A Mode of the "URUMA" Crustal Movement in the Southeastern Part of the Okinawa-jima, Ryukyu Island

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Yuji MARUO* Hiroyasu FURUKAWA* Koshiro KIZAKI**

Abstract

The Ryukyu limestone of the Quarternary period develops well in the southeastern part of the Okinawa-jima, where it is regarded to be one of the type localities together with the underlying Shimajiri group. The limestone formation is divided into quite a few blocks by a series of faults representing platforms of various heights of 150 to 180m. The fault movement signifies the Uruma event of the Quarternary crustal movement. (Okinawa Quarternary Research Group, 1976, Kizaki and Takayasu, 1976)

The present study based on the surface survey, drilling and electric prospecting shows that the structure of the limestone platform and the surrounding staircase topography of the area is resulted from a combination of uplift and subsequent concave landslide-like antithetic step faults. The period of the movement is defined here as after the sedimentation of the Ryukyu limestone and before the sedimentation of the terrace limestone which corresponds to the Machinato limestone of MacNeil (1960).

I Introduction

The Ryukyu limestone develop extensively over the Ryukyu island arc, and form platforms in many islands. These platforms of various heights ranging from 150 to 180m are bordered by cliffs, and are seemed to be the result of block movement. The surface of the platforms are more or less inclined to various directions. From these features the deformations by uplift and faulting after the sedimrntation of the Ryukyu limestone are clearly recognized.

In the southeatern part of the Okinawa-jima, the faults with the WNW-ESE and ENE-WSW directions are predominantly developed, and they divide the Ryukyu limestones into many blocks. This fault movement represents the Uruma event proposed by Okinawa Quarternary Research Group (1976).

However, the details of the movement has not been well established yet. Peculiar topography and geologic configuration of the Chinen area (Fig. 2) can not be explained by simple normal faulting alone. Here a new deformation history is proposed by the writers who carried out the detailed stratigraphic and structural research in the area.

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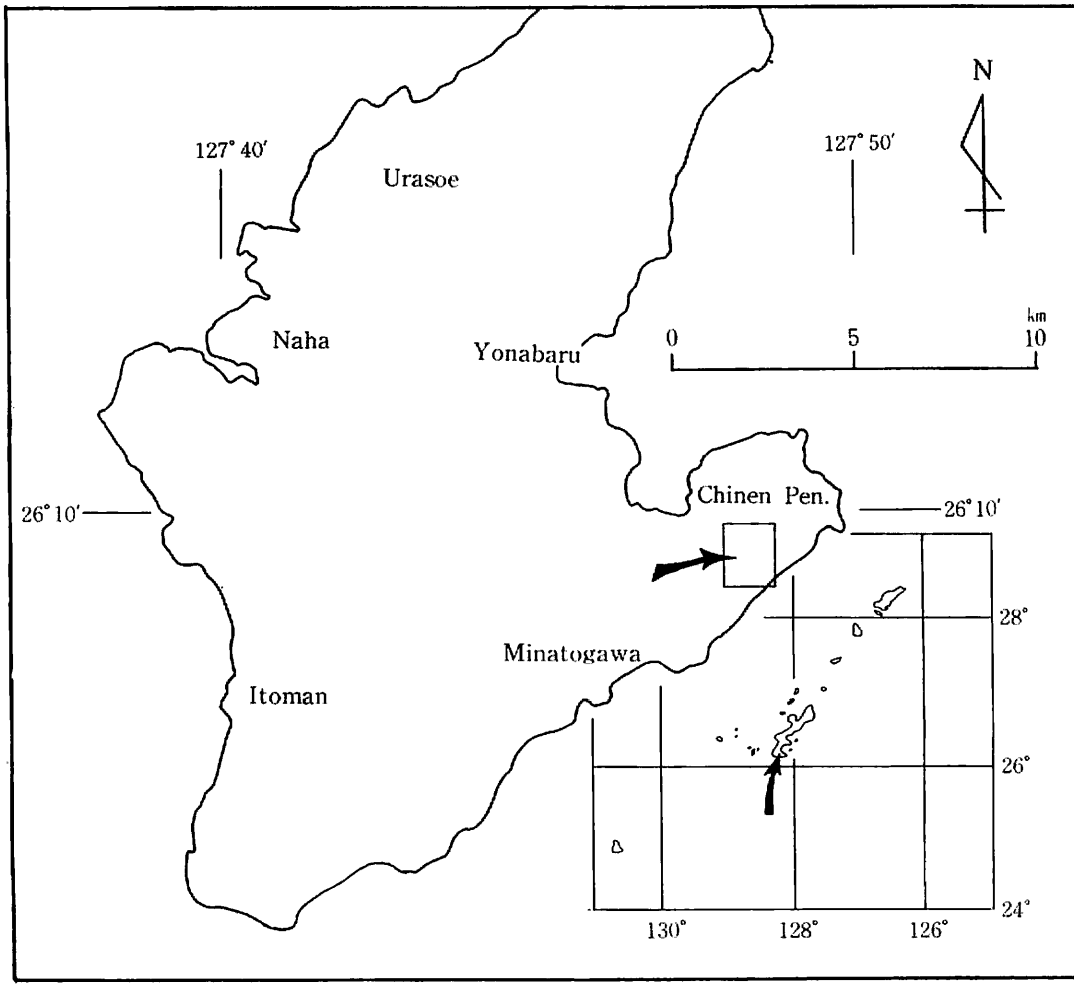

