ISSN 0016-8521, Geotectonics, 2010, Vol. 44, No. 5, pp. 388–404. © Pleiades Publishing, Inc., 2010.
Original Russian Text © V.S. Burtman, 2010, published in Geotektonika, 2010, Vol. 44, No. 5, pp. 22–40.

Tien Shan, Pamir, and Tibet: History and Geodynamics of Phanerozoic Oceanic Basins

V. S. Burtman

Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 119017 Russia
e-mail: vburtman@gmail.com

Received January 11, 2010

Abstract—Geological and biogeographical data on the paleooceanic basins of the Tien Shan and High Asia are summarized. The oceanic crustal rocks in the Tien Shan, Pamir, and Tibet belong to the Tethian and Turkestan–Paleoasian systems of paleooceanic basins. The tectonic evolution of these systems in the Phanerozoic was not coeval and unidirectional. The sialic blocks of the future Tien Shan, Pamir, and Tibet were incorporated into the Eurasian continent during several stages. In the Late Ordovician and Silurian several microcontinents were preliminarily combined into the Kazakh–Kyrgyz continent as a composite aggregation. The territories of the Tien Shan and Tarim became a part of Eurasia after the closure of the Turkestan, Ural, and Paleotethian oceans in the Late Carboniferous and Early Permian. The territories of the Pamir, Karakorum, Kunlun, and most of Tibet attached to the Eurasian continent in the Triassic. The Lhasa and Kohistan blocks were incorporated into Eurasia in the Cretaceous, whereas Hindustan was docked to Eurasia in the Paleogene.

DOI: 10.1134/S001685211005002X

INTRODUCTION

The geological and biogeographical data on the paleooceanic basins of the Tien Shan and High Asia are summarized in this paper.

The territory under consideration (Figs. 1, 2) includes Afghanistan, India, Kazakhstan, China, Kyrgyzstan, Tajikistan, and Uzbekistan. For a long time, geological studies of the territories on opposite sides of the Chinese border were performed independently because of political and linguistic difficulties. This is reflected in different names for tectonic units that extend from one region to the other. In the Tien Shan, the Chinese border is located between the Central Tien Shan and East Tien Shan geographic provinces. In High Asia, this border separates the Pamir from the Kunlun and Tibet. The correlation of the tectonic zones in the Central and East Tien Shan is considered in [5, 44, 45]. Alternative interpretations of the correlation of the tectonic zones and oceanic sutures in the Pamirs, Kunlun, and Tibet are discussed in [6, 84].

OCEANIC BASINS EXISTING IN THE EARLY PALEOZOIC

In the beginning of the Neoproterozoic, the Rodinia supercontinent broke down into several continents separated by oceanic basins. In the Cryogenian and Edicaran, the continental rifting accompanied by accumulation of diamictites and volcanic activity led to further fragmentation of sialic blocks and the formation of oceanic basins [20, 75]. In the Edicaran (Vendian) and Early Paleozoic, the territory under consideration consisted of five continents and microcontinents: East Gonwana, Alay–Tarim, Syr Darya, Issyk-Kul (Ysyk-Köl), and Borohoro, which were separated by the Terskey (Teskey), Yili, Turkestan, and Kunlun oceanic basins (Fig. 2).

The Terskey Basin

The Terskey oceanic basin was situated between the Early Paleozoic Syr Darya and Issyk-Kul continental terranes. The rocks pertaining to the oceanic crust and island arcs of the Terskey Basin make up a belt of ophiolite allochthons, which extends from the Kyrgyz Range to the Terskey (Teskey) Range. In the Kara-Archa ophiolites (Fig. 3, *Kr*), chert interbeds contain Late Cambrian and Early–Middle Ordovician conodonts. The Ar/Ar ages of the gabbro and basalt are 480 and 460 Ma [35]. In the Kenkol (Keng-Köl) ophiolites (Fig. 3, *Kn*) and the Karakatty ophiolites (Fig. 3, *Kk*), the Middle–Late Cambrian and Ordovician fauna are contained in cherts associated with lavas. At the northwestern spurs of the Tien Shan (in the Lesser Karatau Mountains), the Edicaran conglomerate contains pebbles of ultramafic rocks and red chert—probable fragments of the eroded crust of the Terskey oceanic basin. The chemistry of the lavas in the ophiolite sections determines their classification as MORB-like basalts and rocks of oceanic island arcs [1, 8, 19]. In the Late Paleozoic, the rocks of the Syr Darya Terrane were thrust over the Issyk-Kul Terrane and overlapped the Early Paleozoic suture. As a result, the Early Paleozoic Terskey suture is marked on the Earth's surface by Late Paleozoic thrust and strike-slip faults.

A belt of I-type granites is located in the Kyrgyz Range (Fig. 3, *6*), the Jumgal Range (Fig. 3, *7*), and the Terskey Range (Fig. 3, *8*) to the north of the suture of the Terskey oceanic basin. The I-type granites have Ordovician U–Pb and Pb/Pb ages. The S-type granites widespread in the Issyk-Kul Terrane cut through the I-type granites and the Upper Ordovician molasse. The U–Pb and Pb/Pb ages of the S-type granites (460–420 Ma) correspond to the Late Ordovician–Silurian [8, 13, 70].

History and geodynamics. The Terskey oceanic basin probably opened in the Neoproterozoic. The Syr Darya margin of the oceanic basin was passive throughout its entire history. The oceanic island arc which existed in the basin was docked to the Issyk-Kul Terrane in the Early Ordovician.

The subduction of the oceanic crust of the Terskey Basin beneath the margin of the Issyk-Kul Terrane resulted in closure of the oceanic basin and led to the collision of the Syr Darya and Issyk-Kul terranes in the Middle–Late Ordovician. This was the onset of the formation of the Kazakh–Kyrgyz continent. The collision of the microcontinents was accompanied by the development of tectonic nappes composed of rocks pertaining to the oceanic crust, accretionary wedge, and margins of the adjoining terranes. The collision was followed by orogeny and accumulation of Middle–Upper Ordovician molasse [5, 8, 19, 22, 44].

The Yili Basin

The Yili oceanic basin was situated between the Early Paleozoic Borohoro and Issyk-Kul continental terranes (Figs. 2, 3). The rocks of the oceanic crust from the Yili Basin occur as tectonic nappes and klippen at the margin of the Issyk-Kul Terrane.

The Chu–Yili ophiolites (Fig. 3, *Ch*) are localized as a zone more 500 km in extent in the mountains bearing the same name and in the Kendyktas Mountains. The ophiolites are composed of serpentinite melange, harzburgite, dunite, gabbro, plagiogranite, basalt, and chert commonly contacting with one another and with other rocks along the faults. The U–Pb age of the plagiogranite was determined at 510, 519 ± 4, and 521 ± 2 Ma. The cherts associated with the basalts contain Late Cambrian and Tremadocian conodonts [8, 33, 55]. The age of the ophiolite obduction over the Issyk-Kul continent is determined by the appearance of ophiolite pebbles in the Tremadocian sediments covering the continental massif. In the Kendyktas Mountains, the obducted ophiolites are unconformably overlapped by Arenigian rocks. Ophiolite klippen derived from the Yili Basin also occur in the Trans-Yili Range (Fig. 3, *3*), Kungey (Künggó) Range (Fig. 3, *4*), and Ketmen Range (Fig. 3, *5*). In geochemistry, the lavas of the ophiolite association correspond to MORB and basalts of marginal basins [8, 33].

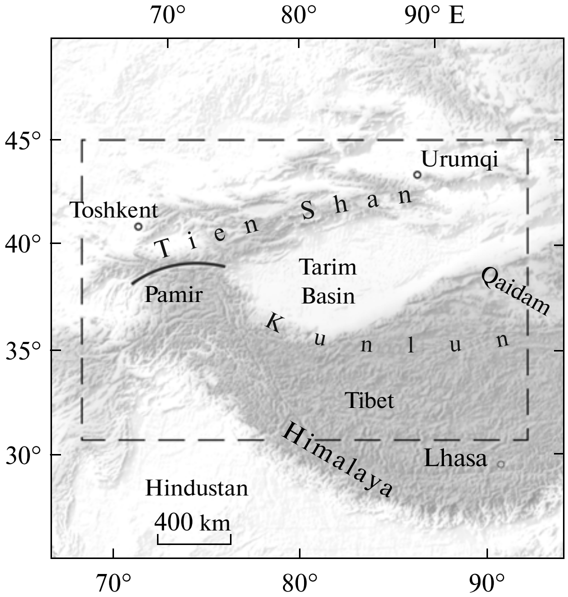

Fig. 1. Regional orography. The dashed rectangle is the contour of Fig. 2.

The Ordovician subduction-related volcanic rocks occurring at the Yili margin of the Issyk-Kul Terrane are known from the Kendyktas Mountains (Fig. 3, *1*) and the Trans-Yili, Kungey, and Ketmen ranges. The Middle–Late Ordovician U–Pb age of the I-type granites is established in the Trans-Yili and Kungey ranges [13]. In the Trans-Yuli Range, they are overlapped by red beds containing Ashgillian fossils. In the Kastek Range (Fig. 3, *2*), calc-alkaline volcanic rocks contact with other rocks along the faults. The late Llandoverian–Wenlockian brachiopods and corals are contained in limestone interbeds among the volcanic rocks. The chemical composition of the volcanic rocks with abundant amygdaloidal basalts suggests that they were formed in an oceanic island arc.

In the Borohoro Terrane, subduction-related volcanic rocks are known in the Middle Ordovician–Lower Silurian sections [54]. The suture of the oceanic basin is Silurian in age.

History and geodynamics. The Yili oceanic basin probably opened in the Neoproterozoic. Metamorphism dated at the Early Cambrian [10] and exhumation of eclogites were related to the formation of an accretionary wedge. In the Ordovician, the oceanic crust of the Yili Basin subducted beneath the margin of the Issyk-Kul Terrane, and beginning from the Middle Ordovician, beneath the margin of the Borohoro Terrane.

The Early Ordovician obduction of ophiolites over the margin of the Issyk-Kul Terrane was probably related to the formation of an accretionary wedge. The rocks of the oceanic island arc obducted over the Issyk-Kul Terrane in the Wenlockian or later during

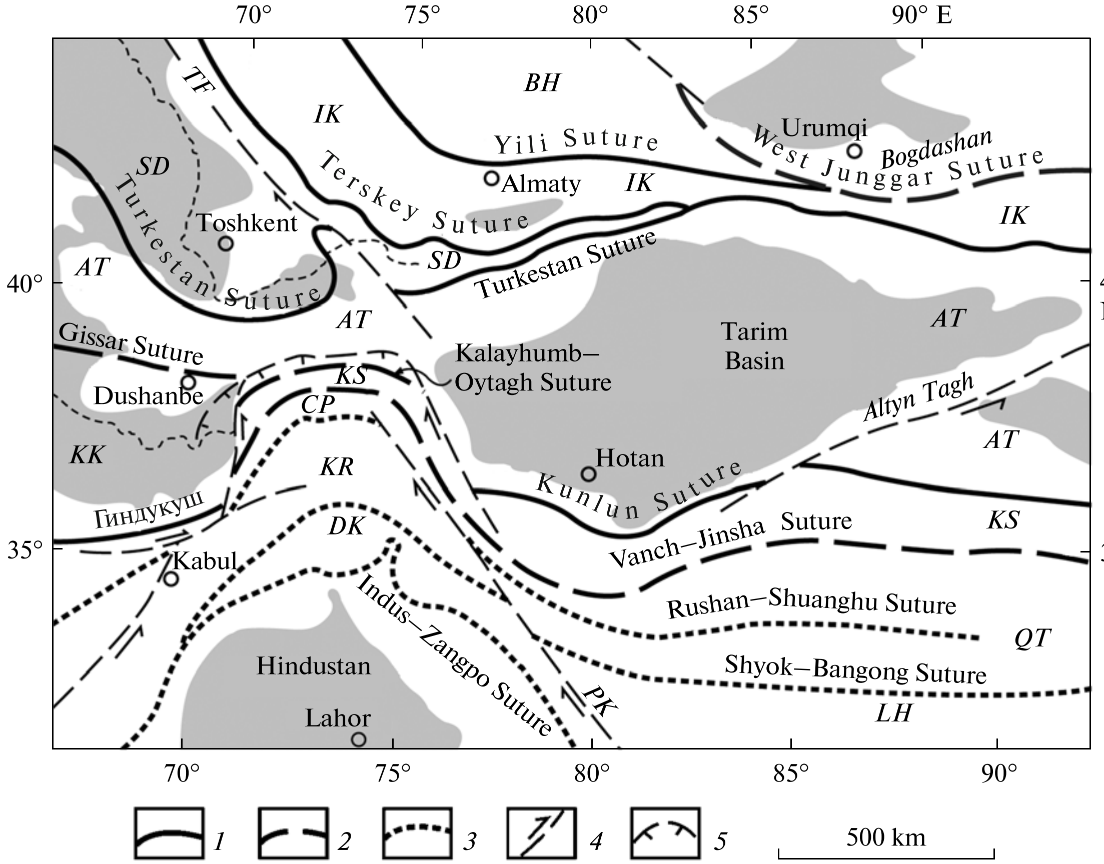

Fig. 2. Sutures of Phanerozoic oceanic basins (oceans, marginal seas, and rifts with oceanic crust) in the Tien Shan, Pamir, and Tibet. (*1–3*) Sutures of oceanic basins that arose in the (*1*) Neoproterozoic, (*2*) Carboniferous, and (*3*) Permian; (*4*) strike-slip faults (*PK*, Pamir–Karakorum and *TF*, Talas–Fergana); (*5*) thrust faults. Terranes with continental crust, including continents, microcontinents, and ensialic island arcs (letters in figure): *AT*, Alay–Tarim; *BH*, Borohoro; *CP* Central Pamir; *DK*, Dras–Kohistan; *IK*, Issyk-Kul; *KR*, Karakorum; *KK*, Karakum; *KS*, Kurgovat–Songpan; *QT*, Qiangtang; *LS*, Lhasa; *SD*, Syr Darya.

the closure of the Yili oceanic basin caused by collision of the Issyk-Kul and Borohoro terranes.

