stow basin were probably deposited in a wide, but relatively small, body or bodies of fresh to slightly saline water with fluctuating shorelines. The basin formed on the northern extremity of the Barstow-Bristol trough.

The most abundant palynomorphs found in the Barstow Formation belong to Asteraceae, Chenopodiaceae, *Ephedra, Eriogonum, Pinus,* and *Quercus.* Also present in lesser abundances are specimens belonging to Onagraceae, Ericaceae, *Juglans, Alnus, Carya, Arbutus, Typha,* and *Platanus.* The palynomorph assemblage is dominated by a lowland shrub community in association with an upland community of oak and pine. This association is indicative of a dry summer climate similar to, but probably wetter than, the present climate.

A middle to late Miocene age has been assigned to a vertebrate mammalian fauna near the sample locality, and radiometric dates of 13.3 to 15.9 m.y.B.P. have been obtained from local tuff beds.

The large relative abundances of *Ambrosia,* as well as the presence of *Artemisia,* indicate an age of early Pliocene for the Barstow Formation, based on present palynologic information.

OMNES, GILDAS, and PHILIPPE ROBERT, CGG, Denver, Co

P-shooter—A Fast Seismic Source for Shallow Exploration

The P-Shooter is a new, light-weight source developed by CGG in collaboration with Shear Wave Technology Inc. Though energy is provided by a mass falling vertically, the source differs from a simple weight-drop system by its coupling device and the additional acceleration provided by a spring. It is designed to work at a very fast rate.

In operating mode the weight travels up and down a vertical tower and is guided between two rails. During the drop it is accelerated by a spring until it hits a baseplate that is coupled to the ground by part of the weight of the vehicle. After the impact and before any rebound can occur, the weight is picked up by a cable and lifted back to the top of the tower ready for a second drop.

The weight is adjustable between 250 and 500 lb. The spring provides a maximum pull of 800 lb. The combined effect of the spring and a 500-lb weight provides a total energy estimated at 9,700 joules and an impact velocity of 30 ft/sec. By comparison, the same figures for a free fall drop would be only 5,400 joules and 23 ft/sec. The time interval between two successive drops is about 3.5 seconds.

Good coupling is very important; on the P-Shooter it is achieved by a special baseplate, which is separated from the impact surface by a ball joint. This allows the baseplate to keep good contact with the ground. The baseplate is decoupled from the rest of the vehicle through rubber springs, and a hydraulic system applies a constant downforce to it. The coupling baseplate also prevents damages to a road surface.

The whole system is mounted on the back of a 4 by 4 truck. The tower can be moved forward, backward, and to some extent laterally, so that it can be vertical even when the truck is on a slope.

The following seismic properties were observed during experiments carried out in Colorado.

1. Signatures recorded on downhole phones, from 400 to 1,000 deep (120 to 300 m), near the Colorado School of Mines have an amplitude spectrum peaking at about 45 Hz, with a 12 dB attenuation at 100 Hz and a fairly steep drop above 100 Hz.
2. Bandpass analysis on a stacked section confirms that the spectrum extends up to 120 Hz at 500 ms two-way time.
3. The source is perfectly repeatable when a sufficient amount of downforce is applied to the baseplate.
4. On a 1,200% stack obtained in southeastern Colorado and shot with 10 drops per station, penetration is good down to 500 ms, below which signal strength becomes weaker.

Assuming that 20 drops per station would be enough in most areas for targets at less than 1 second, and given a rate of 3.5 seconds per drop a shot point can be completed in 2 minutes (including moving time). This means that on a normal working day, production may approach 200 shotpoints per day. With the 55-ft (17-m) spacing common in this type of work, production would be 2 mi (3.2 km) per day.

The P-Shooter is particularly appropriate for surveys that do not require resolution above 120 Hz. Since it is an inexpensive source usable with a fairly small crew, it can give good quality shallow data at a relatively low cost per mile.

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Braided-Stream and Alluvial-Fan Depositional Environment of Lower to Middle Eocene Ione Formation, Madera County, California

The lower to middle Eocene Ione Formation in southern Madera County was deposited in an alluvial-fan, braided-stream complex bordering the ancestral Sierra Nevada. Sandstone and conglomerate occur as a thin veneer unconformably overlying a deeply weathered Mesozoic igneous and metamorphic basement. Two facies are recognized: a braided-stream sandstone and a proximal to midfan conglomerate with sandstone interbeds.

Braided-stream facies display both sandstone and thin matrix-supported conglomerate (debris flows). Sandstone units contain tabular cross-bedded and parallel-laminated bedding units, which may be capped by small-scale trough cross-beds. This longitudinal-bar sequence may locally occur adjacent to large-scale festoon cross-beds of channel origin. Locally, lebensspuren (trace fossils) are abundant in the sandstone units and these traces represent biologic activity on emergent longitudinal bars or inactive channels.

The proximal to midfan facies consists of interbedded conglomerate and sandstone. Matrix-supported conglomerate units were deposited by debris flows and cross-bedded sandstone units were deposited in alluvial channels. Framework-supported conglomerate may have resulted by reworking of the sediment, removing the clay (forming sieve deposits), or as alluvial channel gravels.

The Ione Formation in Madera County is part of a long, narrow alluvial plain between the ancestral Sierra Nevada and the ocean. This part of the Ione Formation differs from the mixed marine and nonmarine environments of the Ione at its type section.

PISCHKE, GARY, Texaco, U.S.A., Los Angeles, CA

Paleomagnetic Study of Neogene Tectonic History of Baja California, Mexico

Paleomagnetic study of 20 Miocene (19 to 5 m.y.B.P.) volcanic flows and one dike in central and southern Baja California has resulted in determination of inclinations too shallow for the present latitude at all sites, suggesting a greater amount of northward movement than can be accounted for by previous studies. Natural remnant directions from 21 units at five sites (24 to 29° north lat.) suggest an average northward translation of roughly 10° since late Miocene time, and a probable 45° clockwise rotation (post 6 m.y.B.P.) of the San Ignacio flows.

