TWO NEWLY-DISCOVERED TECTONIC PATTERNS IN TAIWAN REGION-- THE CIRCULAR PATTERN AND THE NW-SE SHEAR ZONE-- AS INTERPRETED FROM SMALL-SCALE REMOTE SENSING IMAGES

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ABSTRACT

Based on the study of Taiwan SLAR images (on scale 1/250,000) and LANDSAT images (on scale 1/1,000,000), two tectonic patterns are newly discovered, i.e. the circular pattern surrounding the Peikang Basement High and the NW-SE shear zone crossing the middle part of Taiwan. The circular pattern centered at Peikang Basement High and bordered by Taichung, Kaohsiung, and Lishan Fault, is composed of five annular arcs. Each arc, in turn, consists of two or more segments of mountain ridges. The curvature of this pattern is concave toward the west, diverging from the general trend of topography and structures in Taiwan Island. The NW-SE shear zone obliquely crosses the middle part of Taiwan with its north boundary trending N20°W and south boundary trending N15°W and an average width of 50 km, extending south-easterly until reaching the Longitudinal Valley. The intersection angle between the shear zone and the average trend of the Valley (N23°E) is arround 38°-43°.

The strain ellipse model worked out from SLAR lineaments reveals that these two newly-discovered tectonic patterns are possibly formed by the interaction of the resistant forces of Peikang Basement High against the north-westerly compressional forces of the clockwise rotation of the Philippine Sea Plate relative to the Eurasian Plate.

IMPLICATIONS OF LINEAMENTS AND CIRCULAR PATTERN

"A lineament is a mappable, simple or composite linear feature of a surface, whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differs distinctly from the patterns of adjacent features and presumably reflects a subsurface phenomenon" (Hobbs, 1904 and 1912; O'Leary and others, 1976). It is noteworthy that lineaments are "structurally-controlled" (AGI, 1972).

Circular pattern (or so-called ring structure) "consists of rectilinear sectors, arranged regularly with respect to a center of symmetry" (Poroshin, 1981) and implys that they are the expressions of "first-order structures" if small-scale images are concerned (Trofimov, 1981).

These cited definitions for lineaments and ring structures highlight the tectonic significance of the linear or curvilinear features expressed on small-scale images as employed in this study.

THE CIRCULAR PATTERN SURROUNDING PEIKANG BASEMENT HIGH

The ring structures (or circular pattern) which are centered at Peikang Basement High are composed of five annular arcs (Figure 1). Each arc, again, consists of two or more segments of mountain ridges. This pattern is bordered by Taichung City, to the north, Kaohsiung City, to the south, and the Lishan Fault, to the east. And, its curvature is concave toward the west, departing from the overall topographic trend of Taiwan Island which is arcuate to the east.

The apex of the outer arc of this pattern is situated at the vicinity of the junction point of the Lishan Fault and the Laonung Fault. And, this is also the place where the highest peak (the Yushan) of Taiwan Island is located. Obviously, the exposition of Lishan Fault and the geologic structures within this circular zone are both affected by the stress conditions which molded the ring structures. Possibly, this circular zone could extend as far as the outer border of the Coastal Range in eastern Taiwan.

THE NW-SE SHEAR ZONE

As shown in figure 2, the north boundary of the NW-SE shear zone trends approximately N20°W and the south boundary approximately N15°W, with an average width of some 50 km. This zone is situated in the middle part of Taiwan, extending from northwest to southeast, and is terminated at the Longitudinal Valley. The intersection angle between this zone and the average trend of Longitudinal Valley (=N23°E) is about 38°-43°.

