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Basic Characteristics of the Geological History of Tuva

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible] their geo-

[illegible]

[illegible] processes in each part, [illegible] at the end of the Proterozoic and [illegible] of the Cambrian. [illegible] part of Tuva within the limits of the Sangilen highland was [illegible] Cambrian by a wide basin with geosynclinal type of deposits. [illegible] formation of layers at the end of the Proterozoic the eastern part of Tuva was lifted above sea level and transformed into a solid block. Later this eastern region of Tuva was characterized by its tendency to rise and it reacted to all succeeding tectonic stresses by breaking. The development of the western and

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[illegible]

[illegible] quantity of [illegible] the [illegible] region of the [illegible] (see Figure 1). After the [illegible] Caledonian cycle of [illegible] block, [illegible] It reacted to the succeeding tectonic stresses [illegible] differentially moving blocks. [illegible] characterized layers of the lower Silurian in Tuva are unknown; similarly the very bottom and upper portions of the Cambrian are unknown. This period [illegible] is connected for the most part of Tuva with a discontinuity of deposits.

The upper Silurian is characterized by the wide transgression of a small sea moving from the southwest, from the region of Lake [illegible], and for a short time encroaching upon the basins of the Big and the Small Yenisey. It is of interest that in the southwest the boundary of upper Silurian basin has repeated the boundary of the Cambrian (see Figure 2). The upper-Silurian basin abounded in islands, among

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[illegible] Carboniferous. Having [illegible]

[illegible]

[illegible] [2]. [illegible] in the mid-western part of Mongolia. In Tuva we have [illegible] general formations of the Permian (?) age in the Mut watershed (divide) of the rivers [illegible] and Ulug-Khemchik (Yenisei-Ubsu-Nur basin); that is, within the boundaries of the western tectonic zone. Genuine Triassic deposits are unknown in Tuva; possibly later on, a part of the Permian deposits will be related to the Triassic. Jurassic deposits in general form the conspicuous spots, related to the big contemporary valleys of Tuva, the Ulu-Khemchik and the southern boundary of Todzhin [4]. Tertiary deposits were developed in small spots on the southern edge of the Tannu-Ola Mountain Chain [1].

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According to the degree of dislocation, to the general type of folding, and to its origin, the whole stratum of upper Cambrian deposits may be subdivided into three "structural floors": the first floor [illegible] the Cambrian deposits; the second includes the whole remaining part of the Paleozoic deposits; and the third, the deposits of the [illegible]. The folding structure of Cambrian, in contrast to the [illegible], folded and corrugated layers of pre-Cambrian crystalline slates and [illegible] [illegible] of [illegible] (up to 90°-[illegible]), [illegible] joints. The folds of the [illegible] and upper Paleozoic deposits [illegible] from the Cambrian. With the exception of the zones of strong disjunctive dislocations they [illegible] relatively [illegible]; [illegible] [illegible]. In the [illegible] of [illegible] folds [illegible] inclination of layers varies between 0 to 10°; it reaches 25° on the wings, [illegible] 45°. In some spots the deposits [illegible] [illegible], all the way to the layers of [illegible]; but here these dislocations may be clearly related to strong disjunctive structures.

The third "structural floor" is distinguished by a weak display of folding. Jurassic deposits lying on the Devonian-Carboniferous layers, as far as the Silurian inclusively, form sloping folds of large radius, which pass smoothly into horizontal layers; the spots of intensive dislocations are coordinated to zones of disjunctive disturbances and usually are strictly parallel. The dislocations of tertiary deposits are clearly related to thick fractures that separate the horst (fault ridge) of the Tannu-Ola Mountain Chain from the south.

The genesis of Cambrian folded deposits is clear. The latter are typical folded structures of geosynclinal regions. The origin of folds of the second and the third "structural floors" similar to each other is of an intermediate type between dislocations of platform-like and geosynclinal regions. These folds

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originate in consequence of differential vertical shifts of individual rocks of the cracked solid base. A distinguishing peculiarity of the folds considered is the predominance of indisturbed shapes of the brachy-fold type and a sharp difference in size depending on the depth of the deposits: in the central part of basins where the thickness is greater, the folds are bigger and slanting and, on the margins they are smaller and steeper. Independently of thickness of the deposits and location, the presence of relatively narrow linear zones of intensive dislocations with steep folds and overthrust is typical. The linearity of such dislocations and their rapid shift across their course by slanting layers leave no doubt as to their relations with zones of large-scale fractures. Essentially the whole post-Cambrian history of the western part of Tuva consists in the history of differential motion along the fractures of individual rocks, where the boundaries of separate big rocks and the amplitude of their sinking have determined the boundaries of accumulation basins, the depth of deposits, the intensity and direction of folding.

