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ON THE PALEOGEOGRAPHY OF THE RUSSIAN PLATFORM DURING THE UPPER CRETACEOUS EPOCH

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6. On the paleogeography of the Russian platform during the Upper Cretaceous epoch

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CONTENTS

INTRODUCTION

During the Upper Cretaceous a fluctuating marine basin existed in the southern part of the Russian platform. It developed towards the close of the Albian as a result of a great subsidence to the south of the platform. It was united with the sea in the Crimean-Caucasus area, and also had close connection with the epicontinental seas of Western Europe and Central Asia. The courses of the coastline and the shapes of islands changed, owing to differential movements of varying intensity in certain regions. These movements are not strongy reflected in the syneclises,[1] whereas in anteclises even slight changes led to notable paleogeographic differentiation.

In different sections of the same basin in the southern part of the platform there were several kinds of sedimentary conditions, these being

Translation by R. A. REYMENT, University of Stockholm.

[1] Syneclise (definition taken from N. S. SCHATSKY, 1945, p. 122) — a broad, flat, syncline-like structure. The dip of the syneclise limbs is slight, being no more than a few meters per kilometer. The form of a syneclise is elongated, often irregular The term was introduced by A. P. PAVLOV (1909). An anteclise is the corresponding anticline-like structure.

caused by the nature of the adjacent land, the depth of the basin, the direction and strength of currents, the climate, as well as numerous other factors. The typical sedimentation produced mostly different kinds of marls and chalks[1]. The immediate vicinity of the strandline is denoted by the occurrence of arenaceous marls and chalks, with final subsequent replacement by sands, which are often glauconitic and phosphoritic. The sands were deposited, as a rule, in the coastal zone, but in certain cases sands are also known from localities away from the immediate vicinity of the shore. Siliceous sediments such as opoki,[1] kieselgur, diatomaceous rock, silicified sandstones, marls and clays constitute the third principal group of Upper Cretaceous rocks of the platform. They were deposited preferentially in the northerly parts of the Upper Cretaceous basin. The occurrence of phosphatic nodules has proved to be particularly specific of several of the areas of the Upper Cretaceous basin.

It would seem to be often characteristic for the anteclises that there is relatively incomplete development of the carbonate facies. But in connection with extensions of marine conditions they developed almost exclusively carbonate rocks. In some cases details of the lithologic characteristics of certain sections are decided by the existence of special structures.

The distribution of faunas in the Upper Cretaceous of the basin was dominated, firstly, by the facies peculiarities of the deposit and, secondly, by the climatic conditions. Thus, an abundant fauna of serpulids and barnacles, brachiopods, echinoids, sponges, cephalopods, gastropods and pelecypods (partly coarse and thick-shelled forms) is characteristic of the coastal areas. At a distance from the coastline the composition of the faunas is much altered; there is a wider distribution of small, thin-shelled bivalves, but also frequently inocerami; belemnites are particularly characteristic.

CLIMATIC ZONES AND DISTRIBUTION OF SPECIES

The distribution of many organisms in the Upper Cretaceous basins of Europe and Asia is obviously tied up with the existence of climatic zones; spreading took place from WNW to ESE. ARKHANGELSKY, who in 1916 studied the distribution of *Actinocamax* in the Cenomanian and Turonian, rudistids, and representatives of African faunas, postulated a general parallelism in the latitudinal extension of the distributional boundaries accorded with temperature limits. It would seem to be possible to explain the distribution of certain species of Upper Cretaceous belemnites (NAIDIN, 1954) by climatic zonation.

Interesting results on the absolute values of average yearly temperatures on the Upper Cretaceous basin have been obtained of recent years. In

[1] Siliceous rock with calcium carbonate (Polish term).

particular, the isotopic composition of the oxygen in the calcite of belemnite rostra established that in the second half of the Upper Cretaceous, beginning with the Lower Campanian, but perhaps even somewhat earlier, the average yearly temperatures become noticeably lower (LOWENSTAM and EPSTEIN, 1954, NAIDIN et al., 1956). These results, obtained by isotope paleothermometry, agree with the conclusion based on the evidence of the distribution of belemnites and rudistids, "in connexion with a somewhat cold period, beginning in the Santonian and continuing throughout the Campanian and Maestrichtian" (NAIDIN, 1954, p. 27).