The Paleomagnetically indicated rate of absolute motion of the peninsula is 11 cm per year since 5 m.y.B.P. and 3.5 cm per year prior to 5 m.y.B.P., assuming an offset axial dipole. Absolute northward motion, assuming a geocentric axial dipole, is 18 cm per year from 0 to 5 m.y.B.P., and 3.5 cm per year from 5 to 19 m.y.B.P. The rates of northward motion described by Atwater and Molnar, and Dickinson for the same time spans are 3.5 cm per year and 1.5 cm per year, respectively.

Possible solutions to this discrepancy are: (1) Baja California is part of a broad shear zone of the plate margin, and has had more movement along faults within the proto-gulf and the present margin of western Mexico than previously deduced, (2) the North American plate has no northward motion, or (3) the North American plate has had northward motion since the Miocene, with the amount of motion of the plate margin being equal to that described by T. Atwater and P. Molnar; thus, the paleomagnetic data show both motions.

Studies by M. J. Kamerling and B. P. Luyendyk, and continued paleomagnetic studies at San Diego State University, show a comparable amount of northward motion for southern California and northwestern Mexico during the Miocene. Paleomagnetic results would imply that the present palinspastic reconstructions have not completely resolved the tectonic framework of the Pacific–North American plate boundary.

PRITCHARD, J. I., J. M. JORDAN, R. C. WEST, and H. RENICK, Indesco

Resolution of Reefs, Overthrusts, and Pre-Volcanic Sediments by Electrical Geophysics

Today's explorationist is generally unfamiliar with the potential and success of surface-based electrical resistivity methods as geophysical tools useful in reducing exploration and reserve-areas definition costs, as well as drilling costs. Two major reasons for this are: (1) the promise of direct detection of hydrocarbons where surface-based electrical methods have been used to delineate shallow subsurface anomalies; and (2) the geophysical data from electrical methods are more complex than simple anomaly profiles and require a specifically educated and costly consultant to do the interpretation.

In spite of the above, the electrical methods may be used directly as a resistivity-defining tool which not only delineates structure but also provides information necessary to resolve lithologic and stratigraphic problems, such as rock type, fluid content, and porosity. In areas where seismic data quality is poor because of adverse conditions, such as volcanics, electrical techniques are unaffected and, in many instances, the data quality is actually improved.

To help meet the challenge of today's petroleum exploration problems, a multi-methodology electrical resistivity system has been developed. This system is used to great advantage in exploring reef, overthrust, and pre-volcanic sediment prospects. Case histories in Nevada and west Texas show resolution of these problems by electrical methods.

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Aggregate-Resources Evaluation of Lund Nevada Mapsheet

As a result of preliminary research and development work performed in support of a large proposed construction project in Nevada, an aggregate-resource evaluation was completed for 12 major valley areas within the Lund 1° by 2° mapsheet. Construction would require a total of from 95 to 124 million tons of aggregate for production of concrete and base-grade materials in over 40 valley areas where current production is 1 million tons/year.

Within the Lund mapsheet a three-phase program was initiated to assess the relatively unknown aggregate potential of the area. Each phase became more detailed than the preceding one. The phases went from regional-overview to valley-specific analyses. Results of the initial regional aggregate-resources evaluation indicated that sufficient acceptable coarse aggregate could be obtained from Quaternary alluvial-fan and lacustrine basin-fill deposits and Precambrian and Paleozoic carbonate and quartzitic rock sources. Sufficient acceptable fine-aggregate sources were not readily available in the area. During the two subsequent valley-wide studies, geomorphologic division of basin-fill deposits, based on interpretation of aerial photography and ground reconnaissance in conjunction with the results of exploratory drilling and trenching, seismic refraction and laboratory testing, established the extent, composition, and quality of these units. These data refined and confirmed initial aggregate results. Additionally, limited trial concrete-mix test results indicate that high-strength concrete (6,500 psi compressive strength at age 28 days) can be made from selected basin fill and rock sources using standard mix designs and admixtures.

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Evaporite Mineral Cycles, Paradox Basin, Utah and Colorado

The evaporites of the Paradox Member of the Hermosa Formation of Pennsylvanian age in southeast Utah and southwest Colorado are direct precipitates from marine brines and have been changed only slightly by subsequent events. Geophysical logs of deep wells indicate that the Paradox Member is composed of 29 evaporite cycles. Lithologies that make up the cycles, in order of increasing salinity, are: black calcareous shale, dolomite, anhydrite, and halite (with or without potash). Studies of cores from two wells in the central part of the basin show that some of the cycles in the upper part of the Paradox Member are remarkably symmetrical above and below the black shale, indicating regular changes in salinity. Lithic texture, crystal morphology, and bromine distribution are suggestive of primary sedimentation with only minor early diagenesis related to burial dehydration.

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Physical Evidence for Saline Cycles of Deposition in Eocene Lake Gosiute in Southwest Wyoming

The Wilkins Peak Member, the saline unit of the Green River Formation in southwest Wyoming, is more than 985 ft (300 m) thick and contains more than 35 beds of trona or trona with halite. The trona and halite were deposited in the deepest part of the basin of Lake Gosiute, during arid periods of the Eocene Epoch, by the periodic evaporation and contraction of the lake waters. Alternating with the arid periods were more humid periods, when the lake expanded and less saline sediments were deposited across and beyond the previously deposited salt beds. The water-level fluctuations resulted in a concentric pattern of