Introduction

The conception of the East Arctic shelf geological structure is currently based on the results of geophysical surveys and extrapolation of geological data from the adjacent land. However, the weak and uneven exploration maturity, combined with the absence of mapping wells within the shelf, greatly complicates the solution of the geological structure problems of the region which leads to their polemic nature. One of these problems is the nature of the consolidated basement and accordingly the stratigraphic model of the sedimentary cover. Currently, there are several points of view on the stratigraphic range of the sedimentary cover within the Laptev Sea shelf [Drachev et al., 2010; Franke et al., 2001; Khoroshilova et al., 2014; Kim et al., 2011; Kirillova-Pokrovskaya, 2017; Sekretov, 1993]. The use of the latest seismic data and drilling results should contribute solving the problem of the sedimentary cover stratification.

The idea of this study is to transfer the correlation from wells Syndasskaya-1, Ilinskaya-13 and Gurimisskaya-2 located in the immediate vicinity of the MCS lines on the South-West coast of the Laptev Sea to the MCS line A-7, the sedimentary section of which is correlated with the drilling results on the Lomonosov Ridge (ACEX project). The correlation control is performed by attracting geological data of the Taimyr, which the segment of the correlation profile is located by.

Method

We have constructed a continuous correlation profile ADE (Fig. 1). On this profile the seismic complexes of the sedimentary cover are linked to the lithological-stratigraphic complexes drilled by wells on the South-West coast of the Laptev Sea and on the Lomonosov Ridge. The traced seismic complexes correspond to the following geological formations:

Figure 1 The position of the discussed correlation profiles. Pink circles – wells; blue lines – MCS lines; red lines – composite profiles discussed in this paper. Bathymetric basis – IBCAO v. 3.
Eocene-Quaternary terrigenous post-rift on a deformed Late Proterozoic-Mesozoic base (seismic horizons K1-K5 [Kirillova-Pokrovskaya, 2017]);

Cretaceous-Paleocene terrigenous sin-rift on a deformed Late Proterozoic-Mesozoic base (seismic horizons A-K1 [Kirillova-Pokrovskaya, 2017]);

Mesozoic terrigenous of the Siberian craton (seismic horizons P2vk-J);

Permian-Early Triassic volcanogenic-terrigenous of the Siberian craton (seismic horizons C1?-P2vk);

Middle Paleozoic terrigenous-carbonate Siberian craton (seismic horizons Є2?-C1?);

Late Proterozoic-Cambrian carbonate of the Siberian craton (seismic horizons PR3?–Є2?).

MCS time sections were interpreted. The velocity model of the geological section developed at the SSC FSUGE “Yuzhmorgeologiya” [Prokoptseva et al., 2014] was used for converting deep sections of wells into time ones. This model is based on the analysis and comparison of synthetic traveltime curves obtained from VSP data for a number of deep wells in the study region. The interpretation was performed by detailed analysis of the seismic field wave structure and by transferring geological mapping data of the adjacent land to the section.

Seismic horizons P1t, P2vk, T2, T3, J corresponding to lithological and stratigraphic complexes crossed by the wells Syndasskaya-1, Ilinskaya-13 and Gurimisskaya-2 were traced from the southwestern coast of the Laptev Sea. Three seismic horizons that were not crossed by wells were traced in the lower part of the section, they were identified conditionally: C1?, Є2? and PR3?. Indexes corresponding to the age of underlying seismic complexes are assigned due to the lack of a single nomenclature seismic horizon of the studied region.

Results

The interpretation shows that on the segment 240803-240802-240805 of the composite profile AD (Fig. 2) the seismic horizons from PR3? up to J lie sub-horizontally repeat the irregularities of the basement. However, on the PT1133-SWL1301 segment the Late Proterozoic-Mesozoic cover of the Siberian craton is deformed into folds and overlain by younger sediments with angular unconformity and a pronounced erosion surface. The erosion surface is marked with a multiphase high-amplitude reflectors the intensity of which decreases with increasing depth, but this reflectors are still clearly visible in the seismic wave field. Deformed Late Proterozoic-Mesozoic complexes are well identified under the erosion surface for 90 km and only partially are traced further (Fig. 2). Thus, the multiphase reflectors acquire the character of an acoustic (in the geological sense – consolidated) basement and are identified further on the composite profile in this form.

The sedimentary layers lying above the erosion surface (acoustic basement) were interpreted using the seismostratigraphic model of the Laptev Sea Shelf discussed in the study [Kirillova-Pokrovskaya, 2017]. We traced 5 reference seismic horizons of Apt-Cenozoic age: A, K1, K2, K3, K5. The stratigraphic reference of these horizons is based on eustatic fluctuations in sea level associated with major pliotectonic and climatic events in the history of the Arctic. Seismic complexes bounded by traced horizons are characterized by well-identifiable differences in the structure of the wave field: the width and amplitude of the phases, the length and parallelism of the synphase axes, the presence of zones with transparent recording, and the multiphase reflection at the boundaries of the complexes.

The correlation of seismic horizons from the Laptev Sea Shelf to the line A-7 was carried out through the closure region of the Eurasian Basin. This allowed us to solve the problem of wedging the sedimentary cover in the Eastern part of the Laptev Sea, which occurs when using a network of seismic lines on the Shelf (for example, MCS lines A-4 and 90800).

The structure of the sedimentary cover and acoustic basement on both sides of the Eurasian Basin is complicated by normal faults (Fig. 2). They form semi-grabens that are characterized the rift type continental margins. The fullness of the stratigraphic range of traceable Apt-Cenozoic seismic complexes decreases when moving from the Shelf edge to the rift valley of the Gakkel Ridge.
Figure 2 MCS time section along the composite profile ADE with interpretation.

The performed interpretation illustrates the fact that the number of seismic horizons and their position on the seismic profile A-7 (interpreted with reference to the well ACEX-302 [Poselov et al., 2016]) coincided with the horizons transmitted from the Laptev Sea Shelf via the correlation profile ADE. We note a significant increase in the thickness of all seismic complexes within the Shelf part of the profile A-7 compared to its deep-water part located within the Lomonosov Ridge (Fig. 3). We also observe the occurrence of Miocene seismic horizon (Mi) during the transition from the Lomonosov Ridge to the Shelf.

In our opinion, these differences are caused with hiatus from ~44 to ~18 Ma recorded on the Lomonosov Ridge [Backman et al., 2006]. At this time, continental rifting associated with the formation of the Eurasian Basin continued within the Laptev Shelf, and sedimentation continued without such a significant break. In addition, the Shelf is located closer to the sources of sedimentary material than the adjacent part of the Lomonosov Ridge.

Figure 3 MCS time section along the composite profile A-7 with interpretation.
Conclusions

Late Proterozoic-Mesozoic sedimentary complexes of the Siberian craton are folded deformed in the area of Late Cimmerian orogeny. Deformed complexes with angular unconformity over the erosion surface are overlain by Apt-Cenozoic deposits. An erosion surface is an acoustic basement (geologically – a top of consolidated crust).

Correlation of seismic horizons traced from the Laptev sea shelf and highlighted on the profile A-7 based on the results of correlation with the well ACEX-302 demonstrates their correspondence to each other. During the transition from the Lomonosov Ridge to the Shelf the thickness of all seismic complexes significantly increases and the Mi seismic horizon appearances.

References


