USING IODP E312 VERICAL SEISMIC PROFILES TO INVESTIGATE SUB-BASEMENT REFLECTIONS IN MULTI-CHANNEL PROFILES

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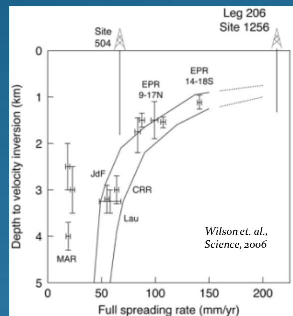
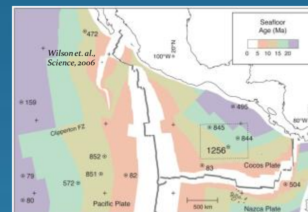
ABSTRACT

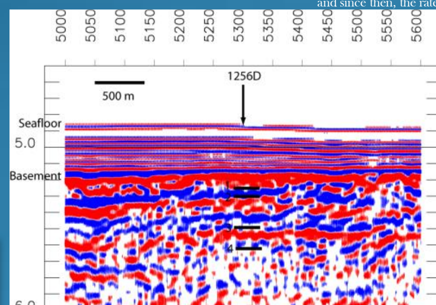
The Ocean Drilling Program (ODP) initiated drilling at Site 1256D in the Guatemala Basin, about 1000km off the East Pacific Rise to penetrate plutonic rocks, anticipated to be relatively shallow in this region formed at an ultra-fast spreading rate. IODP Expedition E312 successfully drilled into gabbros at ~1150m in basement. Multi-channel seismic traces, although not processed for the purpose, show weak laterally-coherent sub-basement reflections at borehole depths. The negative results of the vertical seismic profile are consistent with the topography of geological horizons on horizontal scales less than the Fresnel Zone (~300m). This expedition is the first penetration through volcanic extrusives and dikes into plutonic basement. In such a setting, sub-basement reflections, if present, would have been accurately measured. Absence of such observations in this area strongly suggests that lava flows and igneous contacts in upper ocean crust have significant topography on lateral scales <300 m due to igneous and tectonic processes.

Reflection and Refraction Data from ODP - R/V *Maurice Ewing*,1999 - used to generate, process, interpret MCS Profiles along the Flowlines and Isochrons in the central part of the Cocos Plate, Eastern Pacific Crust (15 Ma). *Hallenborg et al ,2003* documents the findings of a large number of bright reflectors (Upper and Lower Crustal) in this area, typically 1-5km in lateral extent, something not seen near the axis of the EPR.

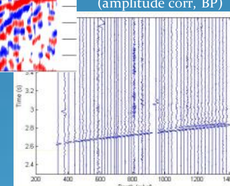




Though a large number of experiments have been performed along and near the axis of the East Pacific Rise, relatively few have investigated the mature (>5 Ma) fast spreading crust in settings where crustal evolution can be studied without interference from geologic complexities. The EPR segment being examined was formed by ultra-fast spreading (~200mm/yr) along the Cocos-Pacific boundary during 11-18 Ma.The era of ultra-fast spreading ended at 10-11 Ma after the formation of the Panama Transform Fault over the CNS and since then, the rate has slown to 140 mm/yr.



LEFT: Hole 1256D- Dashes mark VSP travel times to lithologic boundaries described in *Wilson et al. (2006)*: (1) top of Inflated Flows, (2) top of Sheet and Massive Flows, (3) Transition Zone, and (4) top of Plutonic section.
BOTTOM: VSP data from this Hole from drilling survey E312 (amplitude corr, BP)



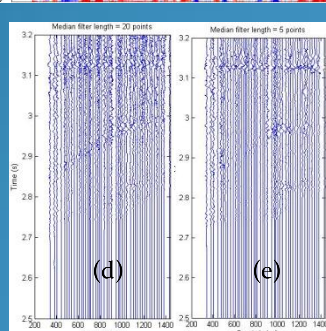
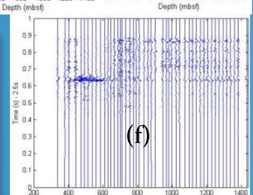


Figure (d), (e):Results of a 20 and 5 point median filter on the spherical divergence corrected VSP seismogram on which an F-K filtering has been performed to remove the DGW. Median filtering, in addition wipes out the remnants and also removes solitary glitches instead of smearing the noise. (f) Final processed, filtered seismogram. The DGW has been removed, but no inclined up-going wave is seen above the vertically coherent noise levels. This seismogram has been amplified to 5 times more gain that the other figures to mark the visible absence of the UGW.



