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NASA TECHNICAL MEMORANDUM NASA TM-88497

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GEOLOGICAL-MORPHOLOGICAL DESCRIPTION OF THE ISHTAR TERRA (PHOTO-MAP OF THE VENUSIAN SURFACE SHEET B-5)

A.L. Sukhanov, A.A. Pronin, Yu. S. Tyuflin, M.V. Ostrovskiy,
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Translation of: "Geologo-morfologicheskoye opisaniye zemli ishtar (fotokarta poverkhnosti venery, list B-5)," Astronomicheskiy vestnik, Vol. 20, No. 2, 1986, "Nauka" Press, Moscow, pp. 99-111 (UDC 523.42)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 SEPTEMBER 1986

(NASA-TM-88497) GEOLOGICAL-MORPHOLOGICAL DESCRIPTION OF THE ISHTAR TERRA (PHOTOMAP OF THE VENUSIAN SURFACE SHEET B-5) (National Aeronautics and Space Administration) 15 p
CSCL 84B G3/91
N87-15143
Unclas
43661

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OF POOR QUALITY

STANDARD TITLE PAGE

1. Report No.
NASA TM 88497

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
GEOLOGICAL-MORPHOLOGICAL DESCRIPTION OF THE ISHTAR TERRA (PHOTOMAP OF THE VENUSIAN SURFACE SHEET B-5)

5. Report Date
SEPT 1986

6. Performing Organization Code

7. Author(s)
A.L. Sukhanov, A.A. Pronin, Yu.S. Tyuflin, M.V. Ostrovskiy, V.A. Kotel'nikov, O.N. Rzhiga, G.I. Petrov, A.I. Sidorenko, Yu.N. Aleksandrov, A.I. Zakharov, A.A. Krymov & N.N. Bobina

8. Performing Organization Report No.

10. Work Unit No.

9. Performing Organization Name and Address
SCITRAN
Box 5456
Santa Barbara, CA 93108

11. Contract or Grant No.
NASw- 4004

13. Type of Report and Period Covered
Translation

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, D.C. 20546

14. Sponsoring Agency Code

15. Supplementary Notes
Translation of: "Geologo-morfologicheskoye opisaniye zemli ishtar (fotokarta poverkhnosti venery, list B-5)," Astronomicheskiy vestnik, Vol. 20, No. 2, 1986, "Nauka" Press, Moscow, pp. 99-111 (UDC 523.42)

16. Abstract

The main part of the Ishtar Terra east of the Maxwell Montes is covered with systems of areal dislocations of several directions, which are called "Parquet". According to the structural patterns these may be divided into: 1) the central stable block; 2) the lesser peripheral blocks separated from the central one by gaps and grabens; 3) the zones of mobilized parquet, whose substance flowed downward at an incline in the directions away from the central block and in the form of plastic flows; 4) the partially "parqueted" lava sheets. The Maxwell Montes were formed as a result of the collision between the central parquet block and the Lakshmi Planum.

17. Key Words (Selected by Author(s))

18. Distribution Statement
Unclassified and Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

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The main part of the Ishtar Terra east of the Maxwell Montes is covered with systems of areal dislocations of several directions, which are called "Parquet". According to the structural patterns these may be divided into: 1) the central stable block; 2) the lesser peripheral blocks separated from the central one by gaps and grabens; 3) the zones of mobilized parquet, whose substance flowed downward at an incline in the directions away from the central block and in the form of plastic flows; 4) the partially "parqueted" lava sheets. The Maxwell Montes were formed as a result of the collision between the central parquet block and the Lakshmi Planum. /99*

INTRODUCTION

The photomap sheet B-5, plotted according to the materials of a radiolocation photo from the AMS [automatic interplanetary station] "Venera-15" and "Venera-16", as well as the photomap of sheet B-4 [2], are located in the latitude belt from $\varphi = 60°$ to $\varphi = 80°$ and plotted in the normal conformal conical projection of Lambert-Gauss. The angles of the map frames of sheet B-5 have venerographic coordinates: $\varphi_1 = 80°$, $\lambda_1 = 0$, $\varphi_2 = 80$, $\lambda_2 = 60$, $\varphi_3 = 60$, $\lambda_3 = 0$, $\varphi_1 = 60$, $\lambda_4 = 60°$.

