The 8th International Workshop on Seismic Anisotropy
(8IWSA)
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by

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I. Purpose and summary of the workshop

The earth scientists engaged in understanding and using seismic anisotropy, multi-component reflection seismology, whether in theory, modeling, or field data applications, gather once every two years to present new work. Ideas are exchanged, and new methods and accomplishments are presented. Academic, research, and industrial concerns are addressed and exhaustively discussed. For those working in multicomponent seismology, or multi-azimuth P-wave analysis, this is the most useful technical meeting to attend, from which corporate strategy can be enhanced, refined, and improved.

The most important developments presented at 8IWSA from the applied-papers included:
1. The method to determine (VP/VS)effective for common conversion point binning (CCP) of PS data by correct use of $(VP/VS)_0$ and $(VP/VS)_{nmo}$. Amoco.
2. Methods to make prestack depth migrations tie the wells. Elf and Chevron.
3. Identification of shale versus non-shale intervals (source rock vs. reservoir rock), through measuring the anellipticity of the reflection hyperbolae. Chevron, Elf, and Stanford.
4. The use of P-wave azimuthal variation in interval velocity and AVO to map high fracture density and thus faults with throw below seismic resolution ("Subseismic faults"). Lynn Inc.
5. The documented ability to measure azimuthal variation in 3D full-azimuth full-offset P-wave field data, as well as azimuthal variation in Vint and AVO, and the desire to use such measurements to map horizontal permeability anisotropy associated with aligned fractures. The ultimate goal is to map the flow conduits (the plumbing) associated with the reservoir. Lynn Inc.
6. The calculation of elastic constants (cij) from P and S velocities at different azimuths and angles of incidence, using a coordinate system independent method (Kelvin notation). Amoco.

II. Important Results

Important contributions are to be found among the "theoreticians" and the "practitioners". I am better equipped to evaluate the latter papers, which is thus the focus of this report.

1. The effects of the layer anisotropy (Transverse Isotropy with a Vertical axis, or TIV).

a) The measurement of the deviation of prestack reflection events from hyperbolic (the anellipticity), generally termed eta, is a measure of the magnitude of the TIV (layer anisotropy), which is proportional to the shaliness of the rocks, with a strong contribution from the organic content in the shales (kerogen). The interval eta curve was shown by Chevron and Stanford to be proportional to the smoothed gamma ray curve from well log data. Thus, the surface seismic discrimination between potential source rock and reservoir rock (nonshale) for thick intervals is demonstrated. The data required are long offset P wave reflection data, either limited azimuth or full azimuth, 2D or 3D, or vertical cable data with long offsets.

b) Tie the well with prestack depth migrations.
The TIV properties of the medium need to be captured, and the VP for imaging is not the VP to use for depth conversion. Credibility in a prestack depth migration is linked to the ability to be able to predict accurately the depth to given reflectors, or tie the well. If estimates of the magnitude of the layer anisotropy can be obtained, then estimates of the shaliness can be extracted. What was formerly a "problem" now becomes "information".

"3D anisotropic post stack imaging on an offshore Africa case study," Elf, CSM.

"Anisotropic parameters estimation on an offshore West Africa case study," Chevon, Elf.

"Seismic anisotropy in Trinidad: Processing and Interpretation,: Stanford, Amoco.

"Prestack F-K migration in anisotropic media", Tx A&M.

The next two papers dealt with P-wave seismic depth migration in the presence of dipping TI media (dipping layered media):
"Anisotropic raytracing and imaging," Shell. The role of a tilted TI-Symmetry system in a sediment layer, dipping adjacent to a salt flank.
"Depth migration of anisotropic physical model data, Univ. Calgary/Foothills Research Project, using the Kelman Seismic Processing Inc. (Calgary) prestack depth migration code.

"Velocity analysis using nonhyperbolic moveout in anisotropic media of arbitrary symmetry-synthetic and field data studies," IFP.