The close connection of the basin with adjacent seas facilitated intermingling of faunas. Thus, in the southeastern parts of the Russian platform there are many localities where the Cenomanian and Turonian faunas contain elements displaying southern aspects, such as ammonites and trigonids (ARKHANGELSKY, 1916). Conversely, in the Campanian and Maestrichtian a broad penetration of a fauna of the boreal type (belemnites) away to the south, as far as Kopet-Dag, occurs.

PALEOGEOGRAPHIC PROVINCES

The faunas and the nature of the sediments of the platform make it possible to distinguish two large paleogeographic provinces — *a southwestern* and a *northeastern*.

In the southwestern province (a great part of the Polish-Lithuanian syneclise and the Black Sea depression) different kinds of carbonaceous sediments accumulated. The distribution of sands, sandstones and clays being less wide. Belemnites make up the prinicipal part of the fauna: representatives of the genus *Gonioteuthis* are very characteristic, also various species of the genus *Belemnitella*, but *Actinocamax* is represented by few species. The influence of the Mediterranean province is reflected primarily in the occurrence of the echinoids and ammonites.

In the northeastern province (the Pechora, Moscow and Caspian synecliseс; northern Polish-Lithuanian and part of the Ukrainian synclises) siliceous sediments accumulated; there were also carbonates and argillaceous sandstones. In this province there is a wide distribution of representatives of the genus *Actinocamax*, but an almost complete absence of species of *Gonioteuthis*. As also in the southwestern province the belemnites are of many kinds, but the abundant occurrence of *Belemnitella praecursor* STOLLEY, and related forms is particularly characteristic. Echinoids and ammonites are of rare occurrence. The typical boreal form *Oxytoma* (*Pteria*) *tenuicostata* ROEMER is typical.

The Danish depression seems to belong to this province. However, as a result of displacement of the boundaries between climatic zones in the north of Western Europe and the effect of warm currents, its environment deviated somewhat, and thus does not permit sharp delineation from the

