Exploration Focus: Hungary*

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Introduction

Hungary has been a petroleum producer since the early 20th century. Situated in the Neogene Pannonian basin, a prolific hydrocarbon province of Central Europe, the country offers various petroleum systems with several well established and some emerging play types. Hungary has seen thousands of wells drilled, having produced approximately 2.3 billion barrels of oil and 13 TCF of gas from hundreds of fields over the last 75 years. The creaming curve shows a characteristic temporal pattern with the majority of fields discovered in the middle of the last century and only a few new fields identified in recent years. Hungary has an increasing dependency on petroleum imports; the annual oil and gas production has been decreasing steadily, now at 5-6 MMBO and 90-100 BCF, respectively, supplying around 10 to 20% of its annual consumption.

With one of the highest shares of natural gas in its energy mix within the EU, and strong dependence on its main supplier, Russia, domestic hydrocarbon production will have to play an important role in securing Hungary's energy needs for the next decades. To achieve that goal, introduction of new exploration ideas and technologies are of key importance. In addition, a predictable and stable legal and financial framework for licensing is also essential to promote substantial investment required for E&P activities. Given the excellent infrastructure in place and highly favourable market conditions (geographic location, oil-linked gas price), the country has a lot to offer for future exploration. This article gives a high-level overview on the well known and emerging petroleum systems in Hungary followed by a summary on exploration status.

Petroleum Systems

Details of the petroleum geology in Hungary, located in the heart of the Pannonian basin, have been outlined in several publications (e.g., Dank, 1988; Horváth and Tari, 1999; Dolton, 2006; Tari and Horváth, 2006; Badics and Vető, 2011). Well-known petroleum systems are

linked to three main tectonostratigraphic units, commonly with overlapping elements and events (Figure 1). Related fields are scattered around the country, testifying to a rather complex Tertiary structural development juxtaposing tectonic units of different geological evolution.

Late Tertiary Pannonian Basin System

By far the most and largest fields have been discovered in the Neogene to Quaternary sedimentary fill of the Pannonian basin. At a large scale, these fields are generally located at the periphery of major depocenters suggesting a strong link between generation and accumulation of hydrocarbons (Figure 2). This young and still active petroleum system is primarily sourced by Miocene dark shales (Tekeres, Szilágy, Budafa, Endrőd formations) with a wide range of geochemical character from marine to lacustrine in origin; i.e., oil and gas-prone (type II and type III, respectively) kerogens, or commonly the mixture of those. Thermogenic oil and gas generation has been taking place below the depth of 2500 m for the last 5-10 Ma. Associated overpressure or buoyancy forces have expelled hydrocarbons vertically along fractures and fault zones to higher stratigraphic levels. Long-distance lateral migration alongside major unconformities or within fractured basement units also took place. Production is mostly coming from middle to upper Miocene reservoirs situated in various structural positions, such as drape or compactional anticlines over basement highs, folding of the strata due to inversion episodes, tilted fault blocks, growth faults, roll-over features, and flower structures at wrench fault zones. Stratigraphic trapping, commonly structurally controlled, took advantage of shale pinch-outs and pinch-outs in turbiditic, delta plain and fluvial sand bodies, patch reefs, and algal limestones, volcanic tuffs; or at regional unconformities between main tectonostratigraphic units.

Historically, most discoveries represent a relatively simple exploration concept focusing on the geophysical imaging and drilling of a variety of structural highs and their immediate flanks (e.g., Algyő field). Thus, given the high level of drilling activity for decades, it is fair to say that most of the largest, structurally controlled, conventional accumulations have been found in the Neogene basin fill. However, related satellite fields and other underexplored or overlooked conventional play types are also of commercial importance. In addition, unconventional plays within the Late Tertiary petroleum system offer a remarkable potential with reported reserve estimates comparable to volumes produced to date.

