Optimization of Multicomponent uphole Geometry

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Abstract:

In conventional 3D seismic survey data is collected at areal grid, two dimensions at the surface (x, y) together with depth (d) gives 3D seismic image of the subsurface. Compared to 2D seismic surveys 3D seismic survey provides better signal to noise ratio, accurate subsurface imaging, increased confidence in reservoir delineation, better estimation of Hydrocarbons. However determination of fracture density and orientation, lithological information, estimation of fluid content, gas identification is not possible just with 3D survey, Multi-component survey that records both P and S wave provides much information about all these. Multi component survey gives both P and S wave sections, combined interpretation of these two will give better characterization of subsurface geology. In processing of both P and S wave data statics play very important role. These statics are calculated from uphole survey. Uphole survey to calculate shear statics is done by 3C sensor (Vector-seis) and detonator as source. In this paper it is studied that offset required to faithfully map the near surface layers and calculate accurate shear statics in Multicomponent uphole data acquisition.

Introduction:

In General in 3D seismic data acquisition Upholes are conducted using geophone (single component) as sensor and detonator as source. Sources are placed along hole and sensors are on the surface at different distances (1 to 5m) from uphole location. First breaks from all the shots at particular sensor location are used to derive near surface velocity, which helps to decide the proper shooting medium. Velocities from different uphole locations are used to build a near surface velocity model that helps to calculate shot and receiver statics.

In multicomponent seismic data acquisition where the source is Explosive energy generated from source travels with P-wave velocity till conversion point and after conversion it travels with S-wave velocity till it reaches the receiver (Fig 1). Shear statics of the receivers plays a vital role in processing of Shear wave data. Compared to near surface P velocity, S velocity is small hence any small change in shear static velocity manifests into large static shifts. To calculate these shear statics shear velocity is derived from Upholes using 3-component sensor and detonator as source.

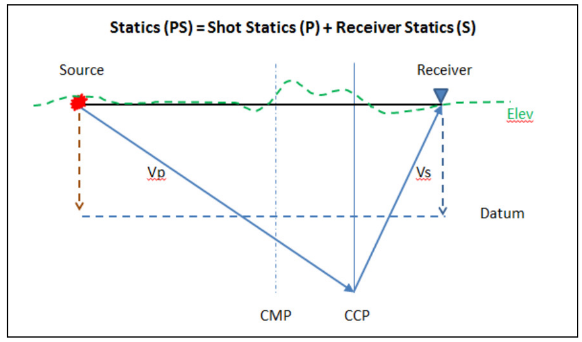


Fig: 01 Ray diagram of C wave recording

Methodology:

Recording of uphole with 3 component sensors offers a methodology to directly compute near surface shear wave velocity model in line with near surface P wave model. Initially the data was acquired in Gandhar and Kalol areas with the layout as fifty one 3C sensors (Vectorseis) placed on each side of source in two orthogonal receiver lines with group interval of 3m.

Later this Geometry is modified to 18 no of channels, each side of the source in Padra Ph-III area. In each limb first 6 sensors are separated by 1m, second 6 sensors are separated by 2m each and last 6 sensors are separated by 3m each (Fig 2). Amounting the total spread length in each limb to 36m from the uphole.

In both the lines sensors were oriented such that X component was parallel to horizontal line (Line-1) in the direction of regular receiver lines and Y component parallel to the orthogonal line (Line-2). Detonators were used as the source. Shots were recorded at an interval of 2m up to 14m depth and at 1m interval from 15 m to 40m depth. The uphole data can be considered as inverse VSP. The first arrivals in all the three components correspond to P waves.

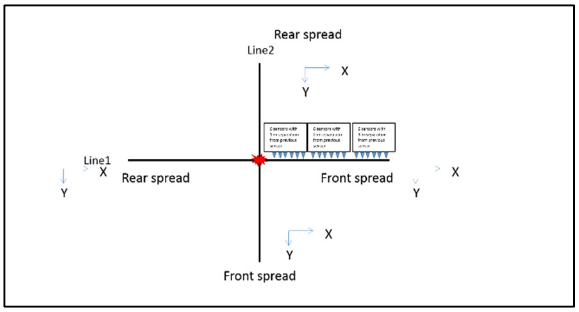


Fig: 02 field layout of Uphole Geometry

In the present paper it is studied the requirement of spread length in all the direction of the uphole. In earlier technical paper (Ref:1) it is established that the shear wave energy propagation is not same in all direction, hence recording of the data should be carried out in all the four directions.

