

April 2020



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# JGSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON  
Volume 10 • Number 8

**Following health agencies recommendations, GSH's technical and social meetings for April have been re-scheduled or postponed. Check individual events for additional information.**

**Technical Article:**

**Time-Lapse Electrical Resistivity and Ground Penetrating Radar Imaging of Young Polygonal Patterned Ground in Victoria Valley, McMurdo Dry Valleys, Antarctica – Page 12**

**Tutorial Nuggets:**

**Virtual Seismic, LLC Announces New Seismic Source – Page 19**

**U of H Wavelets - Geoscience Article:**

**Case Study: Phase Component Amplitude Variation With Angle – Page 25**

**Doodlebugger Diary:**

**Portable Party Discovers Challenging Terrain in Pakistan – Page 40**

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*Seismic acquisition in an environmentally sensitive area.*

*Photo courtesy of Global Geophysical.*



## EDITOR'S NOTE

To ensure your information reaches the GSH members in a timely manner, please note the following deadlines and plan accordingly. Please submit your articles and any questions to Alvaro Chaveste, editor, at [AlvaroChaveste@hotmail.com](mailto:AlvaroChaveste@hotmail.com)

### GSH JOURNAL DEADLINES

June 2020.....Apr 10  
Sept 2020..... July 13  
Oct 2020..... Aug 17

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# A Word from the Board

By Matt Blyth, First Vice President Elect



Back in January, President-Elect Peter Duncan referred to himself as “the new kid on the block” in his Word from the Board article, I think I may have him beat there.

Although I have over twenty-two years in the oilfield, I am relatively

new to the geophysics world and certainly a new face within the GSH. Some of you have already seen me, introducing west side and downtown tech lunches, but I guess this is as good a forum as any to introduce myself – so hello!

Unlike most members of the GSH, I did not arrive at this point by way of the seismic world, instead coming up via formation evaluation, logging-while-drilling (LWD), and borehole acoustics in particular. So, there is a connection to geophysics as both fields deal with noisy wiggles, it’s just that the ones I am more familiar with are smaller and more tightly packed, but no less useful, than those in surface seismic. My first connection to the GSH was back in 2014 when I delivered a webinar series on borehole acoustics at the request of the society and then again in 2017 when I volunteered to do it again. I do however, have a lot of experience in being part of a large professional society, having served as both Vice President and President of the Houston chapter of the SPWLA, on the board of the SPWLA Acoustics SIG and on the organizing committees for various SPWLA events, including the 2019 annual conference.

What that has taught me is that the professional societies like the GSH have a very important role to play in two key areas. The first is in disseminating the latest technical innovations. Conferences, workshops, SIGs, luncheons, etc. all give a platform for the entire industry to present what they are working on and to highlight technology that can change how we work. The

most dramatic of these over the last few years has been the rise of artificial intelligence (AI) and machine learning (ML) within the oilfield. Once what seemed to be something more for the Googles and Amazons of this world has now come straight to the forefront of our industry and will have far reaching consequences no matter what area you work in. It’s a hot topic in petrophysics right now, just as much as it is in geophysics, geophysics being the ultimate in big data after all.

It may not seem like it is going to change much at the moment, when we are still doing things the way we have for several years, but it will at the very least allow us to automate a lot of what we do that is repetitive and time consuming and at the best, open up new solutions that we have not thought of in the past. It’s no surprise therefore that it is the topic for this year’s spring symposium and that the GSH is in the process of setting up a new SIG, with a focus on Data Science. So, I encourage all of you to attend the symposium and our regular schedule of tech lunches, breakfasts and SIG meetings to discover something new. As GSH members we are lucky to have such a packed schedule of quality technical events included within the membership fee. It is certainly much more than the other Houston societies provide.

The other key benefit of membership of a society like the GSH is the contacts and friendships it builds. The people I have met through the professional societies have become friends, co-workers, collaborators and co-authors, to name just a few. They have influenced my career; my personal and professional development and I am not sure I would be where I am now if it were not for them. For the GSH to continue to be a success we need all of you to be involved in the organization, to attend the tech lunches and SIG meetings, to come to the symposiums and even to offer to speak at the events. We will all benefit if you do!

Thanks for the time and I look forward to working with you through my tenure as 1st VP and beyond. □



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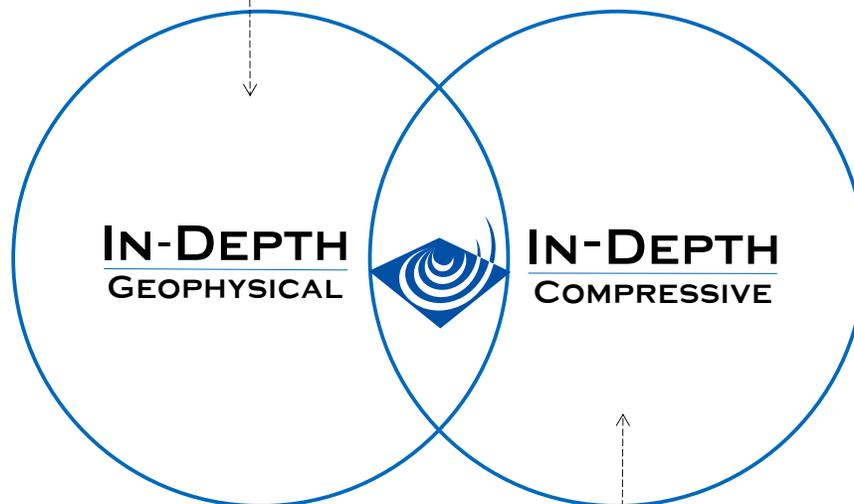


Dear GSH Journal readers,

Please feel free to email us with any and all questions or suggestions.

Sincerely,  
Alvaro Chaveste, Editor,  
[AlvaroChaveste@hotmail.com](mailto:AlvaroChaveste@hotmail.com)

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# From the Other Side

By Lee Lawyer



I attended an EAEG annual meeting in Belgrade, Yugoslavia in June of 1987. As a gift, the delegates received copies of a book entitled Mohorovicic by D. Skoko-J. Mokrovic. What they didn't give-out was how to pronounce "Mohorovicic".

When we think about work done in the late 1800s and early 1900s, we have to remember the restrictions scientists faced during those times. Accurate time measurements of seismological events were critical to the study of earthquakes. As I read the history of Mohorovicic's work, I marvel at the progress he made. At Oklahoma University (1947), I saw a giant drum with a stylus that recorded data using an ink pen. That was the kind of data Dr. Mohorovicic used to detect the Moho layer. Probably still in use today!

The early work of Ludger Mintrop involved the construction of a recording device, which was called a Seismograph. He was not the first but as far as I know, he was the first to record a 'man-made' earthquake. He dropped a large iron ball from about 100 feet several times, recording the results on his Seismograph. The reason I mention Mintrop is the timing between his work and the work of Mohorovicic. Both were in the early 1900s. Ludger was a student. Dr. Mohorovicic was an experienced professor located in Zagreb. The data available to Mohorovicic were from scattered stations recording earthquakes often hundreds of miles from the epicenter. It would be tough for us who make man-made earthquakes to interpret anything with geophones spread 1000 feet apart.

Mohorovicic measured travel times for earthquakes and observed that there was a boundary below which the velocity increased rapidly. Recall that we are dealing with first arrivals and converted waves. The Moho is located just above the Mantle. We are talking about Igneous rocks, not sedimentary ones.

Did you know that there is no basalt under granite? This was a huge surprise. "Seismic suggested that at 9,000 meters the granite would give way to basalt." This is another "Show me the data" situation when seismic data (I assume earthquake sources) is interpreted. The idea that there is an oceanic crust under the continents goes back to the good old days. To believe that basalt is below granite is to assume that oceanic crust (basalt) was formed before continents. Basalt is an extrusive rock by definition. Of course, the discovery of the Moho layer preceded the knowledge that continents (plates) were pushed around by newly formed oceanic crust, i.e., basalt extruded at spreading centers. I guess we could call the rock under granite, "gabbro", which is not extrusive. I am getting into deep water here. Speaking of which, I have seen a strong reflection on marine seismic data that shows oceanic crust diving under a shoreline. Ergo, there must be basalt below something at least temporarily, geologically speaking!

Scientists want to be first to drill to the Moho; first is important. Just reaching the discontinuity remains an important scientific objective. Soviet scientists at the Kola Institute pursued the goal in 1989. After 15 years they reached a depth of 12,260 meters (40,220 ft), the world's deepest hole, before abandoning the project. The Japanese project Chikyu Hakken («Earth Discovery») also aims to explore in this general area with the drilling ship, Chikyū. The Kola Superdeep Borehole was started in 1970 and still holds the world record for the deepest hole in the ground. But they didn't reach the mantle. The Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) expedition 360 on the JR left port on November 30, 2015, to drill to the Earth's mantle. I wonder what happened to that venture.

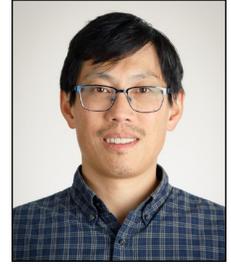
All of the above data is gleaned from the internet. Does anyone know the latest news regarding drilling to the Moho? Plus, don't forget to join the Challenge donation for the GeoScience Center. There could be valuable info available there on the Moho! □

# Technical Breakfasts

## *Finding Lost Tectonic Plate Fragments Using Seismic Tomography - Geological and Hydrocarbon Implications Along the Andean Cordillera*

Register  
for Tech Breakfast  
North

Register  
for Tech Breakfast  
West



Jonny Wu

**Speaker:** Jonny Wu

Assistant Professor, Dept. of Earth and Atmospheric Science  
University of Houston

### North

**Tuesday, Apr. 7, 2020**

7:00 – 8:30 a.m.

**Sponsored by Oxy**

**Location:** Oxy

(formerly Anadarko Bldg.)  
1201 Lake Robbins Drive  
The Woodlands, TX 77380

### Abstract:

Plate tectonic reconstructions of Nazca subduction under the Andes remain debated because the Nazca-Farallon seafloor has been subducted. Here I show a novel approach to plate tectonics. It involves “unsubducting” lost oceanic plates in Earth’s mantle, imaged from seismic tomography.

Subducted Nazca slabs were mapped from tomography using 3D seismic interpretation-style workflows. Tomographic velocities extracted along the slabs reveal details of subducted features. The unfolding of the mapped slabs (i.e. structurally restorations) allows their pre-subduction geometry to be estimated and used as input for quantitative plate reconstructions.

The next generation ‘tomographic’ plate models reveal that Nazca subduction, along the Andes, has not been fully continuous since the Mesozoic; but has included episodes of divergent phases. At the Neuquen basin of Argentina, foredeep sedimentation and compression initiation were linked to deep interactions between the Nazca slab and the lower mantle.

### West

**Wednesday, Apr. 8, 2020**

7:00 – 8:30 a.m.

**Sponsored by Schlumberger  
and WesternGeco**

**Location:**

Schlumberger Facility  
10001 Richmond Ave.,  
Q Auditorium  
Houston, TX 77042

I discuss possible hydrocarbon implications along the Andean Cordillera from these new plate tectonic insights.

### Biography:

Jonny Wu is an Assistant Professor in structural geology, tectonics, and mantle structure at the Department of Earth and Atmospheric Sciences of the University of Houston. Wu conducted his graduate studies at Royal Holloway, University of London, UK, and earned a postdoctoral fellowship at National Taiwan University.

Wu is originally from Canada. He formerly worked at Shell Canada as an exploration geologist on the Canadian East Coast and Mackenzie Delta-Beaufort from 1998 to 2004.

His research interests are global plate tectonics, East Asia tectonics, structural ‘sandbox’ modeling, and sedimentary basins. Wu’s work on the Andes Mountains plate tectonics was published in the journal Nature earlier this year and was featured on the front cover. □

# Unconventional SIG

## *The Role of Geophysics in Engineering WorkFlows*

Register  
for  
Unconventional

**Speaker(s):** Katie Essary  
Reservoir Engineer  
Chevron

**Thursday, Apr. 2, 2020**  
11:30 a.m. - 1:00 p.m.

### **Abstract:**

Does geophysics drive unconventional development? Eh, not really, but maybe it should - A humble reservoir engineer's perspective.

In the last decade, the oil and gas industry has cracked the code on how to produce from a previously uneconomic, but extremely large resource commonly known as unconventional shales and tight rock. We now know that horizontal, multi-frac'd wells can unlock reserves from extremely low-permeability rock, and in many cases, provide quick pay-outs on investments. We believe this can then be replicated over-and-over again across vast amounts of acreage in unconventional basins.

Initially, geophysics aided in the understanding of the overall containers or size of the prize, but type curves and drilling and completion costs dominate as the basis for economics, attract capital, and drive business decisions. Now that companies have drilled their initial wells in unconventional assets (in some cases, hundreds); the question is, how do we continue to keep the capital flowing for the next 20+ years? This talk will focus on previous and current workflows for evaluating, prioritizing and developing unconventional assets, while posing a challenge for what's next.

