KS-1 WELL SECTION (*Khatanga Bay coast, Laptev Sea*): A UNIQUE ARCHIVE OF LATE PALEOZOIC AND MESOZOIC CLIMATE OSCILLATIONS IN NORTHERN SIBERIA INFERRED FROM GLENDONITE OCCURRENCES

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We present data on the finds of glendonites (pseudomorphs after cold-water ikaite) in Permian, Jurassic, and Lower Cretaceous sedimentary rocks according to the drilling results of KS-1 well, located on the coast of the Laptev Sea. This is the only section in the world that contains both Paleozoic and Mesozoic glendonites corresponding to three geological systems. We have found glendonites at all previously known stratigraphic levels in northern Siberia, excluding intervals with relatively rare glendonite finds (Oxfordian, Ryazanian, and Valanginian stages). The most numerous, diverse, and large glendonites are recognized in the Middle Jurassic interval of the section (Bajocian–Callovian). The KS-1 well section is a unique natural archive that reflects significant late Paleozoic–Mesozoic events of cooling in the region under study.

Glendonite, Permian, Jurassic, Cretaceous, climatic fluctuations, paleogeography, Arctic

INTRODUCTION

Glendonites are calcite pseudomorphs after ikaite (a metastable cold-water mineral) that occure primarily in the lower Proterozoic–Holocene marine sediments [Rogov et al., 2021, 2023]. Their finds indicate a low-temperature environment, since ikaite is unstable in nature at temperatures above 7°C. There are other models for ikaite crystallization at significantly higher temperatures according to the specific physicochemical conditions at the near-bottom layer [Teichert and Luppold, 2013; Tollefsen et al., 2020]. However, traditional concepts that consider the crystallization of ikaite at low temperatures are currently consistent with geological data and the distribution of ikaite on the seabed. In Siberia, glendonites are widespread in Jurassic and Lower Cretaceous rocks [Kaplan, 1978, 1980; Rogov et al., 2019]. In this region, rare glendonite finds correspond to Permian and Quaternary rocks. Their spatial distribution is complex. While some stratigraphic horizons containing glendonites extend over tens and hundreds of kilometers, these pseudomorphs can be found in individual parts of the section and rapidly disappear in the lateral direction [Rogov et al., 2023]. Previous studies in Siberia revealed glendonite occurrences at several discrete stratigraphic levels in the Yenisei–Khatanga regional trough and its eastern framing. The sections under consideration (from west to east) are associated with the recently drilled Novoyakimovskaya well (Ust'-Yenisei district) [Rogov et al., 2024a, 2025], the AKh-3 well (eastern Taimyr) [Devyatov and Nikitenko, 2023], Bolshoi Begichev Island, the Yuryung-Tumus Peninsula, and Anabar Bay [Nikitenko et al., 2013; Nekhaev et al., 2015]. In this paper, we describe new glendonite finds from the unique

KS-1 well, drilled in 2017 by Rosneft Oil Company on the coast of the Khatanga Bay in the Laptev Sea (Khara-Tumus Peninsula). This section is the only one in the region that contains a virtually complete stratigraphic sequence of glendonite finds known in Siberia in the Permian–Lower Cretaceous interval.

GEOLOGICAL STRUCTURE. MATERIALS AND METHODS

The study region is located within the junction of the Taimyr fold belt with the Yenisei–Khatanga trough, the Anabar–Khatanga saddle, and the northeastern margin of the Siberian Platform (Fig. 1). Permian and Mesozoic strata contain marine terrigenous and, to a lesser extent (primarily in the basal part of the Triassic), volcanic or volcanic-sedimentary rocks. The total thickness of Permian–Cretaceous strata reaches 4–5 km in the region [Kontorovich et al., 2019]. Here, we present the results of core studies (lithological description and samples of faunal remains and glendonites) of the well KS-1, which penetrated a section from the upper Permian to the upper Lower Cretaceous stratigraphic units. The well section is characterized by complete core recovery in the range of 0 to 2003.1 m. The studied interval includes Permian, Triassic, Jurassic, and Cretaceous terrigenous rocks (Fig. 2).

The Permian section is represented by the Upper Kozhevnikov Formation (1750–2003.1 m) [Saks, 1981] and corresponds to the upper Biarmian and Tatarian series (Guadalupian and Lopingian series in the International Chronostratigraphic Chart, respectively). Permian rocks have a thickness of about 250 m and include sandstone, siltstone, and mudstone with plant detritus and pyrite nodules. There are signs of synsedimentary deformations in sandstone and siltstone, including intraformational breccia. Permian sedimentation occurred in coastal and shallow-sea environments with active influx of sedimentary material by rivers from the continent [Kalinko, 1959; Gerke, 1961; Gramberg, 1967]. Macrofauna remains are rare in Permian rocks; in most cases, they are represented by bivalves of poor preservation. Palynomorphs and foraminiferal assemblages confirm the age of this interval [Popov et al., 2023].

