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2014

Anastasova, E., M. Tarassov, E. Tarassova. 2014. Alteration of zircon from Igralishte granite pluton, southwestern Bulgaria: preliminary investigation. – In: *Bul. Shk. Gjeol. 1–Special Issue. Proceedings of XX CBGA Congress*. Tirana, Albania, General Session G04.

At least four types of alteration were identified for zircon from the Igralishte granite pluton (~243 Ma), Ograzhden Mountain: (i) dissolution and replacement by other minerals (apatite, K-feldspar, allanite, quartz); (ii) recrystallization; (iii) metamictization; (iv) chemical alteration of radiation-damaged parts of the crystal accompanied by depletion in Si and Zr and enrichment in U, Th, Y, Ca, Al, and Fe. It is suggested that the processes (i) and (ii) are caused by high-temperature postamagmatic potassium and sodium metasomatism, while the process (iv) is induced by later tectonic and hydrothermal overprint (~36 Ma) related to Paleogene volcanism in the region.

Baziotis, I., E. Mposkos, P. Asimow. 2014. Continental rift and oceanic protoliths of mafic-ultramafic rocks from the Kechros Complex, NE Rhodope (Greece): implications from petrography, major and trace-element systematics, and MELTS modeling. – *Int. J. Earth Sci*.; DOI: 10.1007/s00531-014-1007-8

The whole-rock chemistry of eclogites, partially amphibolitized eclogites, and dyke amphibolites from the metamorphic Kechros Complex in the Eastern Rhodope Mountains preserves evidence of the geodynamic framework for the origin of their protoliths. Major and trace-element concentrations define two distinct protolith groups for the eclogites. The low Fe-Ti (LFT) eclogites have low-TiO_2 content (<0.67 wt%), negative high field strength element anomalies, and variable enrichments in LILE. The REE patterns are characterized by strong LREE enrichment and HREE depletion. The high Fe-Ti (HFT) eclogites have small to moderate LILE enrichment and lack Nb anomalies. The REE patterns of the HFT eclogites are characterized by LREE depletion and relatively flat MREE-HREE patterns. The rock compositions and petrographic features of the LFT eclogites resemble gabbros formed in a continental rift environment with minor to moderate contamination of a mantle-derived mafic magma by continental crust, whereas the HFT eclogites resemble mafic rocks formed in extensional oceanic environments. We interpret the HFT suite to represent a later stage in an evolution from continental rift to open ocean, following the origin of the LFT suite. Dyke amphibolite compositions, except for probable SiO_2 loss associated with metamorphic dehydration reactions, appear to represent liquid compositions quenched in conduits through the lower crust. MELTS modeling shows that dyke amphibolite compositions can be related to each other by fractional crystallization under strongly oxidizing conditions at ~0.5 GPa pressure, and all can be derived from a low-degree melt of modified fertile peridotite from around 1.7 GPa. Cumulates crystallized from the parental liquids of the amphibolites under oxidizing conditions may have yielded the protoliths of the HFT suite.

González-Jiménez, J. M., M. Locmelis, E. Belousova, W. L. Griffin, F. Gervilla, Th. Kerestedjian, S.-Y. O'Reilly, N. J. Pearson, I. Sergeeva. 2014. Genesis and tectonic implications of podiform chromitites in the metamorphosed ultramafic massif of Dobromirtsi (Bulgaria). – *Gondwana Research*; DOI: 10.1016/j.gr.2013.09.020

Podiform chromitites occur in the meta-dunite horizon of the Dobromirtsi ultramafic massif, in the Central Rhodope metamorphic core complex (Southern Bulgaria). Although these were deformed and metamorphosed together with their host rocks several chromite cores from massive chromitite samples still preserve compositions unaffected by metamorphism at least in terms of major elements. In situ laser ablation ICP-MS analyses of these chromite cores show a bimodality in the composition of chromite between high-Cr and high-Al {Cr# = [Cr/(Cr+Al)], atomic ratio 0.74–0.55) with Mg# between 0.69 and 0.60 [Mg# = Mg/(Mg+Fe^{2+}), atomic ratio]. These compositions of chromite and the whole rock enrichment of Os-Ir-Ru relative to Pt-Pd in the chromitites resemble that reported for podiform chromitites in ophiolites elsewhere. Magmatic platinum-group minerals (PGM), including laurite (RuS_2), Os-Ir alloys and sulfarsenides (irarsite, IrAsS), exhibit a wide range of Os^{187}/Os^{188} (from 0.1097 to 0.1272) whereas Re^{187}/Os^{188} is nearly zero. The distribution of the Os model ages calculated for these PGM ranges between 0.13 and 2.6 Ga, with age peaks at 0.25, 0.4, 0.7, 2.1 and 2.6 Ga. Two xenocrystic zircons were identified in the chromitites and yield concordant U-Pb age of 2257±80 Ma (2 σ) and 1952±82 Ma (2 σ). The oldest zircon exhibits a depleted-mantle Hf model age (T-DM) of 2.77 Ga and a "crustal" Hf model age (T-DM).

Hikov, A. 2014. REE mobility during advanced argillic alteration in some epithermal and porphyry copper systems from Central Srednogorie, Bulgaria. – In: *Bul. Shk. Gjeol. 1–Special Issue. Proceedings of XX CBGA Congress*. Tirana, Albania, Special Session SS9.

REE distribution and behaviour during hydrothermal alteration in 3 deposits is presented. REE are relatively inert during propylitization and become partly mobile with increasing of alteration degree in intermediate argillic and sericitic types. In advanced argillic alteration MREE and HREE are strongly depleted while LREE are immobile. LREE are concentrated in the new-forming minerals – alunite, APS minerals and clay

minerals. The mobility of REE is controlled mainly by pH, the concentration of complexing ions (SO_4^{2-}, Cl^-, F^-) in the hydrothermal fluids and the presence of appropriate minerals which host them in their structures.

Metodiev, L., E. Koleva-Rekalova, D. Ivanova, D. Dochev, S. Velev, I. Dimitrov. 2014. Middle Jurassic fossil and depositional record from the area of the Zimevitsa Plateau (West Balkan Mountains), West Bulgaria. – In: *Bul. Shk. Gjeol. 1–Special Issue. Proceedings of XX CBGA Congress*. Tirana, Albania, General Session G02, 65–68; DOI: 10.13140/2.1.1245.4083

The Zimevitsa Plateau is the highest elevated area of the Ponor Planina Mt., westwards the Iskar River Gorge (West Balkan Mts., West Bulgaria). It is a prominent outlier that is composed of thick Jurassic–Lower Cretaceous rocks. It comprises several prominent Late Alpine disharmonic folds with NW-SE structural arrangement (Moskovski, 2001), which are developed on Bathonian–Berriasian hemipelagic and pelagic rocks, following upon less deformed Aalenian–Bajocian offshore argillaceous sediments, and virtually unfolded shallow-marine terrigenous-carbonate Lower Jurassic rocks. In terms of its regional stratigraphy, the Middle Jurassic strata from this area are well-defined (e. g. Sapunov, Tchoumatchenco, 1995) and subdivided into four lithostratigraphic units, in ascending order: the Ozirovo, Etropole, Bov and Yavorets Formations. However, several recently revealed Middle Jurassic localities provided new biostratigraphic and lithological data. The account that follows is an extension of the Middle Jurassic stratigraphic scheme for this region, as giving details that has been unknown elsewhere in the West Balkan Mts. It includes the Aalenian to Lower Callovian fossil range data (mainly ammonites, belemnites and foraminifera), and allied sedimentary record, which have been obtained from the best exposed stratigraphic sections from the area of the Zimevitsa Plateau.

Petrova, S., D. Ivanova, N. Nikolov, E. Koleva-Rekalova, I. Lakova. 2014. Microfossil record and facies transitions of Oxfordian to Berriasian carbonates in the Western Srednogorie, Bulgaria. – In: *Bul. Shk. Gjeol. 1–Special Issue. Proceedings of XX CBGA Congress*. Tirana, Albania, General Session G02, 79–80.

The study area attracted the present authors' interest for the following reasons: complex relationships and fast facies transitions between Upper Jurassic and Berriasian carbonates of 3 distinct depositional settings (carbonate platform, pelagic basin and flysch trough); scarcity so far of abundant paleontological data on strata, except the Kimmeridgian; new results from the recent 1:50 000 geological mapping. This work presents the description of 5, Oxfordian to Berriasian carbonate sections, in the Western Srednogorie; the calpionellid, foraminiferal and calcareous dinocyst distribution and precise dating and facies transitions. Subject of this study are the Yavoters, Gintsi, Glozhene, Slivnitsa, Salash-Cherni Osam, and Cherni Osam Formations, their vertical and lateral passing, age determination, carbonate microfacies and evolution of the depositional environment.

Proyer, A., I. Baziotis, E. Mposkos. 2014. Ti- and Zr-minerals in calcite-dolomite marbles from the ultrahigh-pressure Kimi Complex, Rhodope Mountains, Greece: Implications for the P-T evolution based on reaction textures, petrogenetic grids, and geothermobarometry. – *Am. Mineral.*, *99*, 1429–1448; DOI: 10.2138/am.2014.4710

Rutile, titanite, and zircon formed as relatively coarse-grained accessory minerals in several samples of high-grade calcite-dolomite marble with an early ultrahigh-pressure history. These minerals decomposed to a texturally complex set of secondary minerals during subsequent stages of retrograde metamorphism. The reactions involve several generations of geikielite-ilmenite as well as zirconolite [(Ca,Th,U)Zr(Ti,Fe,Nb,Ta)(2)O-7], kassite/cafetite [$CaTi_2O_4(OH)(2)/CaTi_2O_5$ center dot H_2O], Ti-bearing humite group minerals, thorianite, and sometimes euxenite [(Ca,U,Th,REE)(Nb,Ta,Ti)(2)(O,OH)(6)]. Stable coexistence of zircon and olivine is observed and stably coexisting titanite with olivine and/or humite-group minerals is reported here for the first time outside of carbonatites, kimberlites, or lamprophyres. Petrogenetic grids constructed for Ti- and Zr-bearing olivine/antigorite-saturated calcite-dolomite marbles show that geikielite is stable at highest pressures, followed by titanite and rutile, and that baddeleyite+diopside replaces zircon+calcite to higher pressures. The observed reaction textures are consistent with an earlier derived P-T path for the Kimi Complex. They corroborate a period of heating during decompression from 25 to 20 kbar and ~800 °C, where the assemblage olivine-diopside-spinel-rutile-zircon formed. This assemblage partially re-equilibrated during subsequent decompression and cooling, thus forming the observed reaction textures. Even though no memory of the UHP path is preserved in the accessory minerals, their reaction relationships turn out to be potentially very useful for geothermobarometry over a large range of metamorphic conditions