MORPHOLOGICAL DESCRIPTION OF THE REGION

This photomap includes the northeastern part of Ishtar Terra, which occupies the entire central part of the described territory (Fig. 1-3). In the west of the region the altitudes reach 11 km (in the strip of Maxwell Montes west of the double Cleopatra Crater). East of this the terrain gets lower--down to 3-4 km on the southern and southeastern boundary of Ishtar Terra and to 0-1 km along its northern boundary.

The surface of this uplift is covered over huge areas with monotonously alternating sloping ridges and furrows with characteristic width of around 10 km (5-15 km) and a length ranging from tens to 100-200 km. These subparallel structures form seemingly straight or bent packets, and in one section we can usually trace the superimposition of two or more mutually intersecting structures. On a small scale this terrain reminds us of "herringbone" or rhomboid placed /100 wood planks. This is why it was called a "parquet" when it was viewed for the first time, although upon subsequent photography significantly different patterns were found. The areal development of monotypic dislocations is common to all such terrain. These dislocations are not united into isolated belts, rings, etc., but uniformly cover hundreds of thousands of square kilometers [1].

For individual large areas of parquet development, the morphological term "tessera" was proposed, and the eastern part of Ishtar Terra was called Tessera Fortuna. Geologically this sphere is related to one of the most complex ones of the photographed territory.

On the whole, the scheme of the parquet structure of this region is represented as follows (Fig. 4): the central homogeneous mass (A) with area of around 800,000 km^2 surrounded by a mosaic of peripheral blocks. These blocks are either small plates separated from the central mass by zones of extension (Z, K), or they are formed by huge influxes of material, seemingly flowing out of it (B, D, Zh). Presented below is a description of the basic blocks.

CENTRAL MASSIVE

Block A which forms the central massive occupies a plateau which slopes very gradually away from Maxwell Montes from 5.5 km in the west to 3-3.5 km in the east. The intersecting systems of the northwestern and northeastern ridges and furrows break the territory up into rhomboid sections, usually elongated latitudinally. In places there are predominant structures of one direction or their rounded arch-like junctures appear (Fig. 2,a). The large breaks of the same orientations form a network with a greater grid size. All these structures must be formed in a field of predominant latitudinal compression.

The western boundary of the block is the submeditional belt of linear dis- /105
locations, after which following a weakly expressed deflection the Maxwell uplift begins. From the eastern part of the block the large faults form a gigantic system of branching grabens up to 100 km in width and up to 1-1.5 km in depth. These are partially filled with lava. This system is an undoubted zone of extension, where smaller blocks are cut off from the main massive. However, the width of the grabens cannot be considered the value of the true displacement. Relics of parquet within the grabens indicate the settling of their bottom, evidently with a relatively small divergence of their edges.

