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Experimental verification of spherical wave effect on the AVO response and implications for three-term inversion

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Summary

A spherical wave AVO response is investigated by measuring ultrasonic reflection amplitudes from a water/Plexiglas interface. The experimental results show substantial deviation from the plane-wave reflection coefficients at large angles. However there is an excellent agreement between experimental data and full-wave numerical simulations performed with the reflectivity algorithm. By comparing the spherical-wave AVO response, modeled with different frequencies, to the plane-wave response, we show that the differences between the two are of such magnitude that three-term AVO inversion based on the AVA curvature can be erroneous. We then propose an alternative approach to use critical angle information extracted from AVA curves, and show that this leads to a significant improvement of the estimation of elastic parameters.

Introduction

Most AVO analysis and inversion techniques employed today are based on the Zoeppritz equations for plane-wave reflection coefficients or their linearized approximations (Downton and Ursenbach, 2006). At the same time, seismic surveys use localized sources which produce spherical rather than plane waves, and it is well known that the AVO (amplitude versus offset) response for the spherical waves differs from that of plane waves (Krail and Brysk, 1983). Winterstein and Hanten (1985) showed that the AVO amplitudes computed for non-planar (cylindrical) waves are much closer to real data than those provided by plane-wave modeling, especially for angles approaching the critical angle, where amplitude values are considerably lower than those which plane-wave theory predicts. More recent work by Haase (2004) highlighted the importance of accounting for spherical wave AVO effects for rock property estimations.

The use of the plane-wave approximation for reflection coefficients is usually justified by the fact that exploration target horizons are in the far field (depth usually exceeding 10-20 wavelengths) where wave-front curvature is small. This justification is adequate for moderate angles of incidence, well below the critical angle. Since the conventional (two-term) AVO analysis requires moderate offsets and angles, the use of the plane-wave Zoeppritz equations is justified.

Conventional linear AVO analysis allows the extraction of two parameters, such as P- and S-wave impedance contrasts, and requires additional *a priori* information about the velocity-density relationship and/or Poisson's ratios.

The introduction of longer spreads and improved processing methods in recent years has enabled recording and preservation of long offset amplitudes. In principle, the use of these long offsets allows the extraction of three independent parameters, such as relative contrasts in compressional and shear velocities, V_P and V_S , and density ρ (Kelly et al. 2001). However, as shown by Haase (2004) and Van der Baan and Smit (2006), the plane-wave approximation becomes increasingly inaccurate for large incidence angles close to the critical angle, which makes the three-parameter inversion inadequate.

In this paper we verify the spherical wave effect on the AVO response by performing laboratory AVO measurements and comparing the experimental results to full-wave numerical simulations. We also show how spherical AVO response changes with frequency and how it can cause wrong parameter extraction. A more robust methodology for three-parameter inversion is suggested.

Experiment

Seismic wave propagation and partitioning of energy at an interface can be effectively studied by using physical modeling, whereby models are constructed in such a way that they resemble real geological structures taking into account the scale factor. Hence, by using scaled models in a controlled environment, it can be assumed that the response from the models is the same as it would have been obtained from real earth materials. An advantage of laboratory experiments is that real seismic waves propagate through models with no approximations made to the propagation process.

Laboratory AVO experiments were conducted using the Curtin University Physical Modeling Laboratory equipment (Luo and Evans, 2004). The system comprises a set of computer controlled ultrasonic piezoelectric transducers operating as seismic source and receivers. Movement of transducers is controlled in three dimensions by high-precision stepping motors. A LabView data acquisition program enables versatile source-receiver configurations, including transmission measurements, 2-D, 3-D and VSP surveys.

Physical properties of model materials need to be precisely measured. For solid media these include P and S-wave velocities and densities. Plexiglas is often a material of choice since it is intrinsically isotropic and has a P-wave velocity of about 2700 m/s which provides a good velocity contrast with a water column. Plexiglas has a density of 1.2 g/cc which allows the material to be submerged in a water tank.

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In order to obtain properties of Plexiglas (required as input parameters for numerical simulations) we performed a set of transmission measurements. The water velocity was also measured to insure accurate numerical simulations. Resulting properties for both Plexiglas model and water are shown in Table 1.

Table 1. The Elastic parameters of the Plexiglas model and water. Velocities are in km/s and densities in g/cc.

