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Silixa's Distributed Seismic Service Expands the Applications of Seismic Acquisition

About the author:

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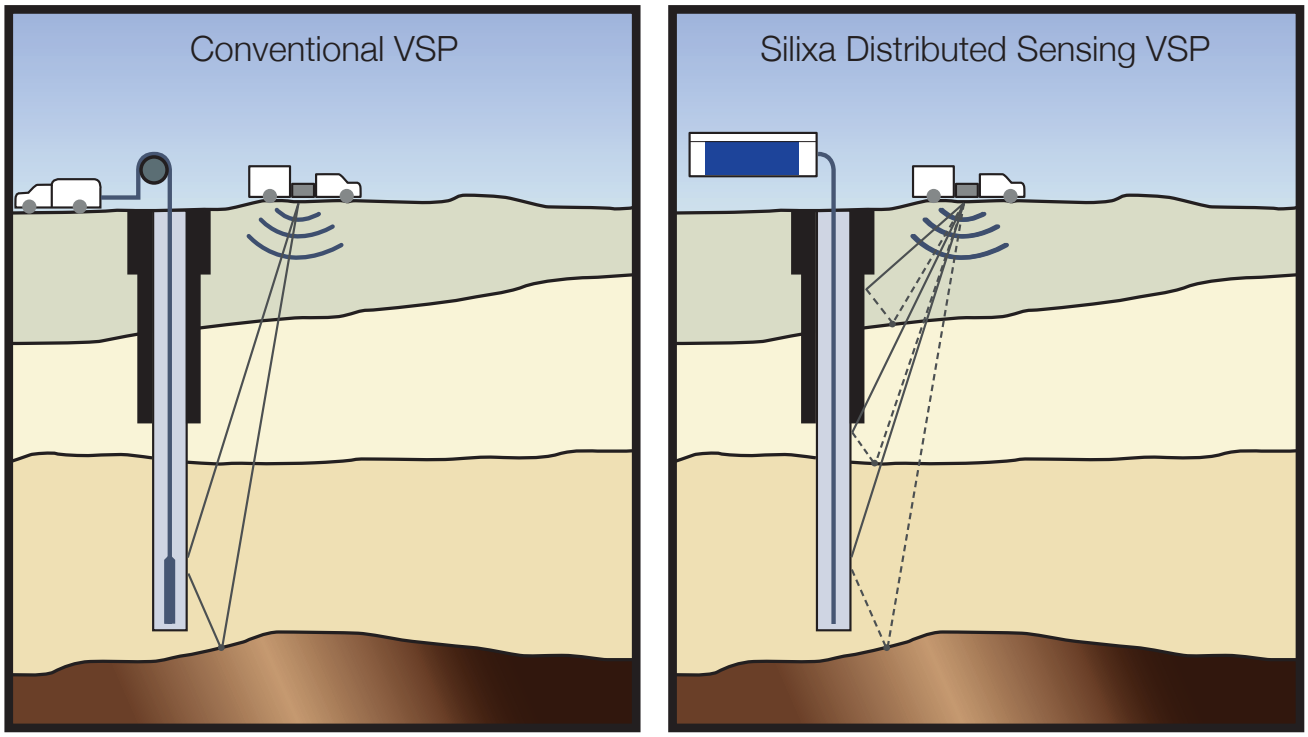

Borehole seismic continues to be a key component of many reservoir characterisation programs; and whether you are calibrating surface seismic, imaging the near-borehole geological structure or looking ahead of the bit to understand petrophysical changes, the original methods are still quickly recognisable in today's technology. Sensors, and the associated telemetry, have improved in terms of signal quality, reliability and packaging and this has led to a shift from conveying a single component stand-alone sensor into the well to running arrays of several multi-component sensors capable of much larger wellbore coverage. However the practicalities of running twenty, forty or even hundreds of discrete sensors into the well still carry with them considerable cost, and so only a small portion of the potential applications appear viable. Recent years may have seen a renaissance moment in borehole seismic applications with the promotion of time-lapse, cross-well, 3DVSP and hydraulic fracture monitoring, but implementation is difficult and the size of that market perhaps still betrays the value of the information attainable.

Enter distributed acoustic sensing, or DAS, and now we are witnessing surely the most significant step forward in borehole seismic technology to date. DAS is a generic term used for an optical fibre technology that has various industry applications but when used for borehole seismic acquisition it brings a versatility that should convert a belief in advanced borehole seismic acquisition to demonstrable returns.

