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STRUCTURAL ENSEMBLES OF THE NORTH BELT OF VENUS DEFORMATIONS AND POSSIBLE MECHANISMS OF THEIR FORMATION

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16. Abstract

The author discusses the structural ensembles in the northern deformation belt of Venus, studied according to the data of the radar pictures obtained with the "Venera" 15 and 16 probes. He shows that it consists of regions of compression with submeridional orientation, regions of displacement, extending in the sublatitudinal direction and individual slightly deformed blocks. He puts forward the hypothesis that the formation of these structures is related with horizontal movements in the mantle in the sublatitudinal direction.

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STRUCTURAL ENSEMBLES OF THE NORTH BELT OF BENUS DEFORMATIONS AND POSSIBLE MECHANISMS OF THEIR FORMATION

M.S. Markov

Introduction

In the article devoted to the geological and morphological description of the northern region of Venus, it was noted that because of the small role played by exogenous processes on the surface of Venus, the characteristics of its relief may be caused by tectonic or volcanic processes, occurring in this planet (1). /77*

In view of the small role of the exogenous processes all the alterations of the relief may be related to the isostatic compensation or its deliquescence, if the Venus crust is thin and has less viscosity (because of the high surface temperature) than the earth's crust. But our knowledge of the strength properties of the crust, its thickness and the thermal flow practically do not exceed the boundries of hypotheses. Therefore in this article we will consider mainly the morphology of structures and their space combinations (structural ensembles) which it seems to us make it possible to recreate the conditions of their formation.

In the collective article, published at the beginning of this issue of the journal, it was already indicated, that on Venus there exists a sublatitude zoning in the distribution of the largest relief forms.

The polar region consists predominantly of plains, complicated by individual linear ridges.

To the south of it are located the mountain ranges of Ishtar Terra and continuing them to the east and southeast the system of elevations Tefia, Telluria and others.

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*Numbers in the margin indicate pagination in the foreign text.

To the south of them we find once again a region of depressed sections of the relief, including in particular the plains of Ginevra, Sedna, Lednaya, Niobe and Atalanta.

Practically no one has any doubt of the origin of the plain regions. They are large depressions, filled with lava discharges. The composition of the lavas is predominately of the basaltic type, which derived from the data obtained with the "Venera" stations 8,9 and 10 and also the nature of the individual lava flows detected on the radar images of "Venera" 15 and 16. These large regions of development of volcanic depressions recall in many characteristics of their structure the "maritime" depressions of the moon, Mars and Mercury. They are divided by a belt of very complex mountain relief, which is the result of the appearance of highly stressed deformations, whose occurrance constitutes a unique characteristic of the structure of Venus as compared with the moon, Mars and Mercury and makes it similar to the tectonically active Earth.

This article will be devoted actually to the characteristics of the structure of this belt of deformation.

Types of Structures of the Belt of Deformation of the Northern Hemisphere of Venus /78

Structures of Compression

These structures on Venus are represented most clearly in the mountains of Akna and Maxwell and are manifested in the form of a system of linear ridges and valleys dividing them, bordering on west and east the Lakshmi Plateau.

The mountains of Akna have an altitude of nearly 7 km above the mean Venus radius and rise 4.5-5 km above the surface of the plain, located northwest of them (between the region of Metide and the Ishtar Terra) and 2-3 km above the Lakshmi Plateau. They are set up asymmetrically, the highest sections are located southeast of the mountain range, and are cut off relatively steeply on the side of the Lakshmi Plateau, whereas in the northwest direction the Akna mountain range has a more gentle slope (see fig.10 in the collective article in this journal).

It is apparent on the radar pictures of the "Venera" 15 and 16 stations that the Akna Mountains do not constitute a single mountain mass, but consist of a series of ridges and valleys, extending parallely to each other and to the contact with the Lakshmi Plateau. The length of the ridges reaches 300 km, the width on the average is 50 km. They are asymmetrical, their steep and shorter slopes are turned towards the Lakshmi Plateau. Sometimes the ridges are connected by links. Such a structure of the Akna Mountains is detected most clearly in the region bordering the Lakshmi Plateau and in the northwest region of the mountain range. This relief of the Akna Mountains is undoubtedly of tectonic origins, and the systems of parallel ridges may be either large inverted faults or a system of tectonic slivers, which could only have been formed in circumstances of sub-latitude compression.

