This paper defines and develops the characteristics of instrumentation that exploit the concepts of CFT (commensurate frequency technology), a modern application of frequency-domain electromagnetics. CFT instrumentation can operate in all modes (i.e., quasi-static, near field, or far field). In all modes, the phase difference between commensurate frequencies is measured to produce a signature relating only to geologic variations. Unlike classical EM measurements, which are apt to be dominated by near-surface features, the CFT process minimizes the effects of near-surface features by common mode rejection (CMR). This characteristic is clearly substantiated by comparison of CFT data and classical EM data.

"Phase" is an ambiguous subject that means different things to different people, and there are differences between phase sensitive detectors and phase meters. There are unique benefits and limitations to use of a phase meter.

Pioneering work has been done using GeoDecca instrumentation and the resulting data show that there is a distinctive, frequency-domain signature associated with a significant number of oil and gas fields in southern California. Recent work using GeOmega instrumentation shows that measurements of commensurate frequency phase difference are insensitive to near-surface pipelines that produce significant distortion of classical EM data taken at the same time and same place. Field data also show the signature enhancement that results when radio signals from four different directions are stacked to produce a composite signature. This will not surprise those who understand that the apparent electrical characteristic of the earth depends on the direction of arrival of electromagnetic waves. This complicates life and one might wish that it were not true, but field data clearly indicate the benefits of illuminating the earth with multiple frequencies from multiple directions.

The shallow skin depth of current GeoDecca (VLF) and GeOmega (LF) sensors is acknowledged. However, a question that cannot be answered at this time is "why the sensors produce a significant signature above a number of California oil fields where the oil and gas are commonly 10 or more skin depths in the earth."

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Closed-Basin Lithofacies in Upper Part of Esmeralda Formation, Clayton Valley, Nevada

The uppermost Esmeralda Formation in Clayton Valley, Nevada, consists of about 330 ft (100 m) of tuffaceous sediment deposited in a closed basin formed by Basin and Range normal faulting about 7 m.y. ago. Five closed-basin lithofacies can be defined on the basis of lithology and sedimentary structures: fluvial, debris flow, shallow lacustrine, spring, and playa. The fluvial lithofacies consists of light-gray to brown, trough-cross-bedded sandstone, lenticular clast-supported conglomerate, and irregularly bedded siltstone and mudstone. The debris-flow lithofacies is made up of pale olive-gray to white, poorly sorted, mud-supported conglomerate and gray sandstone, which commonly displays load structures and convolute bedding. The shallow-lacustrine lithofacies consists of white, light-gray, and greenish-gray, thin to medium-bedded, laminated mudstone, vitric tuff, and diatomite. The spring lithofacies is laminated travertine with convolute bedding. The playa lithofacies is made up of massive gray mudstone, reworked sandstone and siltstone, and mud-clast conglomerate.

Further information regarding the depositional environment can be deduced from studying the petrology of the rocks. The tuff beds and tuffaceous sandstones contain clinoptilolite, opal-CT, and phillipsite as alteration products of vitric material. The laminated mudstone of the shallow-lacustrine lithofacies contains hectorite, calcite, gypsum, halite, clinoptilolite, and opal-CT, but the massive mudstones of the playa lithofacies contain no hectorite. It is concluded that the hectorite and calcite precipitated from alkaline waters in a shallow, spring-fed lake. During playa deposition, the alkaline environment disappeared either as a result of increasing salinity or the deterioration of the spring source.

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Recognition of Middle and Upper Pleistocene Marine Deposits in Downtown San Diego, California

Recent excavations in the downtown area of San Diego have exposed fossiliferous marine sands of middle and late Pleistocene age. Molluscan assemblages recovered from these sands can be grouped into two distinct faunas referred to here as the Broadway fauna (middle Pleistocene) and the "E" Street fauna (late Pleistocene).