Plexiglas	V_p	V_s	ρ	Water	V_{p0}	ρ_0
	2.724	1.384	1.2		1.484	1

We then performed a reflection experiment to analyze angle dependent reflectivity of the water/Plexiglas interface, where the Plexiglas model was submerged in a water tank. Omni-directional cylindrical P-wave transducers with a 220 kHz dominant frequency were also submerged in water and positioned 24 cm above the model. Common mid-point (CMP) recording was employed for data acquisition. The minimum offset was 2 cm and source and receivers were moved apart at an increment of 1 mm in the opposite directions. A total of 270 CMP traces were recorded over the model. At each position, 20 CMP traces were repeated and vertically stacked to increase the signal-to-noise ratio. With a scaling factor of 1:10,000 this model simulated 20 m trace spacing, and a source wavelet of 22 Hz dominant frequency reflecting from an interface at a depth of 2.4 km. The acquisition parameters and the resulting CMP gather are shown in Figure 1a,b.

Numerical simulations and comparison

In order to obtain water/Plexiglas reflection coefficients R_{pp} from the gathers of Figure 1b, we picked the amplitudes of the water/Plexiglas reflection, corrected them for geometrical spreading, and calibrated them at the near offset to the theoretical zero-offset reflection coefficient. The resulting R_{pp} values are plotted in Figure 2 as a function of incidence angle θ . Also shown in Figure 2 are theoretical plane-wave (Zoeppritz) reflection coefficients computed from elastic parameters extracted from transmission measurements. The plane wave solution agrees very well with the physical modeling data for moderate angles of incidence (up to 20°). On the other hand, there is a big discrepancy at large angles, especially those close to the critical angle. This discrepancy is most likely caused by spherical wave effects (Krail and Brysk, 1983; Haase, 2004; Doruelo et al., 2006; and Van der Baan and Smit, 2006).

In order to take into account the spherical wave effects, we simulated the amplitude versus incidence angle (AVA) response using a full-wave reflectivity algorithm with a point source. The resulting amplitudes picked on seismograms and corrected for geometrical spreading are also shown in Figures 2.

We can see an excellent agreement between laboratory-measured AVO response for the water/Plexiglas interface and numerical simulations. This indicates that the laboratory measurements were accurate, and the spherical approximation of the radiation pattern of the transducers was appropriate. This excellent match confirms the effect of a spherical wave on its AVO response and how it differs from that of a plane wave.

To analyze the effect of this difference on the AVO attributes in Figure 3 we re-plotted both experimental and theoretical reflection coefficients (for plane and spherical waves) against $\sin^2\theta$. We see that spherical and plane wave AVO responses show almost the same intercept and gradient, but very different curvature terms.

The agreement for small offsets is understandable; as the reflector is well in the far field (depth-to-wavelength ratio is about 36). However, somewhat surprisingly, we find that the far field (or high-frequency) approximation is still invalid at larger angles. To understand this effect we investigated it further by simulating the point-source AVA response at different frequencies. The results for frequencies 50, 100, 220, and 400 kHz are plotted against $\sin^2\theta$ in Figure 4. The curves show no difference in intercept and gradient terms, but the curvature at larger angles (over 25°) is frequency dependent. Thus we expect that the frequency dependency of reflection coefficients will not affect conventional two-term AVO analysis, but it can distort the results of a three-parameter inversion if the latter is performed using plane-wave Zoeppritz equations or its linear approximations.

Three-term AVO inversion

To analyze the effect of frequency on parameter extraction from reflection coefficients we implemented a least-mean-square inversion routine that attempts to find the medium parameters that give the best match between a given AVA curve (experimental or simulated) and Zoeppritz plane-wave solution. In this single-interface inversion we search for three parameters of the lower medium: P and S-wave velocities V_p and V_s , and density ρ , assuming that the properties of the upper medium V_{p0} , V_{s0} , and ρ_0 are known.

The spherical wave AVO responses at different frequencies along with the best plane-wave approximations are shown in Figure 5. The extracted parameters (V_p , V_s , ρ , as well as P and S impedances Z_p and Z_s) are listed in Table 2. As the frequency decreases, the extracted impedances show little variation (<1% for Z_p and <4% for Z_s) whereas V_p , V_s and density show strong variation (up to 20%). Note that impedance errors can be further reduced by using a shorter range of offsets (say, up to 20°) but this will increase the velocity and density errors even further, especially in the presence of noise.