"Stress dependent shale anisotropy", IKU.

"Seismic properties of petroleum source rocks", Carcione, Osservatorio Goeficico Sperimentale, Italy.

"Anisotropy of shales from a hybrid optimization method with wide-angle seismic data," Univ. of Cambridge.

"A strategy for anisotropic pre-stack depth imaging", Total and GX Technology.

"Ray-based 2D anisotropic prestack depth migration on synthetic and real data," Elf.

The Australians did not attend, but their abstract was included:
"Accuracy and limitations of the small offset P-wave NMO velocity estimation in vertically transversely isotropic media", Curtin Univ. of Tech., W. Australia.

2. The correct way to perform CCP binning of PS data was shown by Leon Thomsen, Amoco. The VP/VS ratio zero offset and the VP/VS ratio from the NMO data are both determined (former from log data, latter from reflection seismic data). The effective VP/VS = $(VP/VS)_{nmo} / (VP/VS)_0$. The asymptotic CCP binning location is determined by:
$XC/XR = (VP/VS)_{eff} / [1+(VP/VS)_{eff}]$

Accurate CCP binning is the critical step for clear images of PS data.
Since Thomsen has already shown that the moveout velocity of PS data depends upon the <u>signed</u> offset, and the nature of the shear wave splitting depends upon the azimuth of the Source-receiver, care must be taken in analysis to keep these effects separate, less smeared images and incorrect velocities result.

"C-wave [converted wave] reflection seismics over anisotropic inhomogeneous media," Amoco

3. The direct detection and mapping of subseismic faults for reservoir compartmentalization studies, using the azimuthal variation of VP int and the azimuthal variation in AVO. The faults with throw too small to be seen as an offset of reflectors are associated with increased fracture density. The increased fracture density affects the velocity by azimuth and the AVO by azimuth. Both of these quantities can be determined from full-azimuth full-offset 3D P-wave data. The mapping of subseismic faults is of concern to those in reservoir development due to the perturbations of flow that these faults cause. Flow may be increased parallel to the fault, but possibly decreased across the fault (if a sealing fault) or enhanced across the fault (if a leaky fault).

P-wave azimuthal variations were addressed in:

"A case study of azimuthal moveout analysis for fracture detection", Li, British Geological Survey.

"Analysis of AVOA for determination of fracture orientation", Elf, and Leeds Univ. I liked their method of display: they displayed the vector quantity determined from the AVOA on a reflector. The length of the vector is the magnitude of the difference of AVO by azimuth, and the direction of the vector is (I presume) the direction of maximum amplitude. Underneath this vector plot was a color-coded time structure map, in order to evaluate the relationship of structure and AVOA.

"Field data observations of azimuthal variations in 3D P-P reflection data", Lynn Inc.

"Weak anisotropic reflections for reservoir characterization", Psencik, Academy of Sciences, Czech Republic. [Also, "qS wave Green Function for inhomogeneous weakly anisotropic media".]

"Multi-azimuthal modeling and inversion of qP reflection coefficients in fracture media," University of Campinas, Brazil.

"Long-wave seismic anisotropy of heterogeneous reservoirs", Sayers and Dean, Schlumberger and Cambridge Univ.

"Long-wave seismic anisotropy of heterogeneous reservoirs," Sayers, Schlumberger.

"Generalized Dix equation and analytic treatment of normal-moveout velocity for anisotropic media", CSM.

"Moveout velocity analysis and parameter estimation for orthorhombic media", CSM.

"3D moveout inversion in azimuthally anisotropic media with lateral velocity variation: theory and a case study," CSM.

"Processing multicomponent sea-floor data for azimuthal anisotropy : theory and overview", Li, BGS. This paper also contained P-P AVOA discussions.