How can geophysics aid in the evolution of our understanding of the fundamental physics at play? How can the acquired understanding support long-term producibility and optimization of these valuable assets?

### **Biography:**

Katie Essary is currently a reservoir engineer at Chevron Corporation in the downtown Houston

### **Sponsored by TGS**

**Location:** TGS  
10451 Clay Rd.  
Houston, TX 77041



**Katie Essary**

office where she is attached to the Mid-Century Business Unit. She attended the University of Kansas where, in 2009, she attained a BSc. Degree in Chemical Engineering. Shortly after graduation she started with Chevron in Bakersfield, California where she focused on developing and optimizing legacy, heavy oil assets within the San Joaquin Valley.

In 2013 she was transferred to Houston where she joined an exploration team tasked with assessing horizontal shale opportunities across the Permian basin. The efforts ultimately led to drilling Chevron's first horizontal wells in the Midland Basin. Over the next four years, she was part of the evolution of the Permian shale boom while working on exploration and appraisal activities, business development, and reserves evaluations.

In 2017, she pursued an opportunity with Marathon Oil Corporation, serving as a Corporate-level Reserves Coordinator with areas of responsibility including unconventional assets (Bakken and Eagle Ford) as well as conventional, international assets (UK, Kurdistan and Libya). In 2019, she returned to Chevron where she currently works with the Business Development group in the Permian for assessing acquisitions, divestitures, trades, joint ventures and farm-outs.

Katie has been an active participant in the Society of Petroleum Engineers where she has held leadership roles in the Gulf Coast Section. She is a reviewer for paper submissions for the 2020 URTeC Conference. Although she finds petroleum engineering very rewarding and exciting, her greatest passion is being a wife and mother to her two toddlers and stepson. □

# Data Processing & Acquisition SIG

## *Complementary Use of FWI in Earth Model Building Workflows in Complex Media*

Register  
for Data  
Processing

**Speaker:** Olga Zdraveva  
Imaging Domain Advisor  
WesternGeco

**Tuesday, Apr. 14, 2020**

4:30 p.m. Sign-in, Snacks, Social Time  
5:00 p.m. Start of presentation

**Sponsored by Schlumberger**

**Location:** Schlumberger  
Q Auditorium  
10001 Richmond Ave.  
Houston, TX 77042



**Olga  
Zdraveva**

### **Abstract:**

Over the last 10 years, full-waveform inversion (FWI) established itself as an integral part of modern anisotropic Earth model building (EMB) workflows. During this time period, the industry witnessed the introduction of many new flavors of FWI, differing either by the portion of the wavefield used in the inversion or by the nature of the objective function. Earlier in the decade, the appearance of FWI implementations less prone to cycle skipping relaxed the requirements for very accurate starting models and/or ultra-low frequencies and long offsets. This led to a wide-spread use of FWI in different geologic environments and with different types of seismic data around the world. More recently, another class of useful FWI implementations, allowing the separation and use of the low-wavenumber component of the reflection data terms in the FWI gradient, enabled many new workflows targeting updates in the deeper portion of the model space.

Using examples from different geologic settings, this presentation will illustrate the evolving role of FWI in anisotropic EMB workflows designed to address specific imaging challenges and achieve given interpretation objectives. Combined with common image point Tomography (with or without borehole

seismic constraints) and extensive use of geologic constraints (including salt geometry interpretation scenarios, when applicable), these more recent types of FWI can have dramatic effect on both model quality and project turn-around time in complex media.

### **Biography:**

Olga Zdraveva made her academic studies in Sofia, Bulgaria. She received a Master of Engineering degree in applied geophysics (1984) from the University of Mining and Geology and a post-graduate engineering degree in applied mathematics (1985) from the Technical University. She started her career in the R&D department of Geology and Geophysics Corporation in Sofia, Bulgaria and joined Western Geophysical in 1996. She currently holds a position as imaging domain advisor in WesternGeco.

Olga's main interests are in multidisciplinary approaches for anisotropic earth model building for depth imaging and beyond. She has authored and co-authored multiple publications on different aspects of anisotropic earth model building and updating, and other practical aspects of imaging. □

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# Time-Lapse Electrical Resistivity and Ground Penetrating Radar Imaging of Young Polygonal Patterned Ground in Victoria Valley, McMurdo Dry Valleys, Antarctica

Myfanwy J. Godfrey<sup>1</sup>, David C. Nobes<sup>2</sup>, Michele T. Bannister<sup>3</sup>, and Ron S. Sletten<sup>4</sup>

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## Summary

Victoria Valley is part of the McMurdo Dry Valleys of Antarctica, an arid polar environment that is difficult for electrical imaging because of high surface contact resistance. Nonetheless, we obtained time lapse electrical resistivity imaging (ERI) of young polygonal patterned ground (PPG), as well as ground penetrating radar (GPR) imaging. The ERI data have a large range of values, and are best viewed using two different scales, one to emphasize the highly resistive materials at depth, and the other to focus on the lower resistivity material of the near-surface active layer. The time lapse imaging highlighted the development of the active layer during the short summer thaw, and the results correlate well with the GPR which shows that the PPG structures are not vertically oriented at depth.

## Introduction

As part of a larger research project, we undertook geophysical imaging of polygonal patterned ground (PPG) in Victoria Valley, using electrical resistivity imaging (ERI) and ground penetrating radar (GPR) profiling. PPG is characteristic of permafrost regions (e.g., Sverinsson et al., 1967; Sletten et al., 2003). Victoria Valley is one of the McMurdo Dry Valleys which make up 95% of the 2% of Antarctica that is ice-free, and are arid polar landscapes that can act as proxies for the Martian environment (e.g., Morris et al., 1972).

One experiment was to do time lapse ERI of what appeared to be relatively young PPG with none of the significant surface topography that is characteristic of older PPG. The ERI in particular is sensitive to the free water content changes in the

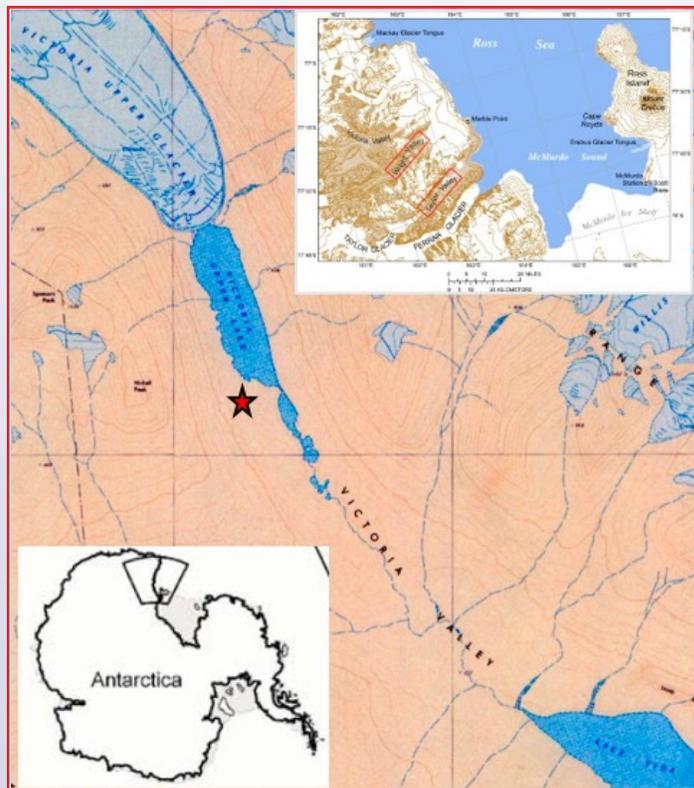


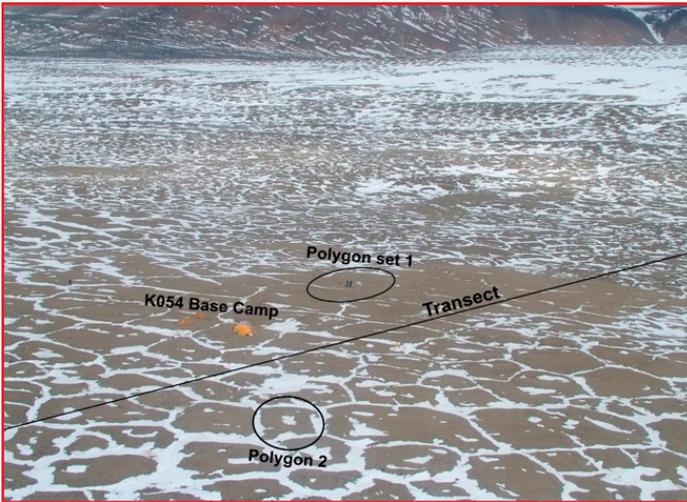
Figure 1: The site of the Victoria Valley PPG imaging experiment (red star) near the southern end of Victoria Upper Lake. (Source: USGS) Upper Inset: Location of Victoria Valley, relative to McMurdo Sound, Ross Island, and the NZ and US Antarctic bases. (Source: Gateway Antarctica) Lower Inset: Location of Ross Dependency relative to Antarctica.

active layer, which is where what little free water present in the area exists (e.g., Lachenbruch, 1962). We also carried out complementary GPR imaging.

We present here the results of that experiment and its correlation with surface PPG features (Godfrey,

*Technical Article continued on page 13.*

For Information Regarding Technical Article Submissions, Contact GSHJ Coordinator Scott Singleton (Scott.Singleton@comcast.net)



**Figure 2a:** The Victoria Valley imaging experiment was located on Polygon 1 (upper centre), close to the base camp, a long transect line, and a separate detailed imaging experiment on Polygon 2. Southwest (SW) is to the upper right, northeast (NE) to the lower left.



**Figure 2b:** Polygon set 1 consisted of a set of four small polygons. A GPR CMP line can be seen running faintly through the middle of the rightmost pair of small polygons.

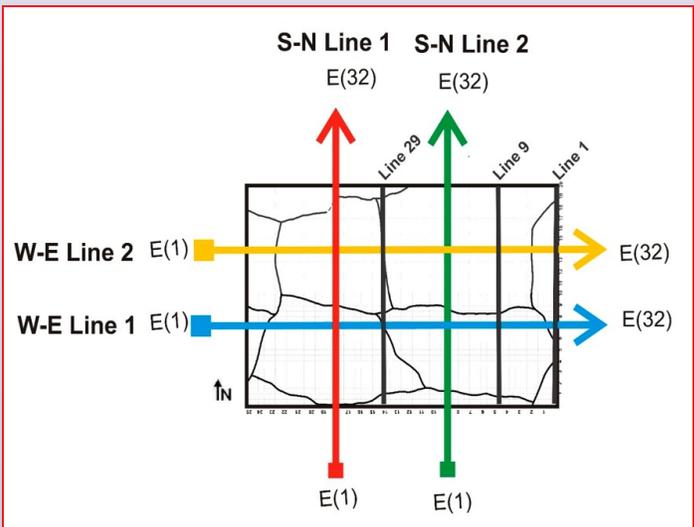
2008). The predominant PPG formation models all show the PPG cracks that are a universal aspect of such features, but our results suggest that the cracks are not vertical, but are dipping. The dipping cracks may arise because of physical property changes at the active layer-permafrost boundary, and vertical cracks may occur at another site because that site is often underlain by buried massive ice.

**Site Description and Methodology**

Victoria Valley is one of the McMurdo Dry Valleys in Antarctica (Figure 1). The detailed polygon imaging study was located in the upper central part of Victoria Valley. The young polygon was relatively flat and less rocky than areas both upslope and downslope (Figure 2). Antarctica is a polar desert, so the setting is arid and cold.

The ERI profiles were completed using a Campus Tigre multi-electrode system. We used four separate 64-electrode configurations, each with 0.5 m electrode spacing. The electrodes were arranged as 2 sets of parallel profiles, one set oriented approximately north-south, and the other oriented approximately east-west (Figure 3). The profiles were all separately inverted using Res2DInv (Loke and Barker, 1996) on its robust setting.

The GPR profiles were completed using a zpulseEKKO 100A system, with 100 and 200 MHz antennas separated 1 m and 0.5 m apart, respectively, and step sizes of 0.1 m. Common midpoint (CMP) profiles were also acquired adjacent to Polygon 1, which yielded a subsurface velocity of 0.13 m/ns (130 m/ms). Using the Fresnel resolution at its limit at the surface, the lateral



**Figure 3:** Layout of the imaging of Polygon 1. The resistivity lines are colour coded. The locations are labelled of the three example GPR lines (1, 9, and 29) shown in Figure 5.

resolution for the 200 MHz signal would be 16 cm, so the step size of 10 cm was clearly adequate to avoid spatial aliasing (e.g. Annan, 2005; Nobes, 2018). The GPR data were processed using EKKOView software.

The long axis of the site was oriented approximately east-west (Figure 3). The GPR worked well in the arid environment, and despite the rocky surface (Figure 4), so did the ERI. Despite the surface high contact resistance, we were able to penetrate the active layer with the electrodes, and thus get good electrical contact.

