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On the Interrelation Between Seismisity and Fault Structures Identified by Space Image Interpretation

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Recent years are remarkable with the abundance of aerospace information in the field of geological and geomorphological research. Many papers together with the acquired observational experience confirm the understanding that a space picture could contribute to reveal some features of the deep earth crust structure. Some of the authors consider possible to determine series of buried structures from the platform fundament, as well as fault structures uplifting to Konradt and Mochorovichich surfaces [1, 6-8, and many others]. Multiple deep crust structure elements are usually determined upon others of a smaller scale, which relates to the large picture generalization of the Earth as a whole, or of separate sectors from it. This paper compares seismicity and fault structures identified by space image interpretation in scale 1:1,000,000. Most suitable for the purpose proved to be the Upper Tracian lowland and the Tundja hilly region, both known as highly seismically active regions in the Southern parts of Bulgaria [3, 5].

The American space photographs (ERTS-1) were used for that interpretation and their resolution is 90-100 m. The pictures are taken at 900 km height on Nov. 17, 1972. Images with wavelengths of 0.6 — 0.7 μm and of 0.8-1.1 μm, i. e. in the orange-red and near infrared range of the electromagnetic spectrum are most valuable for the interpretation. These pictures were published earlier [2, 9], that is why here we shall give only the scheme of interpreting the above-mentioned seismic regions.

The Maritsa seismic region overlaps with the Upper Tracian depression. This is the largest complex graben structure in the Southern part of Bulgaria, 160 km long, oriented in West-Eastern direction and up to 45 km wide from North to South. The Upper Tracian depression is a typical intermontaneous depression, formed between the intensively uplifting Rhodopean Massif and the Sredna Gora range. It is filled with upper Paleogenic and Neogene-Quaternary deposits. The Upper Paleogene is characterized by Preabone and Oligocene sediments and volcanic rocks up to 3,000 m thick. These are mainly conglomerates, sandstones, argillites, limestones, andesite tuffs and andesites. During the Neogene and Quaternary epochs, the depression considerably reduced in size, as three additional structures developed within that format — the Plovdiv graben, the Chirpan threshold and the Zagora graben. The thickness of the younger deposits is over 300 m. The separation from the Upper Tracian crust block by adjacent morphostructures with clearly outlined fault ruptures and

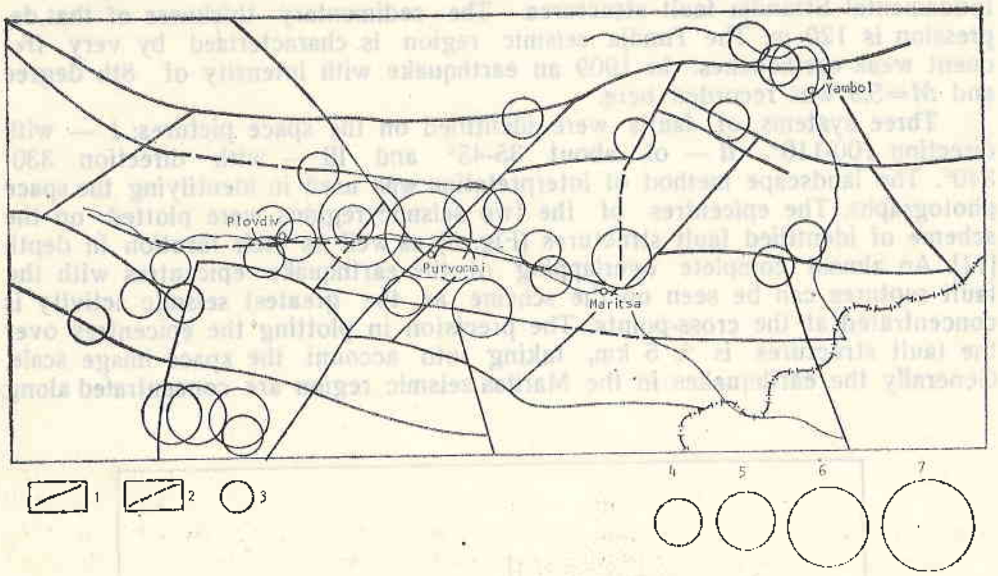

Fig. 1. Interrelations between faults identified by space pictures and earthquake epicentres in the Maritsa and Tundja seismic zones
1 — faults reliably identified by the space images; 2 — suggested faults; 3 — earthquake epicentres with M 3; 4-7 — earthquake magnitudes: 4 — M = 4. 1-5; 5 — M = 5. 1-6; 6 — M = 6.1-7; 7 — M>7

