Carbon Isotope Stratigraphy and Facies Architectures for the Lower Cretaceous Berriasian to Huaterivian Successions in Saudi Arabia; Implications for Global Correlation and the First Cretaceous Oceanic Anoxic Event

Nasser Alghamdi

Saudi Aramco

Abstract

The Lower Cretaceous Berriasian to Huaterivian successions in the eastern part of Saudi Arabia formed an extensive carbonate succession that reflects major fluctuations in sea level, forming thick stacking sequences of almost 2000 feet. These successions, which include the Sulaiy, Yammam and Buwaib formations, were not studied before in this area and the chronostraigraphic correlation is yet to be determined. At a regional scale, these formations show lateral facies changes, but they are dominated here by carbonate rocks all the way from Sulaiy to Biyadh and Shu'aiba formations compared to the same rocks elsewhere in the western and northern parts of Arabia that have both carbonate and clastic systems. Facies correlations and wireline logs of these units were not enough to accurately determine the major contacts and stratigraphic architectures due to the lateral facies changes, diagenetic overprints, and the absence of a diagnostic biostratigraphic zonation. Therefore, carbon and oxygen isotope analyses were collected and analyzed to constrain the age models of these successions. This study is unique because there are no standard records of isotopes done before on these formation in the region. Isotope curves were generated for several wells and calibrated to core descriptions and wireline logs and were used as a relative geochronology tool to conduct stratigraphic correlation between wells. The results of the carbon isotope were astonishing, where major patterns and trends were originally preserved throughout the sections and correlated well with the global standard isotope curves from Europe. Furthermore, the first Cretaceous Oceanic Anoxic Event (OAE) of the Late Valanginian, known as the Weissert Event (133 Mya), was defined and mapped in the Lower Buwaib Formation. This event suggests major sea level rise and a possible Maximum Flooding Surface equivalent to K-40 of Sharland et al., 2001. The Caron isotope ratio of the Late Valanginian ranges from ~ 0 to +2.2 ‰ and the OAE is defined by a sharp shift from +1 to +1.8‰ and reaches its maximum of +2.3 ‰, which is considered to be a significant increase that represents a world-wide anoxia that can be traced globally. This event is associated with an abrupt change in facies and environments from the tight dark-argillaceous mudstone of shallow restricted lagoon to open marine clean carbonate rocks of higher energy environment. These clean grainstones are associated with abundant *Lithocodium* oncoids and *Textularids* (*Paravalvilina Arabica*). The occurrence of the *Lithocodium* is the first appearance of this type in the whole Cretaceous and it is associated with the OAE, similar to the Early Aptian OAE. The use of isotope analysis in this study not only helps in determining the correct age of these intervals but also helps in correcting the *Paravalvilina Arabica* assigned age to be of Late Valanginian age compared to the previous assigned age of Huaterivian.