With the increase of the distance from the Lakshmi Plateau, the characteristic structural picture of the Akna Mountains changes. The clearly marked and extensive ridges of the north and northeast regions are broken up by the large faults of the northwest region, manifested in the relief by extensive (up to 700-800 km) narrow (10-15 km) valleys. The connection of these faults with the ridges of the north-northeast region is different. In some places (especially along the edge of the Akna Mountain range) they transform the north-northeast system of ridges almost to the point of nonrecognizability. And the structural picture of this region becomes different, which will be discussed in detail later. With the movement towards the Lakshmi Plateau it becomes clear that the system of faults of the northwest region intersects the linear ridges of the Akna Mountains, which in places are shifted along the zones by a fault, and sometimes form s-shaped bends (see fig. 10 in the collective article).

Even further to the east the system of northwest faults ends in some places with fine crevasses, disturbing the north-northeastern ridges of the Akna Mountains without visible displacement, and in some places, the northwest faults are bent and transformed into valleys, parallel to the ridges of the Akna Mountains. From our viewpoint all this testifies to the single age of formation of the north-northeast tectonic slivers (or faults) and the system of northwest faults.

The Montes Maxwell are located along the eastern framework of the Lakshmi

Plateau. The highest altitudes of Venus, reaching 11 km above the average radius of the planet are located within its boundaries. They are cut off fairly sharply towards the west, rising 5-6 km above the Lakshmi Plateau, and have a more gentle slope towards the east, becoming the mountain relief of the eastern section of the Ishtar Terra. On the radar pictures of this region of Venus it is apparent that the Montes Maxwell as well as the Akna Mountains consist of a system of parallel ridges and valleys, extending clearly along the eastern framework of the Lakshmi Plateau (see figures 9 and 11 of the collective article).

Along the very boundary with the plateau we find a group of very narrow (2-3 km) ridges and valleys dividing them. The width of this region is nearly 40-50 km. It is wider towards the south and tends to disappear towards the north. When analysing the pictures, an impression is created that this block represents /79 the deformed depressions of the Lakshmi Plateau. Further to the east we find the actual mass of the Montes Maxwell, which consist of the system of parallel ridges and valleys. The largest of them have a width of nearly 10 to 15 km and a length of 300 to 500 km. They are asymmetrical, their western slopes are steeper than the eastern ones. The general picture of this region of extensive ridges and valleys is 150 km. They include the highest section of Montes Maxwell. The large crater, the Cleopatra Crater is located in the eastern section of this zone. Close to it at a distance of 50 to 150-200 km the linear mountain relief of the Montes Maxwell is expressed less clearly, since it is covered with discharges from the Cleopatra Crater. Further to the east the structure of the mountain mass Ishtar Terra changes strongly because of the destruction of the linear ridges and valleys by systems of diagonal faults. It is undoubtedly true that the origin of the relief of the Montes Maxwell is tectonic and basically similar to the structures studied earlier in the Akna Mountains. They are either inverted faults, or tectonic slivers, inclined towards the east.

In other places of the Ishtar Terra structures of compression are also detected, of which the morphology differs from the structures of the Akna and Maxwell Mountains. In many places the eastern portion of the Ishtar Terra is cut up by submeridional valleys, bending over their length, whose width reaches 10 to 15 km. The valleys divide this region into individual sections, which have their own structural outlines somewhat different from the adjacent sections. These forms of the relief correspond probably to the zones of thrusts or upthrusts. Thus in the sublatitude region of tectonic deformations, extending from the region of Metide and Mnemosina through the Ishtar Terra to the region of Tefia and Telluria, structures of compression, having submeridional courses are clearly detected.

Structures of Displacement

Structures of this type are most widespread within the limits of the sublatitude belt of tectonic deformations considered, and are manifested differently in the different sections.

In the northwest end of the Akna Mountains, they are systems of long narrow blocks. Their width reaches 70-100 km, and they are several hundred kilometers long. They are divided by long narrow valleys, whose width reaches 10 to 15 km, which are undoubtedly faults. The sections rise over these valleys dividing them to an altitude of nearly 500 m. Within each of the sections there are characteristics structural and morphological elements. As a rule they consist of systems of relatively short ridges and depressions, which are occasionally oriented parallely to the large valleys and faults, sometimes extending perpendicularly to them, and in many places they are bent into an s-shape, as is observed on the earth in regions of shift deformations.

In many cases one may assume the presence of horizontal displacements and over the displacement along zones of faults, ridges extending perpendicularly to them.