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Table 2. The resulting extracted parameters using three-term AVO inversion.

Parameters	V_p	V_s	ρ	Z_p	Z_s
True values	2.724	1.384	1.2	3.269	1.661
400 kHz	2.635	1.327	1.237	3.259	1.642
220 kHz	2.580	1.280	1.266	3.267	1.621
100 kHz	2.435	1.188	1.337	3.256	1.589
50 kHz	2.294	1.123	1.434	3.290	1.611
Laboratory	2.549	1.187	1.278	3.257	1.516

Inversion using critical angles

The fact that extraction of impedances is more robust than simultaneous extraction of velocities and densities is well known, as at moderate offsets the reflection coefficients are mainly sensitive to P and S impedance contrasts. In order to extract all three parameters we have to use large offsets where reflection amplitudes differ from the plane-wave response. One way to overcome this difficulty is to use information about the critical angle. Critical angle corresponds to the singularity of the plane-wave reflection coefficient, and the first idea is to pick the maximum of the AVA curve. However, as we see in Figure 4, the position of the peak of Rpp also varies with frequency. However, recently Landro and Tsvankin (2007) suggested that the position of the inflection point (the point of the fastest increase) of the AVA curve is more stable and is a good proxy for the critical angle.

To reduce the parameter extraction errors caused by the spherical wave effects, we propose incorporating critical angles as measured by the position of the inflection point on AVA curves. The proposed workflow is as follows:

1. Critical angle θ_{cr} is picked from the AVA curve as the angle corresponding to the inflection point.
2. P-wave velocity of the lower medium is computed using the Snell's law: $V_p = V_{p0} / \sin \theta_{cr}$.
3. Plane-wave inversion routine is used to extract P- and S- impedances only (using angles up to 20°).
4. Density is calculated as $\rho = Z_p / V_p$.
5. V_s is computed from Z_s and density: $V_s = Z_s / \rho$.

We applied the above methodology to both numerically simulated and experimental AVA curves shown in Figures 3 and 4. The inflection points are shown on AVA curves of Figure 4. The extracted parameters are presented in Table 3. We can see that the critical angle based inversion method

gives much better estimates of all three parameters than the curvature-based method. The errors in any parameters do not exceed 5%, except for the lowest frequency of 50 kHz.

Table 3. The new extracted parameters using the new inversion method.

Parameters	V_p	V_s	ρ	Z_p	Z_s
True values	2.724	1.384	1.2	3.269	1.661
400 kHz	2.689	1.399	1.217	3.272	1.702
220 kHz	2.691	1.392	1.219	3.280	1.697
100 kHz	2.694	1.308	1.211	3.262	1.583
50 kHz	2.707	1.471	1.223	3.309	1.799
Laboratory	2.704	1.380	1.217	3.292	1.680

An obvious limitation of the proposed technique is the requirement of a large and positive contrast between the velocities of the upper and lower media ($V_p > V_{p0}$). Of course we need long offsets and good signal to noise ratio. Careful and special processing steps are needed to preserve the true long offset reflected amplitudes. In the case of too low frequency, critical angles are hard to pick since the fastest amplitude increase is not evident even for noise-free numerical simulations (see our example for 50 kHz frequency, Figure 4).

A different methodology of AVO inversion based on the transformation of common-shot gathers to plane-wave gathers using the tau-p transform was recently proposed by Van der Baan and Smit (2006). This is a promising approach for multi-layered elastic inversion.

Conclusions

P-P reflection coefficients measured in the laboratory for a water/Plexiglas interface show substantial deviation from the plane-wave reflection coefficients at large angles. This deviation is explained by spherical wave effects, as demonstrated by full-wave point-source reflectivity simulations, which show excellent agreement with the laboratory experiment. The results demonstrate that the spherical wave effects can distort the results of three-term AVO inversion based on the AVA curvature. An alternative approach to use critical angle information extracted from AVA curves leads to a significant improvement of the parameter estimation.

Acknowledgments

We are grateful to Brian Evans, Bruce Hartley, and Mark Lwin for help with laboratory experiments. We also thank Enru Liu, Abdullah Al Ramadhan, Marcos Grochau, and Putri Wisman for useful discussions. Alhussain thanks Saudi Aramco for his Master's Degree scholarship.

