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PETROLOGICAL CHARACTERISTICS OF THE PIENINY ANDESITES

Abstract: Six samples of the Pieniny andesites were studied (optical microscopy, XRD, SEM-EDS and chemical analyses). Although studied rocks exhibit variation in phenocrysts assemblage composition and degree of secondary alterations their trace elements patterns are homogenous what suggest origin from common parental melt.

Keywords: andesite, Pieniny Mts. , Carpathians

INTRODUCTION

The history of studies of the Pieniny andesites is about two century long (e.g. Zeuschner 1833, 1835). Form of occurrences were determined basing on geophysical methods (Małoszewski 1958) and geological field studies (Małkowski 1924, 1958, Birkenmajer 1958, Youssef 1987). Andesite ages (K-Ar method) vary from 14.8 to 10.8 Ma (Birkenmajer, Pecskey 1999). Ore mineralization in andesites was studied by several authors (e.g. Wojciechowski 1950, 1955). Contact metamorphism and related hydrothermal processes were described by several authors (Birkenmajer 1958, Michalik 1963, Pyrgies, Michalik 1998, Szeliga, Michalik 2003).

Birkenmajer (2003) suggests that magma chamber was formed at the base of the Outer Carpathian accretionary wedge possibly at the depth of 10-12 km.

SAMPLING AND METHODS

Only fresh-looking samples were collected for the study. Three samples from Wzar (from E and W slopes of the hill), one sample from Bryjarka (over Szczawnica) and two samples from the Malinów quarry were selected.

Optical microscopy, X-ray diffraction, SEM-EDS and ICP-MS were applied. Chemical analyses were performed at the ACME Laboratories in Canada.

PETROLOGICAL AND CHEMICAL CHARACTERISTICS

Rocks studied are porphyritic with abundant phenocrysts. Plagioclase phenocrysts are strongly zoned. Plagioclase (An₂₈₋₆₂) predominates over mafic phenocrysts in samples from Malinów and Bryjarka. In some samples plagioclase phenocrysts cores are rich in glass inclusions whereas rims are euhedral and inclusion-free. Clinopyroxene phenocrysts (Wo₃₀₋₃₇; En₃₈₋₄₀; Fs₂₇₋₂₄) are present in

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higher amount only in few samples (from Wzar). Zoned hornblende is common in all samples. Small Fe-Ti oxide phenocrysts are also abundant. Although collected samples are macroscopically fresh looking, all are altered. The degree of alteration is consistent with LOI values. Alterations result in formation of illite-like mineral (potassium rich) observed in SEM, chlorite, fine crystalline calcite (often filling internal parts of mafic phenocrysts) or Mn-Fe oxides of corn-flake morphology aggregates around mafic phenocrysts. Bigger voids are filled with coarse-crystalline calcite. Zeolites are also present however, have not been studied in detail.

The studied andesite samples have SiO_2 content ranging between 51.5 and 61.5 wt %. LOI value varies from 1.3 to 3.8 wt%. Petrographic variation of rocks is from basaltic andesite to andesite according to TAS classification (based on LOI and total C free basis). In the K_2O - SiO_2 diagram samples plot in medium-K field but most of them close to medium-K/high-K fields boundary.

Major element variation trends are relatively clear. Fe_2O_3 , MgO , CaO (Fig. 1) decrease systematically with SiO_2 content increase. Na_2O increases with SiO_2 increase; K_2O vs. SiO_2 exhibits greater scatter (Fig. 1).