The Turkestan Basin

The Early Paleozoic Turkestan oceanic basin separated the Alay–Tarim continent from the Syr Darya Terrane and later from the Kazakh–Kyrgyz continent.

Fragments of the oceanic crust pertaining to the Turkestan Basin occur as allochthons overlying the Alay–Tarim continent. According to paleontological data, the ophiolites are Early Cambrian, Ordovician, Silurian, Devonian, and Early Carboniferous in age. The most complete sections are retained in the Sarytal ophiolites of the West Tien Shan (Fig. 4) and the Seikeyailake ophiolites (Fig. 5, *Se*) in the East Tien Shan [15, 55].

Zircons from metamorphosed Yushugou ophiolites (Fig. 5, *Yu*) have U–Pb (SHRIMP) ages of 596, 430, and 398 Ma [91, 95]. The U–Pb and Pb/Pb ages of the zircons from the dunite and gabbro in the metamorphosed Shaidan ophiolites of the North Fergana are 532 ± 12 and 475–395 Ma, respectively [14]. The Ar/Ar plateau age of the pyroxene from the gabbro in the Changawuzhi ophiolites (Fig. 5, *Ch*) is 439 ± 27 Ma; the amphibole from the ophiolitic melange is dated at 430–420 Ma [49, 63]. The U–Pb age of the basalts from the Kule ophiolitic melange (Fig. 5, *Ku*) is 425–395 Ma [67]. The Rb–Sr isochron age of the plagiogranite from the Gulugou ophiolites (Fig. 5, *Gu*) is 358 ± 15 Ma. In the Liuhuang ophiolites (Fig. 5, *Li*), lavas from the melange have a Rb–Sr isochron age of 340 ± 4 Ma; the Ar/Ar plateau age of the gabbro is 333 Ma [54].

Judging from the chemistry, MORB-like basalts along with basalts of marginal oceanic basins and oceanic islands are identified [15, 36, 49, 54, 67].

Metamorphic green and blue schists occur along the Turkestan Suture. The Rb–Sr isochron age of the eclogite in the Atbashi Zone in the Central Tien Shan (Fig. 4) was determined at 267 ± 5 Ma (garnet, omphacite, phengite, and whole-rock sample) [87]. The chemical composition of the eclogites corresponds to IAB- and MORB-like basalts [34]. The

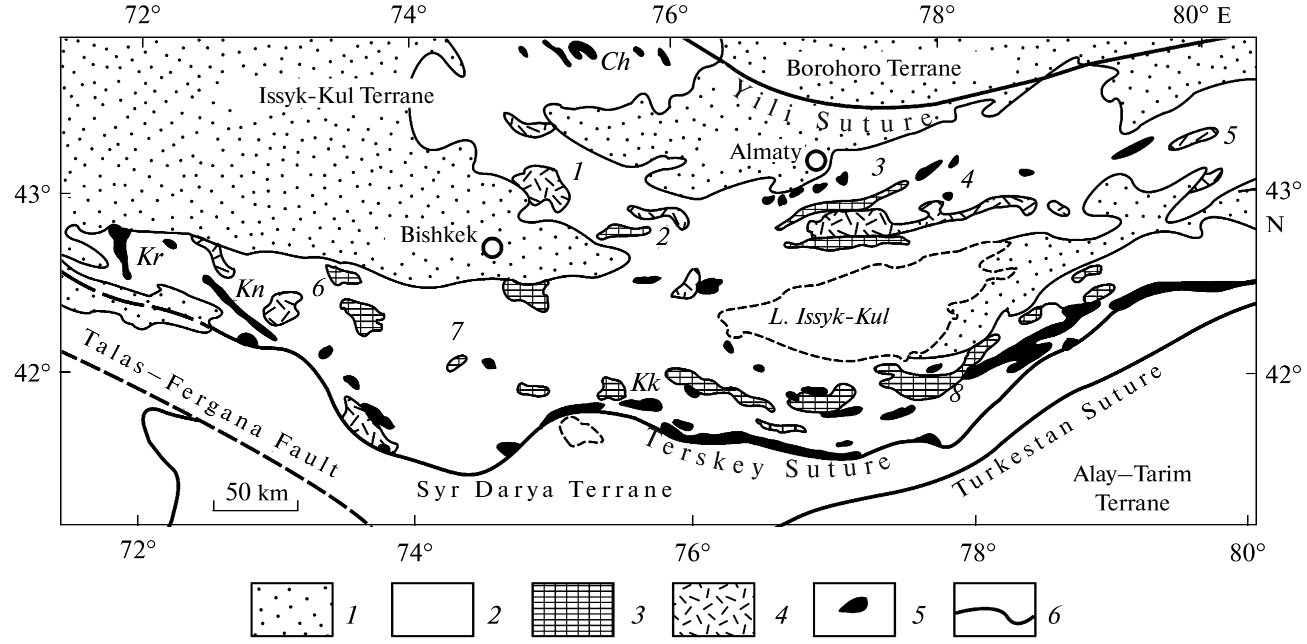

Fig. 3. Ophiolites and subduction-related igneous rocks in the Early Paleozoic Issyk-Kul Terrane. (*1*) Cenozoic and Mesozoic; (*2*) Paleozoic and Proterozoic; (*3, 4*) Ordovician igneous rocks: (*3*) I-type granite, (*4*) subduction-related volcanic rocks; (*5*) Early Paleozoic ophiolites; (*6*) oceanic suture. Ophiolites (letters in figure): *Ch*, Chu–Yili; *Kn*, Kenkol; *Kr*, Kara-Archa; *Kk*, Karakatty; mountain ranges (numerals in figure): *1*, Kendyktas; *2*, Kastek; *3*, Trans-Yili; *4*, Kungey; *5*, Ketmen; *6*, Kyrgyz; *7*, Jumgal; *8*, Terskey.

Ar/Ar plateau age of metamorphism was determined in the East Tien Shan for glaucophane, crossite, and phengite at 420 ± 4, 415 ± 2, 361 ± 2, 351 ± 2, and 345 ± 7 Ma [49, 53, 54, 95].

Silurian, Devonian, Carboniferous, and Permian subduction-related volcanic and plutonic rocks occur to the north of the Turkestan oceanic suture. The U–Pb zircon ages of I-type granites from the East Tien Shan are 298 and 285 Ma [95]; the postcollision A-granites in the Central and East Tien Shan are dated at 296–260 Ma [61, 66].

The Turkestan oceanic suture (Fig. 2) was formed in the Moscovian Age of the Late Carboniferous due to the collision of the Alay–Tarim and Kazakh–Kyrgyz continents. In the Late Permian, the North Fergana Block of the Alay–Tarim Terrane was deformed and thrust over the margin of the Kazakh–Kyrgyz continent; it overlapped the Turkestan Suture. As a result, the Alay–Tarim and Kazakh–Kyrgyz terranes are divided in the North Fergana by a Late Paleozoic thrust fault the line of which is a kenotaph of the buried oceanic suture. In the Permian and Cenozoic, the boundary between the Alay–Tarim and Kazakh–Kyrgyz terranes was displaced for 200 km along the right-lateral Talas–Fergana Strike-Slip Fault. In the Central and East Tien Shan (Figs. 4, 5), the Turkestan Suture continues as a system of left-lateral strike-slip and thrust faults along which northward thrusting occurred in the Late Paleozoic [53, 79, 95].

History and geodynamics. The Turkestan oceanic basin arose in the Neoproterozoic and then existed for about 300 Ma. The spreading of the oceanic crust ceased in the Late Devonian. Neither spreading nor subduction took place in the Turkestan Basin from the Late Devonian to the Visean. Subduction of the oceanic crust beneath the Kazakh–Kyrgyz continent resumed in the Serpukhovian and was followed by the collision of the Alay–Tarim and Kazakh–Kyrgyz continents in the Moscovian. After collision, the subduction of the oceanic crust gave way to the subduction of the continental Alay–Tarim Terrane beneath the Kazakh–Kyrgyz continent. Subduction continued until the Late Permian or Early Triassic and was accompanied by metamorphism and exhumation of eclogites.

As a result of continental collision, a multilayer nappe belt was formed in the Late Carboniferous and Permian at the margin of the Alay–Tarim continent, and orogeny followed this event [2, 5, 45].

The Kunlun Basin

The Kunlun oceanic basin was situated between the Alay–Tarim continent and the sialic Songpan Block, which was a part of East Gonwana in the early Paleozoic. The suture of the Kunlun oceanic basin separates the Tarim and Qaidam from Tibet (Fig. 2) and is marked by a series of ophiolites (Fig. 6).

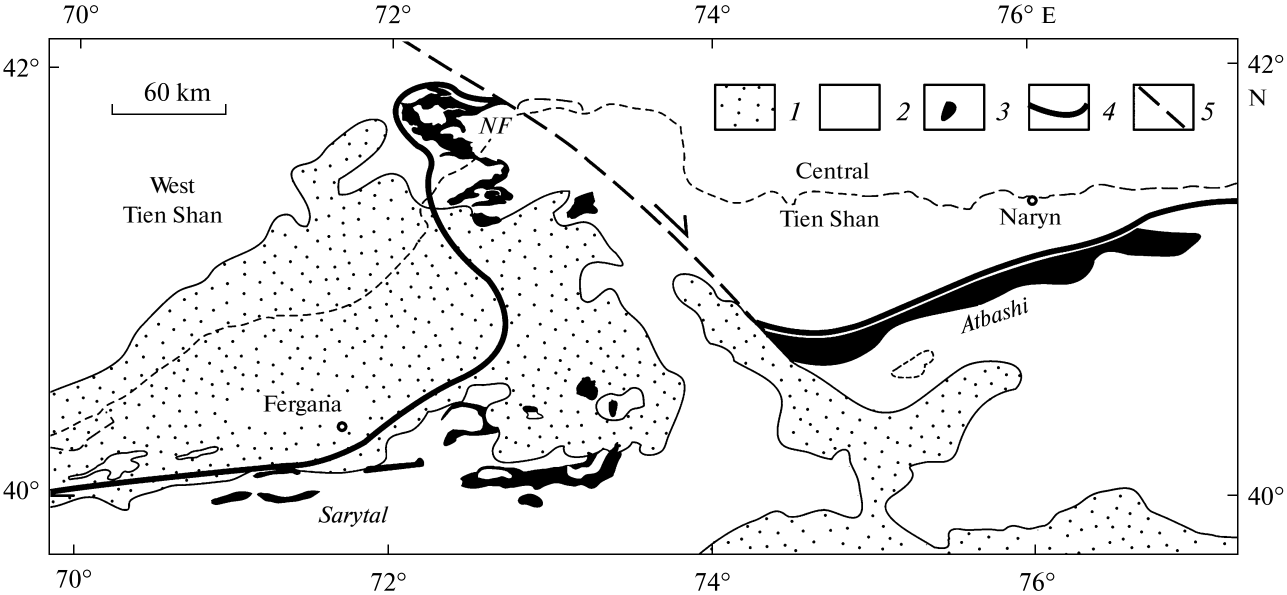

Fig. 4. Oceanic crustal rocks of the Turkestan Basin in the West and Central Tien Shan. (*1*) Cenozoic and Mesozoic; (*2*) Paleozoic; (*3*) oceanic crustal rocks; (*4*) suture of the Turkestan oceanic basin; (*5*) Talas–Fergana Strike-Slip Fault; *NF*, North Fergana.

