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Volcanism in the Mesozoic of the Outer and Central Western Carpathians

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Abstract. Within the time span from the Upper Barremian till the end of the Albian volcanic activity is documented (approx. 100 Ma) in various tectonic units of the Western Carpathians. Volcanic activity are present in the form of hyaloclastites. Dykes or even lava flows are present in lesser amount known. Alkaline basalts/basanites are known to appear in the cover of Mesozoic units (in the Malé Karpaty Mts., Tatry Mts. and the Nízke Tatry Mts.) as well as in a unit of nappe position (the Krížna nappe). But in the Malé Karpaty Mts. and Nízke Tatry Mts. there are sills penetrating variscan granitic massifs.The mineral compositions of alkali basalt/ basanites from different units are very similar. Olivines, pyroxenes and less frequently amphiboles form phenocrysts.There are also other minerals according to the rock type: Ti-biotite, nepheline, analcime, plagioclase, leucite, ore minerals, spinel and others. The majority of lava flows have fine-grained devitrified matrix, the content of which usually does not exceed 40 per cent of the rock.Geochemical studies came to the conclusion that volcanics have the characteristics of alkaline basalt - basanites. Even the application of the principle of immiscible melts is very probable. In the studied volcanics especially the processes of fractional crystallization and assimilation of underlying rock strata (rock fragments) affected the variability of rock types.

Key words: Jurrasic-Cretaceous, alkali basalt/basanites, mineralogy, petrology

Introduction

In the Western Carpathians, alkaline rocks of various types, predominantly of Cretaceous age, occur in some Mesozoic tectonic units (Silesicum, Tatricum, Krížna and Choč Nappes). These rock, in spite of not having a great areal extension, are of key importance for the definition of geotectonic conditions in the time of their formation approx. 100 Ma). In the Outer Western Carpathians (teschinite-picrite association), the volcanites are more differentiated (from picrites to syenites), while mostly only basanite-type rocks (rarely picrites) or their volcanoclastics are found in the Central Western Carpathians. In the Inner Carpathians, rocks of this type (alkaline basanites) do not occur in the Mesozoic. Here they are Upper Triassic volcanites of the Jaklovce development of the Meliata Group.

Geological setting

Alkaline volcanic rocks of the Outer Western Carpathians are related in space to the upper part of the Tešín-Hradište Formation. It is a classic area of occurrence of the teschinite or teschinite-pikrite association. The volcanic activity probably took place in several stages, the volcanic activity reaching the maximum in the Barremian to Albian. A characteristic feature of the whole association is the predominance of shallow subsurface sills and veins over effusive or volcanoclastics rocks. The maximum of volcanic activity is concentrated in the upper Tešín Beds and sandstones to conglomerates of the Hradište type. Opinions on the age of the volcanic activity differ, however, the majority of authors accepts Lower to Middle Cretaceous age. The products of the volcanic activity are various types of intrusive, effusive and extrusive rocks (picrite, basalts-basanites, teschinites and monchiquites). On the basis of mineral composition they are further divided into more, less abundant types (fourchites, ouachites etc., for details see PACÁK, 1926; ŠMÍD, 1978; HOVORKA and SPIŠIAK, 1988). The pre-tectonic, synsedimentary character of the magmatic activity in the Lower Cretaceous of the Silesian Unit sedimentary basin has been proved. The type of sediments occurring in the Cretaceous of the Silesian Unit and the Magura Unit of the Outer Western Carpathians indicates their sedimentation in basins the substratum of which was continental- or subcontinental-type crust. Evidence of this is also turbidite sedimentation, suggesting the existence of a mature basin. The predominance of sills and dikes over effusions on the bottom of the basin is the reflection of the bathymetry of the Silesian Unit sedimentation basin. The sedimentation type - alternation of clayey shales with fine-grained sandstones (distal facies), along with a low proportion of amygdaloidal types,

is proof of the penetration of volcanics into an environment with a great height of the water column (over 200 m).

In the Central Western Carpathians, primitive Mesozoic alkaline volcanism is known from the Tatric (envelope) units, the Krížna and Choč Nappes (the occurrence of picrite at Poniky; SLAVKAY, 1965). Besides these, penetrations of basanite dikes into granitoid rocks have been also reported (HOVORKA et al. 1982 - Malé Karpaty Mts., SPIŠIAK et al. 1991 - Nízke Tatry Mts.). The products of the volcanic activity are low-differentiated rocks of basalt/basanite type, rarely picrites, volcanoclastic rocks are represented substantially (hyaloclastites etc.). A detailed geological setting has been presented in HOVORKA and SPIŠIAK (1988).