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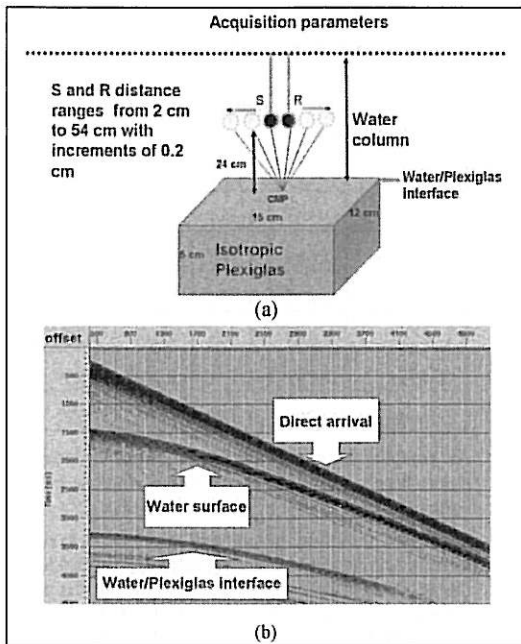


Figure 1. (a) Acquisition parameters of the reflection measurement for water/Plexiglas interface producing CMP gather (b) with three seismic events indicated by arrows.

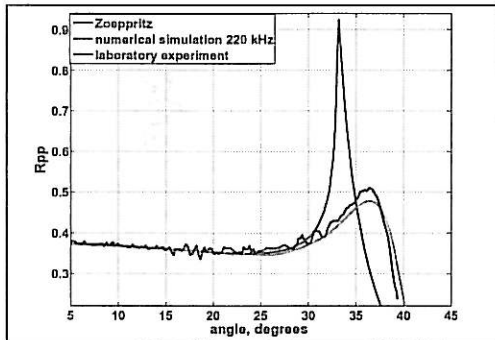


Figure 2. Comparison of measured reflection coefficients versus incidence angle for water/Plexiglas interface (blue line) with plane-wave response computed with Zoeppritz equations (brown line) and point-source numerical simulation (green line).

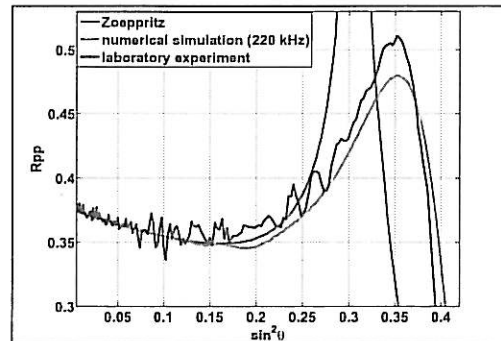


Figure 3. Comparison of measured reflection coefficients vs. $\sin^2\theta$ for water/Plexiglas interface (blue line) with plane-wave response computed with Zoeppritz equations (brown line) and point-source numerical simulation (green line).

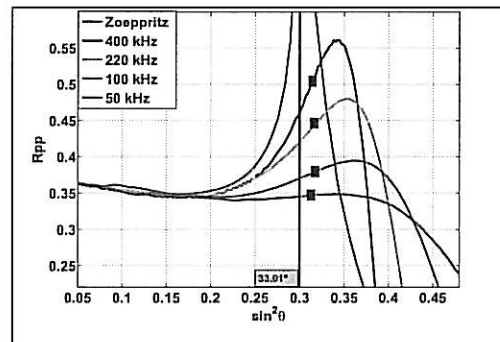


Figure 4. Simulated AVA responses at different frequencies plotted against $\sin^2\theta$. Squares denote inflection points used to estimate critical angles. Brown line is the plane-wave response computed with the Zoeppritz equations.

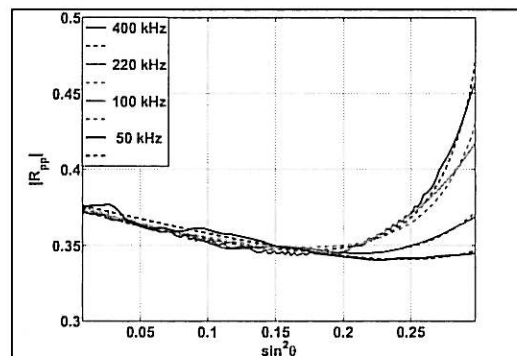


Figure 5. The spherical wave AVA responses at different frequencies along with the best-fit plane-wave approximations.