In the East Kunlun, numerous outcrops of ophiolites occur in the Anyemaqen Zone (Fig. 6, *An*). Blocks and tectonic slices of ophiolites and other rocks are incorporated into flysch. The serpentinite melange contains chert fragments with Ordovician acritarchs and Early Carboniferous radiolarians. Terrigenous flysch with Late Carboniferous and Early Permian radiolarians occur as tectonic slices. The carbonate–terrigenous rocks with Artinskian–Kungurian foraminifers unconformably overlap this melange [77]. The following isotopic ages were obtained for gabbro and basalt from the blocks and tectonic slices: Rb–Sr isochron ages of 518 ± 102, 495 ± 81, 481 ± 130, 480 ± 21, 340 ± 12, and 260 Ma; Pb/Pb zircon ages of 491 ± 44 and 310 ± 150 Ma; and U–Pb zircon ages of 413 and 467 ± 1 Ma [37–39, 83]. The amphibolite from this zone was dated at 579 Ma [97]. The geochemistry of the basalts and gabbro indicates that they were formed in a mid-ocean ridge [37].

Judging from their geochemical attributes, the ophiolites and basic and intermediate volcanic rocks in the Anyemaqen Zone of the southern branch of the Kunlun Suture were formed in an oceanic island arc [74]. These volcanic rocks are overlain by calcarenite with Asselian and Sakmarian conodonts. The Tatuo ophiolites in the northern branch of the Kunlun Suture (Fig. 6, *Ta*) comprise peridotite, troctolite, gabbro, sheeted dikes, and basalts of presumably island-arc origin [47, 77]. The Dur'ngoi ophiolites in the eastern segment of the Anyemaqen Zone (Fig. 6, *Du*) comprise cumulative gabbro, dolerite dikes, and pillow island-arc tholeiites. The rocks are metamorphosed under conditions of amphibolite facies. The U–Pb age of metamorphism is 421–417 Ma [83]. The island-arc granites from the same zone have U–Pb zircon age of 402 ± 24 Ma [38].

The Rb–Sr isochron age of the gabbro and island-arc basalts in the Wanbaogou ophiolites (Fig. 6, *Wa*) is 684 Ma [97]. The suture of the oceanic basin extends along the Cenozoic left-lateral strike-slip fault.

Further to the west, the suture of the Kunlun oceanic basin is marked by serpentinite melange with the Ulugh Muztag peridotite and cumulative gabbro (Fig. 6, *Um*) and the Tuokuzidaban basalts (Fig. 6, *Tu*). The thick sequence of basalts and basaltic andesites in the Tuokuzidaban Mountains contains interbeds of sedimentary rocks with Visean brachiopods and corals [71, 99].

The Kudi ophiolites in the West Kunlun (Fig. 6, *Kd*) comprise dunite, peridotite, cumulative gabbro, dikes, a thick sequence of pillow basalts, radiolarites, and deepwater turbidites. The geochemistry of the igneous rocks indicates that they were formed under conditions of a mid-ocean ridge and island arc [72, 97]. Marble interbeds with Cryogenian and Edicaran stromatolites occur in the ophiolitic section. The U–Pb isochron age of the amphibolite dike in the ultramafic rocks is 816 Ma [59]. The ophiolites are cut through by diorite, granodiorite, and monzodiorite. The Rb–Sr isochron ages of the monzogranite are 423 and 510 Ma (whole-rock samples) and of the diorite and granodiorite 480 Ma. The U–Pb ages of the hornblende and zircon from these rocks are 474 and 458 Ma [59, 72, 96]. The U–Pb (SHRIMP) zircon ages were estimated at 492 ± 7 Ma for the island-arc dacite and at 471 ± 5, 408 ± 7, and 214 ± 1 Ma for the granites of the active continental margin [93, 94]. The Rb–Sr iso-

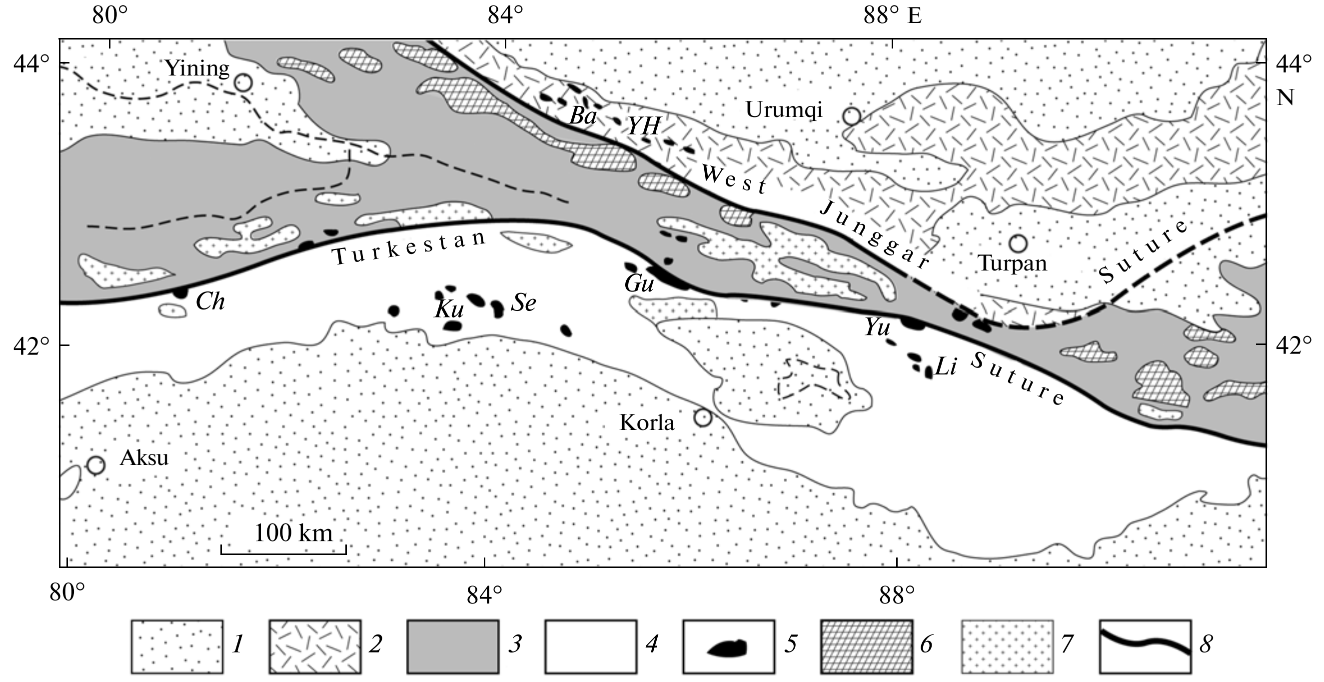

Fig. 5. Ophiolites and I-type granites in the East Tien Shan. (*1*) Cenozoic and Mesozoic; (*2*) Late Paleozoic Bogdashan volcanic island arc; (*3, 4*) Paleozoic and pre-Paleozoic rocks of (*3*) Kazakh–Kyrgyz and (*4*) Alay–Tarim terranes; (*5*) ophiolites; (*6, 7*) I-type granites: (*6*) Late Carboniferous–Early Permian and (*7*) Silurian–Carboniferous; (*8*) suture of oceanic basin. Ophiolites (letters in figure): *Ba*, Bayingou; *Ch*, Changawuzhi; *Gu*, Gulugou; *Ku*, Kule; *Li*, Liuhuang; *Se*, Serikeyayilake; *Yu*, Yushugou; *YH*, Yilinharbergan Mountains.

chron age of the pillow lavas is 359 Ma (whole-rock samples) [47].

The Kudi ophiolites are unconformably overlain by flysch with Ordovician radiolarians [101] and Devonian rocks [72]. Other authors described the tectonic contacts of the Kudi ophiolite with adjoining rocks and reported Late Paleozoic microfossils in the cherts from the ophiolitic section [47, 68]. The Kudi ophiolite zone probably comprises rocks varying in age from the Neoproterozoic to the Late Paleozoic.

Devonian, Carboniferous, and Triassic calc-alkaline volcanic rocks occur in the East Kunlun to the north of the Kunlun Suture [48, 51, 78, 101]. A belt of granites whose geochemistry confirms their formation at the active oceanic margin and after collision extends along the northern slope of the East Kunlun [57]. Rb–Sr ages of 394 ± 13 and 257 ± 26 Ma and U–Pb zircon ages of 431–413 and 240 ± 6 Ma are determined for the granite and granodiorite. The granite and monzogranite which cut through Upper Triassic rocks have Rb–Sr isochron age of 194 ± 17 Ma [50, 56, 78, 85].

In West Tibet, occurrences of subduction-related magmatism (Late Paleozoic and Triassic volcanic rocks, granite and granodiorite) are localized in the Tiznaf Zone to the south of the Kunlun Suture. The Rb–Sr isochron age of biotite from the granodiorite is 267 Ma; the Ar/Ar ages of the granite are 211 ± 8 and 212 ± 11 Ma [68, 96]. The geochemistry of the granites indicates that they are subduction-related [47]. The older granites known in this zone are similar in origin; their U–Pb zircon age and the Ar/Ar age of the biotite are 377 and 320 ± 2 Ma; the Rb–Sr age is 380 ± 10 Ma (biotite) and 392 ± 35 Ma (whole-rock samples) [50, 68]. Red molasse with Late Triassic fossils and a coal-bearing sequence with Jurassic flora unconformably rest upon the older rocks [69].

Granites, the formation of which could be related to subduction of the Kunlun oceanic crust, occur in the sialic Kurgovat–Yarkend Block in the Pamir. The U–Pb age of these granites is 222–215 Ma. The cooling Ar/Ar ages of the biotite and muscovite are 207–191 Ma [84].

The Late Paleozoic and Cenozoic Altyn Tagh Strike-Slip Fault (Fig. 6) may be a trail of the early Paleozoic oceanic basin, a rift-related branch of the Kunlun ocean. A belt of ophiolitic melange with blocks of dunite, harzburgite, gabbro, and tholeiitic basalt extends along the Altyn Tagh Fault. The basalts contain limestone interbeds with Middle Ordovician conodonts and are overlain by turbidites with Middle–Late Ordovician corals and brachiopods [6]. The Sm–Nd isochron age of the basalts from the Mangya melange (Fig. 6, *Ma*) is 481 ± 53 Ma. Granite with Ar/Ar age of 432 ± 8 Ma cuts through the ophiolites and the rocks pertaining to the Tarim Massif [85].

History and geodynamics. The Neoproterozoic age of rift-related volcanics [48, 75, 78, 98] shows that the Kunlun oceanic basin has existed since the Protero-

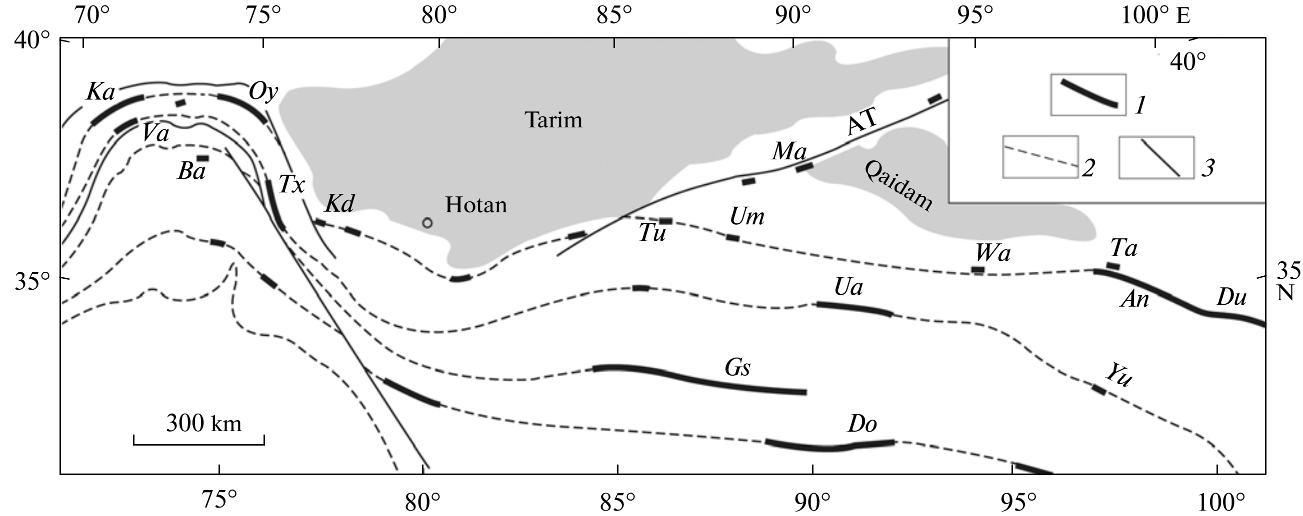

Fig. 6. Ophiolites in the Pamir and Tibet. (*1*) Ophiolite, (*2*) oceanic suture; (*3*) fault (AT, Altyn Tagh). Ophiolites (letters in figure): *An*, Anyemaqen; *Ba*, Bashgumbez; *Do*, Dongkiao–Amdo; *Du*, Dur'ngoi; *Gs*, Gangmaco–Shuanghu; *Ka*, Kalayhumb; *Kd*, Kudi; *Ma*, Mangya; *Oy*, Kungai–Oytagh; *Ta*, Tatuo; *Tu*, Tuokuzidaban; *Tx*, Taaxi; *Ua*, Ulan Ula; *Um*, Ulugh Muztag; *Va*, Vanch; *Wa*, Wanbaogou; *Yu*, Yushu.

zoic. Signs of its existence over all periods of the Paleozoic are retained. The rocks of ophiolitic association with paleontological and isotopic age estimates from the Lower Cambrian to the Upper Permian are known, as well as Ordovician, Silurian, Devonian, Carboniferous, Permian, and Triassic subduction-related volcanic and granitic rocks.

