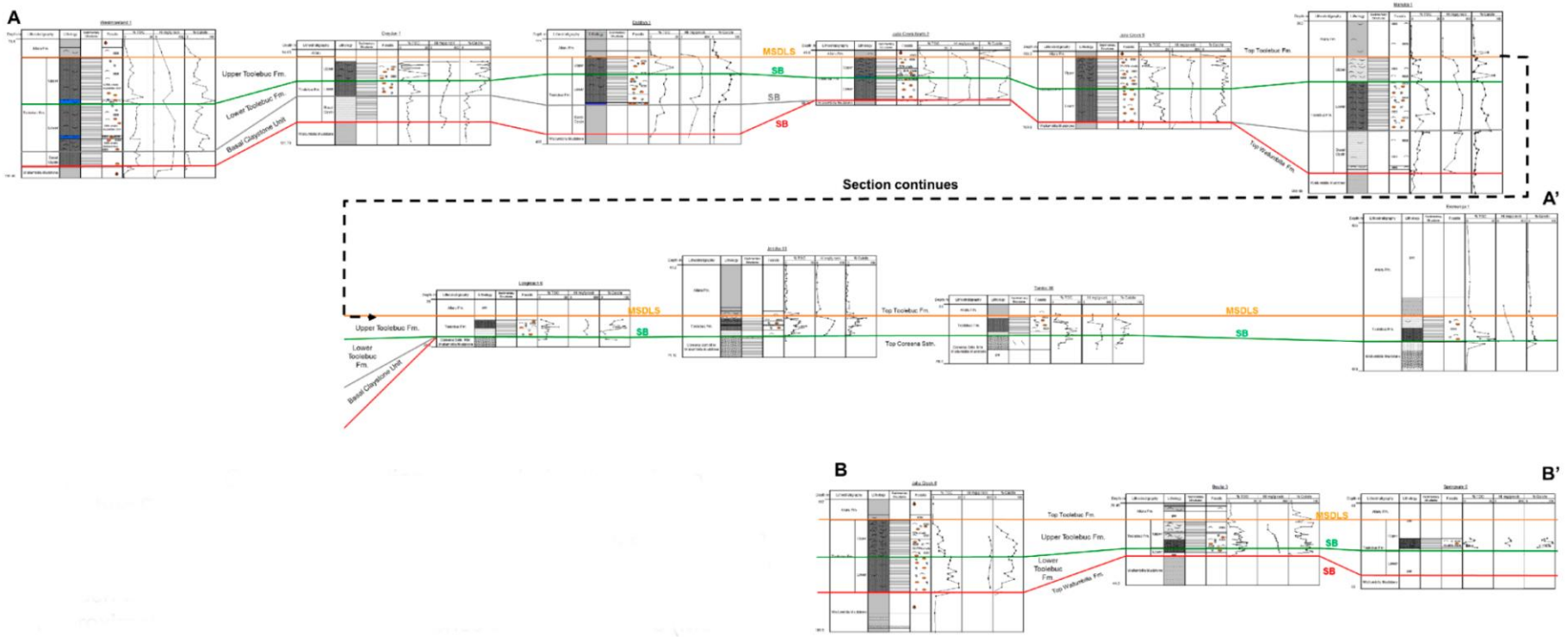

Figure 3. Correlation sections of boreholes through the Toolebuc Formation. Lithostratigraphy, lithology, sedimentary structure, fossils, % TOC, HI from Rock-Eval pyrolysis, and % calcite are plotted for each borehole. Sequence boundaries (SB) at the base of each unit of the Toolebuc are correlated, along with the approximate position of the mid-sequence downlap surface (MSDLS) at the top of the Toolebuc.

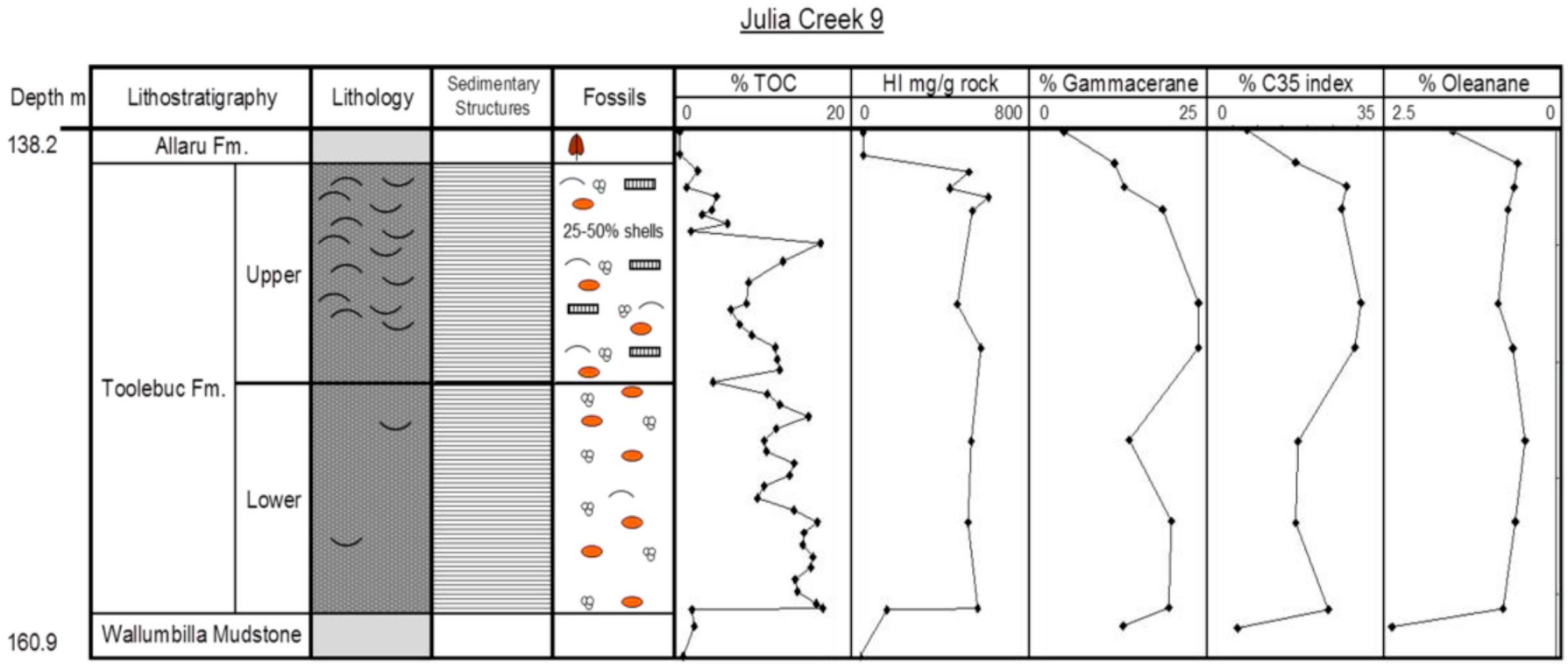

Figure 4. Organic-geochemical parameters for the Julia Creek 9 borehole.