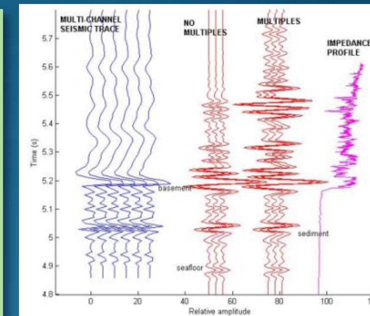
In such a setting, sub-basement reflections, if present, would have been accurately measured. Absence of such observations in this area strongly suggests that lava flows and igneous contacts in upper ocean crust have significant topography on lateral scales <300 m due to igneous and tectonic processes (as fresnel zone ~ 200m).

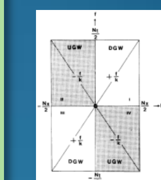
DISCUSSION

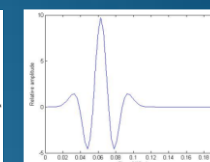
Lack of reflected energy in the VSP seismograms indicates that the laterally coherent reflections in the MCS profiles are likely artifacts of processing. The geophones of the VSP survey are all placed below the basement so cannot record any of the dependable reflections above it, which could serve as yardsticks to analyze the approximate amplitude of reflected energy at the survey area. If this were available, an appropriate contour level could be defined below which noise level could be eliminated.

SYNTHETIC SEISMOGRAMS

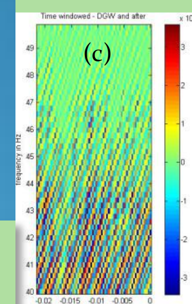
A frequency domain synthetic seismogram generation was implemented for a sample interval of 1 ms and a maximum modeled time of 8s. No attenuation was included. Source was a Ricker wavelet of delay 4.5s. Figure shows that the waveforms of the MCS traces within the sediment section differ from the waveforms within the basement. Though smoother than the MCS peaks above basement, the small amplitude ripples below the basement reflection may be significant. The synthetic seismograms show a significant peak at time = 4.9s and 5.2s, due to the sea-floor and basement reflections respectively, coherent with features at similar times in the MCS traces. The red synthetic traces show sub-basement peaks in amplitude at time = 5.3s and 5.45s, visible above the noise and multiple levels due to its amplitude being comparable to the sea-floor reflection at 4.9s. Based on the difference in frequency content and amplitude, we infer that the portion of the MCS seismograms from above the basement were processed differently than the portion of the MCS seismograms from below the basement surface, which could be a possible cause of the absence of peaks similar to the sea-floor reflection even below the basement.

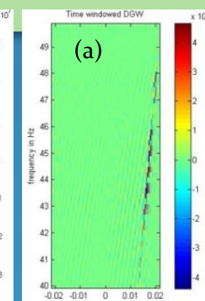






Ricker wavelet source





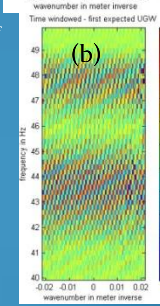


Figure (a) : F-K spectra of the down-going wave (time windowed from 2.6s to 2.9s). (b) Spectra of the seismogram, time windowed from 2.9s to 3.2s i.e. 0.3s after the DGW to check traces of an immediate UGW from the bottom of the hole. (c) F-K spectra of Time windowed (beyond 2.9s) seismogram after median filtering to pick out only the Up-going wave., i.e. spectra after the entire processing sequence.

VSP PROCESSING SEQUENCE

- •Application of statics correction to arrange all the traces after incorporating their respective delay times.
- •Spherical divergence correction of amplitudes by fitting an exponential curve of the form - to the data, by finding the best-fit where r is the source-geophone offset. The difference of the observed amplitudes and theoretical curve values at each offset served as corrected amplitudes (linear ramp gain compensation).
- •Low pass filtered to 80Hz using a 3-pole, minimum phase Butterworth filter.
- •Considering an average velocity of 5km/s in the borehole region, the reflections from the bottom of the hole would reach the shallowest geophone would reach at about 3.2s. For initial processing stages, data at times < 3.2s were considered and the data beyond was muted and replaced by the mean on the time-trace.
- •Tapered zero padding to double the length of the seismogram. F-K filtering to remove noise in the positive quadrants, in the down-going wave.
- •Median filtering (5 point)to remove noisy spikes, bubble pulse, remnants of the down-going wave.
- •Median filtering of the resultant seismogram to output any up-going components, if present.
- •Tapered zero-padding and F-K filtering of the up-going component to interpret any significant energy in the F-K spectra.

REFERENCES

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