Logarithms of the reflectance values form a linear trend with depth. Extrapolation of this trend to 0.20% R_o, a value thought by some to mark the normal surface intercept, reaches only 460 m (1,509 ft) above present ground, instead of the 1,500 m (4,921 ft) predicted on the basis of postulated erosion. Such a deep intercept would indicate that maximum temperatures were attained much more recently than the volcanism (and subsequent to removal of 1,040 m [3,412 ft] of sediment). If the plot is extended up to the +1,500 m (+4,921 ft) pre-erosion level, the intercept is only 0.08% R_o, leading to an unlikely paleotemperature situation.

Time-*independent* models of the general dependence of reflectance on temperature yield a paleotemperature gradient of about 115°C/km and surface intercepts (20°C) of −350 to +250 m (−1,148 to +820 ft) relative to the present ground level. These models require that a strong heating occurred at the site at nearly the present time, and are not in accord with available facts.

Time-*dependent* models give a paleotemperature gradient of 50° to 65°C/km in the sampled interval (41 to 54°C/km in the overlying non-coaly section). Intercepts of 20°C are +1,300 to +1,700 m (+4,265 to +5,577 ft) above the present ground. These models agree logically with the present 46°C/km gradient across the sampled interval and the removal of 1,500 m (4,921 ft) of overburden, with maximum temperature just a bit after maximum burial. Of the three approaches tried, the time-dependent model is the only one which works in this situation.

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Hummocks—Do They Grow?

Now that hummocky cross-stratification is being more widely recognized in the stratigraphic record, investigators are speculating on the hydraulic conditions under which it forms. An accurate knowledge of the geometry of hummocky lamination is necessary if we are going to determine how it is produced.

I maintain that most if not all hummocky lamination is produced where sediment is draped over a scoured hummock-and-swale surface. As pointed out by several early workers, laminae thicken into the swales so that as sediment accumulates, hummocky laminae flatten out within a liminaset. Laminae tend to be parallel to the basal scoured surface. Although very low-angle tangential laminae are not uncommon, their relationship to the lower bounding surface is typically one of onlap. Several well-exposed hummocks in the Cape Sebastian Sandstone and Coaledo Formation, southwest Oregon, will be used to document my case.

It is imperative to recognize that hummocky bedsets consist of several to innumerable laminasets bounded by low-angle truncations. In some places the lower bounding surface of a hummocky bedset is essentially flat (but scoured), and the basal laminae are nearly horizontal. Laminasets above this basal set may show more curvature, but I maintain that they are bounded by scoured surfaces and that the apparent progression upward from flat to hummocky lamination does not reflect growth of hummocks. Hamblin and Walker in 1979 suggested that basal flat lamination was produced by a density-flow mechanism before storm waves resculpted the sea floor. An alternative explanation may be that the scouring ability of a single storm (or several storms in succession) may have varied with time, in some places beginning with conditions that produced a relatively flat sea floor.

Is there any convincing evidence that hummocks grow, i.e., that they develop by thickening of laminae beneath the crest? Thus far, only Hunter and Clifton in 1982 have convincingly illustrated, with a photograph, an example of laminae that thicken to form a hummock. Is this example a fluke? Can we find more? Until there is further documentation of "growing" hummocks, I suggest that we avoid theorizing about how hummocks grow.

If, as I maintain, hummocky cross-stratification is essentially a scour-and-drape phenomenon, can we define its hydraulic significance? In the case of (smaller-scale) vertically climbing, current-ripple lamination, most workers believe that laminae form by fallout from suspension without traction. In the example of hummocky stratification, some authors have observed parting lineation separating hummocky laminae, which would argue *for* traction; others have noted the absence of parting lineation.

