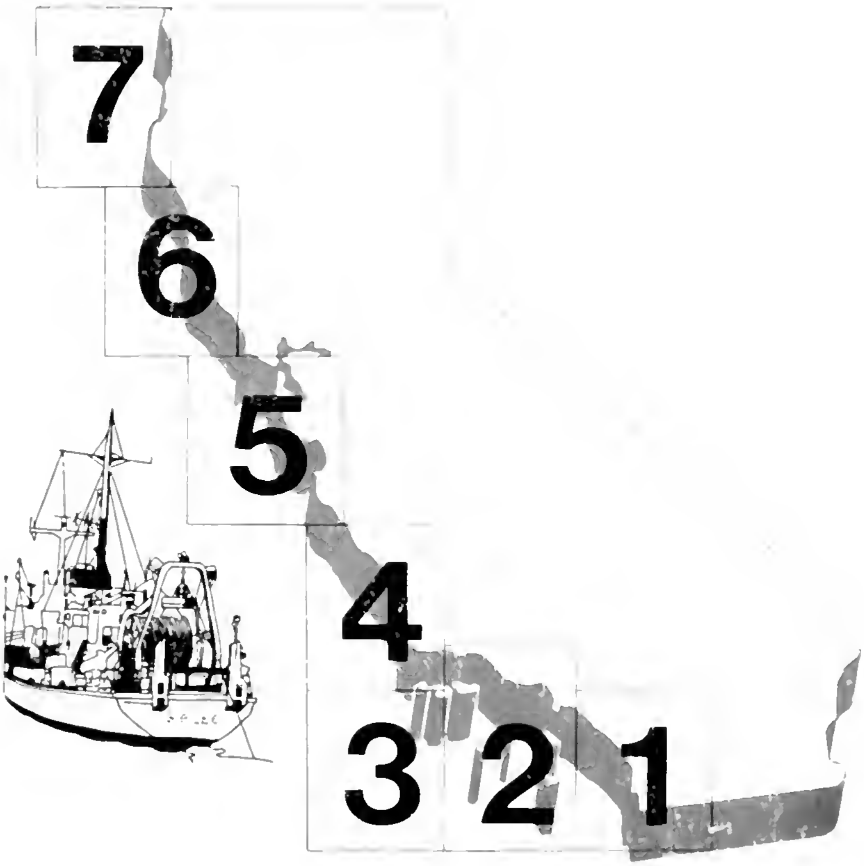
[redacted]OLOGY OF THE CALIFORNIA CONTINENTAL MARGIN

EXPLANATION OF THE CALIFORNIA CONTINENTAL MARGIN GEOLOGIC MAP SERIES



UNITED STATES GEOLOGICAL SURVEY

MINES AND GEOLOGY

BULLETIN 207

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BULLETIN 207

GEOLOGY OF THE CALIFORNIA CONTINENTAL MARGIN:

EXPLANATION OF THE CALIFORNIA CONTINENTAL MARGIN GEOLOGIC MAP SERIES—

INTERPRETIVE METHODS
SYMBOLOGY, STRATIGRAPHIC UNITS, AND BIBLIOGRAPHY

By

Michael P. Kennedy

H. Gary Greene

and

Samuel H. Clarke

1987

Prepared in cooperation with
the U.S. Geological Survey
and the California Coastal Commission

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PREFACE

The California Continental Margin Geologic Map Series and this accompanying bulletin have taken five years to complete. This work could not have been done without the assistance and encouragement of many enthusiastic and supportive people. The idea of producing such a map series was conceived in 1975 during discussions between the U.S. Geological Survey (USGS) and the California Coastal Commission (CCC), while formulating the Geological Element to the California Coastal Plan. However, it was not until 1980 that enough data were available for work to begin, and at that time the California Department of Conservation's Division of Mines and Geology (DMG), with partial funding from the California Coastal Commission, initiated the work. Thus, the publications represent the success of a tripartite (DMG-CCC-USGS) cooperative effort between state and federal government agencies.

Geology, like many sciences, is continuously evolving, and maps portraying geologic interpretations are thus ephemeral. This map series is no exception. However, it is the first standardized offshore geological map series published in the United States, and it does represent a foundation for detailed marine geological mapping. Many data voids exist, as shown on the maps, and new marine geological and geophysical data are being collected that will gradually improve understanding of the geology. Therefore, we foresee the need to modify the maps in the future and we hope to upgrade the series with periodic reprinting. We propose that new map sheets, such as sedimentary isopachs and seafloor resources, be added to the series. We welcome any comment about the maps, and are receptive to constructive criticism. We hope that you find the maps and the method of offshore geology portrayal useful.

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INTERPRETIVE METHODS SYMBOLOGY, STRATIGRAPHIC UNITS, AND BIBLIOGRAPHY

By
Michael P. Kennedy[1], H. Gary Greene[2],
and Samuel H. Clarke[2]

INTRODUCTION

This bulletin is a tool for explorationists, planners and developers with marine geological, geophysical and seismological interests in the California continental margin. It was developed by the California Department of Conservation's Division of Mines and Geology, the U.S. Geological Survey and the California Coastal Commission. We have presented data primarily in planimetric form on map sheets (NOAA/NOS 1:250,000 scale) that cover the area from Mexico north to Oregon and from the California coastline west to the edge of the continental margin (Figure 1). This bulletin is a companion to these map sheets, and presents an explanation of the symbols used in illustrations from marine seismic-reflection profiles, representative composite stratigraphic columns and a comprehensive bibliography of references reviewed or used in the compilation of the maps.

One of the principal purposes of this study was to acquire and compile all readily available geologic data for the California continental margin in a standard format. Although considerable geologic data exist for this area, heretofore no attempt has been made to compile and present it at a common scale with standardized symbology.

Geologic symbols conventionally used onshore have been standardized through years of use. Relatively little effort, however, has been made to develop a standard format for many geologic conditions that are unique to the offshore. Consequently, marine geologic maps that have been produced for offshore areas commonly show inconsistencies in symbology that lead to confusion in interpretation. We present this bulletin in an effort to standardize the symbols needed to illustrate geologic phenomena identified by remote sensing techniques in the marine environment. We hope that this bulletin will assist marine geologists by providing a reference for standard symbols, and general users by providing an explanation of symbols used.

Principal sources of the geologic data used in the compilation of this map series are published, open-file, and publicly available "in progress" studies. The types of data compiled include, where available:

1. General Geology: Geologic structures (folds and faults), bedrock outcrops and (where possible) ages and formational names of units, submarine landslides, oil and gas seeps, shallow gas-charged zones, and areas having unusually high rates of erosion or sediment accumulation.
2. Earthquake epicenter locations superimposed on geologic structure.
3. Focal mechanisms for selected earthquakes superimposed on geologic structure.
4. Regional Bouguer gravity anomalies superimposed on geology and magnetic anomalies.
5. Regional magnetic anomalies superimposed on geology and gravity data.
6. Geologic hazards (in red).
7. Sources of data used, oil and gas wells, platforms, and ship tracklines of data studied.

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[1] California Department of Conservation, Division of Mines and Geology

[2] U.S. Geological Survey

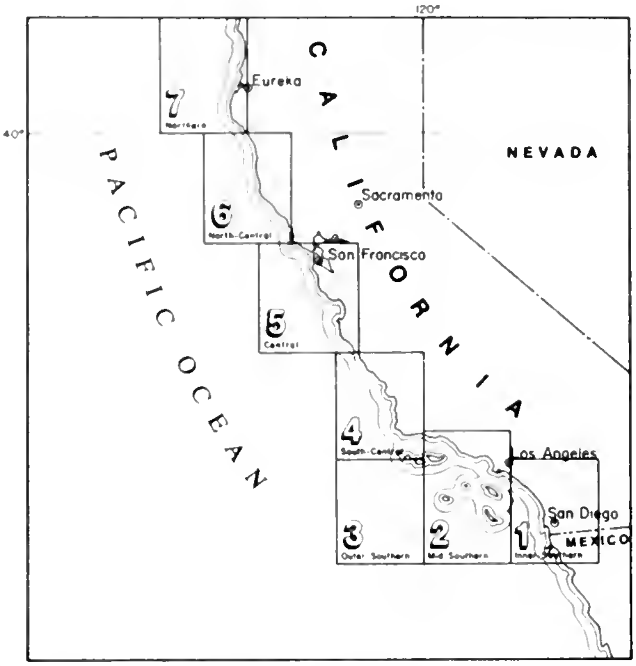


Figure 1. Index to California Continental Margin Geologic Map Series. Numbers in lower left hand corners of boxes refer to bathymetric base sheet used in the compilation.

INTERPRETIVE METHODS

Much of the information presented on the maps and in this bulletin is based on the interpretation of subbottom seismic-reflection data. These data include high-resolution reflection profiles gathered with echo sounder, sparker and mechanical pulsing systems, and intermediate to deep-penetration profiles gathered with 160 kJ sparker, airgun and watergun systems. Subsurface features ranging upward in vertical dimension from approximately 1.0 m to 1.5 m can be resolved in the higher-resolution records that vary in subbottom penetration from 150 m to over 400 m. The deep-penetration records used to determine deep structure can resolve features larger than about 15 m in vertical dimension and commonly record geologic structure at subbottom depths of more than one kilometer.

Ship positioning was accomplished by range-range precision triangulation, augmented in a few remote locations by satellite, radar, and inertial navigation. Location accuracy of the seismic data ranges from about 15 m with precision equipment to about 500 m where the ship's radar alone was used. Although location accuracy was considered in the map compilation, areas and data sets using different navigation techniques are not distinguished. Therefore, the location accuracy of mapped geologic features varies through each map. The structural notations (i.e., well defined, inferred, and questionable) refer to confidence of interpretation of geological and geophysical data rather than location.

Standard interpretive methods were used in the analysis of seismic-reflection data. For a description of these basic methods, the reader is referred to Moore (1960) and Payton (1977). Additional criteria used to interpret faults, seafloor stability and hydrocarbons follow.

Faults

Criteria used here for interpretation of faults are based on descriptions by Greene and others (1973). Well-defined faults: (1) distinct displacement of prominent reflectors; (2) an abrupt termination of prominent reflectors, or the juxtaposition of intervals of prominent reflectors that have contrasting acoustic characteristics; or (3) an abrupt change in the dips of reflectors across a distinct boundary.

Inferred faults: (1) small displacement of prominent reflectors, in which the upper or shallow reflectors may be bent rather than broken; (2) prominent reflectors that are discontinuous, and contrasting seismic characteristics that are present on either side of an acoustically obscure disturbed zone; or (3) apparent changes in dip on either side of the disturbed zone.

Questionable faults (mapped where obscure interruptions of seismic reflectors are present in the subsurface): (1) a shift in the phase of reflectors; (2) bent or broken reflectors that can be correlated with known faults on other lines; (3) termination of weak reflectors; or (4) any other zone of seismic contrast, especially where the zone appears similar to and is aligned with faults identified on adjacent lines. Some questionable and inferred faults have been mapped where anomalous topographic lineaments appear to support the continuation of known faults.

The orientation of faults is determined principally by correlation from one seismic line to another. Faults are correlated between adjacent lines mainly on the basis of their association with similar structural and seismic features on adjacent profiles. Where fault planes dip more than about 35°, the vertical exaggeration common to seismic-reflection records precludes determining the dip, even though the records clearly indicate that a fault is present. Consequently, faults dipping 35° or more are shown as vertical.

Determining the amount and direction of movement on a fault is difficult. Only the apparent vertical component (dip separation) of offset can be measured on the seismic-reflection profiles; the horizontal component (strike-slip separation) can be determined only where piercing points of lines representing equivalent geologic features can be identified on opposite sides of a fault. Faults that displace rocks having similar acoustic characteristics are commonly difficult to detect on seismic-reflection records.

The age of most recent faulting as inferred from seismic-reflection records is commonly determined from the age of the youngest reflector cut by a fault. However, such age assignments may be complicated by several factors so that they may not always accurately reflect fault activity. For example, active faults in some tectonic settings do not penetrate rocks near the earth's surface and are expressed instead by folding at shallow depths. Such faults, though active, might be interpreted as geologically old fractures unless associated seismicity indicates modern activity. Similarly, faults that reach the seafloor in Tertiary or pre-Tertiary rocks where younger deposits are absent might not be identified as geologically youthful unless seismicity data indicate otherwise. Furthermore, in many areas direct physical evidence of the age of rocks cut by a fault is lacking; age assignments in such cases are generally rather loosely contrained by similarities in acoustic character to rocks of known age in other locations. These factors should be borne in mind when using maps derived from seismic-reflection data.

Seafloor Stability

Criteria used for the interpretation of seafloor stability are those described by Clarke and others (1983, 1985). Subaqueous landslides mapped are mass movements of rigid or semi-consolidated sediment masses along discrete shear surfaces, accompanied by relatively little internal deformation (Dott, 1963). Landslides are commonly identified on seismic-reflection records by the presence (in longitudinal sections) of some or all of the following characteristics: (1) a headscarp where the slip surface extends upward to and is expressed in the seafloor; (2) compressional ridges and folded and contorted subbottom reflectors resulting from small-scale thrusting and folding at the toe of the slide; (3) transverse (tensional) cracks in the body of the slide; (4) evidence of rotation or limited internal deformation of the reflectors; and (5) the presence of a slip surface, which may be upwardly concave or planar, represented by a discrete failure plane or by an intensely deformed zone beneath the slide mass.

The term *slump* is commonly applied to a slide that shows evidence of rotational movement along a curved slip surface, and the term *block glide* is used for those landslides having a relatively planar, usually gently dipping slide surface. Subaqueous slides may occur on slopes of less than one degree and may range in size from simple failures covering tens of square meters to composite failure zones thousands of square kilometers in area and from a few meters to hundreds of meters thick (Moore, 1961; Heezen and Drake, 1964; Lewis, 1971; Hampton and Bouma, 1977).

Subaqueous mass flows involve the downslope movement under gravity of water-saturated, unconsolidated sediment; the moving mass may behave plastically or as a very viscous fluid, and movement may be slow or rapid (Dott, 1963). The velocity and displacement of flow characteristically decrease gradually with depth below the surface, so that the deposit lacks a distinct slip surface. Subaqueous flow deposits are identified on seismic-reflection records by (1) the presence of anomalously thick sediment masses apparently detached from underlying strata, (2) the absence of identifiable slip planes, and (3) acoustic transparency or chaotic internal structure.

Sediment creep in the marine environment is a form of flow; it is a poorly understood and poorly documented phenomenon. As it is used here, sediment creep refers to the slow, more-or-less continuous downslope movement of the upper layers of unconsolidated sediment. The occurrence of creep is inferred from seismic-reflection profiles from the presence of hummocky seafloor topography, deformed but identifiable acoustic bedding in the upper sediment layers, a downward decrease in the degree of deformation, and the apparent absence of a slip surface. Creep may extend to subbottom depths of 15-20 m, is commonly associated with other types of failure, and may affect large areas.

Hydrocarbons

Natural gas of biogenic and thermogenic origin may be present in marine sediment. Biogenic gas, principally methane, is derived from bacterial alteration of organic material in sediment. Thermogenic gas, characterized by relatively high levels of hydrocarbons heavier than methane, is a by-product of petroleum formation. The presence of thermogenic gas in sediment can reflect an over-pressurized zone that is discharging gas into the overlying strata via a conduit such as a fault or bedding plane. Gas of either type present as bubbles in the pore space of sediment can increase pore pressure and reduce the shear strength of the enclosing sediment, and thus enhance the likelihood of failure. Under some circumstances, sediment containing dissolved gas can liquefy spontaneously when it is subjected to cyclic loading such as may be imposed by earthquake shaking (Hall and Ensiminger, 1979).

Gas accumulation in sediment is suggested on intermediate- to high-resolution seismic records by (1) the presence of acoustic amplitude anomalies (apparent as enhanced or "bright" subbottom reflectors), (2) the sharp termination or displacement of reflectors commonly associated with acoustically turbid zones, (3) the absence of surface multiples indicating absorption of the seismic signal (Nelson and others, 1978), and (4) the presence of "pull-downs," apparent depressions resulting from the decreased velocity of sound in gaseous sediment and consequent delayed arrivals of acoustic returns. Water-column anomalies on high-resolution seismic records in some cases suggest gas bubbles in the water column, although other phenomena such as kelp and fish produce similar appearing features. Side-scan sonographs and underwater video or photographic coverage can show gas seep mounds or gas-developed craters on the seafloor. Several lines of geophysical evidence are desirable, and sampling and geochemical analysis are needed to verify the presence of gas and to identify its origin.

EXPLANATION OF STRATIGRAPHIC TERMINOLOGY AND MAP SYMBOLOGY

Each of the seven maps in the California continental margin geologic map series has a geologic legend and explanation that explains the symbols and terminology used on that particular map. Here we have presented both a legend of stratigraphic units and unit symbols (see Master Legend) and an explanation of other map symbols (see Master Explanation) that are comprehensive in their coverage of the symbols and terminology used in the map series. We have also presented examples of interpretive line drawings of subbottom profiles (along with the seismograms on which they are based) to illustrate the use of the map symbols in specific geological contexts.

Stratigraphic Units

The stratigraphic units used in this study are lithostratigraphic in nature. In most cases, an age or age range is assigned to each unit. The descriptions and the age designations have been established from fairly widespread core, dredge and dart samples offshore and from outcrops, well logs and cores in the immediate onshore. The units were then correlated across large regions using seismic signal characteristics that differ according to inherent rock properties. These units can be referred to informally as "acoustic stratigraphic" or, as described in the North American Stratigraphic Code (code of stratigraphic nomenclature), as instrumentally defined. The ages should be considered part of the general description of each unit, and the reader should be aware that most are naturally time transgressive or regressive in nature.

The order in which the units appear is approximately youngest to oldest, but this order should not be looked upon as superpositional. As the reader will quickly discern, many of the units given in the Master Legend are local in extent.

Geologic Contacts

Geologic contacts shown on the maps are extrapolated from a combination of seismic-reflection data, samples, and bathymetry, and are approximate in location. Unless otherwise specified, the seafloor geology represented on the geologic maps is covered with a thin (several meters) layer of Quaternary or Holocene sediments. Thus, the geologic maps represent seafloor geology as it would appear if the thin layer of Quaternary sedimentary cover were removed. Where faults offset this thin layer of Quaternary sediments, the faults are given the age symbol for the most recent sediments they cut, even though they are shown on the map as existing in an older geologic outcrop (for example, faults of Holocene age are mapped in undifferentiated volcanic and sedimentary rocks of Miocene age on the top of Tanner and Cortez bank.

Symbols

The symbols used in the offshore (see Master Explanation and examples 1-46 of subbottom profiles) to denote specific geologic features are in part different from those traditionally used in onshore geologic mapping. This difference stems from the data acquisition methods used in offshore versus onshore mapping.

Most offshore geologic data are collected by remote sensing techniques that yield acoustic seismograms like those shown with the examples of subbottom profiles. Many of the examples in this section are modified from Greene and others (1975, 1983) and Yerkes and others (1980). Others are selected from data collected and reported on by Kennedy and Welday (1980), Kennedy and others (1980), Field and others (1980), Richmond and others (1981), and Clarke and others (1983).

Each example shows a short reproduced section of the seismic-reflection profile with an interpretive line drawing that empasizes a particular geologic feature. Beneath each illustration is the symbol used on the maps and a short explanation including the approximate location of the profile. All features considered to be potential geologic hazards are shown in red on the geologic maps. Each example has a number which is keyed to a location map (Figure 2).

MASTER LEGEND OF STRATIGRAPHIC UNITS

Q	Unconsolidated deposits of Quaternary age.
Qf	Fan deposits of Quaternary age.
Qd	Deltaic deposits of Quaternary age.
Q/Qd	Deltaic deposits of Quaternary age overlain by thick (greater than 3m) deposits of Q.
Qcf	Canyon or channel fill deposits of Quaternary age.
Qt	Unconsolidated marine terrace deposits of probable Pleistocene age.
Qp	Unconsolidated marine shelf and slope deposits of late Pleistocene age.
Qsp	Deposits that may correlate with the San Pedro Formation.
Qar	Aromas Red Sands (mostly unconsolidated quartzose sand of Pleistocene age).
Q/Qar	Aromas Red Sands (mostly unconsolidated quartzose sand of Pleistocene age) overlain by thick (greater than 3m) deposits of Q.
QTs	Sediment and sedimentary rock of Quaternary and Tertiary (Pliocene and Miocene) age.
QTt	Terrace deposits of Quaternary and late Tertiary (?) age.
QTpr	Unconsolidated sand, gravel, clay and tuff of Pliocene and Pleistocene age that may correlate with the Paso Robles Formation.
Q/QTpr	Unconsolidated unit of sand, gravel, clay and tuff of Pliocene and Pleistocene age that may correlate with the Paso Robles Formation, and is overlain by thick (greater than 3m) deposits of Q.
Tp	Sedimentary rocks of Pliocene age.
Q/Tp	Sedimentary rocks of Pliocene age overlain by thick (greater than 3m) deposits of Q.
Tpp	Purisima Formation (marine sandstone and siltstone of Pliocene age).
Q/Tpp	Purisima Formation (marine sandstone and siltstone of Pliocene age) overlain by thick (greater than 3m) deposits of Q.
Tpr	Sedimentary rock of early Pliocene and late Miocene age.
Tm	Sedimentary rock of Miocene age.
Q/Tm	Sedimentary rock of Miocene age overlain by thick (greater than 3m) deposits of Q.
Tmv	Volcanic rock of Miocene age.
Tmu	Volcanic and sedimentary rocks of Miocene age.
Tsc	Santa Cruz Mudstone (siliceous organic mudstone of Miocene age).
Q/Tsc	Santa Cruz Mudstone (siliceous organic mudstone of Miocene age) overlain by thick (greater than 3m) deposits of Q.
Tsm	Santa Margarita Formation (sandstone and arkosic sandstone of Miocene age).
Q/Tsm	Santa Margarita Formation (sandstone and arkosic sandstone of Miocene age) overlain by thick (greater than 3m) deposits of Q.
Tmm	Monterey Formation (siliceous sandstone, siltstone and mudstone of Miocene age).
Q/Tmm	Monterey Formation (siliceous sandstone, siltstone and mudstone of Miocene age) overlain by thick (greater than 3m) deposits of Q.
Tmp	Plutonic and hypabyssal rocks of Miocene age.
To	Sedimentary rock of Oligocene age.
Te	Sedimentary rock of Eocene age.
Tep	Sedimentary rock of Eocene and Paleocene age.
Tc	Carmelo Formation (sandstone, siltstone, mudstone and cobble-pebble conglomerate of Paleocene age).
Ts	Sedimentary rock of Tertiary age.
Tv	Volcanic rock of Tertiary age.
Ku	Sedimentary rock of late Cretaceous age.
Kcs	Sedimentary rock of Cretaceous age.
TMz	Undifferentiated igneous rock of Miocene age and metamorphic rock of pre-late Cretaceous age.
Mz	Metamorphic rock of pre-late Cretaceous age.
gr	Granitic rock, chiefly diorite, of Mesozoic age.
gdp	Porphyritic granodiorite.
m	Metamorphic rock of unknown age.
Q/m	Metamorphic rock of unknown age overlain by thick (greater than 3m) deposits of Q.
KTc	Franciscan Complex, Coastal Belt.
KJf	Franciscan Complex, undifferentiated.

MASTER LEGEND OF MAP SYMBOLS

GEOLOGIC CONTACT: Queried where contact is uncertain. Contacts are extrapolated from seismic-reflection data and are approximate in location.

FAULTS: Solid where well defined, dashed where approximately located or inferred, queried where uncertain. Thrust fault barbs shown on upper plate. Where fault offsets sea-floor, age symbol is shown on bar on downthrown side. Elsewhere, age symbol is shown astride fault and relative offset is shown by "D" and "U" on downthrown and upthrown sides. Ages of faults are indicated as follows:

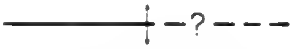
- ■ Cuts strata of Holocene age.
- □ Cuts strata of Pleistocene age.
- ◪ Cuts strata of Quaternary age.
- ○ Cuts strata of late Tertiary and Quaternary age.
- ▲ Cuts strata of Pliocene age.
- △ Cuts Miocene or older strata.

FAULT ZONE

FOLDS: Solid where well defined, dashed where inferred, queried where uncertain. Arrow indicates direction of axial plunge.

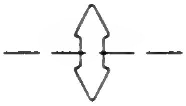
Anticline

Syncline

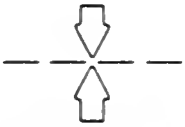


FAULTED ANTICLINE

MAJOR STRUCTURAL FEATURES:



Structural High

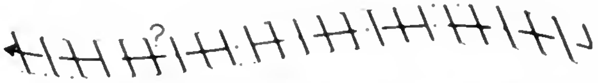


Structural Low

CHANNELS:

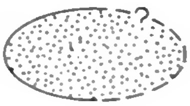
Active: Dash-dot line marks axis, arrow indicates direction of sediment transport.

Filled: Dash-dot line marks axis, arrow indicates direction of paleosediment transport. Channel boundary solid where well defined, dashed where inferred, queried where uncertain.



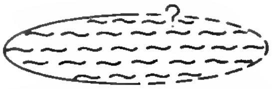
Buried: Dash-dot line marks axis, arrow indicates direction of paleosediment transport. Channel boundary dotted, queried where inferred.

LEVEES: Solid where well defined, dashed where inferred, queried where uncertain.



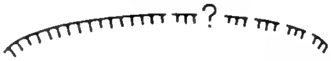
LANDSLIDES:

Creep (noted on single survey line): Arrow indicates direction of sediment movement.

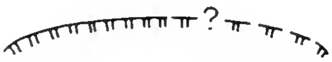


Creep (area): Solid where well defined, dashed where inferred, queried where uncertain.

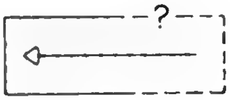
Slump: Solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement.



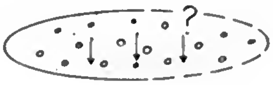
Slump scarp: Solid where well defined, dashed where inferred, queried where uncertain.



Erosional scarp: Solid where well defined, dashed where inferred, queried where uncertain. Generally associated with active channels.



Block glide: Solid where well defined, dashed where inferred, queried where uncertain. Arrow indicates direction of movement.



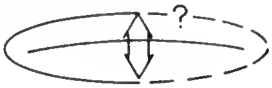
Sediment flow: Solid where well defined, dashed where inferred, queried where uncertain, Arrows indicate direction of movement.

ATTITUDES:

Strike and dip of bedding.

Apparent strike and dip of bedding.

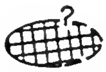
DIAPIR: Solid where well defined, dashed where inferred, queried where uncertain.



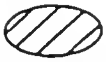
GAS:

Oil and/or gas seep.

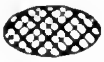
Area of acoustic anomaly (possibly indicating trapped shallow gas): Solid where well defined, dashed where inferred, queried where uncertain.



Zones in which there is a continuous gas-charged reflector. Reflector is generally shallow (30 m) and lies at, or near, the base of the unconsolidated Quaternary sediment.



Zones of discontinuous gas-charged reflectors. Reflectors lie within upper Miocene and Pliocene sedimentary rock, and within unconsolidated Quaternary sediment.



Area of shallow subsurface continuous and discontinuous gas accumulation within Quaternary sediment. Observed on 0.5-second high-resolution (Uniboom) seismic reflection profiles.

Discontinuous gas accumulations within late Tertiary and Quaternary sedimentary deposits. Observed along individual 2-second intermediate-resolution (air gun) seismic-reflection profiles.

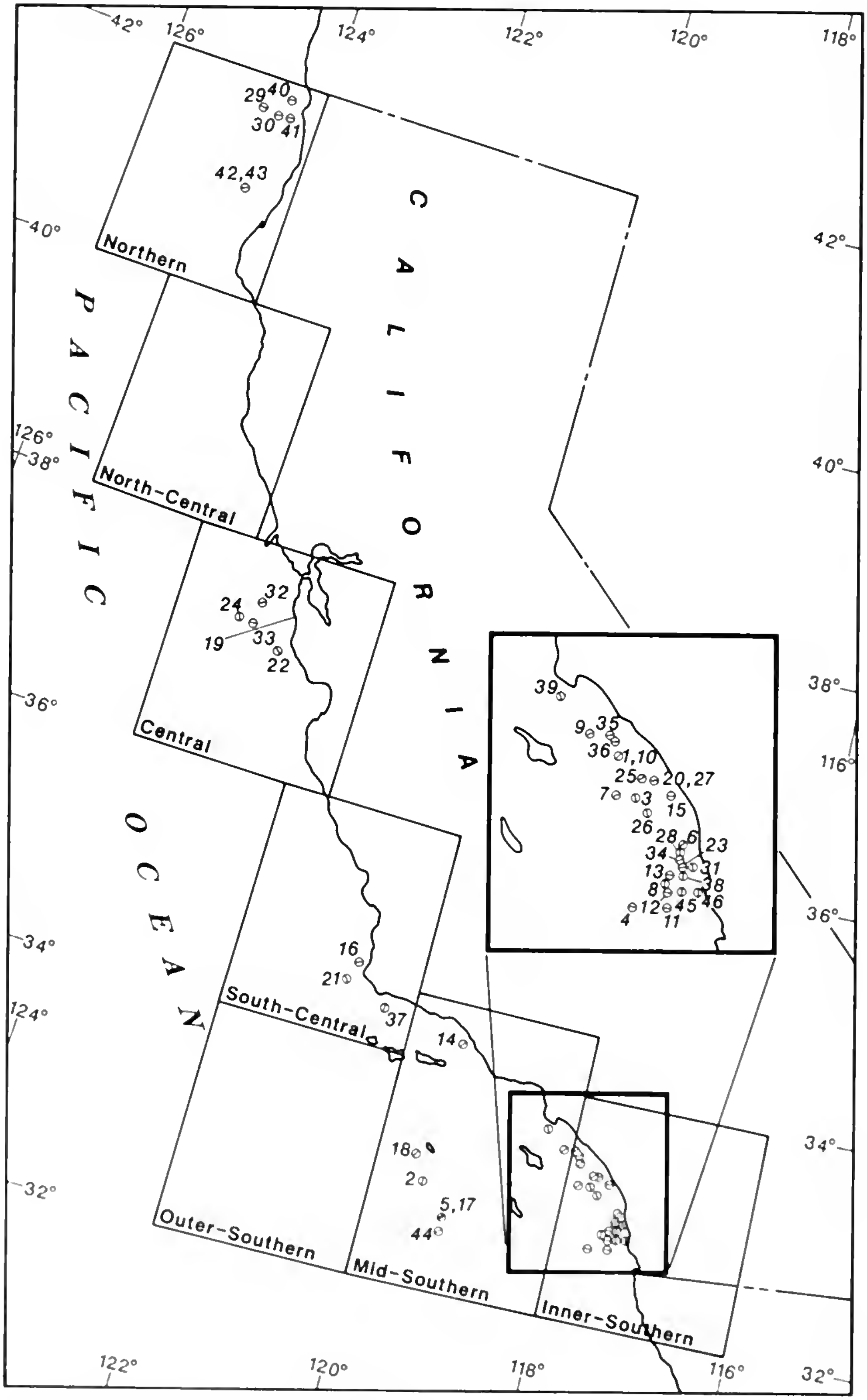
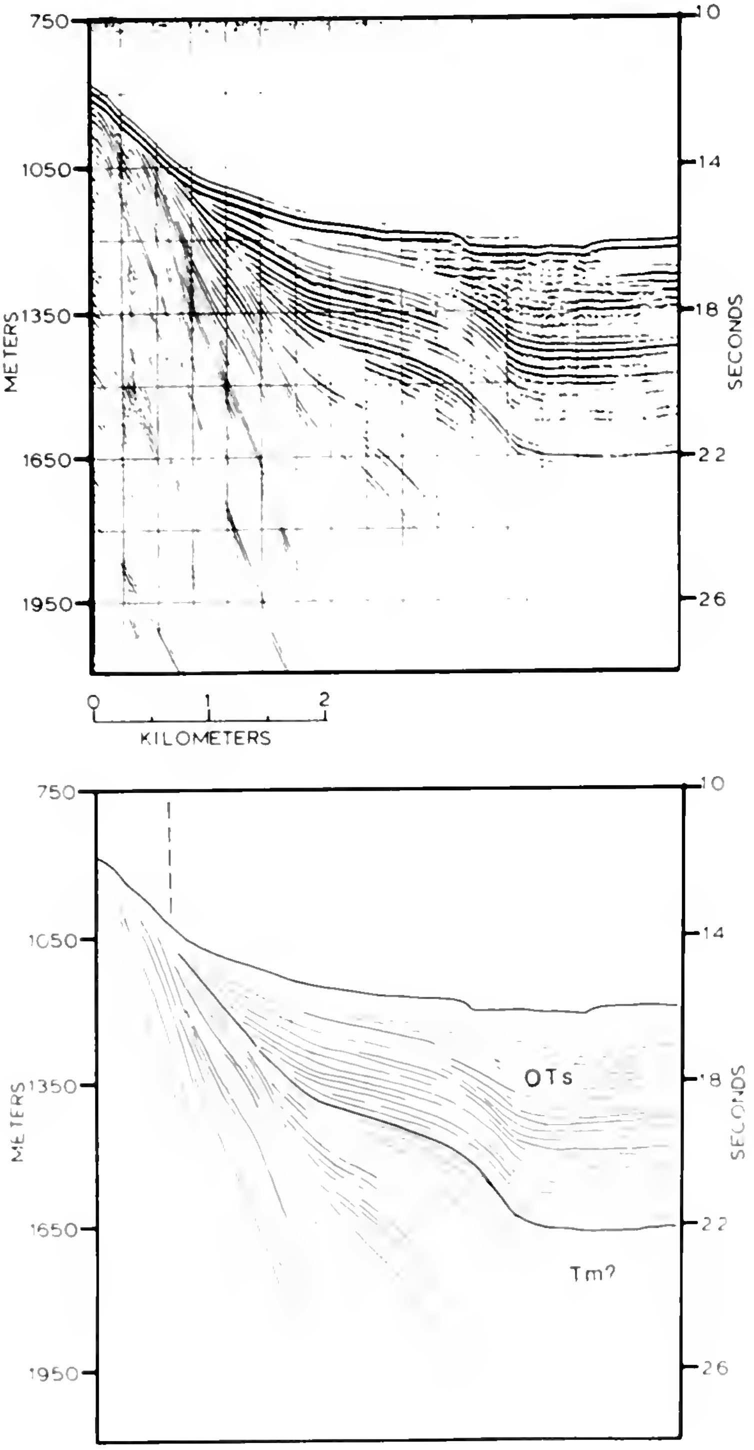


Figure 2. Location map for seismic profile examples.

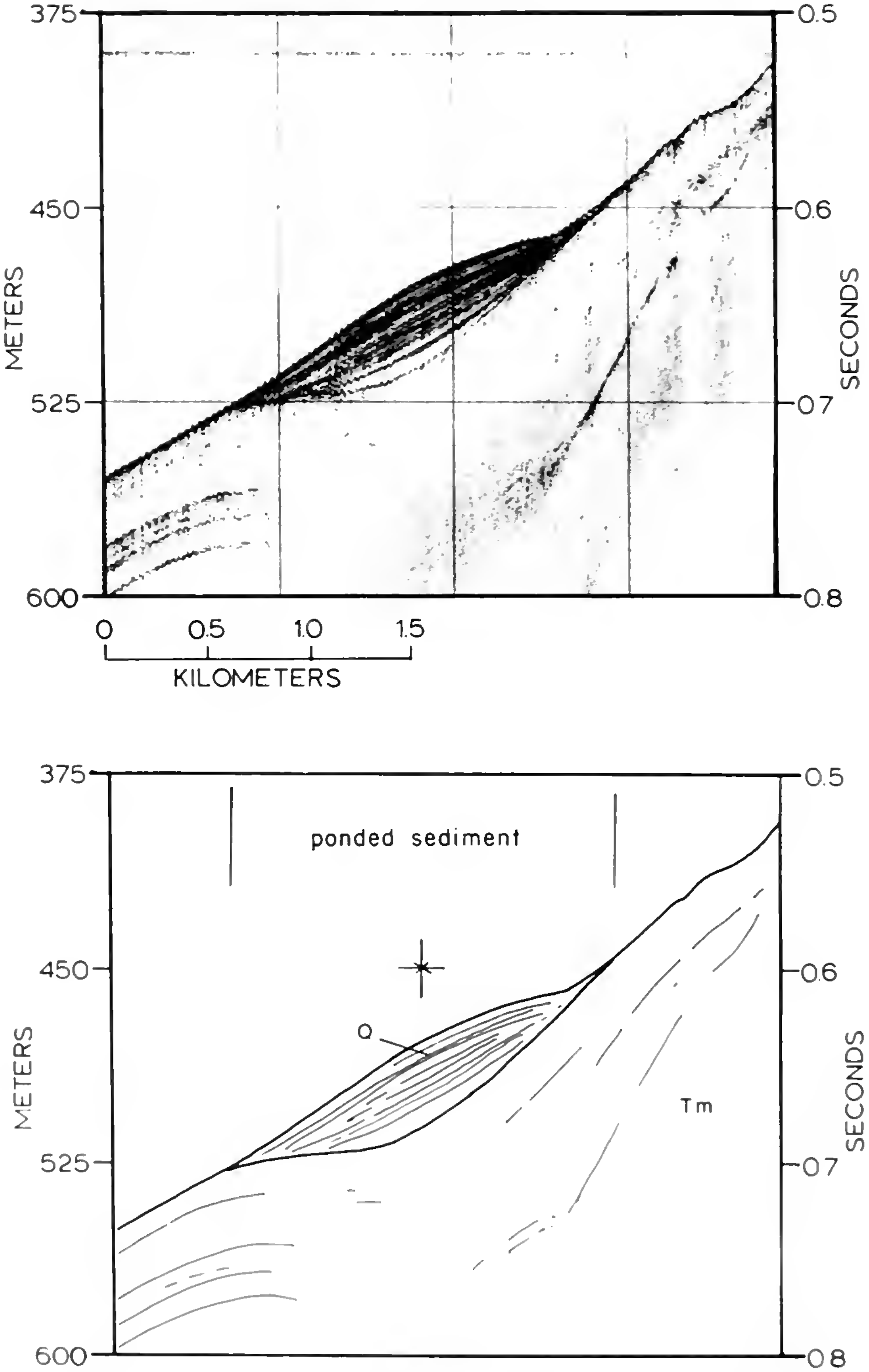
1. GEOLOGIC CONTACT (buttress unconformity)



—————————?

GEOLOGIC CONTACT: queried where contact is uncertain. All contacts are extrapolated from seismic-reflection data and are approximate in location. Example from sparker profile of upper Tertiary and Quaternary (QTs) sediment, ponded in synclinally folded strata on slope of presumed Miocene (Tm?) sediments. Located in the Gulf of Santa Catalina west of Dana Point, inner southern California continental borderland.

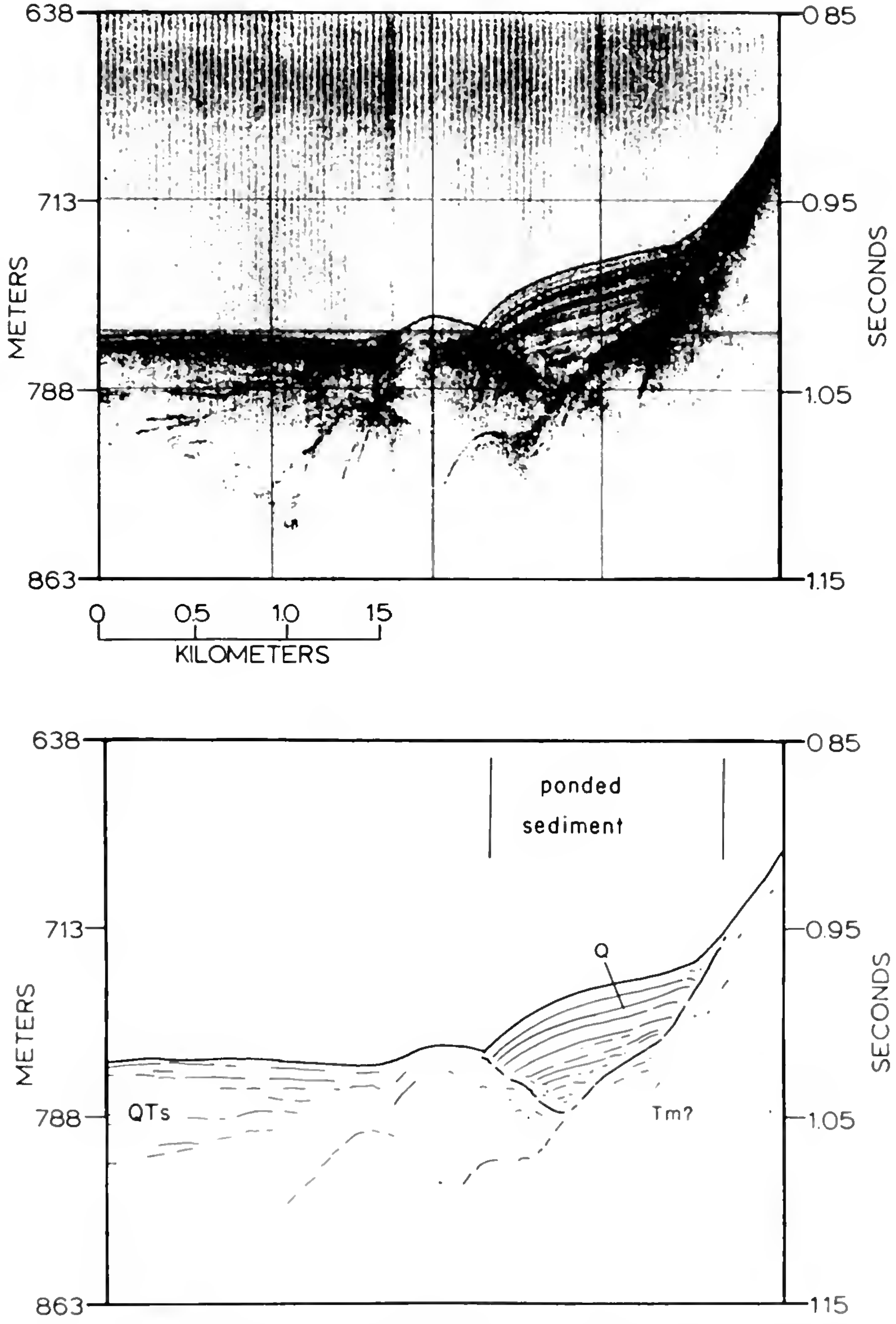
2. GEOLOGIC CONTACT (ponded sediment)



————?

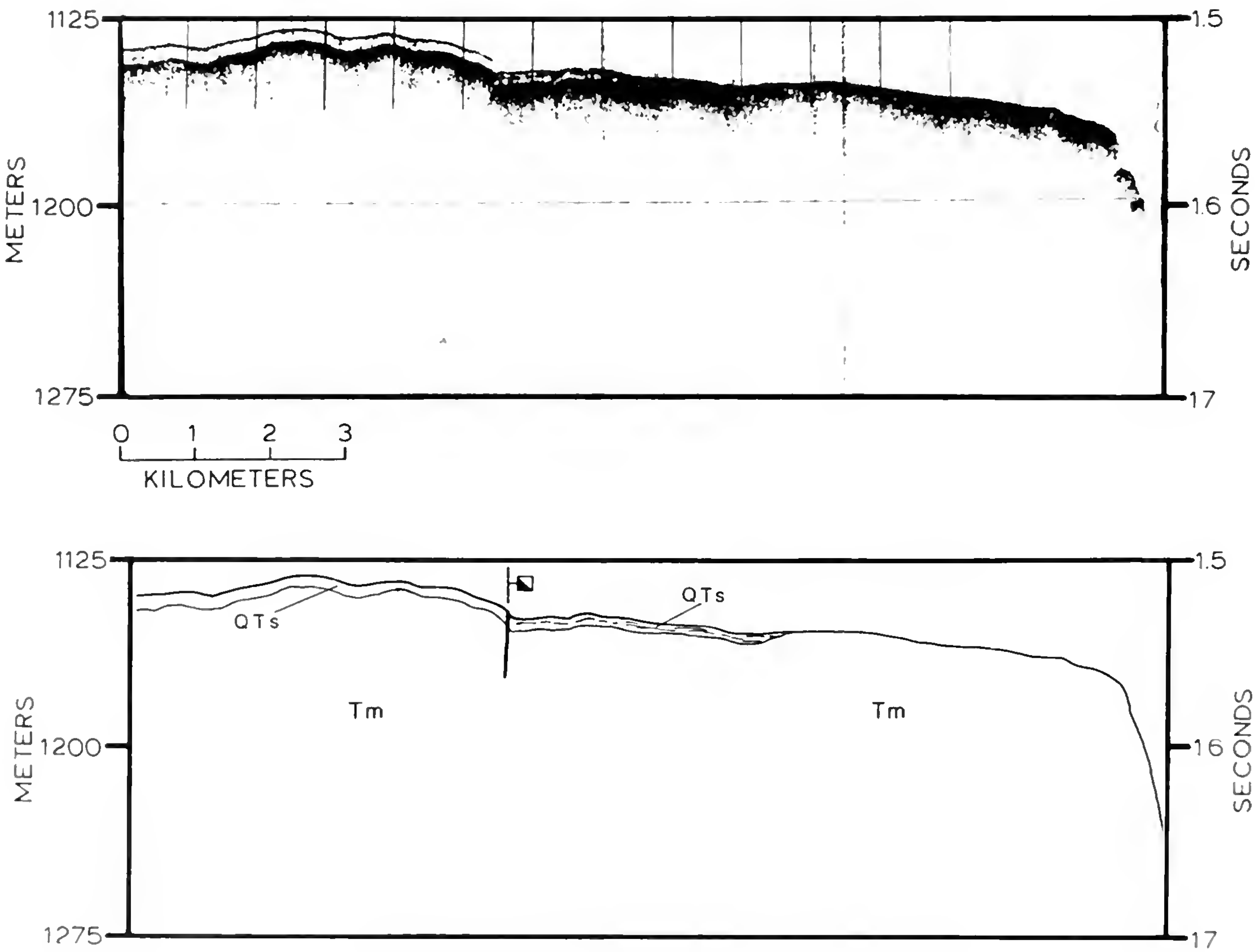
GEOLOGIC CONTACT: queried where contact is uncertain. All contacts are extrapolated from seismic-reflection data and are approximate in location. Example from Uniboom profile of Quaternary (Q) sediment ponded in synclinally folded Miocene (TM) sedimentary rock. Located south of San Nicolas Island, middle southern California continental borderland.

