Geotrace – extending the resolution bandwidth

Reservoir Services company Geotrace has launched a new service, which can recover low and high frequency components of the received wavefield which were lost in transit

US Reservoir Services company Geotrace has launched a new service to replace components of a received wavefield, from the low and high frequencies, which are lost from being absorbed by the earth (high frequencies) or because the recording instruments (geophones, hydrophones, sensors, etc) cannot record them (low frequencies).

The system works by looking for harmonics and subharmonics of the dominant frequencies in the recorded signal, for clues to what information was lost in the high and low frequency components of the wave, and then strengthening the received signal at that exact frequency to try to remodel the lost part of the wave.

Having broader wave data at low and high frequencies can help provide a much clearer picture of the earth, particularly in calculating densities of the rock the source signal has passed through, and this can lead to a completely more evolved view of the subsurface.

You can also push back the limits of the usable offsets, which means you can do much farther amplitude vs offset studies, and also send the wave at angles closer to the horizontal than vertical, which can be very useful (for example) when looking for oil underneath salt.

"Historically you could see 100ft sand, with this, you can see 10ft sand," says Bill Schrom, CEO of Geotrace.

The high frequency component of a seismic wave is often absorbed by the earth as the seismic signal passes through it; earth absorbs high frequencies much more than low frequencies.

The low frequency component of a seismic wave is often chopped off because it gets obscured by ground noises travelling along the earth's surface (eg. ground roll) or because the geophones can't receive it.

There are lots of low frequency waves created if you are using dynamite as a sound source, but if you are using a vibrator, people will often ask that it doesn't create any waves with frequency below 15-20hz because it will get lost in the ground roll.

"A lot of your ground roll noise – is all in the low frequency – people just say, I'm going to filter it all out," says Mike Smith, senior reservoir geophysicist with Geotrace, who invented the process.

Sometimes, when the lower and higher frequency of seismic data is chopped off, you can end up with a bandwidth of as little as one and a half octaves. Then the quality of the sound signal starts to decay from echo, or as Mr Smith puts it, "the data starts looking ringy."

"Instead of getting a clear signal peak amplitude – you start developing lobes on the side. Basically its echoing in some sense, it's a bit like a reverberation," says Dr. Jaime Stein, chief geoscientist with Geotrace. "As you expand the bandwidth – you see that ringy character go away."

Also, many seismic receivers (geophones, hydrophones, etc) are not very good at recording low frequency waves. "A lot of these receivers have resonance frequencies at the low end, they try to avoid those," says Dr Stein.

Systems have been around for a long time to strengthen the high frequency parts of a received wave, but this is the first system which can strengthen the low frequency parts of a wave, and strengthen the high frequency parts at the same time, Geotrace says.

The service was formally unveiled at the NAPE Convention in February 2008, where Geotrace offered to do work free of charge for companies so they can see how well it works for themselves.

"We have many, many requests from people who want to test this thing," says Dr Stein. "It is being used on a lot of projects already."

Geotrace wants to do a lot more testing on the process to get a better understanding of when it can provide the biggest benefits.

"We are trying to build more theoretical evidence about why this works, to lend more credibility to what Mr Smith discovered empirically, so there's more and more evidence that this technique is pretty solid," says Dr Stein.

Benefits

By increasing the high end frequencies, you can start seeing a lot of detail in the seismic wave that you couldn't see before.

"As you increase the frequency content –your ability to see minor faults increases," says Mr Smith. "It's like having a TV that has more lines per inch."

Already the technology is showing results.

It's like using a graphic equaliser to boost certain frequencies on your hi-fi - Dr. Jaime Stein, chief geoscientist with Geotrace

"I have one client that told me, using this he could see turbidites (a kind of depositional kind of rock) that he was not able to see on his normal frequency data," says Mr Smith.

The enhanced data can prove particularly useful to spot or highlight smaller features in the subsurface, such as thin sand layers and small faults.

It can also provide more information about a possible reservoir, to give a stronger hint about whether or not there might be hydrocarbons there. "We can come up with a better structural and rock properties model," says Mr Smith.

The data in the enhanced sound wave is proving much more useful in trying to work out the density of the rock it has passed through, Dr Stein says.

You need a lot of information about the received wavefield to work out the density accurately, he says.

This is very important in working out if a reservoir contains fizz water or hydrocarbon accumulations.

Once that information is available, it opens up a whole new realm of subsurface understanding. "Those rock properties allow us to go into areas we haven't been able to go into before," he says.

Explorers have been sometimes reluctant to explore areas of the world considered not very friendly to seismic inversion techniques, such as the Rocky Mountains area of the US; now it might look a lot easier to explore there.

Another benefit is when doing amplitude vs offset (AVO) studies, looking at how the amplitude of the reflected wave changes as the seismic source moves further away.

AVO studies have been limited in the

past by the weakness of the reflected wave when the offset reaches a certain amount. As the offset gets bigger, the wavelet gets more stretched and you end up with just low frequency signals, which makes it very hard to compare the received signal from how it was with a shorter offset.

But with techniques like this, you can use much bigger offsets and still end up with a usable reflected wave, with a consistent range of frequencies in all of the received waves.

This is much more useful for working out rock density.

With bigger offsets, it becomes possible to have a look at the rock almost from the side, rather than from going straight down, and this can help a great deal, for example when trying to see what is beneath a salt formation.

"You're kind of entering a world where you can see with peripherally instead of downwards," Dr Stein says.

How it works

You could compare the technique to a graphic equaliser, which can boost certain frequencies on your hi-fi - for example, making the bass stronger or making the treble a bit more powerful.

Just like on a graphic equaliser, the important thing is to make sure that you are boosting the right part of the signal.

"Imagine you have an equalizer with many, many buttons that you can slide up and down – if you push them all up to the max, that's like whitening – that will make the music impossible to hear because there will be so much hiss," says Dr Stein. "The hiss will overtake the signal."

The system works by looking for clues as to what the high and low frequency waves would have been like, by looking for harmonics.

Every wave creates additional harmonics and subharmonics, which are waves of double or half the frequency. When you remove the original wave (eg if it is lost by being absorbed by the earth), the harmonics and subharmonics can still remain.

If you are a piano player, you might have a vague understanding of this. If you hold down the sustain pedal, and press a key, lots of strings will start vibrating, not just the one you pressed. The ones which vibrate will be the ones that the harmonics - which is actually the wave which has double, quadruple (and so on) of the frequency of the key you pressed. There are also sub harmonics - the wave which has a half, a quarter and so on of the key you pressed.

So you can find out what frequency a lost high frequency part of the wave was at, by finding its subharmonic. You can find out what frequency a lost low frequency part of the wave was at by finding its harmonic.

Once you know exactly what frequency the low and high frequency waves were at, you can strengthen the wave at precisely that frequency. That way you get more of the part of the wave you want, rather than getting more noise.

"Bandwidth Extension is exploiting the fact that the information is there," says Mr Smith.

"The underlying idea – is that although the high frequency wavelets are absorbed, they are not gone," he says.

"The normal frequencies – give you clues about what is happening in the outer frequencies."