tions predict a decrease in the concentrations of K^+, Na^+, and CA^{++} such that $K^+ < Na^+ < Ca^{++}$ in buffering capacity. This phenomenon is actually observed. Reactions such as from (2) also provide a mechanism to produce H^+, lowering pH, and perhaps also forming secondary porosity during later diagenesis of clastic rocks.

Both examples demonstate that authigenic mineral assemblages, not the appearance or disappearance of single minerals, must be documented to relate diagenetic changes to burial depth. Also, diagenetic mineral assemblages are strongly controlled by water compositions in open systems and these are not a simple function of burial depth. This also implies that any disturbance of fluid compositions during drilling or well completion may profoundly affect mineralogy.

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Temporal Changes in Depositional Facies in Great Valley Forearc Basin of California—Influence of Basin Evolution and Tectonics

The Great Valley forearc basin began in the Late Jurassic as a residual forearc basin on top of oceanic crust, and evolved into a composite forearc basin on top of both oceanic and continental crust in the Late Cretaceous and Paleogene. The depositional basin widened through time owing to the westward and upward growth of the subduction complex and the eastward migration of the coeval magmatic arc. Depositional facies reflect changes in shape, size, tectonic activity, and inherited characteristics of the basin.

Late Jurassic depositional environments primarily consisted of slope with locally incised channels. The basin was relatively narrow and a steep slope allowed sediment movement from the shoreline on the east directly into the trench to the west. By the Early Cretaceous, a bathymetric barrier was formed by the upward- and outward-building subduction complex, thus trapping arc-derived sediment within the forearc basin. Basin-plain environments dominated in this terraced forearc. The subduction complex continued to grow, and the magmatic arc migrated eastward during the Late Cretaceous, resulting in a wider, composite basin. Complex interbedded submarine fan, slope, and basin-plain facies formed in this setting. Submarine fan systems became larger owing to the concentration of sediment gravity flows within submarine canyons incised into the widening shelf on the east side of the basin. The basin evolved into a broad ridged forearc and, eventually, into a broad shelved forearc during the Paleogene as the subduction complex emerged above sea level and the forearc basin filled. As a result, Upper Cretaceous submarine fan complexes are overlain by slope facies, which are overlain by shelf facies. Nonmarine environments have persisted following filling of the basin and sequential termination of subduction by the northward migration of the Mendocino triple junction during the Neogene.

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Basins of East India: Tectono-Stratigraphic Facies

Rocks and structures of east India result from both global and local processes. Global sea level and the breakup of Gondwanaland control the broad aspects of sedimentation and deformation, and local sedimentologic and tectonic variables determine specific lithologic and structural variations. The concept of tectono-stratigraphic facies is convenient in the interpretation of different suites of rocks and structures which are related ultimately to the same global processes. Three tectono-stratigraphic facies are recognized for east India. *Facies 1* is on the craton. It consists of very long, narrow grabens or half grabens containing small normal faults. Most faults are Early Triassic to Early Cretaceous in age but some may be older. Sediments are restricted to the grabens and are late Carboniferous through Early Cretaceous fluviatile or lacustrine clastics. *Facies 2* is in broad basins along the continental margin. Major Late Jurassic to Early Cretaceous normal faults divide the basins into a series of elongate blocks. Sediments are predominantly Late Jurassic through Early Cretaceous marine, paralic and continental clastics. *Facies 3* is found along the continental margin. Faults are Late Cretaceous to early Tertiary in age, while sediments are marine, paralic, and continental deposits of Late Cretaceous to recent age. Marine sediments are more dominant offshore.

The ten most prominent basins of east India can be classified in terms of tectono-stratigraphic facies. The Godavari, Mahanadi, Damodar, and Satpura basins are dominated by facies 1, and the Cauvery, Palar, Godavari-Krishna, and Mahanadi-Brahmani basins are characterized by facies 2 and 3. The Bengal basin is dominated by facies 3. Observed dominant facies may grade into one of the other facies in unexplored parts of these basins or at depths yet to be probed.

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Geologic Framework for Development, Production, and Reclamation of Coal Properties

Today, geology plays an increasingly important role in the development, production, and reclamation of coal properties. The geologic framework of a property is defined by geologic mapping, drilling, logging samples, downhole geophysics, correlation of lithologic units, and review of laboratory analyses. These activities form a data base which is needed by the mine design engineer, the development and production engineers, and the reclamation specialist.

A detailed surface geologic map will be of use throughout the life of a coal mine. This map can best be prepared (after preliminary photogeology) by field mapping, which includes measuring sections and defining structure and stratigraphy. The identification of lithologic units and determination of their engineering characteristics are important because they bear a relation to excavation and slope stability in surface mines, and to roof, pillar, and floor stability in underground mines.