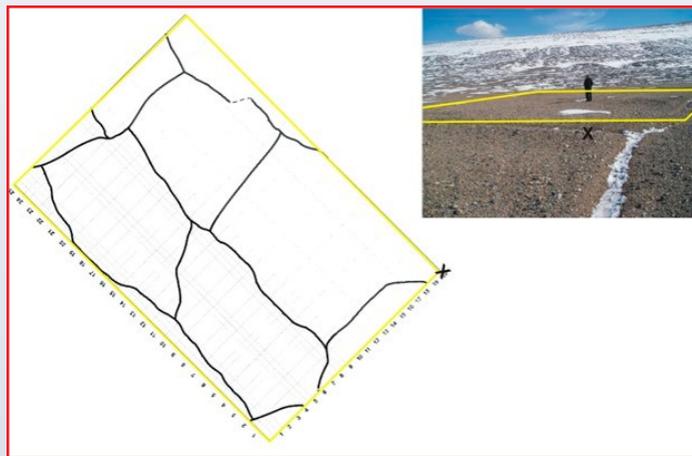


Figure 4: The surface of the polygon experiment (shown outlined in yellow) was arid, relatively flat (inset).

## Results and Discussion

The ERI results are best understood and interpreted in the context of the GPR results (Figure 5 and Figure 6). The CMP profile (Figure 5) has a few clear reflections, but the clearest occurs at about 40 to 50 nanoseconds (ns) two-way travel time, which corresponds to the base of the active layer in the profiles in Figure 6.

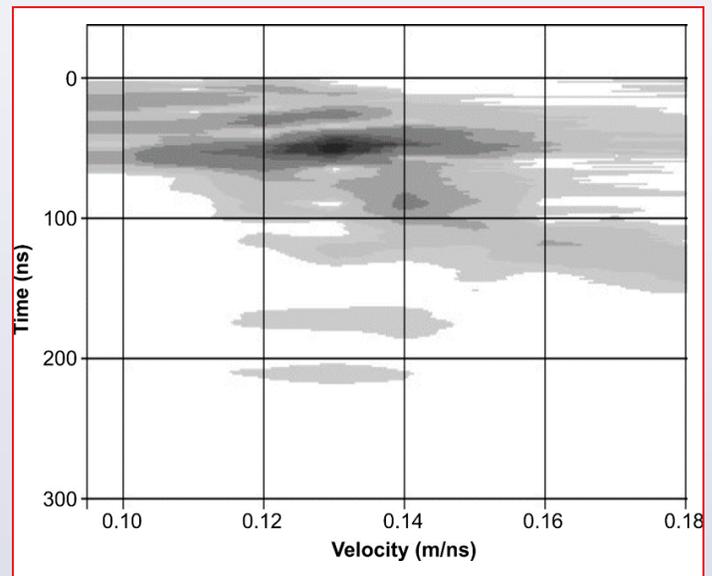


Figure 5: CMP profile adjacent to Polygon 1. Note the strong reflection energy at about 40 to 50 ns travel time, which correlates with the active layer.

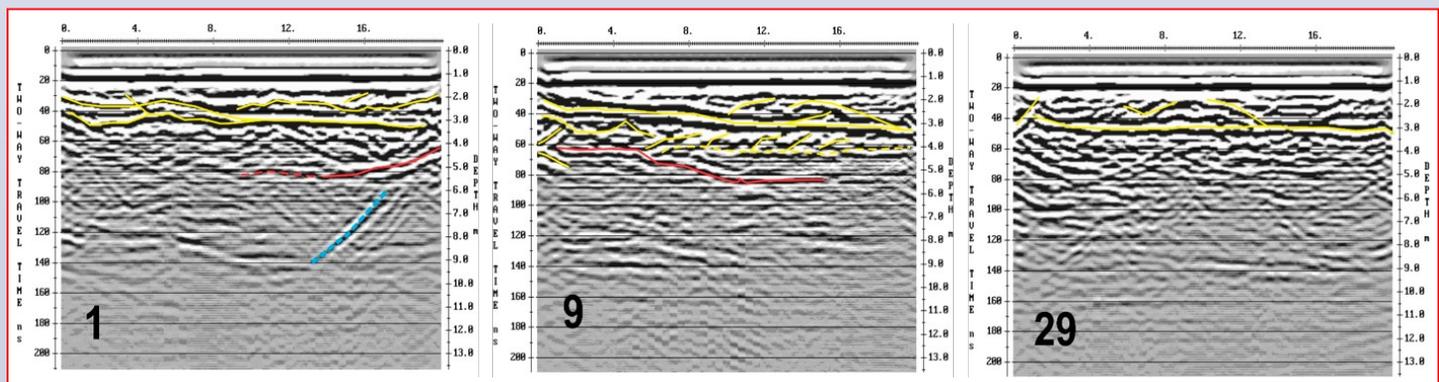
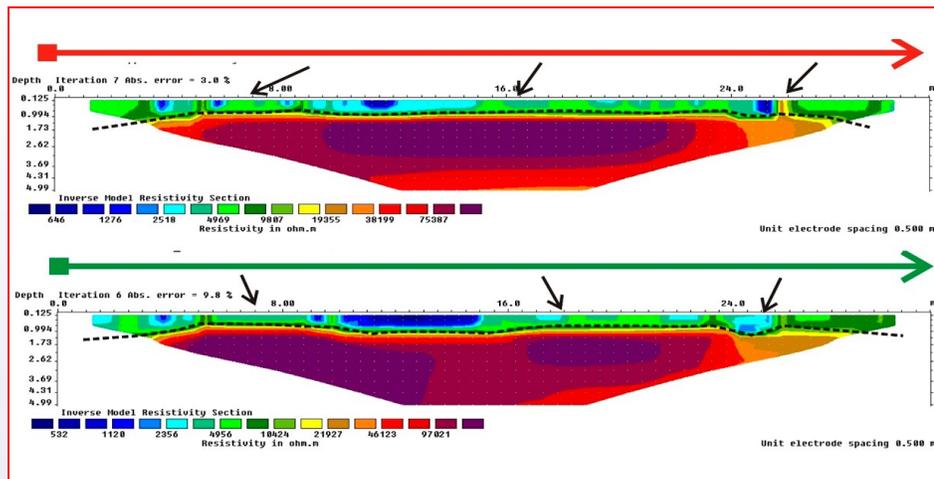


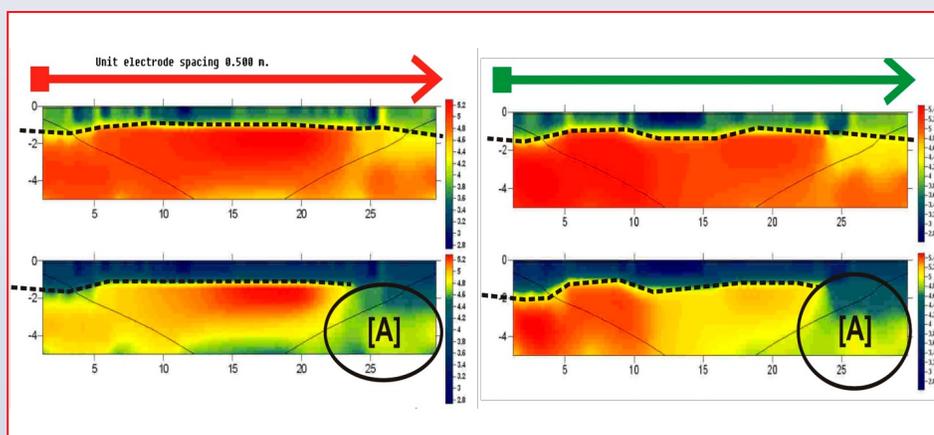
Figure 6: Sample migrated GPR profiles Lines 1 (top), 9 (middle), and 29 (bottom), illustrate both the general stratigraphy of the polygons, as well as the structure. The truncation and offsets of the stratigraphy, and the reflections from the cracks indicate clearly that the polygon cracks are dipping, not vertical, as standard PPG models would suggest. The active layer, highlighted in yellow, is horizontal to sub-horizontal, and is the dominant reflection in the profiles.



dipping structures, not vertical, as suggested in standard PPG models. There are also two sets of dipping features, one with dips of approximately 40 degrees to the north (from left to right in *Figure 6*), and the other with dips of approximately 40 degrees to the south (from right to left in *Figure 6*). The dips are almost perpendicular to each other.

The ERI models can be shown in ways that emphasize different aspects (*Figures 7 and 8*). The south-north (SN) profiles are representative and we focus on them here. The active layer is prominent and correlates well with the reflection from the base of the active layer observed in the GPR profiles (*Figure 6*). The locations of the surface cracks at the boundaries of the polygons do not appear to align with features at depth (*Figure 7*).

*Figure 7: The south-north ERI results are representative, and also indicative of subsurface structure that is not vertical. The variations in the electrical properties do not perfectly align with the surface locations of the cracks (arrows). The dashed line is the base of the active layer, as observed in the GPR profiles.*



The time lapse ERI results (*Figure 8*) highlight the agreement between the ERI and GPR. We also see a lower resistivity zone ([A]) beneath the northern portions of the lines. This could be correlated with increased percolation of meltwater from the active layer during the summer thaw. We also note the good correlation between the dipping reflections seen in the GPR profiles (*Figure 6*), and the anomalous ERI results (*Figure 8*).

*Figure 8: Two of the time lapse ERI profiles, SN Line 1 (top) and SN Line 2 (bottom) illustrate the changes in the surface and subsurface over one summer thaw cycle. The dipping features observed in the GPR profiles (Figure 5) are superimposed, and correlate well with the anomalous electrical responses. A zone of lower resistivity, [A], underlies the northern portion of the profiles. The resistivities are plotted using logarithmic scales (at the right margins) to better visualize the range of values.*

All of the GPR profiles are migrated, and so diffractions have been collapsed. There appear to be dipping structures extending at depth below the PPG cracks (*Figure 6*). In Line 1, we can even see some reflections from the cracks. The truncations and offsets of stratigraphy also correlated with

The dipping reflections don't fit the standard models of polygon formation (*Figures 9 and 10*). The two sets of dipping reflections in the GPR profiles could indicate that cracks are forming due to physical property changes at the base of the active layer. Results from the other, older and better developed

polygon (Polygon 2 in *Figure 2*), however, do appear to be consistent with the standard model. The area of Polygon 2 and the adjacent transect often appear to be underlain by buried massive ice (Bannister, 2007; Godfrey et al., 2008; Bannister et al., 2019).

### Conclusions

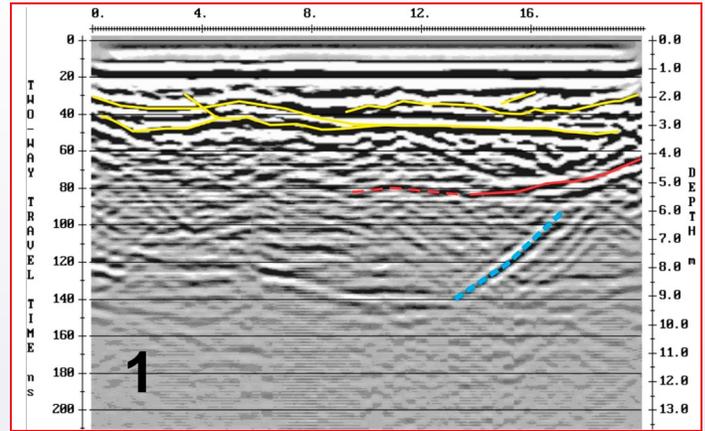
Despite the difficult arid polar desert environment of the McMurdo Dry Valleys of Antarctica, we were able to obtain good repeatable electrical resistivity imaging (ERI) measurements across the polygonal patterned ground (PPG) of the permafrost soils. The results of the ERI and complementary ground penetrating radar on a set of PPG polygons with low topographic relief show dipping reflections and offset or truncated stratigraphy. This conflicts with standard models of PPG formation, in which the cracks between the polygons are vertical or near-vertical.

The dipping reflections beneath the Site 1 polygons suggest that cracks don't form vertically, but as dipping features, possibly parallel to the principal stress directions. The two sets of reflections can arise due to changes in the physical properties at a boundary within the subsurface, and an obvious candidate for such a boundary would be the active layer.