A portion of this deformation system, close to the Akna Mountains is attenuated, transformed into fine systems of faults and forming structures of the "horse-tail" type. Other regions of displacements, bending gradually, are converted into systems of thrust faults and up thrusts of submeridional direction. The formation of faults with vertical or steep hinges in the northwest region of the Akna Mountains is precisely collected with this turning.

The southernmost of the displacement zones continue predominately as scarps of Vesta and ut which limit the Lakshmi Plateau on the south side. In places

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they are covered with deposits of volcanic plains and are frozen only in the form of regions with blood lineaments.

The Ut scarp is essentially such a lineament, whose northern wing is raised over the southern one by 1.5-1 km.

The structures along the Vesta can be identified most clearly. Within the limits of these regions we distinguish clearly systems of faults lying close /80
to each other in the northwest-southeast direction, between which individual ridges are located, directed as a rule parallely to the faults, or connected with them by links. The total width of this region does not exceed 50 km. The system of faults of the Vesta Plateau changes somewhat its direction approximately at the meridian 320^{0}, bending towards the north, limiting the Lakshmi Plateau from the southeast.

Fig. 1. Northern and northeastern framework of the Lakshmi Plateau

A somewhat different picture is observed along the northern extremity of the Lakshmi Plateau within the limits of the Frey Mountains and their northern slopes. According to the morphology of the relief of the Frey Mountains are divided into two sections (fig.1).

The first of these parts corresponds to the northern half of the Frey Mountains. Here it is clearly apparent that it differs from the polar plain by the steep arc-shaped scarp, extending over a distance of nearly 1500 km. South of this scarp the northern section of the Frey Mountains consists of individual mountain masses, extended parallely to it. Occasionally, predominately in the western section of the mountains, the masses have an isometric angular shape. Their width varies between 50 to 100 km. The length fluctuates between 1000 and 500 km. They are divided by relatively wide valleys, whose maximum width reaches 50 km.

The internal structure of the mountain masses is different. Occasionally it consists of systems of fine ridges, extending parallely to the direction of the valleys. Most often we identify within the limits of the mountain masses a peculiar structure, consisting of individual fine ridges and valleys dividing them, oriented transversally to the direction of the mountain mass, and sometimes close to it edges bent in the form of an s. In certain mountain masses it is apparent how the ridges and valleys are located parallely and transversally to its direction.

Within the limits of the main valleys, dividing the northern portion of the Frey Mountains into individual masses, a peculiar relief is also identified, consisting of long narrow ridges and valleys, creating a picture with linear strips. These structures on the ground photographs are sometimes clearly identified along large regions of collapse and mylonization. The valleys are sometimes connected with each other and the mountain masses located between the connecting valleys /81
resemble on the macroscopic scale structures in the metamorphic complexes of the Earth.

At the east-southeastern extremity of the Frey Mountains, part of the valleys change their direction and are transformed into a system of submeridianal defects. The structural picture of the region changes immediately. Here systems of long asymmetrical ridges appear, whose structure resembles the compression structure in the Akna and Maxwell Mountains.

A different picture is characteristic for the southern half of the Frey Mountains. Here a system of narrow (5-10 km wide) ridges and valleys dividing them developed. The length of the individual ridges is several hundred kilometers. At the glance these structures recall those of the Akna and Maxwell Mountains. But with careful examination it is apparent that they have also considerable differences. In many places they have a symmetrical structure. In individual cases it is possible to observe that their steep slopes are turned towards the Lakshmi Plateau, whereas in others this asymmetry is inverse. In individual places among these narrow and not very high ridges, individual long peaks are preserved, apparently the remains of some older structures.

The western-northwestern portion of the Frey Mountains consist of a tongue-shaped mountain mass, whose structures clearly include sublatitude ridges and valleys of the southern Frey Mountains. Such structural shapes are also known along the southern edge of the Vesta Scarp, and are possibly gravitational covers.

A different structural picture is characteristic for the eastern half of the Ishtar Terra, for the region of Tefia and Telluria.

