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Re-Blasting of Blasted Holes in Land Seismic Surveys - A Boon or A Bane? A Case Study from Cambay Basin, India

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Summary

The shooting medium, in seismic reflection surveys on land, in most parts, is relatively unconsolidated. When explosive is blasted in a shot hole, in a relatively unconsolidated medium, a zone of permanent deformation is formed around the hole and a cavity may also be formed around the bottom of the shot hole. If explosive is re- blasted in such a hole, the zone of permanent deformation and cavity formed around the bottom of the shot hole affects (generally assumed to be adversely) energy transmission and frequency content. Zone of permanent deformation is expected to result in improved energy transmission (if cavity formation is little to moderate), whereas cavity formed around the hole bottom may result in higher frequency absorption. Certain areas in north Cambay basin have exhibited improved energy transmission with better or comparable frequency band width on re-blasting of blasted holes.

The observation of improved seismic response through re-blasting of holes may be area-specific and may be used for better seismic imaging in other areas having similar near surface conditions and subsurface imaging problems in Cambay basin and elsewhere.

Introduction

In north Cambay Basin near surface velocity and lithological variations are quite frequent. Near surface lithology, here, consists of clay, hard clay, and different combinations of clay, sand and gravel. Shooting medium in seismic reflection surveys on land is generally unconsolidated. On blasting of explosive in shot holes in such medium, a zone of permanent deformation and a cavity around the bottom of the shot hole is formed. The extent of zone of permanent deformation and cavity depends upon the un-consolidation of the sediments. The more is the un-consolidation the more is the extent of permanent deformation and cavity formation. Second time blasting of already blasted holes results in poor energy transmission and absorption of higher frequencies of seismic signal, due to considerable cavity formed as a result of previous blasting. This is the general assumption in the industry and re-blasting of already blasted holes is normally avoided.

On the contrary to this general assumption, many parts in north Cambay basin (Fig-1), during seismic surveys, have exhibited perceptible improvement in seismic signal characteristics of shots taken by re-blasting already blasted holes. This difference is observed in terms of better signal energy and comparable or even wider frequency bandwidth. This specific improvement is deliberated in this paper.

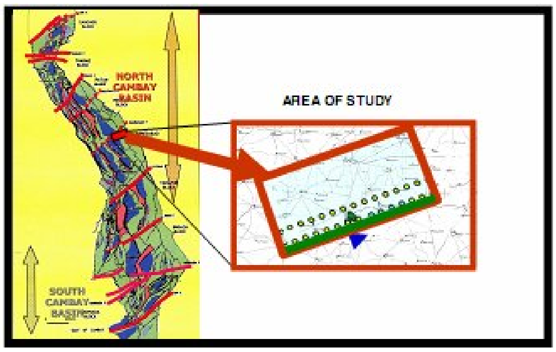

Fig.1 Location of study area

Observations and discussions

On several occasions, during seismic data acquisition in the area of study, different observations have been made as follows.

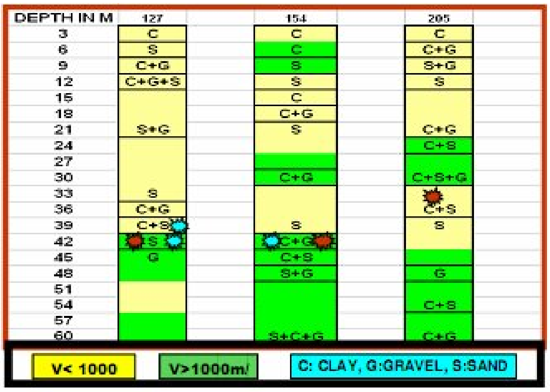

Fig. 2 Near-surface velocity and lithology in the vicinity of analyzed shots (from up-hole survey)

Many a times, when a shot is misfired or partially blasted, additional quantity of explosive is loaded into the hole and blasted. As a result, the earlier remnant explosive and additionally loaded explosive get blasted together. In such cases improvement in signal energy is generally observed. A question arises here – whether increased quantity (remnant plus additional) of explosive has resulted in increased energy? At times data transmission error (due to line connectivity problem) occurs during recording of a shot, the hole is generally reloaded and blasted to record another shot at that location. In such cases it has been observed that re-blasted holes have exhibited enhanced signal energy with frequency bandwidth being either wider or comparable to that of first time blasting.

