Chukchi arctic continental margins: tectonic evolution, link to the opening of the Amerasia Basin

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ABSTRACT

The Arctic margin of Chukotka (Chukotka fold belt) comprises two tectonic units, namely the Anyui-Chukotka fold system (the ACh) and the South Anyui suture (the SAS). In terms of the paleotectonic reconstructions, the ACh represents the Chukotka microcontinent whereas the SAS is the suture, which is the result of collision of the Chukotka microcontinent with the Siberian active margin (the Verkhoyansk-Kolyma fold system). Tectono-stratigraphic units of the South Anyui suture were thrust northward over the passive margin of the microcontinent during the collision.

The tectonic evolution of the continental margin of Chukotka can be divided into four main tectonic stages corresponding to the Late Precambrian-Early Paleozoic, the Late Paleozoic- Early Mesozoic, the Middle Jurassic- Early Cretaceous and the Aptian-Albian. The metamorphic basement has the Neoproterozoic age and is assumed to represent a relict of the ancient Arctida continent. In the Early Paleozoic, Arctida was separated from Siberia and Laurentia by oceanic basins. The Chukotka microcontinent was situated next to Siberia until the Devonian and was accreted to Laurentia during the Ellesmerian orogeny. The wide ProtoArctic Ocean connected with the PaleoUral Ocean can be reconstructed for Late Paleozoic time. The Siberian margin was active whereas the North American margin was passive. After the closure of the PaleoUral Ocean, the ProtoArctic Ocean became a gulf of the PaleoPacific Ocean. However, it separated structures of the North American and Siberian continents. In the latest Permian-earliest Triassic, the continental crust of the Chukotka microcontinent was destroyed as Pangea broke up. The Lower Triassic turbidites contains dikes and sills of diabases.

Starting in Early Jurassic time, tectonic events taking place at the continental margin of Chukotka are well correlated with the main phases of the Amerasia Basin opening. The Late Jurassic was characterized by termination of spreading in the ProtoArctic Ocean and transformation of the latter into the closing South Anyui turbidite basin. The Chukotka microcontinent was subducted beneath the Siberian active margin (the Oloy volcanic belt) until the Valanginian. In the Hauterivian-Barremian, an oblique collision was initiated simultaneously with spreading in the Canada Basin. This collision resulted in formation of the South Anyui suture. As both subduction and collision was terminated, formation of an oceanic crust within the Amerasia Basin ceased.

INTRODUCTION

The origin of the Amerasia Basin is broadly debated in discussions of Arctic region tectonics. Different viewpoints exist on its origin but the rotational hypothesis (Carey, 1955) and its various modifications (Embry and Dixon, 1994; Lawver, et al., 2002; 2011; Grantz, et al., 1990, 2011, and others) are the most popular positions. However, it has been recently sharply criticized (see Lane, 1997; Miller, et al., 2006; Kuz'michev, 2009; and Beranek, et al, 2010).

A composition of the crust in structures of the Amerasia Basin is widely discussed as well. A continental nature of the Lomonosov Ridge crust and an oceanic nature of the Canada Basin crust are more or less proven. However, seismic data available for the crust of the Alpha Ridge and the Mendeleev Uplift cannot currently be unambiguously interpreted based on available evidence.

In this context, the continental margin of Chukotka is an important source of information for testing the rotational hypothesis. The geological peculiarities of Chukotka must be taken into account in tectonic reconstructions. At present, our knowledge of the geology of Chukotka is insufficient to resolve the reconstructions. Therefore, new data, which have been recently obtained by different researchers including authors of this paper, allow for elucidation of different aspects of the tectonic evolution and to construct regional correlations. This paper pays special attention to correlations of tectonic stages of the Arctic margins of Chukotka and the Canada Basin.

GEOLOGICAL SETTING

The Amerasia basin is asymmetric, which is expressed in the narrow North American shelf and the large Eurasian shelf (Fig. 1). Its western part is made of the system of the Lomonosov, Alpha and Mendeleev Uplift and separating them deep-water Makarov and Podvodnikov basins. The eastern part of the basin comprises the Canada Basin and the Chukchi plateau adjacent to the Mendeleev Uplift.

The Arctic margin of Chukotka includes the continental areas from the Kolyma river basin to Chukotka Peninsula and the large shelf of the East Siberian and Chukchi seas. One of the main structures of this region is the Chukotka (Novosibirsk-Chukotka) fold belt (Fig. 2), which is also referred to as the Chukotka Mesozoides in the Russian literature (Til'man, 1980; Zonenshain et al, 1990). The Mesozoides includes the Anyui-Chukotka fold system (the AChS) and the South Anyui Suture (the SAS). The latter is the southern boundary of the Chukotka Mesozoides and separates them for structures of the Verkhoyansk-Kolyma province.