East of the Maxwell Mountains there is gradual lowering of the relief towards the eastern half of the Ishtar Terra(see fig.13, 14 in the collective article) which we propose to call Tessera Fortuna (see article by E.T. Baziavskiy in this issue). In this connection approximately 150 to 160 km from the central region of the Montes Maxwell, the system of meridianal ranges and valleys begins to change considerably. On the geomorphologically marked system of meridianal ridges and valleys is superimposed an additional system, related to the appearance of valleys in two directions: northeast-southwest and northwest-southeast. The latter is the continuation of the faults of the northern region of the Frey Mountains. Close to the Montes Maxwell in the middle of this relief we still find residual meridianal directions of the ridges. But already approximately 150-200 km away from the Montes Maxwell these remains disappear almost completely and at a further distance of 1500 km, all the eastern portion of the Ishtar Terra consists of a very complex combination of narrow partly arc-shaped valleys of different orientations and individual polygonal and rhombic ridges, which were designated conventionally as "parquet" which were described in detail in the article by A.L. Sukhanov in this issue. These valleys of different orientations intersect under angles of 50^0 and less. Within this complex system of ridges and valleys we find individual more level sections, which are also extended in the direction of the predominant systems of orientation of the faults. It is possible that they were earlier deformed bottoms of craters or sections of small plains.

Moreover, the entire surface of the eastern section of the Ishtar Terra is located in individual larger blocks, separated from each other by arc-shaped systems of larger valleys (or rather thrusts), convex in the eastern direction.

Within each of these blocks the orientation of the fine valleys and ridges and the angles under which the valleys with different orientations are connected, differ to some extent.

On the north and the south the eastern section of the Ishtar Terra is framed with volcanic plains. In the south in certain sections it is clearly visible that the lavas cover the "parquet" structures. But in the north the plain lavas are interrupted by the submeridional belt of linear locations, and this arch is covered in its turn under the "parquet". Thus the age relationship of the Ishtar /82
Terra structures with the ore complexes of the plains are different.

In the eastern half of the Ishtar Terra the full deformations are divided into two branches. One of these branches extends in the sublatitude direction towards the region of Tefia. The other assumes the south-eastern direction and follows towards the region of Telluria.

The region of Tefia is an elevated region, formed by structures, consisting of linear blocks, extending in the east-southeastern direction (fig.15 of the collective article). The altitude of the individual blocks, divided by valleys is up to 800-1500 m. Their width reaches 50 to 100 km, their length 200-400 km. The blocks are connected with each other by links, while the easternmost ones are shifted furthermost to the southeast. The surface of the individual block is cut up by finer and mostly transversal valleys (faults). In places the structures are bent in the shape of s. The faults, bordering on these valleys, occur mostly in the northwest. A large sublatitudinal depression is located in the rear section of the Tefia region. The entire picture indicates a movement of the blocks in the southeastern direction along the regions of displacement. Along the eastern edge of the Tefia district it is apparent that the frontal sections of the block are thrust towards the adjacent plain, although in other places the covering of the Tefia structures with young lavas appears clearly.

Further east these structures are attenuated among the volcanic rock of the Atalanta Plain, although within its limits we identify sometimes individual west-northwestern crevasses, and occasionally we find individual raised sections with "parquet" structures. The possibility that this region here is mainly covered by volcanic flows of the plain is not excluded.

The other section of this belt of deformation extends to the northwest-southeast from the east-southeastern border of the Ishtar Terra to the region of Telluria.

Southeastern framing of the Ishtar Terra (southern "parquet") (fig.1 in the collective article). This region from 47 to 63^{0}, from 54 to 52^{0} northern latitude occupies a separate elevation, located south-southeast of the eastern extremity of the Ishtar Terra, and located between it and the Lednaya Terre. The maximum altitudes here reach 4 km, while the region of maximum altitude is shifted to the northeastern end of the elevation. It is separated from the Ishtar Terra by a shallow depression, whose bottom is located at altitudes of nearly 2 km. A very gentle slope, decreasing gradually to 0 km over a distance of nearly 1500 km extends toward the Lednaya Terre. This region consists of a complex combination of ridges and valleys. It is interrupted by relatively narrow valleys (width 15 to 25, rarely up to 100 km) of west-northwestern direction. The longest of them, located approximately in the central portion of the elevation, extends over 1500 km. The length of the other valleys is less, but not less than several hundred kilometers.

In the western-northwestern extremity the valleys often expand, ending with very characteristic drop-shaped depressions. In the east-southeastern direction there is a gradual contraction of the valleys, and some of them gradually disappear, transformed into narrow crevasses. As a result the entire elevation (especially in the northern half) is divided into long blocks, whose width fluctuates between 250-300 in the northwest and 40-100 km in the southeast. These blocks are not monolithic. They represent a complex combination of finer ridges and valleys. In the west-northwestern section of the elevation the ridges and second degree valleys form a complex pattern. They are often bent in the shape of s between two large valleys, often extending parallely to their direction. The distance between the individual ridges fluctuates here between 10 and 15 km.