the formation of smaller block structures over that background shows the complex block structuring of the whole depression. Greater portion of these ruptures is fixed on the space pictures and is shown in the tectonic scheme. These fault structures are specific accumulative areas of significant seismic energy, which at certain periods could be released and results in earthquakes of large intensity and magnitude (Fig. 1).

The Upper Tracian depression is one of the most seismically active regions of Bulgaria. Based on historical data, we can trace there earthquakes with intensity of 9th degree in 1750 and of 7th degree in 1859. Three consequent shocks followed in 1928— on April 14— with intensity of 9th degree and magnitude M=6.8; on April 18 — with intensity of 9th degree and M=7.0 and on April 25— with intensity of 8th degree and M = 5.6. Figure 2 shows the resultant faults from the earthquake in 1928. Two faults were structured after the shock on April 14 with M=6.8— Northern with 39 km of length which starts from Cherna Gora village (Plovdiv district) and continues eastward up to Chirpan and Southern, which overlaps with Maritsa river bed. It starts from Purvomay and reaches Dimitrovgrad eastward. Other faults were ruptured during the second shock on April 18 with M=7.0. The main fault is located at 10 km westward from Purvomay and follows to North-Western direction. The total length of the faults resulting from the two shocks is up to 105 km. The largest depression locates northward from the line Chalakovo village (Plovdiv district) — Purvomay at about 3 m and southward that line we trace an uplift to 0.4 m [10]. Some of the faults structured after the earthquake in 1928 were identified on the space pictures as in certain areas they overlap completely with the actual structures (Fig. 2).

The Tundja seismic region which comprises the hilly area between Yambol and Elhovo along the Tundja river is a part of the Elhovo depression, the latter being a young Neogene-Quaternary structure, formed transversely to the fundamental Strandja fault structures. The sedimentary thickness of that depression is 120 m. The Tundja seismic region is characterized by very frequent weak earthquakes. In 1909 an earthquake with intensity of 8th degree and $M=5.9$ was recorded here.

Three systems of faults were identified on the space pictures: I — with direction 100-110°, II — of about 35-45° and III — with direction 330-340°. The landscape method of interpretation was used in identifying the space photographs. The epicentres of the two seismic regions were plotted on the scheme of identified fault structures (Fig. 3) as well as their location in depth [11]. An almost complete overlapping of the earthquake epicentres with the fault ruptures can be seen on the scheme as the greatest seismic activity is concentrated at the cross-points. The precision in plotting the epicentres over the fault structures is ± 5 km, taking into account the space image scale. Generally the earthquakes in the Maritsa seismic region are concentrated along

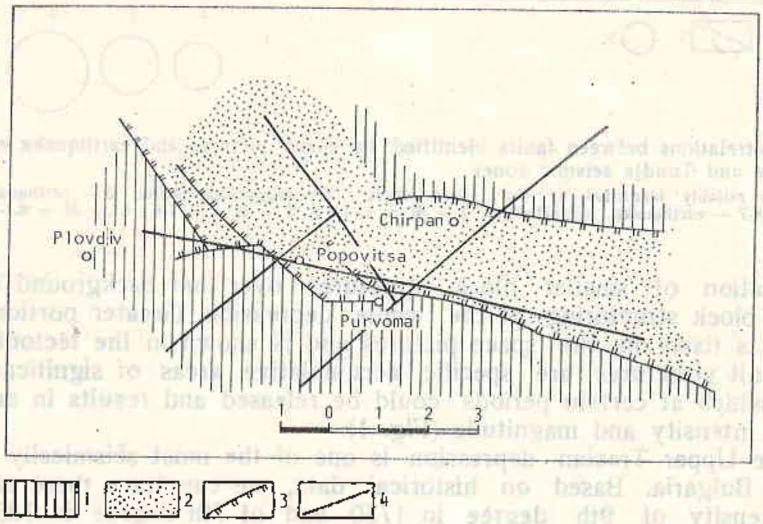

Fig. 2. Scheme of a part of the Maritsa seismic region between Plovdiv and Purvomay