A good example of prolonged successive development of fractures and related directions of folded structures may be found in the regions of the Western Tannu-Ola Mountain Chain and in the territory north of Lake Ubsa-Nur (the Chadan-Khandaysk rock). In contrast to the northwestern directions and trends of the fold of the central parts of Cambrian geosynclines within the limits of the Western Tannu-Ola Mountain Chain, the latitudinal and west northwest directions are clearly marked. These directions, observed in all Paleozoic strata, are due to the slowly developing upheaval, started as early as at the end of Cambrian. A big island existed here during the upper Silurian; a peninsula existed during the Devonian; and an upheaval which closed the accumulation basin from the south occurred in the

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Carboniferous. A confirmation of the further development of latitudinal Cambrian fractures may be found in the contour of boundaries of the lower Devonian transgression, brought about by the sinking of the "Chadan-Khandaysk" rock. The sinking type of rocks of this region is confirmed by the relatively undisturbed layers of great thickness (down to 9 km) of Devonian-Carboniferous and by sharp reduction in thickness right beyond the boundaries of the territory of the above-mentioned rock, northwards and westwards (up to 1 km).

Since the end of the Paleozoic and the beginning of the Mezozoic the degree of difference in existing processes of the separated two zones of Tuva had been leveling off; and at the end of the Mezozoic the differently moving rocks came into a state of equilibrium and to a long relative rest. The whole country has been leveled by erosive processes and is approaching a "peneplain". During the Cenozoic era a stormy revival of rock movements occurred, shaking the whole territory of Tuva by the same amount. The youthfulness of those movements is confirmed, besides by numerous geomorphological facts and frequent earthquakes, by the intensity of the dislocation of Pliocene deposits. During this period old fractures were opened and new ones were started; but in both cases mostly latitudinal and, only in the extreme west, meridional fractures occurred.

Hence Tuva represents an extremely complicated region, and its tectonic structure may be named "folded-rock". Its contemporary structure is a result of a complex geological development, characterized by a long period of gradually increasing rate of crushing of big rocks into smaller ones with simultaneous differential movements relative to each other. The fact that we meet everywhere, in the contemporary Tuva highland, with the phenomena of tightly interwoven forms bearing the seal of deep antiquity together with recent features allows us to conclude that the topographical

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relief of this country is exceptionally recent and has appeared in the place of the ancient "peneplain" as a result of recent movements of rocks.

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(Key to Figures 1-4.)

a- regions of probable dry land; b- Cambrian geosynclinal zone; c- Cambrian platform deposits; d- region of transgression in the upper Silurian; e- region of transgression in the lower Devonian; f- accumulation region of deposits D_{2+3} and C; g- accumulation region of Permian marin deposits; h- accumulation region of Permian continental deposits; i- accumulation region of Jurrassic fresh water deposits; k- regions of pre-Cambrian expansions; l-region of pre-Cambrian and lower Paleozoic expansion; m- region of mostly lower Paleozoic development; n- region of mostly middle and upper Paleozoic development; O- regions of mesozoic development of deposits; p- tectonic cavities, filled with tertiary and quarternary deposits; r- main directions of extensions of folding axes; s- fractures, observed and assumed.

UPHEAVALS. 1- East Sayan Mountain Range; 2- West Sayan Mountain Range; 3- Sangilen highland; 4- Bura Mountain Range; 5- West and East Tannu-Ola Mountain Ranges;

Depressions - regions of sinking; 6- Minusinsk; 7- Ulukhemsk; 8- Ubsanursk; 9- Terekholsk; 10- Arshansk; 11- Saldamsk; 12- Bus-Belimsk; 13- Serlig; 14- Todzhin; 15- Turan; 16- continuation (?) of Ulukhemsk valley.

[Note: Figures 1-4 follow on next page.]

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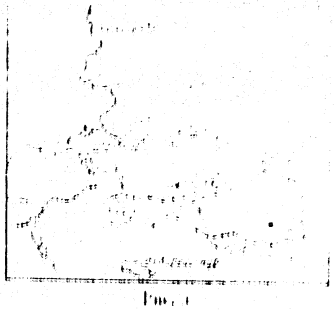

Fig. 1

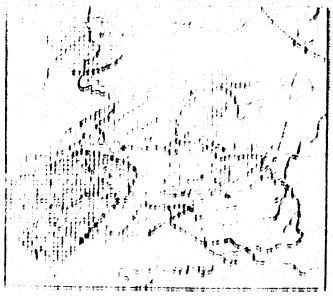

Fig. 2

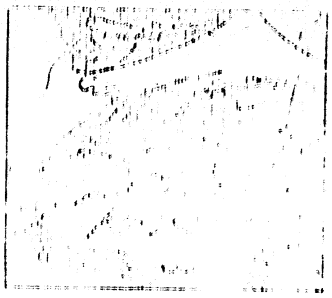

Fig. 3

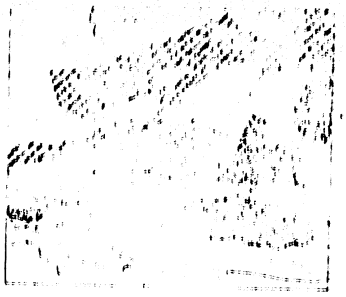

Fig. 4

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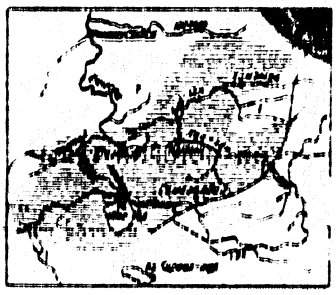

