Deep structure and geodynamics of the Kirovograd ore district (Ukranian Shield): correlation of geological and seismic data

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The central part of the Ukrainian shield, where the Kirovograd ore district is located, has been the subject of prolonged investigation of the Institute of Geophysics in cooperation with another research Institutions. Around 20 years ago, A. V. Chekunov et al. (1989) proposed a geodynamic model of this territory, derived from geophysical and geological data. The model is illustrated by the geotraverse VIII Odessa — Krivoy Rog, which intersects the Kirovograd (now Ingulets) lithospheric block and adjacent protogeosynclines (Fig. 1). The Kirovograd block is distinguished from them in seismic velocities in crust and at the Moho discontinuity and in thickness of the crust (35—38 km against 54—58 km). The block is cut by steep faults and gentle tectonic zones which extend into upper mantle. The suggested model explained these phenomena by the continuous development of a mantle plume or a protoasthenolite, which originated at the beginning of Early Proterozoic, influenced the deposition of the ingulo-ingulets series and caused the emplacement of granites, anorthosites and rapakivi granites in crust at the mature stage.

The current study of deep structure of the Kirovograd ore district [Starostenko et al., 2010], is based on the correlation of geological and seismic data, using modern technologies, and accounts for new isotopic dating [Shcherbak et al., 2008]. The study proceeds from a broad interpretation of space boundaries of the Kirovograd polymetal ore district and the incorporation of uranium, lithium, gold and titanium deposits in these boundaries (Fig. 2).

The study indicates that in the Kirovograd ore district, the Paleoproterozoic magmatism started after deposition of the ingulo-ingulets series and developed in two short-lived (30—40 Ma) stages. During the first stage (2.06—2.02 Ga), the crustal Novoukrainsk-Kirovograd granitoid massif formed. During the second stage (1.75—1.72 Ga), the mantle-derived Korsun'-Novomirgorod rapakivi-anorthosite massif originated. In conjunction, they constitute the Novoukrainsk-Korsun'-Novomirgorod pluton which defines the surface structural pattern of the ore district.

Lithium, uranium and gold deposits are located in the Novoukrainsk-Kirovograd granitoid massif and the connected Kirovograd and Zvenigorod fault zones [Bakarzhiev et al., 2005]. Lithium deposits are close in age (2.0 Ga) to the Novoukrainsk-Kirovograd massif and associated with local granite-migmatite domes. Uranium deposits are dated at 1.8 Ga, overprinted on the massif and controlled by its rejuvenated structural elements. Gold deposit's age is unclear. In combination, the deposits outline a wide