This suggests that the improvement as doubted in the case of misfire and re-blasting, mentioned above, may not only be due to more quantity of explosive but also somethingelse related to conditions around the shot hole bottom which gets changed consequent upon the first time blasting.

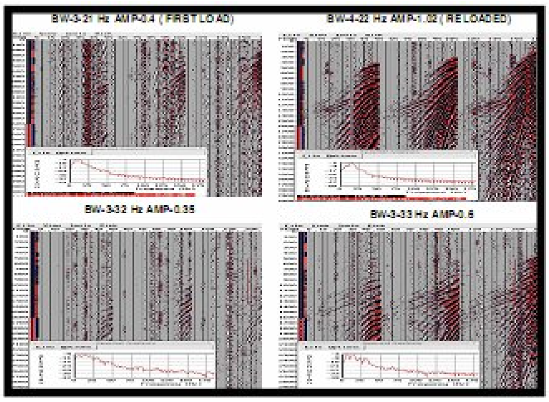

Fig. 3 Field monitor records (raw) of first time blasted (left) and re-blasted (right) in sand layer

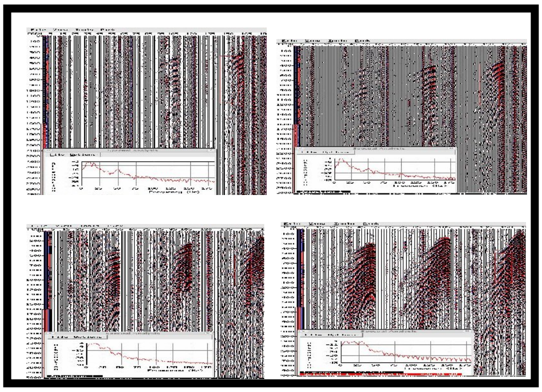

Fig.4 Field monitor records (raw) of first time blasted (left) and re-blasted (right) in sandy clay medium

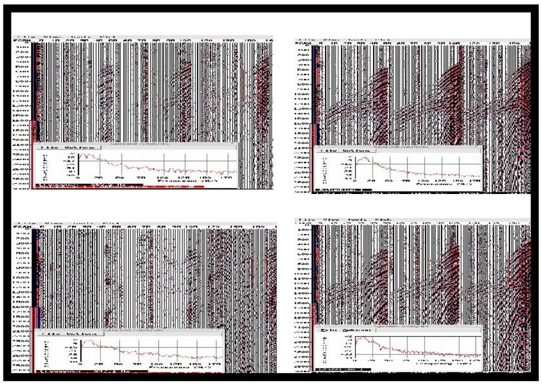

Fig. 5 Field monitor records (raw) of first time blasted (left) and re-blasted (right) in clay + gravel layer

No detailed theory or account is found in literature related to generation of seismic source signal in shot holes. It is the subject matter of detailed laboratory simulation studies to bring out detailed analysis of generation of seismic signal and changes occurring in the material around shot hole bottom as a result of explosive blasting. However the possible explanation to the different observations of improvement in seismic signal from a re- blasted hole could be as follows.

- The formation of a zone of permanent deformation may vary in extent with variation in unconsolidation. As a result of first time blasting, the material around the bottom of hole gets consolidated (as compared to original condition) and this phenomenon should result in better energy transmission on re-blasting. But this should hold good till the cavity formation is very small, beyond which this trend may be reversed due to poor coupling of explosives against the shot hole walls in the bottom (presence of loose material or mud around the explosive).

- Depending upon whether the material around the bottom of the shot hole is more or less unconsolidated, the extent and possibility of cavity formation is also ikely to be more or less. In case of very much unconsolidated material there may be instances of hole collapse and it may not be possible to reoccupy the depths of first time blasting, while re-blasting. In such cases the effect of re-blasting is out of context. In present area reloaded depths are almost same as that of the first time blast. One more thing is also noticeable in present area that the general frequency bandwidth is 10-30 Hz in raw data and frequencies higher than 30-35 Hz are usually absorbed in any way, thus probably the positive effects of re-blasting are outstanding in contrast to seismically friendly areas, wherein the re-blasting would adversely affect very high frequencies. Probably very little extent of cavity in case of hard clay or clay- gravel lithology results in better energy transmission on re-blasting. In this case two slightly different possibilities also arise as follows.

i) Improper shot hole conditions in lower part due to limitations of manual rotary drilling, the explosive may get struck up before the bottom of the hole and on first blasting, the fragile obstructions below the charge get cleared and the improvement occurs in second blasting.

ii) There may be a considerable amount of loose un-washed out gravel in the bottom (especially at a deeper depth > 30 meter), which could not come out of the shot hole due to limitations of the manual rotary method, which gets relatively better consolidated and results in better energy transmission on re- blasting.