EDITED REFERENCES

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REFERENCES

- Doruelo, J., F. Hilterman, and G. Goloshubin, 2006, Head waves as mechanism for azimuthal PP AVO magnitude anomalies: 76th Annual International Meeting, SEG, Expanded Abstracts, 199–203.
- Downton, J. E., and C. Ursenbach, 2006, Linearized amplitude variation with offset (AVO) inversion with supercritical angles: *Geophysics*, 71, no. 5, E49–E55.
- Haase, A. B., 2004, Spherical wave AVO modeling of converted waves in isotropic media: 74th Annual International Meeting, SEG, Expanded Abstracts, 263–266.
- Kelly, M., C. Skidmore, and D. Ford, 2001, AVO inversion, Part 1: Isolating rock property contrasts: *The Leading Edge*, 20, 230–323.
- Krail, P. M., and H. Brysk, 1983, Reflection of spherical seismic waves in elastic layered media: *Geophysics*, 48, 655–664.
- Landro, M., and I. Tsvankin, 2007, Seismic critical-angle reflectometry: A method to characterize azimuthal anisotropy?: *Geophysics*, 72, no. 3, D41–D50.
- Luo, M., and B. J. Evans, 2004, An amplitude-based multiazimuth approach to mapping fractures using P-wave 3D seismic data: *Geophysics*, 69, 690–698.
- Van der Baan, M., and D. Smit, 2006, Amplitude analysis of isotropic P-wave reflections: *Geophysics*, 71, no. 6, C93–C103.
- Winterstein, D. F., and J. B. Hanten, 1985, Supercritical reflections observed in P- and S-wave data: *Geophysics*, 50, 185–195.



THEORY AND METHODS

AVO 2.1

(0239-0243)

Estimation of the fluid indicator from azimuthal AVO gradient variations at a fractured reservoir

Joost van der Neut*, Delft U and Indian School of Mines U; Ranjit K. Shaw, Indian School of Mines U; Mrinal K. Sen, U of Texas Inst for Geophysics, John A. and Katherine G. Jackson School of Geosciences

AVO 2.2

(0244-0248)

Is there a basis for all AVO attributes?

Zhengyun Zhou*, Center for Applied Geosciences and Energy, U of Houston; Fred Hilterman, Geokinetics

AVO 2.3

(0249-0253)

Experimental verification of spherical wave effect on the AVO response and implications for three-term inversion

Mohammed Alhussain*, Boris Gurevich, and Milovan Urosevic, Curtin U of Technology

AVO 2.4

(0254-0258)

AVOaz response of a fractured medium: Laboratory measurements versus numerical simulations

Mohammed Alhussain*, Curtin U of Technology; Enru Liu, British Geological Survey; Boris Gurevich, Milovan Urosevic, and Shahid Ur Rehman, Curtin U of Technology

AVO 2.5

(0259-0263)

Fracture-properties inversion from azimuthal AVO using singular value decomposition

Isabel Varela*, U of Edinburgh; Sonja Maulzsch, TOTAL E&P UK, Geoscience Research Center; Xiang-Yang Li and Mark Chapman, British Geological Survey

AVO 2.6

(0264-0268)

Common-angle processing using reflection angle computed by kinematic prestack time demigration

Didier Lecerf*, Philippe Herrmann, Gilles Lambaré, Jean-Paul Tourré, and Sylvian Legleut, CCGVeritas

AVO 2.7

(0269-0273)

