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Higher Availability and Efficiency of VSP system through Innovation.

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Summary

Vertical Seismic Profiling (VSP) is a very important branch of Exploration seismology. It is just like surface seismic profile except in the placement of receivers. Source is placed at the surface and Sensors are placed in the boreholes to record reflected seismic energy originating from subsurface boundaries.

VSP data is recorded using dual mode Analog Tool as well as Digital Tools with 24 bit sigma delta technology depending upon the borehole conditions. VSP digital tools with 12 to 16 levels recording are used worldwide thus saving considerable amount of rig time and in turn cost. These systems came with major advantage of being single console driven for both acquisition and monitoring. The software's handling the full testing capabilities during acquisition. Today's major challenges for down hole VSP data acquisition include 3D and 4D imaging around deeper wells, and permanent reservoir monitoring in production/ injections areas worldwide.

To face these challenges the number of levels has gone up to 100 simultaneous recording in real time telemetry. This results in the cost effective acquisition of high volumes of quality data for very large size down hole VSP seismic surveys. Digital tools namely WR-MSR digital multi-level VSP system for VSP surveys across all its basins. To increase the efficiency of repair and maintenance of VSP downhole tools in-house designed and developed tools and jigs namely VSP tool test panel and tools for repair of geophone cartridges. The paper deals with the innovation of the tools and its capabilities in maintaining system availability and providing a better continuous improvement in service engineers of Regional Electronics Laboratory (REL) Vadodara.

Introduction

The Vertical Seismic Profile (VSP) technique, as normally executed with a single source position near the well head, ie Zero Offset VSP, provides subsurface information only within the Fresnel zone centered at the well. Offsetting the source (Offset VSP) provides subsurface information laterally. Walk Away VSP where the source seismic energy placed at various points along a line to achieve ray path multiplicity corresponding to the reflecting points and deriving CDP stack benefits and 3D VSP the source of seismic energy placed at various offset points around the well to obtain the three dimensional picture of the subsurface in the vicinity of the well. The schematic view of the various VSP geometries and the output VSP sections is depicted in Fig- 1.

In its simplest form the VSP comprises a seismic source at the surface near the top of a vertical borehole. Receivers are locked onto the wall of the borehole at regular depth intervals (Fig-2). In this simple case, seismic energy travels almost vertically from the source to the receivers and beyond to be reflected back to the receivers from acoustic impedance contrasts below. Since, the receiver locations are so closely spaced through the area of interest in the borehole, VSP survey can provide a finely tuned high- resolution image of the subsurface in the final product.

The ability to record the down going wave field at each receiver location in the borehole is a critical advantage over conventional surface seismic recording methods. The information extracted from the down going waves to enhance the final product of the up going wave field VSP section. And, because

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the receiver locations are so closely spaced through the area of interest in the borehole, VSP survey can provide a finely tuned image of the subsurface in the final VSP product.

Broad Objectives of VSP

- Determination of velocities of longitudinal waves in the vertical section for time-depth calibration.
- Stratigraphic correlation of waves to the geological section, correlation of well seismic (VSP) and surface seismic (CDP) data.
- Identification of reflectors deeper than the bottom of the hole. (information ahead of the bit)

