

mine the effect of pore pressure depletion on elastic framework moduli by using sonic logs from wells drilled at different locations through a reservoir at varying depletion stages. This is done by inverting the sonic logs for elastic framework bulk and shear moduli, cross-plotting these against an increase in net stress, and deriving stress sensitivity of the elastic framework moduli. The observed stress sensitivity is consistent with time-lapse results, and the

log-derived sensitivity is much smaller than predicted by hydrostatic core sample measurements. Their method can be used for both modelling and inversion of time-lapse data for effects of pore pressure depletion.

Sayers, Taleghani and Adachi analyze the effect of mineralization on the ratio of normal to tangential compliance of fractures. In the literature, this ratio has been suggested as a useful fluid indicator. However, since it is also

a function of the geometry and nature of mineralization, caution needs to be exercised in using amplitude versus azimuth data for predicting fluids in fractured reservoirs.

Rabeh, Miranda, Carvalho and Bocin close this issue of *Geophysical Prospecting* with an interpretation study of the Sahl El Qaa area on the southern Sinai in Egypt, based on a combination of a high-resolution land magnetic survey and seismic reflection data.

Galperin meeting still has read on VSP

Victor Manukov, chairman, GR-2008 Programme Committee, provides this report on last year's Galperin Readings meeting in Moscow.



Presentation of downhole VSP tools by Baoding Earth Science & Technology of China.

The Galperin Readings Conference – GR-2008 – held last October in Moscow proved once again that this annual meeting with its focus on vertical seismic profiling (VSP) continues to attract plenty of attention from the geoscience community, not just in Russia but further afield. This year some 110 participants from industry, research organizations, and academia attended the event held on 21–24 October last year. Delegates came from many countries including Belarus, Bulgaria, Canada, China, France, Germany, Kazakhstan,

Norway, Switzerland, United Kingdom, Ukraine, and USA, although the organisers feel that more companies from European and American companies could benefit from attending.

GR-2008 was convened by the Central Geophysical Expedition (CGE) and Geovers with support from the EurAsian Geophysical Society (EAGO), EAGE, and Schlumberger's Moscow Science Centre. Opening speakers Dr George Gogonenko, senior deputy general director, CGE, Dr Nikolay Savostianov, EAGO president, and Dr

Sergey Pletsov, EAGE-PACE representative in Moscow, all emphasized the importance of VSP survey data in the hydrocarbons exploration process, especially in the appraisal and monitoring stages of oil and gas fields in development or production. It was also stated that the Galperin Readings constituted the only forum in the world that discusses all aspects of VSP and surface-downhole geophysics including the integration of 2D/3D seismic with VSP data.

During the meeting 30 papers were delivered along with four international company presentations on downhole tool by Sercel (France), Baoding Earth Science and Technology (China), Avalon Sciences (UK) and Atlas Copco (Switzerland). Papers highlighted new developments in VSP technology as well as a number of case studies. A bonus for those attending was the distribution of conference abstracts as printed copies and in CD format in Russian and English, plus a special issue of No 4, 2008 of *Technologii Seismorazvedki* (Seismic Exploration Journal) which contained a review of the successful GR-2007 meeting.

With all diversity of problems discussed, there are two prevailing trends for surface-downhole seismic which enhances its effectiveness and makes it

attractive to the E&P industry. The first trend is the integration of offset VSP, polarization VSP, FS (floating source) VSP, and well logging with the 2D/3D surface seismic in order to enhance geologic imaging accuracy, especially near-borehole imaging, attenuation of various-noise fields, image resolution improvement, as well as address other challenges.

The second trend is the application of full-wave seismic that carries information about petrophysical parameters of the subsurface. Such data are used to assess hydrocarbon resources and estimate hydrocarbon reserves, update geologic models of hydrocarbon fields, image the subsurface from PP-, PS-, SS-reflections, and streamline and optimize hydrocarbon production practices. VSP of recent years is almost everywhere carried out using multiple shotpoints, 3C geophones, and the tie to completed surface seismic lines, as well as in combinations such as 2D+VSP and 3D+VSP. This helps to realize both trends, which in fact is the innovative integration of surface and downhole seismic exploration enabling estimates of porosity, density, permeability, reservoir fracturing, anisotropy, Poisson ratio, etc to be obtained. A direct result of this integration is enhanced oil recovery through more effective 3D seismic in combination with VSP. This is so because 3D alone cannot cope with complex geology fields under different production phases.

Papers presented at a few recent Galperin Readings Conferences acknowledge the integration of 3D seismic with VSP as one of most important ways to enhance seismic exploration

effectiveness. This was evidenced by case histories in five papers by Geovers in co-authorship with CGE, Moscow University, St Petersburg University, and Unis. They ran comparative analyses and evaluations of the abilities and limitations of VSP and 2D/3D surface seismic methods, to highlight the advantages and disadvantages of each method in providing solutions to geologic problems, especially when there is a need to apply procedures such as migration, inversion, statics correction, etc, with parameters preventing seismic imaging distortions.

The studies primarily aimed to establish how advantages of one method could be used to raise effectiveness of the other method, thus improving seismic exploration. For example, more confident VSP-derived wavelet signature is used in 3D deconvolution to improve 3D data resolution; a velocity model, determined also from VSP data, is used in stacking the events and in generating the converted PS-wave section. This type of processing is highlighted in two Geovers papers, one by Alexander A. Tabakov and Konstantin V. Baranov – 'Integrated land seismic and VSP survey geometries offer improved imaging solution' – was published in the *First Break* in September 2007. The papers summarize real and model data that confirm the effectiveness of the approach. They also show that application of amplitude inversion to VSP-recorded converted waves is unconstructive because of asymmetric VSP acquisition geometry. This is also obvious from the analysis of reflectance vs. wave incidence angle plot.



