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# Paleogeography of the Berriasian–Barremian Ages of the Early Cretaceous

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**Abstract**—Global litholologic–paleogeographic maps are compiled for the Berriasian, Valanginian, Hauterivian, and Barremian ages of the Early Cretaceous. Main features of paleogeography, sedimentation environments in oceans, regularities in distribution of paleogeographic environments in continental margins, spatial position of arid and humid sedimentation settings in continents, and position of latitudinal climatic belts of the Neocomian time are considered. It is noted that clayey–calcareous hemipelagic and pelagic sedimentation prevailed in the Tethys; carbonate-free clayey–siliceous and calcareous pelagic sedimentation was characteristic of the Pacific, whereas hemipelagic terrigenous sediments were mainly accumulated in the Southern Ocean. Morphological–structural lateral series of deep-water trenches, turbidite fore-arc basins, and volcanic belts of island-arcs and continental margins are distinguished at the convergent boundaries between continental and oceanic plates. Five latitudinal climatic belts of the Neocomian time corresponded to the northern circumpolar humid zone with coal deposits, the northern midlatitudinal humid zone with coal–bauxite–kaolinite deposits, the intersubtropical arid zone with evaporites, the southern midlatitudinal humid zone with coal–kaolinite deposits, and the southern humid zone with coal-bearing sequences.

**Key words:** *paleogeography, Berriasian, Valanginian, Hauterivian, Barremian, hemipelagic and pelagic oceanic environments, continental margins, arid and humid climates, evaporite and coal-bearing basins, climatic belts.*

## INTRODUCTION

This paper is the next in a series of publications devoted to characteristics of global lithologic–paleogeographic maps for subsequent Cretaceous ages compiled with the purpose to elucidate the evolution of paleogeographic and paleoclimatic peculiarities in the spatial distribution of sedimentation settings and volcanic belts during the epoch of the warm biosphere. This paper presents lithologic–paleogeographic maps for the Berriasian, Valanginian, Hauterivian, and Barremian ages of the Early Cretaceous (Figs. 1–4). They were compiled using the same method that was applied for previously published maps for the Middle Cretaceous (Zharkov *et al.*, 1995). By means of independent systems of symbols, arid and humid zones in continents, shelves, island arcs, and in the peripheral and central areas of the ocean are distinguished in these maps. The maps are sufficiently informative. They allow us to elucidate peculiarities of the spatial distribution of carbonate, terrigenous, glauconite-bearing, phosphorite-bearing, and chalk sedimentation environments in shelf and epicontinental seas; to demonstrate features of evaporite sedimentation and coal accumulation in continents; to derict patterns of turbidite and black-shale deposition; and to reconstruct the general distribution of hemipelagic and pelagic sediments in oceans. Simultaneously, they provide sufficiently complete information on the distribution of magmatic and sedimentary–volcanogenic rock complexes in the active continental margins, intracontinental areas, and oceans.

It is impossible to consider in one paper all peculiarities of paleogeographic and paleoclimatic confinement of the distinguished sedimentation and volcanism settings. Keeping this in mind, we paid the most attention to the following: (1) to principal paleogeographic features that existed during the first half of the Early Cretaceous and to paleoenvironments of oceanic sedimentation; (2) to the main regularities in distribution of paleogeographic settings in continental margins; and (3) to the spatial distribution of arid and humid sedimentogenesis in continents and to reconstruction of latitudinal climatic belts of the Neocomian time. The reference list includes only those publications that are essential for this paper. All other works that were used in compiling maps were listed in our previous article (Zharkov *et al.*, 1995).

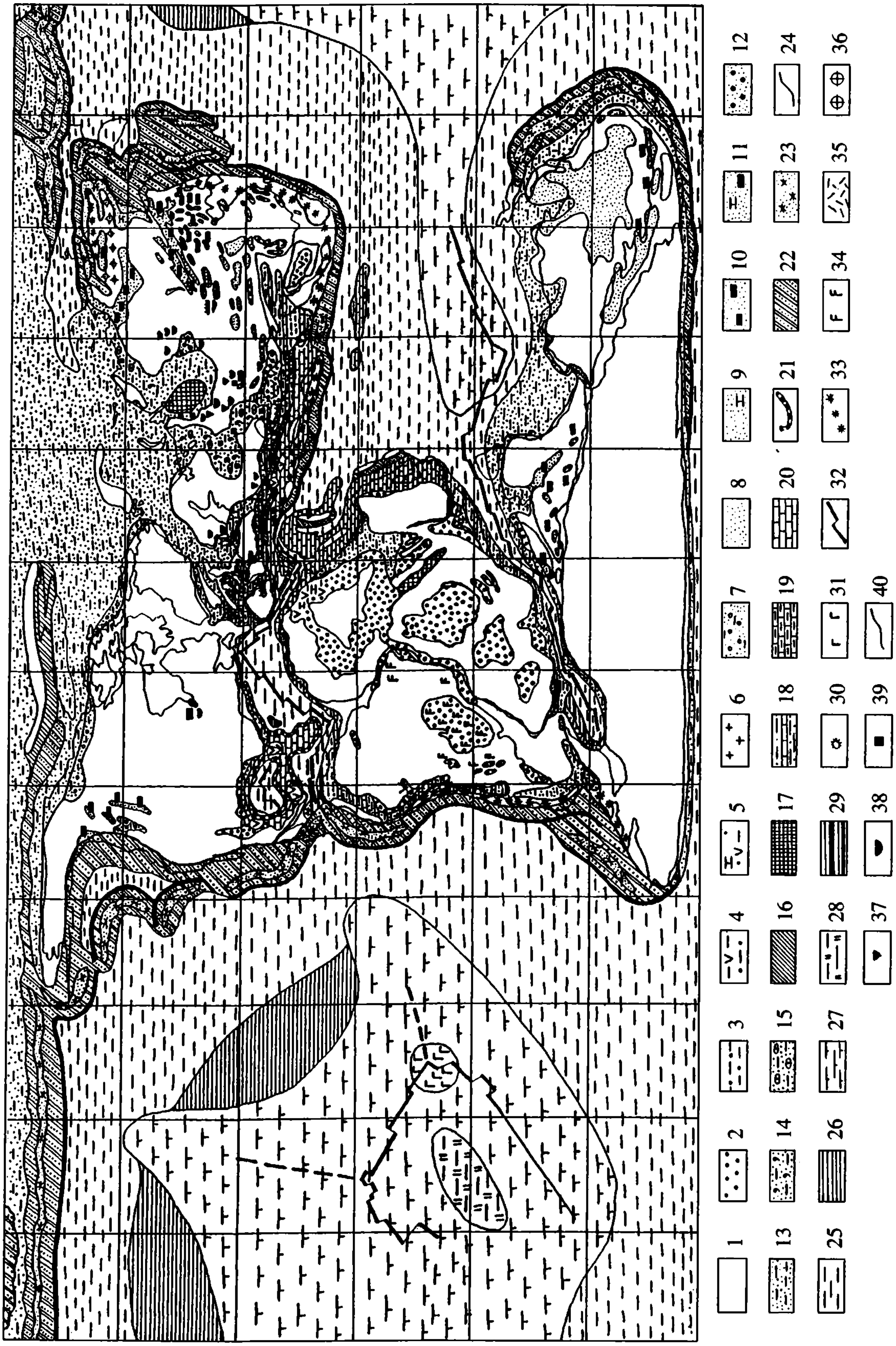
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Fig. 1.

## THE PRINCIPAL PALEOGEOGRAPHIC FEATURES AND SEDIMENTATION ENVIRONMENTS IN OCEANS

Paleogeographic peculiarities of the first half of the Early Cretaceous were controlled by the existence of three major continental blocks—Laurasia, Western Gondwana, and Eastern Gondwana, whose position was relatively stable throughout almost the entire Neocomian (Ziegler *et al.*, 1982; Zonenshain *et al.*, 1984; Barron, 1987; Scotese *et al.*, 1987, 1988; Funnell, 1990; Dercourt *et al.*, 1993). Laurasia was located in the northern hemisphere extending from 20°–30° N to the northern polar areas. Western Gondwana, comprising South America and Africa, was mainly situated within the subtropical–tropical belt between 25°–28° N and 35°–40° S. Eastern Gondwana, including Australia, Antarctica, and India, was located in the southern hemisphere south of 35°–40° S and occupied large areas in the southern polar region. In the Berriasian, Eastern Gondwana represented a single continent. In the Valanginian, India started to separate from Australia and later from Antarctica to finally become an isolated continental block in the Barremian (Veevers, 1984; Scotese *et al.*, 1987, 1988; Patriat and Segoufin, 1988). These major continental masses composed the continental hemisphere of the Earth, which opposed the oceanic hemisphere occupied by the Pacific.

Paleogeography of oceanic basins was controlled in the Neocomian by geodynamic processes initiated in the Middle–Late Jurassic. The Tethys, which extended over almost 20 000 km between Laurasia and Gondwana continents from the Caribbean region in the west to the southeast Asian margin and the Australia–Guinea region of Eastern Gondwana in the east continued to open and advance westward. It comprised the eastern Tethys encompassing the area between the Asian part of Laurasia in the north and India and Australia in the south; central (or Mediterranean) Tethys; and western Tethys; where the Central Atlantic (Atlantic Tethys), Gulf of Mexico, and Caribbean regions can be distinguished (Dercourt *et al.*, 1993). At the beginning of the Early Cretaceous, the seaway between North and South America appeared and resulted in formation of the global western current in the Tethyan and Pacific tropical latitudes of the northern hemisphere (Luyendyk *et al.*, 1972; Berggren and Hollister, 1974).