Present study is carried out in an uphole in Jambusar 3D-3C area

For P-wave uphole plotting in general 3m offset (in any direction) sensor data is used, corrected first break values are plotted with depth, inverse of the slope gives the velocity of the medium. These velocities are used to decide optimum depth (OD) and P wave statics.
For S-wave plotting also we were using 3m offset data, but instead of first break, second major event observed in only X, Y component of the data is plotted after correcting for slant movement.

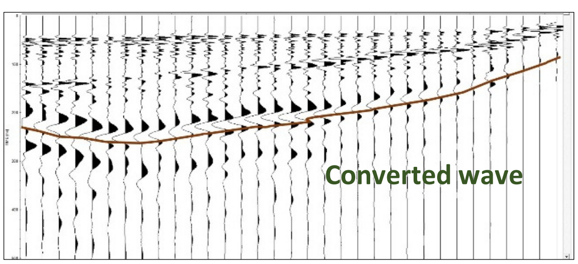
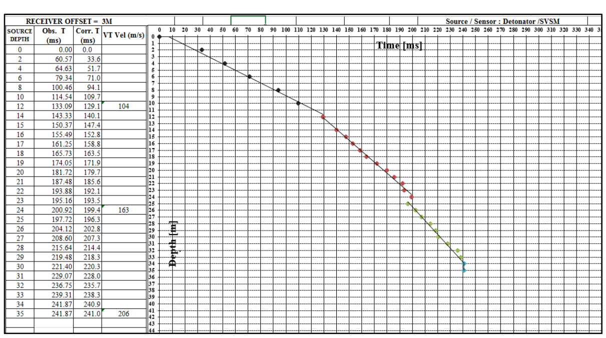


Fig: 03 Converted wave (X-component) data of the Sensor at 3m



SOURCE DEPTH	Obs. T (ms)	Corr. T (ms)	VT Vel (m/s)
0	0.00	0.0	
2	60.57	33.6	
4	64.63	51.7	
6	79.34	71.0	
8	100.46	94.1	
10	114.54	109.7	
12	133.09	129.1	104
14	143.33	140.1	
15	150.37	147.4	
16	155.49	152.8	
17	161.25	158.8	
18	165.73	163.5	
19	174.05	171.9	
20	181.72	179.7	
21	187.48	185.6	
22	193.88	192.1	
23	195.16	193.5	
24	200.92	199.4	163
25	197.72	196.3	
26	204.12	202.8	
27	208.60	207.3	
28	215.64	214.4	
29	219.48	218.3	
30	221.40	220.3	
31	229.07	228.0	
32	236.75	235.7	
33	239.31	238.3	
34	241.87	240.9	
35	241.87	241.0	206

Fig: 04 plot of x component data at offset 3m

Plot of converted wave at three meter after correcting slant movement shows that there a 3 layers at this uphole location. First layer with velocity 104 m/s from 0 to 12 m, second layer with velocity 163 m/s from 12 to 24 m and the third layer with velocity 206 m/s

In the same way converted wave data (X component) of different offset is plotted (up to 35m depth).

