. Picking of the strong energy arrivals selected in the two components of Uphole 1. Red dots correspond to the vertical component and black crosses to the horizontal.

An experiment on Near surface S-wave velocity from upholes

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SUMMARY

Data from two uphole surveys are analyzed here to obtain the near-surface S-wave velocity model. It was assumed that the S-wave events analyzed were generated by the source. Support for this claim is provided. Variations in the velocity model with depth were related to lithological characteristics. Differences between the two upholes can also be related to the geology at each location. Complex behaviour of the S-wave field was also identified, which could give useful details about the S-wave field structure. The uphole data were also compared to data from a 2D seismic line acquired at the same place. The latter gives indications about the characteristics of probable S-wave refractions. However the frequency content of the land data is much lower, and the complex variations noticed in the uphole data are simply part of the ground-roll here.

INTRODUCTION

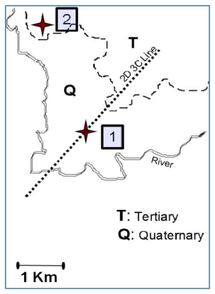
A near-surface velocity model of the S-wave could contribute to improve the near-surface correction, applicable to better processing of Converted waves in land.

The S-wave near-surface velocity model can be obtained from shallow boreholes and from surface seismic data. Surface seismic methods, using surface waves and refractions, have limitations such as low resolution and difficult event picking.

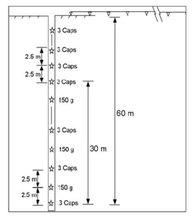
Borehole based surveys allow to relate the velocity information to depth and to lithological properties. Two kinds of borehole surveys are used, downhole, with sources at the surface and receivers inside the borehole, and uphole, the other way around.

This work explores the uphole information to obtain a better velocity model for the near-surface S-wave propagation, and for converted wave processing. It is based on field data acquired by Ecopetrol S. A. in Colombia.

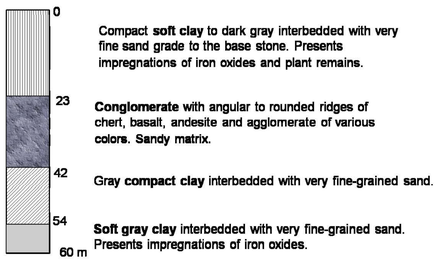
FIELD LAYOUT



Upholes Location, identified by numbers. Notice the difference in the geological settings , and the 2D 3C seismic line.

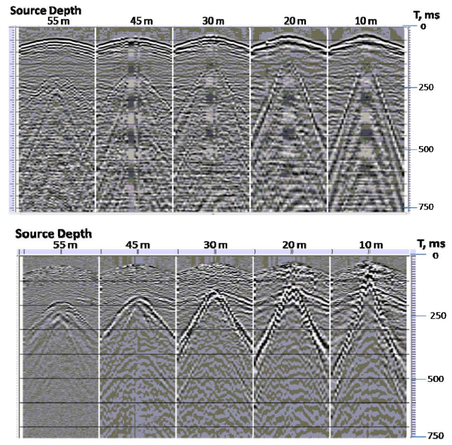


Approximate profile of the boreholes, showing the typical sources distribution and charge.

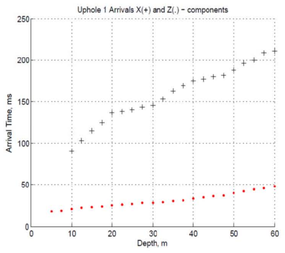


- Stratigraphic profile of borehole 1 from drilling cuttings.

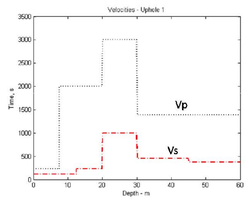
FIELD DATA AND VELOCITY MODEL



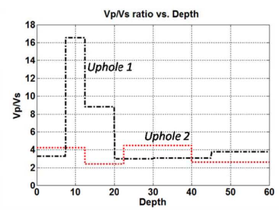
Records from Uphole 1 for some selected source depths.
Top: Vertical Component. *Bottom:* Horizontal component.
The strong event on the horizontal component was selected for S-wave analysis.



Picking of the strong energy arrivals selected in the two components of Uphole 1. Red dots correspond to the vertical component and black crosses to the horizontal.