The SAS extends from Bol'shoy Lyakhovsky

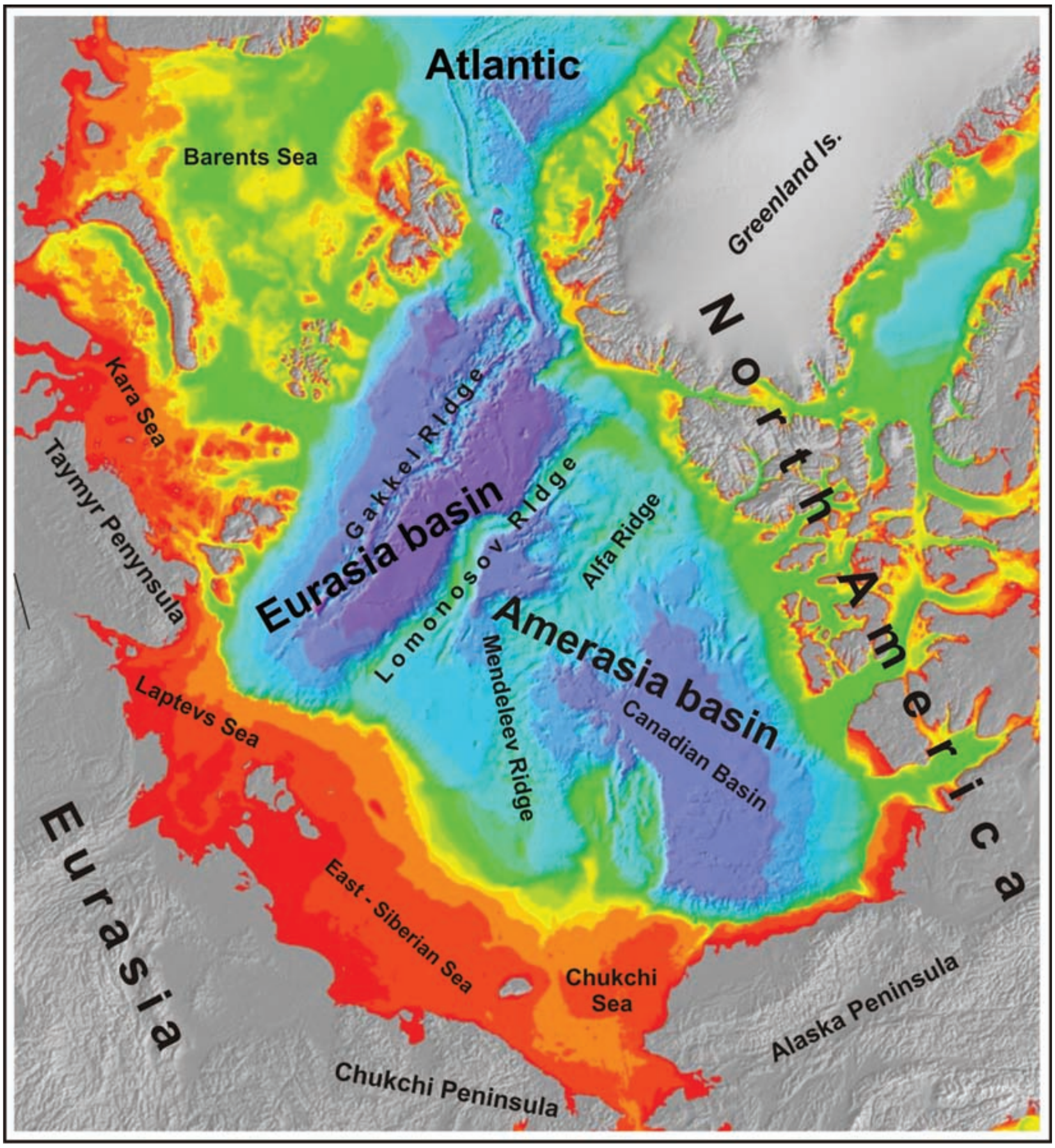
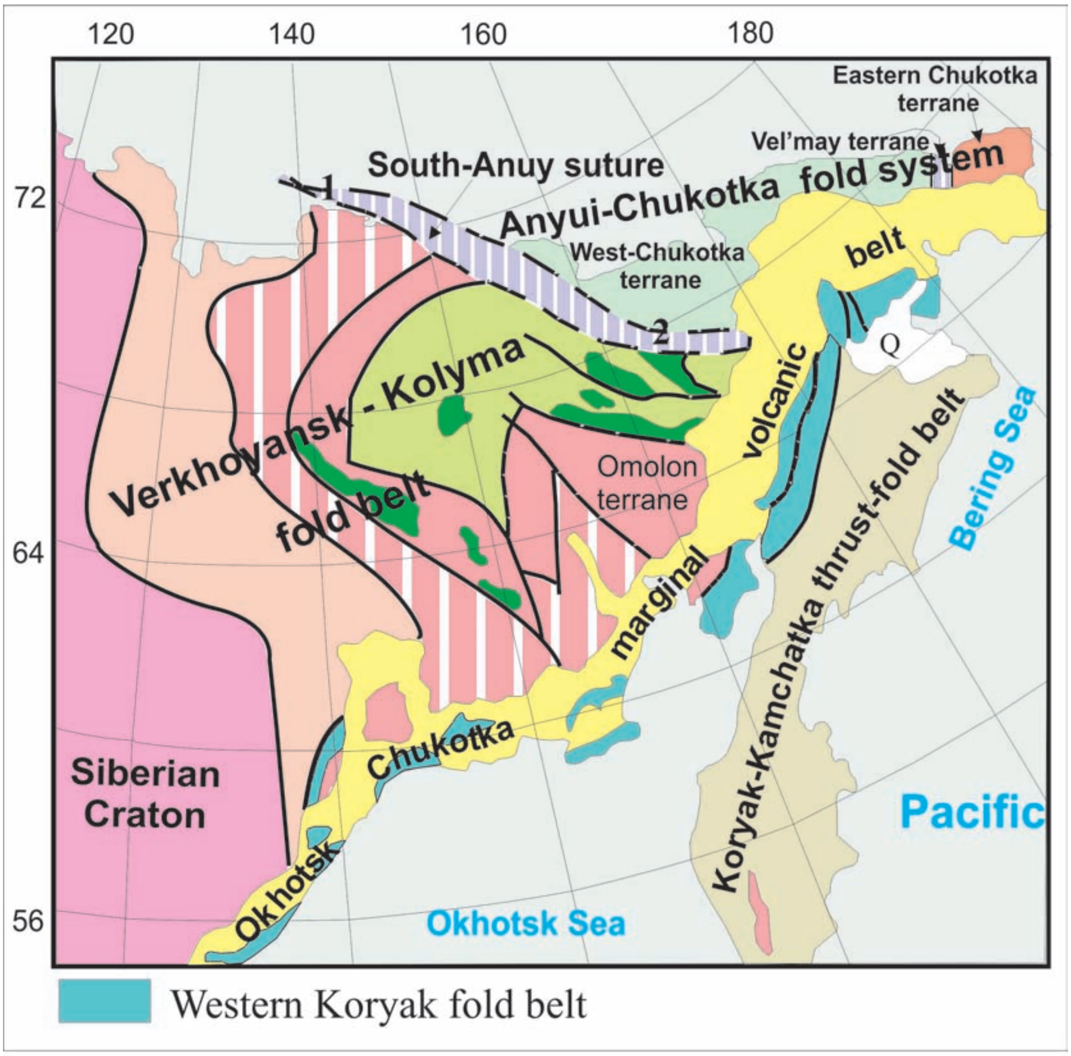


Fig. 1. Main structures of Arctic region

Island (the New Siberian Islands) up to the upper reach of the Bol'shoy and Maly Anyui rivers, where it is unconformably overlain by deposits of the Okhotsk-Chukotka volcanic belt (the OChVB). As suggested, an eastern continuity of the SAS is represented by ophiolites of the Vel'may terrane of eastern Chukotka (Parfenov, et al., 1993; Nokleberg, et al., 1994). A western continuity of this terrane is disputed. Some researchers (Zonenshain, et al., 1990; Parfenov, et al., 1993) extend it to the Polar Urals through the Taymyr. However, Kos'ko et al., (1994) stressed that data on magnetic and gravity fields for areas to the west of Bol'shoy Layakhovsky Island do not provide an unequivocal resolution of this problem. The latter allows the suggestion that a western continuity of the SAS can be represented by ophiolites of the collisional belt of the Chersky Range (Oxman, et al., 2003). In this case, the configuration of the suture would be similar to boundaries of the Angayucham terrane in Alaska. This hypothesis has been recently discussed in detail by Kuz'michev (2009). Direct correlations between ophiolites of the Chersky Range and the SAS are hardly possible as they differ in ages.

The AChS is characterized by an ancient crystalline basement, fold-and-thrust structures of the Paleozoic and Mesozoic deposits and deformation of Kimmeridgian age. The northern boundary is assumed to be marked by the Wrangel-Herald front of deformations. Deposits of the Northern Chukchi



Chukotka fold belt consists of Anyui-Chukotka fold system and South Anyui suture (1- Shalaurova terrane, 2 - South-Anyui terrane

Fig. 2. Tectonic scheme of the Northeastern Russia

depression located to the north of it are undeformed (Verzhbitsky, et al., 2008; Drachev, 2011).

There are differing viewpoints concerning distinguishing the New Siberian Islands as a part of the Chukotka fold area. Based on similar lithology, most researchers recognize a single structure referred to as the New Siberian-Chukotka block (Zonenshain, et al., 1990; Parfenov, et al., 1993 and others) or Benett-Barrovia (Natal'in, et al, 1998) block. However, some recent studies suggest that the New Siberian Islands belong to the Siberian continent (Kuz'michev, 2009; Vernikovsky, 2011, personal comm.). Geology of the New Siberian Islands is not considered in this paper.