4. The direct detection and mapping of strong azimuthal variation in P-P attenuation, as measured in full-azimuth full-offset 3D P-wave data, was demonstrated in field data. (Lynn Inc.). The principal mechanism of attenuation is the movement of fluids within rocks as the seismic wavefront advances (Thomsen, pers. comm., 1997). Many workers consider the

squirt-flow mechanism (fluid moves when particle motion is across the fractures) more important than the Biot mechanism (particle motion is parallel to the fractures). Other mechanisms of attenuation, apart from squirt-flow, exist: scattering (manifest in coda, or trailing legs), mode-conversion, Biot Flow. When these other mechanisms control or affect the total attenuation, our ability to map permeability, i.e., the plumbing or flow conduits in the reservoir, is diminished or made more difficult. When we can separate the effects due to each mechanism, then we can allocate to each mechanism the appropriate amount of attenuation, thus enabling a map of the effective horizontal permeability anisotropy. Lynn Inc.

This paper was presented with the goal of measuring the level of criticism or protest from the audience. No one protested. Since this group is extremely vocal and inherently argumentative, I interpret the result of presenting this paper as people are thinking it over as to its applicability, but that in principle the idea is possible.

"Azimuthal variation in attenuation and interval velocity in 3D P-wave limited azimuth field data over a naturally fractured gas reservoir: steps towards direct detection of horizontal permeability anisotropy," Lynn Inc.

Although the separation of attenuation effects due to different mechanisms, in order to determine the percent of attenuation directly attributable to horizontal permeability anisotropy, sounds daunting, significant advances presented by the British Geological Survey and Dr. Chesnokov and others at 8IWSA make this task within our grasp. The BGS (Enru Liu) can and has modeled the effects of scattering and/or mode conversion (just these two). The effect of scattering is to add trailing legs or energy behind the first arrival, but these trailing legs have the same particle motion as the first arrival. Chesnokov and his colleagues presented equations which can model the effects of the permeability anisotropy. Gelinsky and Shapiro can model the effects of Biot flow. Andrey Bakulin and L. Molotkov can write the equations of seismic wave propagation in which permeability anisotropy is linked with the seismic anisotropy (although they have a few hiccups in their parameterization, that should be fixed). All the pieces of the solutions, although modifications to an individual piece are needed, are at hand--they simply need to be assembled to analyze the situation.

"Boundary element modelling of seismic waves in media with distributed cracks", Liu, BGS, and Univ. of Cambridge, BP plc, and Conoco Inc.

"Velocity of elastic waves in a porous medium with a fracture set", Andrey Bakulin and L. Molotkov, St. Petersbourg State Univ. In their abstract they state:
"Making a measurement of seismic anisotropy we always aim to estimate the permeability and its anisotropy together with the fluid content of fractures." This caught my attention. A fracture is considered as a (flat-lying) thin, soft and highly permeable layer within a finely layered sequence. Fine layering of poroelastic constituents produces both anisotropic

elastic moduli and anisotropic density operators. Velocities are sensitive only to fluid content whereas attenuation contains the useful information about permeability of fracture set. Here, attention is paid only to analysis of velocity information.

They need to change their characterization from flow is proportional to 1/aperture of the fracture, to flow is proportional to 1/aperture cubed.

Anisotropic density operators, or density tensors, have been alluded to by various workers in the past: perhaps these workers were interested in describing the link between seismic anisotropy and permeability anisotropy.

"Wave propagation in finely stratified media containing porous Biot layers," Molotkov and Andrey Bakulin, St. Petersbourg Branch of Steklov Math. Inst.

"Boundaries of the components of effective elastic tensor", Bayuk and Chesnokov, Russian Academy of Sciences.

"Correlation between elastic and transport properties of porous cracked anisotropic media", Bayok and Chesnokov, Russian Academy of Sciences.

"Mathematical modeling the physical properties of reservoirs," Byauk and Chesnokov, Russian Academy of Sciences.

"Frequency dependence of physical parameters of micro inhomogeneous media, space statistics", Chesnokov and Kukharenko, Russian Academy of Sciences.