Rozalen, M., M. E. Ramos, F. Gervilla, Th. Kerestedjian, F. J. Huertas. 2014. Dissolution study of tremolite and anthophyllite: pH effect on the reaction kinetics. – *Applied Geochemistry*, *49*, 46–56; DOI: 10.1016/j.apgeochem.2014.06.009

The effect of pH on the kinetics of tremolite and anthophyllite dissolution was investigated at 25 °C in batch reactors over the pH range of 1 to 13.5, in inorganic buffered solutions. Dissolution rates were obtained based on the release of Si and Mg. Results obtained in this study show different behaviors for both minerals. For tremolite, dissolution rates show a noticeable dependence on pH between 1 and 8, decreasing as pH increases and reaching a minimum around neutral conditions. At basic pH this dependence becomes even stronger, but dissolution takes place together with collateral effects of saturation and carbonation. A preferential release of Ca and Mg is observed in acid media, lowering the Mg/Si ratio to the extent that Mg solubility decreases with pH. For anthophyllite, dissolution rates also show a strong dependence on pH, between 1 and 9.5. At the same pH, anthophyllite dissolves up to 8 times faster than tremolite. For pH >9.5 this dependence is smooth, and it is probably associated with effects of saturation and carbonation. Dissolution is also non-stoichiometric with a faster release of Mg with respect to Si in acid media. SEM observations show differences in the breakage mechanism of the fibers. The antophyllite particle breakage during dissolution consists of the splitting of bundle fibers parallel to the fiber longitudinal direction. However, for tremolite, other than fiber splitting, particles shorten induced by coalescence of etch pits developed perpendicular to c axe.

Stefanova, E., T. Driesner, C. Heinrich, P. Petrov, Z. Vasilev. 2014. Melt and fluid inclusions in hydrothermal veins: The magmatic to hydrothermal evolution of the Elatsite porphyry Cu-Au deposit, Bulgaria. – *Econ. Geol.*, *109*, 1359–1381.

The magmatic to hydrothermal transition in the Upper Cretaceous Elatsite porphyry Cu-Au-(Mo-platinum group element) deposit has been studied in a suite of samples with clear timing relations between porphyry dikes, magmatic-hydrothermal veins, silicate melt inclusions in quartz veins, fluid inclusion generations, and ore minerals. Ore mineralization occurs late, at temperatures ~200 to 300 °C below those of the early, multistage interplay between magmatic and hydrothermal processes at near-magmatic temperature-pressure conditions.

Crosscutting relations and petrography indicate that shortly after the intrusion of the earliest, monzodioritic dikes, fluids precipitated a first generation of granular quartz veins accompanied by potassic alteration. The second vein generation with crystalline quartz textures and K-feldspar alteration halos formed at the same time as the second, granodioritic pulse of porphyry intrusions. Cathodoluminescence imaging of quartz growth textures reveals that the earliest fluid inclusions in the crystalline quartz veins are of intermediate density and ~8 wt% NaCl equiv salinity, probably trapped at near-lithostatic pressures of ~1200 to 1300 bars at near-magmatic temperatures (≤730 °C), and implies a depth of ~4 to 5 km. Depressurization led to phase separation, indicated by a first generation of coexisting brine and vapor inclusions trapped at temperatures of ≥640 °C and suprahydrostatic pressures of ≥920 bars. A second quartz generation in crystalline quartz veins precipitated during progressive depressurization and hosts assemblages of coexisting brine, vapor, and silicate melt inclusions, trapped at temperatures in excess of 600 °C and suprahydrostatic pressures of 630 to 880 bars. Some open-spaced quartz veins were filled with aplite during this stage. Field relations and geochemical evidence suggest that the aplites as well as the silicate melt inclusions in hydrothermal quartz veins represent volumetrically minor residual melts that evolved directly from granodiorite porphyries at the level of deposit formation, and do not represent aliquots of metal-supplying magma at depth. Fluid inclusions coexisting with the silicate melt inclusions are metal rich, but these fluids predate sulfide precipitation and are, therefore, not the dominant fluids responsible for the Cu-Au mineralization at Elatsite. Melt-fluid-metal separation processes recorded in these co-trapped silicate melt and fluid inclusions in vein quartz are small-scale, local phenomena and do not appear to be suited for understanding and quantifying metal segregation in the deeper source.

Microthermometry data of fluid inclusions, trapped during the later stages of the formation of the second quartz generation, show further depressurization to ~260 to 325 bars and cooling to ~460 °C, representing a hot hydrostatic regime. Bornite, chalcopyrite, and magnetite seem to be slightly later precipitated at temperatures ≤460 °C in separate veins or opened spaces of preexisting veins. Dissolution textures of the second quartz generation indicate a subsequent local redissolution of vein quartz, most likely as a result of passing through a window of retrograde quartz solubility upon further cooling below 460 °C. The next, economically most important chalcopyrite-pyrite stage is largely devoid of quartz precipitation and is mostly expressed as "paint veins". Due to the lack of fluid inclusions, the temperature-pressure conditions of formation of these veins could not be constrained. The waning phase of hydrothermal activity is represented by a quartz-carbonate-zeolite stage, formed at low temperature (~145 °C), as indicated by microthermometry of fluid inclusions trapped in quartz from this stage.

Laser ablation-inductively coupled plasma-mass spectrometry analyses of fluid inclusions show very high Cu contents in early intermediate-density fluid inclusions and in the first vapor inclusion generation, followed by a drastic decrease in the second generation of vapor inclusions. The decrease correlates with the appearance of anhydrite inclusions in the second quartz generation and may indicate that a lack of sulfur in these later vapor inclusions led to Cu partitioning into the brine. Alternatively, it is also possible that, unlike early vapor inclusions, the later vapor inclusions were not susceptible to postentrapment copper enrichment, in accordance with recent experiments. A progressive Cu enrichment in the brine phase correlates well with depressurization prior to mineralization. Mass balance considerations based on analyzed fluid components and fluid phase relations indicate that brine was volumetrically minor and therefore likely stagnant, but this may have prepared ore precipitation by accumulating Cu stripped from ascending vapor.

Tarassova, E., M. Tarassov, D. Gergova, E. Tacheva. 2014. Phase and chemical composition of ancient Thracian pigments from Bulgaria: the cases from tumulus no. 21, eastern necropolis of Sboryanovo National Reserve and from Shushmanets tomb-temple. – In: *Bul. Shk. Gjeol. 1–Special Issue. Proceedings of XX CBGA Congress*. Tirana, Albania, Special section SS2.

Pigments from two Thracian tombs from different geographic and historical regions of Bulgaria – from the Royal Necropolis of the Getae in Northeast Bulgaria (Sboryanovo National Reserve, tumulus no. 21) and from the necropolis of the Odrysian Kingdom in the Kazanlak valley (Shushmanets tomb), are studied and compared. It is found that, besides similarities in the used materials like hematite as red pigment and lime as binding material, the two tombs show some differences. In the Sboryanovo (tumulus no. 21), the blue pigmentation results from mixing of lime and fine grained dark-coloured minerals as rutile, ilmenite, magnetite, chrome-spinel, jacobsite, pyrite, cerussite and manganese-oxides. In the Shushmanets tomb, the blue colour is achieved via mixing of lime material and ground charcoal. All pigments in the Sboryanovo tomb no. 21 are used as paint applied in a thin layer, while in the Shushmanets tomb, the pigments are used mainly for colouring the initial mortars.

Vassileva, R. D., R. Atanassova, K. Kouzmanov. 2014. Tennantite-tetrahedrite series from the Madan Pb-Zn deposits, Central Rhodopes, Bulgaria. – *Mineral. and Petrol.*, *108* (4), 515–531; DOI 10.1007/s00710-013-0316-0

Minerals from the tennantite-tetrahedrite series (fahlores) are found as single euhedral crystals and crustiform aggregates in hydrothermal veins of the Gradishte and Petrovitsa Pb-Zn deposits of the Madan ore field, Southern Bulgaria. Unusually large compositional variations and fine oscillatory crystal zoning were investigated with electron microprobe analysis. The Gradishte samples correspond dominantly to tennantite, while Petrovitsa crystals have exclusively tetrahedrite composition. Fahlore compositions at Madan correspond to zincian varieties (1.6–1.95 apfu), with low Fe-content (<0.45 apfu). Minor Ag is characteristic only for the Petrovitsa samples, reaching a maximum of 0.30 apfu. The (Cu+Ag) content of the Petrovitsa tennantites and the Cu content of the Gradishte tetrahedrites systematically exceed 10 apfu resulting in compensation of the excess Cu in the structure by Fe^{3+}. Textural characteristics, mineral relationships and available fluid inclusion and stable isotope data suggest that fahlores precipitated in the late stages of mineralization at Madan, at temperature interval of 300–200 °C from oxidizing fluids with mixed (magmatic-meteoric) signatures.

Zlatkov, G., G. Tasev, V. Stefanova, K. Bogdanov, T. Serafimovski. 2014. Composition of some major mineral phases from the Plavica epithermal gold deposit, Eastern Macedonia. – *Geologica Macedonica*, *28*, 2, 149–163.

High-sulphidation epithermal gold has been determined and studied in the Plavica deposit, which is an integral part of the Kratovo-Zletovo volcanic area. Epithermal gold and associated mineral phases have been determined in silicified tuff, secondary quartzite, quartz-pyrite-enargite veins and mainly disseminated within an altered, but mostly silicified volcanic setting. Beside gold within this acid-sulphate volcanic environment was determined the presence of contaminated pyrite, Zn-tetrahedrite, enargite, and certainly seligmanite regularly and commonly present Cu association led by chalcopyrite, followed by bornite, chalcocite, covellite, as well as slightly higher temperature associations of arsenopyrite and molybdenite. Most of these accessory sulphide mineral phases within this study were observed under state of the art polarized optical microscope, and the electron microprobe, which results are presented in detail in this paper. For illustration we want to emphasize that in pyrite were found increased concentrations of Cu and Zn and less Ag, then enargite with increased Zn concentrations (0.24–7.56%), Sb (0.46–1.33%) and Ag (0.09–0.54%), tennantite with increased Fe (0.21–1.55%), Zn (6.24–9.06%) and Ag (0.08–0.87%), while within the molybdenite elevated concentrations were detected for S and Fe.