Fig. 1. Index Map of the Studied Area

I.Morita, Kuniken Designing Consultant Co. Ltd., who rendered many conveniences to the writers during their field work.

II Topography

The present area is located in the Penisular Chinen in the southeastern part of the Okinawa-jima. (Fig. 1) In this area there is a platform of 150 to 160m high above sea level stretching in the northeast-southwest direction, and both the northwest and southeast sides are demarcated by limestone cliffs of 10 to 30m high.

At the southeast side the platform is cut by a continuous vertical cliff of 20 to 30m high, which extends about 1km with concave shape. The cliff is skirted by flat lands of 150 to 300m wide and then steep slope, repeating this pattern downwards until reaching the coastal alluvial plane. This staircase topography is parallel to the cliff. The flat lands are covered with thick weathered soil of reddish brown colour and sporadic Ryukyu limestone beds.

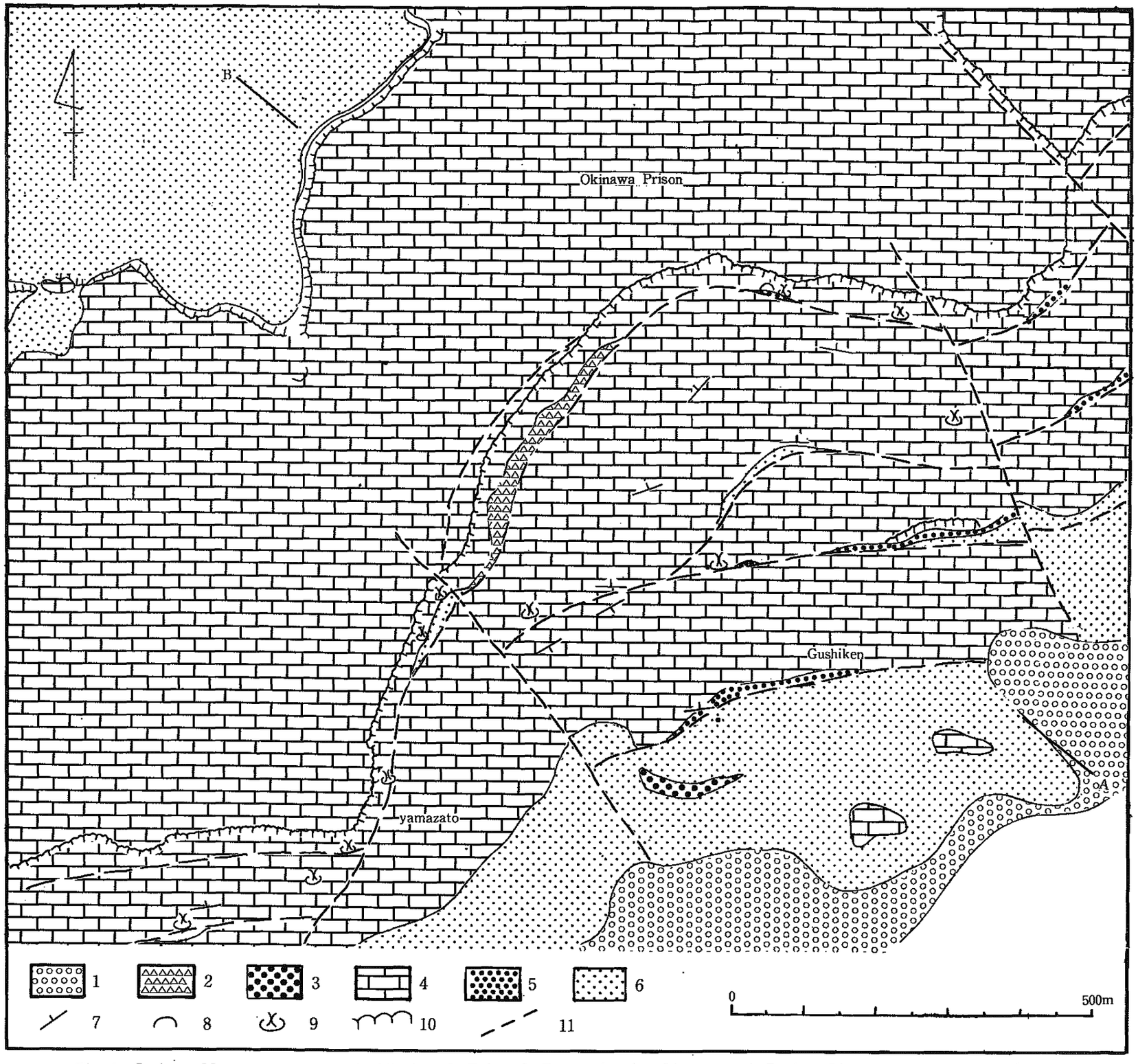

Fig. 2 Geologic Map

1. Alluvium 2. Talus 3. Terrace-forming Limestone 4. Ryukyu Limestone 5. Chinen sandstone
6. Shimajiri group siltstone 7. Strike dip 8. Limestone cave 9. Spring 10. Limestone cliff 11. Fault

However, at the northwest side of the platform, no staircase topogtaphy is seen. Instead the limestone cliff of 10 to 20m high is followed downwards by a steep but smooth slope until it reaches alluvial plane. The slope is composed entirely of the Shimajiri group, and the boundary between the Ryukyu limestone and the Shimajiri group coincides with the topographically recognizable change of curvature of the slope which can be traced over long distance.

The relative height from the alluvial plane to the top of the cliff is about 150m and average inclination is 18°. Thc slopc is traversed by a few deeply scraped valleys which run along transverse faults, otherwise it shows monotonous gentle undulation.

At the east side the platform is cut by a transverse fault of the northwest direction forming a definite fault cliff. The fault plane dips towards the west and vertical dislocation is estimated about 20m.

The surface plane of the platform inclines slightly towards the south. Small domes of 2 to 5m high are seen on the platform aligning in the northeast direction. Some limestone caves extending to the north-south direction are also seen in the platform. They incline slightly steeper than the surface topography towards the south, and some of them reach up to the cliff.

III Stratigraphy

The stratigraphy of the area is briefly described as follows, (Fig. 3)

Alluvium
Terrace limestone
Ryukyu limestone
Chinen sandstone
Shimajiri group