Triassic marine and lagoonal rocks [Kalinko, 1959; Gerke, 1961; Gramberg, 1967] (with tuffaceous sandstone interlayers in the basal part) with a thickness of about 300 m overlie Permian strata with a stratigraphic hiatus. They are composed of mudstone, siltstone, and sandstone with interlayers of conglomerate. There are no Lower and probably lower Middle Triassic rocks in the section. The Triassic strata include the Ust'-Anabar, Gurimiskai, Osipa, and Chaidakh formations. The analysis of palyno-

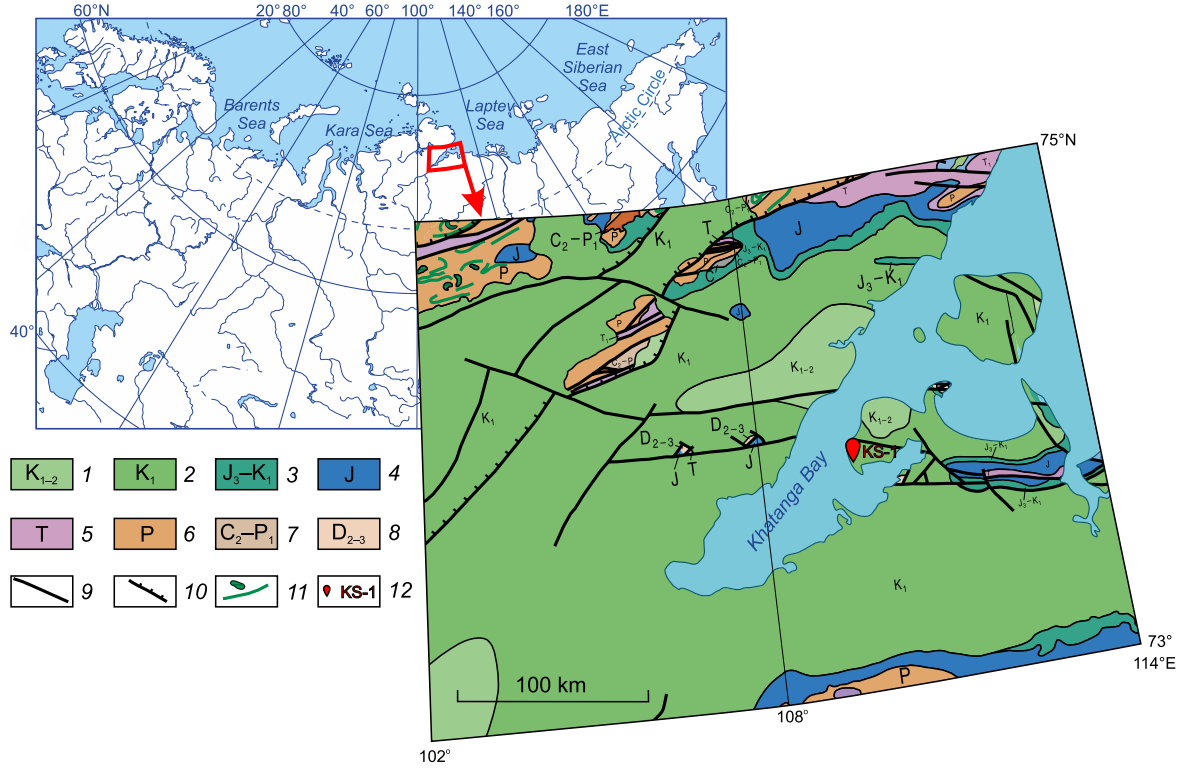


Fig. 1. Geological map of the region under study and location of well KS-1 [Morozov and Petrov, 2004]. *1* – Lower and Upper Cretaceous marine and continental terrigenous rocks; *2* – Lower Cretaceous marine terrigenous rocks and coal; *3* – undivided Lower Cretaceous–Upper Jurassic marine terrigenous rocks; *4* – Jurassic marine terrigenous rocks; *5* – Triassic tuff, basalt, and marine terrigenous and carbonate rocks; *6* – Permian marine terrigenous rocks; *7* – middle Carboniferous–lower Permian marine terrigenous rocks; *8* – Middle and Upper Devonian marine carbonate rocks; *9* – major faults; *10* – major thrusts; *11* – Triassic dolerite intrusions; *12* – location of the well under consideration.

