Book Review

Oil and Gas in Alpidic Thrustbelts and Basins of Central and Eastern Europe, Wessely G. & Liebl W. (Eds.), 1996, Special Publication of the European Association of Geoscientists and Engineers, No. 5, Geological Society, London, 448 pp. ISBN 1-897799-73-X.

The semi-circle of Eastern-Southern Alps and Carpatian fold-thrust belt encircling the Pannonian Basin and continuing SE into Balkan ridges links directly a number of countries of central, eastern and southern Europe. Obviously, the state frontiers do not coincide with geological boundaries so that neighbouring countries find their common interest in exchange of geological information and research data when carrying on petroleum exploration within the same specific geologic units.

The volume reviewed here arosen from European Association of Geoscientists and Engineers (EAGE) conference held in Vienna 1994 represents an outstanding expression of common interest of East and West European countries in exploring the geological structure of the Alpine–Carpathian–Balkan orogenic belt together with its associated depressions. This special EAGE Publication is a set of 50 comprehensive and richly illustrated papers prepared by competent specialists. It is subdivided into five chapters showing the history and status of oil and gas exploration and production, tectonic setting of the thrustbelt basin system and more detailed petroleum geology of thrustbelts, their foreland and intramontane basins.

As mentioned by G. Wessely and W. Liebl (OMV, Vienna, Austria) the editors of the volume, the publication represents an example of co-operation between Middle and Eastern European scientists and also among members of oil and gas companies, universities and geological surveys.

Probably one of the most attractive is the paper presented by K. Decker & H. Peresson (p. 69) discussing the kinematics of the Alpine-Carpathian-Pannonian system. It shows the mechanism and history of tectonic events starting from plate convergence in Eastern Alps and westernmost Carpathians followed by orogen-parallel extension which was balanced by eastward lateral movement of crustal wedges of Eastern Alps into Pannonian area. The retreat of middle Miocene subduction along Outer and Eastern Carpathians triggered extension and back-arc type rifting of the Pannonian basin. The use of gravimetry to access geological structures in areas of complex tectonics in Central Alps and Apennines is presented by I. Marson & M. Štoka (p. 169).

The habitat of hydrocarbons in Austrian Northern Calcareous Alps and Flysch Zone specifically in its Molasse Zone basement, Vienna intramontane basin and Styrian basin is extensively discussed by W. R. Janoschek, O. Malzer & W. Zimmer (p. 43).

Basin analysis of Gossau Group (N. Calcareous Alps) by P. Faupl, M. Wagreich (p. 127) shows the deposition and facies distribution is there controlled by oblique subduction of Penninic Ocean beneath the active margin of Austroalpine microplate. H. Ortner & R. F. Sachsenhofer (p. 237) discuss the Tertiary Lower Inn Valley as an example of strike-slip tectonic graben developed in the substratum of N. Calcareous Alps. As pointed out by C. Regane *et al.* (p. 137) the seismic methods adopted hitherto prevent mapping of horizons within and below Calcareous Alpine thrusted complex. The solution of the problem requires the acquisition of 3-D seismic surveying. Moreover, new kinds of explosives are tested to improve seismic data quality (P. Fink *et al.*, p.147).

As shown by L. R. Wagner (p. 217) the plate tectonics and Alpine orogeny controlled the deposition in Molasse Basin. The original study on paleohydrodynamics explains the distribution of the oilfields in that basin (F. Schmidt, L. T. Erdogen, p. 225). The lithofacies and stratigraphy of Middle and Upper Crataceous marine and delta-like deposits under Austrian Molasse cover is presented by R. Fuchs and G. Wessely (p. 249).

