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Limitations of Rock-Eval Pyrolysis for Typing Organic Matter

Laboratory experimentation on whole-rock Rock-Eval pyrolysis has shown that the characterization of organic matter through the use of a modified van Krevelen-type diagram, where the hydrogen and oxygen indices are substituted for the H/C and O/C ratios, is questionable. The hydrogen and oxygen indices are strongly affected by the matrix mineralogy and by organic enrichment.

Others have assumed that the S_3 peak on the Rock-Eval represents CO_2 liberated solely from the organic matter because the pyrolysis temperature of 390°C, at which trapping of CO_2 ceases, is significantly below the decomposition temperatures for the principal matrix minerals. However, Rock-Eval pyrolysis of pure mineral specimens with decomposition temperatures in excess of 800°C has produced CO_2. Published data suggest that this yield of inorganic CO_2 may be partly a consequence of crystallographic imperfections. Because the oxygen index is calculated relative to the organic carbon content, the leaner the rocks the greater the error will be resulting from interference of inorganic CO_2.

The hydrocarbon yield (S_2) was found also to be dependent on the mineral matrix. Each kerogen type produced greater hydrocarbon yields when associated with a carbonate matrix as compared to an argillaceous matrix. These differences were found to be greater in leaner rocks. In addition, the hydrocarbon yield did not appear to increase proportionately with increasing organic carbon content. Hydrocarbon yields relative to organic carbon content were found to be greater in richer rocks than in leaner ones. Thus, the hydrogen index for a given rock appears to depend not only on the type of organic matter, but also on concentration of the organic matter and the character of the mineral matrix.

It appears, therefore, that although there are advantages to the van Krevelen diagram for tracing evolution pathways as organic matter matures, the complications discussed above require that an alternative method be developed for evaluating pyrolysis data.

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Regional Disconformities and Eustatic History: Cretaceous Trans-Atlantic Test Case

Increasing refinement in contemporary biostratigraphic and geochronologic correlation allows critical testing of space-time relations of regional disconformities within and between large marine sedimentary basins. This is especially true in the Cretaceous Period, where global correlation is possible within 0.5 m.y. or less time/biostratigraphic units. The most critical questions posed by regional disconformities are: (1) their mode of origin, and especially whether or not they reflect regional tectonic/sedimentologic or global eustatic controls; and, (2) their temporal relations—are they regionally diachronous, with minimal correlation value, or synchronous, reflecting global factors?

Regional Cretaceous disconformities are numerous, well studied, and precisely dated in both Europe and North America, providing an opportunity to test various hypotheses concerning their origins. They are most commonly reflected by: (1) mature hardgrounds; (2) broadly erosional disconformities; (3) lag deposits and calcarenites, in some places overlying hardgrounds or erosion surfaces; (4) paraconformities and sediment bypass surfaces identifiable by biostratigraphic/geochronologic gaps; and (5) sharp, flat erosional surfaces truncating the tops of large progradational sequences in areas of highly active sedimentation. An intercontinental test shows precise correlation of many Cretaceous disconformities regardless of type (1 to 5 above) between the Western Interior and coastal plains of North America, and the carbonate platform/shelf facies of central and western Europe, proving a eustatic origin (stillstand events). Most such regional disconformities occur during punctuated eustatic rise (transgression).

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Characteristics of Some Oil Shale, East-Central Uinta Basin, Utah

Oil-yield, lithologic, and mineral-distribution data were determined for cores taken from a 152-m drill hole in the upper part of the Parachute Creek Member of the Eocene Green River Formation. The drill hole, in Sec. 3, T12S, R24E, started just below the contact between the Uinta Formation and the underlying Green River Formation, and ended 10 m below the Mahogany oil shale bed (the richest oil shale bed in the interval examined) in the lower part of the Mahogany zone. Most of the interval studied is composed of kerogen- and carbonate-rich, very fine-grained sediments.