"Bio-Gassman Characteristic tensors of anisotropic porous media -- experimental results in rocks", IFP.

A method to link together the changes in the shear-wave seismic anisotropy which accompany the stress-driven changes in the rocks was discussed by Stuart Crampin (Univ. of Edinburgh):
"Going APE: progress towards understanding shear-wave splitting in a critical crust."
This code could provide useful seismograms to model 4D (time-lapse 3D) field observations.

Four shear wave acquisition techniques were used over a gas reservoir in the Netherlands: crossed-dipole, fixed offset VSP, walkaway VSP, and shear wave surface seismic. "The multicomponent shear wave data were acquired for the purpose of characterizing preferred flow directions in a sandstone gas reservoir in Northern Holland."
"Integrated interpretation of multicomponent sonic and seismic data, Alkmaar, The

Netherlands", Amoco
The results were that the matrix porosity provided the majority of the effective permeability, based upon the low levels of anisotropy. "A secondary permeability, due to thin, poorly connected fractures, may assist. When the reservoir is re-pressurized, the effects of these fractures may become more prominent."

5. An efficient method to determine the natural coordinate system for 3C OBS P-S data. Xian Chang Li, BGS. The receiver line is perpendicular to the sail line. The upcoming shear wave for an aperture along the receiver line is analyzed by rotating each receiver in the aperture to the S-R coordinate system (the inline-crossline direction relative to the source location). When the S-R is in the principal azimuth, the energy will be null on the crossline phone AND THE INLINE PHONE WILL MANIFEST A POLARITY REVERSAL. These two effects are expected to be quite visible on field data.

6. The use of Kelvin notation is recommended for a co-ordinate independent determination of elastic constants and effective symmetry from P and S velocities measured at various angles of incidence and azimuths.
This is necessary for anyone working in multicomponent seismology since modeling of field results and predictions of wave characteristics needs elastic constants to do full azimuth full offset 3D modeling in at least orthorhombic symmetry material.
"Kelvin notation for stabilizing elastic-constant inversion", Amoco.

Baerheim and Macbeth, BGS, also addressed determining the symmetry from the components of the elastic tensor:
"Sensitivity of symmetry determination by decomposition".

7. The "L-wave", the locally S-wave converted wave.
The P-S-P-P-P, with the S leg locally present within a high velocity layer (basalt, or salt), either on the way down, or the way up, was discussed by Colin Macbeth, BGS. "Their amplitude is significant only at offsets of 2 km or greater", and they look like trailing legs behind the P-wave arrival. The amplitude of these waves with azimuth changes significantly.

8. Cross dipole sonic logs and multicomponent seismology to determine fracture characteristics, permeability, and correct imaging P-S data. (Mueller, Amoco).
The VP/VS in North Sea data (Valhall) in the overburden can be as high as 4. Knowledge of the velocity distributions (P and S) are recommended prior to PS data acquisition and processing.

"Crossed-dipole sonics at Valhall: Implications for Ocean Bottom Seismics and field development", Amoco

"Fractured reservoir permeability from integrated borehole acoustic measurements," Western Atlas

9. Bakulin and Molotko, Saint Petersbourg State Univ, presented a set of equations that link permeability anisotropy with seismic anisotropy. Gelinsky, now with Western Atlas (wireline) in Houston, and Shapiro published a similar set of equations for Biot flow prior to the meeting. One minor problem with Bakulin and Molotov's development is that the flow is proportional to the 1/aperture, whereas it should be proportional to 1/aperture cubed. Bakulin deals with TIV symmetry, with flat-lying fractures interlayered with sedimentary fine layers; this approach would have to be modified to make the fractures vertical. In TIV symmetry, the fractures are one type of layer in a finely layered sequence. Finely layered poroelastic constituents produces both anisotropic elastic moduli and anisotropic density operators.