AVO modeling with nonzero-phase spherical waves

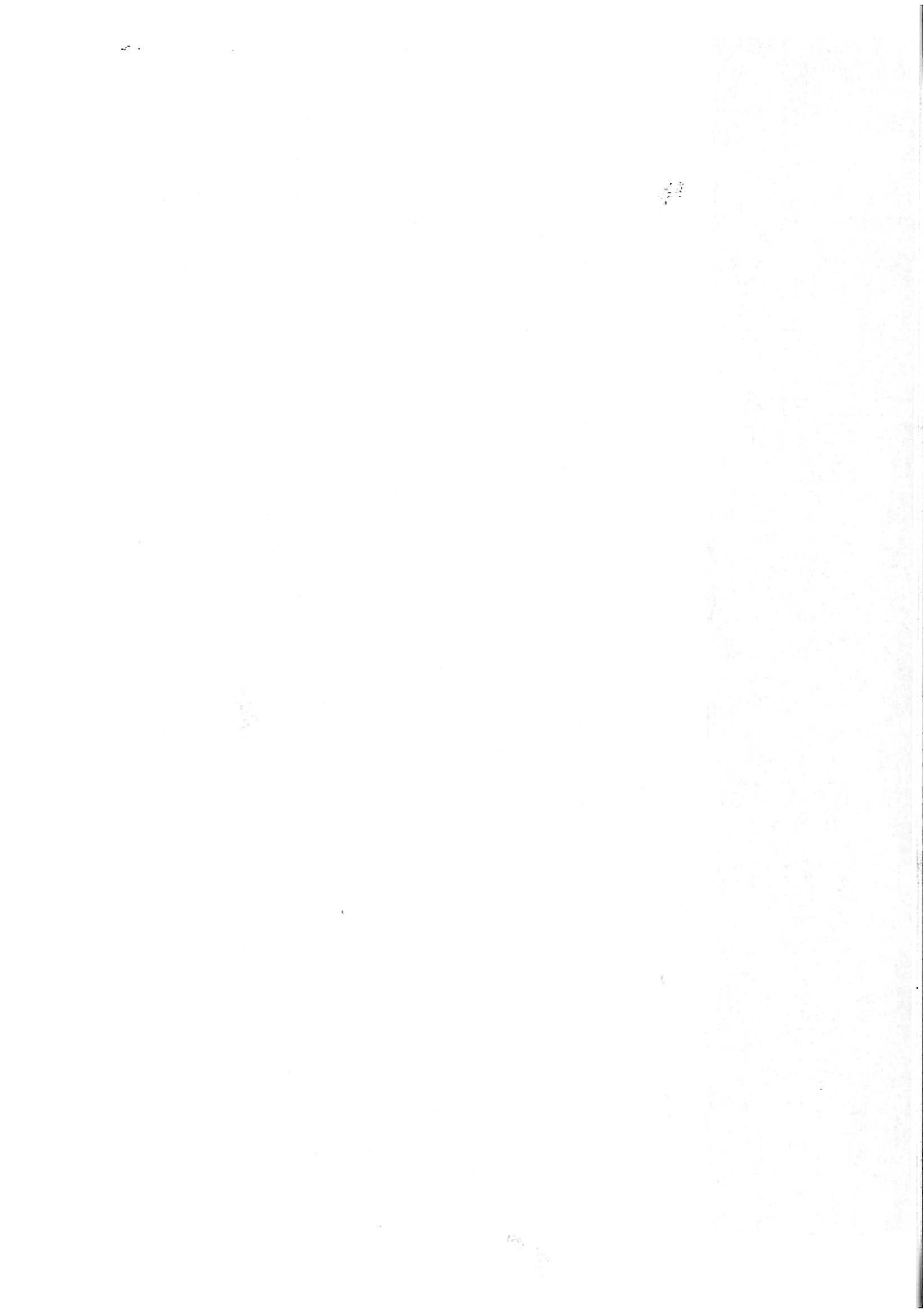
Charles P. Ursenbach* and Arnim B. Haase, Crewes, U of Calgary


AVO 2.8

(0274-0278)

Time-lapse AVO modeling for enhanced coal-bed methane production

Jason McCrank*, Don C. Lawton, Han-xing Lu, and Kevin Hall, U of Calgary





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SEG Annual Meeting 2007 news coverage

SEG Technical Program features full slate, new Special Session

Sylvie Dale

23 September 2007—The SEG Annual Meeting Technical Program begins on Monday afternoon with a full slate of 646 accepted papers (505 oral and 141 poster).

This year's Technical Program is a strong one, commented Bob Hardage, Technical Program Committee chairman. The committee's task was to pare down the more than 800 abstracts received to 646 oral papers and posters.

"We have to go through a rather rigorous peer review process to go through this," Hardage said. A total of 478 peer reviewers participated in the abstract selection process, and combined with the cochairs and session monitors, that number jumps to about 690 people—more than the number of accepted papers.

"I don't think there is any other SEG activity that gets that many members involved."

Some more numbers:

! Accepted papers are from roughly 44 countries around the world.

! More than 200 students submitted papers.

! There are 165 accepted student papers, meaning the student is the primary author of the paper (this number does not include students that may be listed as secondary authors).