Silixa's intelligent distributed acoustic sensor (iDAS™) works by launching a pulse of light into an optical fibre. As the pulse travels along the fibre a small amount of light is naturally scattered and returns to the sensor unit. By analysing these reflections and measuring the time between the laser pulse being launched and the signal being received the iDAS can measure seismic signal at all points along the fibre, which can be tens of kilometres long.

The iDAS accurately measures signal amplitude, frequency and phase which are necessary to enable normal seismic processing steps such as correlation and stacking, and the inherent performance of the system means that seismic traces can easily be delivered down to one metre channel spacing. Conventionally seismic sensors may be spaced at (nominally) fifty feet as this provides adequate sampling to describe the typical frequencies of interest. But now the iDAS, with finer spatial sampling, opens new image processing avenues to explore.

The sensor unit, or interrogator, sits at surface and utilises an optical fibre which extends from surface to the bottom of the well. This fibre acts as a continuous sensor array and so immediately the reliability benefit of having no electronics or moving parts downhole is apparent. The optical fibres are embedded within ruggedized

downhole cables and can be conveyed loosely in the well, as with Wireline, or clamped to tubing and installed with the completion so offering a permanent sensor array. With the latter case it is possible to acquire borehole seismic data along the entire wellbore, again and again, without the need for costly intervention, and critically, without the need to stop production. One further advantage of a permanent cable installation is exact depth matching for 4D surveys.

Silixa has been performing borehole seismic surveys for over four years. Initially this involved working with interested partners keen to explore the possibilities, but in the last twenty four months the evaluation has become more targeted and commercially focused. To date the company has executed over thirty surveys in a wide range of environments across the globe. Around one third of the surveys have been offshore and around half of the wells were highly deviated to horizontal. Within the case histories there are Wireline conveyed optical fibre cables, pushed stiff rod, cables clamped to production tubing and cables cemented into the casing annulus. The total shot count numbers tens of thousands and ranges from weight drop, dynamite, vibroseis, airgun large and small, string-shots, cross well sources and, in one chance encounter, an earthquake.

In the past twelve months Silixa has continued to address requests from industry experts for increased signal to noise ratio and for a better account of the relationship between acoustic signal and a true geophysical response. The results in 2014 have been an impressive combination of increased operational capabilities and data quality improvements.

DAS sensitivity will continue to increase as a function of improved optics; data processing techniques and optical fibre cable design, however within the last year Silixa has developed acoustic de-noising techniques in post processing capable of SNR improvement from 8dB to 14dB as shown in figure 1. Greater improvement has been achieved in certain unpublished cases and the work continues to enhance this further.

Figure 1: Illustration of the effect of Silixa de-noising processing and geophone-similar transforms

A significant amount of the data gathered by Silixa in the past year has been recorded passively and in parallel with planned surface

