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Seismic stratigraphy and tectonic features revealed by shallow continuous seismic reflection profiling, offshore Lithuania

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Only a few wells have penetrated the pre-Quaternary layers in the Lithuanian and adjacent offshore. Information on the distribution and lithological features of the pre-Quaternary units may be derived from shallow seismic profiles. In 1993–1999, joint Lithuanian–Swedish geological-geophysical expeditions have obtained new data on the geology of shallow parts of the bedrock (to 600 m deep) in the Baltic Proper. Continuous seismic reflection profiling data have revealed a very complicated reflector character in the southeastern part which is offshore Lithuania. Geological identification of the seismic units is based on comparisons with onshore geology and on available data from offshore wells. Tectonic features, glacial incisions, disturbances of seismic reflections of various origins, multiples due to shallow water make the interpretations of seismic profiles a delicate matter. The paper is focused on the geological identification of Late Palaeozoic and Mesozoic seismic units and their tectonic features.

Key words: the Baltic Sea, continuous seismic profiling, seismic unit, seismostratigraphy, tectonics

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INTRODUCTION

The Baltic Sea is situated in the western deepest part of the Baltic sedimentary basin. There are only scarce wells that penetrated the pre-Quaternary succession. On the other hand, a rather dense network of shallow seismic profiles was performed in recent years. In particular, continuous seismic reflection profiling was carried out during joint Lithuanian–Swedish expeditions in 1993–1995 and 1998–1999, aiming at recognition of the geological features of the upper part of the Palaeozoic and Mesozoic sedimentary bedrock in the eastern and south eastern parts of the Baltic Sea (Fig. 1).

The geological identification of the Late Palaeozoic and Mesozoic seismic sequences is problematic due to the lack of well material, complicated tectonics, and various disturbances of the seismic reflections. The geological identification of the Late Palaeozoic and Mesozoic seismic units is based on comparisons with the onshore geology, offshore wells and previously published data.

The structuring style of the upper part of the pre-Quaternary succession and its influence on the Quaternary complex and recent relief remains an object of discussions. The shallow offshore profiles provide an excellent possibility to look into this problem. The seismic profiles were collected during five expeditions with R/V *Vėjas* in 1993–1995 and R/V *Skagerak* in 1998–1999 (Fig. 1).

GEOLOGICAL SETTING OF LITHUANIAN OFFSHORE

The Lithuanian offshore area is situated in the central part of the Baltic sedimentary basin (Poprawa et al., 1999). The thickness of the sedimentary cover is in the range of 2–2.9 km. It is dominated by the Palaeozoic rocks comprising the Cambrian, Ordovician, Silurian and Devonian sediments that overly the crystalline basement of the Early pre-Cambrian consolidation. The present Baltic proper is confined to the central part of the Baltic sedimentary basin.

The Cambrian represents the base of the sedimentary pile and is as thick as 170–260 m. It is composed of a triple alternation of sandstones, siltstones and claystones overlain by a 70–130 m thick Ordovician shale and carbonate rocks turning into 750–1150 m thick Silurian graptolitic shales with subordinate carbonate rocks. The lithology of a 600–1050 m thick Devonian succession varies considerably. The Lower Devonian, upper Eifelian and Givetian comprise sandstones, siltstones, claystones, whereas the Eifelian, Frasnian and Famennian are dominated by marlstones, limestones and dolostones. A prominent unconformity which separates respectively the Caledonian and Variscan structural complexes is identified between the Lochkovian and Praghian Stages. The upper 50–450 m thick part of the Devonian succession was increasingly eroded southward during the Carboniferous – Early Permian uplift event.

The younger sediments of the Upper Permian, Lower Triassic, Jurassic, and Cretaceous age are distributed in most of the offshore area, except the northernmost part subject to intense faulting (wells E6-1, E7-1). They compose an Alpine structural complex unconformably overlying the Devonian succession. The thickness of the Permian reaches 125 m in the south. Evaporites predominate in the south, passing to a carbonate platform in the north. The thickness and stratigraphical completeness of the Mesozoic also increases to the south. The Lower Triassic red beds up to 280 m thick are overlain by Jurassic sediments up to 100 m thick (Grigelis, 1991). The Lower Triassic sediments are dominated by carbonaceous mudstones intercalating with subordinate sandstones and rare limestones. The Jurassic is represented by the Callovian and Oxfordian sandstones, clays and limestones. The Albian and Upper Cretaceous terrigenous /

