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.

Oil and Gas Prospects of Southern Taranaki Bight, New Zealand[1]

Potentially petroliferous sediments of early Tertiary age are preserved in several subbasins and graben-synclines along the western parts of both islands of New Zealand. Collectively these constitute the now extensively disrupted, linear, and platformlike Cretaceous to Tertiary "West basin" or "geosyncline," which is separated from the more specifically volcanic "East geosyncline" by the geanticlinal backbone of the New Zealand continental block. The geanticlinal zone which is "geosuturelike" constitutes a major transcurrent fault system within the circum-Pacific tectonic belt.

Following a major break from the Jurassic to Cretaceous graywacke-breccia flysch-type deposition, Upper Cretaceous to Tertiary platformlike sedimentation in the newly forming West basin was regionally extensive and about 10,000–15,000 ft (3,050–4,600 m) thick. The basal unconformity is angular and sharp, whereas internal unconformities tend to be local and marginal. Facies changes are also important locally, but these are superimposed on regional sequences that are traceable through the full longitudinal extent of the platform.

Upper Cretaceous-lower Tertiary sediments are predominantly freshwater and coal bearing. Later sediments are dominantly marine, and include considerable thicknesses of mudstone and limestone.

Oil seeps along the West basin are associated almost entirely with the lower Tertiary coal measures. In the Taranaki basin a small oil field in Pliocene sandstone at New Plymouth has produced a total of 200,000 bbl of oil and 65 MM cu ft of gas (1.85 MM cu m). The Kapuni condensate-gas field in the Taranaki basin, discovered in 1959, is capable of producing 60 MM cu ft (1.70 MM cu m) of gas-condensate per day. Hydrocarbons are considered to be mainly indigenous to the coal measures, but some may be from overlying marine sediments.

Several geophysical surveys have outlined the broader structure of the southern Taranaki basin. Upper Cretaceous-lower Tertiary coal measures, together with a lower Tertiary limestone, provide the principal reflectors, except where masked by thicker Plio-Pleistocene section in the east (D'Urville trough). Sedimentary thicknesses in the area attain 10,000–15,000 ft (approx. 3,000–4,500 m), but thin considerably over conspicuous structural "highs." A variety of structural and stratigraphic traps is predicted.

Broad comparisons have been made with recently discovered major oil and gas fields of the Gippsland basin, Australia, directly across the Tasman Sea.

DANIEL J. STANLEY, Div. Sedimentology, Smithsonian Inst., Washington D.C., and RAFAEL UNRUG, Dept. Geology, Jagellonian Univ., Cracow, Poland.

Coarse Channelized Deposits and Other Indicators of Slope and Base-of-Slope Environments in Ancient Marine Basins

Submarine slopes are distinctive depositional environments because of their gradients and their position between sediment source locales at their upper level and areas more favorable for preservation on basin floors beyond. The model for slope sedimentation must incorporate such factors as gradient, dissection, type and rate of sediment input, and processes. Slopes are most often represented as inclined planes reflecting depositional instability, *i.e.*, relatively temporary resting places for sediments during their passage to depositional sites in more distal environments. Sediments are, however, preserved in a multiple set of slope subenvironments, and there are criteria for recognizing most of these.

Fine-grained pelagic deposits (some entirely reworked by benthonic organisms), hemipelagic materials influenced by bottom current activity, turbidites with mixed faunas and mineralogy, contorted slumped units, and allochthonous slabs which slid into deeper water generally are recognized as the dominant slope facies assemblage. However, the problem of distinguishing slope from basin-floor sediment remains because criteria for distinguishing facies are found in both environments, especially near their juncture. Marine geologic investigations have detailed the three-dimensional geometry, vertical-lateral relation, sedimentary properties, and have defined processes on modern slopes. These investigations and studies of paleoslope deposits in certain Tertiary flysch formations of the Alps and Carpathians, bring to light methods that permit more precise paleogeographic interpretations.

Channelized deposits, coarse units representing fills of submarine canyons and valleys and answering the description of *fluxoturbidites,* are important in this respect. They can be mapped regionally as shoestring bodies that migrate downslope and are incised in pelagic and bottom-current transported units and turbidite bundles. They are well developed on lower slopes, subsea fans, and rises, and can be traced well into basins; they are not necessarily proximal. Primary structures are generally indicative of traction processes. Their value in measuring primary dip and major slope trends, in pinpointing important source input along basin margins, and in serving as funnels in the transfer of sediments downslope can be demonstrated.

In association with these channels, wedges of pebbly mudstone are common at the base of slopes and, where concentrated, indicate the position of an important break (decrease) in gradient. Large, commonly rounded blocks and boulders enrobed in contorted mud suggest conditions of rapid sedimentation as off river mouths or along rapidly eroded coastlines, where materials are periodically moved across narrow shelves and then, *en masse,* on relatively steep slopes, perhaps between canyons.

JAMES H. STITT, Dept. Geology, Univ. Missouri, Columbia, Mo.

Evolution of Trilobite Populations, Late Cambrian Biomeres

New data from the southwestern United States on Late Cambrian trilobite biomeres suggest that the nonagnostid trilobite population of each biomere underwent four successive stages of evolution before becoming extinct. The first and stratigraphically lowest stage is characterized by species with considerable morphologic variability and short stratigraphic ranges. The second stage is characterized by species with longer stratigraphic ranges and less individual morphologic variability. The third stage is characterized by high species diversity and species with long stratigraphic ranges and increasingly less morphologic variation. The fourth, stratigraphically highest stage is characterized by low species diversity, coquinoid abundance of at

[1] Published with the permission of the Directors, Tasman Petroleum Ltd.