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,