Conference audience including (left) the late Professor Yevsey Galperin's widow Rimma, and in the red dress Galperin's grand daughter Yelena.

PermNefteGeofizika Co showed in its paper that geologic parameters predicted from polarization VSP data exhibit a satisfactory match with the drilling data. The paper also recommended how to use polarization VSP traveltimes characteristics in the processing and interpretation of surface 3D+VSP data in order to improve data resolution, how to image more accurately near-well space and determine optimal acquisition offsets. Further recommendations included converted PS-wave processing methodology to aid the study of near-well geologic structure and also the study of variations in polarization and in traveltimes characteristics of various waves recorded from source locations at different azimuths.

Among theory and experimentation papers a noteworthy paper, authored jointly by MIFI Moscow Engineering Physics Institute and St Petersburg University, highlighted a method of sizing fractures that intersect a well from VSP-recorded hydrofracture waves or from any other source waves. The method is model-based, featuring certain boundary conditions and approximations. This theoretically proven possibility is planned to be realized as a ready-for-use technology of interest to both geophysicists and oilmen. KrasnoyarskGeofizika presented its first results from applying focusing transform to 3D data acquired in an area of 1360 km² in combination with VSP data recorded in 20 wells.

One more step forward in integrating surface and downhole seismic, as advanced by Geovers, was the processing of 2D/3D surface data in a Geovers-developed VSP software. Three papers



Victor Manukov made the point that 2D/3D is incomplete and insufficient without VSP in the study of complex oilfields.



EAGO President Dr Nikolay Savostianov opens GR-2008, flanked by Dr George Gogonenov, chairman of GR-2008 Organizing Committee (right) and Dr Alexander Tabakov, deputy chairman.



Poster presentation.



GR-2008 dinner finale.

by Geovers and CGE demonstrated the results of applying the VSP software programs to the processing of 2D/3D surface seismic data. This included:

- Acoustic and vector migration of seismic wavefields using finite difference method. Model-tested algorithms allow a correct subsurface image to be produced within an appreciably shorter time.
- Auto picking of reflections on common-source gathers. The reflections are confidently picked on both model and real data.
- Parameter assessment and subtraction of sound waves. Real data have been used to assess and reduce sound wave velocity variations and moveout, and to subtract sound waves from common-source gathers.

As the results obtained so far are encouraging, plans are to continue along these lines using other processing and analytical procedures.

A new methodology development featuring integration of offset VSP and floating source VSP (FS VSP) with details of the first results obtained in East Siberia were highlighted in a joint paper by VNIIGeofizika Research Institute, EvenkiaGeofizika, and KrasnoyarskGazDobycha Co. The paper presented an example of quality imaging for the near-well space by providing solutions, for example, to the merging of sections obtained from different source locations in the bottomhole zone when the target of interest is below the bottomhole, to the elimination of distortions in the post-migration images, and to chal-

lenges associated with steep incidence angles of waves and near-surface section variations. Along with improved processing procedures, the integration of VSP and FS VSP is based on the authors' developed method for auto determination of, and regard for, CMP trim statics as well as migration of offset VSP recorded shear, pressure and converted waves.

Two more VNIIGeofizika's papers discussed the ever topical issue of field data quality assurance and identification of various types of waves recorded by full-wave seismic. The papers gave practical recommendations. One *VinSeisTehnologia* paper assessed offset VSP processing mistakes and inaccuracies in tying seismic reflections to stratigraphic boundaries caused by errors in determining first arrivals of events and by some other factors. The error values, obtained by the paper's authors, will primarily be good for comparing with another party's measurements. Also interesting is the observation that the acquired data accuracy, while possibly good for the processing aimed at imaging the geologic structure, may be insufficient for seismic amplitude problem solution.

A Kazan City State University paper described integration of a surface refraction polarization survey with polarization VSP for the study of internal block structures of hydrocarbon reservoirs in a number of Tatarstan fields. BashNefteGeofizika and its affiliated companies run highly effective wide-scale exploration and additional exploration using VSP. Their

technology of VSP monitoring for deep exploratory drilling is well known, as they are working in close contact with BashNefte and other oil production companies. Geostra Science and Production Centre, BashGeoProject and partners OrenburgNefte, and TNK-BP presented four papers that summarize technological and geological results they accumulated during many years of employing VSP in combination with other methods. The papers accentuate the decisive role VSP data play in defining ways to explore for oil deposits and enhance oil recovery through rational field development and progressive technologies. Many case histories were presented to show how structurally complex fields can successfully be developed thanks to predictions of reservoir saturations from dynamic analysis of full-wave surface-downhole seismic data integrated with well logs, geology, and drilling data. A stunning prediction success ratio of 90–94% for reservoir saturations by offset VSP data for the past 8–10 years was shown. Similar highly effective results were obtained by BashNefteGeofizika from its fields, also of complex geology, in the western Orenburg region of Russia. Its experience is undoubtedly worth applying to other oil-prospective areas.

Canadian-Kazakhstan SBS of Almaty City reported on how it used 3D, polarization VSP, and well logging data to successfully refine an eaves-shaped structure model for an oil deposit in one of the Kazakhstan fields. Three companies presented new tools – a high temperature VSP telemetry coder (NIIMorGeofizika-Interservice, Russia) (Russia); vibro-impact pipe-string VSP (BelarusNefte, Belarus), and parameter selection for an electromagnetic pulse VSP energy source (Anega (Ufa City, Russia). A great deal of interest was also shown in products from international providers such as Sercel, Avalon Sciences, Baoding Earth Science & Technology, and Swiss Green Field, an Atlas Copco affiliated company.