Several thin (less than 1 m) oil shale beds which yield as much as 25 gal of oil per ton (104.3 l per metric ton) are above the Mahogany zone, but are probably not of economic interest. The studied sequence contains several tuff beds; the maximum thickness of these beds is about 0.6 m, but the average thickness rarely exceeds 0.2 m. Two oil-saturated tuff beds occur approximately 20 m above the Mahogany oil-shale bed. Although these two tuffs are exposed in nearby surface outcrops, they do not contain oil in these outcrops. The Mahogany zone is approximately 21 m thick at the drill site; the lowermost few feet were not penetrated. The Mahogany zone is covered by 132.6 m of overburden. Fischer assays indicate that 12.9 m of oil shale within the Mahogany zone could yield at least 25 gal of oil per ton (104.3 l per metric ton) from beds at least 3 m thick.

Although analcime is a common accessory mineral in the upper 50 m of the core hole, it was not identified in the Mahogany zone. Illite and mixed-layer clay minerals occur together above the Mahogany zone. The mixed-layer clays decrease in quantity as the Mahogany zone is approached, and no mixed-layer clays are detected in the Mahogany zone. Illite was detected in all samples examined from the Mahogany zone. Examination of X-ray diffraction patterns obtained from bulk rock samples from cores did not reveal the presence of any potentially valuable accessory minerals in the stratigraphic interval studied.

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Geotechnical Properties and Stability Characteristics of Continental Slope Deposits Influenced by Coastal Upwelling

Studies to date on continental slope deposits of Peru and Oregon indicate that coastal upwelling indirectly contributes to the alteration of sediment mass physical properties and stability characteristics by concentrating organic matter in the underlying and nearby sediments. Those sediments in close proximity to areas of intense upwelling display distinctly different geotechnical properties than do those of comparable sediment type some distance away. The ability of organic matter to adsorb water and to aggregate clay-size particles to form an open fabric appears to result in exceptionally high water content (853% by dry weight), porosity (89%), and plasticity as well as very low bulk density (1.09 Mg/m^3). The undrained shear strength (cohesion) of these sediments is also unexpectedly high, resulting apparently from some form of bonding of the sediment particles by organic matter. Sensitivity (ratio of natural to remolded or disturbed shear strength) is also unusually high (21), indicating a high susceptibility to failure if the sediments should become severely disturbed. All sediments along the margins behave as if they are overconsolidated. The greater the organic content the greater the degree of overconsolidation. In some areas this degree is on the order of six to seven times that of similar slope deposits but with relatively low organic contents. This degree of overconsolidation suggests that organic-matter related, interparticle bonding may be responsible for the apparent overconsolidation.

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Controls on Diatomaceous Lithofacies in Obliquely Rifted Marginal Basin: Gulf of California

DSDP Leg 64 dissected Quaternary sedimentation patterns in the Guaymas Basin which confirm many similarities but underline some differences with other Neogene circum-Pacific diatomite basins. Tectonic setting in this morphologically complex basin includes broad hemipelagic slopes, fault-controlled outer slope basins and highs, and relatively small transform-bounded, obliquely rifted deeper basins with complex ocean crust. Frequent mass flows are triggered from either muddy delta foreslopes or hemipelagic diatom ooze drape. These accumulate as mud turbidites in the narrow rift zones at rates exceeding 2,000 m/m.y. Interaction of climatic and oceanographic parameters control the intensity of biogenic productivity (ergo, the oxygen budget) producing alternating sequences of laminated and homogenous diatomaceous ooze, generally confined to slope regions (400 m/m.y.). Laminated diatom-ooze also accumulated in deeper basins which were deprived of turbidity flows during limited periods.