3. GEOLOGIC CONTACT (ponded sediment)



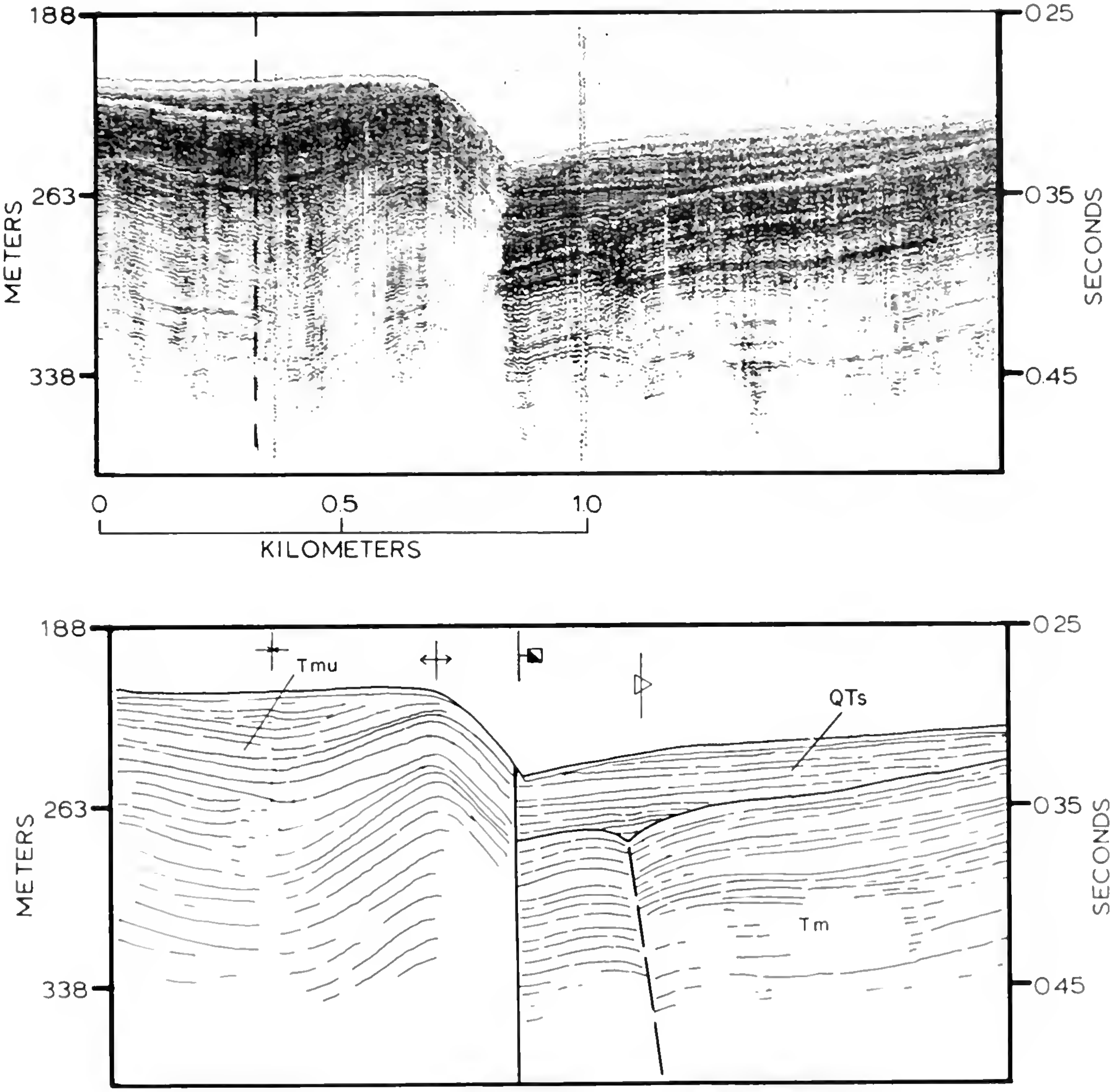
———————————? GEOLOGIC CONTACT: queried where contact is uncertain. All contacts are extrapolated from seismic-reflection data and are approximate in location. Example from Uniboom profile of unconsolidated Quaternary (Q) sediment ponded between base of slope and exposed bedrock (?) of probable Miocene (TM?) age located in the Gulf of Santa Catalina, inner southern California continental borderland.

4. FAULT (seafloor expression)



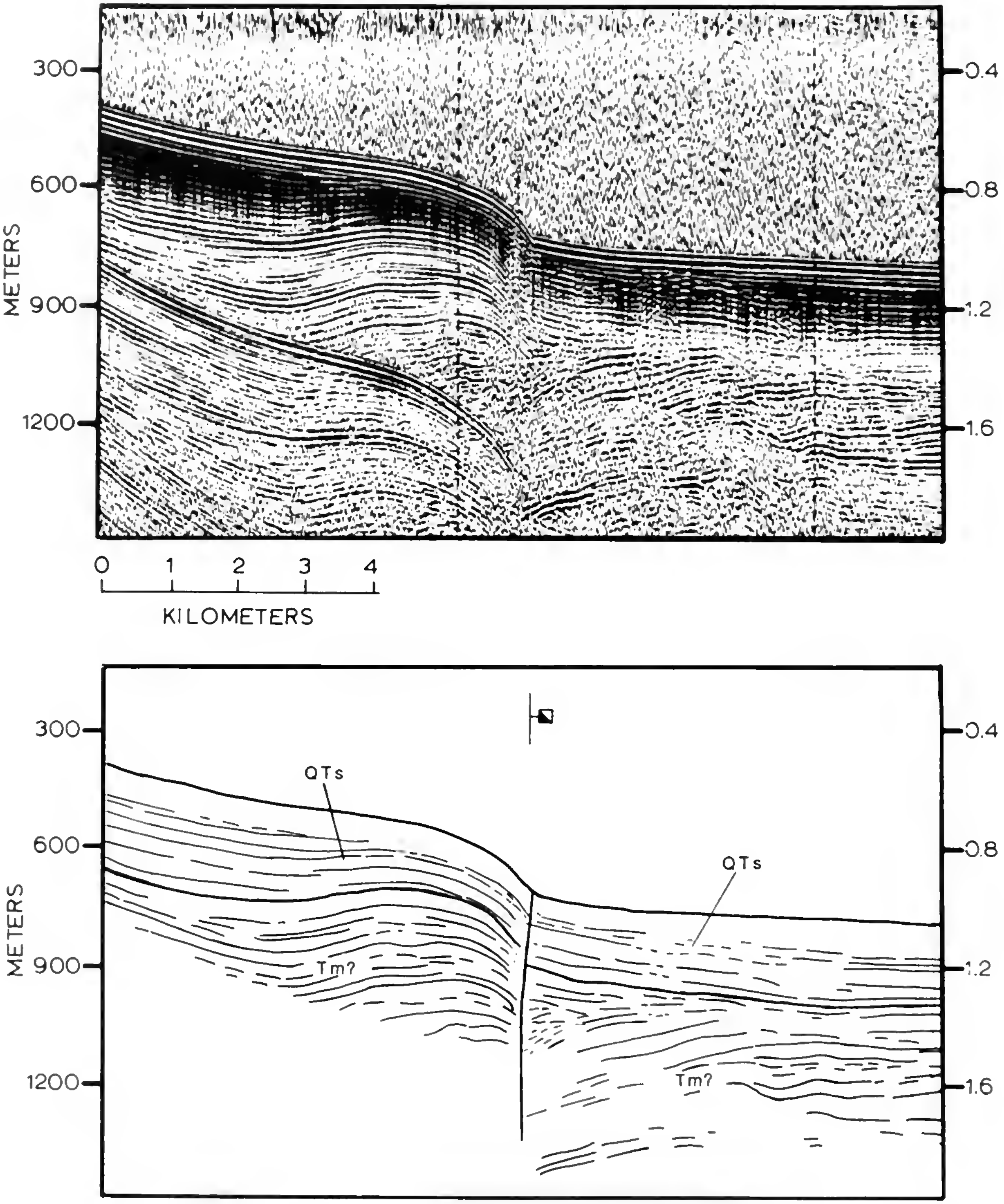
FAULT: solid where well defined, dashed where inferred, queried where uncertain. Bar and age symbol shown on downthrown side of fault with seafloor expression. Fault displaces seafloor, offsetting acoustically transparent unit (QTs) of presumed late Tertiary and Quaternary age. Example from 3.5 kHz profile across inner southern California continental borderland near San Diego.

5. FAULT (seafloor expression)



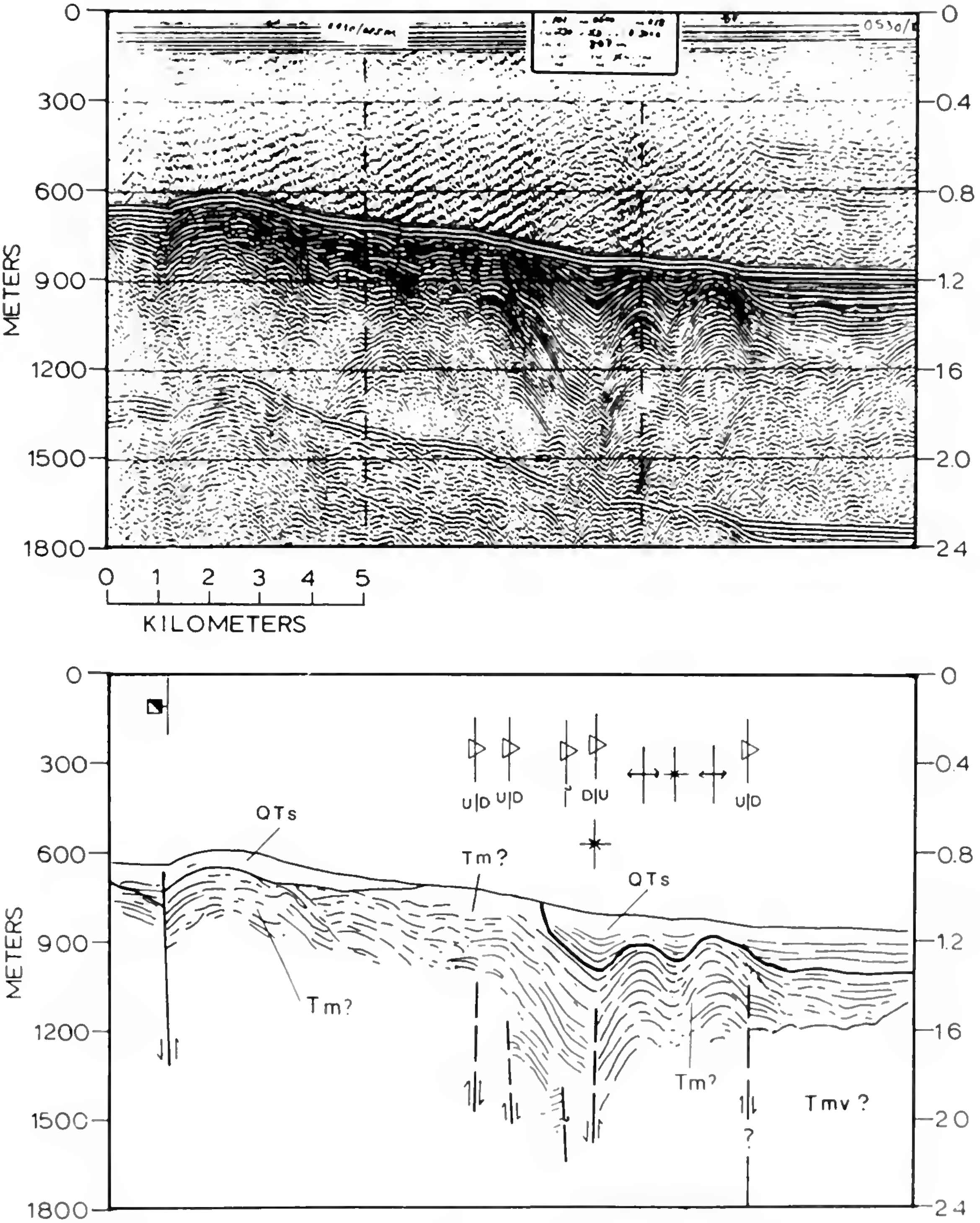
FAULT: solid where well defined, dashed where inferred, queried where uncertain. Bar and age symbol shown on downthrown side of fault that has seafloor expression. Fault displaces seafloor, offsetting sediments of presumed late Tertiary and Quaternary (QTs) age and juxtaposing subjacent units of Miocene (Tm) and possibly Pliocene (Tp?) ages. Also note inferred fault within probable Miocene section, and folded strata. Example from Uniboom profile across Tanner Bank, middle southern California continental borderland (after Greene and others, 1975, their Figure 3).

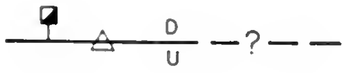
6. FAULT (seafloor expression)



FAULT: solid where well defined, dashed where inferred, queried where uncertain. Bar and age symbol shown on downthrown side of fault that has seafloor expression. Fault displaces seafloor, offsetting units of late Tertiary amd Quaternary (QTs) age and juxtaposing subjacent units of probable Miocene (Tm?) age. Example from sparker profile across mainland shelf, inner southern California continental borderland near Oceanside.

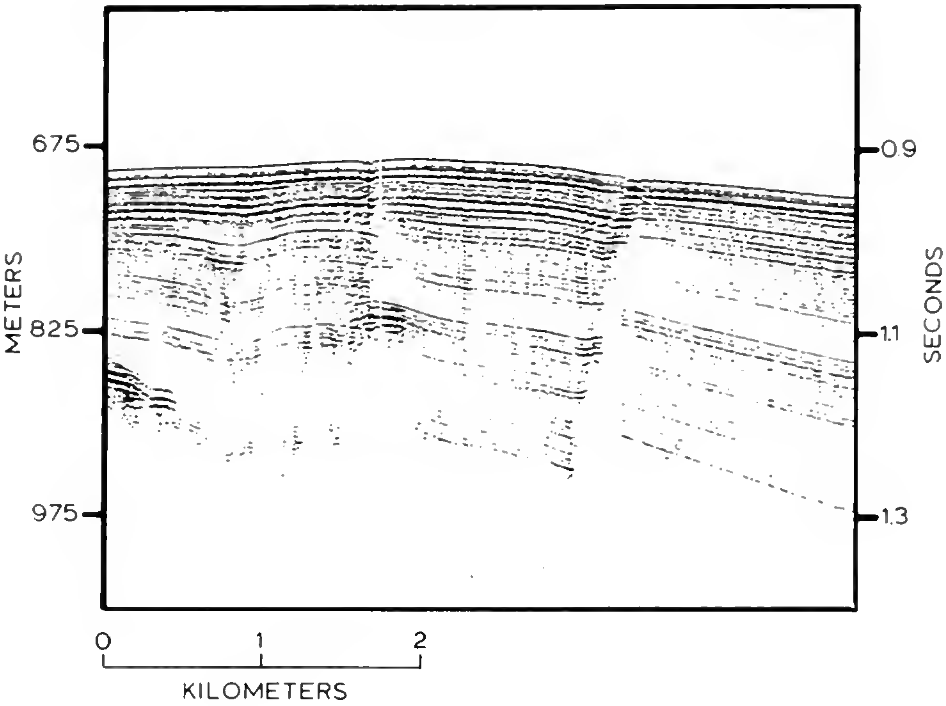
7. FAULT (seafloor expression)

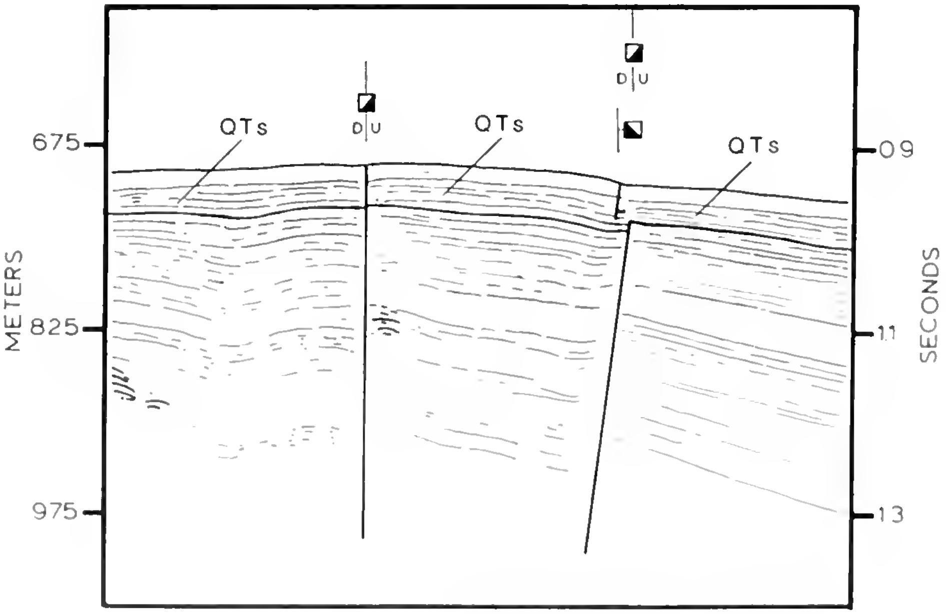


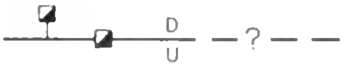


FAULT: solid where well defined, dashed where inferred, queried where uncertain. Bar and age symbol shown on downthrown side of fault that has seafloor expression. Divided box indicates youngest strata cut are of Quaternary age. Note that one questionable and four inferred faults cutting Miocene (Tm?) or older strata are indicated by open triangles astride fault symbol. "D" designates downthrown block; "U" designates upthrown block. These strata are also folded, as shown by anticline and syncline symbols. Example from sparker profile across Gulf of Santa Catalina, inner southern California continental borderland.

8. FAULT (Quaternary)

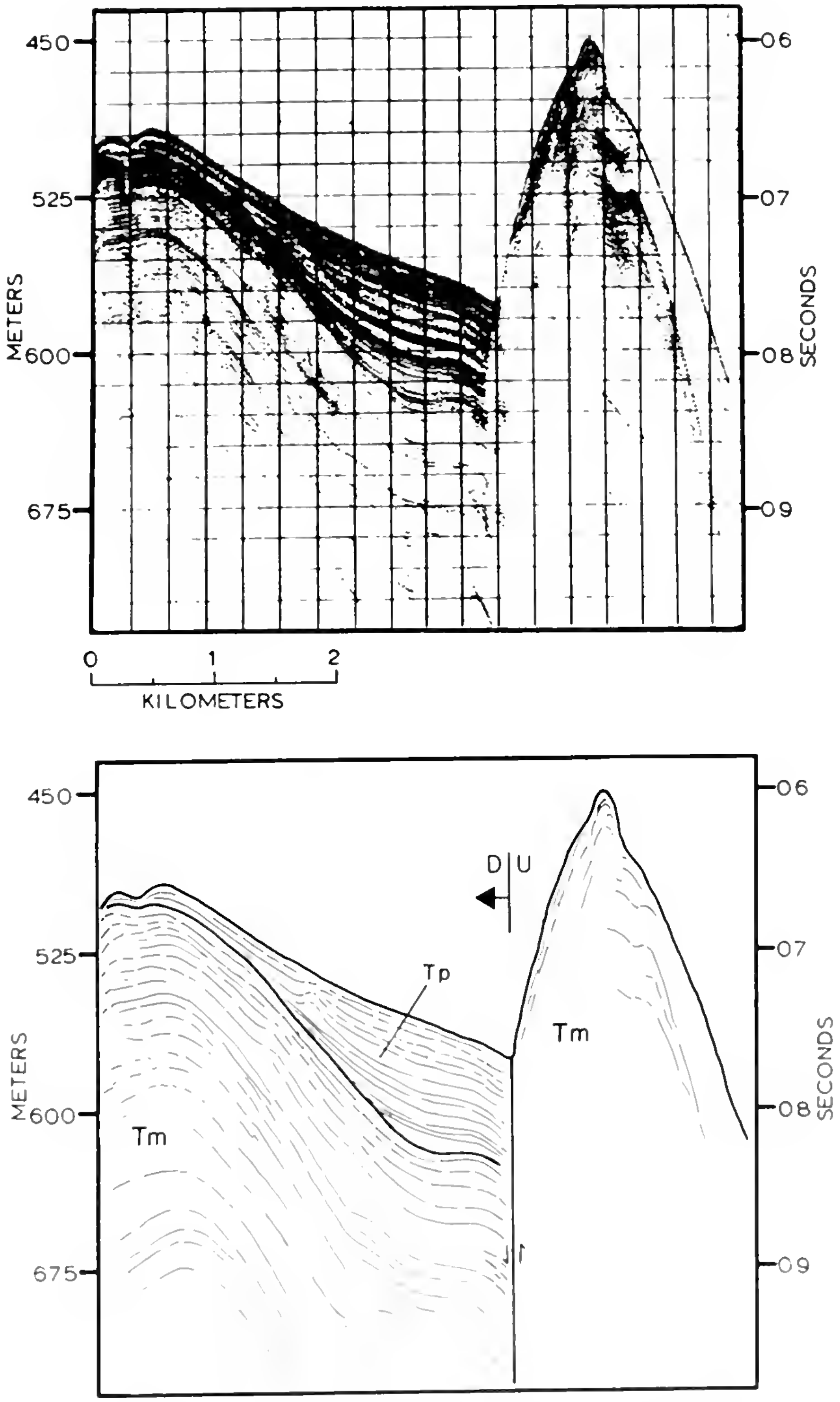






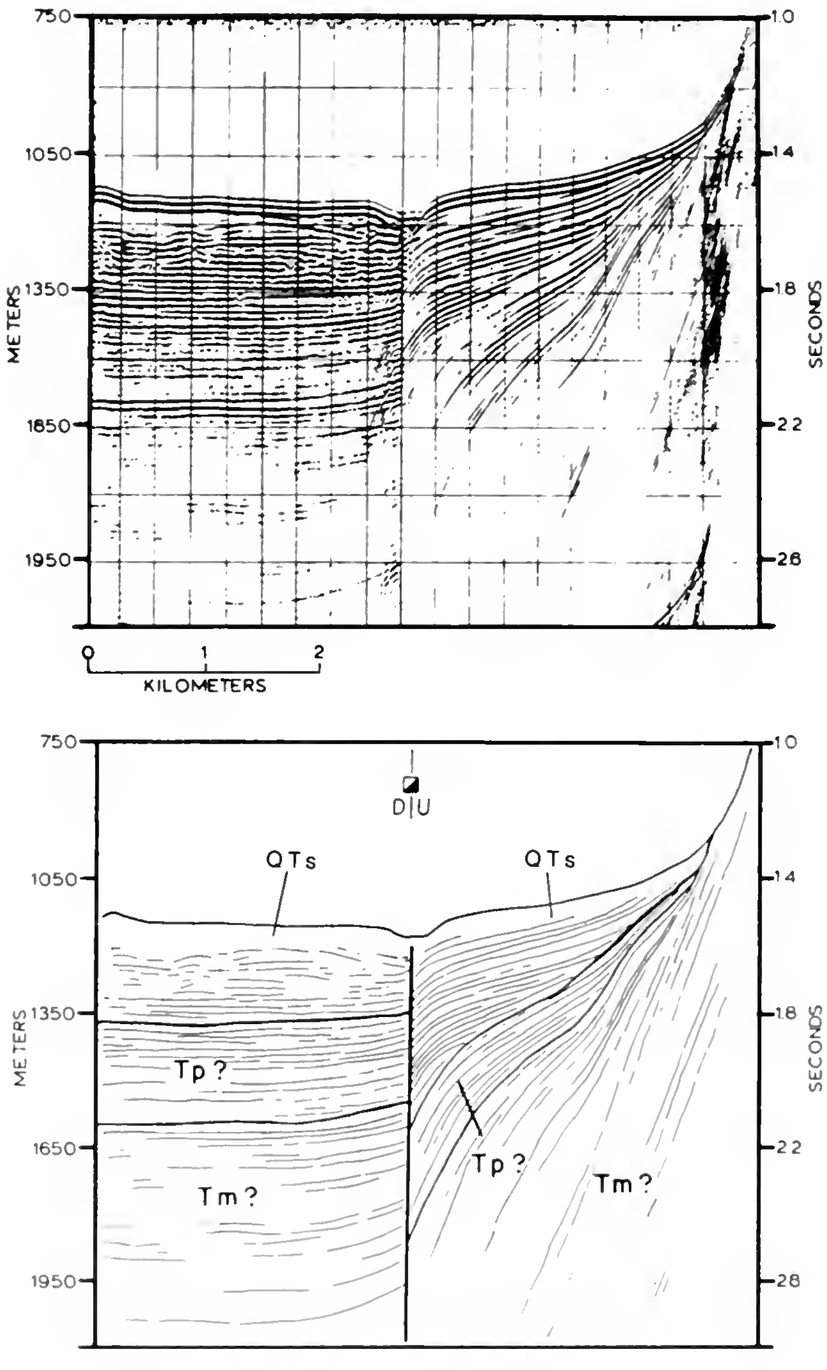
FAULT: solid where well defined, dashed where inferred, queried where uncertain. Faults designated by divided boxes indicate that strata of late Tertiary and Quaternary age are cut. One of these has seafloor expression, indicated by bar and age symbol on downthrown side; another reaches but does not displace seafloor, as indicated by age symbol astride fault. "D" designates downthrown block; "U" designates upthrown block. Example from sparker profile within Loma Sea Valley, inner southern California continental borderland.

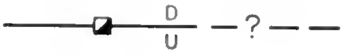
9. FAULT (Tertiary)



FAULT: solid where well defined, dashed where inferred, queried where uncertain. Filled triangle (age symbol) indicates youngest strata cut are Pliocene (Tp) in age. Folded Miocene (Tm) sedimentary rock is overlain by Pliocene strata; both lie in fault contact with exposed bedrock ridge of folded Miocene strata. Example from sparker profile across mainland shelf near Carlsbad, inner southern California continental borderland.

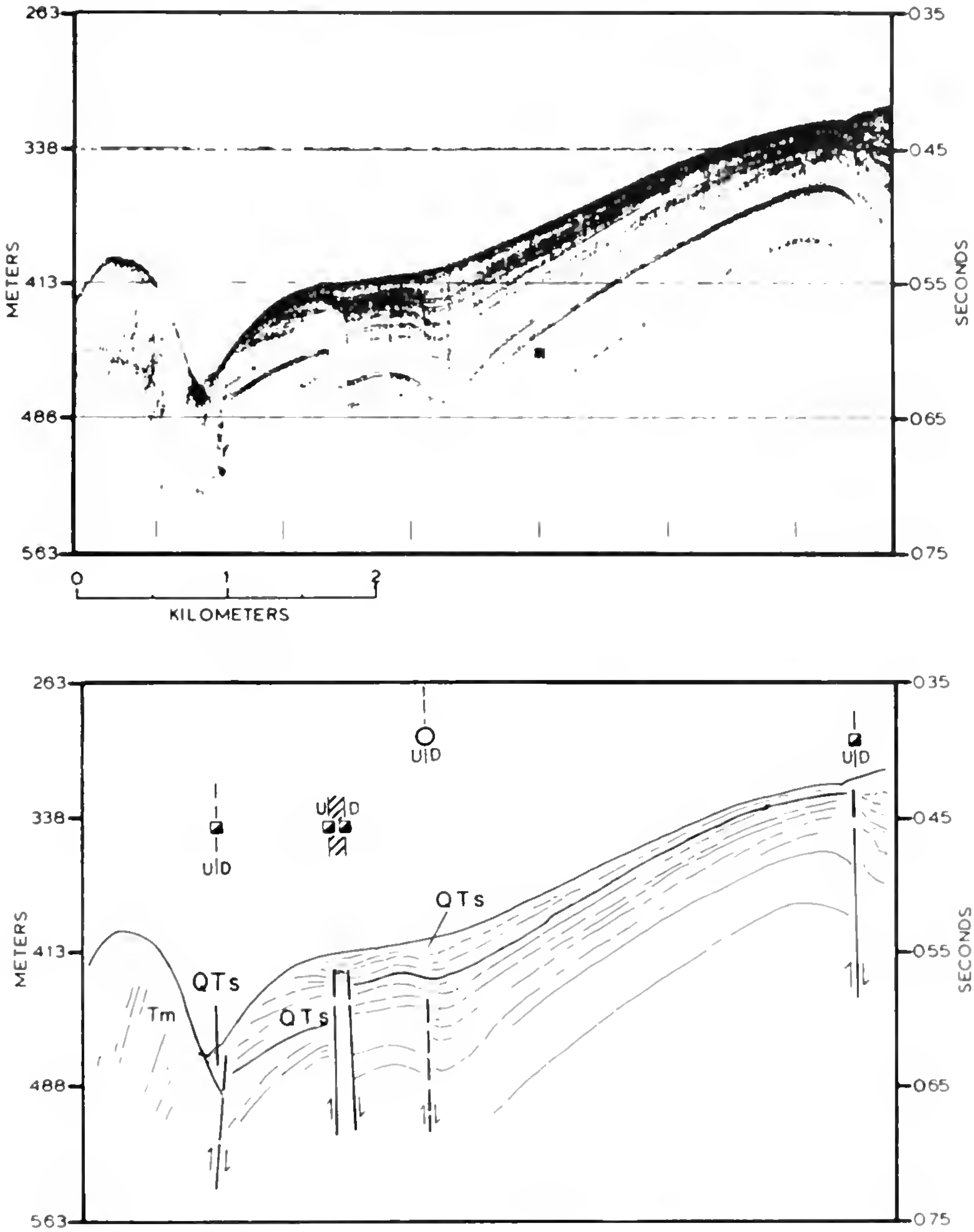
10. FAULT (late Tertiary and Quaternary)





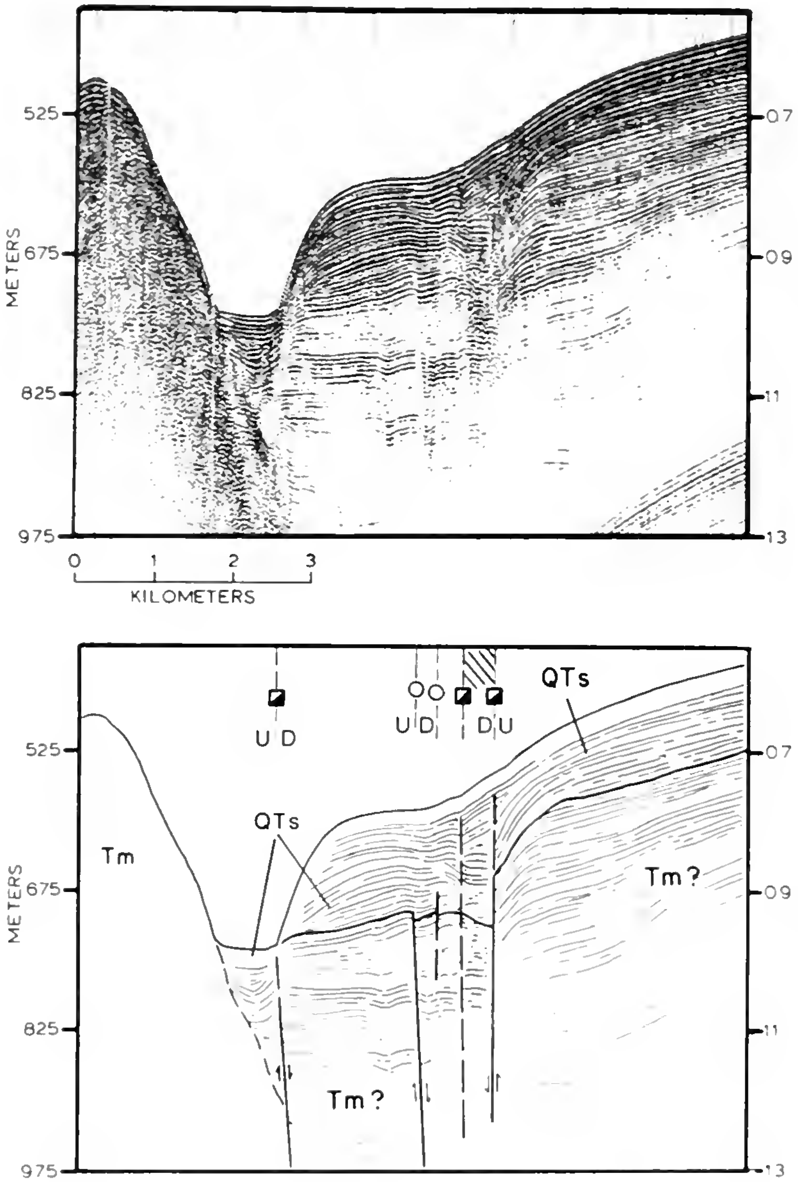
FAULT: solid where well defined, dashed where inferred, queried where uncertain. Divided box astride fault symbol indicates fault does not have seafloor expression and that youngest strata cut are of late Tertiary and Quaternary (QTs) age. "D" designates downthrown block; "U" designates upthrown block. Fault extends to base of "bubble pulse," but apparently does not reach the seafloor. Note two unconformities within strata to right of fault. Example from sparker profile across inner southern California continental borderland near Newport Beach.

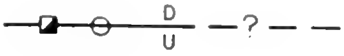
11. FAULT (late Tertiarty and Quaternary)



FAULT: solid where well defined, dashed where inferred, queried where uncertain. Open circle astride fault symbol indicates fault does not have seafloor expression and that youngest strata (QTs) cut are late Tertiary and Quaternary in age. Divided box astride fault symbol indicates that the strata cut are undifferentiated Quaternary in age. "D" designates downthrown block; "U" designates upthrown block. Fault at far left juxtaposes late Tertiary and Quaternary (QTs) and older units with an exposed bedrock ridge of Miocene (Tm) rock. Example of fault zone from Uniboom profile across San Diego shelf, Loma Sea Valley, and Coronado Bank, inner southern California continental borderland.

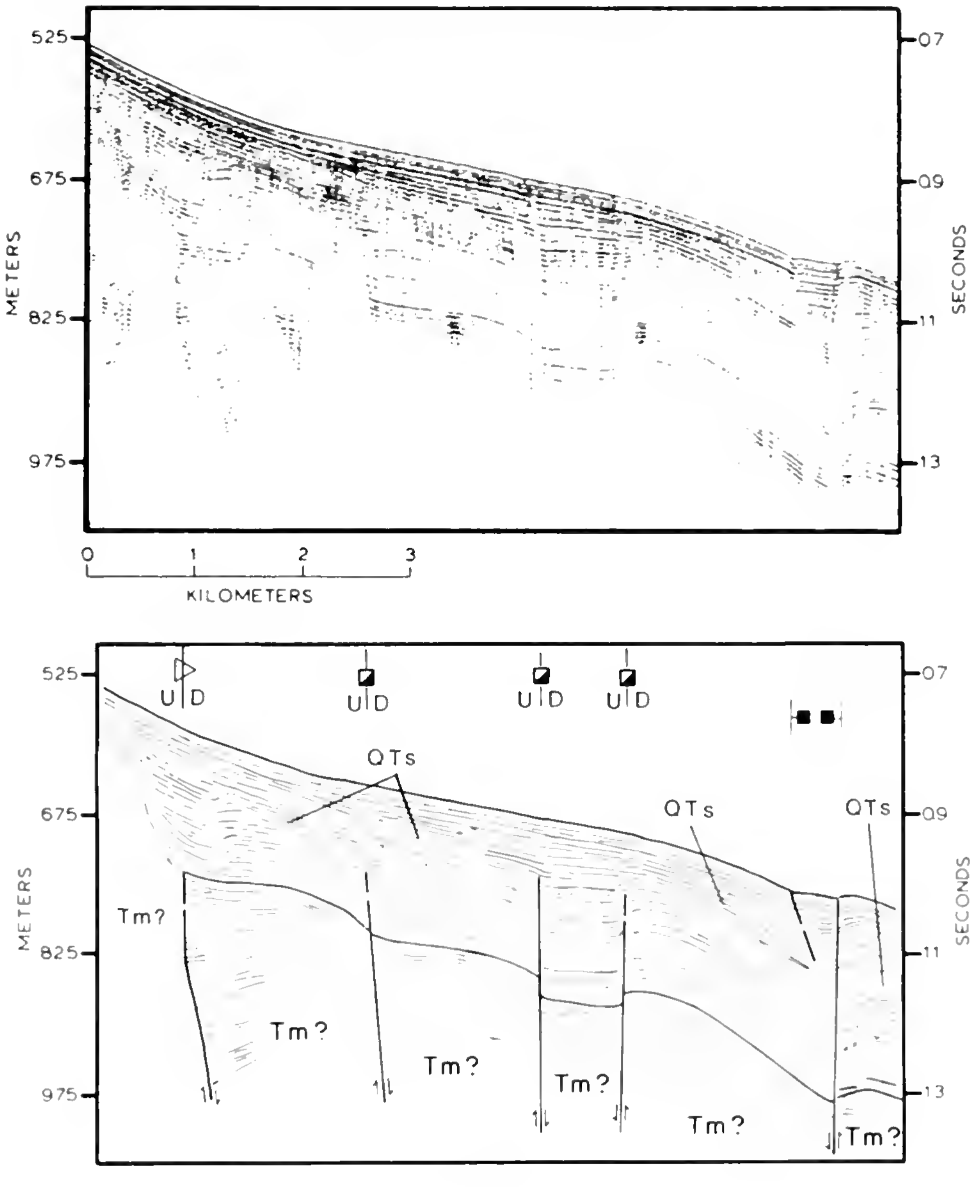
12. FAULT (late Tertiary and Quaternary)

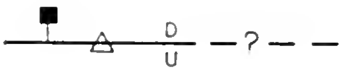




FAULT: solid where well defined, dashed where inferred, queried where uncertain. Open circles astride fault symbol indicates faults do not have seafloor expression and youngest strata cut are late Tertiary and Quaternary (QTs) in age. "D" designates downthrown block; "U" designates upthrown block. Where faults are close together, they are sometimes mapped as a FAULT ZONE (see Example 15). Note that fault at left juxtaposes late Tertiary and Quaternary strata with an exposed bedrock block of Miocene (Tm) age. Example from sparker profile across San Diego shelf, Loma Sea Valley, and east flank of Coronado Bank, inner southern California continental borderland.

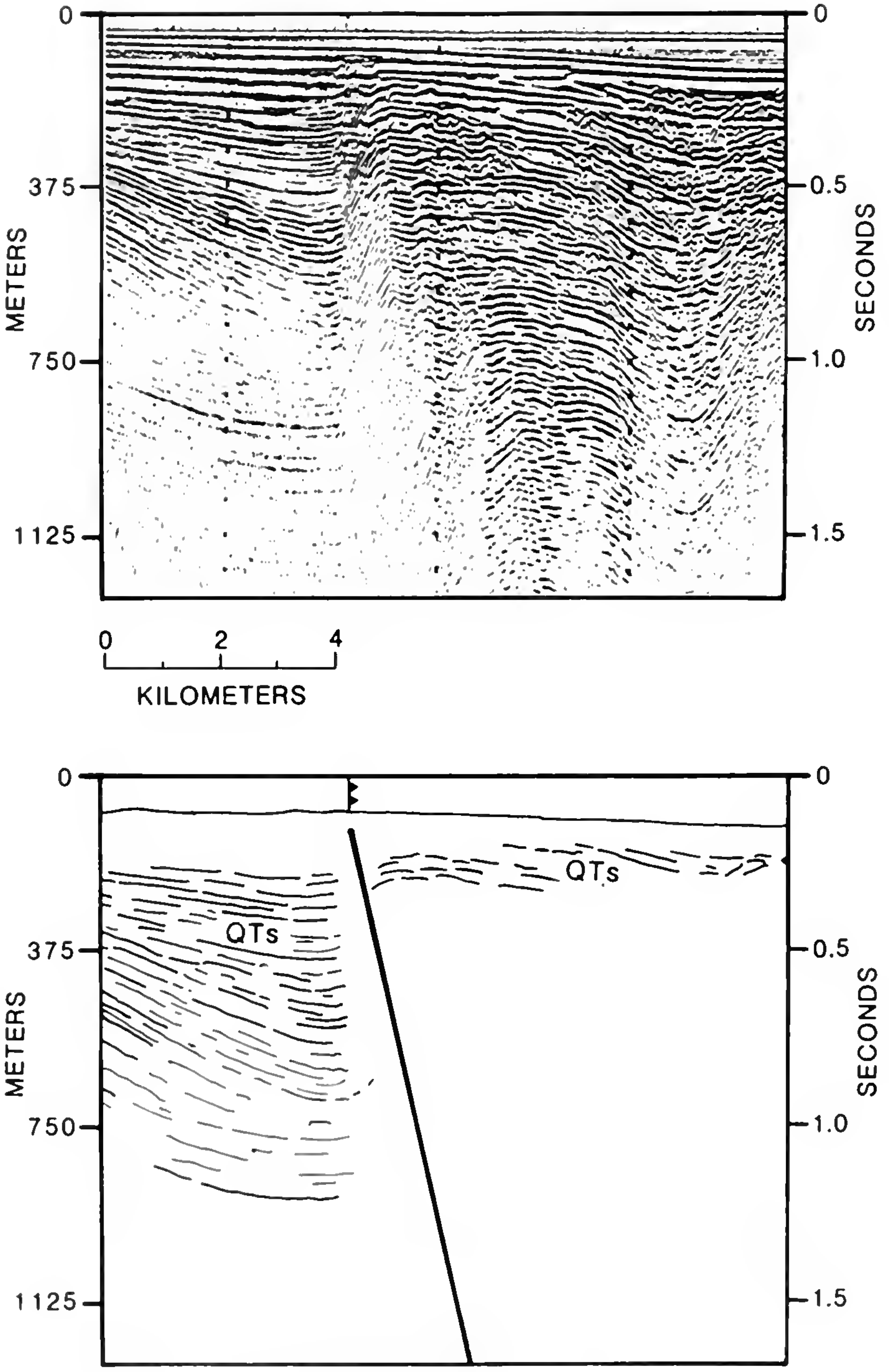
13. FAULT (late Tertiary and Quaternary)





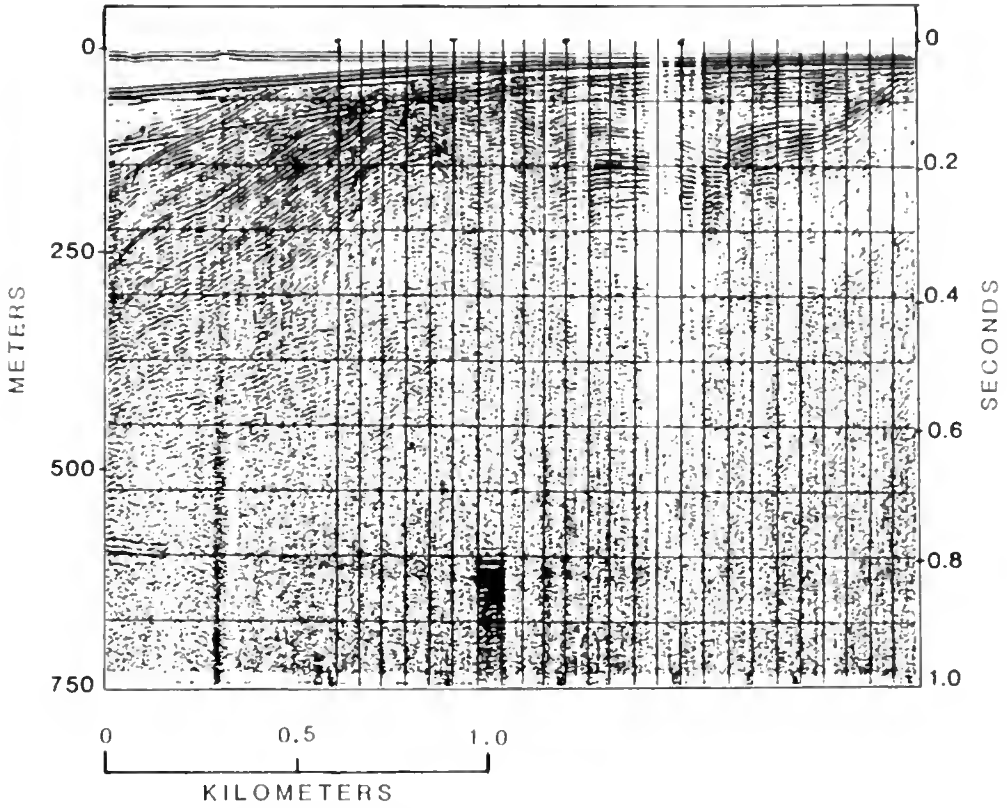
FAULT: solid where well defined, dashed where inferred, queried where uncertain. Open triangle astride fault symbol indicates fault does not have seafloor expression and strata cut are probably Miocene (Tm?) in age. "D" designates downthrown block; "U" designates upthrown block. Note also the two faults at the far right that are designated by filled box and bar on the fault symbol. These have seafloor expression, and cut strata of presumed Holocene age. Example from sparker profile across San Diego shelf to Loma Sea Valley, inner southern California continental borderland.