The Shimajiri group consists exclusively of thick dark gray siltstone with a few intercalations of sandatones and tuff layers. The siltstone contains Gastropoda, Bivalvia and Foraminifera fossils, and occasionally shows sedimentary structures such as sand lenses or sand pipes. The Shimajiri is conformablly overlied by the Chinen sandstone (MacNeil, 1960). The Chinen sandstone consists of alternation of silt and calcareous sandstone in the lower part, which includes calcareous nodules and lenses along the bedding planes. The order of the alternation thickness is some tens of centimeters. Calcareous sand predominates in the upper part. The sand abundantly produces well preserved Bivalvia, Gastropoda and Brachiopoda as well as Bryozoa fossils. After his studies of these fossils, Noda (1977) points out that the sedimentary facies show a depth of more than 100m in the lower and middle part, and neritic in the upper.

The thickness of the Chinen varies from 1 to 10m in the outcrops. However, drilled cores show that in some places underneath the platform it is devoid of the Chinen. This fact coupled with the presence of burried fossil valleys which will be discussed later, suggests the existence of a regression and erosion phase in between the sedimentations of the Chinen and the Ryukyu limestone. Therefore it is concluded that the relation between the Chinen sandstone and the Ryukyu limestone is unconformity.

The Ryukyu limestone unconformablly overlies the Chinen and in some places directly the Shimajiri group. In general it consists of arenaceous limestone and clastic limestones with recognizable bedding planes in the lower part. At the upper part it consists mainly of algal ball lime-

stone. In the west of Yamazato hamlet the algal ball limestone alternates with arenaceous limestone, and the facies change rapidly both vertically and horizontally.

At the basal part the limestone contains muddy terigenous materials such as rounded pebbles or cobbles of the Shimajiri group. The thickness of the basal part is about 3m. Secondary lithification by casehardening is taking place down to 5 to 10m deep from the surface, and the deeper part of the limestone shows loose clastic lithology.

These limestones occupy the main part of the platform and also occur repeatedly at the upper part of the staircase flat lands of different altitude. (Fig. 7)

The arenaceous limestone constructing terraces occur in the altitude of 40m near the western corner of the Gushiken hamlet overlying unconformably the Ryukyu limestone. The limestone can be called to be a calcarenite containing rounded boulders of the Ryukyu limestone at the base. Judging from its lithofacies and the altitude of the occurence it can be safely correlateted to the Machinato limestone of MacNeil (1960). The thickness of the limestone is 4 to 5m. The field occurence clearly shows that the sedimentation of the arenaceous limestone took place after the formation of the staircase topography.

IV Structure

The bedding plane of the Shimajiri in the northwestern slope of the platform shows the southwest dipping monoclinal structure having the N30°-50°E strikes and 8°-15°SW dips. Whereas the structure of the Ryukyu limestone on the platform is almost horizontal. It suggests that before the sedimentation of the Ryukyu limestone a pile of the Shimajiri and the Chinen tilted slightly towards the south.