The fine ridges and valleys are usually directed perpendicularly to the direction of the large valleys. In the movement to the east-southeastern direction, the distance between the ridges decreases and the valleys become increasingly narrow. /83

The southern half of the elevation has a somewhat different structure. In its southeastern portion as well as the northern one, a system of ridges and furrows have developed, normal to the direction of the large valleys. In the southwest corner the direction of the ridges and valleys become irregular and the large valleys of the west-nortwestern direction disappear. In the south this elevation is gradually covered by deposits of volcanic plains. In the west and north linear belts run near them, but between them we find narrow depressions, filled with deposits of volcanic plains.

In the east they are directly in contact with structures of the linear belt, which are the boundaries of extension of the "parquet".

The region of Telluria is an elevation slightly extended in the meridional direction, placed between the plains of Lednaya and Niobe (fig. 16 in the collective article). Its altitude reaches 3.5 km. Its entire surface is complicated by small ridges and valleys in different directions, among which we distinguish several main directions.

In the west and eastern sections of the elevation large valleys are detected, extending northwest and northeast. They are undoubtedly connected with large faults.

The area between them consists of fine blocks, directed parallely to these large faults. Along the periphery of the Telluria region, this orthogonal network of blocks is disturbed and the structural picture becomes less orderly.

Meandering submeridional zones of faults, which are rather thrusts run along the western and eastern slopes.

In the southwest region of Telluria we find individual depressions (diameter up to 30-150 km) filled with lavas.

Thus the area of faults-fold deformations on Venus is located within a single belt, running from the region of Metide to the plain of Atalanta over a distance of nearly1300-1500 km. In places it branches out, and the individual zones of deformation are divided into monolithic blocks, which are slightly deformed and within which only individual faults are identified. The largest of such blocks ("microcontinents") is called the Lakshmi Plateau.

It is an extensive high altitude plain between 58 and 75^o latitude north and 310 and 355^o longitude west, surrounded on all sides by a belt of mountain structures. The main portion of the Lakshmi Plateau has on the plane the shape of a hexagon of diameter nearly 1200 km with trapezium shape projection in the north, and only in the east right until the foot of the Montes Maxwell, the plateau continues in the form of a "bay" 600 km long and 400 km wide. The smooth surface of the plateau has an altitude of 4-4.5 km above the average radius and is complicated by a number of structures of smaller dimensions (see fig. 8 in the collective articles).

They include the Colett depression, located in the western half of the plateau. In the plane it has an oval shape of dimensions 130 x 80 km, extended in the meridional direction. The depth of the depression is nearly 2 km. It has a plane or slightly convex bottom and internal slopes in the form of terraces. Southeast of the depression a system of ridges and furrows may be seen, extending over a distance of nearly 50 km, concentric to the Colett structures. In the Colett region, over a distance of up to 250 km we find narrow strips (15-20 km) of a lighter surface, which in the plane are similar to flows of liquid lava. They are directed mainly radially with regard to the depression. As a whole the Colett depression with the system of diverging flows seems rather to be a giant plate-shaped volcano of diameter nearly 600 km, occupying nearly the entire western half of the Lakshmi Plateau.

In the eastern half of the Lakshmi Plateau we find yet another oval depression /85
Sakadzhaveya of dimensions on the plane 200 x 120 km and about 1.5 km deep. It is expressed less clearly in relief than Colett. In the southeastern edge of the depression a number of projections start in the form of narrow dark and light lines lying at the limit of resolution; they form a system of flat-bottom furrows 3-10 km

