Static correction from First Break for onshore VSP data

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Keywords

Static Correction, VSP data, Simulated Annealing, First Break

Summary

Methodology is developed to calculate source Static for VSP data using first break. A synthetic model for near surface and sub-surface is used to generate synthetic first break for VSP. Source static is calculated by using proposed methodology and found to produce good results.

Introduction

The main challenge while calculating static correction for VSP data is that, there may not be a pre-existing accurate near surface model for the shot point. Therefore nearest available (previously conducted) up-hole data is usually used. At times, the available up-hole data is far from shot location and because of undulating terrain and rapid lateral near surface velocity variations; it may not give satisfactory results. The problem worsens when the well is deviated, because then the shot points move along the deviation maybe up to 700m. In such cases previously conducted up-holes may not be able to produce proper statics. Therefore a methodology has been developed and tested on synthetic models to calculate statics from first break of VSP data, and is independent of near surface models prepared by using up-holes.

Method

Methodology discussed in this paper is an attempt to remove the effects of topographic undulations and near surface complexity in order to calculate source statics from VSP data. This method exploits the fact that often there are multiple closely spaced receivers recording for a single source in VSP operation.
Since the ray path travelled by these rays from source to datum is close, they are assumed to be a single ray.

In the discussed method, static for each source point is computed individually. The complexity in near surface from source to datum is replaced by a single velocity *Vnsm*, such that the time travelled by ray in near surface from source is same if the velocity were to be *Vnsm*. Also, the complex sub surface, i.e from datum to geophone is replaced by a single velocity *Vsub*. Next step is to pick first break of VSP data accurately. For this purpose, method described by *Vishwakarma* (2018) is used.

This provides observed first break. Since, the height of source point from datum and depth of receiver from datum can be derived; required source static can be calculated if *Vnsm* and *Vsub* are predicted. To achieve this, the error between observed first break time and calculated first break time is minimized using Simulated Annealing algorithm in which various *Vnsm* and *Vsub* are tested.

However, non-uniqueness of inversion tends to estimate different values of velocities. Therefore, upper and lower bounds of these velocities were fixed to restrict the search space, in order to reduce the probability of generating the non-unique results. There are multiple receivers active for a single source, hence we have used first break from all those receivers to further constrain our search for *Vnsm* and *Vsub*. The flowchart in figure 1 explains the proposed methodology.

Following are steps involved:

1. Pick first breaks of VSP data
2. Import Shot and receiver information
3. Fix upper and lower bound for *Vnsm* (usually near surface velocity varies from 4000m/s to 2000 m/s)
4. Fix upper and lower bounds for *Vsub*. To fix these bounds, we use observed first break times, shot elevation from datum and depth of receiver.

If

Shot Elevation	=	h_s
Depth of receiver	=	d_r
First break observed	=	*fb*

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Then

Average velocity (*Vavg*) = $(h_s + d_r) / fb$

Vavg acts as a lower bound for *Vsub* and upper bound for *Vsub* is taken as *Vavg*+ d*V* (d*V* is taken as 100m/s).

5. *Vsub* and *Vnsm* are initialized randomly and they are feed into simulated annealing, where the error between observed and calculated first break time is minimized.
6. Since multiple receivers are recorded for each source, *Vnsm* for all these receivers should remain the same (or should be very close to each other). Same is the case for *Vsub*. This condition on *Vnsm* and *Vsub* forces only those values of velocities which have minimum variance among them.

Example

In order to test the discussed method, a synthetic near surface (complex) and sub-surface model is taken as shown in figure 2. Receivers are placed inside the deviated well (black line shows deviation of well).

Shots are placed along the deviation of well. Synthetic first breaks (without reflection/multiples) were generated figure 3(a) using the model, assuming 3 receivers recording for each shot with 20m group interval.

After picking first break for the model, the *Vsub* and *Vnsm* were calculated for each shot. To achieve this, simulated annealing was run to optimize/minimize the error between *fb* and calculated first break. Once the condition mentioned in flowchart was met, *Vsub* and *Vnsm* were finalized and subsequently the source static was calculated.

Conclusion

The comparison between figure 3(a) and 3(b) shows that there is improvement in the deeper part of the VSP data. The proposed methodology works well throughout the data. There is some residual static observed at shallower level, which may be due to non-unique results of inversion. This methodology is proposed as another way to compute statics for VSP data.

