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Identifying and Understanding Suppressed Vitrinite Reflectance through Hydrous Pyrolysis Experiments

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Reflectance of vitrinite in some shales has been shown to be lower than the reflectance of vitrinite in neighboring humic coals, which have experienced the same level of thermal stress (Goodarzi et al., 1993; Kalkreuth and Macauley, 1987; Wenger and Baker, 1987). These suppressed reflectance values may be lower by as much as 0.55 percent R_o and are typically observed at reflectance values less than 1.5 percent R_o. The occurrence of suppressed vitrinite reflectance values has also been observed in hydrous pyrolysis experiments conducted to simulate natural petroleum formation (Lewan, 1985). Figure 1 shows significant differences in mean reflectance values measured on vitrinite isolated from aliquots of thermally immature (<0.5 percent R_o) humic coals and shales that have been isothermally heated in liquid water at temperatures from 300 to 360°C for 72-hour durations.

After being heated at 300°C for 72 hours, vitrinite in the humic coals and some shales reach a mean reflectance of 1.0 percent R_o; whereas, the vitrinite in some shales show only a slight increase approaching a mean reflectance of 0.55 percent R_o. This difference in mean reflectance values continues to increase to 340°C after 72 hours. At this level of thermal stress, a difference of 0.8 percent R_o is reached. This maximum difference diminishes at higher thermal stress levels and becomes insignificant at mean reflectance values greater than 1.8 percent R_o. These differences in reflectance values are of considerable concern because petroleum formation is typically defined within this range of reflectance values (i.e., 0.6 to 1.2 percent R_o). Therefore, identifying vitrinite that follows the suppressed reflectance trend and understanding the factors responsible for its suppression becomes imperative to modelling thermal histories and predicting petroleum formation in sedimentary basins.

Identifying vitrinite that follows the suppressed reflectance trend with maturation is especially difficult when humic coals are not encountered in a sedimentary rock sequence for reference. Although methods to make this identification have been developed (e.g., Toxopeus, 1983; Wilkins et al., 1992), hydrous pyrolysis may provide a simpler and more objective identification. The proposed method involves measuring the reflectance on vitrinite before and after being subjected to hydrous pyrolysis. As shown in Figure 1, the identification of thermally immature vitrinite that follows the suppressed reflectance trend can be made by subjecting them to hydrous pyrolysis at 300°C for 72 hours. Under these conditions, the mean reflectance of suppressed vitrinite will show only a slight increase of several *hundreths* of a percent R_o. Conversely, the mean reflectance of vitrinite that follows the reflectance of vitrinite in humic coals will show a greater increase of several *tenths* of a percent R_o. Currently, research is under way to determine specific experimental conditions needed to make this identification for vitrinite at higher levels of thermal maturity (i.e., 0.6 to 1.8 percent R_o). An alluring attribute of this proposed method is that the response of vitrinite reflectance to experimentally induced thermal stress is used to calibrate the use of vitrinite reflectance in determining natural thermal stress levels.

Understanding the factors responsible for the suppressed reflectance of some vitrinite may also be developed through hydrous pyrolysis experiments. Currently, three observations from hydrous pyrolysis experiments provide some understanding of suppressed vitrinite reflectance. The first observation is that there appears to be only one main suppressed reflectance trend and not a continuum. Although this suppressed reflectance trend has mean reflectance variations within a band width of 0.25 percent R_o, a significant gap exists between it and the vitrinite reflectance trend for humic coals. The second observation is that the mean reflectance of vitrinite from humic coals may vary by 0.25 percent R_o, but vitrinite from humic coals does not occur on the suppressed reflectance trend. The third observation is that the suppressed reflectance of vitrinite in shales is not caused by the presence of oil generated from other macerals within the rock. Future research with hydrous pyrolysis experiments may also help in understanding whether all vitrinite-like macerals in pre-Silurian rocks follow the suppressed reflectance trend and whether different lithologies have a significant effect on the mean reflectance of vitrinite with increasing thermal stress.