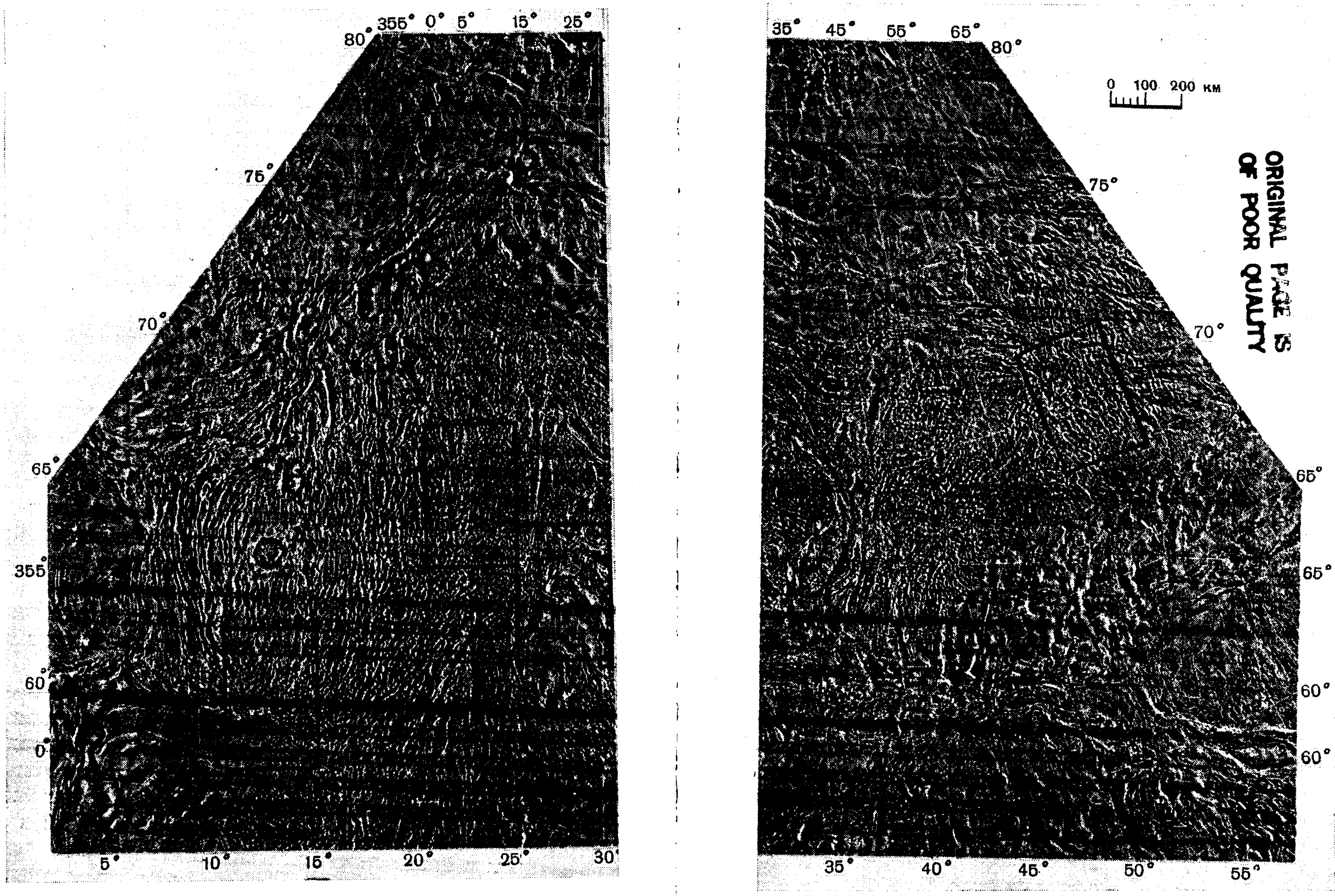

Fig. 1. Photomap of Venus, sheet 5. Shown is the position of fragments presented in Fig. 2. /100-101

