Introduction

Report 17 of the Consortium project "Seismic Waves in Complex 3–D Structures" (SW3D) summarizes the work done towards the end of the thirteenth year and during the fourteenth year of the project, in the period June, 2006 — May, 2007. It also includes the compact disk with updated and extended versions of computer programs distributed to the sponsors, with brief descriptions of the programs, and with the copy of the SW3D WWW pages containing papers from previous reports and also from journals.

Our group working within the project during the fourteenth year has consisted of six research workers Václav Bucha, Petr Bulant, Vlastislav Červený, Luděk Klimeš, Ivan Pšenčík Václav Vavryčuk, and of PhD student Peter Cigánik, who works on the algorithm for stochastic inversion of travel times.

Henrik Bernth, Paul Childs and Leo Eisner (Schlumberger Cambridge Research, United Kingdom), Naum Derzhi (Rock Solid Images, Houston, USA), Ellen de Nazare Souza Gomes (Universidade Federal de Para, Belem, Brazil), Einar Iversen (NORSAR, Kjeller, Norway) and Bjorn Ursin (Tech. University Trondheim, Norway) visited us during the period June, 2006 — May, 2007.

The first part of the proceedings of the workshop "Seismic waves in laterally inhomogeneous media VI", held at Hrubá Skála, Czech Republic in June 2005, appeared in No. 3 of the Studia Geophysica et Geodaetica, **50** (2006), and the second part appeared in No. 1 of the Studia Geophysica et Geodaetica, **51** (2007). The first part was sent to the Consortium members by mail, the second part will be distributed during the Consortium meeting, June 18–19, 2007, together with this Report 17.

Research **Report 17** contains mostly the papers related to seismic anisotropy (11 of 13 papers). Report 17 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 & L. Klimeš show how to calculate the "sonic–log" travel times in the geological structure from the sonic–log velocities while taking into account the effects of the non–vertical propagation of seismic waves due to the source offset and due to the heterogeneous velocity in the structure, together with the effects of the well trajectory differing from strictly vertical. These travel times serve for comparison of sonic logs with vertical seismic profiling.

L. Klimeš studies how the perturbations of a generally heterogeneous isotropic or anisotropic structure manifest themselves in the wavefield, and which perturbations can be detected within a limited aperture and a limited frequency band. Perturbations of elastic moduli and density are decomposed into Gabor functions. The wavefield scattered by the perturbations is then composed of waves scattered by individual Gabor functions. The paper is a revised version of the manuscript distributed during the Consortium meeting, June 19–20, 2006.

E.N.S. Gomes, I. Pšenčík & G. Ball study uncertainty in the local determination of anisotropy parameters determined from a walkaway VSP data. The analysis is performed assuming isotropy, transverse isotropy with a vertical symmetry axis, and general

anisotropy. In the latter case, the found anisotropy has finally been fit by transverse isotropy with an inclined axis of symmetry. With the present data, the uncertainty in the estimates of the anisotropy parameters seems to be large.

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 anisotropic viscoelastic media, which have been postponed to the third and fourth parts.

The contribution of E. Iversen & I. Pšenčík represents a generalization and extension of the procedure presented at the Consortium meeting, June 19–20, 2006, in which they proposed an efficient ray-tracing procedure for inhomogeneous anisotropic media of higher symmetry. A new formulation of the ray tracing is presented, and the procedure is extended to also include inhomogeneous dynamic ray tracing. Main advantages are improved efficiency, lower computer memory requirements, and conservation of anisotropic symmetry throughout the model.

V. Vavryčuk considers inhomogeneous plane waves which are defined as waves with an exponential decrease of amplitude along a plane wavefront, and are usually treated in ray theory as waves with complex–valued slowness and polarization vectors and complex–valued rays. He treats the inhomogeneous plane waves in real–valued ray theory, considering higher–order ray approximations. He demonstrates that the real–valued ray expansion of inhomogeneous waves consists of an infinite number of terms and may converge to an exact solution.

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

L. Klimeš proposes the coupling ray series, which yields the coupling ray theory in a similar way as the standard ray series yields the standard ray–theory solution of the elastodynamic equation.

