diastems are commonly characterized by a hardground which ideally has a bored or abraded surface; holdfasts of sessile organisms or encrusting fauna; and intraclasts derived from the hardground in overlying sediments.

Petrographic examination of Holocene hardground samples from the Persian Gulf and the Bahamas establishes the morphologic habit of contemporaneous interparticle submarine cements. Micritic high-magnesium calcite, fibrous aragonite, fan druses of aragonite, and a graded calcite mosaic (crystal size increases away from nucleation site and crystals exhibit sweeping extinction) are characteristic cements.

Inspection of relict cement morphologies in ancient hardgrounds suggests at least five petrographic criteria for the recognition of synsedimentary cementation: (1) a graded calcite mosaic in which crystals exhibit sweeping extinction; (2) impurities incorporated in blocky calcite which occur in fibrous bundles perpendicular to the site of nucleation; (3) a graded clastic mosaic with incorporated layers of micrite (only on the up side) that parallel the nucleation site; (4) radiaxial fibrous cement; and (5) micritization present only on the upper surface of the hardground horizon with no intergranular penetration of micrite below. Further observations include borings which cut grains; truncated grains at apparent breaks in sedimentation; absence of overlying sediment in grain interstices; intraclasts exhibiting borings and/or encrusting fauna; and obvious absence of compaction of grains.

Because permeability and porosity are greatly reduced along hardgrounds, they may provide effective seals within carbonate reservoirs acting not only as hydrocarbon traps but also as inhibitors to vertical migration of potentially cementing fluids.

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Seismic Stratigraphy Interpretation of Paleocene, Fort Union Formation, Wind River Basin, Wyoming

The integrated use of seismic reflection data and conventional well logs allows a time stratigraphic reconstruction of lithofacies in the Fort Union Formation in the western part of the Wind River basin, a sedimentary and a structural basin formed during the Laramide deformation. During latest Cretaceous through early Eocene time, the basin was infilled with a continuous sequence of alluvial, fluvial, and lacustrine sediments. The Paleocene Fort Union Formation can be divided into two general lithologic units: a lower fluvial unit of sandstone, conglomerate, shale, and carbonaceous shale and an upper unit of fine-grained clastics deposited in and adjacent to Waltman Lake.

Lithofacies in the Fort Union Formation can be recognized on seismic reflection data as lateral variations in the reflection amplitude and continuity. Three major unconformities are recognized within the Fort Union Formation. Two unconformities are indicated by strong reflectors with widespread continuity at the top of the lower Fort Union and about 300 ft (91 m) below the top of the lower Fort Union. A third unconformity is present at about the middle of the upper Fort Union Formation. Mapping of seismic facies with the aid of scattered well control allows the reconstruction of regional depositional settings and lithofacies.

Analysis of the stratigraphic framework of the Fort Union Formation is useful in providing a rationale for future hydrocarbon exploration. Gas production from the Fort Union Formation at Pavillion, Fuller Reservoir, and Frenchie Draw fields is a combination of structural and stratigraphic trapping.

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Carbonate Platform Slopes of Extensional Continental Margins

Carbonate platforms of extensional margins may be grouped into five major categories. *Homoclinal ramps* have gentle slopes into deep water and may have skeletal or ooid/pellet sand shoal complexes that grade without break in slope into deep ramp nodular limestone and thence into pelagic/hemipelagic basin facies. Homoclinal ramps generally lack significant slump and sediment gravity flow deposits in the deeper water facies. *Distally steepened ramps* differ from the above in having a marked increase in slope at the seaward edge of the deep ramp and abundant slumps, slope breccias, and turbidites. However, clasts of shallow platform margin facies are generally absent from breccias. *Rimmed shelves* have linear trends of shelf-edge lime sands and reefs, a marked increase in slope into deep water, and foreslope and slope sands, breccias (with clasts of platform margin rocks), and turbidites, grading seaward into basin margin hemipelagic/pelagic muds. They may be divided into accretionary, bypass, and erosional margins. *Isolated platforms* are broad flat-topped shallow platforms surrounded by deeper water (few hundred meters to 4 km deep). Most are bypass margins but accretionary and erosional margins also occur. Finally, *drowned or open platforms* may develop by rapid submergence of ramps, shelves, or isolated platforms. Platform margin facies are shifted landward and the earlier shallow-water platform is covered with transgressive lags and deeper water blankets of hemipelagic or pelagic facies, or open-marine, whole fossil wackestones. The various platform types may be recognized from continental margin sequences ranging from Proterozoic to Holocene in age.

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Paleoecology of Oligocene Reef Tract, Southwestern Puerto Rico

A well-exposed, late Oligocene, barrier-reef sequence, approximately 60 m thick, outcrops for at least 25 km between Guayanilla and Guanica near the southwestern coast of Puerto Rico. A virtually complete range of reef tract environments, from lagoon to deep fore-reef and basin slope, is present. *Porites-Caulastrea* patch reefs occur in lagoonal miliolid wackestone and packstone, while reef-flat coral shingle is represented by rudaceous grainstones. The reef-crest and reef-front zones are constructed of more than 30 species of hermatypic scleractinian corals. The reef core consists of coral boundstone framework with massive heads in point-to-point contact. The upper fore-reef facies is wackestone with a distinctive assemblage of reef corals, many of which exhibit flattened growth form. Deep fore-reef deposits are packstones of the prolific large foram *Lepidocyclina (E.) undosa,* while deep-basin facies are composed of pelagic mudstones, clays, and chalks which are interbedded with coral-bearing turbidites. The sequence of reef development displays a classic example of community succession from pioneer through intermediate and climax seral stages, with the coral *Porites* occupying a dominant to predominant role.

