

Recent stress deformation in disjunctive zones on the base of remote sensing data

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Scientific Centre for Aerospace Research of the Earth, IGS,
National Academy of Sciences of Ukraine, Kiev, Ukraine

azimov@casre.kiev.ua

It is identified that by their formation mechanisms the known and forecasted fracture dislocations at a recent stage of their geotectonic development manifest themselves mainly as the zones of stretching. The disjunctive structures of this type are always well decoded on different-scale remote sensing data (RSD) of any region of study. Their geoindicators are characteristic of zones of increased fluid-geological permeability.

Let's consider a territory of the Chernobyl Exclusion Zone and an adjacent region of the Korosten pluton. For its landscape-geological conditions the geoindication constituents of fractures are represented usually by the negative relief forms, super-humid sites with developed species of hygrophilous vegetation, elongated lines of anomalous phototone change to darker hues, etc. At once for mentioned region as an example (specifically for the Tovstyi Lis site within its borders) we classified the basic landscape geoindicators of the discriminating geodynamic fields at the recent tectogenesis stage. The fields are related to the Earth's crust disjunctive structures. Peculiarities of the fields' reflection in the RSD are characterised too [Azimov, 2008; 2009].

During investigation first of all it was taken as a base the framework of a tectonic structure of the studied area (Fig. 1, 2) chosen in the course of the regional research stage [Azimov, 2001; 2002; 2003]. It was worked out in detail within the Tovstyi Lis site and its adjacent areas [Azimov, 2004; 2006; Geo-

logical ..., 2006]. For example, determination of the rectilinear known and forecasted structural elements of disjunction character (or structural lines, lineaments) on the remote images of high space resolution and topographic materials was performed with using a set of criteria (geoindicators): boundaries of sites with a different degree of the relief dissection and dynamics of erosion processes; rectified boundary segments of hypsometric benches, gradient steps of the relief, river valleys, banks of small lakes and swamps, erosion network, troughs, grooves, gullies, water divides, bent water courses and valleys, linearly elongated chains of suffusion depressions, mikrodepressions, erosion-denudation bodies, sandy ranges, as well as boundaries of the Quaternary deposit complexes and their lithofacies, sections with specific facies of hygrophilous vegetation, elongated lines of anomalous variations of image phototone, etc.

A location scheme for the lineament structures obtained by decoding show high lineaments density, for this reason direct identification of the fracture dislocations is difficult. For finding regularities of the lineaments distribution, their typification was done according to their manifestation indicators at remote images or the site, their relation with geological objects and inter-correlation between each other, elongation, width, etc. Usually zones of decoded lineaments appear to be wider than zones of fractures revealed by geological-geophysical methods. The latter ones are located in the middle of linea-

