

SPECIAL-PURPOSE MAPPING OF BURIED STRUCTURAL UNCONFORMITIES IN A BASEMENT AND SEDIMENTARY COVER

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ABSTRACT:

This paper deals with results of interpretation which, covering northwestern area of the East-European plain, has been based on a nontraditional technique. As a result of thus handling remote sensing data, particular information has been acquired as to structural pattern of geological formations in a Preriphean basement with a depth interval of 0.1 km to 9.0 km, as well as about the basement's tectonics and those geodynamic processes which the sedimentary cover overlying the Preriphean basement has been subject to.

1. INTRODUCTION

Within a period since 1966 up to 2001 Sevzapgeologia State Geological Enterprise has been working on a quite new and nontraditional technique of remote sensing data interpretation, just in order to meet additional requirements in respect to covered territories. Using such interpretation technique one can construct geological, structural and geodynamic sketch maps of structural stages' planes (scouring) within a depth interval of 0.1 km to 10 km, and even deeper. Definition of rock composition is based, for the most part, upon textural and structural patterns of buried bodies which, as seen on photos, show themselves through the cover in the form of symbols that reproduce these patterns.

2. CASE STUDIES

Major goal of interpretation of remote sensing data covering northwestern area of the East-European plain (EEP) within the confines of EEP-Baltic Shield conjunction zone consisted in producing sketch maps showing geological formations of the Preriphean basement, its tectonic framework, and geodynamic processes in a sedimentary rock complex. As it follows from the information thus obtained, three components, differing in terms of composition of rock complexes, constitute the area in question, namely (1) metamorphic formations, in particular - three varieties of gneiss (according to succession in which they have formed and their textural-structural features), and crystalline schist (2) intrusive and volcanogenic formations: ultrabasic rocks in tension zones, gabbroids, dikes, endogenic dikes including, volcanites that vary in composition and make up depression slopes, and (3) dynamometamorphism zones made up of cataclastic rocks, tectonites with slide marks, filling extended fault zones, as well as fusion and torsion tectonites. A conventionally accepted model reproducing succession in which they had formed has been constructed.

As long as tectonics is concerned (Figure 1), established was the fact that in the said area the major portion of the Preriphean basement's plane betrays that large structural forms striking NE, NW, in meridional and latitudinal directions. Meridional section (lake Vozhe projection) of the territory over a larger portion of its plan view is cut into one western and one eastern megablock,

these two contrasting in intensity of tectonic processes. In the western active megablock an arcuate structural zone was outlined as the one that had undergone incessant process of activation. What is more, Sevzapgeologia SGE was the first to detect and plot here six flat troughs ranging in size from 55 x 45 km to 115 x 150 km.

These troughs could be compared with volcano-tectonic depressions regarded as promising in terms of mineral deposits. Further southwards off them, in the adjacent Tver province, nearby the town of Tver, mapped was a classical specimen of a large spiral structure with a downslope movement. Its total area amounts to 10,000 sq. km, and it seems most likely that the structure originated in upper layers of the basement under the influence of one-sided mechanical movements. The eastern megablock has become consolidated and steady in regard to the western megablock, and a limited amount of intrusive formations has injected its body. Along its meridional sections the megablock is divided into three small-scale blocks, and along the boundaries thereof displacements, varying in amplitude, took place while these blocks had been forming. Such movements are reckoned to be as large as 100 km. Once the eastern megablock had become dissected along meridionally oriented faults, it never underwent more or less intense tectonic movements since then. Latitudinal block structure is 15-60 km wide and it extends from the western periphery of the investigated area to the eastern one for more than 1,100 km. It is known to run, either definitely or less surely, across all structural zones, and it features unsteady tectonic setting.

Evidences of tectonic activity are shown on a sketch map of geodynamic processes in sedimentary rocks (Figure 2). Within the confines of the whole area under research faults were detected and classified according to injection fillers.