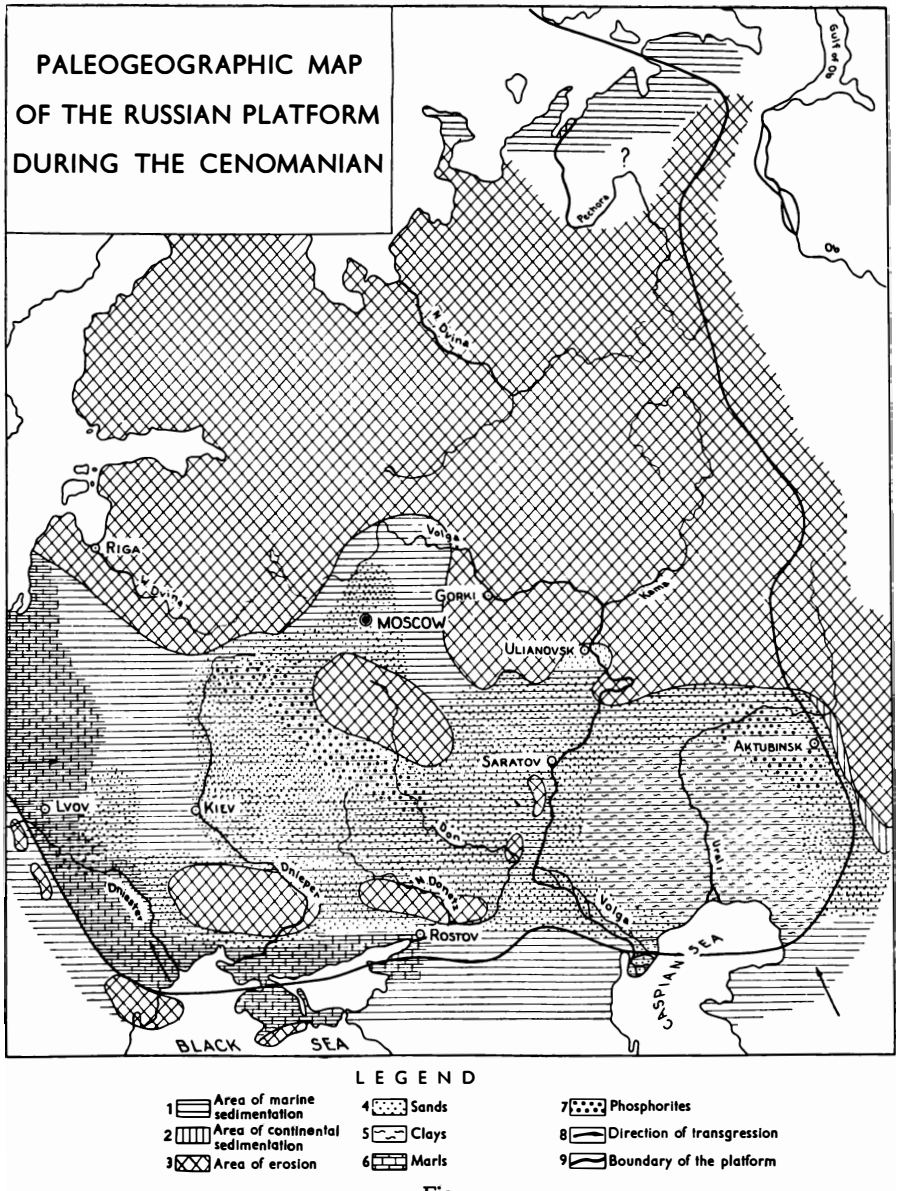

Fig. 1

southern area. Generally speaking, some special sedimentary and organic environments, as already noted above, distinguish parts of the areas of each of the both paleozoogeographic provinces. Thus, SAVCHINSKAIA (1950) on the basis of the occurrence of endemic species and a certain faunistic property in the Upper Cretaceous of the Donetz Basin distinguishes in the southwestern province special Donetz paleozoogeographical regions for the various stages of the Upper Cretaceous.