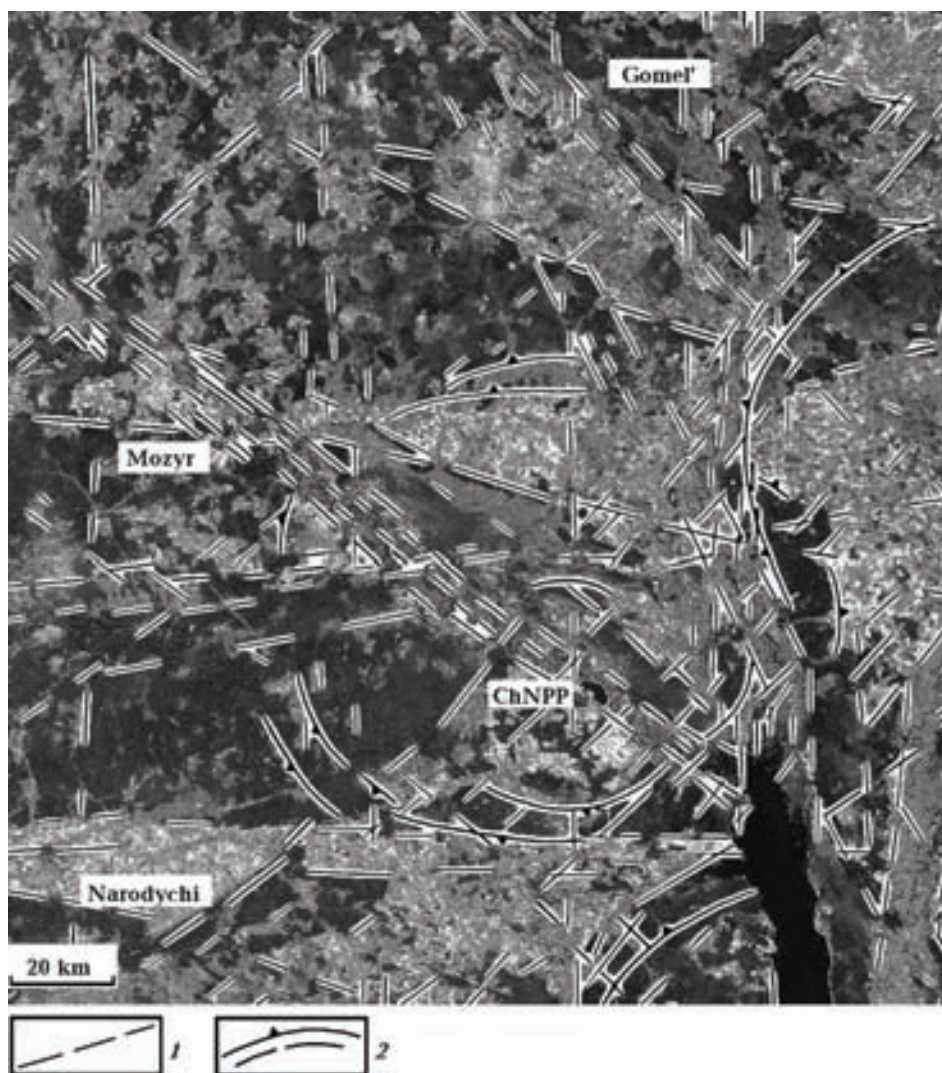


Fig. 1. General synthesized multiband space image LANDSAT MSS (07.09.1977) on the ChNPP Exclusion Zone territory and adjacent regions with elements of the regional structural decoding: 1 — lineaments and their zones depicting the fault-block frame of the crystalline basement and sedimentary cover, 2 — contours of ring-type and arc-type landscape elements conditioned of the presence of deep lithosphere structures.

ment zones. This gave possibility to refine the areas of anomalous geodynamic influence of fractures activated at the recent stage of the Earth's crust evolution.

In the course of direct study of the general structure of an elementary lineament field within studied the Tovsty Lis site it was found that differently oriented separate elementary structural lines are grouped in lineaments and their zones, saturating and depicting their internal construction. They are grouped into regularly built systems of definite directions, mainly diagonal with prevailing azimuths from 40 to 50° (north-eastern), and 310° (north-western), and orthogonal ones directed with azimuth $0 \pm 5^\circ$ (submeridional), and $270^\circ \pm 5^\circ$ (sublatitudinal). These

systems control each other by stretch and size. Practically each of them finds its orthogonal system, forming with it a dynamic pair, and one system from this pair prevails in its development. Within boundaries of the definite site the structural lines of definite direction dominate (Fig. 3). Linear elements correspond well by their directions to the main fracture systems of Ukraine revealed by different methods [Chebanenko, 1977]. The latter ones during the platform stage had been developing in correlation, forming the entire dynamic system of co-subordinated stably coupled fractures of diagonal and orthogonal orientations.