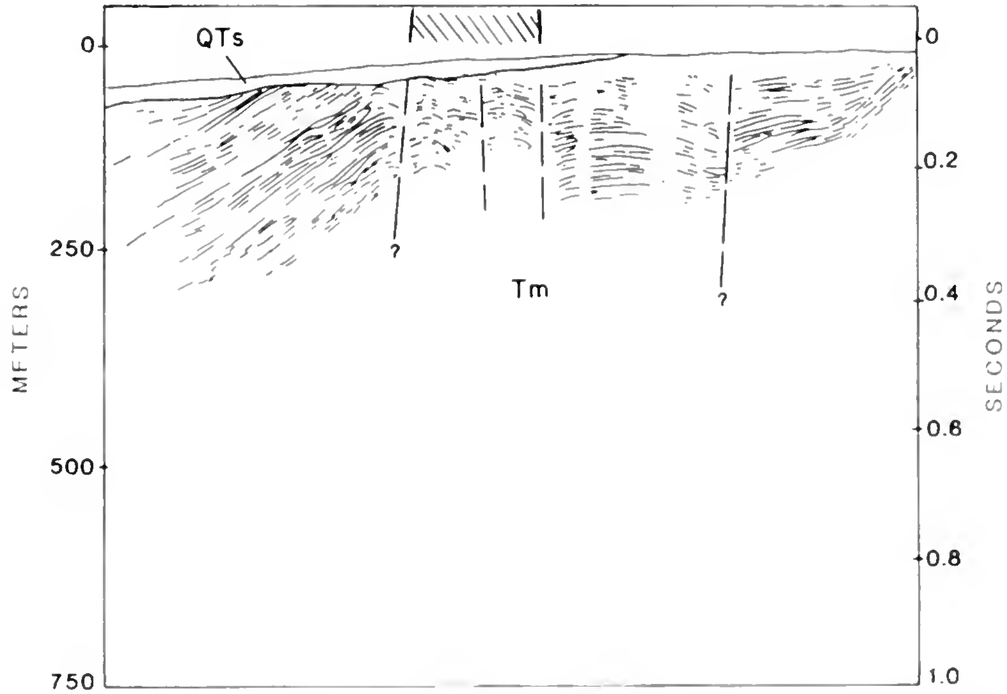
14. FAULT (thrust)

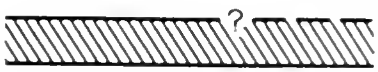


FAULT (thrust): solid where well defined, dashed where inferred, queried where uncertain. Barbs are shown on upper plate. Note that the youngest strata cut are of late Tertiary and Quaternary (QTs) age. Example from sparker profile across shelf west of Ventura, middle southern California continental borderland (after Greene and others, 1978, their Plate 1).

15. FAULT ZONE

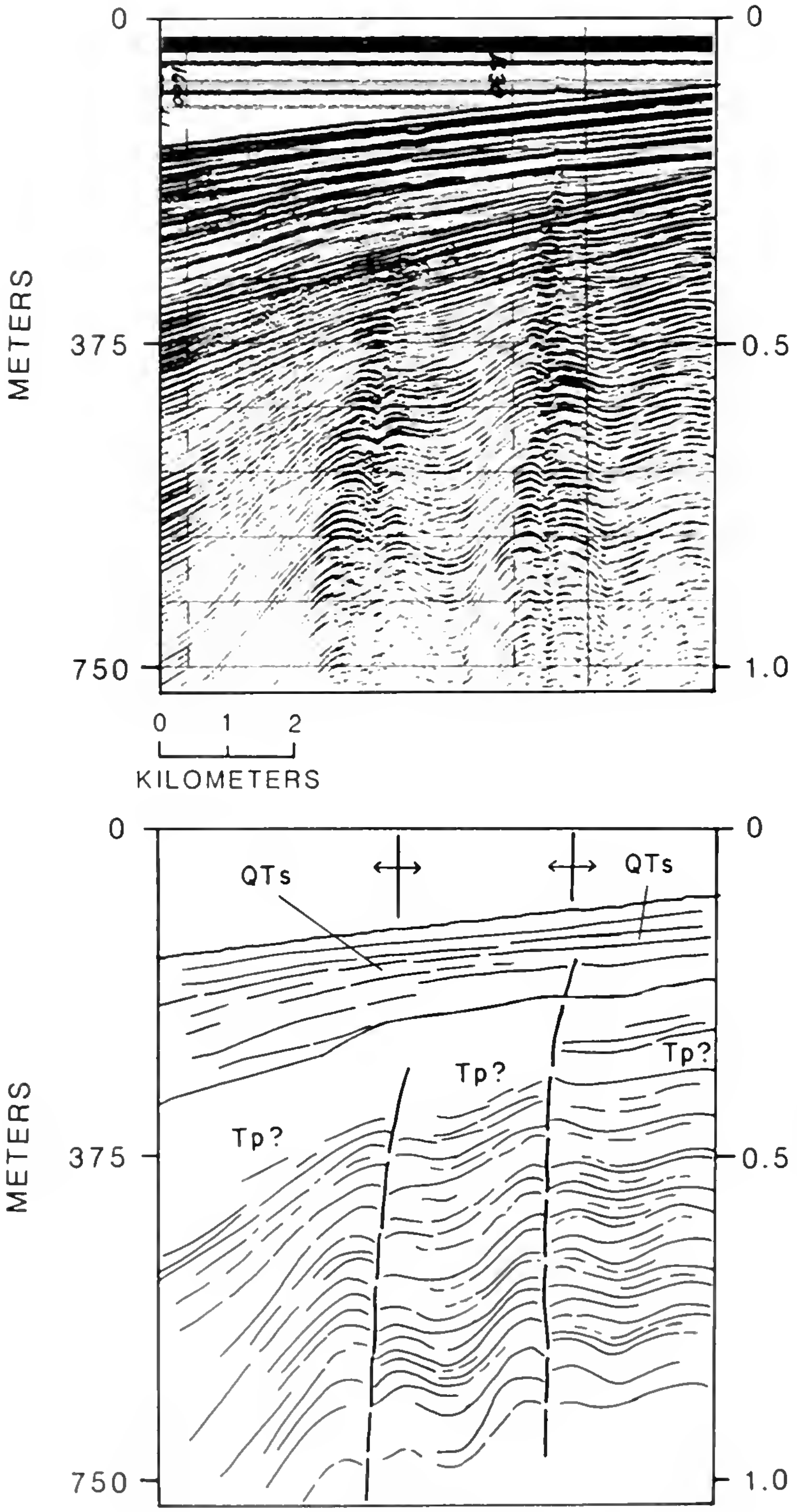






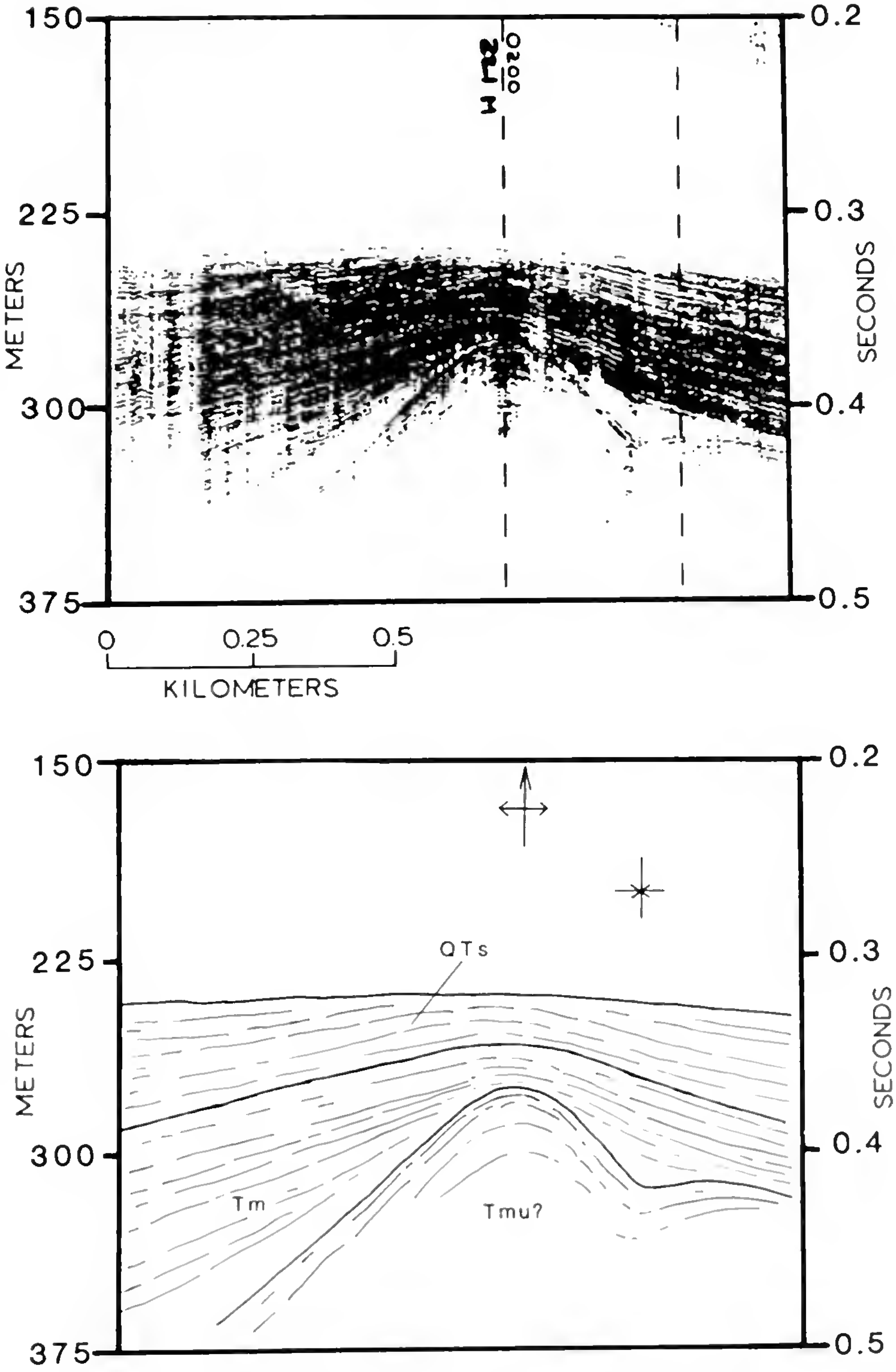
FAULT ZONE: solid where well defined, dashed where inferred, queried where uncertain. Fault zone offsets sedimentary rocks of Miocene (Tm) age and locally may extend to the seafloor. Example from the sparker profile across shelf south of San Mateo Point, inner southern California continental borderland (after Greene and Kennedy, 1981).

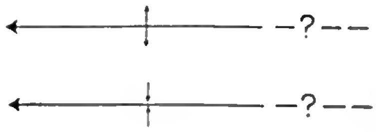
16. FAULTED ANTICLINE



FAULTED ANTICLINE: Gas migrating upward along faults in late Tertiary and Quaternary (QTs) strata has accumulated along the faulted anticlinal crest, increasing the acoustic contrast. Example from 2-sec, single-channel airgun reflection record in offshore Santa Maria basin, south central California continental margin.

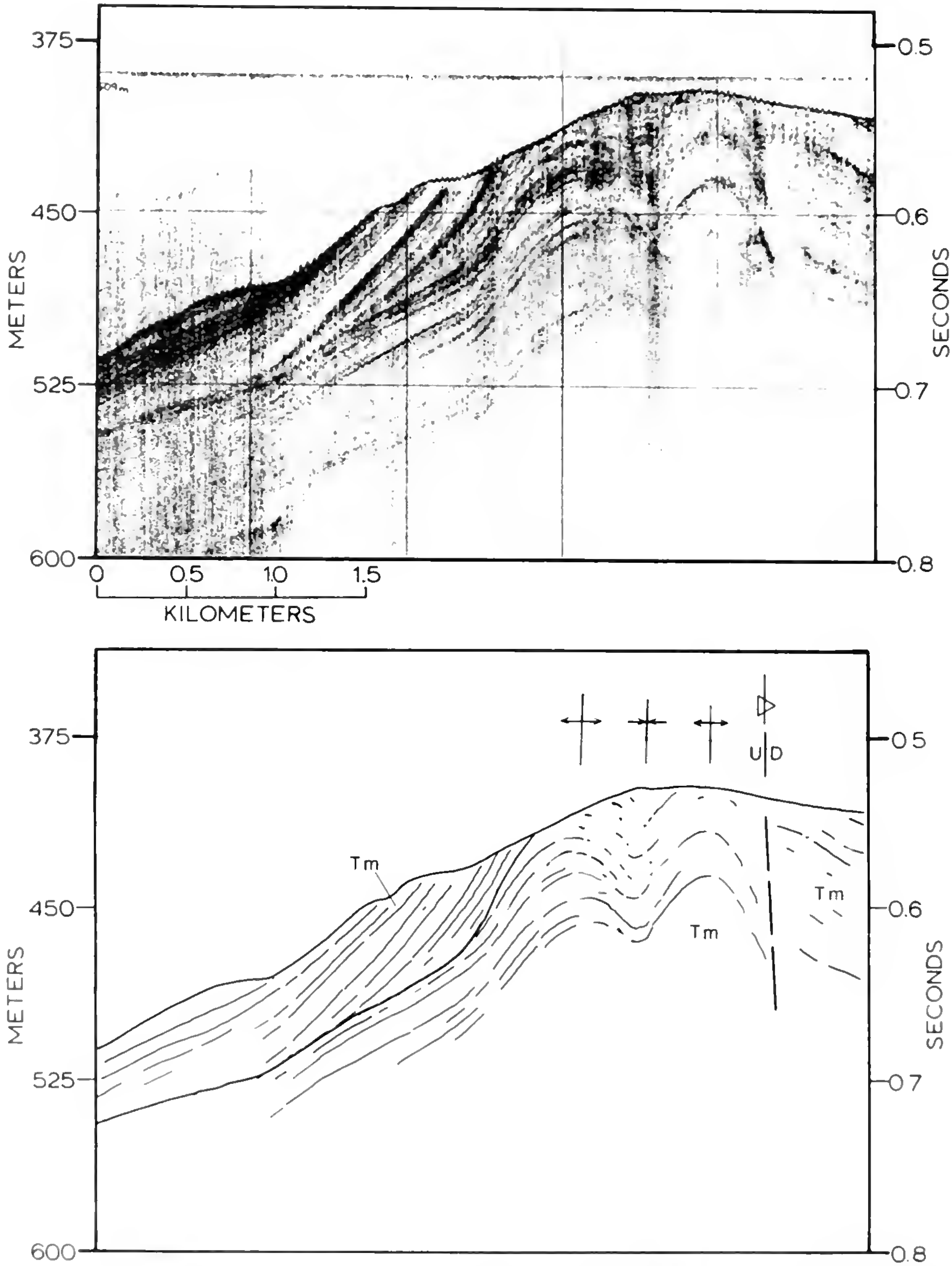
17. FOLD (anticline)

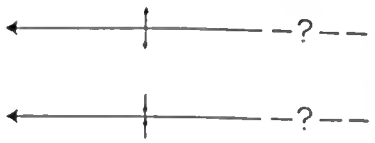




FOLD (anticline): axis shown as solid line where well defined, dashed where inferred, queried where uncertain. Arrow indicates direction of axial plunge. Also note small syncline to right of anticline, and angular unconformity between undifferentiated igneous and sedimentary rocks of probable Miocene age (Tmu?), and overlying strata of Miocene (Tm) age. Example from Uniboom profile between the Tanner and Cortes Banks, middle southern California continental borderland.

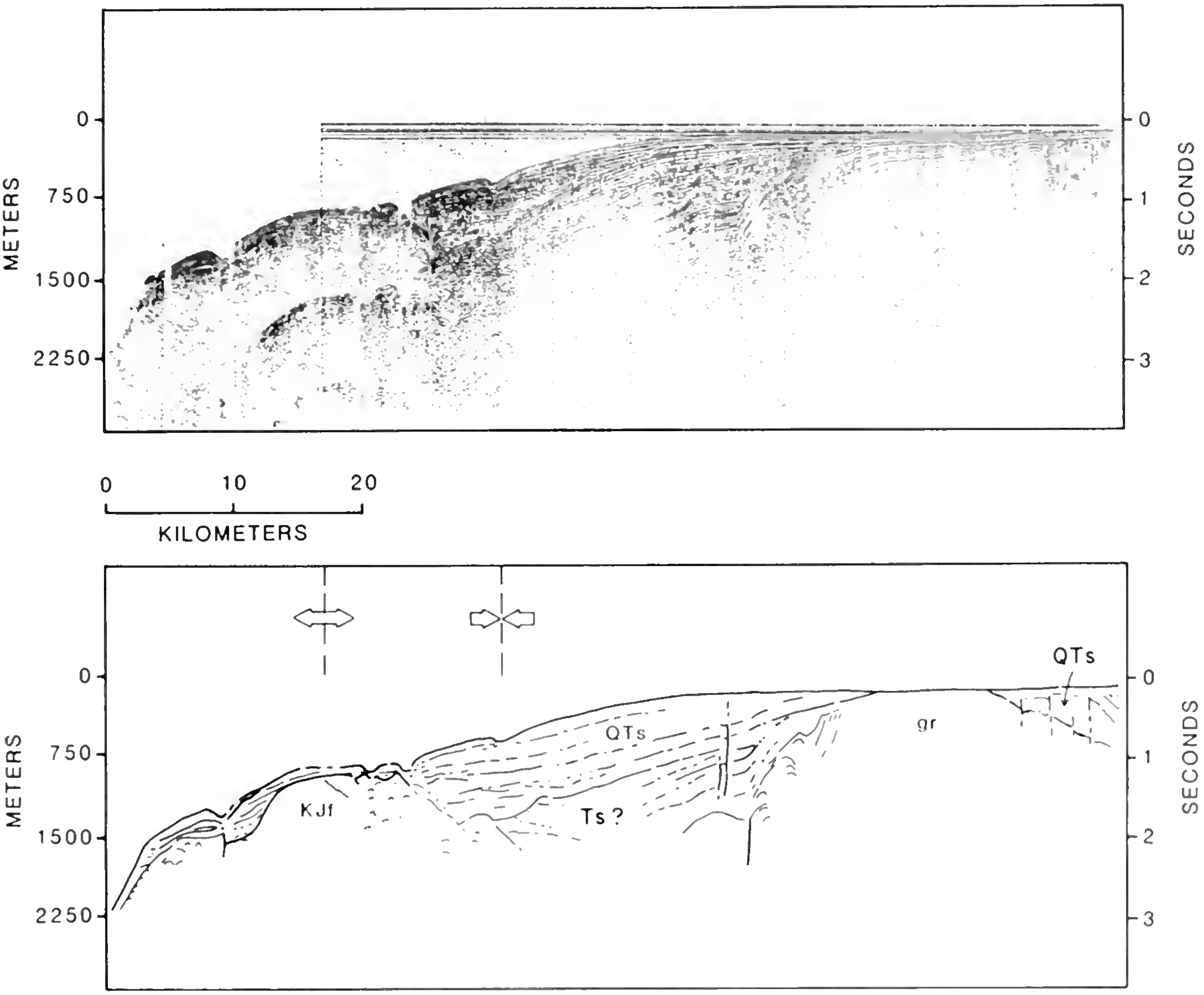
18. FOLD (anticline, syncline)

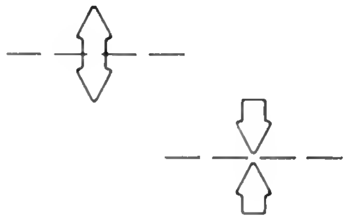




FOLD (anticline): axis shown as solid line where well defined, dashed where inferred, queried where uncertain. Arrow indicates direction of axial plunge. Also note small syncline located between the two anticlinal folds, and the angular unconformity between folded strata of Miocene (Tm) age and the progradational sequence of Miocene (Tm) sedimentary rocks. Example from Uniboom profile across San Nicolas Island platform, middle southern California continental borderland.

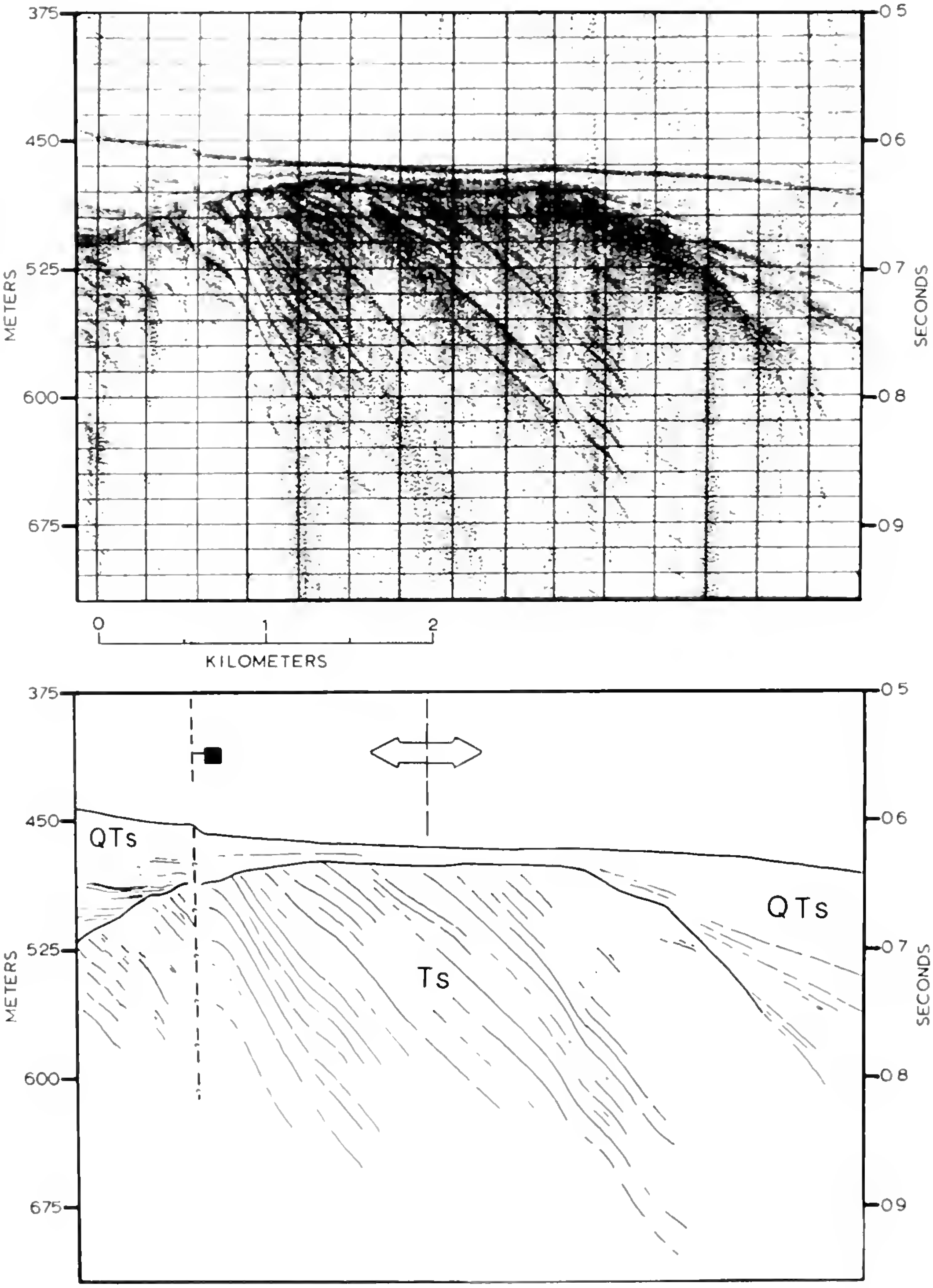
19. STRUCTURAL HIGH AND LOW

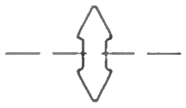




STRUCTURAL HIGHS AND LOWS: solid where well defined, dashed where inferred. Structural highs formed by the Farallon Ridge (Cretaceous granitic rocks, gr, of the Salinian terrane of Siberling and others, 1984) and the Santa Cruz high (Cretaceous subduction melange of Franciscan Complex, KJf) and the intervening structural low filled by late Tertiary and Quaternary sediments of the outer Santa Cruz basin. Line drawing from a 4 second, single-channel sparker profile run across the continental shelf and slope west of Half Moon Bay, offshore central California.

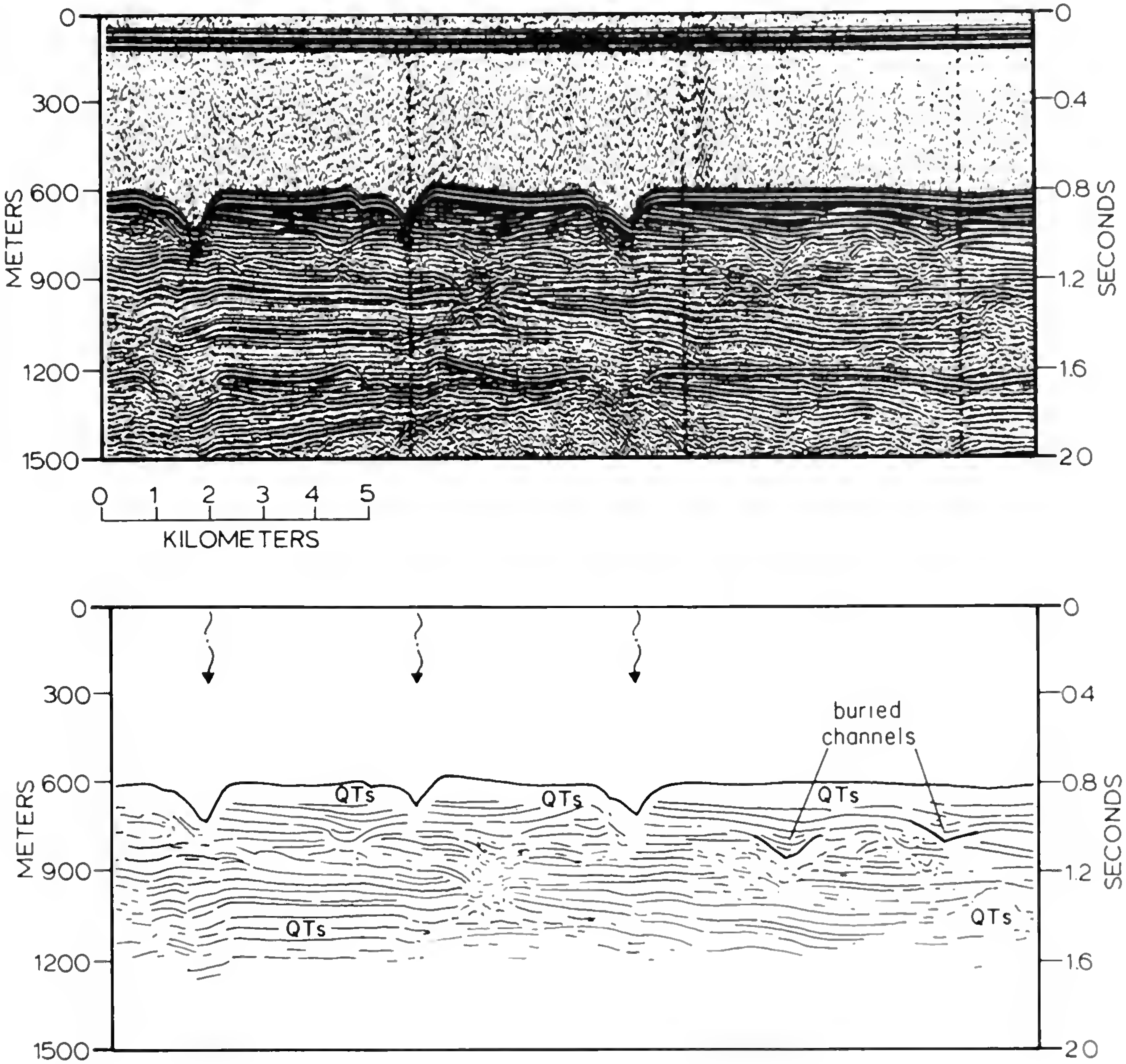
20. STRUCTURAL HIGH





STRUCTURAL HIGH: solid where well defined, dashed where inferred. Top of structural high is surface eroded onto presumed sedimentary rocks (Ts) of Tertiary age buried beneath undifferentiated sedimentary rocks and sediments (QTs) of Tertiary and Quaternary age. Example from sparker profile across the Gulf of Santa Catalina.

21. CHANNEL (active)



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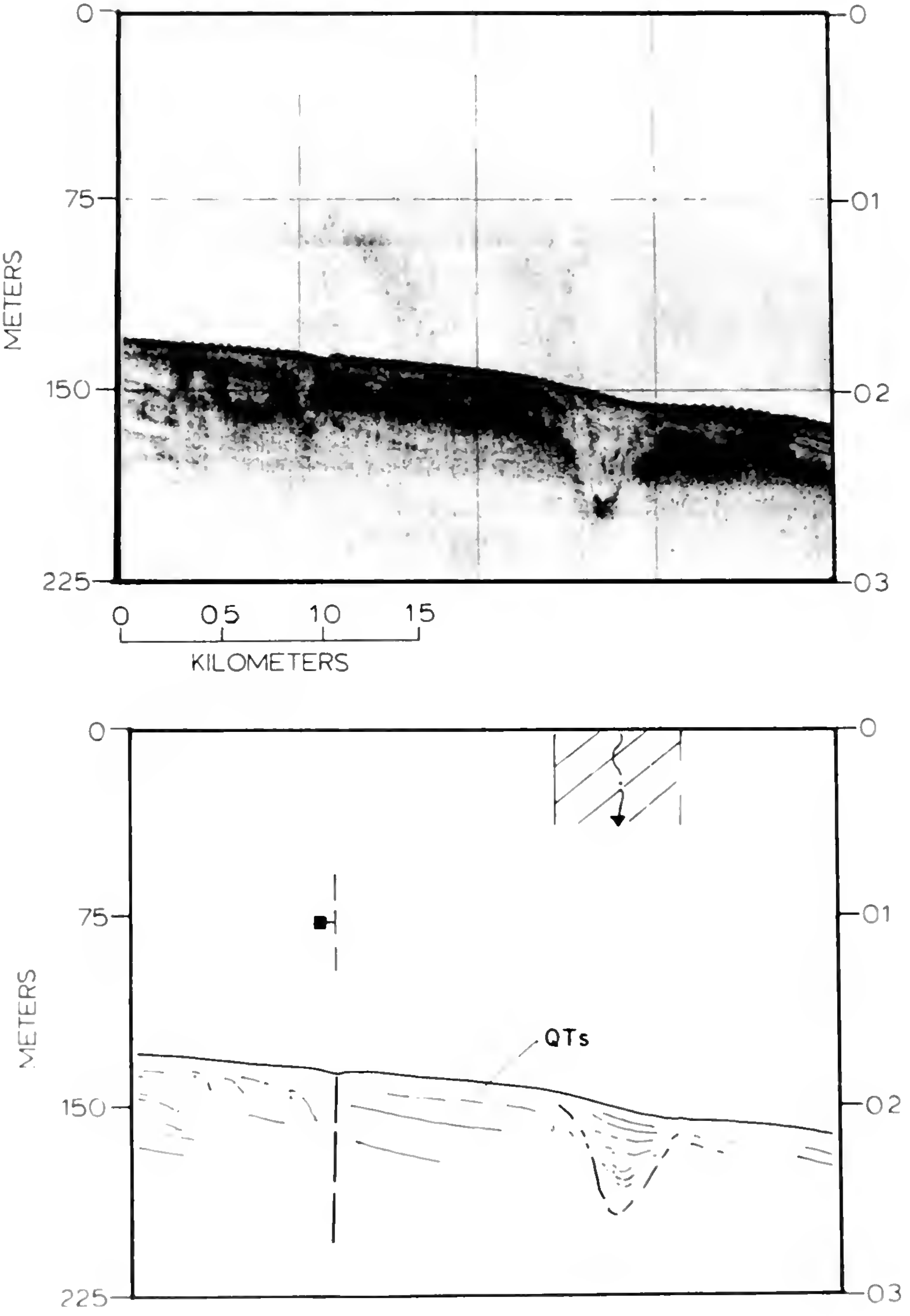
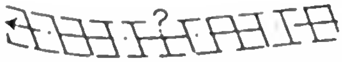
CHANNEL (active): dash-dot line marks channel axis, arrow indicates direction of sediment transport. Also note two buried channels beneath the modern seafloor of presumed Quaternary-Tertiary, undifferentiated age to right of active channels. Example from sparker profile across head of Arguello Canyon, off Point Arguello, central California continental margin.

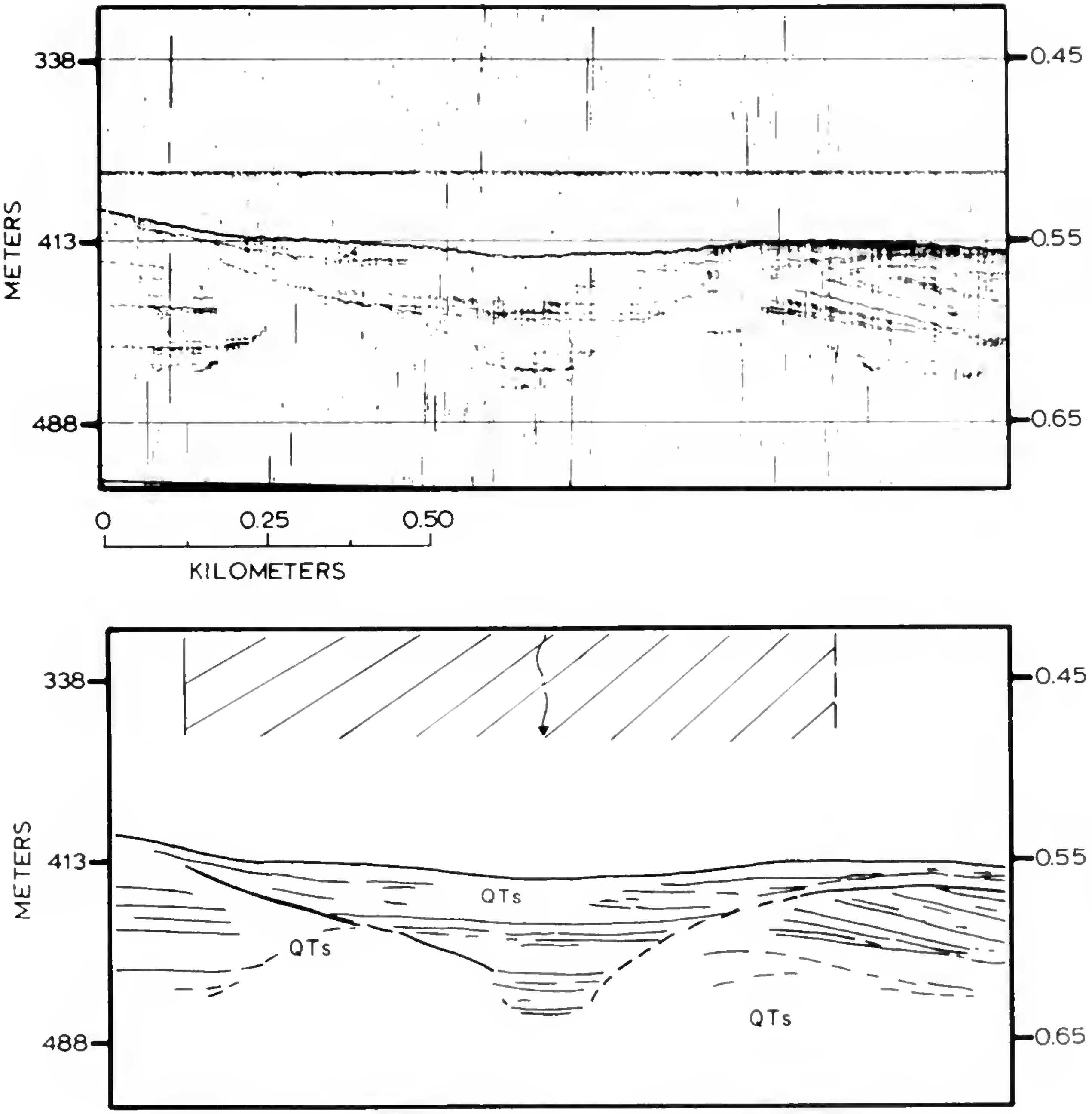
22. CHANNEL (filled)

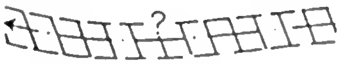




CHANNEL (filled): dash-dot line marks paleochannel axis, arrow indicates direction of sediment transport. Channel margins indicated by solid line where well defined, dashed where inferred, queried where uncertain. Also note fault that cuts flat lying sediments of presumed Holocene age and is expressed in the seafloor. Example from Uniboom profile off Point Ana Nuevo, central California continental margin.

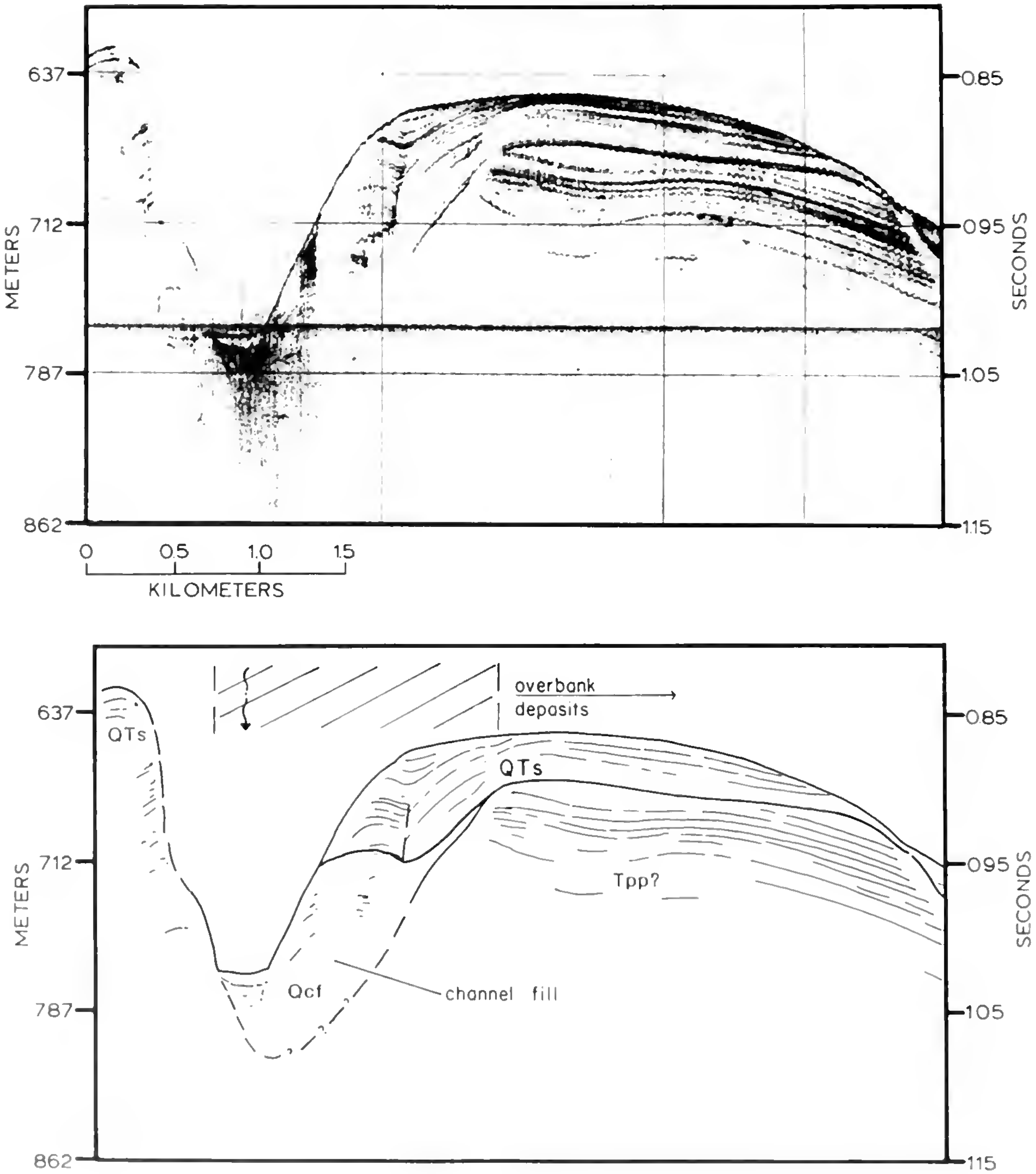
23. CHANNEL (filled)





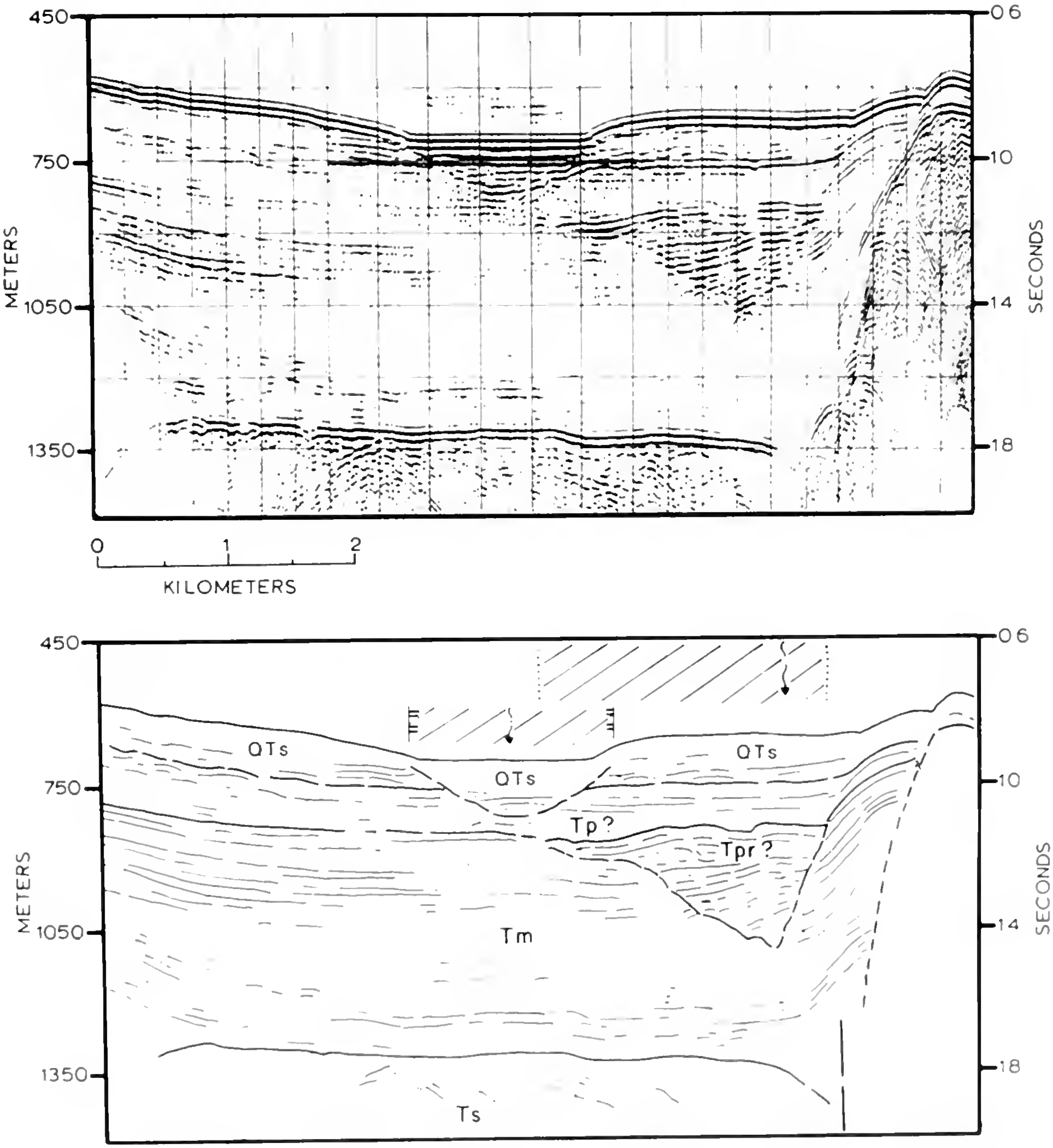
CHANNEL (filled): dash-dot line marks paleochannel axis, arrow indicates direction of sediment transport. Channel margins indicated by solid line where well defined, dashed where inferred, queried where uncertain. Example from Uniboom profile of upper Tertiary and Quaternary (QTs) sediments filling an erosional channel located off Point La Jolla, inner southern California continental borderland.

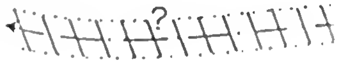
24. CHANNEL (filled)



CHANNEL (filled): dash-dot line marks paleochannel axis (not located on profile above), arrow indicates direction of sediment transport. Channel margins indicated by solid line where well defined, dashed where inferred, queried where uncertain. Note that old channel deposits (Qcf) have been incised by subsequent erosion, resulting in the formation of a modern, active channel. Symbols: QTs, upper Tertiary and Quaternary sediments; Tpp?, Pliocene Purisima (?) Formation. Example from Uniboom profile across Ascension Canyon, central California continental margin.

