Characteristics of Hydrocarbon Fields in the Croatian Part of the Pannonian Basin

By J. VELIC, T. MALVIC, M. CVETKOVIC and B. VRBANAC

Abstract
Approximately $104 \times 10^6$ m$^3$ of oil from 39 fields, $6.93 \times 10^6$ m$^3$ of condensate (11 fields) and $64.92 \times 10^6$ m$^3$ of gas (52 fields) were recovered in the Croatian part of the Pannonian basin during 63 years of exploitation (1941–2004). The total production peak was attained in 1980, when exploitation began in 12 new fields. The longest production period is assumed to be for the largest fields; for oil it is approximately 55 years, whereas for condensate and gas 46 and 36 years of exploitation are expected, respectively. Water-flooding will probably be the dominant secondary-recovery method for increased production in the future, because CO$_2$ injection requires transport and analysis of fluid interactions.

Croatia’s Pannonian Basin Fields
Four large Neogene and Quaternary geotectonic units, regional structural depressions, are described for the Croatian part of the Pannonian basin system. Generally 30 years (1959–1989) can be described as a highly successful exploration period (Fig. 1a, 1b).

The total (geological) reserves are about $740 \times 10^6$ m$^3$ of equivalent oil, with recoverable reserves of $112 \times 10^6$ m$^3$ of oil, $10.74 \times 10^6$ m$^3$ of condensate and $100.67 \times 10^6$ m$^3$ of gas. Up to 2004 a total of $175.89 \times 10^6$ m$^3$ of equivalent oil had been recovered from Croatian fields, including 104.05 $\times 10^6$ m$^3$ of oil from 39 fields, 6.93 $\times 10^6$ m$^3$ of condensate from 11 fields and 64.91 $\times 10^6$ m$^3$ of gas from 52 fields [1, 5] (Fig. 1a).

The number of new fields rapidly increased in the sixties for oil and in the eighties for gas (Fig. 1b). This period was followed by a drastic decline in new discoveries. Generally 30 years (1959–1989) can be described as a highly successful exploration period, when potential structural and combined traps could be observed by use of several easily applied methods.

The cause for a rapid decrease in production after 1989 is threefold: depletion of older fields, and consequently a substantial decrease in exploration activities. The most often used production mechanisms were: (a) for the largest fields, artificial lift and gas lift, rarely flowing; (b) for medium fields, artificial lift; (c) for small fields, artificial and gas lifts. The most applied secondary recovery method for many fields is water injection.

For the largest oil fields, reservoirs are sandstones of Pannonian and Pontian age, mostly favourable values of petrophysical properties and recoveries [4]. The reservoir permeability is significantly decreased in the smaller reservoirs: The largest fields could have the longest production.

The results obtained can be viewed in context with the results published earlier in this journal [2]. Dobrova et al. ranked Croatia in third place according to the remaining recoverable liquid reserves in the central and eastern European states at the end of 2002 (Romania first, 39%; Ukraine second, 25%; and Croatia, Austria and Belarus third, 6%). This is why we have rechecked our calculated values of recoverable reserves, cumulative production and remaining reserves against values published earlier [2]. It is obvious that more recent production data from Croatian hydrocarbon regions are lower, compared with data published in 2003. Even if condensate reserves are added...
Comparison of Croatian's recoverable reserves of oil and gas, cumulative production and remaining reserves based on data from two sources

DOBROVA et al., 2003 [2]

<table>
<thead>
<tr>
<th>Recoverable reserves</th>
<th>Cumulative Production</th>
<th>Remaining Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (10^6 m^3)</td>
<td>Gas (10^6 m^3)</td>
<td>Oil (10^6 m^3)</td>
</tr>
<tr>
<td>141.18</td>
<td>108.11</td>
<td>109.70</td>
</tr>
<tr>
<td>26.16</td>
<td>104.05</td>
<td>(106 m^3)</td>
</tr>
</tbody>
</table>

(preserves given in brackets at the right columns are condensate volumes)

Conclusions
Some remaining hydrocarbons could be recovered from proven reserves in the Croatian part of the Pannonian basin. It is obvious also that there are some subtle, potentially large reservoirs [3] and the remaining reserves given in Table 1 also supports this. Significant reservoir volumes can be expected in Neogene basement rocks as well as Lower and Middle Miocene sediments, consisting of different lithofacies. The targets are also typical heritage structures above pre-Neogene buried hills. In Pannonian and Pontian sediments in which the main focus should be stratigraphic traps, typically along subtle or gentle anticlinal structures, and in areas of large thicknesses of Neogene areas of differential compaction are very interesting.

References


Josipa Velic joined the Institute of Geology in 1972. In 1974 she began work at the Faculty of Mining, Geology and Petroleum Engineering of the University in Zagreb (Department of Geology and Mineral Resources), where she is presently employed. She received her Ph D in 1980 and was promoted from Assistant to Full Professor in 1991. In 1989-1995 she was Vice Dean and Dean of the Faculty, and in 2005-2009 she was Head of the Department of Geology and Geological Engineering. Now she is the principal investigator for the scientific project "Stratigraphic and geomathematical research of petroleum geological systems in Croatia".

Tomislav Malvic received his Ph.D. in 2003 from the University of Zagreb, Croatia, working on the description of petroleum systems and hydrocarbon potential in the Bjelovar subdepression (Pannonian basin). He spent seven years (1995–2002) at the University of Zagreb as a teaching and research assistant in petroleum geology. Now he works as an advisor in geostatistical and stochastic modeling with the INA-Industry of Oil Plc and also as an Assistant Professor in the Faculty of Mining, Geology and Petroleum Engineering in Zagreb.

Marko Cveticovic graduated in 2007 from the Faculty of Mining, Geology and Petroleum Engineering in Zagreb, where he focused on the application of neural networks in petroleum geology. From 2007 to the present he has worked as a research novice and as an assistant in the Department of Geology and Geological Engineering on the Faculty of Mining, Geology and Geological Engineering in Zagreb.

Boris Vrbanac received his Ph.D. in 1997 from the University of Zagreb, Croatia, describing depositional models of the Ivanic Grad Formation in the Sava depression (Pannonian basin). From 1972 to the present he has worked in the INA-Industry of Oil Plc. on different projects in the Department for Exploration of Oil and Gas.