The Mediterranean and western Tethys represented a system of deep basins fringed by shallow pericratonic carbonate platforms and terrigenous shelves; the basins were also separated in some areas by groups of relatively small isolated carbonate platforms (Dercourt *et al.*, 1985; Dercourt *et al.*, 1993; Bogdanov *et al.*, 1994). Pericratonic and isolated carbonate platforms were areas of intense accumulation of biogenic carbonates; from the outer side, they were usually bounded by reefal carbonate buildups (Wilson, 1975; Masse and Philip, 1981; Wilson *et al.*, 1984; Frazier and Schwimmer, 1987; Schlager and Philip, 1990; Masse, 1992). Such carbonate platforms are often referred to the Urgonian type (Masse, 1992). Pericratonic carbonate platforms extended along the eastern margin of Africa, eastern and northern Arabia, and the northern and northwestern coast of Africa. In the southern periphery of Laurasia, they are traceable along the North American margin, in the southern and southwestern coast of the Gulf of Mexico near Baltimore Canyon and in the Blake Plateau, and also in the northern Tethyan margin around Iberia and from the Pyrenees platform to the Carpathian–Balkan region and further eastward to Elbrus and Central Afghanistan (Viniegra, 1981; Seibold, 1982; Young, 1983; Wilson *et al.*, 1984; Dercourt *et al.*, 1985; Tucholke and McCoy, 1986; Zonenshain *et al.*, 1987; Schwimmer, 1987; Schlee *et al.*, 1988; Rakus *et al.*, 1988, 1989, 1990; Watts and Blome, 1990; Masse, 1992; Dercourt *et al.*, 1993). Isolated carbonate platforms were mainly concentrated in two areas, in the Caribbean basin of the western Tethys and in the Mediterranean Tethys. Particularly remarkable were compact groups of isolated carbonate platforms in the Bahamas zone and near the eastern margin of the Med-

**Fig. 1.** The lithologic–paleogeographic map for the Berriasian age of the Cretaceous.

(1) land; (2–6) deposits of alluvial–proluvial plains, intermontane depressions, lakes, sebkhas, and lagoons in arid zones: (2) red-bed conglomerates, gritstones, and sandstones; (3) red-bed and variegated sandstones, siltstones, and clays; (4) sandstones, siltstones, and clays with gypsum; (5) gypsiferous calcareous, and terrigenous–calcareous sediments; (6) salt-bearing sediments; (7–12) deposits of alluvial and lacustrine–palustrine plains, intermontane depressions, coastal plains intermittently flooded by the sea, and lagoons: (7) gray conglomerates, gritstones, and sandstones; (8) gray sandstones, siltstones, and clays; (9) calcareous–terrigenous sediments; (10) terrigenous coal-bearing (intracontinental) sequences; (11) calcareous–terrigenous coal-bearing (maritime) sequences; (12) terrigenous red-bed carbonate-free sediments; (13–21) deposits of shelf and epicontinental seas: (13) sandstones, siltstones, and clays; (14) glauconite-bearing sediments; (15) phosphorite-bearing sediments; (16) turbidites of shelf slopes and back-arc basins; (17) carbonaceous clayey, clayey–calcareous, and calcareous–siliceous sediments (black shales); (18) siltstones, clays, and limestones; (19) clayey limestones and marls; (20) carbonate platforms; (21) reefs; (22–25) deposits of the continental and island-arc slope and peripheral zones of oceans: (22) turbidites; (23) calc-alkaline and tholeitic basalts and also island-arc terrigenous–volcanogenic rock complexes; (24) deep-sea trenches; (25) hemipelagic clayey, calcareous–clayey, calcareous sediments; (26) pelagic (red) clays; (27) pelagic calcareous and siliceous–calcareous sediments; (28) pelagic siliceous sediments; (29) carbonaceous clayey, calcareous–clayey, calcareous–siliceous, and siliceous sediments (black shales); (30) carbonate atolls; (31) intraplate alkalic and tholeitic basalts; (32) midocean ridges with tholeitic lavas; (33) calc-alkaline magmatic rocks of volcanic–plutonic associations in continental margins; (34) intraplate alkalic, tholeitic, and bimodal volcanic series of continents; (35) distal ash belts; (36) belts of S-granitoid massifs in the collision sutures; (37) bauxites; (38) kaolinite clays, kaolin-bearing rocks; (39) iron ores; (40) boundaries between lithologic complexes and paleogeographic regions.