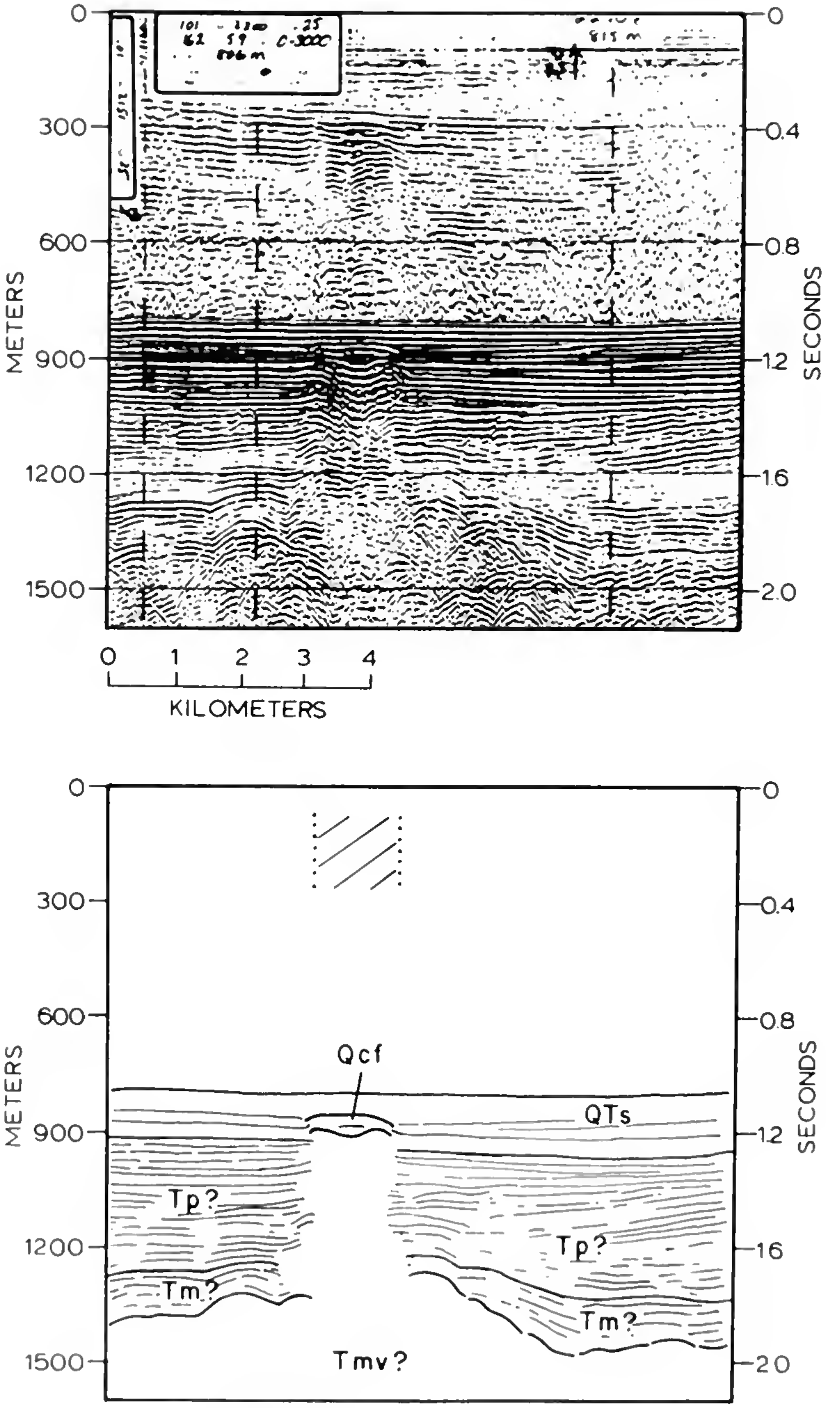
25. CHANNEL (buried)

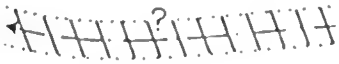




CHANNEL (buried): dash-dot line marks paleochannel axis, arrow indicates direction of sediment transport. Channel margins indicated by dotted line. Also note the channel at surface, above and to the left of buried channel, filled with undifferentiated sediments of late Tertiary and Quaternary (QTs) age. A modern channel occupying the site of this older, filled channel may be indicated by the presence of low-relief erosional scarps at the surface. Example from sparker profile across the Gulf of Santa Catalina, off Dana Point, inner southern California continental borderland.

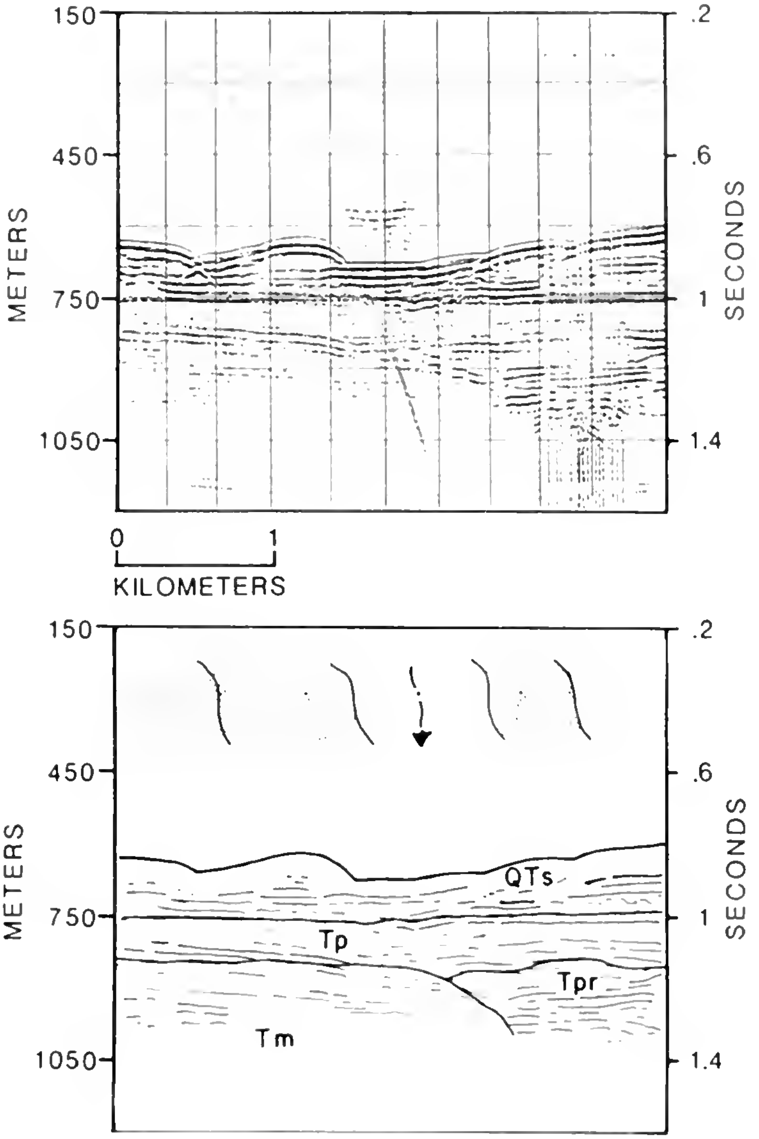
26. CHANNEL (buried)

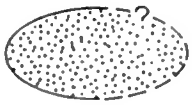




CHANNEL (buried): dash-dot line marks paleochannel axis (not indicated on profile above). Within upper Tertiary and Quaternary (QTs) sediments, the channel margins are indicated by dotted lines. Pulled-down reflectors immediately beneath the channel and incoherent reflectors at depth probably result from low acoustic velocities associated with unconsolidated channel fill materials. Example from sparker profile across the Gulf of Santa Catalina, inner southern California continental borderland.

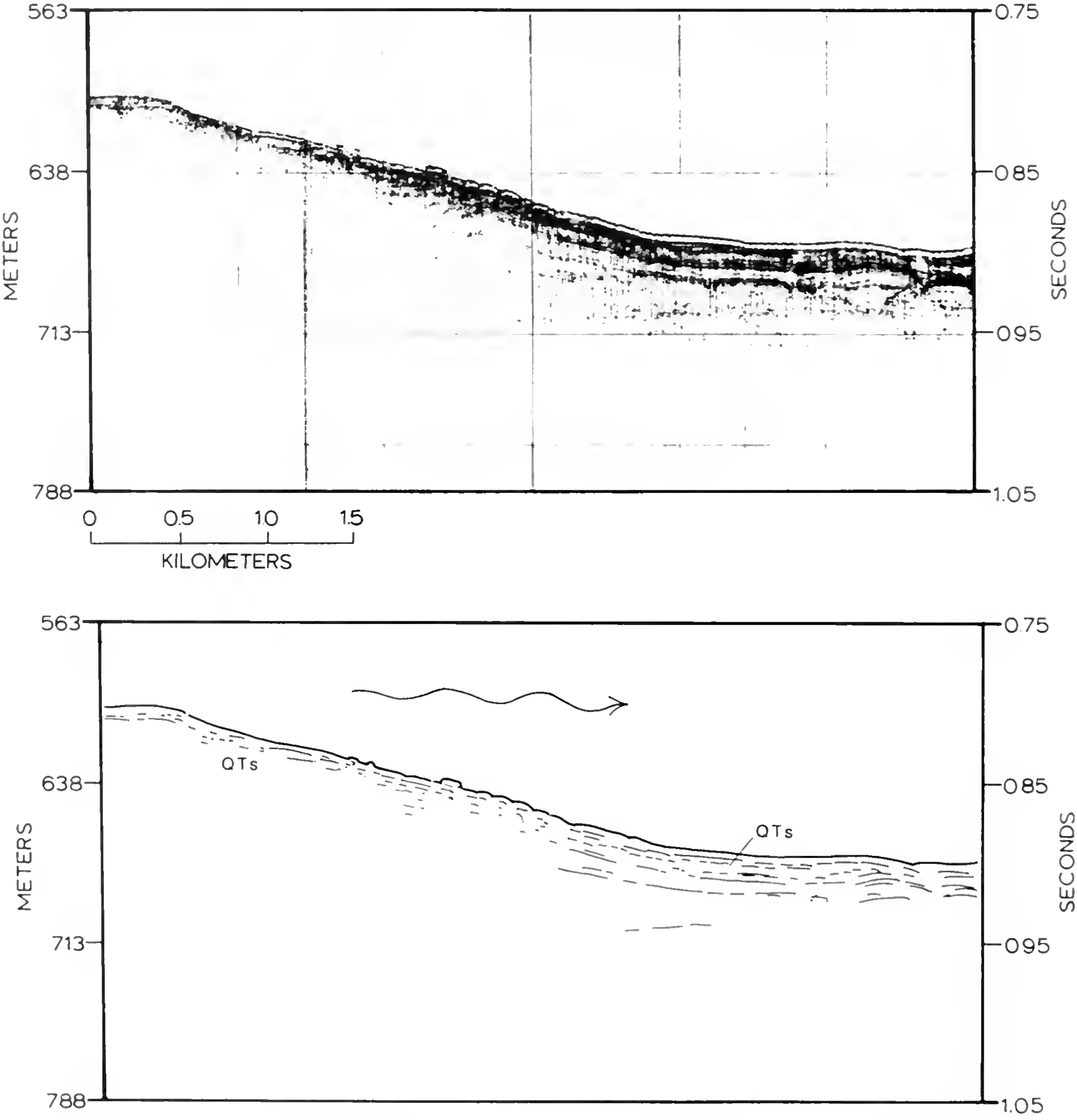
27. LEVEE





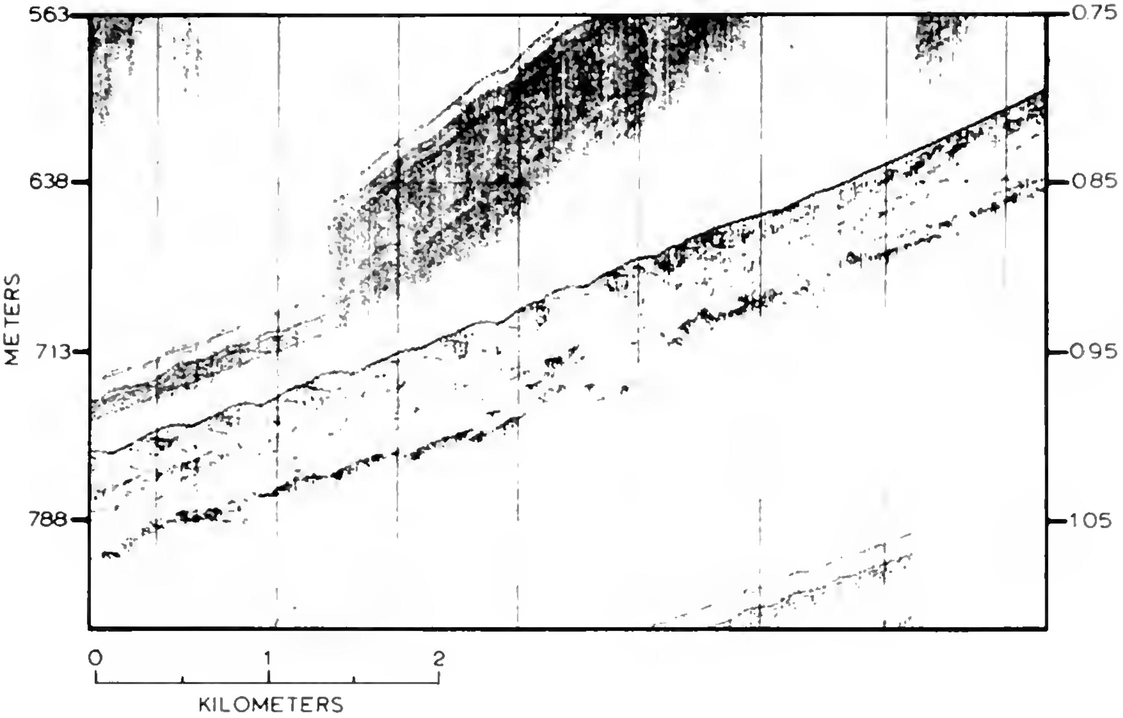
LEVEE: solid where well defined, dashed where inferred, queried where uncertain. Levees constructed from sediment overflow of active submarine channel (shown as dash-dot line with arrow indicating direction of sediment transport). Levees of Quaternary age are deposited upon flat lying strata of sediments and sedimentary rocks of Quaternary and Tertiary, undifferentiated, age (QTs). Example from sparker profile across floor of Gulf of Santa Catalina at base of slope west of San Mateo Point, southern California continental borderland.

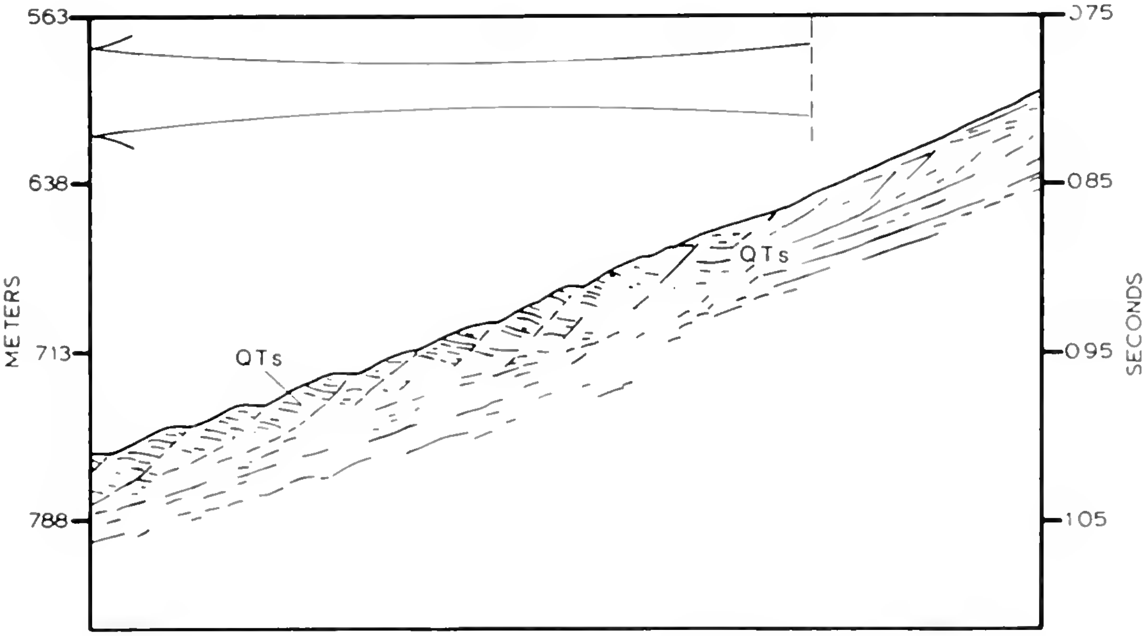
28. LANDSLIDE (creep)

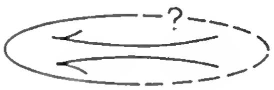


CREEP (noted on a single survey line): arrow indicates apparent direction of sediment movement in upper Tertiary and Quaternary (QTs) sediments. Example from Uniboom profile off Oceanside, inner southern California continental borderland.

29. LANDSLIDE (slump)

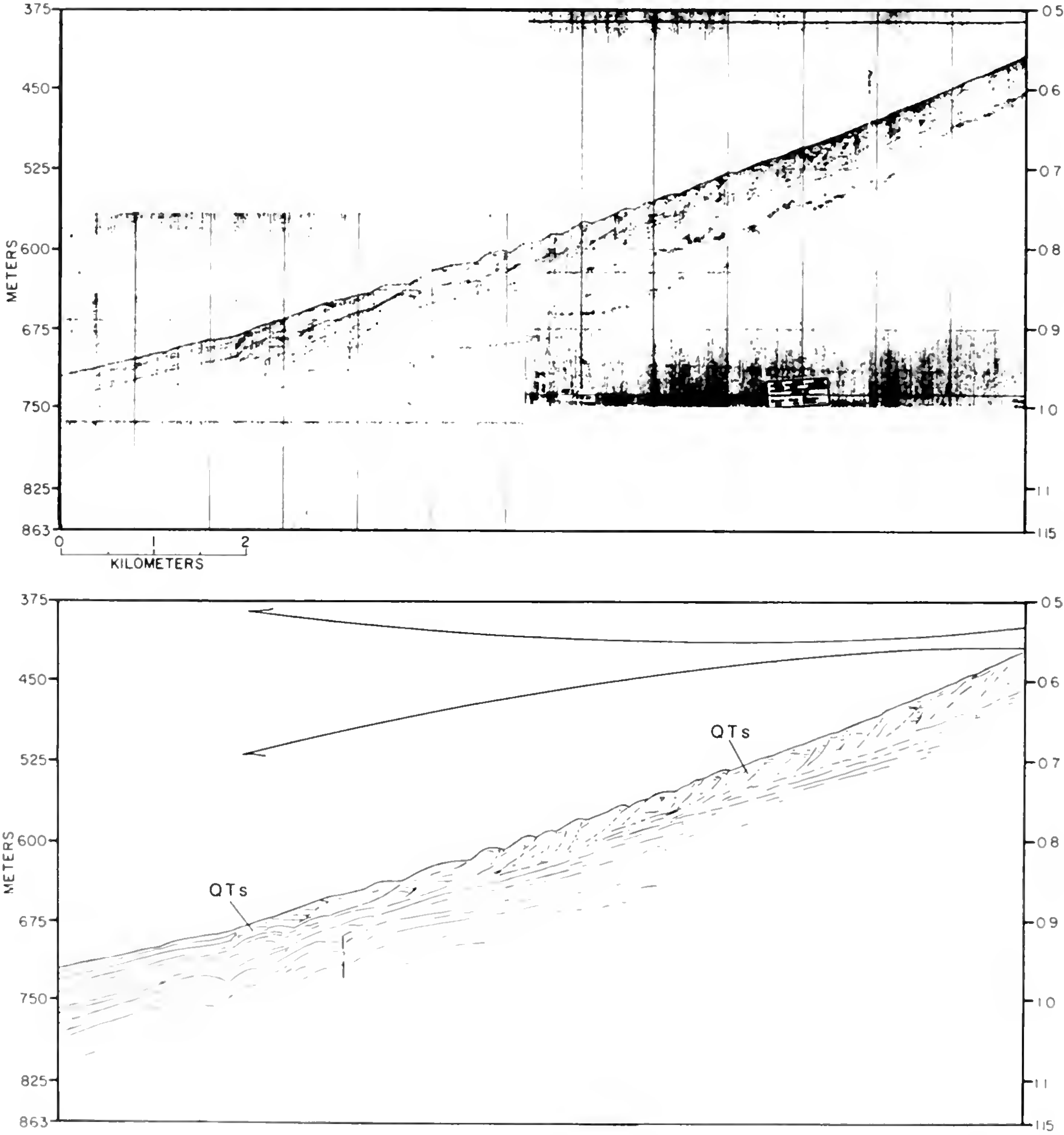


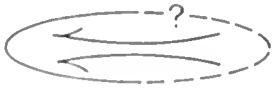




SLUMP: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of approximately 20 m. Note hummocky seafloor surface and back-rotated subbottom reflectors (slip surface). Example from Uniboom profile across continental slope off Crescent City, northern California continental margin.

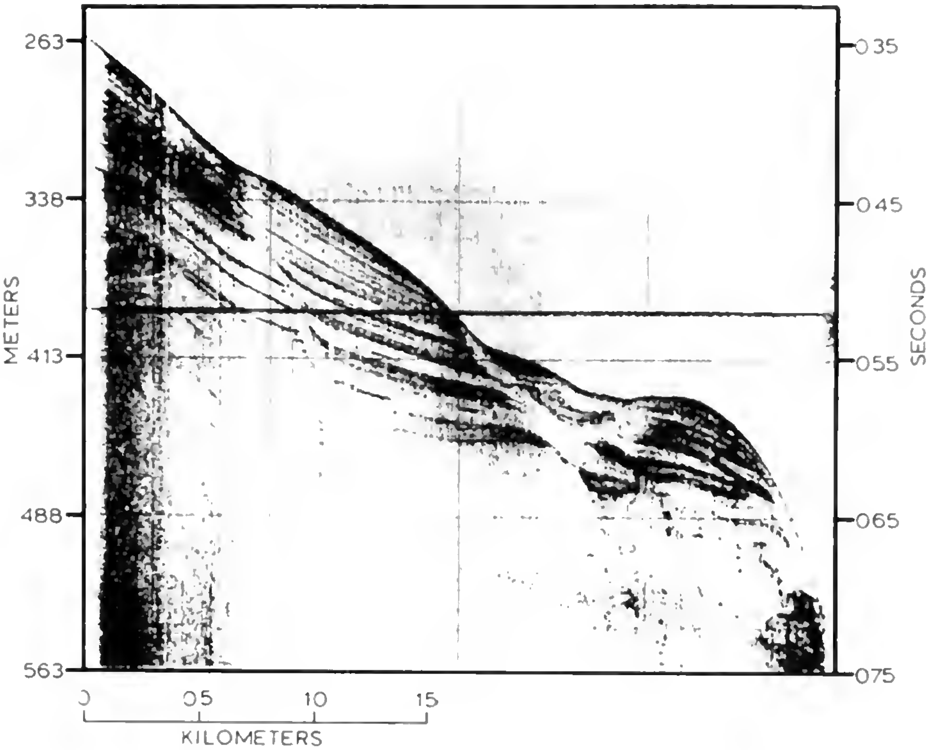
30. LANDSLIDE (slump)

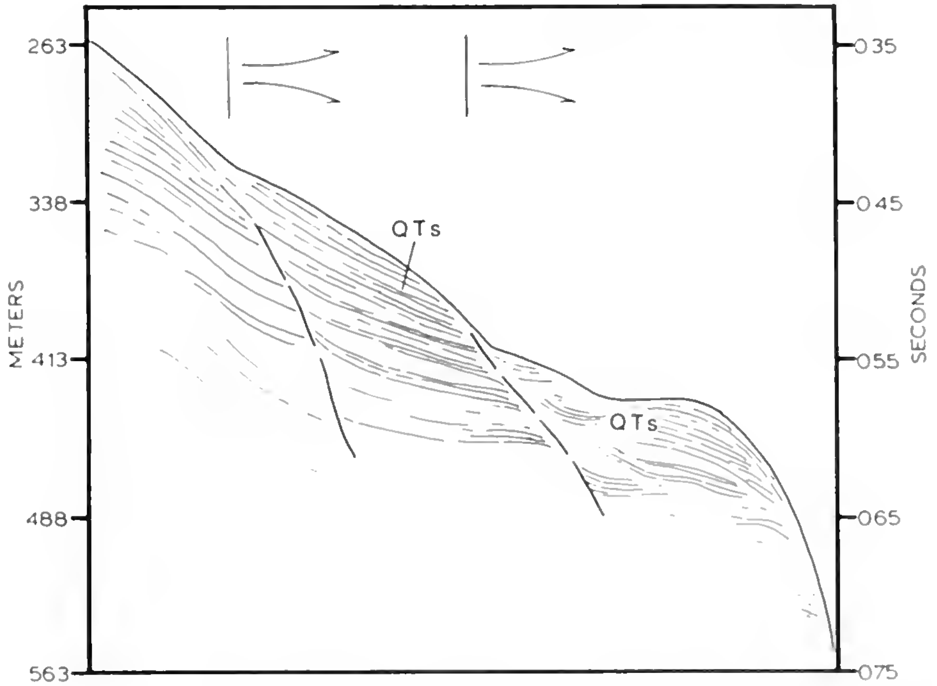


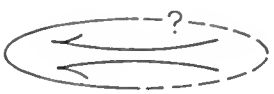


SLUMP: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of 30 m. Note hummocky seafloor surface, slip surfaces and back rotation of reflectors within moving sediment mass. Example from Uniboom profile across slope west-northwest of Crescent City, northern California continental margin (after Field and others, 1980, their Figure 15).

31. LANDSLIDE (slump)

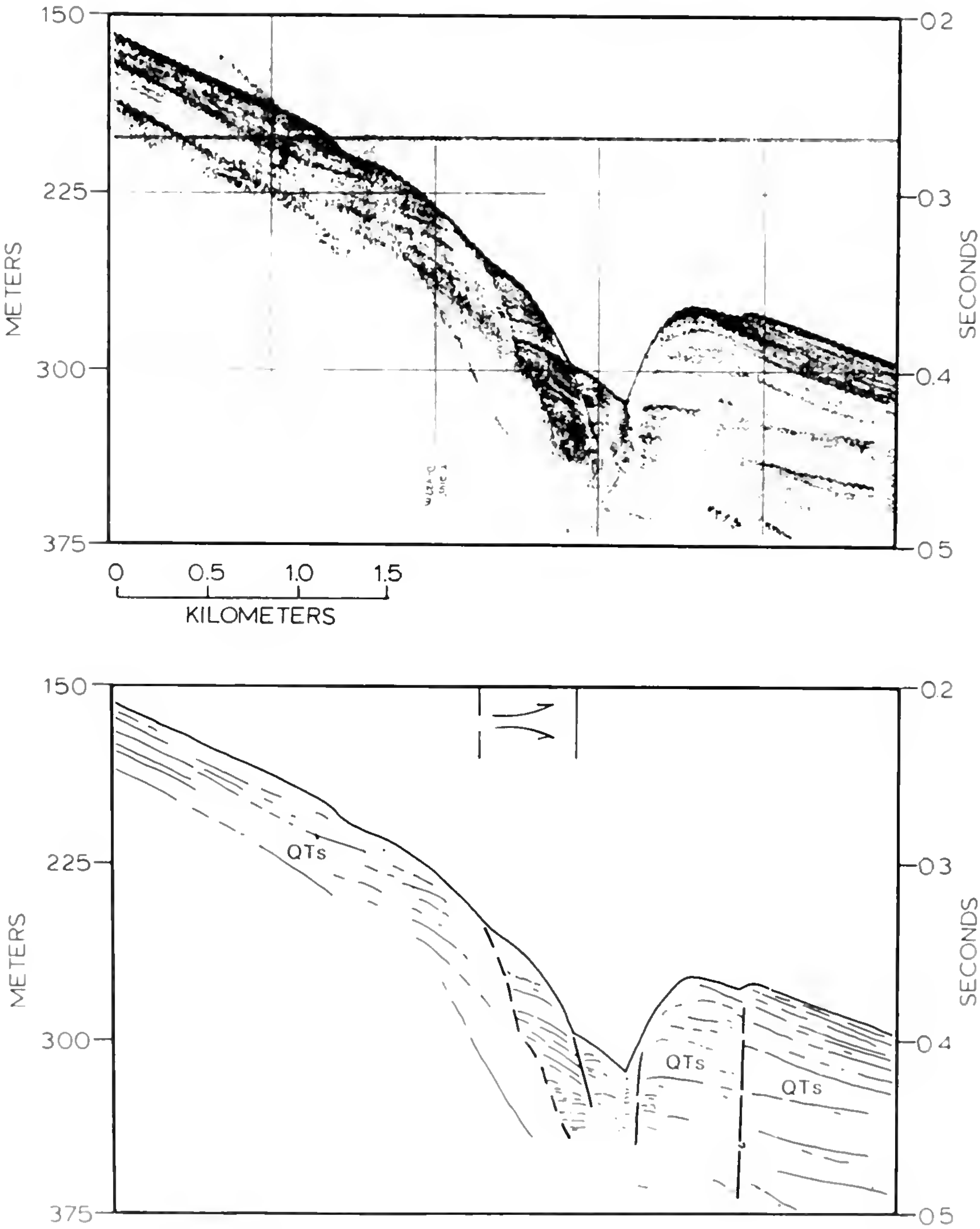


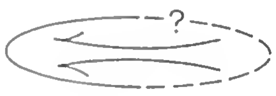




SLUMP: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of in excess of 100 m involving sediments of late Tertiary and Quaternary (QTs) age. Note slip surfaces and apparent drag folding of strata adjacent to slip surfaces. Example from Uniboom profile near La Jolla Canyon, inner southern California continental borderland.

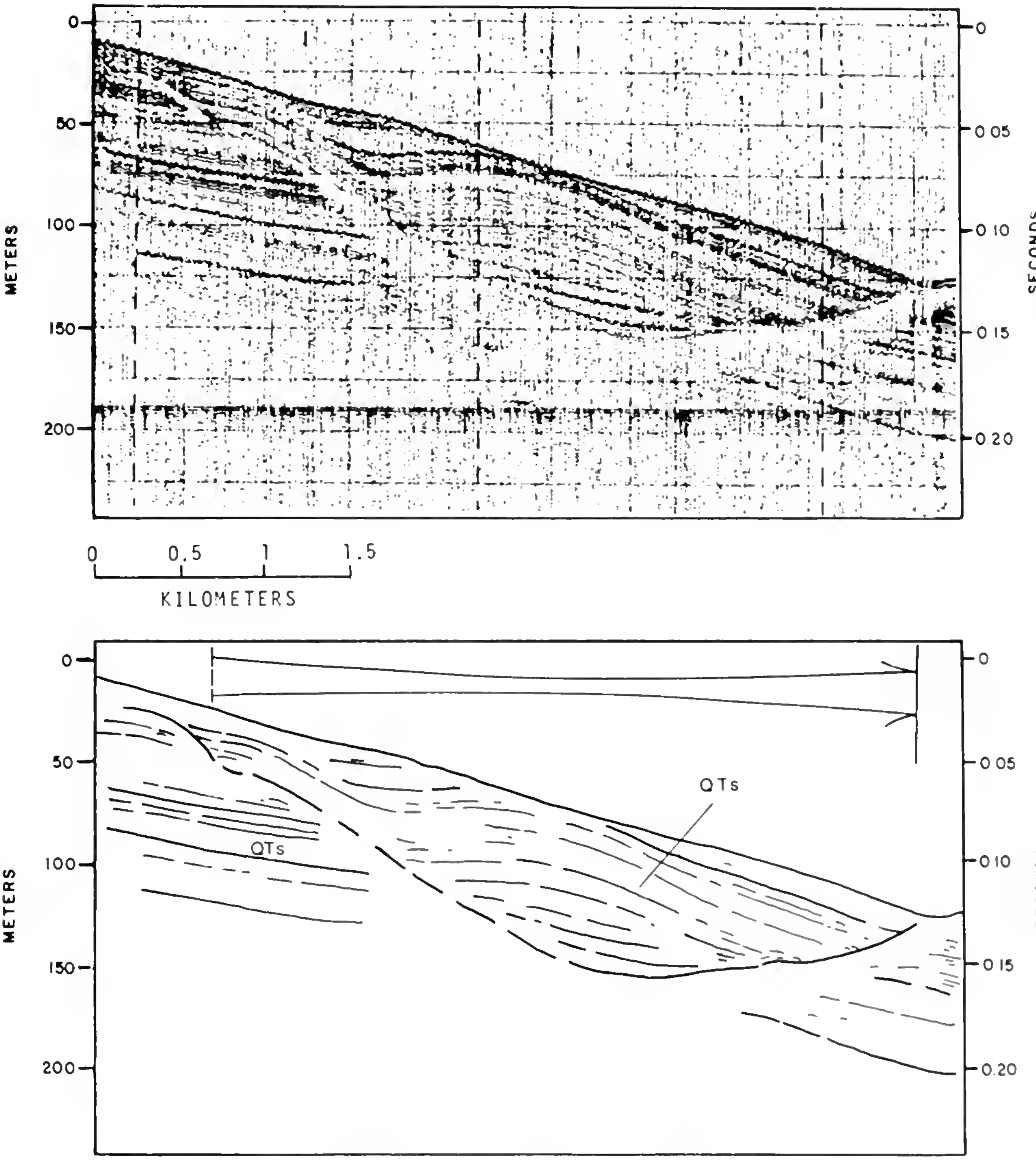
32. LANDSLIDE (slump)

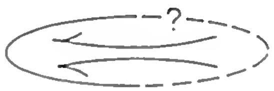




SLUMP: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of approximately 90 m in sediments of late Tertiary and Quaternary (QTs) age. Note apparent slip surfaces and back-rotated reflectors. Example from Uniboom profile across Ascension Canyon, central California continental margin.

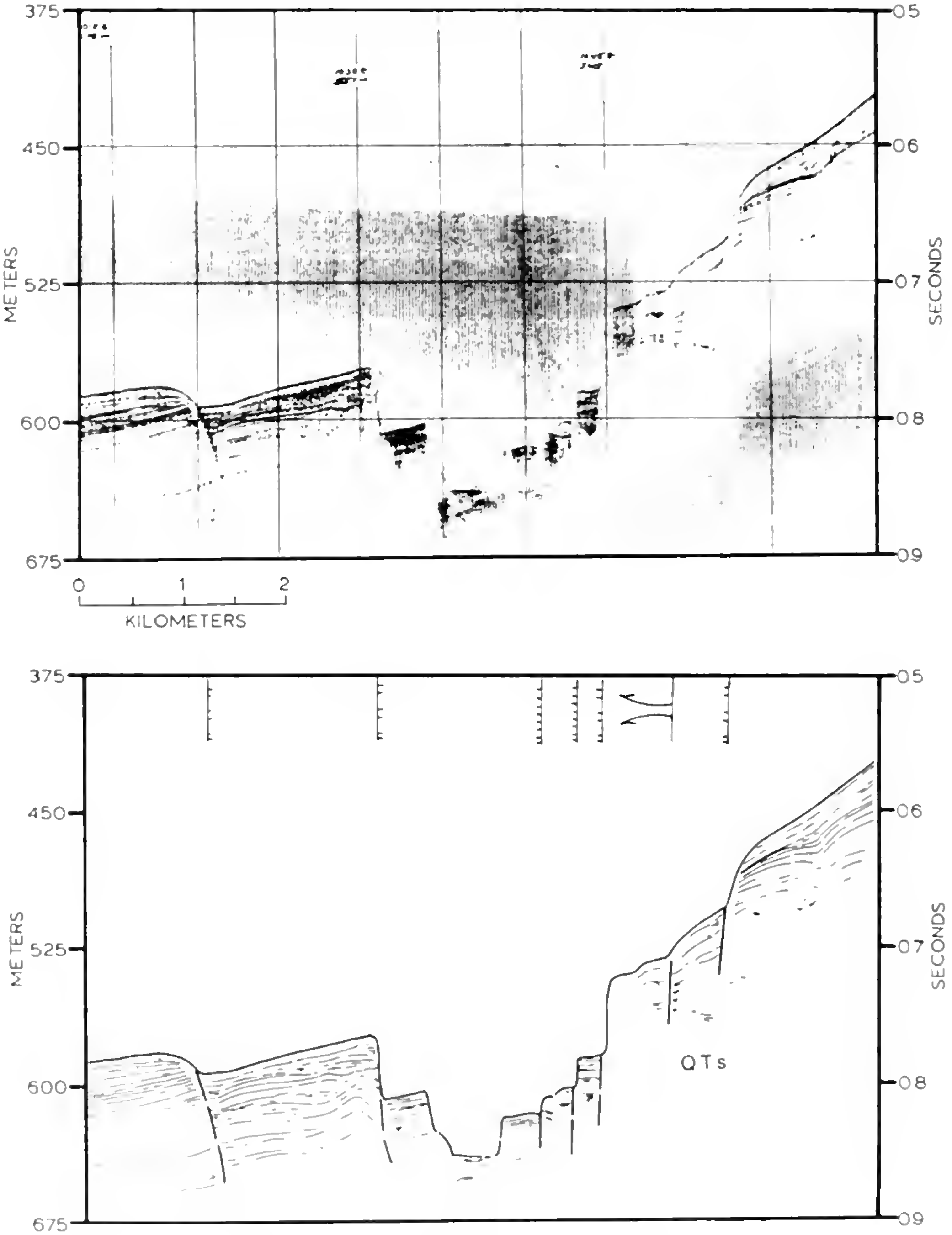
33. LANDSLIDE (slump)

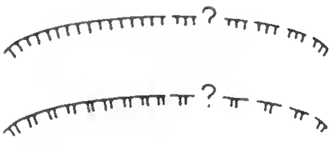




SLUMP: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate apparent direction of movement in deposits of late Tertiary and Quaternary (QTs) age. Movement of the slump mass along a generally arcuate failure surface has destroyed the bedding and produced a nonreflecting zone. Example from Uniboom profile across the continental slope off outer Santa Cruz basin, central California continental margin.

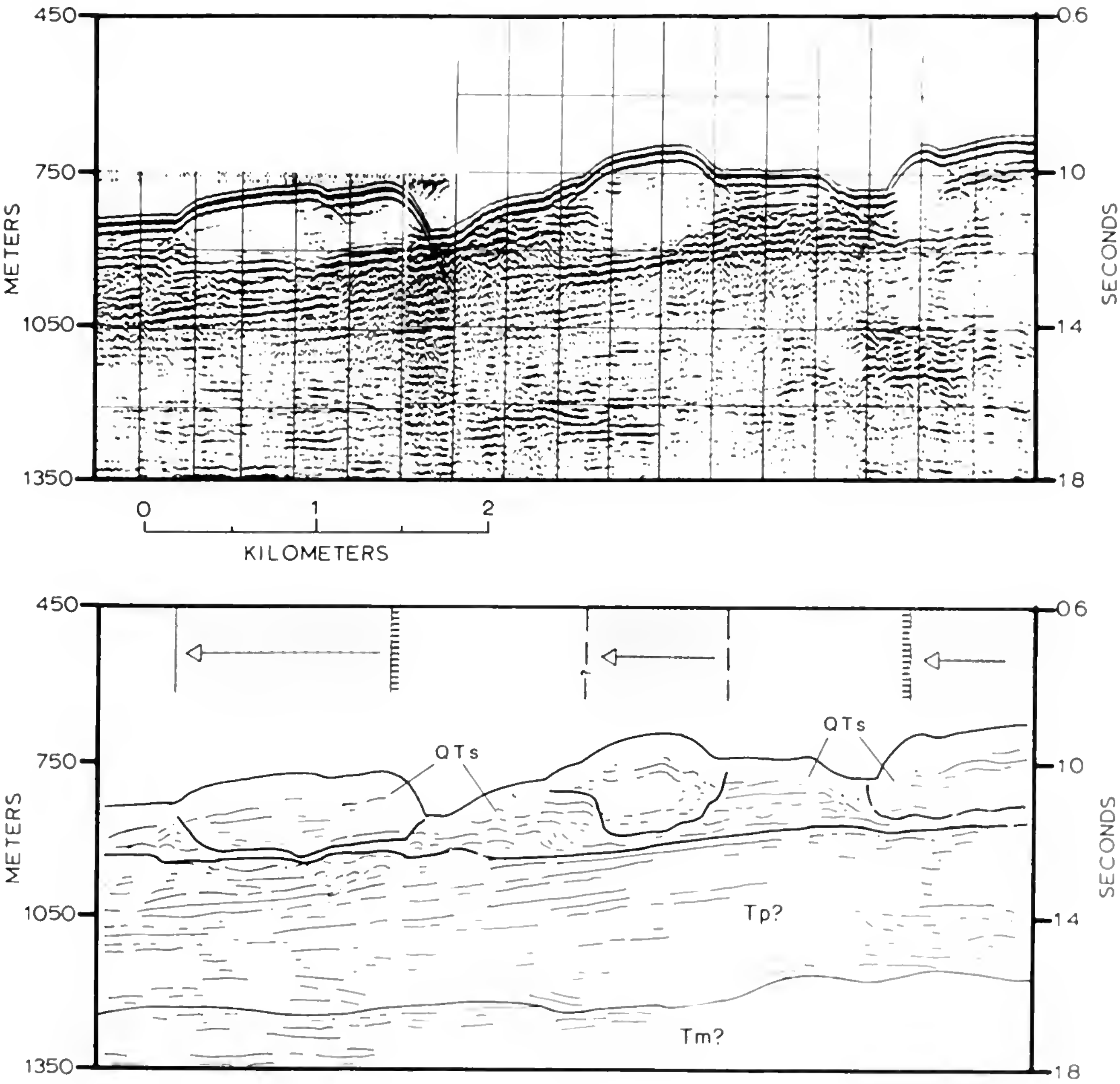
34. LANDSLIDE (scarps)

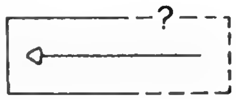




SCARPS: boundaries solid where well defined, dashed where inferred, queried where uncertain. Hachures indicate slump scarp. Zone of movement involves sediment of late Tertiary and Quaternary (QTs) age. Note double hachures indicate erosional scarps. Example from Uniboom profile across La Jolla Canyon, inner southern California continental borderland.

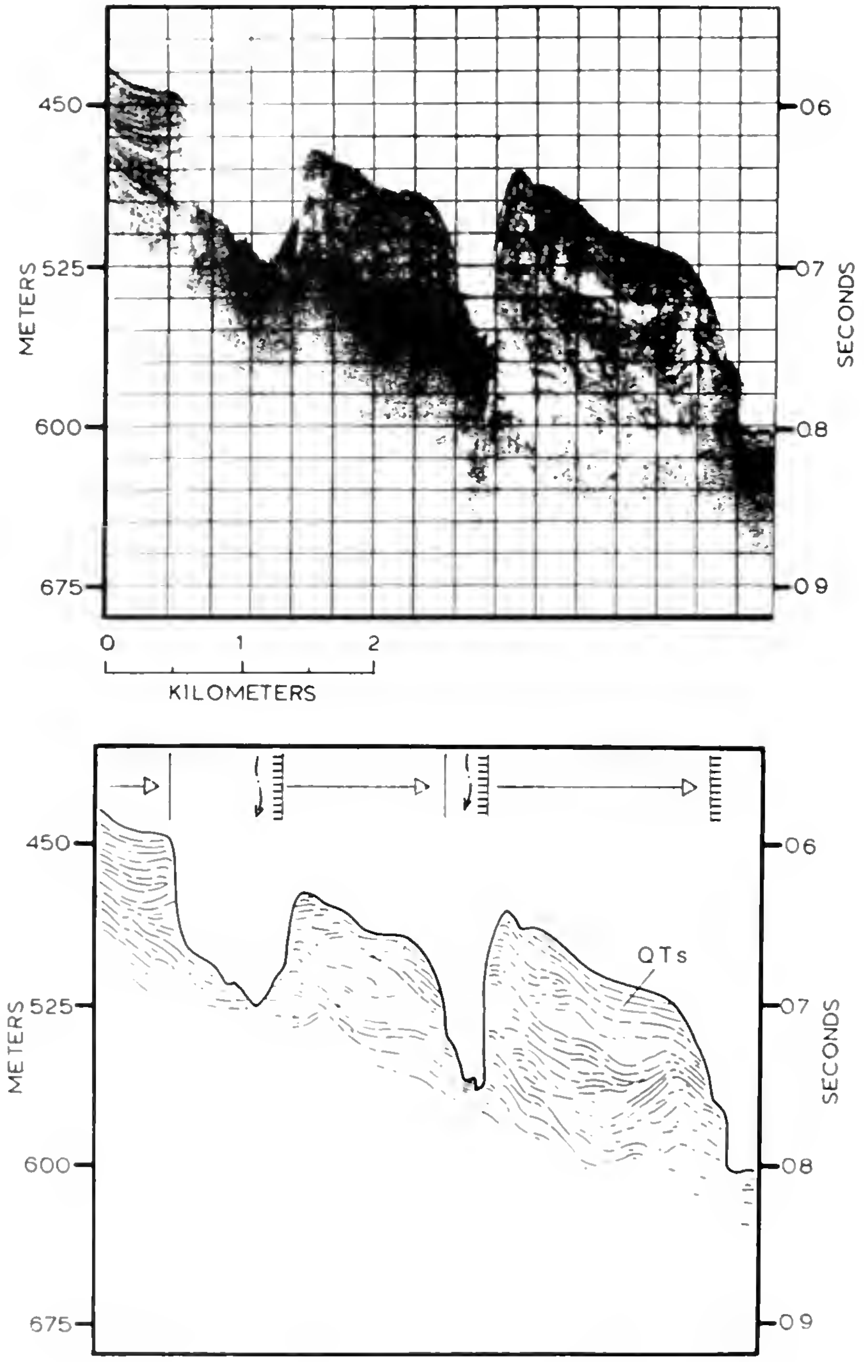
35. LANDSLIDE (block glide)

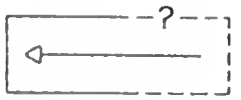




BLOCK GLIDE: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate apparent direction of movement. Zone of movement extends to a subbottom depth of 150-190 m, involving sediments of late Tertiary and Quaternary (QTs) age. Note relative acoustic transparency of blocks, possibly the result of intense deformation of strata within the blocks. Erosional channels may develop locally along pull-apart fractures between blocks, shown by double hachures (erosional scarp). Example from sparker profile across base of slope off Newport Beach, inner southern California continental borderland (after Greene and others, 1983, their Figure 2-10).

