carbon generation. These mechanisms operate at different depths and temperatures, but may, in some cases, operate together to produce hydrodynamic flow. The result of flow is development of secondary porosity by dissolution of grains or cement and by hydrocarbon migration. Oil and gas accumulate in local, low-potential volumes of reservoir rock in which the pressures can be either slightly or greatly in excess of normal hydrostatic pressures.

Deficient pressures in Rocky Mountain basins are caused by uplift, exposure, and recharge of aquifer systems by meteoric waters. Downdip hydrodynamic flow results in oil columns of unusual height in which the oil trapped by flow greatly exceeds that which can be trapped by capillary-pressure barriers alone. These basins may have locally excess pressures due to clay transformation, or hydrocarbon generation, or locally deficient pressures due to gas blockage in fine-grained rocks.

The principles of flow are well established but not widely applied, and there is a need for better documentation of causes for abnormal pressures and the effects of flow. Knowledge of fluid-pressure regime can often be determined from relatively few points of subsurface control for a better understanding of fluid-migration history. Such knowledge is essential to oil and gas exploration in both poorly tested and mature basins.

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The Age of the Eocene/Oligocene Boundary is ...

In the construction of geologic time scales and the related exercise of discussing the chronology of chronostratigraphic units and boundaries, it is important to clearly distinguish between radiochronologic, biochronologic, magnetochronologic, and magnetobiochronologic input to their formulation. Failure to do so has, in some places, led to the confusion which surrounds the discussion and uncritical acceptance of some of the variant scales now being used. A brief critical examination will be made of several of the currently used Cenozoic chronologies and their bearing on the age of the Eocene/Oligocene boundary.

Current age estimates of the Eocene/Oligocene boundary range from about 32 to 38 Ma based on the assessment of various (predominantly glauconitic) radiometric dates, poleontological control of varying reliability, and quality and paleomagnetic chronologies employing different calibrations. High temperature radiometrically dated polarity stratigraphy in the middle Eocene (polarity chron 20-21 interval) and the latest Eocene-early Oligocene (chron 15/16-12 interval) in North American continental sections with mammalian faunas provide the framework for much needed calibration points in the mid-Cenozoic and for a revised Cenozoic time scale. This also provides constraints on age estimates of the magnetobiostratigraphically determined Eocene/Oligocene boundary in deep sea and continental marine sections. The Eocene/Oligocene boundary (biostratigraphically linked with the LAD's of the *Globorotalia cerroazulensis-cocoaensis* group, *Hantkenina* and *Globigerapsis*, and the rosette-shaped discoasters, *i.al. Discoaster barbadiensis* and *d. saipanensis*), is situated within the reversed interval between marine magnetic anomalies 15 and 13 with younger and older boundary estimated age values of 37.24 and 35.87 Ma, respectively. Our best estimate of the age of the Eocene/Oligocene boundary (subject to minor changes as a result of further magnetobiostratigraphic studies) is 36.6 Ma.

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Paleozoic Lithofacies in Southwestern Sinai and Their Depositional Environments.

Major breaks in sedimentation, accompanied by well-developed paleosols, have been successfully used to subdivide the 600 m (1,968 ft) of Paleozoic sandstone and shale sequence of southwestern Sinai, Egypt, into five smaller facies association units (i.e., formations). The lowest unit (the Araba Formation) is dominated by 1 to 10 m (3 to 32 ft) thick coarsening-up sequences of parallel-bedded, varicolored, fine-grained arkosic sandstone and muddy sandstone with abundant *Skolithos* burrows and in places *Cruziana* traces. This is the deposit of a low-energy prograding sandy coastal plain complex that grades upward into a thin, fining-up channel-overbank deposits with poorly developed paleosols. The overlying Naqus Formation scours deep into the Araba, and is characterized by lenticular, coarse to medium-grained, cross-bedded quartz sandstone with only a few clayey intervals. Well-rounded vein quartz and quartzite pebbles are scattered in the lower half, but form lenses in upper half. Cross-beds are common. The Naqus is interpreted as alluvial fan-braided stream deposits. A 15 to 20 m (49 to 66 ft) thick, conspicuous dark brown, ferruginous shale, ochre-yellow dolomitic sandstone and fossiliferous gray siltstone sequence, persistent all along the Qabeliat valley, overlies the Naqus and represents lagoonal deposits laterally equivalent to the shallow marine shale-dolomite sequence of the Um Bogma Formation farther north. The upper few meters of this unit developed into a paleosol. Basal fluvial channel sands of the succeeding Ataqa Formation cut into the Um Bogma paleosol, and grade upward into the fossiliferous green-red marine shales and subordinate sandstones in shoaling-upward sequences. Laterally, these shallow marine beds grade into coastal swamp deposits of carbonaceous shale and coal. Excellent paleosols developed at the top of the Ataqa Formation which in turn is deeply channeled by a thick succession of fining-upward, lenticular fluvial channel-sand-overbank paleosol facies of the Budra Formation. Southward in the Qabeliat valley, a parallel-bedded sequence of thick green shales and thin brown sandstones, both nonfossiliferous, intervenes in the middle of the Budra Formation and represents ephemeral lake deposits related to the fluvial system. Although the repetition of facies associations in the Paleozoic sequence of southwestern Sinai points to the repetition of events, each lithofacies shows characters of its own sufficient to assign it to a specific environment. Marked asymmetry in the facies sequences suggests spasmodic character of the events.