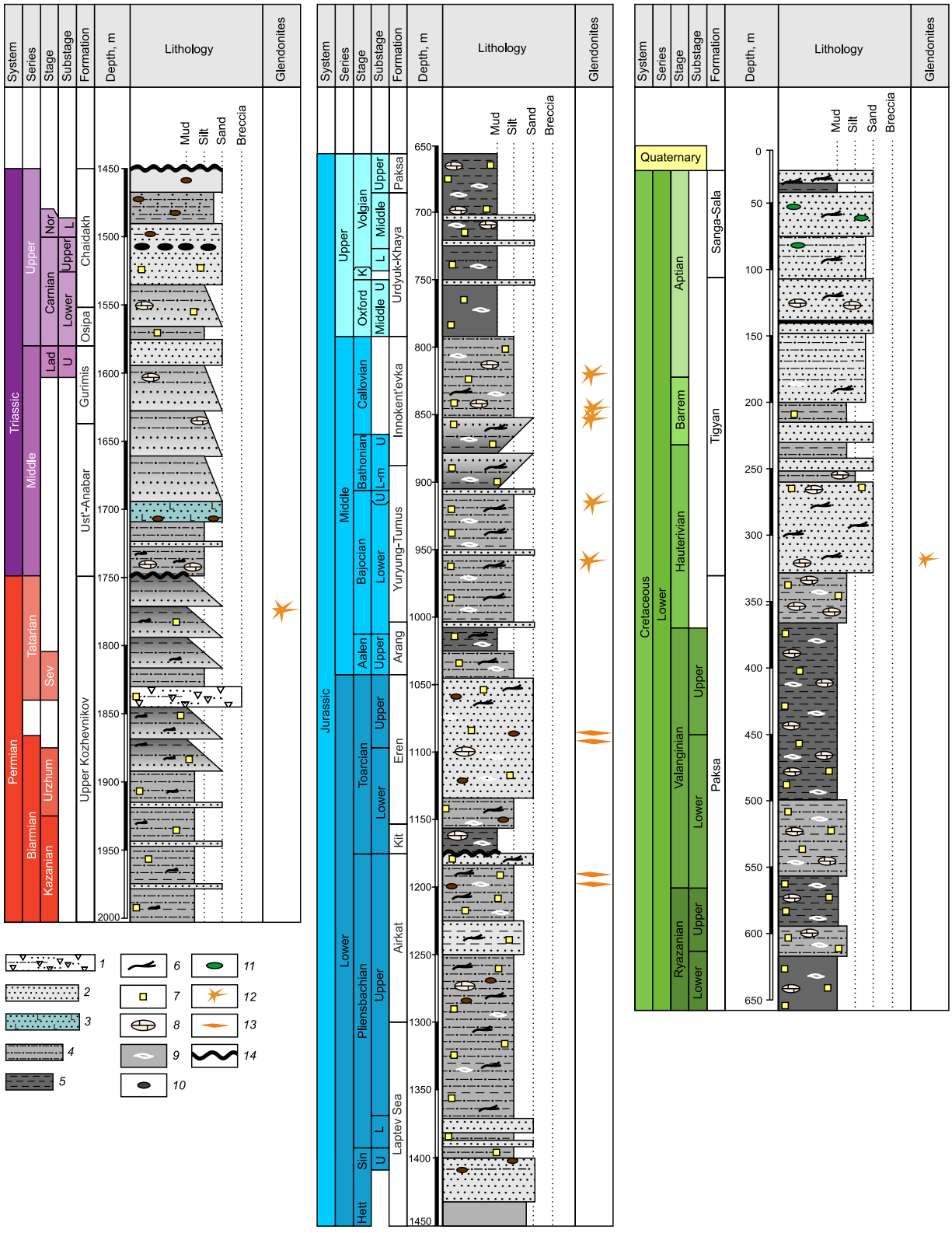


Fig. 2. Stratigraphy of rocks penetrated by well KS-1 and position of glendonite finds. Abbreviations for stage names: Aalen – Aalenian, Barrem – Barremian, Hett – Hettangian, K – Kimmeridgian, Lad – Ladinian, Nor – Norian, Oxford – Oxfordian, Sev – Severodvinian, Sin – Sinemurian, Urzhum – Urzhumian; abbreviations for substage names: L – lower, M – middle, U – upper; abbreviations for formation names: Arang – Arangastakh, Gurimis – Gurimiskai, Kit – Kiterbyut. *1* – intraformational breccia; *2* – sandstone; *3* – tuffaceous sandstone; *4* – siltstone; *5* – mudstone or clay; *6* – carbonaceous plant detritus; *7* – pyrite nodules; *8* – carbonate nodules; *9* – macrofauna remains; *10* – pebble; *11* – glauconite grains; *12* – stratigraphic position of stellate glendonites; *13* – stratigraphic position of bipyramidal (spindle-shaped) glendonites; *14* – hiatus.

morphs primarily confirms the Middle Triassic age of the lower part of the section, while the Carnian Osipa Formation also contains numerous bivalves and rarer brachiopods, allowing us to date the enclosing rocks.