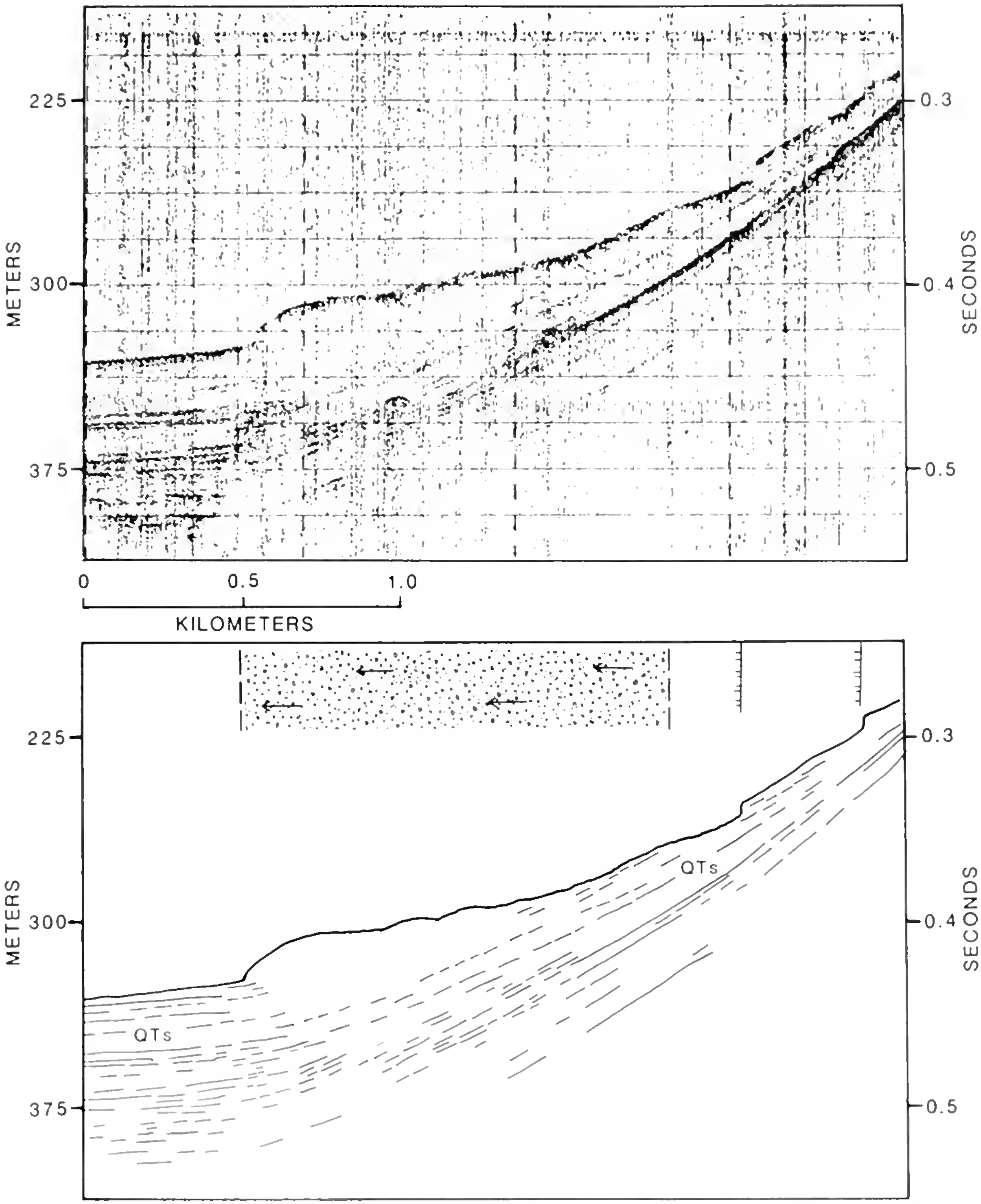
36. LANDSLIDE (block glide)

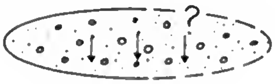




BLOCK GLIDE: boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate apparent direction of movement. Zone of movement extends to a subbottom depth of approximately 90-100 m, involving sediments of late Tertiary and Quaternary (QTs) age. Note that internal deformation of blocks is greatest toward the front edge (downslope), and sole (base) of the mass. Locally, erosional channels may develop along pull-apart fractures between the blocks. These are shown with double hachures (erosional scarp). Example from mini-sparker profile across slope south of Newport Beach, inner southern California continental borderland.

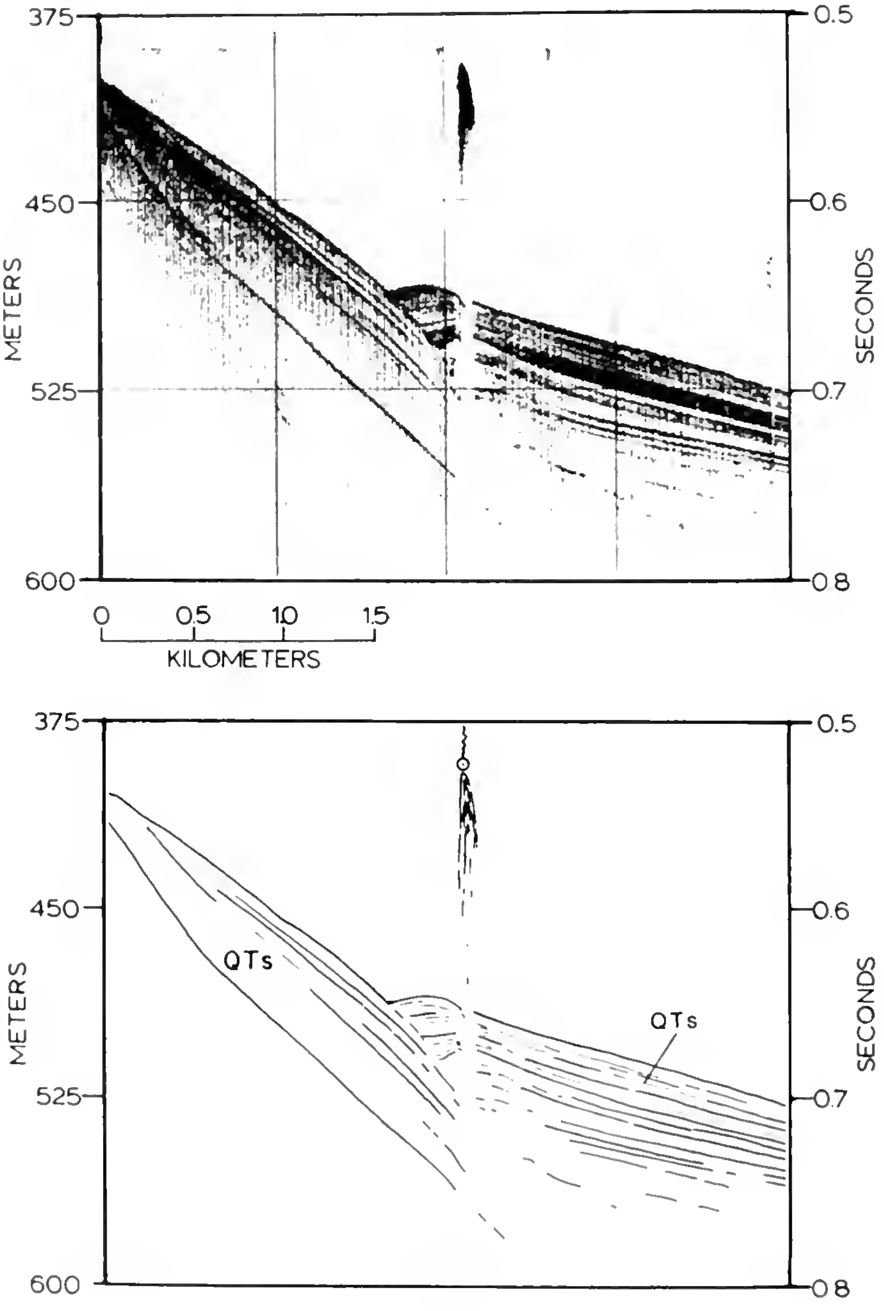
37. LANDSLIDE (sediment flow)





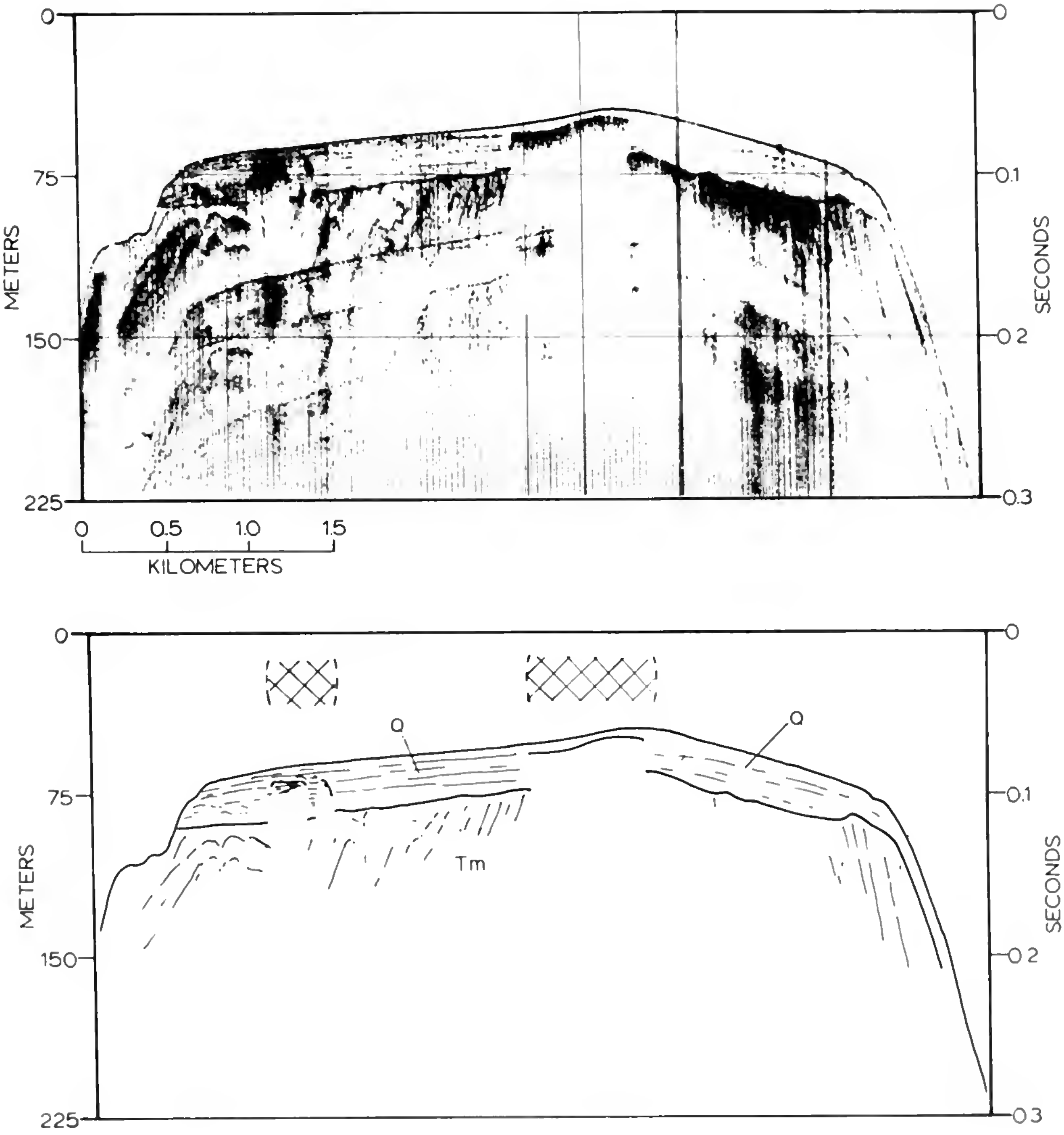
SEDIMENT FLOW: Boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement in sediments of late Tertiary and Quaternary (QTs) age. Note multiple headscarps above thick, detached sediment mass, acoustic transparency of this mass, and absence of an identifiable slip surface. Example from Uniboom profile across north slope of Santa Barbara Channel, (approximately 35 km) west of Santa Barbara (from Edwards, 1982).

38. GAS (seep)



OIL AND/OR GAS SEEP: symbol indicates presence of subbottom and water column acoustic anomalies associated with gas seeps. Gas seep occurs in sediments of late Tertiary and Quaternary (QTs) age. Queried where uncertain. Example from Uniboom profile across base of slope off Point La Jolla, inner southern California continental borderland (after Greene and others, 1983, their Figure 2-16).

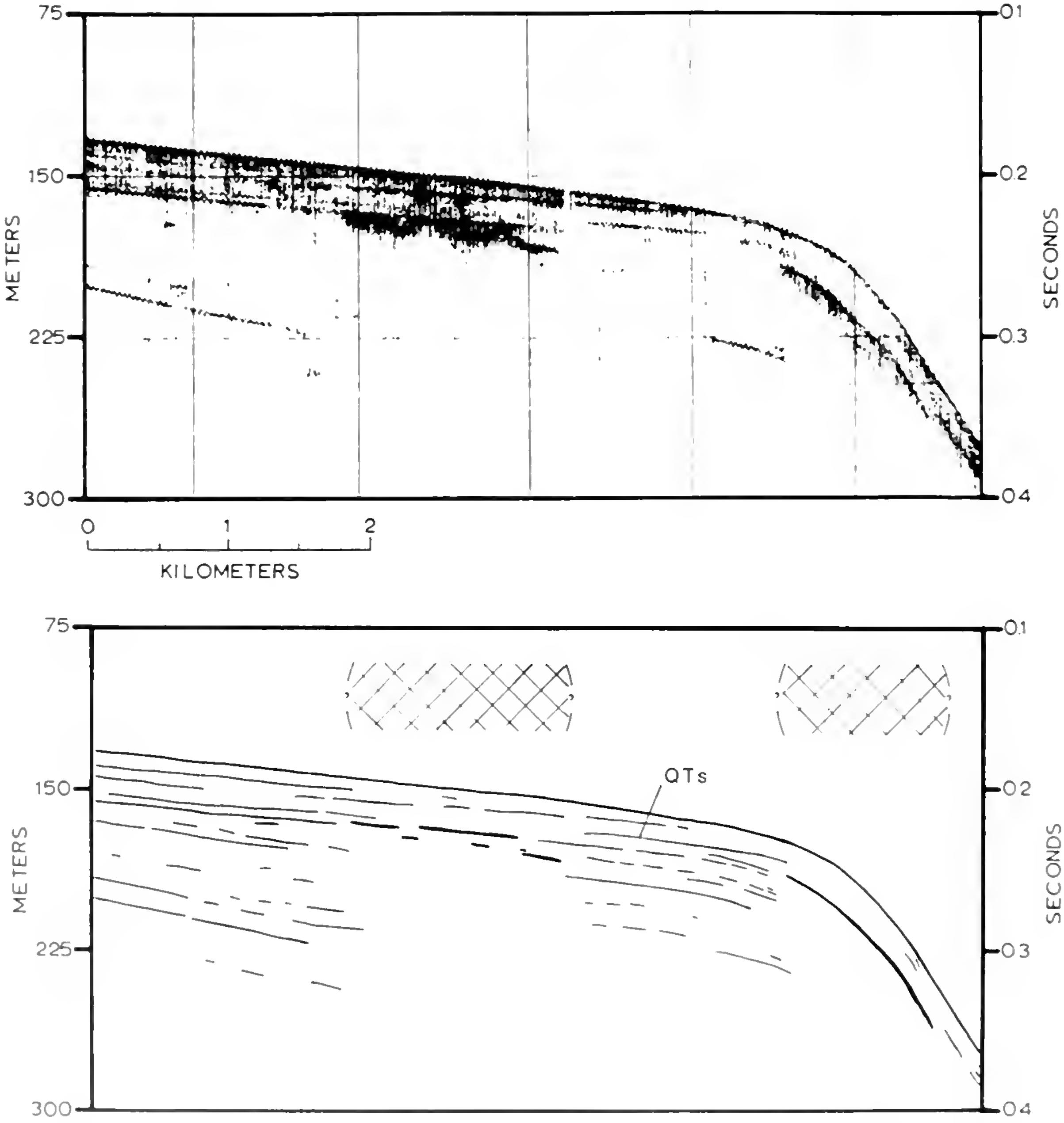
39. GAS (bright spot, subsurface)



▨?

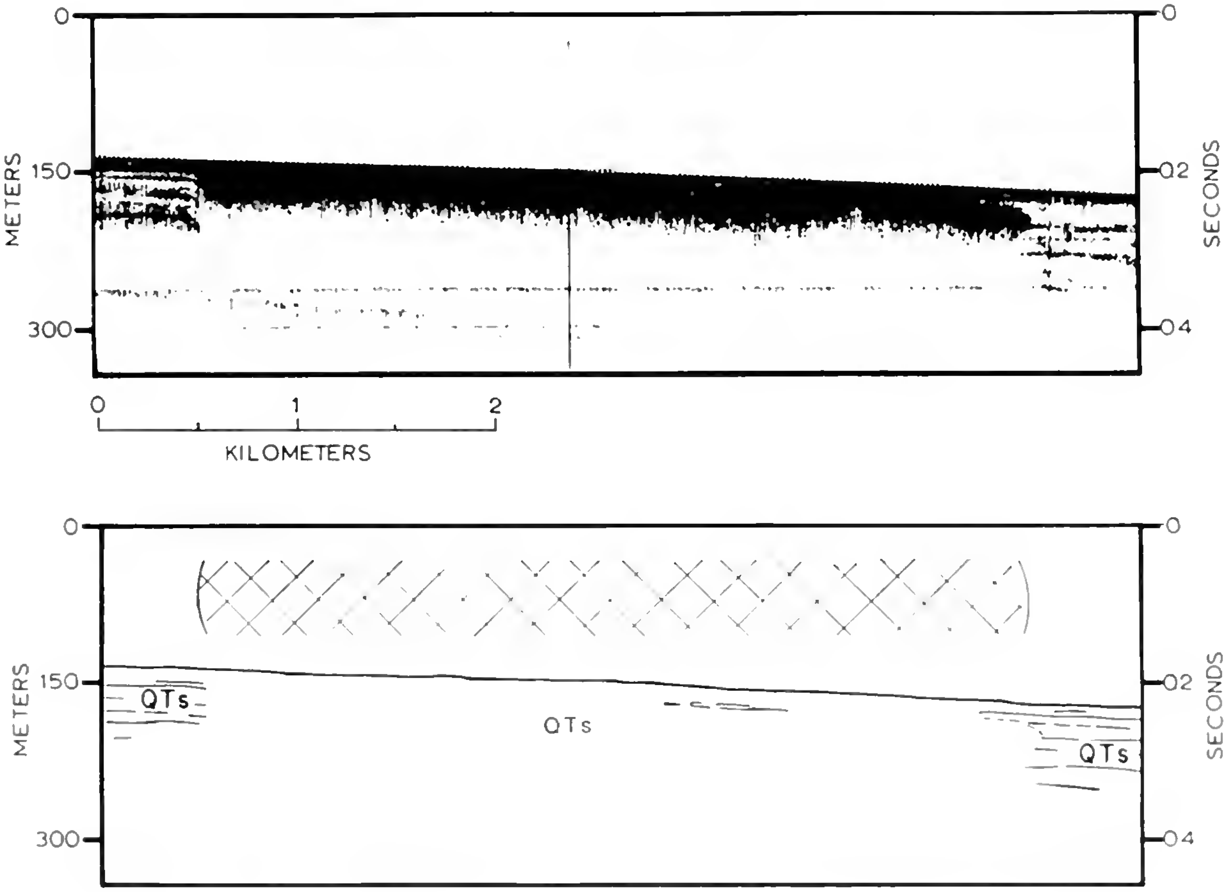
GAS: area of acoustic anomaly, possibly indicating the presence of gas-saturated sediments. Solid where well defined, dashed where inferred, queried where uncertain. Acoustic anomalies above occur in flat-lying Quaternary (Q) sediment overlying an eroded, flat-topped, Miocene (Tm) bedrock ridge. Example from Uniboom profile across San Pedro escarpment and shelf, middle southern California continental borderland.

40. GAS (bright spot, subsurface)



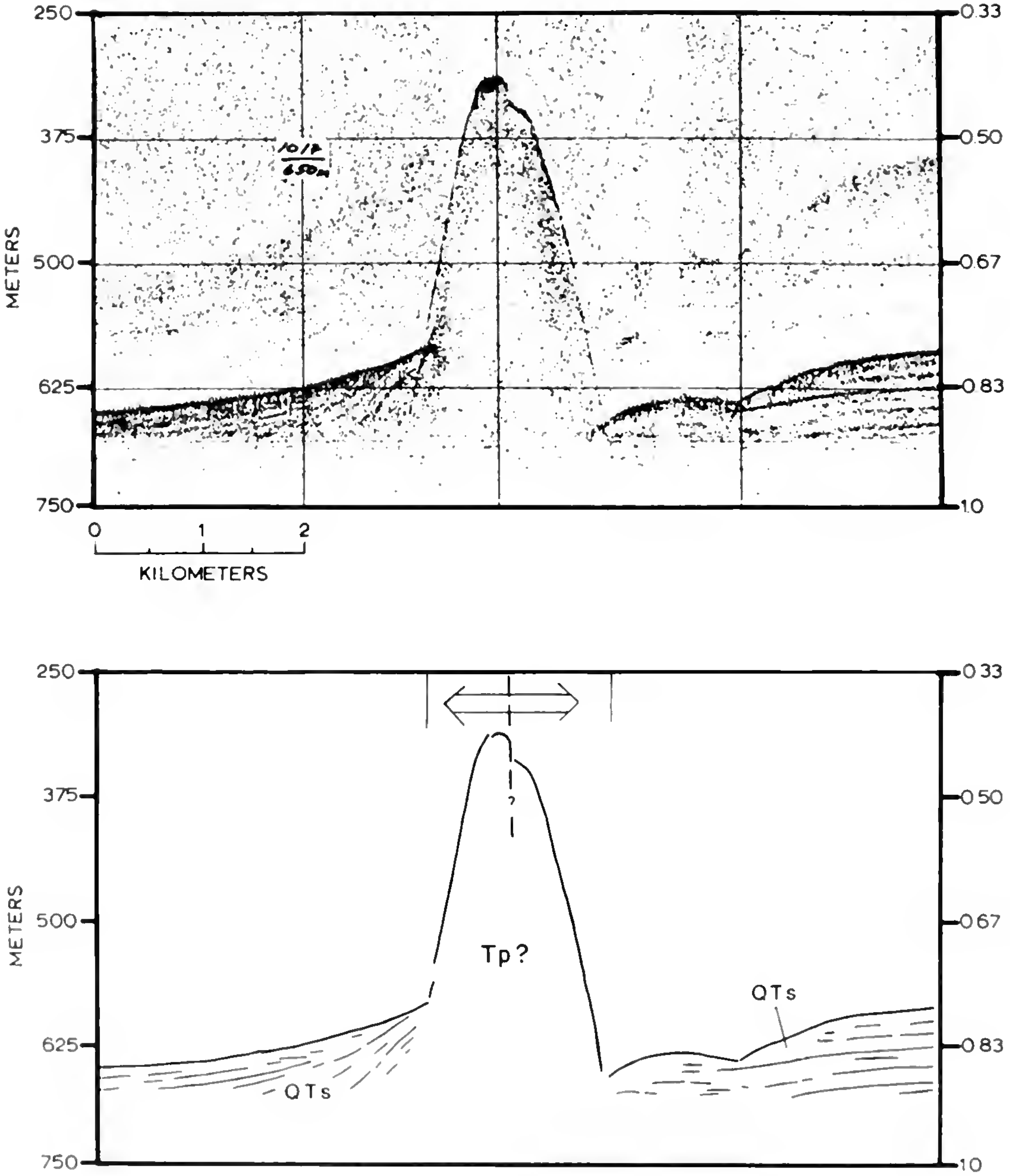
GAS: area of acoustic anomaly, possibly indicating the presence of gas-saturated sediment. Solid where well defined, dashed where inferred, queried where uncertain. Example from Uniboom profile across shelf and upper slope west of Crescent City, northern California continental margin.

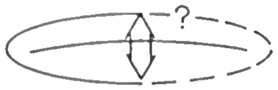
41. GAS (bright spot, subsurface)



▨ GAS: area of acoustic anomaly, possibly indicating the presence of gas saturated sediment. Solid where well defined, dashed where inferred, queried where uncertain. Example from 3.5 kHz profile across shelf off Crescent City, northern California continental margin

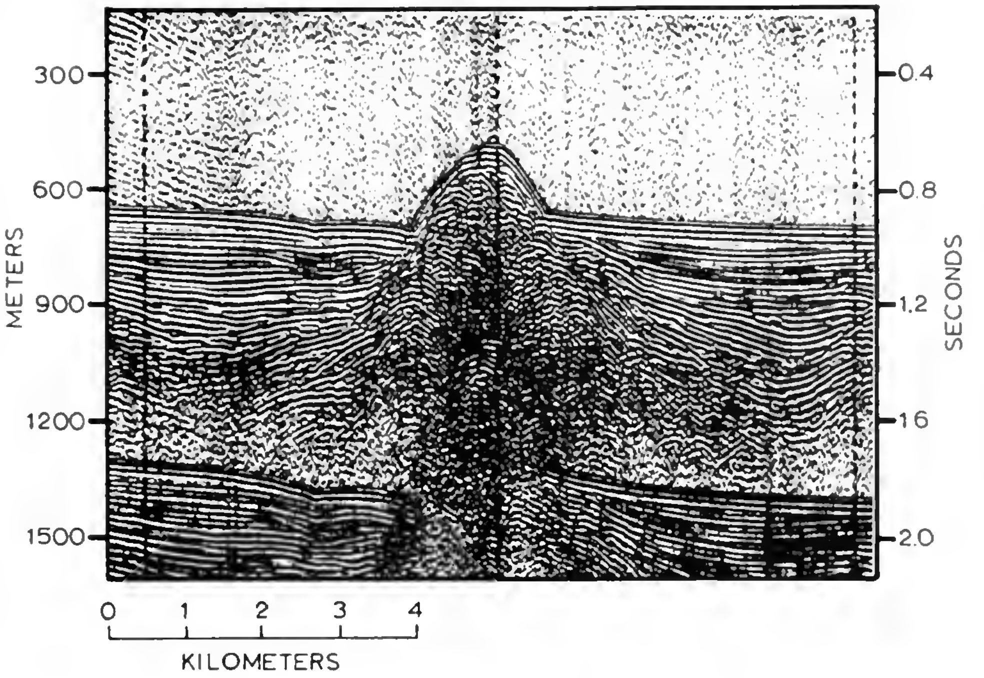
42. DIAPIRIC RIDGE

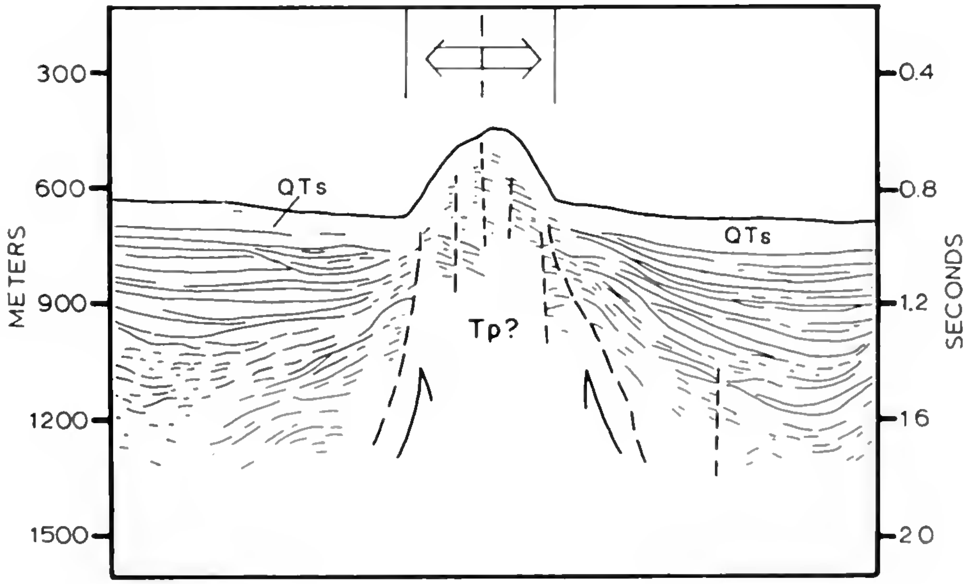


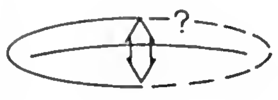


DIAPIRIC RIDGE: Solid where well defined, dashed where inferred, queried where uncertain. Shale-cored diapir pierces upper Tertiary and Quaternary (QTs) strata and extends above the seafloor. Example from 3.5 kHz profile across marginal plateau west-northwest of Eureka, northern California continental margin.

43. DIAPIRIC RIDGE

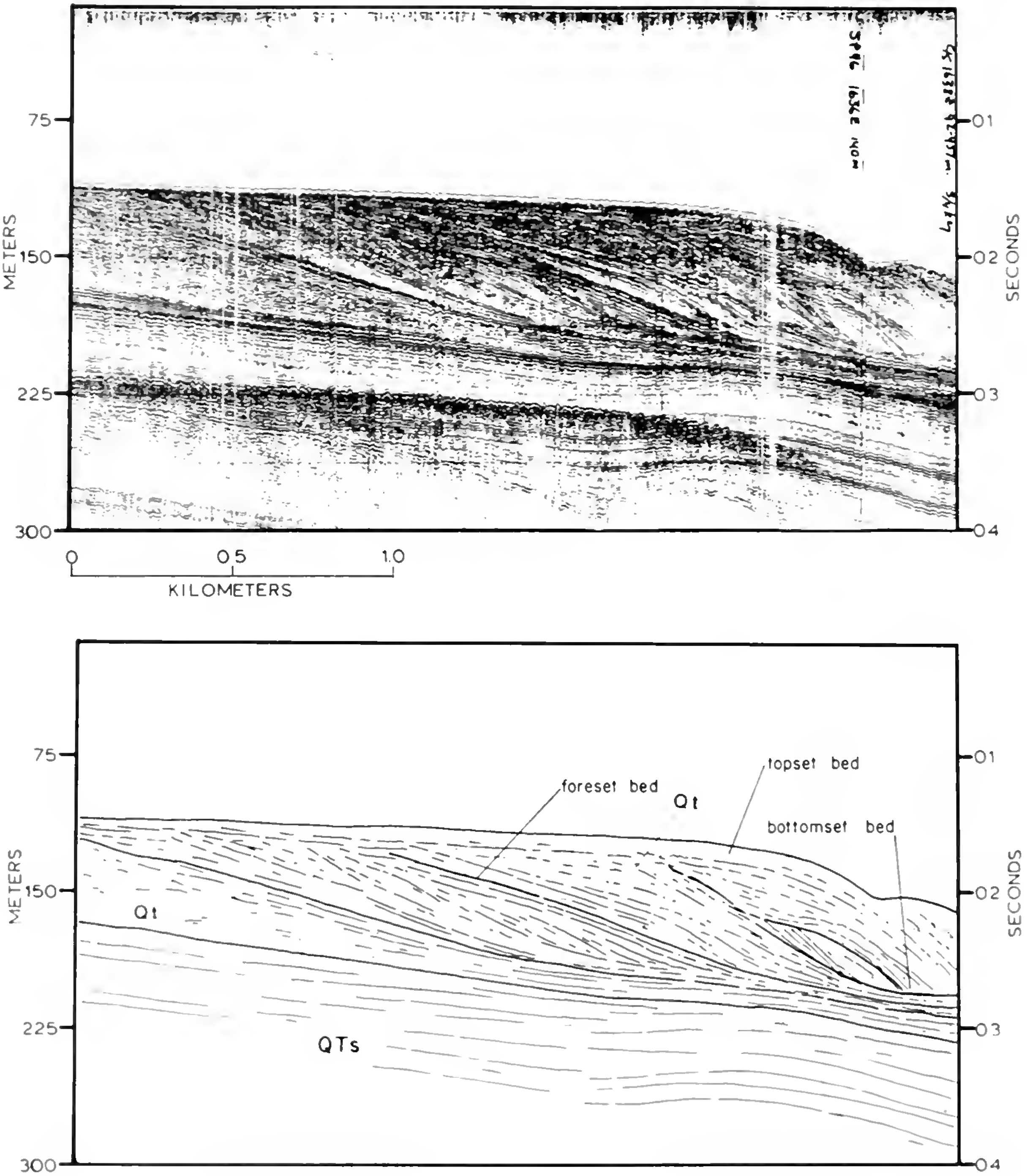






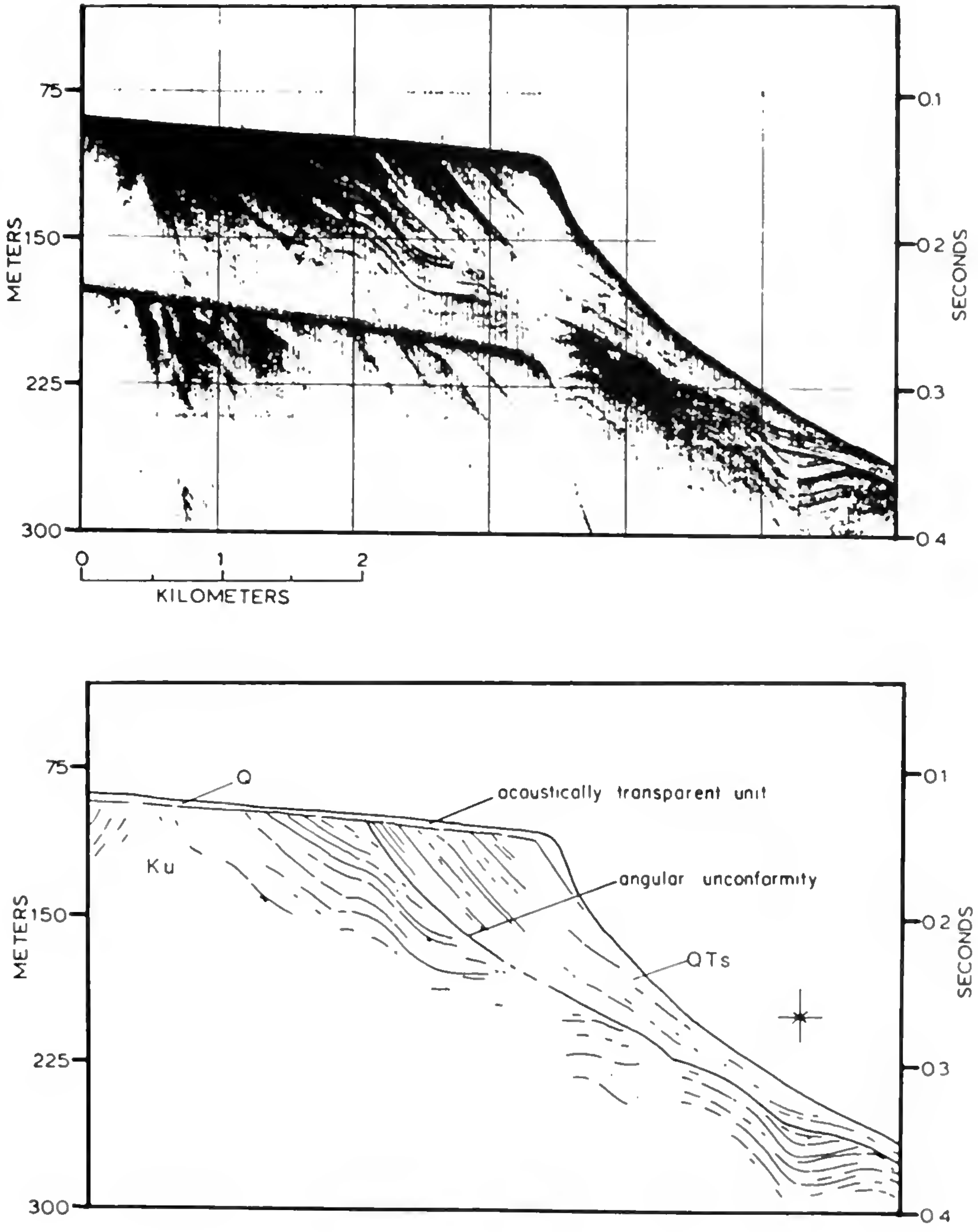
DIAPIRIC RIDGE: Solid where well defined, dashed where inferred, queried where uncertain. Shale-cored diapir pierces upper Tertiary and Quaternary (QTs) and older strata and extends above the seafloor. Example from sparker profile across marginal plateau west-northwest of Eureka, northern California continental margin.

44. TERRACE (constructional)



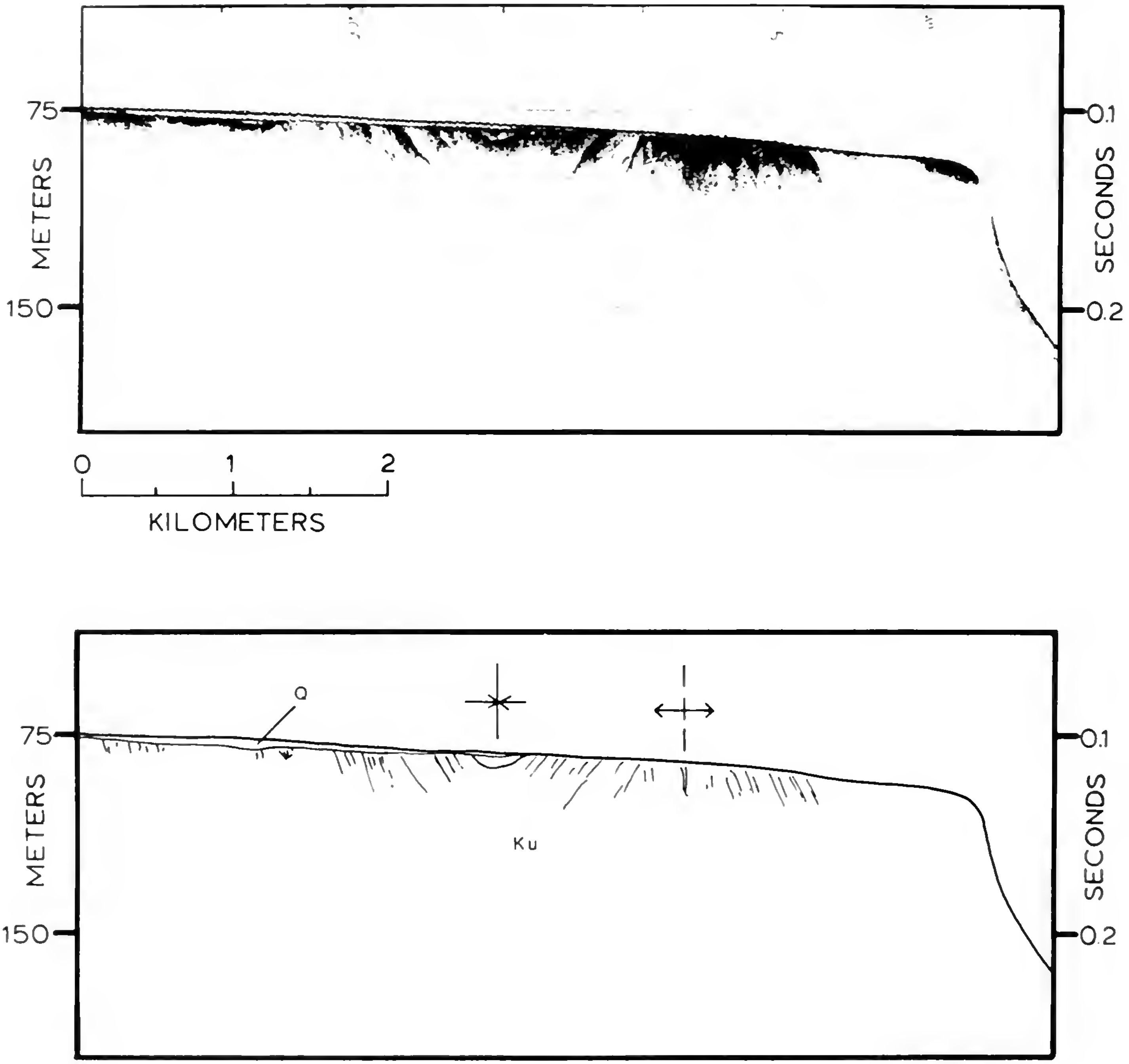
TERRACE (constructional): Example from Uniboom profile across east flank of Cortes Bank, middle southern California continental borderland, showing Pleistocene (QT) progradational terrace sequences forming a constructional or depositional marine terrace (after Greene and others, 1975, their Figure 5).

45. TERRACE (erosional)



TERRACE (erosional): Example from Uniboom profile across shelf off Point La Jolla, inner southern California continental borderland. Undifferentiated, folded Cretaceous strata (Ku) and overlying upper Tertiary and Quaternary (QTs) progradational sequence have been bevelled by wave action. Acoustically transparant unit overlying wave-cut platform is probably Holocene (Q) in age.

46. TERRACE (erosional)



TERRACE (erosional): Wave-planed, platform composed of undifferentiated, folded Cretaceous (Ku) strata, forming a wave-cut terrace, partially overlain by acoustically transparant layer of Holocene (Q) age. Example from Uniboom profile across shelf off Point La Jolla, inner southern California continental borderland (after Greene and others, 1983, their Figure 2-18).

COMPOSITE STRATIGRAPHIC SECTIONS

The stratigraphic columns are composite, generalized sections developed by compiling and modifying onshore and offshore data from Greene and Clark (1979), Hoskins and Griffiths (1971), Howell and others (1978), McCulloch and others (1982, 1985), Vedder and others (1974, 1976, 1980), and Clarke (1987), as well as from unpublished sources.

Each of the columns shows the generalized geology for the area in which it is located. Each section has a number that is keyed to a location map (Figure 3). The reader should not attempt to correlate the stratigraphic units from the columns to the maps because the maps are constructed primarily from acoustic stratigraphic units and the columns represent rock stratigraphic units exclusively. Rock stratigraphic names are tentatively correlated to acoustic units on the geologic legends only where dredge and core data support their use. The thickness of geologic units shown on the columns is approximate and was derived, where available, from seismic velocities, well logs, and onshore geologic maps.

The reader should note that the diagramatic stratigraphic columns from Hoskins and Griffiths (1971) included in the text are not individual well sections, but are composite representative sections for entire offshore basins, and that the indicated thicknesses are the interval maximum for the entire basin.

Figure 3
Areas

1.	Eel River Basin	I
2.	Point Arena Basin	B
3.	Bodega Basin	B
4.	Outer Santa Cruz Basin	B
5.	N. Monterey Bay Region	A
6.	S. Monterey Bay Region	A
7.	Offshore Santa Maria Basin	B
8.	N. Santa Barbara Channel (OCS-CAL 78-164 No. 1)	E
9.	Santa Ynez Unit and vicinity	C,G
10.	Dos Cuadros oilfield and vicinity	G,H
11.	San Miguel Island	F
12.	Santa Rosa Island	F
13.	Santa Cruz Island	F
14.	N.E. Coast Santa Cruz Island	C,G
15.	Offshore Santa Monica Basin	C,G
16.	N. Santa Rosa - Cortes Ridge	C,G
17.	Northern Patton Ridge	C,G
18.	Santa Cruz - Catalina Ridge	C,G
19.	San Pedro Basin	C,G
20.	Newport Beach - Dana Pt. Shelf	C,G
21.	Santa Catalina Island	F
22.	San Nicolas Island	F
23.	San Clemente Ridge	C,G
24.	S. Gulf of Santa Catalina	C,G
25.	San Clemente Island	G
26.	San Nicolas Basin	C,G
27.	Dall Bank	C,G
28.	Thirtymile Bank	C,G
29.	San Diego Shelf	C,G
30.	Fortymile Bank	C,G
31.	Central Blake Knolls	C,G
32.	Cortes Bank (OCS-CAL 75-70 No. 1)	C,G
33.	Northeast Bank	C,G

Figure 3
References

A.— Greene, H.G., and Clark, J.C., 1979, Neogene paleogeography of the Monterey Bay area, California, *in* Armentrout, J., Cole, M.R., and Terbest, H., editors, Cenozoic paleogeography of the western United States, Pacific Section Society of Economic Paleontologists and Mineralogists, Pacific Coast Paleogeography Symposium 3, p. 277-296.

B.— Hoskins, E.G., and Griffiths, J.R., 1971, Hydrocarbon potential of northern and central California offshore; Future petroleum provinces of the United States—their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 212-228.

C.— Howell, D.G., McCulloch, D.S., and Vedder, J.G., 1978, General geology, petroleum appraisal, and nature of environmental hazards, eastern Pacific shelf latitude 28 degrees to 38 degrees north: U.S. Geological Survey Circular 786, 29 p.

D.— McCulloch, D.S., Clarke, S.H., Jr., Dalton, G.L., Field, M.E., Scott, E.W., and Utter, P.A., 1982, Geology, environmental hazards and petroleum resources for 1982 OCS lease sale 73, offshore central and northern California: U.S. Geological Survey Open-File Report 82-1000, 77 p.

E.— McCulloch, D.S., Utter, P.A., and Menack, J., 1985, Maps showing location of selected pre-Quaternary rock samples from 34°30" N latitude to 42° N latitude, California continental margin: U.S. Geological Survey Miscellaneous Field Investigation Map, MF 1719 (in press).