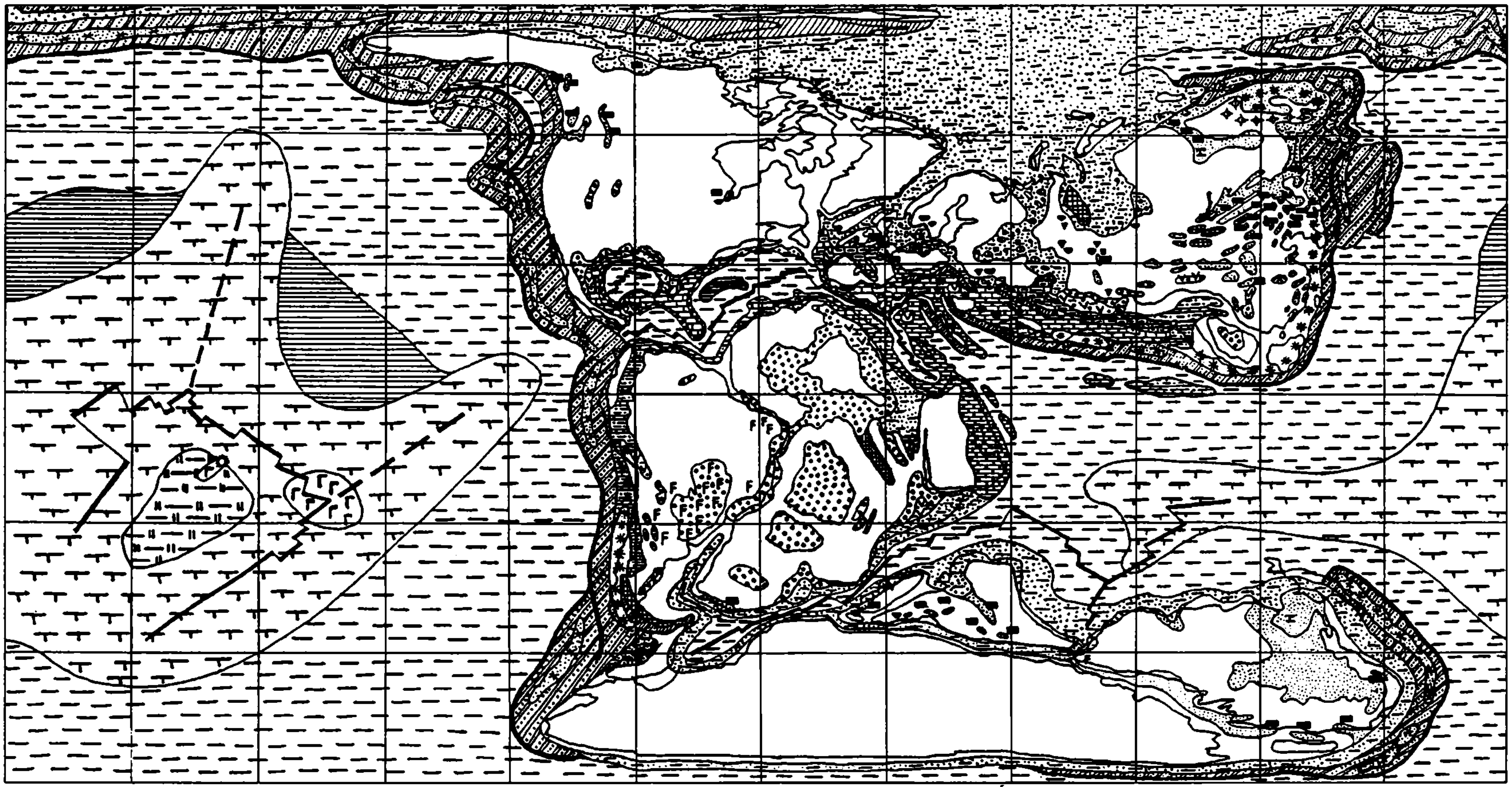

**Fig. 2.** The lithologic–paleogeographic map for the Valanginian age of the Cretaceous (symbols as in Fig. 1).

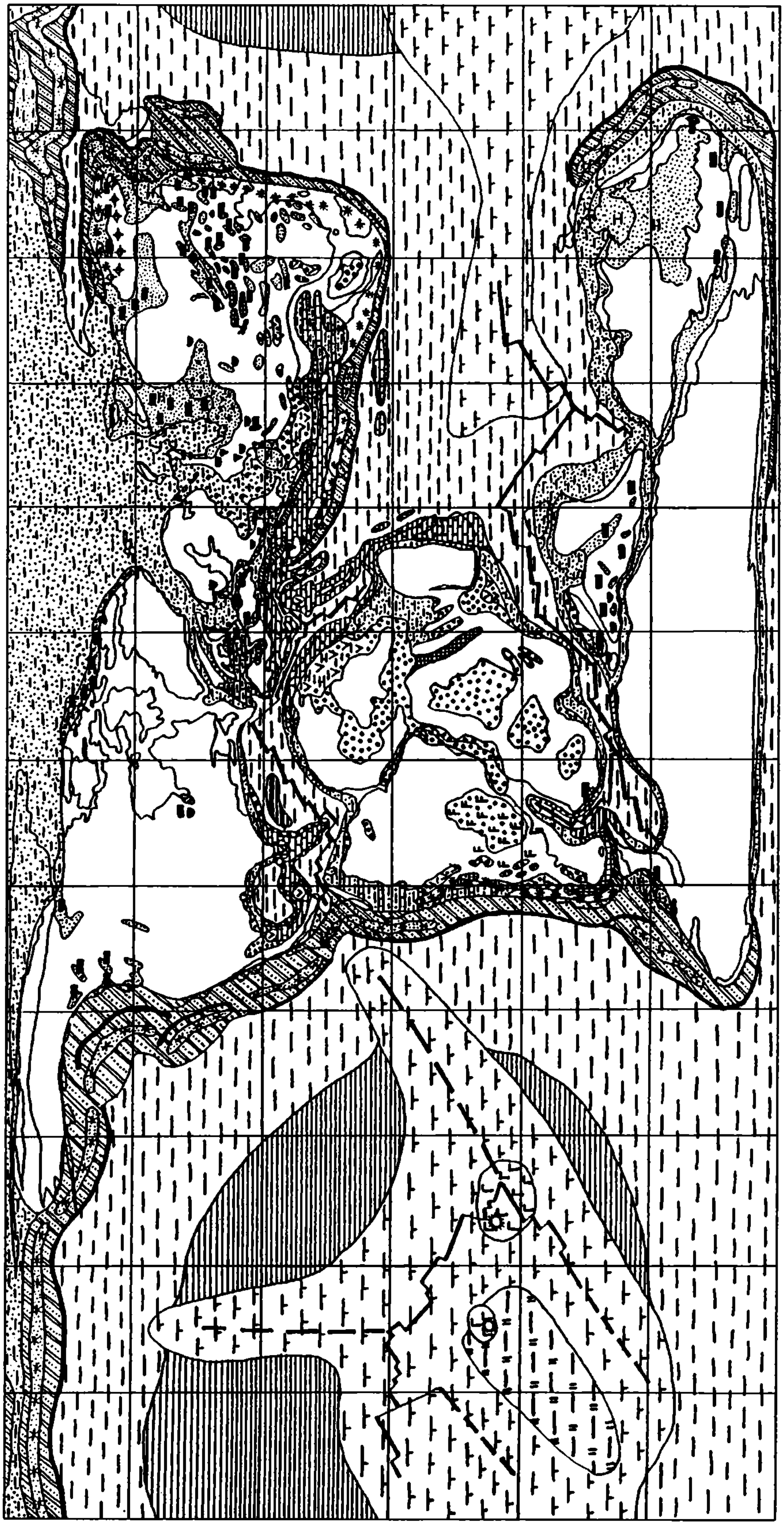

**Fig. 3.** The lithologic–paleogeographic map for the Hauterivian age of the Cretaceous (symbols as in Fig. 1).

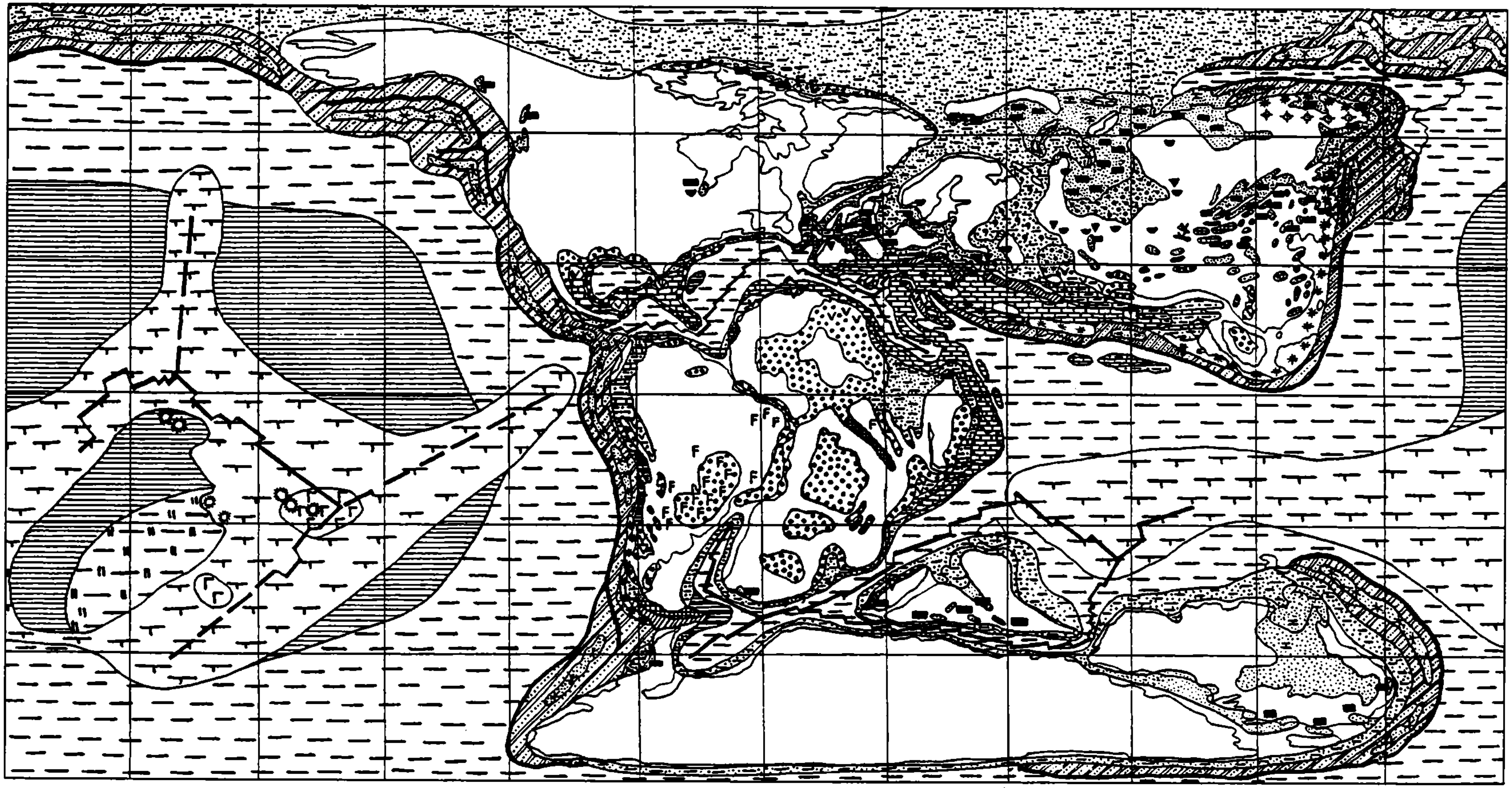

**Fig. 4.** The lithologic–paleogeographic map for the Barremian age of the Cretaceous (symbols as in Fig. 1).

iterranean Tethys, where they crossed almost the entire basin in the meridional direction and thus created a barrier to westerly surface currents in the tropical belt of the northern hemisphere. Isolated carbonate platforms (Apennines, Apulian, Gavrovo, Taurus, Midian, Bahamas, Mayan, and others) were separated from each other and from pericratonic carbonate platforms by narrow and deep basins, which accumulated either marly–calcareous sediments enriched in planktonogenic organic matter and enclosing the pelagic ammonite fauna or the hemipelagic and pelagic limestones of the Majolica facies and turbidites (Bernoulli, 1972; Bourbon, 1978; Emery and Uchupi, 1984; Dercourt *et al.*, 1985; Dercourt *et al.*, 1993). Because of their small dimensions, some pericratonic and isolated carbonate platforms and the deep basin separating them are not shown in lithologic–paleogeographic maps. All these areas are arbitrarily defined as settings of the shallow-water shelf calcareous sedimentation demonstrating the principal location of the carbonate platform areas.

In the Central Atlantic, Gulf of Mexico, and Caribbean areas, deep-water sedimentation prevailed throughout the Berriasian–Barremian time of the Early Cretaceous. Gray thin-bedded micritic limestones and marls, calcareous hemipelagic sediments, and pelagic limestones were accumulated in these areas (Lancelot *et al.*, 1978; Murdmaa *et al.*, 1979; Tucholke *et al.*, 1979; Owens, 1983; Emery and Uchupi, 1984; Tucholke and McCoy, 1986; Schlee *et al.*, 1988; Stephan *et al.*, 1990; Salvador, 1991; Dercourt *et al.*, 1993). Judging from the difference between modern hypsometric positions of deep-water facies and coeval shallow-water limestones (Blake Plateau), these basins were up to 3–3.5 km deep (Sclater *et al.*, 1977; Murdmaa *et al.*, 1979; Emery and Uchupi, 1984). Clayey–calcareous sediments enriched in organic matter, the deposition of which was most intense during the Valanginian and Hauterivian (Weissert, 1981; Cotillon and Rio, 1984; Emery and Uchupi, 1984; Arthur and Dean, 1986), were characteristic of some areas in the northwestern Atlantic Tethys, Gulf of Mexico, and several limited areas in the Mediterranean Tethys. One of such areas (the northwestern Atlantic Tethys) is arbitrary defined in maps as a basin of black-shale sedimentation.

It was presumed that deep-water hemipelagic facies of clayey–calcareous sediments were also widespread in the eastern part of the Tethys (Dercourt *et al.*, 1993), though geological records about this spacious oceanic basin were almost wholly destroyed by subsequent subduction and collision between Hindustan and Asia. The hypothetical belt of pelagic calcareous sediments is also shown along the reconstructed spreading ridge in the central part of the eastern Tethys.

During the Berriasian–Barremian, the gradual opening of the Southern Ocean and sea-floor spreading advancing southwestward separated Gondwana into two major western and eastern continental blocks. At the initiatial opening stage, the South Atlantic represented a narrow gulf of the Southern Ocean (Rabinowitz and La Brecque, 1979; Scotese *et al.*, 1987, 1988; Patriat and Segoufin, 1988). Mainly terrigenous and calcareous–terrigenous hemipelagic sediments accumulated in the narrow though relatively deep Southern Ocean. In the Hauterivian and Barremian, black shales enriched in organic matter were deposited along its western margin (Malumian *et al.*, 1983; Thomson, 1983; Krasheninnikov and Basov, 1985; Kavun and Vinnikovskaya, 1993).

Beginning in the Barremian, Hindustan started to move away from Antarctica, because a spreading zone appeared between them and created the deep-water seaway. This event marked the initial opening of the Indian Ocean, and its floor became a new area of hemipelagic terrigenous deposition (Patriat and Segoufin, 1988).

In the Neocomian, the Pacific represented a spacious and deep oceanic basin exceeding in size its modern area. According to reconstructions (Zonenshain *et al.*, 1984; Kononov, 1989) and available new data, four major lithospheric plates (Kula, Farallon, Phoenix, and Pacific) continued to evolve here along the system of spreading ridges with two triple-junctions. Reliable data on sedimentation environments are obtained (from deep-sea drilling) only for the Pacific plate, whereas three other plates are completely eliminated by subduction, and their history can be depicted only from isolated blocks (terranes) incorporated into accretionary structures of surrounding continents. The sediment distribution in these vanished plates is shown hypothetically by analogy with the Pacific plate and on the basis of general regularities of oceanic sedimentation.

During the Neocomian, the small Pacific plate born in the Jurassic was located in the southern hemisphere, in the center of the oceanic pelagic area far from the continents, and this resulted in accumulation of typical pelagic facies, whose characteristic features are red coloration, prevalence of biogenic and authigenic components, absence of terrigenous material (except for the finest clay), insignificant thicknesses, and a low sedimentation rate (Murdmaa, 1987).

In the central part of the Pacific plate most distant from the spreading axis, an oceanic area below the carbonate compensation depth (CCD) existed from the Berriasian through the Barremian. Red carbonate-free clayey–siliceous (radiolarian) sediments were accumulated in this part of the basin. This area of abyssal pelagic facies gradually widened during the indicated period of time. In the Barremian, typical pelagic clays including zeolite varieties were accumulated together with radiolarites.

Pelagic calcareous (nannofossil–foraminiferal) oozes were accumulated above the CCD along the mid-oceanic ridges and on submarine rises existing from the Jurassic. On the Schatsky Rise, the Berriasian–Valanginian(?) was marked by the accumulation of black siliceous sediments enriched in organic matter.