2015

Burchfiel, B. C., R. Nakov. 2015. The multiply deformed foreland fold-thrust belt of the Balkan orogen, northern Bulgaria. – *Geosphere*, *11*(2), 463–490; DOI: 10.1130/GES01020.1

The generally east-west-trending Balkan orogen (Eastern Europe) consists of a northern belt of folded and thrusted Mesozoic and Cenozoic strata that forms the external fold-thrust belt of Late Mesozoic and Early Cenozoic age, and a southern belt that consists of deformed igneous and metamorphic rocks overprinted by Cenozoic extensional basins. Unlike most foreland fold-thrust belts, wherein deformation commonly migrates toward the foreland, the fold-thrust belt within the Balkan orogen is marginal to the Moesian Platform to the north, but was deformed in at least 3 events related to 3 different dynamic systems caused by changes in plate interactions. The earliest event of Late–Early to Early–Late Cretaceous deformed strata deposited within the Moesian continental margin and within a continental rifted belt containing deep-water flysch of Late Jurassic–Early Cretaceous age, a probable eastward extension of oceanic troughs from the Southern Carpathians. The shortening was a consequence of south or southwest synthetic subduction within the Vardar zone along the southern margin of the Balkan orogen. In Late Cretaceous time a backarc and/or intraarc rift zone developed along the southern margin of the fold belt, terminating shortening. The backarc and/or intraarc basin closed in Late Cretaceous–Early Paleocene time, deforming the foldthrust belt for a second time, but antithetically to north or northeast subduction in the Vardar zone. North- and northwest-vergent subduction within the Vardar zone caused magmatism, metamorphism, and deformation within the Rhodope area of Southern Bulgaria south of the foreland thrust belt. In Paleogene time the southern part of the Balkan orogen became extensional with development of extensional basins and abundant magmatism due to trench rollback. The time of the final foreland fold-thrust belt deformation was Late Eocene extending into Oligocene or Early Miocene, contemporaneous with the extension to the south. The deformation within the fold-thrust belt was caused by a transfer of transpressional right shear within North Bulgaria and the Southern Carpathians as crustal units were translated northward west of the Moesian foreland crust and moved northeast and eastward into the Eastern Carpathian west-dipping subduction zone. During the third event of deformation crustal units were molded around the Moesian foreland crust. The shortening ceased by Early Miocene time and the right shear west of Moesian foreland crust was manifested by discrete right-slip faults to the present. During this third event Southern Bulgaria was in an extensional regime that dominated the south- to southwest-vergent Hellenide orogen throughout the Cenozoic, thus dividing the Balkan orogen into two different deformational regions.

Colás, V., J. M. González-Jiménez, I. Fanlo, W. L. Griffin, F. Gervilla, S.-Y. O'Reilly, N. J. Pearson, Th. Kerestedjian. 2015. Thermodynamic modelling of the mobility of minor and trace elements in metamorphosed chromites. – In: *Goldschmidt 2015*, Prague.

Chromites in high-Al and high-Cr chromitites from the ultramafic massifs of Golyamo Kamenyane and Jakovitsa (Bulgaria) preserve 4 types of microstructures: i) partly-altered chromite, with primary cores surrounded by porous chromite enriched in Cr and Fe^{2+} and depleted in Al and Mg; ii) porous chromite, with chlorite in the pores; iii) zoned chromite, with primary cores surrounded by non-porous chromite enriched in Fe^{3+}; and iv) non-porous chromite. The different patterns of zoning are the consequences of two-stage processes associated with the infiltration of different fluids. P-T-X diagrams for high-Al and high-Cr chromitites indicate that the first stage of alteration takes place by reaction of primary chromite with olivine in presence of SiO_2-rich fluids, to produce chlorite and porous chromite. The highest changes in Cr# and Mg# in chromites are generated coevally with: i) significant enrichment in Zn, Co and Mn but depletion in Ga, Ni and Sc in high-Al porous chromite, and ii) diffusion of these elements between cores and porous rims (with higher Ga, Ti, Ni, Mn, and Sc, but lower V) in high-Cr partly-altered chromite. Our thermodynamic model suggest that porous chromite is stable from 700 to 450 °C, in eclogite to amphibolite facies. Calculated temperatures for the second stage using isothermal Al-Cr-Fe^{3+} sections indicate the formation of ferrian chromite from 450 to 600 °C, overlapping with those modeled for the first stage. High-Al and high-Cr cores of zoned chromite show the same pattern of minor and trace elements (depleted in Ga, Ni and Sc and enriched in Zn and Co) due to their diffusion through the non-porous chromite (with high Zn, Co, Mn, Fe_{tot} and, more in Ti, Ni and Sc, but low Ga) grains and rims of zoned chromite. Thus, the alteration of chromite is a consequence of the evolution of fluids from reducing SiO_2-rich to more oxidizing, obliterating the geochemical fingerprint of the magmatic chromite.

Colás, V., J. M. González-Jiménez, W. L. Griffin, I. Fanlo, F. Gervilla, S.-Y. O'Reilly, N. J. Pearson, Th. Kerestedjian, J. A. Proenza. 2015. Fingerprints of metamorphism in chromite: New insights from minor and trace elements. – *Chemical Geology*, *389*, 137–152; DOI: 10.1016/j.chemgeo.2014.10.001

A suite of minor and trace elements (Ga, Ti, Ni, Zn, Co, Mn, V, Sc) in chromite grains from ophiolitic chromitites subjected to high-pressure metamorphism defines a metamorphic signature. A two-stage process associated with the infiltration of fluids during retrograde metamorphism from eclogite- to amphibolite-facies has produced 4 types of chromites: (1) porous chromite strongly enriched in Cr and Fe^{2+} but depleted in Al and Mg, with abundant chlorite filling the pores; (2) non-porous chromite strongly enriched in Fe^{3+} (i.e., ferrian chromite); (3) partly altered chromite with primary cores surrounded by chlorite-bearing porous chromite; and (4) zoned chromite made

up of primary cores surrounded by non-porous rims of ferrian chromite.

Dinarès-Turell, J., K. Stoykova, V. Pujalte, M. I. Ivanov, J. Elorza. 2015. Integrated Upper Maastrichtian stratigraphic record: correlation of Basque and Bulgarian sections and implications for global sea-level trends. – In: *Workshop of IGCP 609: Climate-environmental Deteriorations during Greenhouse Phases and EARTHTIME-EU Sequence. Stratigraphy Workshop: Eustasy and Sequence Stratigraphy in the Cretaceous Greenhousere*. Bucharest, Romania; DOI: 10.13140/2.1.2923.9688

We present an integrated cyclo-magnetostratigraphy, nannofossil biostratigraphy, sequence stratigraphy and quantitative calcareous nannofossil study for the Upper Maastrichtian interval of two distant hemipelagic sections: Sopelana, Basque Basin and Bjala, Bulgaria. Both sections display similar rhythmic sedimentary successions imprinted by astronomical climate forcing (Milankovich cyclicity). The cyclo-magnetostratigraphy framework has been developed from the K/Pg (Cretaceous/Paleogene) boundary, within Chron C29r, down to the Lower/Upper Maastrichtian boundary, C31n-C31r. It encompasses a total of ~60 m in Sopelana and ~45 m in Bjala. We integrate in the cyclostratigraphic framework the previously defined 3rd order depositional sequences in the studied sections (Pujalte et al., 1995; Stoykova, Ivanov, 2002; Baceta et al., 2004). This allow us to estimate the duration of the sequence stratigraphic units UMa-2, UMa-1 and Ma-Da, which appear to be strongly paced by the long-term 1.2 My obliquity amplitude modulating cycle (Dinarès-Turell et al., 2013). Finally, we have undertaken a quantitative nannofossil study to check additionally the sequence stratigraphic units UMa-2, UMa-1 and Ma-Da. It has been demonstrated by previous authors, that peaks in micro- and nannofossil abundance can be used to locate intervals of condensed sedimentation which, when integrated litholog and lithofacies data, enable recognition and dating of maximum flooding surfaces. Conversely, abundance minima and changes in microplankton assemblage character have been associated with sequence boundaries. In this way, a stratigraphic framework has been established which aims to provide a nannofossil signature for each depositional sequence. This has been calibrated using low-latitude UC"TP" scheme of Burnett (1998), integrated with the Cretaceous Eustatic Cycle Chart of Haq (2014).

Dinarès-Turell, J., K. Stoykova, I. O. Yilmaz. 2015. Geochronological accuracy around the Cretaceous–Paleogene boundary interval: Insights and challenges to the age of Chron C29r and intervening events. – In: *26th IUGG General Assembly Conference*. IUGG-3042; DOI: 10.13140/RG.2.1.2877.4883

The need for precise and accurate time constraints in Earth sciences is pivotal to successfully unravel geological mechanisms and rates of processes. Timescale accuracy is a prerequisite for reliable event correlation and to disentangle intricate complex climatic and biotic changes. The Late Cretaceous, a time interval of major biodiversity adjustments culminating in the end-Cretaceous mass extinction, has been the subject of intense debates regarding not only its causes but also the timing. The Cretaceous–Paleogene (K–Pg) boundary occurs within Chron C29r. Its numerical age and the relative position within C29r has changed significantly over different instances of the GPTS. The radiometric absolute age of the K–Pg boundary has now been established at 66.043±0.043 Ma by high-precision $^{40}Ar/^{39}Ar$ dating on tektites and bentonites associated with the boundary. The age close to 66 Ma is compatible with astronomical tuned chronologies derived from integrated magneto/chemo/biostratigraphic studies from marine sequences that have provided complete orbital chronologies for the Maastrichtian and Paleocene at eccentricity resolution (~100–400 ky). These studies also place the K–Pg halfway C29r with a calibrated Chron duration of ~710 ky. However, a recent chronostratigraphic study of the terrestrial K–Pg transition in the Hell Creek region (Montana) including $^{40}Ar/^{39}Ar$ dating of 15 tephra layers challenge the duration of C29r to as brief as ~345 ky. Here, the chronological framework of C29r is reappraised and studied at orbital precession resolution (~21 ky) using an array of deep sea records and new data from pelagic strata from the Bjala section (Bulgaria) and the Mudurnu–Goynuk basin (NW Turkey).

Jefferson, I., Ch. Rogers, D. Evstatiev, D. Karastanev. 2015. Improvement of collapsible loess in Eastern Europe (Chapter 7). – In: *Ground Improvement Case Histories. Compaction, Grouting and Geosynthetics*. Elsevier, 215–261.