The main features of this zone appeared on SLAR images include:

(1) The arcuate topographic/structural features in the Hsueshan Range are southwardly terminated at this zone and re-appear, at the opposite side, as rectilinear or counter-arcuate topographic/structural features;

(2) To the north of this zone, the Lishan Fault trends arcuately northeast. However, it becomes nearly south-north linear in this zone and, furtherly southward, very wavy at the southeast of Yushan, and then meets the Laonung Fault;

(3) Cho-shui Hsi, the biggest stream in Taiwan, linearly and eastwestly crosses this zone and its trend is approximately perpendicular to the Lishan Fault;

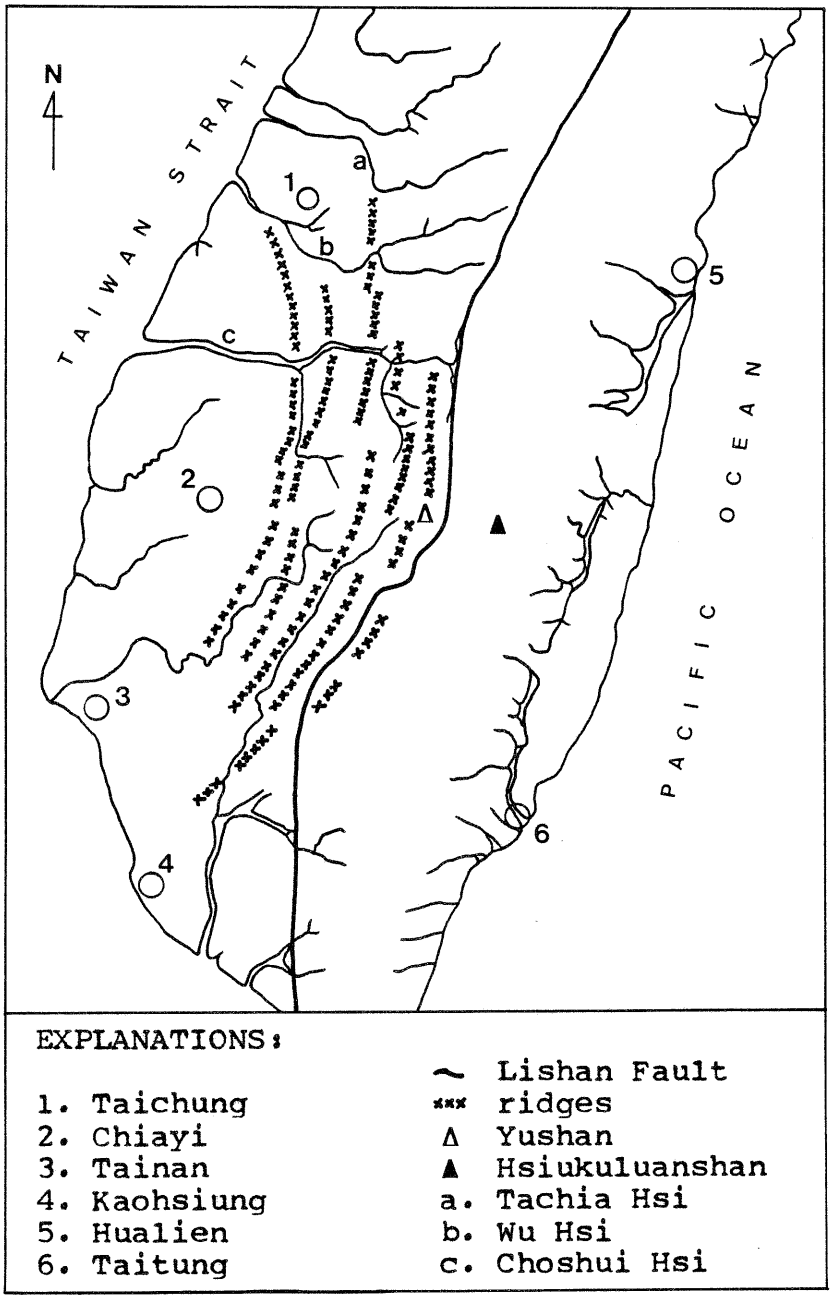


Figure 1. The circular pattern surrounding the Peikang Basement High as interpreted from LANDSAT images.

