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Eocene-Oligocene: A Time of Transition

The Eocene-Oligocene is a time of transition from a warm early Tertiary world with low vertical and latitudinal thermal gradients to the Neogene world with steep vertical oceanic gradients and high latitudinal gradients between equator and poles. The transition between these two regimes occurred primarily between the middle Eocene and middle Oligocene and can be observed in faunal and floral assemblage changes, associated paleotemperature changes, periodic current intensification as implied by increased carbonate dissolution and hiatuses, eustatic sea level changes, and the curious association of microtektites and iridium anomalies with several of these intervals.

Population studies of planktonic foraminifers in 14 DSDP sites in the Atlantic, Pacific, and Indian Oceans indicate a general cooling trend between the middle Eocene and Oligocene. Major faunal changes indicating cooling episodes occur, however, at discrete intervals: middle Eocene 44 to 43 Ma (P13); middle/late Eocene boundary 41 to 40 Ma (P14/P15); late Eocene 39 to 38 Ma (P15/P16); Eocene/Oligocene boundary 37 to 36 Ma (P18); and late Oligocene 31 to 29 Ma (P20/P21). Each cooling episode resulted in the extinction of warmer water species and evolution and dominance of cooler water species. This trend is associated with the development of a steep vertical thermal gradient and resulting stratification in the upper water masses (0 to 300 m, 1,000 ft) in the latest Eocene. ^{18}O analyses of individual planktonic species indicate that distinct surface, intermediate, and deep dwelling assemblages appear in the latest Eocene (P17), nearly coincident with the development of the psychrosphere. Major deep-sea hiatuses occur coincident with changes in the eustatic sea level at the middle/late Eocene boundary, the late Eocene, and in shallow sections in the Oligocene (30 to 29 Ma). These hiatuses suggest that vigorous bottom water circulation began developing in the middle Eocene, consistent with the faunal cooling trend and well before the development of the psychrosphere.

The presence of microtektites and iridium anomaly in latest Eocene sediments has resulted in the scenario of catastrophic extinctions due to a bolide impact. The present study reveals multiple microtektite occurrences at 43 Ma, 40 Ma, 38 Ma, 34 Ma, and 30 Ma. Moreover, these microtektite occurrences coincide with intervals of increased carbonate dissolution and/or hiatuses. This suggests that microtektites are concentrated as a result of carbonate dissolution and selective winnowing of sediments at these intervals. Consequently, a concentration of microtektites in deep-sea sediments may not always imply a bolide impact, nor is there any evidence of catastrophic extinctions during Eocene-Oligocene time.

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Use of Fission-Track Annealing Systematics in Constraining the Thermal Evolution of Sedimentary Basins

Fission-track annealing systematics in detrital apatite provide a promising means for evaluating the thermal histories of sedimentary basins. Significantly, the temperature range for fission-track annealing, 90° to 135°C (194 to 275°F), is similar to the temperature range for petroleum maturation. Compared to vitrinite reflectance measurements and other techniques currently used to monitor thermal histories of sediments, the fission-track annealing technique is superior, as it is not affected by chemical complexities or fluid composition. In addition, the kinetic laws for track annealing are relatively well characterized.

The usefulness of the technique is demonstrated by examination of natural annealing data from drill holes and by calculation of hypothetical fission-track age versus depth relations for particular thermal histories. These results are used to evaluate currently popular models for the evolution of sedimentary basins. Simple instantaneous stretching models for sedimentary basin evolution do not appear to predict thermal and subsidence histories consistent with fission-track data. Temperatures necessary to account for petroleum maturation and fission-track annealing require stretching rates that, in the published models, lead to subsidence of a factor of 2 to 3 times greater than that observed.

As the temperatures predicted by the simple tectonic stretching models are not consistent with the fission-track data, other factors that affect the temperature distribution in a sedimentary basin must be considered. These include basin hydrodynamics and the time-varying thermal properties of the basin sediments. It is concluded that the thermal history of petroleum source rocks within sedimentary basins is primarily controlled not by the processes and parameters that form the basis of the tectonic stretching models, but rather by processes operating within the basin. The relative thermal effects of these processes within basins can be effectively monitored using fission-track annealing systematics.

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New Cements for Old Radiaxial Fibrous Calcite—A Reassessment

No abstract.

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Unconformity-Associated Replacement Limestones After Anhydrite in Mississippian of Williston Basin

Locally in southeastern Saskatchewan, Mississippian nodular anhydrites (after subaqueous gypsum) beneath an unconformity have been altered to limestone—limestones that are commonly porous and oil-bearing. Such carbonates are commonly intergrown with pyrite and celestite, and thus are difficult to interpret from logs. At localities with calcitized anhydrite, the unconformity is overlain by Jurassic red beds in which pigments have been reduced to green hues. In the region, carbonates beneath the unconformity are normally overlain by red beds and have been completely dolomitized and plugged with anhydrite to form an impermeable caprock. Mississippian anhydrites subcrop at the unconformity surface and reveal little evidence of alteration—even to gypsum.

Textures in replaced anhydrites indicate that calcitization involved both creation of porosity and in-situ (small-scale) replacement leading to retention of anhydrite (and later gypsum) fabrics. Celestite formed as strontium was released from anhydrite during replacement by gypsum and calcite. Sulfur in associated pyrite is isotopically lighter than the anhydrite, suggesting anhydrite-alteration involved the activities of sulfate-reducing bacteria. Evidently, H_2S liberated during the reaction migrated across the unconformity to reduce overlying red beds.

Limestones of this type do not appear to have been reported previously. Stratigraphic and petrographic evidence indicates replacement, although spacially related to the unconformity, was not a weathering phenomenon. It occurred after the unconformity was buried.

Unexpectedly heavy $\delta^{13}C$ and $\delta^{18}O$ values (+1.22 to 1.54, and −1.0 to −3.7) obtained from the replacement limestones seem to preclude the utilization of organic carbon in the reaction. The