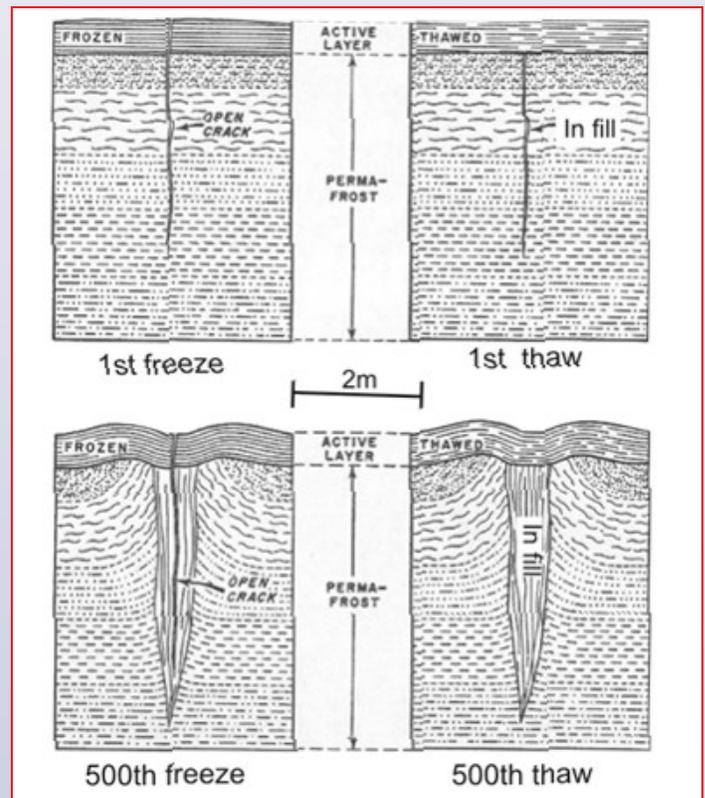
The differences in the polygon subsurface geometry between Sites 1 and 2 require further investigation to explain those differences. Is Site 1 at the base of a scree slope or debris fan, or at a moraine high point? Is the buried massive ice correlated with more highly developed PPG? Additional research is needed to address these questions.

### Acknowledgments

The authors thank the New Zealand Antarctic Program, and the Departments of Geological Sciences and of Physics and Astronomy at the University of Canterbury, for their support of project K054. Jon Lapwood helped with the data acquisition. MTB thanks Peter Cottrell for advice and guidance. We also thank all of the staff at Scott Base; they make it their mission to support as much as possible the scientific research programs down on "The Ice". □



*Figure 10: The subsurface structure beneath the presumed young Polygon 1, with low surface topography, has dipping features, as exemplified in Line 1 from Polygon 1. The standard model of PPG formation (Figure 9) has vertical cracks.*



*Figure 9: The standard model of PPG formation has vertical cracks which gradually fill with sediment, preventing crack formation and generating stresses that deform the PPG, thus giving rise to surface topography formation. (Modified from Lachenbruch, 1962.)*

## References

Annan, A.P., 2005, The Principles of Ground Penetrating Radar: In Butler, D.K. (ed.), *Near-Surface Geophysics*, Society of Exploration Geophysicists, Tulsa, OK, *Investigations in Geophysics*, No. 13, 357–438.

Bannister, M.T., 2007, Polygonal patterned ground and ancient buried ice on Mars and in Antarctica: Unpublished B.Sc. (Honours) project in Astronomy and Geology, Department of Geological Sciences and Department of Physics and Astronomy, University of Canterbury, 24 pp.

Bannister, M.T., D.C. Nobes, M.J. Godfrey, and R.S. Sletten, 2019, Imaging Buried Massive Ice in Victoria Valley, Antarctica, with Multi-electrode Electrical Resistivity and Ground Penetrating Radar: SEG Annual Meeting Expanded Abstracts, San Antonio.

Godfrey, M.J., 2008, 2D and 3D Geophysical Imaging of Polygonal Patterned Ground in the McMurdo Dry Valleys, Antarctica: M.Sc. thesis, Geological Sciences, University of Canterbury, Christchurch, 186 pp.

Godfrey, M.J., M.T. Bannister, D.C. Nobes, and R.S. Sletten, 2008, 3D Time-Lapse Imaging of Polygonal Patterned Ground in the McMurdo Dry Valleys of Antarctica: In Proceedings of GPR2008: 12th International Conference on Ground Penetrating Radar, Birmingham, UK.

Lachenbruch, A. H., 1962, Mechanics of Thermal Contraction Cracks and Ice-Wedge Polygons in Permafrost, Geological Survey of America Special Paper No 70, New York.

Loke, M.H., and R.D. Barker, 1996, Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method: *Geophysical Prospecting*, 44, 131–152.

Morris, E., T. Mutch and H. Holt, 1972, Atlas of geologic features in the Dry Valleys of South Victoria Land, Antarctica: possible analogs of Martian surface features: Intragency Report: *Astrogeology* 52, United States Department of the Interior Geological Survey, for the National Aeronautics and Space Administration.

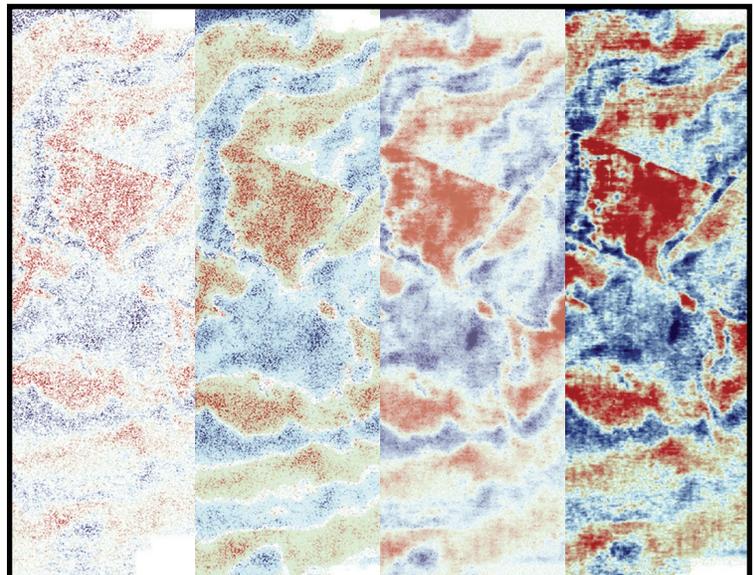
Nobes, D.C., 2018, Interpretation pitfalls to avoid in void interpretation from ground-penetrating radar imaging: *Interpretation*, 6 (4), SL21–SL28.

Sletten, R. S., B. Hallet and R.C. Fletcher, 2003, Resurfacing time of terrestrial surfaces by formation and maturation of polygonal patterned ground: *Journal of Geophysical Research*, 108 (E4), 8044–8053.

Svensson, H., H. Kallander, A. Maack, and S. Ohrgren, 1967, Polygonal ground and solifluction features: photographic interpretation and field studies in Northernmost Scandinavia: *Lund Studies in Geography: Series A Physical Geography*, No. 40, Department of Geography, the Royal University of Lund, Sweden.

Turnbull, I., A. Allibone, P. Forsyth, and D. Heron, 1994, Geology of the Bull Pass-St Johns Range area, southern Victoria Land, Antarctica, scale 1:50,000: Institute of Geological and Nuclear Sciences Geological Map 14, Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand.

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# Honors and Awards Banquet

Thursday, June 25, 2020  
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Cocktails | 6:00 pm  
Dinner | 7:15 pm

Spouses and guests welcome.

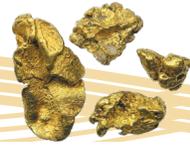
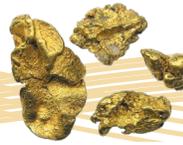


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- Henry Ford*

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## Item of Interest

In 1735, Pierre Bouguer, while on an expedition to Peru, used the pendulum to indicate gravity anomalies and in 1740 made the first attempt to evaluate the density of the Earth. Gravity data is reduced to Bouguer maps, i.e., corrections for elevation above and below a given datum.



## THE TUTORIAL NUGGETS RETURN

**A Note from the Editorial Board.** It is with heavy heart and unmitigated fear for the minds of our young readers, that we are legally forced to grant another tutorial tour to the Editor's Nemesis, the self-appointed "Guru". If you a new reader or easily persuaded by technical double talk and flawed logic, you are urged to practice restraint in implementation of his dubious technology. And please don't try to explain these inane writings to your boss.



### The Guru Speaks ...

Pay no attention to the mindless babblings of the Deep State Editorial Board. The last time they had a technical thought was two Ice Ages ago. It was, incidentally, wrong (and cold). I have been on a sabbatical to the Great Learning Centers of the World. I now know some stuff which I shall pass on to you.

First, I think it only right to bring my faithful readers (at last count, 3) and you new folks with malleable minds (or "heads full of mush", as Rush cheerfully puts it.) **up to date in the geophysical world.** Much has transpired, but we'll stick to the highlights which alter and illuminate our geophysical times. Some of these happenings impacting the Earth itself.

### Virtual Seismic, LLC Announces New Seismic Source

"This is a game changing technical breakthrough," said CEO Arthur Sullivan III about the successful testing of **SED** (Sound-Emitting Diode), purported to be the smallest and yet potentially most powerful **P- and S-Wave** generators ever made available to the industry.

Based on the seminal work of **Nick Holonyet**, inventor of the **LED**, a Nobel prize winner, and student of **John Bardeen** (two Nobel prizes), the transition from **light to sound** was done by **William Shockley**, another Nobel awardee, for his **transistor** work. Shockley, known for his paranoid approach to technical development, as well as his enthusiasm for eugenics (once offering \$1000 to anyone with an IQ of 80 or less to be sterilized), he refused to patent the original SED for fear the basic idea could easily be altered to avoid patent infringement and made into a very lucrative product.



Nick Holonyet



Bardeen



Shockley

Consequently, the technical details are among the missing in today's press release by Virtual Seismic, who by contractual agreement with the Shockley Corporation, must protect the technology as a trade secret. They did, however, release spectacular test results for the prototype. Both modes of seismic sources were of surprising strength,



Tutorial Nuggets continued on page 20.



with the **P-wave packing** the wallop of **5.5 Lbs. of dynamite**, at a depth of **100 feet**. The **spectrum of frequencies** is fully controllable from the surface and can be tailored to the needs and goals of the survey in a manner analogous to the **color control of the LED**, its predecessor. Another demonstration revealed the ability of a pair of the SED units to generate targeted trajectories in a manner reminiscent of **Spin-Along™**, the original invention which put **Virtual Seismic** at the top of seismic source providers. [See the April 2011 issue of *The GSH Journal* for details. Also available in **Tutorial Nuggets – The Book**, for a mere pittance, through the **GSH**.] The **SED** is the size of an **iPhone 11**; it is deployed in a **recoverable** fashion and will **fire at full strength** for a day's 3D recording before needing recharging (approximately 72 minutes on 110-volt systems).

## Climate Matters

The Guru was moved close to tears by the emotional plea of **Lee Lawyer**, published in his **From The Other Side** column in the February issue of the *Journal*. (An excerpt appears at the right.) He issued orders to his staff that he wanted action taken to resolve the issue.

There are still a lot of people who are skeptical of "man-made" global warming. I know the globe is warming. I know we are putting "Greenhouse Gas" in the atmosphere, which undoubtedly contributes to warming. What we need to do and how soon we need to do it is what's problematic. Shut down oil companies? Tough statement.



Prudence Purity

The **Nuggetorial Committee on Environmental Matters** is pleased to announce the Appointment of **Prudence Purity** to the post of **Chief of Environmental Stuff**. Her first task is to staff her committee with scientists like herself, unafraid of controversy and more than willing to take on the chief spokeswoman for the **One World Stop Climate Change Now Movement**, **Greta Thunberg**. Depicted, inappropriately, at the far right.

**Miss Purity**, author of "**So Who Caused the Warming Between Ice Ages?**", promises that she will have an answer for **Lee Lawyer** from this side. "I will be happy to tell columnist **Lee** **what we need to do and when to do it**. I'm not sure he'll like it, but it's time to put a halt to this hand wringing, teeth gnashing, self hating, weeping and wailing *Mea Maxima Culpa* for **Climate Change**. Next thing you know, we'll get the blame for **subduction** and a demand will be issued for **reparations to Gondwanaland** to cover reuniting fees. We'll hear more from Prudence as she snuggles into her committee duties.



Greta Thunberg

## Unfinished Business

The sudden departure of the Guru, on an extended Sabbatical, left several matters hanging. These will be attended to forthwith and heretofore. One of these is **the mess with the seemingly unending inversion discussion**. This will be handled in manner which answers the demands of the **Thompson – Lynn** wing of the **Anisotropy Gang**. Next month we'll look at **inversion of azimuthal seismic data** leading to a useful role in predicting stuff of reservoir significance. It will be fun.





**[Unfinished Business – continued]** The last puzzle to appear in *The Tutorial Nuggets*, back in 2019 is undergoing a Redux (as is true for so many topics within these pages). It has been mildly updated, with an answer to appear in the May issue.



## Improbably Possible and Impossibly Probable Puzzle Time 2020



Down at the GSH International Headquarters, the buzz is about the new **Austerity and Frugality** Program, initiated on January 1, with much fanfare and hoopla (including an astonishing **\$21374.65** bar tab). Heading up the new initiative is **Marie Clavaud**, **Treasurer** and **Chief Bean Counter** of the **GSH Morals and Money Department**. Her first cost cutting exercise was to reduce **outrageous power costs at the HQ**. Her move in that direction was to cut all electrical power to the HQ. Higher Powers on the office staff prevailed, and power was restored to the computers. She held firm, however, on powered light systems, AC, and other non-essentials.