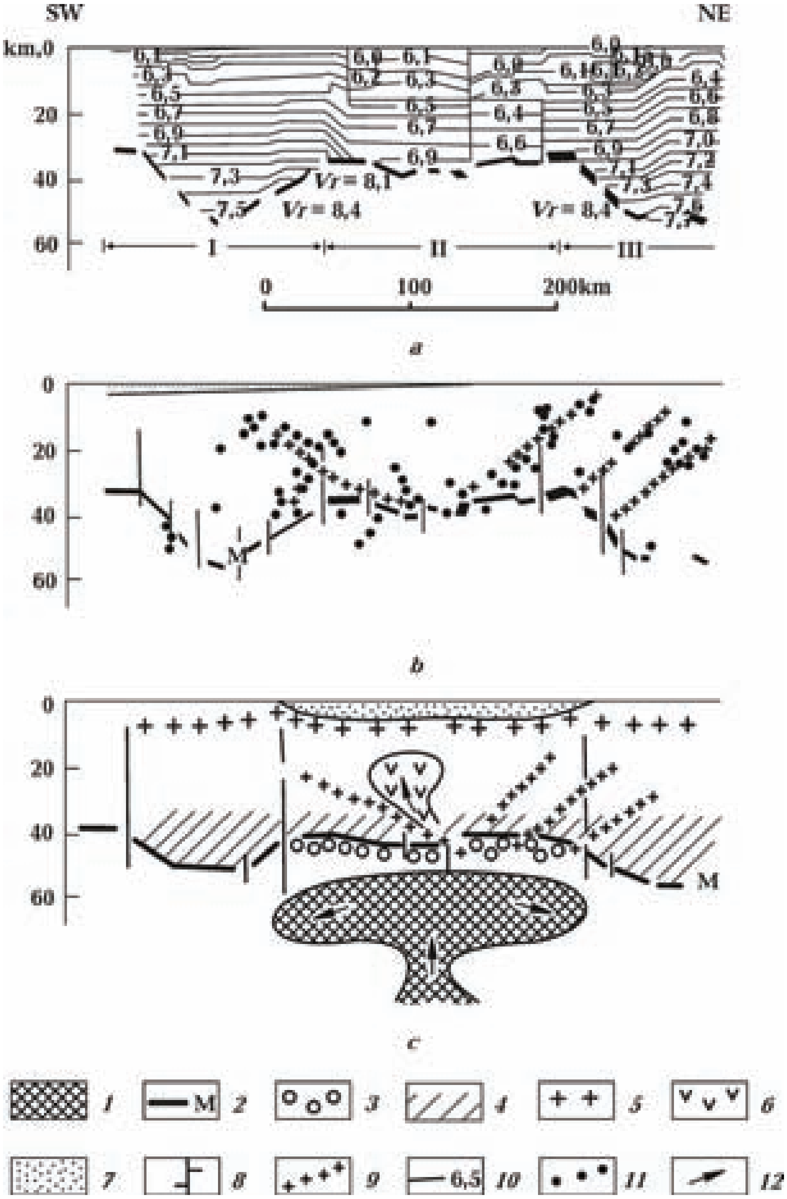

Fig. 1. Deep structure of the Kirovograd lithospheric block along the geotraverse VIII (modified after Chekunov et al., 1989): *a* — velocity section, *b* — seismic section, *c* — geodynamic section *(1* — protoasthenolite; *2* — Moho discontinuity; *3* — zone of the matter transformation at the crust-mantle boundary; *4* — basaltic layer; *5* — crystalline basement; *6* — mantle-derived magmatic rocks in crust; *7* — sediments; *8* — faults; *9* — gentle thrusts; *10* — seismic velocities (km/s); *11* — diffraction points; *12* — direction of the matter transfer); I — Odessa-Yadlov protogeosyncline; II — Kirovograd lithospheric block; III — Krivoy Rog protogeosyncline.

(30—35 km) longitudinal band going in parallel to the Subbotin-Moshorin fault zone and across the Novoukrainsk-Korsun'-Novomirgorod pluton. It was previously assumed that within the latitudinal band, the uranium deposits and host rocks had been subsided by east-west faults that preserved them from erosion [Genetic …, 1995]. Nowadays the band is related to a deep sublatitudinal trough in the Moho discontinuity relief (Fig. 3). The discovery is the first to establish the spatial association of Paleoproterozoic hydrothermal ore deposits with a middle-scale anomaly of the crust-mantle boundary [Starostenko et al., 2007].

The Korsun'-Novomirgorod rapakivi-anorthosite massif is devoid of Li, U, Au deposits and contains titanium mineralization of magmatic origin. Where-

