mechanism in which shearing processes were dominant.

The rudites are interpreted as a complex of submarine channel fills, excavated in base-of-slope sediments and possibly representing the lower ends of small submarine canyons. The more extensive proximal turbidite bodies may then be regarded as fan accumulations fronting the canyon mouths and feathering out into the distal representatives. One of the most interesting features of this sequence is the abruptness of the change from channel rudite through proximal facies to distal turbidites, which in several localities may be shown to occur within less than 8 km downcurrent. The short-lived and unusual character of the turbidity currents in this example may be linked to the clean, mud-deficient nature of the original supply of gravel and sand.

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Modes of Formation, Sedimentary Associations, and Diagnostic Features of Shallow-Water and Supratidal Evaporites

Production of a brine depends critically on favorable geometry and climate. The required geometry rarely is achieved on a large scale but commonly is developed on a small scale in the form of lagoons, pans, and supratidal areas, during processes of nearshore sedimentation; large brine basins normally will exhibit these environments peripherally. The small size and exposed nature of shallow brine bodies and supratidal surfaces give them an inherent instability, *e.g.*, short-term, extreme temperature fluctuations, brine dilution, or brine concentration. These instabilities may be reflected by features of the sediments and evaporite minerals.

Stability and kinetic data indicate that gypsum is always the first calcium sulfate mineral precipitated and that anhydrite is either an early or late post-burial diagenetic mineral. Gypsum crystals precipitated from brine bodies normally lack inclusions and are elongated whereas those precipitated diagenetically within supratidal sediments or below the sediment-brine interface in brine pans commonly contain inclusions of host sediment and are lensoid and stubby. Rate of crystal growth is thought to account for these differences in crystal morphology. Anhydrite in supratidal sediments exhibits a nodular structure. Recent occurrences in the Persian Gulf and Baja California indicate that anhydrite is precipitated where mean annual air temperatures exceed 22°C., only gypsum being precipitated below this temperature. Gypsum and anhydrite emplaced diagenetically within supratidal sediments are in places crudely layered but not laminated; brine-pan environments may exhibit sediment-evaporite laminae, each couplet representing a period of dilution and evaporation. Elongate gypsum crystals occur in the evaporite laminae whereas early diagenetic stubby gypsum crystals may occur in both evaporite and sediment laminae.

Several other evaporite minerals may be developed in these environments. Celestite occurs as a trace mineral. Halite may be dominant under high net evaporation conditions and a triplet of sediment-gypsum-halite may be developed as a result of one dilution-evaporation cycle, the halite normally being redissolved, however, at the next influx of dilute water. Polyhalite may replace early gypsum under very high net evaporation conditions. Small amounts of bassanite may result from near-surface dehydration of gypsum in supratidal environments. If local sediments are carbonate, then dolomitization is common. Magnesite and huntite are other recorded minor carbonate minerals. Some of these minerals are stable for only limited periods of time or under a limited set of conditions and are not carried into the subsurface.

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Muskeg Evaporites of Western Canada and Associated Oil

The Muskeg or Prairie Formation is part of the Middle Devonian Elk Point Group of Western Canada. Muskeg rocks grade from marine shale and carbonate in northeastern British Columbia through anhydrite and salt to highly concentrated potassium salts in Saskatchewan. The same progression from less to more concentrated end members is repeated in vertical succession in six composite lithologic units. The cyclic succession of beds and their lateral and vertical facies relations provide a textbook example of an intracratonic salt basin, barred by prominent barrier reefs and fringed by reefoid banks and vast anhydrite platforms.

Large reserves of oil are trapped in pools arranged along the western and southern edge of the Muskeg salt. This association is too consistent to be accidental.

Growth patterns and distribution trends of porous carbonate and sandstone facies from Devonian to Cretaceous suggest that the rim of the salt basin was a persistent locus of epeirogenic differentiation. The regional tectonic trends were modified further by movement of salt and possibly salt solution, providing a variety of local structures where oil was pooled.

In northwestern Alberta Muskeg evaporites are directly involved in the pooling of oil as source rocks, as cap rocks, and as flank seals to prolific pinnacle reefs. Some reef sections are equivalent in age to Muskeg evaporites in the salt basin. Muskeg carbonates sandwiched between evaporites also produce oil.

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AAPG Research Committee

Over the years the AAPG Research Committee has maintained a strong interest in evaporites, largely encouraged by the discovery of major quantities of hydrocarbons in an evaporitic environment. Many of the papers in the main session of this annual meeting deal with "giant fields" which have been found associated directly with or very near to evaporites. The symposium of 12 papers presented earlier today gave a closer look at many of the details involved with evaporite deposition, oil generation, porosity development, environmental conditions, *etc.* In brief, from this symposium the listener has heard about supratidal and conventional deeper water evaporitic deposits. Also he has heard that bedded salt is a normal marine sediment and not a "chemical freak." Source beds occur in the basin deep and moderately tectonic shelf areas where porosity conveniently is available in reefs (limestone) and dolomite. Oil accumulations occur in both environments. Salt movement and solution furnish a variety of structures and begin with an overburden of only 2,000 ft.

Most workers feel that, of all sediments, evaporites have received perhaps the least attention from American geologists and researchers. The writer finds that evaporitic conditions provide S.P.P.S.S.; that is to say they provide source conditions; they preserve organic material; they provide porosity; they provide excellent seals (aquicludes); and they are subject to plastic flow, thus providing a variety of structures.

