VSP's - Teaching an Old Dog New Tricks

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Summary

For a variety of practical reasons, traditional VSP acquisition techniques have not achieved widespread use proportional to their benefits. This paper takes a look at the some of the historical reasons why the technique has not achieved universal acceptance. In addition, this paper introduces an alternative acquisition methodology which overcomes many of the limitations of the traditional method. This new methodology promises larger (often greater than the drainage area of the well), more economical surveys than previously possible. These techniques are ideally suited to 4D surveys and multi-well surveys.

Introduction

For some years the Vertical Seismic Proflie (VSP) has been a standard instrument in the geophysicist's tool box. It has been observed for some time that the inherent geometry often produces higher fidelity images than those produced from conventional surface seismic (Figure 3). Despite this obvious advantage VSP usage has not seen any dramatic increase in usage by geophysicists.

The underlying reason for this apparent apathy on the part of the industry is not related to the technique but rather the economics surrounding the acquisition process.

Traditional VSP Operations

Traditional VSP operations have historically been linked to the completion phase of a well. Whether run in an open or cased hole, the acquisition process inevitably involves the use of rig time and the services of a wireline operator.

In an effort to streamline their business, most wireline operators offer a wide variety of services (including VSP's) from a common platform. While this is a necessary choice on the part of the wireline company, it does impose certain restrictions on their VSP acquisition capabilities. The requirement to power locking systems and downhole electronics through 20,000 feet of wireline cable places certain restrictions on the number of levels which can be acquired without moving the tool in the hole. After the tool has been moved, all source locations must be repeated – during which time the rig operator's clock remains running. As a result, most VSP surveys are designed around the minimum acquisition effort necessary to meet the geophysical objectives.

Alternative VSP Operations

An alternative to traditional VSP operations is now available and while not universally applicable (i.e. it is sometimes necessary to look ahead of the bit – such operations may still require traditional techniques), this alternative offers a significant number of advantages.

The method relies on breaking away from the traditional wireline paradigm. In doing so, a larger number of conductors become available, thus it is possible to support a larger number of levels in a single cable. These currently range from 40 to 80 three component levels on a single cable.

These cables can be deployed permanently (i.e. cemented behind g as in Figure 1) or constructed in a redeployable format (Figure 2). The redeployable format has the added advantage of being operated from a service rig rather than a drilling rig (at a substantial cost savings).

Benefits

As a direct result of supplying a greater number of levels in a cable, it is no longer necessary to move the cable to acquire a full image of the geophysical objective. Furthermore, since no source point needs be repeated to achieve this image, the operation is often more efficient (i.e.less costly).

In addition to the economic benefits, when coupled with a large number of sources (i.e. a surface 3D as in Figure 4), the image can be expanded to unprecedented sizes. Single well surveys commonly exceed the drainage area of the target well. When multiple wells are used in proximity to one another, continuous subsurface images can be constructed (Figure 5).

An obvious benefit of this acquisition geometry is its repeatability. This makes it an excellent candidate for 4D surveys. Given the enhanced bandwidth of VSP data (Figure 3), this has the potential to be an outstanding tool when fluid movement must be monitored within the reservoir over time.

Conclusions

An alternative to traditional VSP acquisition techniques is now available. Benefits of this technology are larger, true 3D images. These images can be acquired in a single pass and are therefore much more economical. They are also particularly well suited to 4D surveys.

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Figure 1

Clamping a 3C sonde on the outside of casing before cementing operations.

Figure 2

Redeployable 80 level array running into the hole.