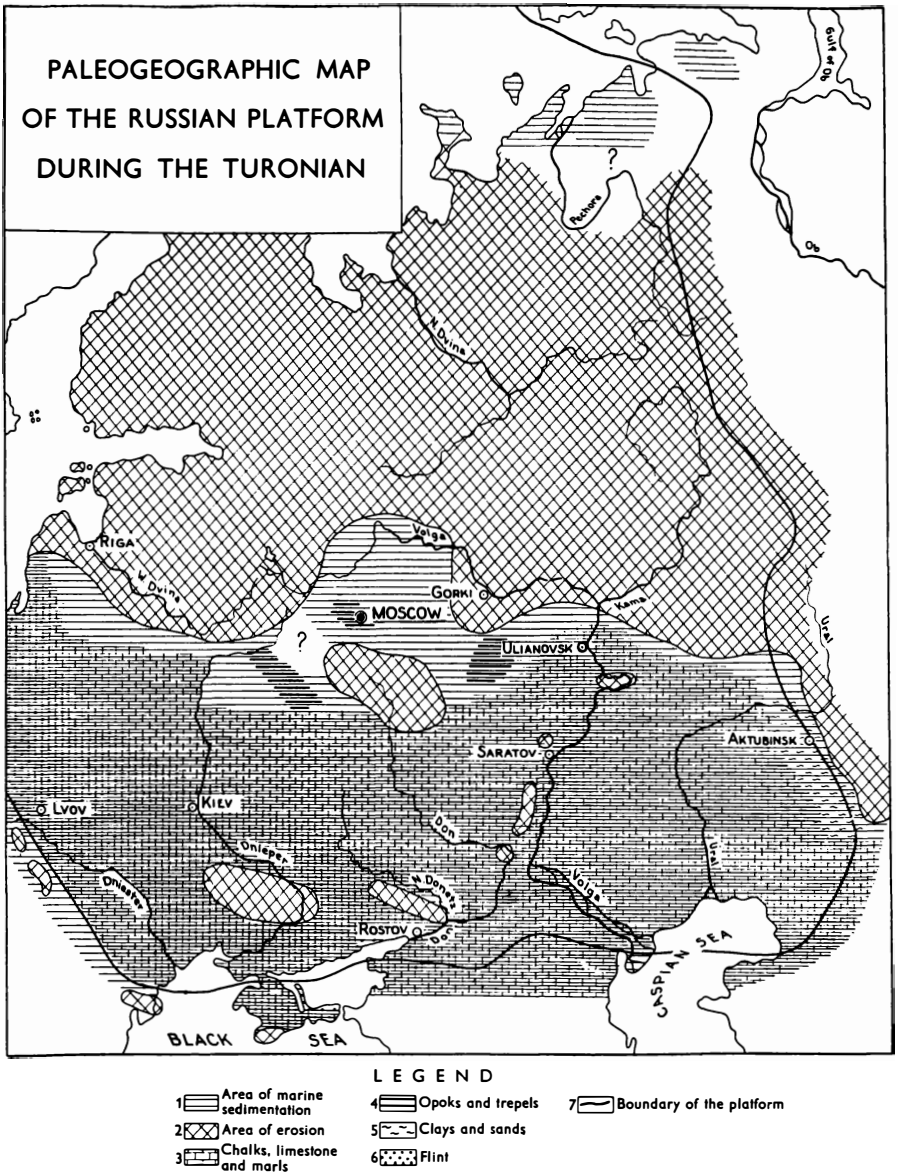

Fig. 2

REVIEW OF PALEOGEOGRAPHIC SEQUENCES

In the following the main steps in changes in the paleogeographic conditions on the Russian platform during the different stages of the Upper Cretaceous are given.

A general wave of submergence, initiated at the close of the Albian, resulted in a southern transgression. The Cenomanian sea was characterised by an exceptionally shallow-water environment; sedimentation occurred under conditions of strong, rapidly changing currents; the basin contained several islands that contributed material. Large bays stood in connection with the basin by sounds. In Cenomanian time (fig. 1) sands (partly glauconitic) were deposited almost everywhere; they have phosphatic nodules. To the southeast of the platform, and even around the periphery of the Ukrainian shield, Albian-Cenomanian accumulations of continental sands and clays, with plant remains, took place.

In the later half of the Cenomanian and in the first half of the Turonian the transgression was interrupted; Upper Cenomanian and Lower Turonian deposits are missing over considerable areas of the platform. In the other half of the Turonian there was a further expansion and widening of marine conditions. During this time it seems as though the sea flooded over a large part of the Ukrainian shield (fig. 2). It is possible to see support for such an hypothesis in occasional remnants of the marine Turonian in some points of the shield, and also in the absence of shore-facies sediments in the Turonian beds surrounding the shield.

A widening of marine conditions during the Turonian is also apparent in other regions of the platform. Thus, in the Ulianovsk-Volga area, where Cenomanian beds are unknown, white hard chalk of Upper Turonian age is widely represented; it overlies older Mesozoic sequences. Particular interest is attached to the find of Upper Turonian echinoids (*Conulus subrotundus* MANTELL, *Micraster corbovis* FORBES, and many more) in the Saratov section of the Volga area, they are frequently encountered in the southern and southwestern areas of the platform (Donetz Basin, Lvov-Lublin Basin), and usually also in the northern Caucasus and in the Crimea.

The Turonian deposits consist of chalk and chalky marls, partly arenaceous and containing considerable quantities of broken shells of inocerami. To the south there are flint concretions. In the outer reaches (Aktiobinsk) of the basin sands and clays dominate, to the north, kieselgur and diatomaceous rock.

During the Coniacian the physico-geographical conditions of the Turonian persisted. The Coniacian beds are intimately connected with the Turonian, with which they from a natural complex. It should be observed however, that there was a slight recession in the extension of the sea. This contraction has been clearly established in sections located in the outer parts of syneclises and anteclises.

The Santonian represents a new phase of widening of marine conditions. To the east of the platform in the Caspian syneclise and connected structures, there is, at the base of the Santonian beds, the so-called "Sponge bed"; this also occurs at other levels of the Upper Cretaceous.The Santonian beds transgress onto older Mesozoic deposits and also beds of Paleozoic