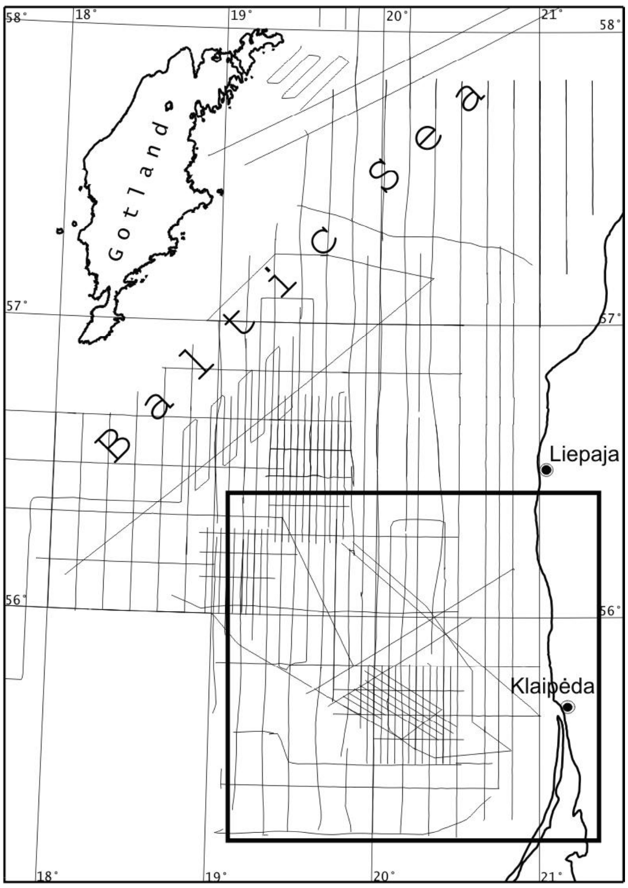

Fig. 1. Seismic reflection grid run during Lithuanian–Swedish surveys in 1993–1999. Solid square shows the study area

1 pav. Lietuvos ir Švedijos 1993–1999 m. ekspedicijos metu nustatytos seisminių profilių linijos

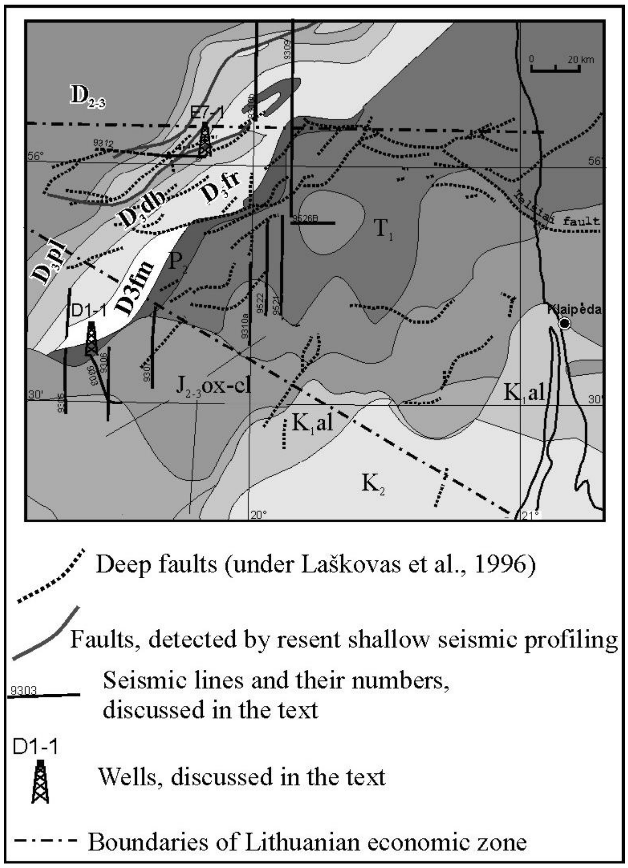

Fig. 2. Seismogeological map of sub-Quaternary surface of the southeastern Baltic Sea correlated with onshore pre-Quaternary geological map

2 pav. Su sausumos prekvartero geologiniu žemėlapiu koreliuotas Baltijos jūros prekvartero seismogeologinis žemėlapis carbonaceous succession up to 120 m thick has been mapped in the south-eastern half of the Lithuanian offshore. The sedimentary cover is crowned by glacial Quaternary deposits several dozens of meters thick.

In terms of the tectonic grain, two regions are defined (Šliaupa et al., 2004). The main structuring phase took place during the latest Silurian – earliest Devonian, relating to a far-field stress transmission from the Scandinavian Caledonides (Šliaupa, 1999; Šliaupa et al., 2000; Poprawa et al., 2006). Two dominating families of reverse faults oriented W–E (WSW–ENE) and SW–NE (SSW–NNE) have formed (Fig. 2). The fault amplitudes range within 50–500 m and they show compressional and and transpressional geometries. Scarce small-scale faults of NW–SW and WNW–ESE orientation are mapped in the offshore region, their amplitudes reaching 50 m. The age of this fault population is not clear. The faults oriented north–south and west–east controlled the igneous activity during the Carboniferous–earliest Permian times (Motuza et al., 1996; Šliaupa et al., 2001).

The northern and western parts of the offshore area are fragmented by SW–NE and W–E striking faults of the Liepaja–Saldus ridge formed during the late Caledonian stage as a transpressional feature. The amplitude of the ridge exceeds 600 m someplace. The bounding faults dip northward at an angle of 50–80°. The flower structures are typical of fault geometry, implying a strike-slip component. The faults of the Liepaja–Saldus ridge were amplified during the Late Palaeozoic (Šliaupa et. al., 2004).