Amino-acid racemization age estimates by K. R. Lajoie on shells of *Chione* from these faunas are 560,000 ±75,000 years B.P. and 250,000 years B.P., respectively. Both faunas possess a decidedly warm-water aspect and reflect protected littoral to sublittoral environments. The Broadway fauna contains several local biostratigraphic index genera including *Turritella gonostoma* Valenciennes, *Argopecten abietis abbotti* (Hertlein and Grant), and *Pecten vogdesi* (Arnold), that are not present in the younger "E" Street fauna.

Historically, all marine Pleistocene deposits in the San Diego area have been referred to as the Bay Point Formation. New evidence suggests that temporally, faunistically, and geologically distant units can be recognized within the local Pleistocene section.

The deposits containing the Broadway fauna and the "E" Street fauna occur in low-lying areas at or near sea level and appear to have been deposited in an earlier formed topographic depression. This is in marked contrast to other, younger Pleistocene marine deposits in the San Diego area which occur as thin veneers on elevated marine abrasion platforms (i.e., the Nestor Terrace and the Bird Rock Terrace).

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Basin Analysis of Miocene Mint Canyon Formation, Southern California

The nonmarine upper Miocene Mint Canyon Formation crops out in a broad southwest-plunging syncline within the Soledad basin, about 30 mi (48 km) north of Los Angeles, California, between the San Gabriel and San Andreas faults. The formation is comprised of fluvial and lacustrine deposits.

Clast counts and paleocurrent directions indicate that the fluvial parts of the Mint Canyon Formation were deposited in a broad westward-draining trough. The distribution of local basement-rock source areas indicates that the alluvial wash crossed the San Andreas fault in the general vicinity of Soledad Pass, near Palmdale. Clasts in the central part of the trough are predominantly of volcanic origin, and most are foreign to the area and have no known local source. They must have been derived from east of the San Andreas fault. Among the wide variety of volcanic-clast types within the Mint Canyon Formation is an unusual rapakivi-textured quartz-latite porphyry. A tertiary volcanic field, located about 169 mi (240 km) southeast of the Mint Canyon Formation in the northern Chocolate Mountains east of the San Andreas fault, contains the same variety of volcanic rock types as those that occur as clasts in the Mint Canyon Formation, including the unusual rapakivi-textured porphyry. Chemical analysis and isotope ratios of volcanic clasts from the Mint Canyon Formation and rocks from the volcanic field show them to be strikingly similar.

These data indicate that the Mint Canyon Formation is offset from the volcanic source by about 169 mi (240 km) of right slip along the San Andreas fault.

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Correlations Between the Onshore and Offshore Santa Maria Basins — A Dilemma

In an unexplored basin, extrapolation from known hydrocarbon-producing trends is ideal. However, along transform margins such extrapolations are difficult, owing to lateral displacement between individual blocks on both regional and local scales. An example of this is the relationship between the onshore and offshore Santa Maria basins, which are separated by the Hosgri fault.

Stratigraphic packages have been used widely to approximate amounts of displacement. Lower Miocene volcanics in the offshore Santa Maria P-060-Oceano well may correlate with onshore outcrops, located across the Hosgri fault, 30 mi (48 km) to the east and 45 mi (72 km) to the south, near Point Arguello. Additionally, lower Miocene volcanics also are present in two exploratory wells across the Hosgri fault, 10 mi (16 km) to the east and 25 mi (40 km) to the north, near Point Buchon. These are the Honolulu-Tidewater U. S. L. Heller Lease 1, with 4,722 ft (1,440 m) thickness of volcanics, and the Tidewater Motadoro 1, with 3,873 ft (1,180 m) of lower Miocene volcanics. These wells provide two volcanic sections onshore to tie with the offshore volcanics.

