Stromatoporoids have a "plastic" morphology which makes them sensitive indicators of paleoenvironments but which presents problems for stratigraphic correlation. A zone at adjacent outcrops may have different genera and species. Nevertheless, stromatoporoids can be useful to determine the time framework of strata.

An *Amphipora* Zone has been recognized for years in the Mid-Continent North American Middle Devonian. Range charts also have been made previously, and at least one work has established several stromatoporoid zone fossils, but authors have noted difficulties of correlation.

A small fauna was collected from two adjacent localities in the Niagara Peninsula of Ontario, near the contact of the Onondaga Limestone with the underlying Bois Blanc Formation. The fauna consists of seven species belonging to three genera (22 specimens), not a statistically significant number. However, the stratigraphic ranges of previously reported occurrences of the species accurately determine the correct age when equated to the continental European standard section. The plotted ranges are based on systematic works in which descriptions and illustrations can give some idea of the validity of species identifications. Stratigraphic works with species lists which cannot be documented were not considered.

The longest ranging species is *Stromatoporella granulata* from the lower middle Siegenian well into the Frasnian. Other previously described species in the fauna are confined to the Eifelian, especially to the lower Eifelian. Three species (representing 77% of the specimens collected)—*S. granulata, S. selwyni,* and *S. tuberculatum*—were all previously reported many years ago from the "Corniferous" Limestone at Port Colborne by H. A. Nicholson. *S. selwyni* has also been reported from the basal Jeffersonville Limestone of Indiana. *Stictostroma excellens* and *Stromatoporella perannulata* are described from the area for the first time. Both have been described previously from the Jeffersonville Limestone; *Stictostroma excellens* from Indiana and *Stromatoporella perannulata* from Kentucky. One specimen is compared with *Stromatoporella composita* Yavorsky. Although Yavorsky's species is not conspecific, it is morphologically similar enough to be of stratigraphic significance. Yavorsky's species comes from the lower Eifelian beds on the margin of the Kuznetz basin.

A question has been raised as to whether Nicholson's fauna reported from nearby Port Colborne came from Onondaga or Bois Blanc beds. Despite of the relatively small number of specimens, one can say that due to strong faunal similarities, Nicholson's material came from the same zone as the material herein reported and further, that both faunas are probably lower Eifelian in age, equivalent to the Edgecliff Member of the Onondaga Formation, which is in agreement with previous correlations based especially on corals and brachiopods.

Although stromatoporoid faunas may differ significantly from outcrop to outcrop at the same stratigraphic zone, and although stromatoporoid faunas are frequently represented in collections by small numbers of specimens, they can give a good indication of their position in geologic time when the identified taxons are compared with the world literature.

STONE, DALE G., Seismograph Service Corp., Tulsa, OK

Prediction of Depth and Velocity on VSP Data

The Vertical Seismic Profile (VSP) method can often be used to assist in making drilling decisions. These decisions may involve anticipation of overpressured zones, distance to the seismically determined target, and verification of geologic or geophysical interpretation.

A VSP is recorded with a seismic source on the surface and receivers in the borehole. Both up and downgoing waves are recorded and are separable. Layers beneath the borehole are recorded in the upgoing waves at every receiver position. This redundancy can be exploited to achieve a high signal-to-noise ratio and good quality time-amplitude information. The conversion of amplitude to acoustic impedance gives time and interval velocity with density held constant. Depth is then a function of time and interval velocity.

A VSP has several advantages over surface seismic data in inversion. These include knowledge of attenuation, waveform, and multiples from averaging downgoing waves. The borehole coverage allows use of a control zone for establishing optimal inversion parameters. Averaging of upgoing waves gives an unusually good signal-to-noise ratio so that deconvolution with the averaged downgoing waves yields an excellent estimate of primary reflections. These considerations, combined with the favorable geometry of the VSP, provide for considerable accuracy in estimation of velocity and depth below the bit.