MATERIALS AND METHODS

The analogical single channel sub-bottom profiler used for the present investigation was based on a PAR-600B airgun. A 20 m hydrophone eel containing 100 hydrophone elements (Flodén, 1981) received the reflected signals. The signals were filtered onboard the ship and two sets of recordings filtered 250–500 Hz, with one stacked four times and the other one unstacked, were displayed on precision graphic recorders. The unfiltered signals were furthermore recorded digitally on a PC-computer for subsequent computer processing. A Raytheon GPS navigator was used for positioning. The navigator was attached to a PC, and longitude / latitude positions in WGS-84 were stored as computer data files. The accuracy obtained for the positioning was approximately +/- 50 m. The seismic profiles were collected during five expeditions with R/V *Vėjas* in 1993–1995 and R/V *Skagerak* in 1998–1999 (Fig. 1).

In seismic reflection surveys, the travel time is measured by arrivals reflected from subsurface interfaces between media of different acoustic impedance, and sound velocity measurement in the layers is very important. The equation of the average velocity in n layers should be:

$$V = Z_n / T_n,$$

where Z_n is the total thickness of the top n layers and T_n is the total one-way travel time trough n layers.

Seismic velocities for the correlation of seismic profiles with the well core material were obtained from sonic logic measurements in wells E7-1 and D1-1 (Nasedkin, 1994).

The thickness Z_n (in meters) of the seismic layer n in the recent seismic profiles can be found by measuring the vertical scale of profiles in milliseconds by the following equation:

$$Z_n = V * T_p / 2000,$$

where V is the average sound velocity in a layer (m/s) and T_p is a two-way travel time (milliseconds) through the layer, recorded on a seismic profile.

SEISMOSTRATIGRAPHY

In the Lithuanian offshore area, the upper part of the sedimentary pile is composed of Devonian, Permian and Mesozoic carbonaceous and terrigenous seismic sequences (Grigelis, 1991) which are strongly affected by Pleistocene glacial activities which introduced abundant disturbances of the seismic reflections as well as frequent glacial structures and incisions (Flodén et al., 1997; Monkevičius, 1999). Gas and water discharges are indicated to occur at the seafloor (Blazhchishin, 1995). Hydrocarbon traps are possibly present in the upper parts of the seabed. Apart from the disturbances just mentioned, the shallow water in the eastern part of the area makes the seismic interpretation of the deeper reflectors impossible due to strong multiples.

The shallow seismic profiling has revealed that the Mesozoic sedimentary basin fill of the north eastern part of the Baltic basin is dissected by well-expressed unconformities that can be used to subdivide the sediment accumulations into mappable, genetically coherent units. Thus, the recorded reflections have been subdivided into seismic units. The identifcation of the Devonian seismic units was based on the characteristic seismic reflection signature, and some of them were tied to well data. The unit boundaries have been followed across a grid of intersecting seismic lines. The exposures of the seismic units were mapped on the pre-Quaternary surface (Fig. 2).

Devonian seismic units

The oldest Devonian sediments of the Lower Frasnian age sub-cropping under the Quaternary succession are identified in the northern part of the study area which was affected by intense fault tectonics in the Saldus–Liepāja Ridge. The E6-1 and E7-1 wells indicate a sub-cropping of the Pliavini and Dubniki Formations, respectively. The seismic profile #9312 was acquired close to well E7-1 which assures a reliable seismostratigraphical control (Fig. 3). The Dubniki Formation is characterized by distinctly layered reflection and is underlain by the less distinctly layered Pliavini Formation passing down into the Šventoji Formation of a rather massive structure. The Dubniki Formation is composed of alternating marlstones, gypsum and dolostones. The Pliavini Formation is dominated by dolostones with subordinate marlstone. It rests on a sandy succession of the Šventoji Formation containing clay layers. These lithological features explain the differences in the seismic signatures of the formations.

The seismic profiles acquired further east of well E7-1 (#9309, 9310) (Fig. 4) show a stratigraphically more complete section of Frasnian deposits. The Dubniki Formation is overlain by a thin-layered seismic unit attributed to the Pamūšis Formation composed of marlstones interlayed with sandstones and dolostones. The different resistance to erosion of Frasnian units is well expressed in the sub-Quaternary relief, the structural features of the dolomite-dominated layers controlling the sub-Quatenary relief and the related recent relief, whereas the marlstone-dominated units are rather evenly truncated (Fig. 4).

In the south-eastern part of the study area, the Frasnian sediments are overlain by Fammenian deposits that are stratigraphically rather complete as indicated by well D1-1 (Fig. 3). The quality of the profile #9303 which crosses the well is rather poor, therefore the adjacent seismic profiles were inspected for a more consistent seismostratigraphic subdivision of the Fammenian succession. Two parts have been identified, the upper showing a distinct thin-layered seismic reflection and the lower having a thicker layered reflection. Tentatively, the upper part is attributed to the Žagarė–Ketleri Formations and the lower portion is correlated with the Šiauliai–Švėtė Formations underlain by Kruoja dolostones well seen on the seismic profiles. The upper unit is composed of dolostones, limestones, sandstones and marls,