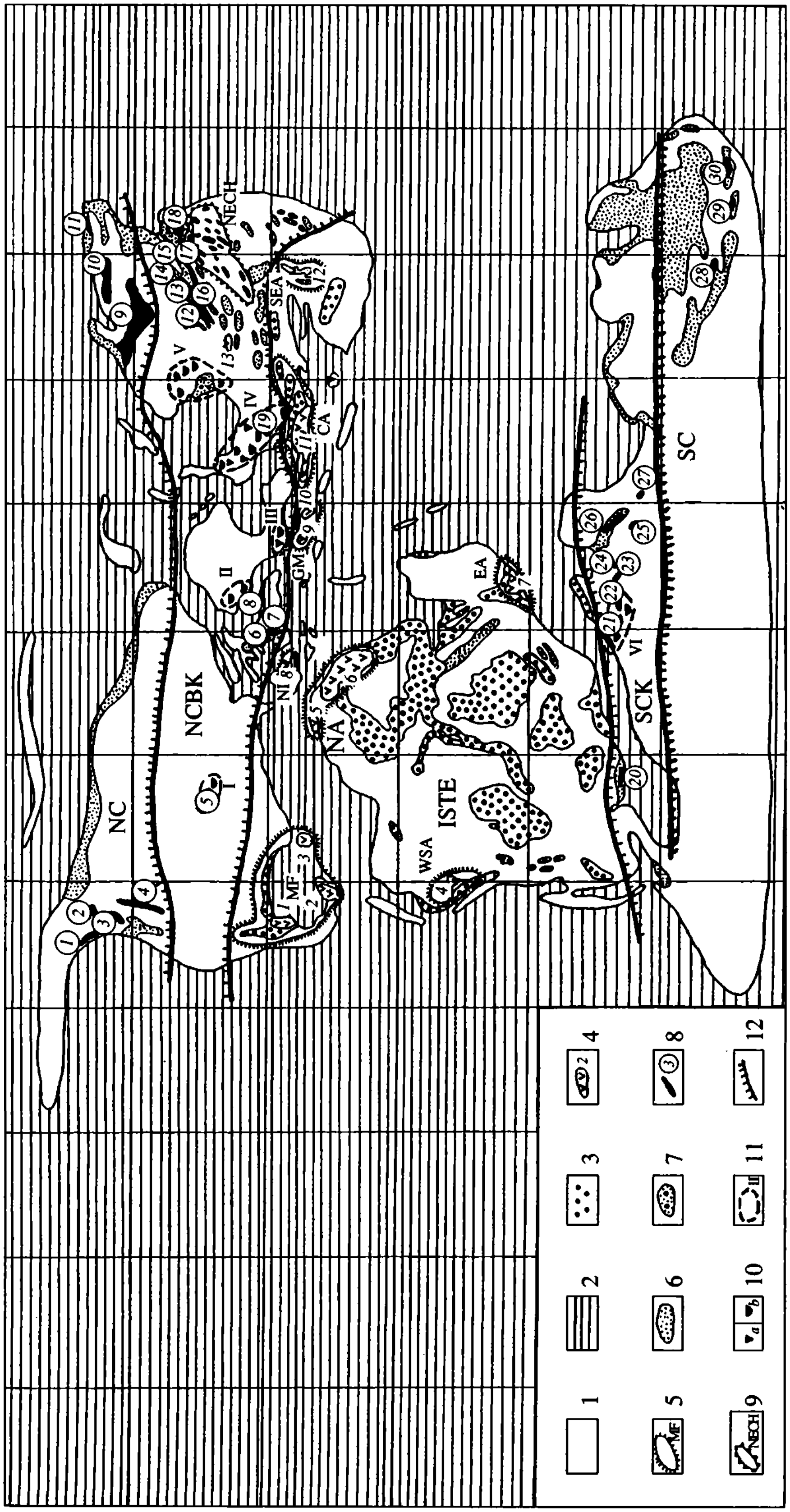
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Fig. 5.

There were several areas of active intraplate volcanism, the largest of which—the Darwin Rise—was situated during the Neocomian near the spreading axis, probably in an area of triple-junction at the eastern corner of the Pacific plate. Volcanic edifices that appeared there in the Hauterivian–Barremian now compose the constituents of the Mid-Pacific Mountains. Volcanoes of the Japanese guyot group in the northern part of the plate, as well as those of the Schatsky Rise, were probably active in earlier epochs as well. As a result of intraplate volcanism, the Ontong-Java and Hess rises were formed in the Barremian. Many volcanic islands rose above the sea level and were subsequently (beginning in the Hauterivian–Barremian) transformed into atolls (Sager *et al.*, 1993).

## MAIN DISTRIBUTION PATTERNS OF PALEOGEOGRAPHIC ENVIRONMENTS IN CONTINENTAL MARGINS

This section is dedicated to characteristics of paleogeographic environments in active continental margins of the western, eastern, and southern parts of Laurasia and in marginal areas of Gondwana, except for those adjacent to the Central Atlantic, Tethys, and Southern Ocean (Figs. 1–4).

As was mentioned previously (Zharkov *et al.*, 1995), the method of compiling paleogeographic and paleogeodynamic maps of the ocean–continent transition zone for successive ages of the Early Cretaceous included the analysis of Mesozoic orogenic belts, which fringe continents and are composed of tectonically imbricated nappes and thrust sheets of heterogeneous and heterochronous rock complexes—the terranes of oceanic (sedimentary, ophiolitic, island-arc) and marginal continental formations. The main purpose of this analysis was to determine the primary nature of allochtonous terranes occurring in modern orogenic belts as highly dislocated structural units.

The ocean–continent transition zones considered below encompass peripheral parts of oceanic basins (often comprising chains of volcanic island arcs) and marginal areas of continents. Interaction of oceanic and continental plates along convergent boundaries was responsible for the conformable spatial distribution of paleogeographic settings in the ocean–continent transition zone. As a result, lithologic complexes of different genesis in the peripheral oceanic zones and continental margins show the lenticular–banded distribution in the plan (Figs. 1–4).

In the Berriasian through the Barremian, almost the entire periphery of the paleo-Pacific was fringed by systems of volcanic island arcs, which were connected along the strike with volcanic belts of continental margins in some regions. The lateral succession of structures in the ocean–continent transition zone commonly included a deep-sea trench, a fore-arc basin with turbidite deposits, a volcanic island arc with volcanic rocks of the calc-alkaline and tholeitic series and also with terrigenous–volcanogenic deposits, and a back-arc basin filled with turbidites. Continental margins adjacent to the peripheral oceanic zones were different in their paleogeographic environments. Land areas alternated with shelf seas, which accumulated sandy–clayey and, less commonly, terrigenous–calcareous sediments. In addition, some segments of the circum-Pacific belt were occupied by chains of land volcanoes of marginal continental volcanic chains. These volcanic belts were accompanied by fore-arc depressions filled with turbidite or sandy–clayey sediments.

The small back-arcs occupied by basins were the accumulation areas of red-bed molasses and gray-colored terrigenous and calcareous deposits often in combinations with alkalic basaltic rocks of the intraplate type. In rare cases, such basins were transformed into marginal seas where turbidites and tholeitic basalts that were similar to MORB lavas accumulated.

Characterizing more thoroughly paleogeographic environments in the transition zone from the past

**Fig. 5.** Belts and provinces of arid and humid sedimentation of the Berriasian Age of the Early Cretaceous.

(1) land; (2) oceans, shelves, and epicontinental seas; (3) provinces and basins of the red-bed arid sedimentation; (4) evaporite basins (*1*, Sabians; *2*, Yucatan; *3*, South Floridan; *4*, Acre; *5*, Moroccan; *6*, Algerian–Tunisian; *7*, Mandera; *8*, Soria; *9*, Moesian; *10*, Georgian; *11*, Central Asian; *12*, Lanpang–Simao; *13*, Dzabhan, Banernur); (5) evaporite provinces and their indices (MF, Mexico–Floridan; WSA, Western South American; NA, North African; EA, East African; NI, North Iberian; GM, Georgian–Moesian; CA, Central Asian; SEA, Southeast Asian); (6) provinces, areas, and basins of terrigenous humid sedimentation (gray beds); (7) humid provinces and areas of variegated and red-bed sedimentation; (8) coal-bearing basins: *1*, Saint Elias; *2*, Whitehorse; *3*, Bowser, Sastus, Skeena; *4*, Foothills and Front Ranges of Rocky Mountains; *5*, Moose River; *6*, Celtic, Bristol, Wild, and Channel; *7*, Parisian; *8*, Western Netherlands, Lower Saxonian, and Altmark–Branderburg; *9*, Lena; *10*, Zyryanka; *11*, Pegtymel'; *12*, West Transbaikalian (Gusinoe Ozero, Uda, Khilok–Chikoi, Eravnoe, and others); *13*, Olekma–Vitim (Ukshum, Vitim, and others); *14*, Southern Yakutia; *15*, Udsk; *16*, East Transbaikalian (Chikoi, Chita–Ingoda, and others); *17*, Amur–Zeya; *18*, Bureya; *19*, Karakamys; *20*, Algoa; *21*, Sakoa; *22*, Palar and others; *23*, Eluri, Ongole, and others; *24*, Wardha, Nagpur, and others; *25*, Talcher; *26*, Narmada (Satpura and others); *27*, Damodor and others; *28*, Otway; *29*, Bass; *30*, Gippsland, Strzelecki; (9) Northeastern Chinese (NECH) coal-bearing province (Songliao, Hailar, Erlian, and other basins); (10) areas of bauxite formation (*a*) and kaolinite-formation (*b*); (11) provinces of kaolinite or kaolinite–bauxite formation: I, Moose River; II, Western Baltic; III, Northern Black Sea; IV, Central Asian–Western Siberian; V, Eastern Siberian; VI, Southern Madagascar–Southern Hindustan; (12) boundary between climatic belts. Climatic belts: NC, northern coal-bearing of the circumpolar humid zone; NCBK, northern coal–bauxite–kaolinite belt of the humid zone in middle latitudes; ISTE, intersubtropical evaporite belt of the arid zone; SCK, southern coal–kaolinite belt of the humid zone in middle latitudes; SC, southern coal-bearing belts of the humid zone.