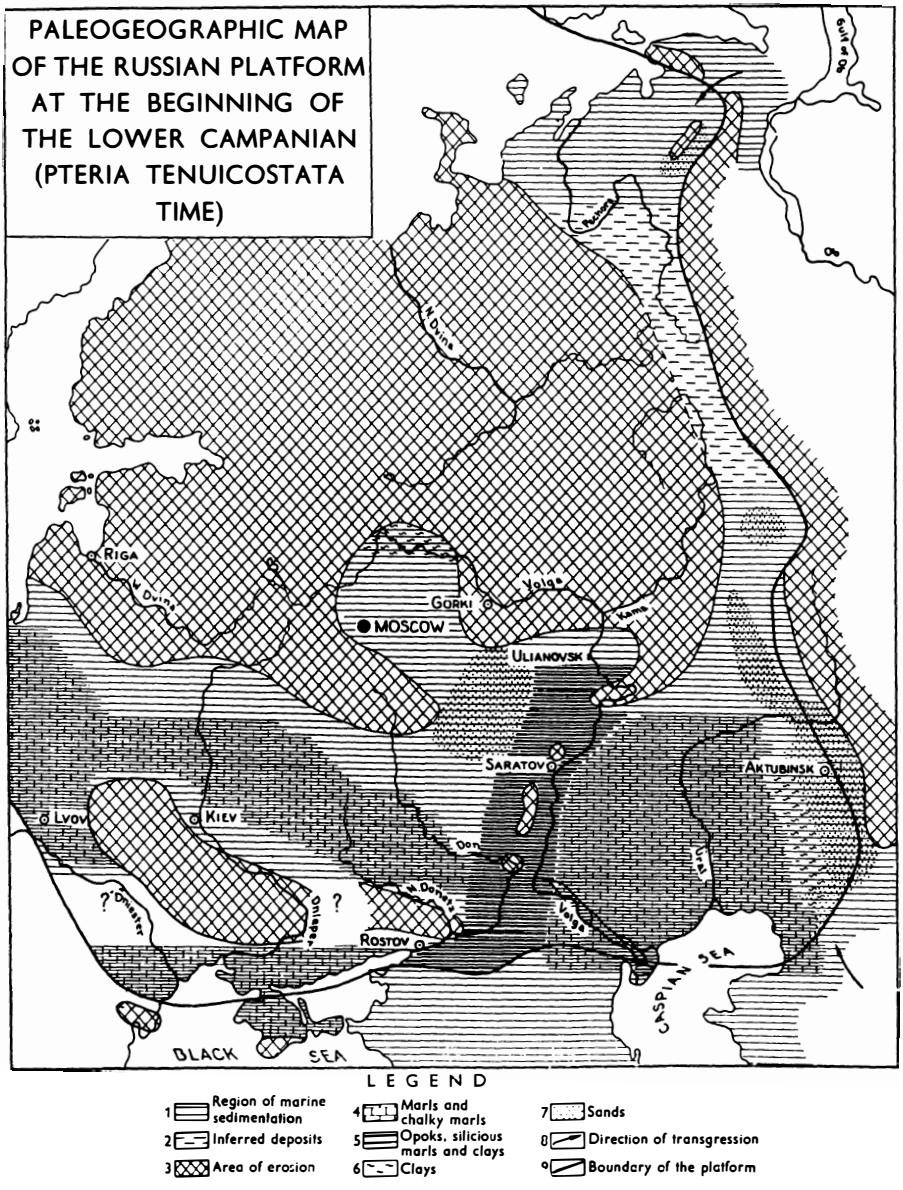

Fig. 3

age in the eastern, subsided part of the Ukrainian shield, the southern limb of the Byelorussian anteclise, as well as other places.

A division into characteristic earth movements becomes apparent in the Santonian; it embraces, on the one hand, the east and southeast of the platform, and the west and southwest on the other. It is more noticeable in the Campanian and in the first half of the Maestrichtian. The

result was that the downwarping in the eastern periphery of the platform, compared with its western part, became more intensive. A large subsidence in the eastern outskirts of the platform was apparently attended by the formation of a connection between the basin in the southern part of the platform and the basin of the Pechora syneclise. The existence of similar connections is disclosed by the presence of marine deposits with *Oxytoma tenuicostata* ROEMER at several points along the western slope of the Urals (fig. 3). During the existence of a sound in the Ural area, there was apparently, to the south, an invasion of such boreal forms as *O. tenuicostata* and some *Actinocamax* species. Naturally, it is not possible to regard the existence of a narrow meridional sound as definitely proved, because "*Pteria* beds" are not yet known between the Krasnoufimsk region and the river Usa. It is possible that the boreal faunas invaded the basins of the platform, across to Siberia, the Turgay Sound and the region to the north of the Aral Sea. During the Upper Campanian and Maestrichtian, at least. this connection existed as outlined.