STRAUSS, ALAN M., Univ. Maryland, College Park, MD

Morphological Variation of the Ostracode *Krithe*

Ostracodes, like other organisms, react to a changing environment by altering their morphology. This paper reports how the recent ostracode *Krithe* changes when temperature, oxygen, salinity, and depth vary. Eight specimens were chosen from varying localities in the north and south Atlantic Oceans. Although temperature and salinity did change in these locations, they did not vary enough to warrant study. Due to a lack of oxygen data, depth was the only environmental parameter available for examination. The Theta-Rho analysis technique was used to study the specimens. Marginal outline, anterior and posterior vestibules, and pore canals were all examined to see if they changed with depth. The outer margin area did not change in any consistent way with increasing depth. The area of the posterior vestibule decreased with increasing depth, and the anterior vestibule showed a possible trend for the area of increasing with increasing depth. Finally, the pore canals did seem to change with a variation in depth, but no direction for this change was found. It is suggested, in conclusion, that further studies use a larger number of specimens, so that any indicated trends can be better substantiated.

STUEBER, ALAN M., Louisiana State Univ., Baton Rouge, LA, and PAUL PUSHKAR, Wright State Univ., Dayton, OH

Application of Strontium Isotopes to Origin of Smackover Brines and Diagenetic Phases, Southern Arkansas

The abundance of the isotope ^{87}Sr is variable in nature, as it is the radiogenic product of ^{87}Rb decay. The relative amount of this Sr isotope that is dissolved in a brine, as expressed by the $^{87}Sr/^{86}Sr$ ratio, might be used as a tracer of the origin and subsequent history of the brine, including its diagenetic effects in petroleum reservoirs. Strontium isotopic analyses of 40 brines from oil fields in southern Arkansas have been conducted to investigate the sources of the dissolved Sr, the pathways of brine migration, and the relationship between the brines and diagenetic phases in the Jurassic upper Smackover Formation. The $^{87}Sr/^{86}Sr$ ratios of 33 brines from the upper Smackover lime-grainstone range from 0.7071 to 0.7101; seven brines from formations stratigraphically above the Smackover range from 0.7090 to 0.7112. Thus the Sr in these brines is variably more radiogenic than Jurassic sea water

(~0.7070). The brines are from 15 oil fields within an area of approximately 2,000 mi² (5,200 km²); the isotopic variability shows no geographic pattern in the study area. The variation in $^{87}Sr/^{86}Sr$ ratios of brines occurs to a lesser degree within individual oil fields. For example, over a distance of about 10 mi (16 km) at Walker Creek, the isotopic ratios of 11 Smackover brines range from 0.7080 in the east to 0.7086 in the west.

The observation that Smackover brines are variably more radiogenic than Jurassic seawater is important because it indicates that a significant proportion of the Sr dissolved in these brines has been acquired from a source material that has not formed wholly by precipitation from Jurassic seawater. That is, some radiogenic Sr must have been added to the brines from a detrital source material. The nature and distribution pattern of the $^{87}Sr/^{86}Sr$ ratios indicate the acquisition of variable amounts of radiogenic Sr on a local basis. If the Smackover brines originated in the Louann Salt, with $^{87}Sr/^{86}Sr$ equivalent to that of Jurassic seawater, their present isotopic compositions may be the result of varying degrees of subsequent interaction with detrital sediments or they may have been produced by mixing in variable proportions with solutions containing more radiogenic Sr. Potential sources of the radiogenic Sr are the Norphlet Formation and the lower Smackover argillaceous lime-mudstone, both of which lie stratigraphically between the Louann salt and the upper Smackover, as well as the Bossier shale which interfingers with the upper Smackover in the North Louisiana salt basin. Anhydrites from the Werner and Buckner formations and from northern Louisiana salt domes, which constitute additional potential sources of brine Sr, yield $^{87}Sr/^{86}Sr$ ratios equivalent to those of Jurassic seawater.

Diagenetic phases of the upper Smackover, such as post compaction calcspar cement and baroque dolomite, have $^{87}Sr/^{86}Sr$ ratios more radiogenic than Jurassic seawater, suggesting their subsurface precipitation in Sr isotopic equilibrium with Smackover brines. However, ooids and oncolites from the upper Smackover lime-grainstone yield $^{87}Sr/^{86}Sr$ ratios indicating isotopic equilibrium with Jurassic seawater.