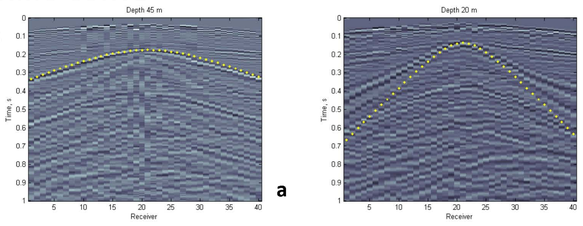
The velocity model for P- and S-wave vs. Depth for the uphole 1. Notice the increase of Vp velocity at about 8 m depth and on Vs at about 20 m and compare with the lithology.



Variation with depth of the Vp/Vs ratio for both upholes.. Notice the larger values in uphole 1.

TEST OF Vs USING THE NMO CURVE

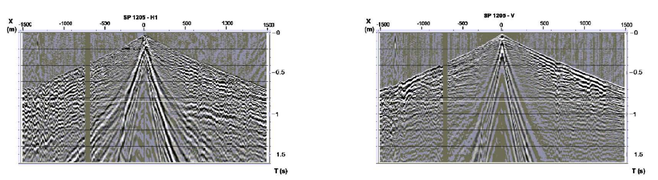
The NMO Dix equation was used to test the S-Wave velocity model



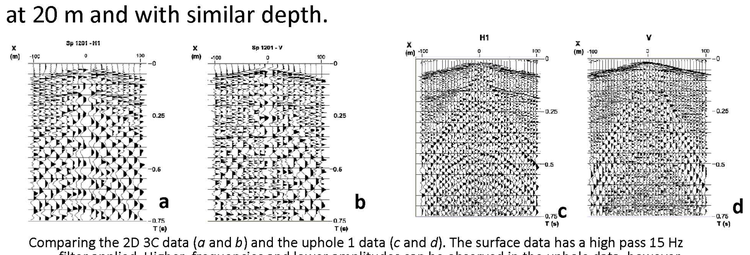
Comparing arrivals of the event in the horizontal component with the arrivals calculated according to the NMO equation for source depths of 45 m and 20 m.. The stronger energy corresponds to a higher velocity event at 20 m, which can be a refraction from the 24 m interface.

COMPARISON WITH SURFACE DATA

- Uphole 1 data of 7.5 m depth was compared with a Shot gather located at 20 m and with similar depth.



Shot gathers of the 2D 3C seismic line, shot at .20 m of uphole 1. Left: Horizontal component. Right: Vertical component. Notice the differences in the low velocity cone. The source of energy has 2700 g.



Comparing the 2D 3C data (*a* and *b*) and the uphole 1 data (*c* and *d*). The surface data has a high pass 15 Hz filter applied. Higher frequencies and lower amplitudes can be observed in the uphole data, however the horizontal components (*a* and *c*) and the vertical (*b* and *d*) have resemblance.

DISCUSSION AND CONCLUSIONS

Events on the horizontal component that appear as S-waves generated at the source enabled us to obtain a near-surface velocity model for the upholes.

S-waves generated by an explosive source of energy inside of the boreholes:
Support: Shown theoretically (Heelan, 1953; Lee and Balch, 1982).
From amplitude analysis: Generated as P-wave at the source and converted to S upon its transmission through an interface. Low energy. Transmitted S-wave energy of an incident S-wave: high energy. (Muskat and Meres, 1940).
Test using the Dix NMO equation.
Published works (e. g. White and Sengbush, 1963; Lash, 1985).

Resolution: If the velocity is 150 m/s, the wavelength would be 5 m for 30 Hz. It can be the order of magnitude of the near surface geological variations that can affect waves from deeper layers.

The S-wave velocity model:
Picking of this event is more difficult and prone to errors than the FB picking used for P-waves, specially for depths shallower than 15 m. So, there is uncertainty in the resulting velocity models, and reduced resolution.

Comparing to surface seismic data: surface data shows lower frequency and stronger amplitude. A strong event on the surface seismic survey, identified as a refraction, can be generated by S-wave energy generated at the source.

Velocities and Lithology: The velocity model of uphole 1 agrees with the lithological profile available. Differences between the two upholes can be related to the geological setting of each one.

Future Work: Techniques like geological modeling, and tomography could help interpret the information from the two surveys. Also inversion of the uphole data can contribute with additional information and a velocity model with more resolution.

- **ACKNOWLEDGEMENTS**
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