Sediments in slope areas contain a uniform 4% carbon but $CaCO_3$ (mostly foraminifera) ranges episodically from 2 to 25%. Phosphate occurs as fish-debris-rich laminae or rare, soft, centimeter-size pellets. Diagenetic dissolution of silica is recorded at Site 479 on the slope where finely laminated hard muds occurring below an unconformity at 380 m subbottom are now devoid of frustules, except those cemented in dolomite beds. Paradoxically, porcellanites were not encountered, although traces of clinoptilolite suggest that some silica reactions are presently active. Chert only occurs in proximity to basaltic intrusions. Dolomite precipitation occurs at shallow subbottom depths in zones of high alkalinity and methanogenesis, gradually forming decimeter-thick hard layers by slow vertical accretion. These layers commonly preserve primary fabrics. Petrologic and heavy carbon isotope evidence suggest that ions for dolomite precipitation are mainly derived from interstitial waters.

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Amorphous and Crystalline Ferromanganese Deposits from Seamounts in Gulf of Alaska

Both amorphous and crystalline ferromanganese deposits have been dredged from depths between 1,400 and 2,250 m on the flanks of Welker, Miller, Murray, and Patton Seamounts in the Gulf of Alaska (53-55°N, 140-150°W). Prominent 1 to 11-cm thick massive crusts, consisting largely of black amorphous oxide and poorly crystalline δMnO_2, occur as rounded multishelled coatings on the surfaces of alkali-basalt pillows and volcanic breccia. These crusts are characterized by a simple internal stratification constructed from isotropic oxide microlaminations in alternating colloform and columnar aggregates. Detrital fragments of quartz, plagioclase, palagonite, and mafic volcanic rock are concentrated along cusps or channels within crenulated oxide layers. Bulk-chemical analyses of the massive amorphous crusts yield Mn/Fe ratios of 1.5 to 2.5 and relatively high Ni (0.26 to 0.65%), Co (0.23 to 0.66%), and Cu (0.03 to 0.12%). The occurrence and composition of these amorphous crusts suggest that they are authigenic deposits with a growth mechanism similar to that for the top surfaces of Pacific deep-sea manganese nodules.

Thin (1 to 10 mm) subparallel crusts, interconnecting veinlets, and nodular infillings associated with friable tuffaceous sediment are composed of well-crystallized todorokite and cryptomelane; δMnO_2 and birnessite(?) are minor constituents. Complex textural variations are characteristic, but broad colloform bands of variably anistropic radiating oxide fibers, and massive zones of very coarse grained (as much as 1 mm long) strongly anisotropic acicular todorokite or cryptomelane crystals, are common. These massive anisotropic oxide zones contain abundant recrystallized radiolarian tests. Ferromanganese samples from Patton Seamount have a third association: undulating bands of columnar or nodular todorokite-rich oxide and volcanic detritus (mostly palagonite) occurring in a matrix of microcrystalline phosphorite (carbonate-apatite). Crystalline ferromanganese oxide deposits have bulk-chemical compositions similar to those of the amorphous oxides but with somewhat higher Mn/Fe ratios, higher Ni, and lower Co. In contrast to the amorphous crusts, crystalline ferromanganese accumulations on Gulf of Alaska seamounts are analogous to the bottoms of deep-sea nodules; that is, the formation of these accumulations is closely related to diagenetic modification of the associated sedimentary substrate.

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Evolution of Late Holocene Beach Accretion Plain on Pacific Coast: Grayland, Southwestern Washington

An extensive (140 km +) beach-accretion plain and lagoon-barrier coast has evolved over the last thousand years in southwestern Washington and northern Oregon. Before 1,100 years, a highly indented shoreline with a steep straight wave-cut cliff and terrace faced the Pacific much like the remainder of the American west coast. In the Grayland area, the first beach-accretion ridge formed at distances varying up to 7 to 10 km seaward from the former sea cliff, followed by two additional beach-accretion ridges with a maximum 2.5 km width of the plain at its southern end. A boring in the bog between the first ridge and older wave-cut cliff included a 1.2-m thick peat underlain by beach sands. Bog pollen is dominated by *Picea* and *Tsuga heterophylla*, with significant *Pinus*, Cupressaceae, and *Alnus*, essentially a modern flora. A basal peat RC^{14} date indicates the earliest barrier formed approximately 1,100 years ago. South of the Grayland accretion plain between Cape