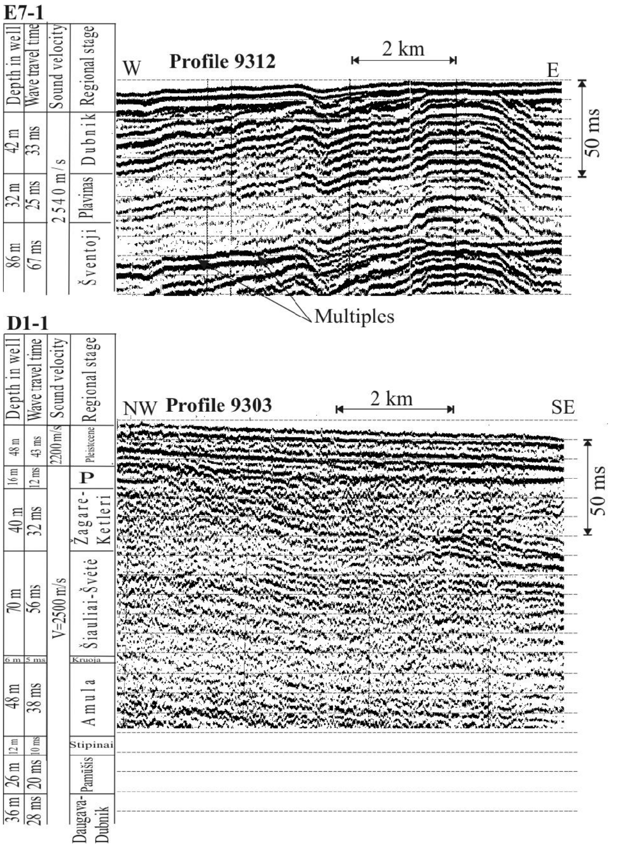

Fig. 3. Correlation of well data with seismic profiles
3 pav. Gręžinių koreliacija su seisminiais profiliais

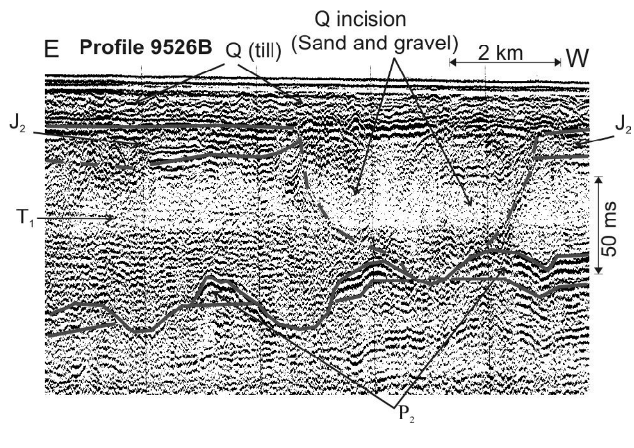

Fig. 5. Geological interpretation of seismic profile 9526B
5 pav. 9526B seisminio profilio geologinė interpretacija

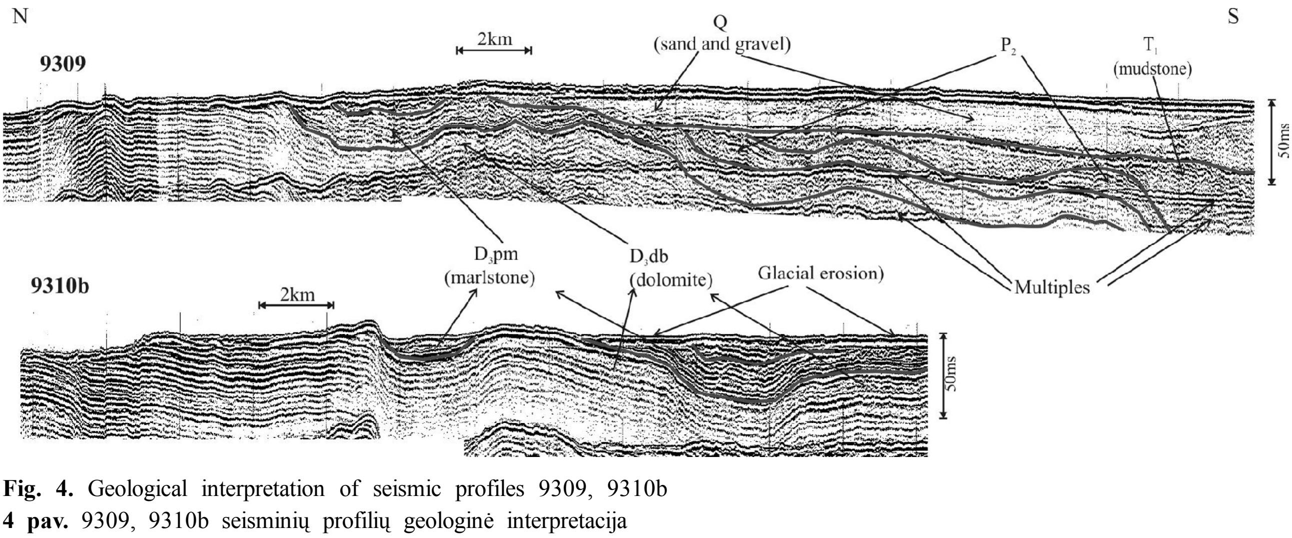

Fig. 4. Geological interpretation of seismic profiles 9309, 9310b
4 pav. 9309, 9310b seisminių profilių geologinė interpretacija