The Anyui-Chukotka fold system (ACh)

The ACh includes several terranes and subterranes (the Wrangel, West-Chukotka and East-Chukotka) that somewhat differ in composition and stratigraphic successions of these deposits (Fig. 3). From the paleotectonic viewpoint, they are interpreted as Chukotka microcontinent (Parfenov, et al., 1993; Kos'ko, et al., 1993, 1994; Khanchuk (ed), 2006) with the ancient crystalline basement and Paleozoic-Mesozoic cover. This continent was considered either as a part of the Arctida continent (Zonenshain, et al., 1990) or as a fragment of the Arctic Alaska-Chukotka microplate (the AACM).

The basement of the ACh is exposed in Wrangel Island and in the East-Chukotka terrane. On Wrangel Island, it is composed of amphibole schists, epidote-amphibole schists and greenschists derived from sedimentary and volcanic rocks. These deposits are intruded by granites (609-677 Ma) and are unconformably overlain by Devonian-Lower Carboniferous deposits (Kos'ko, et al., 1993). In eastern Chukotka, exposures of the Precambrian basement are represented by deposits that are strongly metamorphosed to greenschist, amphibolite and locally granulite facies and there are sedimentary strata with horizons of marbles, granitic gneisses and ultrabasites (Til'man.., 1980; Zhulanova, 1990). Most of the researchers points out the similarity of metamorphic complexes of eastern Chukotka and the Seward Peninsula of Alaska and combine them into a single terrane (Parfenov, et al., 1993; Nokleberg, et al, 1994; Natal'in, et al., 1999).

The oldest dates were obtained by Rb/Sr (2565 and 1990 Ma) and K/Ar (1570 and 1680 Ma) methods (Zhulanova, 1990; Kotlyar, et al., 2001; Khanchuk (ed), 2006). Zircons from presumably Pre-Cambrian metamorphic rocks, which were chronologically dated in the last few years, yield younger Paleozoic and Cretaceous ages. They chiefly relate to granite-metamorphic domes that formed at the end of the Early Cretaceous (Gel'man, 1995; Bering Strait.., 1987). Most of orthogneisses are deformed granites of Cretaceous age (108-104 Ma, U-Pb SHRIMP zircon ages). Zircons of only two samples yielded ages of 369±.2 and 274.5±0.5 Ma (Natal'in, et al., 1999). Zircons from metamorphic rocks of the Chegitun complex have ages that vary between 650-540 Ma (Natal'in, et al., 1999).

Paleozoic strata are represented by carbonate, carbonate-terrigenous and terrigenous deposits of the Middle Ordovician to Middle Carboniferous ages (Fig. 3). In the granite-metamorphic domes, they are metamorphosed to greenschist and amphibolite facies. Upper Carboniferous and Permian marine deposits do not occur in the Chukotka Peninsula. On Wrangel Island, they are represented by carbonate and terrigenous rocks that accumulated in shallow water conditions to the north and deeper water conditions to the south (Kos'ko, et al., 1993).

Triassic deposits rest unconformably on Paleozoic strata and are mainly represented by shelf, continental slope and rise turbidites (Tuchkova, et al., 2007b). Sediment provinces were located to the north or northeast. In the lower part, this sequence is cut by numerous sills and small intrusions of gabbro, gabbro-diabases and gabbro-dolerites. They are dated at 218-233 Ma (Khanchuk (ed), 2006). The first U-Pb zircon age of 252±4 Ma of gabbroic rocks from the area of the Kolyuchinskaya Bay (Ledneva et al., 2011) proves the existence of the Permian deposits in the cover. Unique findings of flora, spore and pollen indicative of the continental genesis were previously known.

Upper Jurassic – Lower Cretaceous deposits are represented by clastic rocks with horizons of conglomerate and slates with plant detritus. Some units contain tuff and volcanic material.

The South Anyui Suture (SAS)

The SAS is the result of collision of the Chukotka microcontinent with structures of the active margin

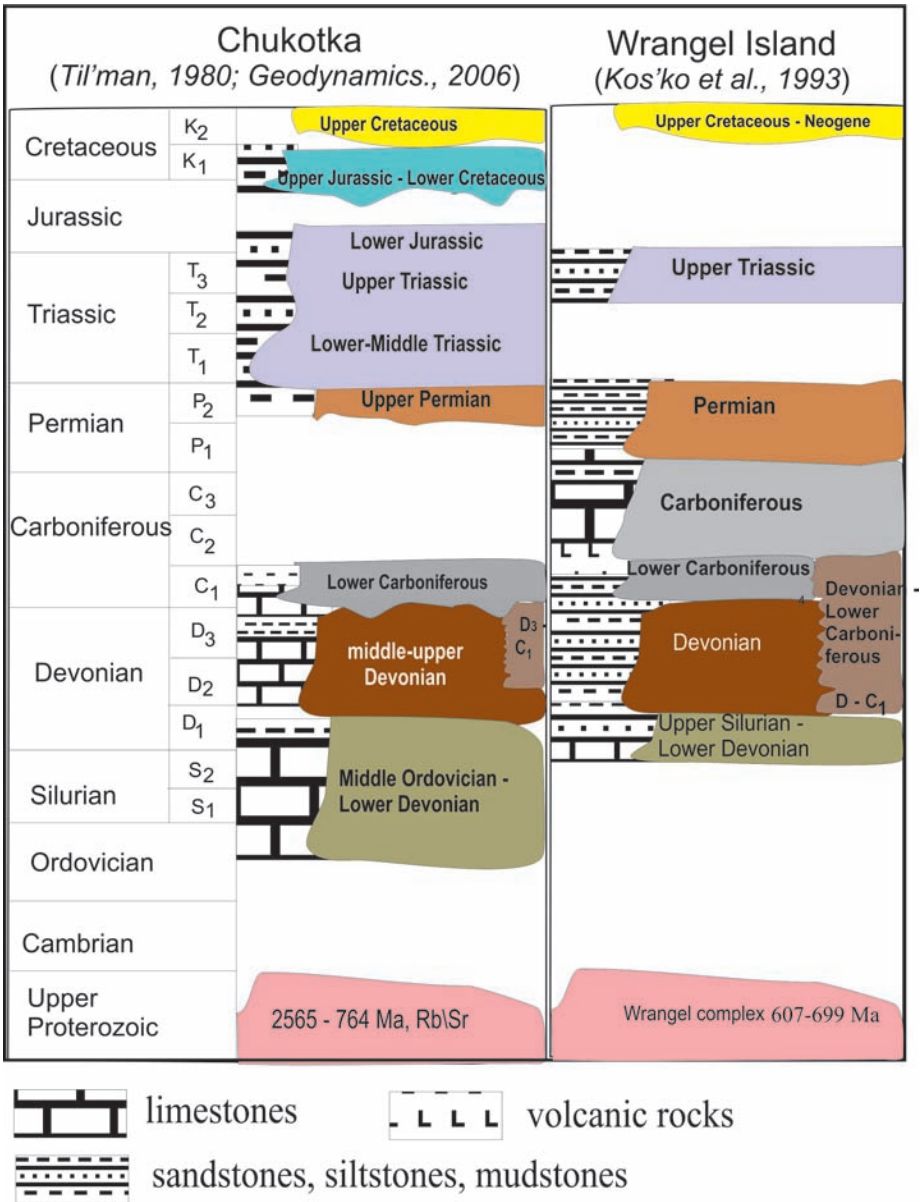


Fig. 3. Stratigraphic schemes of Chukotka and Wrangel Island

of the Siberian continent (Seslavinsky, 1979; Natal'in, 1984; Zonenshain, et al, 1990; Parfenov, et al, 1993). The SAS includes three terranes, which are separated by overlying Cretaceous, Tertiary and Quaternary deposits. The Shalaurova terrane is located in the northwestern part of the suture; the South Anyui terrane is situated in its central part; and the Vel'may terrane occurs in its eastern part. Main features of the geological structure and model of tectonic evolution of the SAS are discussed in detail in several publications (Natal'in,1984; Sokolov, et al., 2001, 2002, 2009; Khanchuk (ed), 2006) and are only briefly considered in this paper.