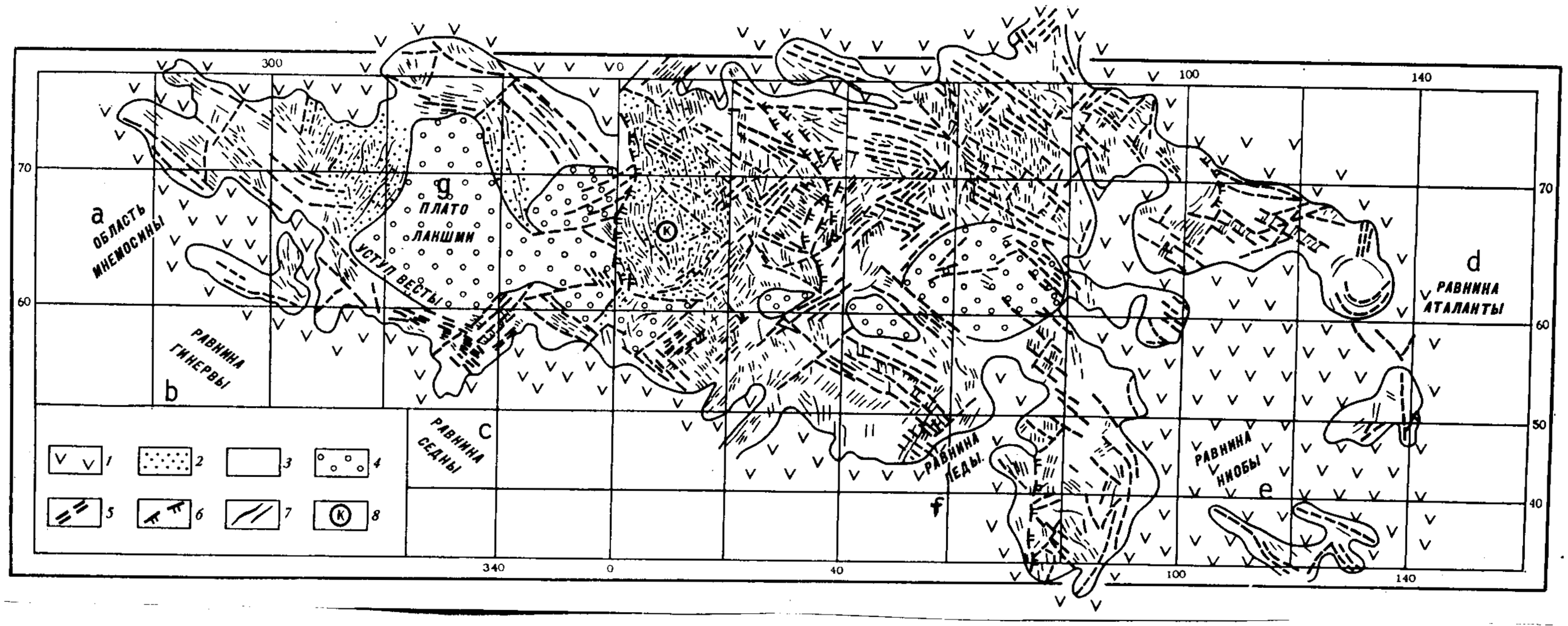

Fig. 2 Structural scheme of the northern belt of deformations of Venus
1- the region of solid development of volcanic rocks of the plains, 2- regions of compression, 3- regions of development of shift deformations, 4- slightly deformed blocks within the limit of the belt, 5- faults, 6- thrusts, 7- structural lines of extension of the ridges and valleys, 8- Cleopatra Crater

key:
a- region of Mnemosina
b- Ginevra Plain
c- Sedna Plain
d- Atalanta Plain
e- Niobe Plain
f- Lednaya Plain
g- Lakshmi Plateau

wide, which are similar to the superficial appearance of conjugare grabens and horsts.

North of the depression of Sakadzhaveya, through the entire eastern half of the Lakshmi Plateau, a strip of plain top monadnocks, rising over the plain region of the plateau on the average by 500 m, extends in the latitudinal direction. Their surface broken up by a network of orthogonal ridges and furrows obviously bears traces of earlier deformations, which have not affected the younger plain deposits of the Lakshmi Plateau.

In the extreme sections of the plain forming material, the Lakshmi Plateau is crushed into a system of linear ridges, parallel to the course of the deformation zones framing it. Apparently they represent a reaction of the relatively rigid material of the plateau the deformation in the neighboring regions, which is similar to the deformations at the convergant limits of the lithospheric platforms on the earth, as was described in the publications of P.Molnar and M. Tapponnier, also V.G. Trifonov (4,8).

Individual finer nondeformed blocks are found east of the Lakshmi Plateau. In places they create the impression, that they were cut off from the plateau in a system of sublatitudinal and northeastern faults.

A series of blocks may be assumed along the southern edge of the Ishtar Terra. The largest of them lie within the limits of 50 and 80^{0} longitude east and 68 and 55^{0} latitude north. It is located in the area of doubling of the deformation belt between its sublatitude and southeastern branches. The extreme sections of this block are broken up by faults, parallel to its contour, and the rocks, constituting them are crushed in places. Its eastern boundary is insufficiently clear. An ovoid structure is located on its eastern edge.

Within the limits of the undeformed blocks individual regions of faults may be found and only occasionally are individual ridges detected. The clearest of such faults with a system of full fledged crevasses of extension may be found in the southeastern region of the Lakshmi Plateau from the southern end of the Montes Maxwell.