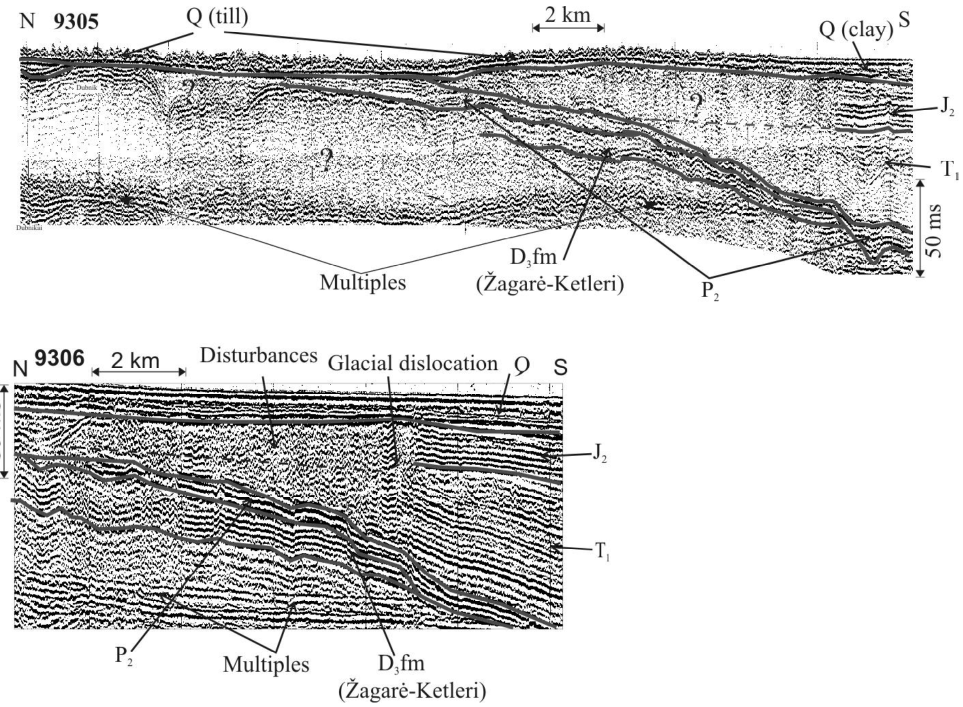

Fig. 6. Geological interpretation of seismic profiles 9305, 9306
6 pav. 9305, 9306 seisminių profilių geologinė interpretacija

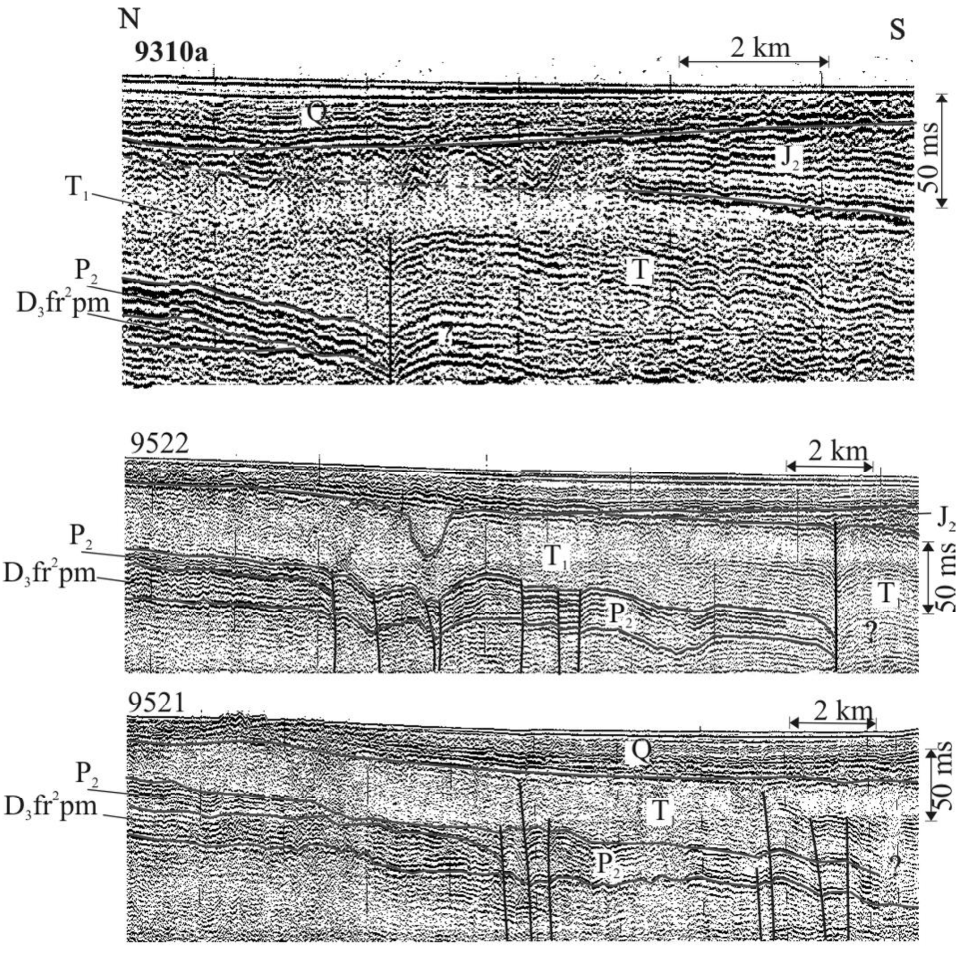

Fig. 7. Geological interpretation of seismic profiles 9310, 9522, 9521 with emphasis on tectonic features
7 pav. 9310, 9522, 9521 seisminių profilių geologinė interpretacija; pažymėti lūžiai