While others frittered away their time with family, Christmas and New Year's festivities, **Marie** and **Craig** analyzed her new light and heat source for the GSH, namely, **Dollar Store Candles**. Her observations on the two finalists for GSH Frugal Light are as follows:

**Candle A is 1 inch longer than Candle B. Candle A was lit at 3 PM, and Candle B began burning at 5 PM. At 9 PM, they are the same lengths. Candle A burns out at 11 PM, while Candle B self-extinguishes at 10:30 PM.**

**Clearly, they burn at different rates, probably due to different diameters and wax quality (one of the candles consisting of basically human ear wax, the other, Sperm Whale wax and traditional Beeswax).**

**What are the original lengths of the candles? Send your answers to the GSH with supporting evidence and a sizable donation for Craig's Cause (preferably in cash).**

## Bonus Puzzle for Avid Solutionists



The jar (left) is known to contain **1692** coins worth **\$100.54**.

Your challenge, should you care to accept it, is to determine how many **pennies, nickels, dimes, and quarters** will it take to satisfy the conditions stated.

**Be aware that there may be more than one solution, but one will do.**



# GSH Outreach

## Committee Activities *By Lisa Buckner, [outreach@gshtx.org](mailto:outreach@gshtx.org)*

The GSH was invited back for the **12th Annual First Colony Middle School Career Day in Sugar Land on Thursday, January 23** to host a career exhibit booth. GSH Outreach volunteers, Segun Adeniyi and Mac Hooton, educated the 8th grade students about geophysical and geological careers in the oil and gas industry, educational requirements, and starting salaries. Mac let them handle a wide variety of rock and mineral samples and watch the waves display on a cell phone app that they created by knocking on the table. They gave 289 GSH logo coiled toy springs to those who watched a P-wave and S-wave motion demonstration and/or listened to a presentation. Interested students picked up the "Earth is calling ... will you answer?" brochure (<http://www.beageo.com>).



In the evening on the same day, **Thursday, January 23**, GSH Outreach was invited for the first time to **Science Night at The Honor Roll School**, a Pre-K through 8th grade private school in Sugar Land. Students and their family members looked at a rock and mineral sample collection, cut-away geophone and ION interpreted Gulf Coast regional seismic line. Students of all ages enjoyed playing the Drilling for Oil Game. I gave away 79 GSH logo coiled toy springs, and the older students were given the "Earth is calling ... will you answer?" brochure. It was a very exciting night with a very diverse student body.

Thursday evening, **January 30**, Huw James and I hosted the GSH booth at the **Felix Morales Elementary School Science Night in Pasadena**. The event was scheduled after their school science fair awards ceremony and was very well attended by very curious students and their families. At our booth, the students played the Drilling for Oil (black shoe polish) game with a pencil in the Gulf of Mexico (plastic box filled with cat litter). They had to avoid drilling near the coral reef (Nemo's home) and archeological site (pirate ship). About half of them drilled dry holes, but they all had fun trying. We also showed them some rock samples, including one from the Hockley salt mine, and gave away 105 GSH logo coiled toy springs to students.



### UPCOMING EVENTS – Volunteers Needed

**April 4, 2020 (10:00 AM – 3:00 PM)**

**Scout Fair @NRG Arena** (over 10,000 Scouts)

**April 18, 2020 (9:00 AM – 2:00 PM)**

**HISD When I Grow Up Career Expo** in the HISD Administration Building parking lot

Do you know of a school that has a career day seeking speakers, career fair or science night at which GSH might be able to host an exhibit booth? If so, please contact Lisa Buckner at [outreach@gshtx.org](mailto:outreach@gshtx.org), and we can work together to bring awareness of geophysics to the students. □



# GSH Funding 2019 Summer Internship

## OpenSpace at the Houston Museum of Natural Science

Abstract from Dr. Carolyn Sumners (HMNS) article

The goal of the OpenSpace project is to build a pipeline for transmitting visualized science content from across NASA Science Mission Directorate (SMD) divisions to Informal Science Institutions (ISI), secondary school classrooms, and the public. Central to achieving this goal is the development of open source software, known as OpenSpace, and the promotion of the software's use in informal settings through the establishment of a network of ISI partners.

The Astronomy Department of the Houston Museum of Natural Science (HMNS) created an Open Space Theater in the rotunda of the Astronomy Department to showcase OpenSpace simulations and to show how the data collected help us determine what it would be like to visit different places in the solar system.

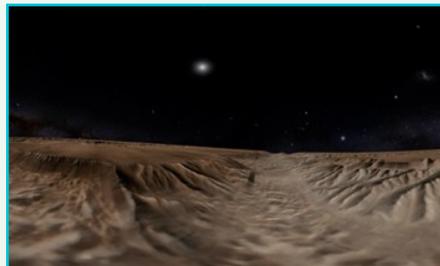
HMNS partnered with The Houston Engineering and Scientific Council to fund an internship program for high school students to provides OpenSpace experiences for the public.

### The Interns

The summer **2019 OpenSpace program (June 10 – August 16, plus September 7)** employed 18 high school student interns. Three of these are returning interns and one was a volunteer in 2018. The remaining interns were selected from the Senior Division at the regional Science and Engineering Fair of Houston (SEFH) and sponsored by different scientific and technical societies. **Corumbe Jamisen, age 15, was sponsored by The Geophysical Society of Houston (GSH).** Her SEFH research project was titled *"The effects of geotextiles and vegetation on slope erosion"*.

### The Events

Six different experiences featuring OpenSpace were delivered to over 14,730 Museum visitors.



### 1. Apollo II Introduction for the Moon Tour

Each day three interns made two presentations about the Moon to complement a tour of the Museum Moon exhibit. For this introduction the Interns used a pre-recorded landing of Apollo 11 produced on OpenSpace.

### 2. Mars landing in the Expedition Center

The NASA experience is captured in a Mission to Mars, featuring a pre-recorded landing created in OpenSpace. The Career Challenge program, funded by Exxon Mobile, finally has a



realistic approach to landing on Mars. The program brings over 1,000 sixth graders to the Museum to experience different careers that will be available to them when they enter the labor market.

GSH Funding continued on page 23.



### 3. Destination Moon: 360° VR Experience

This spring the Museum purchased a 7-meter internally lit moon, the creation of acclaimed artist Luke Jerram. The Astronomy Department developed a VR moon trip to accompany the big Moon exhibit. The VR experience begins with a lunar fly-around where the visitor moves his head to see the moon from all directions. The program ends with the famous Earthrise from the Moon of Apollo 8.



### 4. Expedition Center Lunar Landing Tours

At noon, interns provided a 45-minute tour of the Expedition Center, open to Museum visitors. In Mission Control visitors

selected the tasks they would like to perform and watched a live OpenSpace presentation of their landing on the moon.



### 5. Apollo 11 Celebration

On Wednesday of Space Week (7/17) the Museum hosted an Apollo 11 Celebration in which 13 NASA retired Mission Controllers flew their 25 grandchildren to the Moon.

Controllers were assigned consoles similar to theirs 50 years ago. An intern was also assigned to each desk. The program received press from every major television station and a front-page photo in the Houston Chronicle.



### 6. Intern Debate: To the Moon or Mars

On Friday, July 19, the Museum hosted its second event: a debate between Team Moon and Team Mars on whether we should focus on going to the Moon or to Mars. One of the images shows an intern explaining how exciting it was to explore the Moon with the Apollo 17 astronauts.

#### Why the interns?

These young people, chosen from the science fair, are idealistic, love doing science and want other students to be engaged as well. They make the perfect presenters to the large audiences of HMNS's summer programs and provide the perfect platform for new and exciting programs.

As the interns focus on every visitor with personal attention and sharing science discoveries, we cherish and enjoy their enthusiasm as tour guides for the cosmos. □

# U of H Wavelets - Geoscience Article



## Case Study: Phase Component Amplitude Variation With Angle

By Elita Selmar De Abreu<sup>1</sup>, John Patrick Castagna<sup>1</sup>, Gabriel Gil<sup>2</sup>

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<sup>2</sup>Lumina Technologies Inc., Research and Development, Houston, Texas, USA., E-mail: gabriel.gil@luminageo.com.

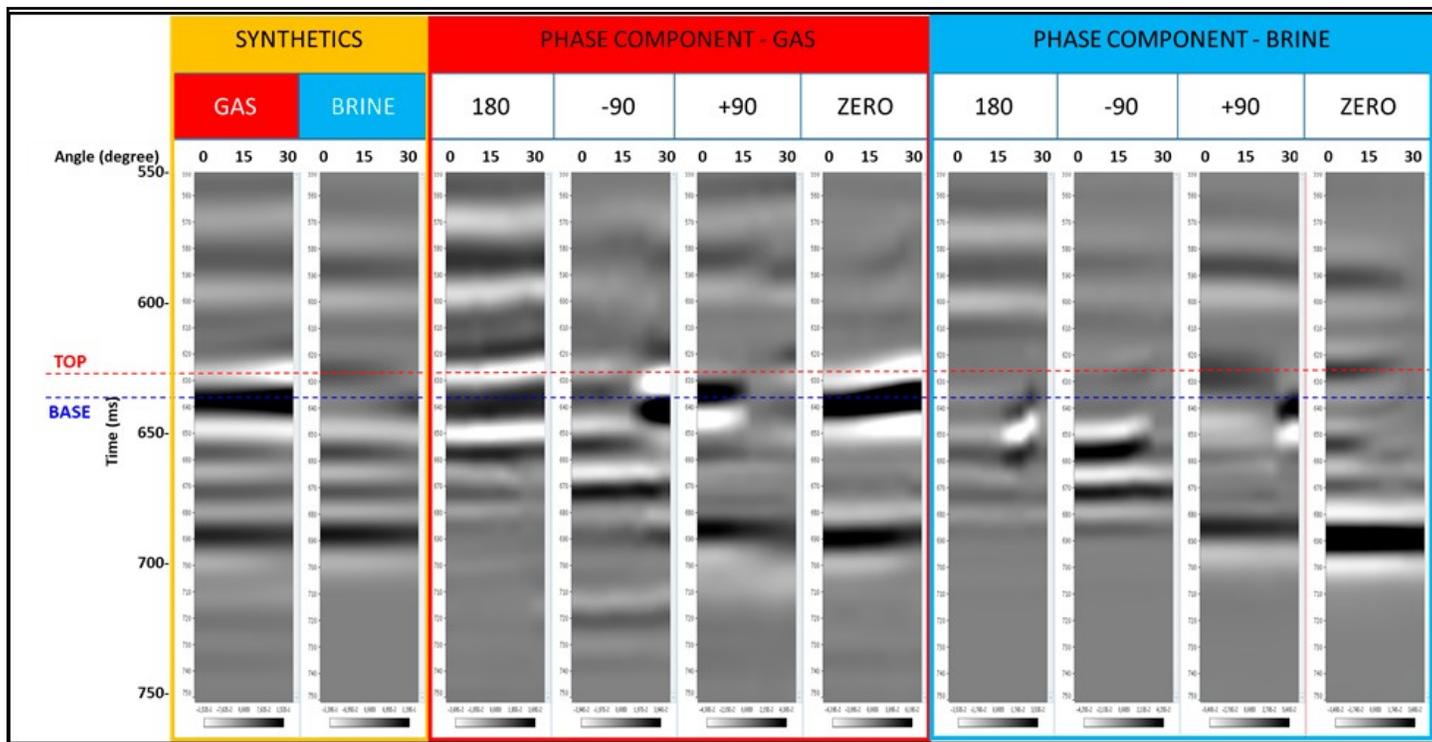


Figure 1: Phase components for fluid-substituted pre-stack synthetics calculated from the well logs. The two panels in the left (yellow highlighted) show the synthetic data for the gas and brine saturated cases. The following 4 panels in the center (red highlighted) show the phase components for the gas saturated case; and the last 4 panels in the right (blue highlighted) show the phase components for the brine saturated case. The phase components displayed are labeled at the top of each track.

Phase decomposition provides a new way of interpreting seismic data. Thin beds, subtle fluid responses and changes in lithology, otherwise hidden in seismic waveforms, can be amplified on specific phase components improving seismic interpretation. Assuming zero-phase, normal polarity seismic data, seismically thin layers that are high impedance relative to overlying and underlying half-spaces are seen on the  $+90^\circ$  phase component, while a relatively low-impedance thin layer will appear on the  $-90^\circ$  phase component. In this study we applied phase decomposition to pre-stack data across a gas-bearing channel sand. The results showed that the amplitude-variation-with-angle is magnified on the  $-90^\circ$  phase

component allowing for a better delineation of the lateral extent of the reservoir, when compared to a traditional AVO analysis. These results are corroborated by phase decomposition of fluid-substituted synthetic gathers which shows for the gas-case the same phase component relationships for near and far angle stacks as are observed on the real data. A comparison between the brine-case and the gas-case shows that no amplitude variation is observed on the phase component for the brine-case, while for the gas-case, a strong amplitude-variation-with-angle response is observed for this same component. In a seismically thin layer scenario, where the tuning effect can either lead to a pitfall or mask

Wavelets continued on page 26.

