Geodynamics and ore deposit evolution of the Alpine-Carpathian-Balkan-Dinaride Orogenic System

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Editorial

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Introduction

This Thematic Issue is one of several outcomes of an international research initiative within the framework of the European Science Foundation Programme *Geodynamics and Ore Deposit Evolution* (ESF, 1998–2003). The GEODE Programme aimed at integrating the tectonic evolution of Europe with its diverse endownment of mineral deposits. Some of these were of world-class significance historically while others are currently mined or re-explored based on modern methods and geological concepts. This diversity of ore deposits in Europe and the increasing global need for essential mineral resources are calling for a compilation of relevant regional data and modern research, to understand the fundamental processes that govern the distribution of European mineral resources in space and time. In conjunction with a sound economic, social and environmental assessment, an improved geological information base and a rigorous understanding of ore-forming processes should help establishing a new era of responsible use of mineral resources in Europe and worldwide. International interest as well as public concern currently focus on countries in southeastern Europe, where some of the greatest potential for undiscovered deposits still exists, but also some of the most severe environmental threats left behind by mining in the past. The development of modern mines can contribute not only to wealth generation in commonly very poor communities, but also raise the funds and introduce the technology needed for environmental rehabilitation of large regions that are already polluted by centuries of earlier mining.

The ABCD-GEODE project

The largest project within the GEODE Programme has focused on the Alpine – Balkan – Carpathian – Dinaride (ABCD) belt, one of Europe's major metallogenic provinces in a geologically young geodynamic setting. This project involved funding and intense collaboration between scientists from many countries including Austria, Bulgaria, Croatia, France, the Netherlands, Romania and Switzerland. Given the fragmented nature of geoscientific information and relevant expertise ten years ago, particular recognition is due to the organisers of initial preparation workshops, as well as the participants and sponsors in government and the exploration industry. The initial GEODE planning meeting was organised by Derek Blundell (London, 1996). Important ABCD-GEODE workshops and field excursions were held at Borovets (2000, Bulgaria; organised by I. Peytcheva and K. Bogdanov), Vaţa Bai (2001, Romania; E. Roşu, G. Udubaşa and P. Ivascanu), Sofia (2002, Bulgaria; R. Moritz and A. von Quadt), and finally in Grenoble (2002; N. Arndt) and Seggauberg (2003; F. Neubauer and R. Handler), where scientific results were compiled and the present issue of SMPM was planned. First results of the ABCD-GEODE research were published in a special issue of Mineralium Deposita (Heinrich and Neubauer, 2002) and a Special Publication by the Geological Society of London (Blundell, Neubauer and von Quadt, 2003). A thematic issue of Ore Geology Reviews is in preparation by Blundell and others (2005) summarising some of the broader-scale outcomes of the GEODE Programme. A publication list of all refereed publications and abstracts from the ABCD project and other GEODE results are available at http://www.gl.rhul.ac.uk/geode/news.html
Although GEODE has been formally completed, collaborative research is continuing and the GEODE homepage including access to the LODE ore deposit database will be maintained.

The Alpine–Balkan–Carpathian–Dinaride geodynamic and metallogenic belt

The ABCD belt is one of the world's oldest mining areas which profoundly influenced the history of European evolution. It is Europe's premier Cu-Au province, especially for porphyry-style and epithermal deposits associated with calc-alkaline magmatism. The ABCD metallogenic and geodynamic province is part of the Alpine–Himalayan orogenic system, which is the result of convergence of the African, Arabian and Indian plates and their collision with Eurasia. As a result of the

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complex geometry of the closing Tethys ocean, major calc-alkaline magmatism is associated with certain segments along the Alpine-Himalayan system, whereas other segments are characterised by extension or by crustal metamorphism. The segmented character of this orogen is reflected by an equally discontinuous distribution of hydrothermal base and precious metal deposits of Cretaceous and Tertiary age, some of which are intrusion-related while others originated as a result of regional metamorphism and postorogenic collapse.

The first paper in this issue, serving as a regional introduction, describes a major product of the GEODE project. It adresses the call by government agencies as well as the exploration industry for a consistent and spatially coherent dataset of geographical, geological, geophysical, geochemical and mineral deposit data in a Geographic Information System. The *GIS Central Europe* includes a 3-D representation of the structure of the lithosphere based on seismic tomography, as well as a number of environmental data layers.

The following three papers present new results about late-metamorphic ore deposits in the Rhodope region of Bulgaria. The classic polymetallic vein and carbonate replacement deposits of Madan have been studied by high-precision geochronology. A geochemical investigation of inclusion fluids led to the first intergration of ore-metal analyses in the evolving fluid with thermodynamic modelling of hydrothermal mass and heat transfer, leading to an estimate of the duration of lead–zinc mineralisation. Ada Tepe is a new type of epithermal gold deposit hosted in sediments immediately above the detachment of a large extensional core complex and has the potential of becoming the next modern gold mine in Bulgaria.

All significant porphyry and high-sulfidation epithermal Cu-Au deposits of Bulgaria are located in the so-called Panagyurishte corridor, obliquely traversing the E–W-extended Srednogorie zone of Cretaceous calc-alkaline magmatism. Basement evolution, igneous geochronology and geochemistry, and a review of the mineralogical and isotopic characteristics of the major epithermal Cu-Au deposits including Chelopech are presented in a series of four papers, indicating an intimate association of epithermal deposits with coeval porphyry copper mineralisation. The Apuseni Mountains of Romania are Europe's largest epithermal Au-Ag-Te province, including world-class gold deposits at Roşia Montană and Săcărâmb as well as significant porphyry-Cu-Au deposits. Geology, K–Ar ages, paleomagnetic and geochemical data indicate that the mineralising magmas were generated by extensional melting of previously metasomatised mantle in the Miocene, with magma emplacement attending large-scale block rotation around a promontory of the former European continental margin.

Idrija is the worlds second largest mercury deposit after Almaden, located in the Dinarides of Slovenia. It formed as part of a diverse family of low-temperature hydrothermal ore deposits of Fe, Hg and base metals hosted in sediments associated with Permian to Triassic rifting that preceded the opening of the Tethys. Sulphur isotope and fluid inclusion data indicate that Idrija formed in a surface-venting hydrothermal system driven by basaltic intrusions. Carbonate-hosted Pb–Zn deposits of Triassic age were metamorphosed during Tertiary regional metamorphism in the Central Alps, leading to mobilisation and reprecipitation of galena by fluid mixing in small but locally high-grade late-metamorphic veins, as documented with a microchemical study of fluid inclusions in the last paper of the issue.

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