Collapse phenomenon of loess, typically under a combination of wetting under load, causes many challenges to engineers working in loess regions across the world. The collapsibility is highly variable due to the complex nature of loess formations. Thus a detailed knowledge of geomorphogical and geological peculiarities are a vital part of any investigation of loess terrains. This coupled with a detailed measurement of collapse, preferably in situ, is required if the best mitigation techniques in the treatment of loess soils are to be applied effectively. The effectiveness of these depends on numerous factors including the timing of mitigation, source of loading, source of wetting, and cost. Thus to be effective, treatment should carefully integrate each of these elements in the overall process of loess improvement. The main objective of this chapter is to present the state of the knowledge associated with the improvement of collapsible loess soils, drawing on the considerable experience from Eastern Europe, and in particular Bulgaria. This is achieved by description of the features of Bulgarian loess, main principles and methods of collapsible loess treatment. Examples from Bulgaria show how 3 main techniques, developed to deal with the collapsible loess, can be effective in the treatment of such soils. These approaches have successfully provided a cost effective and durable foundation soils in each case. This has been true even when operating under harsh environments over several decades. The approaches adopted in Bulgaria and across Eastern Europe have provided a useful insight into techniques that could be used in the future to treat loess from across the world.

Kounov, A., E. Wüthrich, D. Seward, J.-P. Burg, D. Stockli. 2015. Low-temperature constraints on the Cenozoic thermal evolution of the Southern Rhodope Core Complex (Northern Greece). – *Intern. J. Earth Sci*., *104*, 1337–1352.

The South Rhodope Core Complex (SRCC) of Northern Greece is probably the most studied metamorphic core complex of the Rhodope Massif, and yet its geological evolution has not yet been fully unravelled, especially the later stages of its thermotectonic evolution. We applied the fission-track method on apatite and zircon and the [U-Th-(Sm)]/He method on apatite in order to reconstruct the low-temperature thermal history. The main detachments responsible for the unroofing of the core complex are the Kerdilion and the Strymon Valley detachments. The Kerdilion detachment initiated the exhumation

of the SRCC at the latest at 42 Ma and controlled it until about 24 Ma. Between 24 and 12 Ma, the Strymon Valley detachment accommodated the exhumation. Since 12 Ma brittle normal faults, some of them cutting the Strymon Valley detachment were responsible for the final cooling of the basement rocks in the studied area and the formation of syn-tectonic sedimentary basins. Activity along these brittle normal faults lasted until 6 Ma or probably even until today, as indicated by recent seismic activity in the area.

Sachanski, V., H. Kozlu, M. C. Göncüoğlu. 2015. Thuringian affinity of the Silurian–Lower Devonian succession from the Eastern Taurus, Turkey. – *Turkish J. Earth Sci.*, *24*, 303–324.

The Silurian–Lower Devonian succession in the Değirmentaş-Halevikdere section (E. Taurides) shows considerable lithostratigraphic similarities to the three-partite subdivision, initially documented in the same stratigraphic interval in Saxo-Thuringia and later in other peri-Gondwanan terrains. The Llandovery–Wenlockian part of the studied section (~40 m) is characterized by black graptolitic shales. The Landoverian part is dominated by radiolarian ribbon cherts (~20 m). The Rhuddanian Akidograptus ascensus, Parakidograptus acuminatus, and Cystograptus vesiculosus biozones have been recognized in its lower part, while in the upper part of the succession, the lowermost Telychian Rastrites linnaei Biozone has been documented. The Telychian Spirograptus turriculatus and Streptograptus crispus biozones, as well as the Sheinwoodian Cyrtograptus rigidus/Monograptus belophorus Biozone, have been identified within this succession. Graptolites of the Homerian (Colonograptus deubeli + Col. praedeubeli and Col. ludensis biozones) are only found in the Pekmezköy and Gürleşen areas, in the black shales, immediately before the first ocher-colored limestone, which is characteristic for the Ockerkalk Formation in the Thuringian facies. The dominantly ocher-colored shale-limestone alternation in the Değirmentaş-Halevikdere section is ~50 m in thickness. The lower Ludlowian part is enriched by nautiloids, while in the Pridolian part crinoids are abundant. It is covered by 60-m-thick black shales and siltstones, corresponding to the Upper Graptolite Shale Formation in the Thuringian. The Silurian–Devonian boundary is located in the lower part of this unit on the basis of lobolith findings. The depositional model proposed here accounts for the migration of the considered peri-Gondwana terrains from high to low paleogeographic latitudes that has triggered changes not only in the ocean water thermohaline circulation but also in the wind-driven downwelling or upwelling systems. These changes are responsible for the progressive transition from an oxic regime to an anoxic one in the deep oceanic depositional environments (outer continental shelf, slope, and ocean basin settings) and the deposition of light and dark sediments there.

Satsukawa, T., S. Piazolo, J. M. González-Jiménez, V. Colás, W. L. Griffin, S.-Y. O'Reilly, F. Gervilla, I. Fanlo, Th. N. Kerestedjian. 2015. Fluid-present deformation aids chemical modification of chromite: Insights from chromites from Golyamo Kamenyane, SE Bulgaria. – *Lithos*, *228–229*, 78–89; DOI: 10.1016/j.lithos.2015.04.020

Chemical signatures of chromitites are commonly used to track the evolution of Earth's mantle. However, chemical modification during deformation may have important implications for the interpretation of chromites' signatures. Here, we describe the details of how deformation promotes chemical modification in chromite. Physicochemical characteristics of the chromites were quantified by measuring crystallographic orientation relationships using Electron Back-Scattered Diffraction (EBSD) and electron microprobe analysis (EMP). Chromites show porphyroclastic textures with coarse-grained porphyroclasts (ca 0.2 ~5 mm) and fine-grained neoblasts (<200 μm). Coarse-grained chromites are chemically zoned in terms of major elements from core to rim, preserving this initial igneous feature in the cores, while outer rims reveal a metamorphic signature. Large chromite grains are characterized by local crystal-plastic deformation, exhibiting distinct inter-crystalline deformation including continuous crystal bending and subgrain boundaries as well as chemical modification in their outer, deformed parts. Two types of fine-grained chromite, F1 and F2, are present. While F1 exhibits a well-developed polygonal texture, straight grain boundaries and low intercrystal misorientation (<1°), F2 shows low-angle boundaries and significant intercrystalline misorientation (2~8°). Both F1 and F2 have higher Fe^{3+} and Cr and lower Mg# values than the cores of large grains. We interpret F1 and F2 to represent chromite recrystallized by heterogeneous nucleation and subgrain rotation recrystallization, respectively. Crystallographic preferred orientation (CPO) and misorientation data on the well-developed low-angle (subgrain) boundaries in coarse grains and F2 grains indicate that deformation in chromite was accommodated mainly by dislocation creep with the dominant activation of the {111}<100>slip system. The retrograde P-T exhumation path predicted by thermodynamic and chemical modeling suggests that these fine-grained chromites were produced when the initial chromitites reacted with oxidizing fluids during retrograde metamorphism (~1.0 GPa and 500–700 °C). Our results show that deformation in the dislocation-creep regime in a chemically open system has induced chemical modification and homogenization within chromite aggregates as well as strain localization. This close physicochemical link offers new avenues of interpreting the chemical signatures of chromites, utilizing their microstructurally controlled variation or lack thereof.

Tchoumatchenco, P. 2015. Bulgaria. – In: *INHIGEO Annual Record No 47 (Covering Activity Generally in 2014).* Online publication.

Отчита се, че геоложкият живот в България през 2014 г. е посветен на 160-та годишнина от рождението на първия български геолог Георги Златарски. В негова чест са се състояли няколко събития. Първото е откриване в Университетската библиотека на изложба на неговите публикации и ръкописи от декана на ГГФ проф. М. Иванов. Той проследи живота на юбиляра и изтъкна приносите му в българската геология. С мило и непринудено изказване правнучката на проф. Г. Златарски Светла Златарска благодари на организаторите. Второто събитие бе експонирането на материалите от тази изложба в НМ „Земята и хората". Тук доклад за живота на проф. Г. Златарски прочете доц. Ф. Мачев. За това мероприятие пристигна от САЩ внукът на проф. Г. Златарски д-р Васил Златарски. На паметта на проф. Г. Златарски бе посветена и редовната научна сесия с международно участие „Геонауки 2014" на Българското геологическо дружество. Тази сесия бе посветена и на 110-та годишнина от рождението на голямия български геолог от руски произход Андрей Янишевски (1904–1949). Дава се и информация, че Руският академически съюз в България е издал книгата „Геолозите от руски произход в света" под редакцията и съставителството на П. Чумаченко и Олга Дитл. Материалите за нея са събрани от голям международен колектив, а книгата е посветена на проф. М. Дюранд-Делга. В материала се съобщава и за кончината на голямия български литолог проф. дгн Иван К. Начев (1927–2014).

Tchoumatchenco, P., M. Wiazemsky. 2015. Geologists of Russian origin in the USA. – *Ann. Geol. Peninsule Balkanique*, *76*, 115–150.

Many ethnic Russian geologists lived and worked in the Unites States of America. We describe in this paper the life and career of geologists, (i. e. all Earth scientists – geologists, mineralogists, tectonicians, geophysicists, geochemists, paleontologists, mining and drilling engineers, hydrogeologists, cosmos- geologists, etc.), regardless of their original nationality (Russians, Ukrainians, Tatars, Germans, etc.) who were born in the Russian Empire, the Soviet Union or the Russian Federation, as well as descendants of Russian emigres who had the call of geology and worked in this part of the world, without necessarily settling there. We subdivide the history of the Russian emigration into three periods: a) first generation emigrants, before the October 1917 Revolution, or their descendants (6 persons); b) second wave of emigration after the Revolution (white emigration) and their descendants (47 persons); c) a third wave, during and after WW II (1941–2013) (27 persons), totalling 80 Russian geologists in the United States of America.

Wawrzenitz, N., A. Krohe, I. Baziotis, E. Mposkos, A. R. C. Kylander-Clark, R. L. Romer. 2015. LASS U-Th-Pb monazite and rutile geochronology of felsic high-pressure granulites (Rhodope, N. Greece): Effects of fluid, deformation and metamorphic reactions in local subsystems. – *Lithos*; DOI:10.1016/j.lithos.2015.06.029.