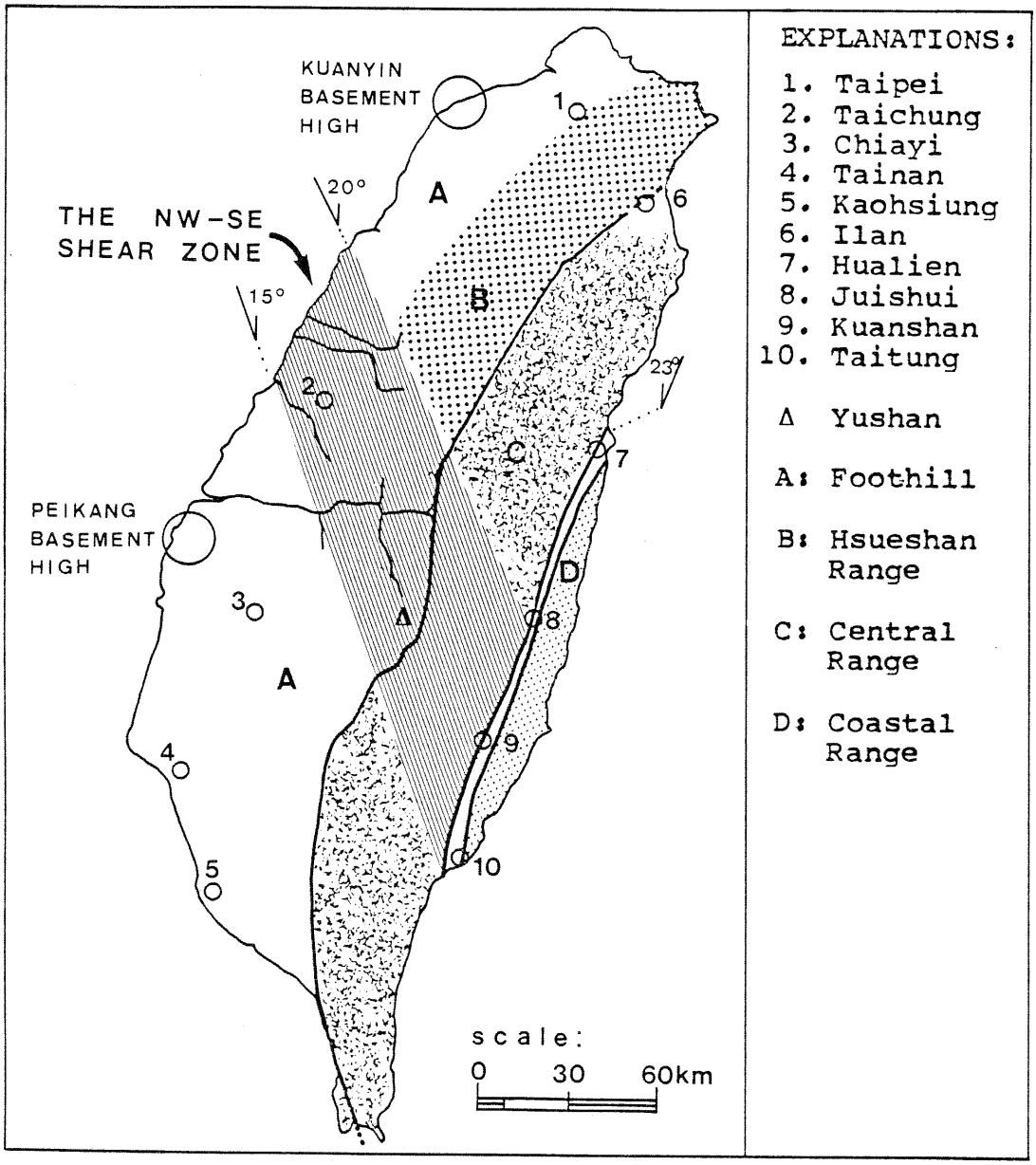


Figure 2. The NW-SE shear zone observed on Taiwan SLAR images.

(4) The drainage anomaly of Tachia Hsi, Wu Hsi, and the three biggest tributaries of Cho-shui Hsi, i.e. Chin-ta Hsi, Ch'en-yu-lan Hsi, and Ching-sui Hsi, as well as the uppermost segment of Cho-shui Hsi, happens in this zone with nearly 90 degrees of junction angles or direction change of stream course;

(5) The highest peak of Taiwan, i.e. the Yushan peak (3997 meters) and the Hsiu-ku-luan-shan (3833 meters) took place in this zone;

(6) The long axis of the NW-SE zone obliquely goes between the Peikang Basement High and the Kuanyin Basement High;

(7) The shear zone transcrosses from northwest toward southeast through the Quaternary sedimentary rocks, the Tertiary sedimentary rocks, and the older metamorphic rocks;

(8) The last but most significant point is that lineaments running NW-SE are more frequent and densely-spaced in this zone than in the other areas. Especially, the expositions of lineaments at the southern and northern borders of this zone are even more complicated. An N15°W structural trend located at the Alishan Area, the southern border of the shear zone, had been observed from LANDSAT-1 imagery, too (Wang, 1974) (Figure 3).