In the southeastern slope a set of the Ryukyu limestone, the Chinen and the Shimajiri appears repeatedly in each step of the staircase structure. Here the Ryukyu limestone dips 15° to 45° towards the north having concave step boundaries parallel to the cliff of the platform. This staircase structure might be resulted from repeated antithetic faultings, and the concave fault planes are quite similar to a topography of landslide.

V Basement structure of the Ryukyu limestone

It is clear now that the Shimajiri siltstone and the Chinen sandstone compose the basement of the platform, upon which the Ryukyu limestone deposited. The writers tried to depict the basement structure of the platform examining drilled cores and the result of the earth specific resistance survey. (Fig. 4, 5) The electric earth specific resistance meter used here is Yokokawa Co.Ltd. Model 3244 and took the Wenners method. The measured points are numbered altogether 64 and average depth is 50m. The writers reffered the Sundberg's standard curves for the data analysis.

110 drillings were done within 350x200m tract of land on the platform. Each drilling reached down to the Shimajiri siltstone. The localities of electric prospecting and drillings are shown in Fig. 7.

The contour map of the basement is also shown in Fig. 7. The elevation of the basal plane in the northern end is 145m and 125m above sea level in the south. Consequently the basement surface inclines towards the south by 1/12.5. The degree of the inclination is larger than that of

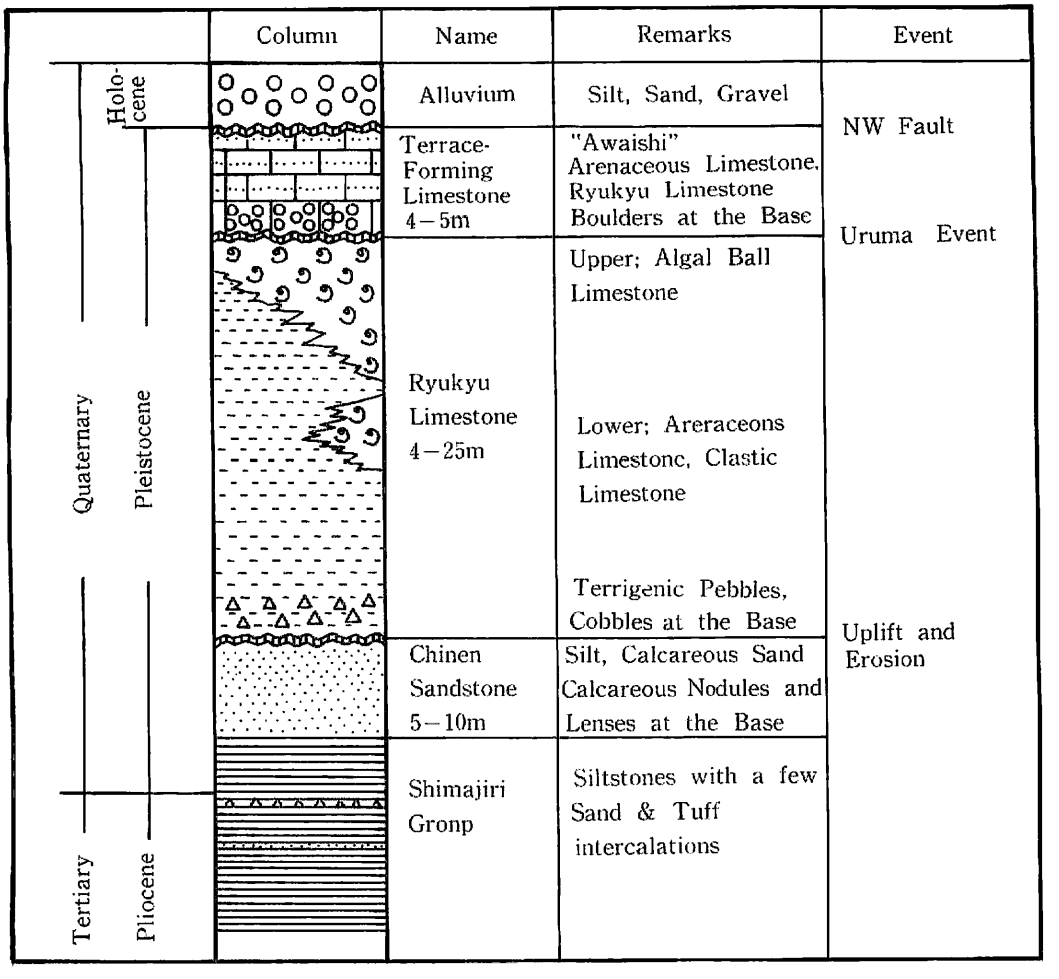

Fig. 3. Standard Stratigraphic Column

the surface of the platform. So that the thickness of the limestone increases towards the south, namely 4 to 5m thick in the north and 20m thick in the south. The features of the southwards thickening of the limestone is observed also by one of the writers in Miyako island.