The specific chemical composition of monazite in shear zones is controlled by the syndeformation dissolution-precipitation reactions of the rock-forming minerals. This relation can be used for dating deformation, even when microfabric characteristics like shape preferred orientation or intracrystalline deformation of monazite itself are missing. Monazite contemporaneously formed in and around the shear zones may have different compositions. These depend on the local chemical context rather than reflecting successive crystallization episodes of monazite. This is demonstrated in polymetamorphic, mylonitic high-pressure (HP) garnet-kyanite granulites of the Alpine Sidironero Complex (Rhodope UHP terrain, Northern Greece). The studied mylonitic rocks escaped from regional migmatization at 40–36 Ma and from subsequent shearing through cooling until 36 Ma. In-situ laser-ablation split-stream inductively-coupled plasma mass spectrometry (LASS) analyses have been carried out on monazite from micro-scale shear zones, from pre-mylonitic microlithons as well as of monazite inclusions in relictic minerals complimented by U-Pb data on rutile and Rb-Sr data of biotite. Two major metamorphic episodes, Mesozoic and Cenozoic, are constrained. Chemical compositions, isotopic characteristics and apparent ages systematically vary among monazite of four different microfabric domains (I–IV). Within 3 pre-mylonitic domains (inclusions in (I) pre-mylonitic kyanite and (II) garnet porphyroclasts, and (III) in pre-mylonitic microlithons) monazite yields ages of ~130–150 Ma for HP-granulite metamorphism, in line with previous geochronological results in the area. Patchy alteration of the pre-mylonitic monazite by intra-grain dissolution-precipitation processes variably increased negative Eu anomaly and reduced the HREE contents. The apparent age of this altered monazite is reduced. Monazite in the syn-mylonitic shear bands (IV) differs in chemical composition from unaltered and altered monazite of the 3 pre-mylonitic domains by having a significantly more pronounced negative Eu anomaly, a flatter HREE pattern, and high Th content. These compositional characteristics are linked with syn-mylonitic formation of plagioclase and resorption of garnet in the shear bands under amphibolite facies conditions. The absence of pre-mylonitic monazite in the shear zones, in contrast to the other domains, suggests complete dissolution of old and formation of new monazite. This probably results from an increased alkalinity and reactivity of the fluid that again is controlled by syn-mylonitic interaction with feldspar and apatite in the shear zones. There, the deformation was accommodated by dissolution precipitation creep at ~690±50 °C and 6−7.5 kbar. Growth of monazite at 55±1 Ma dates this deformation, which precedes the regional migmatization of the Sidironero Complex, whereas rutile and biotite ages reflect these later stages. This new Pressure-Temperature-time constraint for a relictic deformation structure provides insight into the still missing parts of the overall metamorphic, deformation and exhumation processes of the UHP units in the Rhodope.

2016

Benderev, A., V. Hristov, K. Bojadgieva, B. Mihailova. 2016. Thermal waters in Bulgaria. – In: Papić, D. (Ed.). *Mineral and Thermal Waters of Southeastern Europe.* Springer Intern. Publish., Switzerland, 47–64; DOI: 10.1007/978-3-319-25379-4_3

The geological structure of Bulgaria is a complex mosaic of plates and orogenic structures, characterized by deep faulting and lithofacial and magmatic contrasts. Three types of reservoirs are found in the country: stratified (Northern Bulgaria), fractured, and mixed, where mineral water from a fractured reservoir is secondarily accumulated in a younger sediment reservoir (Southern Bulgaria). The water temperature of all discovered geothermal reservoirs ranges between 25 and 100 °C, while those with temperatures up to 50 °C prevail. The flow rate varies from 1 to 20 L/s in about 75% of the reservoirs. The established chemical content (TDS) is in the range from 0.1 to 1.0 g/L in Southern Bulgaria and 0.1 g/L (100–150) g/L in Northern Bulgaria. About 70% of the discovered thermal waters are slightly mineralized (<1 g/L) and suitable for drinking. Direct thermal water application has an ancient tradition in Bulgaria. Current uses include balneotherapy, space heating and air-conditioning, greenhouses, thermal water supply, ground source heat pumps (GSHP), bottling of potable water and soft drinks. The present installed thermal capacity amounts to about 83.1 MWt, excluding GSHP. An extensive review of the geological background, thermal water characteristics and existing applications is presented. Thermal waters are an integral part of Bulgaria's total water resources but due to their particular qualities, they are treated separately by legislation. Water management and legislation are briefly presented.

Benderev, A., Z. Stevanović, **B. Mihaylova**, **V. Živanović**, **K. Kostov**, **S. P. Milanović**, **S. B. Shanov.** 2016. Development and protection of transboundary karst and karst aquifers in West Stara Planina Mountains (Bulgaria–Serbia). – In: Stevanović, Z., N. Krešić, N. Kukurić (Eds.). *Karst without Boundaries*. IAH – Selected Papers on Hydrogeology. CRC Press, Balkema Book, 71–86; DOI: 10.1201/b21380-8

The West Stara Planina Mountains are situated on the territories of two countries – Serbia and Bulgaria. The karstification is developed mainly in 2 carbonate complexes: Triassic and Upper Jurassic while in western extension, in Vidlich Mt., karstified Cretaceous carbonate rocks are prevailing. The complicate geologic and tectonic conditions are the reason for the disclosure of carbonate rocks in long strips, oriented east-west. They formed a typical mountain karst with wide distribution of classical karstic landforms. The region is thus characterized by dolines,

poljes, and blind valleys. In the study area there are some hundreds caves in both countries, many of them well explored.

Due to the relatively low air temperatures, high rainfalls and relatively flat parts of the area with a lot of negative karst landforms, the conditions for extensive infiltration of precipitations and abundant groundwater reserves are created. The drainage is taking place over numerous large karst springs. Most of these are overflow sources while some of them drain the deeper saturated zones. Their discharge regime thus varies in very wide ranges from relatively constant to highly changeable. Some of springs are tapped and used for potable water supply as in case of Pirot, Dimitrovgrad (Serbia) or Svoge (Bulgaria).

The most of the karst springs are with relatively clear catchments areas and are not subject to transboundary discharge. Till now unclear is the water movement between the two countries in a small area near the boundary, where the direction of the sink river water is unknown. The common water balance of the border territories of Serbia and Bulgaria needs more hydrological, hydrogeological and climatic data, field survey and water tracings.

Bonev, N., R. Spikings, P. Marchev. 2016. Comment on Georgiev et al. "Structure and U–Pb zircon geochronology of an Alpine nappe stack telescoped by extensional detachment faulting (Kulidzhik area, Eastern Rhodopes, Bulgaria). – *Intern. J. Earth Sci.*; DOI: 10.1007/s00531-016-1376-2

Caracciolo, L., A. Orlando, P. Marchev, S. Critelli, P. Manetti, R. Raycheva, D. Riley. 2016. Provenance of Tertiary volcanoclastic sediment in NW Thrace (Bulgaria): Evidence from detrital amphibole and pyroxene geochemistry. – *Sediment. Geol.*, 136, 120–137; DOI:10.1016/j.sedgeo.2016.01.026

Detrital heavy mineral and bulk rock geochemistry and a review of sandstone petrographic data have been used to investigate the post-collisional effusive magmatism that followed the closure of the Vardar Ocean and the generation of volcanic sediments in a complex and compositionally variable volcanic region. Available petrographic data gives evidence of contributions from three key source areas corresponding to the three main tectonic units: the structurally lower Gneiss-Migmatite Complex (Byala Reka–Kechros and Kesebir–Kardamos domes) and the upper Variegated (Kimi) Complex, both fringed by the low-to-medium-grade Mesozoic rocks of the Circum-Rhodope Belt. Besides the deposition of siliciclastic material, volcanic contributions from both, intermediate and acid products represent an important source of sediment in the area. Despite dominant intermediate to acid volcanic products, volcanic lithic fragments in sandstones (microlithic, lathwork and brown vitric textures) indicate main inputs from intermediate and basic-intermediate products generating questions on the interpretation of volcanic detritus in reconstruction of provenance. Detrital amphibole and pyroxene chemistry is used to characterise the supply of volcanic material as well as the dispersal mechanisms and understand the role played by each of the volcanic centers present in the area in the infill of the north-western Thrace basin. Amphibole chemistry reveals high compositional heterogeneity according to both compositional variability of the numerous volcanic centres active at the time of deposition and presence of metamorphic amphibole. ^{4}Al and Al_T a.p.f.u. values indicate that most of the amphiboles from the NERZ are not of volcanic origin and their presence can only be attributed to the numerous amphibolite facies metamorphic rocks abundantly documented in the area. Detrital amphibole compositions from the ZKVS indicate major contributions from the Iran Tepe and Zvedzel volcanoes. Analysed detrital clinopyroxenes from the NERZ are mostly diopside-augite, with no hedenbergite or Fe-augite detected. The ^{4}Al/^{6}Al ratio is comparable with compositions of volcanic pyroxenes from the Momchilgrad–Arda (ZKVS) region and products from the pre-caldera phase of the Borovitsa.

Collings, D., I. P. Savov, K. Maneiro, E. Baxter, J. Harvey, I. Dimitrov. 2016. Late Cretaceous UHP metamorphism recorded in kyanite-garnet schists from the Central Rhodope Mountains, Bulgaria. – *Lithos*; DOI: 10.1016/j.lithos.2016.01.002

In this study we report the first discovery of microdiamond inclusions in kyanite-garnet schists from the Central Rhodope Mts. in Bulgaria. These inclusions occur in garnets from metapelites that are part of a meta-igneous and meta-sedimentary mélange hosted by Variscan (Hercynian) orthogneiss. Ultra-high pressure (UHP) conditions are further supported by the presence of exsolved needles of quartz and rutile in the garnet and by geothermobarometry estimates that suggest peak metamorphic temperatures of 750–800 °C and pressures in excess of 4 GPa. The discovery of UHP conditions in the Central Rhodopes of Bulgaria compliments the well-documented evidence for such conditions in the southernmost (Greek) part of the Rhodope Massif. Dating of garnets from these UHP metapelites (Chepelare Shear Zone) using Sm-Nd geochronology indicates a Late Cretaceous age (70.5–92.7 Ma) for the UHP metamorphic event. This is significantly younger than previously reported ages and suggests that the UHP conditions are associated with the Late Mesozoic subduction of the Vardar Ocean northwards beneath the Moesian platform (Europe). The present day structure of the RM is the result of a series of subduction exhumation events that span the Cenozoic, alongside subsequent post-orogenic extension and metamorphic core complex formation.

Georgiev, G. V. 2016. Bulgarian shale gas potential estimate. – In: *The Handbook of Environmental Chemistry*. Berlin, Springer, 1–26.