A TENTATIVE HYPOTHESIS

Four major trends of lineaments are interpreted from Taiwan SLAR images (Liu and Yuan, 1982). These composite of lineament trends can be explained by the strain ellipse model which is caused mainly by a compressional stress at 125° in azimuth, as indicated in figure 4. In other words, the lineaments stand for the strain features or structures observed on images. The stress is primarily built up by the clockwise rotation of the Philippine Sea Plate relative to the Eurasian Plate (Seno, 1977). In turn, this stress condition can be used to decipher the origin of the circular pattern and the NW-SE shear zone (Figure 5).

As shown in figure 5, the compressional force in 125° azimuth is applied westerly to Taiwan Island and resistant forces are, consequently, formed radially from the Peikang Basement High (Chou, 1972; Tang, 1977). To the north of Cho-shui Hsi, because the resistant force of the Basement High sharply decreases (Chiu, 1971), the displacement caused by the northwesterly force should increases accordingly and, thus, molds this area the greatest curvature (concave to the east) of topography/ stratigraphy of whole Island. On the contrary, the resistant force near Yushan area is largest, so that the northwesterly displacement is obstructed and the energy

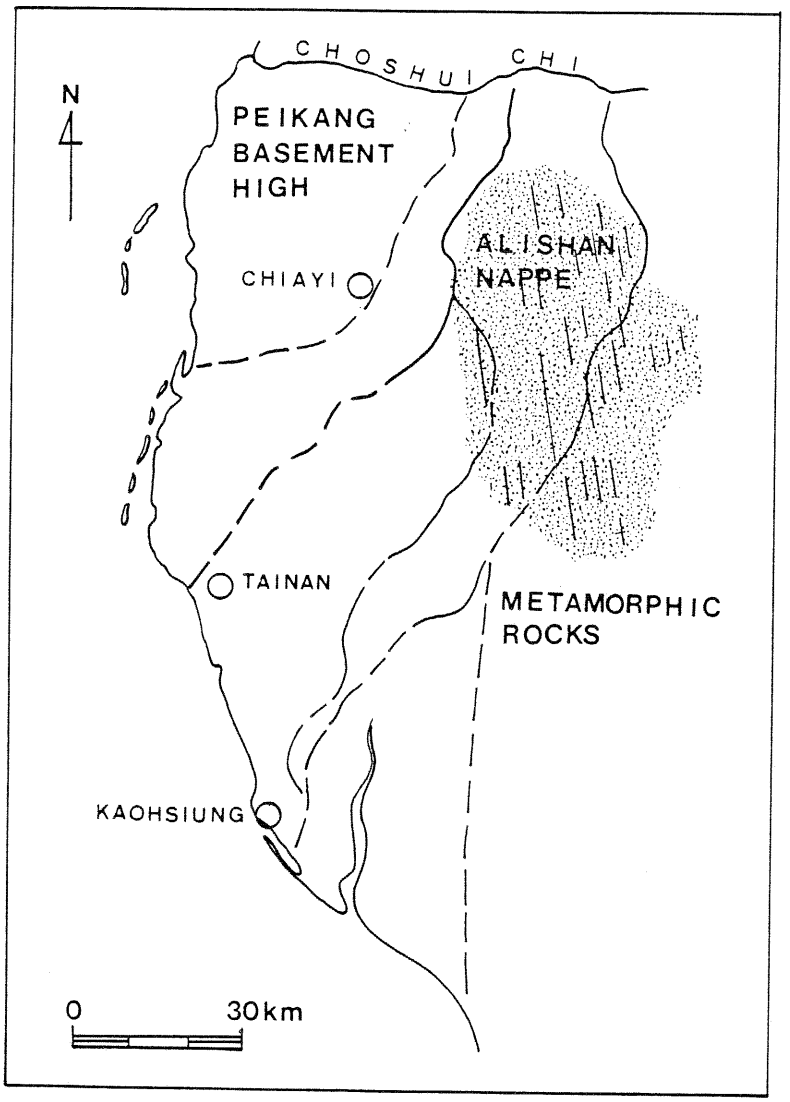
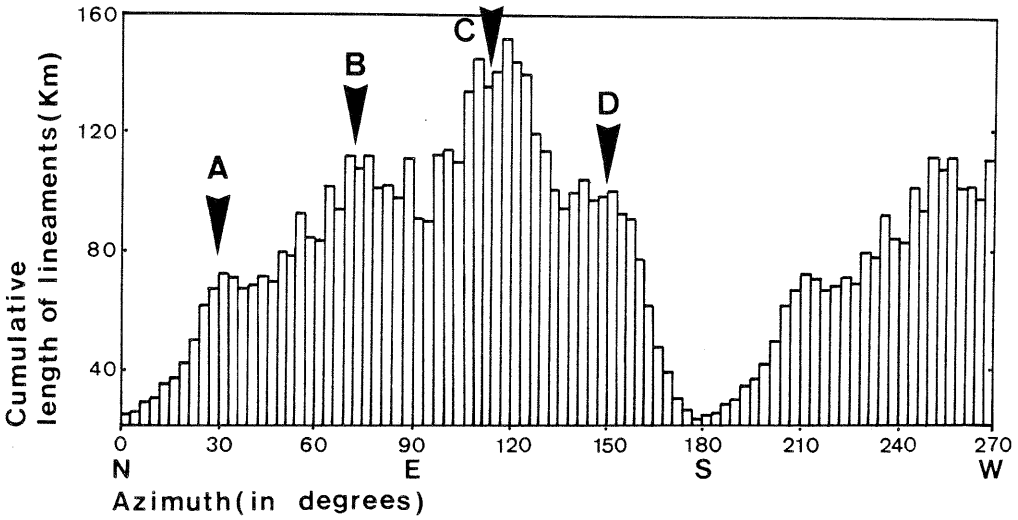