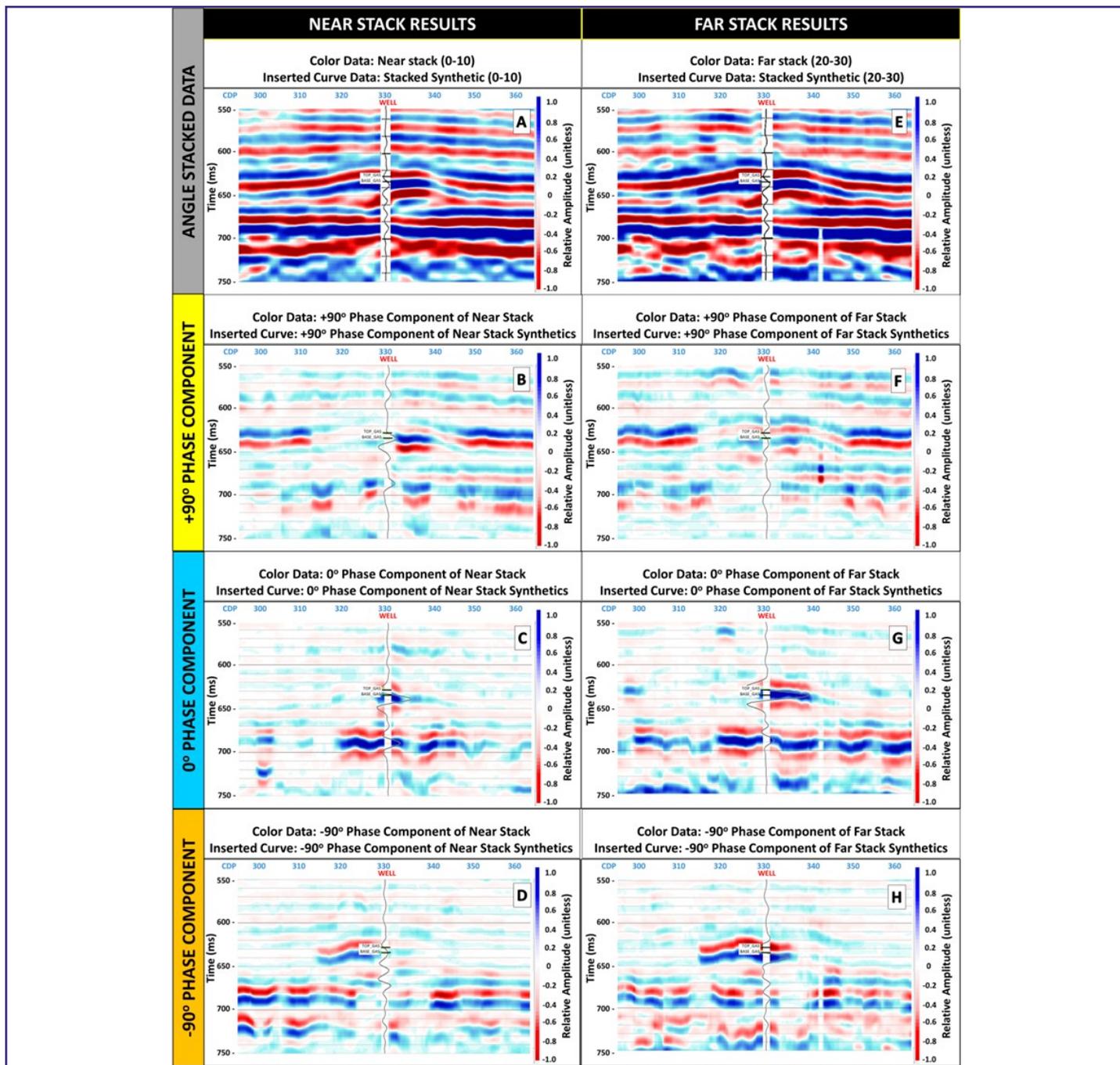


Figure 2: Phase components of near-angle ( $0^{\circ}$ – $10^{\circ}$ ) and far-angle ( $20^{\circ}$ – $30^{\circ}$ ) stacks with the phase decomposed synthetic trace from the well for the corresponding phase component displayed in the vertical section at the well position. (a) Near-angle stack with inserted near synthetic curve, (b) near stack  $+90^{\circ}$  phase component, (c) near stack  $0^{\circ}$  phase component, (d) near stack  $-90^{\circ}$  phase component, (e) far-angle stack with inserted far synthetic curve, (f) far stack  $+90^{\circ}$  phase component, (g) far stack  $0^{\circ}$  phase component, and (h) far stack  $-90^{\circ}$  phase component.

the gas response, the phase component amplitude-variation-with-angle can be used as a tool to de-risk prospects and as a direct hydrocarbon indicator. It also can provide a better volumetric estimate of hydrocarbon in place.

A detailed results and explanation of phase component amplitude-variation-with-angle has been recently published in *GEOPHYSICS*, VOL. 84, NO. 4 (JULY-AUGUST 2019); P. 1–13 (<https://doi.org/10.1190/geo2018-0762.1>). □

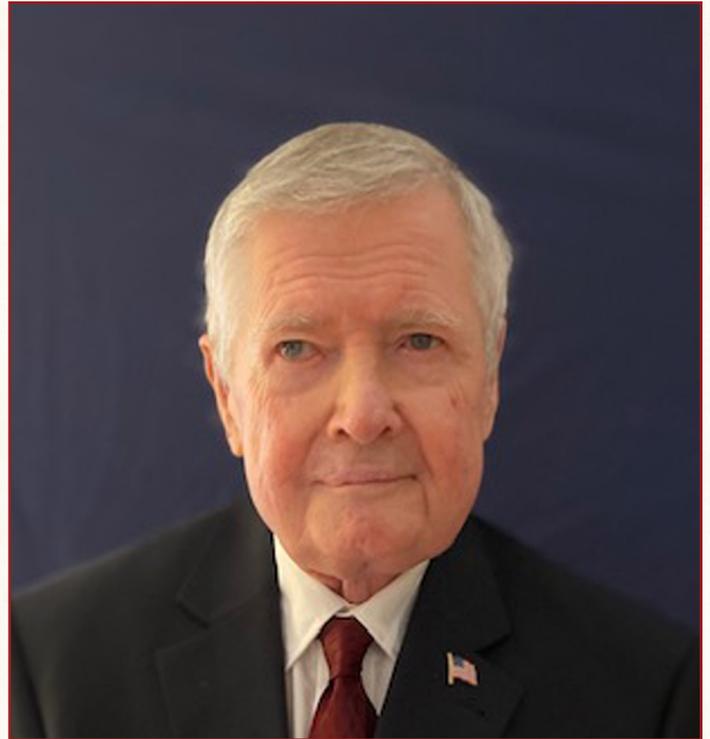
# Recognizing Outstanding GSH Volunteers...

*Mike Graul* By Tommie Rape

*The many social and technical opportunities offered by the Geophysical Society of Houston (GSH) for the geophysical profession of Houston and beyond are due largely to many dedicated volunteers. The GSH wants to recognize some of these dedicated volunteers and will do so through this series of articles where we will present a selected volunteer and provide our readers with some of the volunteer's professional and volunteer background. Hopefully, this will increase our readers' appreciation of these volunteers and encourage them to join the GSH volunteer ranks where they can partake in the many benefits that this work provides.*  
– Tommie Rape

This is a special article in the Volunteer Recognition series. We are recognizing the many volunteer efforts of Mike Graul for the GSH, and we are also recognizing Mike as the special honoree of this month's GSH Spring Symposium where he will be honored for his many professional accomplishments. You should attend the Spring Symposium because, in addition to two days of high-quality presentations on the advancements in computing technology in the geophysical arena, a special entertaining Toast and Roast presentation by Peter Duncan will describe the many escapades of Mike Graul.

Mike Graul was born in New York City and grew up in upstate New York. Mike attended Rensselaer Polytechnic Institute (RPI) where he earned a BS in geology with a geophysics option; he chose the geophysics option because he preferred differential equations over micropaleontology. After college, Mike joined Chevron and then traveled south of the Mason Dixon Line for the first time. One of his first assignments was working on a seismic crew in the swamps of South Louisiana; Mike got little sleep when he discovered that alligators do live in the United States. The next 3 years were spent traveling across the United States on a variety of Chevron's seismic field crews in some of the most romantic Texas towns: Sherman, Snyder, Big Spring, and Midland. This exciting tour included Wibaux and Billings, MT and Minot, ND; after which he explored big city life in Denver and New Orleans, where he got his training in analog processing. He



was assigned to the Chevron research facility in La Habra, CA where he assisted in the design of analog processing devices including a correlation device for statics and another analog device for the migration of seismic data (!), also used for processing in New Orleans.

The Applied Research division moved into the digital age and also to Houston, TX. His research efforts were focused on developing techniques in seismic signal processing. His work in complex trace analysis, Radon filtering, and array analysis have been in use for over 30 years. Houston became Mike's permanent home, where he spent the remainder of his 24-year career with Chevron.

In 1980, Mike established Exploration Education Consultants, an organization that enhanced the calling for which Mike is most renowned throughout the industry, i.e. teaching. He has taught public and private classes for many companies and organizations, enlightening thousands of students in both professional and academic settings. His recent teaching topics have been focused on AVO,

*Volunteers continued on page 28.*



azimuthal processing and various technical aspects of seismic processing and acquisition, always with a liberal sprinkling of the fundamentals of convolution, correlation, and Fourier analysis. His co-instructors have been some of the most highly regarded geophysicists in our industry. Mike has taught graduate courses at the University of Houston and Rice University and has lectured or presented short courses at many other universities. He has served on the faculties of both the University of Texas and the University of Houston. He's developed courses in Deconvolution, AVO, and Static Corrections for the SEG Continuing Education Program, some of which are still being taught after many years. Mike currently writes a monthly technical article for the GSH Journal. These articles have also been published in two volumes: Tutorial Nuggets The Book and Tutorial Nuggets Book II. These articles have a profoundly unique style that highlights Mike's ability to explain complex subjects with a penchant for humor that makes learning very entertaining. I am but one of many that have been the subject of his humor, and I am sure that many of you have as well. We should combine our efforts to solicit a portion of his income from teaching.

In 1986 Mike formed Texseis, Inc. with Cheri Williams (formerly of Chevron). Texseis, Inc. provides full-service 2D and 3D seismic processing.

Mike still serves as the president and owner of Texseis, Inc. today. He also served as a consultant to the Bureau of Economic Geology in the development of processing techniques for the implementation of Bob Hardage's SvP converted wave applications. He has frequently been called as an expert witness on geophysical matters, one off occasion involving the South African government in which his co-expert for 6 years was Ted Ulrich – an unequalled experience.

Mike married his wife, Susan, who also worked at Chevron, in 1974. They have four children, a geophysicist, a doctor, a lawyer, and an engineer. Mike and Susan have 14 grandchildren.

In addition to a well known professional career, Mike has also become renowned for his generous volunteer efforts for the GSH and other organizations. While still at Chevron Mike became Chair of the Education Committee of the GSH where he worked to establish various curricula for the local geophysical community. His efforts toward the GSH were recognized when he was elected 1st VP of the GSH in 2006. He later was voted President-Elect in 2008 and then served as President of the GSH in 2009-10. He later served the GSH as one of its SEG Section Representatives. However, Mike's efforts did not end after the completion of his duties; in 2010 he worked with Lee Lawyer and others to initiate the publication of the GSH Journal. In 2011 Mike became Chair of the GSH Webinar Committee and helped initiate the very popular GSH Webinar series. In this effort Mike realized that students in a class would be far less distracted if they did not have to look at his face; in a webinar, the students could concentrate on the screen and the subject matter and lessen the stomach distress by not seeing Mike. To prove the concept Mike and Fred Hilterman presented the first GSH Webinar in 2011 on the subject of AVO. This presentation was very successful and also provided the opportunity for students from all over the world to partake in the online presentation without having to incur travel costs. The GSH continues its very popular webinar series today. The webinars have also provided a very critical source of income for the GSH. Mike's presence continues to provide the GSH with valuable wisdom and experience in all aspects; from providing valuable education, networking, and socializing opportunities for the geophysicists of Houston.

When asked why he volunteered for the GSH, Mike said that he gained as much from his efforts as did those on the receiving end. As many teachers would recognize, there is much to be gained from preparing lessons for class presentations. Maybe the teacher persona also explains why Mike gets satisfaction from helping others in multiple ways, e.g. providing technical advice in the organization of many GSH technical events, improving deliverables for GSH members, etc. Mike loves to see students do well, and he enjoys having a positive influence on them. He also enjoys making things funny; life is too short not to enjoy things.