Can we explain the geometry of a hummocky scoured surface by the nature of the waves about it, i.e., are there predictable hydraulic conditions under which hummocky cross-stratification forms? Can we treat hummocks as bed forms that grow and/or migrate? Do observations concerning vertically climbing ripples in an unidirectional flow apply to conditions beneath a storm-wave surface? How important is unidirectional flow during formation of hummocky cross-stratification? Careful observation and documentation of the geometry of hummocky cross-stratification are necessary in our search for the answer to these questions.

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An Incipiently Drowned Platform Deposit in Cyclic Ordovician Shelf Sequence: Lower Ordovician Chepultepec Formation, Virginia

The Chepultepec interval, 145 to 260 m (476 to 853 ft) thick, in Virginia contains the Lower Member up to 150 m (492 ft) thick, and the Upper Member, up to 85 m (279 ft) thick, of peritidal cyclic limestone and dolomite, and a Middle Member, up to 110 m (360 ft) thick, of subtidal limestone and bioherms, passing northwestward into cyclic facies. Calculated long term subsidence rates were 4 to 5 cm/1,000 yr (mature passive margin rates), shelf gradients were 6 cm/km, and average duration of cycles was 140,00 years.

Peritidal cyclic sequences are upward shallowing sequences of pellet-skeletal limestone, thrombolites, rippled calcisiltites and intraclast grainstone, and laminite caps. They formed by rapid transgression with apparent submergence increments averaging approximately 2 m (6.5 ft) in Lower Member and 3.5 m (11.4 ft), Upper Member. These submergence increments may have resulted from small (about 1 m; 3.2 ft) relative sea level rise, coupled with subsidence due to loading by water and accumulating sediment. Progradation of tidal flat facies did not occur until subsidence had ceased. Tidal flats were shifted westward from 70 to 380 km (43 to 236 mi) after each submergence event, but in peritidal sequences, had sufficient time to prograde back into the shelf.

Deposition during Middle Member time was dominated by skeletal limestone-mudstone, calcisiltite with storm generated fining-upward sequences, and burrow-mixed units that were formed near fair-weather wave base, along with thrombolite bioherms (subwave base to wave agitated shallow water settings). Locally, there are upward shallowing sequences, (subtidal cycles) of basal wackestone/mudstone to calcisiltite to bioherm complexes (locally with erosional scalloped tops). Apparent submergence increments during Middle Member deposition averaged 7.0 m (23 ft), ranging up to 23 m (75 ft) in southeastern belts. Following each submergence, carbonate sedimentation was able to build to sea level prior to renewed submergence. Large submergence events caused tidal flats to be shifted far to the west, and they were unable to prograde out onto the open shelf because of insufficient time before subsidence was renewed, and because the open shelf setting inhibited tidal flat deposition. The Middle Member represents an incipiently drowned sequence that developed by repeated submergence events. Such incipiently drowned shelf sequences are common but poorly documented in the geologic record. They punctuate many aggraded cyclic shelf sequences and may ultimately provide important information for construction of relative sea level curves for the Paleozoic.

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Oil-Bearing Glacial Deposits from Permo-Carboniferous Haushi Group, Oman

A sequence of glacial and related deposits up to 700 m (2,296 ft) thick in the lower part of the Haushi Group contains significant quantities of oil in several fields in south and central Oman and is the main exploration target along the eastern flank of the South Oman salt basin. More than 300 well penetrations demonstrate that the glacial deposits extend over more than 60,000 km^2 (23,166 mi^2) in outcrop and subsurface. The Late Carboniferous to Early Permian Haushi Group (dated through palynology) unconformably overlies Precambrian to Devonian rocks of the Huqf and Haima Groups with, locally, a considerable paleorelief. The glacial deposits are overlain by fluvial and shallow marine deposits of the upper Haushi Group which include a fossiliferous limestone dated as Early Permain (probably Sakmarian).

The glacial origin of units within the lower part of the Haushi Group is established from the outcrop area on the west flank of Huqf massif where striated pavements of Precambrian dolomite have been found. One pavement is directly overlain by a 4 m (13 ft) thick diamictite interpreted as a basal till. In nearby exposures striated boulders have been found.

