
Application of Palynomorph Darkness Index ('PDI') for thermal maturity assessment: a case study from the early Silurian Qusaiba Member of the Qalibah Formation, Saudi Arabia

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Abstract

Organic-rich marine shales of early Silurian (Llandovery) age (also known as "hot shales") are developed regionally over the entire Gondwanan margin, where they constitute the primary source rocks for the Paleozoic petroleum systems especially in North Africa and the Middle East. In Saudi Arabia, early Silurian "hot shales" occur within the Qusaiba Member of the Qalibah Formation. In this study, we investigate the application of Palynomorph Darkness Index (PDI) for assessing the thermal maturity of the Qusaiba organic-rich shales. Usually the thermal maturity of vitrinite-lacking, pre-Devonian rocks, is assessed using various proxies for VR (Vitrinite Reflectance) such as pyrolysis-based Tmax determination, graptolite reflectance, palynomorph color, and Raman spectroscopy. The resulting values, expressed as 'Vitrinite Reflectance Equivalent' (VRE) all have limitations, including inapplicability to the full range of thermal maturity and imprecise correlation to VR. The Palynomorph Darkness Index (PDI) is increasingly used, in academia and industry, as an alternative, rapid, inexpensive and fully quantitative method of determining thermal maturity of pre-Devonian sediments. The PDI is based on the quantitative measurement of the degree of thermal-induced darkening of palynomorphs under transmitted light. In this study, PDI was determined on palynomorphs obtained from core samples from several sections in Saudi Arabia, spanning the maturity interval from sub-mature, through the oil, condensate and gas windows into the post-mature stage. In addition, qualitative fluorescence characteristics of the palynomorphs were investigated. The PDI values obtained were correlated to VRE derived from Tmax and graptolite reflectance. Results suggest that the *Veryhachium* / *Neoverhachium* group of acritarchs are the most useful for PDI determination on the study rocks. PDI results based on the more diverse total acritarch assemblage proved very similar in most samples, except where significant numbers of thick-walled taxa were present. In terms of changes seen with increasing maturity, PDI (*Veryhachium* / *Neoverhachium*) remains low (*Veryhachium* / *Neoverhachium*) then increases more slowly through the Condensate Window and into the Gas Window to > 80 %, remaining at or above this value into the postmature zone.

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Keywords: Silurian, Saudi Arabia, Qusaiba Member, Palynomorph Darkness Index, PDI, Maturity, Vitrinite Reflectance Equivalent, Veryhachium, Hot Shales