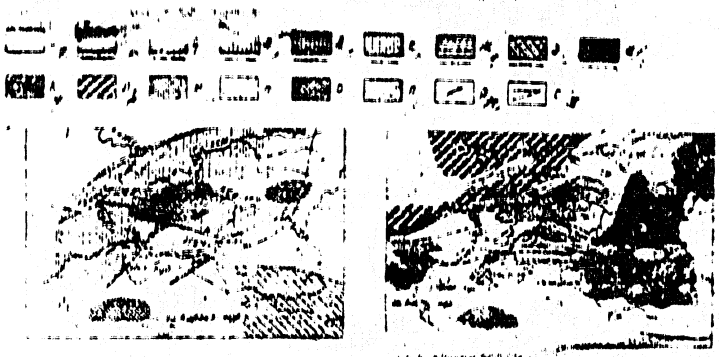

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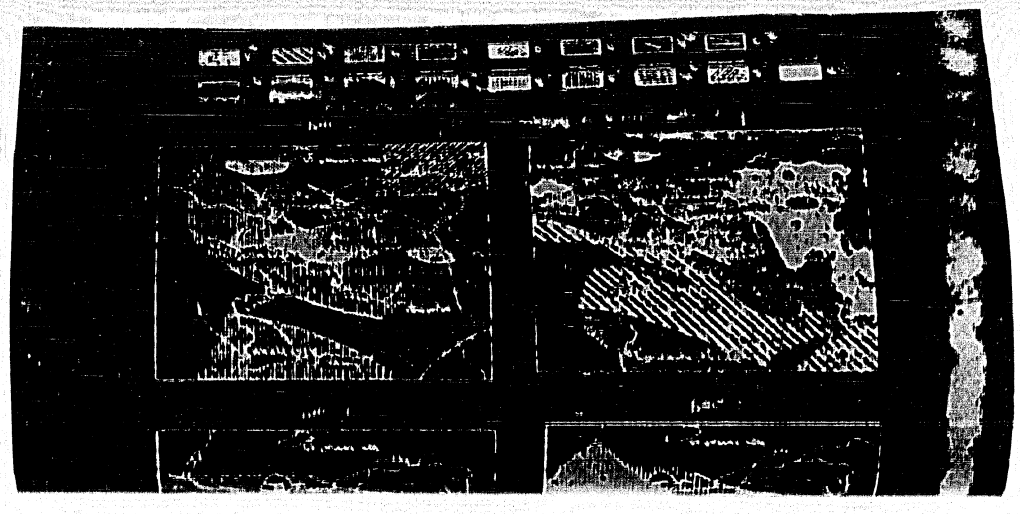

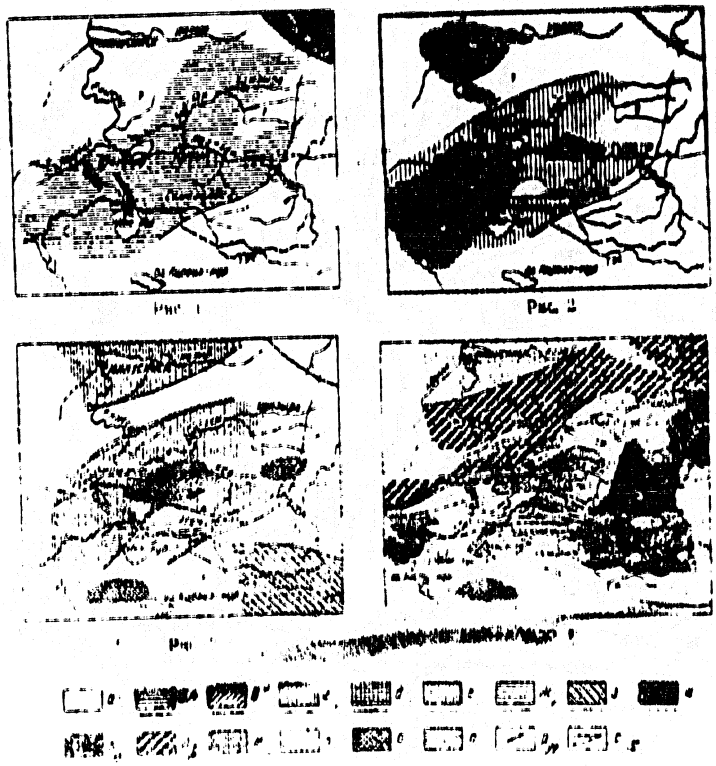

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