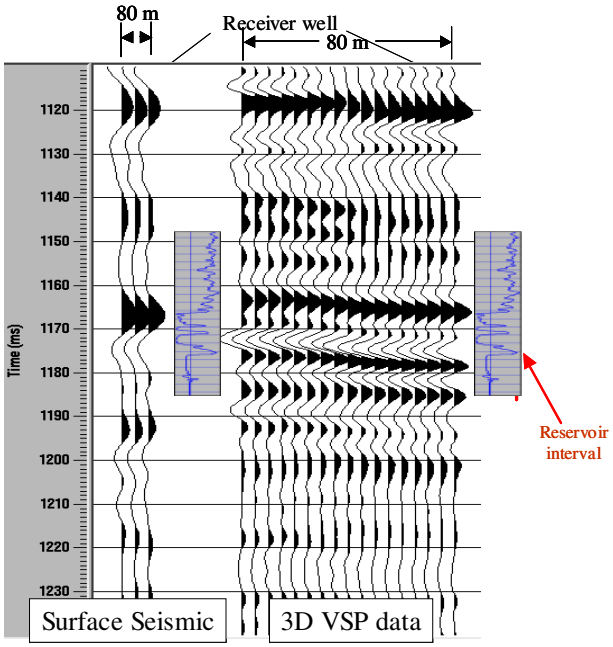

Figure 3

Resoultion comparison between surface and 3D VSP data.

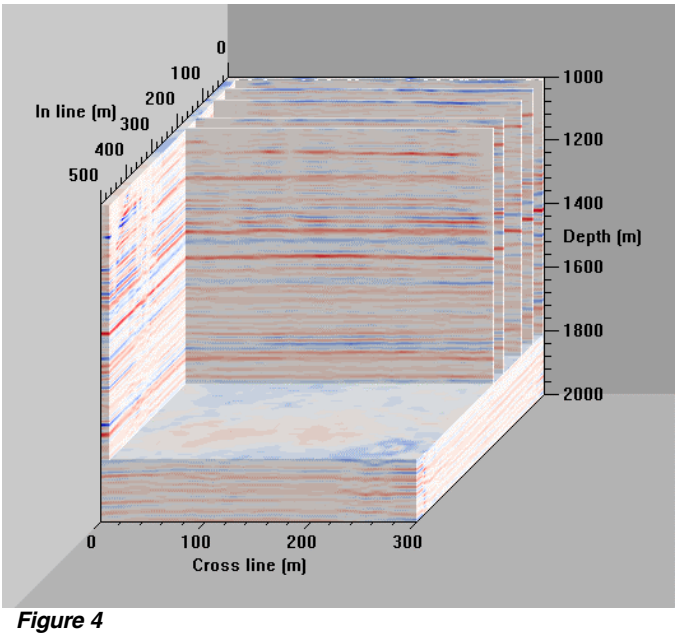

Figure 4

Subset of 3D VSP volume acquired using a 80 level redeployable array.

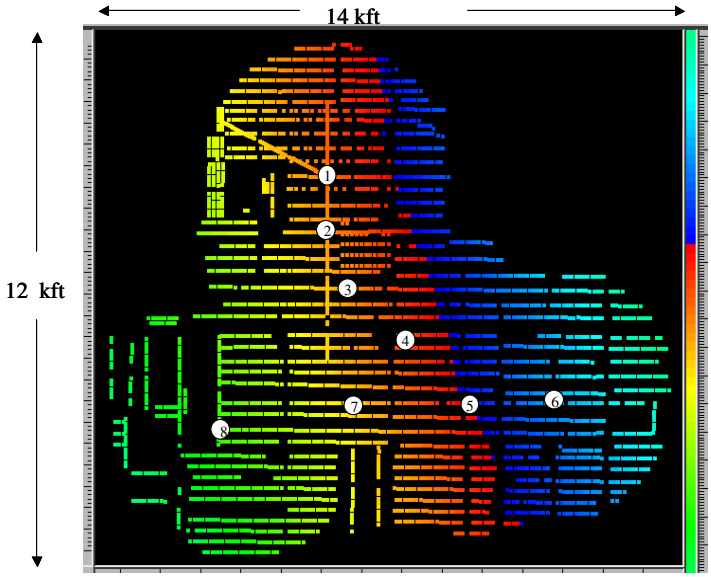

Figure 5

Shotpoint map of a multi-well VSP. Survey consisted of 8 40 level arrays and 5200 source points.