uplift, erosion, and subsidence. Evidence for this conclusion comes from regional geologic and tectonic mapping and the collection of samples of shallow-water deposits of Cenozoic age at depths exceeding 1–2 km that lie on surfaces cut across deformed and indurated Mesozoic deposits.

Although the writers recognize that the origin of submerged surfaces on continental margins that are underlain by lithified rocks cannot everywhere be ascribed to subsided erosional surfaces, this explanation appears to be more generally applicable than others that have been considered. The broader implications of this conclusion are: (1) postulated offshore landmasses, *e.g.*, Appalachia and Cascadia, may indeed have existed and foundered along former continental edges, (2) continental accretion may be interrupted by relatively long episodes of continental regression or wasting, and (3) the widespread evidence for marginal foundering suggests that a general mechanism of crustal thinning, possibly including "oceanization," is involved.

JOHANNES H. SCHROEDER, Rensselaer Polytechnic Inst., Troy, N.Y., and FREDERIC R. SIEGEL, George Washington Univ., Washington, D.C.

EXPERIMENTAL DISSOLUTION OF CALCIUM, MAGNESIUM, AND STRONTIUM FROM HOLOCENE BIOGENIC CARBONATES: A MODEL OF DIAGENESIS

Laboratory experiments at ordinary temperatures and pressures for periods up to 240 days on Holocene biogenic carbonate sediments showed that fresh water and seawater dissolve aragonite and Mg-calcite.

The observed rates of dissolution of calcium, magnesium, and strontium indicate that these elements are incorporated in aragonite and magnesium calcite in more than one way (in lattice positions, in lattice interstices, or in inclusions). This suggests the presence of more than one mineral phase in the skeletal materials studied; these phases differ in response to solution and probably in chemical composition. The more soluble phase may influence initiation of dissolution of the material and initiation of calcite nucleation in the aragonite-to-calcite inversion process.

Calcium, magnesium, and strontium are dissolved in proportions different from those in the original solid, *i.e.*, incongruently. The experimentally established sequence of preference is, as a rule, Mg-Ca-Sr.

Factors found to determine direction and degree of incongruency in dissolution include mineralogy (number, kind, and relative abundance of phases present), physiologic effects operating during lifetime of the organism, and chemical composition and volume of waters effective in dissolution.

Incongruent dissolution determines presence, absence, and abundance of ions derived from solids in the diagenetic environment and, hence, ion availability for precipitation in cement and for inhibition or catalysis in inversion or cement precipitation. Magnesium and strontium contents in shell material have been used by others as temperature and salinity indicators in Holocene environments. The present study shows that because of incongruent dissolution these indicators are not dependable for paleoenvironmental analysis.

S. A. SCHUMM, Dept. of Geology, Colorado State Univ., Ft. Collins, Colo.

PALEOCHANNELS

The width (w), depth (d), meander wavelength (l), gradient (s), shape (w/d), sinuosity (P) of stable alluvial river channels are dependent on the volume of water moving through the channel (Q_w, expressed as either mean annual or bankfull discharge or mean annual flood) and the type of sediment load conveyed through the channel (Q_s, expressed as either the ratio of bedload to total sediment load or the percentage of total sediment load that is sand size or larger):

$$Q_w \simeq \frac{w, d,}{s}$$

and

$$Q_s \simeq \frac{w, l, s}{P}.$$

Empirical equations developed from data collected along modern rivers permit calculation of the effects of changes of hydrologic regimen (Q_w, Q_s) on channel morphology. Conversely, these relations permit estimation of paleochannel gradient, meander wavelength, sinuosity, discharge, and type of sediment load from the dimensions of the paleochannel as exposed in cross section when the bed and banks of the paleochannel are composed of alluvium transported by the ancient river.

The recognition of paleochannels within valley-fill or other complex fluvial deposits is a major problem. Some criteria for the delineation of paleochannel cross-section shape and dimensions have been developed from studies of the shapes and sediment characteristics of Australian paleochannels.

Although major changes of river morphology during both historic and geologic times support the empirical relations, they, nevertheless, must be applied with caution because the effects of colonization of the land by primitive vegetation and the progressive evolution of vegetation have influenced markedly the paleohydrology of ancient drainage systems.

JOHN SCOTT, Petroleum Engineer Pub. Co., Dallas, Tex.

DEEP DRILLING COST TRENDS

A yearly study by Petroleum Engineer Publishing Company tabulates the number of wells, locations, total well costs, and bit use, and notes trends toward deeper drilling in various oil-country areas such as the Delaware basin of west Texas.

Deep drilling (15,000 ft and deeper) has increased in recent years. The locality and success ratio of ultradeep drilling (20,000 ft and deeper) are reviewed, and the 1968 deep-drilling data, which are available early in 1969, are compared with 1965, 1966, and 1967 data.

FRANCIS P. SHEPARD, Univ. California, Scripps Inst. Oceanography, La Jolla, Calif.

