support the widely accepted view that tectonism and source-rock type exert the dominant control on sandstone composition. Because various kinds of tectonic provinces exist, corresponding sandstone provinces such as cratonic-sandstone provinces, fault-block basin sandstone provinces, and others also exist. However, within these provinces anomalous sandstone compositions occur (*e.g.*, quartz arenite in a fault-block basin), because other processes such as recycling, transportation, deposition, and diagenesis obliterate or mask the effects of tectonism. Although it normally is possible to recognize the anomalies, it is difficult to determine which processes have caused the anomaly and is almost impossible to measure the individual effect of each. Thus attempts to reconstruct the paleogeography of sandstone provinces and to compare and contrast the significance of sandstone provinces in various tectonic settings are hampered.

Compositional norms for recent sand derived from a variety of source rocks, in a variety of tectonic settings, and deposited in a variety of environments are needed before the process variables that have influenced the compositions of ancient sands can be identified and measured. New and improved studies of the relative destructibility of mineral types and rock fragments also are required before reliable semi-quantitative provenance interpretation within a sandstone province is possible.

SWAIN, F. M., Dept. Geol., Univ. Minnesota, Minneapolis, Minn.

PROVINCIAL ASPECTS OF SOME NEOGENE OSTRACODA OF UNITED STATES

Marine Neogene fossil ostracod assemblages that show some degree of provinciality include those from the Louisiana subsurface, the Florida panhandle, North and South Carolina, Virginia, Maryland, and southern California. Nonmarine Pleistocene fossil ostracod assemblages from Illinois, Ohio, Kansas, Minnesota, Utah, Idaho, and Nevada, and Miocene and Pliocene assemblages from Nevada and Idaho also are represented to some extent by restricted species.

One of the main problems in the analysis of the assemblages is determination of the limiting effects of environmental factors on the species having restricted distribution versus other less tangible limiting factors. Comparisons of the fossil distributions with those of living representatives are helpful.

As an example of provincial restriction of marine Neogene Ostracoda not obviously controlled by facies, the Atlantic Coast of the United States is typified by certain species of *Murrayina* and *Hulingsina*, whereas rocks of similar age are typified (1) in the Caribbean by *Ambocythere*, (2) in east Africa and the Mediterranean by *Chrysocythere*, and (3) in Germany perhaps by *Urocythereis* and *Kuiperiana*.

SWEET, W. C., and S. M. BERGSTRÖM, Dept. Geol., Ohio State Univ., Columbus, Ohio

PROVINCIALISM EXHIBITED BY ORDOVICIAN CONODONT FAUNAS

Throughout the Ordovician, 2 well-distinguished provinces were delineated by distribution of conodonts in the northern hemisphere. One, the North Atlantic province, includes all of northwest Europe, the British Isles, and a tract in the eastern Appalachians that stretches from Newfoundland on the north to Georgia and Alabama on the south. A second, the North American Mid-Continent province, embraces all of interior North America, the western belts of the Appalachians, and at least part of the Canadian Arctic Archipelago. Although there was limited and episodic exchange between North Atlantic and North American Mid-Continent conodont faunas, and vicarism is evident between some elements, the two were strikingly different and apparently largely unrelated.

Limited information suggests that Mid-Continent faunas were also characteristic of at least parts of the Siberian platform, and elements of these faunas are known also from the Ordovician of New Zealand and Australia. Paleogeographic, paleotectonic, and paleomagnetic considerations suggest that the Mid-Continent fauna developed at low latitudes, perhaps astride the Ordovician equator, and that the North Atlantic fauna was characteristic of higher latitudes. This suggestion is reinforced by the presence of mixed or modified North Atlantic and Mid-Continent faunas in rocks that accumulated at relatively more deeply submerged sites in the Mid-Continent or Cordilleran areas. Water temperature was probably the most important factor in defining boundaries between the 2 recognizable provincial faunas.

SWEET, W. E., JR., and R. A. GEYER, Texas A&M Univ., College Station, Tex.

NATURAL HYDROCARBON SEEPAGE IN MARINE ENVIRONMENT

Evidence of hydrocarbon seepage in the marine environment has been documented back to prehistoric times. Hydrocarbons are held in structural and stratigraphic traps by overlying, impervious layers, and they can escape only if the capping layer is destroyed. Escape channels through the capping layer are formed primarily by faulting, which may be essentially due to tectonic forces, as in the Santa Barbara Channel area, or may be due to diapiric uplift as in the Gulf of Mexico.

Unconsolidated sediments of varying thickness overlie consolidated sediments and bedrock in most marine environments. Because of the incompetency of these sediments, fault traces usually are not transmitted to the surface as open fractures. Hydrocarbons are forced to flow or bubble up through these sediments in a manner that may be analagous to diapirism. The more viscous the hydrocarbon the more probable it is that traces will remain in the sediment. Traces have been found at various locations in the Gulf of Mexico and off the California coast.

Seepage is intermittent and aperiodic with unpredictable rates. Viscosity and the passage up through the sediments may be the controlling factor in the intermittent flow. Tidal effects may be significant.

Hydrocarbons have a specific gravity lower than that of seawater. There is no evidence that floating oil or tar through self distillation will increase enough in specific gravity to sink. It has been suggested that accretion of sediment particles could cause floating tar to sink. This could occur only along the surf zone, or at the mouths of heavily laden streams if at all.

It is, therefore, almost axiomatic that tar or tarry residues found in marine sediments originated from a natural seep. No oil from pumped bilges or ruptured fuel tanks ever sank to the bottom.