whereas the lower unit is represented by dolostones and limestones intercalating with marlstones and sandstones.

Permian seismic units

The sequence of Upper Permian Naujoji Akmenė Formation carbonate rocks is under question in the present study. The seismic unit P_2 is interpreted as dolostones and limestones in the northern part, with an expressed well parallel reflector seismic signature. The shape of the seismic signature drastically changes towards the south (Figs. 5, 7). In this part the Permian organogenic build-ups can be present, thus the velocity changes can distort the visual geological view of the seismic profiles. The unit is deeply eroded by palaeokarst in the eastern part of the study area (Fig. 5).

Triassic seismic units

The Lower Triassic mudstone succession is distributed in the central and southern parts of the study area. It is underlain by a strong reflector of the Upper Permian carbonate rocks. The Lower Triassic seismic unit can be subdivided into two subunits. The lower subunit is characterized by rather weak irregular reflectors. It is correlated with the Nemunas Formation dominated by mudstones that explain disordered seismic reflections. The upper subunit shows a more distinct layered reflection, essentially in the south. It is attributed to the Palanga Formation.

In the northern part, the reflections become disrupted and merge with the lower subunit to form a single unit T which is intensely intersected by glacial incisions and has no regular internal reflectors. In some places the border of the disrupting reflector correlates with tectonic features (Fig. 7). Sub-Quaternary incisions somewhere cross the whole Triassic succession and reach the Permian carbonate layers (Figs. 4, 5).

Jurassic seismic units

The Jurassic succession is represented by Middle Jurassic Callovian (Papartinė and Skinija Formations) and Upper Jurassic Oxfordian (Ąžuolija Formation) sediments that mark the maximum transgression of the Jurassic marine basin in the Baltic region. They are distributed in the southernmost part of the study area. The Jurassic succession is composed by alternating sands, silts, clays, marls and limestones. This lithological layering is well expressed in the seismic profiles showing a well defined layered seismic reflection. It is therefore easily distinguishable from the underlying Triassic terrigenous showing a massive reflection (Figs. 5–7). In some profiles (e. g., #9306) a distinct unconformity is reported between the Jurassic and the Triassic. The Jurassic succession is subdivided into four seismic units.

Cretaceous seismic units

The Cretaceous succession was subdivided into two seismic units. Unit 1 is tentatively interpreted to represent Albian Lower Cretaceous glauconitic sands and silts. Unit 2 is attributed to Upper Cretaceous marls, chalks, sandstones and sands. Reflectors within the units are of a complicated oblique character.

Quaternary seismic unit

The uppermost seismic unit of the Quaternary is interpreted as Pleistocene glacial sand, gravel, clay and till. Clay is characterized by parallel layered reflectors, till shows chaotic reflectors with a rough surface, sand and gravel are identified by a clear reflector character. If gravel dominates, it absorbs the seismic energy and disturbs the underlying reflectors. In the deeper parts of the Baltic Sea (e. g., Gdansk Basin), glacial deposits are overlain by Holocene mud.

TECTONIC FEATURES

The study area is situated in the central part of the Baltic basin which was affected by fault activity at different stages of the basin development. The major faults are well identified on the seismic profiles acquired during oil and gas exploration in the Baltic Sea area (Šliaupa et. al., 2004). However, the shallow seismic profiles provide a better resolution of small-scale tectonic features and therefore may contribute significantly to the understanding of the tectonic history of the region.

The most abundant faults were identified in the northern part of the study area affected by the Saldus–Liepaja Ridge and in the central part which is confined to the axial part of the Baltic basin. In the latter area, small-scale faults predominate (Fig. 7), their amplitudes not exceeding 10 m. The faults show high angle geometries that make the cinematic interpretation rather difficult. Nevertheless some faults show quite clear features of a compression regime (e. g., the southern part of the profile #9621). The faults dissect the Devonian, Permian, and Triassic successions. Their amplitudes do not change upwards along the particular faults, implying the post-Triassic age of the faulting. Where the layering is distinct in the Triassic seismic unit the faults are well traced across the Triassic succession. In case of a massive seismic fabric, the characteristic disturbances are identified above the faults that evidence development of fractured zones in the Triassic shale (e. g., the central part of the seismic profile #9522). There is no good control as regards the fault tectonic impact on the Jurassic succession. Some scarce evidences seem to be in favour of the faults affecting the Jurassic which accordingly implies the fault activity during younger (post-Jurassic) periods.

