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Graphical Approach to Determination of Hydrocarbon Maturation in Overthrust Terrains

With current exploration efforts in areas of overthrust tectonics, it is important to evaluate efficiently and effectively the effects of thrust-related thermal perturbations on hydrocarbon maturation. Because of the transient nature of the temperature field during and after thrusting, the simple assumption of constant geothermal gradients is inappropriate in most cases. A simple graphical technique that combines Lopatin diagrams with thermal models for thrusting allows the explorationist to develop relatively detailed models for the timing of hydrocarbon maturation in overthrust terrains. The thermal regime that exists after thrusting may be calculated by solving the equation for the one-dimensional conduction of heat. Geothermal gradients after thrusting can then be derived from solutions to the heat conduction equations that have been plotted on depth versus temperature diagrams. By superimposing the appropriate geothermal gradients on the Lopatin diagram for a given sedimentary unit, the theoretical vitrinite reflectance can be calculated at any point along the burial history of that sediment.

It is critical in these models to modify the geothermal gradients used in the Lopatin diagrams according to the perturbations in the normal gradient caused by the thermal effects of thrust faulting. The effect of thrusting is to cool the overriding sheet and heat the sediments being overridden. The sheet being thrust from deep within the earth's crust to a shallower level will cool and lose heat to the sediments below. Consequently, the overridden sediments will become warmer as they attain equilibrium with the new thermal conditions imposed by burial beneath the thrust plate. The thermal effects due to thrusting can be quite pronounced. A calculated example demonstrates that the same stratigraphic unit located in the hanging wall of a 21,000 ft (6,400 m) thick thrust sheet in the Overthrust belt is still in the liquid window while the equivalent unit in the footwall of the thrust is overmature.

The graphical approach developed here is applicable not only to cases of simple overthrusting, but can also be modified to include the effects of multiple thrusting events, subsurface thrust planes, and post-thrust erosion. All of these models can provide critical constraints on the timing of maturation and migration as well as information on the degree of maturity of potential source rocks. Integration of maturation data generated from the Lopatin diagrams with the structural history of the region can help predict prior to drilling whether a prospective structure may contain hydrocarbons or if it is more likely to be a dry hole.

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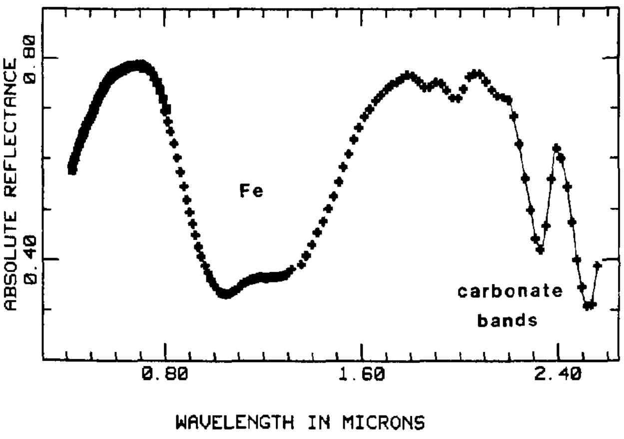
Spectral Reflectance of Carbonate Rocks and Minerals

Spectral reflectance in the visible and near infrared (0.35 to 2.5 μ) offers a rapid, inexpensive, nondestructive technique for determining the mineralogy and minor element chemistry of the hard-to-identify carbonate minerals, and can, in one step, provide information previously obtainable only by the combined application of two or more techniques.

When light interacts with a mineral, certain wavelengths are preferentially absorbed. The positions, intensities, and widths of these absorption bands are diagnostic of the sample's mineralogy and chemical composition. Absorption bands in the 1.5 to 2.5 μ region are due to vibrations of the carbonate radical, and their precise positions are used for mineral identification. At shorter wavelengths, absorption features are due to electronic processes within the partly filled d-shells of transition metal ions such as Fe^{+2} and Mn^{+2}. Positions, intensities, and widths of these bands allow determination of the chemical composition of the mineral. Studies indicate detection limits for these cations are less than 0.5 mole %. The figure shows a typical carbonate spectrum and the sources of the absorption bands.

Reflectance Spectrum of Ferroan Dolomite



Absorption bands caused by water also occur in reflectance spectra. The exact shapes and positions of these bands indicate the form in which the water occurs (i.e., as bound water in clay minerals, or as liquid water in fluid inclusions), and relative band intensities indicate the amount of water present. Fluid inclusions appear to be nearly ubiquitous in carbonate rocks and are particularly abundant in skeletal material. Diagenesis of skeletal material results in loss of a large percentage of these inclusions, and spectral studies can be used to monitor these changes.

Reflectance spectra may be obtained from powders, sands, rock surfaces, and thin sections.

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VSP Fundamentals that Improve CDP Data Interpretation

This paper emphasizes the fundamentals of the vertical seismic profile (VSP) that improve the interpreter's confidence and understanding in its use as an exploration tool. The areas covered are VSP acquisition, critical points of the processing sequence, and applications to borehole information in depth and CDP data in time.

Correlating reflection character to the stratigraphic section is done typically with synthetic seismograms computed from sonic logs and check shot traveltimes. Problems often make this task difficult, even in areas where the synthetic or surface seismic data are of good quality. The VSP provides an alternative approach and a valuable link between the synthetic and CDP data.

A VSP extends check shot surveys from first break traveltime analysis to reflection analysis by recording the complete seismogram at a fine depth interval in the borehole (at least two depths per seismic wavelength). The unique feature of a VSP is the simultaneous measurement of downgoing and upgoing seismic waves as they propagate at depth.

A repeatable source such as Vibroseis and the fine depth sampling make it possible to separate the VSP downgoing waves