In the Inner Western Carpathians, alkaline volcanism does not occur in the Mesozoic, but basalts are present here as a component of the ophiolite sequence (HOVORKA and SPIŠIAK, 1993)

Petrology and mineralogy

The products of the Mesozoic magmatic activity in the area of the Outer and Central Western Carpathians are intrusive, effusive and extrusive rock types. The most frequent forms are sills and dikes, with a thickness of X dm to X m. The majority of Mesozoic alkaline rocks (with the exception of picrites) are characterised by the presence of a fine-grained devitrified matrix (up to 40 %). Olivines, pyroxenes and less amphiboles form phenocrysts and locally they accumulate into golomerophyres. The Mg/Mg+Fe ratio in olivines varies from 0.86 to 0.87. Clinopyroxenes (Cpx) are the determining and dominant minerals in all rock types. Besides phenocrysts of various shape and size, they form also microlites in the devitrified matrix. A characteristic feature of the clinopyroxenes is sector and oscillation zoning. Cpx microlites have a composition corresponding to the rim of phenocrysts. According to the IMA pyroxene classification (MORIMOTO 1988), they correspond to diopside, the differences in their composition being indicated in the classification by different adjectives (aluminian, calcian, ferroan etc.). According to POLDEVAART and HESS (1951) the predominant part of Cpx corresponds to salite. On the basis of various discrimination diagrams (LE BAS 1962, LETERRIER et al. 1982 etc.) the studied clinopyroxenes correspond to pyroxenes from alkaline (peralkaline) rocks (see HOVORKA and SPIŠIAK 1988, SPIŠIAK and HOVORKA in press). The modal proportion of amphiboles varies in relation to the rock types or their evolution. The highest modal contents are in thin basanite dikes. Similarly as pyroxene, amphibole forms phenocrysts (usually smaller than Cpx) with observable zoning. Besides rare sector zoning, oscillation zoning is typical, with Ti, Al and Fe increasing, and Si and Mg decreasing from core to the rims. In the IMA amphibole classification (LEAKE 1978) they correspond to kaersutite or low-silicium kaersutite. Dark micas occur mostly in picrites as large flakes - their composition corresponds here to phlogopites, and also in thin basanite dikes, where they form tiny flakes (Ti-biotite).

From other minerals, rarely present are alkali feldspars (orthoclase) - only in some varieties of leucocratic rocks nefelinite syenites, MAHMOOD 1973). Plagioclases are also rare and their composition depends on the rock type and its genesis. Their basicity varies from An_{5-8} in spilites to An_{40} in teschenites, or An_{60} in basanites (KUDĚLÁSKOVÁ 1982). Feldspars are mostly strongly altered (sericitisation). They occur locally also in resorbed non-carbonate xenoliths, where they may constitute even an essential mineral phase (SPIŠIAK et al. 1991). In this case they form thin, frequently zoned laths (basicity decreasing from centre - An_{32} - to the rim - An_{21}). Depending on the rock type, other minerals are also represented: nepheline, analcime, pseudoleucite, spinel, ore minerals and others.

Even though Mesozoic alkaline rocks of the Western Carpathians have a very variable mineral and modal composition, the chemical composition is, except for end members, similar. In the Outer WC, a wider differentiation range of rocks is found (from picrites to syenites), while in the Central WC the rock composition corresponds mostly to basanites (rarely picrites). Generally, determining is the low SiO_2 content in the rocks (approx. 41 wt.%) and high contents of TiO_2 and P_2O_5 (3.2 and 0.8 wt.%, respectively). Characteristic features of these rocks are also: increased contents of Cr (280 ppm) and Ni (190 ppm), increased contents of incompatible elements, such as Ba (650 ppm), Sr (700 ppm) and LREE, increased contents of Nb (78 ppm), V (245 ppm) and Zr (305 ppm).

The age of these rocks (K/Ar data - approx. 100 Ma and paleontological data, e.g. KOTANSKI and RADWANSKI 1959, BUJNOVSKÝ et al. 1981, HOVORKA and SPIŠIAK 1988) is similar. The setting of these rocks has been affected by extensional tectonic conditions in the units where they occur (Silesian Unit, Tatricum and Fatricum, HOVORKA - SPIŠIAK, 1989). Our results indicate that approx. 100 Ma ago, in these units there was extensional, non-subduction, supra-continental regime. The character of magmatism and its similarity to all other parts of the Alpine-Carpathian region suggests extensional tectonic conditions (rifting) in all mountain ranges of the Alpine-Carpathian-Balkan sector of the Tethyan Neoeurope.

Based on the alkaline character of the volcanic rocks we assume that the volcanism was related to an initial rifting zone. However, the riftogenesis lasted only a short time, compression processes started in the next period, closing the volcanic vents. In reality, these were not continuous subaquatic effusions of trap type, or linear eruptions, but a system of linearly arranged eruption centres. Astenolith upbulging in this weakened zone is inferred - it was volcanism above hot spots or above a mantle plume.

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