The above data enable to conclude that the majority of lineaments and their zones decoded from

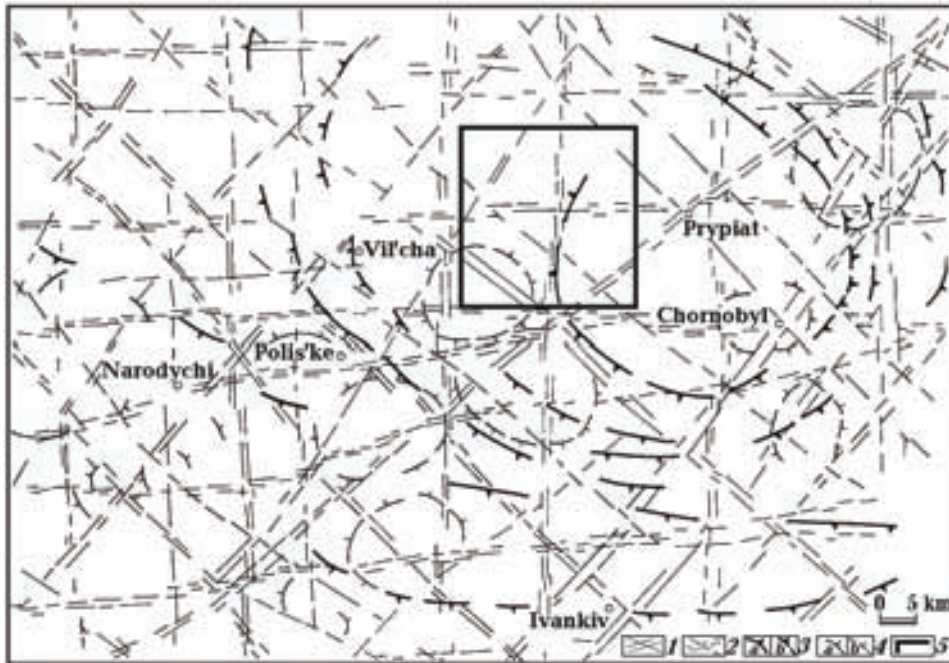


Fig. 2. Scheme of lineaments and ring-type structures of the Chornobyl NPP Exclusion Zone and adjacent region of the Korostensky crystalline massif (on the basis of the results of remote sensing data decoding): 1, 2 — lineaments and their zones depicting the fault-block frame of the crystalline basement and sedimentary cover (1 — confidently recognized, 2 — indefinitely recognized); 3 — contours of ring-type and arc-type landscape elements decoded on space images of high generalization level, depicting probably structures related with the under-crust magmatism (a — confidently recognized, b — indefinitely recognized); 4 — curvilinear landscape elements decoded on middle- and large-scale space images, depicting blocks of the crystalline basement activated at the recent tectogenesis stage (a — confidently recognized, b — indefinitely recognized); 5 — contour of the Tovstyi Lis site of detailed investigation.

the RSD come along the axes of discharge of stress-deformed rock state, that indicate a presence of the local disjunctive fractures or components of break structures of various lower-rank morphogenetic types developed in the Earth's crust within studied area. They represent the boundaries of main block fields within which the localization of anomalous geodynamic stresses takes place.

In the course of interpreting the neo- and recent geodynamical situation the known facts were taken into account [Chebanenko, 1977; Pavlinov, 1977; Geodynamic ..., 1989] stating that during the tensile deformations the fractures are formed followed by faults, separations, rifts, combined shift-faults, and during the compressing stress deformations — by uplifts, joints, thrusts and coverings with combined forms of shift-uplifts and shift-thrusts.

Linear contraction zones within the Tovstyi Lis site are of significantly scarcer occurrence, or their distinguishing by aerospace decoding materials is difficult (see Fig. 3). This is obvious. Structures of this type are indicated mainly by additional relief forms, such as: rectified sections of water divides, erosion-denudation bodies, sandy ranges, etc.,

which are often distinguished in the aerosurvey data by the anomalous (lighter) image phototone. Sometimes fractures change their characteristic along their stretching direction from strain to contraction zones, that is evident from the interaction of stresses and location of axes of regional and local stresses in each particular tectonic block formed by the disjunction system.

According to morphological assessments, the majority of fracture deformations studied in more detail are represented in plane by typical shift faults (proper shifts and transformed fractures) related with horizontal movements of rock masses. This follows from the analysis of an internal structure of zones represented by bands of shingling longitudinal separate chips, and their spatial relation. The latter is most prominently seen in the regions of intersection nodes of these dislocations.