The sketch map of geodynamic processes illustrates those movements that affected all sedimentary strata varying in overall thickness from 0.1 km to 9.0 km. The following conclusion was drawn from comparing (a) tectonic sketch map of Preriphean basement, (b) additional structural and tectonic sketch maps of two levels of scouring surfaces in sedimentary strata, and (c) sketch map of Cenozoic processes. The latitudinal block structure and arcuate structural zone proved to be active objects. Other geodynamic events occurred, and indeed are

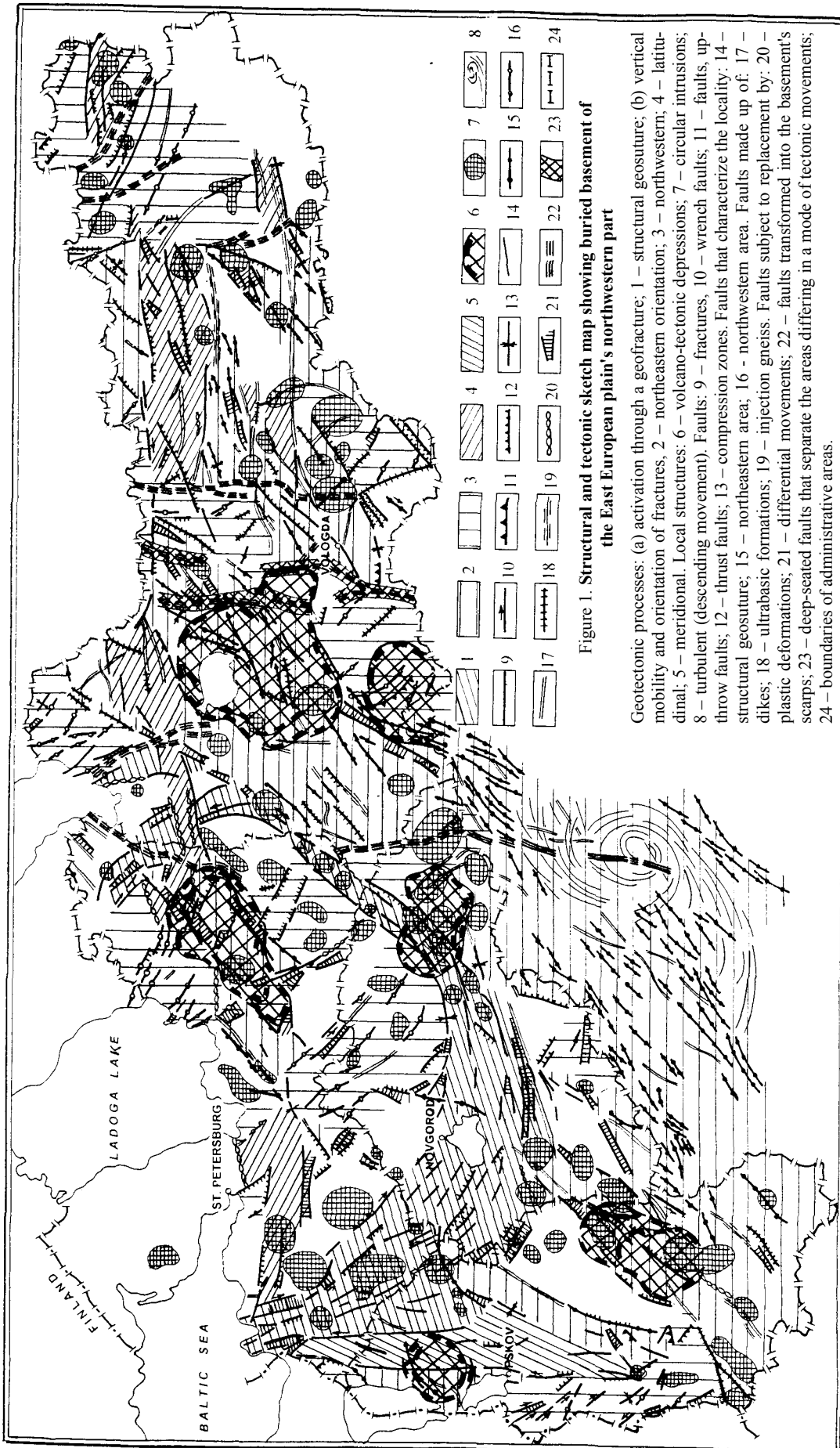


Figure 1. Structural and tectonic sketch map showing buried basement of the East European plain's northwestern part

