FROM THE OTHER SIDE

A column by Lee Lawyer with stories about geophysics and geophysicists

I gave you a test last month (you failed). Here is another one. What is mu over rho? For the people who do not have a classical education, mu and rho are Greek letters. To give you helpful clues, consider the following. Mu is the 12th letter in the alphabet. Rho is the 17th letter. Wow! This is little known information in geophysical circles. You could say that 12/17 is 0.7058823529411764 etc. . . . Wrong answer!

I can keep the suspense going for several paragraphs, but I am going to give you the answer now. Mu divided by rho is the square of the shear velocity in a homogeneous medium. Another wow!

Shear-wave technology was a very big subject back in the seventies. This was shortly after GEOPHYSICS "Bright Spots" hit the scene. All research labs were breaking rocks and analyzing fluid effects by measuring elastic properties. The word "modulus" became a household term. Poisson's ratio made headlines. Start-up companies were organized. Universities developed rock labs and graduate studies.

A big problem was how to generate SH waves. I understand the Russians used side-by-side holes, one with a charge and the other to absorb energy going that way. It creates one-half of the SH. By reversing the hole arrangement, one could generate the other half. Changing the polarity and summing them could give a usable SH section. I vaguely recall some kind of hammer to generate SH waves. I don't think I ever saw data from any of these unique field methods. However, there was one development that showed real promise, the shear-wave vibrator.

In 1982, The Virgil Kauffman Gold Medal was awarded to two people who had a great deal to do with the development of the shear-wave vibrators at Conoco in the early 1960s. They were Ted Cherry and Ken Waters.

What happened to that technology? What happened to SH generation and interpretation? Where are the shear-wave vibrators? (Forgive me if I have asked these questions before.)

With the development of the shear-wave vibrator, Bill Laing and Charles Payton originated the idea for a group shoot. As a result, the Vibroseis Shear Wave Seismic Group shoot was initiated in 1977 and 1978. Twelve companies plus Conoco were participants, all the majors and a couple of others. Twenty projects were nominated and approved by the group. The only one I recall vividly was the first one, Putah Sink, California, probably because of the name. Other interesting names were Siberia Ridge, Horse Butte, and Madden Deep in Wyoming, and Yolo and Paloma fields in California. Of course, there were a bunch in Oklahoma and Texas.

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Conoco processed the data through brute stack. (Does every one know what is meant by a brute stack?) It was up to the participants to analyze and interpret the data beyond that point. Because of the competitive nature of shear waves back then, I am not sure how much of the data was published.

Along these same lines, make a dark spot on a piece of paper. Get a clear crystal of calcite and look through it at the dark spot. You will see two spots! This is called birefringence. If one properly acquires SH seismic data in the right geologic setting, there is information about the amount and direction of the fracturing in the reservoir, birefringence, sort of. Sounds great, doesn't it? What happened to that? Maybe there is no geologic setting that is economically appropriate for that technique.

I asked for comments on plate tectonics (*TLE,* 2008). The following came from Gerhard Kepner:

> Continental drift—seafloor spreading—plate tectonics, what a fascinating story!
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> Alfred Wegener was born in 1880—like Mintrop, and died exhausted during an expedition in the Greenland ice in 1930—the same year when a certain Lee Lawyer was born (editor's note: 1929 is accurate)—I presume. . . .When Wegener published his idea in 1915, he was convinced that it might last no longer than 10 years for his theory being accepted by the geoscientists in the world. Too overwhelming seemed to him the fitting of the continents to what he called Pangaea, too striking the parallel position of the mid-Atlantic rift as scar and starting line of the movement, too clear the correspondence of Paleozoic and paleobotanic features on opposite sides. The crucial question was: What is moving the continents and on what do they drift? The topic of the famous AAPG meeting in New York in 1926 reads: "Theory of continental drift. A symposium on the origin and movement of land-masses both inter-continental and intra-continental as proposed by Wegener." The theory was torn to pieces. As a consequence, the revolution was postponed for decades. Nobody found a plausible force strong enough to move the continents. (Could we allow apples to fall from trees when we do not know what gravity is?) . . . Van Waterschoot van der Gracht, the initiator of the meeting and taken with Wegener's theory, pleaded for further investigations. And he was right: 30 years after Wegener's death, Harry Hess and Robert Dietz discovered the moving force of continents. But there were others long before Hess and Dietz who were on the right track. The Austrian geologist Otto Ampferer realized as early as 1906 the significance of magma flows beneath the Earth's crust for moving continents and mountain building. The sketches he made and published could well serve, even today, to demonstrate the driving force of the movement. And Robert Schwinner defined convective magma flows and subduction features in 1919, long before H. Benioff gave his name for such zones.

This is interesting information, but one question arises. Would Wegener have known about the "mid-Atlantic rift" in 1915?

A little research on the Internet says Wegener probably did know this. The existence of the ridge was first inferred as far back as 1850 by Matthew Fountaine Maury and discovered in 1872 by a team of scientists led by Charles Wyville Thomson on the famous voyage of the *HMS Challenger*. It was one of many discoveries (subsequently published in 50 volumes!) made during this four-year voyage around the world. The geophysical confirmation began in 1925 with echo sounding on the first voyage of the German *Meteor*.

Back in September's FTOS, I stated: "Hess was aboard the 'junky' U.S. Navy submarine S-41 while cruising in the Bahamas with a Vening Meinesz pendulum aboard. Princeton University had arranged for Hess to keep the meter working. Interestingly, engineering officer, Lt. Hyman Rickover, was able to keep the boat from sinking permanently. Hess was also on a later submarine cruise, assisted this time by Maurice Ewing (sorry about all that name dropping)." I think I dropped one too many names. Lamar Worzel sent a refinement (correction) to that item.

> Hess made soundings and Vening Meinesz made gravity observations on S-21. Reference: Vening Meinesz, F.A. and F. E. Wright, 1930, "The Gravity Measuring Cruise of the U.S. Submarine S-r1" Publ. of the U.S. Naval Observatory 2nd series, vol. 13 Appendix 1, 94 pp.
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> Hess made soundings and Maurice Ewing made gravity observations on *U.S.S. Barracuda*. Reference: Ewing, Maurice, 1937, "Gravity Measurements on the U.S.S. Barracuda" Amer. Geophys. Union, Trans. p 66–69.

Wow! Contrary to popular belief, I am not always right, just 99% of the time. Thanks, Lamar.

When I wrote about the origins of plate tectonics, I knew I had left out important contributors. John Diebold, chief scientist for Marine Operations at Lamont-Doherty suggests some that I missed.

> You did miss J. Tuzo Wilson and Lynn Sykes, who spelled out the important existence and role of transform faults, and also my colleague Walter Pittman, who demonstrated for the first time that those magnetic stripes were symmetrical on either side of the ridge axis.

Thanks, John. If anyone knows of others who were instrumental in developing plate tectonics, let me know. The two mentioned by John were highly instrumental in furthering our understanding of plate tectonics. How could I have missed them? (Don't answer!) TLE