At the Tovstyi Lis site right shears prevail (except for zones 4—4, 5—5, 7—7, the south-eastern part of zone 6—6 and the submeridional zone without number located to south-east from Tovstyi Lis village). Some elongated shear dislocations in their stretch direction change their movement sign to the

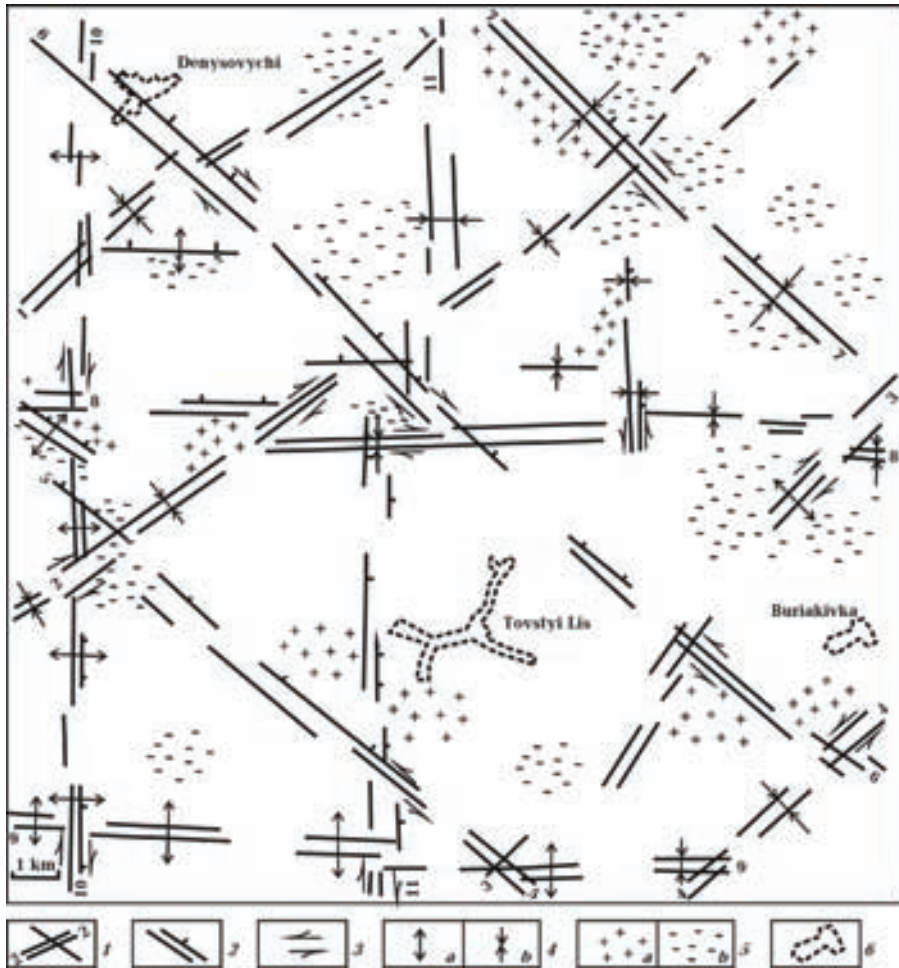


Fig. 3. Scheme of the fault-block structure of the Tovstyi Lis site with elements of the recent geodynamics (via results of remote sensing data decoding): 1 — lineaments and their zones depicting the fault-block framework of the crystalline basement and sedimentary cover; 2 — forecasted direction of descending of the disjunctive structures area; 3 — sections of revealed and forecasted fractures with the clearly distinguished shift component; 4 — forecasted linear zones of stretching (a) and contraction (b); 5 — local areas of stress (a) and strain (b) deformation development; 6 — settlement borders.

opposite (from left to right and vice versa). This is caused also by changing the active direction of shear stresses.

Hence, based on the tectonic-physical interpretation of available aerospace image decoding materials and geological-geophysical survey data, within the studied area the regularities of a systematic hierarchy of the fault-blocked structures are revealed. More detailed analysis of the distribution of different-directed deformations at the studied site enable to separate the local areas of predominant development of the strain and compression stresses which concentrate around the nodes of intersection of paragenetically related diagonal and orthogonal fractures (see Fig. 3).