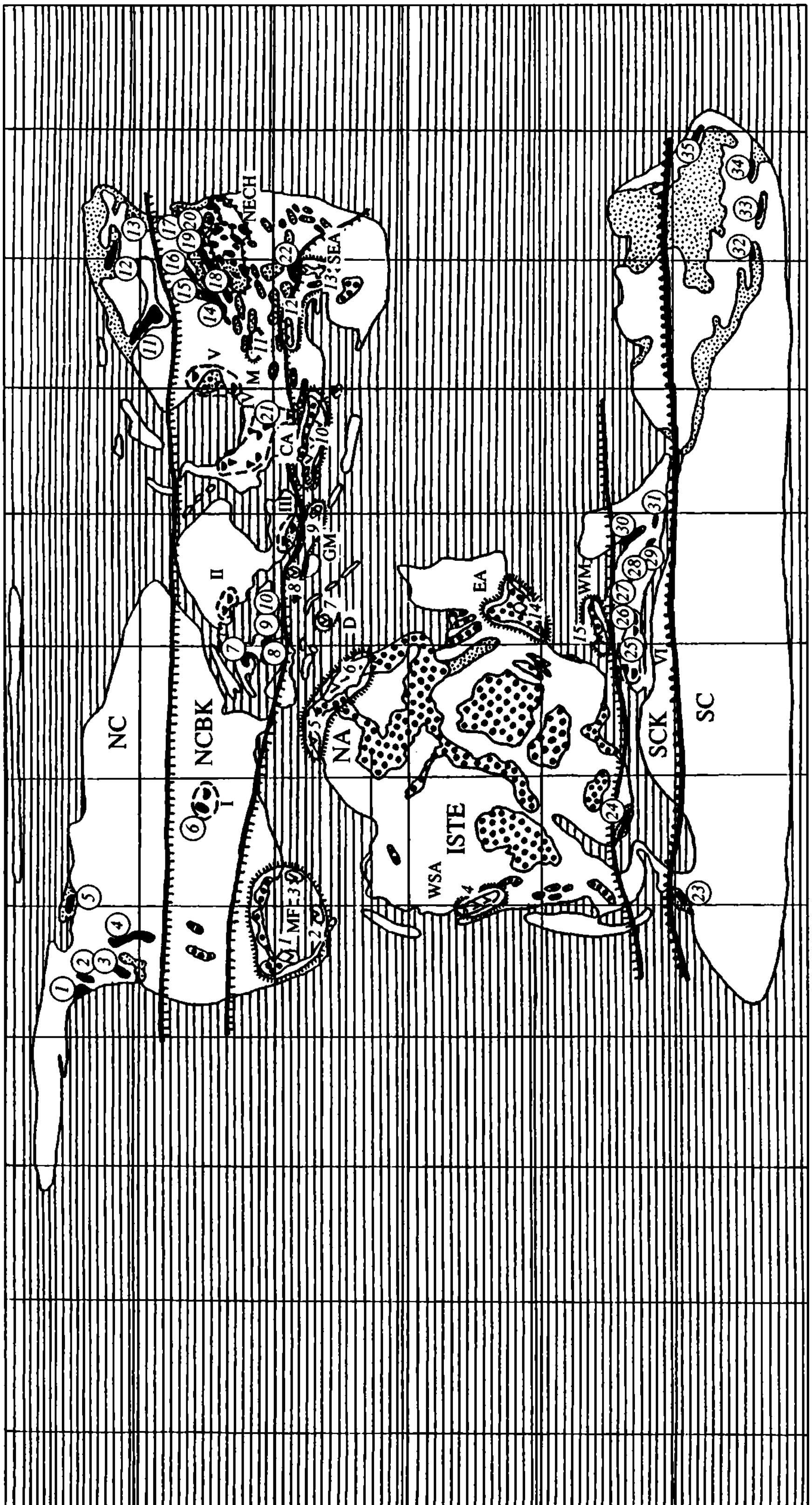


Fig. 6.

Pacific ocean to its continental margins, we should note that a complex segmented system of volcanic island arcs evolved during the Neocomian along the western coasts of Laurasia (Csejtev *et al.*, 1982; Monger *et al.*, 1982; Shervais and Kimbrough, 1985; Bogdanov and Dobretsov, 1987; Frazier and Schwimmer, 1987; Pindell *et al.*, 1988; Wallace *et al.*, 1989; Miller and Hudson, 1991; Samson *et al.*, 1991; Tardy *et al.*, 1991; Underschulz and Erdmer, 1991; Wilson *et al.*, 1991; Currie and Parrish, 1993). Deep-sea trenches that accompanied these volcanic arcs were locally situated on both the oceanic and the continental sides of island arcs (Wallace *et al.*, 1989). Chains of the Early Cretaceous island arcs along the western coast of Laurasia appeared as early as in the Jurassic time. In the Late Jurassic, some of their segments experienced collision and were integrated into more extended systems (Harper and Wright, 1984; Wallace *et al.*, 1989). In addition to active volcanic island arcs, an underwater chain of the superterrane Talkeetna consisting of dead volcanic arcs of the Paleozoic and Early Mesozoic age existed in the Early Cretaceous along the northeastern periphery of the Mesozoic Pacific Ocean (Jones *et al.*, 1986; Wallace *et al.*, 1989). The Berriasian–Barremian time was marked by the gradual convergence of segments of volcanic island arcs with the Laurasian margin, which continued until the Aptian, when they were amalgamated to the continent (Lanphere *et al.*, 1978; Csejtev *et al.*, 1982; Armstrong *et al.*, 1986; Vaughan, 1995; Zharkov *et al.*, 1995; Filatova, 1996). In the southeastern peripheral part of the ocean, a complex system of island-arc and marginal continental volcanic belts evolved during that time (Figs. 1–4). The northern segment of this system (10°–15° S) included the volcanic island arc situated near the northwestern margin of Gondwana (Colombia, Ecuador, Peru), when volcanoes erupted boninitic and tholeitic lavas (Megard, 1987; Wallrabe-Adams, 1990; Van Thournout *et al.*, 1992). Southward, the Chile–Argentine margin of Gondwana was an area of mountainous landscape. A volcanic belt with thick calc-alkaline volcanic sequences existed there (Coira *et al.*, 1982; Lomize, 1983). A trough with tholeitic and alkalic basalts appeared in the rear of the belt (Dalziel *et al.*, 1974; Suarez, 1979; Grier *et al.*, 1991). This belt continued farther to the south into the Patagonia–Antarctic segment. However, the back-arc depression of this structure represented a marginal sea basin, which accumulated turbidites and MORB-type basalts.

Along the New Zealand–Australia margin of Gondwana in the southwestern periphery of the Mesozoic Pacific ocean, the active volcanic island arc of that time (Lundbrook, 1978; Howell, 1980; Swarko *et al.*, 1983) was conjugated with the deep-sea trench (Figs. 1–4) and surrounded by narrow zones of turbidite sedimentation. The continental margin was occupied here by a shelf sea.

In the northwestern Pacific, the narrow South Anyui sea gulf separating the system of Chukchi continental blocks from the Kolyma–Omolon part of Laurasia existed during the Berriasian–Barremian period. This sea gulf, which gradually narrowed by the mid-Cretaceous time (Filatova, 1988, 1995; Bogdanov and Til'man, 1992; Parfenov *et al.*, 1993), hosted a winding chain of island arcs, which joined the island arcs of the Koryak and Far East regions of the northwestern circum-Pacific margins (Bogdanov, 1988; Faure *et al.*, 1988; Kojima, 1989; Zonenshain *et al.*, 1990; Natal'in and Faure, 1991; Sokolov, 1992).

The Chinese–Korean margin of Laurasia represented in the Neocomian time a land of ragged topography with an extended chain of land volcanoes (Wang and Lin, 1986; Wu and Pei, 1988; Filatova, 1990, 1991). Its rear parts were occupied by depressions with red-bed, evaporite, and, often, coal-bearing deposits. The seaward part of the volcanic belt was fringed by the fore-arc basin and deep-sea trench.

The southern margin of Laurasia in western and eastern Tethys had a similar evolutionary trend during the Neocomian time (Knipper, 1985; Zonenshain *et al.*, 1987; Bogdanov *et al.*, 1994). Spacious areas of this margin were occupied by the epicontinental sea with calcareous sedimentation. The edge of the continent was fringed by the Pont–Transcaucasus ensialic volcanic island arc with turbidites accumulated in the fore-

**Fig. 6.** Belts and provinces of arid and humid sedimentation in the Valanginian Age of the Early Cretaceous (symbols as in Fig. 5) *Evaporite basins: 1,* Sabinas; *2,* Yucatan; *3,* South Floridan; *4,* Altiplano (Chicamos, Hunin, and others); *5,* Moroccan; *6,* Algerian–Tunisian; *7,* Dinarids; *8,* Moesian; *9,* Georgian; *10,* Central Asian; *11,* Dzabhan; *12,* Weihe; *13,* Lanpang-Simao; *14,* Mandera; *15,* Murundava, Mazhunga. *Evaporite provinces:* MF, Mexico–Floridan; WSA, Western South American; NA, North African; D, Dinarids; GM, Georgian–Moesian; EA, East African; CA, Central Asian; SEA, Southeast Asian; WM, Western Madagascar. *Coal-bearing basins: 1,* Saint Elias; *2,* White Horse; *3,* Bowser, Sastus, Skeena, and others; *4,* Foothills and Front Ranges of Rocky Mountains; *5,* Eastern Mackenzie; *6,* Moose River; *7,* Celtic; *8,* Bristol, Wild, Channel; *9,* Parisian; *10,* Western Netherlands, Lower Saxonian, Altmark–Branderburg; *11,* Lena; *12,* Zyryanka; *13,* Northern Okhotsk; *14,* West Transbaikalian; *15,* Olekma–Vitim; *16,* Southern Yakutia; *17,* Udsk; *18,* East Transbaikalian; *19,* Amur–Zeya; *20,* Bureya; *21,* Karakamys; *22,* Weihe; *23,* Alexander; *24,* Algoa; *25,* Sakoa; *26,* Palar and others; *27,* Eluri, Ongole, and others; *28,* Wardha, Nagpur, and others; *29,* Talcher; *30,* Narmada (Satpura and others); *31,* Damodor and others; *32,* Otway; *33,* Bass; *34,* Gippsland, Strzelecki; *35,* Maryborough and Miscellaneous; (NECH) Northeastern Chinese coal-bearing province. *Provinces of kaolinite and kaolinite–bauxite formation*: I, Moose River; II, Western Baltic; III, Northern Black Sea; IV, Central Asian–Western Siberian; V, Eastern Siberian; VI, Southern Madagascar–Southern Hindustan. *Climatic belts*: NC, northern coal-bearing of the circumpolar humid zone; NCBK, northern coal–bauxite–kaolinite belts of the humid zone in middle latitudes; ISTE, intersubtropical evaporite belts of the arid zone; SCK, southern coal–kaolinite belts of the humid zone in middle latitudes; SC, southern coal-bearing belts of the humid zone.

