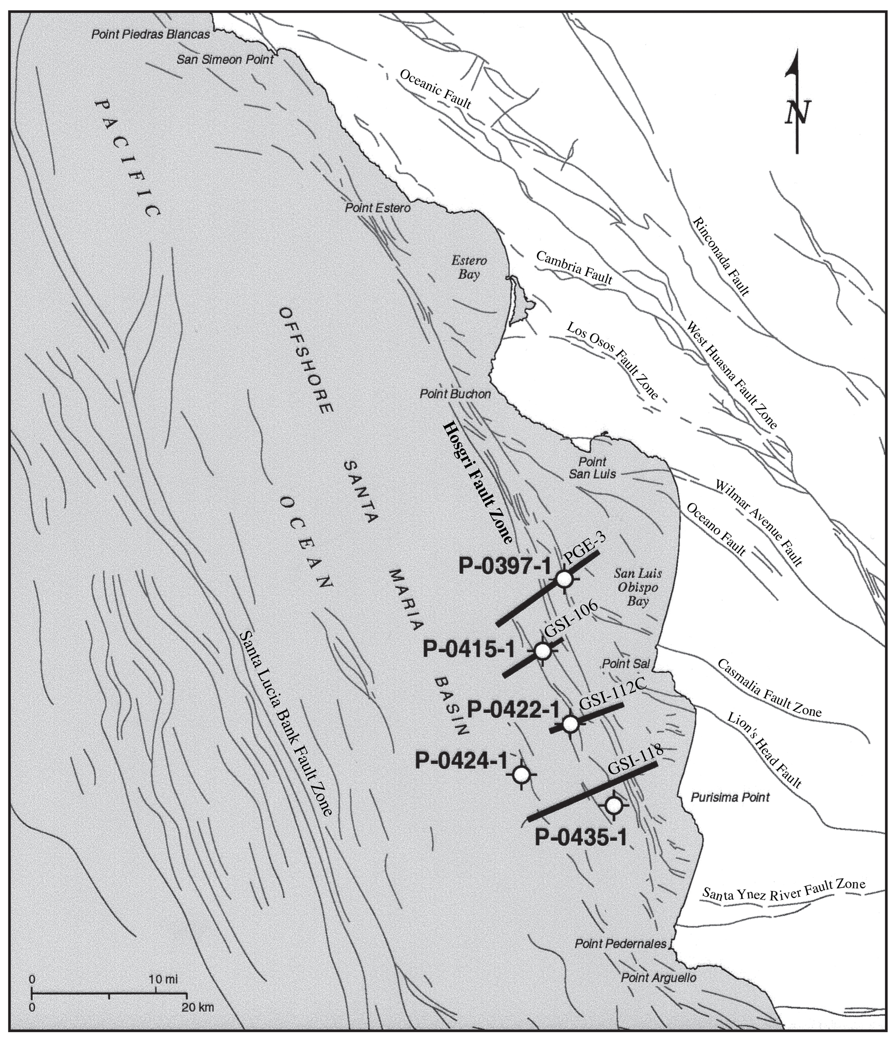
CORRELATION BETWEEN WELL LOGS AND SEISMIC REFLECTION DATA

The accompanying illustrated data are from five wells and adjacent seismic lines along a 35-km reach of the offshore Santa Maria Basin. These data illustrate structural and stratigraphic relations and are similar in content and character to data from the 29 wells used to establish our seismic stratigraphy, onshore-to-offshore correlations, and chronostratigraphy. The well and seismic line locations are shown in the index map. The seismic line locations are shown on plate 1, and all 29 well locations are shown on plate 2. The well logs available for this study are summarized in table 2.

The well logs are used to generate a synthetic seismogram that simulates seismic reflection patterns expected at the well site. A general knowledge of the regional velocity structure derived from well check shots and seismic stacking velocity data allows approximate positioning of the synthetic seismogram patterns with respect to patterns observed on actual seismic data recorded near the well. After the approximate correlations are established, the synthetic seismogram is adjusted for best fit. Because the reflection patterns of the synthetic seismogram are associated with log responses at known depths in the well, a precise local time/depth relation can be established and the seismic signature can be determined for specific geologic events, such as unconformities. In the accompanying data, the synthetic seismograms are presented by embedding the synthetics at the projected well locations on the seismic lines. This method circumvents the difficulties that arise in correlating small portions of seismic lines with synthetic seismograms in areas of steep dip. The ability to observe overall character of the seismic data in the vicinity of the synthetic seismogram improves the quality of the correlations.