The Shalaurova terrane is situated in the southeastern part of Bol'shoy Lyakhovsky Island (Parfenov, et al, 1993; Tectonics.., 2001; Kuz'michev, 2009). It comprises serpentinized peridotites, gabbro-diabases, pillow MORB lavas, amphibolites and glaucophane schists. Metamorphic rocks and ophiolites are thrust over Upper Jurassic – Lower Cretaceous flysch deposits. It is assumed that the flysch was deposited in a foredeep formed via the collision of the Svyatoy Nos arc and the Novosibirsk continental block. Postcollisional granites show 40Ar/39Ar biotite plateau age of 114.4±0.5 Ma (Layer, et al., 2001)).

Geochronological data on metamorphic rocks and ophiolites are not reliable. For example, bulk-rock pillow basalts are dated at 291±62 Ma; K-Ar bulk-rock amphibolites age is 473 Ma (Drachev and Savostin, 1993). Metamorphic minerals from basalts exhibit K-Ar age of 133.5±4.5 and 139±8 Ma (Kuz'michev, 2009) that can be treated as an age of young alteration.

The South Anyui terrane is situated in the interfluves of the Bol'shoy and Maly Anyui rivers. It is made of a system of intensively deformed tectonic nappes. Four stages of deformation are distinguished (Sokolov et al., 2002, 2009). The first and second stages of deformation is characterized by thrusts and folds of northern and southern vergence, respectively. The collision between Chukotka microcontinent and North-Asian craton that occured in the Early Cretaceous was oblique and resulted in the formation of dextral strike-slip faults. Deformation of the final stage was related to nearly latitudinal sinistral brittle strike-slip faults that exerted an influence on the Albian-Cenomanian deposits of the Okhotsk-Chukotka volcanic belt.

Tectonic nappes are made of the following tectono-stratigraphic units (Fig.4) that originated in different provinces of an oceanic basin and its margins:

1. The Ustieva Unit, turbidites, Upper Triassic, deposits of the continental slope. The lower structural unit is interpreted as distal turbidites of a passive margin of the Chukotka microcontinent;
2. The Polyarnyui unit, volcanic-chert-carbonate assemblage, Lower Carboniferous. The unit is interpreted as a fragment of the oceanic crust composing the base of the Kulpolney island arc;
3. The Kulpolney unit, volcanic and clastic rocks, Oxfordian-Kimmeridgian, a fragment of an ensimatic island arc;
4. The Tenvel unit, clastic rocks with volcanic layers, a Kimmeridgian-Lower Tithonian, forearc basin;

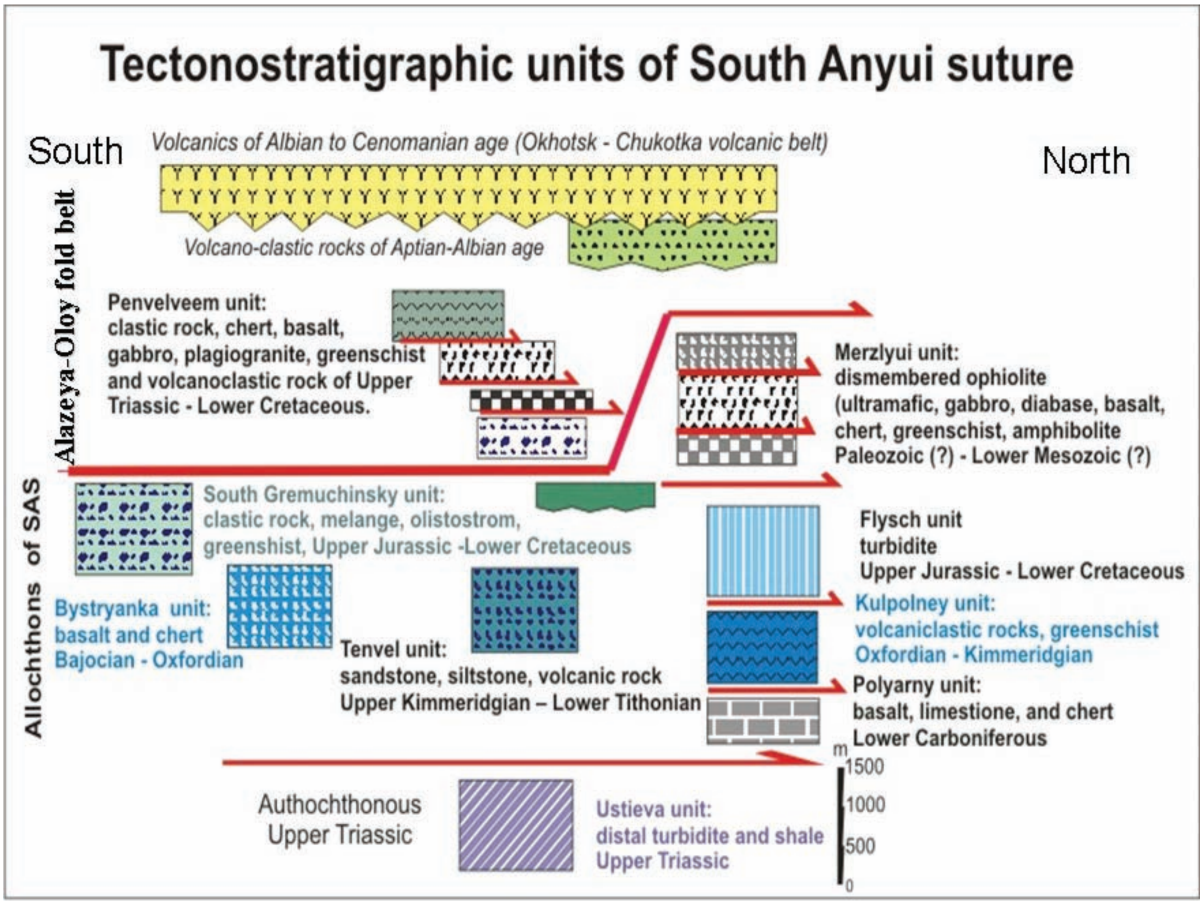


Fig. 4. Tectono-stratigraphic units of South Anyui suture.