Jurassic marine and shallow-sea strata with a thickness of about 790 m are composed of alternating mudstone, siltstone, and sandstones. Lower Jurassic rocks are usually characterized by interlayers of conglomerate, floating pebble, coal fragments, and representative bivalve species. There are bivalves and individual belemnites in the Middle Jurassic section and numerous ammonites and bivalves of the genus *Buchia* in the Upper Jurassic one. Micropaleontological data and the abovementioned remains provide the opportunity to unambiguously date the Jurassic part of the section and establish the complete sequence of formations characteristic of this region (from the bottom upwards): Laptev Sea (or Zimnyaya Formation, according to [Nikitenko et al., 2013; etc.]), Airkat, Kiterbyut, Eren, Arangastakh, Yuryung-Tumus, Innokent'evka, and Urdyuk-Khaya formations, as well as the lower part of the Paksa Formation [Nikitenko et al., 2013; Lutikov et al., 2024]. The Lower Cretaceous strata conformably overlie the Upper Jurassic ones; based on biostratigraphic data, the boundary between the Volgian and Ryazanian stages can be established within the Paksa Formation.

The Cretaceous section with a thickness of about 600 m comprises all stages, from the Ryazanian [Rogov et al., 2024b] to the Aptian ones. This interval corresponds to the upper part of the Paksa Formation, as well as the Tigyan and Sanga-Sala formations. The Ryazanian stage (Boreal Berriasian) is represented primarily by marine mudstone and siltstone; sandstone predominates in the upper part of the section, and contain coal interlayers. There are bivalves and cephalopods in the Ryazanian and Valanginian rocks; higher up the section, bivalve remains are rare, and palynological and micropaleontological studies confirm the age of the rocks. The Quaternary strata overlie the Mesozoic ones.

We performed petrographic and cathodoluminescence studies on six polished and uncoated thin sections of glendonite using an Olympus BX-53 microscope with cold cathodoluminescence equipment. We used a CITL Mk5-2 cold cathode stage (Cambridge Instrument Technology Ltd., United Kingdom) in automatic mode under the following operation conditions: voltage 7–12 kV, current 230 μA, and remaining vacuum 0.003 mbar.

STRATIGRAPHIC RANGE AND MORPHOLOGY OF GLENDONITES

Glendonites vary significantly in size and morphology in the upper Paleozoic and Mesozoic section penetrated by KS-1 well. In the upper part of the Upper Kozhevnikov Formation, there are the earliest glendonites in the interval of 1770.4–1774.4 m (Fig. 3); they occur in dark gray and black silty-clayey rocks, which also contain pyrite grains and rare calcite cementation. Glendonites range in



Fig. 3. Photographs of glendonites in the core of well KS-1: upper Permian Upper Kozhevnikov Formation (1, 2); Lower Jurassic Airkat Formation (3, 4); Middle Jurassic Yuryung-Tumus and Innokent'evka formations (5–8); and Lower Cretaceous Tigyan Formation (9, 10). Depth (m): 1 – 1770; 2 – 1774.7; 3 – 1193.8; 4 – 1192.9–1193; 5 – 954.5; 6 – 954.5; 7 – 921.3; 8 – 853.8; 9 – 327.37; 10 – 328.46.