10. Various theoretical papers.

"Maslov shear-waveforms in highly anisotropic media and implications for shear-wave splitting", Caddick, Western Geophysical, and Univ. of Leeds.
"Maslov ray summation is in principle better than the ordinary ray theory because it is less local: the receiver waveform depends on neighboring rays and more information about the wavefront than just local Gaussian curvature." This technique permits more reliable estimates of waveforms at and near caustics.

"Synthetic seismograms in transversely isotropic plane layered media," Univ. de Bretagne Occidentale.

"3D seismic traveltime tomography in orthorhombic media," Institut de Physique du Globe de Paris, France.

The next paper met with heated debate (criticism?):
"An acoustic wave equation for anisotropic media," Stanford. The shear modulus was set to zero, and yet TIV media were modeled. "A wave equation, derived under the acoustic medium assumption for P-waves in transversely isotropic media with a vertical symmetry axis (VTI media), though physically impossible, yields good kinematic approximation to the familiar elastic wave equation for VTI media".

"Condition for the occurrence of decoupling planes in anisotropic elastic media," Klaus Helbig, Hannover. Also, "A formalism for the consistent description of non-linear elasticity of anisotropic media."

"Converted wave, asymptotic inversion, in the presence of caustics," CSM.

"Approximate dispersion relations for qP-qSV waves in VTI media", Schlumberger and

CSM.

"Transverse isotropy from vertical fractures," Schlumberger and Lawrence Berkely Lab.

"Gyrotropy and anisotropy: similarities and differences". Inst. of Geophy. of Russ. Acad. of Sciences.
"If the micro-objects are arranged in such a way that the medium has no centre of symmetry, gyrotropy may arise: the medium in the whole also has no centre of symmetry...The shear wave splits into two waves with slightly different velocities and elliptical [or circular] polarizations of opposite circulation directions. If, in addition to the absence of a center of symmetry, the rock contains left- or right-handed micro-objects, in unequal quantities, it becomes itself "left" or "right." One possible scenario in which gyrotropy might be manifest is in a cylinder of material which has undergone or is undergoing a torqueing stress field, or a spiral-ing flow pattern due to torqueing stresses (salt or shale in-situ?). It was mentioned at the conference that biological material can have a "handed-ness". If there were a sea-floor bottom that had considerable organic debris, and if that organic debris preserved a relict handedness, perhaps this phenomenon might happen. However, I consider recording shear wave data that exhibit this phenomenon a low-probability event, in the depths and bandwidths of oil-company interests.

11. Various laboratory and field data measurement papers.
"Anisotropic velocity analysis of a fractured and vuggy carbonate," Amoco.

"Fracture estimation from walk-away VSPs recorded in a deviated well," BGS and Saga.

III. Where, How Many, and Who

The meeting was held at the Elf Training Center in Boussens, a small village in the south of France about 70 km ESE of Toulouse. The hillside complex is first rate, containing opportunities for a variety of exercise, including climbing stairs to travel anywhere, premier dining with a succession of fine local wines, and all modern conference facilities. This center is recommended and available for rental by outside groups. Interaction among the attendees was increased and enhanced by the venue because the only two available activities apart from the meeting were exercise (bicycling, golf, squash, gymnasium, climbing wall, country walks, etc.) and talking/dining/drinking and musical group activities in the bar with colleagues. The technical presentations were scheduled Monday, Tuesday, Thursday,m and Friday, as usual for IWSA. The oil company field data were presented mostly on Monday and Tuesday and theoretical papers were presented mostly on Thursday and Friday. This organization is optimal and produced the most successful IWSA meeting. Morning oral paper sessions and afternoon poster sessions were scheduled. Among the benefits of field data first and theory later are that the usefulness and assumptions embodied within the field data applications were then available for discussion and dissection throughout the whole week. 34 oral talks, 35 posters, and one TV animation were presented during the workshop. The traditional Wednesday outing was comprised of tours of the local area: prehistoric cave paintings, the Regional Pyrenees Museum, a wonderful gourmet lunch at a quiet riverside hotel, the medieval castle of Foix, and a boat ride on a subterranean river through limestone caves, complete with fault. The grand finale banquet on Thursday evening was enlivened by a performing costumed troupe of local dancers, singers, and musicians. Audience participation at the end of the performance was a highlight of the evenings' activities.