5. The Flysch unit, turbidite, Upper Jurassic-Lower Cretaceous, the syncollisional South-Anyui basin;
6. The South Gremyachinsky unit, clastic rocks, tuffs, terrigenous mélange, greenschists, Upper Jurassic-Lower Cretaceous, an accretionary prism;
7. The Merzlyui Unit, dismembered ophiolite, greenschists, amphibolites, Paleozoic-Early Mesozoic (?);
8. The Penvel'veem unit, volcanic-tuff-terrigenous deposits, Upper Triassic-Valanginian. A fragment of an island arc assumed to be a klippe of the Yarakvaam terrane.

The Aluchin and Vurguveem ophiolites are located along the boundary of the South Anyui and Yarakvaam terranes. They were originally included into the SAS as fragments of the Late Jurassic-Early Cretaceous oceanic crust (Seslavinsky, 1979; Natal'in, 1984). New data indicates their Paleozoic and Triassic ages and suggests their suprasubduction origin (Lychagin, et al, 1991; Ganelin et al., 2003; Ganelin and Silantyev, 2008). As a result, the age of the South-Anyui oceanic basin was revised. In relation to these new age data, we propose to refer to the oceanic basin as the ProtoArctic Ocean and to keep the South Anyui name for the Late Jurassic – Early Cretaceous basin characterized by turbidite sedimentation.

The Vel'may terrane is composed of ultrabasic rocks, gabbroids, plagiogranites and volcanic-chert-terrigenous deposits that occurr in the areas to the north of Cross Bay and to the south of Kolyuchinskaya Bay. Tectonic mélanges that are typical of disintegrated ophiolite assemblages are pointed out. The age of these terrane deposits is disputed and are suggested to be either Late Jurassic-Early Cretaceous (Kosygin, et al., 1974) or Late Triassic in age (Tynankergav and Bychkov, 1987).

THE TECTONIC HISTORY: A DISCUSSION

The tectonic history of the Arctic margin of Chukotka can be divided into four periods: the Late Precambrian – Early Paleozoic, Paleozoic – Early Mesozoic, and Late Mesozoic. Marine sedimentation is terminated by the late Early Cretaceous, during Aptian-Albian time; and post-collisional, continental deposition commenced.

The Late Precambrian – Early Paleozoic time

Metamorphic complexes of the Chukotka fold belt have not been objects of sophisticated investigations thus far; therefore regional correlations and general reconstructions are invoked for reconstructing its early stages of tectonic evolution. Most of the researchers considered Chukotka as a fragment of an ancient continental block that had occupied the central part the Arctic Ocean. It was referred to as the Hyperborean platform (Shatsky, 1935), the Ancient Arctida (Eardly, 1948), Arctida (Zonenshain, et al., 1990), Crockerland (Embry, 1993), and Bennett-Barrovia block (Natal'in, et al., 1999).

Relicts of the Arctida basement are preserved as ancient Arctic continental massifs such as the Kara massif (including the northern Taymyr and the southern part of the North Zemlya Archipelago) and the Chukchi massif of Wrangel Island and Alaska (the Seward Peninsula and the Brooks Range). The basement of the Arctic Alaska and Chukotka terranes is composed of Neoproterozoic metamorphic rocks that are intruded by granites with an age of 609-677 Ma in Wrangel Island (Kos'ko, et al, 1993). Augen gneisses of eastern Chukotka contain zircons dated at 650-540 Ma (Natal'in et al., 1999). The Nome complex of the Seward Peninsula contains lenses of orthogneiss dated at 670-680 Ma (Amato, et al., 2009).

In the Early Paleozoic, Arctida represented a carbonate platform that had been separated from Siberia, Laurentia and Baltica by oceanic basins (Zonenshain, et al., 1990). The most ancient Ordovician, Silurian and Early Devonian deposits of the Chukotka block (Wrangel Island and the Eastern Chukotka terrane) are represented by shallow-water carbonate and clastic rocks.

A precise position of Arctida and the Chukotka block is not determined as no paleomagnetic data are available. Paleontological data neither help in resolving of this problem as the platform rocks of the Arctic Alaska-Chukotka microplate, especially those of Ordovician age, contain conodont faunas characterized by mixed Laurentian, Siberian, and Baltic affinities (Dumoulin, et al., 2002, 2012). Blodgett et al (2002) reviewed the evidence for Paleozoic (especially Cambrian-Devonian) megafossils from Arctic Alaska and they note that the component terranes of Arctic Alaska show their closest affinities with Siberia and Northeast Russia. Until the Devonian, Arctic Alaska and Chukotka had been placed close to Siberia as shown in the reconstructions (Drachev, 2011; Lawver, et al., 2011). During the Ellesmerian orogeny (the Devonian), which resulted in the complete closure of the Neoproterozoic-Early Paleozoic Iapetus Ocean, they were displaced from Siberia toward Laurentia. An emplacement of deformed granites dated at 369.6±1.2 and 374.8±0.5 Ma from a metamorphic complex of the Chukotka terrane (Natal'in, et al., 1999) and Early Carboniferous granites of the Kiber Cape (unpublished data) probably resulted from the Ellesmerian orogeny. The findings of andesitic tuff horizons suggest that an island arc existed along the southern flank of the Bennett-Barrovia block. The Devonian volcanic arc extended to the Pacific Ocean (Plafker, 1990) and is also known in Alaska (Moore, et al., 1994).

The Late Paleozoic – Early Mesozoic time

Dates available on ophiolites of the Yarakvaam terrane (Ganelin et al., 2003; Oxman, et al., 2003; Ganelin and Silantyev, 2008; Ganelin, 2011) and fragments of an oceanic crust in the SAS (the Polyarnyui Unit) suggest the existence of the ProtoArctic oceanic basin (Sokolov, et al, 2009). In Devonian-Carboniferous time, prior the collision of Siberia and Baltica, this ocean had been connected to the Pacific and the Paleo-Urals Oceans (Zonenshain et al., 1990; Sokolov et al., 2002; Vernikovsky, et al., 2003). Following the closure of the Pale-Urals Ocean and the collision of Kara block with Siberia and termination of the Ellesmerian orogeny, this ocean became a large gulf of the Pacific Ocean.

The southern margin of the Proto-Arctic Ocean adjacent to the Siberian continent was active and extended toward the Pacific structures (Khanchuk (ed), 2006; Sokolov, 2010). A building of this convergent margin commenced simultaneously with a termination of the Ellesmerian orogeny in Laurentia, framing the formation of a passive margin. In Paleozoic – Early Mesozoic time, this convergent margin was surrounded by enigmatic arcs: the Alazeya, Oloy, Yarakvaam and other terranes (Parfenov, et al, 1993; Nokleberg, et al., 1998). In the Yarakvaam terrane (Fig. 5), the Aluchin and Vurguveem suprasubduction ophiolites are associated with glaucophane schists and island-arc complexes of the Carboniferous, Permian and Triassic ages (Shekhovtsov and Glotov, 2001; Sokolov, et al., 2002, Sokolov, 2010).

The Triassic dike complex of the Yarakvaam terrane originated in an island arc-marginal sea system (Ganelin, et al., 2003). It should be stressed that Triassic volcanic-sedimentary deposits of the Yarakvaam terrane contain Tethyan fauna. The occurrence of boreal fauna of the northern passive margin of the ProtoArctic Ocean mixed with the Tethyan fauna of its southern border suggests that the oceanic basin was very large in the Triassic.