The proof of more intense downwarping of the eastern part of the platform is also observable in the slow transgression in the Hercynian folded system of the Urals during the Santonian, Campanian and Maesttrichtian (BEZRUKOV, 1939). Thus, in the western section of the southern part of the region to the west of the Urals, Santonian lies directly on deposits of Paleozoic origin. To the east, Campanian sands lie on a Paleozoic basement. Still further eastward the oldest beds of the Upper Cretaceous disclose deposits with the zone of *Belemnitella langei*.

ARKHANGELSKY (1912) made various deposits of the Upper Cretaceous of the southeastern part of the shield the subject of a detailed paleooceanographic analysis. This study makes ARKHANGELSKY the first in Russia to have constructed paleooceanographic maps for stages of the Upper Cretacous, in which the position of the coastlined and disposition of the sediments were inferred. These maps indicated a definite zonality in the distribution of marine sediments: from sands deposited in a coastal environment to chalk sedimented in open seas. Siliceous sediments were widely distributed in the western Caspian syneclise during the Santonian and Campanian. The siliceous material represents mainly the remains of siliceous organisms (diatoms, radiolaria). It is usually taken that recent siliceous organisms are mainly characteristic of cold water, and the fossil siliceous sediments support the concept of a cold environment. The result of the investigations on paleotemperatures seem to suggest that Lower Campanian belemnites were the inhabitants of regions with relatively high average yearly temperatures. It is clear that to the west and northwest of the Caspian syneclise, and in the Ulianovsk-Saratov downwarping, the paleogeographic conditions were very complicated in Santonian and Campanian time. Apart from the cold northerly current, with the favorable development of boreal faunal elements (*Oxytoma tenuicostata* ROEMER, *Actinocamax mammillatus* NILSSON, etc.), there were