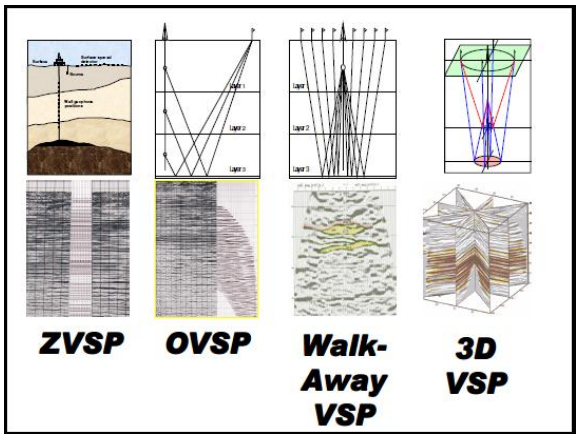

Fig 1: Various types of VSP's and its seimic outputs

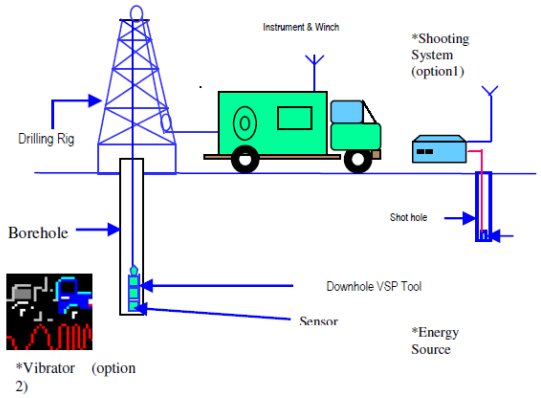

Fig 2: Schmetic diagram of VSP's operation

Current Trends

Today's major challenges for down hole VSP data acquisition include 3D and 4D imaging (which take long time) around deeper wells, and permanent reservoir monitoring in production/ injections areas worldwide. These 100 level 3 component tools are the most advance developments in terms of real time telemetry and mechanical reliability, that makes this system the optimal solution to address today's challenges in a cost effective acquisition of high volumes of quality data for very large size down hole seismic surveys. The telemetry data rates available with these tools is of the order of 3.5 Mbps. These tools are permanently coupled with winch cable and can be wound on the winch drum. These tools avoid repetitive shooting and down hole tools movements and significantly reduce well downtime & survey cost. Capturing the down- going wave field on a long array allows improving in S/N ratio and wave field separation during processing stage. This helps in providing high signal to noise data with broad frequency bandwidth which in turn improves the resolution of the acquired data.

Digital multi-level VSP system

The WR-MSR (Wide Range Mono Cable Seismic Receiver) is a digital multi-level VSP system

(Fig-3) used for VSP operations in Western Onshore Basin since 2006. The system consists of 12 level down-hole tool (expandable up to 16 levels) and is equipped with VSP Prowess Software for Data Acquisition, Quality Control as well as Real Time Processing. These tools had a single Telemetry unit for transmission of digital data from down hole tools to surface equipment. The data transfer rate was in the range of 128 to 512 Kbytes/ sec. Its high efficiency results in the saving of valuable Rig Time. The embedded WR-MSR software is user friendly and displays all the shuttles (levels) with continuous measures of arm-positions (closed, opened or anchored), temperature and tension. A Weight Unit relays early warnings to protect the Tool-Array from getting stuck. The physical characteristics of these tools as given by the manufacturer are as follows:
Operating temperature: 170˚ C
Operating pressure: 20000 psi

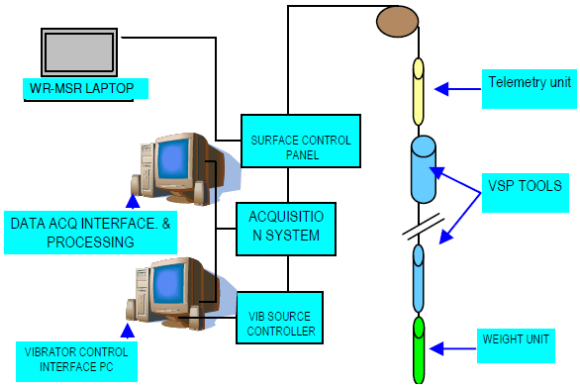

Fig 3: Schmetic diagram of multilevel VSP system

Dual mode analog tools

Since digital tools supplied by leading manufacturers worldwide have high temperature constraint only so there is a need of tools which can work in high temperature basins across the globe. To overcome this limitation now a days, Dual mode Analog tools are being used or high temperature wells. These analog tools have a capacity to work up to 225˚C and pressure rating of 25000 psi. Two levels can be recorded at a time thus saving important rig time.

These tools consist of

- Three orthogonal geophones for picking up the seismic signal.
- Pre-amplifier section for amplifying the seismic signal before it travels through the winch cable.
- Electrical section for anchoring and closing of the tool arms

The dual mode analog tools can be used in single mode also in open hole for safe operation and shallow wells to save time.

These tools are supplied by the manufacturers of digital tools and can be used along with same surface data acquisition system used for digital tools. However a tool control unit is required separately.

Constraints

1. Temperature:

Digital tools are not working efficiently in wells with temperature of more than 120˚C, however, if used at high temperature the recorded data quality is of poor quality.

2. *Open hole VSP*:

In an openhole VSP operation the no. of digital tools or levels used better not more than two tools so as to avoid a long array to be stuck up.

Innovations

Higher Availability and Efficiency of VSP system is becoming a tough due to the above constraints and regular ware and tear. There is need for developing new tools VSP test panel and Geophone cartridge tools were developed to upkeep the system.