Characteristic landscape elements of the local blocks areas subjected to compression forces are

the positive relief forms (mainly water divides), increasing of the part of sandy litho-facies, etc. Characteristic for the areas of dominating development of the strain deformations are the negative relief forms manifesting in swamped areas, small lakes, reservoirs, homogeneously distributed microdepressions, suffusion forms, etc., determined by runoff-less character of surface waters. On the aerospace images they can be identified by presence of characteristic soil-geobotanic features manifesting themselves mainly by anomalous (darker) image phototone, as compared to neighboring areas.

Thus, considered aspects of RSD using are evidence of the high geologic informativity of aerospace survey materials. Methodological techniques of RSD using can be employed efficiently for solving a whole number of the interiorusing problems.

References

- Azimov O. T.* Complex geological aerospace investigation of the Chornobyl estrangement zone and the adjacent Korosten' pluton region in the search for deep deposition of radioactive waste // *Space Science and Technology*. — 2002. — 8, № 2/3. — P. 134—142 (in Ukrainian).
- Azimov O. T.* Investigation of the tectonic features of the Korostensky crystalline massif region and the ChNPP Exclusion Zone on the base of aero- and space images decoding with the purpose of promising sites selection for the RAW deep disposal // *Sci. collection, Nat. Acad. of Mines of Ukraine*. — 1, № 12. — Dnepropetrovsk, 2001. — P. 284—289 (in Ukrainian).
- Azimov O. T.* Landscape geoindicators of the fractures' descriptions as the foundation of their investigation via remote sensing methods. 2. Geodynamic features of the disjunctive structures // *Geoinformatics*. — 2009. — № 2. — P. 71—79 (in Ukrainian).
- Azimov O. T.* Practical results of using the automated systems for remote sensing data processing during specification the block structure of the ChNPP Exclusion Zone territory (with connection of the problem of the radioactive waste disposal within its borders in deep boreholes) // *Sci. collection, Ukrainian State Inst. for Geological Prosp.* — Kiev, 2003. — № 1. — P. 78—86 (in Ukrainian).
- Azimov O. T.* Research of disjunctive dislocations in the Earth's crust with remote sensing methods (by the examples of some Ukraine's regions): Thesis in speciality 04.00.01 — General and Regional Geology // *Inst. of Geological Sci., NAS of Ukraine*. — Kiev, 2008. — 485 p. (in Ukrainian).
- Azimov O. T.* Results of the structural and geodynamic decoding of remote sensing data in connection with the problem of grounds most promising for the radioactive waste isolation // *Intern. Conf. "Twenty Years after Chernobyl Accident. Future Outlook"*, (Kiev, Ukraine, April 24—26, 2006). — Kiev: Innovation Publ. Centre "HOLTEH", 2006. — P. 221—225.
- Azimov O. T.* The block structure scheme of the Tovsty Lis site (the Korosten pluton) with elements of the modern dynamics by the results of decoding of remote sensing data // *Rep. of the Nat. Acad. Sci. of Ukraine*. — 2004. — № 10. — P. 114—119 (in Ukrainian).
- Chebanenko I. I.* Theoretical aspects of the Earth's crust tectonic divisibility (Ukraine as an example). — Kiev: Nauk. dumka, 1977. — 84 p. (in Russian).
- Geodynamic reconstructions: (Methodical supply for regional geological investigation) / Ed. V. A. Unksov.* — Leningrad: Nedra, 1989. — 278 p. (in Russian).
- Geological disposal of radioactive waste in Ukraine (Problems and solutions) / Ed. V. M. Shestopalov* — Kiev: Radioecol. Center, Nat. Acad. Sci. of Ukraine, 2006. — 398 p. (in Russian).
- Pavlinov V. N.* Deep landslides and disjunctive structures paragenically connected with them. Article 1 // *Proc. of Inst. of Higher Education. Geology and Prospecting*. — 1977. — № 8. — P. 3—14 (in Russian).