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Continental Reserves and Deliverability

A computer system for oil and gas reserves and deliverability developed by Florida Computer Systems Co. for Florida Gas Transmission Co. and Florida Exploration Co. (subsidiaries of Continental Resources Co.) is described. The basis of the system is a data base consisting of identification, reserve and deliverability parameters, contract data, prices, and production and purchase histories. Individual data items from the data base are retrieved and manipulated to create reports.

This system was a joint project of data processing, exploration, and pipeline personnel and, as a result, it handles oil and gas information from both the buyer's and the seller's viewpoints.

Major user features of the system are: (1) on-line mode of operation with interactive programming for rapid response; (2) extensive report generation capability based on parameters specified by the user; (3) graphics capability that includes a four-color CRT terminal and printer; (4) programmed data editing and error recovery; (5) manual overrides at all levels; (6) security levels determined by user's password; (7) three methods of data access: alphanumeric name, code number, or selection from a list using a light pen.

Major technical aspects of the system are: (1) developed and running on IBM 370/138 under DOS/VSE; (2) on-line control by CICS; (3) data base maintained by DL-I Data Management System; (4) structured programming techniques; (5) parameter-driven logic; (6) documentation prepared with HIPO.

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Hypothesis Combining Dilation, Natural Hydraulic Fracturing, and Dolomitization to Explain Petroleum Reservoirs in Monterey Shale, Santa Maria Area, California

Fractured reservoirs in the generally siliceous Monterey Shale of the Santa Maria area represent an anomalous lithology and type of fracturing. Some, perhaps all, are not fractured chert but parts of the Monterey embrittled by dolomitization. Reservoir fractures, unlike ubiquitous Monterey fractures, are mostly abundant, disordered, open extension fractures that commonly produce epigenetic, dolomitic breccias. These dolomite-cemented breccias commonly contain open voids, many of which are 15 cm across or larger. Breccias locally have an exploded appearance and contain some matched fragments separated by vein-like or dike-like matrix, which apparently was an injected slurry of water and oil containing fragments of dolomite and dolomitic Monterey Shale.

The highly organic Monterey also served as the source rock and probably originated as a rich diatomaceous slope sediment beneath an oxygen-minimum zone. The depositional site was much larger than the Santa Maria area and unconfined to silled basins. Local dolomitization may have been due, at least in part, to rising solutions and injected slurries.

The reservoirs are explained by a hypothesis involving repeated episodes of rock dilation followed by natural hydraulic fracturing, all produced by episodic but continued tectonic compression of the region (principal, maximum, effective stress oriented northeastward). Increasing fluid pressures enlarged underpressured dilation microfractures into macrofractures and produced breccias by hydraulic fracturing. Viscous oil expressed from indurated Monterey was pumped into voids as part of overpressured slurries whose fragments were propping agents. Dolomite precipitated from slurries, on pressure release by fracturing, partly healing the fractures. Repetition of these events fractured additional rock, so that the reservoirs grew outward and somewhat upward.

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Methane Oxidation in Anoxic Marine Sediments

A major part of the upward methane flux in anoxic marine sediments appears to be consumed in a subsurface zone of anaerobic methane oxidation. Slope changes in the depth distributions of methane, sulfate, and total carbon dioxide concentration indicate that the downward flux of sulfate and the upward flux of methane approach zero in this zone and that the upward flux of carbon dixoide increases. A minimum in the stable carbon isotope ratio of carbon dioxide ($\delta^{13}CO_2$) coincides with this zone; the minimum appears to be due to local injection of isotopically light, methane-derived carbon dioxide. Differences in methane distributions from freshwater and marine sediments suggest that sulfate reducers are responsible for anaerobic methane oxidation in marine systems. Recent "quasi in-situ" tracer experiments using $^{14}CH_4$ confirm that methane is anaerobically oxidized. Depth distributions of methane oxidation rates in Chesapeake Bay and Skan Bay sediments show a maximum whose location and magnitude are in accord with model predictions.

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Some Recent Developments in Drill-Stem Test Interpretation Useful to Explorationists in Tight Gas Sand Plays and in Identifying Reservoirs with Linear Geometry

Two major areas of recent development in drill-stem testing are of particular interest to geologists. The first is the use of closed chamber DST's to evaluate the very tight gas sands currently under intense exploration in areas such as Alberta's Deep Basin and various intermontane basins in the United States Rocky Mountain province. Conventional DST's of such zones frequently provide little usable data, especially in very deep wells where the time for gas to fill the drill string, reach surface, and thereby be detected, commonly exceeds allocated flow time. This problem of definitive identification of gas presence and verification of rate is overcome where closed chamber tests are utilized, since downhole gas influx is determined from instantaneous surface pressure change. Interpretation processes are explained which have enabled initial detection of gas and rate verification, and have sometimes allowed differentiation between truly impermeable and badly damaged zones. Field examples from the Deep Basin of Alberta are shown together with results after completion. Other applications are shown.

The second development is the use of DST data to identify reservoirs with linear flow geometry. Geologic situations where flow into the well bore during a test can be considered linear rather than truly radial include long narrow reservoirs with parallel boundaries such as channel sands, zones bounded by parallel sealing-fault boundaries, or naturally fractured reservoirs where an open fracture intersects the well bore. Many such situations may be identified utilizing simple graphic techniques involving plots of the pressure buildup during shut-in periods versus the square root of various time functions. These plots allow extrapolation to correct reservoir pressure (not possible with conventional Horner plots which assume radial flow, and which sometimes result in false interpretations of depletion).