Paleogene Basin

In Northern Hungary, lower Oligocene shaly sequences (Tard and Kiscell Clays) have been identified as good source rocks for both oil and gas. Geochemical data and basin modeling suggest that hydrocarbon generation took place during the last 10 Ma, i.e. during the intensive thermal event associated with Pannonian extension and related volcanic activity. Fields are limited in size and confined primarily to Oligocene sands interfingering with shales, commonly providing effective self-sealing of the strata. Underlying fractured basement rocks and overlying Miocene carbonates also contain hydrocarbons. Traps are mainly structurally controlled as fault compartments or tilted blocks. Parallel to the main tectonic lineaments in Hungary lies the NE-SW-trending Szolnok Paleogene Flysch zone, a strongly deformed unit offering source as well as reservoir rocks with a variety of lithology. This gas-prone system contains relatively modest-size accumulations and is also feeding the overlying Neogene strata. Mixture of thermogenic gases from different sources and gases of biogenic origin makes up a good example of interacting hydrocarbon systems (e.g., Hajdúszoboszló field).

Pre-Tertiary Basement Units

Abundant Mesozoic units, and possibly Paleozoic sequences, provide excellent source rocks at several stratigraphic levels including Upper Triassic organic marls, and Lower Jurassic and Upper Cretaceous (Senonian) dark shales. These rocks are sourcing reservoirs with a wide spectrum of age and lithology, such as Triassic carbonates, Senonian reef limestones and Miocene siliciclastic sequences (e.g., Nagylengyel field). Exact timing of events in this petroleum system is difficult to assess due to complex basin evolution and deformation history. Tentatively, the peak of hydrocarbon generation and subsequent migration and trapping took place relatively late, during Late Neogene times. Interaction between petroleum systems also occurred, top to bottom, when hydrocarbons generated from Miocene source rocks were squeezed into fractured and weathered basement units. In fact, sizeable fields in Hungary commonly produce from multiple pay zones involving different basement units as well as stacked sandstones within the Neogene basin fill.

Underexplored and Emerging Plays

This section focuses on targets that may get special attention in future exploration efforts, including known yet underexplored play types with proven potential and production, and the emerging unconventional plays that have come into focus in recent years.

Biogenic Gas

Biogenic production of isotopically light methane is recognized as a pervasive process within the Late Neogene through Quaternary sediments in Hungary. Paleoenvironments of this alluvial system with immature, organic-rich floodplain sediments (organic-rich shales, lignites, coal seams) and interfingering clean sand bodies (pointbars, levee systems), complemented by favourable thermal regime, provide appropriate conditions for the generation and trapping of dry gas. Accumulations occur mostly above depth of 2000 m (e.g., Hajdúszoboszló, Tatárüllés-Kunmadaras fields) mostly in uplift areas, where related pressure drop increases free gas content within pay zones. It is commonly associated with small- to moderate-sized fields, but commerciality is boosted by the shallow depth, typically 500-1500 m, of reservoirs. Systematic exploration of this play is in its infancy, although required methodology, AVO analysis of 3D seismics, is relatively straightforward.

Sub-thrust and Fractured Basement Play

Potential traps associated with the underexplored Alpine (mostly Cretaceous) thrust and fold belt beneath the Cenozoic basin fill offer important exploration targets in the basement of the Pannonian basin. These various, typically fractured Precambrian to Mesozoic units sometimes represent prolific producers discovered in relatively simple structural setting, i.e., on the flanks of basement highs adjacent to deep Neogene troughs and depocentres. Advancements in seismic imaging, however, now allow a systematic approach targeting more complex geometries beneath the basin floor, commonly within allochtonous imbricates at or below major thrusts and detachment horizons of Eoalpine (Cretaceous) origin. Various source rocks within the Mesozoic sequence may charge these structures, making up an exciting play of great potential. The considerable exploration risk inherently associated with this pre-Tertiary petroleum system can be mitigated by using highly sophisticated seismic technologies and modern subsurface interpretation techniques.