Mike says that there are many opportunities for GSH members to improve themselves while raising their volunteer efforts. He suggests that members come to the GSH Board Meetings to see how things are run and what the needs are; then maybe you will find the perfect slot for yourself.

Being honored at the upcoming GSH Spring Symposium is not a new experience for Mike. After serving as Chair of the Education Committee for the SEG, he served as 1st VP. In 2013-15 Mike was elected as the first Chair of the SEG Council, an international body representing the entire 33,000 membership. He is a Trustee of the SEG Foundation and in recent years has received the Special Commendation Award, the prestigious Honorary Membership award, and the Life Membership award from the Society of Exploration Geophysicists. In addition to the GSH officer positions that he previously held, he received the GSH Honorary Membership Award in 2004 and the Life Membership Award in 2013.

The GSH has benefitted greatly from its association with Mike Graul and continues to do so. His generosity with both his time and dollars has helped the GSH provide many benefits to its members and other geophysicists worldwide. The next time you see Mike, be sure to thank him for all that he has done for the GSH. Better yet, attend his Roast and Toast at the GSH Spring Symposium and after toasting him, share some of the embarrassing stories about Mike, of which there are many. Thanks, Mike. □

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## Mystery Item

*This is a geophysical item...*

*Do you know what it is?*



*This month's answer on page 35.*

# Apache

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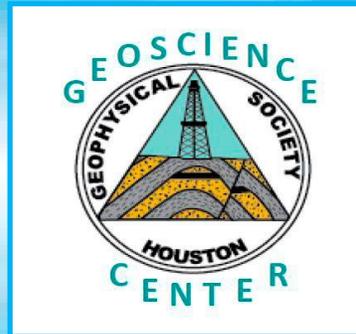
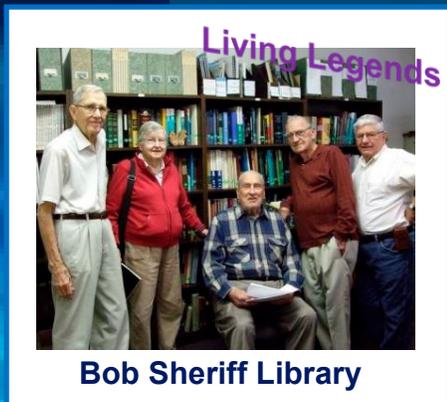
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# GSH GEOSCIENCE CENTER CHALLENGE

Match donations by Scott Petty, Jr., Lee Lawyer, Tom Smith, and Dick Baile

**DONATE NOW** at <https://www.gshtx.org/> or send a check to the GSH office.



Donations recieved support Programs and Activities of the GSH Geoscience including: Geoscience Artifact Cataloging and Storage, Loans to Colleges and Universities for Display, Bob Sheriff Library, Meeting and Seminar space, and Living Legends. The GSH is a 501(c)3organization.

# GEOSCIENCE CENTER

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Donations support Programs and Activities of the GSH Geoscience Center including: Artifact cataloging and storage, Loans to Universities for display, Bob Sheriff Library, Instruction space and the Living Legends Doodlebugger Social Gathering.

The GSH is a 501(c)3.

# Geoscience Center

## *The History of Geophysics* By Bill Gafford

1790 W. Sam Houston Pkwy. N. (Right on Shadow Wood)



Living Legends Doodlebugger social event February 12.

We had a good meeting at our Living Legends Doodlebugger social event on February 12 in spite of the weather that day. There were some new visitors who enjoyed seeing the geophysical artifacts on display and browsing our library collection. We still have a bookcase full of duplicate books that are **free** to visitors. Alan Foley is shown here selecting a few books for himself. In addition to duplicate books, this bookcase includes books or manuals that may not be related to geoscience but could be of interest to visitors. We continue to receive donations of a variety of books, training manuals, and periodicals to add to our collection. This includes publications from AAPG and SEG. A recent addition was a set of books from Enders Robinson, which he had authored, and included books about his

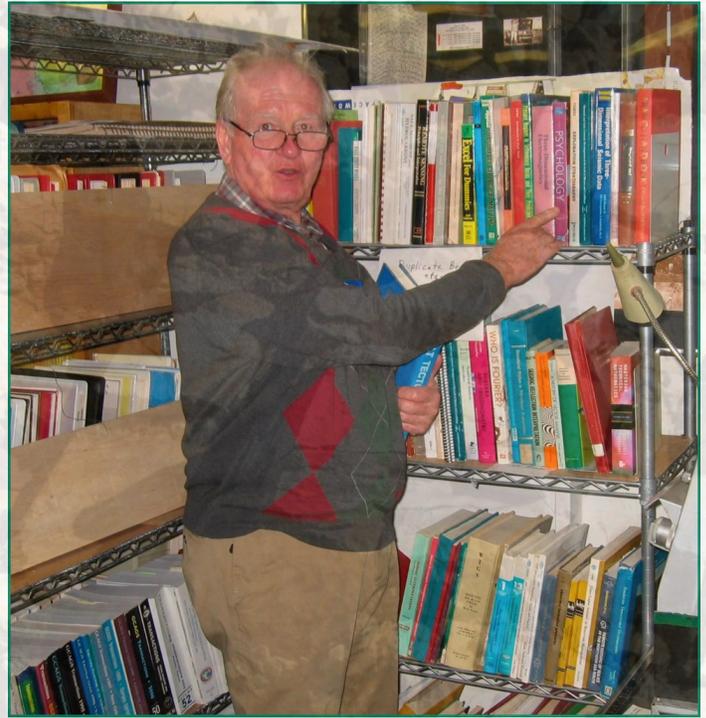
time at MIT with the Geophysical Analysis Group in the 1950's.

Some of the regular visitors to the Doodlebugger event are shown in the other picture discussing the artifacts on the tables and trading stories of their experiences in the oil patch. Some of the Mystery Items that have appeared in the GSH Journal are included on the tables. We are always interested in information about some of the older items in our museum collection and especially about how, when, and where they were used in exploration. Our next Doodlebugger event will be on Wednesday, May 13. And remember, all are welcome!

We have a few geophysical instruments from the 1930's that were donated by Burton McCollum

*Geoscience Center continued on page 35.*

and McCollum Exploration Company. We are looking for some documentation or information about these items. Burton McCollum was a founding member of the SEG and one of the geophysicists credited with founding exploration seismic prospecting. He was awarded SEG Honorary Membership in 1958. There were 15 geophysical patents in his name. Like many of our older artifacts, pictures or details about the items are very difficult to find. Any suggestions or references would be welcomed. □

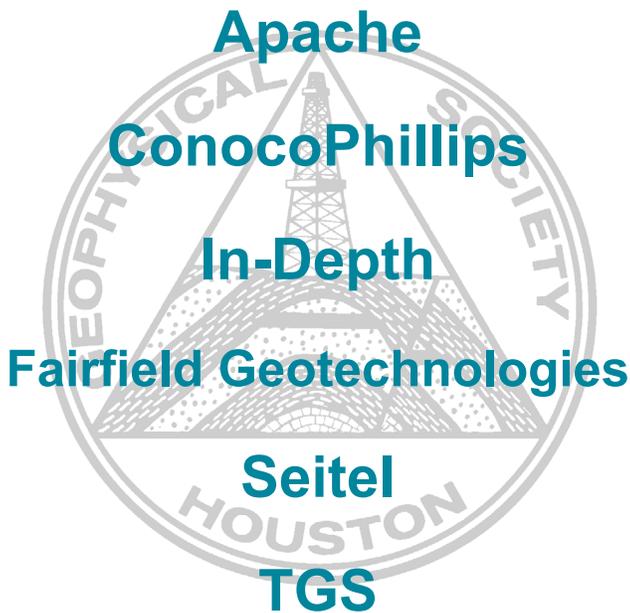


Alan Foley selecting some free books from our duplicates.

The Geoscience Center is open on Wednesday mornings from 9:00 am to 12:00 pm or by appointment, and visitors are always welcome.

Please contact me at: [geogaf@hal-pc.org](mailto:geogaf@hal-pc.org) or by phone at: 281-370-3264 for more information.

## We appreciate our Corporate Members



For more information about becoming a Corporate Member, go to [GSHTX.org](http://GSHTX.org)

The Mystery Item on [page 30](#) is a **Helmholtz Coil.** Used to calibrate magnetometers



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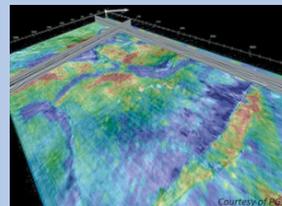
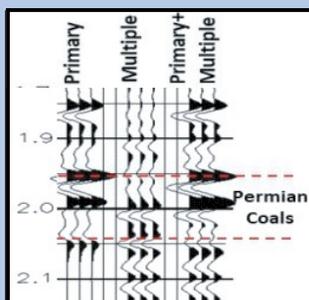
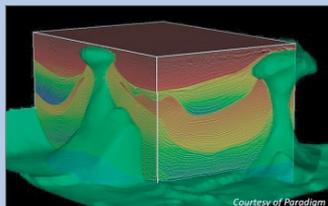
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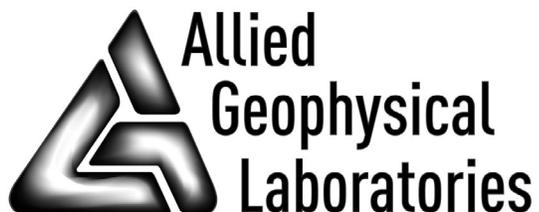
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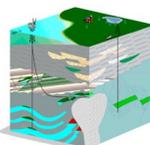
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# Doodlebugger Diary

## Portable Party 55 Discovers Challenging Terrain in Pakistan

By Tom Doherty, Western Geophysical, 1979; Photos by Raul Martinez, Western Geophysical, 1979; originally published in the 1979 Summer Western Profile Recounted by Scott Singleton

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. I've published extensively on my own experiences and encourage those of you with experiences of your own to also contribute. Your fellow industry professionals would love to hear your stories.

Last fall I started reprinting a series of early 1980's articles from the GSI Shotpoints that can be found at <http://gsinet.us/>. In March I shifted to reprints of archived Western Geophysical Profile articles. These can be found at <https://seg.org/Publications/Journals/Western-Profile>.

### Prolog by Scott Singleton

Oil production in Pakistan was restricted to the Potwar Basin in the Punjab Province (south of Islamabad, *Figure 1*) from the early to mid-twentieth century<sup>1</sup>. Although production continues in the prolific Punjab Basin, Union Texas Pakistan discovered the first oil field in the Sindh Province (the region around and north of Hyderabad, *Figure 1*) in 1981. By 1998, production from the Sindh Province exceeded that of the historic Punjab Province oil fields. Currently, 50% of the oil production in Pakistan is produced from the Badin District in the Sindh Province<sup>2</sup>.

And with that as a contextual reference, we turn to the story of our intrepid doodlebuggers in 1978:

### Party 55 forms and perseveres

SOMEWHERE, high up in the Himalayas of central Asia, melting snows and glaciers give birth to one of the mightiest waterways in the world, the Indus River. Several thousand miles southward, in the Sindh Province of Pakistan, these waterways breathe life into the dry, arid soil

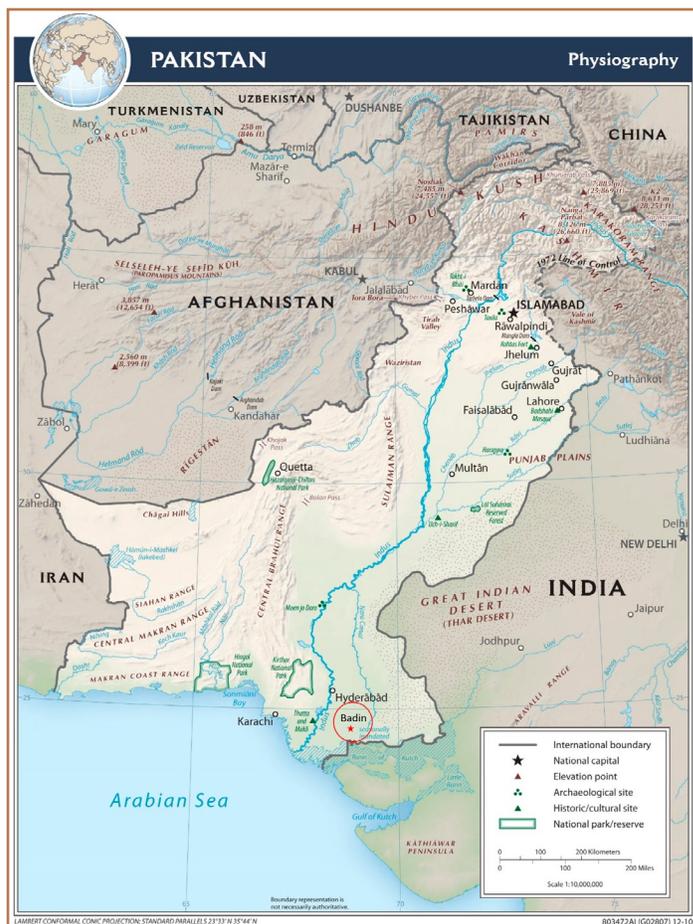


Figure 1: Physiographic map of Pakistan, CIA publications library (<https://www.cia.gov/library/publications/resources/cia-maps-publications/Pakistan.html>) with modifications to show Badin (red circled area in south).

of the Thar Desert (*Figure 1*) and, with the help of dredging and canal building, yield hundreds of square miles of rich, fertile, green farmland. Hence, there is a checkerboard pattern of canals enclosing periodically-flooded fields of rice and sugar cane. This "checkerboard" is populated by a

Doodlebugger continued on page 41.