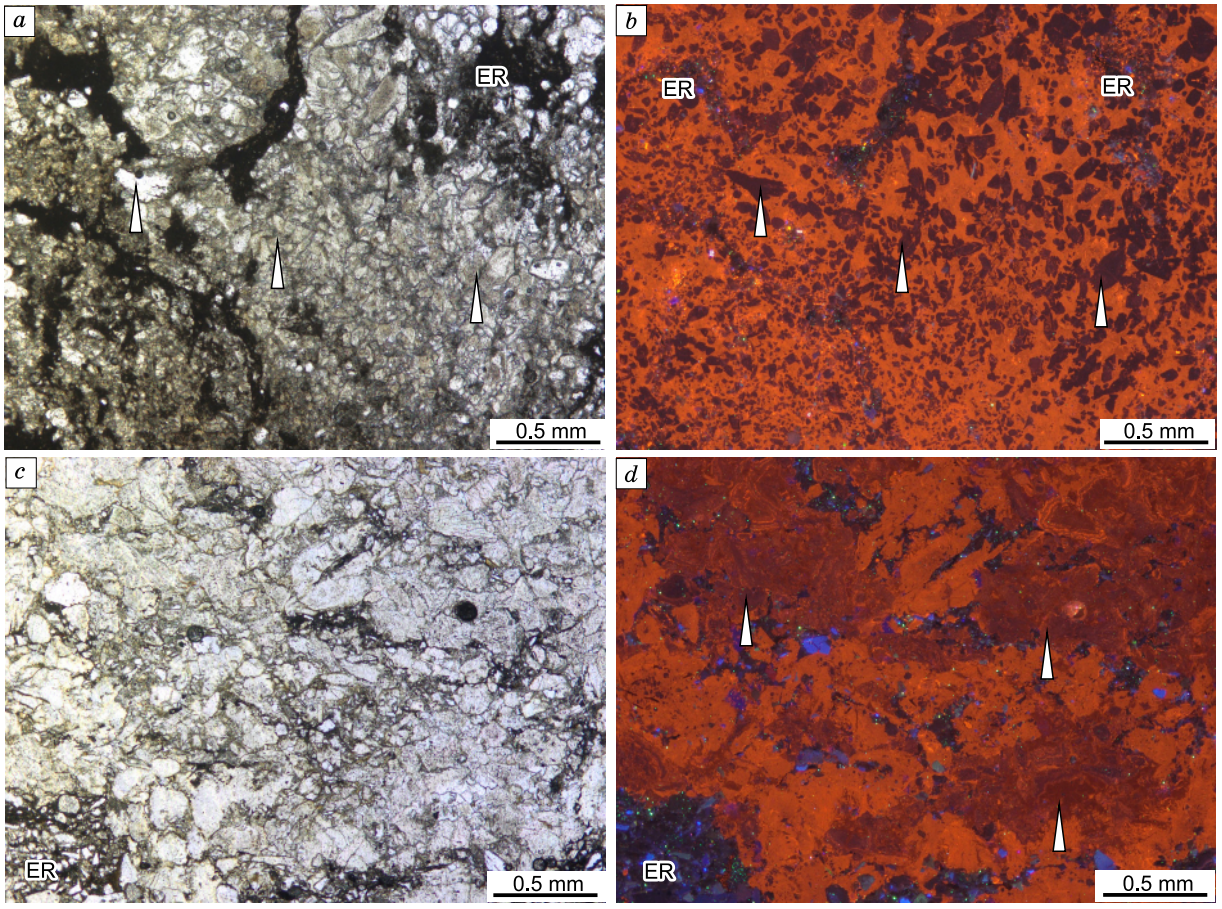


Fig. 4. Petrographic and cathodoluminescence characteristics of glendonites from the Upper Kozhevnikov Formation (*a*, *b*) and the Yurung-Tumus Formation (*c*, *d*). There are micrographs taken in transmitted light without an analyzer on the left and with cathodoluminescence on the right. White arrows – nearly non-luminescent calcite, ER – enclosing rock.

size from 5 to 10 cm and have a stellate shape. Glendonites microscopically consist of milky calcite crystals (up to 0.2 mm), which sometimes exhibit undulose extinction and include fragments of the organic-rich silty mudstone. The calcite composing the glendonites is characterized by heterogeneous luminescence: some fragments are non-luminescent, while others show orange luminesce (Fig. 4a, b). There are no macrofaunal remains near this interval (biostratigraphic analysis of the core revealed that the latest finds of Triassic mollusks and the earliest finds of Permian ones are located 200 m higher and approximately 100 m lower in the section, respectively). At 30–40 m below the glendonite finds, there is a foraminiferal assemblage with *Saccammina arctica* and *Ichthyolaria* ex gr. *reliqua* (1811.7–1839.9 m), which corresponds to the second half of the Severodvinian age, Tatarian epoch (from the end of the Capitanian age to the first half of the Wuchiapingian age in the International Chronostratigraphic Chart), with a certain degree of conventionality [Popov et al., 2023]. The interval with glendonite finds has only a palynological characteristics. During the study of the core from KS-1 well, we have established the P2-3SP palynocomplex of primarily the Tatarian epoch in the interval of 1754.0–1913.7 m. Gymnosperm pollen dominates its composition and is represented by characteristic taxa for the Tatarian series of the Permian system, such as *Ginkgocycadophytus* sp., *Cordaitina tuberculata* Krugovykh, *Cordaitina uralensis* (Luber) Samoilovich, *Cordaitina rotata* (Luber) Medvedeva, *Bascanisporites* sp., *Samoilovitchisaccites turboreticulatus* (Samoilovich) Dibner, *Samoilovitchisaccites* sp., *Luberisaccites stipticus* (Luber) Dibner, *Crucisaccites* sp., and *Potonieisporites* sp.