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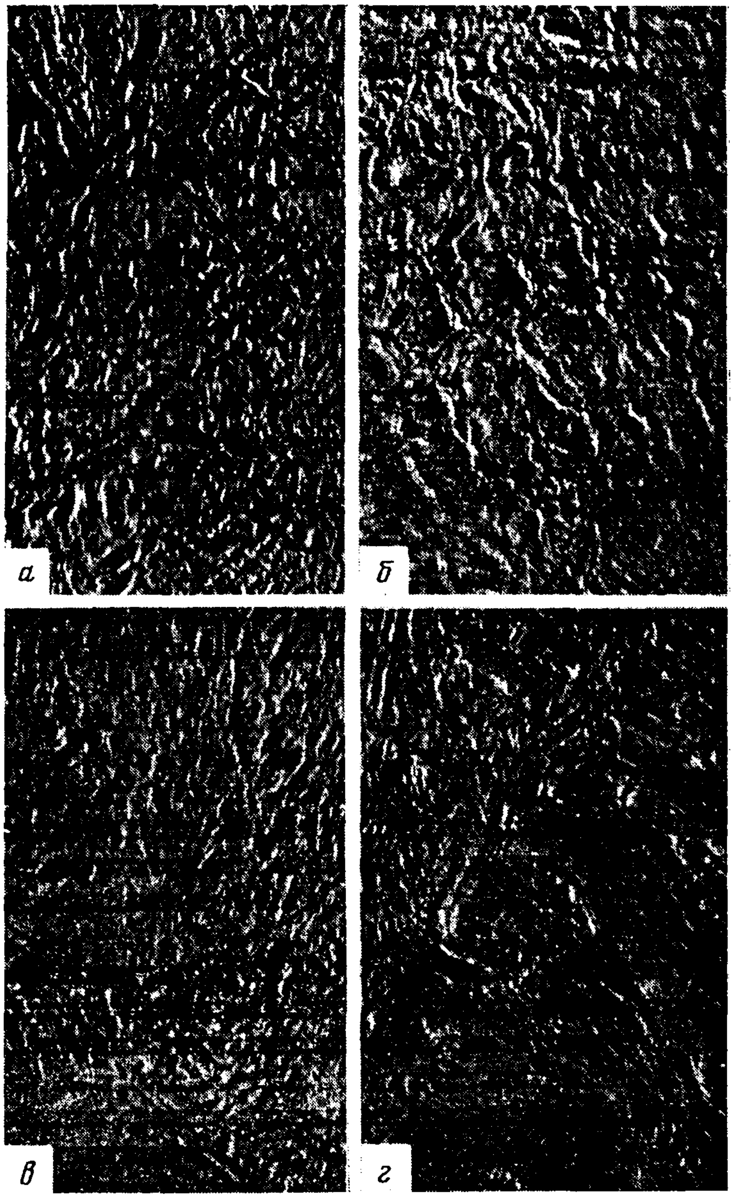

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Fig. 2. Certain characteristic sections of the surface of Ishtar Terra
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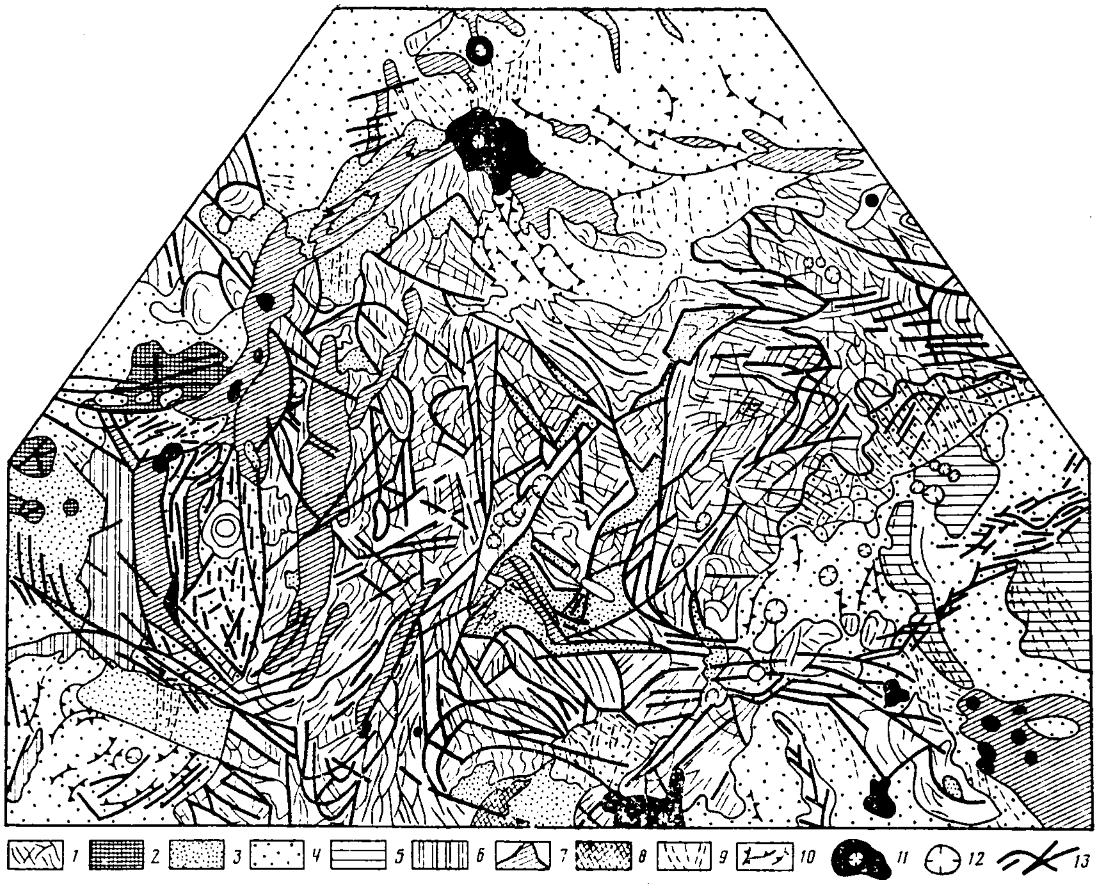