The petroleum geology of the Molasse Basin extending to Germany is presented by G. H. Bachmann & M. Müller (p. 65). There, the distribution of overpressures in Bavarian Alps and their foreland caused by Alpine nappes thrusting is strictly related to the conditions of hydrocarbon generation and migration (M. Müller, F. Nieberding, p. 119). The Molasse Basin of Perialpine foredeep extends eastwards into West Carpathian Foredeep developed over southern slopes of Bohemian Massif (Czech Republic) where a number of oil and gas fields were discovered in crystalline – Palaeozoic relief highs, Jurassic and Paleogene reservoirs as well as in Miocene deposits filling the depressions and extending below Carpathian fold-thrust belt (J. Adamek *et al.*, p. 39). At the slope of Bohemian Massif there occur a number of canyons cut deeply by Late Cretaceous Early Tertiary rivers then filled with Paleogene marine sediments (R. Jiřiček, p. 269). Besides, the occurence of erosional deppresions of Karpatian age filled with Karpatian and Bohemian deposits was proved by recent seismic survey (J. Horacek, p. 267). This may be compared with the results of seismic modelling of Oligo-Miocene Gonfolite series filling the deepmarine canyon cut on the margin of Padan Foredeep (N. Lombardy, Italia) during South Alpine thrust movements. True vertical extension of the canyon and lithostratigraphic intervals of its fill have been recognized by A. Valdisturlo *et al.* (p. 155).

One of the most interesting papers is given by O. Krejči *et al.* (p. 177) showing depositional and tectonic evolution of autochthonous substratum of West Carpathians as referred to petroleum generation conditions.

Intramontane pull apart type Vienna Basin formed during Mid Miocene, containing more than 10 km thick autochthonous Paleozoic–Mezozoic, allochtonous Alpine–Carpathian flysch folds and thrusts and Neogene infill, represents an attractive petroleum basin extending from Austria to Moravian Bohemia and Slovakia. In subthrust complexes in the Alps and below Vienna basin there occur unconventional reservoir types under overpressure conditions (W. Zimmer, G. Wessely, p. 81). As results from seismic and sequence stratigraphy data during Early to Middle Miocene the terrestial-fluviatile sedimentation of Karpatian resulting from pull-apart effects changed into shallow-marine deposition during Badenian concurrently with strike slip deformation (M. Weissenbäck, p. 355). The Carpathian Nappes

overthrust took place between Late Oligocene and Early Miocene and terminated in Mid-Miocene times (G. Milan, R. Saver, p. 109). Soon after the hydrocarbons migrated up along deep-seated faults from autochthonous Jurassic source beds through the Alpine nappes into Tertiary traps (P. Seifert, p. 331). Jurassic and Paleogene source rocks entered oil window at least at 3.5 km depth and oils were expelled still much deeper at 4–5 km depth as reported by J. Francu *et al.* (p. 343) for Czech and Slovak parts of the Vienna Basin. The authors also suggest fractionation of hydrocarbons during two principal migration events.

The seismic survey in South Moravian part of Vienna Basin showed the importance of Schrattenberg Fault System for petroleum accumulation in Miocene reservoirs (V. Ciprÿs *et al.*, p. 391).

In Slovak part of the Vienna basin 20 oil and gas deposits were discovered (V. Hlavaty, p. 41). Within its basement the continuation of Austrian Glinzendorf Syncline was found (E. Ralbovsky, P. Ostrolucký, p. 145). The interpretation of 3-D survey using Geo Quest workstation showed the geological structure of Neogene infill and proved for petroleum perspectives of Lower Miocene (B. Šály, V. Jureňa, p. 385).