In two contributions on the first–order P–wave and S–wave ray computations, I. Pšenčík & V. Farra and V. Farra & I. Pšenčík propose approximate first–order (in deviations of anisotropy from isotropy) equations for computing P– and S–wave ray synthetic wavefields. Formulae for P–waves represent an extension of the work presented at the Consortium meeting, June 27–29, 2005, towards the computation of the complete wavefield. In case of S waves, formulae for the first–order common S–wave ray and dynamic ray tracing as well as formulae for evaluation of coupling effects are presented.

The fourth part, **Anisotropic viscoelastic media**, is devoted to the problem of homogeneous and inhomogeneous waves propagating in anisotropic viscoelastic media, and to perturbation methods from perfectly elastic media to dissipative anisotropic media.

In the first paper of this part, by V. Červený and I. Pšenčík, weakly inhomogeneous plane waves propagating in weakly dissipative anisotropic media are discussed. The first–order perturbations are used to derive simple expressions for the propagation and attenuation vectors and for the polarization vectors. It is shown that the scalar product of the attenuation vector with the energy–velocity vector represents an intrinsic attenuation factor, which does not depend on the inhomogeneity of the plane wave under consideration. Actually, the intrinsic attenuation factor represents $1/Q$, where Q is the quality factor. The accuracy of the perturbation method is studied by comparison of approximate and exact results.

The second paper by V. Červený and I. Pšenčík is devoted to the quality factor Q for an anisotropic dissipative medium. Exact and approximate quality factors of homogeneous and inhomogeneous plane waves, propagating in generally anisotropic dissipative media, are derived from a classical definition of Buchen (1971). The approximate expression for $1/Q$ corresponds to the intrinsic attenuation factor, derived in the the first paper of this part. The same value of $1/Q$ is obtained no matter whether the considered wave is homogeneous or weakly inhomogeneous. Attenuation coefficients of the wave along different straight line profiles are also studied. To obtain the intrinsic attenuation factor $1/Q$, the profile parallel to the energy–velocity vector must be used. The results are generalized to waves generated by point sources and propagating in heterogeneous media. The computation of Q then requires a quadrature along the reference ray. In weakly dissipative anisotropic media, Q can be expressed in terms of weak–attenuation parameters.

In the third paper of this part, by V. Červený, L. Klimeš and I. Pšenčík, the attenuation vector of seismic body waves propagating in heterogeneous weakly dissipative anisotropic media is studied, using the travel–time perturbation theory by Klimeš (2002). The final expressions for the attenuation vector require simple quadratures along the reference ray, constructed in a relevant reference perfectly elastic anisotropic medium. The results are applicable to any type of seismic source, including a point source. It is shown that the waves in heterogeneous weakly dissipative anisotropic media are, in general, inhomogeneous. The exception are waves generated by a point source in a homogeneous isotropic medium, which are always homogeneous.

V. Vavryčuk generalizes exact and asymptotic Green functions for homogeneous anisotropic elastic media to be valid also in viscoelastic media. He numerically checks the formulae against closed–form solutions for isotropic and simple anisotropic viscoelastic models. He shows that the slowness vector corresponding to a stationary wave is generally complex–valued and inhomogeneous.

V. Vavryčuk then studies how the inhomogeneity of the stationary wave affects the asymptotic quantities of the wavefields generated by point sources, and how it complicates their computation. The critical quantities are attenuation and the Q–factor, which can significantly vary with the slowness vector inhomogeneity. When the inhomogeneity of the slowness vector is neglected, the errors in attenuation and the Q–factor can attain values commensurate to strength of velocity anisotropy, so up to tens per cent for sedimentary rocks.

The fifth and final part, **CD–ROM with SW3D software, data and papers**, contains the CD–R compact disk SW3D–CD–11.

Compact disk SW3D–CD–11, 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–11 also contains over 260 complete papers from journals and previous reports in PostScript, PDF, GIF or HTML, refer to the copy of the Consortium WWW pages on the compact disk. Compact disk SW3D–CD–11 is included in Report 17 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 fourteenth year of the project. We are very pleased to welcome a new Consortium member, Rock Solid Images (Houston, Texas, U.S.A.). We hope that Rock Solid Images will find the membership in our Consortium profitable.

The Research Programme for the current, fourteenth 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 18–19, 2007. More detailed information regarding the SW3D Consortium Project is available online at "http://sw3d.mff.cuni.cz".

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