The standard units of measure for these types of data in the United States petroleum industry at the time the data were recorded are feet and seconds. All primary data in our well log database are in these units, and we used these units in the accompanying data. Metric units are used in the remainder of our report.

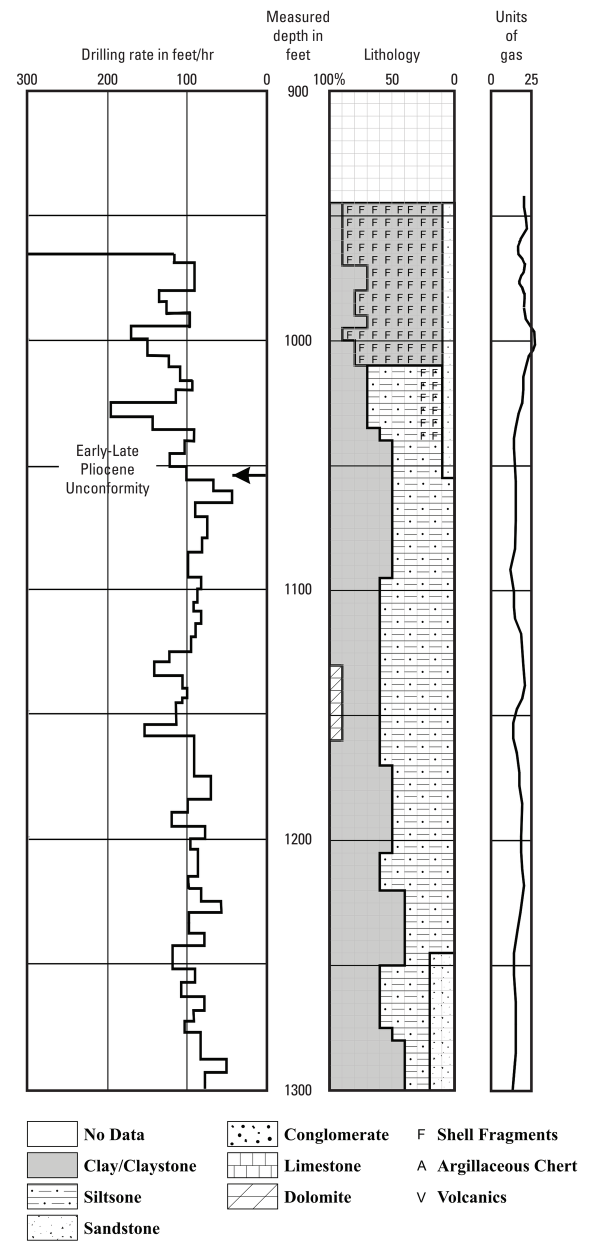


Index map showing well and seismic line locations

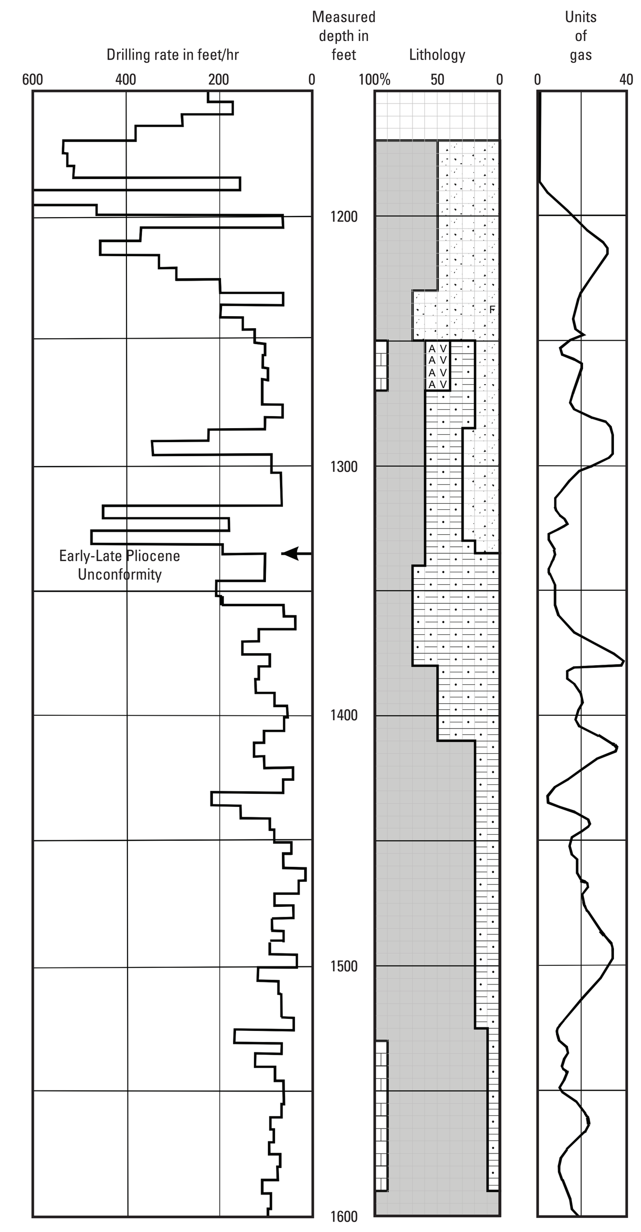
Mud logs, right. In most offshore wells stable log response does not begin until depths of 600 ft or more below the mudline. This is a result of mechanical considerations in offshore well design and the mechanics of borehole logging tools. Therefore the early-late Pliocene unconformity is not recorded in the log suites from many of the wells cited in this paper. However mud logs, which contain geologic descriptions of cuttings from the drilling process and records of rates of penetration, are commonly recorded at shallower depths and are often diagnostic of changes that can be correlated with the shallow rock units.