Small oceanic basins (the Oymyakon) of the Verkhoyansk-Kolyma Mesozoides existed in back-arc areas adjacent to the Siberian continent (Kuzmin.&Parfenov, 2001; Oxman, et al., 2003). These basins were originated via the rifting and splitting off the large continental blocks (the Omolon, Okhotsk and other terranes) from the Siberian continent. Fragments of the oceanic crust and suprasubduction ophiolites occur in the collisional belt of the Chersky Range.

The Northern, Chukotka (or Arctic) continental margin was a passive one. Terrigenous and carbonate strata were deposited in the Devonian-Middle Carboniferous time. In Chukotka, these deposits are commonly metamorphosed and their facies changes are well documented. On Wrangel Island, shallow-water shelf sediments of the Carboniferous and Permian sequences grade southward and upward into deeper water strata (Kos'ko, et al., 1993). In the northern area of the island, Early Carboniferous (?) deposits contain rift-related volcanic rocks (Moiseev and Sokolov, 2009). Note, Upper Carboniferous and Permian deposits (Fig. 3) bearing age-dated faunas are not known in Chukotka. It was presumably an area of erosion at the time.

Late Devonian and younger faunas of the AACM have strong northern Laurentian affinities (Dumoulin, et al., 2002). The AACM was, therefore, a part of the Laurentia continent or was placed close to it. A translation of a number of blocks from the Siberian continent close to the Laurentia is substantiated in the reconstructions of Lawver, et al. (2002, 2011) and others (for example Zonenshain et al., 1990). Additionally, fusulinids occur in

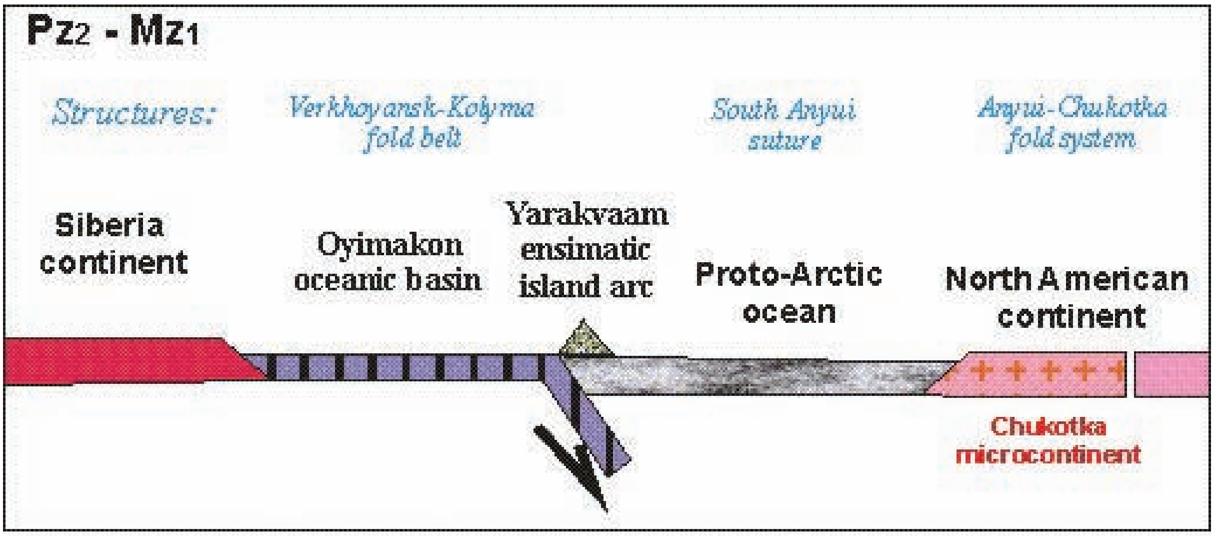


Fig. 5. Paleogeodynamic profiles for Late Paleozoic –Early Mesozoic time.

Middle Carboniferous limestones on Wrangel Island and Kotel'nyi Island, which is consistent with a sediment deposition in the relatively lower latitudes (Solovieva, 1975). Similar faunas have not been described in deposits of the Siberian passive continental margin so far. These faunas occur in allochthonous terranes of the Pacific rim (Sokolov, 1990, 1992).

In the latest Permian and earliest Triassic time, continental crust of the eastern Arctic region was destroyed (Til'man, et al., 1980; Sokolov, 2010; Ledneva, et al., 2011). Permian-Lower Triassic deposits of Chukotka are intruded by numerous sills and small hypabyssal bodies of diabases, gabbro and dolerites. Locally, tuffs and basalts geochemically similar to the Siberian traps occur (Ledneva, et al., 2011). The destruction of the continental crust was related to plume tectonics and break off from the Pangean continent. A genetic affinity of this magmatism, whether to an incipient Meso-Cenozoic Arctic plume or to one of the Siberian plume branches has yet to be investigated.

Triassic strata-bearing turbidites were deposited on the continental shelf, slope and rise. These deposits contain faunas typical of boreal provinces. The Norian carbonate-clay deposits of Kotel'nyi Island are an exception as they contain mixed boreal and Tethyan faunas (Konstantinov, et al., 2003). An occurrence of North American faunas (Yegorov, et al., 1987) and its similarity with faunas from the upper reach of the Bol'shoy Anyui River (the Yarakvaam terrane) has been pointed out. Occurences of faunas common to British Colombia and Yukon indicate a faunal exchange with eastern Pacific Ocean.

Upper Triassic distal turbidites of the Chukotka microcontinent are described in the tectono-stratigraphic units of the South-Anyui terrane (the Ustieva Unit). Facies distribution and orientations of turbidity currents indicate that a sedimentary province was located to the north or northeast (Morozov, 2001; Tuchkova, et al., 2007b). The source of sediments was probably situated in Arctida or Crokerland.

Early Jurassic deformation recently recognized in the Chukotka microcontinent (Tuchkova, et al., 2007a) probably resulted in a general uplift of the area, leaving only a local occurrence of Lower Jurassic deposits and a lack of Middle Jurassic strata.

The Late Mesozoic (the Middle Jurassic-Early Cretaceous)

The Middle Jurassic is an important period in the tectonic history of the Arctic and Pacific continental margins of Northeastern Russia that was characterized by structural transformation and deformation (Sokolov, 1992; Parfenov. et al., 1993; Tectonics.., 2001). Its formation was coeval to the generation of an incipient system of Pacific plates that defines modern appearance of the Pacific Ocean (Larson and Hide, 1975).