A typical drilling program includes rotary, spot-core, and full-core drilling, geophysical logging, and sample logging. Bulk sampling of coal for physical testing can be acquired by open-cut, adit, or test drilling. Core logging is particularly important for determination of the engineering characteristics of rocks. Structure-contour, isopach, overburden, and interburden maps are required in mine design, and ultimately in mine development. Reclamation requires determinations of overburden and interburden chemistry.

Cost and time advantages result if hydrologic and soils/rock quality data are collected early, thereby saving time in the permitting process, and reducing the ultimate cost of reclamation.

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Application of Cingulum Index to *Dinogymnium* in Hilliard Shale, Southwestern Wyoming

The cingulum index (CI) was defined for fossil dinoflagellates of the genus *Dinogymnium* as a two-digit number expressing the distance from the middle of the cingulum to the apex divided by the total length of the test and multiplied by 100. This morphologic statistic, which is independent of specimen size, was interpreted as a character of interspecific taxonomic importance. Analysis of CI values of specimens of *Dinogymnium* sp. from the Hilliard Shale (Upper Cretaceous) of southwestern Wyoming suggests that the CI has biostratigraphic significance.

CI values were calculated for *Dinogymnium* from the Hilliard Shale at Cumberland Flats, Lincoln County, Wyoming. When plotted against stratigraphic position of samples, mean and maximum CI values for successive populations show an increasing trend upward through the formation. Population size and sample spacing are variable, and it is uncertain whether evolution or paleoecology is the controlling factor, but the progressive change through more than 1,000 m is useful for biostratigraphic zonation of the formation. The cumulative frequency distribution for all specimens measured in this study is quadramodal, suggesting that four morphologic variants, indistinguishable by transmitted light microscopy, are present.

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Stratigraphic Relations of Permian Formations in Parts of Colorado and Utah

This study suggests that the Permian rocks in northwestern Colorado and northeastern Utah were deposited in shallow-marine shelf, transitional, and terrestrial environments. The Wolfcampanian and early Leonardian upper layers of the Weber formation are predominantly eolian quartz sandstones deposited in a broad coastal area of low relief. This coastal area was at the northwestern end of the ancestral Uncompahgre uplift, and was intermittently covered by seawater as indicated by the few thin marine carbonate rocks. The upper Weber intertongues with the Grandeur Member of the Park City Formation in the study area. The carbonates and cherts of the Grandeur were deposited in shallow-marine waters during a transgressive cycle which was probably caused by a crustal downwarping of the shelf.

The Meade Peak Member of the Phosphoria Formation was deposited on top of the Grandeur by cold, phosphorous-rich, upwelling water as a result of continued Early Permian transgression. Landward from the phosphorites, carbonates were contemporaneously deposited, and further landward, siltstones.

Regression near the end of Leonardian shifted the depositional environment belts westward and resulted in deposition of the Franson Member carbonates and cherts on top of the phosphorites. Maximum regression during the Guadalupian produced very shallow and highly saline waters in the area and subaerial exposure for long periods, combined with a significant increase of terrestrial, fine-grained sediment supply. These conditions led to the deposition of interstratified gypsum, silt, and shale of the Mackentire Tongue redbeds.

The eastern half of the study area is characterized by greenish-gray and tawny beds which are partly time-equivalent of the Meade Peak, Franson, and Mackentire. The environments of deposition are interpreted to be those of a reducing, restricted marine embayment. These beds are more closely related to the Goose Egg Formation in central Wyoming than to any other formation in the area and are so designated.

Extensive regression beginning in late Guadalupian continued into the Triassic and caused the deposition of the Moenkopi red beds.

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Sedimentology of Lower Cretaceous Subtidal Sand Complex, Woburn Sands, Southern England

The Lower Cretaceous Woburn sands have long been considered a transgressive and partly open marine tidal sand deposit. They form a 60-m thick, northward-wedging sandstone body between Jurassic shales, which they unconformably overlie, and a transgressive marine clay which oversteps them northward.

Our studies identify three southward-imbricated, erosionally bounded sand units as follows.

Orange Sands (oldest) comprise alternations of cross-bedded, channel-fill sands and thinner bedded, bioturbated, heterolithic sands. Bidirectional paleocurrents show a dominant northeasterly flood direction.

Silver Sands are characterized by tabular cross-bed sets (up to 3 m thick) which overlie subhorizontal, low-angle (4 to 8°) or concave-upward erosion surfaces. Bidirectional paleocurrents reflect a slight dominance of the southwesterly ebb direction.

Red Sands (the youngest) are structurally similar to the Silver Sands but are distinctive on the basis of abundant detrital ferric oxide and strong horizontal burrowing. Northeasterly dipping cross-bedding is relatively uncommon, producing an overwhelmingly dominant southwesterly, ebb-directed paleocurrent mode.

The interfingering of high-energy tidal channel-fill deposits and heterolithic beds is typical of subtidal estuarine deposits. Furthermore, the upward decrease in the proportion of heterolithic facies and burrowing intensity, the upward increase in the proportion of large-scale cross-bedding and channel width/depth ratios,