Furthermore the contour map clearly shows the presence of buried fossil valleys extending from the north to the south. The direction of the valleys are identical to that of the limestone caves.

Near the southeastern edge of the platform the basement as well as the surface topography depresses several meters. (Fig. 6) This can be explained by a subordinate parallel faults to the cliff which signifies the principal fault scarp.

VI Geologic History

The formation of the platform and the limestone cliffs are explained by previous authors(e.g. Flint, 1953 or Okinawa Quarternary Research Group, 1976) simply as (1) sedimentstion of the

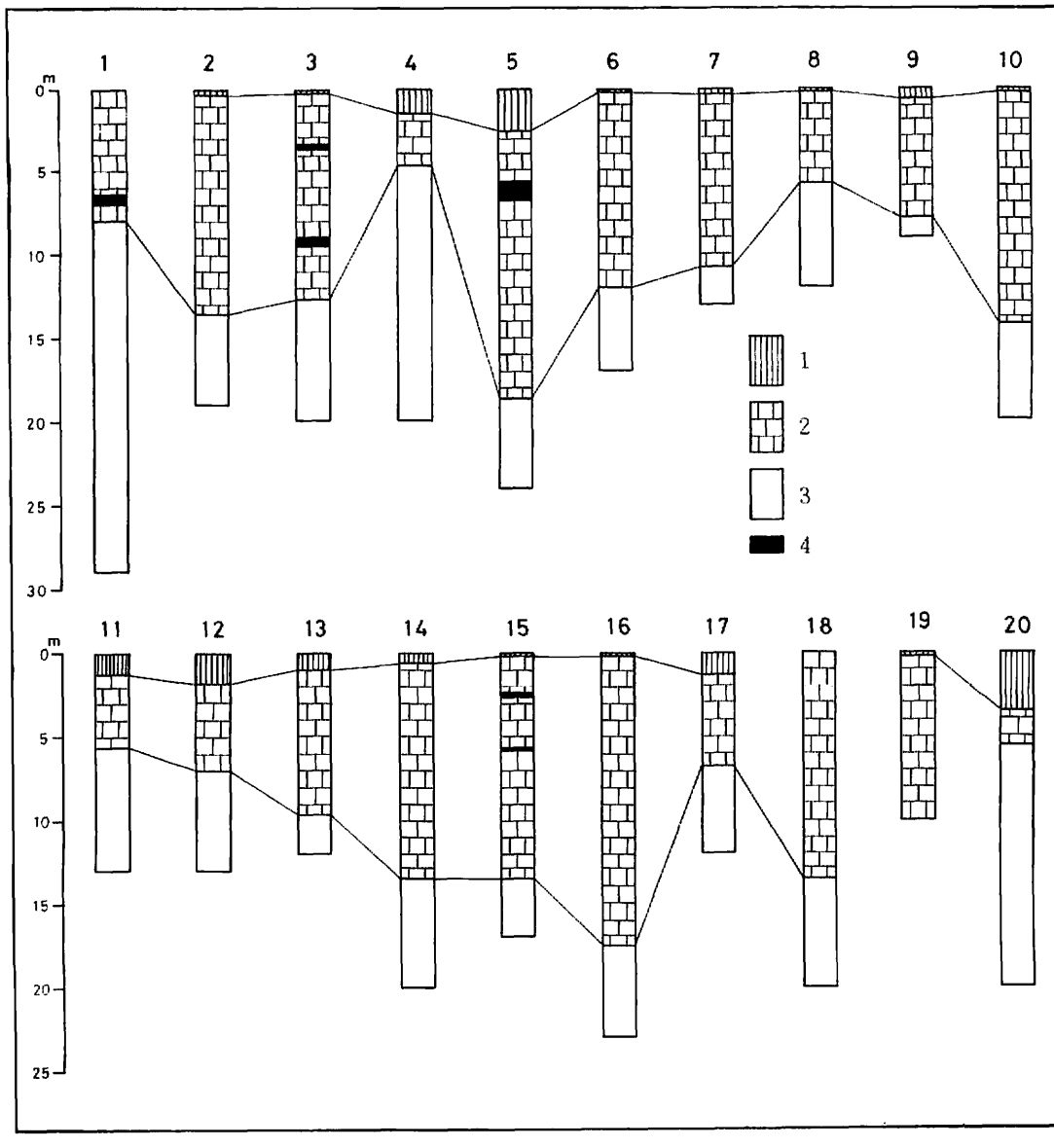

Fig. 4 Colnmns of Drilled Cores

1. Reddish-brown soil 2. Ryukyu Limestone
3. Chinen sandstone and Shimajiri siltstone
4. Limestone cave

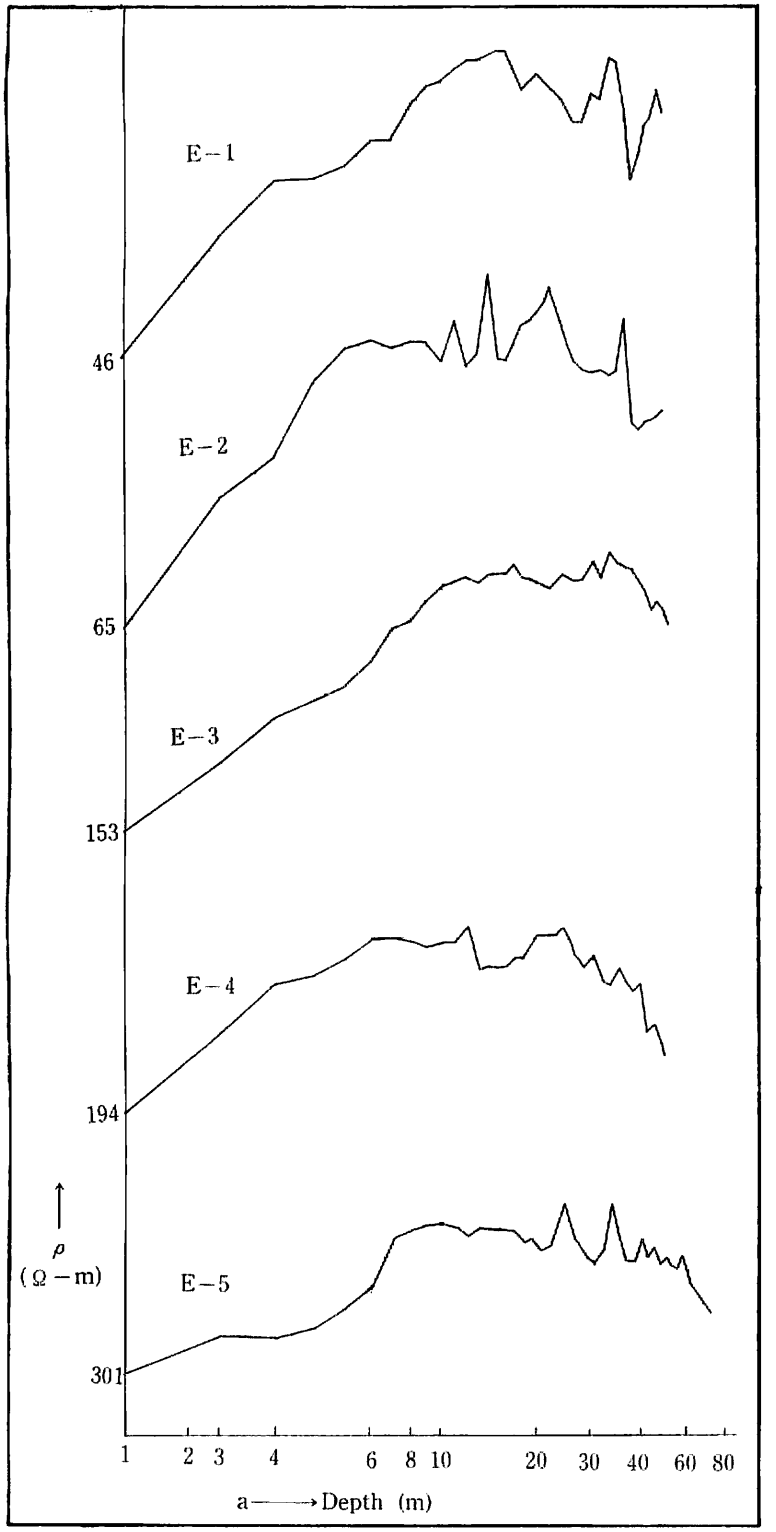

Fig. 5 Selective $\rho-a$ curves of the Electric Prospectings
E−2 Point is on the flat land south of the limestone cliff. Others are on the platform.