The Devonian metamorphism, deformation, and granites, in combination with the Upper Devonian molasse occurring in the Kunlun furnish evidence for the Tibet–Tarim collision in the Middle Devonian and disappearance of the Kunlun oceanic basin [68, 73]. At the same time, no evidence for resumed rifting in the Late Devonian–Early Carboniferous are known. The available data, however, indicate that a mid-ocean ridge, oceanic island arcs, and marginal seas existed in the Kunlun oceanic basin in the Carboniferous. It cannot be ruled out that the manifestation of orogeny in the Devonian was a result of short-term transpressional contact of East Gondwana with the Alay–Tarim Block. It is, however, more probable that these phenomena were a consequence of collision of East Gondwana with an island arc. Rocks of the oceanic island arc that collided with Tibet in the Devonian are known in the East Kunlun.

The Late Paleozoic subduction zone plunged toward the Qaidam in the East Kunlun and toward Tibet in the West Kunlun. The polarity of subduction changed along the Altyn Tagh Fault, which was a transform boundary. Angular unconformities in the Upper Triassic and Triassic sequences and accumulation of Permian molasse indicate that orogeny started in the Permian as a result of collision with an island arc and continued in the Triassic due to the collision of the northern block of Tibet with the Alay–Tarim continent. The Kunlun oceanic basin had closed completely before the deposition of the Upper Triassic continental sediments.

The western continuation of the Kunlun Suture Zone is concealed beneath the Pamir Block, which thrust over this zone in the Cenozoic [43, 46], and may occur in the West Hindu Kush (Fig. 2). Evidence for the existence of the Early Paleozoic Hindu Kush oceanic basin was given in [40, 44]. The sutures of oceanic basins that existed in the Carboniferous as marginal seas of the Kunlun ocean are retained in the Northwest Kunlun, North Pamir, and South Tien Shan.

OCEANIC BASINS THAT AROSE IN THE CARBONIFEROUS

The sutures of the Vanch–Jinsha ocean and the marginal basins of the Kunlun and Paleoasian oceans (Gissar, Kalayhumb–Oytag, West Junggar) that arose in the Carboniferous are localized in the territory under consideration (Fig. 2).

The Vanch–Jinsha Basin

The suture of the Vanch–Jinsha oceanic basin separates the Kurgovat–Songpan and Central Pamir–North Qiangtang sialic blocks. In East Tibet, the Jinsha Suture is marked by the Yushu ophiolites (Fig. 6, *Yu*), which are incorporated into the Upper Triassic rocks as tectonic blocks. The ophiolites are composed of gabbro, pillow basalt, picrite, and silicite. The geochemistry of the igneous rocks indicates that volcanic eruptions occurred in the mid-ocean ridge [74]. In Central Tibet, the Jinsha Suture is marked by the Ulan Ula ophiolitic zone (Fig. 6, *Ua*), where serpentinite melange, ultramafic rocks, gabbro, pillow lava, picrite, and chert with Tournaisian microfossils crop out. In chemistry, the igneous rocks are similar to OIB. The Rb–Sr age of the gabbro is 266 ± 41 Ma. The ophiolitic melange is unconformably overlain by Upper Permian–Lower Triassic rocks [47].

The lack of data makes it possible to compare several variants of the western continuation for the Jinsha Suture. In the accepted variant, the suture extends via the East Pamir, where it is marked by the Taaxi ophiolites (Fig. 6, *Tx*) [4, 59], to the North Pamir, where it separates the Kurgovat and Central Pamir sialic blocks. In the Vanch ophiolitic zone (Fig. 6, *Va*) of the North Pamir, the suture is marked by a belt of serpentinized ultramafic protrusions and lenticular gabbro and diorite bodies. Low-Ti and high-Mg dunite, peridotite, and pyroxenite close to the Alpine-type ultramafics are discernible among the serpentinized rocks [7]. The ultramafic rocks are associated with basic pillow lavas. The limestone lenses hosted in the lavas contain Visean corals and Permian fusulinids [12, 27]. In chemistry, the volcanic rocks correspond to tholeiitic basalts [3]. This belt of volcanic and ultramafic rocks extends to the southwest in Northeast Afghanistan.

The Triassic–Liassic granitic belt is located in the North Pamir and Northwest Kunlun, to the north and east of the Vanch–Jinsha Suture. The U–Pb zircon age of the granites from the Northwest Kunlun is 204 Ma; in chemistry, these granites correspond to igneous rocks formed in subduction-related and collision settings [59, 102]. The Early Jurassic granites occurring to the north of the Vanch–Jinsha Suture in the Tianshuihai Zone of West Tibet apparently had the same origin. Their U–Pb zircon age is 192 Ma; the Ar/Ar plateau ages of the muscovite and biotite are 190 ± 8 and 177 ± 3 Ma, respectively.

History and geodynamics. The age of the ophiolites shows that the Vanch–Jinsha oceanic basin existed from the Carboniferous to the Permian. The time of origination of this basin is not documented and may be older. The oceanic basin closed in the Permian–Triassic due to subduction of the oceanic crust beneath the sialic Kurgovat–Songpan Block marked a belt of subduction-related and collision granites. Deformation and obduction were concomitant to the closure.

The Gissar Basin

The rocks derived from the Gissar oceanic basin contact the adjacent Paleozoic rocks along faults. The base of the visible ophiolitic section is composed of sheeted basaltic and microdioritic dikes. The dikes intruded one another and the Lower Paleozoic metamorphic schists pertaining to the continental crust and occurring to the north and south of the dike belt. This indicates that the dike complex is rift-related. Small protrusions of serpentinized peridotite and blocks of gabbro occur within this belt. Upsection, the dikes give way to volcanic rocks. The lower part of the volcanic pile is occupied by low–Ti tholeiitic pillow basalts, picrites, and hyaloclastites. In the middle part of the section, the basalts and basaltic andesite contain chert and limestone interbeds with late Serpukhovian conodonts and goniatites. Andesitic, basaltic andesitic, and dacitic lavas, tuffs, and tuffites alternate in the upper part of the section; Bashkirian and early Moscovian foraminifers are contained in the limestone interbeds. The turbidites at the walls of the rift contain Moscovian and Kasimovian foraminifers and brachiopods [9, 26]. The Ar/Ar age of the biotite from the postcollision granite is 277 ± 6 Ma [84].

History and geodynamics. The oceanic Gissar Rift followed by deepwater sea existed during the Serpukhovian–Kasimovian ages. Continental rifting began in the Tournaisian, and bimodal volcanic and clastic rocks accumulated in the rift(s) and marine basin. In the late Serpukhovian, the rupture of the crust attained the upper mantle and a rift with oceanic crust separated the sialic Karakum (Qaraqum) Block from the Alay–Tarim Terrane. The progressive fractionation of the melt resulted in the formation of Serpukhovian–early Moscovian basalts and andesites. In the east (in present-day coordinates), the Gissar oceanic rift opened into the Kunlun oceanic basin; in the west, the rift probably abutted on the Turan Platform.

The Gissar Basin closed in the Kasimovian or Gzelian, when the deposition of flysch had been completed. The collision of the Karakum and Alay–Tarim terranes, which combined them again, was accompanied by obduction of fragments of the Gissar oceanic crust, folding, and emplacement of collision granites. The suture of the Gissar Basin was deformed in the Permian and Cenozoic.

The Kalayhumb–Oytagh Basin

The suture of the backarc Kalayhumb–Oytagh Basin that extends in the North Pamir and the Northwest Kunlun (Fig. 2) is marked by Carboniferous ophiolites.

The Kalayhumb ophiolites (Fig. 5, *Ka*) are composed of dunite, peridotite, and a stratified sequence of pillow basalts with limestone interbeds containing Serpukhovian ammonites in the upper part of the section. The basalts are MORB-like in chemical composition. The ophiolite complex is overlain by a series of calc-alkaline and subalkaline basaltic andesite, andesite, dacite, and rhyolite, which make up a section of oceanic island arc. The volcanic rocks are replaced by tuffaceous and terrigenous rocks and olistostrome sequence with Early Serpukhovian ammonites in the olistoliths [26, 30]. The U–Pb and Ar/Ar ages of the metavolcanic rocks range from 358 to 325 Ma [84]. The volcanic rocks and coeval sedimentary rocks are unconformably overlapped by conglomerate and limestone with late Bashkirian and Moscovian foraminifers.

The Kungay–Oytagh pillow basalts (Fig. 6, *Oy*) with chert interbeds and ultramafic bodies are overlapped by bimodal volcanic rocks and sedimentary members with Visean corals [99]. The Rb–Sr age of the basalt is about 360 Ma [97]. The rocks are cut through by granite with a U–Pb zircon age of 277 ± 6 Ma [96].

History and geodynamics. The age of the ophiolites and island-arc rocks indicates that the Kalayhumb–Oytagh Basin evolved from the early Serpukhovian to the late Bashkirian and closed in the Bashkirian or early Moscovian as a result of collision of the oceanic island arc and the sialic Kurgovat–Songpan Block [26, 30].

The West Junggar Basin

The West Junggar Basin separated the Bogdashan island arc from the Kazakh–Kyrgyz continent. The suture of this oceanic basin extends along the Late Paleozoic Junggar Strike-Slip Fault and probably continues eastward beneath the Cenozoic sediments of the Turpan Basin (Fig. 2).

The klippen of ophiolitic allochthons rest upon the Upper Carboniferous rocks in the Yilinharbergan Mountains to the northeast of the oceanic suture. The Bayingou ophiolites (Fig. 5, *Ba*) are composed of dunite, peridotite, cumulative gabbro, plagiogranite, dike complex, and massive and pillow tholeiitic basalts alternating with cherts. The chemical composition of the basalts shows that they were formed in a mid-ocean ridge. The Rb–Sr age of the basalts is 325 ± 7 Ma [92]. The U–Pb (SHRIMP) zircon age of the gabbro varies from 344 ± 3 to 325 ± 7 Ma [88]. The obduction of the ophiolites was directed from the southwest to the northeast (in present-day coordinates) [54, 89].

The belt of volcanic and granitic rocks is located at the margin of the Kazakh–Kyrgyz Terrane to the west of the Junggar Fault (Fig. 5). The trace element contents in these rocks confirm their subduction-related origin. The Rb–Sr isochron age of the andesitic and dacitic lavas and tuffs is 345 ± 9 Ma [54]; the granites are dated at 339 and 292 ± 15 Ma [54, 90]. The molasse is Upper Permian in age. The eastern continuation of the belt of subduction-related igneous rocks is situated to the south of the Turpan Basin, where Carboniferous calc-alkaline igneous rocks are cut through by Late Carboniferous and Permian granites [62].

History and geodynamics. The belt of subduction-related igneous rocks in the Borohoro Range at the margin of the Kazakh–Kyrgyz paleocontinent and ophiolitic allochthons and turbidites capping the Bogdashan oceanic island-arc rocks provide evidence for the actual existence of the West Junggar oceanic basin. The Bogdashan volcanic arc evolved in the Carboniferous and probably postdated the Devonian arc. One can speak of the West Junggar marginal sea of the Paleoasian ocean, which existed in the Devonian and Carboniferous. The suture of the Paleoasian (Irtysh–Zaisan) ocean is localized in East Kazakhstan; the ocean existed from the Neoproterozoic to the Late Paleozoic [52]. In the Middle Paleozoic, this ocean separated the Kazakh–Kyrgyz and Siberian paleocontinents.

