EVALUATION OF THE EFFECTIVENESS OF REGIONAL SEALS USING CARBON ISOTOPE MUD GAS DEPTH PROFILES, WEST-CENTRAL ALBERTA, CANADA

Barbara Tilley, Ryan Miller and Karlis Muehlenbachs
University of Alberta, Edmonton, Alberta, Canada

Carbon isotope analyses of gases extracted from drilling muds during the drilling of a new well (carbon isotope mud gas depth profiles) provide a unique view of the variation of gases throughout a stratigraphic section at one well location. Previous studies of the carbon isotope composition of natural gases have relied on geographically spread production gases, thereby limiting information about the origin, alteration and migration of gases to the production horizons. The advantage of our carbon isotope mud gas depth profiles is that we have essentially continuous gas samples from the surface (Upper Cretaceous) down into the Mississippian, through both production horizons and the intervening shales, silts and coals. We can therefore look at the variation of gases within a reservoir, across the overlying and underlying potential seal rocks (which may also be gas sources) and into the next successive reservoir rocks. With this information we can observe sharp transitions in isotopic ratios at some formation boundaries (effective seals), no change in isotope ratios across other formation boundaries (ineffective seals), or mixing trends of carbon isotope ratios across a seal (partially effective seal). Within each gas package (including those separated by seals and those within the seals themselves) we can gain information about the source, maturation, alteration, and mixing of gases. By looking at the results from the entire stratigraphic section we can make general inferences about the regional gas dynamics.

This paper will present two very detailed carbon isotope mud gas depth profiles (Figure 1) from west-central Alberta, Canada. The first is from the Kakwa Field in the Deep Basin Gas Trap of the Western Canadian Sedimentary where the Lower Cretaceous sediments are within the active gas window. The second is about 150 km to the north in the Belloy Field of the Peace River Arch area, where Lower Cretaceous sediments are presently within the oil window. Each mud gas depth profile consists of over 100 carbon isotope analyses and over 175 compositional analyses. Gas samples, taken at frequent intervals, encompass the depth range of 100 to 3800 meters in the Kakwa well and 300 to 1550 meters in the Belloy well, and include Upper Cretaceous down through Mississippian sediments.

Figure 1 shows a correlation of the regional principle seals in the Western Canadian Sedimentary Basin (as identified by Creaney and Allan, 1990), between the two carbon isotope mud gas depth profiles. In the Kakwa profile, the Harmon shale is an effective seal separating gases with very different carbon isotope ratios (e.g. 10 per mil difference for C2). Below the Harmon shale, the homogeneity of the C1, C2 and C3 carbon isotope ratios indicates that the putative seals are ineffective. Extensive mixing of gases from the Mississippian Debolt up through the Lower Cretaceous Falher has occurred, probably a result of the local over pressuring caused by the large quantity of gas actively generated in this area. In the Belloy Field of the Peace River Arch area, the three principle seals below the Harmon shale are all effective seals, separating gases with different sources and degrees of biodegradation. The largest isotopic change for C2 and C3 occurs across the Jurassic Fernie Group, which marks a change from dominantly thermogenic, unaltered gas below, to biodegraded gases above. Extensive mixing of these two groups of gases occurs across the Fernie Group seal.

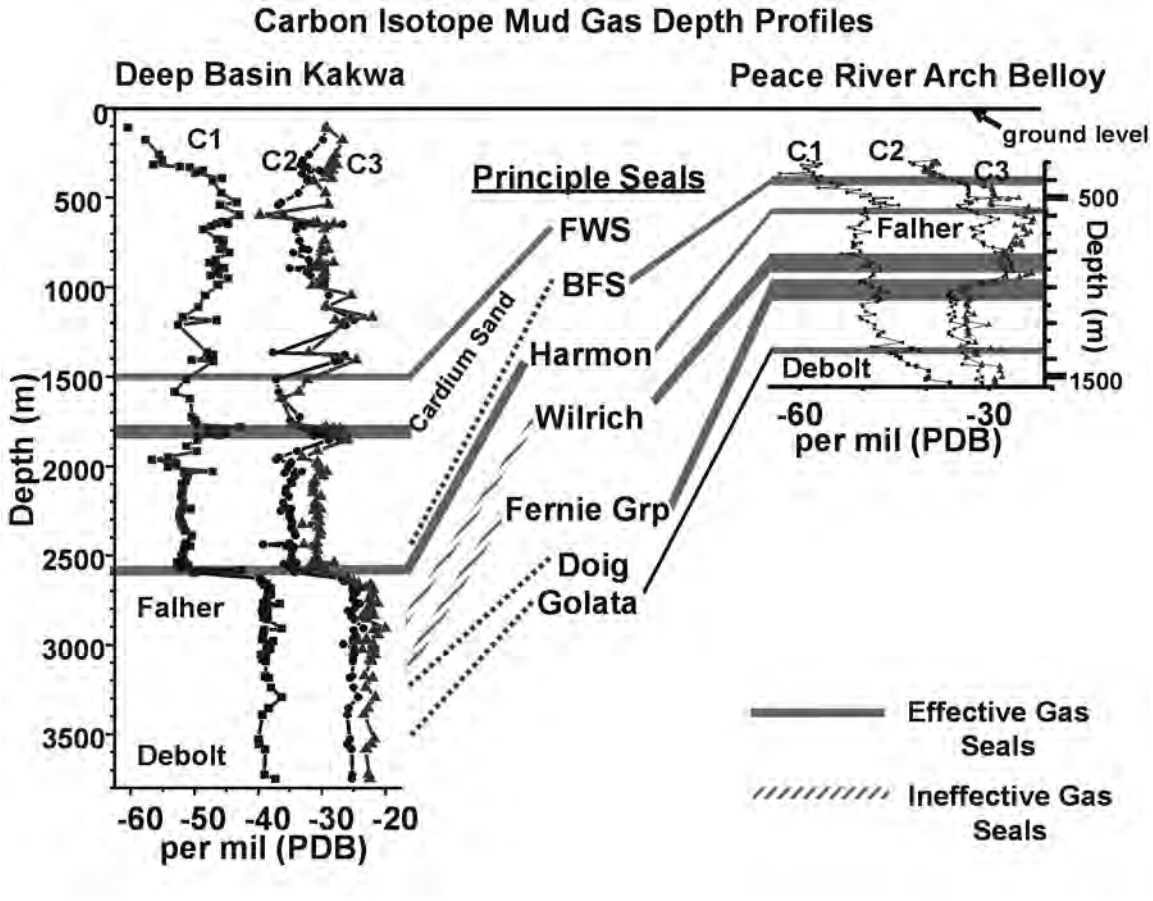

Figure 1. Correlation of regional principle seals between two carbon isotope mud gas depth profiles in west-central Alberta, Canada. Correlations are based on geophysical well logs not shown.