STURCHIO, NEIL C., Washington Univ., St. Louis, MO

Geologic Evolution of Precambrian Basement of Eastern Desert of Egypt

The Eastern Desert of Egypt contains an exposure of approximately 80,000 km² (30,000 mi²) of late Precambrian basement between the River Nile and the Red Sea. The dominant lithologic units of the basement are low-grade basaltic and andesitic metavolcanics and immature metasediments. These are associated with serpentinite-gabbro units, which have been interpreted as fragments of obducted ophiolites, and large syntectonic diorite-tonalite-granodiorite intrusions. A regional unconformity separates the above units from a sequence of molasse-type sediments which are intruded by post-tectonic Pan-African (~580 m.y.) granites.

Geographic patterns of age, lithology, petrochemistry, and structure have been interpreted in terms of multistage development and accretion of intra-oceanic island arcs and intervening basins. The age of intrusions, and the depth of crustal exposure, generally increases toward the south. No evidence has yet been reported for ages greater than ~1,200 m.y., or unequivocally continental lithologies, among the older units.

Structural analysis suggests that the region was affected by at least two distinct compressional events. The first event involved compression along a northwest-southeast axis, and may be related to an episode of northwest-vergent folding and thrusting, with concomitant magmatic activity. The second event involved compression along a WSW-ENE axis which initiated uplift, molasse-type sedimentation, large-scale open folding along NNW-SSE axes, and WSW-directed thrusting or gravity sliding. The emplacement of the Pan-African granites and rhyolites apparently occurred upon relaxation of the second compressional event, signifying the maturation of the crust of the Eastern Desert of Egypt.

The dominant trends (NNW-SSE and WSW-ENE) of high-angle faults and fractures were well established by the end of the Precambrian. These seem to have controlled the positions of various Phanerozoic features, such as alkaline complexes, local sedimentary basins, and the Red Sea.

SUNDERMAN, JACK A., Indiana Univ./Purdue Univ., Fort Wayne, IN

Role of Neptunian Dikes in Structural Evolution of Reefs

Sedimentary dikes, mostly of the neptunian type, are common if not universal features of submarine carbonate buildups, particularly reefs, and also have been reported from submarine volcanic mounds and pelagic marine sediments. Most of the neptunian dikes occupy widened joints that exhibit clear evidence of tensional origin. Large neptunian dikes reported from Gotland, Sweden, from central Europe, and from the upper Wabash Valley region of the United States also exhibit multiple (polyphase) banding, suggesting repeated joint formation.

The largest dikes appear to occur only in the margins of reefs or other sediment mounds, suggesting an origin related to local sediment accumulation rather than to regional tectonic forces. Dike joints that occur in reef flank rocks of the upper Wabash Valley region exhibit both radial and concentric orientation with respect to reef centers, and most of the dikes are essentially vertical. The vertical dike crevices appear to be simple extension fractures, but the orientation of a few outward-dipping dikes and sills in some reefs is somewhat anomalous. The joint crevices which they occupy have the orientation of shear fractures, but probably represent extension fractures that were diverted from their initial vertical orientation by the inclined bedding of the reef flank rock.

The fact that most neptunian dikes are oriented vertically strongly suggests that principal compressive stress axes were oriented vertically throughout the development of reefs and other submarine mounds, which in turn suggests that the dike crevices probably were produced in response to gravitational load stresses developed within the mounds. The existence of both radial and concentric dike crevices in reefs suggests that the intermediate and least principal stress axes were oriented both radially and concentrically during reef development. This in turn suggests that the confining pressures of surrounding interreef sediment, and the internal cohesion within the reefs, were great enough to prevent reef expansion by concentric joint formation at some times, but not at other times. Relief of stress by reef expansion along concentric vertical fractures probably increased the likelihood of later expansion along the radial fractures.

Dike crevice formation probably is closely related to differential compaction or other differential volumetric changes that occurred within the reef parts, or that occurred between the reefs and the interreef sediments, but crevice formation also may have been affected to some extent by sagging of the sea floor beneath the reefs and other sediment piles.