Both in the outcrops and in the subsurface diamictites with abundant far-traveled material (granite and volcanic boulders) occur. They are considered to be mostly debris-flow deposits of glacially transported material. Their common interbedding with "varved" shales with dropstones is diagnostic of a glaciolacustrine setting. The association of varved shales and diamictites is commonly of sealing quality.

Reservoirs in the glacial sequence are formed by sandstones and clast to matrix-supported sandy conglomerates which are interpreted as deltaic and fluvial deposits. Depositional models and paleogeographic reconstructions have been made with the help of core studies and correlation of facies units using wireline logs. These correlations demonstrate the limited lateral predictability of reservoirs which is not unexpected in view of the geometrical complexity of many modern glacial deposits.

The geometry of facies units is, however, also complicated by syndepositional subsidence, due to both progressive dissolution of Precambrian salt, and to differential erosion at the contact between the glacial sediments and the underlying, unconsolidated sands of the Haima Group.

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Critical Appraisal of Fluvial Facies Models

Interpretation (and subsequent prediction) of the lithofacies geometry of ancient river-channel deposits requires *full* understanding of the formative processes. This is ideally gained by linking channel geometry and hydraulics with sediment erosion, transport, and deposition, using generalized (quantitative) physical models. Such models exist for high-stage deposition in single curved channels of simple planform: they are capable of approximating the three-dimensional variation of mean grain size and internal structure of point-bar deposits in channels with differing geometries and flow characteristics. However, such models cannot presently predict processes operating on point bar tops (e.g., sheet floods, chute channel and bar formation, scroll bars, flow separation zones) or the nature of low-flow deposits. Lateral lithofacies variation due to meander-loop evolution and cutoff is also inadequately understood.

Generalized physical models of braided and anastomosed river deposition are particularly poorly developed, and need urgent attention. Single-channel and braided rivers can be distinguished on the basis of their water discharge, slope, width/depth ratio, and sinuosity; *quantitative* analysis of ancient alluvium is required for reconstruction of these parameters. Although braided river deposits should typically have a high proportion of coarse-grained channel fills relative to lateral accretion deposits, coarse-grained channel fills are also common in sinuous rivers with cutoffs. It appears that presently available qualitative facies models do not adequately represent the range of lithofacies geometries expected from different kinds of rivers, and therefore do not allow thorough and unequivocal interpretation of paleochannel geometry, flow characteristics, and evolution.

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Computer-Assisted Map Evaluation of a Coal Prospect

Posted maps of coal bed thickness, overburden, aquifers, etc were made from reconnaissance drilling of a 15 mi^2 (39 km^2) prospect. These data were then interpreted and hand-contoured to form individual maps of the several geologic factors that influenced the feasibility of in-situ gasification. Contours from each individual map were then digitized, thus allowing expert human interpretation, as reflected in the hand-drawn contours, to be entered into the computer. The computer then formed individual geological maps, structure surface and isopachs, from the sets of contour data. By devising various algebraic combinations of the maps and assigning various favorability weighting factors to the geologic conditions embodied within maps, several alternative interrelations and evaluations of the combined maps could be formed quickly within the computer. These alternate interpretations embraced a range of uncertainties in geological, engineering, and processing conditions.

Several features of this computer method are beneficial to geologic evaluation. The system of computerized combined map interpretation allows both continuous-valued and quantized data to be brought together in one analysis. Human insight and experience are included insofar as original data are input to the computer as complete hand-contoured maps, rather than as isolated points left to a "non-interpreting" gridding algorithm. To produce a computer evaluation of several maps, the geologist is obliged to organize his ideas and think in a quantitative and reproducible fashion about the interrelations of his data sets. Finally, the computer allows the geologist to explore and compare alternative hypotheses in far less time than is required by conventional methods.