VSP tool test panel

During the break down of down-hole tools namely GTU (Geowaves Telemetry Unit) and GAU's (Geowaves Acquisition Unit), the entire Instrumental setup comprising of Instruments van, Winch with winch head and the down hole was needed to check/ repair the tools. For testing/repair one engineer had to sit in front of instrument and one engineer had to test the tool.

A big obstacle was the inability of testing or repairing faulty down-hole tools during VSP operations in a Laboratory environment. To overcome this problem and to achieve more efficiency in the repair and maintenance of VSP downhole tools (GAUs & GTU), an in-house "VSP Tool Test Panel"(Fig-4) was designed, developed and tested by an team of engineers from Regional Electronics Lab of Western sector Vadodara. The block diagram of this tool was shown in Fig-5.

Technical details

- Generates stable 120 Volts DC voltage to test/ repair GTU and GAU for system configuration, transmission error problems.
- Provides testing of GAU arm opening/ closing functions in lab environment for checking whether the problem lies with mechanical or electrical side
- The output signals from GTU's and GAU's can be monitored in the test panel through the CRO and provisions have been made to check the 7 Core + Ground point signals coming out from the tools.

Fig 4: VSP tool test panel

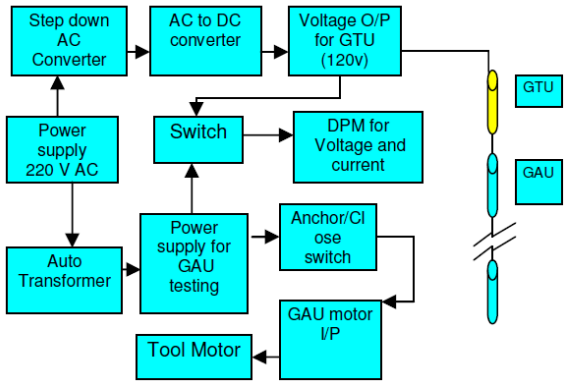

Fig 5: Block Diagram of VSP Tool Test Panel

Advantages

- Enables testing of GTU and GAU in stand-alone mode without using the VSP main system / Instrument thus with no interruption to the system at drill site.
- Testing Capability in lab environment ensures the saving of time and thus leads to higher availability and efficiency of the system results in huge cost saving.

Geophone cartridge repairing tool

The GAU (Geowaves Acquisition Unit) or VSP tool consists of two parts:

1. Geowaves Seismic unit with anchoring unit
2. Geowaves Digitizer unit

The Geowaves Seismic unit comprises of SMC 1850 Geophone cartridge in Gimbaled form. The Geophone cartridge consists of 3 geophones namely
X: Horizontal 1,
Y: Horizontal 2 and
Z: Vertical
These geophones are located in to the drum out of which two geophones are capable of turning 360˚ free on ball bearings (2 nos.). The drum is always located in the same angular position in the vertical plan independently of the deviation of the well. This result due to the weights fixed on the drum and of the position of the gravity point. The horizontal transverse "X" geophone is always in the horizontal position even in the deviated well. The horizontal axial "Y" geophone is clamped on a hanger who turns ± 90˚ on the two ball bearings. The gravity point position and the weight of the horizontal axial "Y" assembly and the drum occurs that horizontal axial "Y" geophone is always in a horizontal position in a deviated well.

The vertical "Z" geophone is clamped on a hanger who turns ± 90˚ on the two ball bearings. The gravity point position and the weight of the horizontal axial "Z" assembly and the drum occurs that horizontal axial "Z" geophone is always in a vertical position in a deviated well. The drum of geophones is electrically linked by slip ring. This results that the drum can turn 360˚ free on its axis. These geophones, in some case horizontal and in some cases vertical had started giving problems (Tool test failure) off late and hence needed replacement. The OEM M/s Sercel, France had not provided relevant tools required to open Geophone cartridge and thus replace faulty geophones. Thus to overcome this problem and to achieve more efficiency in the repair and maintenance of VSP down hole tools. Innovative tools designed and developed inn house using local market and very in were successful in repairing the Geophone cartridges.

The tools (Fig-6) developed in house are as under

1. Hexagonal screw driver set
2. Open-end spanner
3. 3.Bearing puller
4. Allen key set with long handles

Fig 7: Geophone cartridge along with designed tools

Conclusion

- The inception of Test panel and tools for geophone cartridge repair many tools have been repaired successfully. This has given tremendous confidence and strengthened the capability in maintaining system availability and providing a better process continuity.

- The success of the in-house development of the tools for the Geophone cartridge repair will be a great incentive/motivation to develop further world class tools as and when required in future

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