In the Carboniferous, the oceanic crust of the West Junggar Basin subducted beneath the Kazakh–Kyrgyz continent. The West Junggar Basin closed in the Late Carboniferous or Early Permian due to the collision of the Bogdashan island arc and Kazakh–Kyrgyz paleocontinent. In the course of collision, ophiolites were obducted over the territory of the former island arc.

OCEANIC BASINS THAT AROSE IN THE PERMIAN AND TRIASSIC

The Rushan–Shuanghu Basin

The suture of the Rushan–Shuanghu Basin is marked in the Tibet by the Gangmaco–Shuanghu ophiolite zone (Fig. 6, *Gs*). In plan view, the zone is a lens more than 500 km long and about 100 km wide. The composition of the lavas varies upsection from alkali to tholeiitic basalts (MORB). Lower Permian limestone blocks occur in the basalts; the chert in the ophiolitic melange contains Triassic radiolarians. The ophiolites are associated with Upper Carboniferous–Lower Permian diamictites, which are foliated and partly transformed into glaucophane schists. The crossite from this schist has an Ar/Ar age of 223 ± 4 Ma [47, 60]. Calc-alkaline volcanic rocks, apparently of subduction-related origin, occur to the north of the Gangmaco–Shuanghu Zone.

To the east of this zone and along its strike, rocks with Upper Permian fusulinids and brachiopods crop out. The lower part of the stratigraphic section consists of limestone and basic and intermediate lavas, which give way upsection to the intercalation of basalts, sandstones, and slates. In geochemistry, the basalts correspond to intracontinental volcanic rocks. The upper part of the section is composed of clastic rocks with limestone interbeds and coal seams [47, 51, 100].

In the Pamir, the suture of the Rushan–Shuanghu Basin is a zone of thrust faults and tectonic sheets with fault-line serpentinite lenses. The tectonic sheets are composed of Permian and Triassic cherty–terrigenous and cherty–carbonate rocks, basalts, basaltic andesite, and trachyte. The tectonic sheets composed of serpentinite and harzburgite crossed by gabbro, gabbrodiorite, and plagiogranite dikes, as well as of alkali olivine and tholeiitic pillow basalts and cherts, are exposed to the south of the suture from under a Cenozoic nappe in the Bashgumbez tectonic window (Fig. 6, *Ba*). The chemistry of the basalts indicates their oceanic origin. Sequences of silicic lavas and pyroclastic rocks and olistostrome with limestone blocks with Permian and Triassic (up to the Carnian Age, inclusive) fauna rest upon the basalts. To the north, in the zone of tectonic suture, a similar olistostrome overlaps the Permian–Triassic volcanic and sedimentary rocks and contains Jurassic crinoids in limestone interbeds [11, 16, 24, 25].

History and geodynamics. The character of volcanic activity in the Rushan–Shuanghu Suture Zone shows that the continental rift originated in the Permian and was then followed by opening of the oceanic basin. The rift-related basin bluntly ends within the Qiangtang Terrane; to the east of the Gangmaco–Shuanghu ophiolite zone the continental rifting did not reach the upper mantle. The subduction zone dipped to the north (in present-day coordinates). The oceanic basin closed before the accumulation of the Lower Jurassic molasse. Judging from the age of high-pressure metamorphism in the suture zone, the Rushan–Shuanghu Basin closed in the Late Triassic.

The Neotethian Basins

The ocean of Neotethys evolved from the Triassic to the Paleogene. The sialic Lhasa Block and the Dras–Kohistan island arc separated a marginal basin currently marked by the Shyok–Bangong Suture from the Neotethys (Fig. 2). The suture consists of the Shyok and Bangong segments, displaced relative to each other by 100 km along the Pamir–Karakorum Strike–Slip Fault [76, 82].

The Bangong Suture is a boundary between the Qiangtang and Lhasa sialic blocks. In Central Tibet, the suture is marked by the Dongkiao–Amdo ophiolites (Fig. 6, *Do*) comprising intensely deformed ultramafic rocks, cumulates, pillow basalt, and packets of sheeted dikes. As follows from the chemistry, the igneous rocks were formed in oceanic and island-arc settings [74]. The Late Triassic Ar/Ar age (220–200 Ma) was determined for gabbro and amphibolites. The cherts associated with the basalts contain Early and Middle Jurassic radiolarians [47, 64].

Wild flysch or tectonic melange with blocks of harzburgite, serpentinized peridotite, gabbro, basalt, radiolarite, and limestone incorporated into the flysch matrix extends along the suture in West Tibet. A section of the ophiolite association—from peridotite via cumulates and dike complex to pillow lavas and radiolarites with Middle–Late Jurassic fauna—is described. In addition to the suture, ophiolites occur as numerous allochthonous massifs thrust over the Lhasa Block. The Rb–Sr age of the basalts ranges from 207 to 182 Ma; sedimentary rocks with Liassic and Tithonian fauna are noted among the basalts. The intensely folded flysch and ophiolitic melange is unconformably overlapped by limestone with endemic fauna of the Lower and Upper Cretaceous [64, 68, 80].

The Shyok Suture separates the Karakorum Block (Fig. 2, *KR*) from the Mesozoic Dras–Kohistan island arc (Fig. 2, *DK*), where volcanism was active in the Jurassic and Early Cretaceous. The rocks of the ophiolite association (peridotite, pyroxenite, gabbro, basalt, chert) occur as blocks in olistostrome, which also contains fragments of the Aptian–Albian limestones abundant in Kohistan. The rocks in the suture zone are folded; the isotopic age of deformation is estimated at 100–90 Ma [81]. This deformation probably was a result of collision of the Dras–Kohistan island arc with the Karakorum–Qiangtang Block related to the closure of the Shyok–Bangong marginal sea.

History and geodynamics. The Shyok–Bangong Basin was a marginal sea separated by an island arc from the Neotethys ocean. The available data indicate that the Shyok–Bangong Basin existed in the Triassic, Jurassic, and Early Cretaceous. The basin closed either by the end of the Early Cretaceous or at the beginning of the Late Cretaceous.

The ocean of the Neotethys marked by the Indus–Zangpo Suture (Fig. 2) closed in the Eocene as a result of collision of Hindustan and Eurasia; the subduction zone plunges beneath Tibet.

MAIN PHANEROZOIC EVENTS

The tectonic evolution and regional geodynamic setting are illustrated by the geodynamic sections shown in Fig. 7.

In the Cryogenian, the East Gonwana, Alay–Tarim, Syr Darya, and Issyk-Kul sialic terranes were separated by the Kunlun, Turkestan, and Terskey oceanic basins. In the Edicaran (Vendian) or Early Cambrian, the Borohoro Block detached and the Yili oceanic basin arose.

Cambrian. In the Early Cambrian, the Turkestan ocean separated benthic communities of trilobites belonging to the Indo–Australian and Pacific–Atlantic biogeographic domains. This basin was the main biogeographic barrier and the widest Cambrian ocean in this region [5].

The territory of High Asia together with the Tarim and China platforms was located in the Indo-Australian biogeographic trilobite domain [28, 29, 42], which is characterized by trilobites of the Redlichiidae family revealed in the Lower Cambrian of Australia, India, and Iran and in the Tarim, China, and Korean platforms. The Pacific–Atlantic biogeographic domain was a territory of present-day Asia situated to the north of the Tarim and China platforms, as well as Europe, North Africa, and North America.

In the second half of the Early Cambrian, a barrier also existed between the Syr Darya and Altay–Sayan provinces of the Pacific–Atlantic biogeographic domain. The Altay–Sayan biogeographic province included Kazakhstan and Mongolia as well. In the Tommotian and the Atdabanian ages, the basins of the Syr Darya and Altay–Sayan provinces connected with each other, whereas in the Botomian and Toyonian ages they were almost completely isolated [21]. The Terskey oceanic basin could have been a barrier between the Syr Darya and Altay–Sayan benthic communities, as is suggested by its considerable width. At the end of the Early Cambrian, exchange of fauna

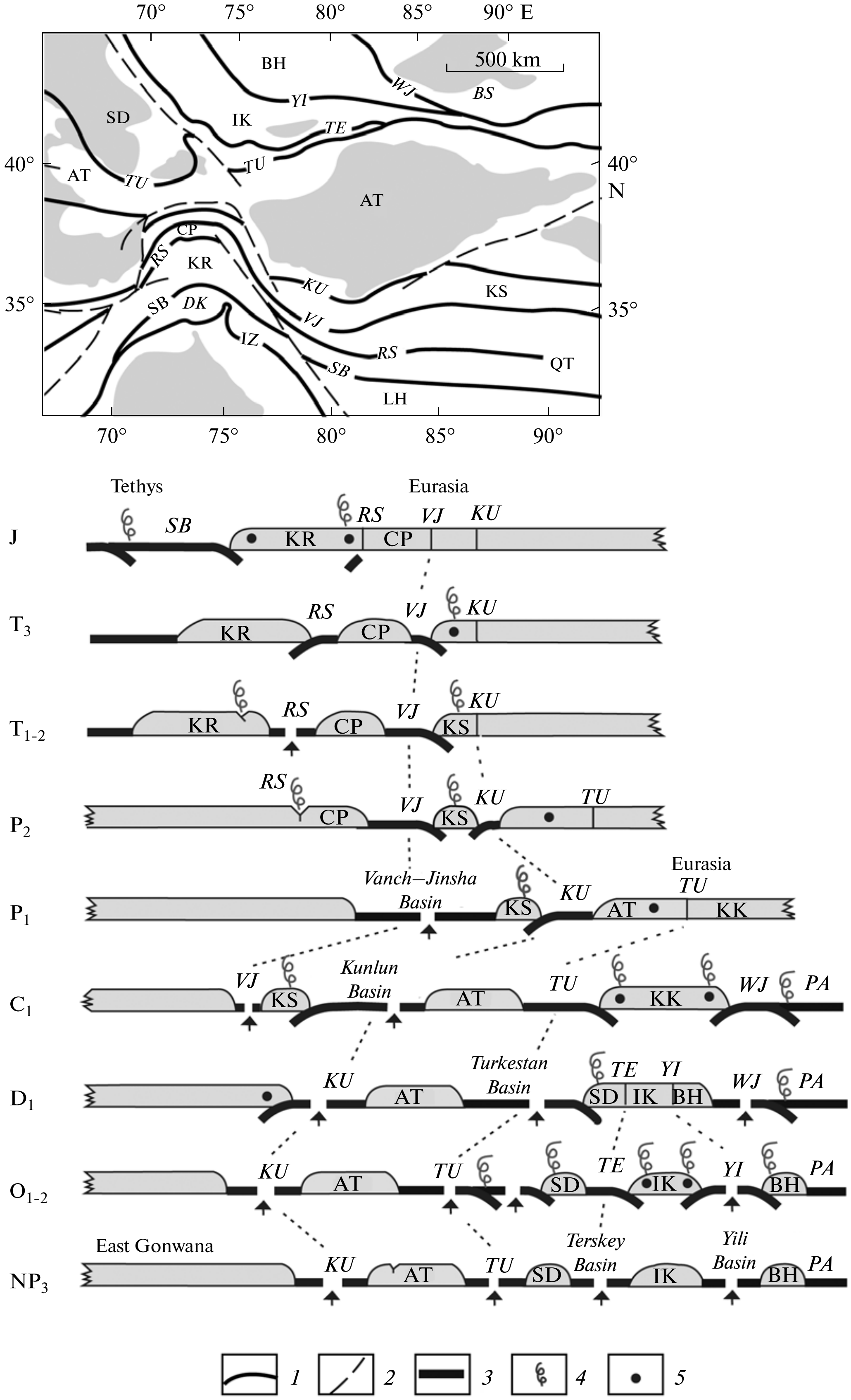
70°
75°
80°
85°
90° E
500 km
BH
BS
YI
WJ
SD
IK
TE
TU
AT
40°
N
CP
RS
KR
KU
KS
35°
SB
DK
VJ
IZ
QT
LH
Tethys
Eurasia
J
T3
T1-2
P2
P1
C1
D1
O1-2
NP3
Vanch–Jinsha Basin
Kunlun Basin
Turkestan Basin
Terskey Basin
Yili Basin
KK
PA
East Gonwana
1
2
3
4
5

Fig. 7. Tien Shan–Tarim–West Kunlun–West Tibet–Karakorum–Kohistan geodynamic sections. (*1*, *2*) in map: (*1*) oceanic suture, (2) fault; (*3*–*5*) in sections: (*3*) oceanic crust, (*4*) subduction-related volcanic activity, (*5*) granite. Continental terranes (letters in figure): AT, Alay–Tarim; BH, Borohoro; CP, Central Pamir; IK, Issyk-Kul; KR, Karakorum; KS, Kurgovat–Songpan; QT, Qiangtang; SD, Syr Darya; oceanic basins and their sutures (letters in figure): *KU*, Kunlun; *PA*, Paleoasian; *RS*, Rushan–Shuanghu; *SB*, Shyok–Bangong; *TE*, Terskey; *TU*, Turkestan; *VJ*, Vanch–Jinsha; *WJ*, West Junggar; *YI*, Yili; volcanic island arcs: *BS*, Bogdashan; *DK*, Dras–Kohistan.

began between biogeographic domains and provinces, probably owing to narrowing of the Turkestan and Terskey oceanic basins; this is indirect evidence for the existence of the active margins of these oceanic basins in the Cambrian.

