Ore deposits related to felsic magmatism through time

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Shallow magmatic-hydrothermal ore systems, such as copper porphyries, molybdenum porphyries and tin-tungsten ore systems, as well as their epithermal superstructures, form at high level in orogenic belts (≤ 4 km) and have the same age distribution as their low-grade or non-metamorphic host environment, i.e. ≥ 90 % of their resources are of Phanerozoic age [1]. This is different from orogenic (mesothermal) gold deposits which form at deeper levels in metamorphic terrain (in a continuum of 2-20 km), with only about 50 % of gold resources of Phanerozoic age [2]. Rare-metal pegmatites (Ta-Sn-Li) form mostly in medium-grade metamorphic terrain (staurolite-kyanite stable), with spodumen present (≥12 km depth). Such relatively deep tectonometamorphic basement terrains are much less sensitive to erosional dispersion than the shallow orogenic domains and their ore deposits (and Ta resources) are dominantly of Precambrian age.

However, it is striking that major tantalum resources in western Australia (Greenbushes district, Yilgarn craton; Wodgina district, Pilbara craton) are all of Archean age, with about 2.8 Ga for the Wodgina and 2.5 Ga for the Greenbushes rare-metal pegmatite, respectively. The substantial rare metal enrichment in these pegmatites requires about 1000 times larger cogenetic peraluminous granite systems and an environment favorable for extreme reaction progress of magmatic fractionation processes, i.e. a reasonably thick continental crust. Further back in time, the giant Mesoarchean Witwatersrand gold-uranium placer province can be traced back to an Early Archean source domain of granitic affinity [3], underlining the presence of felsic magmatism with efficient metal enrichment already at ~3.1 Ga, although this domain has not survived tectonic diffusion.

The direct evidence of evolved felsic magmatism and related Ta ore formation in the Archean, and the indirect evidence for granite magmatism and large-scale hydrothermal Au-U ore formation in the Early Archean point to significant volumes of continental crust for that time. This is in accord with models of crustal evolution which suggest higher rates of crust generation in the Archean than in later times [4].

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Hydrocarbon Generation and Accumulation in the Unconventional Petroleum System of the Silurian Shale, Lublin Basin, Poland

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As natural gas demand increases worldwide, exploration for gas is increasingly focused on unconventional reservoirs, such as shale gas formations. The economic value of shale gas plays is determined by reservoir and completion quality. Reservoir quality parameters include porosity, permeability, clay content, cementation factors, the diagenetic history and other factors that affect the storage and deliverability of fluids contained in the pores of those rocks. Organic geochemistry input parameters for reservoir quality assessment take account of the fluid types in shale gas plays, their compositional characteristics, and the evolutional generation history of hydrocarbons in such systems.

We constructed a numerical model for the petroleum system of the Silurian Shale to integrate parameters that influence generation and migration/accumulation of hydrocarbons in the Lublin Basin. The Silurian strata in Poland are at present the target of intensive shale gas exploration, due to relatively high total organic carbon content (TOC), and good hydraulic fracturing and production potential based on its silica content. The Silurian Shale is a marine (Type II) source rock with hydrogen index (HI) below 600 mg/g and TOC up to 12%. Vitrinite macerals from vascular land plants are absent in these shales. Thus, the visible reflectance equivalent (VRE) based on analyses of bitumen was used to calibrate the heat-flow. The reflectance data suggest that the Silurian shale is within the gas generation window in the study area.

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