Earthquake Swarms in the Major Focal Zone of the West Bohemia/Vogtland Seismoactive Region

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West Bohemia/Vogtland region situated at the contact of Moldanubikum, Saxothuringikum and Bohemicum is well-known in Quaternary volcanoes and many post-volcanic events. In these set are included mineral springs, carbon dioxide emissions and, last but not least, a frequent reoccurrence of earthquake and micro-earthquake swarms.

West Bohemian earthquake swarms have been reported since 16th century. The most intensive known seismic sequency occured there in time span 1896–1909 (Grünthal,1989). After the severe December 1985/January 1986 swarm the first permanent Czech local station NKC was established and our interests in this region started.

The foci of most of the micro-earthquakes cluster in several focal zones (Horálek et al., 1996, 2000). We present a comprehensive, integrated pattern of the space and time distribution of seismic energy release in the principal Nový Kostel focal zone since 1985/86 swarm. Further 27 swarm-like sequences (micro-swarms) and many solitary micro-earthquakes (background activity) were identified in this zone for the period 1991 to 2001. Most of the seismic energy was released during the two intensive 1985/86 and 2000 swarms. More than 3000 earthquakes, recorded by the WEBNET, the KRASNET and by temporal stations VAC, TIS and OLV, were re-located using the master event technique (Fischer and Horálek, 2000). Relative location revealed a pronounced planar character of the Nový Kostel focal zone. Most of the events, including those of the intensive 1985/86 and 2000 swarms, were located at the main focal plane (MFP) striking 349°N and dipping 80° westward at depths between 6 and 11 km. A singularity was the January 1997 swarm together with a micro-swarm that were both located across the MFP. The position and geometry of the MFP match quite well the Nový Kostel – Počátky – Zwota tectonic line. Detailed analyses of the spatial distribution of the foci lead to the conclusion that the larger events predominantly grouped in two-dimensional clusters while the micro-swarms lined up along two parallel seismogenic lines. It was also found that several segments of the MFP were liable to reactivation and the seismic activity in the time span 1991–2001 migrated in an area of about 12×4 km.