Geotectonic processes: (a) activation through a geofracture; 1 - structural geosuture; (b) vertical mobility and orientation of fractures, 2 - northeastern orientation; 3 - northwestern; 4 - latitudinal; 5 - meridional. Local structures: 6 - volcano-tectonic depressions; 7 - circular intrusions; 8 - turbulent (descending movement). Faults: 9 - fractures, 10 - wrench faults; 11 - faults, up-throw faults; 12 - thrust faults; 13 - compression zones. Faults that characterize the locality: 14 - structural geosuture; 15 - northeastern area; 16 - northwestern area. Faults made up of: 17 - dikes; 18 - ultrabasic formations; 19 - injection gneiss. Faults subject to replacement by: 20 - plastic deformations; 21 - differential movements; 22 - faults transformed into the basement's scarps; 23 - deep-seated faults that separate the areas differing in a mode of tectonic movements; 24 - boundaries of administrative areas.

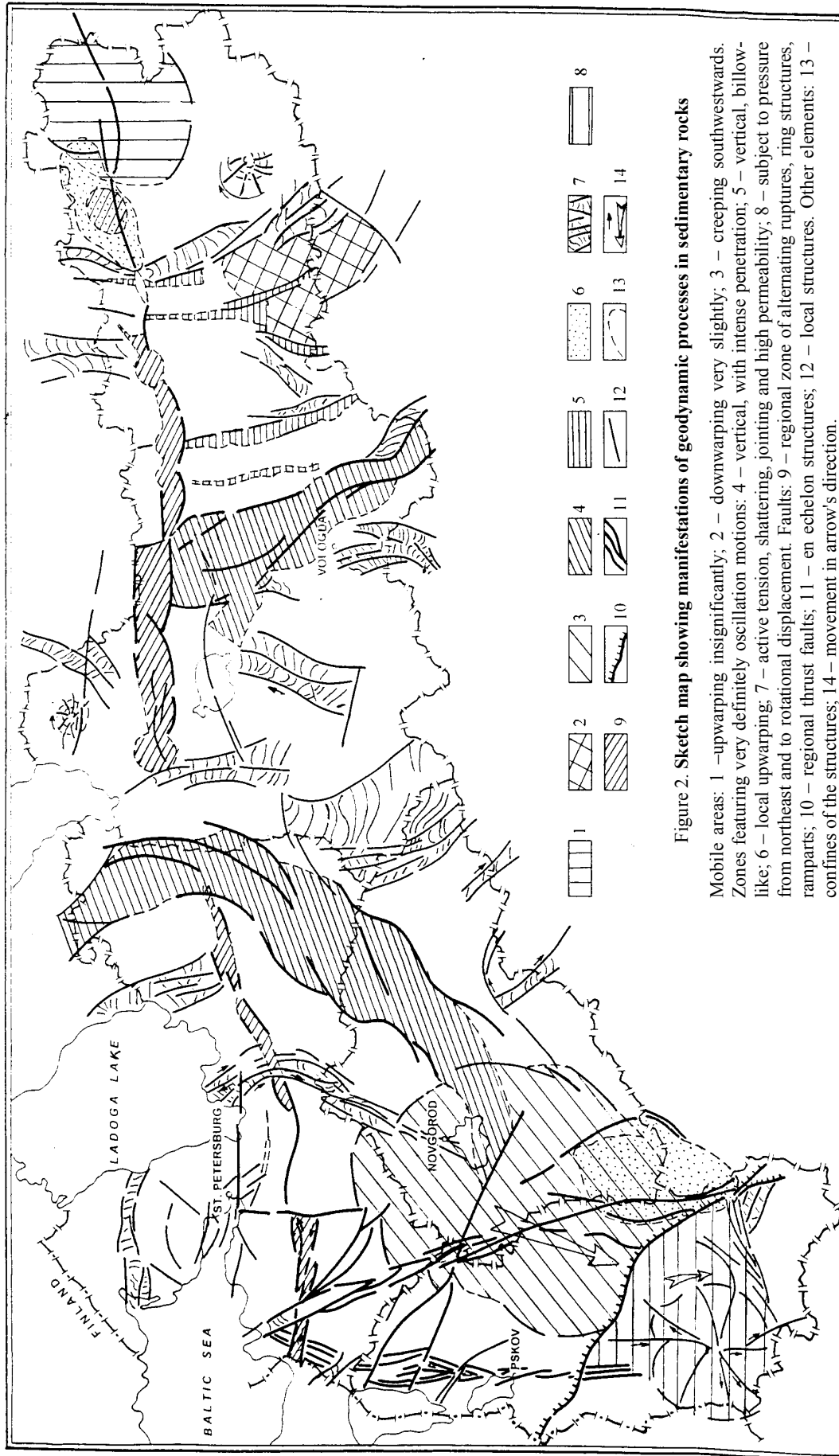


Figure 2. Sketch map showing manifestations of geodynamic processes in sedimentary rocks

Mobile areas: 1 -upwarping insignificantly; 2 - downwarping very slightly; 3 - creeping southwestwards. Zones featuring very definitely oscillation motions: 4 - vertical, with intense penetration; 5 - vertical, billow-like; 6 - local upwarping; 7 - active tension, shattering, jointing and high permeability; 8 - subject to pressure from northeast and to rotational displacement. Faults: 9 - regional zone of alternating ruptures, ring structures, ramparts; 10 - regional thrust faults; 11 - en echelon structures; 12 - local structures. Other elements: 13 - confines of the structures; 14 - movement in arrow's direction.

actually recorded, in sedimentary rock series only. The latitudinal block structure, which is plainly mature in the Preriphean basement, runs further into sedimentary formations, while in Cenozoic it is plotted as a strip, up to 40 km in width, made up of a combination of proportional ring structures, ramparts and faults. Such block structures can reasonably be referred to the areas which caused a whole series of mineral deposits to originate, for in such areas there is a mixture of practically all deposit-growing initiative elements, or constructions, which have formed not at the same time and not under the same conditions. There, in