Miocene Pannonian Basin system is carried by several wedges which extruded from compressive Alpine West Carpathian sector during Neogene. Early to Middle Miocene strike slip and detachment faulting coincided there with thrusting and subduction of the Outer Carpathians. It was culminated by exhumation of metamorphic core complexes then, followed by regional subsidence and deposition of 4 km thick postrift sediments during Late Miocene concurrently with termination of thrusting in Eastern Carpathians. Postrifting thermal subsidence was interruped by two compressional events the first of them controlled the entrapment of hydrocarbons in Miocene strata (F. Horvath *et al.*, p. 415). In Hungary the most important for hydrocarbon accumulation are South West Miocene Graben and Miocene–Quaternary interior sag systems (G. Pogacs *et al.*, p. 37). Styrian Basin in Austria belonging to Pannonian Region can be subdivided into Ottnangian to Karpatian synrift and subsequent postrift phase. The rised heat flow due to Miocene volcanic activity resulted in early generation of petroleum (R. F. Sachsenhofer *et al.*, p. 393). It was also confirmed by J. Milička *et al.* (p. 431) for Danube Basin in Slovakia that the volcanism active during Miocene accelerated hydrocarbon generation in Neogene source rocks at depth over 2600–3000 m. The basin was formed there by crustal extension, faulting and rapid subsidence from Karpatian to Earliest Pannonian then, subjected to thermal subsidence and deposition of Neogene reaching 5500 m in thickness. The main perspective Neogene sequences are Lower Pannonian, Sarmatian–Badenian and pre-Neogene besement – possibly Triassic (J. Hrušecky *et al.*, p. 417).

In Eastern Slovakian Neogene Basin, where a few gas fields were discovered, there occurs high geothermal gradient of 45-58 °C/km and high reservoir pressure gradient of 1.5–1.8 (P. Danko, J. Lacny, p. 441). The temperatures reach 150 °C at 3000 m depth in central part of the basin. Formation pressures vary largely both in horizontal and vertical directions (R. Rudinec, J. Magyar, p. 445).

P. Karnkowski (p. 3) gives characteristics of the Polish Flysch Carpathians and Carpathian Foredeep as related to other petroleum provinces of Poland. The problem of searching for deep-seated structures of Borislav–Dolina type continuing westward onto the Polish territory remains still open. As noted by A. Ślączka (p. 187) the possibility of the new discoveries at greater depth in folded flysch structures is still high but requires the application of modern seismics and drilling technology. The autochthonous Miocene and Paleozoic substratum extends southwards under the central and western parts of Polish Flysch Carpathians which provides the best prospect for further petroleum exploration.

The same author in his second paper printed in this volume (p. 17) presents brief overview of petroleum geology of Ukrainian Carpathians and their Foredeep. In outer part of the Foredeep there prevail the gas fields accumulated in Miocene molasse and its Mezozoic substratum. Within inner part of the Foredeep 28 oil fields and 2 gas fields have been found in Borislav–Pokucie Upper Cretaceous to Lower Miocene fold zone (A. Ślączka, p. 17).

C. Dinu *et al.* (p. 23) give the overview of hydrocarbon resources of Romania where the first oil accumulations were discovered in Ploesti district in 1862 with its giant Moreni field discovered in 1900. Romanian Carpathians consist of eastern and southern segments, with Apuseni Mts in NW, all embracing Transilvanian Depression and a number of other intramontane depressions superimposed on Carpathian chain. The Romanian petroliferous basins occur in external part of East Carpathians, Carpathian Foredeep, Transilvanian Depression and a Pannonian Basin as well as Foreland Basins in Moesian, Moldavian and Scythian Platforms.

The tectonic and sedimentary reservoir conditions and burial history of Cretaceous to Early Miocene source rocks within Inner and Outer Moldavides are presented by M. Stefanescu & M. Melinte (p. 197).

New refraction profiling and DSS data from Russian part of East European Platform showed multistage structure of the crust disturbed by deep lystric faults which opens new petroleum prospects connected with the structures related to overthrusting of basement plates (V. B. Piip, E. A. Efimova, p. 283). Seismic reflection and refraction profiling data acquired recently inland Romania resulted in identification of lower and uper crust transition zone, sedimentary–basement boundary and some prominent reflections from autochthonous Mezozoic and Lower Sarmatian horizons. All these data enabled to present a new overall seismogeological image of Moesian and Moldavian platforms as well as Transylvanian and Pannonian depresions as related to Carpathian orogenic belt (V. I. Mocanu *et al.*, p. 289). As shown by C. Pene (p. 301) the Moesian Platform represented failed continental rift during Permo-Triassic which controlled the petroleum entrapment conditions in Triassic reservoirs. In Focsani Depression (NE part of Moesian Platform) the subcompaction zone occuring in the uppermost part of Miocene deposits creates the effective hydrodynamic sealing cover for possible gas accumulations entrapped in overpressured bodies in deeper parts of the basin (A. Damian, p. 309).