On the base of comprehensive analyses of geological structure and sedimentary basins of Bulgaria, 6 organic-enrich dark-shale-dominated intervals have been identified. Besides Silurian and Etropole shales (earlier determined), another 4 newly defined shale intervals are Lower Carboniferous, Lower Jurassic, Oligocene and Oligocene–Middle Miocene. The optimum area for each of them is outlined. The shale gas estimate is made by up-to-date methodology with consideration of the determined critical parameters. From the estimated 6 targets, only the Lower Carboniferous shales (in the pointed western zone) and both Jurassic shaly intervals may present moderate shale gas interest.

Georgiev, N., N. Froitzheim, Z. Cherneva, D. Frei, V. Grozdev, S. Jahn-Awe, Th. J. Nagel. 2016. Structure and U-Pb zircon geochronology of an Alpine nappe stack telescoped by extensional detachment faulting (Kulidzhik area, Eastern Rhodopes, Bulgaria). – *Intern. J. Earth Sci.*; DOI: 10.1007/s00531-016-1293-4

The Rhodope Metamorphic Complex is a stack of allochthons assembled during obduction, subduction, and collision processes from Jurassic to Paleogene and overprinted by extensional detachment faults since Middle Eocene. In the study area, the following nappes occur in superposition (from base to top): an orthogneiss-dominated unit (Unit I), garnet-bearing schist with amphibolite and serpentinite lenses (Unit II), greenschist, phyl-

lite, and calcschist with reported Jurassic microfossils (Unit III), and muscovite-rich orthogneiss (Unit IV). U-Pb dating of zircons from a K-feldspar augengneiss (Unit I) yielded a protolith age of ca. 300 Ma. Garnet-bearing metasediment from Unit II yielded an age spectrum with distinct populations between 310 and 250 Ma (detrital), ca. 150 Ma, and ca. 69 Ma (the last two of high-grade metamorphic origin). An orthogneiss from Unit IV yielded a wide spectrum of ages. The youngest population gives a concordia age of 581±5 Ma, interpreted as the age of the granitic protolith. Unit I represents the Lower Allochthon (Byala Reka–Kechros Dome), Unit II the Upper Allochthon (Krumovitsa–Kimi Unit), Unit III the Uppermost Allochthon (Circum-Rhodope Belt), and Unit IV a still higher, far-travelled unit of unknown provenance. Telescoping of the entire Rhodope nappe stack to a thickness of only a few 100 m is due to Late Eocene north directed extensional shearing along the newly defined Kulidzhik Detachment which is part of a major detachment system along the northern border of the Rhodopes. Older top-to-the south mylonites in Unit I indicate that Tertiary extension evolved from asymmetric (top-to-the-south) to symmetric (top-to-the-south and top-to-the-north), bivergent unroofing.

Georgiev, N., N. Froitzheim, Z. Cherneva, D. Frei, V. Grozdev, S. Jahn-Awe, Th. J. Nagel. 2016. Reply to: Bonev, N., Spikings, R. and Marchev, P. (2016) Comment on Georgiev et al. "Structure and U-Pb zircon geochronology of an Alpine nappe stack telescoped by extensional detachment faulting (Kulidzhik area, Eastern Rhodopes, Bulgaria)". – *Intern. J. Earth Sci.*; DOI: 10.1007/s00531-016-1378-0

Grabowski, J., I. Lakova, S. Petrova, K. Stoykova, D. K. Ivanova, P. Wojcik-Tabol, K. Sobieri, P. Schnabl. 2016. Paleomagnetism and integrated stratigraphy of the Upper Berriasian hemipelagic succession in the Barlya section Western Balkan, Bulgaria: Implications for lithogenic input and paleoredox variations. – *Palaeogeogr.*, *Palaeoclimat.*, *Palaeoecol*., *461*, 156–177; DOI: 10.1016/j.palaeo.2016.08.018

A continuous Late Berriasian sedimentary and stratigraphic record is here presented from a hemipelagic succession from the Western Balkan (Barlya section, Bulgaria). The section, 39 m thick, was stratigraphically calibrated using a variety of methods: biostratigraphy (calpionellids, calcareous nannofossils and calcareous dinocysts), magnetostratigraphy and carbon isotope stratigraphy. Additionally, hemostratigraphy and rock magnetic stratigraphy were applied in order to identify major paleoenvironmental changes: lithogenic input and paleoredox variations. Polarity zones from M17r to M14r were identified from the uppermost Lower Berriasian up to the Berriasian/Valanginian boundary (Elliptica to Darderi calpionellid subzones and NK-1 to NK-3 nannofossil zones). Late Berriasian calcareous dinocyst zones of *Stomiosphaerina proxima*, *Stomiosphaera wanneri* and *Colomisphaera conferta* were correlated with magnetostratigraphy for the first time. A carbon isotope profile correlates very well with the $\delta^{13}C$ records from SE France and the Western Atlantic, documenting some well-resolved minima and maxima in a generally decreasing trend. Magnetic susceptibility (MS) reveals a very good positive correlation with lithogenic elements (e.g., Al, Ti, Zr, Th and others) and is regarded as a reliable proxy of detrital input. Influx of fine grained terrigenous material increases in the Upper Berriasian up to the Berriasian/Valanginian boundary. A prominent MS increase takes place in the lowermost part of polarity zone M16n (close to the Simplex/Oblonga subzonal boundary). The MS event can be traced in the Central Carpathian, Apennine and SE France sections, exactly in the same stratigraphic position. It is coeval with an important climatic turnover in Western Tethys; however, it might have been strengthened by a general regression and regional tectonic events in the Carpatho–Balkan area. Two oxygen deficient intervals were documented: the first in the Lower Berriasian (M17r to M16r); the second one in the uppermost Upper Berriasian up to the boundary with Valanginian (M15r to M14r). Both intervals correlate with an elevated sea-level in the Western Tethys.

Güngör, Y., S. Y. Şahin, N. Aysal, I. Peytcheva. 2016. Preliminary results of geochronological and geochemical investigations of the Kula metagranitoids in Strandja Massif, NW Pontides, Turkey. – In: *7th Geochemistry Sympossium*. Antalya, vol. 1, p. 201.

Istranca (Strandja) Massif, extend into and continued Bulgaria from West Pontides until Late Precambrian–Early Cambrian from a different set up to the Late Cretaceous magmatic activity including polymetamorphic massifs. Istranca Massif, northwestern part of Istanbul (near Çatalca) tectonically separated from Istanbul Paleozoic sequence, in southern part covered with the Thrace basin sediments. In this study, it will present geochemical and geochronological prior data of Kula metagranitoid that lenghten in both of sides of Turkish-Bulgarian boundary. Medium-coarse grained, mylonitic-blastomylonitic textured Kula metagranitoid is pluton a granodioritic. It locally includes quartz and feldspars' rich vein rocks. Mineralogical composition of pluton composed of quartz (20–25%), albitized plagioclase (45–50%), ortoclase (10–20%) and mica (muscovite and biotite) minerals and secondary minerals chlorite and epidote. It's affected dense tectonism and alteration. Kula metagranitoids has classified as the I-type, metaluminous-peraluminous granite. According to K_2O content of this metagranitoid presents calc-alkaline character. The samples of this metagranitoid plotted volcanic arc and post-collision granite areas in tectonic discrimination diagram. In magmatic zoning zircon grains belonging to Kula meatagranitoid are found 310.1±2.0 Ma (Carboniferous–Pennsylvanian) concordia age. $^{206}Pb/^{238}U$ ages are between 288±12 Ma and 322±8 Ma, whereas inherited core age is 370±12 Ma. Zircon Th/U rate is 0.03–1.97 (average 0.46) and intensely 0.15–0.72 values. In the zircon classification according to Th/U rate, a metamorphic zircon taken place rim-core 307±25 Ma age and Th/U rate 0.03, four zircon grains plotted in transition zone area and have Th/U rate 0.15–0.17, all of rest of the zircon grains plotted magmatic zircon area. Kula metagranite, according to the regional geological and geochemical characteristics, Istranca Massif, Rhodope and Serbo-Macedonian Massif widely observed in the Carboniferous period, can be considered a product of the active Variscan magmatism. Carboniferous metagranitoid observed in western part of Istranca Massif was similar to the younger metagranitoid in eastern part of massif (Tepecik cataclastic metagranitoid, 249–254 Ma). All of these metagranitoids are evaluated to revealed by subduction of the northern branch of Paleo-Tethys Ocean. In addition, these are products of the longlived (Ordovician to Triassic) Variscan magmatic arc that represented different magmatic phasesand they may have been concluded.

Haque, U., Ph. Blum, P. F. da Silva, P. Andersen, J. Pilz, S. R. Chalov, J.-Ph. Malet, M. Jemec Auflič, N. Andres, E. Poyiadji, P. C. Lamas, W. Zhang, I. Peshevski, H. G. Pétursson, T. Kurt, N. Dobrev et al. 2016. *Landslides.* Berlin, Heidelberg, Springer-Verlag; DOI: 10.1007/s10346-016-0689-3

Landslides are a major hazard causing human and large economic losses worldwide. However, the quantification of fatalities and casualties is highly underestimated and incomplete, thus, the estimation of landslide risk is rather ambitious. Hence, a spatio-temporal distribution of deadly landslides is presented for 27 European countries over the last 20 years (1995–2014). Catastrophic landslides are widely distributed throughout Europe, however, with a great concentration in mountainous areas. In the studied period, a total of 1370 deaths and 784 injuries were reported resulting from 476 landslides. Turkey showed the highest fatalities with 335. An increasing trend of fatal landslides is observed, with a pronounced number of fatalities in the latest period from 2008 to 2014. The latter are mostly triggered by natural extreme events such as storms (i.e., heavy rainfall), earthquakes, and floods and only minor by human activities, such as mining and excavation works. Average economic loss per year in Europe is approximately 4.7 billion Euros. This study serves as baseline information for further risk mapping by integrating deadly landslide locations, local land use data, and will therefore help countries to protect human lives and property.

Karastanev, D. 2016. Site selection approach to geological disposal of high-level waste in Bulgaria (Chapter 3). – In: *International Approaches for Nuclear Waste Disposal in Geological Formations: Report on Fifth Worldwide Review*. Lawrence Berkeley National Laboratory, California, USA, LBNL-1006984 (in press).