Typically, faults make clusters of 3–5 faults spaced at about 1 km. The layers are flexed close to the faults that can be interpreted as the initial flexuring stage before the fault formation. Alternatively, it can indicate the fault drag mechanism.

Some faults show inversion features which are very spectacular on the profile #9307 (Fig. 8) where the fault crosses the Devonian, Permian, and Jurassic sediments. The uplifted northern flank indicates a stratigraphically

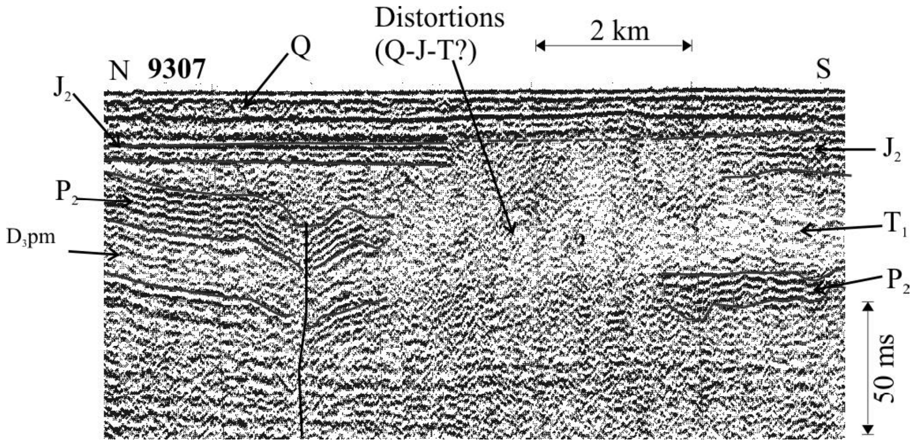

Fig. 8. Geological interpretation of seismic profile 9307
8 pav. 9307 seisminio profilio geologinė interpretacija

more complete upper part of the Devonian succession implying dawn thrust, whereas the Permian–Jurassic succession points to the uplifting of the northern block. This kind of tectonic features is well identified in West Lithuania (J. Bitinas, 2000 – unpublished mapping report of the Šilutė area).

The seismic reflection characteristics often drastically change across the larger-scale faults (e. g., profiles #9306, 9310a), the opposing flanks showing respectively massive and layered seismic features. It can hardly be related to the lithofacies changes of the pre-Quaternary layers. More likely it reflects lithology changes in the overlying Quaternary and Holocene sediments that have a considerable influence on the seismic reflection features of the underlying layers. If so, an impact of the fault tectonics on glacial and postglacial sedimentation should be assumed. This relationship was well documented in Central Lithuania (Baltrūnas et al., 2005). Some shallow seismic profiles seem to corroborate this correlation. For instance, the profile #9310a indicates different seismic reflection characteristics of Quaternary sediments to the south and north of the pre-Quaternary fault, which show respectively massive and layered reflections (Fig. 7). The fault identified in profile #9306 affects the shape of the base of the Quaternary succession (Fig. 5). On the other hand, it seems unaccountable that seismic reflection disturbances are indicated only in the clayey Mesozoic layers, and the underlying reflectors from carbonate layers don't change their shape, therefore it can indicate disruptions within the formations (Monkevičius, 1999). The loss of reflection occurs on the relatively uplifted blocks (Fig. 6). It is therefore very likely that they are induced by glaciotectonic activity, as identified by palaeomagnetic studies of Triassic mudstones in North Lithuania (Katinas, 2001). The other distortions (Fig. 8) may be related to gas escape.

In the north of the study area, the tectonic structures indicate much larger amplitudes related to activity of the Saldus–Liepaja zone. The offset of the Devonian layers along some faults exceeds 50 m (e. g., profile #9310b, Fig. 5). The faults have a considerable effect on the recent relief, causing formation of morphological features as high as 10–15 m (e. g., scarps). Most likely they are related to selective erosion. Besides the fault tectonics, the flexuring of the Devonian layers is common in the north, similarly to the structures mapped onshore (e. g., detailed mapping of the Biržai area in North Lithuania). These features also influence the recent relief by accommodating lithologies of different resistance to erosion. Some flexures exceed 50 m in amplitude. The wavelength of those high-amplitude features is of the order 2–3 km.

CONCLUSIONS

The seismic units under analysis are well correlated with the major lithological units of the upper part of the pre-Quaternary succession. The oldest sub-cropping layers in the northern part of the Lithuanian offshore are attributed to the Frasnian Stage of the Upper Devonian. Four major units have been identified, which are correlated with the Šventoji, Pliavini, Dubniki and Pamūšis Formations. They show different seismic reflection features related to a specific lithological composition of each formation. The sandy Šventoji Formation is characterized by a massive seismic reflection. The overlaying Pliavini and essentially the Dubniki Formations show a distinct layering, the lower unit being related to the dominating dolomites and the upper unit reflecting an alternating sequence of carbonate rocks, shale and gypsum. The Pamūšis Formation is distinctive by its thin-layered seismic fabric and is therefore easily recognized on the seismic profiles.

