

FROM THE OTHER SIDE

A COLUMN BY LEE LAWYER WITH STORIES ABOUT GEOPHYSICS AND GEOPHYSICISTS



This column is a potpourri of interesting subjects. Gerhard talks about using side-by-side vertical vibrators side by side to generate SH energy. He then confirms that Wegener was aware of the mid-Atlantic ridge.

Dave gives us this spectacular picture of a hammer source for SH generation. He claims he stole the picture from Steve. Steve claims that the hammer creates a non-Hookeian forcing function (egad!) and gave permission to publish the picture.

Gerhard Kepner. Shear-wave technology was a big subject at Prakla-Seismos. We studied the Russian method you mentioned and discussed the hammer-stroke philosophy. We built an SH vibrator and made it horizontally vibrate. But we stuck to our SHOVER, a trademarked method. Two conventional vertical vibrators operated simultaneously side-by-side but phase-reversed in order to produce SH-waves with the P-waves adding destructively (so we hoped). As you mentioned, shear-wave generating passed away in silence.

Wegener often mentions the mid-Atlantic threshold or cleft (Schwelle or Spalte) in his publications. He takes it as debris, left behind after the separation of the two diverging plates. He mentions that basalt played or might have played a certain role. For him and his friend, Du Toit, the ridge was a dead scar and not a living and basalt-bleeding gash, as we understand it today.

Dave Johnston. The hammer SH source you recalled was the Marthor, developed by IFP and CGG in France. The first prototype, built in 1977, had a large free-fall hammer that swung outside the frame of the vehicle, hitting a baseplate with reverse polarity blows. Although impressive looking, I gather that the source was cumbersome to use and, because the base plate was separate from the truck, it could not compete with vibrators. IFP later developed a refined version where the hammer fit inside the frame of the vehicle and a lift system moved the base plate (not as cool looking as the prototype). A paper by Layotte at the 1983 SEG meeting suggested that the impulsive Marthor source might be advantageous over vibrators, particularly in VSPs. But I don't know what happened with the source since then.

Tom Davis at the Colorado School of Mines remains a firm proponent of SH acquisition and his Reservoir Characterization Project has shot numerous 3D SH surveys (some time-lapse as well) over the years.

I've attached a photo of the first Marthor prototype that I stole from a lecture Steve Danbom gives at Rice (the wonders



of Google).

Steve Danbom. The picture...it is CGG's Marthor, circa 1975, operating in the Black Forest of Germany, if I remember correctly...Robert Garotta of CGG gave me this years ago...the name Marthor is a combination of the two gods of the hammer...the second of which is Thor.

CGG later redesigned it for two initial flaws...the first is safety...(can you guess why???)...the second is the ripping of the soil...it was too big and created a somewhat nonlinear, non-Hookeian forcing function attempting to generate the "pure" (horizontally-polarized) shear wave that would (supposedly for flat-lying reflectors) not convert to another wave form upon reflection or transmission at an Earth boundary according to the Zoeppritz equations...about this ripping, you can see the "ripped" soil for previous positions of the baseplate (adjacent to the position of the men in the picture)...

Albin K Kerekes (Ret. ARCO). I enjoyed reading about the "broomstick" in the romantic hope that vertical source arrays might one day be resurrected by the exploration industry. There is more, much more that vertical arrays can do, besides attenuating surface ghost reflections. For me the main benefit is in the directional enhancement of the downgoing P-wave. A vertical source array will attenuate side-going seismic energy by destructive interference (superimposing compression and rarefaction) and, since directivity increases with frequency, it will also increase both penetration and resolution. A vertical source array also provides a uniform azimuthal response which is ideal for 3D and 4D. Since only a single hole is required, it is environmentally attractive.

Not mentioned in your column is the follow-up to the early "broomstick" design. The "DelayStick" (patented by AMOCO) consisted of a vertical source array of charges connected by a combination of certain lengths of "Nonel" and "Primacord" to achieve the desired delay between individual charges, all according to delays previously obtained by an uphole survey. The follow-up to the "DelayStick" design was the "Phaser" developed and patented by ARCO that perfected the vertical source array. Let me give you a nutshell-description of how the system worked.

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Each unit charge of the string of distributed charges was coupled to a dedicated electric detonator and disposable electronics. The disposable electronics did not contain any batteries and were incapable of firing the charge during the loading process. In addition the electronics were protected by a short-circuiting fuse for the loading process. All disposable electronic units were connected to a single twisted pair of wire as they were loaded into the borehole. Upon completion of the loading, the twisted pair of wires was connected to a specially designed "shooter's box." All functions of the electronics were controlled through this single twisted pair of wire. Each disposable electronic unit contained a piezoelectric pressure sensor that could be "listened to" once the shot hole was fully loaded. Sensitivity could be controlled from the shooter's box and reduced to a safe level so that charges would not fire unexpectedly. Once quiet, the circuit was primed by burning the safety fuses, then charging all the electrolytic capacitors in each unit that served as "battery" to fire the charge. The top-most charge that contained no electronics was detonated in a conventional way severing the twisted wire. The primed electronic units sensed the arrival of the pressure wave and detonated the attached individual charges accordingly. The significant advantage of the Phaser over the previous vertical source arrays is that it is able to syn-

chronize precisely with the downgoing pressure wave, reinforcing it in phase to produce the sharpest possible impulse.

Your column is probably the most read in *TLE*. Maybe, just maybe, this additional information about the Phaser will help to resurrect the idea of using vertical source arrays with significantly lesser fold against the current industry trend of increasing source redundancy.

Lee Lawyer. This is an interesting set of notes, but the one that caught my attention was the side-by-side vertical vibrators, phase-reversed to generate SH waves. I cannot recall hearing about this technique before. A follow up from Gerhard clarifies the subject!

Your digging up fossil SH devices made me contact the shear-wave expert H.A.K. Edlmann of Prakla-Seismos. He immediately flooded me with information. I quote: "It was a special satisfaction for me when I could show the gentlemen of Conoco in Ponca City our results gained by SHOVER on a line near El Reno, Oklahoma. Our results were as good as those yielded by Conoco's three heavy shear-wave vibrators." SHOVER was indeed a cheap procedure, for you could use conventional vibroseis. **TLE**