The Kunlun oceanic basin was not wide in the Cambrian, and the trilobite fauna retained a common habitat on both margins of this basin [42].

Ordovician. The Yili margin of the Borohoro Terrane in the Early Ordovician was passive and then converted into the active state. Both margins of the Issyk-Kul Terrane were active in the Ordovician. The subduction-related magmatic activity at the Yili margin of the Issyk-Kul Terrane started in the Tremadocian and continued until the early Silurian. In the Middle Ordovician, the oceanic crust of the Yili oceanic basin obducted over the margin of the Issyk-Kul Terrane, probably in the course of formation of the accretionary wedge. At the Terskey margin of the Issyk-Kul Terrane, the magmatic belt was active from the Middle Ordovician to the Caradocian.

An oceanic island arc existed in the Terskey Basin in the Cambrian and Early Ordovician. The oceanic crust of the forearc basin subducted beneath the volcanic arc. In the Arenigian, the forearc basin closed and the island arc attached to the Issyk-Kul microcontinent. The subduction of the oceanic crust of the Terskey Basin beneath the Issyk-Kul Terrane resulted in closure of the Terskey oceanic basin and collision of the Issyk-Kul and Syr Darya sialic blocks in the Middle–Late Ordovician. The obduction of the ophiolites over the Issyk-Kul Terrane and thrusting of the rocks of the continental slope over the Syr Darya Terrane were related to this collision. The events at the margins of the Issyk-Kul continent initiated deformation of its crust and origination of orogenic and taphrogenic basins therein. The thick molasse sequence was deposited within these basins in the Middle and Late Ordovician. The Issyk-Kul and Syr Darya sialic blocks were amalgamated in the Ordovician with the formation of the Kazakh–Kyrgyz continent.

In the Early Paleozoic, the Terskey margin of the Syr Darya Terrane was passive, whereas the Turkestan margin was likely active. The margins of the Alay–Tarim Terrane were passive over their entire extent; the Middle–Late Ordovician calc-alkaline volcanic rocks are known only in the Qaidam.

The Kunlun margin of the East Gondwana was passive in the early Paleozoic. Biogeographic data indicate that the Kunlun oceanic basin was significantly widened in the Ordovician. The different communities of Ordovician nautiloids and conodonts separated by the Kunlun Basin indicate weak links between the North China and South China domains at that time [42].

Silurian and Devonian. In the beginning of the Middle Paleozoic, four continental blocks—East Gondwana, Alay–Tarim, Kazakh–Kyrgyz, and Borohoro—were separated by the Kunlun, Turkestan, and Yili oceanic basins. The Yili oceanic basin closed in the Silurian, so that the Borohoro Terrane attached to the Kazakh–Kyrgyz continent. The Bogdashan oceanic island arc, which separated the West Junggar Basin from the Paleoasian ocean, is known from the Devonian.

The margins of the Alay–Tarim continent remained passive in the Middle Paleozoic. Intracontinental rifting was accompanied by volcanic activity. The subduction of the Turkestan oceanic crust beneath the Kazakh–Kyrgyz microcontinent started or continued in the Silurian, and a magmatic belt was formed on the microcontinent. The subduction of the Turkestan oceanic crust occurred until the Middle Devonian.

The biotic difference between the domains separated by the Kunlun ocean arose in the Ordovician, was retained in the Silurian and Early and Middle Devonian, and smoothed out in the Late Devonian [41]. In the Devonian, the Kunlun margin of East Gondwana was active and underwent folding. In the Northwest Kunlun, the folding is marked by uncon-

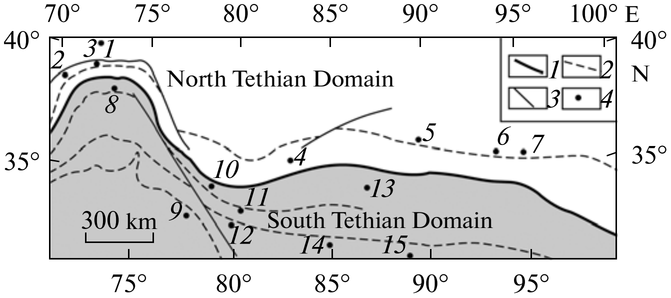

Fig. 8. Boundary between North Tethian and South Tethian biogeographic domains in the Early Permian. (*1*) Vanch–Jinsha oceanic suture; (2) other sutures; (*3*) fault; (*4*) location of samples with Early Permian fauna and flora (numerals in figure): *1*, Alay Range; *2*, Darvaz Range; *3*, Trans-Alay Range; *4*, Panshuihe; *5*, Aqqikkolhu; *6*, Naiji Tal; *7*, Golmud; *8*, Kalaktash; *9*, Kashmir; *10*, Kongka Pass, *11*, Rutog–Gegua; *12*, Shiquanghe; *13*, Gangmaco–Xiyargang; *14*, Cogen; *15*, Xainza.

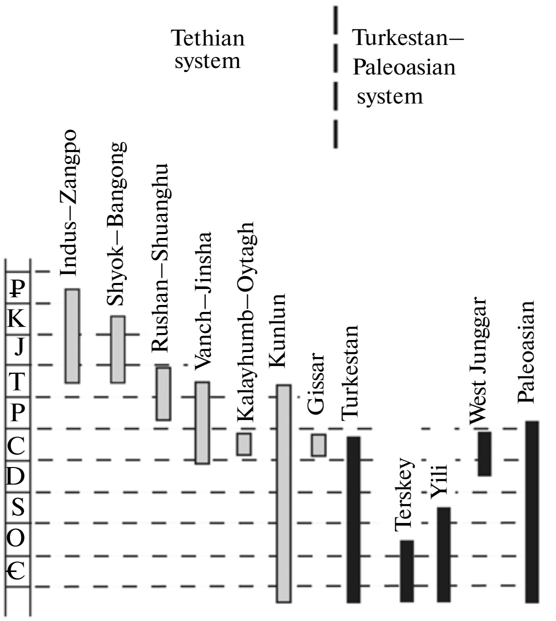

Fig. 9. Duration of oceanic basin existence.

formity in the Middle Devonian, whereas in the North Pamir it is characterized by stratigraphic hiatus in the Late Devonian–early Tournaisian.

Carboniferous. After the hiatus lasted for more than 50 Ma, the subduction of the Turkestan oceanic crust beneath the margin of the Kazakh–Kyrgyz continent was resumed in the Serpukhovian Age. In the Early Carboniferous, the subduction-related magmatic belts arose at both margins of this continent. The accretionary wedge composed of rocks pertaining to the oceanic crust was formed at the Turkestan continental margin. By the mid-Moscovian, the Turkestan oceanic crust had been subducted completely, giving rise to the collision of the Alay–Tarim and Kazakh–Kyrgyz continents. After collision, the subduction of the oceanic crust was transformed into continental subduction, i.e., underthrusting of the continental slope of the Alay–Tarim continent beneath the margin of the Kazakh–Kyrgyz continent and its accretionary wedge. As a result, collision-related nappes started to form in the South Tien Shan [5, 45].

In the Carboniferous, the oceanic crust of the East Junggar Basin subducted in opposite directions: beneath the margin of the Kazakh–Kyrgyz continent and beneath the Bogdashan island arc. This oceanic basin closed in the Late Carboniferous.

The Carboniferous Kunlun oceanic basin comprised mid-ocean ridge, oceanic island arcs, and marginal basins. In the Serpukhovian and Bashkirian ages, the island arc separated the Kalayhumb–Oytagh marginal basin from the ocean. Accretion proceeded actively at the margin of the sialic Kurgovat–Songpan Terrane facing the Kunlun Basin. In the Late Carboniferous, this terrane collided with oceanic island arc(s) of the Kunlun Basin.

The Karakum Block had broken away from the Alay–Tarim continent in the Early Carboniferous and the Gissar Rift with oceanic crust arose between them. The rift opened into the Kunlun oceanic basin. In the Late Carboniferous, the rift closed and the Karakum Terrane was attached to the Alay–Tarim continent.

The fragmentation of East Gondwana started in the Early Cafboniferous. The Kurgovat–Songpan Block broke away and the Vanch–Jinsha oceanic basin arose and began to expand rapidly.

Permian. In the Permian, the subduction of continental crust of the Alay–Tarim Terrane beneath the margin of the Kazakh–Kyrgyz continents progressed. As a result, a multilayer assembly of South Tien Shan collision-related nappes was formed. Afterward, this assembly was folded and squeezed. As a result of tectonic flow along the foldbelt, giant horizontal oroclinal protrusions formed in the West Tien Shan and Kyzylkum (Qizilqum) [5, 18, 45].

In the Permian, the Vanch–Jinsha oceanic basin continued to expand and was transformed into a vast ocean by the Artinskian Age. This ocean separated the sialic blocks, which were situated in the biogeographic domains (Fig. 8) belonging to the tropical and nodal extratropical belts of the Earth. The North Tethian tropical domain that encompassed the Eurasian Tethys and Cathaysia was characterized by thermophilic fusulinids, corals, and tropical flora. The Early Permian fauna in the Alay (Fig. 8, *1*), the north and northwest of the Pamir (Fig. 8, *2, 3*), and the Kunlun (Fig. 8, *4–7*) belongs to the North Tethian type [17, 86].

The South Tethian nodal domain encompasses the Tethys of Gonwana. This is a domain of glacial and glacial–marine sedimentation, cold-enduring fauna, and glossopterid flora. The fauna of the Sakmarian Age in the Central Pamir (Fig. 8, *8*) and of the Sakmarian and Artinskian Ages in the Himalayas (Fig. 8, *9*), Qiangtang terranes (Fig. 8, *10–12*), and Lhasa Block (Fig. 8, *13–15*) belongs to the South Tethian type [16, 86]. The climatic contrast between the North and South Tethian biogeographic domains was the highest in the Asselian Age and smoothed out at the end of the Artinskian Age, when Gondwana drifted to the tropical zone.

In the Permian, the margin of Gondwana continued to break up. The Rushan–Shuanghu Rift with oceanic crust was formed near this margin as a result of intracontinental rifting. The rift bluntly ended in the east (in present-day coordinates); in the west, it probably opened into the Vanch-Jinsha ocean.

In the Late Permian, all components of the future High Asia transferred to the tropical belt and probably converged with shrinkage of the oceanic basins.

Triassic–Paleogene. The Late Permian and Early Triassic was the time of the most intense fragmentation of the territory covering the future High Asia. At that time, the Kunlun oceanic basin separated the Kurgovat–Songpan sialic island arc (the western promontory of the South China continent) and the Alay–Tarim continent. The Vanch–Jinsha ocean separated the Kurgovat–Songpan and Central Pamir–Qiangtang sialic terranes. The Rushan–Shuanghu Rift dissected the Qiangtang Block, while the Bangong Rift separated the Qiangtang and Lhasa blocks.

The Kunlun, Vanch–Jinsha, and Rushan–Shuanghu oceanic basin closed in the Triassic, and the collision of the sialic terranes was accompanied by the Indo–Sinian Orogeny. The Shyok–Bangong closed in the Cretaceous and the Neotethys ocean in the Eocene. Collision was a driving force of the Alpine–Himalayan Orogeny.

General tendencies of tectonic evolution. The fragmentation of Rodinia and then East Gonwana was a multistage process that developed from the Neoproterozoic to the Triassic. The formation of the oceanic basins was a consequence of rifting. In the region under consideration, the Phanerozoic oceanic basins make up two historical–geological systems that evolved in different times and styles [5, 23, 31, 32].

The Tethian system comprises the basins of Paleotethys (Vanch–Jinsha and Kunlun) with their marginal seas and rifts (Kalayhumb–Oytagh, Gissar, Rushan–Shuanghu) and Neotethys. The tectonic evolution of this system was unidirectional. Oceanic basins progressively opened from the north to south (in present-day coordinates) and then closed in the same direction (Fig. 9). The sutures of the oceanic basins pertaining to the Tethian system are localized in the territory of High Asia.

The main Turkestan and Paleoasian oceanic basins of the Turkestan–Paleoasian system existed from the Neoproterozoic to the Late Paleozoic and evolved in different time and direction compared to the basins of the Tethian system (Fig. 9). Their sutures are localized in the territory of the Tien Shan, Urals, Kazakhstan, and Siberia. In the Tien Shan, this system comprises the sutures of the Turkestan, Terskey, Yili, and West Junggar basins.