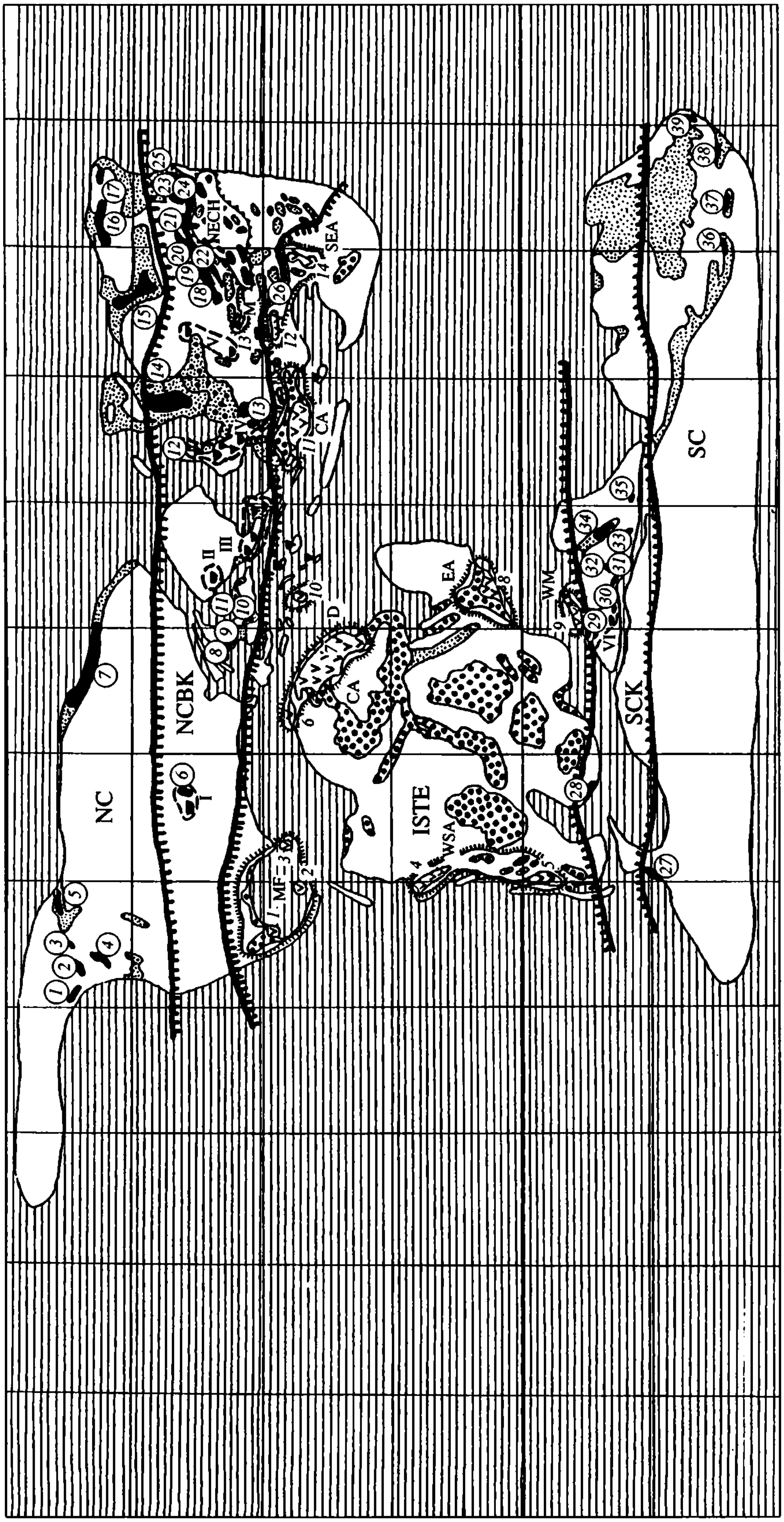


Fig. 7.

arc basin of its seaside part. The deep-sea trench, whose outer oceanic slope was in contact with hemipelagic and calcareous–clayey deposits of the Tethys, occupied the most frontal position. The incipient Black Sea and South Caspian marginal basins, which appeared as early as in the Late Jurassic, existed in the rear of the Pont–Transcaucasus volcanic arc (Zonenshain *et al.*, 1987; Kaz'min *et al.*, 1987; Dercourt *et al.*, 1993).

Further eastward, in the Tibetan region, the Pontids–Transcaucasus ensialic belt marged into the volcanic island arc of the peripheral zone of the ocean in front of the southern edge of Laurasia, which was bounded by zones of turbidite accumulation (Tapponnier *et al.*, 1981; Bard, 1983; Dietrich *et al.*, 1983; Allegre *et al.*, 1984; Coulon *et al.*, 1986). Even further to the east, the Laurasian margin within the Indochina region of Southeast Asia represented a differentiated mountain land with a chain of volcanoes adjoining the fore-arc trough with turbidite sedimentation and the deep-sea trench (Otsuki, 1985; Wang and Lin, 1986; Poltser and Tapponnier, 1988).

The peculiar feature of landscapes in southern Laurasia and the adjacent peripheral oceanic zone consisted of the presence of undersea rises with carbonate and terrigenous–carbonate sedimentation in the latter zone (Figs. 1–4). These rises are usually considered to represent fragments detached from the African–Arabian plate. The raised blocks (Central Afghanistan, Pamirian, South Tibetan) gradually neared the edge of the Laurasian continent from the Berriasian through the Barremian and collided with the latter in the Aptian–Albian (Allegre *et al.*, 1984).

Thus, the spacious Neocomian ensembles of perioceanic ensialic island arcs existed along the deep-sea trenches of the Mesozoic Pacific, for instance, in its northeastern and northwestern sectors including the southern Anyui gulf. In the southeastern sector of the ocean, the situation was more complicated: the island arc located near northwestern Gondwana merged southward into the central Andean–Antarctic volcanic belt of the continental margin, which further extended along the eastern margin of Gondwana into the southwestern sector of the Pacific. Similarly, island arcs of the northwestern Pacific were replaced southward, in the Chinese–Korean region, by marginal continental volcanic belts.

Volcanic belts along the northern periphery of the Tethys also occupied the marginal position in continents, though segments of oceanic ensimatic island arcs were also formed in some of these areas (for instance, in the North Tibetan region). It is interesting that, in the rear regions of volcanic belts, back-arc and marginal basins existed throughout the Neocomian and tectonic extension in continental margins progressed with time. This can be exemplified by the Rocas-Verdes basin in the Patagonia region of South America, where this period of time resulted in formation of the oceanic-type crust.

The considered paleogeographic settings existed in active margins of Gondwana and Laurasia until 110–105 Ma, i.e., until the cardinal reorganization of lithosheric plates (Knipper, 1985; Bogdanov, 1988; Larson, 1991; Zonenshain and Kuz'min, 1992; Khain and Balukhovskii, 1993; Zharkov *et al.*, 1995; Filatova, 1996).

## PECULIAR FEATURES OF SPATIAL DISTRIBUTION OF ARID AND HUMID SEDIMENTATION AREAS

Schemes illustrating the distribution of coal accumulation areas and basins of red-bed or gray-bed sedimentation in the arid and humid zones also show the sites of kaolinite and bauxite formation. They are based on lithologic–paleogeographic reconstructions and also on an analysis and systematization of published data (Bogolepov, 1961; Butov *et al.*, 1962; Douglas, 1964; Martinis and Visintin, 1966; *Atlas litologo–paleogeograficheskikh...*, 1968; Gol'tbert *et al.*, 1968; Busson, 1972; Blant, 1973; Beltrandi and Pyre, 1973; *Poverkhnosti vyravnivaniya...*, 1974; Gevork'yan, 1976; Traves and King, 1976; Kauffman, 1977; Ludbrook, 1978; De Klasz, 1978; Dingle, 1978; Nairn, 1978; Benson *et al.*, 1978; Saint-Mare, 1978; Yasamanov, 1978; *Kory vyvetrivaniya...*, 1979; Megnien, 1980; Monakhov *et al.*, 1981; Parrish *et al.*, 1982; Ziegler, 1982,

**Fig. 7.** Belts and provinces of arid and humid sedimentation of the Hauterivian Age of the Early Cretaceous (symbols as in Fig. 5). *Evaporite basins*: *1*, Sabinas; *2*, Yucatan; *3*, South Floridan; *4*, Altiplano (Chicamos, Hunin, and others); *5*, Neuken; *6*, Moroccan; *7*, Algerian–Tunisian; *8*, Mandera; *9*, Murundava; *10*, Dinarids; *11*, Central Asian; *12*, Qaidam; *13*, Dzabhan; *14*, Lanpang-Simao. *Evaporite provinces:* MF, Mexico–Floridan; WSA, Western South American; NA, North African; EA, East African; WM, Western Madagascar; D, Dinarids; CA, Central Asian; M, Mongolian; SEA, Southeast Asian; *Coal-bearing basins*: *1*, Saint Elias; *2*, White Horse; *3*, Peel; *4*, Laberge, Bowser, Sastus, and others; *5*, Eastern Mackenzie; *6*, Moose River; *7*, Sverdrup; *8*, Celtic; *9*, Bristol, Wild, Channel; *10*, Parisian; *11*, Western Netherlands, Lower Saxonian, Altmark–Branderburg; *12*, North Uralian; *13*, Karakamys; *14*, Enisei–Taz; *15*, Lena; *16*, Zyryanka; *17*, Anui; *18*, West Transbaikalian; *19*, Olekma–Vitim; *20*, Southern Yakutia; *21*, Amur–Zeya; *22*, East Transbaikalian; *23*, Udsk; *24*, Bureya; *25*, Partizansk, Razdol'naya; *26*, Central Qinling; *27*, Alexander; *28*, Algoa; *29*, Sakoa; *30*, Palar; *31*, Eluri, Ongole; *32*, Wardha, Nagpur; *33*, Talcher; *34*, Narmada (Satpura and others); *35*, Damodor and others; *36*, Otway; *37*, Bass; *38*, Gippsland, Strzelecki; *39*, Clarence, Moreton, and Miscellaneous; (NECH) Northeastern Chinese coal-bearing province. *Provinces of kaolinite and kaolinite–bauxite formation*: I, Moose River; II, Western Baltic; III, Northern Black Sea–Donets; IV, Uralian–Western Siberian; V, Eastern Siberian; VI, Southern Madagascar–Southern Hindustan. *Climatic belts*: NC, northern coal-bearing belt of the circumpolar humid zone; NCBK, northern coal–bauxite–kaolinite belt of the humid zone in middle latitudes; ISTE, intersubtropical evaporite belt of the arid zone; SCK, southern coal–kaolinite belt of the humid zone in middle latitudes; SC, southern coal-bearing belt of the humid zone.