The two mud logs (right) are sections of the uppermost parts of wells P-0397-1 and P-0424-1 and show drilling rates, lithology, and units of gas. A common response to drilling through the early-late Pliocene unconformity is a general decline in drilling rate from greater than 200 feet/hour to a range of 80 to 150 feet/hour. Lithologic changes are also sometimes diagnostic. In well P-0424-1 the sandstone unit that occurs in the depth range of 1,150 to 1,340 feet is not time-correlative with similar onshore lithologies.

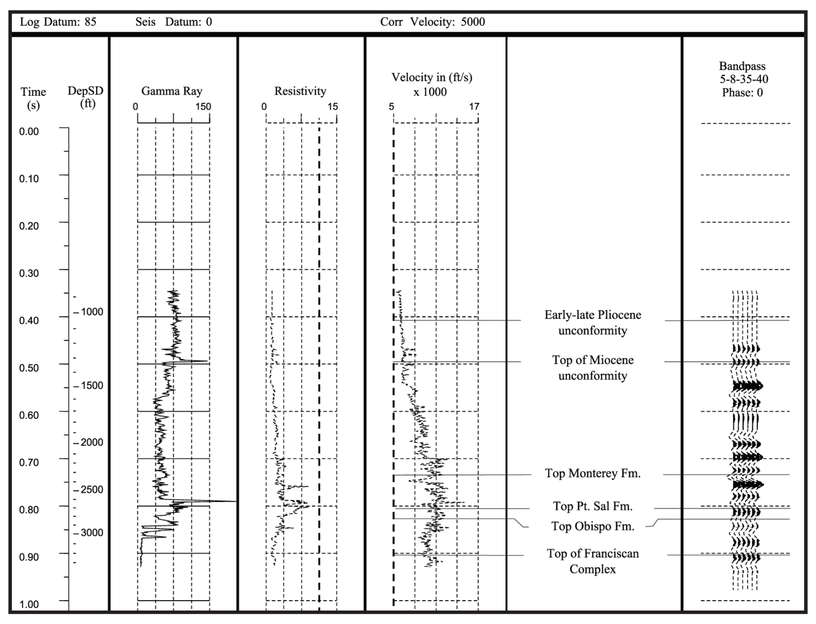
Mud Log, Well P-0397-1



Mud Log, Well P-0424-1



Well Logs and Synthetic Seismogram, Well P-0397-1



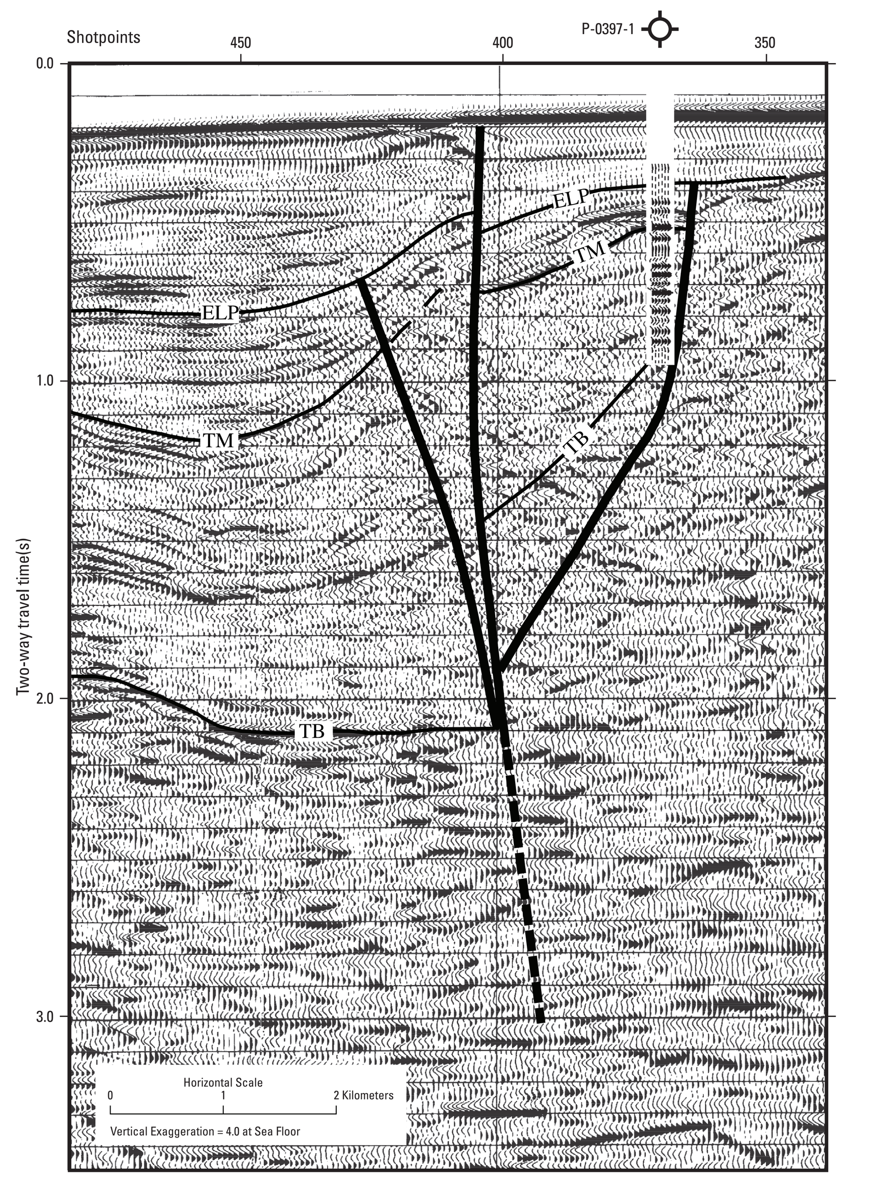
Well P-0397-1 is the only well in the offshore Santa Maria basin that was drilled on the east side of the Hosgri Fault Zone. The correlation of this well with nearby seismic lines establishes the seismic character of the top of Miocene and the top of pre-Miocene basement unconformities on the east side of the fault zone. In this region, the Hosgri Fault Zone displays a near-vertical trace to reflection times of 2 to 3 seconds. Correlation of top of pre-Miocene basement unconformity reflectors on opposite sides of the fault indicates that over 850 m of basement displacement occurs across the fault zone in this area.