The sialic blocks of the future Tien Shan, Pamir, and Tibet were incorporated into the Eurasian continent during several stages. Preliminarily, in the Late Ordovician and Silurian, small microcontinents combined into the Kazakh–Kyrgyz composite continent. The territories of the Tien Shan and Tarim became a part of Eurasia in the Late Carboniferous–Early Permian after closure of the Turkestan, Ural, and Paleotethian oceans. The territories of the Pamir, Karakorum, Kunlun, and most of Tibet attached to the Eurasian continent in the Triassic. The Lhasa Block and Kohistan were incorporated into Eurasia in the Cretaceous. In the Eocene, Eurasia was combined with Hindustan.

ACKNOWLEDGMENTS

I thank I.I. Pospelov and S.V. Ruzhentsev for their constructive criticism, which allowed me to improve this paper.

REFERENCES

1. A. B. Bakirov and K. S. Sakiev, "Geodynamic Formation Conditions of Metamorphic Complexes in the Tien Shan," in *Geology and Geography of Kyrgyzsatn* (Ilim, Bishkek, 1999), pp. 14–21 [in Russian].
2. Yu. S. Biske, *The Paleozoic Structure and History of the South Tien Shan* (St. Petersburg State Univ., St. Petersburg, 1996) [in Russian].
3. V. I. Budanov and B. R. Pashkov, "The Scope of Early Carboniferous and Permian Volcanism in the Eastern North Pamir," Byull. Mosk. Ob-va Ispyt. Prirody, Otd. Geol. **63** (1), 33–38 (1988).
4. V. S. Burtman, "New Data on the Structure of the Kunlun and Karakorum," Geotektonika **27** (1), 108–111 (1993).
5. V. S. Burtman, *Tien Shan and High Asia: Tectonics and Geodynamics in the Paleozoic* (Geos, Moscow, 2006) [in Russian].
6. V. S. Burtman and S. G. Samygin, "Tectonic Evolution of High Asia in the Paleozoic and Mesozoic," Geotektonika **35** (4), 34–54 (2001) [Geotectonics **25** (4), 276–294 (2001)].
7. A. G. Vladimirov, M. M. Malykh, V. I. Dronov, et al., *Indosinian Magmatism and Geodynamics of the South Pamirs* (UIGGM, Novosibirsk, 1992) [in Russian].
8. M. D. Ges, *Magmatism and Geodynamic Evolution of the Caledonides in the Tien Shan* (Nat. Acad. Sci., Republic of Kyrgyzstan, Bishkek, 2008) [in Russian].
9. T. N. Dalimov, T. Sh. Shayakubov, V. I. Troitsky et al., *Geology and Mineral Resources of the Republic of Uzbekistan* (Tashkent State Univ., Tashkent, 1998) [in Russian].
10. K. E. Degtyarev and A. V. Ryazantsev, "Cambrian Arc-Continent Collision in the Paleozoides of Kazakhstan," Geotektonika **41** (1) 71–96 (2007) [Geotectonics **41** (1), 63–86 (2007)].
11. V. I. Dronov, "FirstFindings of Triassic Fauna in Volcanic Rocks of the Rushan–Pshart Pamir," Dokl. Akad. Nauk **390**, 225–227 (1999).
12. A. Kh. Kafarsky, B. R. Pashkov, and I. V. Pyzh'yanov, "Late Paleozoic Rifting in the North Pamir," Dokl. Akad. Nauk SSSR **264**, 384–386 (1982).
13. V. V. Kiselev, "U–Pb Zircon Geochronology of Igneous Rocks in the North Tien Shan," in *Geology and Geography in Kyrgyzstan* (Ilim, Bishkek, 1999), pp. 21–33 [in Russian].
14. V. T. Komarevtsev, V. V. Kiselev, A. V. Mikolaichuk, and E. V. Khristov, "Isotopic Dating of Ophiolites in the South Tien Shan," Izv. Akad Nauk Kirgiz SSR, Fiz.-Tekhn. Matemat. Nauki, No. 3, 48–53 (1987).
15. S. A. Kurenkov, A. N. Didenko, and V. A. Simonov, *Geodynamics of Paleospreading* (Geos, Moscow, 2002) [in Russian].
16. E. Ya. Leven, "Evolution Stages of Fusulinid Community in the South Tethys and Their Relationships with

Abiogenic Events," Byull. Mosk. Ob-va Ispyt. Prirody, Otd. Geol **70** (5), 66–72 (1995).

17. E. Ya. Leven, T. B. Leonova, and V. Yu. Dmitriev, *Permian of the Darvaz–Transalay Zone of the Pamir* (Nauka, Moscow, 1992) [in Russian].
18. M. G. Leonov, *Tectonics of the Consolidated Crust* (Nauka, Moscow, 2008) [in Russian].
19. M. G. Lomize, L. I. Demina, and A. A. Zarshchikov, "The Kyrgyz-Terskei Paleoceanic Basin, Tien Shan," Geotektonika **31** (6), 35–55 (1997) [Geotectonics **31** (6), 463–482 (1997)].
20. R. A. Maksumova, "The Upper Riphean–Vendian Rift-Related Sequences of the Tien Shan," in *Stratigraphy, Lithology, Geochemistry, and Mineral resources of the Upper Riphean–Vendian in Central Asia, Kazakhstan, and Siberia* (Ilim, Bishkek, 1992), pp. 3–23 [in Russian].
21. A. M. Mambetov and L. N. Repina, "The Lower Cambrian of the Talas Alatoo and Its Correlation with the Sections of the Lesser Karatau and Siberian Platform," in *Biostratigraphy and Paleontology Of the Lower Cambrian of Siberia* (Nauka, Novosibirsk, 1979), pp. 98–138 [in Russian].
22. A. V. Mikolaichuk, S. A. Kurenkov, K. E. Degtyarev, and V. I. Rubtsov, "Northern Tien Shan: Main Stages of Geodynamic Evolution in the Late Precambrian-Early Paleozoic," Geotektonika **31** (6), 16–34 (1997) [Geotectonics **31** (6), 445–462 (1997)].
23. A. A. Mossakovsky, S. V. Ruzhentsev, S. G. Samygin, and T. N. Kheraskova, "Central Asian Foldbelt: Geodynamic Evolution and Formation History," Geotektonika **27** (6), 3–32 (1993).
24. B. R. Pashkov and V. I. Budanov, "The Tectonics of the Early Cimmerides in the Southern Pamirs," Geotektonika **37** (1), 19–35 (2003) [Geotectonics **37** (1), 15–30 (2003)].
25. B. R. Pashkov and V. A. Shvol'man, "Rifted Tethian Margins in the Pamirs," Geotektonika **13** (6), 42–57 (1979).
26. I. I. Pospelov, "Formations and Tectonic Evolution of the Late Variscides in the South Tien Shan and the North Pamir," in *Early Eugeosynclinal Formations and Structures* (Nauka, Moscow, 1987), pp. 149–178 [in Russian].
27. *Subdivision of Stratified and Intrusive Rocks of Tajikistan* (Donish, Dushanbe, 1976 [in Russian].
28. L. N. Repina, "Paleobiogeography of Early Cambrian Seas from Trilobites," in *Paleozoic Biostratigraphy and Biogeography of Siberia* (UIGGM, Novosibirsk, 1985), pp. 5–15 [in Russian].
29. L. N. Repina, "Early Cambrian Seas of the Earth and Paleobiogeographic Subdivisions Based on Trilobites," in *The Environment and Life in the Geologic Past* (Nauka, Novosibirsk, 1985), pp. 5–17 [in Russian].
30. S. V. Ruzhentsev, I. I. Pospelov, and A. N. Sukhov, "Tectonics of the Kalayhumb–Sauksay Zone in the North Pamir," Geotektonika **11** (4), 68–80 (1977).
31. S. V. Ruzhentsev, V. F. Shvol'man, B. R. Pashkov, and I. I. Pospelov, "Tectonic Evolution of the Pamir–Himalayan Sector of the Alpine Foldbelt," in *Tectonics of the Tien Shan and Pamir* (Nauka, Moscow, 1983), pp. 167–175 [in Russian].
32. S. V. Ruzhentsev, V. F. Shvol'man, I. I. Pospelov, and S. D. Sokolov, "Ophiolitic Sutures and Tectonic Evolution of Asia," Dokl. Akad. Nauk SSSR **265**, 1471–1474 (1982).
33. A. V. Ryazantsev, A. V. Mikolaichuk, T. Yu. Tolmacheva, et al., "Ophiolites and Island-Acr Complexes of the Zhalair–Naiman Zone and Chu–Kendyktas Massif, South Kazakhstan," in Geodynamics of Intracontinental Orogens and Geoecological Problems (2009), No. 4, 53–58 [in Russian].
34. N. V. Sobolev, V. S. Shatsky, A. B. Bakirov, and A. E. Gilbert, "Eclogites and Glaucophane Rocks of the Tien Shan," in *Eclogites and Glaucophane Schists in Fold Regions* (Nauka, Novosibirsk, 1989), pp. 83–107 [in Russian].
35. A. V. Travin, V. A. Simonov, S. A. Kurenkov, et al., "The First Data on Absolute Age of Ophiolites in the North Tien Shan," in *Geology, Geochemistry, and Geophysics on the Turn of XX and XXI Centuries* (Svyazprint, Moscow, 2002), Vol. 1, pp. 105–106 [in Russian].
36. M. B. Allen, B. F. Windley, and C. Zhang, "Paleozoic Collisional Tectonics and Magmatism of the Chinese Tien Shan, Central Asia," Tectonophysics **220**, 89–115 (1993).
37. Q. Bian, D. Li, I. Pospelov, et al., "Age, Geochemistry and Tectonic Setting of Buqingshan Ophiolites, North Qinghai–Tibet Plateau, China," J. Asian Earth Sci **4**, 577–596 (2004).
38. Q. Bian, X. Luo, H. Chen, et al., "Petrochemitry and Zircon U-Pb age of Granodiorite–Tonalite in the Anyemaqen Ophiolitic Belt and Its Tectonic Significance," Sci. Geol. Sinica **8**, 375–381 (1999).
39. Q. Bian, X. Luo, H. Li, et al., "Discovery of Early Paleozoic and Early Carboniferous–Early Permian Ophiolites in the Anyemaqen Mts., Qinghai Province, China," Sci. Geol. Sinica **8**, 437–438 (1999).
40. J. Boulin, "Afghanistan Structure, Greater India Concept, and Eastern Tethys Evolution," Tectonophysics **72**, 261–287 (1981).
41. C. Burrett, J. Long, and B. Stait, "Early-Middle Palaeozoic Biogeography of Asian Terranes Derived from Gondwana Palaeozoic Palaeogeography and Biogeography," Geol. Soc. London Mem., No. 12, 163–174 (1990).
42. C. Burret and B. Stait, "China and Southeast Asia as Part of Tethian Margin of Cambro-Ordovician Gondwanaland," In *Shallow Tethys-2* (Balkema, Rotterdam, 1986), pp. 65–77.
43. V. S. Burtman, "Cenozoic Crustal Shortening Between the Pamir and Tien Shan and a Reconstruction of the Pamir—Tien Shan Transition Zone for the Cretaceous and Palaeogene," Tectonophysics **319**, 69–92 (2000).
44. V. S. Burtman, "The Tien Shan Early Paleozoic Tectonics and Geodynamics," Russian J. Earth Sciences **8** (3), 1–23 (2006), doi: 10.2205/2006ES000202.
45. V. S. Burtman, "Nappes of the Southern Tien Shan," Russian J. Earth Sciences **10** (1), 1–35 (2008), doi: 10.2205/2007ES000223.
46. V. S. Burtman and P. Molnar, *Geological and Geophysical Evidence for Deep Subduction of Continental Crust*

beneath the Pamir. (Geol. Soc. Amer. Spec. Paper, 1993), Vol. 281.