It is hoped that all will learn their "evaporite" lesson and use it in their oil search. The support of all geologists for research is earnestly solicited.

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LATE PALEOZOIC SEDIMENTS DERIVED FROM PEDERNAL UPLIFT

The Pedernal uplift, elongated northward from southern Otero County, New Mexico, to the present-day position of Pedernal Hills, was a late Paleozoic feature 40–75 mi wide and about 225 mi long; at the time of maximum development, the uplift connected southward with the Diablo platform and northeastward with Sierra Grande arch and Amarillo-Wichita uplift. This is Hill's (1958) Pedernal-Sacramento-Otero uplift, Adams' (1962) Pedernal arch, and Meyer's (1966) Pedernal uplift, but differs from Galley's (1958) Pedernal massif which he extended northeastward to encompass the southern Sierra Grande arch.

The southern Pedernal area was beneath pre-Pennsylvanian seas, which derived their minor detritus from Peñasco dome of northern New Mexico and southern Colorado. The Pedernal uplift emerged during Early Pennsylvanian time. Sediments which became sandstone, dark shale, and silty limestone were deposited westward in Orogrande and Estancia basins and eastward in Delaware basin. During Desmoinesian time, there was wide expansion of shallow seas; the Pedernal barely was awash, and provided only silt and clay for the limestone-choked seas, except for some deltaic subgraywacke in the Orogrande basin. Uplift of the northern part of the Pedernal uplift during late Desmoinesian time supplied arkose northeastward to the Rowe-Mora basin and westward to the Joyita-Los Piños area and Estancia basin.

Beginning in late Missourian, the uplift took on the aspect of a tilted fault block, with the western edge higher (especially near Ruidoso) and providing more detritus westward into the Orogrande and Estancia basins, whereas only minor amounts of fine-grained materials swept eastward into the Delaware basin. These conditions continued into Virgilian time, culminating during the late Virgilian and early Wolfcampian with the westward dumping of a thick sequence of subgraywacke, arkose, and red to dark shale.

Early Wolfcampian sediments derived from the west side of the Pedernal uplift range from quartzite and granite-cobble conglomerate to red shale, but by middle Wolfcampian the major detritus source was the Uncompahgre highland of north-central New Mexico and southwestern Colorado. Reddish clastics from this highland flooded Wolfcampian seas southeastward where Abo redbeds intertongue with Hueco Limestone. By late Wolfcampian time, most of the Pedernal uplift was buried beneath redbeds; only locally, as at the present-day Pedernal Hills and Pajarita Mountain, did remnant Precambrian-rock monadnocks rise above the red clastic flood. Higher remnants supplied minor detritus to lagoonal seas during Leonardian time.

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TRANSGRESSIVE FACIES PATTERNS IN DELAWARE COASTAL AREA

Studies of Recent sediments in coastal Delaware show complex sediment-distribution patterns resulting from lateral and vertical movements of successive environments of deposition over a Pleistocene unconformity. Recent sediments are infilling a drowned topography with a local relief of 70 ft and possibly up to 125 ft eroded on highly variable Pleistocene sediments. Identification of the Pleistocene surface is a problem. However, it may be recognizable as a soil zone or intermixture of marsh clay with Pleistocene sands at the unconformity; it also may be recognized on the basis of radiocarbon dates.

Larger depositional features forming around eroding Pleistocene headlands and infilling the estuaries include characteristic depositional shoreline environments, such as spits, dunes, baymouth bars, an intermeshing network of tidal deltas, nearshore marine erosional-depositional sand and gravel, and the bays or estuaries and fringing *Spartina* and *Distichlis* marshes which form the westernmost edge of the transgressive units. The thickness and areal extent of the sedimentary bodies are controlled largely by the morphology of the Pleistocene unconformity. A large part of these Recent sedimentary units is being eroded by the transgressing Atlantic Ocean.

Cores of sediment taken under the shallow bays, such as Rehoboth, Indian River, and Assawoman Bays, and in the fringing marsh environment, show that the depositional units are thin, highly irregular in areal extent, extremely variable in thickness, and difficult to project. Sedimentary processes active in the shallow bays include shoreline marsh erosion and the formation of thin, possibly ephemeral, beach-dune complexes consisting of clean, well-sorted sand having typical beach and dune sedimentary structures. They are anomalous in that they are completely surrounded by *Spartina* marshes on the landward side and extremely muddy sand grading into dark gray lagoonal mud on the bay side. It appears that distinctive sedimentary structures, and sediment size-sorting relations such as those that characterize the larger more common sedimentary units of the coastal area may be formed in miniature at the very thin edge of transgression and may lead to considerable confusion in the interpretation of sediments of this type in the geologic record.

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BURBANK FIELD, OKLAHOMA—A GIANT GROWS

The Burbank field of Osage and Kay Counties, Oklahoma, a "giant" oil field by any standard, has dominated oil activity in northeastern Oklahoma since its discovery in the 1920s.

The major producing formation in the field is the Burbank Sandstone which is in the Desmoinesian Cherokee Shale of Middle Pennsylvanian age. Several lenticular and semiblanket sandstone bodies comprise