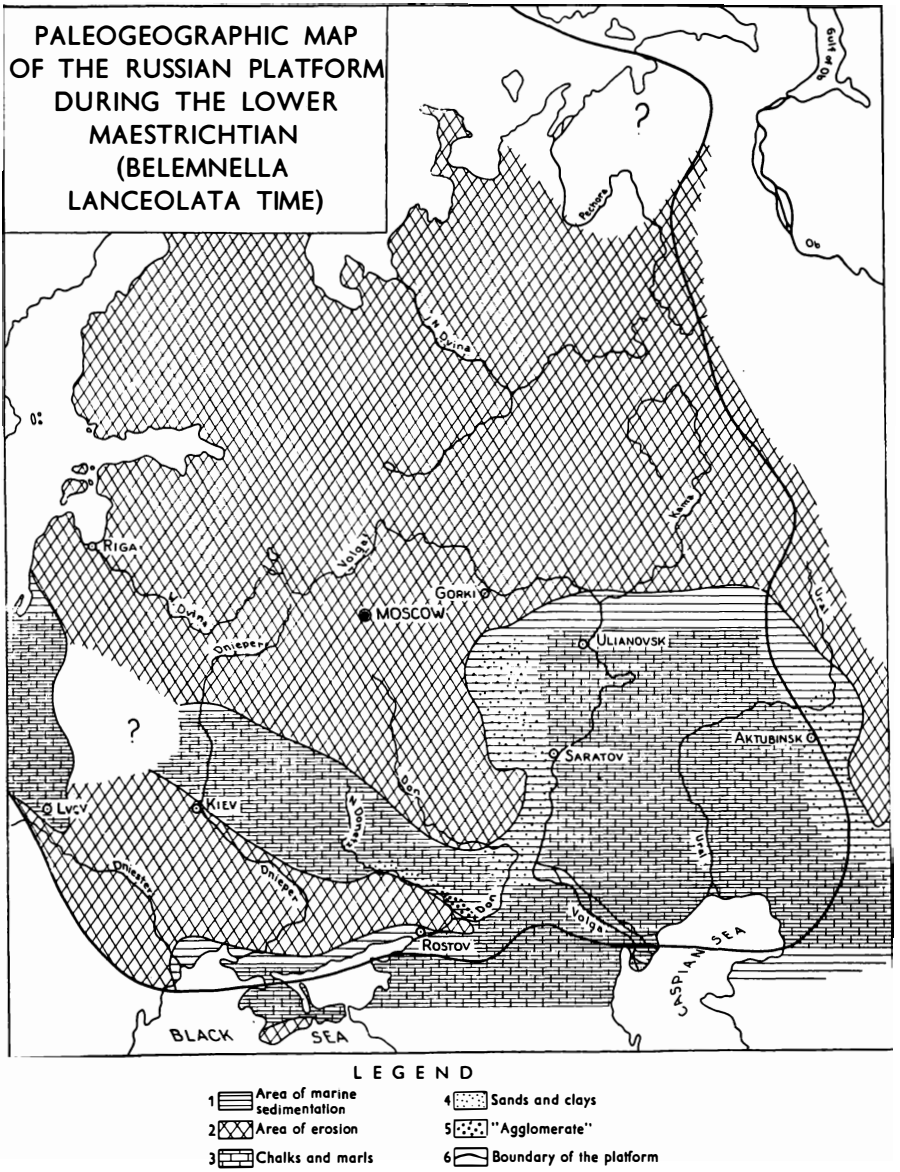

Fig. 4

at the same time warm currents, for only by this assumption is it possible to explain the influx into the Volga region of Campanian echinoids, characteristic of the northern Caucasus.

The conditions behind the accumulation of phosphorites and the Khoper River deposits are of particular interest for the unravelling of the climatic relationships. They were formed during the Santonian, perhaps in the

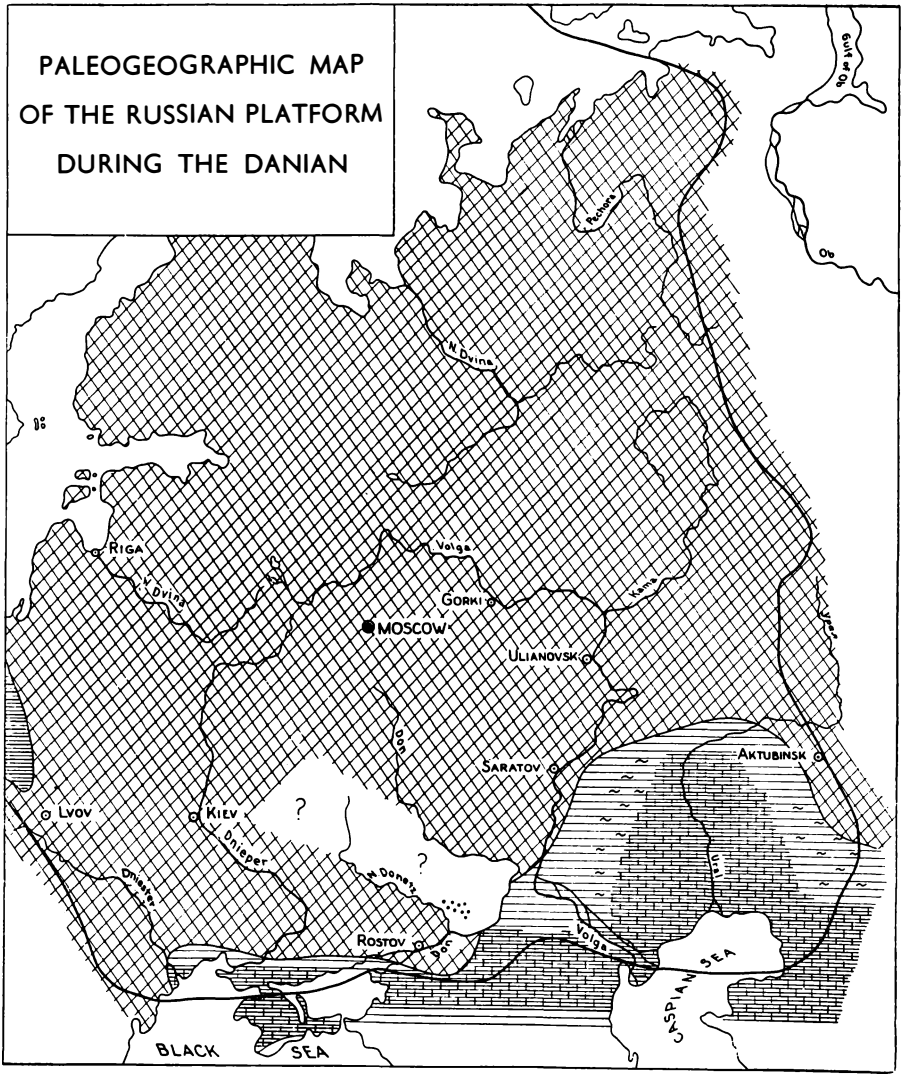

Fig. 5

coastal zone of the sea around the outskirts of the Voronezh anteclise. According to BUCHINSKY (1954), large amounts of iron and phosphorus occur in compounds precipitated chemically in the marine basin by the breakdown of previous combinations under the influence of warm, humid climatic conditions.

