Summary

The Békés basin (Bb) is one of the largest members of the Pannonian basin system. It is located in SE Hungary and is buried beneath 2000-7000 m of Miocene-Holocene sediments. The sub-basin is surrounded by metamorphic and magmatic basement highs, which produces due to their high fracture porosity significant quantities of petroleum. One of the largest basement highs is the Szeghalom Dome (SzD), located on the northern margin of the Békés sub-basin. The wells in this intensively explored unit have encountered hydrocarbons of significantly different compositions at different depths, suggesting that separate fluid regimes may exist side by side (PAP ET AL., 1992). The sources and migration history of the oils are largely unknown, as is the evolution of the fracture networks that lead to establishment of the independent fluid regimes.

Mainly Neogene movements governed the structural evolution of the crystalline basement north of the Bb. The syn-rift phase of the basin evolution, which essentially occurred during the Badenian, was characterised by uplift and exhumation of the basement highs as metamorphic core complexes (TARI ET AL, 1992). The post-rift episode started with the coeval subsidence of both the basins and the previously elevated high regions and was followed by re-activation of old WSW-ENE strike-slip structures. This is shown by the common negative flower structures, which can be followed from the metamorphic basement up into the upper Pliocene cover. The strike-slip movements, which have occurred since the Late Miocene, are probably responsible for the alignment of the WNW-ESE trending zones of different metamorphic PTt evolution across the SzD (M. TÓTH ET AL., 2000) These units are separated by tectonized zones. SZŰCS (2001) studied fracture network geometry of sliced core specimens from the SzD and suggested a system of single generation steeply dipping conjugate fractures. The cracks probably formed during the Lower Miocene extension and uplift events, and were filled by a well-defined mineral sequence of pyrite – kaolinite/illite/chlorite - calcite1 - quartz - calcite2 - laumontite ("general sequence"), whereby the laumontite apparently formed during post-exhumation subsidence (JUHÁSZ ET AL., 2002). The first considerable mineral phase is quartz with high hydrocarbon inclusion density aligned usually along growth zones. The subsequent calcite2 is volumetrically abundant, in contrast to calcite1. Calcite2 evidently formed during exhumation of the basement high, as indicated by the

presence of primary, all-liquid, aqueous inclusions and by pollen grains and cuticles of terrestrial plants enclosed within the calcite (M. TÓTH ET AL., 2003). Some of these plants were typical for the Badenian, while others appeared after the Oligocene indicating that the SzD reached the most elevated vertical position during or before the Badenian. Pale yellow, UV-fluorescent fluid inclusions are also present along healed microfractures.

The goal of the dissertation was to appoint the wells of the SzD, which contain hydrocarbon-bearing quartz phase, and to characterize the conditions of the precipitation as well as to clarify the temporal and spatial distribution of the different hydrocarbon-bearing fluid inclusion assemblages within samples and between boreholes.

Euhedral, prismatic quartz crystals were found from 12 wells in the SzD but only 9 of them contain traces of liquid hydrocarbon (Sz-2, -11, -12, -20, -43, -110, -167, -176, -180). Petrographic observations using a modified spindle-stage unambiguously show a multistage precipitation history of the quartz, characterised by several parallel growth zones and primary inclusions trapped along them. At room temperature, the fluid inclusion assemblages (FIA) are composed either of petroleum-bearing inclusions (L_{HC} + V or V + L_{HC}), aqueous inclusions ($L_{aq.}$ + V), or mixtures of both (L_{HC} + $L_{aq.}$ + V). The assemblage textures indicate heterogeneous entrapment of coexisting, immiscible oil and aqueous fluids. Also in accord with heterogeneous entrapment, Raman spectroscopy shows that the vapour phase within the aqueous inclusions contains methane. These features allow the homogenisation temperatures of the aqueous inclusions to be interpreted as formation temperatures, i.e. as the precipitation temperature of the quartz phase. Because of the small size and rarity of the co-genetic aqueous inclusions, comparison of the formation conditions among the individual growth zones is impossible. Based on the T_{hom} values of the unevenly distributed aqueous inclusions, cementation of the HC-bearing quartz phase occurred at about 130 °C in the whole SzD.

Based on petrography, Raman spectroscopy and UV fluorescent microscopy, different oil types can be distinguished in certain wells and also along subsequent quartz growth zones.

