Introduction

For the Russian extended continental shelf project, regional seismic data - 2D MCS (multichannel seismic) and wide-angle reflection/refraction seismic sonobuoy soundings were obtained in the Arctic Ocean in 2011, 2012 and 2014 years.

All obtained data has been processed according to the technique developed by the specialists of the Russian Research Institute FGBI “VNIIOkeangeologia”. This technique consists of several stages of joint processing of multichannel seismic (MCS) and wide-angle reflection/refraction data and its interpretation. This approach representing an analysis of two datasets allowed to reveal characteristic seismic features of the acoustic basement of the Central Arctic region.

Seismic attributes of the acoustic basement

Arctic offshore survey depended on ice conditions. Part of MCS work with 4500 m length streamer was made on ice-free water without using sonobuoys. At the area with a hard ice conditions two methods were used - MCS with short streamer (600 m) and wide-angle reflection/refraction seismic sonobuoys (Piskarev A.L., 2018). The experience of combining these types of work was also used by other researchers (Geissler W.H., 2004; Brullov V., 2012). About 150 sonobuoys soundings were completed at 2011, 2012 and 2014 years (Figure 1). Soundings were accomplished as an inverse flank observation system with common receiver point. The interval between sonobuoy soundings was about 50 km.

Combining MCS data and sonobuoys data, reflection and refraction seismic data allowed to construct a reliable velocity model (Butsenko V.V., 2018) and to reveal seismic attributes of the basement in the Central Arctic region.

Figure 1: The regional 2D seismic reflection (MCS) and sonobuoy data in Central Arctic obtained in 2011, 2012 and 2014 years.
Ray-tracing modelling of wide-angle refraction/reflection sonobuoy data was done during processing. Depth MCS sections with major interpreted reflectors were used to specify the boundary geometry on initial velocity models in the Seiswide software.

A typical sonobuoy seismogram is shown in reduction 6 km/s on the Figure 2 (a), and a fragment of MCS section in a sonobuoy drop point is shown on the Figure 2 (b). The seismogram may be divided into near-field and far-field zones (Butsenko V.V., 2018). Near-field zone is a zone of reflected waves in the top right which corresponds with reflectors in sedimentary cover on MCS data (e.g. PsedP, PinnP). And in far-field zone at least two refracted waves may be traced with different velocities. First one, PINM, is a P-wave refracted in the complex which represents a base of stratified sediments on MCS data. We interpret it as an intermediate complex between sediment cover and crystalline basement, and it may be identified throughout all the Arctic Ocean. The refraction wave in the crystalline basement (P_b) is traced as intense low-frequency P-wave and its velocity varies in different parts of the Arctic Ocean.

![Figure 2 Seismogram of sounding with computed traveltime curves made by ray-tracing modelling (reduction 6.0 km/s).](image)

The velocities in the intermediate complex in the Central Arctic vary over a wide range - from 4.2 to 5.3 km/s, so that any regularity is hardly seen.

Another interesting feature was discovered on sonobuoy records in central part of Podvodnikov Basin, is a presence of waves with apparent velocity of about 3.5 km/s (Figure 3) in a far-field zone. The waves were interpreted as converted (PSP). In particular, the record shows an intense PS_P converted wave refracted in the crystalline basement as a vertically polarized shear wave (SV-wave). It has a velocity of 3.5 km/s, which gives a V_P/V_S = 1.71, a ratio typical for the upper continental crust.

As one of the results of joint data processing and interpretation of MCS data and wide-angle reflection/refraction seismic sonobuoys data are P-waves interval velocities in the crystalline basement (Butsenko V.V., 2018). A scheme of wide-angle soundings carried out in the Central Arctic region with indication boundary velocities in the crystalline basement determined from refracted P_b waves is shown on the Figure 4. In Central Arctic Basin velocities vary from 5.7 to 6.3 km/s which is typical for upper continental crust while in Amundsen Basin (part of Eurasian Basin) velocities exceed 6.8 km/s which is typical for oceanic layer 3 (oceanic crust).
Figure 3 Seismogram of sounding with computed travelt ime curves made by ray-tracing modelling (reduction 3.5 km/s).

Figure 4 The scheme of wide-angle reflection/refraction soundings in the Central Arctic region with P-waves interval velocities (km/s) in the crystalline basement.

Conclusions

1. Integrated processing and interpretation of sonobuoy and multichannel seismic CDP data is carried out to receive a reliable result.
2. An intermediate complex (INM) is clearly identified throughout all parts of the Arctic Ocean with p-wave interval velocities 4.2-5.3 km/s. The top of this complex is represented by acoustic basement on MCS CDP data.

3. MCS data shows clear difference in structure of INM in oceanic Eurasian Basin and continental Podvodnikov Basin.

4. Continental type of crust in Podvodnikov Basin is also supported by Vp/Vs ratio of 1.71 which derived from velocities of converted PSP waves of 3.5 km/s.

5. P-wave velocities in crystalline basement in the Podvodnikov Basin vary from 5.9 to 6.2 km/s, that is typically for the upper continental crust. P-wave velocities in crystalline basement in the Amundsen Basin vary from 6.8 – 7.2 km/s, that are characteristic of oceanic layer III.

References