Originally, the lower Miocene volcanics now situated in the northern and southern extremities of the Santa Maria area, may have been joined near the midpoint of their present positions. As the onshore basin pulled apart, the volcanics were divided and transported in opposite directions. Synchronous pull-apart movements occurring in the offshore kept pace with the adjacent onshore. Alternatively, significant intrusive pathways may have opened in the later stage of basin development, allowing igneous material to migrate vertically. These pathways have been termed "leaky" transforms in the literature. Neither of these models necessitates significant lateral displacement once the onshore and offshore basins formed.

Onshore the middle Miocene Monterey Formation and upper Miocene to Pliocene Sisquoc Formation correlate well with equivalent chronostratigraphic units in the offshore P-060-Oceano well, implying that relatively minor lateral displacement has occurred since the middle Miocene. If the offshore basin history is similar to that of the onshore its petroleum potential may approximate that of the onshore, which has been projected to produce 900 million bbl of oil.

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Significance of Neogene Phosphorites in Capistrano Embayment, Southern California

The post-Relizian Monterey, Capistrano, and Niguel Formations comprise about 3,280 ft (1,000 m) of phosphorite-bearing marine sediments. Primary deposition appears to have been as pelletal and nodular phosphorite forming phosphoritic shales with occasional high-grade zones ranging up to 20 to 40% P_2O_5 and individual beds ranging up to 7 ft (2 m) or more in thickness. Most high-grade shale beds, however, are less than 3 ft (1 m) thick and average 20 to 25% P_2O_5. Some of the best exposures are in Aliso and Oso Canyons within the San Juan Capistrano quadrangle. Excavations for construction have exhumed weathered phosphorites at and below the water table exposing remobilized phosphate which is readily recognizable as vivianite [$Fe_3(PO_4)_2$.$8H_20$]. The purple (azurite colored) vivianite oxidizes on drying to a brownish color within a few weeks, thus it is rarely identified during conventional field mapping.

Large-scale landsliding within the Monterey and Capistrano Formations has commonly fractured phosphorite-bearing beds and allowed mobilization and redeposition of the original phosphorite as vivianite above the basal shear plane of block-glide landslides and downstream. Water in downstream drainages has the potential for being misidentified as a pollutant from septic systems. This suggests that geochemical techniques might provide valuable methods of exploration for certain phosphate occurrences.

Of several phosphorite basal conglomerates within or between the Monterey, Capistrano, and Niguel Formations, the best exposed and one of the best developed lies along the angular unconformity between the Monterey Formation and the overlying Niguel Formation on the east flank of the San Joaquin Hills, immediately north of the U.S. Geological Survey office at Laguna Niguel. This resistant phosphorite bed is composed of what appears to be nodules derived from the underlying Monterey Formation. They have been redeposited in and just below the littoral zone. Some of the phosphorite is concentrated in downslope channels within the neritic zone.

Additional exploration within the Capistrano embayment would probably yield economic amounts of phosphate rock. Rapid urban expansion in this part of southern California will probably preclude further exploration and development. However, as the Neogene phosphorite-bearing formations of the Pacific slope become better known, there may be substantial incentive for exploration and development in other areas. California is one of the largest consumers of phosphate in the United States and imports almost 100% of its supply from Florida, Idaho, and other areas. Potentially, millions of dollars could be saved annually in transportation costs and a strategic commodity (petroleum) would be conserved, if local deposits could supply the California market.

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Biostratigraphy and Paleoecology of a New Ostracode Fauna from Rincon Formation (Oligocene-Miocene), Los Sauces Creek, California

An ostracode fauna consisting of 10 new species occurs in the uppermost Zemorrian and lowermost Saucesian sections of the lower Rincon Formation, Los Sauces Creek, Ventura County, California. *Paracosta* and *Buntonia* dominate the assemblage, which is also represented by *"Paijenborchella," Loxoconcha, Acanthocythereis, Asymmetricythere, Cytherura, Xestoleberis,* and a new genus.

A predominance of complete carapaces infilled with pyrite and calcite indicates rapid burial in a slightly basic and reducing