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Fan-Delta Deposition in Lower Cotton Valley Group Sandstones of Northeast Texas

Fan deltas have been defined as progradation of alluvial fans into a standing body of water from a proximal highland area. Sedimentary environments associated with fan delta complexes have been described in detail in Holocene examples. The subaerial fan is composed of braided channels, gravelly beaches, flood plains, and marshes. The subaqueous fan includes tidal lagoons, channel-fill complexes, marginal islands, breaker bars, and is also characterized by steep slopes and submarine channels where mass-gravity processes may dominate.

Few fan delta complexes have been recognized in the subsurface. The Cotton Valley Taylor "B" Sandstone is interpreted as the distal part of a prograding fan delta based on the vertical sequence in cores from Kildare field, Cass County, Texas. Three major sandstone facies are distinguished on the basis of sedimentary structures, composition and texture. They are, in descending order, (1) a massive to laminated, well-sorted sandstone, (2) a laminated, pebbly sandstone, and (3) a very fine-grained sandstone interbedded with black shale.

Facies 1 is fine-grained (0.21 mm), lacks bedsets, and is mostly massive or indistinctly laminated. Monocrystalline quartz content is high, reaching 95%. Other minerals are minor at 4%, and rock and shell fragments range from 5 to 15%. Facies 1 is only 10 ft (3.1 m) thick and is interpreted as bar or beach deposits formed by reworking of sand by waves at the margins of the delta plain. Facies 2 is composed of conglomeratic bedsets which fine upward from a pebbly erosive base to a parallel or cross-laminated top. Bedsets range from 0.5 to 3 ft (15 cm to 1 m) thick. There is an increase in rock and shell fragments and a decline in monocrystalline quartz from Facies 1, averaging 34% and 63% respectively. The facies remains fine-grained (0.19 mm); however, average grain size and bed thickness increase upward. Facies 2 is interpreted as a complex of shallow, braided, distributary channels. Thickness is variable but ranges from 10 to 20 ft (3.1 to 6.2 m). Facies 3 bedsets are graded and the sequence of sedimentary structures reflects deposition under conditions of decreasing flow regime. The thin, 1 ft (0.3 m), graded sandstone beds are separated by black laminated shale. This facies is very fine-grained (0.09 mm), relatively poor in quartz, 70%, and rich in matrix which may exceed 30%. Facies 3 is interpreted as thin-bedded turbidites deposited in channels and channel margins downdip from the break in slope at the edge of the delta platform. The thin AE, ABE, BE and CDE bedsets alternate with intervals, 1 to 3 ft (0.3 to 1 m) thick, of bioturbated siltstone or rippled sandstone indicative of normal, shallow marine biotic and current activity. There is a sharp, erosive relationship between Facies 2 and 3.

Resistivities are variable and SPs depressed due to extensive carbonate cement (up to 50% total rock) which is also responsible for low porosity and permeability. Dissolution of authigenic carbonates results in secondary porosity up to 17%. Cross-plots of resistivity (R_t) versus porosity are useful in characterizing facies and enable identification of facies in non-cored wells.