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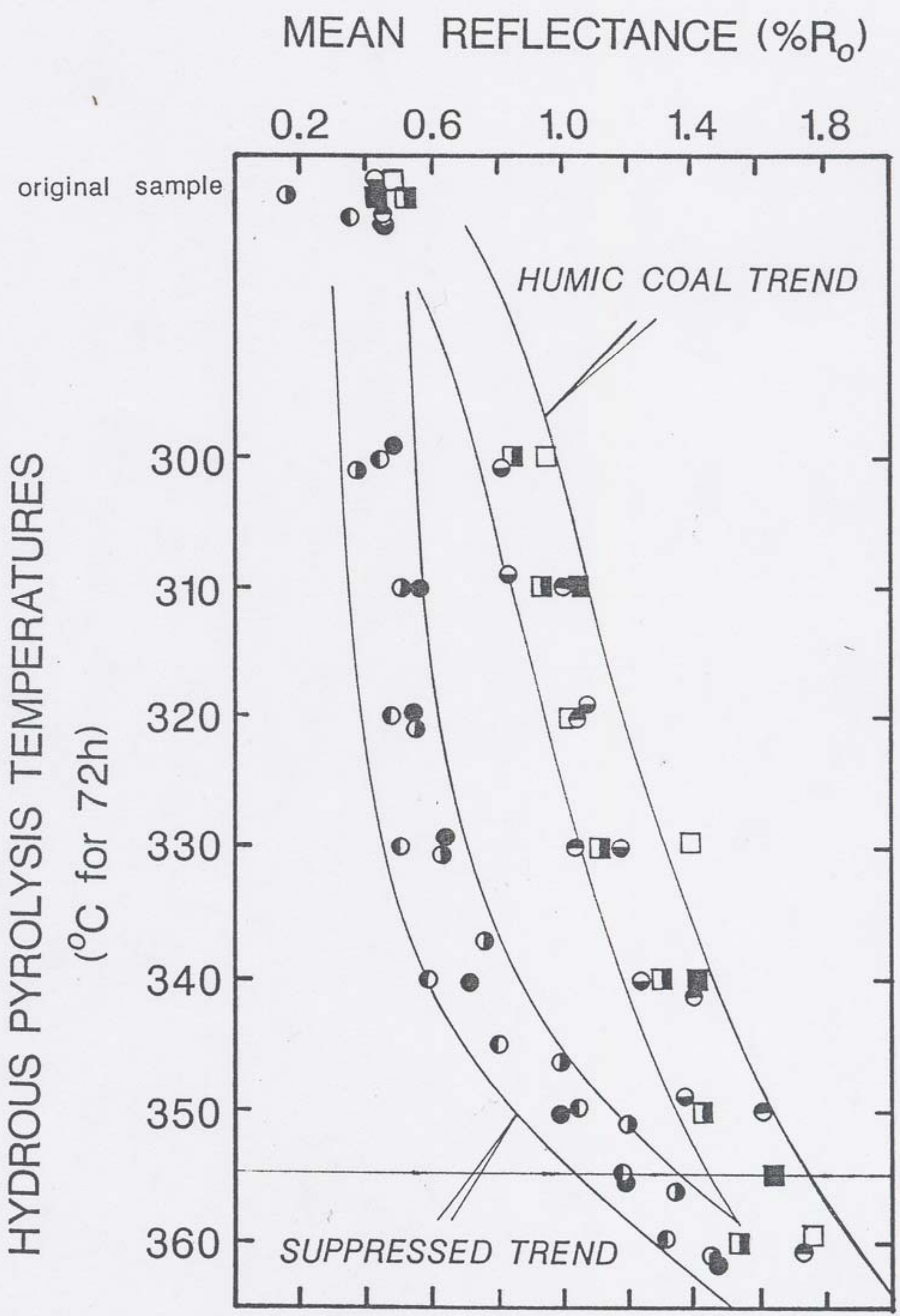

Figure 1: Mean random reflectance of vitrinite isolated from aliquots of humic coals (open squares, Blackhawk Fm.; half solid squares, Frontier Fm.; solid squares, Wilcox Fm.) and shales (right half solid circles, Phosphoria Fm.; left half solid circles,Woodford Shale; solid circles, Alum Shale; bottom and top half solid circles, Mowry Shale) heated isothermally at temperatures from 300 to 360°C in contact with liquid water for 72-hour durations.