Figure 3. An N15°W structural trend revealed by LANDSAT-1 imagery (redrawn from Wang, 1974).

transforms and becomes the uplifting forces of the Yushan and Hsiu-ku-luan-shan. Evenmore, the curvature of topography/structure in this area is concave to the west. As a result of these two opposite directions of curvatures, the shear zone are formed northwest-southeastly in the middle area.

(4a)



(4b)

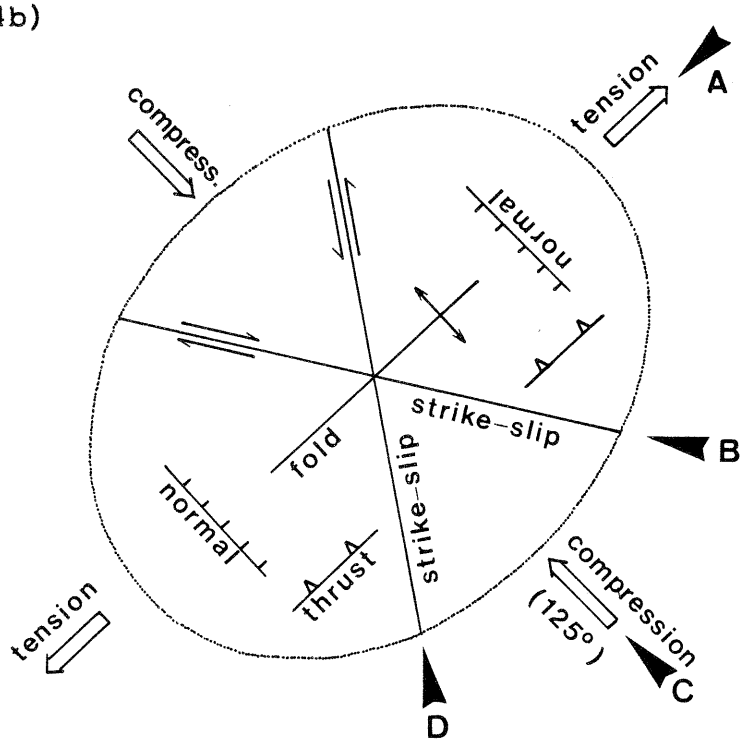


Figure 4. Four major trends of lineaments are revealed by Taiwan SLAR images. They are N29°E(=029°), N72°E(=072°), N66°W(=114°), and N31°W(=149°), (4a). These composite of lineament trends can be explained by the strain model which is caused mainly by a horizontally compressional stress from 125 degrees in azimuth (4b).