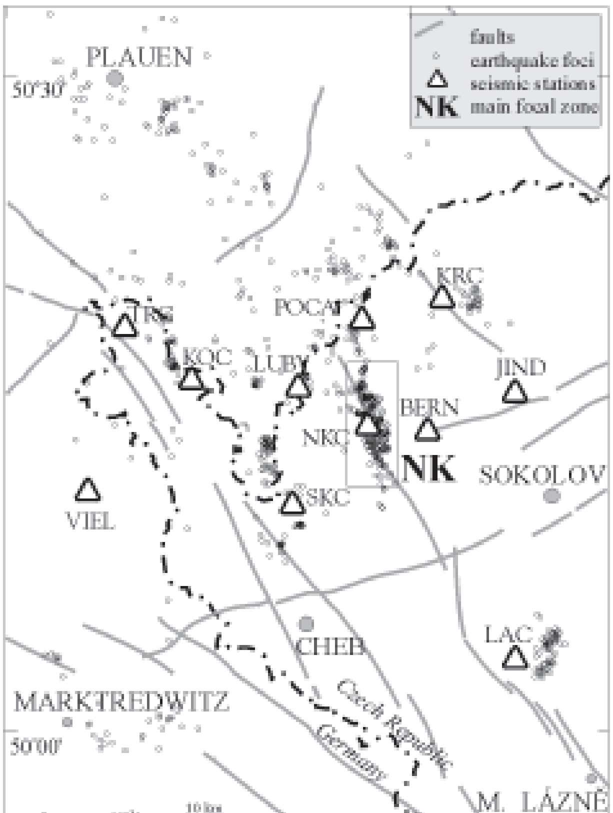

Fig. 1. Map of epicentres of microearthquakes in Western Bohemia/Vogtland region

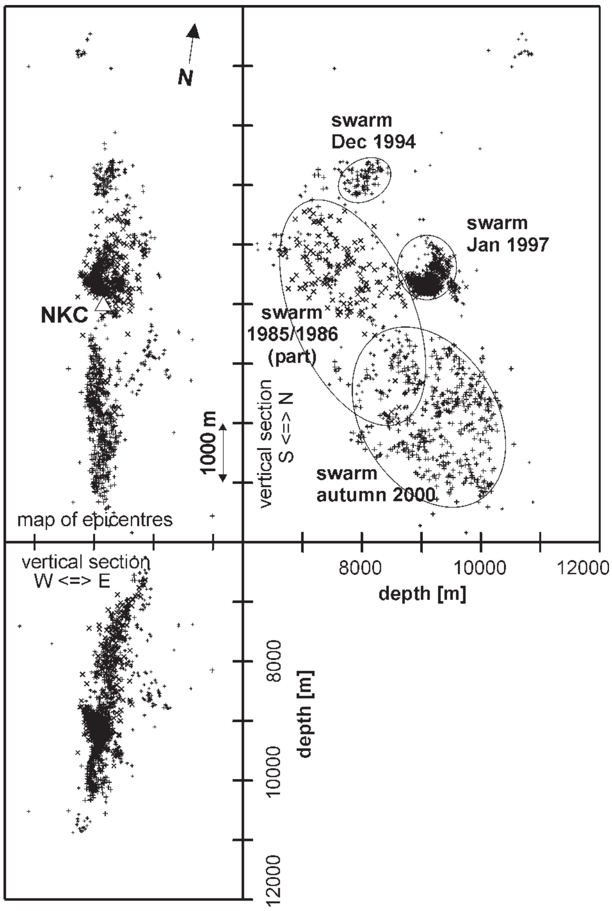

Fig. 2. Space distribution of larger swarms in Nový Kostel focal zone

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Tourmaline-Bearing Leucogranites from the Třebíč Pluton in the Moldanubicum

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Peraluminous leucogranites with accessory tourmaline derived from crustal sources are widespread in mountain belts formed by continental collision (London et al., 1996). In eastern part of the Moldanubicum they are spatially associated with the Třebíč pluton, and three distinct types of leucocratic, medium- to fine-grained, biotite and muscovite-biotite granites with accessory tourmaline were distinguished.

(i) Two mica granites with tourmaline concentrated in orbicules (OTG) compose small intrusive bodies and dykes, scarcely up to 200 m thick. Quartz + tourmaline ± feldspars orbicules, up to 10 cm in diameter, or rare veins, up to 2 cm thick, are randomly distributed or concentrated in several m thick zones within bodies of leucocratic granites. Subhedral tourmaline is intersticial between euhedral grains of feldspars and quartz, and it replaces dominantly plagioclase. The accessory minerals include apatite, andalusite, cordierite, ilmenite, zircon, allanite, xenotime and monazite in granite; apatite is fairly abundant in orbicules. The tourmaline-quartz orbicules and veins seem to be a product of crystallization of evolved, B-rich medium (melt and/or fluid) during late solidus to early subsolidus stage of the granite formation.

(ii) Two mica granites with disseminated tourmaline (DTG) form relatively large intrusive bodies and dykes, up to several km2. They do not exhibit such apparent spatial relationship to durbachite plutons as OTG. Euhedral to subhedral tourmaline grains, up to several mm long, are rather regularly distributed in the rock. The accessory minerals include apatite and zircon. In contrast to the OTG, disseminated tourmaline crystallized from granitic melt.

(iii) Biotite granites with tourmaline (MTG) typically occur in marginal zone of the Třebíč pluton. They form relatively small bodies (up to several hundred m thick) and are associated with migmatites and aplites. Euhedral tourmaline grains occur in coarse-grained pegmatoid facies, subhedral intersticial grains in rare quartz + tourmaline ± feldspars orbicules, up to 5 cm in diameter. Poikilitic garnet forms grains from 5 to 25 mm in diameter, randomly distributed in the rock, further accessory minerals include apatite, zircon and sillimanite.

All types of tourmaline granites have very similar geochemical signature corresponding to leucocratic and peraluminous (ASI = 1,0–1,3), syn- to post-collisional S-type granites: K2O = 2.77–6.14; Fe2O3tot = 0.42–2.08; Rb = 194–234 ppm; Mg/Fe = 0.08–0.33; Rb/Sr = 1.00–5.56 in OTG, 5.24–7.34 in DTG and 0.5 in MTG; CaO = 0.49–0.87, 0.36–0.66 and 1.67, respectively. The normalized REE patterns are very similar for OTG and DTG granites; low REE concentrations ÍREE = 20.08–99.81 ppm and slight LREE enrichment (LaN/LuN = 1.9–6.8). The MTG indicate HREE depletion (LaN/LuN = 10.14) with distinct positive europium anomaly (Eu/Eu* 2.5). Similar mineral assemblages, whole rock major, minor and trace chemistry suggest that positive and negative europium anomalies (Eu/Eu* 0.5–1.6) found in both OTG and DTG rather reflect different fO2 during crystallization. Lower CaO/Na_2O ratios (0.10–0.22) in OTG and DTG are typical for melts derived from clay-rich, plagioclase-poor pelitic rocks (Sylvester, 1998). The high CaO/Na2O ratios (0.53) in MTG are typical for melts generated from plagioclase-rich psammitic rocks.

The zircon saturation temperatures 784–725 °C obtained for durbachitic rocks in Třebíč pluton (Watson and Harrison, 1983) are similar to those the MTG (778 °C); DTG and OTG provided 660–713 °C, and 660–746 °C, respectively.

The geochemical signatures suggest relatively primitive character of all granite types. The OTG and DTG had similar protoliths (metapelites) and conditions of melting (probably muscovite dehydration melting). Geochemical and mineralogical signatures of MTG exhibit less primitive character and higher temperature of melting (probably biotite dehydration melting).

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