Unconventional Resources

In Hungary, Falcon-TXM Oil and Gas Ltd. has been pioneering the exploration of unconventional resources in its Makó trough licence (Figure 3). After completing a 1100-km^2 3D seismic campaign and a drilling program with 7 deep (>3500 m) wells, an active petroleum system with pervasive hydrocarbon saturation has been identified. This involves shale oil and gas play at the bottom of the basin within the organic-rich Endrőd shales and a tight gas play in the overlying Szolnok and Algyő turbiditic sand bodies. Falcon-TXM has reported some 40 TCF gas resources and 100 MMB oil resources from their production licence, while producibility and commercial assessment of this play is in progress. MOL, Hungary's national oil company, is running similar projects in the Derecske and Makó troughs, targeting the lower sections of the Neogene basin fill. Delcuadra, a consortium of Delta Hydrocarbons, Cuadrilla Resources, and RAG, has successfully fraced and produced tight Miocene sequences in the Kiskunhalas trough. WildHorse Energy has been working on an underground coal gasification (UCG) pilot, using their CBM exploration licence in the Mecsek Hills, S. Hungary. Near the borders of Hungary, several other unconventional operations have been taking place. Ascent's Petisovci project in Slovenia, INA/MOL's pilot in the Drava trough in Croatia and NIS's Majdan project in Serbia all target lower to upper Miocene high TOC shales and adjoining tight sediments. Further to the west, OMV is considering to drill two deep pilot wells to test the potential of the Jurassic Mikulov Shale in the Vienna basin. Inferences abroad will have a major impact on the evaluation of unconventional resources in the Hungarian part of the Pannonian basin.

Critical point in all of these unconventional projects is the commercial viability of establishing long-term production. High investment profile is typical for developing these HT/HP resources with stimulation (fracing) seen as a prerequisite, recognized and supported by the Hungarian government via a favourable royalty scheme. As with other major European unconventional programs, it remains to be seen how the industry in Hungary can make these unconventional plays economically feasible.

Exploration Status

The exploration arena in Hungary is fairly calm with only <20 wells drilled annually, some of them for appraisal and development purposes. MOL, Hungarian Horizon Energy (Aspect Energy), RAG, Pelsolaj (Ascent Resources) and Wildhorse Energy are the primary players holding licences, often in partnership with a handful of other companies, such as DualEX Energy, Geomega, JKX Oil and Gas, NIS, PetroHungaria, and Swede Resources. Since shutting down the open-door policy in October 2010, areas covered by exploration permits in Hungary have been and will be shrinking considerably and at a rapid pace (Figure 4). In spite of the sustained interest from investors, this is an undesirable process hampering exploration activity. Therefore, the Hungarian government is to introduce a new permitting system in the near future. E&P companies will be invited to a licensing round for various concessions blocks in a transparent, open-bid-round procedure. Locations of the first three concession blocks have been published, reflecting genuine intentions to grant prospective areas with decent hydrocarbon potential.

Conclusion

Hungary offers excellent opportunities for the exploration community. While being a mature petroleum province, the country holds considerable reserves in its known petroleum systems. In addition, several underexplored and emerging play types present challenging yet very exciting targets for a wide spectrum of investors, from small-cap companies to international majors.