Fig. 3. Geological-morphological map of the surface of Venus, sheet B-5. Designations: 1 - structural lines of parquet; 2 - ancient "brittle" relief; 3 - flat plains; 4 - hilly plains; 5 - striated plains; 6 - Lakshima folding framing; 7 - belts of linear dislocations; 8 - ovoid; 9 - dikes; 10 - swells on plains; 11 - volcanoes; 12 - depressions and caldera; 13 - large faults and basic structural lines.

In some places, on a background of uniform intersecting dislocations we /105
see structures of other types: 1 - relics of ring-like or subconcentric structures of unclear genesis; they retain their outline, although they are intersected by faults, i.e., displacements along the faults were slight; 2) the system of extended loops set into one another at 71° n. lat and 17° e. long. It seems that they outline the flow of some substance which moved to

the southeast. In fact, these ridges and furrows are located along the slopes of a local trench 200 x 100 km across and 1.5 km wide and, it seems, were formed during displacement of the material from the slopes of the trench toward its axis (Fig. 2,a); 3) long bands of a somewhat uplifted substance with smoothed surface (one of them extends to the south from this same trench). In places the material of the bands covers the material of the parquet, and they are formed, evidently, by the effusive-extrusive activity along the large zones of linear permeability.

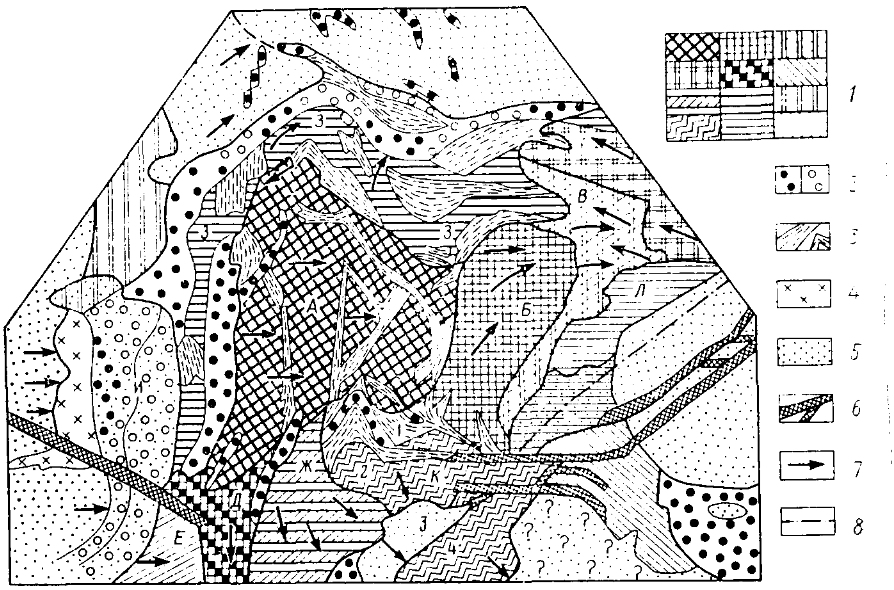

Fig. 4. Structural regionalization of Tessera Fortuna. Designations: 1 - individual blocks of parquet; 2 - bands of linear dislocations (light circles show partially covered bands); 3 - zone of extension; 4 - Lakshima framing; 5 - lava plains; 6 - breaks; 7 - directions of displacements; 8 - axis of chain of volcanic centers.