particular, are high-angle fractures that could be nothing but filtration channelways or feeders, as well as dikes, ring structures and many other forms of elements and events which provoke ore-forming processes in connection with physical and mechanical properties of country rocks at certain horizons. The arcuate structural zone, well preserved in crystalline formations of the sedimentary strata, has developed and matured along the fault, and its eastern portion corresponds to the said zone's geometry in the basement and still displays signs of vertical mobility and permeability. The zone's western part is remarkable for en echelon faults.

Other geodynamic processes are plotted as taking place in sedimentary strata, and their origin is probably related with the basement's topography. Thus, billow-like warping of sedimentary layers occurred within a gap between regional step faults running parallel to each other. Zones of intense tension and jointing, as well as shatter zones and permeable zones (all of

them being so common in Cenozoic rock complexes) are forming and developing over the tilted segments of the Preriphean basement's surface. Additional maps of two scouring levels within the formations and in the cover enabled the following elements to be reconstructed therein: fault-line uplifts and flexural folds, plicated and ring structures, grabens, regional block-forming faults and fault zones. As an exception, the western active megablock features widespread shatter zones, tectonically weak zones of different rank and genesis, as well as mobile zones and compression zones.

3. CONCLUSIONS

It may be thus concluded that the nontraditional interpretation technique, while it requires minimum of costs, labour and time, enables the problems of deep geological mapping to be effectively solved, and on the other hand it reasonably cuts down the areas to be covered by geophysical and geochemical exploration and drilling. Again, such technique gives power to check and maintain geodynamic and ecological safety when developing mineral resources. By applying this technique, the territories can be allocated and classified in terms of safeness, zones exposed to danger can be outlined, industrial averages and emergency state of environment with ruinous ecological aftereffects can be precluded.