Since the 4th Worldwide Review in 2006, the State Enterprise Radioactive Waste (SE RAW) has carried out a comprehensive preliminary analysis of geological conditions in Bulgaria with the purpose of selecting a potential site suitable for the construction of a deep geological disposal facility for high-level nuclear waste (HLW). The developed methodological framework included a step-by-step analysis and evaluation of the Bulgarian territory for selecting potential host rocks and a further detailed survey to study options to house HLW disposal in the deep geological environment. On the basis of multi-criteria comparative analysis, 5 potential sites with respective host rocks have been selected for further consideration. In 4 of these sites the potential host rock is Lower Cretaceous clayey marl, in one – Miocene clay. The present report summarizes the results of the preliminary site selection. First, the methodology applied for the selection of potential sites and their respective host rocks is described. Then, a short overview of the 5 candidate sites is given. We conclude that according to the preliminary analysis, there is potential for development of a deep geological HLW repository in Bulgaria.

Kostov, R. I. 2016. Symmetry of form and weight: standardization of gold and mineral artifacts from the Varna Chalcolithic necropolis (5th millennium BC). – In: Darvas, G. (Ed.). *Symmetry Festival 2016.* Vienna, 176–179.

The Varna Chalcolithic necropolis (middle of the 5th millennium BC) has become synonymous with gold, and the amount of gold finds is regarded as the "oldest gold of mankind". The finds in the necropolis demonstrate clearly that standardized forms of different gold implements and mineral artifacts were used. A Chalcolithic weight unit, called van (~0.4 g = 2 carats) is introduced and a possible prehistoric weight unit system is discussed, based on Fibonacci sequence numbers and/or common multiples. Other metrological studies include a possible length unit called vul (~0.7 cm). Measurements of angles and proportions can also be considered. Attention is paid to the so-called "anthropomorphic" gold ring-shaped artifacts. The Balkans in prehistoric times are declared as a cradle of gemstone, gemmological, goldsmith and metalwork activities, all corresponding to the forgotten knowledge of a protourban civilization. The standardization and miniaturization of gold and other mineral artifacts underlines the application of an early metrological system.

Kostova, I., Sh. Dai, J. C. Hower. 2016. Mineralogy, geochemistry and mercury content characterization of fly ashes from the Maritza 3 and Varna thermoelectric power plants, Bulgaria. – *Fuel*, *186*, 674–684; DOI: 10.1016/j.fuel.2016.09.015

The goal of the present study is to characterize the mineralogy and geochemistry of the bulk fly ashes (FA) and some separated fly ash fractions sampled from each row of electrostatic precipitators (ESP) of two Bulgarian thermoelectric power plants (TPP), namely Maritza 3 and Varna, and to reveal the influence of the mineral matter and chemical composition on the FAs mercury capture behavior. A separation procedure was conducted on 3 selected fly ash samples as follows: (1) FAs from the Maritza 3 1st-row ESP; (2) FAs from the Maritza 3 3rd-row ESP; and (3) FA from the Varna 5th-row ESP. Following the sequential separation procedure, 5 fractions were obtained from each bulk FA sample including water leach ate of FA, water-washed FA (FAW), char concentrate (FAC), magnetic fraction (FAM), and FA residue (FAR). Phase-mineralogical composition, the concentration of 30 trace elements, and Hg content of bulk FA samples and separated FA fractions were determined. The data obtained reveal that the phase-mineral composition of the char-rich fly ash fractions isolated from the FAs of the Maritza 3 1st-row ESP consists mainly of char and quartz with lesser contents of anhydrite and hematite; while the FAC fraction derived from the FAs of the 3rd-row ESP in Maritza 3 is highly enriched in char and anhydrite with insignificant amounts of magnetite-hematite and quartz. The results indicate that there is a synergetic effect between char and Ca sulphate, and anhydrite could play a significant role in the Hg capture in the fly ashes from Maritza 3. In contrast to the FAC fraction from Maritza 3, the FAC fraction isolated from the FAs of the Varna 5th-row ESP contains almost pure char with insignificant amount of magnetite and quartz. Mercury capture in the FA from the Varna 5th-row ESP is strongly dependent on the bituminous-derived FA char and the mineral matter does not have significant influence on the Hg capture behaviour. It was established that very high enrichment of trace elements in the studied FAs does not occur, excluding the concentrations of Cd, Mo, As, Mn, and Ag in Maritza 3 FAs, and the contents of Be, Cd, Cs, Rb, Se, and Ag in Varna FAs. The high capture behaviour of Hg by char and sulphates in the Maritza 3 3rd-row ESP is accompanied by simultaneous capture behaviour of hazardous and volatile elements such as Cd, Mo, and As, and probably others when compared with FAs from the 1st-row ESP in the same TPP. This observation indicates that the capture mechanism of such elements tend to be similar to that of Hg.

Kydonakis, K., J.-P. Brun, D. Sokoutis, F. Gueydan. 2016. Kinematics of Cretaceous subduction and exhumation in the Western Rhodope (Chalkidiki block). – *Tectonophys.*; DOI: 10.1016/j.tecto.2015.09.034

In the Chalkidiki Peninsula of Northern Greece a thrust complex made of a basement (Vertiskos Unit), a cover (Circum-Rhodope belt) and arc/back-arc units (Chortiatis Magmatic Suite and eastern Vardar Ophiolites) is exposed in the Chalkidiki Peninsula of Northern Greece. The complex forms

the western part of the Rhodope Metamorphic Province and lies on the hanging-wall of the Kerdylion Detachment, the structure responsible for the exhumation of the Southern Rhodope Core Complex and the most prominent and visible ductile structure related to the Tertiary Aegean extension. The Chalkidiki thrust complex arguably preserves a complete record of Cretaceous deformation and related fabrics. In this contribution we describe the geometry of foliation, stretching lineation and shear sense(s) on a regional scale. The regional foliation strikes NW-SE and displays different patterns in the 3 studied units: (i) dominantly dipping at low angle in the Vertiskos Unit, (ii) affected by upright folding in the Circum-Rhodope belt and (iii) systematically steeply dipping to the NE in the Chortiatis Magmatic Suite. Stretching lineation trend dominantly SW-NE in the three mentioned units. On the basis of new mapping, neglecting local perturbations and deformation related to Tertiary extension, we infer the regional kinematics of Cretaceous syn-metamorphic thrusting and subsequent exhumation of the metamorphic units. Thrusting took place toward the SW (in present-day coordination) and the related fabrics are recorded throughout the metamorphic pile. On the contrary, exhumation-related fabrics are related to shear toward the NE and are preferentially recorded in the uppermost part of the metamorphic pile suggesting that extension was more localised and of less finite intensity compared to thrusting.

Kydonakis, K., J.-P. Brun, M. Poujol, P. Monié, E. Chatzitheodoridis. 2016. Inferences on the Mesozoic evolution of the North Aegean from the isotopic record of the Chalkidiki block. – *Tectonophys.*, *682*, 65–84; DOI: 10.1016/j.tecto.2016.06.006

The Chalkidiki block is a major domain in the North Aegean that, contrary to other domains in the region, largely escaped thermal perturbations during Tertiary extension. As a result, the Chalkidiki block is an ideal candidate to glean information related to the timing of Mesozoic thermal events using appropriate geochronological techniques. We have undertaken a laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) study (U-Th-Pb on monazites and U-Pb on zircons) coupled with $^{40}Ar/^{39}Ar$ dating on nine samples from various structural levels within the thrust system of the Chalkidiki block. The eastern, and structurally lower part of the system revealed a complete isotopic reset of Carboniferous–Early Triassic monazites coeval with partial monazite destruction, REE-mobilisation and formation of apatite-allanite-epidote coronas at ~132 Ma, a reaction that is commonly observed in amphibolite-facies rocks. These coronas formed after crystallisation of garnet (i.e., at T > 580 °C) and, in all probability, either close to the peak-temperature conditions (~620 °C) on a prograde path or during retrogression between the peak-temperature and the low-temperature boundary of the amphibolite facies. Cooling of these rocks and arrival at mid-crustal levels occurred at 95–100 Ma. By contrast, the western, and structurally uppermost part of the system went through the same event by 120–125 Ma. Further structural considerations with respect to medium-temperature geochronology data imply that syn-metamorphic thrusting must have ceased by early Late Cretaceous. We emphasize that, with the sole exception of the Chalkidiki block, no pre-45 Ma medium-temperature geochronology data are preserved in other North Aegean domains, a feature that is clearly related to the extension-induced thermal perturbation of the region during the Tertiary.

Maravelis, A. G., D. Boutelier, O. Catuneanu, K. St. Seymour, A. Zelilidis. 2016. A review of tectonics and sedimentation in a forearc setting: Hellenic Thrace Basin, North Aegean Sea and Northern Greece. – *Tectonophys*., *674,* 1–19.

Exposure of the forearc region of the North Aegean Sea, Greece, offers insight into evolving convergent margins. The sedimentary fill of the Thrace Basin during the Late Eocene to Oligocene time provides a record of subduction-driven processes, such as growth of magmatic arcs and construction of accretionary complexes. This large sediment repository received sediment from two sources. The southern (outboard) basin margin reflects the active influence of the exhumed accretionary prism (e.g. Pindic Cordillera or Biga peninsula), while the northern (inboard) margin records the effect of the magmatic arc in the Rhodope region. The forearc basin sedimentary fills shoal upward into shallow-marine strata but are dominated mainly by deep-marine facies. The depositional trend and stacking pattern are dominated by progradational patterns. This trend, which is observed in both basin margins, is related to tectonic deformation rather than sea-level fluctuations. Additional evidence for this tectonic uplift comes from the backstripping analysis. The accretionary complex provided material into the forearc basin. This material was transported northeast and formed a sand-rich turbidity system that evolved upslope into shallow-marine deposits. Stratigraphic data indicate that this turbidity system exhibits a successive landward (inboard) migration of the depocenter. Provenance data utilizing sandstone petrography, conglomerate clast composition, and bulk-rock geochemistry suggest that this system reflects an increased influx of mafic material into the basin. Volcanic arc-derived material was transported south and east and accumulated in deep-marine settings. Both stratigraphic and provenance data indicate a seaward (outboard) migration of the basin depocenter and a significant increase in felsic detritus into the forearc.

Natal'in, B., G. Sunal, E. Gün, B. Wang, Y. Zhiqing. 2016. Precambrian to Early Cretaceous rocks of the Strandja Massif (Northwestern Turkey): evolution of a long lasting magmatic arc. – *Canadian J. Earth Sci.*, 53 (11); DOI: 10.1139/cjes-2016-0026

The Strandja Massif, Northwestern Turkey, forms a link between the Balkan Zone of Bulgaria, which is correlated with the Variscan orogen in Europe, and the Pontides, where Cimmerian structures are prominent. Five fault-bounded tectonic units form the massif structure:

(1) The Kırklareli Unit consists of the Paleozoic basement intruded by the Carboniferous to Triassic Kırklareli metagranites. It is unconformably overlain by Permian and Triassic metasediments.

