

WHEN BIODEGRADATION SCALES FAIL: BASIL FAWLTY DOES ATHABASCA

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Biodegradation of crude oils in subsurface petroleum reservoirs is an important alteration process affecting most of the world's oil deposits. The process preferentially removes light components from conventional oil to form heavy oil and ultimately the bitumen of the tar sands. Detailed analysis of the hydrocarbon components in a suite of sequentially biodegraded oils sometimes reveals a number of systematic changes amongst the hydrocarbon compositions and Peters and Moldowan (1993), among others, proposed a ten point scale system to give an indication of the level of biodegradation that had been encountered during petroleum biodegradation. In this study, we show the difficulties that we have encountered in applying the usual biodegradation schemes to indicate relative levels of biodegradation in the Athabasca tar sands.

The Athabasca tar sand deposit contains an estimated 1.7 trillion barrels of heavily biodegraded oil in L. Cretaceous sandstone reservoirs of the McMurray Formation. The levels of degradation according to the Peters and Moldowan (1993) scheme is at least PM level 5, characterized by the lack of n-alkanes and branched alkanes such as isoprenoids, pristane and phytane. In general, the levels of biodegradation range from PM level 5 (heavy) to PM level 9 (severe) as indicated by changes amongst the biomarker compounds, such as the steranes, diasteranes and hopanes. So far, so good! We observe however that across the tar sand province several variations on geochemical transformation themes exist. Thus the degradation of hopanes may occur simultaneously with the formation of 25-norhopanes but with variable conversion efficiencies and it is also noted that hopane degradation can also occur without 25-norhopane formation (Bennett et al., 2006). The presence of hydrocarbon compositional gradients, showing increasing degradation towards an oil-water contact is common in the Athabasca tar sand reservoirs. Figure 1 shows the mass fragmentograms displaying the changes in sterane distributions over a ten metre depth interval. The example here shows increasing extent of the degradation of steranes and diasteranes down through the oil column such that the most degraded oil is shown at the base of the oil column. The degradation of steranes is equivalent to PM level 7 while the degradation of diasteranes is represented by PM level 9 (incidentally the hopanes are also being attacked in this interval indicating PM level 8).

We also illustrate how degradation schemes based on the aromatic hydrocarbons may also show very different systematics. Thus amongst the methylphenanthrene isomers, 9-methylphenanthrene often shows selective resistance to degradation but sometimes this compound may be preferentially removed. We indicate how charge history, reservoir environment (e.g. presence/absence of water legs) and variations in the facies and extent of the basal biodegradation reaction zone lead to the many and varied petroleum compositions that are a feature of the Athabasca tar sands, and we expect many other degraded oil provinces.

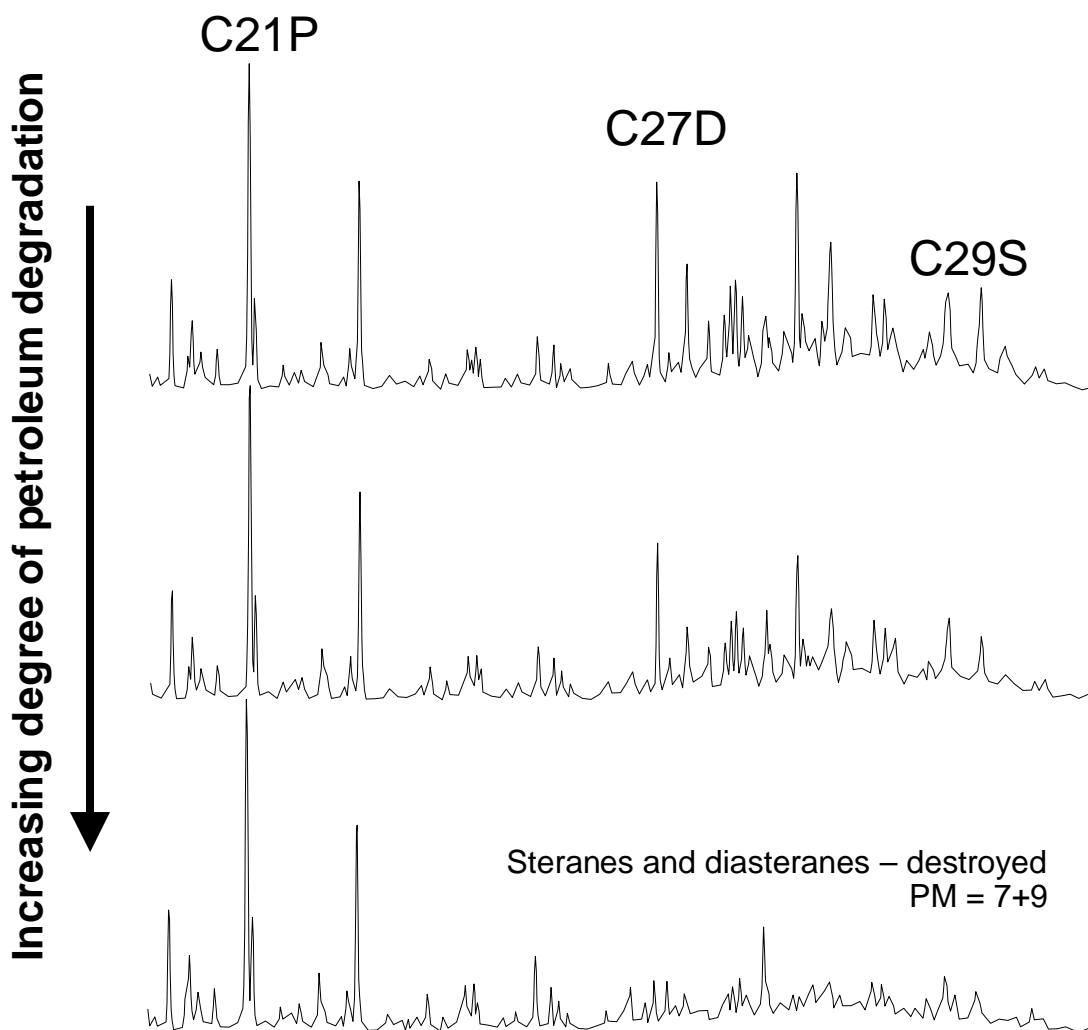


Figure 1. Partial reconstructed mass fragmentograms (m/z 217) showing the distributions of C_{21} - C_{29} steranes in the Athabasca tar sands. $C_{21}P = C_{21} \alpha\alpha\alpha+\alpha\beta\beta$ pregnane, $C_{27}D = C_{27} \beta\alpha 20S + 20R$ diasteranes, $C_{29}S = C_{29} \alpha\alpha\alpha+\alpha\beta\beta$ ($20R+20S$) steranes.

REFERENCES

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