RELATION OF SUBMARINE CANYONS TO CONTINENTAL SLOPE

Except in areas of gentle inclination, the continental slopes are cut by numerous submarine canyons. There is ample evidence that these canyons are loci of active erosion and represent the chutes down which sediments are transported to build the great fans that have

formed along the base of the slopes. The numerous photographs of ripple-marked sand to depths of 3,500 m, and the observation from deep-diving vehicles of scoured hard rock walls at depths to 1,350 m provide evidence of this activity. The relative importance of turbidity currents and currents of unknown causes is still uncertain. Mass movements undoubtedly are an important contributing cause.

Most submarine canyons are located off relatively large land valleys. In some places, the canyons apparently originated as submerged river valleys, but submarine erosion appears to have played a major role in developing their present configuration. Evidence of more than one cycle of excavation of canyons exists in various places. Apparently canyons have become filled and then reopened by some type of rejuvenation that is not well understood.

L. L. SLOSS, Dept. Geology, Northwestern Univ., Evanston, Ill.

SHELF SEDIMENTS IN ROCK RECORD—A SUMMARY

(No abstract submitted)

MARK K. SMITH, Geophysical Service Inc., Dallas, Tex.

DEVELOPMENTS IN SEISMIC PROCESSING FOR GEOLOGIC INTERPRETATION

Since the introduction in the early 1960s of digital recordings and processing of seismic data, the effectiveness of the seismic method as a petroleum exploration tool has improved substantially by providing better solutions to many problems such as water reverberations and resolution of discrete reflectors. Thus far, the primary emphasis has been on the development and application of new signal-processing techniques through the utilization of communication-theory concepts. With the development of large rapid-access bulk-storage devices and high-resolution on-line display capabilities, the scope of computer processing can be enlarged to include interpretation and the integration of geophysical and geological data.

Continuous interval-velocity information, with an estimated associated error, can now be extracted from seismic data on a routine basis. Examples from field tests show that, in favorable cases, lateral variations in interval velocity of the order of 1% may be detected. In addition to obtaining a major increase in the accuracy of structural information, continuous velocity data provide a means for detecting lithologic and stratigraphic variations. This capability coupled with a means for extracting and displaying quantitative information about reflector amplitude and waveform provides new possibilities for stratigraphic-trap exploration.

Examples from the Gulf of Mexico show how the computer may be utilized to obtain an interpretation of a grid of seismic data with the assistance of an interpreter to make difficult interpretation decisions and to correct the inevitable errors which can occur in the processing sequence. The capability of the computer to deal with and migrate all the relevant data in three dimensions will lead to a more accurate and complete three-dimensional model of the subsurface from seismic data. As this capability is realized, it will become useful to record seismic data on a tighter grid than is done with current practices.

ROBERT G. SNEAD, P.O. Box 1509, Midland, Tex.

NEW APPROACH TO CLASSIFICATION OF *Azolla* MEGASPORES SPECIES

Four geologic sections in central Alberta which span the contact between the Paskapoo and Edmonton Formations were measured, described, and sampled for their palynological content. Previous studies, mainly of plant megafossils, vertebrates, and nonmarine invertebrates from units slightly above and below the sampled interval, had confirmed a Tertiary age for the Paskapoo Formation and a Late Cretaceous age for the Edmonton Formation.

Many megaspores of the genus *Azolla* were recovered in every geologic section sampled. Nine species were recorded, eight of which are new and classified according to a new approach based mainly on the nature and structure of the megaspore wall and perispore lamellae. To date, in almost every palynological study, the nature of the "swimming apparatus" has been the primary basis for classification of *Azolla* megaspore species. The "swimming apparatus" is not well defined on every specimen, which limits the application of a classification based on it. Because the method of classification proposed in this study can be used to identify species from mere fragments of the perispore wall, it may prove to be of greater utility in establishing identifications than the system presently in use.

R. S. SPENCER, Old Dominion College, Norfolk, Va.

MULTIVARIATE ANALYSIS OF VARIANCE STUDY OF *Neochonetes granulifer* (OWEN): ITS IMPLICATION WITH RESPECT TO GEOGRAPHIC VARIATION AND EVOLUTION

Twelve characters on the dorsal valve of *Neochonetes granulifer* (Owen) were measured and subjected to multivariate analysis of variance. The specimens were collected from 26 localities which represent seven different geologic units ranging in age from late Desmoinesian to late Wolfcampian. The statistical procedures successfully resolved geographic variation and evolutionary change. They also showed the relations between many measured characters as they evolved. Three-space graphs were constructed, using as axes three discriminant functions which explained 95–98% of the variation. Means projected onto discriminant functions and discriminant functions alone were plotted on these graphs for ease in visualizing relative similarities between sampled populations and influence of the measured characters on the sampled populations. Geographic variation within any one sampled stratigraphic unit was small. The statistical method tended to separate limestone assemblages from shale assemblages. This finding raised the question of whether a population as a continuum or two ecologically controlled populations of the same species were represented by the samples. If, on further investigation the latter is found to be correct, the statistical method employed will have been shown to be a very useful tool for discerning morphologically similar but ecologically different populations of the same species.

R. C. SPRIGG, Geosurveys of Australia Pty. Ltd., J. C. BRAITHWAITE, Mining and Exploration, Lime and Marble, A. YAKUNIN, Geosurveys of Australia Pty. Ltd., and R. B. WILSON, Geosurveys of Australia Pty. Ltd., Adelaide, S. Australia.