Eighty-one scientists were registered at the workshop, from at least eleven countries (France, USA, UK, Netherlands, Russia, Norway, Italy, Canada, Germany, Brazil, Czechoslovakia). The distribution of attendees follows, tabulated as O (Oil company), C (Contractor), R (Research), P (Post doc/professor), or S (Student). By "Applied", I indicate those whose work and interests appear to be primarily in field data <u>results</u>.

Those engaged in "Research" are employed by a national lab (IFP, BGS, etc.) or an oil company (Amoco, etc.) or a contractor research lab (Schlumberger), or supported by a major industrial consortium (CSM-Center for Wave Phenomena; CREWES-Univ. of Calgary; etc.). The Research talks (equations, etc.) are the foundations on which processing and modeling and inversion codes are built, so that field data personnel can have tools to process and analyze field data.

81 attendees =

30 University + 51 Industrial =

10 Students + 20 Post doc/Prof	+ 24 Applied	+ 27 Research
10 S + 20 P	+ 13 Oil Co. + 11 C	+ 27 R

The oil companies represented by attendees are: Amoco, Elf, Total, Chevron, AGIP, and Shell. The contractors represented are: Schlumberger, CGG, PGS Tensor, Western Geophysical, PGS Reservoir, Geco-Prakla, and Lynn Inc.

The sponsors of the 8IWSA were: Elf, IFP, Arco, Amoco, Schlumberger, Geco-Prakla, CGG, and Chevron. The organizing committee was Elf Exploration Production, and Institut Francois du Petrole. Jean Arnaud of Elf was the lead host of the 8IWSA: his efforts and fine accomplishments of the 8IWSA are gratefully appreciated by all the attendees. Jean Arnaud may be e-mailed to request a copy of the Abstracts at: jean.arnaud@elf-p.fr

As at all IWSAs, there were private debates as to whether the meeting contained "too much theory" (-practitioners) or "too much field data" (-theoreticians). This situation is necessary and to be expected, because each group needs to know what the other group is talking about and working on, even though the acquisition of such knowledge is occasionally difficult. An approximate 50/50 applied/theoretical allocation of time, as accomplished at 8IWSA, contributed to the better-than-ever nature of this meeting. The field data presentations contained the early fruits of truly practical mainstream issues being addressed and forecasts for the coming state-of-the-art implementations.

IV. Important Trends of Future Technology Development

A. P-P wave two-azimuth approaches (parallel and perpendicular to the faults/fractures, or maximum horizontal stress direction) or two-step approaches (V_{offset}, $V_{zero\ offset}$) for processing and interpretation are being done as the interim method to obtain or treat the azimuthal anisotropy or the TIV anisotropy. These approaches will be replaced by the new codes in which a smooth continuum of analysis of seismic property over azimuth and offset (angle of incidence) in 3D data shall be accomplished. Far more geologic information can be retrieved if 3D P-P and P-S full azimuth full offset data, which includes vertical cable, can yield the orthorhombic parameter distributions of interest. The goals to be accomplished include:
a) correct CCP binning of P-S data for clear images
b) interval VP/VS for lithology discrimination (sand, shale, carbonate)
c) interval eta (anellipticity) distributions for nonshale/shale/organic content estimates
d) pore fluid distributions (gas vs. liquid)
e) fracture density and fracture orientation
f) equant porosity distribution
g) stress distributions
h) flow conduit mapping (permeability, or "plumbing" maps)

B. Wave equation modeling and migration of seismic waves with permeability anisotropy linked to the seismic anisotropy being explicitly calculated or determined.