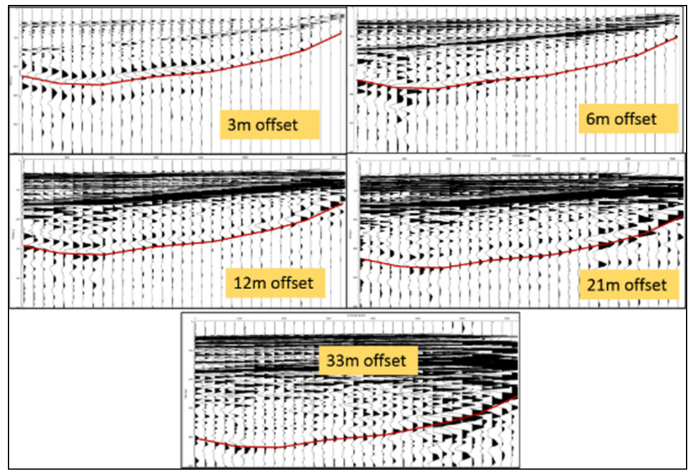


Fig: 05 Converted wave highlighted in different offset data

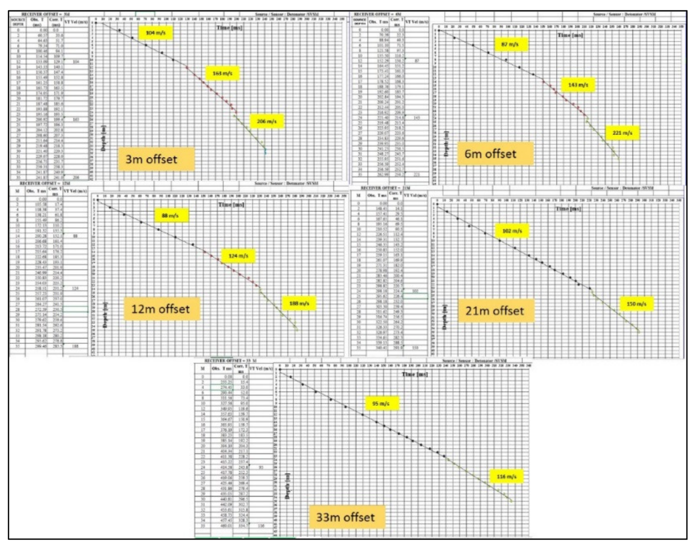


Fig: 06 Uphole plot of X component with different offsets

Plots of different offset data at same uphole location Velocities and the thickness of the layers drawn from the plots of different offsets is not same in an uphole location. In general the first layer thickness is increasing as we go towards higher offsets. At the offset of 21 m and beyond that first and second layers are merging in to single layer (Shown in Table 1). Velocity difference between layers also decreasing in

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between first and second layers as the offset of the receiver is increasing in uphole.

Sensor offset	Layer Thickens in m			Velocity (m/s)		
3m	0-12	13-24	25-35	104	163	206
6m	0-14	15-24	25-35	87	143	221
12m	0-14	15-24	25-35	88	124	188
21m	0-24		25-35	102		150
33m	0-24		25-35	95		116

Table: 1 Summary of uphole plots

This inability in distinguishing the layers can be attributed to the large correction being applied to correct the observed times to vertical times. This correction is done using the formula

$$T' = T * (\text{Source depth} / \text{sqrt}((\text{source depth})^2 + (\text{offset})^2))$$

Where T is observed time and, T' is corrected time for slant movement. In this at near offsets very small correction is applied to the observed time to correct for slant movement. Hence the variation in the observed time due to the change in velocity is preserved while plotting. In case of far offset multicomponent data the correction is large hence variation in observed time in not being preserved. Hence far offset data is not useful in finding near surface shear wave velocity accurately.

GP 06 in Jambusar 3D 3C area to calculate shear statics it was planned to acquire total 87 number of upholes 35 number of upholes are acquired with 18 number of channels (36 m offset) in each limb and later on geometry is optimized to 6 number of channels (6m offset)

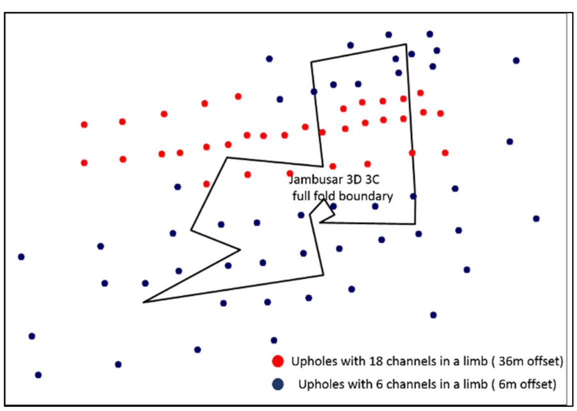

Fig: 07 Uphole location map in Jambusar 3D -3C area

Conclusion:

From the above observation it is clear that with higher offset uphole data it is difficult to demarcate the near surface layers based on shear wave velocity, which is very important to calculate the shear statics. This is observed in all the upholes acquired using 3C sensor. Hence uphole geometry has been optimized to 6 number of channels in each limb with the separation of 1m between the receivers. This offset of 6m from uphole location is sufficient to find the near surface velocity of converted wave.

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