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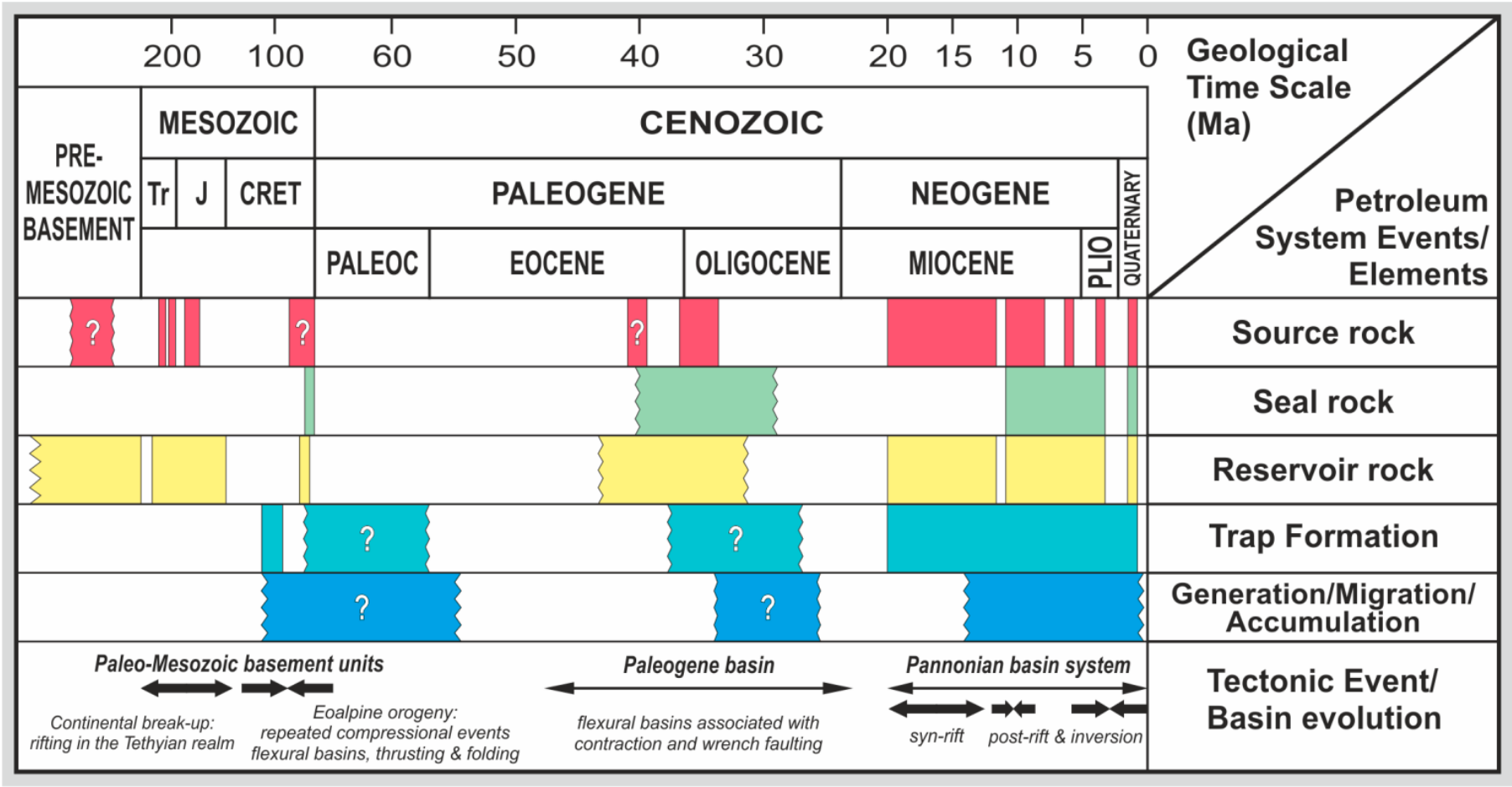

Figure 1. Principal petroleum system events and elements in the Hungarian part of the Pannonian basin, compiled after Dolton (2006), Tari and Horváth (2006), Badics and Vető (2011).

