bed. Because sediment is thus transferred from dunes to underlying strata, bed forms must decrease in cross-sectional area or in number, or both, unless sediment lost from dunes during deposition is replaced with sediment transported from outside the depositional area.

Using equations that relate the amount of sediment lost by dunes to the amount gained by sets of cross-strata, we calculate that the dunes which deposited the De Chelly (Permian), Navajo (Triassic? and Jurassic), and Entrada (Jurassic) Sandstones had mean heights with lower and upper limits of 16 and 450 m, respectively. Although these calculated dune heights are surprisingly large, two kinds of field obsevations support the hypothesis that the dunes that deposited 10-m thick sets of cross-strata common in eolian sandstones may have been 100 m high or higher—comparable in size to large modern dunes or draas. First, many sets of eolian cross-strata are primarily bottomset beds; they rarely contain dune-crest deposits or convex-upward cross-strata deposited on lupper lee slopes, and some sets contain sand-flow toes that pinch out near the top of the set. Second, the sand-flow layers in these eolian sandstones are thicker and laterally more extensive than in modern 10-m high dunes. The hypothesis that large dunes deposit relatively thin sets of cross-strata explains the absence in the geologic record of sets of eolian cross-strata comparable in thickness to the height of large modern dunes.

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Model of Transgressive Barrier Island Stratigraphy

Cape Romain, South Carolina, is a large cuspate foreland, 50 km north of Charleston. Geomorphically, it is a barrier-marsh-lagoon complex in a state of rapid transgression. Historically, the shoreline has retreated more than a kilometer; the present retreat rate averages 10 m/year. A detailed coring program was undertaken to determine the Pleistocene-Holocene stratigraphy of the cape. The resulting depositional model has been correlated to the Cretaceous of Wyoming and the Carboniferous of Alabama.

Unconsolidated Pleistocene and Holocene sediments lie unconformably over Oligocene marls. These late Pleistocene facies consist of shallow embayment sand shoals. Silty highly protected lagoon fills and shell storm lags are found laterally. During the Wisconsin lowstand of sea level, the area was emergent, and a freshwater swamp developed forming a 1.8 m thick peat. The swamp existed for about 7,000 years, until the leading edge of the Holocene transgression overtopped it. Rapidly rising sea level exceeded sediment supply resulting in the deposition of laminated silts. A barrier island probably had already developed offshore, affording protection for the lagoon. As the rate of sea level rise slowed, the lagoon filled with a coarsening-upward sequence of flasered sands and silts, overlain by a silty sand tidal-flat facies. The lagoonal facies were capped by the barrier island and its associated marshes and tidal creeks. These barrier-related deposits consist of silty marshes and clean sand and shell washovers, inlet fills, and spit platforms. As the system moves landward, much of the lagoonal sequence is truncated at the shoreface, forming a ravinement surface overlain by an offshore sand; however, the Pleistocene deposits and the peat will be preserved below wave base.

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Mineralogic and Chemical Composition of Antrim Shale, Michigan

The Antrim Shale is the Michigan basin equivalent of Devonian-Mississippian black shales of the eastern United States. The Dow Chemical Co., with DOE funding, has investigated the possibility of in-situ gas production from the Antrim by underground combustion. This paper summarizes some results obtained in the shale characterization program that was a part of that study.

Antrim Shale is rather uniform in composition and contains about 30% Si, 8% Al, 4% Fe, 2% Mg, 3% Ca, 2% S, and 5% organic carbon. Mineralogically, Antrim Shale consists of 50 to 60% quartz, 20 to 35% illite, 5 to 10% kaolinite, 0 to 5% chlorite, and up to 5% pyrite. Calcite and dolomite, when present, occur as limestone nodules, lenses, and interbeds up to 5 ft (2 m) thick in the lower half of the Antrim. Bedford Shale, which overlies the Antrim in eastern Michigan, contains more total clays, illite and kaolinite, and less quartz. Ellsworth Shale, which interfingers with the upper part of the Antrim in western Michigan, contains up to 25% dolomite.

Antrim Shale contains up to 12.8% organic material, as measured by low-temperature ashing. Bitumen contents range from 0.2 to 0.8%. Average molecular weights of bitumen components are 360 to 370. Deeper drill holes have higher bitumen contents. Kerogen, which makes up the rest of organic material, is of low functionality, about 1 functional group per 25 carbon atoms. Hydroxyl (1 group/50 C atoms) and alkene double bonds (1 group/50 C atoms) are the most common groups present.

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Bridges to *What* Future?

The theme title of this annual meeting demands an answer to the question: what will be the principal energy source for mankind in 50 years? In 100 years? When our petroleum supplies are gone or so reduced as to be unimportant, what will be the alternatives? Geothermal and other minor sources will help, but the major possibilities are our other fossil fuels (oil shale, tar sands, and especially coal), nuclear energy, and solar energy. Because the other fossil fuels are also nonrenewable resources, they can only serve as a bridge to the ultimate major source: nuclear or solar. An examination of these in terms of adequacy, effects on man's environment, and the quality of human life, indicates that solar energy is the logical choice. It is not true that solar power is inadequate; recent studies indicate that solar energy could provide liquid and gaseous fuel and electricity, not only for the present world population of about 4 billion, but for the 10 billion forecast by the demographers by 2080, if adequate planning and development are started now. Present policies seem to be locking us into a nuclear future, with all of the major problems and dangers it entails. Rational, realistic decisions are needed, and we geologists can provide valuable advice to the policy makers.

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Influence of Pore Geometry on Future Enhanced Recovery in Ordovician (Red River) Carbonate Reservoirs at Cabin Creek Field, Montana

This study related the distribution of pore geometry to enhanced recovery within the Upper Ordovician Red River