Convergent margins of the Asian continent

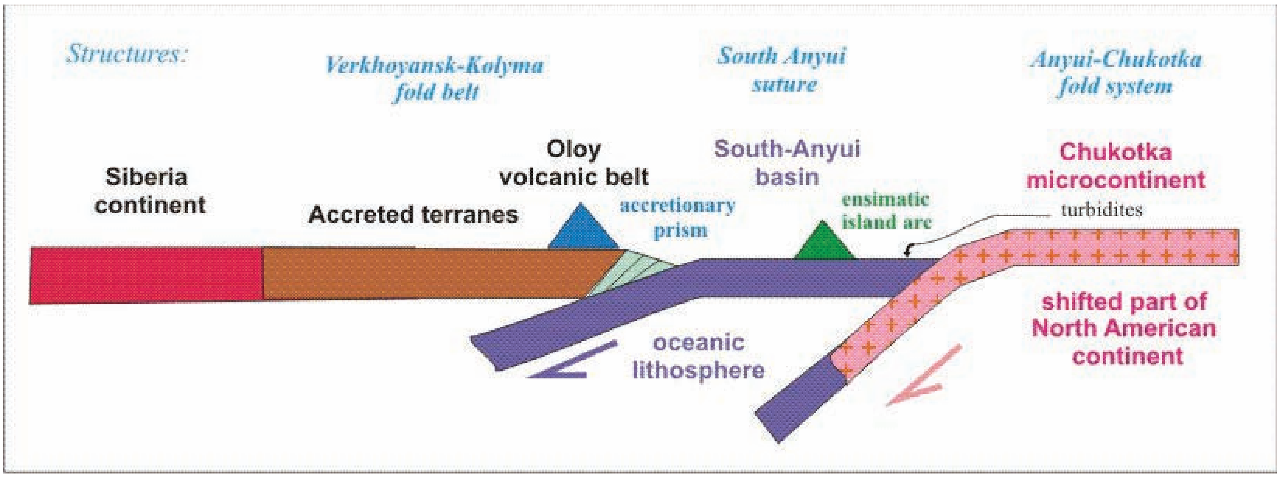


Fig. 6. Paleogeodynamic profiles for Late Jurassic –Early Cretaceous time.

were reorganized. Development of the Uda-Murgal volcanic belt commenced along its Pacific margin (Sokolov, 1992; Parfenov et a;., 1993). The Verkhoyansk-Kolyma terranes were amalgamated by this time and formed the single Kolyma-Omolon superterrane (Parfenov et al., 1993; Tectonics.., 2001). The collision of this superterrane with the Siberian continent commenced.

The new extended volcanic belt, referred to as the Oloy belt (Tii'man, et al., 1980) or the Oloy-Svyatoy Nos belt (Parfenov, et al., 1993), was created along the northern margin of the Kolyma-Omolon supperterrane at the boundary with the ProtoArctic Ocean. Volcanic-sedimentary deposits of the Late Jurassic – Early Cretaceous unconformably overlie the older arc complexes of the Paleozoic and Early Mesozoic. Volcanic rocks of the Svyatoy Nos area can be included into the belt only partially as they show the narrow Oxfordian-Kimmeridgian age interval. They are coeval volcanic rocks of the Kupolney arc situated in the ProtoArctic Ocean (Sokolov, et al., 2002, 2009). These volcanic rocks might represent fragments of the same arc. A termination of volcanic activity in the arc coincides with termination of spreading in the ProtoArctic Ocean.

A new stage in the tectonic evolution of the ProtoArctic Ocean (Fig. 6) started in the Volgian (Tithonian) time. The spreading was terminated and the volcanism in ensimatic arcs (the Kupolney and the Svyatoy Nos) became extinct. Closure of the ProtoArctic Ocean commenced and this resulted in the formation of the syncollisional South-Anyui oceanic basin that was filled with terrigenous sediments. Concurrently. turbidites were deposited along the northern Chukotka margin. As the ensimatic arcs became extinct, a localized subduction developed along the southern margin. An accretionary prism incorporating offscraped blocks of basalts and cherts (the South-Gremuchinsky unit) developed along its boundary with the Yarakvaam terrane. The accretion of the Kupolney arc was followed by the subduction of the Chukotka continental lithosphere.

The last stage of the collision occurred in the Hauterivian-Barremian time. A system of pull-apart basins filled with the shallow-water coarse-grained deposits developed along dextral strike-slips in the area affected by the collision.

The Middle Cretaceous (the Aptian-Albian)

The principal structural reorganizations took place during Aptian-Albian time. At approximately the same time, collision of the Chukotka microcontinent with an active margin of Siberia was completed. The accretion and collision was accompanied by the intrusion of granites indicating the formation of a new granite-metamorphic layer, which covered the Siberian, Omolon, AACM and other continental blocks. The Okhotsk-Chukotka volcanic belt then developed along the newly formed continental edge and the convergent margin was of the Andean type.

This stage was characterized by extensional structures that originated immediately after the collision of the active continental margin with the Chukotka microcontinent. The collapse of the collisional orogen and exhumation of subducted deposits of the Chukotka microcontinent resulted in the formation of granite-metamorphic domes and superimposed depressions filled with continental volcanic-sedimentary deposits.

Correlations with the Canada basin

According to the rotation hypothesis, the formation of the Amerasian basin and the generation of the oceanic crust of the Canada basin resulted from the break-up of the Arctic Alaska-Chukotka microplate from the Laurentia, followed by the counter-clockwise rotation of this block. The Chukotka microcontinent, whose rotation had caused the closure of the Proto-Arctic Ocean and which collided with the Siberian active margin, is a part of the AACM. This collision resulted in formation of the SAS. The testing of the rotation hypothesis reveals the detailed correlation of tectonic events of the Amerasian basin and structures of the Arctic continental margin of Chukotka.

According to Grantz, et al. (2011), the Amerasia basin was formed by two phases of counterclockwise rotational opening about a pole in the Mackenzie Valley of NW Canada: (phase 1) an initial phase of extension in the Early Jurassic to Neocomian, and (phase 2) spreading (131-127 Ma) and intrusion of mid-ocean ridge basalt crust in the central part of the Amerasia Basin in the Hauterivian and Barremian.

The initiation of the Amerasia basin is attributed to the Early Jurassic, a generation of the ocean-continental transitional crust, and rifts. The coeval uplift in Chukotka appears to have resulted from deformation at the shoulders of an incipient rift. Synrift strata are 2 km thick or more and they are interbedded with volcanic rocks of the Alpha-Mendeleev Ridge. Moore, et al. (2011) suggest an Early Jurassic-Valanginian age for the synrift volcanism. This is proven by new geochronologic dates for basaltic rocks of the Frantz Josef Land (FJL) of 190.1±4.4, 156.8±3.8, and 132.5±1.2 Ma (Karyakin, et al., 2009). The closure of the Eurasian basin allows the reconstruction of the large igneous province comprising the FJL, the Alpha and Mendeleev ridges, and the DeLong Massif. Compositional variations of the intraplate volcanic rocks of the FJL are consistent with the continental nature of the crust of this province.

Termination of spreading in the ProtoActic Ocean at the Tithonian-Kimmeridgian boundary (150 Ma) was followed by terrigenous sedimentation (the South Anyui turbidite basin). A subducted oceanic crust was intensively pulled beneath the Siberian margin. Relicts of this oceanic crust are preserved in the South Gremuchinsky accretionary prism. These processes were approximately simultaneous with the opening of the Amerasian basin. Grantz, et al. (2011) assumed that the North Chukotka depression was established at about 145.5 Ma ago. The depression could be have resulted from an extension of the AACM that caused its rapid subduction.

Later, in the Early Cretaceous, when the Chukotka microcontinent continental lithosphere had started to be consumed, the subduction process slowed and volcanism in the Oloy belt became less voluminous. The South Anyui basin continued to shorten and fill with sediments of a significant thickness.

The spreading of the second phase in the Canada Basin was simultaneous with the closure of the South Anyui basin. Turbidite sedimentation was followed by deposition of shallow-water strata during the Hauterivian-Barremian. Conglomerates in this basin contain various clastic fragments that were transported from the northern and southern provenances. Any traces of coeval volcanism are absent. It should be emphasized that Hauterivian-Barremian strata were deformed during the latest stages of the collision.