In the south, the upper part of the Devonian succession is sratigraphically more complete. The Fammenian Stage is characterized by a distinct layered seismic reflection, mostly its upper part related to intercalation of the terrigenous and carbonaceous lithologies, whereas the lower portion is composed of marl and carbonaceous rocks.

The Permian carbonate rocks show a distinct unconformity with the underlying Devonian succession. They dip southwards at a higher angle than the Devonian layers, implying a regional-scale inversion of the vertical tectonic movements. The Permian seismic unit is well identified by a strong reflection marking a significant change in the seismic impedance from Permian dolostones and limestones to the Lower Triassic mudstones. The mudstones show an either massive or indistinct layered seismic reflection. The latter is more distinct in the Palanga Formation. Furthermore, the type of the reflection depends on the composition of the overlying Quaternary succession, showing in some places the fault control. The layered fabric of the Triassic unit is related to the presence of sandstone interlayers and a cyclic distribution of the silt admixture in the mudstones.

The Jurassic sediments have a distinct seismic layering caused by the alternation of sands, silts, marls, clays, limestones. In some profiles, a clear unconformity with the Triassic succession was identified.

The shallow seismic profiles reveal a rather dense network of small-scale faults in the Upper Palaeozoic and Mesozoic sediments. These faults show amplitudes less than 10 m. Those features are traced across the Devonian–Permian–Jurassic successions and therefore are dated as post-Jurassic. It is important that faults are well traceable in the Triassic mudstones. These mudstones represent an important aquitard and are considered as a prospective formation for the deep geological disposal of radioactive waists in Lithuania (Čyžienė et al., 2005). Data collected from the Baltic Sea indicate that this formation can be considerably damaged along the fault zones. The available seismic data are not conclusive concerning the kinematic features of the faults, though some evidences seem to be in favour of a compression tectonic regime. In many cases small-scale faults compose clusters (swarms) 3–5 km wide.

In the north, the structuring style is different and is related to the activity of the Saldus–Liepaja Ridge. Furthermore, the Mesozoic succession is missing. The amplitudes of the identified faults exceed 50 m. The tectonic regime remains unclear. Also, flexures and related structures with amplitudes up to 50 m have been recognized.

The pre-Quaternary structures exert an important impact on the sub-Quaternary surface and the recent relief. It is likely that they acted as passive forms that influenced erosion processes during the Quaternary time.

ACKNOWLEDGEMENTS

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LIETUVOS ŠELFO SEISMOSTRATIGRAFIJA IR TEKTONIKA SEKLIŲJŲ SEISMINIO ATSPINDŽIO TYRIMŲ DUOMENIMIS

S a n t r a u k a

Lietuvos šelfe ir gretimose teritorijose išgręžta tik keletas gręžinių. Prekvartero geologinių sluoksnių paplitimas ir jų geologiniai ypatumai gali būti identifikuoti pagal sekliųjų seisminių tyrimų duomenis. 1993–1999 m. atlikta Lietuvos ir Švedijos geologinė-geofizinė ekspedicija suteikė daug naujos informacijos apie Baltijos jūros prekvartero sluoksnius (seklioje dalyje iki 600 m gylio). Seisminių bangų atspindžio tyrimais nustatytos labai sudėtingos atspindžio charakteristikos Lietuvos šelfe. Geologiniai sluoksniai išskirti remiantis koreliacija su gretimos sausumos gręžinių duomenimis, taip pat keliais jūriniais gręžiniais. Sudėtinga tektoninė sandara, ledyniniai įrėžiai, įvairios prigimties seisminiai trukdžiai, seklios jūros dugno seisminiai pasikartojimai (atspindėjimai) labai apsunkina seisminės informacijos interpretaciją. Straipsnyje analizuojami mezozojaus ir viršutinio paleozojaus sluoksnių geologiniai ir tektoniniai ypatumai.

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СЕЙСМОСТРАТИГРАФИЯ И ТЕКТОНИКА ШЕЛЬФА БАЛТИЙСКОГО МОРЯ ЛИТОВСКОГО СЕКТОРА ПО ДАННЫМ ПОВЕРХНОСТНЫХ СЕЙСМИЧЕСКИХ ИССЛЕДОВАНИЙ МЕТОДОМ ОТРАЖЕНИЯ

Р е з ю м е

На шельфе Балтийского моря Литовского сектора и на прибрежных территориях пробурено лишь несколько скважин. Распределение дочетвертичных геологических отложений и их геологические особенности можно идентифицировать по данным наземных сейсмических исследований. Осуществленная в 1993–1999 гг. литовско-шведская геолого-геофизическая экспедиция предоставила много новой информации о дочетвертичных отложениях Бал-тийского моря (в наземной части до глубины 600 м). Исследования сейсмических волн отражения выявили очень сложные характеристики этих волн в шельфе Балтийского моря Литовского сектора. Выделение геологических слоев обосновано корреляцией с ближайшими данными наземного бурения, а также с данными бурения нескольких морских скважин. Сложное тектоническое строение, ледниковые врезы, различная природа сейсмических шумов, многократные отражения от дна мелкого моря значительно осложняют интерпретацию сейсмических исследований. Рассмотрены геологические и тектонические особенности отложений мезозоя и верхнего палеозоя.