F.— Vedder, J.G., Beyer, L.A., Junger, A., Moore, C.W., Roberts, A.E., Taylor, J.C., and Wagner, H.C., 1974, Preliminary report on the geology of the continental borderland of southern California: U.S. Geological Survey Miscellaneous Field Studies Map FM-624, 34 p., 9 sheets, scale 1:500,000.

G.— Vedder, J.G., Greene, H.G., Scott, E.W., and Taylor, J.C., 1976, A summary report of the regional geology, petroleum potential, environmental geology and technology for exploration and development in the area of proposed lease sale 48, California continental borderland: U.S. Geological Survey Open-File Report 76-787.

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I.—Clarke, S.H., 1987, Geology of the California continental margin north of Cape Mendocino, *in* Scholl, D.W., Grantz, A., and Vedder, J.G., editors, Geology and resource potential of the continental margin of western North America and adjacent ocean basins—Beaufort Sea to Baja California: Circum Pacific Council for Energy and Mineral Resources, Earth Science Series (in press).

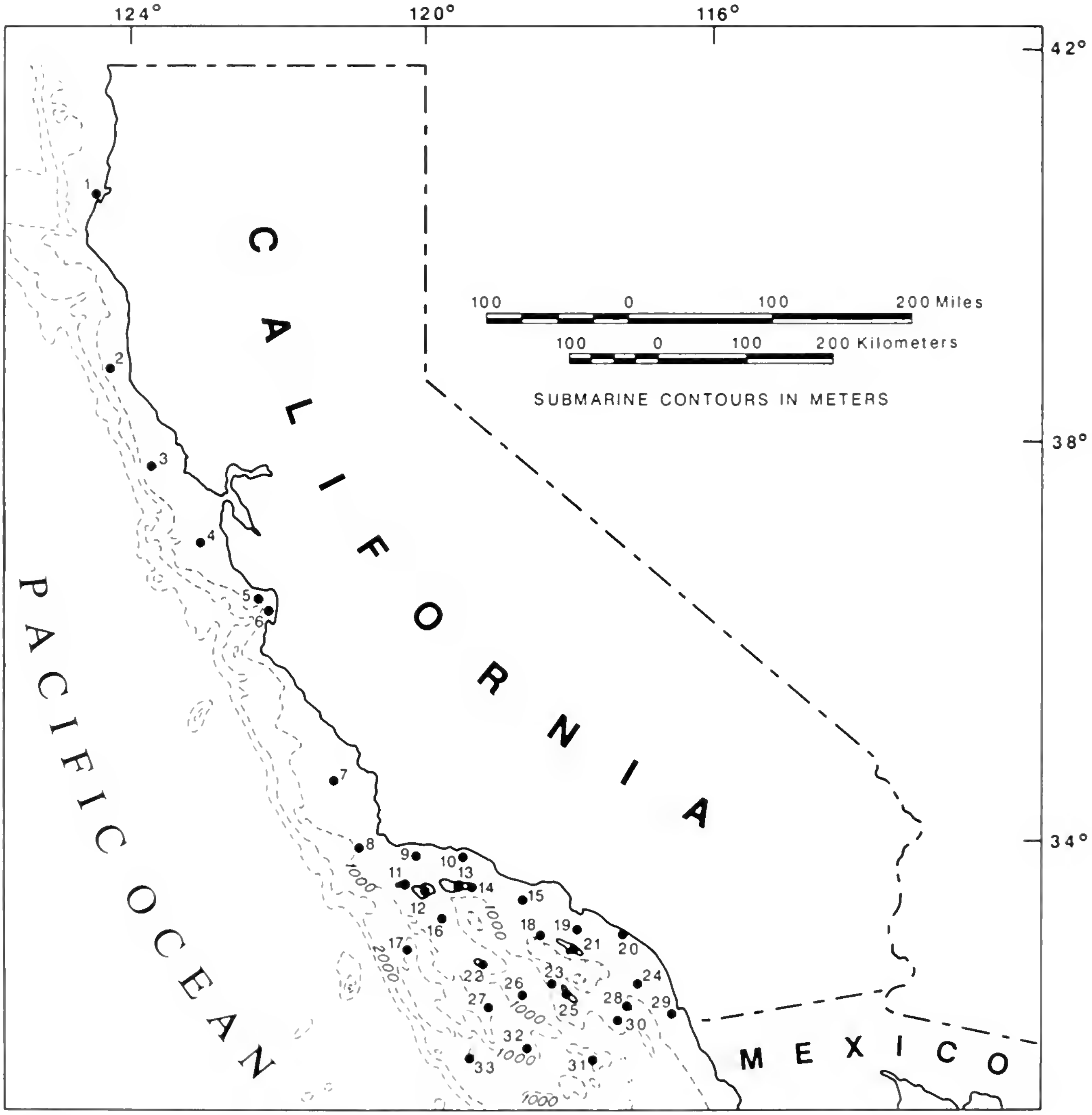
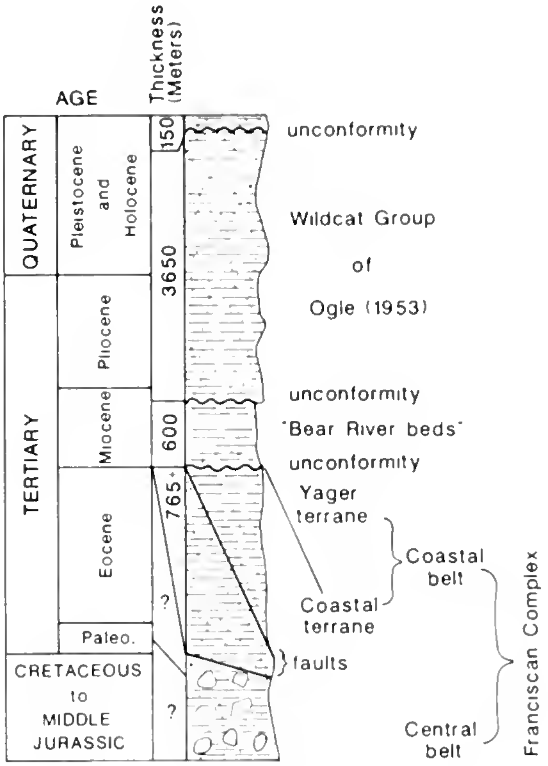
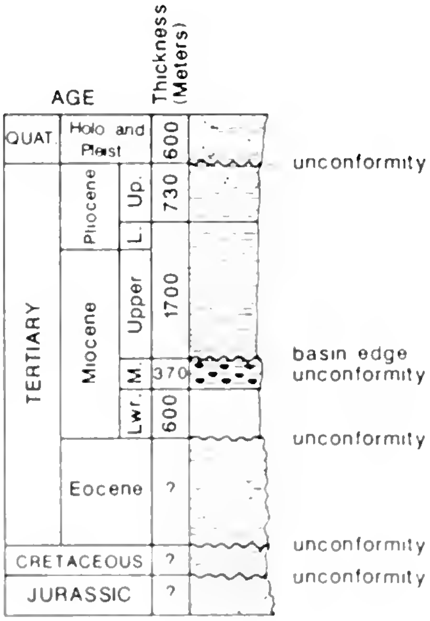


Figure 3. Location map for stratigraphic sections.

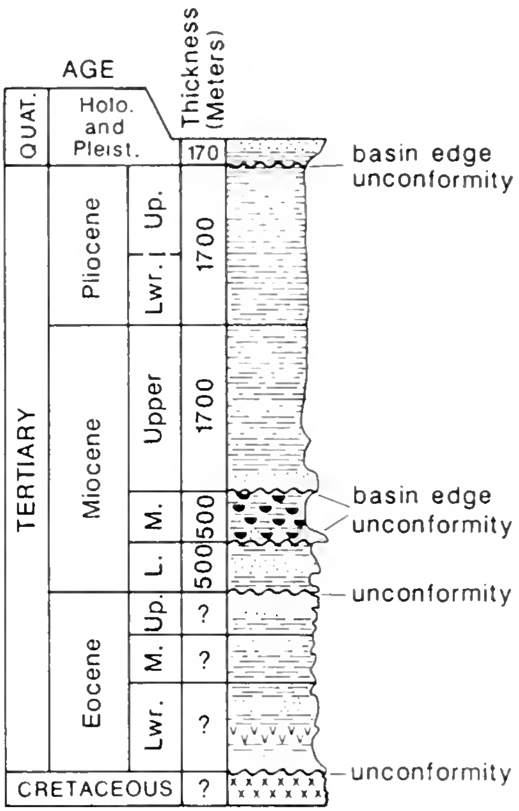


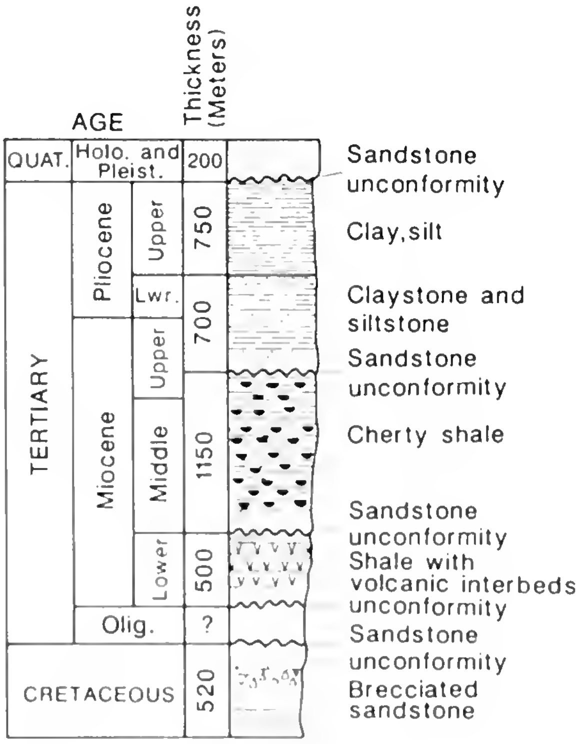
1. Eel River Basin



2. Point Arena Basin

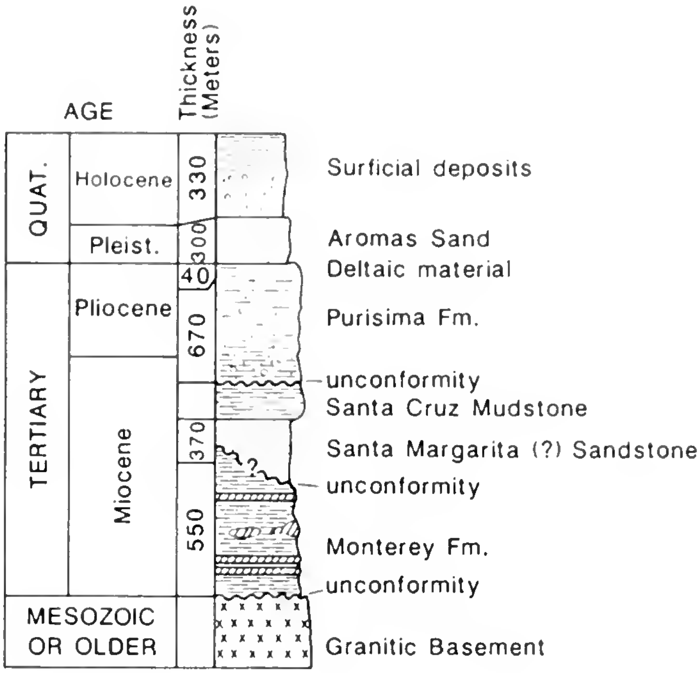
3. Bodega Basin

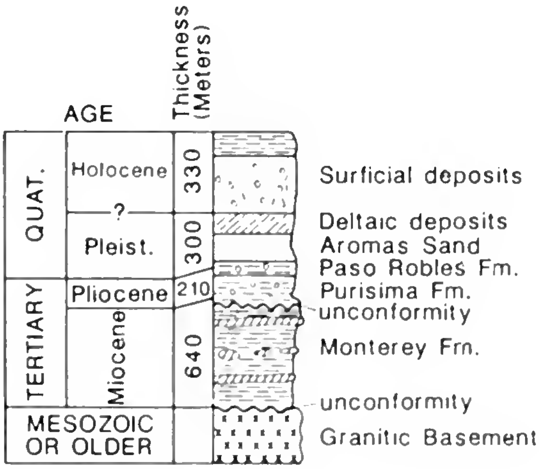




4. Outer Santa Cruz Basin

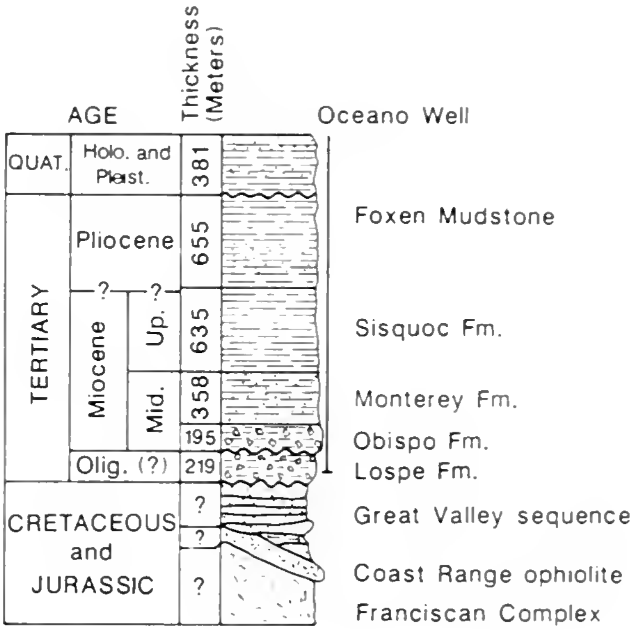
5. Northern Monterey Bay Region

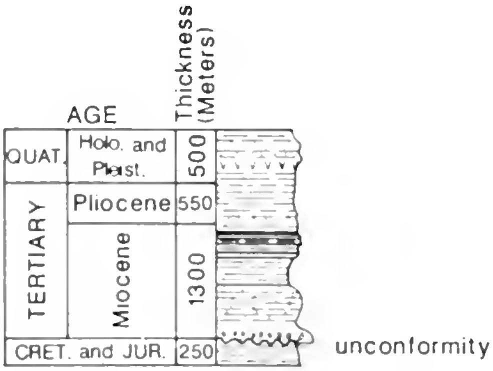




6. Southern Monterey Bay Region

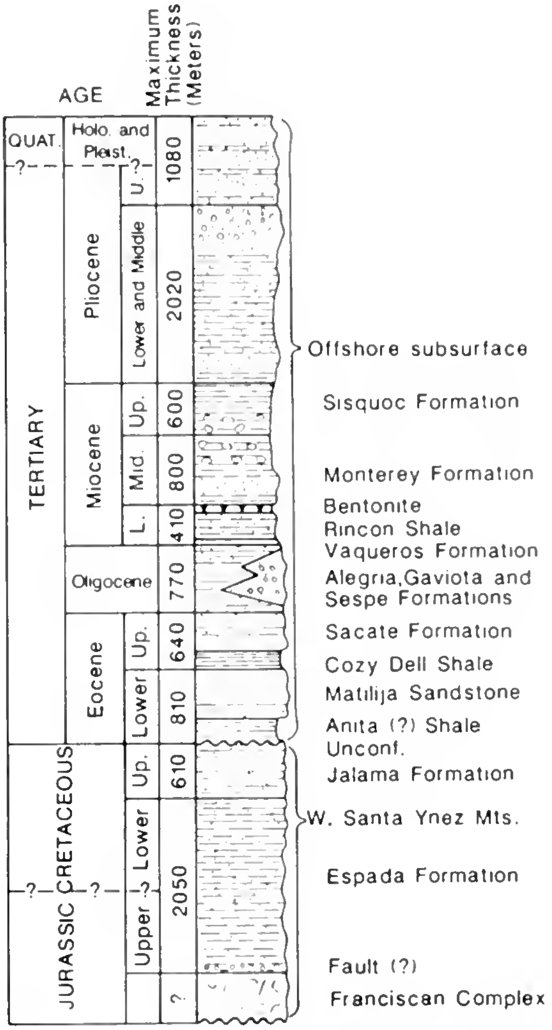
7. Offshore Santa Maria Basin



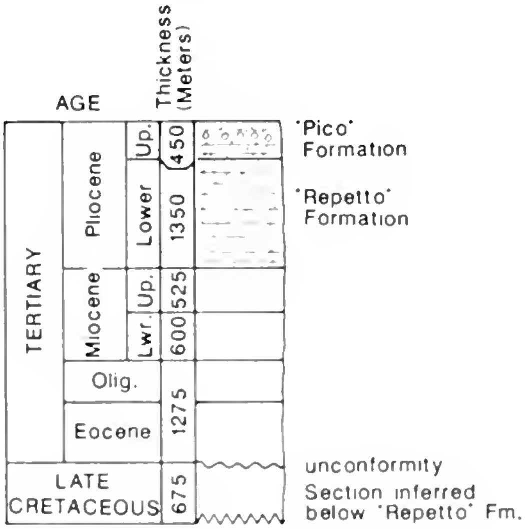


8. Northern Santa Barbara Channel (OSC-CAL 78-164 No. 1)

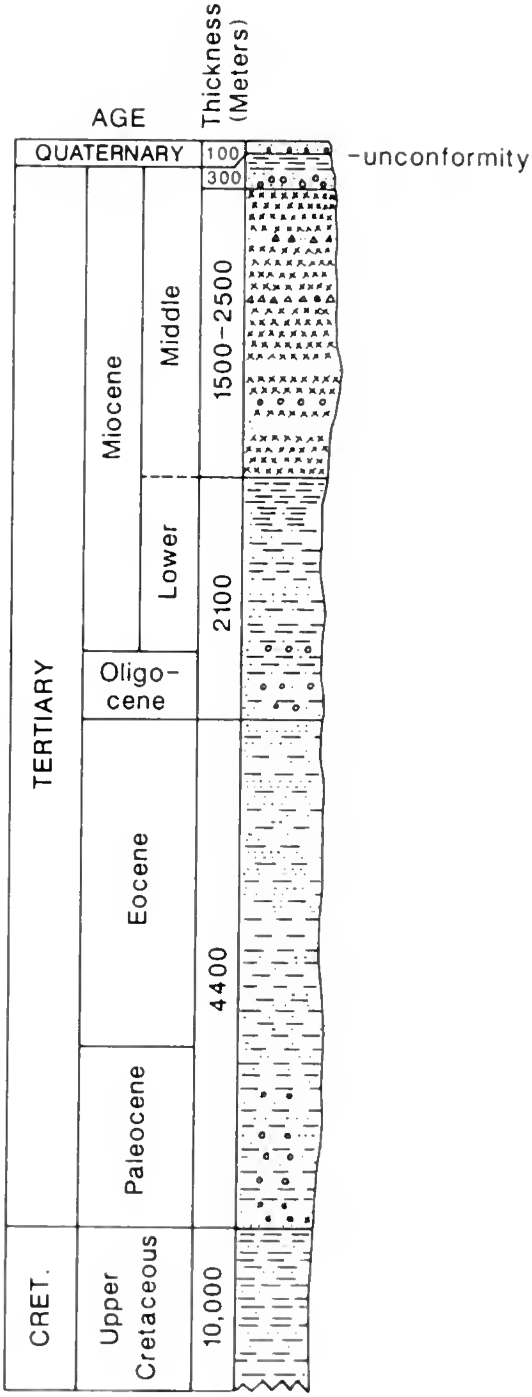
9. Santa Ynez Unit and vicinity



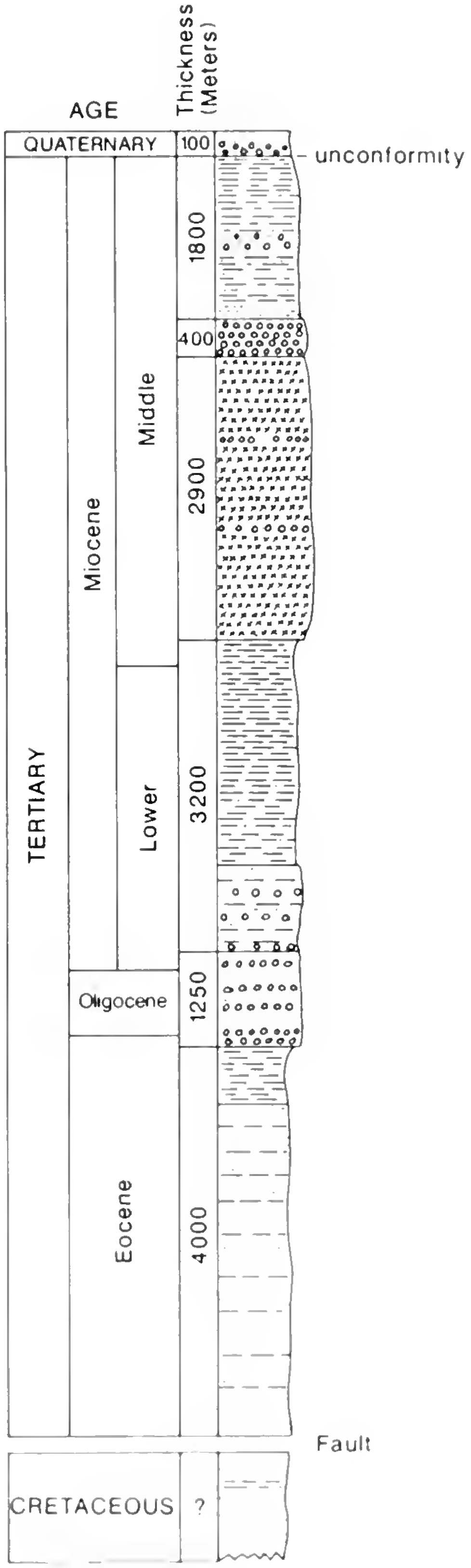
10. Dos Quadras Oilfield and vicinity



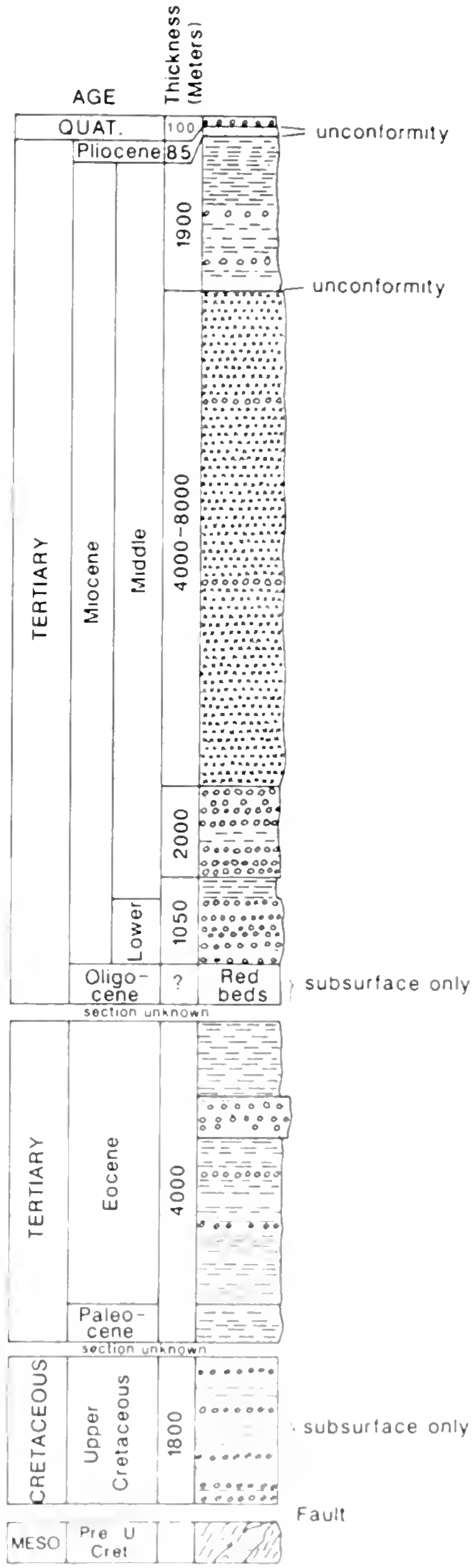
11. San Miguel Island



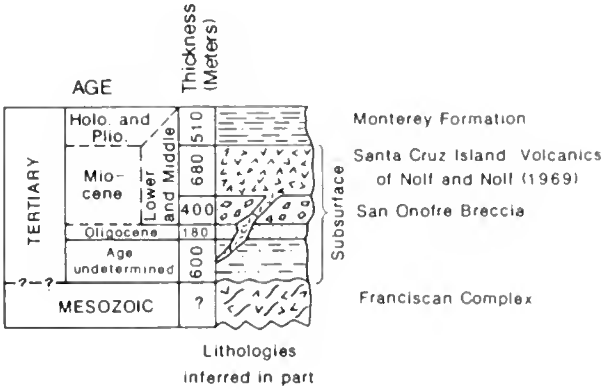
12. Santa Rosa Island



13. Santa Cruz Island



14. Northeast Coast Santa Cruz Island



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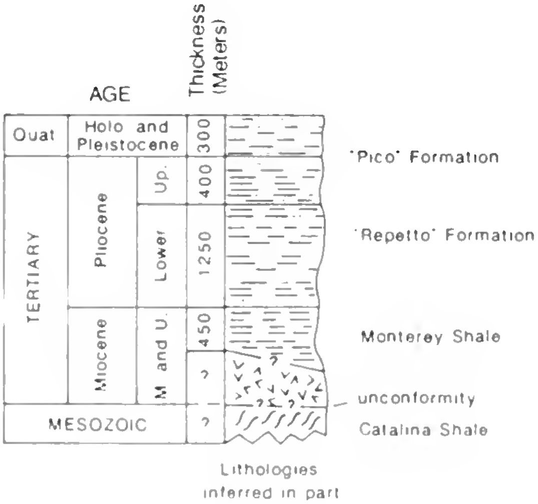
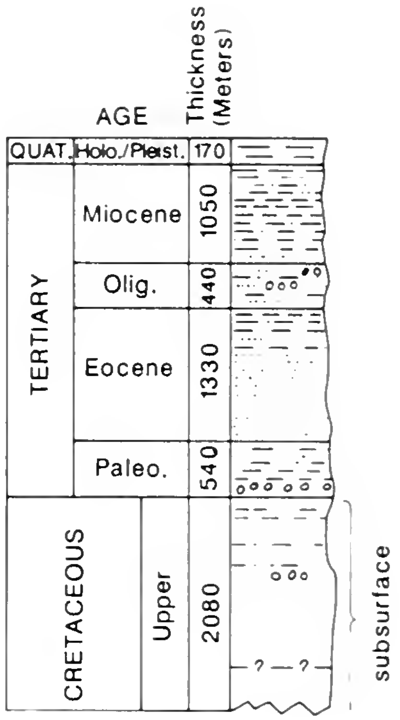
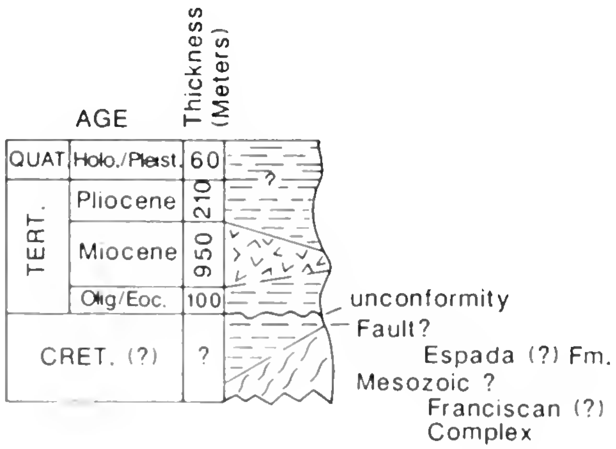
15. Offshore Santa Monica Basin



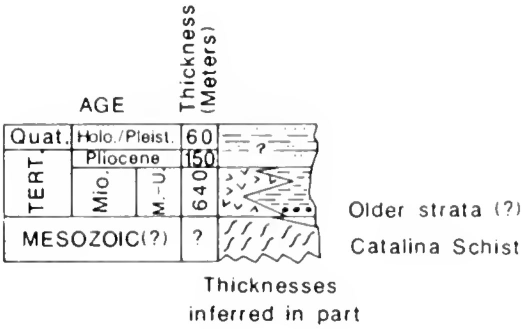
16. Northern Santa Rosa–Cortes Ridge

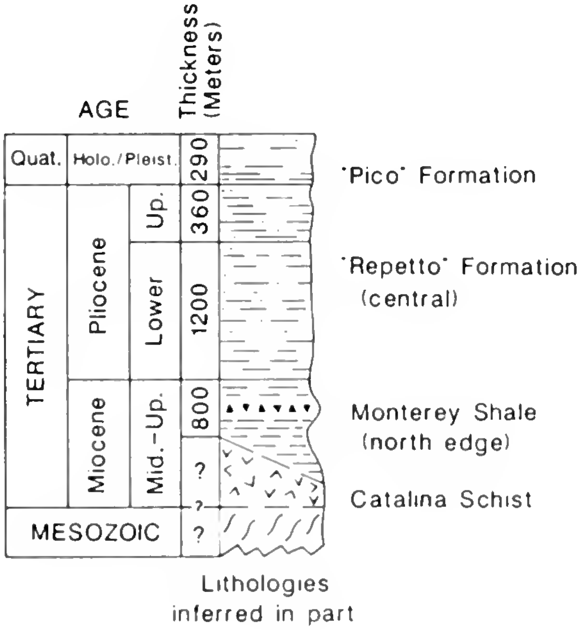




17. Northern Patton Ridge

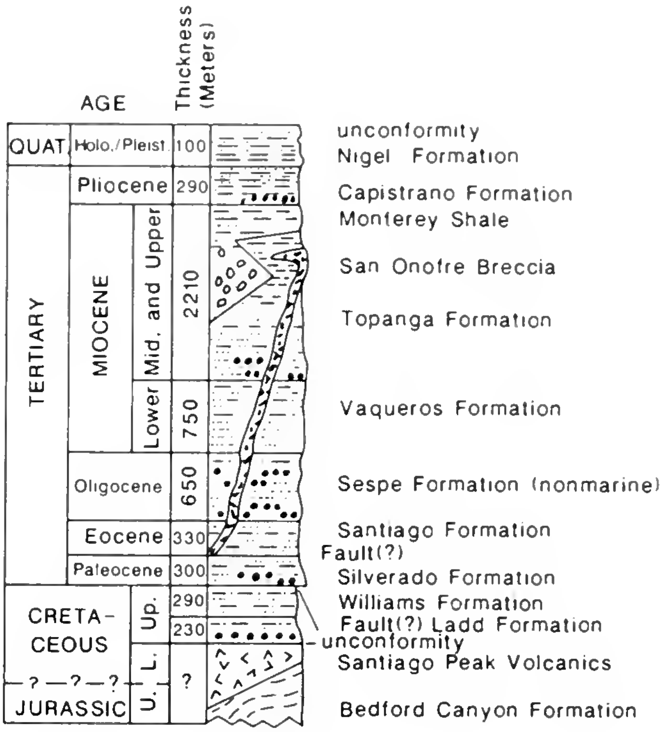
18. Santa Cruz–Catalina Ridge





19. San Pedro Basin

20. Newport Beach–Dana Point Shelf



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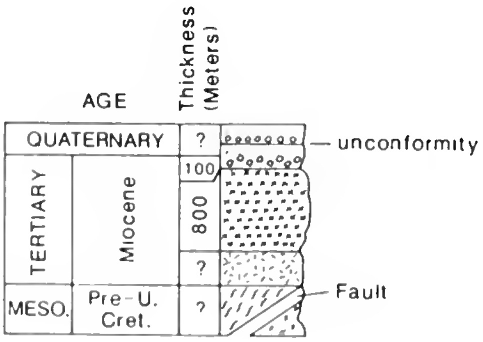
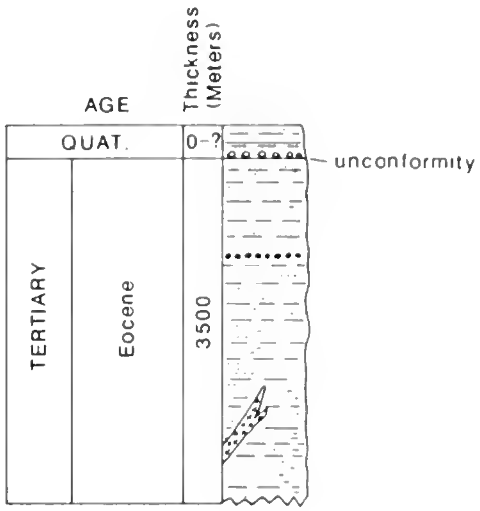
21. Santa Catalina Island



22. San Nicolas Island



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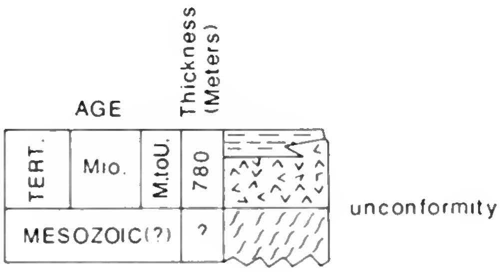
23. San Clemente Ridge



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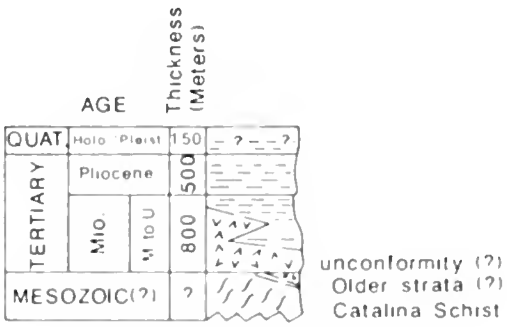
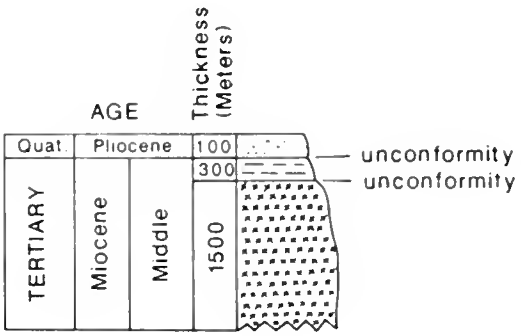
24. Southern Gulf of Santa Catalina



Lithologies and thicknesses inferred in part

25. San Clemente Island



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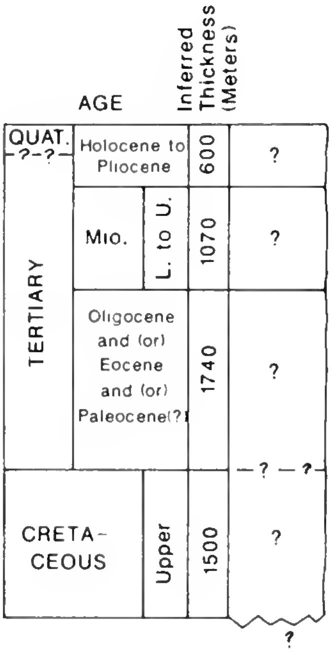
26. San Nicolas Basin



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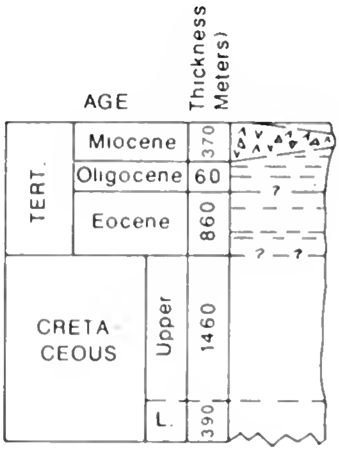
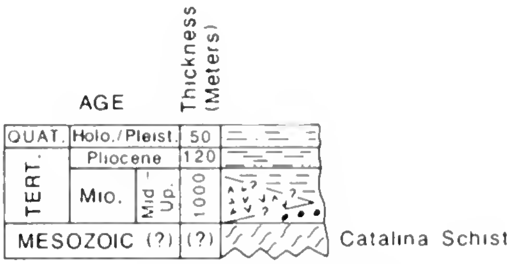
27. Dall Bank



28. Thirtymile Bank



Lithologies and thicknesses inferred in part

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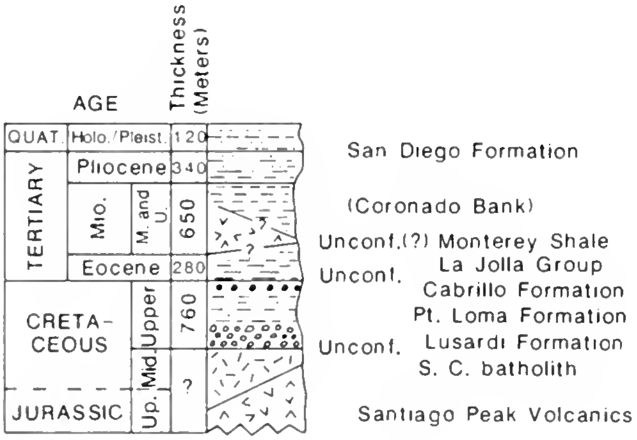
29. San Diego Shelf



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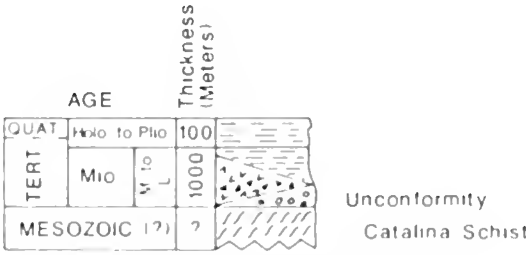
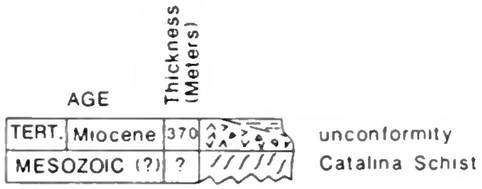
30. Fortymile Bank



Lithologies inferred in part

31. Central Blake Knolls



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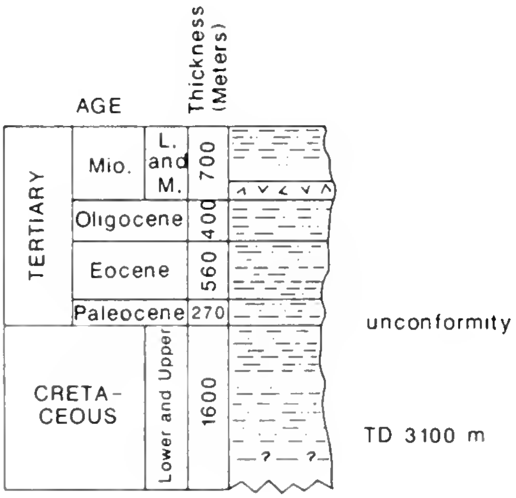
32. Cortes Bank (OSC-CAL 75-70 No. 1)



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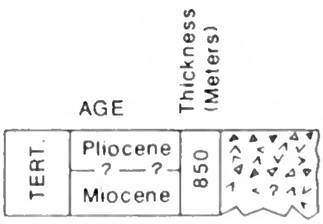
33. Northeast Bank



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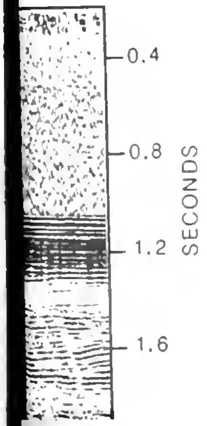
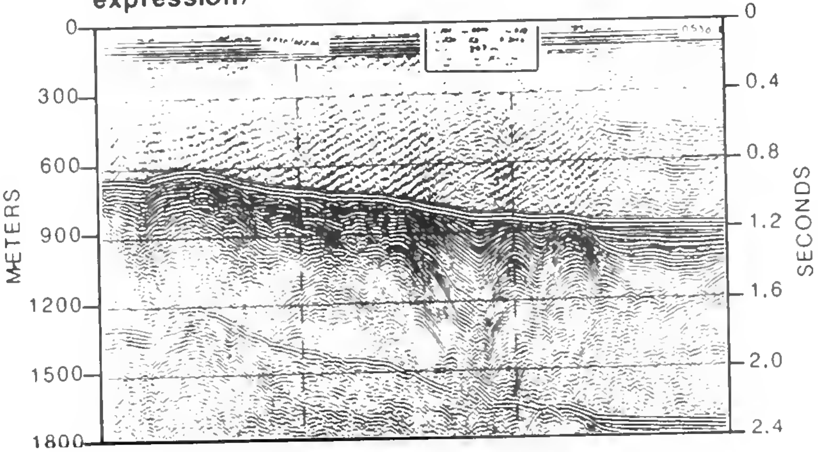
CALIFORNIA CONTINENTAL MARGIN GEOLOGIC MAP SERIES MASTER LEGEND AND EXAMPLE SEISMIC REFLECTION PROFILES WITH SYMBOLS AND TERMINOLOGY. (PLATE 1)



7. FAULT
(seafloor expression)



DIVISION OF MINES AND GEOLOGY
BRIAN E. TUCKER, ACTING STATE GEOLOGIST

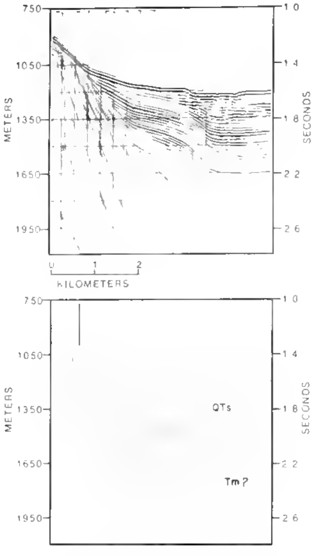
STATE OF CALIFORNIA-GEORGE DEUKMEJIAN
THE RESOURCES AGENCY-GORDON K VAN VLECK, SECRET
DEPARTMENT OF CONSERVATION-RANDALL M WA

Master Legend of Stratigraphic Units

Q	Unconsolidated deposits of Quaternary age
Qf	Fan deposits of Quaternary age
Qd	Deltaic deposits of Quaternary age
Q/Qd	Deltaic deposits of Quaternary age overlain by thick (greater than 3m) deposits of Q
Qcf	Canyon or channel fill deposits of Quaternary age
Qt	Unconsolidated marine terrace deposits of probable Pleistocene age
Qp	Unconsolidated marine shell and slope deposits of late Pleistocene age
Qsp	Deposits that may correlate with the San Pedro Formation
Qar	Aromas Red Sands (mostly unconsolidated quartzose sand of Pleistocene age)
Q/Qar	Aromas Red Sands (mostly unconsolidated quartzose sand of Pleistocene age) overlain by thick (greater than 3m) deposits of Q
QTs	Sediment and sedimentary rock of Quaternary and Tertiary (Pliocene and Miocene) age
QTt	Terrace deposits of Quaternary and late Tertiary (?) age
QTpr	Unconsolidated sand, gravel, clay and tuff of Pliocene and Pleistocene age that may correlate with the Paso Robles Formation
Q/QTpr	Unconsolidated unit of sand, gravel clay and tuff of Pliocene and Pleistocene age that may correlate with the Paso Robles Formation and is overlain by thick (greater than 3m) deposits of Q
Tp	Sedimentary rock of Pliocene age
Q/Tp	Sedimentary rock of Pliocene age overlain by thick (greater than 3m) deposits of Q
Tpp	Purisima Formation (marine sandstone and siltstone of Pliocene age)
Q/Tpp	Purisima Formation (marine sandstone and siltstone of Pliocene age) overlain by thick (greater than 3m) deposits of Q
Tpr	Sedimentary rock of early Pliocene and late Miocene age
Tm	Sedimentary rock of Miocene age
Q/Tm	Sedimentary rock of Miocene age overlain by thick (greater than 3m) deposits of Q
Tmv	Volcanic rock of Miocene age
Tmu	Volcanic and sedimentary rock of Miocene age
Tsc	Santa Cruz Mudstone (siliceous organic mudstone of Miocene age)
Q/Tsc	Santa Cruz Mudstone (siliceous organic mudstone of Miocene age) overlain by thick (greater than 3m) deposits of Q
Tsm	Santa Margarita Formation (sandstone and arkosic sandstone of Miocene age)
Q/Tsm	Santa Margarita Formation (sandstone and arkosic sandstone of Miocene age) overlain by thick (greater than 3m) deposits of Q
Tmm	Monterey Formation (siliceous sandstone siltstone and mudstone of Miocene age)
Q/Tmm	Monterey Formation (siliceous sandstone siltstone and mudstone of Miocene age) overlain by thick (greater than 3m) deposits of Q
Tmi	Plutonic and hypabyssal rock of Miocene age
To	Sedimentary rock of Oligocene age
Te	Sedimentary rock of Eocene age
Tep	Sedimentary rock of Eocene and Paleocene age
Tc	Carmelo Formation (sandstone siltstone mudstone and cobble-pebble conglomerate of Paleocene age)
Ts	Sedimentary rock of Tertiary age
Tv	Volcanic rock of Tertiary age
Ku	Sedimentary rock of late Cretaceous age
Kcs	Sedimentary rock of Cretaceous age
TMz	Undifferentiated igneous rock of Miocene age and metamorphic rock of pre late Cretaceous age
Mz	Metamorphic rock of pre late Cretaceous age
gr	Granitic rock chiefly diorite of Mesozoic age
gdp	Porphyritic granodiorite
m	Metamorphic rock of unknown age
Q/m	Metamorphic rock of unknown age overlain by thick (greater than 3m) deposits of Q
KTc	Franciscan Complex Coastal Belt
KJf	Franciscan Complex, undifferentiated

HIGHLIGHTED BOXES INDICATE UNITS DEPICTED ON THIS PLATE

1. GEOLOGIC CONTACT
(buttress unconformity)



GEOLOGIC CONTACT queried where contact is uncertain All contacts are extrapolated from seismic-reflection data and are approximate in location Example from sparker profile of upper Tertiary and Quaternary (QTs) sediment, ponded in synclinally folded strata on slope of presumed Miocene (Tm?) sediments Located in the Gulf of Santa Catalina west of Dana Point, inner southern California continental borderland