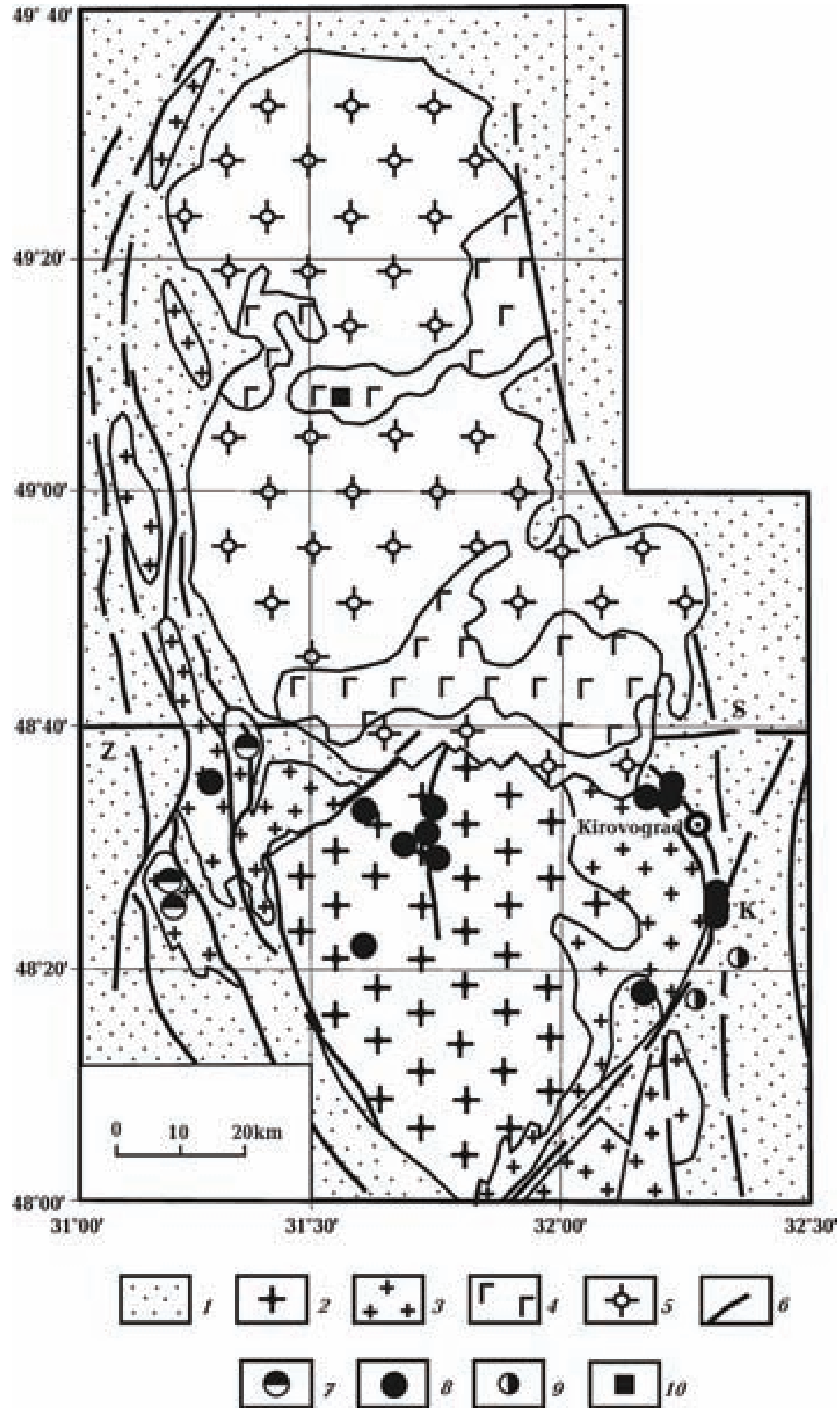

Fig. 2. Geological map of the Kirovograd polymetal ore district (modified after Starostenko et al., 2010): *1* — stratified ingulo-ingulets series; *2*, *3* — Novoukrainsk-Kirovograd massif (*2* — diorite-monzonite complex, *3* — granite-migmatite complex); *4*, *5* — Korsun'-Novomirgorod massif (*4* — gabbro-anorthosites, *5* — rapakivi granites); *6* — faults; *7*—*10* — ore deposits (*7* — lithium, *8* — uranium, *9* — gold, *10* — titanium). Fault zones: K — Kirovograd, S — Subbotin-Moshorin, Z — Zvenigorod.

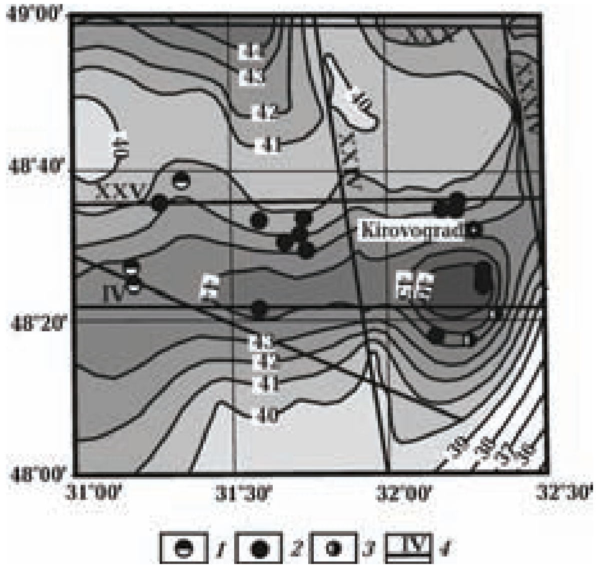

Fig. 3. Projection of ore deposits on the Moho discontinuity relief (depth isolines in km): *1—3* — ore deposits (*1* — lithium, *2* — uranium, *3* — gold); *4* — DSS profiles.

