Summary
This course is designed to provide geophysicists and other geoscientists with a practical knowledge of borehole seismic techniques with the emphasis on the practical and effective application of VSP technology. The course makes extensive use of examples and case studies and includes some exercises to reinforce key learning points.

Learning Outcomes
Participants will learn to:

At Competency Level 1: Awareness:
1. Appreciate the role of various VSP methods in describing the properties of the subsurface.
2. Describe the various wave modes characterized by three component VSP recording and their potential for evaluation and calibration.

At overall Competency Level 2: Basic Application:
1. Appraise the key stages in any VSP processing sequence.
2. Interpret VSP images and correlate them with logs, synthetic seismograms and surface seismic data.
3. Employ check shot or VSP data in the process of velocity log calibration.
4. Employ borehole data including synthetics and VSPs for the measurement and calibration of seismic attributes including AVO, P-S responses and anisotropy.
5. Propose the most suitable type of VSP survey for a particular objective.
6. Demonstrate the role of downhole seismic measurements for reservoir surveillance and management.
7. Examine, with other technical staff including suppliers, the key acquisition and processing parameters for any type of VSP objective. Explain the key processing steps for any VSP geometry.

Duration and Training Method
A three-day classroom course taught by using examples and case studies. Some exercises are included to reinforce concepts such as the depth time domain versus the offset time domain, interpretation of near well bore geology, identification of multiples and converted wave modes and the principles of survey design against objectives.

Who Should Attend
The course will be suitable for any geoscientist who wishes to be educated in the technology and methodology of this branch of Geophysics. It is particularly suitable for those geophysicists who wish to learn about how borehole geophysical data, particularly seismic, can add value to the development and production of a reservoir. Even those who are well versed in the “art” of VSP should find value from many of the application modules particularly for mode converted seismic, anisotropy, demultiple and processing QC.

Prerequisites and Linking Courses
A basic knowledge of the seismic method is required. For those wishing to acquire this knowledge, N080 (Geophysics for Subsurface Professionals) is recommended prior to taking N038.

**Course Content**

Borehole geophysical data in the form of the synthetic seismogram and vertical seismic profiles (VSP) is fundamental to the modelling, calibration and interpretation of modern surface seismic data. In the industry at large, an effective working knowledge of the application of VSP in exploration, development and production is generally lacking. Borehole seismic data particularly in the form of VSP are the best possible calibration of surface seismic data in that they are measures not models. Oil-company and Supplier geophysicists and others need to understand the technology available, the methods of acquisition, processing and the calibration and interpretation of the data. Additionally there is a wealth of already acquired multi component VSP data, the use of which would be beneficial to current surface seismic projects.

The course comprises modules on the acquisition, processing and interpretation of various forms of borehole seismic (VSP) data including 3D and measurements while drilling.

The concept of the VSP image as a near borehole high resolution “log” is introduced.

The integration of borehole geophysical data with other forms of data, particularly surface seismic, is a key topic for much of the course. The use of borehole geophysical data in surface seismic feasibility study, acquisition design, processing QA and the interpretation of conventional p-wave seismic including time-lapse data are discussed in this context.

The use of VSP data to measure and calibrate parameters such as polar and azimuthal anisotropy and absorption are illustrated by examples and case studies.

The application of VSP technology to mode-converted surface seismic data is illustrated principally through case studies.

Special techniques such as cross well, salt-proximity and micro-seismic monitoring are reviewed.

Finally a view of future developments is given.

**Introduction**

Vertical Seismic Profiling

- Basis theory
- Types of VSP
- Acquisition techniques
- The processing sequence including key QC steps
- Data displays, the corridor and transposed stacks
- 3C: description of and processing of various wave modes
- Methods for imaging VSP data; VSPCDP transform, migration
Basic Interpretation including evaluation of multiple activity

The 3D VSP

- Acquisition design
- Processing and Imaging including imaging multiples
- Examples including time-lapse monitoring

VSP for Surface Seismic Feasibility, Survey Design, Processing and Interpretation

- The Calibration (AVO) Walkaway, acquisition and processing
- Measurement of Q
- Measurement of anisotropy using p and converted waves
- Wavelet extraction, the three way match.
- Processing QC, the dip-corrected VSP
- Calibration of model based demultiple processes

Multi-Component Analysis

- Shear information content of various VSP geometries
- Use of VSP data for multi-component surface seismic survey evaluation, acquisition design and data processing.
- Borehole guided anisotropic processing of converted wave modes.

VSP Survey Planning

Interferometry (Virtual Source) Techniques

- Principles of method
- Examples for structural imaging and time-lapse

Cross Well Seismic

- Tomography
- Reflectivity

Salt Proximity Surveys

Monitoring and interpreting reservoir “noise” using downhole seismic arrays.

VSP and Smart Well Technology

- Updating time-depth information while drilling
- Casing point location
- Quantitative measures ahead of the bit
- Detection and location of drilling hazards such as overpressure.
- Prediction ahead of bit using virtual source techniques
- The velocity log as a seismic imaging tool
- Permanent downhole sensors