Termination of spreading in the Canada Basin coincides with a termination of collision in the Chukotka fold belt. Post-collisional granites are dated at 117-108 Ma in Chukotka (Katkov, et al., 2010) and at 114 Ma in the Shalaurova terrane (Layer, et al., 2001). Post-rift strata of the Canada Basin are Aptian-Albian in age. In Aptian-Albian time, extension taking place in Chukotka resulted creation of the Aynakhkurgen, Nutesyn and other postorogen depressions. These depressions are filled with shallow-water, lagoonal and continental volcanic-sedimentary deposits. Extensional structures partially formed during this time period in the Arctic shelf of the East Siberian and Chukchi seas (Miller and Verzhbitsky, 2007). Main stages of the tectonic evolution of the Chukotka continental margin are well correlated with stages of the Canada Basin formation.

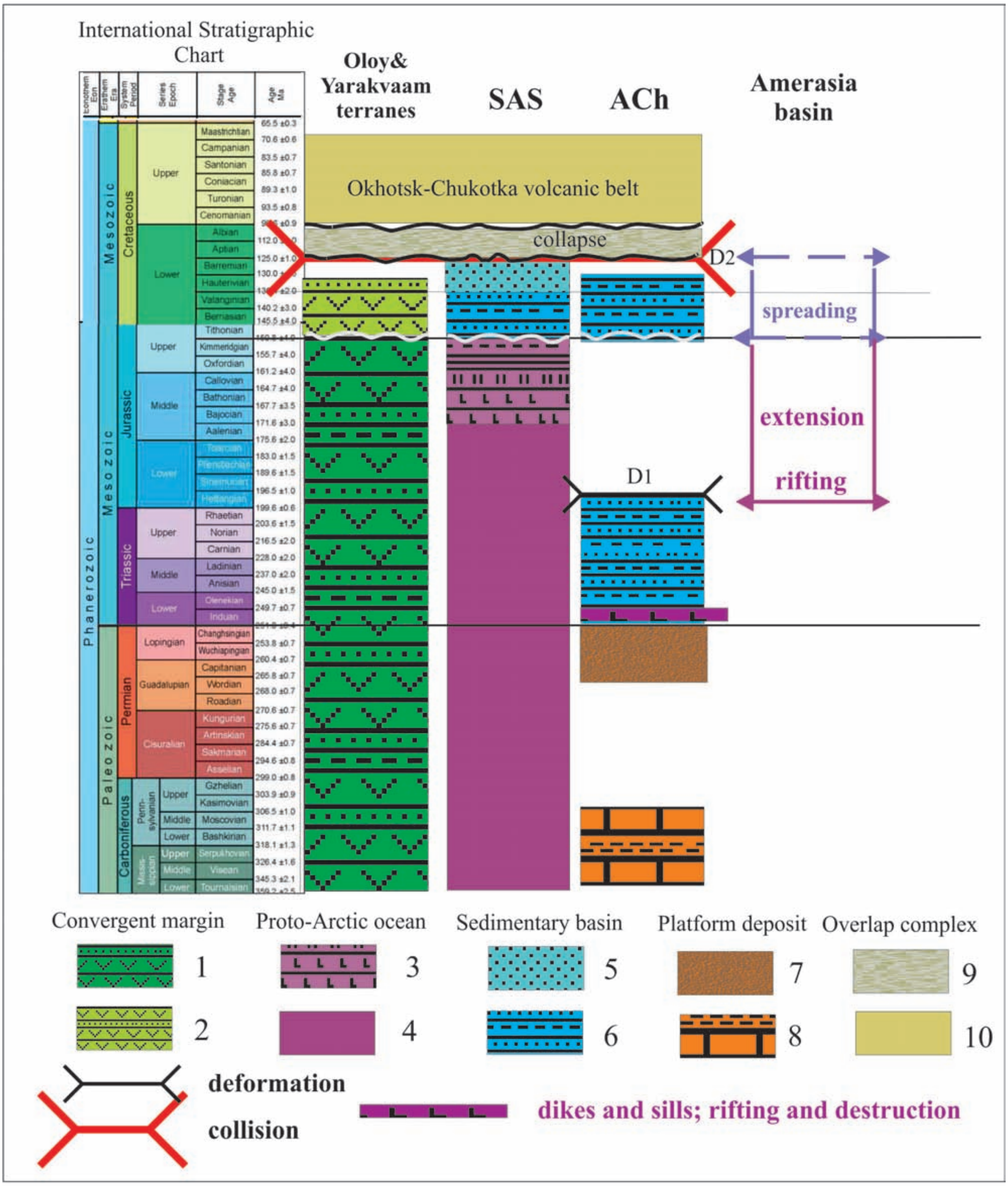


Fig. 7. Time-space diagram. 1 – island arc complexes of the Yarkvaam terrane; 2 – Oloy volcanic belt; 3 – basalt-chert assemblage (Bystryanka unit); 4 – oceanic comlexes; 5 – clastic rocks; 6 – turbidutes; 7 – terrestrial and shallow-water beds; 8 – limestone and clastic rocks; 9 – Aptian –Albian volcanic and sedimentary terrestrial rocks; 10 – Okhotsk-Chukotka volcant marginal belt.

CONCLUSION

The Chukotka fold belt comprises two structural elements: the Anyui-Chukotka fold system (AChS) and the South Anyui suture. They formed during collision of the Chukotka microcontinent with the Siberian active margin. The tectono-stratigraphic units of the South Anyui suture were thrust northwards over the passive margin deposits of the microcontinent, whose sedimentary cover is strongly deformed.

Complexes of the Chukotka microcontinent were geographically placed close to Siberia in the Early Paleozoic. They became a part of Laurentia during the Ellesmerian orogeny. In the Late Paleozoic – Early Mesozoic, Laurentia and Siberia were separated from each other by the ProtoArctic Ocean. The American margin was a passive one, whereas the Siberian margin was an active one. In the latest Permian –earliest Triassic, destruction of Pangea resulted in destruction of the continental crust. However, this crustal thinning did not cause the formation of oceanic crust. In the Early Jurassic, formation of the Amerasia Basin commenced. The rifting followed by spreading in the Canada Basin caused the splitting of the Chukotka microcontinent from Laurentia. The Tithonian was characterized by the termination of spreading in the ProtoArctic Ocean that had been transformed into the South Anyui syncollisional turbidite basin. The opening of the Amerasia Basin coincided with shortening of the South-Anyui turbidite basin that was deposited on oceanic lithosphere and concurrently subducted beneath the Verkhoyansk-Kolyma foldbelt (see Fig. 6).

As a result of this collision, a large block of the continental crust which includes the Mendeleeva uplift and the Chukchi plateau was amalgamated onto Siberia. After the collision, extensional structures (the Aynakhkurgen and Nutesyn depressions) were developed along with commencement of continental and marine sedimentation. The extensional events were accompanied by volcanism and crustal thinning; however, this did not result in the destruction of the continental crust.

The good correlation and relationships between the tectonic events evident in the Amerasia Basin and the Chukotka fold belt prove the rotation hypothesis. Tectonic models based on this hypothesis will be improved when new data are obtained.

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