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Potential Contribution of Oil Shale to Energy Needs of United States and Other Parts of the World

The present worldwide dependence on imported crude oil may be partly relieved by production of oil from oil shale. More than 3 trillion bbl of oil are contained in known organic-rich shale deposits that will yield 10 or more gal of oil per ton of shale. About two-thirds of this resource is in the Green River Formation that underlies parts of northwestern Colorado, northeastern Utah, and southwestern Wyoming in the United States.

Oil shale, which has been mined mainly utilizing conventional mining and surface-retorting techniques, has produced shale oil continuously during the past century. Although Scotland has the longest history of production (more than 100 years), Russia and China combined have produced about 80% of the approximately 1 billion tons of oil shale mined since 1919. The United States has yet to spawn a commercially viable oil-shale industry; however, since 1919 almost half a million bbl of shale oil have been produced, chiefly from the oil shales of the Green River Formation in Colorado. More than 350,000 bbl of this amount has been produced in large-scale pilot operations since 1964.

Sufficient resources are available on the United States federal prototype oil-shale lease tracts in Colorado and Utah to sustain a 300,000-bbl-per-day industry. Private land in Colorado and Utah, owned by major oil companies, contains enough thick, rich oil shales to produce an additional 550,000 bbl of oil per day. Known deposits outside the United States contain a large enough resource base to maintain a 2.2-million-bbl-per-day shale-oil industry. In addition, some developing countries that have oil-shale deposits of lesser magnitude may establish labor-intensive, less expensive industries with smaller rates of production.

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Deep-Sea Benthic Foraminifera and Their Biostratigraphic Potential

Since the advent of the Deep Sea Drilling Project, late Mesozoic and Cenozoic benthic foraminifera have been recovered from cores drilled in the Indian, Pacific, and Atlantic Oceans. These faunas represent a broad range of low-middle latitude depositional environments from water depths of about 1,500 to 5,000 m. At the present time, analysis of fossil deep-sea benthic foraminifera is in a nascent stage. However, it is evident that many taxa occur in all the world's oceans, have easily recognized shell morphologies, and are generally more preservable than planktonic foraminifera. The major drawbacks to benthic species in biostratigaphic investigations are their long duration per species, compared to planktonic species, and the taxonomic confusion surrounding many taxa.

In the Cretaceous there was little difference between deep ocean and continental slope faunas. Important stratigraphic markers, such as the *Bolivinoides* lineage, *Bolivina incrassata, Gavelinella* and *Gyroidinoides* species established in North America and Europe, were present in the deep ocean. Following a major evolutionary turnover in the early Paleogene, deep-sea faunas became less similar to those of continental margin as many new lower bathyal-abyssal genera evolved. Tertiary stratigraphic boundaries, including the top of the Paleocene, middle Eocene, top of the Eocene, upper Oligocene, and middle Miocene, are readily identifiable. After the middle Miocene, benthic foraminifera changed little and it is difficult to subdivide late Neogene faunas.

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Status of Antler Orogeny in Central Idaho—Clarifications and Constraints from Pioneer Mountains

Structural telescoping of argillaceous lower Paleozoic sequences with coeval calcareous and quartzitic rocks in central Idaho has commonly been presumed to be analogous to the Roberts Mountains thrust in Nevada. However, all datable thrusts in the Pioneer Mountains are post-middle Permian to pre-Eocene in age; if Antler age thrust existed, they were reactivated or obscured by major post-Antler movement. Furthermore, differences in fabric or structural style between thrusted argillaceous pre-Mississippian sequences and calcareous-arenaceous Pennsylvanian-Permian sequences, which have been cited in support of Antler orogenesis, are equivocal. These differences more likely resulted from disharmonic response to entirely later thrusting in rocks of different competencies or at different structural levels.

The Copper Basin Formation, a dominantly clastic deposit requiring an argillite-chert-quartzite western highland source in Mississippian time, remains the only evidence in central Idaho for an Antler highland. The Copper Basin now occurs in two superimposed allochthons which, when palinspastically restored, require that their original depositional basin extended at least 50 to 75 km west from the present Pioneer Mountains. Thus, in Mississippian time, the Antler highland reached no farther east than westernmost Idaho.

Emplacement of the Pioneer Mountains allochthons during mainly Mesozoic time involved (1) tectonic slices of high-grade metamorphic rocks and Precambrian crystalline basement, (2) eastward movement and imbrication of Antler detritus, and (3) thrusting of argillaceous facies lower Paleozoic rocks from the Antler highland over the tectonic remnants of its own debris. At least 100 km of post-Antler eastward translation is estimated; a comparable amount of earlier facies telescoping could be accommodated within the Antler highland based on reasonable facies reconstructions, but thrusting has not yet been demonstrated to have accompanied Antler highland development in Idaho.

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Sands and Sand Transport on Palimpsest Carbonate Shelf

The West Florida Shelf east of Cape San Blas, an