The entire block evidently was initially formed in a single field of tension with predominating latitudinal compression, but with slight amplitude of dislocation. Then it was dissected by large faults, along which grabens and zones of permeability were formed, but only with slight horizontal movements.

ZONES OF PLASTIC FLOW OF MATERIAL

Zone B was formed by a series of gigantic V- and U-shaped structural arcs, seemingly inset into one another and turned with their apices to the east (unfortunately, the illustration presented shows the apices of these arcs as being blurred due to poor coordination of the photo bands at different altitudes of orbit, but they are easily read in viewing the series of bands under a stereoscope). On the whole, the picture reminds us of the crust of a gigantic flow of a plastic substance flowing to the east from block A, with extension to the back sections. The axial part of this "flow" has a smoother and more uniform relief as compared with its edges, as if the substance here was more plastic and, judging by the pattern of structures, it is moved farther to the east as compared with the edges. This axial part is generally several hundred meters higher than the edges, but on the whole this zone lies 2-2.5 km below block A, and 0.5-2 km below the southeastern edge of Ishtar Terra. The impression is formed that blocks A and B, together with the zones K and L described below at one time formed a single huge mass with common surface, which sub- /106
sequently was divided due to collapse and "flow away" of the material in Zone B to the east and the northeast.

At the eastern edge of the "flow", sharp arches become ever broader and more open and are gradually replaced by convoluted submeridional structures of block C (Fig. 2,b), which represents a zone of accumulation of the material, a connecting strip compressed between blocks B and G (in block G, which is related to the following sheet 6, the movement is directed as oncoming--to the west and northwest).

On the background of precociously bent structures of block C we see straight shears oriented along the ZSZ [expansion unknown]. However, it is unclear whether they are formed due to the oncoming movement of the material of neighboring zones or whether some ancient structures are "showing through" here.

The most elevated portion of the central block A adjoining the Maxwell Montes declines in elevation as it moves to the south and turns into block D. Here on a background of short diagonal structures there also appear circular arches, turned with their apices to the south and down along the slope, as if the flow of plastic substance had run down here under the force of its own weight. This impression is confirmed by the fact that the substance of the block "flowing down" covers over the underlying structures of Block E (in block E the predominant northwesterly structures are created, evidently, by latitudinal stresses, and here we also see U-shaped forms in the plane, but turned with their apices to the east).

The neighboring block Zh represents a fan-shaped protrusion of the material, seemingly flowing downward at an angle to the south of block A. The narrow, slightly bent and winding ridges forming the "plates" of this fan look like small folds or scales superimposed in an easterly direction, while the marginal ridges of the fan clearly cover over the older structures. In the lower part of the fan we see a series of sublatitudinal winding cracks, which cut the material across the incline into plates, descending in a steplike manner and seemingly slipping down to the local depression.

It remains unclear why the unidirectional flow of the substance of the neighboring blocks D and Zh created in them such different structures. Possibly the substance of block Zh (the fan) was more softened and (or) some part of this block was formed by lava flows.

On the whole, the described zones show indications of simultaneously acting joined compressions and extensions as a result of horizontal displacements of the surface material in the form of plastic "flows" with a downward movement along the incline, even if the incline visible today is very slight.

PERIPHERAL ZONES OF EXTENSION

In the north and northwest, the mass of parquet is bordered by the extended durved zone Z. It consists of bands of parquet whose structures are oriented /107
primarily along the margins of the central mass, of deflections running parallel to them and filled with lava (evidently these are areas of extension), and of bands of linear dislocations.

The bands of linear dislocations on the order of 100 km in width consist of subparallel ridges and furrows which are more sharply expressed than the ridges and furrows of the parquet. They do not form intersecting structures as on the parquet, but stretch far along the extent of the bands, compressing and expanding. In the northwestern part of the map such a band clearly cuts off the structures of the parquet, but in the north, between 30 and 40° east long. part of this same band is "eaten up" by the arch-like structures of the parquet, i.e., the band and (or) parquet were formed in several stages. In this same band there are narrowed flexure-like sections created by compression, but along the extent they are replaced by distentions, in the center of which we can see depressions with small volcanoes or extrusions. These sections should be interpreted as zones of extension. Finally, there are also indications of horizontal displacements along the boundaries of the bands, so that trailing forms are formed in the adjoining parquet. Aside from the mechanical dislocations in these bands there are grabens, formed by large magmatic dikes.

