here, too, the lines of equal overall distortion of the pre-Neogene surface are parallel over relatively small sections.

The above arguments are borne out by the information from deep seismic probing [9]. The Mohorovičić surface is greatly disturbed and shattered. Analysis of the wave pattern shows it to vary substantially from region to region. Each has its own waves which cannot be followed into other regions. The origin of subsurface wave groups is due to the different physical properties of seismic boundaries. For example, on the profile Nogaysk-Konstantinovka-Roven'ki crossing the eastern part of the Ukrainian shield (East Ukrainian irregularity in the upper mantle), the western Donbas (Donets irregularity) and the Dnieper-Donets depression, the cutoff velocities at the Mohorovičić surface range from 8.2 km/sec near the East Ukrainian irregularity to 8.5 km/sec (even to 8.9 km/sec in some sections) in the vicinity of the Donets irregularity. At the same time, on the profile Crimea-Voronezh mass passing west of the Donets irregularity, the cutoff velocities on the Mohorovičić surface are considerably lower in the Donbas and Dnieper-Donets depression than within the Donets irregularity and range from 8.1 to 7.9 or 7.7 km/sec. It is the same for other irregularities in the upper mantle of the Ukraine.

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LOCAL AND REGIONAL PALEOGEOTHERMAL GRADIENTS[1]

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The paleogeothermal gradient can be considered that increase in temperature (per unit thickness of rock) expressed by a progressive replacement in space of mineral parageneses reflecting the steady variation in thermodynamic conditions of metamorphism. There are both local and regional paleogeothermal gradients. The former originate in regional metamorphism and are caused by a rise in geoisotherms (i.e., sagging of the crust) over wide areas. The latter originate in contact metamorphism, where the rock is locally heated by intrusive magma. In contact metamorphism the thermal gradient diminishes away from the intrusion, at right angles, into the country rock. In regional metamorphism the thermal gradient diminishes from the earth's interior to the surface; in general, it coincides closely with the position of the earth's radius.

According to A. Lillie and B. Mason [20], the paleogeothermal gradient in the zoned green schist complex of ghe New Zealand Alps was 20 deg/km in the period of regional metamorphism. On G. Chinner's data [13], the regional metamorphism in the Dalradian complex of Scotland occurred at a gradient of 10 deg/km. In this case, however, G. Chinner did not use altogether authentic information about the position of the triple point of Al_2SiO_5 in the PT field. When this point shifts into the more hypothermal region of about 600° at P = 8 kb, the geothermal gradient here should approach a figure of around 17 deg/km. The metamorphic complex of the Grampian Mountains, Scotland [18, 19],

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originated at a thermal gradient of about 12 to 15 deg/km. The latter figures were obtained by interpolation into the high pressure region of H. Winkler's experiments [8, 24] on the upper limit of stability of chlorite with quartz or muscovite and quartz and L. Hsu's experiments [16] on the lower almandine stability limit. These experiments provided controlled data on the position of the biotite and garnet isotherms (isogrades) in PT coordinates. The pressure was estimated from the intersection of the garnet isotherm [9] with the sillimanite-kyanite equilibrium [21], for in the Grampian Mountains, Scotland, kyanite was formed in the garnet stability field. The paleogeothermal gradient in existence during Precambrian regional metamorphism in the Southwest Baikal region can also be put at less than 20 deg/km [7]. Here, in a roughly 15-km thick formation of metamorphic rocks, there are the garnet, stauroloite-andalusite, sillimanite, microcline and hypersthene isogrades, i.e., the temperature interval from 200 to 300° is spanned [1]. This estimate may well apply, too, to the gradient in areas of epithermal regional metasomatism, where rocks of the so-called zeolite facies are developed. In particular, W. Fyfe [6] has obtained a figure of around 15 deg/km for such rocks [14].

Consequently, the regional paleogeothermal gradient did not usually exceed the normal figure of 20 to 30 deg/km. But in certain, perhaps not so rare cases it may have reached higher values, of about 40 to 60 deg/km, as follows from the fact of palingenesis in metamorphism at depths of not more than 15 to 20 km.

It is questionable whether gradients of more than 60 deg/km could be attained in regional metamorphism, as W. Fyfe et al. suppose [6]. This conclusion was drawn by W. Fyfe largely as a result of his examination of old geologic works [10-12], where the authors had arbitrarily assumed that the temperature interval between geologically recognizable isogrades was 100°. But by reconsidering the facts of these publications in the light of fresh experimental information [8, 9, 16, 21, 24], it can certainly be concluded that the paleogeothermal gradients here were only slightly in excess of 30 deg/km.