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Use of Precise Temperature Logs in Determination of Thermal Properties of Sedimentary Rocks and Investigation of Thermal Evolution of Sedimentary Basins

The temperatures within a sedimentary basin during its evolution are controlled more by the variation in thermal properties of the contained rocks with space and time and with hydrodynamic effects such as dewatering and regional ground-water flow than with transient heat flow variations at the base of a thick sedimentary pile. Although the effect of basal heat flow has been extensively discussed, the effects of thermal property variations and the evolution of fluid flow systems in basins have rarely been addressed. The thermal properties of many sedimentary rocks are not well known and the depth and time variable changes associated with compaction, diagenesis, etc are difficult to evaluate. In one of the dominant rock components, clays, anisotropy, and sampling difficulties make laboratory measurements difficult if not impossible. Hydrodynamic systems associated with basins are just beginning to be understood and much remains to be learned. Heat flow and temperature studies are techniques for investigating these effects.

Accurate temperature logs associated with measurements, where possible and suitable, of the thermal conductivities of the rock result in two quantities which can be used to unravel some of the unknown temperature controls in a sedimentary basin. These accurate data can be sued for correlation of geothermal gradient and thermal conductivity with well log properties such as seismic velocity (travel time), density, and gamma ray activity. These resulting correlations can then be used to infer the spacial variations in heat flow within the sedimentary basin and to accurately evaluate the effects of present fluid motions in the basin. The data can also be used to develop a catalog of thermal property variations as a function of the many variable parameters.

Examples are presented from the Mid-Continent showing the correlation between geothermal gradient, natural gamma ray activity, and seismic travel time for the suite of rocks occurring there. A major result of this study is that the thermal properties of shale have been misestimated in the literature and that the thermal properties of Paleozoic shales appear to be 50 to 100% lower than those assumed in most thermal modeling, leading to a consequent *error* of 50 to 100% in temperature calculations of basin thermal history.

Temperature and heat flow data are used to evaluate regional fluid circulation, with possible associated petroleum migration, in units such as the Madison Limestone and the Dakota Group. In addition, heat flow studies may outline areas where conditions are locally favorable for maturation. An example of large-scale basement heat flow variation in Nebraska is used to illustrate an area of unusually radioactive basement rocks producing local areas of higher temperature.

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Pebble Shale (Early Cretaceous) Depositional Environments in National Petroleum Reserve in Alaska (NPRA)

A "pebble shale" of Lower Cretaceous age occurs across the North Slope and continues into northwestern Canada. This organic shale (1 to 5% organic carbon) is possibly the source for the Prudhoe Bay hydrocarbons and includes localized well-developed sand bodies such as those in the giant Kuparuk oil field. The inferred rifting of the Arctic basin, subsequent subsidence of a northern source area, and the southern orogeny during the Late Jurassic and Early Cretaceous contributed to the unique lithology and regional setting of the pebble shale.

The pebble shale in NPRA consists of black anaerobic-dysaerobic shales, silty aerobic shales, pebbly mudstones, and sandstones. The shales contain matrix-supported, very well rounded aeolian-derived, fine to very coarse floating quartz grains. Deposition of these diagnostic floating quartz grains occurs rarely in the late Oxfordian (Late Jurassic) time by are abundant during the Neocomian (Early Cretaceous). In the south and central area of NPRA on the southern flank of the Barrow arch, an almost continuous sedimentation record of pebble shale deposition exists, as penetrated by the Tunalik 1 well. To the north the "formation" thins in a series of intraformational unconformities converging on the Barrow arch. Overlying the uppermost unconformity on the Barrow arch a pebbly mudstone 3 to 8-m (10 to 26 ft) thick, of Hauterivian-Barremian age contains well-rounded sand grains, pebbles and cobbles, pelletal glaunconite, shell fragments, wood chips, and burrows. Chert pebbles from this pebbly mudstone were processed for radiolarians and recovered spumellarians of probable pre-Late Devonian age. A thin zone, basal to an intra-pebble shale sand at Walakpa No. 2 contains siderite and appreciable phosphate in the form of carbonate fluorapatite. A zone of intense gamma radiation (GRZ), which is an easily traced seismic and gamma-ray log horizon across NPRA, is a black carbonaceous papery shale with a