The most common oil type is a colourless, translucent and highly light-reflective liquid phase with rather variable liquid to vapour ratios. I refer to this oil as "type 180" in order to make the distinction of the other wells easier. The low fluorescent intensity made application of the Raman spectroscopy possible. The observed peaks show presence of alkane and cycloalkane compounds in the liquid phase as well as methane and subordinate quantity of ethane in the vapour phase. The very weak fluorescence implies to the low concentration of the aromatic components. This later assumption is confirmed by the absence of any aromatic peaks on the ^1H MAS NMR spectrum, as well. At low temperature "type 180" fluid shows a LLV→LV transition, which is typical for gas-condensates (LUKS ET AL., 1983). This oil type occurs in the wells Sz-20 and Sz-180.

Quartz crystals of wells Sz-2, Sz-12 and Sz-176 probably enclosed identical types of hydrocarbon; in the early growth zones this kind of oil is dark brown in normal light and light greenish-blue in UV light. The intense fluorescence precluded Raman spectroscopic measurements. In the outer, younger growth zones this brown oil is replaced by the "type 180" oil. Micro-fluorimetric measurements suggest that the early oil types in these 3 wells are less mature/more degraded than the "type 180" fluid (HAGEMAN AND HOLLERBACH, 1985; STASIUK AND SNOWDON, 1997). Simultaneously to the appearance of the "type 180" fluid in the late inclusions, in the co-existent aqueous fluid a salinity drop can be observed.

Quartz samples from the Sz-11 well also contain several oil-bearing growth zones, which are crosscut by younger secondary, HC-bearing fluid inclusion trails. Based on micro-fluorimetry measurements, the primary inclusions of the Sz-11 well contain the less mature/most intensely degraded oil types in the whole SzD. The results of the mass spectrometry analysis are consistent with this assumption, showing a maximal enrichment in the high-molecule weight components in this oil. The quartz crystals of the neighbouring Sz-167 well enclose HC-bearing fluid in several growth zones. Based on micro-fluorimetry, this oil type has an intermediate stage of maturity between the fluids of the Sz-11 and the fluids trapped in the early growth zones of the wells Sz-2, Sz-12 and Sz-176.

The sample size and quantity of quartz crystals representing the Sz-43 and Sz-110 wells is rather low (less than 2 grams), so that the measurements could only serve very restricted information. Mass spectrometry analysis makes oil of well Sz-43 similar to the early fluid of Sz-2, 12 and 176, while Sz-110 contains "type 180" hydrocarbon exclusively.

The wells Sz-É-2 and -11 are situated in the Déva orthogneiss zone (M. TÓTH AND ZACHAR, 2003) and expose a mylonitic shear zone, which was firstly described by SCHUBERT AND M. TÓTH (2001). They could reveal detachable changes in the microstructural elements along a vertical profile from the upper, slightly deformed orthogneiss to the lower, intensively sheared, fine-grained mylonite. T_h values of secondary, homogeneously trapped aqueous inclusions in calcite from steeply dipping fractures imply much higher formation temperatures (T > 212 °C) than those typical for quartz precipitation in the central part of the SzD (130 °C). The much less quantity of the quartz phase, the high formation temperature of the subsequent calcite and the lack of any hydrocarbon traces in the fracture-filling minerals suggest different processes operating during the cementation of the cracks in the northern flank of the SzD.

The westernmost well in the SzD, which contains quartz-bearing cracks, is Sz-Ny-3. The fracture-filling mineral sequence is similar to the central part of the SzD, but there are some distinct points as well. The freestanding quartz is followed by a calcite phase with a T_{hom}>90 °C. This relatively "high temperature" calcite-producing event is unknown in the other parts of the SzD. The quartz phase shows a multistage precipitation history with pseudosecondary and primary fluid inclusion assemblage of rather similar composition and formation conditions during the final stage of the quartz cementation. Although the vapour phase usually consists of methane, the liquid hydrocarbon inclusions are completely absent.

Aqueous inclusions are not present in all samples that contain oil-bearing inclusions, rendering the direct correlation of formation temperatures between the various wells difficult. However, the Raman spectroscopic and UV-fluorimetric properties of the inclusions aid in this correlation. Thus during the early stages of quartz growth it appears that wells Sz-2, -12, -176 and probably -43 were all affected by the same fluid regime, while during the formation of the younger zones the former wells together with the Sz-20 and -180 (and probably Sz-110) were under the rule of the more mature, "type 180" fluid.

Although well Sz-11 shows the same mineral sequence and precipitation temperature of quartz as the other wells of the central SzD, the immature character (based on micro fluorimetric parametres), and the lack of "type 180" oil, suggest that a fluid of different characteristics migrated through the part of the SzD sampled by well Sz-11, at least during the period of quartz precipitation.

The fluid inclusion evidence in the fracture-filling quartz argues for the simultaneous existence of several diverse fluid regimes while the basement rocks were at temperatures of around 130°C, i.e. prior to the peak of Middle Miocene exhumation.