The petroleum exploration interest in the Black Sea has developed during the last 25 years. The seismic and drilling

data acquired from Romanian offshore demonstrate the southeastern continuity of Scythian Platform, North Dobrogean Orogeny and Moesian Platform seperated by first order faults and thrusts (I. Moroanu, p. 315).

In Russian sector of the Black Sea petroleum prospects are related to the extension of Tamansky Peninsula folds and southwestern continuation of Caucasus. Most perspective is northwestern Caspian with its continuation of Karpinsky Ridge and Prikumskaya Zone. Offshore petroleum prospects of Black and Caspian seas are connected with wide range of reservoirs from Jurassic to Neogene (Ya. P. Malovitsky *et al.*, p. 277).

In Bulgaria the Alpine orogenic belt was formed as a result of Mid-Cretaceous to Mid-Eocene collision of Thracian Massif microcontinent between African Plate and stable Precambrian–Paleozoic Moesian Platform of Euroasian plate. Most perspective for petroleum exploration is the transitional zone of Forebalkan and southern margin of Moesian Platform as evidenced by G. Georgiev (p. 29). The same author reports the widespread occurence of thick evaporites in NE zone of Eastern Forebalkans showing that the best reservoirs may occur beneath evaporites in depocentral zone of the basin (G. Georgiev, p. 201). The Bulgarian offshore petroleum prospects in the Black Sea attracted the attention of foreign companies (R. Ognyanov, p. 35). There, several new potential petroleum accumulation trends have been defined in offshore continuation of major tectonic units from Moesian Platform in the north to Burgas Depression in the south (P. Bokov *et. al.*, p. 325).

Besides, the structural evolution of Outer Hellenides fold belt is shown from 180 km long deep seismic reflection profile offshore Greece (E. Kemberis *et al.*, p. 207).

Summing up, the presented papers show that advanced sedimentary, stratigraphic, tectonic and geochemical studies result in precise modelling and a new concept of the evolution of petrolifenous basins of Carpathians and their related depressions. The source rocks are identified, their degree of maturity and petroleum potential are quantified, the time–temperature conditions of petroleum generation, the directions of fluid migration and most favourable sites for petroleum accumulation are established.

Special attention is given to the buried paleorelief of Carpathian foredeep autochtonous substratum. Its cut-in-fill canyons, paleoriver channels, paleomorphologic highs and drape structures control the occurence of subtle stratigraphic and lithostratigraphic traps. The application of modern seismics, seismic and sequence stratigraphy allowed to recognize potential reservoir sand bodies like deltaic channels and sand-bars within Tertiary infill of Carpathian foredeeps.

As evidenced by numerous authors the development of paleohydrodynamic flow conditions, subcompaction barriers, evaporite deposition and salt structures was important factor favouring the petroleum accumulation in Carpathian foredeep and intramontane depressions.

It has also been stressed that autochthonous platform basement extends at a long distance under the cover of Carpathian fold-thrust orogene which opens new attractive perspectives for petroleum exploration. It's only a pity that less attention was paid to the structure and tectonic development of Carpathian orogenic belt itself.

Nevertheless, the volume represents impressive step forward in understanding the evolution and petroleum perspectives of Alpian-Carpathian Region and related areas. The book is worth to be recommended to all the geoscientists working on sedimentation, stratigraphy, tectonics, petroleum geology and geophysical research of the Carpathians.

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