SEISMIC LINE EXPLANATION

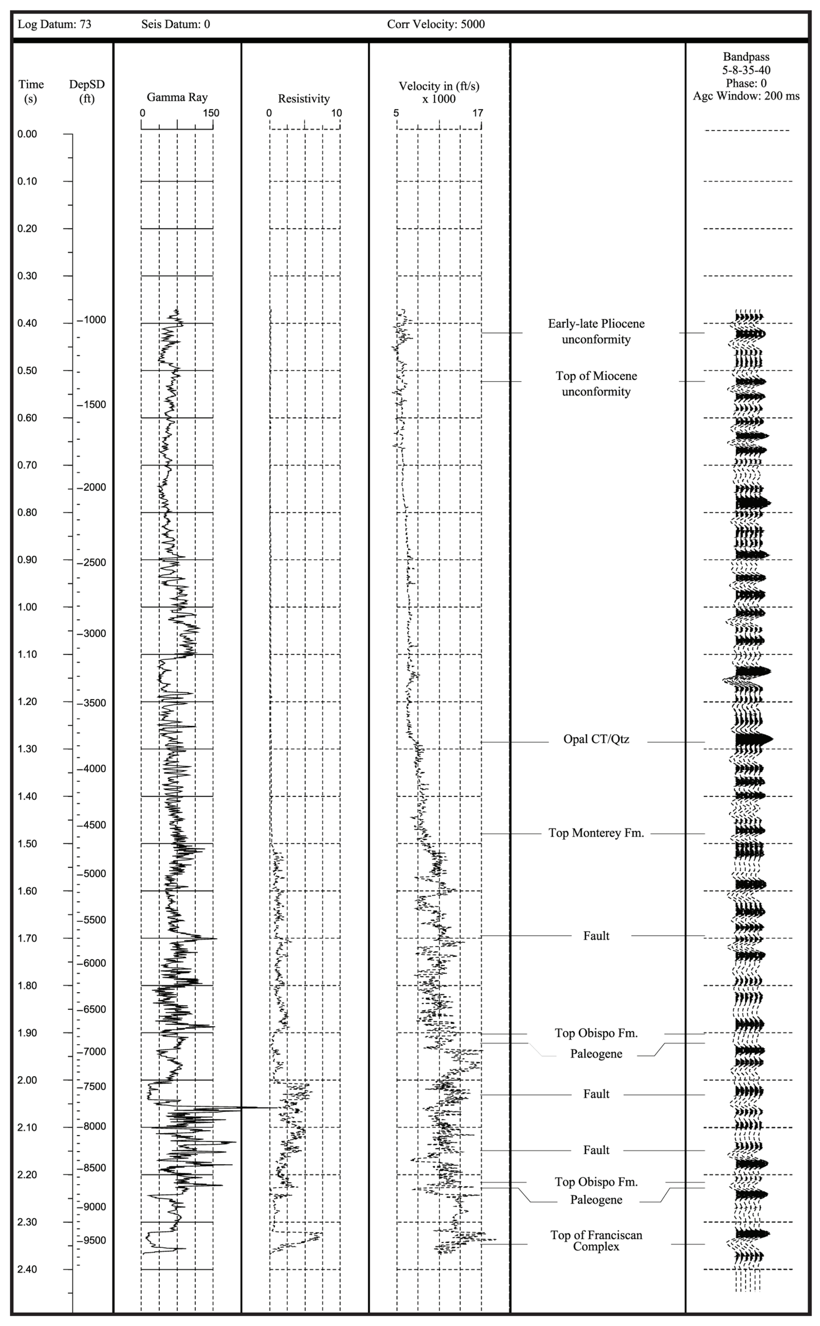
[Labels on the seismic sections indicate three basin-wide unconformities that are mapped in this study]

ELP	Early-late Pliocene unconformity
TM	Top of Miocene unconformity
TB	Top of pre-Miocene basement unconformity
	Faults, arrows show direction of relative movement on low-angle detachments