as the Novoukrainsk-Kirovograd massif and the ingulo-ingulets series build up an intrusive-ultrametamorphic basement of the district, the autonomous Korsun'-Novomirgorod massif is inserted in the basement. By seismic methods, the first is traced to a depth of 15—20 km, the second to a depth of 40—50 km, that is below the Moho boundary (Fig. 4). Against this background seismic anomalies are interrupted over and below the mantle trough. It should be emphasized that this seismic "gap" extends from the surface into the upper mantle.

The above-listed geological, age and seismic data suggests that the Kirovograd ore district developed under three different geodynamic environments (Fig. 5). The first was marked by the formation of the Novoukrainsk-Kirovograd granitoid massif as a constituent of the intrusive-ultrametamorphic basement, the second resulted in the tectonic activization of the basement, the third was dominated by the emplacement of the Korsun'-Nowomirgorod rapakivi-anorthosite massif. Taking into consideration a unique combination of tectonic structures, intrusive rocks, deposits and geodynamic environments, we regard the Kirovograd ore district as a Paleoproterozoic center of intense conjugated mantle-crust magmatism and endogenous ore formation.

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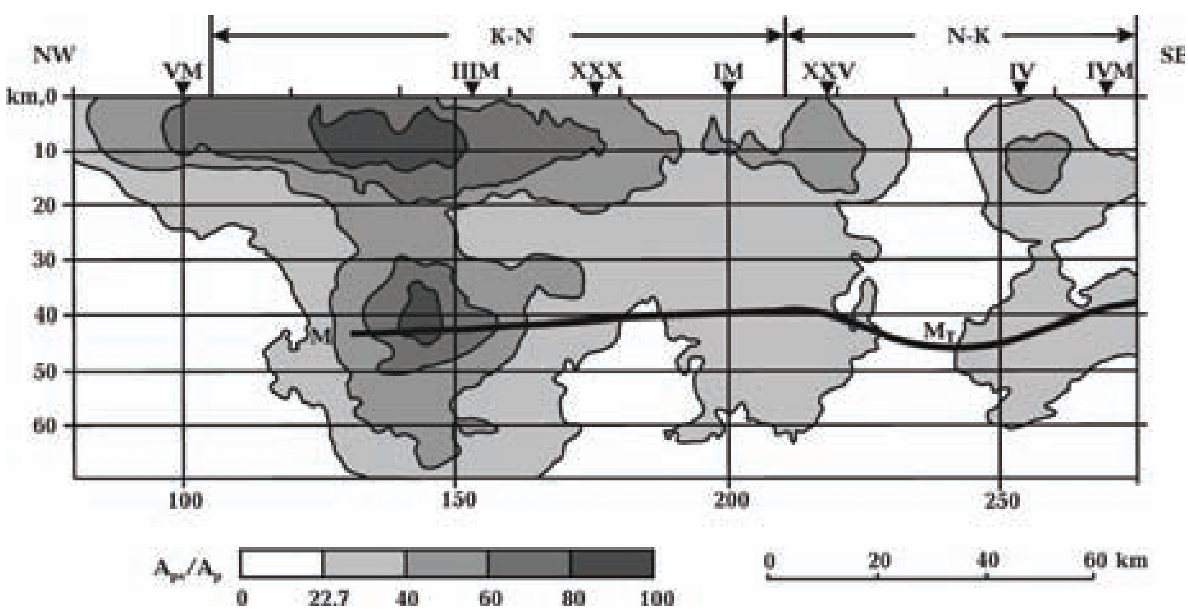

Fig. 4. Convertability of environment by MCWE data along vertical section of the Novoukrainsk-Korsun'-Novomirgorod pluton. A_{PS}/A_P — ratio of the converted wave amplitude to same of *P*-wave generates by former one. K-N — Korsun'-Novomirgorod rapakivi-anorthosite massif; N-K — Novoukrainsk-Kirovograd massif; M — M discontinuity; M_T — mantle trench. VM, IIIM, IVM — intersection points by deep sections along MCWE profiles; XXX, XXV, IV — intersection points by deep sections along DSS profiles.

