# Dibenzothiophenes as molecular markers to trace paleo-oil filling orientations in the Lower Cambrian reservoir of Sichuan Basin

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The unique Moxi–Gaoshiti Bulge of Sichuan Basin in southwestern China provides insights into the biomarker signatures of bitumens and their geological significance for paleo-oil reservoirs in Precambrian strata. Solid bitumens with various shapes occur widely in the voids, solution pores, cracks, stylolites, and veins of reservoir rocks. Biomarker analysis was conducted on bitumens and the associated source rocks by quantitative detection with gas chromatography–mass spectrometry (GC–MS) to constrain thermal maturity, sedimentary environments, bitumen/paleo-oil sources, and the possible paleo-oil filling directions, which are dominant geological factors that control paleo-oil accumulations. Quantitative analysis of biomarkers showed that the bitumens in the Sinian dolomite of the Moxi–Gaoshiti Bulge belong to the same ethnic group. The bitumens are highly matured, and their reflectance values (Rb) are greater than 1.5% with an average of 2.96%. These bitumens originated from thermal cracking of oil (pyrobitmen) via a high-temperature process. Results show that all solid bitumen samples in the MG Bulge exhibit similar compositions of molecular markers, thereby implying that they belong to the same population and that paleo-oils should be derived from the same source kitchen/bed.
Low pristane/phytane and dibenzothiophene (DBT)/phenanthrene ratios, as well as the predominance of DBT among DBT, dibenzofuran, and fluorene, are observed in the bitumen samples, which suggest that related paleo-oil reservoirs likely originate from a highly reduced marine shale environment. The marine shales of the Sinian Dengying and lower Cambrian Qiongzhusi formations are their major source rocks. All isopleth maps of the DBT concentrations, 4-/1-methyl DBT, 4,6-/(1,4 + 1,6)-dimethyl DBT (DMDBT), and (2,6 + 3,6)-/(1,4 + 1,6)-DMDBT ratios consistently indicate that the overall orientation of oil migration in the MG Bulge is primarily from the west-to-east direction, with the strongest filling point located at approximately the Mx12 Well. The north-to-west direction is an additional filling orientation. These indicators show that paleo-oils cracked by bitumens mainly originate from a source kitchen in the western part of the MG Bulge. A hydrocarbon source kitchen in the northern part of the MG Bulge may have developed. A research related to this initial study should be conducted in the future. The recognition of these bitumen molecular signatures, particularly the consistent results that use DBT concentration and alkyl DBT thermal maturity indicators, suggests a potential approach that can be applied to the study of paleo-oil reservoirs.