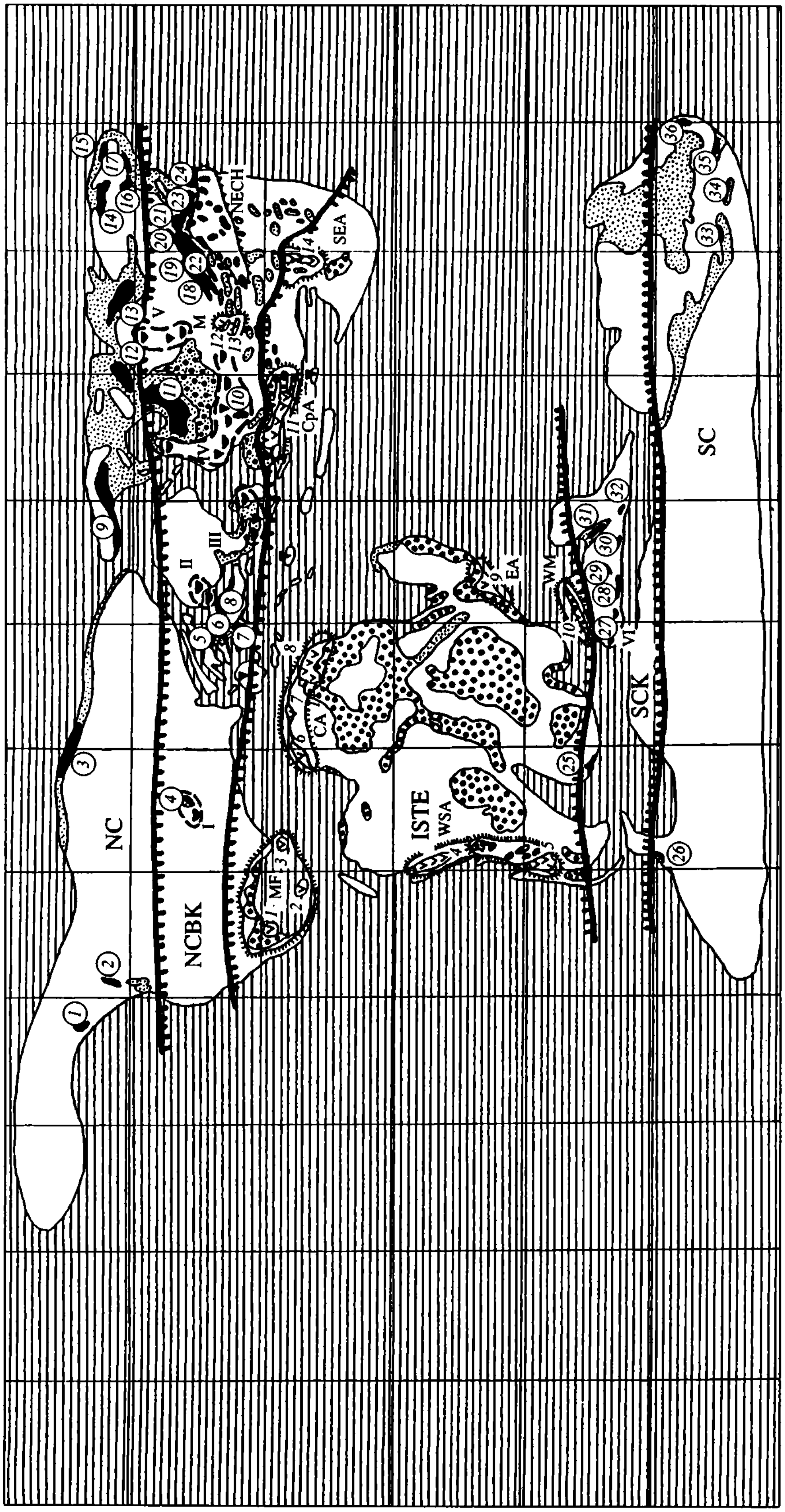


Fig. 8.

1988; Balkwill *et al.*, 1983; Malumian *et al.*, 1983; Dingle *et al.*, 1983; Petri and Mendes, 1983; Thomson, 1983; Emery and Uchupi, 1984; Cahen *et al.*, 1984; *Atlas...*, 1985; Salomon and Drillien, 1985; *Stratigrafiya...*, 1986; Chen Pei-Li, 1987; Frazier and Schwimmer, 1987; Liu Qun *et al.*, 1987; Petri, 1987; Reyment and Dingle, 1987; Riccardi, 1987; Zirsmeister, 1987; Blakey *et al.*, 1988; Butterwarth *et al.*, 1988; Hutchison, 1989; Smith, 1989; Arthur *et al.*, 1990; Bardossy and Aleya, 1990; Bardossy and Dercourt, 1990; Bussert *et al.*, 1990; Luger *et al.*, 1990; Wycisk *et al.*, 1990; Acharyya and Lahari, 1991; Basov and Vishnevskaya, 1991; Wycisk, 1991; *Atlas paleogeograficheskikh...*, 1992; Tashliev and Tovbina, 1992; Dercourt *et al.*, 1993; Kavun and Vinnikovskaya, 1993; Shulgina *et al.*, 1994; Rehakova *et al.*, 1995; Sitian *et al.*, 1995). These schemes allow the main features of zonal arrangement of arid and humid sedimentation environments on continents to be distinguished and the position of climatic belts throughout the indicated time interval to be reconstructed (Figs. 5–8).

In the Berriasian, the environments of arid sedimentation prevailed over all of western Gondwana, along the southern margin of Laurasia, and in adjacent areas of the Tethys (Fig. 5). Various evaporite basins with predominant sulfate sedimentation existed in these regions either as floodplain, lacustrine, limnoalluvial, deltaic, lagoonal, coastal, and continental sebkhas or as evaporite–carbonate platforms. Simultaneously, the red-bed terrigenous sedimentation was characteristic of spacious areas of the West Gondwanan interiors, as well as of the southwestern and southeastern parts of Laurasia.

The extended evaporite-accumulation belt became traceable at that time also along the entire southern margin of Laurasia and northern periphery of the Tethys. It was spread over more than 15 000 km from the Caribbean region in the west to Southeast Asia in the east within the limits of the northern subtropical and tropical zones. The belt comprised a series of isolated evaporite basins located in the Mexican–Floridan, North Iberian, Georgian–Moesian, Central Asian, and Southeast Asian regions, where many of them, e.g., the Yucatan, Sabinas, South Floridan, Soria, Moesian, Georgian, Central Asian, and Lanpan-Simao basins, had variable sedimentation enviroments.

Three isolated regions of Berriasian evaporite sedimentation are distinguished in the territory of western Gondwana. In the western part of the continent, the western province of South America is outlined by the distribution of evaporites of the Akra basin. The spacious North African region of evaporite accumulation encompasses the Moroccan, Algerian–Tunisian, and a series of smaller continental and coastal evaporite basins distinguished in the north. In the east, the extended East African evaporite region is traceable along the past continental margin running through boundary areas of Kenya, Somalia, and Ethiopia and comprising the Mandera and some other smaller basins. Some peculiar features of the spatial distribution of evaporite-accumulation regions in western Gondwana attract attention. For instance, the North African region is located north of the equator, mostly in the northern tropical belt. Two other evaporite regions in western South America and East Africa extend to the southern tropical belt approximately between 10° S and 30° S. It is seen that the North African evaporite region is situated near the South Laurasian evaporite belt, and, in fact, it is a part of the northern tropical to subtropical zone of evaporite sedimentation. In its western half, this zone covered not only the southern areas of Laurasia but also the entire western and central Tethys, along with adjacent areas of Gondwana, whereas in its eastern half, it occupied the southern and southeastern areas of Laurasia and the northern periphery of the eastern Tethys.

These peculiarities in the spatial distribution of the Berriasian evaporite basins and areas reveal their confinement to two latitudinal belts: the northern Tethyan–South Laurasian belt and the southern one, which is tentatively termed as the Southwestern Gondwanan belt encompassing the western South American and East African evaporite-accumulation regions. Environments of continental red-bed sedimentation of the arid type prevailed between these belts and in many interior basins of western Gondwana. They were widespread in many equatorial, tropical, and subtropical areas. Thus, it is evident that almost all of western Gondwana,

**Fig. 8.** Belts and provinces of arid and humid sedimentation in the Barremian Age of the Early Cretaceous (symbols as in Fig. 5). *Evaporite basins*: *1*, Sabinas; *2*, Yucatan; *3*, South Floridan; *4*, Altiplano (Chicamos, Hunin, and others); *5*, Neuken; *6*, Tindouf–Ayun; *7*, Moroccan; *8*, Algerian–Tunisian; *9*, Mandera; *10*, Murundava; *11*, Central Asian; *12*, Dzabhan; *13*, Banemur; *14*, Lanpang-Simao. *Evaporite provinces*: MF, Mexico–Floridan; WSA, Western South American; NA, North African; EA, East African; WM, Western Madagascar; M, Mongolian; SEA, Southeast Asian. *Coal-bearing basins*: *1*, Saint Elias; *2*, Bowser, Sastus, and others; *3*, Sverdrup; *4*, Moose River; *5*, Celtic; *6*, Bristol, Wild, Channel; *7*, Parisian; *8*, Western Netherlands, Lower Saxonian, Altmark–Branderburg; *9*, Northern Barents; *10*, Karakamys; *11*, West Siberian; *12*, Khatanga; *13*, Lena; *14*, Zyryanka; *15*, Anui; *16*, Omsukchan; *17*, Taigonos; *18*, West Transbaikalian; *19*, Olekma–Vitim; *20*, Southern Yakutia; *21*, Amur–Zeya; *22*, East Transbaikalian; *23*, Bureya; *24*, Partizansk, Razdol'naya; *25*, Algoa; *26*, Alexander; *27*, Sakoa; *28*, Palar, Eluri, Ongole; *29*, Wardha, Nagpur; *30*, Talcher; *31*, Narmada (Satpura and others); *32*, Damodor and others; *33*, Otway; *34*, Bass; *35*, Gippsland, Strzelecki; *36*, Clarence, Moreton, Miscellaneous; (NECH) Northeastern Chinese coal-bearing province. *Provinces of kaolinite and kaolinite–bauxite formation*: I, Moose River; II, Western Baltic; III, Northern Black Sea–Donets; IV, Uralian–Western Siberian; V, Eastern Siberian; VI, Southern Madagascar–Southern Hindustan. *Climatic belts*: NC, northern coal-bearing belt of the circumpolar humid zone; NCBK, northern coal–bauxite–kaolinite belt of the humid zone in middle latitudes; ISTE, intersubtropical evaporite belt of the arid zone; SCK, southern coal–kaolinite belt of the humid zone in middle latitudes; SC, southern coal-bearing belt of the humid zone.

except for its extreme southern areas, was under the influence of the predominantly arid climate of the Berriasian. In general, the Berriasian was the formation period of a single and very wide belt of arid sedimentation, which covered not only subtropical and tropical regions of the northern and southern hemispheres of the Earth but also the equatorial zone of western Gondwana. This arid belt is recognized as the intersubtropical evaporite belt (ISEB). Its northern boundary was near 30° N, and the southern one was approximately between 40° S and 50° S.