FIGURE 1

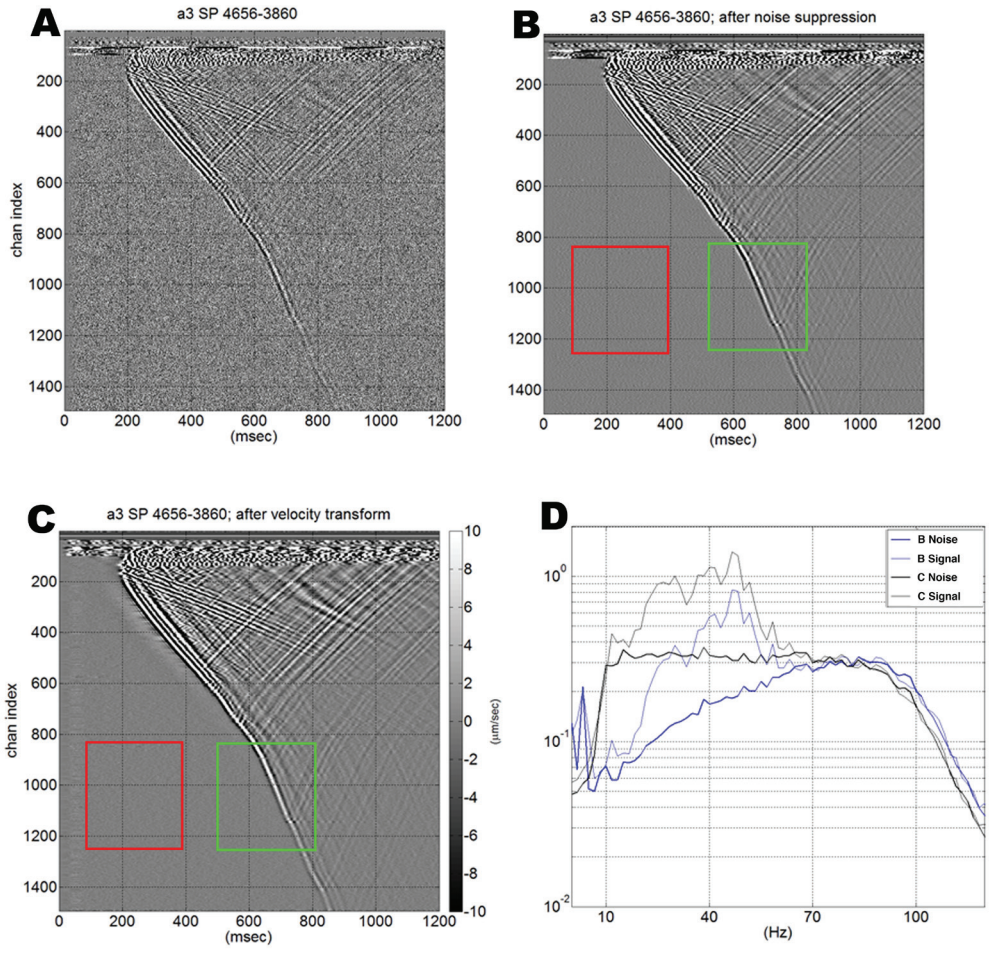

FIGURE 2

or ocean bottom seismic. To do this effectively Silixa has further improved the iDAS to enable the use of GPS time for continuous acquisition over any period with no time drift. At the same time, the system has been updated to ensure that continuous data can be written to storage media in manageable file sizes with no loss of samples between files. Extensively tested, this new time-perfect, sample-perfect iDAS-Seismic is now readily deployable and has been the basis for large-scale data acquisition throughout 2014.

Whether triggered or passively recorded, iDAS data will continue to be compared to geophone data until potential users gain confidence in the technology. This has been a point of debate as, although both sensors respond linearly, the lack of unit equivalence has left some questions open. Simply put the iDAS measures localised unit-less strain-rate while the geophone is a velocity measurement which can be quantified by means of a conversion from voltage. To address this, Silixa has used data from a range of sources with known energy levels to formulate a transform from acoustic signal to a geophone similar response with velocity like units, an optional processing step that is available today.

For the past two years Silixa has demonstrated in the field that the iDAS performs equally well on either singlemode or multimode optical fibre. Multimode fibres, as the name suggests, allow multiple modes of light transmission simultaneously and are typically associated, outside the telecoms domain, with the use of Distributed Temperature Sensing. Whereas singlemode optical fibre, which has a much smaller core diameter than multimode, is typically required by DAS systems.

Silixa's intelligent Distributed Acoustic Sensor operates on multimode fibre without the introduction of any external or additional apparatus, while retaining the true acoustic nature of the measurement. This is significant in the industry partly because large numbers of oil and gas wells have historically been equipped with only multimode fibres for DTS measurements, these wells now present an opportunity to acquire high quality, densely sampled borehole seismic data with no well intervention or break in production.

The advances in the past twelve months have been in response to customer feedback and also to what the company has seen as necessary steps to advance the use of DAS for seismic applications. The work does not stop here though and efforts to improve overall system performance are continuing.

It is perhaps illustrative of the step change we are experiencing in borehole seismic that in the summer of 2014 Silixa acquired, handled and delivered over half a billion shot-receiver traces, the vast majority from simultaneous multi-well acquisitions without any well intervention, without any loss of production and with only a handful of man-days offshore.

Figure 2: Silixa Rack Mounted intelligent Distributed Acoustic Sensor

In parallel with the continued interest in DAS for borehole seismic there is a growing movement towards the use of DAS for permanent reservoir and production monitoring. The result is an increasing number of downhole optical fibre cables which immediately enable borehole seismic measurement. The larger opportunity is a compelling economic argument for optical fibre cable installations to provide on-demand seismic acquisition, production monitoring and well integrity diagnostics over the life of the well.

Silixa offers the industry leading distributed acoustic and distributed temperature systems as well as the engineering solutions and operational expertise to provide and safely install downhole optical fibre cables.

ABOUT SILIXA:

Founded in 2007 to develop and commercialise the next generation of distributed optical fibre sensors, Silixa delivers monitoring solutions based on its distributed acoustic and distributed temperature sensing technologies.

With its headquarters and research facilities in London, United Kingdom, and an operational base in Houston, USA, Silixa Ltd. operates globally, across five continents.

The company is ISO accredited.