

CARBON ISOTOPE FRACTIONATION IN COAL AND MARINE SOURCE ROCKS AND IMPLICATIONS FOR EXPLORATION

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Stable isotope composition of gas is widely used in hydrocarbon exploration to determine the composition and thermal maturity of source rocks. The analyses of Australian coal and marine shale samples indicate that during gas desorption both molecular and isotopic compositions change with time. Therefore, a detailed understanding of the mechanism of isotope fractionation is required to improve our ability to better characterize source rocks and fluids.

$\delta^{13}\text{C}$ of Permian coals range between -22 and -26‰ (VPDB) and that of thermogenic methane generated from these range from -25 to -40‰. $\delta^{13}\text{C}$ of gas desorbed from coal varies with time according to molecular weight and sorption properties. For example, in a set of deep Bowen Basin coals the difference in $\delta^{13}\text{C}$ -CH₄ between early and late desorbed gas varies from 2‰ to 29‰. For higher hydrocarbons this fractionation is lower, where for ethane it is <8‰ and for propane <3‰.

Similar isotope fractionation happens during desorption from marine source rocks in the Beetaloo Basin. $\delta^{13}\text{C}$ for an immature kerogen from the Velkerri shale is -33‰. Where the Velkerri shale is gas mature, during desorption, $\delta^{13}\text{C}$ -CH₄ shows fractionation of up to 28‰. $\delta^{13}\text{C}$ -C₂H₆ and $\delta^{13}\text{C}$ -C₃H₈ show lower isotope fractionation of 1.6‰ and 0.9‰, respectively.

Many published classification systems relating isotope composition of gas to source rock and thermal maturity do not consider the effects of such isotope fractionation. The fractionation mechanism may also have an impact on the so-called “isotope reversal” behaviour in some shale reservoirs which, at present, is poorly understood.