The first and second time blasted pairs analysed in the present study fall into three categories as follows.

Case-I: The shot ends up in sandy layer (Fig.2). Re-blasted holes show a tremendous increase in signal energy with perceptible increase in signal bandwidth (Fig. 3).

Case-II: The shot ends up in clay-sand medium (Fig.2). Re- blasted hole exhibits perceptible improvement in signal energy and frequency bandwidth (Fig.4).

Case-III: The shot ends up in clay-gravel layer (Fig.2). In this case, cavity formation effect is only for adjustment of left out gravel. It is observed that there is a significant improvement in signal energy and frequency bandwidth in re-blasting of the hole (Fig. 5).

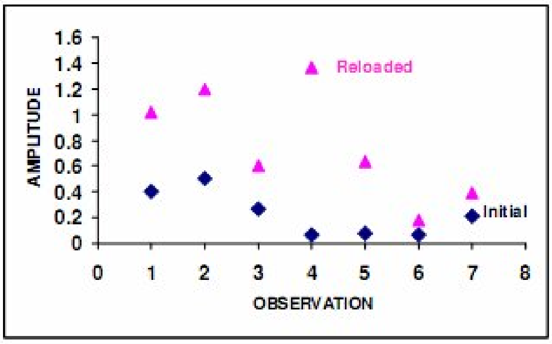

Fig.6 Variation of amplitude in reloaded case

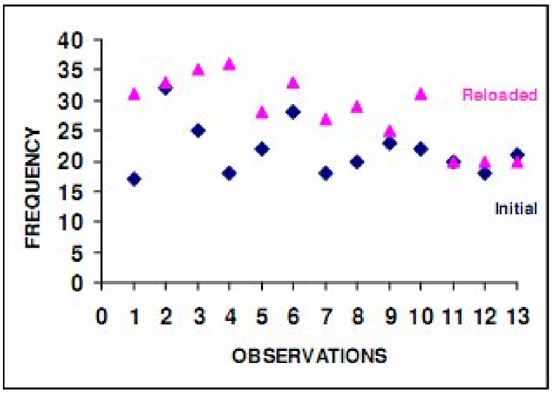

Fig.7 Variation of high end frequency in reloaded Case

The increase in signal amplitude and frequency, in case of a re-blasted hole is well depicted in Fig 6 & 7.

In case-I and II, in the present area, the water table is very deep (generally below shot hole depth) and instances of hole collapse are rare i.e. the material is well-bound. It appears that a considerable energy is spent in subjecting the material around hole bottom to permanent deformation and cavity formation. In this process, higher frequencies are also absorbed.

In case of re-blasting, the initial dissipation of energy and higher frequency absorption is reduced in the vicinity of the hole and the net energy as well as the frequency bandwidth is higher in case of the re-blasted hole.

Conclusion

The resultant change in transmission of energy and frequency band width in seismic signal from a re-blasted hole, may be positive or negative depending upon the consolidation of the shooting medium and seismic friendliness of the sub-surface. In case of unconsolidated sandy material, in areas seismically not so friendly, extensive cavity may be formed and re-blasted holes may exhibit poor energy transmission and reduction in frequency bandwidth. In such a case, re-blasting may be a bane. In case of unconsolidated but well-bound shooting medium (clay, sand, gravel combinations or sand with clay above local water table) in seismically unfriendly areas, the cavity around shot hole bottom is relatively small and re-blasted hole may exhibit significant gain in energy transmission and frequency bandwidth. In such cases, re- blasting of blasted shot holes may be a boon (as observed in the present study area). In seismically friendly areas, with relatively compact near surface, re-blasting of blasted holes may result in moderate reduction in frequency band width with no perceptible change in energy transmission.

Sometimes, a reduced quantity of explosive is to be used for taking a shot near some man made structures or any other obstacle and if improvement in data quality is observed on re-blasting, re-blasted shots may give better data. Secondly, in such areas, if acquisition geometry involves overlap of shot lines, this observation can be used advantageously to get better quality data with reduced drilling expenditure.

The observation of increased energy transmission and frequency bandwidth in similar other areas in Cambay basin or elsewhere, can be used advantageously for better sub-surface imaging.

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