The main mass of the bands is found farther east, from 150 to 260° east. long., and these will be described later, in other articles. Here we may only say that in all probability that these bands represent juncture zones between the lithospheric blocks and the repeated differential movement of these blocks created in some periods compression stresses, and in others--extension, or, with the appearance of the shear component--compression in some sections with simultaneous extension in others.

In the west this peripheral zone of parquet is elevated and turns into the Maxwell Montes (zone I). Its characteristics and the characteristics of sections to the west and northwest of the mass are given in the description of sheet 4 [2]. Here it is sufficient to note the following.

At a latitude of approximately 68° the band of linear dislocations bordering the parquet, together with a sharp uplift, is hidden under a younger mass by a covering which is evidently effusive. In some places the band structures are entirely covered over or their outlines "show through" the covering, being expressed in elongated depressions. In the apical portion of the Maxwell Montes this band "emerges" from under the covering clearly due to extension. The remainders of the covering are clearly visible between the band structures, and since large scale erosion is absent on Venus [1], the material could not be removed from here by water or wind.

The covering itself is evidently a marginal part of the Lakshima Plateau, i.e., a lava formation which at one time was joined with the main plateau. Subsequently, this part of the plateau was sheared away along the northwestern faults and uplifted by several kilometers, which was accompanied by the breaking up of a surface which was once smooth. In the southeastern section of the Maxwell Montes this broken up covering approaches the parquet by its degree of dislocation. However, it differs from it by its structure and photo tone (Fig. 2,c). In its northwestern part, the triangular remnant of the covering /108
is separated away from it by rather deep extension valleys.

The zone of very narrow linear structures of the western foot of Maxwell differs noticeably from the band structures at its apex. This zone consists of clear force folds, folding the very youngest lava formations on the surface of the Lakshima Plateau.

The southern part of the Maxwell Montes is sheared off and descended along the latitudinal left-sided fault displacement. The descended wing is covered with lava, and only by the warping and cracking of their surface can se guess the continuation of the linear dislocation bands described above. Directly to the south of the displacement, the latitudinal deflection is additionally covered with young lava, which also cover over the warping structures of lavas in the intermediate stage.

Displacements along the fault are not directly fixed, and its fault character is determined by the pattern of feather cracks and relation of the structure of Maxwell with the neighboring regions, while the fault itself disappears in the young zones of the parquet to the east. Evidently, here this fault gradually diminishes, and its displacement component turns into vertical components, so that there is a simultaneous bending outward of the northern wing upward with formation of the Maxwell Montes, while the southern wing is bent downward with subsequent filling of the deflection by lava.

The second, even more interesting peripheral zone K, adjoins blocks A and B from the south. It lies at the intersection of the meridional graben, approaching from the north, and the latitudinal band of breaks which are over 1500 km long seen to the east. In this zone from north to south we see the following structures: 1) a curved depression 150 km in width, filled with lava, with close contours along the northern and southern edges; along the axis of the depression, repeating the contours of its edges, there extends an arch-like swell with longitudinal furrows and cracks (Fig. 2,d); 2) two sublatitudinal blocks up to 2.5 km in elevation above the neighboring lavas: their structure looks like the structure of the parquet, but differs by its more ordered frequent furrow pattern; the blocks are separated by a narrow crevice; 3) the angular depression extended to the northeast, filled with lava, with a network of intersecting dikes; 4) the elevated block elongated to the northeast and adjoining block 2. Evidently, this entire zone represents a sphere of extension, in which individual blocks moved away from the main mass of parquet with a simultaneous expansion to the southeast--like the blades of open scissors with a hinge at 43° north lat., 63° east long. Here the lava depression 3 looks like an independently moving microplate, while the central swell in depression 1 represents a miniature analog of the central-oceanic ridge (the similarity of this swell with many sections in the bands of linear dislocations once again testifies to the significant role of extension in the formation of these bands).