Thus the northern belt of tectonic structures contain regions with three types of deformations: 1) submeridional regions of compression, which are inverse faults, tectonic upthrusts and thrusts; 2) sublatitudinal and northwest-southeast regions of displacements; 3) individual slightly deformed blocks, located within the belt (fig. 2). The relationships between these three types of deformations, observed in the radio pictures, makes it possible to assume that they are of the same age, and consequently form a single structural ensemble (3).

Geodynamic Interpretation of the Structural Ensembles of the Northern Belt

Structures different in their genesis, located within the limits of the studied belt, are associated very regularly. The sublatitudinal and northwestern faults within this belt, are quite obviously displacements. The difference in their structure in different regions of the belt may be explained by the different aptitude of displacement, the different thickness of the lithosphere or the different warming capacities of the crust, and consequently the different degree of plasticity. All these circumstances lead to a different more morphology of the deformations in the regions of displacement. The presence inside the belt of individual nondeformed or slightly deformed blocks is probably connected with the last two causes. The submeridional fault disturbances within the belt are regions of compression, manifested wither in the form of thrusts (eastern portion of the Ishtar Terra, the region of Telluria and /86 others), or in the form of tectonic upthrusts or systems of inverted faults (Akna and Maxwell Mountains).

Thus the entire belt is an extensive region of disruption, whose structural ensembles are related with the overall movement of the masses in the sublatitudinal direction. The same data were obtained basically by L.B. Ronka (see article in this issue of the journal) in the analysis of the ellipsoids of stresses in the Montes Maxwell and the eastern portion of the Ishtar Terra.

It is very difficult to explain the direction in which the movement took place in this belt, since we do not find on Venus well marked objects, according to which it would be possible to evaluate the direction of displacement and their extent.

On of the few items of evidence of the possible direction of displacement is a fault passing along the southern face of the Ishtar Terra and Montes Maxwell and ending in the southeastern corner of the Lakshmi Plateau. In its western extremity (already within the limits of the Lakshmi Plateau) we recognize clearly its fullfledged crevasses of extension, while the width of opening of each of these crevasses reaches 500-700 m.

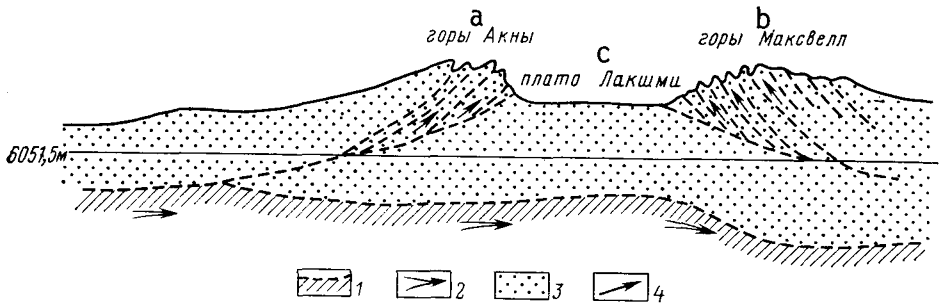

Fig.3 Proposed scheme of movements and deformations in the western region of the northern Venus belt
1- Asthenosphere, 2- parallel movements in the asthenosphere, 3- lithosphere, 4- relative direction of movements in the lithosphere

Key: a) Akna Mountains
b) Montes Maxwell
c) Lakshmi Plateau

This makes it possible to assume that the relative movement within the limits of the belt occurred mainly in the eastern direction.

In this connection it is not particularly easy to understand the occurrance of tectonicthrusts (or inverse faults) in the Akna and Maxwell Mountains on the side of the Lakshmi Plateau. But this may be explained if it is assumed that the eastern edge of the plateau is submerged under the Montes Maxwell, while the Akna Mountains are thrust over the plateau, as shown on fig. 3. This hypothesis could be explained in the structure of the Venus lithosphere, which may be evaluated approximately according to the gravimetric data, obtained with the "Pioneer-Venus" spacecraft. According to these data it may be assumed that the thickest crust exists under the Montes Maxwell (9).

The structure of the northern belt of deformation has yet another characteristic: structural ensembles, related to the existence of an extensive region of disruption, and clearly complicated by a phenomenon: gravitational slumping. Some of these phenomena has been described in great detail in the article by A. L. Sukhanov in this journal. One should add to them unusual sheets lobes, occurring in the Frey Mountains, along the Vesta Scarp and in the northern section east of the Ishtar Terra. These are undoubtedly gravitational sheets, which are widespread in regions of the submerged sections of the relief.

