wave and tidal frequency, provided bulk densities are less than 1.20 g $cm^{-3}$. Suspended-sediment concentrations in the nearshore region are typically 1 to 10 × $10^3$ mg $l^{-1}$. Thickness of brown oxidized mud which overlies steel-gray muds beneath provides an indication of the depth to which suspension and redeposition occur.

In addition to serving as a storehouse for littoral sediments and as a buffer to wave attack, tidal-flat muds serve as a source of sediment for longshore transport processes. Because of high suspended-sediment concentrations, sediment transport rates can be enormous, even under relatively weak currents.

WELLS, NEIL, Univ. Michigan, Ann Arbor, MI

Nearshore Marine and Continental Facies in Eocene of North-Central Pakistan

Stable-shelf carbonate sedimentation along the northwestern edge of the Indian subcontinent preceded the post–mid-Eocene Indian-Asian collision. The early Eocene section in Pakistan displays very rapid facies changes controlled by a cycle of regression and transgression. Beginning with the Paleocene Patala Formation in the Kohat area, quiet-water offshore dark shales grade up-section to include increasingly thick, extensive, and common marly limestones, becoming a foraminiferal limestone sequence. This section then becomes shalier with progressively thinner and more argillaceous micrites and grades upward into the unfossiliferous green Panoba Shale, which then passes into the nearshore, medium-energy, fossiliferous, and bioturbated limestones of the Shekhan Formation. The upper Shekhan beds are mud-cracked, festoon-bedded, channelform dolostones, presumably tidal deposits. The topmost dolostones contain zones of small disruptive anhydrite nodules and pass rapidly into gypsum laminated with varicolored clays. To the west, the Panoba Shale and the Shekhan Formation grade into a massive salt deposit; to the northeast they grade into deeper water limestone. The evaporites are interpreted as sabkha deposits. All are covered by the mostly continental, mammal-bearing Kuldana Formation red beds. Drowning of the coastline then caused rapid development of (1) local lacustrine dolomite and chert units, (2) oyster-rich lagoonal or estuarine limestones, and finally (3) open-bay nummulitic limestones and shales of the mid-Eocene Kohat Formation. The succession is truncated by a regional unconformity that records uplift, erosion, and dolomitization of the underlying carbonate rocks. The unconformity is then buried by continental Himalayan molasse.

WENRICH-VERBEEK, KAREN J., U.S. Geol. Survey, Denver, CO, and EUGENE M. SHOEMAKER, U.S. Geol. Survey, Flagstaff, Az

Uranium Mineralization in Hopi Buttes, Arizona

The Hopi Buttes dominate the landscape north of Holbrook, Arizona, rising to heights of ~1,000 ft (305 m) above the surrounding countryside. The buttes, erosional remnants of lava-filled diatremes and associated sediment-filled diatremes, are approximately 5 m.y. in age. The volcanic rocks of the diatremes are limburgite and monchiquite, which are distinguished from normal alkalic basalts of the Colorado Plateau in their extreme silica unsaturation, high water, $TiO_2$, and $P_2O_5$. Many trace elements are also unusually abundant, most notably Zr, Ba, Nb, Ce, and U (average value of about 4 ppm U compared to an average of 1 ppm for continental basalts). Many of the diatremes are filled with local maar lake sediments believed to have been deposited in part by rising thermal solutions. Limestone lake beds locally resemble travertine deposits and contain high concentrations of phosphate, sulfate, Ba, Sr, and As, as well as U and Se. Areas of high Se content are recognizable in the Hopi Buttes by the abundance of *Astragalus patersoni* ("loco weed").

Approximately 300 diatremes occur in the Hopi Buttes area. Of 79 studied during the past year, 35 contain lake-bed deposits with radioactivity exceeding background levels. Scintillometer traverses have shown 20 of these diatremes to have radioactivity exceeding 5 times background. An airborne gamma-ray survey shows sharp-peaked anomalies over all 20 of these diatremes. Hydrogeochemical sampling in the area also revealed anomalous concentrations of uranium in spring and well waters from the Hopi Buttes area. Uranium ore was mined during the 1950s from the Morale claim. Production records show the average grade for 186 tons of ore was 0.15% $U_3O_8$. Extensive drilling in this diatreme in October 1979 revealed intervals within limestone and siltstone maar lake sediments up to 20 ft (6 m) thick and 500 × 300 ft (152 × 91 m) in area containing an average of 0.015% $U_3O_8$. The potential for uranium in the Hopi Buttes is for low grade deposits within 50 ft (15 m) of the surface, some of which may contain on the order of 100 tons of $U_3O_8$ per diatreme.

WHITLEY, DONALD L., Univ. Iowa, Iowa City, IA, and GREG A. LUDVIGSON and BILL J. BUNKER, Iowa Geol. Survey, Iowa City, IA

"Middle" Cretaceous (Albian-Turonian) Depositional Environments Along a Part of Eastern Margin of North American Epicontinental Seaway

In Iowa and bordering states the Dakota Formation, Graneros Shale, Greenhorn Limestone, and Carlile Shale were deposited along the eastern margin of the North American epicontinental seaway during the middle part of the Creteceous (Albian to Turonian). The pre-Cretaceous physiographic surface of northwestern Iowa consisted of ridges and valleys developed upon tilted Paleozoic rock. This surface profoundly affected the deposition of sediment. Detailed studies of surface outcrops, subsurface cores and cuttings, and gamma-ray well logs reveal that this part of the seaway was the scene of fluvial-deltaic deposition followed by an extensive marine transgression. The Dakota Formation commonly consists of a quartzarenite sequence which has a sharp basal contact and grades upward and laterally into clay shales. This sequence is commonly capped with organic-rich mudrocks, or lignite beds. Analyses of textures, sedimentary structures, and lateral relations indicate that these lithologies represent southwestward-flowing fluvial systems which floored topographic valleys. The Dakota Formation grades upward into fluvial-