1 — the sunk part of the Thracian lowland after the earthquake in April 1928 (more than 3 m); 2 — the uplifted part of the lowland after the earthquake with 0.4 m; 3 — faults identified on the space pictures; 4 — actual faults formed during the earthquake in 1928

the Maritsa river flow between Pazardjik and Purvomay at a distance of 100 km and 40 km width. In the other seismic region they are concentrated along the Tundja river flow between Yambol and Elhovo and about the Monastery uplifts. The vertical profile of the same scheme plots the earthquakes by amplitude. It can be seen that the earthquake epicentres are mostly at the depths of Konradt boundary or in the granite layer of the earth crust. Only few of them reach the Mocho boundary. The thickness of the earth crust in the two seismic regions varies between 35 and 42 km. The greatest thickness of the earth crust is within the limits of the Chirpan treshold. At the same time, this earth crust block is seismically most active.

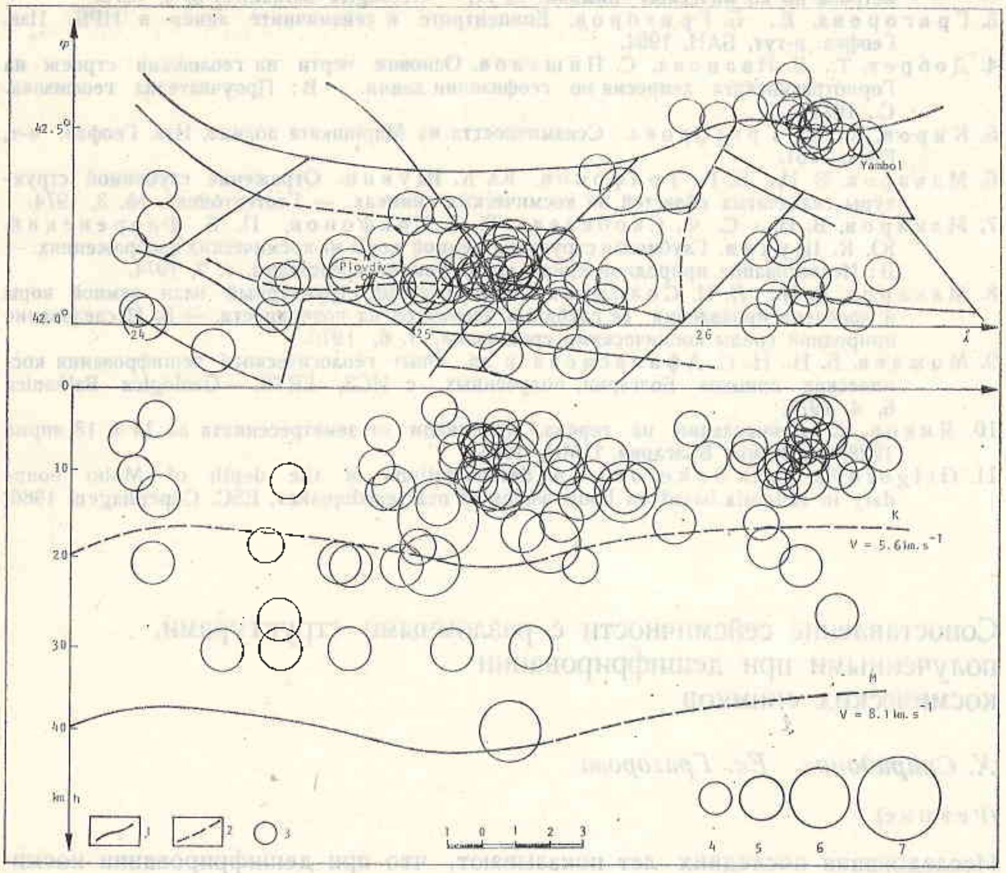

Fig. 3. Scheme of the identified fault structures and the earthquake epicentres, the focal depth being also given