Glendonites re-appear in the upper Pliensbachian rocks composing the upper part of the Airkat Formation (Fig. 3), which corresponds to another time interval of widespread glendonite distribution. At a depth of 1192.9–1193.8 m, we have found pyrite nodules and large individual glendonites in a member consisting of alternating siltstones and mudstones. It should be noted that in the upper Pliensbachian rocks, there are only "rosette-shaped" glendonites (e.g., [Suan et al., 2011]) in natural outcrops of the Anabar Bay, located near the Khara-Tumus Peninsula, and individual glendonites primarily in

the Vilyui River [Kaplan, 1978; Rogov et al., 2023]. The reason for the occurrence of different morphotypes of glendonites in different regions is still unclear. We have established a bivalve assemblage characteristic of the upper Pliensbachian age (*Taimyrodon pliensbachiensis* Shurygin, *Tancredia* cf. *schiriaevi* Bodyl.) in the interval of 1189.1–1192.3 m and a representative foraminiferal and ostracod assemblage at a depth of 1991 m, allowing us to assign the strata to the Anmarginulina arctica JF8 Foraminiferal Zone and the Nanacythere costata JO3 Ostracod Zone [Nikitenko, 2009; Nikitenko et al., 2013] of the upper part of the upper Pliensbachian substage.

In the upper Toarcian rocks (depth 1102 m), we have identified small flattened individual glendonites in clayey siltstones rich in organic matter and pyrite nodules. These finds are particularly interesting, since glendonites are unknown in any section in the world in the lower Toarcian substage, and their occurrences are rare in the upper Toarcian one [Rogov et al., 2023]. There is no microfauna in the Eren Formation; however, the bivalves *Arctotis (Praearctotis) marchaensis* (Petr.), characteristic of the upper Toarcian age (the index species of the oxytomid phylozone [Lutikov, 2024]), occur above and below the stratigraphic level with the glendonites (depth 1100.8–1102.3 m).

In the Bajocian–Callovian rocks (Yuryung-Tumus and Innokent'evska formations, depth 840–989 m), we have established the most numerous, diverse, and largest glendonites, including their three main morphotypes: rosette, stellate and bipyramidal. Glendonites of each type occur in isolated groups. Stellate and rosette-shaped glendonites usually exceed the core diameter (3.9 cm), while bipyramidal glendonites, primarily oriented subvertically, may reach more than 10 cm in length. We have found glendonites both within and, to a greater extent, outside large carbonate nodules. The enclosing rocks are represented by thinly alternating mudstones and siltstones, as well as shells, dominated by the bivalves of the genus *Arctotis* and their fragments. Microscopically, the glendonites are composed of calcite crystals 0.1–0.5 mm in size, which are colorless in plane-polarized light and have a heterogeneous, sometimes zonal, orange and dark red luminescence (Fig. 4c, d). The finds of bivalves, belemnites, and microfossils confirm the age of this stratigraphic interval. The bivalves of the genus *Arctotis*, most characteristic of the Bajocian–Bathonian boundary interval, are widespread here and primarily assigned to *A.* (*A.*) ex gr. *lenaensis* (Lahusen) (depth 874.5–1051 m). Juvenile *Retroceramus* are rare; we have determined their latest finds at a depth of 846.8 m. In Siberia, retroceramids occur up to and including the upper Bathonian substage [Shamonin et al., 2025], but their finds are unknown in younger deposits. Belemnites are rare; we should note the presence of the species *Paramegateuthis ishmensis* Gustomesov (depth 844.6 m), characteristic of the early–middle Bathonian interval [Ippolitov, 2018]. Foraminifers found in the upper part of the section, at depths of 837.9 and 863.1 m, allow us to attribute it to the upper Bathonian–Callovian zone [Nikitenko et al., 2013] (Dorothia insperata, Trochammina rostovzevi JF25).

There are no glendonites in the Upper Jurassic section of the KS-1 well. We have established small (up to 2 cm in diameter) rosette-shaped and stellate glendonites in highly bioturbated green sandstones of the Lower Cretaceous Tigyan Formation (depth 327–329 m). These finds are associated with extremely shallow-sea coastal sediments, which are characterized by the presence of numerous *Arctichnus* (=*Rosselia*) ichnofossils. The age of these finds is partly arbitrary. *Buchia* ex gr. *sublaevis* (Keys.), characteristic of the Valanginian–Hauterivian boundary interval, was found together with the glendonites at a depth of 329.3 m. In the interval of 257.2–355 m, the foraminiferal assemblage belongs to the Cribrostomoides concavoides–Trochammina gyroidiniformis KF5 zone, the lower boundary of which is located within the *Bojarkensis* Ammonite Zone [Marinov and Zakharov, 2001; Nikitenko et al., 2013]. The age of this zone is controversial: carbon isotope composition [Nunn et al., 2010] and strontium isotope ratio [Efremenko et al., 2025] indicate the Valanginian stage and the early Hauterivian substage, respectively. In this paper, we consider the age of the *Bojarkensis* Ammonite Zone as late Valanginian–early Hauterivian [Nikitenko et al., 2013; Rogov et al., 2025] and refer the glendonite finds to the lower Hauterivian substage.

