Introduction

Report 13 of the Consortium project "Seismic Waves in Complex 3-D Structures" (SW3D) summarizes the work done towards the end of the ninth year and during the tenth year of the project, in the period June, 2002 — May, 2003. It also includes the compact disk with updated and extended versions of computer programs distributed to the sponsors, and brief descriptions of the programs.

Our group working within the project during the tenth year has consisted of seven research workers: Johana Brokešová, Václav Bucha, Petr Bulant, Vlastislav Červený, Luděk Klimeš, Ivan Pšenčík and Václav Vavryčuk, and of two PhD students: Karel Žáček and Xuyao Zheng.

Karel Žáček works on the algorithm of Gaussian packet migrations. He also worked for 3 months (July–September 2002) together with Ross Hill in the San Ramon branch of ChevronTexaco, and is going to spend autumn 2003 again in ChevronTexaco in San Ramon. Xuyao Zheng finished his PhD thesis "Determination of weak anisotropy parameters from qP–wave slowness and polarization vectors", and will defend it on September 8, 2003. Since the beginning of 2003, he works in Petroleum Applied Research Group (OPERA) at Pau, France. Ellen Gomes from Belem, Brasil, spent with us five months. Her research was devoted to the local determination of parameters of anisotropic media from observed travel times and polarizations of qP waves. Leo Eisner (Cambridge, U.K.), Véronique Farra (France), Yury A. Kravtsov (Russia), Anatoly L. Levshin (Boulder, U.S.A.), Ivan A. Molotkov (Russia) and Tijmen–Jan Moser (Amsterdam, Netherlands) visited us during the tenth year of the project.

Two of four issues of volume **46** (2002) of *Studia Geophysica et Geodaetica* were dedicated to Vlastislav Červený on the occasion of his seventieth birthday. The special issue No.2/**46** was distributed to the consortium members together with Report 12 (2002), and the special issue No.4/**46** was sent to the consortium members in January 2003. Ivan Pšenčík served as the guest editor of both issues.

Research **Report 13** contains mostly the papers related to seismic anisotropy (11 of 15 papers). Report 13 may be roughly divided into five parts, see the Contents.

The first part, **Seismic models and inversion techniques**, is devoted to various kinds of inverse problems, to the theory developed for application to their solution, and to the construction of velocity models suitable for ray tracing and for application of ray–based high–frequency asymptotic methods.

P. Bulant, in his paper on the construction of velocity models suitable for ray tracing, focuses on the detailed description of smoothing the SEG/EAGE Salt Model.

K. Žáček presents the approximate decomposition of the wavefield into Gabor wavelets of shape varying in dependence on spatial position, slowness vector, time and frequency. This decomposition represents a principal step in the algorithm of Gaussian–packet prestack depth migrations.

In the contribution by E. Gomez, I. Pšenčík & X. Zheng, inversion scheme for local determination of anisotropy from qP-wave VSP observations is studied on synthetic data. The effects of the choice of the wave normal and of the velocity in the reference isotropic medium are studied together with the effects of the number and orientation

of profiles. A special attention is devoted to the study of stability of the inverted parameters.

The last paper of this part, by E. Gomez, X. Zheng, I. Pšenčík, S. Horne & S. Leaney, is a considerably revised version of the paper presented in Report 12. This synthetic test, which mimics the Java Sea VSP experiment, helps to understand better the results of inversion of the real data. It is shown that parameters controlling prevailingly vertical propagation can be determined with a higher reliability than the remaining parameters. Important correlation among some parameters is revealed. The results seem to indicate that the axis of symmetry of the studied medium is not vertical.

The second part, **Ray methods in isotropic and anisotropic media**, is devoted to the high–frequency methods in general, but does not contain the papers more specifically addressing problems of weak anisotropy or of viscoelastic media, which have been postponed to the third and fourth parts.

In the first paper of this part, V. Vavryčuk studies conditions, under which triplications and cusp edges can occur in homogeneous transverse isotropy (TI). It is found that the strength of anisotropy must exceed a critical value. No TI medium with strength less than the critical can display triplications. The critical strength of anisotropy depends on the type of triplication.

In his second paper, V. Vavryčuk presents approximate formulas for a critical value of anisotropy parameter sigma, for which an incipient off-axis SV-wave triplication occurs in transversely isotropic media. The formulas are simple and approximate the exact solution with a high accuracy. The best results are obtained by the third-order approximation, which yields accuracy at least 20 times higher than the formulas presented by Thomsen & Dellinger (2003).

In the third paper of this part, L. Klimeš derives explicit equations for the perturbations and spatial derivatives of amplitude in isotropic and anisotropic media. The perturbations and spatial derivatives of the amplitude exponent can be calculated by numerical quadratures along an unperturbed ray in the reference medium, analogously as the perturbations and spatial derivatives of travel time.