The elevated blocks 2 and 4 were evidently formed by parquet with a modified surface. To retain their elevation they had to be either lighter than the surrounding basalts, or had to consist of these same basalts, but of much /109 greater strength. If the main mass of parquet is built in the same way, this means that it has roots which partially support its elevated position.

However, we cannot exclude the possibility that these blocks were formed as a result of extrusion of hot deap-seated material.

The last section of parquet--zone L on its southwestern edge--has a relatively smoothed surface, corrugated by thin meridional furrows and ridges. In the north the material in this zone clearly covers over rougher parquet structures, which are barely discernible within this zone by the slight bends in its surface. In the south, this zone gradually into an almost non-dislocated hilly lava plain. Hypsometrically, zone L represents a broad swell with absolute elevations of up to 3-4 km, and along its southern edge there passes a chain of circular depressions, in all probability volcanic caldera. It seems that here the southern edge of the parquet is covered over by massive volcanic coverings even before completion of the movements on the parquet, and these coverings were included in the last phases of "parquetization," which led to their corrugation. Possibly, these coverings were formed at the same as the Maxwell coverings.

OTHER FORMATIONS

From the north the parquet is covered with hilly lava flows of the Snow White Plain, which possibly consists of several blocks. Thus, from the west the tip of the sublatitudinal plate, extending from 320° east. long. comes here. Yet in general the details of the foundation structure are hidden under the lava. We must note only the displacement of sections of the double swell in the northwest corner of the map along several faults, reminiscent of transform breaks, with an overall amplitude of at least 90 km.

Here, at 78° north lat., 20° east long., at the bend in the band of linear dislocations, the terrain is covered with a gently sloping volcano with caldera having a cross-section of 50 km and extended lava flows moving away from it, as well as a network of radial structures (dikes?). Evidently, this structure is a relatively fresh variety of the "spiders"--volcanic-tectonic forms which will be characterized in describing the southern maps.

The plain in the southeastern part of the map is the western half of the oval depression which evidently is related to the hard plates, judging by how the structures of the parquet and the band of linear dislocations are stream-liked around it. At the bottom of this depression, banded plains emerge from under the material of the hilly plains. These are areas intersected by narrow low ridges and bands, joining and intersecting. In their own relief they may be considered dikes, or narrow horsts, or insets along the breaks. The combination of such small forms of relief, forming a step-like or "ribbed" surface, the position of these plains under the material of hilly and especially smooth /110 plains, as well as the covering of the striated material with the parquet material on sheet 6, allow us to relate them to ancient formations.

GEOLOGICAL HISTORY OF THE REGION

The final clarification of the sequence of geological events depends in large part on the results of mapping other territories. Therefore, here we give only a general scheme.

1. The formation of structures of the main mass of parquet in the form of a huge plateau or a gently sloping cupola from 0° in the west to 90° e. lat covered with northwesterly and northeasterly dislocations and framed by a linear band of dislocations in the north and in the west. The flowing of ancient lavas.

2. The flowing of lavas of the central stage and their partial covering of the mass of parquet and the linear bands with formation of hilly plains.

3. The movement of the blocks of the Lakshmi Plateau to the east and their collision with the parquet mass. To the north at 68° and to the south at 62° n. lat. these blocks moved relatively farther to the east, folding the parquet and sagging. In the interval between them, part of the parquet with its covering was warped and broken up, forming Maxwell's massive. At the same time there was a regional warping of the central mass of parquet with formation of slopes in the direction to the east, north and south away from Maxwell.

4. Heating, softening and creep of the marginal zones of the parquet in the directions away from the central block A in the form of individual blocks (zones Z and K) and by means of plastic flow of large masses (zones B, D, and Zh) with formation of grabens in the first case and arch-like structures in the second. The involvement of part of the lavas of the intermediate stage in the "parquetization".

5. Lava flows of flat plains.

6. Formation of a folded zone at the western foot of Maxwell by means of folding of the young lava material of the Lakshmi Plateau.

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