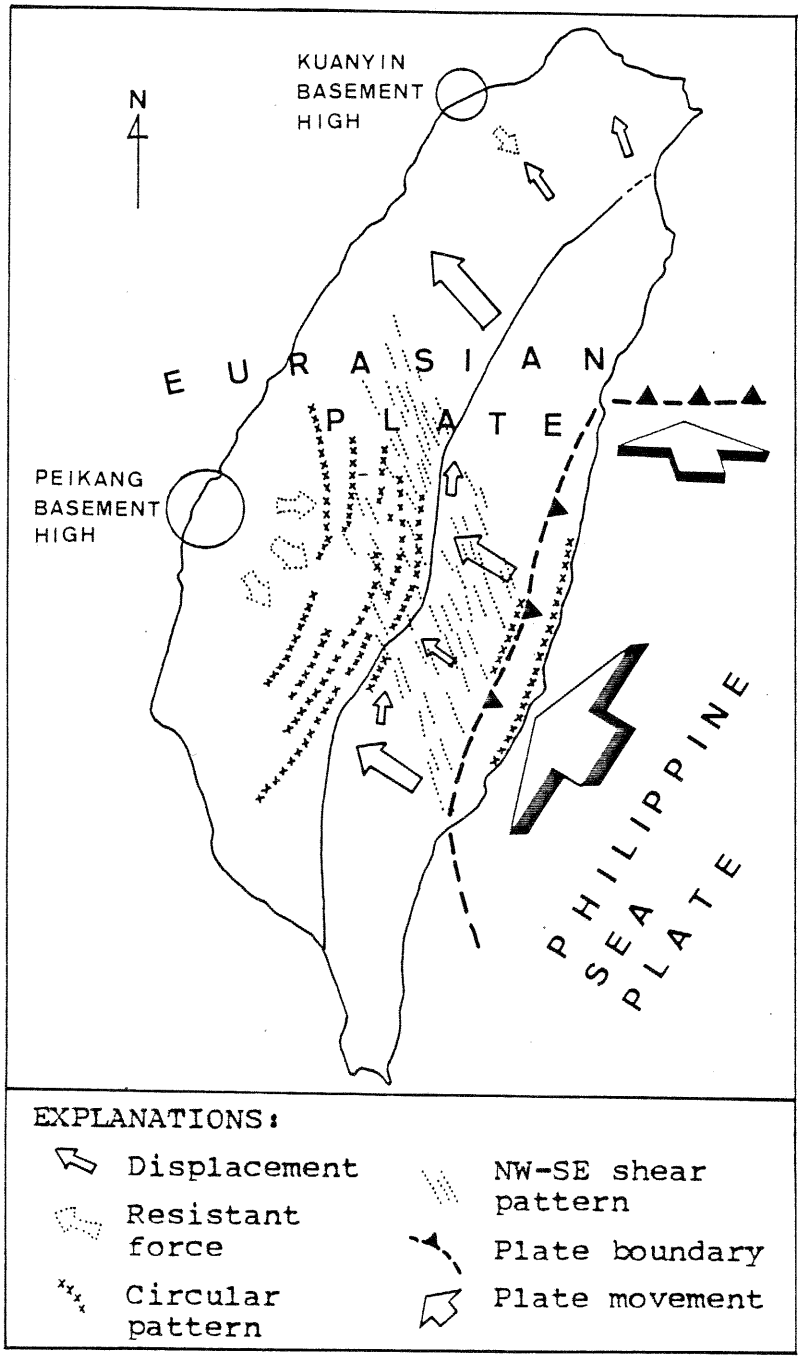


Figure 5. Schematic diagram showing the relations between the circular and the NW-SE shear patterns, the stress and displacement, and the Peikang and Kuanyin Basement Highs.