If you would like to add stories to the Doodlebugger Diary, send them to: Scott Singleton at [scott.singleton@comcast.net](mailto:scott.singleton@comcast.net) or mail them to Box 441449, Houston, TX 77244-1449



*Figure 2: Portable Party 55's drill crews are spaced along a line near Badin, Pakistan, as the bullocks wait patiently for all to finish.*

host of species of wildlife and, of course, man, all attracted by the life-giving waters of the Indus River and the rich soil nutrients that it carries down from higher ground.

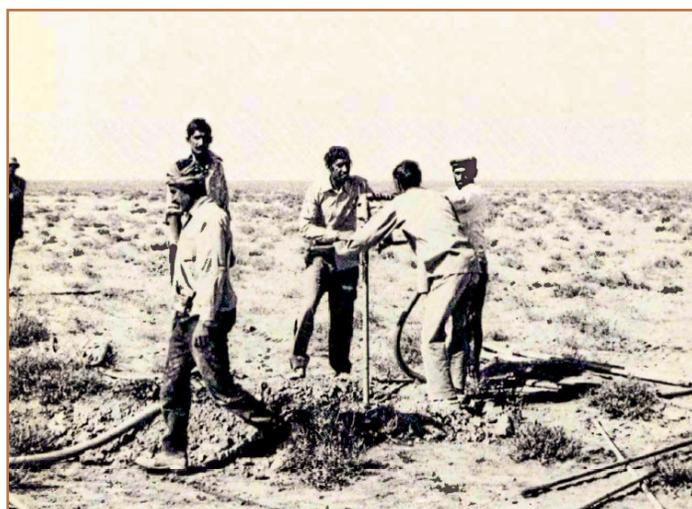
This peaceful, picturesque, almost utopian landscape, however, caught the inquisitive eye

of oil searchers, who consequently instigated exploration proceedings. Hence, enter Western Geophysical Company's Party V-25, who vibrated their way down the blacktops, canal banks, and any other land that could handle the width and weight of a vibrator and was accessible. Subsequent promising geophysical results led to a need for more detailed seismic work; so the portable explosive crew Party 55 was conceived and, in May 1978, was born.

The terrain in question basically consists of snake infested swamps punctuated by islands of dry



*Figure 3: Portable crew Party 55 has set up its recording tent next to a prospect near Badin, Pakistan, in a relatively accessible area.*



*Figure 4: One of Party 55's Pakistani drill crews does just that – drill.*



*Figure 5: Observer and Profile Reporter Tom Doherty is hard at work in Party 55's recording tent. That it is hot in Pakistan is attested to by the small fan that Tom has placed directly in front of him.*



*Figure 6: Portable Party 55 is letting no obstacles stand in its way while the crew lays cable down the line in Pakistan, not even a wide canal.*

lands. Since the easier and more negotiable areas previously had been vibrated, ways and means of drilling, cable-laying, and general seismic data acquisition had to be formulated in-between.

The personnel who were cajoled, hoodwinked, or shanghaied into Party 55 were blissfully unaware of what they were letting themselves in for when they moved into a shell of a house that had been leased in the town of Badin

(Figure 1). Since some of the crew were present before the arrival of the necessary equipment, their time was spent in domestic tasks, such as installation of electricity, plumbing, and the general trappings of a civilian existence. These unfortunate "lemmings" included Party Manager D. M. (Mike) O'Brien, from Tunisia; Assistant Party Manager Tom Simmons, from Kansas; Junior Observer Raul Martinez, from Kuwait; Observer Tom Doherty, from Denmark; Drillers Graham



*Figure 7: This Party 55 field camp moves along the line in Pakistan.*

Coppin, from London, and Eric Taylor, from Texas; and a whole string of mechanics.

The eventual arrival of the equipment brought blessed relief to these men from enforced captivity in the Pakistani hinterland and also to the 200-or-so members of a portable labor force who had been bused down 1,000 miles from the north (by virtue of their previous seismic experience) and who were "chomping at the bit" for some work to do.

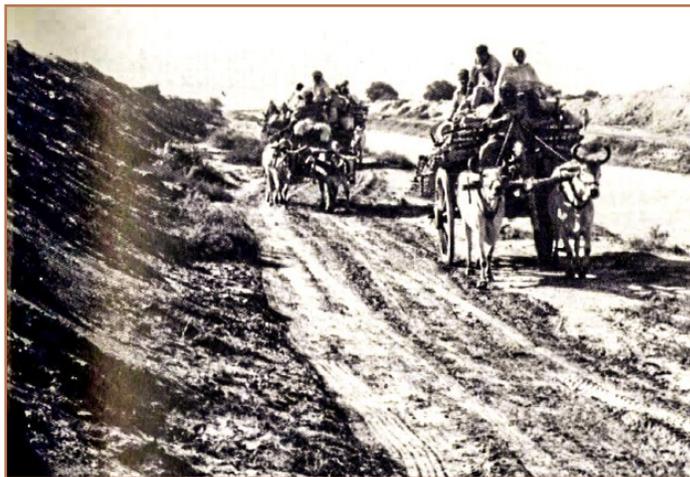
Immediately after the arrival of the equipment, three days of instrument tests were made in



*Figure 8: Party 55 is unloading geophones and cables from a buggy in Pakistan. Rarely does the crew have the luxury of being able to use vehicles in such difficult terrain as this prospect in which it is currently working.*



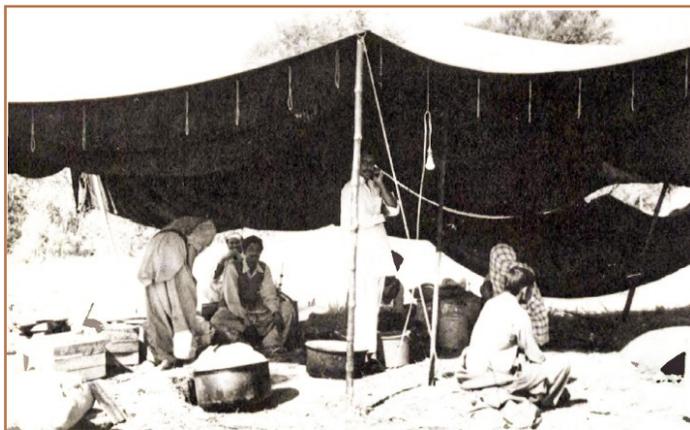
*Figure 10: Many of portable crew Party 55's vehicles can get to the line in Pakistan with just a little help from the crew. Here, the help for this water truck comes in the form of a quickly-built bridge.*



*Figure 9: Portable Party 55's bullock carts move slowly down a canal bank in Pakistan.*

order to hammer out the shooting parameters for the prospect. Then at last, like a sleeping giant, Party 55 arose from its slumber and (slowly at first) began to grind its way across the sunbaked, canal-meshed fields of southeast Pakistan. Problems were solved on a trial-and-error basis; and eventual modifications led to a general increase in efficiency, including, ironically, the replacement of man, not by computer but by ox-carts, of all things, the inherent mode of transportation and haulage in the area.

Several weeks later and also the time of arrival of Surveyor Willie Stebelski, from Abu Dhabi, the onset of the annual monsoon stretched the



*Figure 11: The cook tent in Party 55's field camp is never empty.*

resilience of both man and machine, when even getting to work became a definite case of "Inshallah" (God willing). During this two-month period innumerable man-hours were employed in the use of such refined implements as shovels, jacks, and towropes as the torrential rains and resulting quagmire served to entrench all of the modes of transport, including the oxcarts. Frequent, long power cuts (days sometimes) and general chaos in the local area led to a lifestyle of damp, depressing days and cold, candlelit nights and, consequently, break schedules and "sits vac" (help wanted) columns became areas of keen interest to crew members.

The eventual "dry out" became a period of repair and renovation; and a complete overhaul of virtually all of the equipment was undertaken, with the considerable brunt being borne by Mechanics Brian Mayne and Armando Arellano. Slowly but surely, Party 55 slipped into higher gear (it never actually stopped) and has been rolling along ever since. Much of the terrain is permanently waterlogged, so that in effect the dry out meant only that we could actually reach

the lines dry but were doomed to continue our "mud lark" existence upon arrival.

Despite a constant flux in personnel, Party 55 has managed to maintain its cosmopolitan, youthful character (with average crew age in the young 20's) and, using Bangkok, Thailand, as the local "watering hole" or "pressure-release valve," now seems to be reasonably stable. The crew whose only original notable trait was that of being "wet behind the ears" certainly has earned its spurs; so we continue to rationally convince 200 grown men to spend their work time wading through chest-deep, snake-infested, rancid mud and then to splash along in there with them. Yet with a hard-working, industrious labor force, coupled with a liberal dose of patience, a sense of humor, and a streak of masochism, Party 55 looks as if it is going to grind along for quite some time.

1 *Exploration History of Pakistan, Pakistan Association of Petroleum Geoscientists* (<http://www.papg.org.pk/ehis.asp>), accessed on 2/13/20.

2 *Badin District, Wikipedia* ([https://en.wikipedia.org/wiki/Badin\\_District](https://en.wikipedia.org/wiki/Badin_District)), accessed on 2/13/20. □

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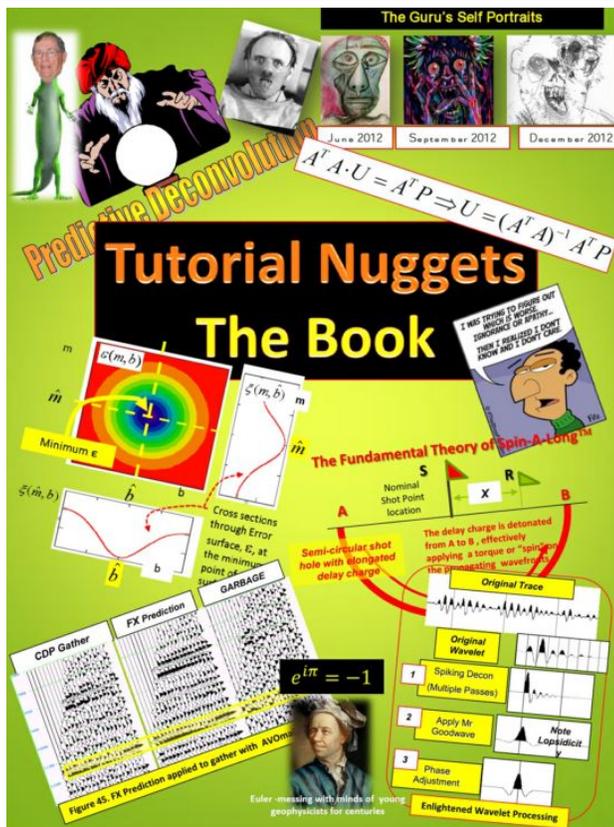
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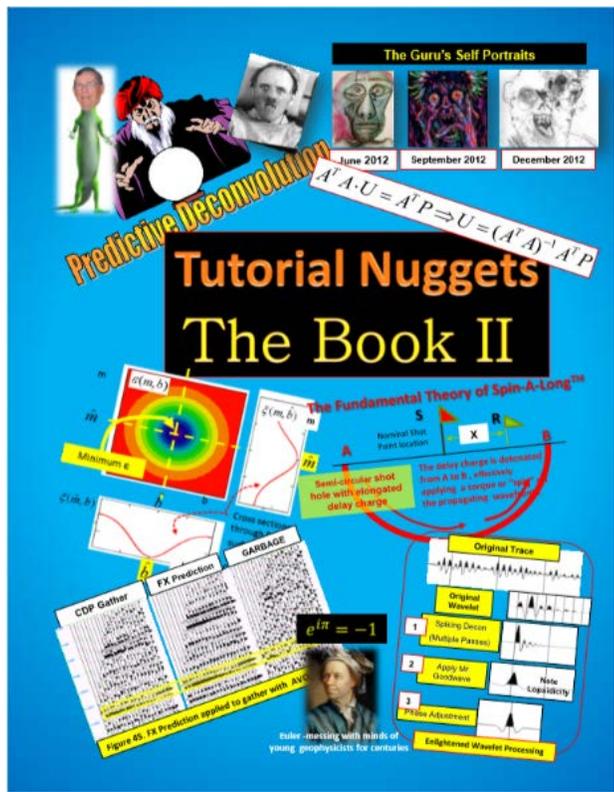
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