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Abstract - Note

The Lower Pannonian (s.str.) in the Sava River Depression - - A Great Challenge for More Economical Oil Exploration

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The lateral extent of the Lower Pannonian within the Sava basin will be discussed. Sediments of this sub-age have been mapped and separated on outcrops in the rim of depression and in cores and logs of drilled deep wells as: the lithostratigraphic unit *Prkos formation*; the biostratigraphic units *Cenozoone Radix croatica* and *Cenozoone Sinzowella (Nubecularia) novorosica*, and the chronostratigraphic unit *Lower Pannonian sub-stage*.

There are significant data showing that these units may be serious targets for the existence of trapped or bypassed oil and/or gas. Sediments of the Lower Pannonian substage were deposited over a relatively short period from 11 Ma till 9.5 Ma in a duration of 1.5 million years. A set of palaeogeographic and biochemical conditions resulted in a deposition of a **limestone facies** (of algae and of chemical origin) and a **calcareous sandstone** with benthic foraminifera, ostracods and molluscs. Due to their petrographic, palaeontological and stratigraphic characteristics these sediments have been studied by numerous authors (GORJANOVIĆ-KRAMBERGER, 1891; LASKAREV, 1924; OŽEGOVIĆ, 1944; JENKO, 1944; MOOS, 1944; BOŠKOV ŠTAJNER & TOMASOVIĆ, 1967; PLETIKAPIĆ, 1969; BOŠKOV ŠTAJNER & KOCHANISKY DEVIDE, 1975; PAPP, 1985; YANKO & LARCHENKOV, 1991; ŠIKIĆ, 1995 and others). The immediate basement of these sediments is the Lower Sarmatian clayey deposit. The overlaying rock is a marlstone of the Upper Pannonian.

Three **orogenic phases** affected this area after these sediments and overlaying rocks have been deposited (BOŠKOV STEINER, 1986): the **Attican phase** (10 Ma ago), the **Rhodanian phase** (5 Ma ago), and the **Walachian phase** (2.5 Ma ago). All these factors, together with an adequate temperature and presence of catalysts, could have resulted in the generation of oil in Lower Pannonian sediments. Oil may have migrated into thin sandstone layers, fissures formed during mentioned orogenic phases and, what is most important, into the axial crests of brachi anticline (BOŠKOV

ŠTAJNER, 1961; BRITVIĆ et al., 1989). Longitudinal and transverse regional faults could have effected the decay of once existing reservoirs, as seen for example by the presence of high density and oxidised oil in outcrops of the Northern rim of the Sava basin, in Paklenica (BOŠKOV STEINER & STEINER, 1995)

Oil production exists from deep wells drilled at more localities from these sediments in the Sava basin (BOŠKOV ŠTAJNER & MARINOVIĆ, 1971). In these sediments oil was found:

- a) in the calcareous component in fissures of more generations;
- b) in sand lenses of small dimensions;
- c) in sand layers of large dimensions;
- d) in rock mirrors;
- e) in fractures and fissures along faults;
- f) in crests of brachi anticline axes.

I have chosen these sediments to propose the recovery of the by-passed and captured oil by horizontal or extended-reach wells, since it may be relatively easy to do the preparation for various reasons: basic geological maps showing outcrops of these sediments are available; outcrops with oil in fissures, in lenses and in members are disposable; outcrops containing oil are disposable in the earlier subsurface mining works; there are cores from deep wells drilled on several localities through these sediments; 2D seismic sections are available and may be reinterpreted; well logs and dip measurements of deep wells are available; and structural maps of bedding and thickness of the Prkos formation are available.

A reinterpreted map of oil and gas saturation forecast may be elaborated from earlier maps with additional analyses and supplementary 2D and/or 3D seismics. The potential area has to be defined using: correlation of seismic time markers; correlation of chronostratigraphic units; a study of the generative potential (after Lopatin, Waples, Barker and/or other methods); and Newendorp's method of Monte Carlo simulation of the oil or gas reservoir net recent value.

As to get a higher degree of certainty of the prognosis, on each of prospective area a vertical well may be drilled for checking the accuracy of existing data and

for the measurement of fissure orientation. The established reserves of the by-passed and captured oil we may put into production by conventional and non-conventional methods (HORVAT & BOŠKOV STEINER, 1990). By the rational teamwork of geologists, reservoir engineers and drillers, horizontal drilling of structures containing reservoirs with the by-passed and/or captured oil can be programmed and realised (STEINER & BOŠKOV STEINER, 1994).

These sediments, based on their recognised characteristics, may aid the reconstruction of the Sava depression area as a Datum Level for the professional petroleum geological understanding of the area and for forecasting of potential places of oil accumulation, and as a Datum Level for the broader geological scientific study of the Sava basin.

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