The third part, **Weak anisotropy**, addresses the problems relevant to weakly anisotropic media.

In the first paper of this part, by L. Klimeš, the equations required for common S–wave ray tracing in a smooth elastic anisotropic medium, and for the corresponding dynamic ray tracing, are presented in a form suitable for numerical coding.

The paper by V. Farra & I. Pšenčík is a substantially revised version of the text, which appeared in Report 12. It contains some new results. Most of the attributes of seismic waves depend on the weak anisotropy (WA) matrix. The sensitivity of this matrix to the parameters of the medium is studied in detail. Another interesting result is the observation that although the first-order perturbation formulae for the phase velocity are common for both qS waves, in higher orders the qS waves are described separately.

The fourth part, **Anisotropic viscoelastic media**, is devoted to the problem of inhomogeneous plane waves propagating in homogeneous viscoelastic anisotropic media.

In the first paper of this part, by V. Červený, general algorithms to compute the complex-valued slowness vectors of plane waves are proposed, which can be used both

for homogeneous and inhomogeneous plane waves, propagating in elastic or viscoelastic, isotropic or anisotropic media.

In the second paper of this part, V. Červený & I. Pšenčík study numerically the complex-valued slowness vectors of qP, qSV and qSH inhomogeneous waves propagating in a plane of symmetry of a hexagonal anisotropic viscoelastic medium, using the algorithms proposed in the previous paper. They show that the inhomogeneous plane waves propagating in viscoelastic anisotropic medium exhibit certain phenomena, not known from viscoelastic isotropic and from elastic anisotropic media.

The third paper of this part, by V. Červený, is devoted to homogeneous plane waves, propagating in elastic or viscoelastic, isotropic or anisotropic media.

In the fourth paper, by V. Červený, two cases which allow analytical solutions for the slowness vector are studied. They apply to P and S waves propagating in viscoelastic isotropic media, and to qSH waves propagating in the plane of symmetry of a monoclinic anisotropic viscoelastic medium.

The final fifth part, **CD–ROM with SW3D software, data and papers**, contains the CD–R compact disk SW3D–CD–7, and the papers describing applications of the SW3D software contained on the compact disk.

In the first paper of this part, V. Bucha shows the application of the SW3D software to two–point ray tracing and to calculation of ray–theory seismograms in the SEG/EAGE Salt Model, smoothed by P. Bulant (the first paper of this report).

In the second paper, V. Bucha & P. Bulant demonstrate a new feature related to the initial conditions for ray tracing, recently coded according to suggestions by Matt Lamont.

Compact disk SW3D–CD–7, edited by V. Bucha & P. Bulant, contains the revised and updated versions of the software developed within the consortium research project, together with input data related to the papers published in the consortium research reports. A more detailed description can be found directly on the compact disk. Compact disk SW3D–CD–7 also contains over 170 complete papers from journals and previous reports, mostly in PostScript and GIF, few in PDF or HTML, refer to the copy of the Consortium WWW pages on the compact disk. V. Bucha scanned 18 papers published from 1983 to 1999 (total of 369 pages in 150 dpi and 369 pages in 300 dpi). The resulting GIF images are now available online from compact disk SW3D–CD–7, together with the GIF images of the papers from previous reports. For example, paper "Complete seismic–ray tracing in three–dimensional structures" by Červený, Klimeš & Pšenčík (In: Doornbos, D.J., ed.: Seismological Algorithms, pp. 89–168, Academic Press, New York, 1988), frequently referred in the ray tracing software, is now online available. SW3D–CD–7 contains new routines for anisotropic common S–wave ray tracing and dynamic ray tracing in models without structural interfaces according to suggestions by Peter Bakker, and new subroutine `coef52` by J. Brokešová & V. Červený for calculation of the displacement R/T coefficients of inhomogeneous P, SV and SH plane waves at a stack of homogeneous isotropic dissipative layers between two homogeneous isotropic dissipative halfspaces. Compact disk SW3D–CD–7 is included in Report 13 in two versions, as the UNIX disk and DOS disk. The versions differ just by the form of ASCII files.

This Introduction is followed by the list of members of the SW3D Consortium during the tenth year of the project. We have been very pleased to welcome a new consortium member, BHP Billiton Petroleum (Houston, U.S.A.; Perth, Australia). We hope BHP Billiton Petroleum will find the membership in our Consortium profitable.

The Research Programme for the current, tenth year of the Consortium project comes after the list of members. The Research Programme for the next year will be prepared after the discussion at the Consortium meeting, June 9–11, 2003. More detailed information regarding the SW3D Consortium Project is available online at "http://sw3d.mff.cuni.cz".

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