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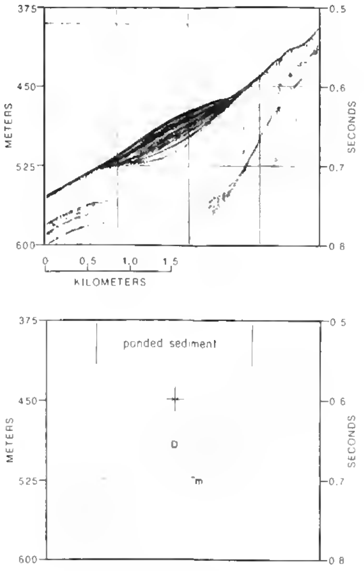
2. GEOLOGIC CONTACT
(ponded sediments)



GEOLOGIC CONTACT queried where contact is uncertain All contacts are extrapolated from seismic-reflection data and are approximate in location Example from Uniboom profile of sediment of Quaternary (Q) age ponded in synclinally folded strata on slope of Miocene (Tm) sedimentary rocks Located south of San Nicolas Island middle southern California continental borderland

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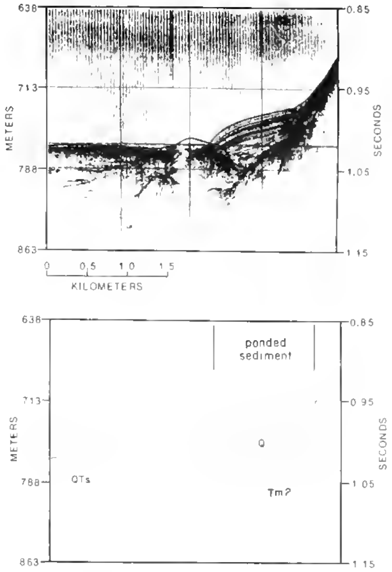
3. GEOLOGIC CONTACT
(ponded sediments)



GEOLOGIC CONTACT queried where contact is uncertain All contacts are extrapolated from seismic-reflection data and are approximate in location Example from Uniboom profile of unconsolidated Quaternary (Q) sediment ponded between base of slope and exposed bedrock (?) of probable Miocene (TM?) age located in the Gulf of Santa Catalina inner southern California continental borderland

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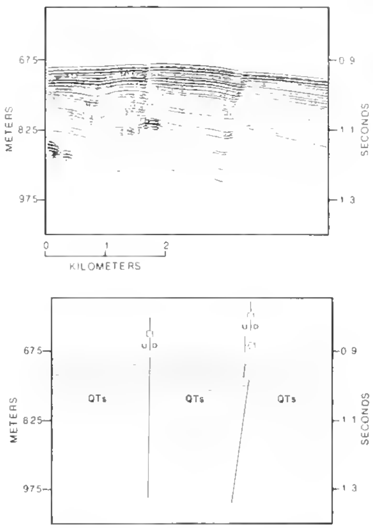
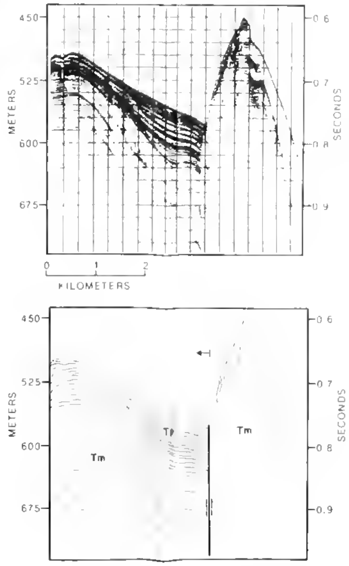
8. FAULT
(Pleistocene)



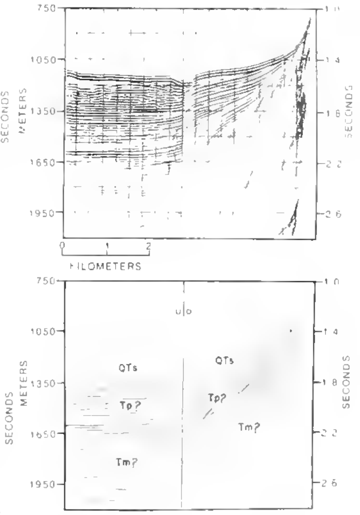
FAULT solid where well defined, dashed where inferred, queried where uncertain Faults designated by divided boxes indicate that strata of late Tertiary and Quaternary age are cut One of these has seafloor expression, indicated by bar and age symbol on downthrown side another reaches but does not displace seafloor, as indicated by age symbol astride fault "D" designates downthrown block "U" designates upthrown block Example from sparker profile within Loma Sea Valley inner southern California continental borderland

9. FAULT
(Tertiary)



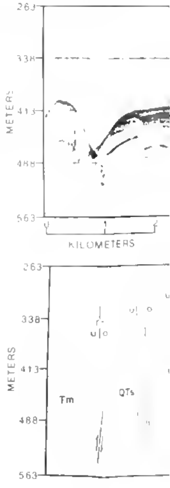
FAULT solid where well defined, dashed where inferred, queried where uncertain Filled triangle (age symbol) indicates youngest strata cut are Pliocene (Tp) in age Folded Miocene (Tm) sedimentary rock is overlain by Pliocene strata both lie in fault contact with exposed bedrock ridge of folded Miocene strata Example from sparker profile across mainland shelf near Carlsbad inner southern California continental borderland

10. FAULT
(Quaternary)



FAULT solid where well defined dashed where inferred, queried where uncertain Divided box astride fault symbol indicates fault does not have seafloor expression and that youngest strata cut are of late Tertiary and Quaternary (QTs) age "D" designates downthrown block "U" designates upthrown block Fault extends to base of "bubble pulse" but apparently does not reach the seafloor Note two unconformities within strata to right of fault Example from sparker profile across inner southern California continental borderland near Newport Beach

11. FAULT
(Quaternary and Late Tertiary)

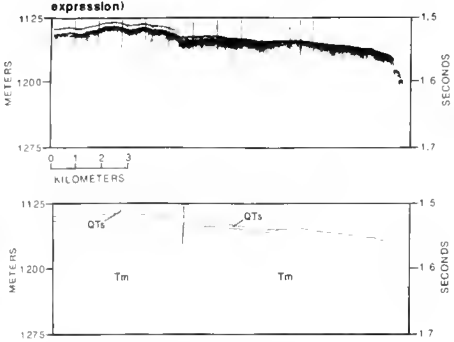


FAULT solid where well
where uncertain Open cir
does not have seafloor exp
cut are late Tertiary and
fault symbol indicates that
ternary in age "D designa
upthrown block Fault at fa
ternary (QTs) and older
Miocene (Tm) rocks Exam
across San Diego shelf, Lom
southern California contine

A-GEORGE DEUKMEJIAN, GOVERNOR
RDON K VAN VLECK, SECRETARY FOR RESOURCES
NSERVATION-RANDALL M WARD, DIRECTOR

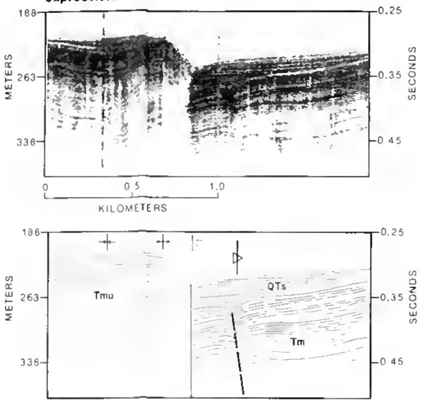
CALIFORNIA CONTINENTAL MARGIN GEOLOGIC MAP SERIES
MASTER LEGEND AND EXAMPLE SEISMIC REFLECTION PROFILES
WITH SYMBOLS AND TERMINOLOGY. (PLATE 1)

4. FAULT
(seafloor expression)



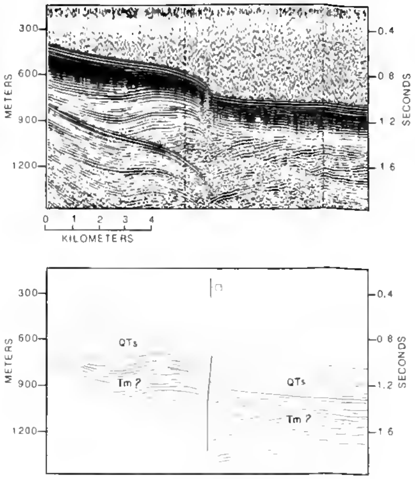
FAULT solid where well defined, dashed where inferred, queried where uncertain Bar and age symbol shown on downthrown side of fault with seafloor expression Fault displaces seafloor, offsetting acoustically transparent unit (QTs) of presumed late Tertiary and Quaternary age Example from 3 5 kHz profile across inner southern California continental borderland near San Diego

5. FAULT
(seafloor expression)



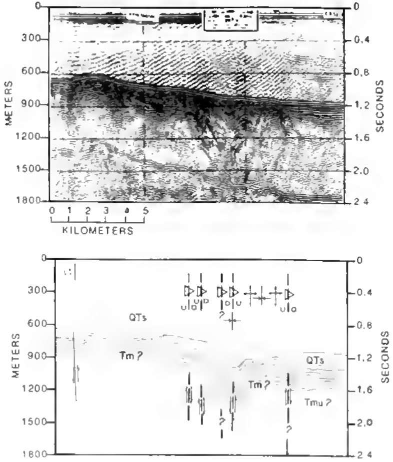
FAULT solid where well defined, dashed where inferred queried where uncertain Bar and age symbol shown on downthrown side of fault that has seafloor expression Fault displaces seafloor, offsetting sediments of presumed late Tertiary and Quaternary (QTs) age and juxtaposing subjacent units of Miocene (Tm) and possibly Pliocene (Tp?) ages Also note inferred fault within probable Miocene section, and folded strata Example from Uniboom profile across Tanner Bank middle southern California continental borderland (after Greene and others 1975, their Figure 3)

6. FAULT
(seafloor expression)

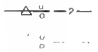


FAULT solid where well defined, dashed where inferred, queried where uncertain Bar and age symbol shown on downthrown side of fault that has seafloor expression Fault displaces seafloor, offsetting units of late Tertiary amd Quaternary (QTs) age and juxtaposing subjacent units of probable Miocene (Tm?) age Example from sparker profile across mainland shelf inner southern California continental borderland near Oceanside

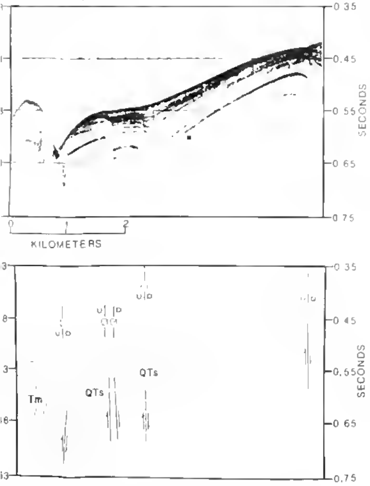
7. FAULT
(seafloor expression)



FAULT solid where well defined, dashed where inferred, queried where uncertain Bar and age symbol shown on downthrown side of fault that has seafloor expression Divided box indicates youngest strata cut are of Quaternary age Note that one questionable and four inferred faults cutting Miocene (Tm?) or older strata are indicated by open triangles astride fault symbol "D" designates downthrown block "U" designates upthrown block These strata are also folded, as shown by anticline and syncline symbols Example from sparker profile across Gulf of Santa Catalina, inner southern California continental borderland

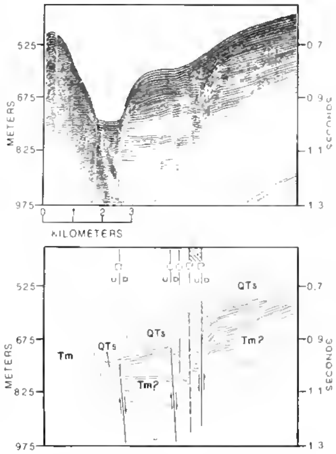


1. FAULT
(Quaternary and Late Tertiary)



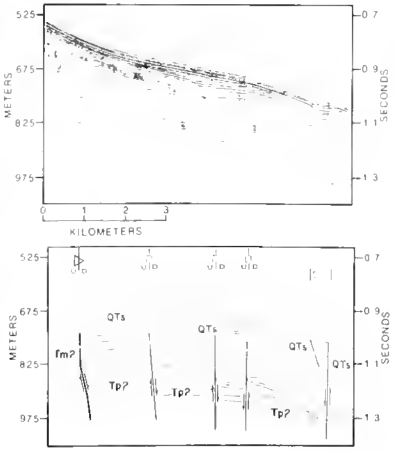
FAULT solid where well defined, dashed where inferred, queried where uncertain Open circle astride fault symbol indicates fault does not have seafloor expression and that youngest strata (QTs) cut are late Tertiary and Quaternary in age Divided box astride fault symbol indicates that the strata cut are undifferentiated Quaternary in age "D" designates downthrown block, "U" designates upthrown block Fault at far left juxtaposes late Tertiary and Quaternary (QTs) and older units with an exposed bedrock ridge of Miocene (Tm) rocks Example of fault zone from Uniboom profile across San Diego shelf, Loma Sea Valley, and Coronado Bank, inner southern California continental borderland

12. FAULT
(Quaternary and Late Tertiary)

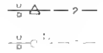


FAULT solid where well defined, dashed where inferred, queried where uncertain Open circles astride fault symbol indicates faults do not have seafloor expression and youngest strata cut are late Tertiary and Quaternary (QTs) in age "D" designates downthrown block, "U" designates upthrown block Where faults are close together, they are sometimes mapped as a FAULT ZONE (see Example 15) Note that fault at left juxtaposes late Tertiary and Quaternary strata with an exposed bedrock block of Miocene (Tm) age Example from sparker profile across San Diego shelf, Loma Sea Valley, and east flank of Coronado Bank, inner southern California continental borderland

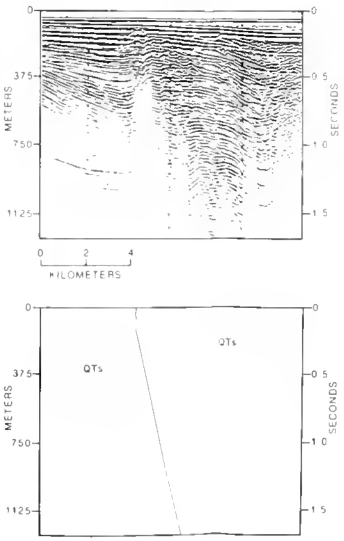
13. FAULT
(Quaternary and Late Tertiary)



FAULT solid where well defined, dashed where inferred, queried where uncertain Open triangle astride fault symbol indicates fault does not have seafloor expression and strata cut are probably Miocene (Tm?) in age "D" designates downthrown block "U" designates upthrown block Note also the two faults at the far right that are designated by filled box and bar on the fault symbol These have seafloor expression, and cut strata of presumed Holocene age Example from sparker profile across San Diego shelf to Loma Sea Valley, inner southern California continental borderland

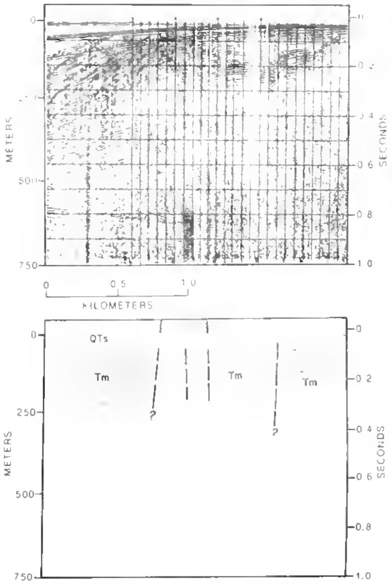


14. FAULT
(thrust)



FAULT (thrust) solid where well defined, dashed where inferred, queried where uncertain Barbs are shown on upper plate Note that the youngest strata cut are of late Tertiary and Quaternary (QTs) age Example from sparker profile across shelf west of Ventura, middle southern California continental borderland (after Greene and others, 1978, their Plate 1)

15. FAULT ZONE

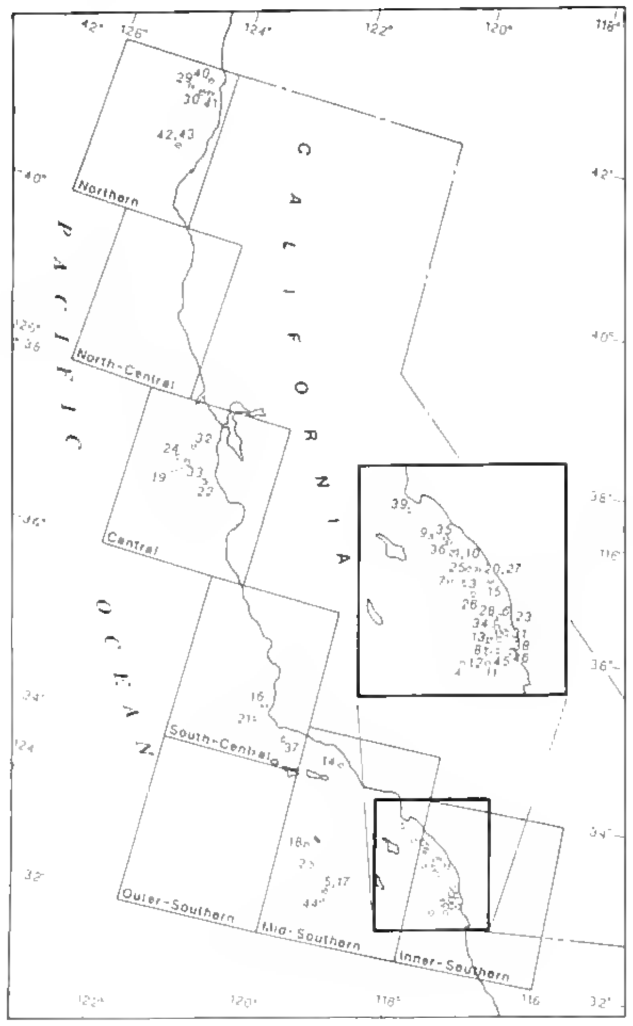


FAULT ZONE solid where well defined, dashed where inferred, queried where uncertain Fault zone offsets sedimentary rocks of Miocene (Tm) age and locally may extend to the seafloor Example from the sparker profile across shelf south of San Mateo Point, inner southern California continental borderland (after Greene and Kennedy, 1981)

thrown block. Example from sparker profile within Loma Sea Valley, inner southern California continental borderland.

Pliocene strata, both [illegible] fault contact with exposed bedrock ridge of folded Miocene strata. Example from sparker profile across mainland shelf near Carlsbad, inner southern California continental borderland.

profile across inner southern California continental borderland near Newport Beach.



LOCATION MAP OF PROFILE EXAMPLES

Index map showing locations of seismic-reflection examples. Locations of examples are approximate and the editors may be contacted for more information. The circle and number give approximate location of the seismic line and the line within the circle is aligned in the same direction as the seismic trackline. Example 19 is represented by a line only. Examples spaced close together are plotted within the same circle as one line, i.e., 1,10. Examples which are on the same line but at different shotpoints are shown with two crossbars on the line inside the circle, i.e. 5,17.

KEY TO RECENCY OF FAULTING

FAULTS

Solid where well defined, dashed where inferred, queried where uncertain. Barbs shown on upper plate of thrust fault. Where fault offsets sea floor, age symbol is shown on bar on downthrown side. Where age was determined, age symbol is shown astride fault and relative offset is shown by "D" and "U" on downthrown and upthrown sides. Ages of faults are indicated as follows, all faults considered active or potentially active shown in red.

- ○ cuts strata of Holocene age
- ☐ cuts strata of Pleistocene age
- ◌ cuts strata of Quaternary age
- ○ cuts strata of late Tertiary and Quaternary age
- ▲ cuts strata of Pliocene age
- △ cuts Miocene or older strata

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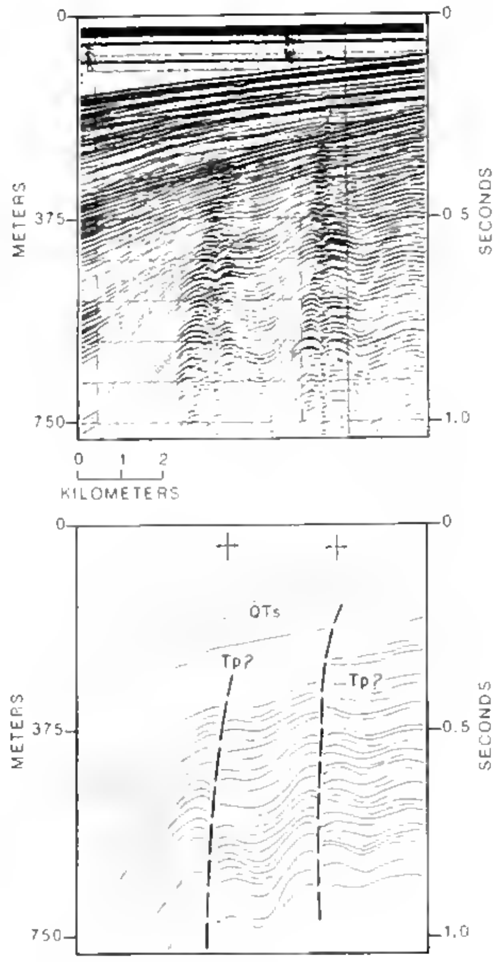
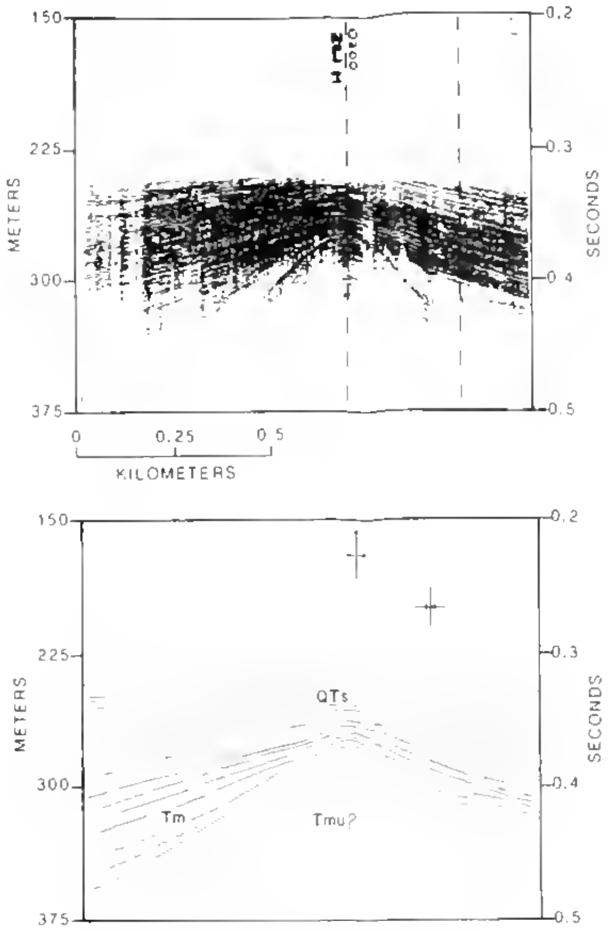
16. FAULTED ANTICLINE



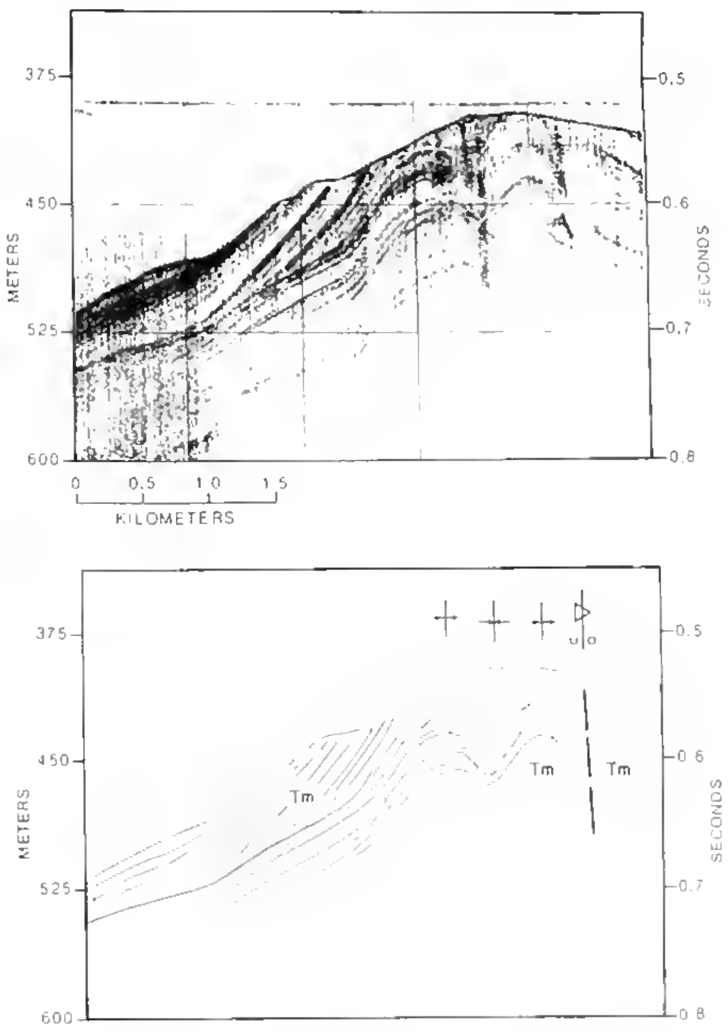
FAULTED ANTICLINE. Gas migrating upward along faults in late Tertiary and Quaternary (QTs) strata has accumulated along the faulted anticlinal crest, increasing the acoustic contrast. Example from 2-sec. single-channel airgun reflection record in offshore Santa Maria basin, south central California continental margin.

17. FOLD
(anticline)



FOLD (anticline) axis shown as solid line where well defined, dashed where inferred, queried where uncertain. Arrow indicates direction of axial plunge. Also note small syncline to right of anticline, and angular unconformity between undifferentiated igneous and sedimentary rocks of probable Miocene age (Tmu?), and overlying strata of Miocene (Tm) age. Example from Uniboom profile between the Tanner and Cortes Banks, middle southern California continental borderland.

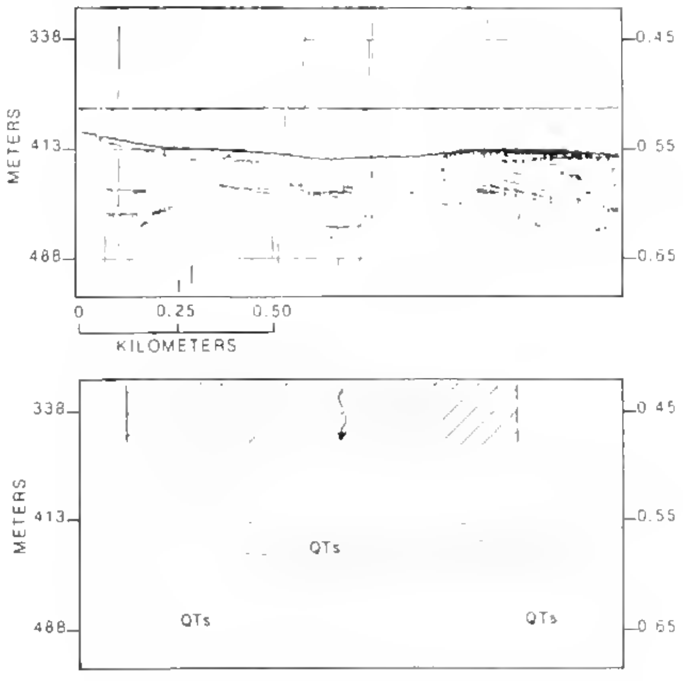
18. FOLD
(anticline, syncline)



FOLD (anticline) axis shown as solid line where well defined, dashed where inferred, queried where uncertain. Arrow indicates direction of axial plunge. Also note small syncline located between the two anticlinal folds, and the angular unconformity between folded strata of Miocene (Tm) age and the progradational sequence of Miocene (Tm) sedimentary rocks. Example from Uniboom profile across San Nicolas Island platform, middle southern California continental borderland.

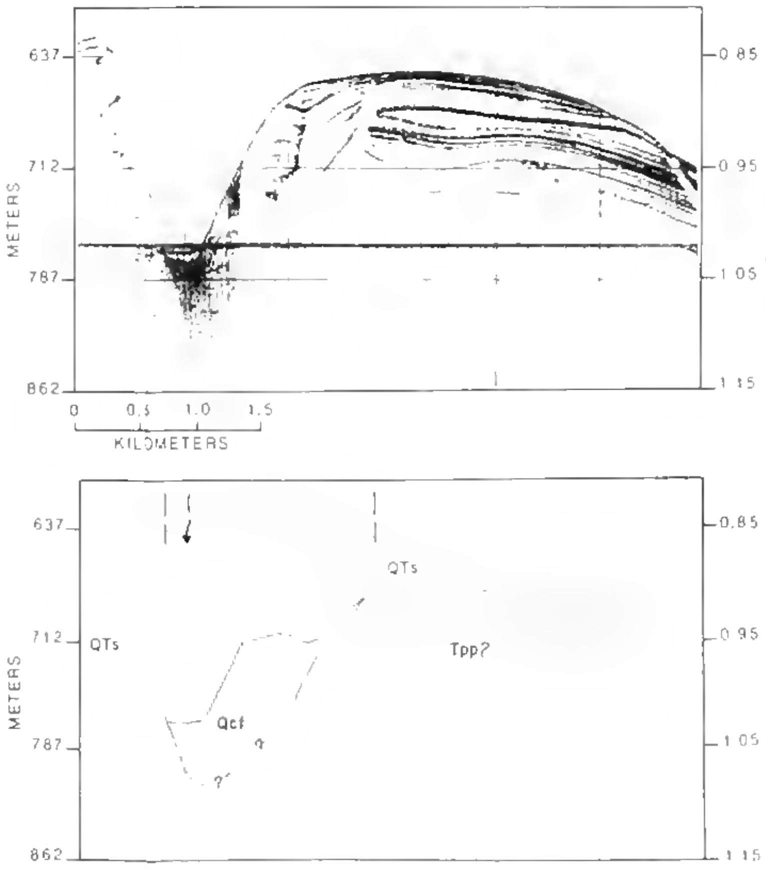
19.

23. CHANNEL
(filled)



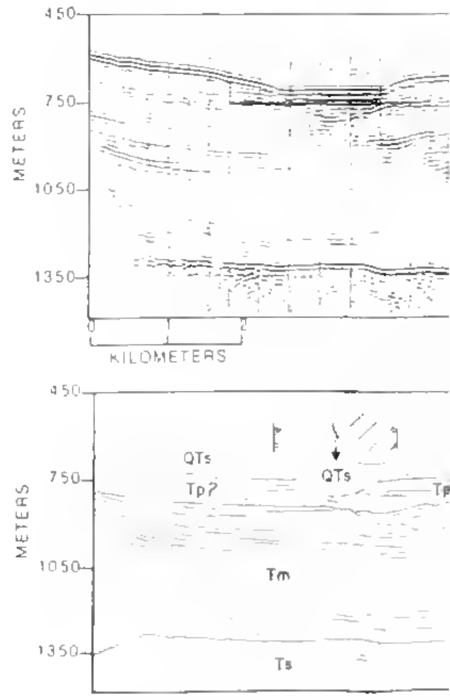
CHANNEL (filled) dash-dot line marks paleochannel axis, arrow indicates direction of sediment transport. Channel margins indicated by solid line where well defined, dashed where inferred, queried where uncertain. Example from Uniboom profile of upper Tertiary and Quaternary (QTs) sediments filling an erosional channel located off Point La Jolla, inner southern California continental borderland.

24. CHANNEL
(filled)



CHANNEL (filled) dash-dot line marks paleochannel axis (not located on profile above), arrow indicates direction of sediment transport. Channel margins indicated by solid line where well defined, dashed where inferred, queried where uncertain. Note that old channel deposits (Qcf) have been incised by subsequent erosion, resulting in the formation of a modern, active channel. Symbols: QTs, upper Tertiary and Quaternary sediments. Tpp?, Pliocene Purisima (?) Formation. Example from Uniboom profile across Ascension Canyon, central California continental margin.

25. CHANNEL
(buried)



CHANNEL (buried) dash-dot line marks pa
row indicates direction of sediment transpor
indicated by dotted line. Also note the channel
to the left of buried channel, filled with undiff
of late Tertiary and Quaternary (QTs) age
occupying the site of this older, filled channel
the presence of low-relief erosional scarps at t
from sparker profile across the Gulf of Santa
Point, inner southern California continental b

30. LANDSLIDE
(slump)

31. LANDSLIDE
(slump)

32. LANDSLIDE
(slump)

33. LANDSLIDE (?)
(slump)(?)

34. LANDSLIDE
(scarps)

Mateo Point, inner southern California continental borderland (after Greene and Kennedy, 1981)

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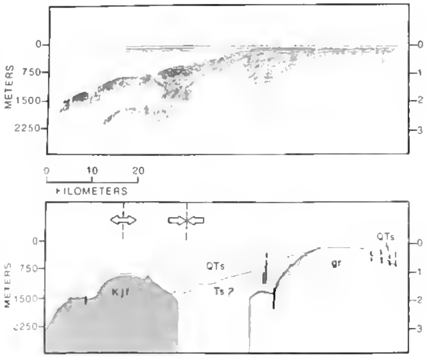
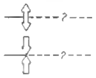
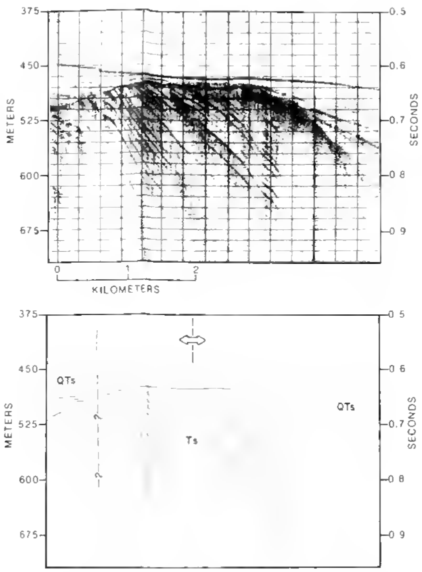
19. STRUCTURAL HIGH AND LOW



STRUCTURAL HIGHS AND LOWS solid where well defined, dashed where inferred, queried where uncertain Structural highs formed by the Farallon Ridge (Cretaceous granitic rocks, gr, of the Salinian terrane of Silberling and others 1984) and the Santa Cruz high (Cretaceous subduction melange of Franciscan Complex, KJf) and the intervening structural low filled by the late Tertiary and Quaternary sediments of the outer Santa Cruz basin Line drawing from a 4-second, single-channel sparker profile run across the continental shelf and slope west of Half Moon Bay, offshore central California

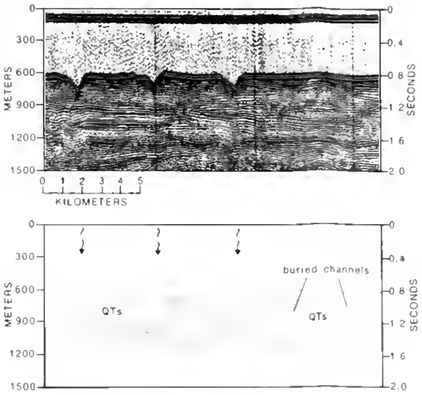


20. STRUCTURAL HIGH



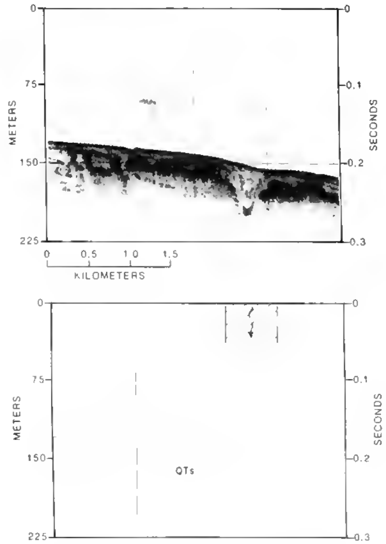
STRUCTURAL HIGH solid where well defined, dashed where inferred, queried where uncertain Top of structural high is surface eroded onto presumed sedimentary rocks (Ts) of Tertiary age buried beneath undifferentiated sedimentary rocks and sediments (QTs) of Tertiary and Quaternary age Exampk from sparker profile across the Gulf of Santa Catalina

21. CHANNEL
(active)

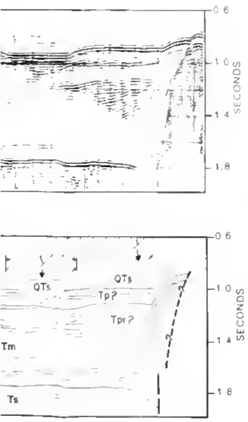


CHANNEL (active) dash-dot line marks channel axis, arrow indicates direction of sediment transport Also note two buried channels beneath the modern seafloor of presumed Quaternary-Tertiary, undifferentiated age to right of active channels Example from sparker profile across head of Arguello Canyon, off Point Arguello, central California continental margin

22. CHANNEL
(filled)

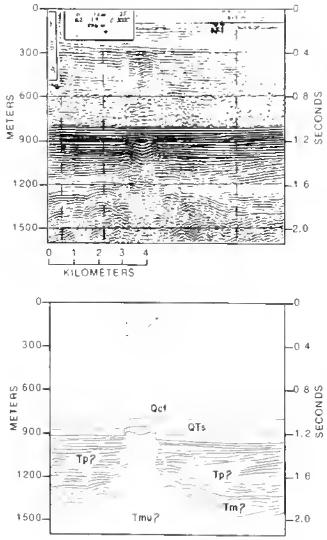


CHANNEL (filled) dash-dot line marks paleochannel axis, arrow indicates direction of sediment transport Channel margins indicated by solid line where well defined, dashed where inferred, queried where uncertain Also note fault that cuts flat-lying sediments of presumed Holocene age and is expressed in the seafloor Example from Uniboom profile off Point Ano Nuevo, central California continental margin



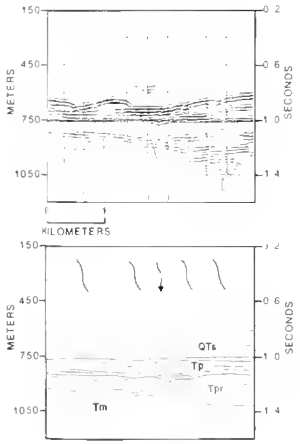
dash-dot line marks paleochannel axis, ar-
on of sediment transport Channel margins
ie Also note the channel at surface, above and
hannel, filled with undifferentiated sediments
Quaternary (QTs) age A modern channel
this older, filled channel may be indicated by
elief erosional scarps at the surface Example
across the Gulf of Santa Catalina, off Dana
California continental borderland

26. CHANNEL
(buried)



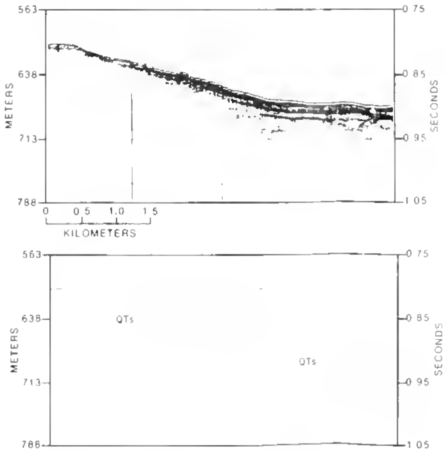
CHANNEL (buried) dash-dot line marks paleochannel axis (not indicated on profile above) Within upper Tertiary and Quaternary (QTs) sediments, the channel margins are indicated by dotted lines Pulled-down reflectors immediately beneath the channel and incoherent reflectors at depth probably result from low acoustic velocities associated with unconsolidated channel fill materials Example from sparker profile across the Gulf of Santa Catalina, inner southern California continental borderland

27. LEVEE



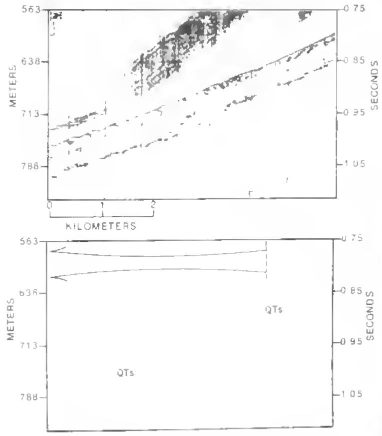
LEVEE solid where well defined, dashed where inferred, queried where uncertain Levees constructed from sediment overflow of active submarine channel (shown as dash-dot line with arrow indicating direction of sediment transport) Levees of Quaternary age are deposited upon flat lying strata of sediments and sedimentary rocks of Quaternary and Tertiary, undifferentiated, age (QTs) Example from sparker profile across floor of Gulf of Santa Catalina at base of slope west of San Mateo Point, southern California continental borderland

28. LANDSLIDE
(creep)



CREEP (noted on a single survey line) arrow indicates apparent direction of sediment movement in upper Tertiary and Quaternary (QTs) sediments Example from Uniboom profile off Oceanside inner southern California continental borderland

29. LANDSLIDE
(slump)



SLUMP boundaries solid where well defined, dashed where inferred queried where uncertain Arrows indicate direction of movement Zone of movement extends to a subbottom depth of approximately 20 m Note hummocky seafloor surface and back rotated subbottom reflectors (slip surface) Example from Uniboom profile across continental slope off Crescent City, northern California continental margin

ANDSLIDE
cerps)

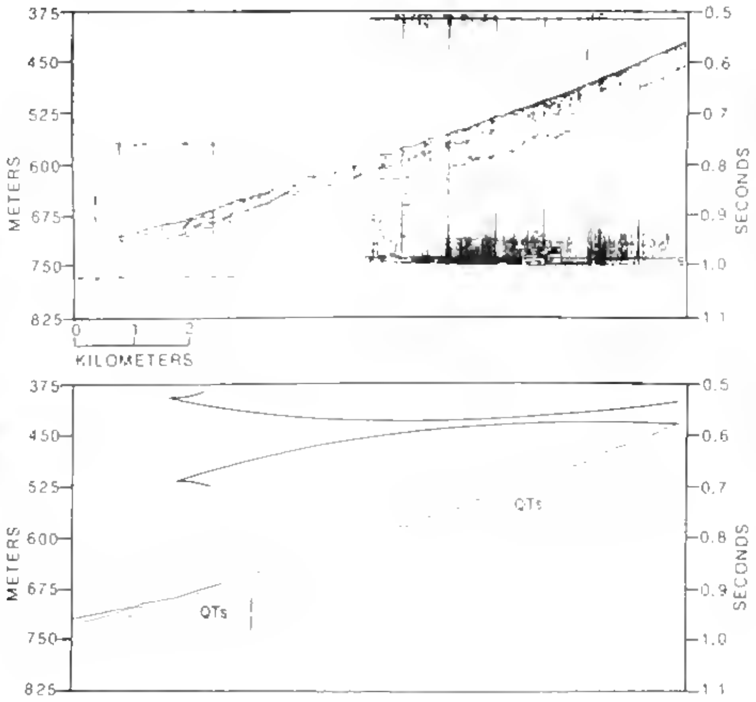
35. LANDSLIDE
(block glide)

36. LANDSLIDE
(block glide)

37. LANDSLIDE
(sediment flow)

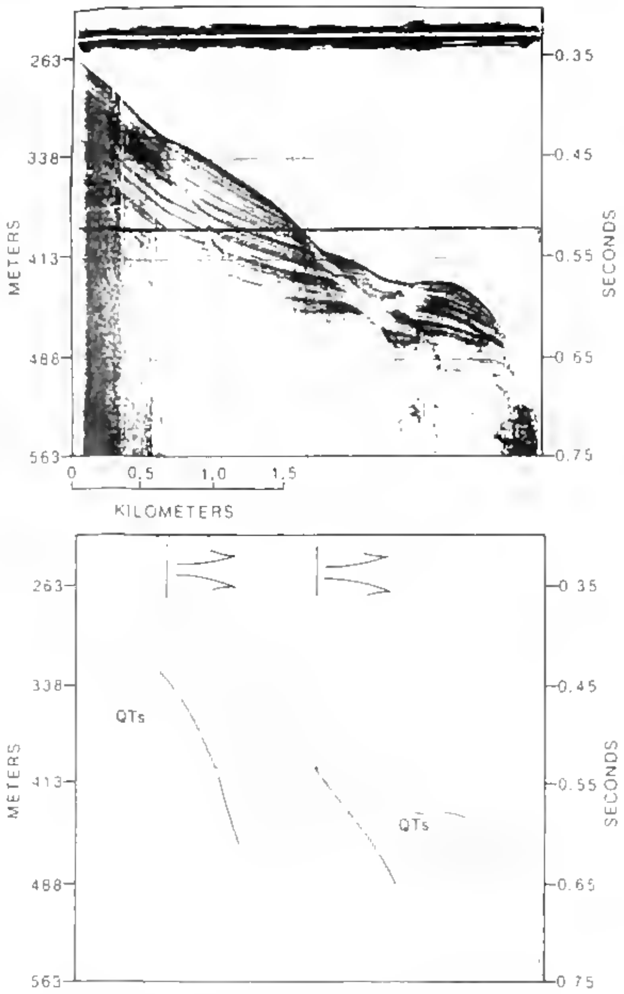
38. GAS
(seep)