The white chalk facies (fig. 4) was particularly characteristic of "*lan-*

ceolata time". In the other half of the Maestrichtian stage signs of a regression may be observed and there was a wide production of sandy calcareous sediments and sands. Finally during the Danian the marine basin shrank even more (fig. 5).

As far as the remaining regions are concerned (Ukrainian, Polish-Lithuanian and Moscow syneclises, the Black Sea depression) there was here a successively more rapid contraction of the marine conditions during the other half of the Upper Cretacecus epoch, than in the east.

The basin of the Moscow syneclise ceased to exist at the close of the Lower Campanian. In the other troughs, marine conditions were more persistent. Chalks and assorted marls are among the characteristic sediments of the Santonian, Campanian and Maestrichtian of this area; at the periphery of the troughs they were replaced by sandstone varieties and sands.

The course of the ancient coastlines is perhaps delineated by the development of coastal facies at various localities on the slopes of the syneclises. The area taken up by the sea gradually diminished, although there were still connections with the open sea (Carpathians, Crimea and Caucasus).

At the opening of Upper Maestrichtian time the sea withdrew from the Ukrainian syneclise. During the course of the Upper Cretaceous the erosion of the Donetz folded system took place. This erosion was especially strong in the eastern Donetz basin along the Northern Donetz overthrust during the Maestrichtian. The products of this erosion, large blocks of Carboniferous and Permian rocks, accumulated in the coastal zone ("agglomerate", see figs. 4 and 5).

In the southern part of the Polish-Lithuanian syneclise marine conditions existed longer. But even here land areas increased rapidly. It is therefore possible to judge on the basis of the fossil floras of Potylicz (Nowak, 1907) the location of the land that fringed the Maestrichtian basin in the southwest; the dominating climate was dry.

In the Black Sea depression there was also a gradual regression towards the close of the Cretaceous.

РЕЗЮМЕ

Морской бассейн, занимавший южную часть Русской платформы в верхнемеловую эпоху, был тесно связан с морями Западной Европы и Крымско Кавказской области.

По характеру осадконакопления и по распростаранению фауны намечаются две палеозоогеографические провпии: юго-западная с преимущественно карбонатным осадконакоплением, с разнообразными видами родов *Belemnitella* и *Gonioteuthis*, некоторыми актинокамаксами, морскми ежами и аммонитами и северо-восточная, характеризующаяся накоплением, наряау с карбонатными, также песчано-глинистых и кремнистых осадков, широким

распространеием представителей родов *Actinocamax* и *Belemnitella*, почти полным отосутствием аммонитов и морских ежей, приступствием типичной бореальной формы *Oxytoma tenuicostata* Roemer.

Представдяется возможным выделить следующие этапы в развитии палеогеографической обстановки на Русской платформе в течение верхнемеловой эпохи. Погружения в конце альба повлекли эа собой трансгрессию, расширившуюся в сеноманский век. В конце сеноманского века и в первую половину турона развитие трансгрессии приостанавливается. Вторая половина туронского века знаменуется дальнейшим расширением морских условий. В коньякский век площадь, занятая морем, несколько сокращается. Сантонский век представляет фазу нового расширеиня морских условий. Наиболее широкое распространение морские условия получают в »птериевое время», отвечающее началу нижнего кампана. В это время была установлена свяэь посредством уэкото пролива вдоль эадапного склона урала между морем южной части платформы и баессейном Печорской синеклиэы. Во вторую половину верхнемеловой эпохи (кампанский, маастрихтский и датский века) для платформы в целом характерно последовательное сокращение морских условий, более быстрое на западе по сравнению с её восточной частью. В датский век омрские бассейны сохранились лишь на юго-востоке платформы, а также вдоль её южного и юго-эападного обрамления.

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