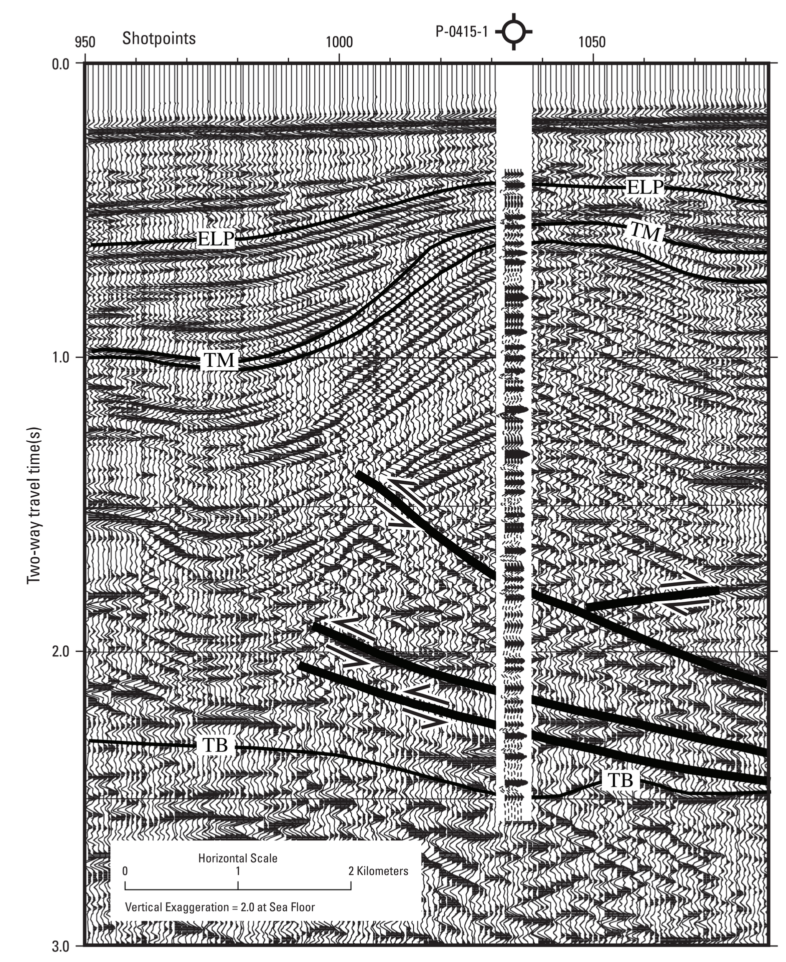
Seismic Line PGE-3



Well Logs and Synthetic Seismogram, Well P-0415-1

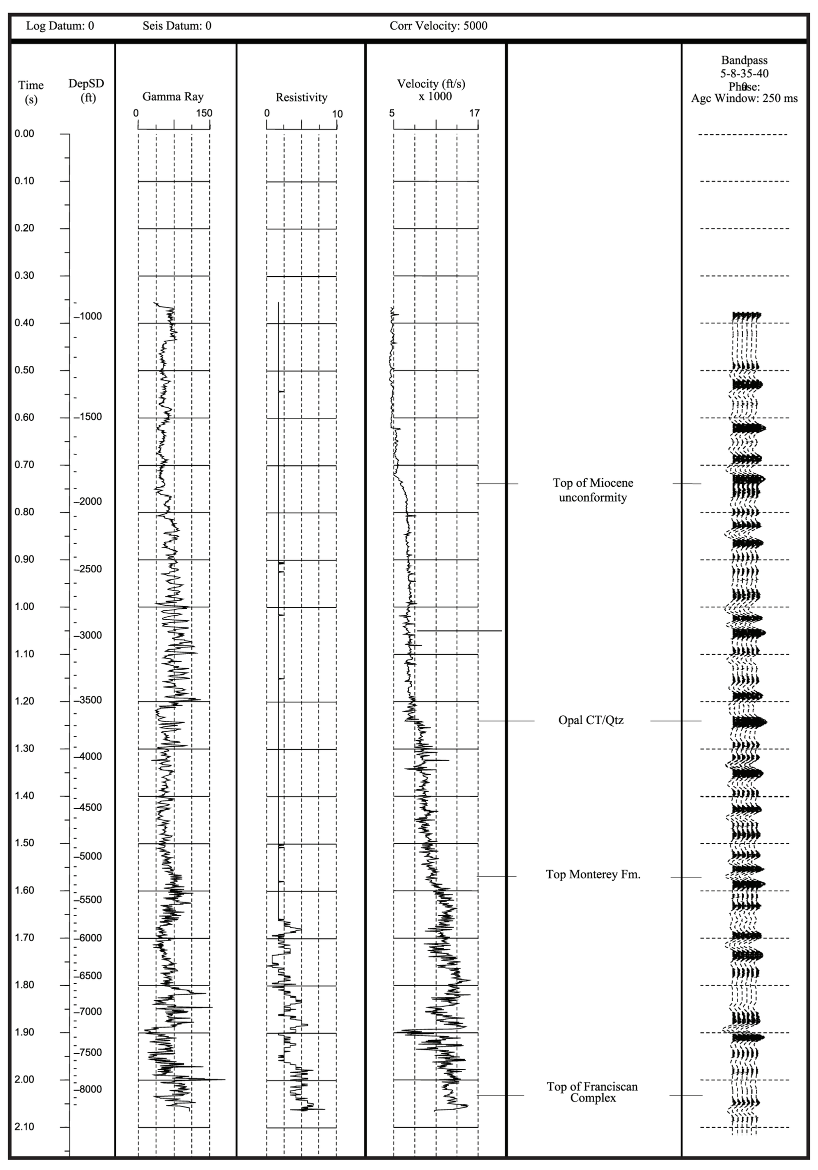


Seismic Line GSI-106

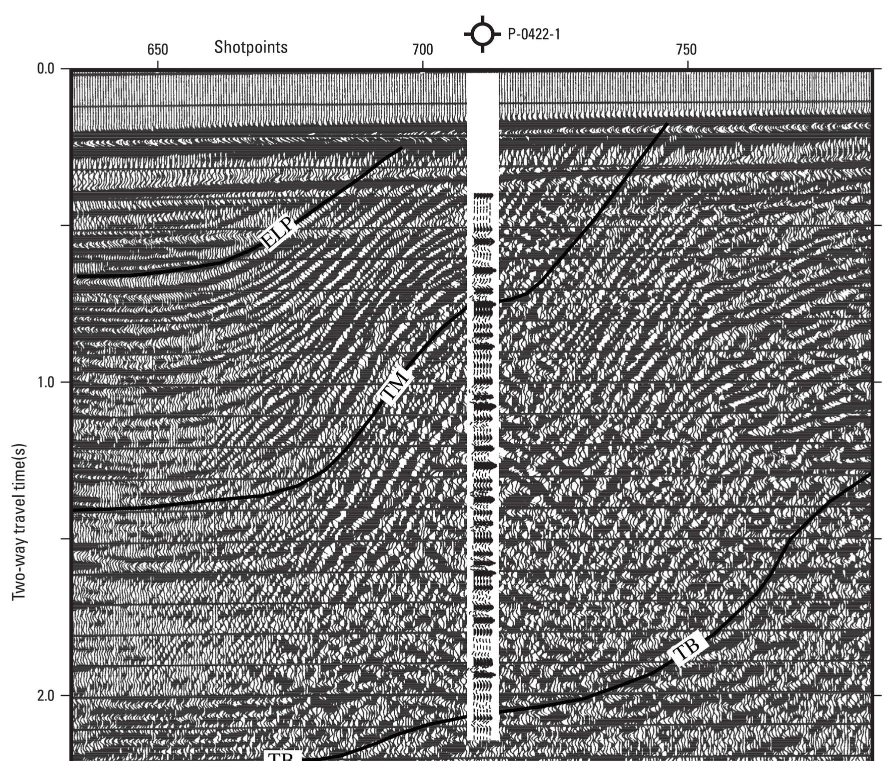


Well P-0415-1 penetrates a complexly folded part of the Purisima structure. Other wells along this structure include P-0415-2, P-0416-1, P-0422-1, and P-0435-1 (pl. 4). The well log data and seismic section both indicate multiple overthrusting in the basal portions of the fold. Formation tops and other horizons were identified through a combination of paleontological control, log analysis, and correlation with regional seismic signatures. The opal CT-to-quartz diagenetic transformation boundary is a prominent reflector at 1.3 seconds at this well. The top of pre-Miocene basement unconformity is a strong reflection even on this part of the section. A comparison of this reflection character with the same unconformity on lines GSI-112C and GSI-118 (below) illustrates the variability of the seismic signature of the basement.

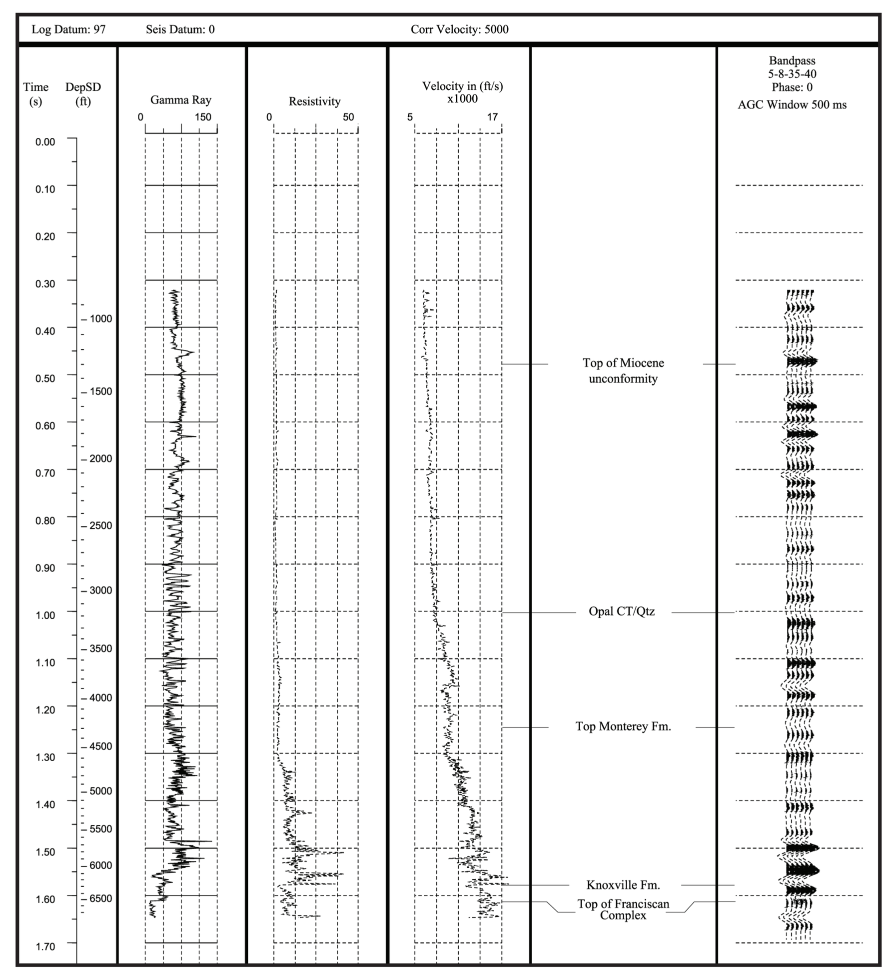
Well Logs and Synthetic Seismogram, Well P-0422-1