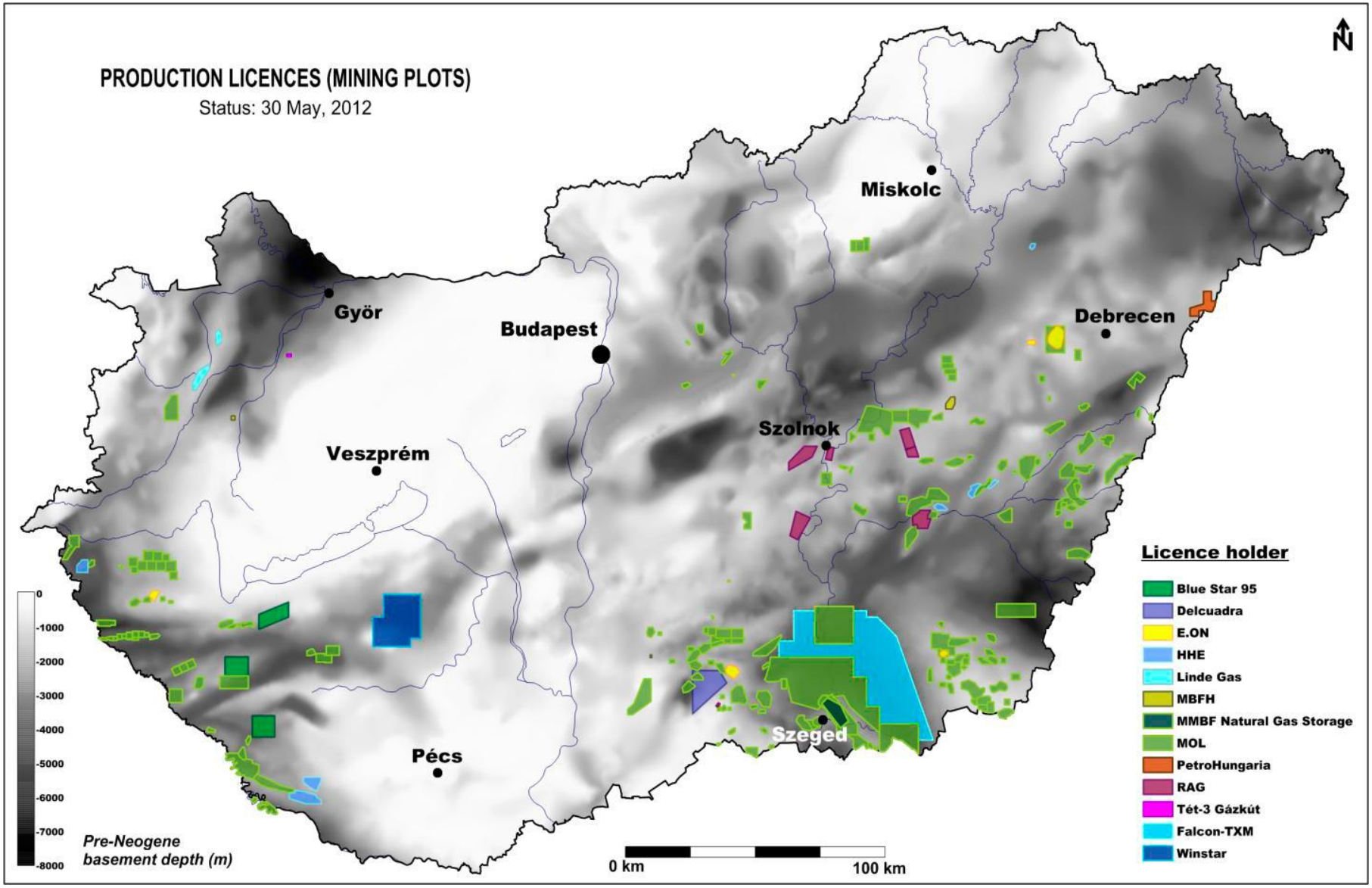

Figure 2. Location of producing fields in Hungary as reflected in the areal distribution of production licences ("mining plots") overlain on the depth map of pre-Neogene basement. Status: 30 May, 2012. Source: Hungarian Office for Mining and Geology (MBFH).