(2) The Vize Unit that is made of Neoproterozoic metasediments, which are intruded by Cambrian metagranites, and overlain by the pre-Ordovician molasse. Unconformably laying the Ordovician quartzites pass upward into quartz schists and then to alternating marble and chert of, possibly, latest Devonian age. Rocks of the Vize Unit are intruded by the Late Carboniferous metagranites. The Vize Unit may be correlated with the passive continental margin of the Istanbul Zone.

(3) The Mahya accretionary complex and (4) the paired Yavuzdere magmatic arc were formed in the Carboniferous.

(5) Nappes consisting of the Jurassic dolomites and marbles thrust to the north in Late Jurassic–Early Cretaceous time. They occupy the highest structural position on all above-mentioned tectonic units. Tectonic subdivision of the Strandja Massif is supported by new 18 ages of magmatic and detrital zircons. The long duration of subduction-related magmatism in the region and its continuity in the Triassic contradicts with the widely accepted ideas about the dominance of the passive continen-

tal margin settings in the tectonic evolution of the Strandja Massif. The massif is interpreted as a fragment of the long-lived, Cambrian to Triassic Silk Road magmatic arc. At least since the Late Paleozoic this arc evolved on the northern side of Paleo-Tethys.

Nikova, I., V. Tsolova, B. E. Hristov, A. Zdravkov, K. Rouskov. 2016. Geochemical pattern of soils in Bobovdol valley, Bulgaria. Assessment of Cd and Co contents. – *Eurasian J. Soil Sci*., *5* (3), 172–181; DOI: 10.18393/ejss.2016.3.172-181

The chemical composition of soils spread in the Bobovdol valley was studied in order to reveal the natural and anthropogenic patterns of Cd and Co spatial distribution. A sampling procedure based on the irregular grid of points and validated analytical methods were used in the field and laboratory studies. It is found that Cd content varies from 0.21 to 0.90 mg kg^{-1} in studied soils and the average value of 0.55 mg kg^{-1} coincides with concentration demarcating soil pollution (0.5 mg kg^{-1}). Co content ranges from 2.22 to 15.76 mg kg^{-1} and in 70% of sampled points exceeds the natural background content of 7.8 mg kg^{-1} found in local rocks. Still, Cd enrichment of studied soils is more significant than Co's with coefficient of Clarke concentration of 3.67. Hence, the secondary deposition of studied elements as a result of the Bobov dol Thermal power plant air emissions is verified by results obtained. The spatial distribution of Cd and Co is featured with an altitudinal gradient in deposition and a trend of quantitative depletion in the south of plant. Soil organic matter and pH have no influence on the content and spatial distribution of studied elements. Elements Fe affinity governs their geochemical linkage in soils although Co occurs allied with Al and Ti.

Petrík, I., M. Janák, N. Froitzheim, N. Georgiev, K. Yoshida, V. Sasinková, P. Konečný, S. Milovská. 2016. Triassic to Early Jurassic (c. 200 Ma) UHP metamorphism in the Central Rhodopes: Evidence from U-Pb-Th dating of monazite in diamond-bearing gneiss from Chepelare (Bulgaria). – *J. Metamorph. Geol*., *34* (3); DOI: 10.1111/jmg.12181

Evidence for ultrahigh-pressure metamorphism (UHPM) in the Rhodope Metamorphic Complex comes from occurrence of diamond in pelitic gneisses, variably overprinted by granulite facies metamorphism, known from several areas of the Rhodopes. However, tectonic setting and timing of UHPM are not interpreted unanimously. Linking age to metamorphic stage is a prerequisite for reconstruction of these processes. Here we use monazite in diamond-bearing gneiss from Chepelare (Bulgaria) to date the diamond-forming UHPM event in the Central Rhodopes. The diamond-bearing gneiss comes from a strongly deformed, lithologically heterogeneous zone (Chepelare Mélange) sandwiched between two migmatized orthogneiss units, known as Arda-I and Arda-II. Diamond, identified by Raman micro-spectroscopy, shows the characteristic band mostly centred between 1332 and 1330 cm^{-1}. The microdiamond occurs as single grains or polyphase diamond+carbonate inclusions, rarely with CO_2. Thermodynamic modelling shows that garnet was stable at UHP conditions of 3.5–4.6 GPa and 700–800 °C, in the stability field of diamond, and was re-equilibrated at granulite facies/partial melting conditions of 0.8–1.2 GPa and 750–800 °C. The texture of monazite shows older central parts and extensive younger domains which formed due to metasomatic replacement in solid residue and/or overgrowth in melt domains. The monazite core compositions, with distinctly lower Y, Th and U contents, suggest its formation in equilibrium with garnet. The U-Th-Pb dating of monazite using electron microprobe analysis yielded a c. 200 Ma age for the older cores with low Th, Y, U and high La/Nd ratio, and a c. 160 Ma age for the dominant younger monazite enriched in Th, Y, U and HREE. The older age of around 200 Ma is interpreted as the timing of UHPM whereas the younger age of around 160 Ma as granulite facies/partial melting overprint. Our results suggest that UHPM occurred in Late Triassic to Early Jurassic time, in the framework of collision and subduction of continental crust after the closure of Palaeotethys.

Popova, M., R. I. Kostov. 2016. Gold and "silver-like" (graphite) glittering decoration: symmetry patterns on Chalcolithic (5th mill. BC) pottery from Eastern Bulgaria. – In: Darvas, G. (Ed.). *Symmetry Festival 2016*. Vienna, 180–183.

Symmetry patterns attributed to some of the G20 (rosettes) or G21 (friezes) symmetry groups are described on both gold and "silver-like" (graphite) decorated pottery from the Chalcolithic (middle-end of the 5th millennium BC) Varna I Chalcolithic necropolis (Varna culture) and from sites of the Kodžadermen-Gumelniţa-Karanovo VI culture in Eastern Bulgaria.

Stübner, K., K. Drost, R. Schoenberg, M. Böhme, J. Starke, T. A. Ehlers. 2016. Asynchronous timing of extension and basin formation in the South Rhodope core complex, SW Bulgaria, and Northern Greece. – *Tectonics*, *35*; DOI: 10.1002/2015TC004044

Upper crustal extensional structures range from steep normal faults to shallow-dipping detachments. The relationship between extension and formation of synkinematic hanging wall basins including their relative timing is not well understood. The South Rhodope core complex, Southern Balkans, has experienced extension for >40 Ma leading to a number of extensional structures and Cenozoic sedimentary basins. We present new bedrock and basin detrital zircon and apatite (U-Th-Sm)/He ages from the Pirin and Rila Mountains and the Sandanski basin. Results identify 3 episodes of Cenozoic extension in SW Bulgaria accommodated by (1) the Eocene/Oligocene Mesta detachment; (2) the Early to Middle Miocene Gorno Spanchevo fault (circa 18–15 Ma), which is the northern prolongation of the Strymon low-angle detachment; and (3) the Late Miocene West Pirin fault (≤10 Ma). Detachment faulting on the Strymon fault accommodated tens of kilometers of ENE-WSW extension and created ~1500 m topographic relief, but because the resulting hillslopes were gentle (≤10°), extension did not lead to enhanced footwall erosion or formation of a hanging wall basin. In contrast, the West Pirin normal fault resulted in mostly vertical motion of its footwall causing steep topography, rapid erosion, and formation of the synrift Sandanski basin. Digital topographic analysis of river channel profiles identifies the latest episodes of deformation including westward tilting of the Sandanski and Strymon basins and Quaternary N-S extension. This study demonstrates that basin formation in the South Rhodope core complex is related to normal faulting postdating the main pisode of crustal stretching by detachment faulting.

Tchoumatchenco, P., M. Durand-Delga, J. Ricour, M. Wiazemsky. 2016. Geologists of Russian origin in the francophone countries. – *Boletin Geologico y Minero*, *127* (2/3), 689–716.

Many ethnic Russian geologists have lived and worked in francophone countries. We describe in this paper the life and career

of geologists (i.e. all Earth scientists – geologists, mineralogists, tectonicians, geophysicists, geochemists, paleontologists, mining and drilling engineers, hydrogeologists, cosmos-geologists, etc.), regardless of their original nationality (Russians, Ukrainians, Tatars, Germans, etc.) born in the territoryof the Russian Empire, the Soviet Union or the Russian Federation.

Tsirambides, A., A. Filipidis. 2016. Gold metallogeny of the Serbomacedonian-Rhodope metallogenic belt (SRMB). – *Bull. Geol. Soc. of Greece, 50. Proc. 14th Conf.*, Thessaloniki.

The Alpine-Balkan-Carpathian-Dinaride (ABCD) metallogenic belt, which tectonically evolved during Late Cretaceous to the present, is Europe's premier metallogenic province, especially for gold. Three spatially distinct tectonic and metallogenic belts are associated with this belt. One of them is the Serbomacedonian-Rhodope Metallogenic Belt (SRMB) which intersects with a NNW-SSE trend the SE Balkan countries. This belt includes the geotectonic zones of Vardar (Axios), Circum-Rhodope, the Serbomacedonian and Rhodope Massives. It comprises dominantly carbonate replacement or porphyry metal deposits, stratiform volcano-sedimentary deposits, skarns and various isolated magmatic-hydrothermal deposits. The most significant Au metallogeny centers of this belt are found in Bulgaria (i.e., Madzharovo, Adatepe, Madan, Lozen), Greece (i.e. Perama Hill, Sapes, Maronia, Olimpias-Stratoni-Skouries, Gerakario-Vathi-Pontokerasia), F.Y.R.O.M. (Buchim, Ilovitza, Alshar), Kosovo (i.e. Trepca), and Serbia (i.e. Lece district: Kiseljak, Bacrenjaca). The metal reserves in all categories in the SRMB are 24 t Au, 14 t Ag and >100 Mt (Pb+Zn) ore in Bulgaria, 743 t Au, 4100 t Ag, 5345 th. t Cu, and 3125 th. t (Pb+Zn) in Greece, 106 t Au, 96 t Ag, and 834 th. t Cu in F.Y.R.O.M., >150 Mt (Pb+Zn) in Kosovo, 118 t Au and 1270 th. t Cu in Serbia. In addition many other sites inside this belt exist which are very promising for precious metals.