30. LANDSLIDE
(slump)



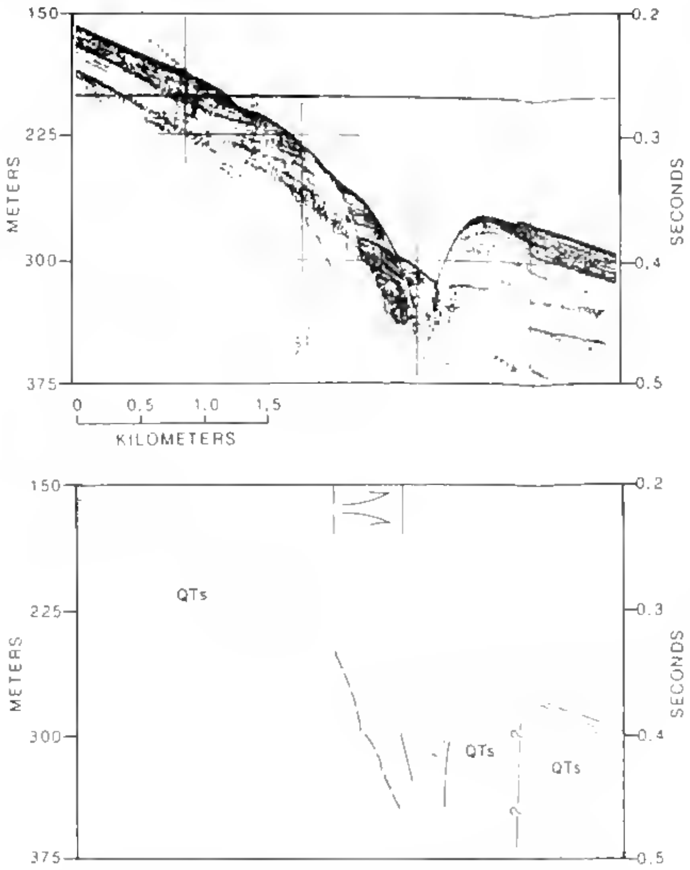
SLUMP boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of 30 m. Note hummocky seafloor surface, slip surfaces and back rotation of reflectors within moving sediment mass. Example from Uniboom profile across slope west-northwest of Crescent City, northern California continental margin (after Field and others, 1980, their Figure 15)

31. LANDSLIDE
(slump)



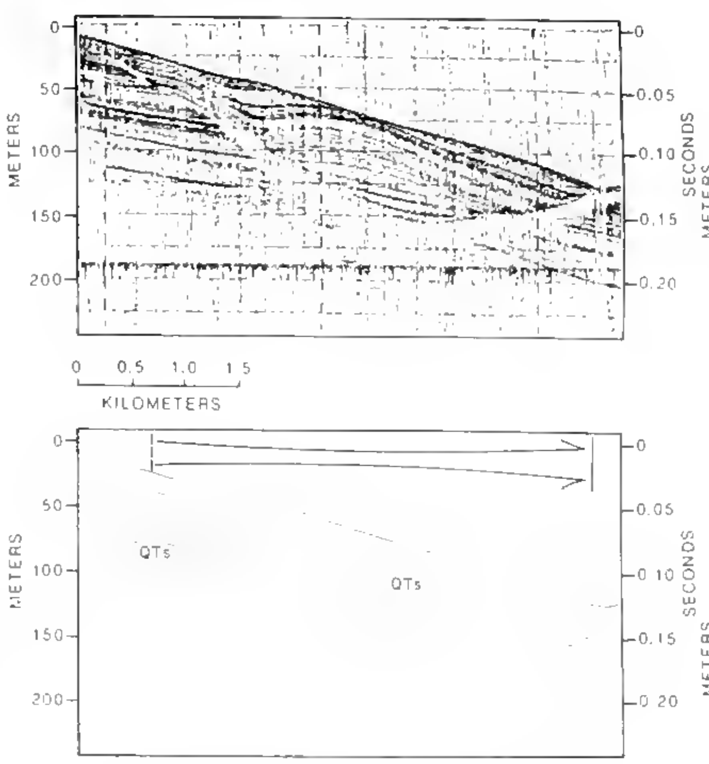
SLUMP boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of in excess of 100 m involving sediments of late Tertiary and Quaternary (QTs) age. Note slip surfaces and apparent drag folding of strata adjacent to slip surfaces. Example from Uniboom profile near La Jolla Canyon, inner southern California continental borderland

32. LANDSLIDE
(slump)



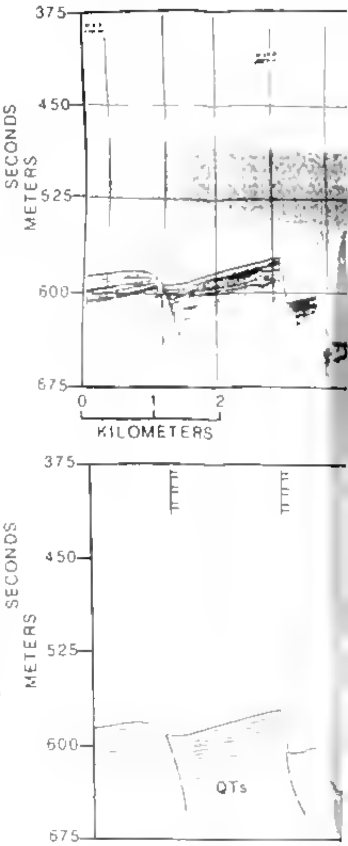
SLUMP boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate direction of movement. Zone of movement extends to a subbottom depth of approximately 90 m in sediments of late Tertiary and Quaternary (QTs) age. Note apparent slip surfaces and back-rotated reflectors. Example from Uniboom profile across Ascension Canyon, central California continental margin

33. LANDSLIDE (?)
(slump)(?)



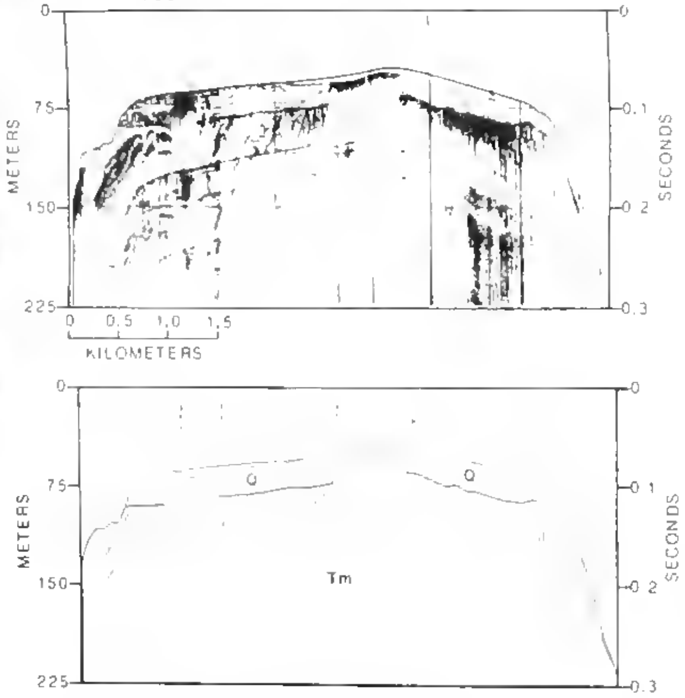
SLUMP boundaries solid where well defined, dashed where inferred, queried where uncertain. Arrows indicate apparent direction of movement in deposits of late Tertiary and Quaternary (QTs) age. Movement of the slump mass along a generally arcuate failure surface has destroyed the bedding and produced a nonreflecting zone. Example from Uniboom profile across the continental slope off outer Santa Cruz basin, central California continental margin

34. LANDSLIDE
(scarps)



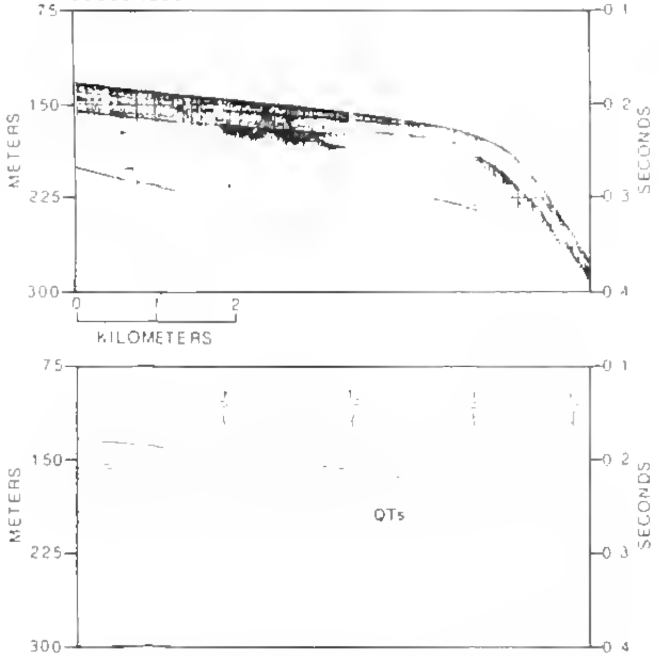
SCARPS boundaries solid whe
queried where uncertain. Hach
movement involves sediment of
age. Note double hachures ind
Uniboom profile across La Joll
continental borderland

39. GAS
(bright spot, subsurface)



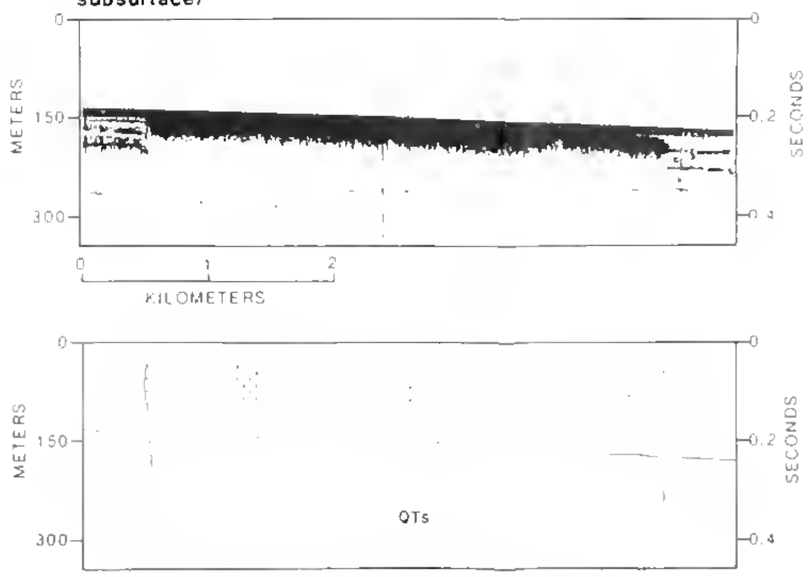
GAS area of acoustic anomaly, possibly indicating the presence of gas-saturated sediments. Solid where well defined, dashed where inferred, queried where uncertain. Acoustic anomalies above occur in flat-lying Quaternary (Q) sediment overlying an eroded, flat-topped, Miocene (Tm) bedrock ridge. Example from Uniboom profile across San Pedro escarpment and shelf, middle southern California continental borderland

40. GAS
(bright spot, subsurface)



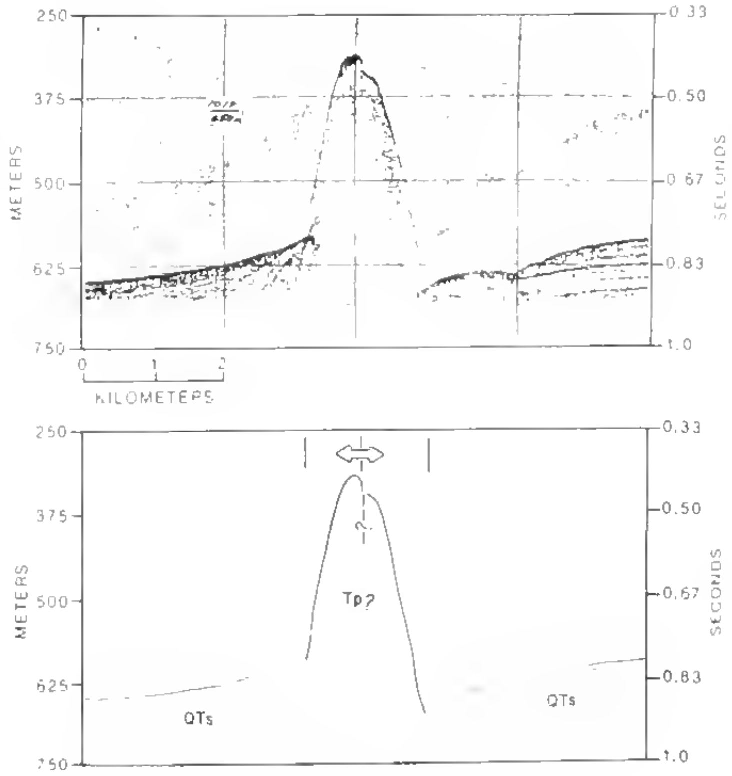
GAS area of acoustic anomaly, possibly indicating the presence of gas-saturated sediment. Solid where well defined, dashed where inferred, queried where uncertain. Example from Uniboom profile across shelf and upper slope west of Crescent City, northern California continental margin

41. GAS
(bright spot, subsurface)

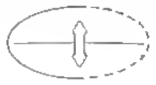


GAS area of acoustic anomaly, possibly indicating the presence of gas saturated sediment. Solid where well defined, dashed where inferred, queried where uncertain. Example from 3.5 kHz profile across shelf off Crescent City, northern California continental margin

42.DIAPIR



DIAPIRIC RIDGE Solid where well defined, dashed where inferred, queried where uncertain. Shale-cored diapir pierces upper Tertiary and Quaternary (QTs) strata and extends above the seafloor. Example from 3.5 kHz profile across marginal plateau west-northwest of Eureka, northern California continental margin



43

MASTER LEGEND AND EXAMPLE
PROFILES WITH SYMBOLS A

H. GARY GREENE* AND MICHAEL P.

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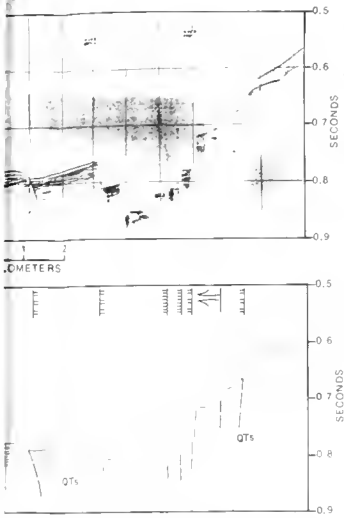
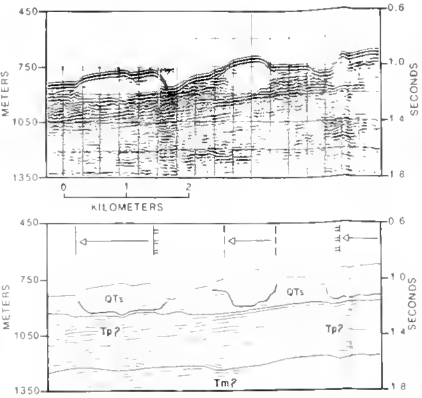
*U.S Geological Survey
**California Department of Conservation, Division of Mines and Geology, Scripps Institution of Oceanography

IDSLIDE
rps)



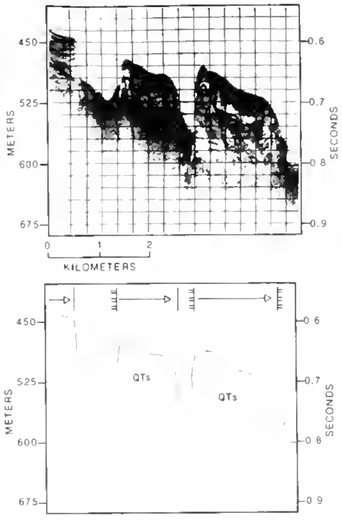
RPS boundaries solid where well defined dashed where inferred, ied where uncertain Hachures indicate slump scarp Zone of ement involves sediment of late Tertiary and Quaternary (QTs) Note double hachures indicate erosional scarps Example from boom profile across La Jolla Canyon, inner southern California inental borderland

35. LANDSLIDE
(block glide)



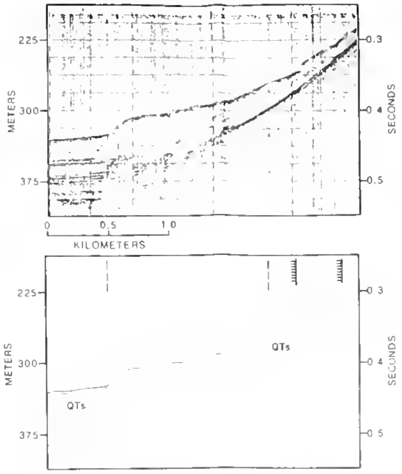
BLOCK GLIDE boundaries solid where well defined, dashed where inferred, queried where uncertain Arrows indicate apparent direction of movement Zone of movement extends to a subbottom depth of 150-190 m, involving sediments of late Tertiary and Quaternary (QTs) age Note relative acoustic transparency of blocks, possibly the result of intense deformation of strata within the blocks Erosional channels may develop locally along pull-apart fractures between blocks, shown by double hachures (erosional scarp) Example from sparker profile across base of slope off Newport Beach, inner southern California continental borderland (after Greene and others, 1983, their Figure 2 10)

36. LANDSLIDE
(block glide)

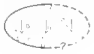


BLOCK GLIDE boundaries solid where well defined, dashed where inferred, queried where uncertain Arrows indicate apparent direction of movement Zone of movement extends to a subbottom depth of approximately 90-100 m, involving sediments of late Tertiary and Quaternary (QTs) age Note that internal deformation of blocks is greatest toward the front edge (downslope), and sole (base) of the mass Locally erosional channels may develop along pull-apart fractures between the blocks These are shown with double hachures (erosional scarp) Example from mini-sparker profile across slope south of Newport Beach, inner southern California continental borderland

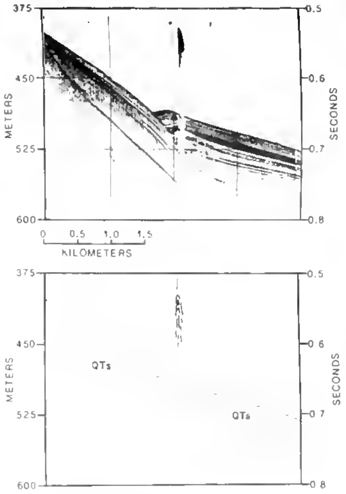
37. LANDSLIDE
(sediment flow)



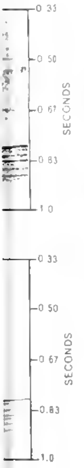
SEDIMENT FLOW Boundaries solid where well defined, dashed where inferred, queried where uncertain Arrows indicate direction of movement in sediments of late Tertiary and Quaternary (QTs) age Note multiple headscarps above thick, detached sediment mass, acoustic transparency of this mass, and absence of an identifiable slip surface Example from Uniboom profile across north slope of Santa Barbara Channel, (approximately 35 km) west of Santa Barbara (from Edwards, 1982)



38. GAS
(seep)



OIL AND OR GAS SEEP symbol indicates presence of subbottom and water column acoustic anomalies associated with gas seeps Gas seep occurs in sediments of late Tertiary and Quaternary (QTs) age Queried where uncertain Example from Uniboom profile across base of slope off Point La Jolla, inner southern California continental borderland (after Greene and others, 1983, their Figure 2-16)



ferred.
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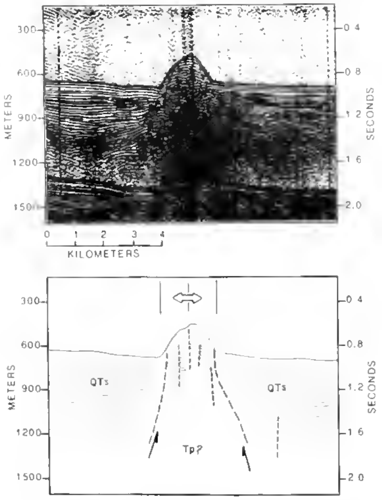
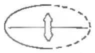
e from
north-

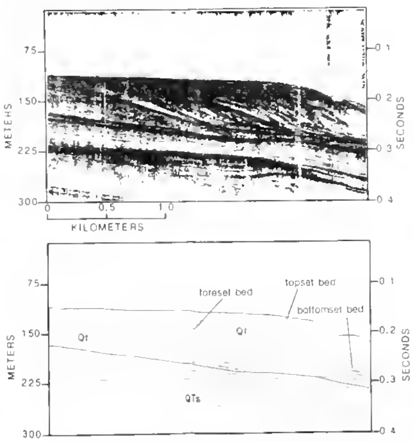
43. DIAPIR



DIAPIRIC RIDGE Solid where well defined, dashed where inferred, queried where uncertain Shale-cored diapir pierces upper Tertiary and Quaternary (QTs) and older strata and extends above the seafloor Example from sparker profile across marginal plateau west-northwest of Eureka, northern California continental margin

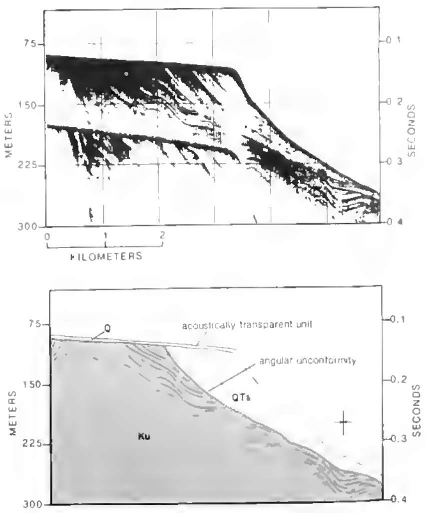


44. TERRACE
(constructional)



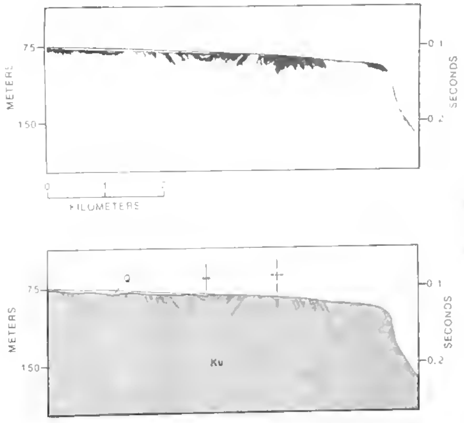
TERRACE (constructional) Example from Uniboom profile across east flank of Cortes Bank middle southern California continental borderland, showing Pleistocene (QT) progradational terrace sequences forming a constructional or depositional marine terrace (after Greene and others 1975 their Figure 5)

45. TERRACE
(erosional)



TERRACE (erosional) Example from Uniboom profile across shelf off Point La Jolla, inner southern California continental borderland Undifferentiated folded Cretaceous strata (Ku) and overlying upper Tertiary and Quaternary (QTs) progradational sequence have been bevelled by wave action Acoustically transparant unit overlying wave-cut platform is probably Holocene (Q) in age

46. TERRACE
(erosional)

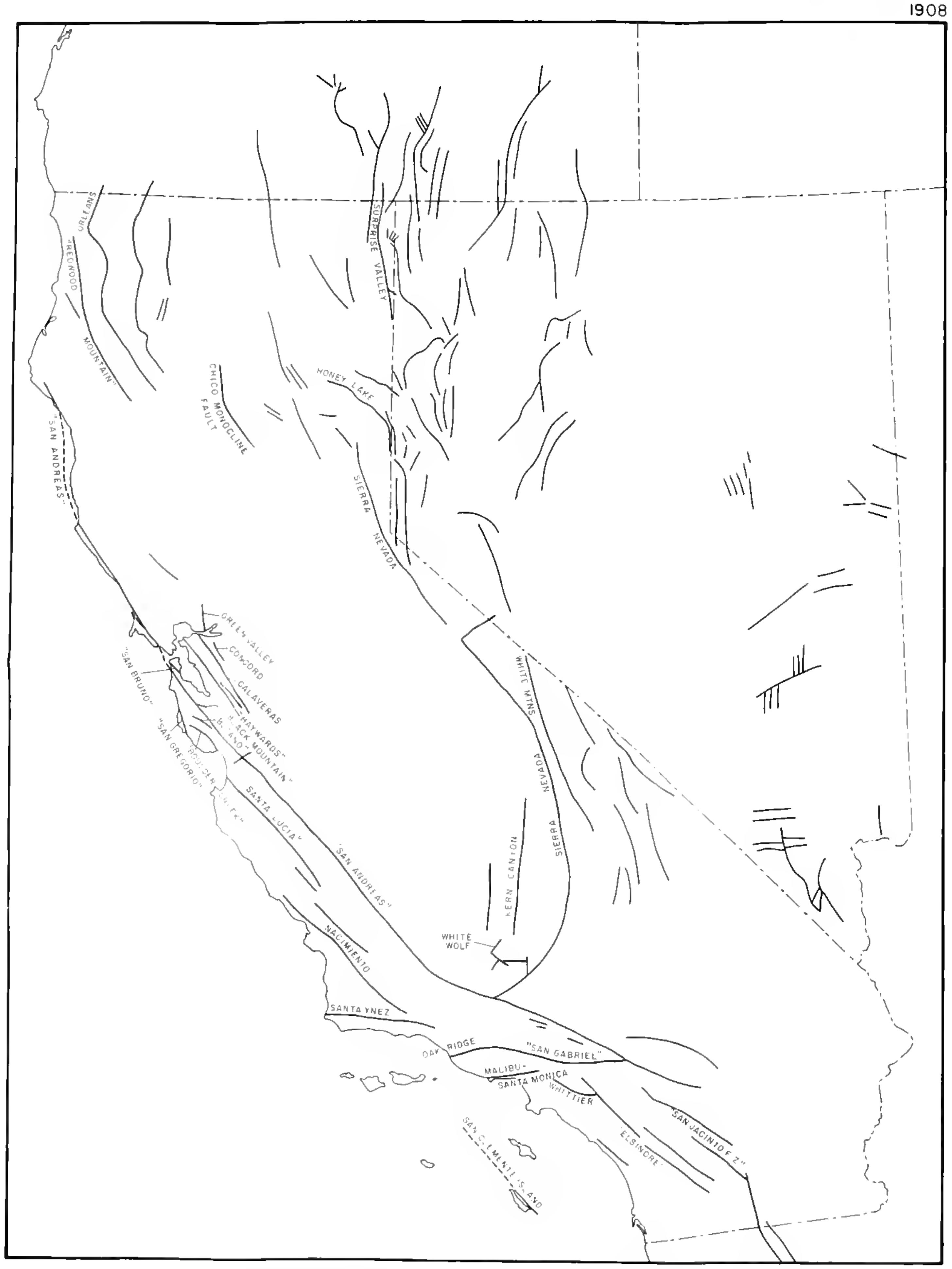


TERRACE (erosional) Wave-planed, platform composed of undifferentiated folded Cretaceous (Ku) strata forming a wave-cut terrace, partially overlain by acoustically transparant layer of Holocene (Q) age Example from Uniboom profile across shelf off Point La Jolla inner southern California continental borderland (after Greene and others, 1983, their Figure 2-18)

EXAMPLE SEISMIC REFLECTION
MBOLS AND TERMINOLOGY.

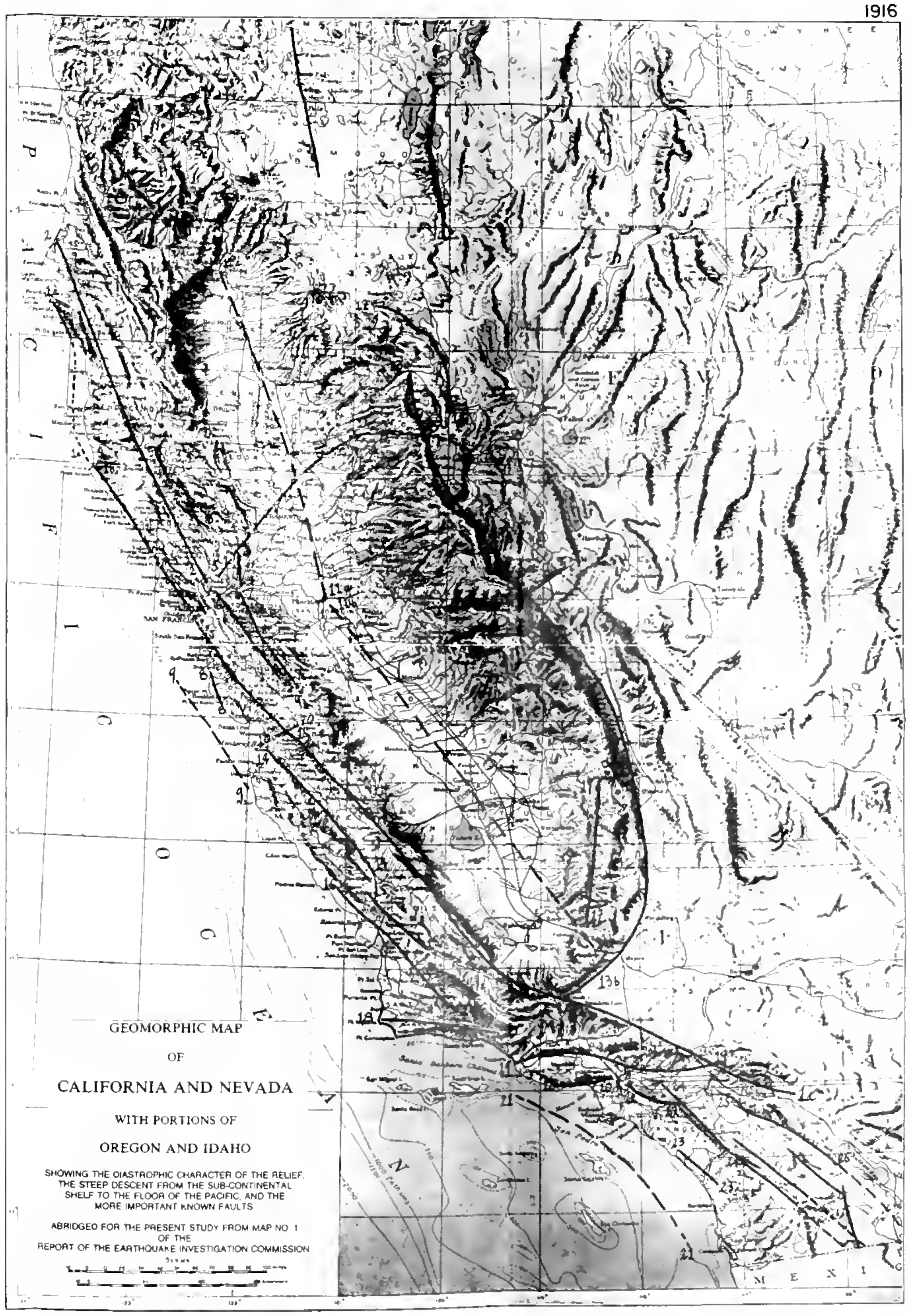
) MICHAEL P. KENNEDY**, EDITORS

1908



MAP A: Faults shown on the first fault map of California. From Map No. 1 of the State Earthquake Investigation Commission report on the California earthquake of April 18, 1906 (Lawson, and others, 1908). Fault names shown in quotation marks are from text of 1908 report; other fault names were added from current usage.

1916



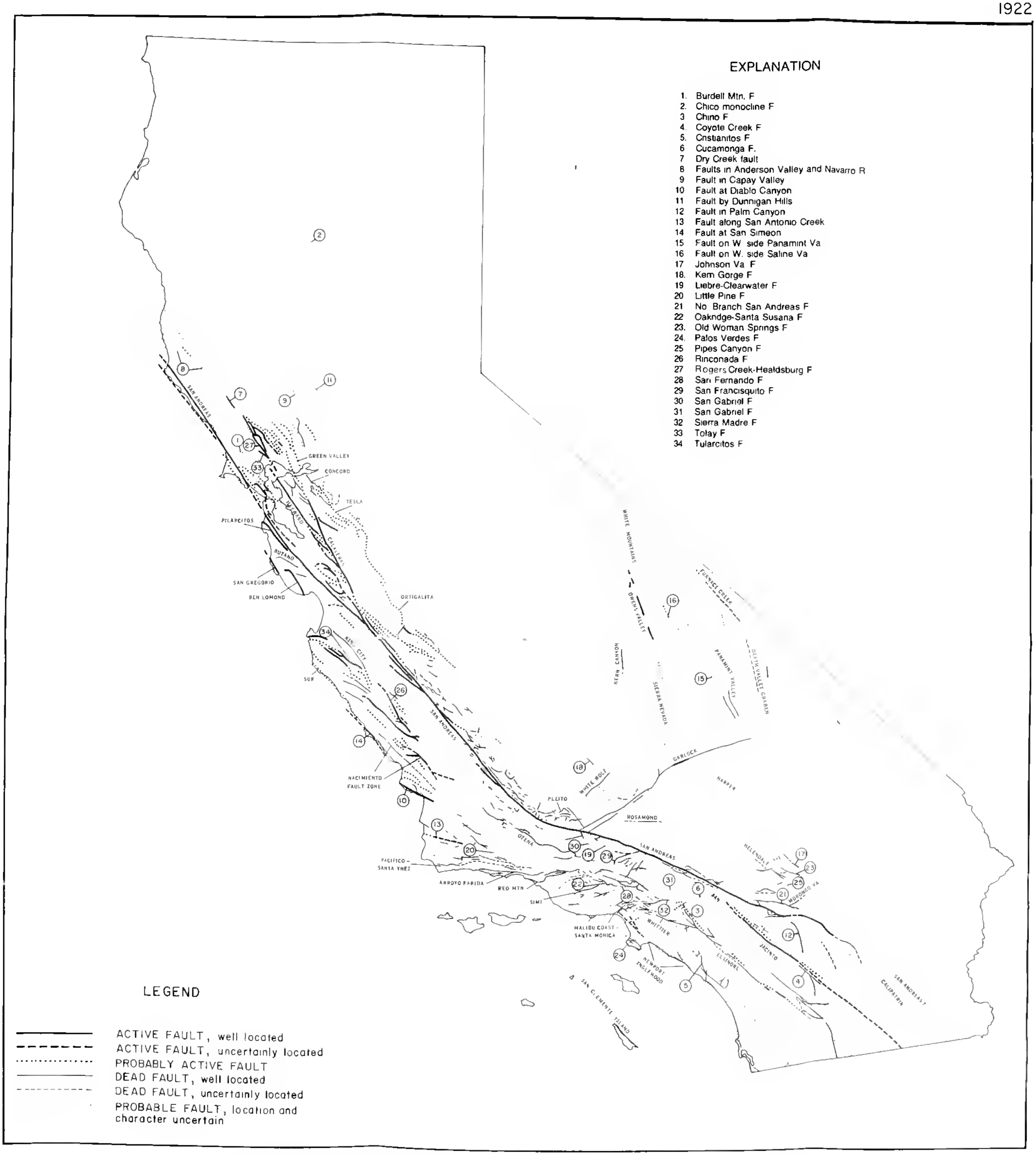
MAP B: H.O. Wood's (1916) abridged version of Lawson's 1908 fault map of California, showing faults and "lines" tentatively considered by Wood to be generatrices of earthquakes.

EXPLANATION

1. San Andreas fault
   a) Punta Gorda-Point Arena segment
   b) Point Arena-San Juan segment
   c) San Juan-Tejon segment
   d) Tejon-Colorado segment
2. Eureka-Ukiah-San Pablo line
3 Mount St. Helena fault
4 Suisun fault (now called Green Valley fault)
5 Mare Island-Nevada-Carson line
6 Haywards fault (now Hayward fault)
7. Sunol fault system (also known as Calaveras fault)
8 San Gregorio fault
9 Monterey submarine fault-zone
10 Pajaro fault
11 Great Valley axis
   a) Shasta-Stockton segment
   b) Stockton-Tehachapi segment
12 Honey Lake fault-zone
13 Sierra fault system
   a) Beckwith-Mono segment
   b) Mono-Tejon segment
14 Santa Lucia fault
   Lockwood fault
15 Templeton fault
16. San Luis Obispo fault (now part of Nacimiento fault-zone)
17 Kern fault (now Kern Canyon fault)
18 Santa Ynez fault
19 San Gabriel fault
20 Santa Monica fault
21 San Pedro submarine fault-zone
22 Whittier fault
23. Santa Ana fault
24. Elsinore fault
   Agua Caliente fault
   North, and South Canzo (*sic*) fault
25 San Jacinto fault

Unnumbered, but identified, faults by Wood: Klamath Lake fault, "Warren" Mountains fault (should be Warner Mountains fault), Bodie fault

1922



EXPLANATION

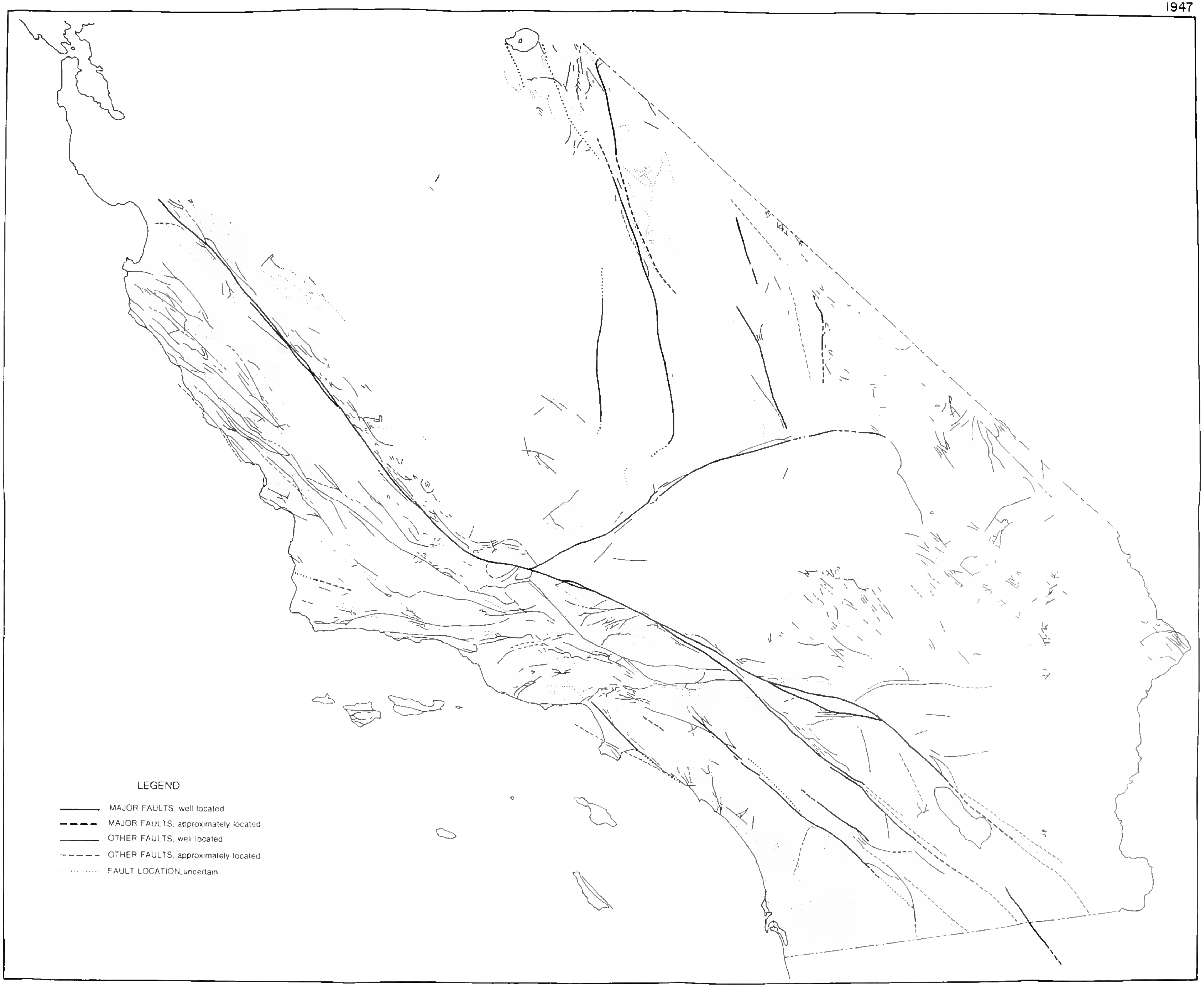
1. Burdell Mtn. F
2. Chico monocline F
3. Chino F
4. Coyote Creek F
5. Cristianitos F
6. Cucamonga F.
7. Dry Creek fault
8. Faults in Anderson Valley and Navarro R
9. Fault in Capay Valley
10. Fault at Diablo Canyon
11. Fault by Dunnigan Hills
12. Fault in Palm Canyon
13. Fault along San Antonio Creek
14. Fault at San Simeon
15. Fault on W side Panamint Va
16. Fault on W. side Saline Va
17. Johnson Va F
18. Kern Gorge F
19. Liebre-Clearwater F
20. Little Pine F
21. No Branch San Andreas F
22. Oakridge-Santa Susana F
23. Old Woman Springs F
24. Palos Verdes F
25. Pipes Canyon F
26. Rinconada F
27. Rogers Creek-Healdsburg F
28. San Fernando F
29. San Francisquito F
30. San Gabriel F
31. San Gabriel F
32. Sierra Madre F
33. Tolay F
34. Tularcitos F

LEGEND

———	ACTIVE FAULT, well located
– – – –	ACTIVE FAULT, uncertainly located
········	PROBABLY ACTIVE FAULT
———	DEAD FAULT, well located
- - - - -	DEAD FAULT, uncertainly located
·	PROBABLE FAULT, location and character uncertain

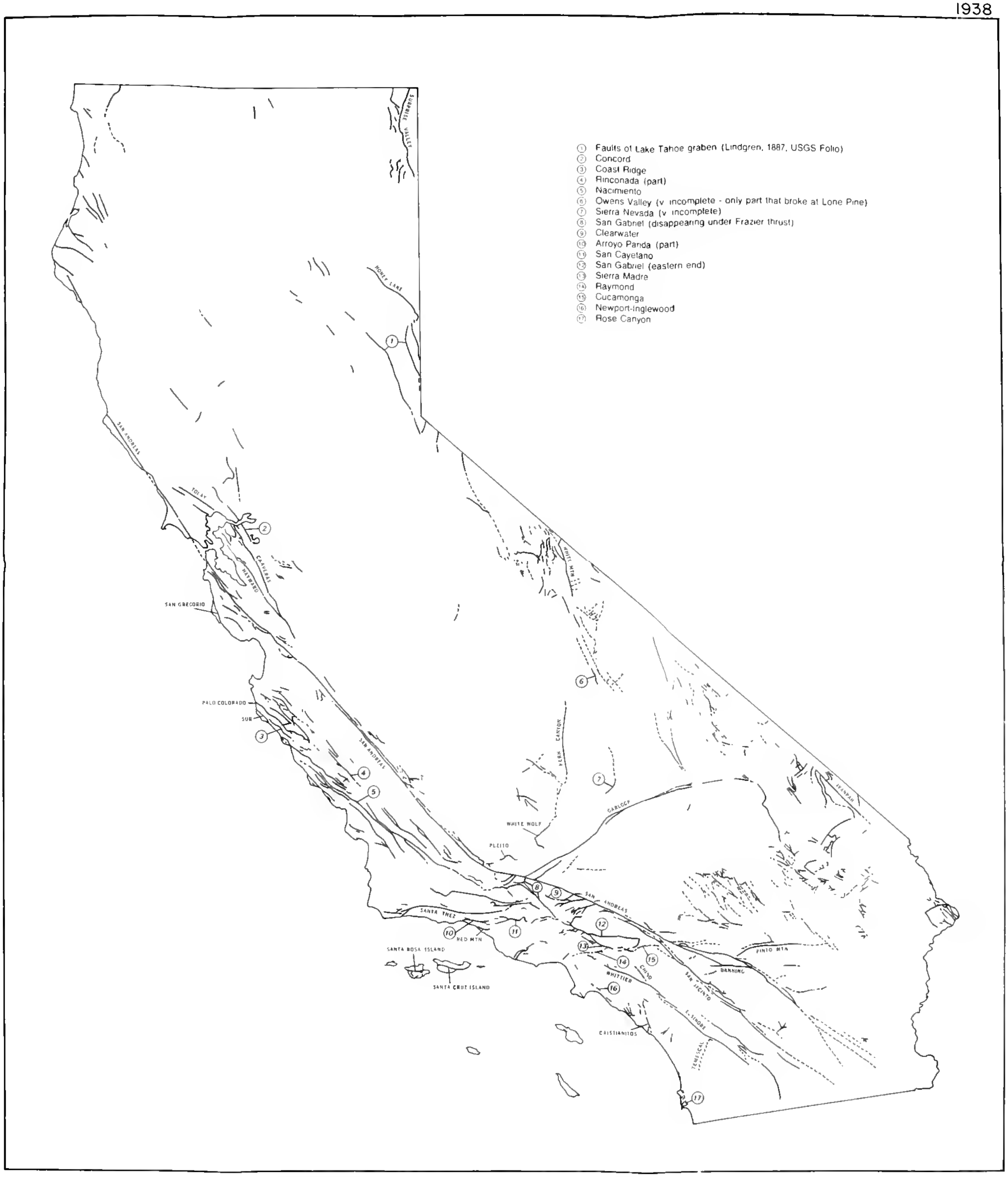
MAP C: Faults shown on the Fault Map of California compiled by B. Willis and H.O. Wood and published by the Seismological Society of America in 1922 at a scale of 1:506,880. Faults were not shown by name on the original map, but have been identified on this plate.

1947



MAP E: Fault map of southern California (here slightly generalized) compiled by H.O. Wood. Faults were taken largely from the 1922 Fault Map of California and the 1938 Geologic Map of California. This fault map (with epicenters) was published in the Bulletin of Seismological Society of America, July 1947.

1938



MAP D: Faults shown on the Geologic Map of California published in 1938 at 1:500,000 scale. This reduced version, showing faults only, includes all those faults shown on the larger scale map. Faults were not shown by name on the original map, but have been identified on this plate.