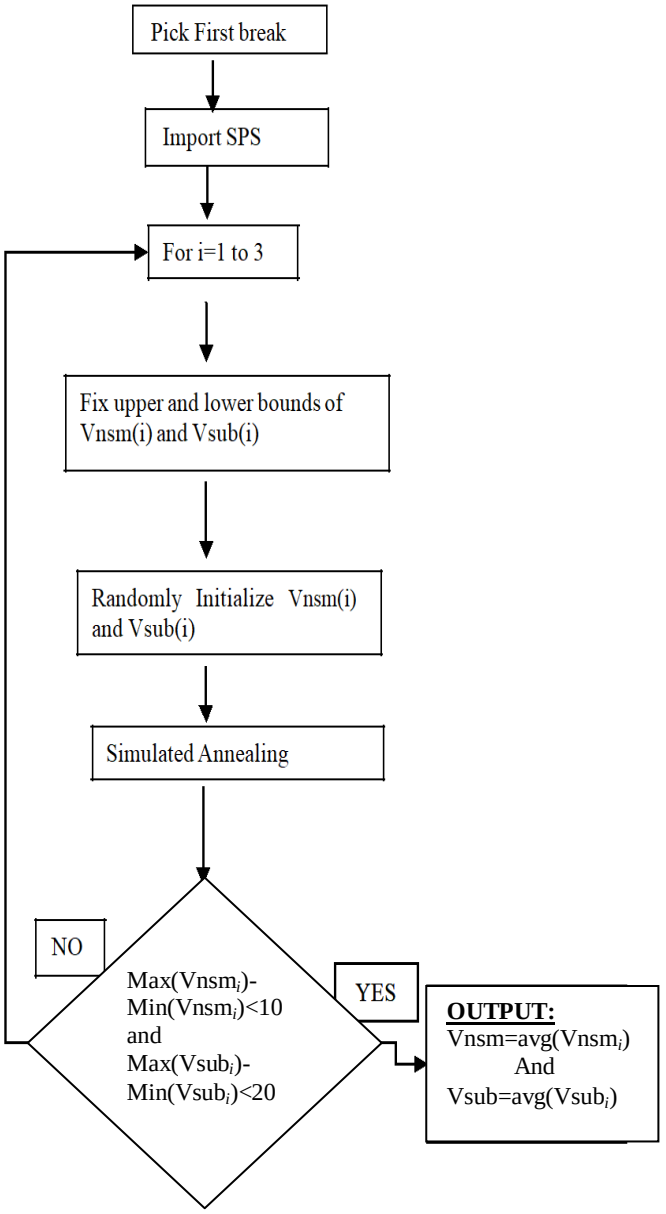

Figure 1: Flowchart to explain the steps involved

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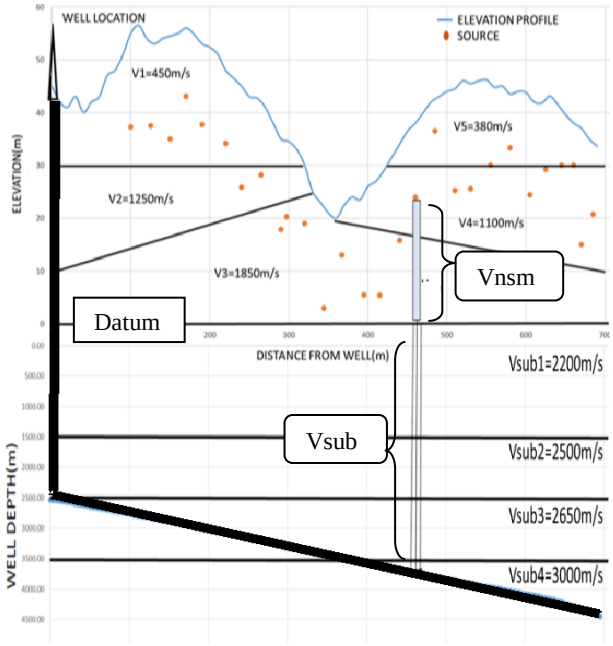

Figure 2: Synthetic model with elevation profile, source, well, receiver and near surface-sub surface model

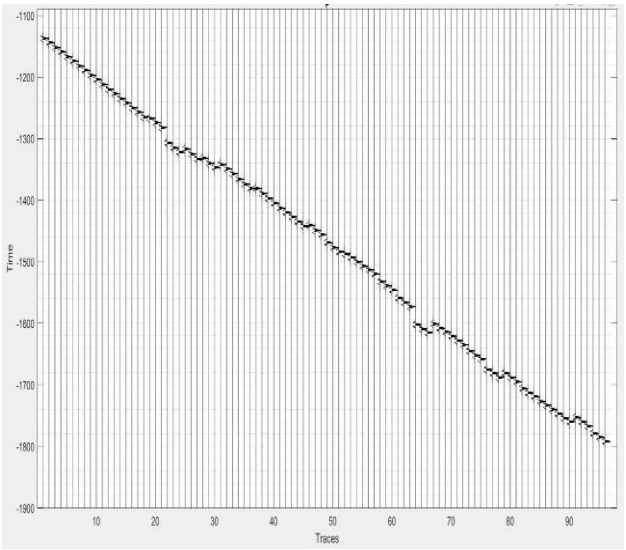

Figure 3(a) Synthetic first breaks for VSP generated (time in ms)

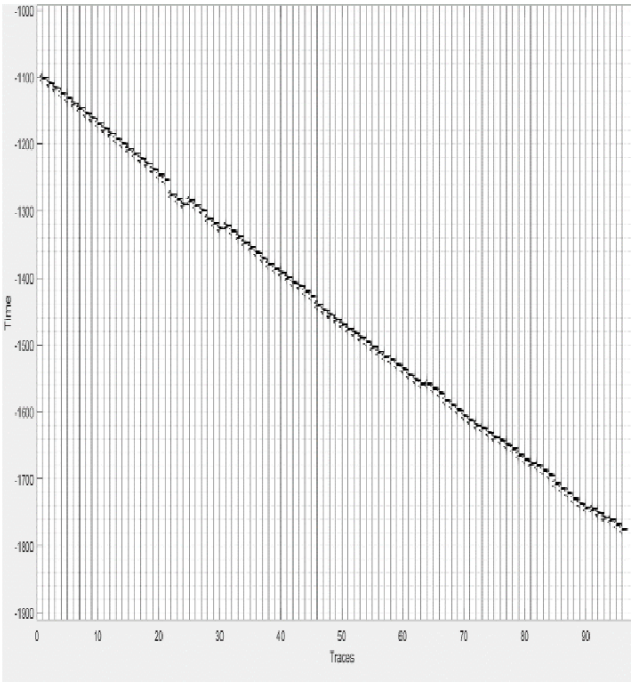

Figure 3(b) Statics applied to first breaks in figure 3(a) (time in ms)

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Views expressed in this paper are of authors only and may not necessarily be of ONGC.

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