47. C. Chang, *Geology and Tectonics of the Qinghai-Tibet Plateau* (Science Press, Beijing, 1996).
48. B. Chen and X. Jin, "A Geologic—Geophysical Excursion from Golmud, Qinghai to Lhasa, Tibet," in *The 30th Intern. Geol. Congr. Field Trip T390 Guidebook* (Beijing, 1996).
49. C. Chen, H. Lu, D. Jia, et al., "Closing History of the Southern Tianshan Oceanic Basin, Western China: An Oblique Collisional Orogeny," Tectonophysics **302**, 23–40 (1999).
50. E. Cowgill, A. Yin, and T. M. Harrison, "Reconstruction of the Altyn Tagh Fault Based on the U—Pb Geochronology: Role of Back Thrusts, Mantle Sutures, and Heterogeneous Crustal Strength in Forming the Tibetan Plateau," J. Geophys. Res **108**, 1–28 (2003).
51. *Excursion Guide of the International Symposium on the Qinghai-Xizang (Tibet) Plateau*, Ed. by L. Zhu and Y. Pan (Beijing, London, 1998).
52. I. B. Filippova, V. A. Bush, and A. N. Didenko, "Middle Paleozoic Subduction Belts: The Leading Factor in the Formation of the Central Asian Fold-and-Thrust Belt," Russian J. Earth Sciences **3** ((6)), 405–426 (2001), doi: 10.2205/2001ES000073.
53. J. Gao, G. He, M. Li, et al., "The Mineralogy, Petrology, Metamorphic PTDT Trajectory and Exhumation Mechanism of Blueschists, South Tianshan, Northwestern China," Tectonophysics **250**, 151–168 (1995).
54. J. Gao, M. Li, X. Xiao, et al., "Paleozoic Tectonic Evolution of the Tianshan Orogen, Northwestern China," Tectonophysics **287**, 213–231 (1998).
55. S. Gruschka, A. Kröner, A. V. Avdeev, and N. S. Seitov, and R. Oberhansli, "Early Palaeozoic Accretion of Arcs and Microcontinents in the Central Asian Mobile Belt of Southern Kazakhstan as Deduced from Pb—Pb Zircon and Sm—Nd Ages," Terra Nova **7**, 340 (1998).
56. N. B. V. Harris, R. Xu, and C. L. Lewis, C. J. Hawkesworth, and Y. Zhang, "Isotope Geochemistry of the 1985 Tibet Geotraverse, Lhasa To Golmud," Phil. Trans. Roy. Soc. London, **A327**, 263–285 (1988).
57. N. B. V. Harris, R. Xu, C. L. Lewis, and C. Jin, "Plutonic Rocks of the 1985 Tibet Geotraverse, Lhasa To Golmud," Phil. Trans. Roy. Soc. London Vol. A327, 145–168 (1988).
58. K. J. Hsu, Y. Yao, J. Hao, et al., "Origin of Chinese Tianshan by Arc—Arc Collisions," Eclogae Geol. Helv. **87**, 365–292 (1994).
59. *Introduction to Integrated Scientific Investigation on Karakorum and Kunlun Mountains*, Ed. by Y. Pan (China Meteor. Press, Beijing, 1992).
60. P. Kapp, Y. An, C. E. Manning, M. Murphy, T. M. Harrison, M. Spurlin, L. Ding, X. Deng, and C. Wu, London), "Blueshist-Bearing Metamorphic Core Complexes in the Qingtang Block Reveal Deep Crustal Srtructure of Northern Tibet," Geology **28**, 19–22, (2000).
61. D. Konopelko, G. Biske, R. Seltman, et al., "Hercynian Post-Collisional A-Type Granites of the Kokshaal Range, Southern Tien Shan, Kyrgyzstan," Lithos **97**, 140–160 (2007).
62. J. Li, W. Xiao, K. Wang, et al., "Neoproterozoic—Paleozoic Tectonostratigraphy, Magmatic Activities, and Tectonic Evolution of Eastern Xinjiang, NW China," in *Tectonic Evolution and Metallogeny of the Chinese Altay and Tianshan* (CERCAMS, Natural History Museum, London, 2003), pp. 31–74.
63. B. Liu, Z. Wang, H. Ma, et al., "Tectonic Evolution of South-West Tianshan and the Relationship between Tarim and Kazakstan Plates," in *The 30th IGC Abstracts*, Vol. 1, p. 270.
64. C. Liu, B. Lu, M. Zheng, et al., "Possible Extending of Bangonghu-Dingqing Suture and Its Geological Relevations," Earth Sci. Frontiers **7** Suppl., 162–163 (2000).
65. X. Liu, D. Fu, J. Yao, et al., *The Sedimentary—Tectonic Evolution of Tarim Plate and Its Surrounding Area* (Xinjang Sci. Tech. Publ. House, Urumqi, 1997) [in Chinese, pp. 212-257 in English].
66. L. Long, J. Gao, J. Wang, et al., "Geochemistry and SHRIMP Zircon U-Pb Age of Post-Collision Granites in the Southwest Tienshan Orogenic Belt of China: Examples from the Heiyngshan and Laohutai Plutons," Acta Geol. Sin. **82**, 415–424 (2008).
67. L. Long, J. Gao, X. M. Xiong, and Q. Quan, "The Geochemical Characteristics and the Age of the Kule Lake Ophiolite, the Southern Tianshan," Acta Petrol. Sinica **22**, 65–73 (2006).
68. P. Matte, P. Tapponnier, N. Arnaud, et al., "Tectonics of Western Tibet Between the Tarim and Indus," Earth Planet. Sci. Lett. **142**, 311–330 (1996).
69. F. Mattern and W. Schneider, "Suturing of the Proto- and Paleo-Tethys Oceans in the Western Kunlun," J. Asian Earth Sci **18**, 637–650 (2000).
70. Mineral Deposits Map of Kyrgyzstan on a Scale 1 : 1000000, Ed. by R. Jenchuraeva, A. Bakirov, M. Ghes, R. Seltmann, V. Shatov, and V. Popov (London—Bishkek, 2001).
71. P. Molnar, D. C. Burchfield, Z. Zhao, et al., "Geologic Evolution of Northern Tibet: Results of an Expedition to Ulugh Muztagh," Science **235**, 299–305 (1987).
72. Y. Pan, "Geological Evolution of the Kunlun and Karakorum Mountain Ranges," in *Proceedings Intern. Symp. Karakorum and Kunlun Mts.* (China Meteor. Press, Beijing, 1994), pp. 31–43.
73. Y. Pan, "Formation and Evolution of Tethys in the Tibetan Plateu," Earth Sci. Frontiers **7** Suppl., 334–335 (2000).
74. J. A. Pearce and W. Deng, "The Ophiolites of the Tibetan Geotraverses Lhasa to Golmud (1985) and Lhasa to Kathmandu (1986), Phil. Trans. Roy. Soc. London **A327**, 215–238 (1988).
75. J. A. Pearce and H. Mei, "Volcanic Rocks of the 1985 Tibet Geotraverse," Phil. Trans. Roy. Soc. London **A327**, 169–201 (1988).
76. A. V. Peive, V. S. Burtman, S. V. Ruzhentsev, and A. I. Suvorov, "Tectonics of the Pamir-Himalaayan Sector of Asia," in *The 22nd IGC Report* (New Delhi, 1964), Pt. 11, pp. 441–464.
77. I. I. Pospelov, E. Y. Leven, Q. Bian, et al., "Lower Permian Formations of the Buqingshan Mountains in the A'Nyemaqen Ophiolitic Zone (Eastern Kunlun,

Qinghai Province, China) on the Beginning of the Paleotethys Closure," Russian J. Earth Sciences **6**, 1–13 (2005).

78. *Regional Geology of Qinghai Province (with Maps in scale 1 : 1500000 and 1 : 2000000)* (Geol. Publ. House, Beigjing, 1991) [in Chinese, pp. 604–662 in English].

79. Regional Geology of Xinjiang Uygur Autonomous Region (with Maps in scale 1 : 1500000 and 1 : 2000000). (Geol. Publ. House, Beigjing, 1993) [in Chinese, pp. 783–841 in English].

80. Regional geology of Xizang (Tibet) autonomous region (with maps in scale 1 : 1500000 and 1 : 200000). Beigjing: Geol. Publ. House, 1993. 707 p. (in Chinese, p. 638–707 – in English).

81. M. P. Searle, *Geology and Tectonics of the Karakoram Mountains* (Wiley, Chichester, 1991).

82. M. P. Searle, "Geological Evidence Against Large-Scale Pre-Holocene Offsets Along the Karakoram Fault: Implications for the Limited Extrusion of the Tibetian Plateau," Tectonics **15**, 171–186 (1996).

83. R. Shi, J. Yang, X. Wang, and X. Zheng, "Two Suites of Ophiolite Recognized in the Maqen Area, Northern Tibetan Plateau," Earth Sci. Frontiers **7** Suppl., 132–134 (2000).

84. M. Schwab, L. Ratschbacher, W. Siebel, et al., "Assembly of the Pamirs: Age and Origin of Magmatic Belts from the Southern Tien Shan to the Southern Pamirs and Their Relation to Tibet," Tectonics **23**, 1–31 (2004).

85. E. R. Sobel and N. Arnaud, "A Possible Middle Paleozoic Suture in the Altyn Tagh, NW China," Tectonics **18**, 64–74 (1999).

86. D. Sun, "On the Permian Biogeographic Boundary Between Gondwana and Eurasia in Tibet, China as Eastern Section of the Tethys," Palaeogeogr., Palaeoclimat., Palaeoecol. **100**, 59–77 (1993).

87. M. Tagiri, T. Yano, A. Bakirov, et al., "Mineral Parageneses and Metamorphic *P–T* Paths of Ultrahigh-Pressure Eclogites from Kyrghyzstan Tien-Shan," Island Arc **4**, 280–292 (1995).

88. B. Wang, M. Faure, L. Shu, et al., "Paleozoic Tectonic Evolution of the Yili Block, Western Chinese Tianshan," Bull. Soc. Geol. Fr. **179**, 483–490 (2008).

89. B. Wang, Z. Lang, X. Li, et al., *Comprehensive Survey of Geological Sections of the West Tianshan of Xinjiang, China* (Urumqi, 1994).

90. Z. Wang, J. Wu, X. Lu, et al., *Polycyclic Tectonic Evolution and Metallogeny of the Tianshan Mountains* (Science Press, Beijing, 1990).

91. B. F. Windley, D. Alexeiev, W. Xiao, et al., *Tectonic Models for Accretion of the Central Asian Orogenic Belt,* J. Geol. Soc. London **164**, 31–47 (2007).

92. L. Xia, X. Li, X. Xu, et al., "Petrogenetic Evolution of the Bayan Gol Ophiolite–Geological Record of the Early Carboniferous Red Sea Type Ocean Basin in the Tianshan Mountanes, Northwestern China," Acta Geol. Sin. **79**, 174–192 (2005).

93. W. J. Xiao, B. F. Windley, H. L. Chen, et al., "Carboniferous–Triassic Subduction and Accretion in the Western Kunlun, China: Implications for the Collisionall and Accretionary Tectonics of the Northern Tibetan Plateau," Geology **30**, 295–298 (2002).

94. W. J. Xiao, B. F. Windley, D. Y. Liu, et al., "Accretionary Tectonics of the Western Kunlun Orogen, China: A Paleozoic–Early Mesozoic, Long-Lived Active Continental Margin with Implications for the Growth of Southern Eurasia," J. Geol. **113**, 687–705 (2005).

95. W. J. Xiao, L. C. Zhang, K. Z. Qin, et al., "Paleozoic Accretionary and Collisional Tectonics of the Eastern Tienshan (China): Implications for the Continental Growth of Central Asia," Amer. J. Sci. **304**, 370–395 (2004).

96. R. Xu, Y. Zhang, Ph. Vidal, and N. Arnaud, "Two Plutonic Belts in Western Kunlun," in *Proceedings Intern. Symp. Karakorum and Kunlun Mts, Kashi, China* (1992), p. 62.

97. J. S. Yang, P. T. Robinson, C. F. Jiang, and Z. Q. Xu, "Ophiolites of the Kunlun Mts., China and Their Tectonic Implications," Tectonophysics **258**, 215–231 (1996).

98. A. Yin and T. M. Harrison, "Geological Evolution of the Himalayan–Tibetan Orogen," Annual Rev. Earth Planet. Sci **28**, 211–280 (2000).

99. J. Yin, "Carboniferous Sedimentary Environment and Tectonic Setting in the Western Kunlun and Adjacent Regions," in *Proceeding Intern. Symp. Karakorum and Kunlun Mts.* (China Meteor. Press, Beijing, 1994), pp. 130–142.

100. J. Yin, J. Xu, C. Liu, and H. Li, "The Tibetan Plateau: Regional Stratigraphic Context and Previous Work," Phil. Trans. Roy. Soc. London **A327**, 5–52 (1988).

101. C. Yuan, M. Sun, and J. Li, "The Evolutionary History of the West Kunlun Mts: A Tectonic Reconstruction Based on Studies of Magmatism," Earth Sci. Frontiers **7** Suppl., 262–263 (2000).

102. Y. Zhang, Y. Xie, R. Xu, et al. "Element Geochemistry of Granitoid Rocks in the Western Part of the Qunnghai–Xizang Plateau," in *Proceedings Intern. Symp. Karakorum and Kunlun Mts* (China Meteor. Press, Beijing, 1994), pp. 152–163.

Reviewers: S.V. Ruzhentsev and I.I. Pospelov