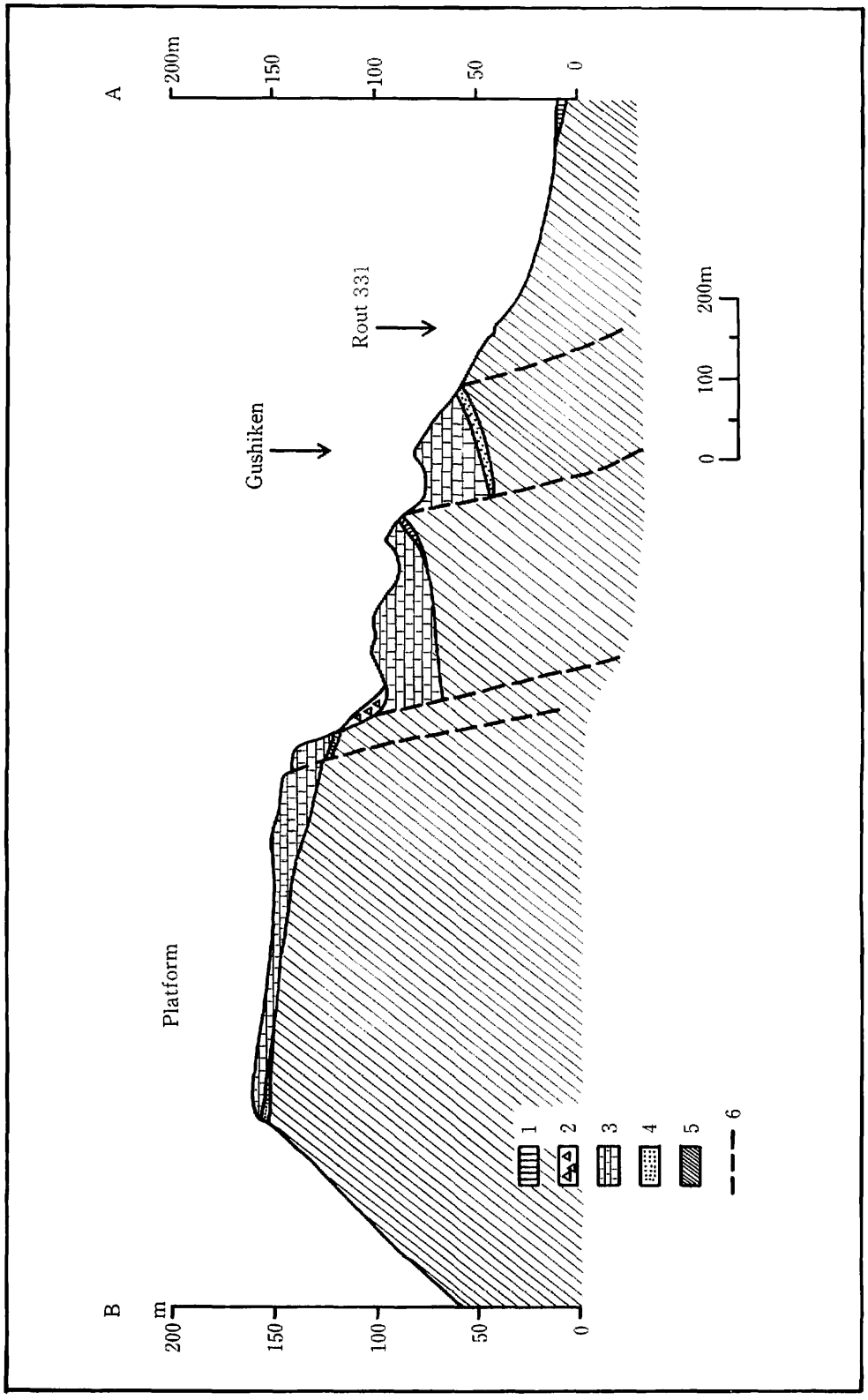

Fig. 6 Geologic Profile

1. Alluvium 2. Talus 3. Ryukyu Limestone 4. Chinen Sandstone
5. Shimajiri Group (Siltstone) 6. Fanlt

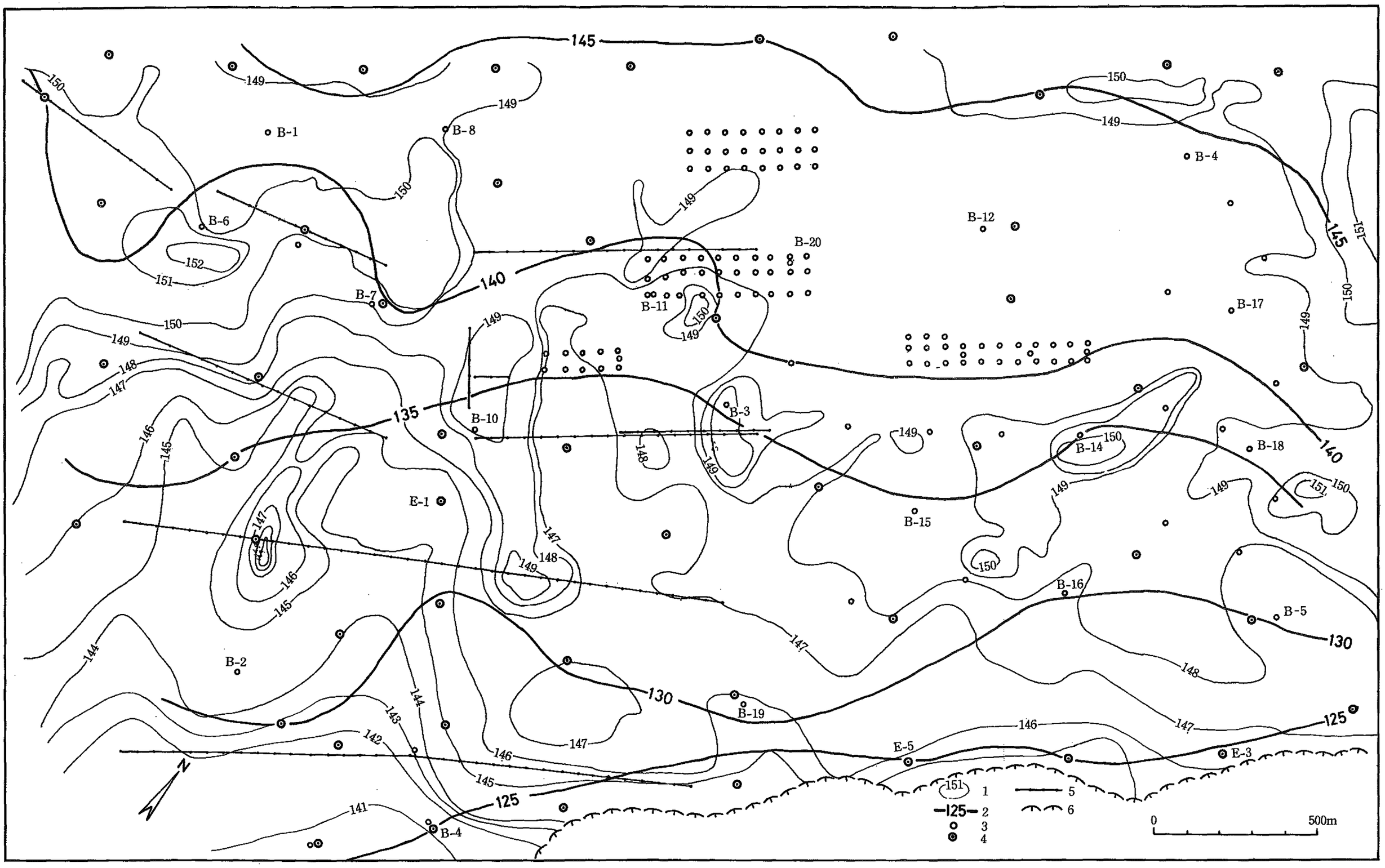

Fig. 7 Contour Map of Basement Structure on the Platform

1. Original Topography 2. Basemert contour (A. S. L.) 3. Localities of Drilling 4. Localities of Electric Prospeiting (Vertical)
5. Localities of Electric Prosecting (Horizontal) 6. Limestone cliff

Ryukyu limestone (2) uplift (3) following normal faulting or differrential erosion.

However, the present research in the Chinen Village drew a different conclusion from the formers regarding the geologic history of the area as follows,

1) Sedimentation, uplift and erosion of the basement (the Shimajiri group and the Chinen sandstone)

The sedimentation took place during from Miocene to early Pleistocene. The facies of the sediments changes gradually upwards from abyssal to neritic. (Noda, 1977) After the sedimentation, it emerged above the sea and subjected to erosion, at least some parts of it. This is clearly proved by the presence of the buried fossil valleys and occassional absence of the Chinen sandstone underneath the platform limestone.

2) Sedimentation of the Ryukyu limestone

The sedimentation took place on the eroded surface of the basement abutting from the south to the north. The basement had been tilted towards the south before the sedimentation. Therefore the thickness of the limestone increases towards the south.

3) Rapid uplift and the subsequent concave antithetic step faulting

After the sedimentation of the Ryukyu limestone the area was subjected to a rapid uplift. The vertical dislocation by differential uplift reached at least 150m. Following the uplift, concave landslide-like antithetic step faulting took place in the southeastern slope and formed the present structure and topography.

4) Sedimentation of the terrace arenaceous limestone

After the formation of the staircase structure the arenaceous limestone deposited on the terrace at the altitude of 40m in the present topography. The limestone can be correlated to the Machinato limestone of MacNeil (1960).

5) The northwest transverse faulting

The platform is traversed by the normal faults of the northwest direction.

6) Formation of the northwestern slope

The slope is well known as a notorious landslide area, and therefore the slope is considered generally. being very younger stage, so that it is still unstable condition. Similar characteristics are also seen at the southeastern slope below 50m level, where landslides of various scales are taking place along the Rout 331.

VII Couclusion

The present study revealed that the staircase topography of the platform and the adjacent slopes in the Chinen village were formed by a combination of uplift and subsequent landslide-like concave antithetic step faulting during the Uruma event of the Quarternary crustal movement. It is resulted from a combination of the Shimajiri siltstone of lower shear strength at the base and overlying relatively hard and heavy limestone. It is further reinforced by the southwards inclination of the basement.

It comes also clear that the Ryukyu limestones distributed at the lower levels of the southeastern slope below the platform indicate identical stratigraphic horizon to the limestone of the platform, which had slipped down by the antithetic step faulting resulting the staircase structure. This signifies a style of the deformation of the Uruma event.

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