It is most doubtful whether in all cases when the regional paleogeothermal gradient exceeded 40 to 60 deg/km, the vigorous flow of heat from the earth's interior was due to shallow intrusive masses. When they crop out, the picture becomes clear [25]. In other cases, this possibility is merely hypothetical [17]. It is thus obvious enough why such regional metamorphism, when developed over large areas, is often called plutonic metamorphism.

It may be supposed that the aftereffect of plutonic metamorphism is to produce all types of transition between contact and regional metamorphism. The thermal gradients in zones of plutonic metamorphism are, of course, in excess of those of regional metamorphism, although they are less than the normal gradients of contact metamorphism. Judging by the distribution of isogrades, the contact metamorphism requires considerably higher thermal gradients in excess of 50 to 60 deg/km. In the formation of contact-metamorphic rocks of the spurrite-merwinite facies [4] they often equaled thousands of degrees per kilometer. For example, at the outer contacts of the Anakit trap intrusion, Lower Tunguska River, the paleogeothermal gradient is estimated at 5000 to 10,000 deg/km [3]. The buchitization at the outer contacts of a basalt neck near Apsley [22] was caused by heating of host sandstone at a temperature gradient of not less than 2000 to 100,000 -six) deg/km. At granitoid contacts the paleogeothermal gradient was not so high and usually amounted to hundreds of degrees per kilometer.

Large local thermal gradients can only appear at shallow depths where there is a considerable difference between the initial temperatures of intrusive magma and country rock. The greater this difference is, the larger must be the thermal gradient and the shallower the depth of the magma chamber from the earth's surface. It is thereby quite obvious that at considerable depths, of more than 15 to 20 km, i.e., in the medium zone of metamorphism of V.S. Sobolev et al. [5], the rock temperature due to regional heat flow will surpass the lower limit of fusion of the quartz-feldspar eutectic, thus inducing anatexis. Conditions for the development of normal (typical) contact metamorphism in connection with granitoids are, of course, absent here.

In the upper zone of regional metamorphism [5] no palingenesis can occur. It might be imagined, of course, that even at shallow depths local heat flow of great power could bring about double local fusion of sedimentary rocks against the background of generally low temperatures and zones of contact metamorphism around the magma chamber. Here, however, it must be assumed that the local temperature gradient would have to be almost an order more than the regional for the heat flow field to be sharply defined (in its cross section) and for the heat flow to continue over any long period of time in the epithermal environment [2]. The improbably high local thermal gradient and certain other conditions concerning the nature of the heat conductor make it necessary to doubt whether isolated granite bodies could originate through double local fusion of epithermal rocks by nonregional heat flow.[2] Such doubts are also shared by other scientists [15, 23].

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MIOCENE FLORA OF THE OKA-DON PLAIN[1]

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The Oka-Don Plain abounds in Neogene deposits. They were studied for many years by P. A. Nikitin and A. A. Dubyanskiy [7] as well as by M. N. Grishchenko [2-6]. The entire Neogene sedimentary complex was originally considered to be Pliocene [2, 3]. It was later found as a result of paleobotanical research that one of the thickest and most widespread formations, the Lamki suite, was of Miocene age [1, 4, 8].

In 1965, Yu. I. Iosifova detected a Miocene plant assemblage in another Neogene suite, the Gorelki beds, the age of which was highly controversial since it had previously been regarded as barren. Plant remains were found in the best known sequence of the suite after its type section, in the exposure at the village of Lysyye Gory on the right bank of the Chelnovaya River, 20 km west of Tambov. Here, in a gulley entering the river 0.5 km above the bridge, the following sequence of Gorelki beds is visible beneath moraine (7 m thick): 1) grayish green, micaceous silt (1 m thick); 2) lilac-gray clay (0.16 m); 3) thin-bedded ironstone abounding in plant remains (0.25 m); 4) grayish-green silt (1.2 m); 5) white fine sand with basal pebbles of quartz, flint and sandstone from 1 to 5 or, less commonly, 15 cm in size (3 m). The formation unconformably overlies sand and silt of Aptian to Albian age (?). From bed 3 a considerable number of plant remains were collected with more than 200 well-preserved casts of leaves, fruit and conifer twigs. Pieces of sandstone were continuously covered by traces of Sequoia langsdorfii Brong. needles. Less

[1]Translated from: K miotsenovoy flore Oksko-Donskoy ravniny. Doklady Akademii Nauk SSSR, 1968, Vol. 179, No. 6, pp. 1424-1427.