DISCUSSION

In KS-1 well section, glendonites occur in individual Permian, Jurassic, and Cretaceous strata. However, the stratigraphic range of glendonites and their shape and size vary and probably depend on local depositional environments and paleoclimatic features of the study region. The glendonites in KS-1 well core were determined by their shape, relationship with the enclosing rocks, and characteristic microscopic structure (Fig. 4). In KS-1 well, glendonites are composed of calcite, either nonluminescent or with orange luminescence, often exhibiting the heterogeneous luminescence characteristic of glendonites. This structure indicates the transformation of ikaite into glendonite: non-luminescent calcite is ikaite-derived, and the remaining space is filled with calcite with orange cathodoluminescence formed due to cementation after dehydration, cementation contributes to the preservation of the pseudomorph's shape.

The earliest glendonites occur in the second half of the Severodvinian age, when the studied region, located at high latitudes (north of 60° N [Torsvik and Cocks, 2016]), was occupied by a shallow shelf, the land was located further south. In both the Permian and younger strata penetrated by the KS-1 well (see below), glendonites are associated with shallow-water sediments of the upper and middle sublittoral. In addition to low seabed

temperatures, a necessary condition for the crystallization of the glendonite precursor (ikaite) is the formation of a carbonate ion during organoclastic sulfate reduction [Qu et al., 2017], the intensity of which is maximum in shallow-water environments [Bowles et al., 2014]. Therefore, in shallow and relatively shallow-water environments, seabed temperatures and high levels of sulfate reduction contributed the most favorable conditions for ikaite crystallization and stabilization, which determined the presence of pseudomorphs in the sediments of the shallow shelf. The paleogeographic position and general climate cooling at the end of the Permian period [Torsvik and Cocks, 2016] were favorable for the occurrence of large (5–10 cm) stellate glendonites in the section. There is a description of similar shallow-sea Holocene glendonites from the White Sea, where they occurred in environment with seasonal temperature fluctuations. Ikaite crystallized during the cold season, when seabed temperatures dropped below 6°C [Vasileva et al., 2021]. In the upper Permian rocks, glendonites are widespread in the north and northeast of Russia (New Siberian Islands, Pronchishchev Ridge, Taimyr Peninsula, Yenisei–Khatanga trough, and Belkovskii Island). As a rule, these glendonites are small (a few centimeters) and bipyramidal [Rogov et al., 2023]. They are represented by a stellate morphotype on the Pronchishchev Ridge [Biakov et al., 2021], while there are relatively large (up to 5 cm) stellate and rosette-shaped glendonites in the KS-1 well section. It is assumed that their age is similar to the age of the glendonites from the Pronchishchev Ridge [Biakov et al., 2021].

The Mesozoic climatic events are controversial. According to Crowley and Berner [2001], the Mesozoic climate was warm and hot, but some researchers [Eyles, 1993; Price, 1999; Nordt et al., 2024] suggest that there were separate stages of cooling and probable glacial events in the Mesozoic era, including in the Late Cretaceous epoch [Rodríguez-López et al., 2025]. However, the influence of the proposed cooling events on the temperature in the near-bottom layer is not entirely evident, and ikaite crystallization at temperatures above 7°C remains controversial. Teichert and Luppold [2013] and Tollefsen et al. [2020] proposed other models for the formation of ikaite crystals. There are no glendonites in the Triassic rocks, neither in the KS-1 well nor worldwide [Rogov et al., 2023], which may be due to high average annual temperatures even at high latitudes [Frakes et al., 1992]. In the KS-1 well section, the next interval of widespread glendonite development is the Lower Jurassic series, where glendonites are present in the upper Pliensbachian (Airkat Formation) and the upper Toarcian (Eren Formation) sections. These finds are assumed to be associated with two stages of climate cooling in the Arctic: the late Pliensbachian [Hollaar et al., 2023; Merkel and Munnecke, 2023] and the late Toarcian [Il'ina, 1985; Zakharov et al., 2006; Nikitenko, 2009; Korte et al., 2015] events, separated by the early Toarcian warming and anoxic period [Suan et al., 2010; Dera et al., 2011]. In the core from the studied well, Pliensbachian and Toarcian glendonites are represented by individual forms. Pliensbachian specimens are large, comparable to the largest specimens from the rocks of the same age in the Vilyui River [Rogov et al., 2023], while the Toarcian ones are small. In the upper Toarcian section of the Yuryung-Tumus Peninsula (outcrop 16 in [Meledina et al., 1987]), glendonites, located near the studied well, are also small (up to 3 cm), but they correspond to a different morphotype (designated as "star-shaped calcite intergrowths" in [Meledina et al., 1987]).