A new Special Session has debuted this year and, if it goes well, may be a permanent addition. *Special Session 2, Science and Technologies, the Horizon and Beyond*, is similar in scope to the very popular *Special Session 1, Recent Advances and the Road Ahead*. They are both suited to a more general audience and deal with cutting-edge technologies and methods of the future.

The Technical Program consists of 63 Technical Sessions scheduled Monday through Thursday with a maximum of 11 concurrent Technical Sessions scheduled at any time during the program period. Topic areas that had high abstract submissions, and thus will have several scheduled sessions, include EM exploration, near-surface and environmental, rock properties, seismic inversion, seismic processing: migration, seismic processing: multiples, and time lapse.

Poster sessions will be effective this year because the layout of the Henry B. Gonzalez Convention Center in San Antonio allows us to distribute posters along the major traffic area between the Exhibit Hall (Floor 1) and the Technical Sessions (Floor 2). It remains to be seen if the expected high rate of foot traffic through the poster area will aid or disrupt poster presentations, but we are hopeful that this decision will return a positive response.

When asked if anything about the submissions surprised him, Hardage said he was surprised the program didn't receive more papers on what he terms multi-azimuth technology. The technology is new enough that the experts are still working out the proper terms, but in a nutshell, it is a seismic acquisition method using more than one source and more than one vessel and involving multiple tows in the same area.

"It is a red-hot topic for subsalt imaging—arguably the most challenging imaging problem that the industry has in the Gulf of Mexico, and in other areas where subsalt is a big part of the subsurface layers. That's going to control the destiny of subsalt hydrocarbon exploration for the next decade or so."

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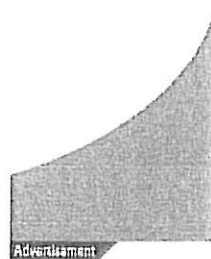
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Hardage said it will be a great session and plans to attend it, but it may take some time for the topic to attract a lot of papers because people are probably going to need a little more experience, and there may be some confidentiality issues this early in the process.

The usual topics got a lot of papers, including rock physics, seismic migration, and imaging, potential fields (gravity and EM).

A new no-show policy is being tested this year in San Antonio. The Executive Committee, with guidance from the Technical Program Committee, has voted that oral paper authors must give sufficient notice if they cannot present their paper as scheduled. If they do not, they are barred from consideration for the next two SEG Annual Meeting Technical Programs. SEG leaders are hoping this will reduce gaps in the program when a paper cannot be presented at the scheduled time.

Incidentally, attendees may notice that the Steering Committee has largely the same makeup as that of SEG 2001, which also was held in San Antonio but was interrupted by the passenger jet attacks of 11 September 2001. Because they set up a great program in 2001 but were unable to carry it out, everyone but the general chairman agreed to finish what they started in San Antonio this year. If the attitude of the Technical Program Chairman is any indication, the 2007 meeting should be very successful.

Expanded Abstracts

Many of the *Expanded Abstracts* have been posted to the SEG Technical Program Online site. At the conclusion of the Annual Meeting, this site will be taken offline, but the Expanded Abstracts will continue to be available (full text to members and subscribers, and abstract views only to nonmembers) in SEG's Digital Library. The *Technical Program Expanded Abstracts CD* is also available through the Book Mart (booth #659).

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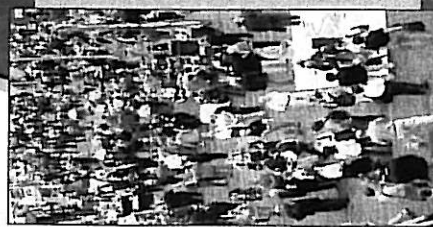
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SEG ONLINE: Technical publications and a variety of Society information and services are available on SEG's Web site and related sites. Online versions of GEOPHYSICS and THE LEADING EDGE include many value-added features, including reference linking and the ability to build and share your own article collections. The two journals are part of the SEG Digital Library that also includes a complete archive of Technical Program Expanded Abstracts and an online version of Robert E. Sheriff's Encyclopedic Dictionary of Applied Geophysics, fourth edition. SEG Web services include a member search, the Digital Cumulative Index, all SEG Technical Shortlands, the Online Book Mart, dues payment, meeting registration, Continuing Education course registration, Geophysics and Technical Program paper submission, audio and video of technical presentations, an Annual Meeting booth browser, and information about the full range of SEG activities.