CONCLUSION

Many authors have emphasized that the linear or circular features observed on small-scale remote sensing images are tectonically significant. However, the genesis of these two newly-discovered tectonic patterns mentioned in this paper has not been clarified so far. Further study is worthwhile and suggested.

REFERENCES CITED

1. AGI (1972) Glossary of Geology, p.408: American Geological Institute.
2. Chiu, H.T. (1971) Folds in the Northern Half of Western Taiwan: Petroleum Geology of Taiwan, No.8, p.7-19.
3. Chou, J.T. (1972) A Sedimentologic and Paleographic Study of the Upper Cenozoic Clastic Sequences in Chiayi Region, Western Taiwan: Petroleum Geology of Taiwan, No.10, p.141-158.
4. Hobbs, W.H. (1904) Lineaments of the Atlantic Border Region: Geol. Soc. American Bull., V.15, p.483-506.
5. Hobbs, W.H. (1912) Earth Features and their Meaning: New York, Macmillian Co., 506 p.
6. Liu, J.K., and W.J. Yuan (1982) Lineament Analysis of Taiwan SLAR Imagery: Mining Technology, V.20, p.95-106.
7. O'Leary, D.W., J.D. Friedman and H.A. Pohn (1976) Lineament, linear, lineation: Some proposed new standards for old terms: Geol. Soc. American Bull., V.87, p.1463-1469.
8. Poroshin, S.V. (1981) Ring Structures Based on Interpreting Satellite Photographs: International Geological Review, V.23, No.12, p.1373-1378.
9. Seno, T. (1977) The Instantaneous Rotation Vector of the Philippine Sea Plate relative to the Eurasian Plate: Tectonophisics, No.42, p.209-226.
10. Tang, C.H. (1977) Late Miocene Erosional Unconformity on the Subsurface Peikang High Beneath the Chiayi-Yunlin Coastal Plain, Taiwan: Memoir of the Geological Society of China, No.2, p.155-167.
11. Trofimov, D.M. (1981) Interpretation of the Linear-domal Tectonics of the East European Platform (first-order structures, Based on Satellite Photographs): International Geological Review, V.23, No.12, p.1367-1372.
12. Wang, S. (1974) Structural Trend Revealed by ERTS-1 Imagery in Southern Taiwan: Mining Technology, V.12, No.2, p.26-27.

SOMMAIRE

Deux réseaux tectoniques trouvés récemment dans la région de Taiwan, suite à l'étude d'image de SLAR (Echelle: 1/250,000) et LANDSAT (Echelle: 1/1,000,000). Ils répresentent le réseau circulaire autour du Socle Haut de Pei-kang et la NW-SE zone de cisaillement traversant la partie au milieu de Taiwan. La courbure de ce réseau est concave vers l'ouest, divergeant de la tendance générale de topographie et de la structures insulaire de Taiwan. La zone NW-SE de cisaillement traverse obliquement la partie au milieu de Taiwan avec ses bordures nord de N20°W et bordure sud de N15°W et un large moyen de 50 km.

Le modele d'ellipsoide des deformations resulté d'alignement de SLAR, revéle que ces deux résaux decouvérts récemment sont formés peut-être par l'interaction de la force resistant du Nord-Ouest de rotation dans le sens des aiguilles d'une montre de la plaque de la Mer des Philippines relative a la Plaque Eurasienne.

ZUSAMMENFASSUNG

Wir haben einige neve geologische Strukturen im Taiwan Gebiet gefunden, die wir von dem SLAR Bild (der Maβstab: 1/250,000) und dem LANDSAT Bild (der Maβstab: 1/1,000,000) studiert haben. Die Strukturen schlieβen ein Kreisförmiges Muster ein, das den Peikang Kellergeschoβ Hügel umgebet, das im mittle-Westlichen Taiwan liegt. Auβerdem haben wir ein NW-SE scherförmig Muster, das durch den mittliches Taiwan lauft, gefunden. Wir können vom Model des Verförmungsellipses, das vom Gesichtszug im Bild untersucht hat, verstehen, daβ die Strukturen von der Vermittlung des Peikang Kellergeschoβ Hugels und der Spannung, die vom der Philippine Plate relativ mit der Eurasian Plate bewegt, gemacht haben.