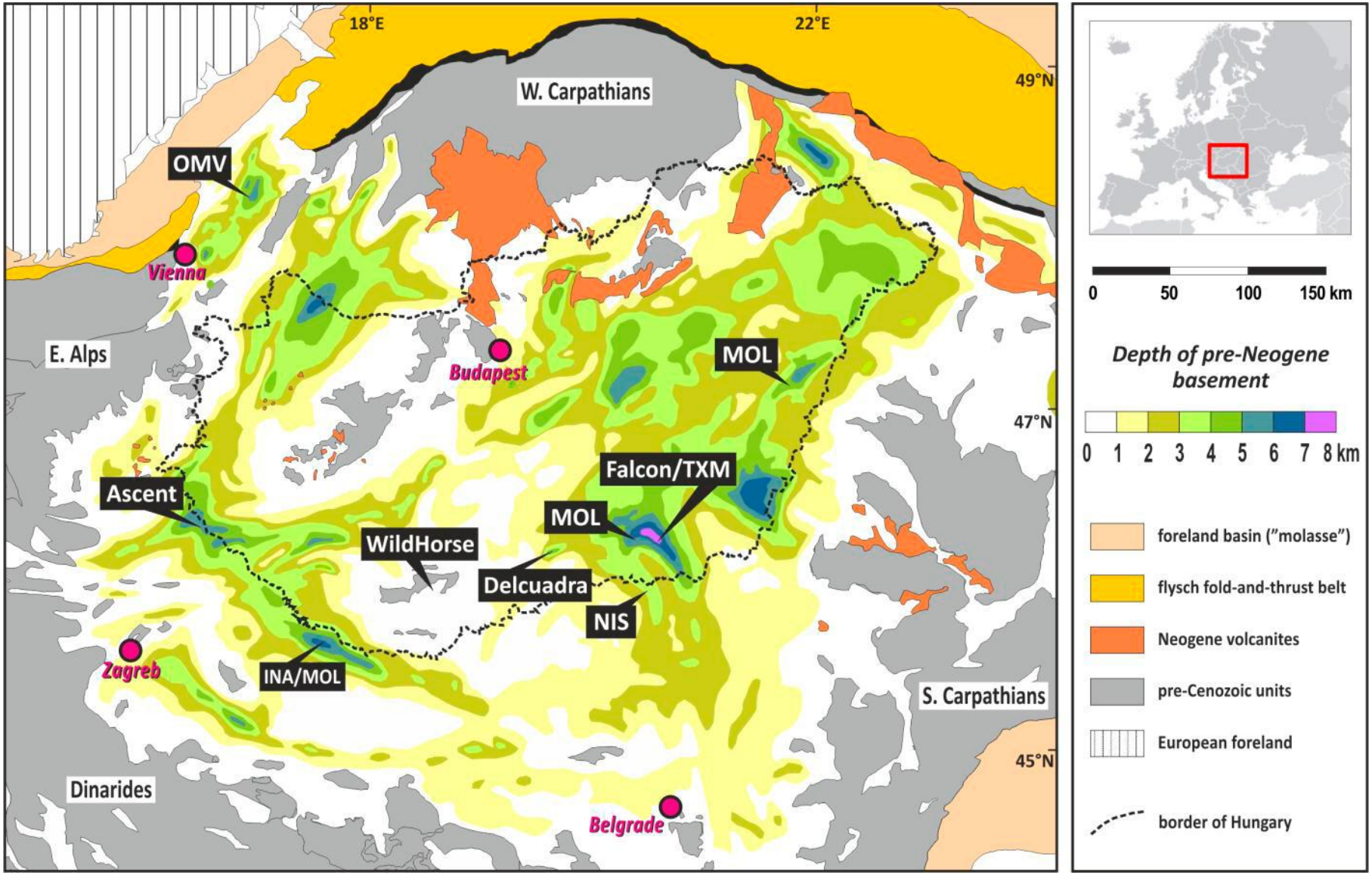

Figure 3. Activity map of unconventional exploration in Hungary and immediate vicinity overlain on the depth of pre-Neogene basement in the Pannonian region.