REFERENCE PUBLICATIONS: SEG publishes books, CD-ROMs, DVD-ROMs, videos, and slide sets covering the entire spectrum of applied geophysics topics. Robert E. Sheriff's Encyclopedic Dictionary of Applied Geophysics, fourth edition and Orlin's Seismic Data Analysis: Processing, Interpretation, and Inversion are best-sellers. SEG members receive major discounts on SEG publications. Online ordering is available.

Meetings & Expositions

Yearbook: Published annually and available only to SEG members, the SEG Yearbook is an alphabetical and geographic directory of all members. It includes lists of the Society's committees, meetings, educational opportunities, awards, publications, historical records, and governance documents. It is published on a CD-ROM that also includes the previous year's journal articles, and it is distributed to all members. Information in SEG's Yearbook also is available on the SEG Web site or can be purchased in print through the SEG Book Mart.

Annual Meeting: SEG's Annual Meeting and Exposition is the world's premier geophysical event, featuring more than 700 technical paper presentations and an exposition showcasing the latest in geophysical products and services. It regularly brings together more than 8,000 exploration industry professionals from around the globe.

Development and Production Forum: This annual event brings new and emerging development and production technologies into open discussion, with the dual purpose of education and exchange of ideas.

Summer Research Workshop: Held annually, this workshop examines, clarifies, and promotes research in a wide range of applied geophysics topics.

International meetings: More than 50 percent of SEG's members live outside the United States, and one of the ways SEG serves them is through a growing international meetings program.



Professional Development

SEG offers many professional development opportunities in a variety of settings.

- Continuing Education courses: SEG offers public and contract continuing education courses on many aspects of applied geophysics.
- SEG/EAGE Distinguished Instructor Short Course: Each year a new instructor of renown is selected to teach worldwide a course of broad relevance. Registration fees for members are minimal.
- Distinguished Lectures: SEG-sponsored Distinguished Lectures on geophysical topics of high interest are presented in dozens of locales throughout the world.
- Regional Lectures: This new program brings geophysical topics of relevance to geophysicists in local regions around the world.
- Annual Meeting: The SEG Annual Meeting includes more than 500 technical paper presentations covering the latest developments in the geosciences.

Geoscience Center: The SEG Geoscience Center in Tulsa, OK, captures the history of exploration geophysics and provides visitors young and old with hands-on learning experiences. The center also develops and distributes K-12 Earth Science teaching aids. With its online presence and its partnership with SEG sections, the Geoscience Center brings youth outreach programs and resources to members and the public around the world.



Foundation

As an integral partner of SEG, the Foundation and its generous donors work to help support programs and projects directly related to the mission and vision of SEG. These mission-related programs benefit our professional and student members, support projects within our global community, and teach and inspire the geoscientists of tomorrow. All programs fall into the following broad categories:

- PROFESSIONAL DEVELOPMENT
- STUDENT SUPPORT
- YOUTH OUTREACH



Recognizing the Remarkable

Maurice Ewing Medal: The recipient of this award is recognized for having made major contributions to the advancement of the science and the profession of exploration geophysics.

Virgil Kauffman Gold Medal: This award is given to an individual who has made an outstanding contribution to the advancement of the science of geophysical exploration as manifested during the previous five years.

Cecil Green Enterprise Award: The Society names an individual who has demonstrated courage, ingenuity, and achievement while risking his or her own resources and future in developing a product, service, organization, or activity which is recognized as a distinct and worthy contribution to the industry.

Regional Fessenden Award: Since its inception, this award recognizes an individual who has made a specific technical contribution to exploration geophysics, such as an invention or a theoretical or conceptual advancement.

J. Clarence Karcher Award: A young geophysicist (younger than 35 years of age) of outstanding abilities is given this award for significant contributions to the science and technology of exploration geophysics.


Distinguished Achievement Award: This award is given to a company, institution, or other organization for a specific technical contribution or contributions, which have substantially advanced the science of exploration geophysics.

Life Membership and Honorary Memberships: Awarded to members of SEG for special achievements within the profession. Other Society awards are Special Commendation, Best Student Paper, Best Student Poster, Best Paper Presented at Annual Meeting, Best Poster Presentation at Annual Meeting, Best Paper in GEOPHYSICS, Best Paper in THE LEADING EDGE, and Distinguished Lecturer.





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