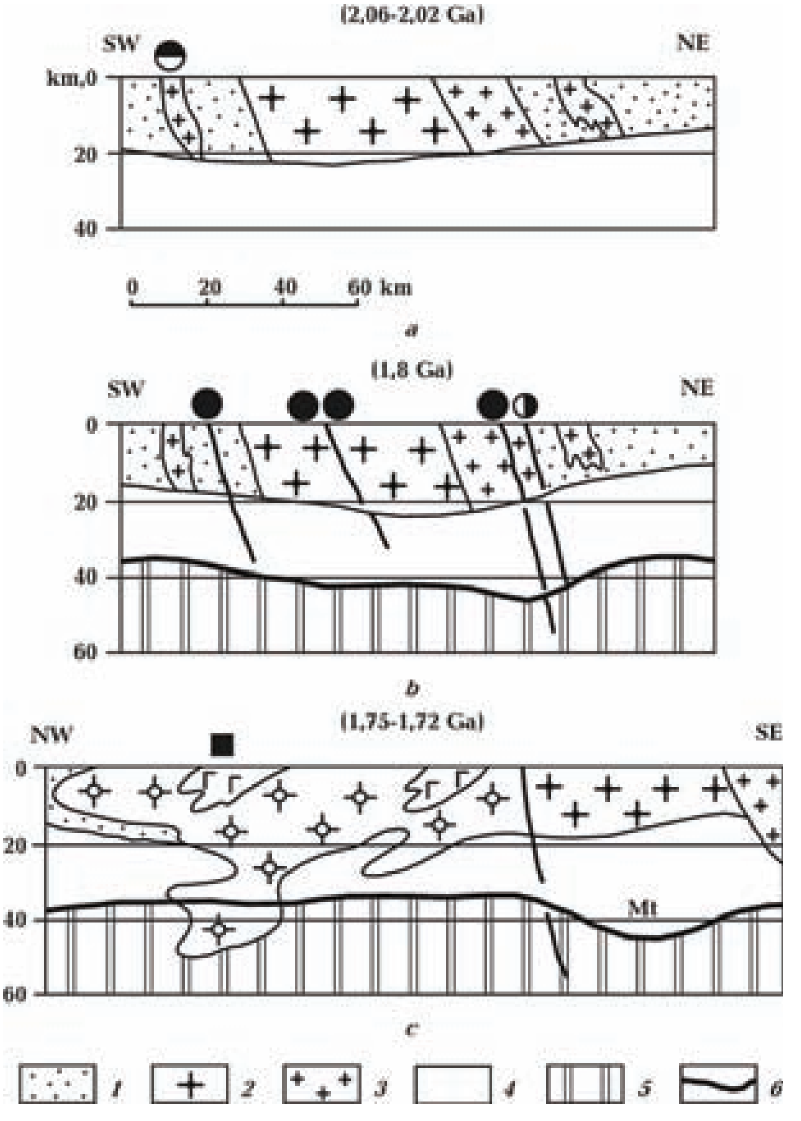

Fig. 5. Geodynamic and metallogenic evolution of the Kirovograd ore district: *a* — formation of the intrusive-ultrametamorphic basement and lithium deposits; *b* — tectonic activization of the basements and metasomatic uranium ore formation; *c* — emplacement of mantle-derived anorthosites and rapakivi granites accompanied by titanium mineralization. Figure captions: *1—3* — intrusive-ultrametamorphic basement (*1* — stratified ingulo-ingulets series; *2* — diorite-monzonite complex; *3* — granite-migmatite complex); *4* — middle-low crust; *5* — upper mantle; *6* — Moho boundary; Mt — mantle trough. For other captions see Fig. 2.

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