Apparently this phenomenon is fairly frequent on Venus, predominately related with the relatively low thickness of the lithosphere and the high warming capacity of the crust and its lower viscosity (5,7,9). In this connection the surface of modern Venus may be used as a model of the tectonics of an earlier Earth, since, as many researchers believe the crust of our planet in the earliest stages of its evolution was relatively thin and heated more intensely because /87 of the higher thermal flow in the early pre-Cambrian era (2).

But if it is assumed for the Earth, that the regions of brittle-plastic deformations occurred at a certain depth in the lower regions of the Earth's crust, for Venus because of the specifics of its atmosphere these deformations occur close to the surface, if our hypotheses on the small role of erosion processes on this planet are justified.

It appears that such a comparison is really justified, since during the lastyears in the metamorphic complexes of the pre-Cambrian era many regions of disruptions have been described, along which very interesting viscous-plastic deformations take place (10). Part of these structures studied by means of aerial methods recall in their structural outlines certain structures of Venus (6).

It should be noted that within the portion of the Venus surface which had been covered by the radar photography of the "Venera" 15 and 16 probe, several more types of structures are known, whose relationship with the studied deformation belt is not very clear. These are primarily large annular structures (ovoids) which may possibly be zones of vertical raising of the mantle material (plumages) and which frame the northern belt of tectonic deformations from the west, south and east.

Moreover within the volcanic plains linear deformation belts appear, whose time relationships with the structures of the sublatitude belt are not totally clear. In many places (eastern section of the Ishtar Terra) they seem to be younger than the belt and are superimposed on its structure. In other places the relationships are reversed.

thus the belt of tectonic deformations in the northern hemisphere of Venus is a large region of horizontal displacements of the crust material, within which we can recognize clearly zones of displacements, thrusts, inverse faults or tectonic upthrusts, combined into a single structural ensemble. This type of deformations of the Venus lithosphere is apparently similar to the deformations of the early pre-Cambrian region of the Earth.

This type of deformations is peculiar to the northern belt. Unfortunately we cannot compare it now with the central region of elevations near the equator, which includes the Aphrodite Terra and were according to the data of the "pioneer-Venus" probe, many grooved regions were detected (7).

A further study of Venus will make it possible to make a more complete comparison of the characteristics of the tectonics of this planet with the Earth and reveal the characteristics of their resemblance and differences.

REFERENCES

1. Barsukov V.L., Bazilevskiy A.T., Kryuchkov V.P. et al, "Types of Structures on the Venus Surface", Astron. Vestn., 1985, no.1, pp.16-31.

2. Markov M.S., "Early Stages of the Earth's Crust",in the book: Problemy Tektoniki Zemnoy Kory (Problems of Tectonics of the Earth's Crust), Moscow Nauka, 1982, pp. 104-112.

3. Razlomy Ei Gorizontal'nyye Dvizheniye Zemnoy Kory (Faults and Horizontal Movements of the Earth's Crust), Moscow Nauka, 1963, 312 pp.

4. Trifonov V.G., "Interaction of Continental Sheets in Conditions of Compression", in the book: Tektonichesoye Razveitiye Zemnoy Kory Ei Razlomy (Tectonic Developement of the Earth's Crust and Faults), Moscow Nauka, 1979, pp.185-201.

5. Head J.W., Solomon S.C., "Tectonic Evolution of the Terrestrial Planet", Science, 1981, v.213, pp. 62-76.

6. Hepworth J.V.,"Photogeological Recognition of Ancient Orogenic Belts in Africa", Quart. J. Geol.Soc., London, 1967, v. 123, pt. 3, pp. 253-292.

7. Masursky H., Eliason E., Ford P.G., McGill G.E., Pettingill Schaber G.G., Schubert G., "Pioneer Venus Radar Results: Geology from Images and Altimetry", J. Geophys. Res., 1980, v. 85, pp. 8232-8260.

8. Molnar P., Tapponnier M., "Cenozoic Tectonics of Asia: Effects of a Continental Collision", Sciences, 1975, v. 189, no. 4201, pp. 419-426.

9. Phillips R.J., Kaula W.M., MsGill G.E., Malin M.C.,"Tectonics and Evolution of Venus", Science, 1981, v. 212, pp. 879-887.

10. "Shear Zones in Rocks", J. Struct. Geol., 1982, v. 2, no. 1/2, 287 pp.

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