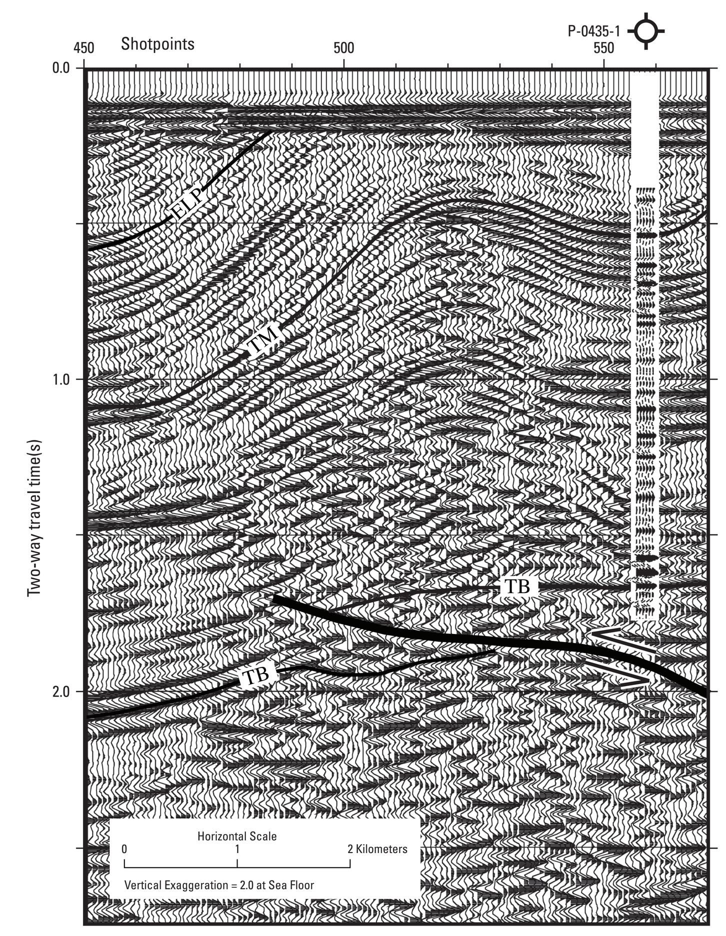
Seismic Line GSI-112C



Well Logs and Synthetic Seismogram, Well P-0435-1



Seismic Line GSI-118



Well P-0435-1 is approximately 3 km south of line GSI-118 and is projected into this line using the southeast trending line GSI-111 (pl. 1). The opal CT-to-quartz diagenetic transformation boundary is associated with a seismic doublet in the synthetic seismogram and seismic section. The associated reflector crosscuts folding on the flank of the Purisima structure. The doublet is at 1.05 seconds at the well on the right hand side of the record and at about 1.45 seconds at shotpoint 450 on the west side of the record. This time difference represents an approximate 500 m difference in elevation across the fold (based on an average velocity of 2638 m/s for the Miocene, figure 10). This suggests significant differential displacement across the fold since the time of formation of the boundary. The basal Monterey Formation and the Knoxville Formation, not the top of Franciscan Complex, form the high-amplitude reflections near the base of the synthetic seismogram and on the seismic record. At this location the Knoxville Formation reflector is the top of pre-Miocene basement unconformity.

Well P-0422-1 is drilled through a complexly folded part of the Purisima structure. It is on the southwestern flank of the structure and the well is important in establishing the stratigraphy in this area. It also aids in the mapping of seismic horizons from the less deformed areas of the offshore Santa Maria basin to the west and northwest into the folds of the Purisima structure. The opal CT-to-quartz diagenetic transformation boundary is associated with an overall increase in the rate of velocity increase with depth beginning at about 3700 foot depth on the velocity log. A similar increase is also apparent at this boundary on the velocity logs for wells P-0415-1 and P-0435-1.

Correlation Procedures Between Well Logs and Seismic Reflection Data

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