C. The book of abstracts contains much relevant information. The reader is encouraged to obtain the abstract book through e-mail contact of jean.arnaud@elf-p.fr

V. 9IWSA - April/May, 2000, Houston, Texas.

Amoco has offered to be, and been accepted as, the lead host for the 9IWSA, in Houston, the oil capitol of the world. Leon Thomsen is the lead Amoco spokesman. The other local geophysical companies interested in anisotropy and multicomponent seismology are invited to co-host/sponsor the event.

The 9IWSA venue will be a quiet secluded conference center located such that outside distractions are minimal, and weeklong attendance with overnight stays chosen by all participants. Thus, the IWSA character and style are preserved. The Wednesday outing is planned to be deep sea fishing, followed by cooking the catch that night at the Lynn Ranch in west Houston, weather permitting.

Registration is planned to be restricted to about 100 participants, with precedence given to authors and presenters.

VI. Summary

The marketable uses for measuring and using seismic anisotropy include:

1. Estimating the magnitude of the layer anisotropy.
Tie the well in pre-stack depth migration: the imaging velocity is not equal to the vertical velocity. Extract the interval magnitudes of layer anisotropy and use as estimates of shaliness.
For pre-stack reflection data, use eta, the deviation from hyperbolicity caused by the layer anisotropy, to calculate interval eta. Interval eta is proportional to the magnitude of the TIV in the interval, which is related to the shaliness (and organic content) of the interval. The interval eta curve resembles the filtered gamma ray curve.

2. The correct CCP binning for P-S data using the correct combination of $(VP/VS)_{zero\ offset}$ and $(VP/VS)_{nmo}$ provides improved clarity for the P-S data and more accurate interpretation.

3. Determine azimuthal variation in 3D P-wave Vint to determine relative fracture density, with the fast P-wave velocity direction being the fracture parallel (or maximum horizontal stress) direction, which is usually the preferred flow direction in the reservoir.

Mapping of subseismic faults can be accomplished by searching for azimuthal variation in both P-wave Vint and AVO. The high fracture density associated with subseismic faults are detectable with these methods. Reservoir compartmentalization can thus be more powerfully addressed.

Direct mapping of the effective horizontal permeability anisotropy can be accomplished by measurement of the S-wave anisotropy (velocity and amplitudes), and/or by 3D P-wave full-azimuth full-offset data, when evaluating the P-P azimuthal variation of attenuation, Vint, and AVO, joined with the separate evaluations of the relative contributions of the different attenuation mechanisms (scattering, mode-conversion, squirt-flow [the local permeability], Biot flow [a "global" flow]).

P-wave field data papers outnumbered S-wave field data papers by about 10 to 1. This is the first IWSA in which this proportion has occurred (usually the situation is the other way around). It is considered likely that the number of S-wave papers will once again increase within 3 to 5 years, due to ocean bottom 4-component data being presented (comments by Suat Altan).

Appendix:

The Nature of the "International Workshop on Seismic Anisotropy" Community

The community has no by-laws, no officers, and no affiliation with any major organization (SEG, EAGE, etc.).* We are a group of earth scientists who meet once every two years in order to speak, to listen, and to discuss the nature and use of seismic anisotropy. The proceedings are usually published. Our history is:

Date	Meeting	Place	Host	
1984, 1986:	1 and 2 IWSA	Russia	(Univ.)	
88	3	Berkeley, USA	Univ.	HBL
90	4	Edinburgh, UK	Univ	HBL
92	5	Banff, Canada	CREWES	HBL
94	6	Trondheim, Norway	IKU	HBL
96	7	Miami, USA	Univ	HBL
98	8	Boussens, FR	Elf	HBL
2000	9	Houston, USA	Amoco	

[HBL indicates that H. Lynn attended the meeting.]

The progression of hosts indicates the growth and development of our community: from university and academicians, to research organizations, to mainstream oil companies.

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*Comments by Leon Thomsen to the 8IWSA, April 23, 1998.