Since the end of the Aalenian age, a general cooling of the climate has occurred at high latitudes in the Northern Hemisphere (ABCE event) [Frakes et al., 1992; Bodin et al., 2020]. It is assumed that this cooling could have led to the formation of glaciers, at least near the poles [Frakes et al., 1992], as well as increased contrast and seasonality of the climate. According to another viewpoint [Chumakov, 2015; etc.], the presented arguments are "highly speculative assumptions that, against the prevailing background of a glacial climate, there were cold snaps in the Mesozoic era, which occurred only at high latitudes and led to insignificant polar glaciations." The Middle Jurassic section (primarily Bajocian–Bathonian and, to a lesser extent, Callovian rocks of the Yuryung-Tumus and Innokent'evka formations, respectively) contains numerous and large glendonites in the KS-1 well. Glendonites are widespread in this interval at high latitudes of the Northern Hemisphere [Rogov et al., 2019, 2021, 2023], which apparently confirms at least seasonally low seabed temperatures in the marine basin of sedimentation.

There are no glendonites in the Upper Jurassic rocks of KS-1 well. Their occurrences in this stratigraphic interval are rarer worldwide than in the Middle Jurassic one and are individual in northern Siberia [Rogov et al., 2023]. During the Late Jurassic age, a warm and humid climate prevailed in Siberia, and sea levels gradually rose [Nikitenko et al., 2015].

In the Lower Cretaceous rocks of the Northern Hemisphere, glendonites first occur in the lower Ryazanian substage [Rogov et al., 2025]. They become widespread in the upper Ryazanian substage, and their finds prevail in the Valanginian and Hauterivian strata [Rogov et al., 2021, 2023]. In the KS-1 well core, the Tigyan Formation (Hauterivian stage of the Lower Cretaceous series) contains only small individual glendonites. According to the characteristics of the strata penetrated by the KS-1 well (Paksa Formation, Ryazanian and Valanginian stages) and biotic assemblages, the Early Cretaceous sedimentary environment is considered shallow-sea (upper and middle sublittoral [Nikitenko et al., 2013, 2023]). The Tigyan Formation was deposited in an even shallower environment (upper sublittoral [Nikitenko et al., 2013]). The occurrence of glendonites in Lower Cretaceous rocks may be associated with short-term cooling periods against the high average temperatures during the Cretaceous period.

CONCLUSIONS

We have established that the KS-1 well section penetrates a wide stratigraphic interval from the upper Kazanian substage of the Biarmian series (corresponding to the Permian system in the International Chronostratigraphic Chart) to the Hauterivian stage. The following finds confirm the stratigraphic range of glendonites: palynocomplexes for the Permian system; foraminifera and ostracods for the Pliensbachian stage of the Lower Jurassic series; bivalves for the Toarcian stage of the Lower Jurassic series; bivalves, belemnites, and microfauna for the Bajocian, Bathonian, and Callovian stages of the Middle Jurassic series; and bivalves and foraminifera for the Lower Cretaceous series. The well section contains glendonites from virtually all upper Paleozoic and Mesozoic stratigraphic intervals penetrated by drilling, where they were previously recorded in other regions of northern Siberia. Their occurrences coincide with periods of climate cooling. All glendonites are associated with mudstones, siltstones, and, to a lesser extent, sandstones formed in shallow and relatively shallow-water environments of the upper and middle sublittoral, where a high intensity of sulfate reduction and diagenesis provided the influx of carbonate ions into the sediment, and low seabed temperatures contributed to the crystallization of ikaite. Glendonites include all morphotypes: bipyramidal, stellate, and rosette-shaped specimens; however, there are no patterns in the distribution of morphotypes across the section. The largest and most numerous glendonites occur in the Middle Jurassic interval (Bajocian and Bathonian rocks). They are rare in the Callovian stage and are relatively large and individual in the upper Pliensbachian substage, while stellate and rosette-shaped glendonites occur in the upper Permian section. Toarcian and Hauterivian rocks contain individual and smaller glendonites.

The intervals of glendonite development identified in the KS-1 well core (markers of paleoenvironments with low temperatures) provide unique information about the Permian–Early Cretaceous cooling episodes or epochs, as well as increased contrast and seasonality of the region's climate. The obtained results should be considered for reconstructing of the paleoenvironments and climatic fluctuations in the late Paleozoic–Mesozoic time.

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