The ISEB retained its boundaries almost unchanged throughout the Valanginian, Hauterivian, and Barremian times (Figs. 6–8). Only the number of evaporite basins and areas changed, and the spatial distribution of red-bed arid terrigenous sedimentation insignificantly varied. For instance, beginning in the Valanginian, the evaporite accumulation stopped in the northern Iberian region and, beginning in the Hauterivian, in the Georgian–Moesian region. A new evaporite accumulation area appeared in their place in the central Tethys. Configuration and boundaries of the North African region also somewhat changed, as it became more spacious in the Barremian time owing to the appearance of evaporite sedimentation in the Tindouf–Aayun basin. The configuration of the western South American evaporite region also changed, when the center of evaporite accumulation moved here southward into the Neuken basin during the Hauterivian and Barremian. However, despite all these changes, the spatial distribution of evaporite basins and areas was persistent in its general patterns, and they were steadily confined to two latitudinal belts: the northern Tethyan–South Laurasian and the southern Southwest Gondwanan. During the Valanginian, Hauterivian, and Barremian ages, environments of red-bed arid sedimentation also continued to exist not only in tropical but also in equatorial areas of western Gondwana.

During the first half of the Early Cretaceous, humid areas and belts comprised coal-bearing basins, areas of kaolinite and bauxite formation, and regions of gray-colored terrigenous sediments. The zonal patterns in distribution of areas with humid sedimentation were most clear in the northern hemisphere, within the Laurasian continent. Two latitudinal humid belts were pronounced here through all the Neocomian ages. There were the northern mid-latitude coal–bauxite–kaolinite (NCBK) belt and the northern circumpolar coal-bearing (NC) belts.

The NCBK belt is traced both in the Eurasian and North American parts of Laurasia. In the eastern part of Asia, it corresponds to the spacious East Asian coal-bearing province comprising more than 300 coal-bearing basins formed in a system of parallel and subparallel flow-through freshwater lakes and river valleys and also in internal-drainage depressions separated by extended ridges. The following coal-bearing regions are distinguished within this province: West Transbaikalian (Gusinoe Ozero, Uda, Eravnoe, Hilok-Chikoi, and other basins), East Transbaikalian (the Chikoi, Chita–Ingoda, and numerous smaller coal-bearing basins), Olekma–Vitim (the Ukshum, Vitim, and other basins), Northeastern China (Hailar, Erlian, Songliao, and a number of other coal-bearing basins), and also the South Yakut, Udsk, Amur–Zeya, Bureya, and other regions. The Partizansk and Razdol'naya basins appeared here in the Hauterivian and Barremian, whereas the Weihe and Central Qinling basins near the southern boundary of the belt were formed in the Valanginian and Hauterivian. Thick black-shale bituminous sequences of argillite, siltstone, and marl were intermittently formed during almost the entire Neocomian period in many lake basins (Gusinoe Ozero, Zaza, Eravnoe, Unda–Onon, Songliao, and others). The system of coal-bearing and black-shale lacustrine basins extended far westward to Mongolia.

In the rest of Eurasia, the humid belt of middle latitudes comprised not only the basins of continental and coastal coal-accumulation but the provinces and areas of kaolinite- and bauxite-formation as well. Five major kaolinite and kaolinite–bauxite provinces always existed there in the Neocomian, through they changed their configuration and dimensions with time. They were the Moose River, West Baltic, and northern Black Sea region (beginning in the Hauterivian, the Northern Black Sea–Donets province) and also the Central Asian–West Siberian (in the Hauterivian–Barremian, Uralian–West Siberian) and East Siberian provinces. These regions were constantly or, probably, intermittently marked by the formation of lateritic weathering crusts, secondary kaolinites, bauxite-bearing deposits, kaolinite-to-bauxite clays, and kaolinite–quartz sands and also by the accumulation of other reworked weathering products. The Neocomian coal-bearing basins in the central and western areas of Eurasia were mostly confined to the southern zones of the midlatitudinal belt. This can be exemplified by the Celtic, Bristol, Wild, Channel, Paris, Western Netherlands, Lower Saxonian, Altmark–Branderburg, and Karakamys basins. In the Hauterivian–Barremian, coal formation was also characteristic of spacious areas of the West Siberian basin.

In the North America territory, the Neocomian humid belt of northern middle latitudes includes only the Moose River basin, where the Mattagami Formation encloses the Onakawana lignite beds alternating with kaolinite clays and quartz sands.

The humid belt in question was peculiar because of the the simultaneous development of coal-, kaolinite-, and bauxite-formation environments in continents and specific sedimentation in spacious epicontinental seas confined to it (Figs. 1–4). The most characteristic in this respect were the East European, West Siberian, and Enisei–Khatanga seas, which represented typical marine basins of terrigenous sedimentation with autigenic glauconite, phosphate, and iron minerals combined, sometimes with black-shale accumulation (the West Siberian basin of the Berriasian and Valanginian ages).

The southern boundary of the NCBK belt remained almost stable during the entire Neocomian and is now reliably traceable in the central areas of Laurasia. There, it passes near 28°–30° N between closely spaced evaporite provinces on the one side, and coal-bearing, kaolinite, and kaolinite–bauxite provinces on the other side. In eastern Asia, this boundary turns to the south, where the belt comprises a number of continental basins of eastern China with volcanogenic and gray-colored terrigenous sediments of the humid zone. In North America, the southern boundary of the belt is not far north of the Mexican–Floridan evaporite province. The northern boundary of the belt is arbitrarily drawn near 57°–60° N with due regard for the position of both the areas of coal-accumulation and kaolinite-formation and the epicontinental seas with glauconite, phosphate, and iron-oxide terrigenous sedimentation.

The northern circumpolar coal-bearing belt of the Berriasian, Valanginian, Hauterivian, and Barremian ages encompassed marginal regions of Laurasia located north of 57°–60° N. It is established on the basis of distribution of coal-bearing basins there. In the Berriasian–Valanginian, these basins were concentrated in two regions of the opposite continental margins of Laurasia corresponding to northwestern North America and northeastern Asia. The first of these regions comprises the Saint Elias, White Horse, Bowser, Sastut, Skeena, and Eastern Mackenzie basins and coal deposits of the foothills and Front Ranges of the Rocky Mountains. The other belt includes the Lena, Zyryanka, and Pegtymel' basins. In the Hauterivian and, particularly, Barremian, environments of coastal coal accumulation were characteristic of almost the entire territory of coastal regions of the circumpolar belt, where the Sverdrup, North Barents, Khatanga, Anyui, and Omsukchan coal-bearing basins were formed in addition to the basins mentioned above.

The data available for the southern hemisphere are also sufficient for recognizing and tracing two Neocomian humid belts similar to those outlined in the northern hemisphere. The southern coal–kaolinite (SCK) humid belt can be detected in the middle latitudes of the southern hemisphere. It is recognized as comprising many coal-bearing basins, such as the Sakoa, Palar, Eluri, Ongole, Vardha, Nagpur, Talcher, Narmada, and Damodor deposits in the northern regions of eastern Gondwana (southern margins of Madagascar and southeastern and eastern parts of Hindustan), and also the kaolinite and kaolinite-bearing deposits in the spacious territory tentatively termed as the Southern Madagascar–Southern Hindustan province. The southern margin of Africa, where the Algoa coal-bearing basin was discovered, also belongs to this coal–kaoilinite belt. The northern boundary of the belt is quite unambiguously traced along the eastern margin of the Western Madagascar evaporite province, as well as along the periphery of the arid areas with the red-bed deposits in Africa and South America. This boundary is located near 40°–50° S. The southern boundary of the belt is less obvious and arbitrarily placed at approximately 60° S, because only a few areas and basins of coal formation have been located south of this latitude for all the Neocomian ages.

The southern coal-bearing (SC) humid belt is distinguished by the presence of continental and coastal basins of red-bed humid sedimentation in Australia and some areas of the Antarctic continent, also including isolated coal-bearing basins spaced from each other. In the western margin of eastern Gondwana, only one coal-bearing basin, the Alexander, is known in the island of the same name near the West Antarctic coast, whereas a series of the Otway, Bass, Gippsland, Strzelecki, and other coal-bearing basins in Australia is located in the eastern part of Gondwana. Despite the limited number of coal-bearing basins, the peculiarities of their spatial distribution allow us to define rather reliably the southern coal-bearing humid belt with the northern boundary located near 60° N.

## CONCLUSION

The presented analysis of original lithologic–paleogeographic maps compiled for the Berriasian, Valanginian, Hauterivian, and Barremian ages of the Early Cretaceous allows the following conclusions to be drawn.

(1) The Neocomian was the period of the final formation of the Tethys Ocean, the sublatitudinal seaway between Laurasia and Gondwana for the global western current. Hemipelagic clayey–calcareous sediments prevailed in the deep Tethyan basins, where shallow-water carbonate platforms and reefs also existed. In the incipient Southern Ocean and also in the narrow seaway between Hindustan and Antarctica that emerged beginning in the Hauterivian, hemipelagic terrigenous sediments were deposited. The central part of the Pacific was separated by a system of midocean ridges (spreading zones) into several deep basins with prevailing red-bed pelagic clayey–siliceous sedimentation, while ridges and submarine rises accumulated pelagic calcareous sediments. Subalkalic basaltic volcanism occurred in several areas of the Pacific plate.

(2) From the Berriasian through the Barremian time, the convergent boundaries of lithospheric plates were represented by a combination of marginal continental and island-arc (ensialic and ensimatic) volcanic belts, in the frontal part of which fore-arc basins and deep-sea trenches with turbidite sedimentation represented the successive lateral morphostructures related to volcanic belts. One of the peculiar environmental features of this period was the moderate crustal extension behind the volcanic belts of continental margins, where it resulted in the formation of back-arc and marginal sea basins.

These environments existed until the Aptian–Albian time, when the Middle Cretaceous orogeny substantially changed the paleogeography of the ocean–continent transition zones.

(3) The revealed spatial distribution of arid and humid sedimentation areas allows us to distinguish five latitudinal climatic belts of the Berriasian–Barremian time: the northern circumpolar coal-bearing humid zone, the northern coal–bauxite–kaolinite belt in the humid middle latitudes, the intersubtropical evaporite belt of the arid zone, the coal-bearing–kaolinite belt of the southern middle latitudes, and the southern coal-bearing belt. Two peculiar features of the Neocomian climatic zoning are interesting. The first, the asymmetric distribution of the Earth's humid belts, is evident. In the northern hemisphere, the humid belt occupies the largest territory of all the regions of Laurasia located north of 30° N, whereas humid areas of the southern hemisphere are displaced to the south beyond 40°–50° S. This was probably related to the particular position of Laurasia and eastern Gondwana in the northern and southern hemispheres, respectively, and also the position of the Tethys in the northern tropical belt. In addition, a single very wide intersubtropical arid belt between 30° N and 40°–50° S is unambiguously defined as the zone of evaporite and red-bed sedimentation in both the tropical and equatorial areas. The prevalence of arid environments in this spacious zone probably resulted from the fact that the vast western Gondwana continent was located near the equator.

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Reviewer A.P. Lisitsyn

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