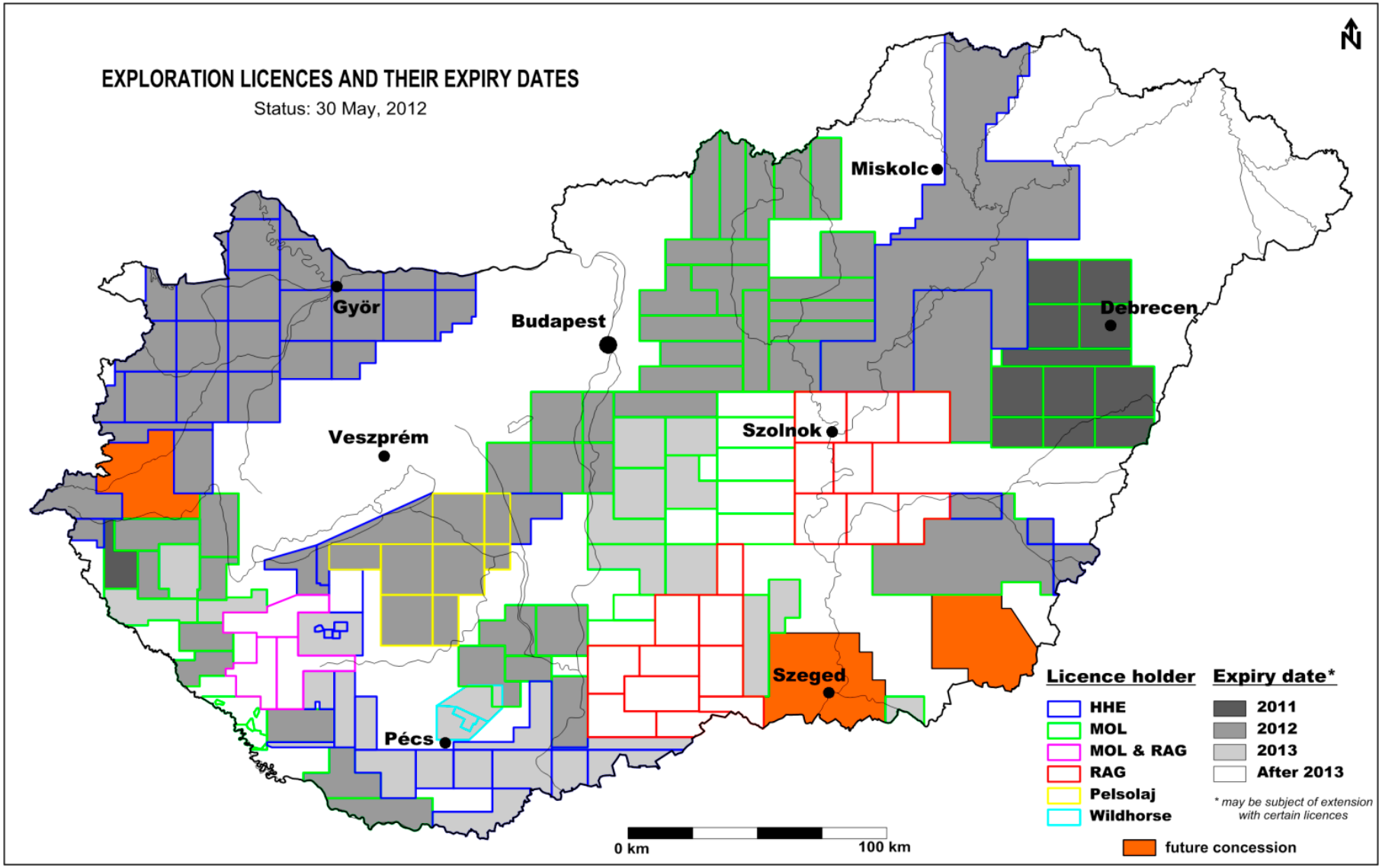

Figure 4. Exploration licences and their expiry dates in annual breakdown, and the location of 3 future concession blocks. Status: 30 May, 2012. Source: Hungarian Office for Mining and Geology (MBFH).