Above: 1 — faults reliably identified on the space pictures; 2 — assumed faults; 3 — earthquake epicentres with $M > 3$; Below: 4 — $3 \leq M \leq 4$; 5 — $4.1 \leq M \leq 5$; 6 — $5.1 \leq M \leq 6$; 7 — $6.1 \leq M \leq 7$

The complex inner block-fault structuring of the Upper Thracian complex depression which is confirmed by the geophysical investigation [4] is reflected in the earth surface relief. This relief is mainly observed on the space pictures. Therefore, the summing effect from the tectonic movements of the earth crust, including the deep layers, would be reflected "enlightened" in the relief. The overlap of the fault structures identified from the space photographs with the epicentres of the earthquakes in the Maritsa and Tundja seismic regions shows that reliable information on the deep earth crust structure could be obtained. In our case, this information goes as far as the Mochorovichich boundary.

References

1. Ананин, И. В., В. Г. Трифонов. Сопоставление сейсмичности с элементами дешифрирования космических изображений.— В: Исследование природной среды космическими средствами, т. 5. М., 1976.
2. Гочев, П. Новые данные о разломной тектонике Болгарии и части Балканского полуострова по космическим снимкам, ЕРТС — Geologica Balkanica, 6, 4, 1976.
3. Григорова, Е., Б. Григоров. Епицентрите и сеизмичните линии в НРБ. Изв. Геофиз. и-тут, БАН, 1964.
4. Добрев, Т., В. Иванова, С. Пищалов. Основни черти на геоложкия строеж на Горнотракийската депресия по геофизични данни. — В: Проучвателна геофизика. С., 1972.
5. Киров, К., Е. Григорова. Сеизмичността на Мариниката долина, Изв. Геофиз. и-т, БАН, 1961.
6. Макаров. В. И., В. Г., Трифонов, Ю. К. Щукин. Отражение глубинной структуры складчатых областей на космических снимках. — Геотектоника, №, 3, 1974.
7. Макаров, В. И., С. Ф. Скобелев, В. Г. Трифонов, П. В. Флоренский. Ю. К. Щукин. Глубинная структура земной коры на космических изображениях. -- В: Исследование природной среды космическими средствами, т. 2, 1974.
8. Макаров, В. И., Л. И. Соловьева. Перекрастный структурный план земной коры и проблема проявления ее глубиных элементов на поверхности. — В: Исследование природной среды космическими средствами, т. 6, 1976.
9. Можаев, Б. Н., Н. С. Афанасиева и др. Опыт геологического дешифрования космических снимков Болгарии, полученных с ИСЗ, ERTS. -- Geologica Balkanica 6, 4, 1976.
10. Янков, К. Денивелации на терена, причинени от земетресенията на 14 и 18 април 1928 г. в Южна България, ЦМИ, 1945.
11. Grigorova, E., D. Sokerova. A determination of the depth of Moho boundary in Bulgaria based on body waves of near earthquakes. ESC. Copenhagen, 1966.

Сопоставление сейсмичности с разломными структурами, полученными при дешифрировании космических снимков

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(Резюме)

Исследования последних лет показывают, что при дешифрировании космических снимков вполне возможно вскрыть элементы глубинного строения земной коры. Для исследования этой возможности были дешифрированы космические снимки, и полученные разломы были сопоставлены с эпицентрами землетрясений в Верхнефракийской низменности и в Тунджанской холмистой области, известных как сильно сейсмические районы Южной Болгарии. Результаты сопоставления показывают, что разломные структуры, выявленные на космических изображениях, отражают глубинное строение земной коры до границы Мохоровичича.