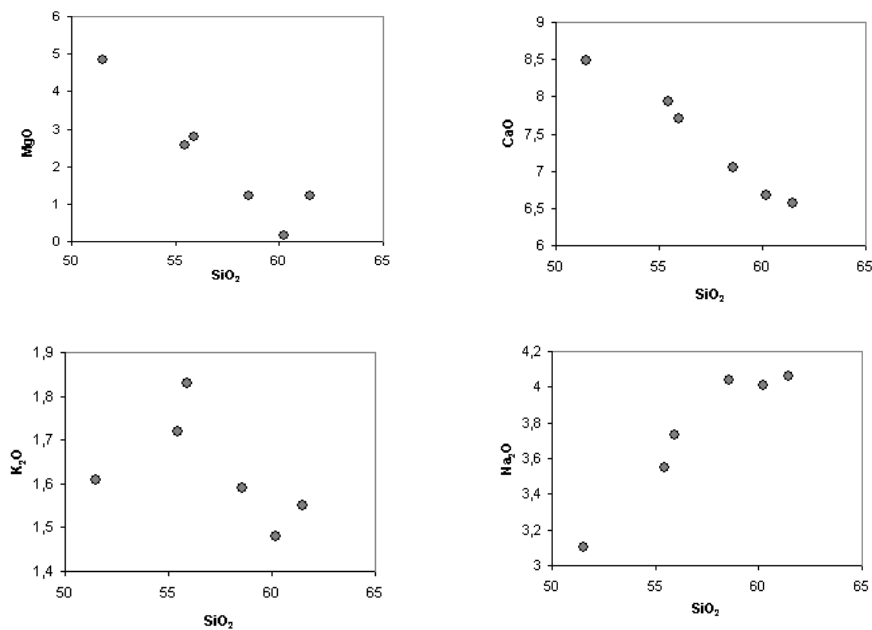


Fig. 1. Major element Harker variation diagram for Pieniny andesites.

Low concentration of compatible elements indicates nonprimitive nature of studied volcanic rocks (e.g. Ni from 2 to 4.5 ppm). N-MORB and chondrite normalized contents of trace elements are presented in Fig. 2 and 3.

DICUSSION AND CONCLUSIONS

Co-variation of major elements is caused by fractional crystallization related to magma evolution. Scattered patterns (e.g. SiO_2 vs. Al_2O_3 ; SiO_2 vs. K_2O) can be related to secondary alterations. Presence of partly internally melted plagioclase

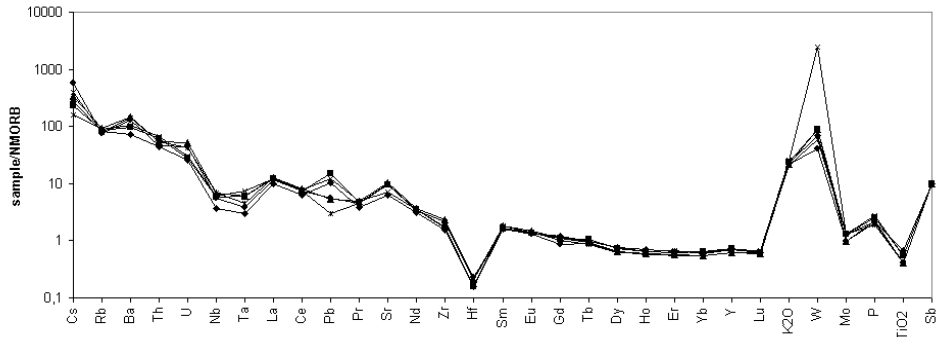


Fig. 2. (above) N-MORB normalized incompatible trace element diagram for Pieniny andesite samples (normalization coefficients from Sun and McDonough; 1989).

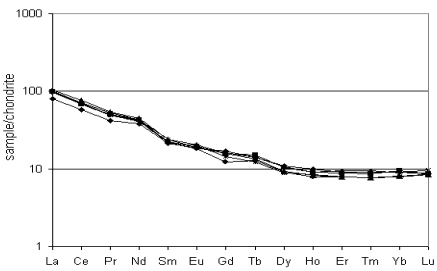


Fig. 3. (left) Chondrite normalized REE diagram for Pieniny andesite samples (normalization coefficients from Boynton 1984).

phenocrysts (with overgrowths of equilibrium plagioclase) can also suggest that rocks originated from solidification of non-equilibrium melt-crystals systems. Absence of Eu anomaly indicates lack or low degree of plagioclase fractionation. Narrow range of Nb/Zr ratio (0.074 – 0.108) can suggest origin of magma from homogeneous source and low degree of partial melting of the mantle. Based on similarity of trace elements patterns (except of Pb; see Fig. 3) and narrow range of their variations, origin of studied rocks from the same parental melt can be postulated.

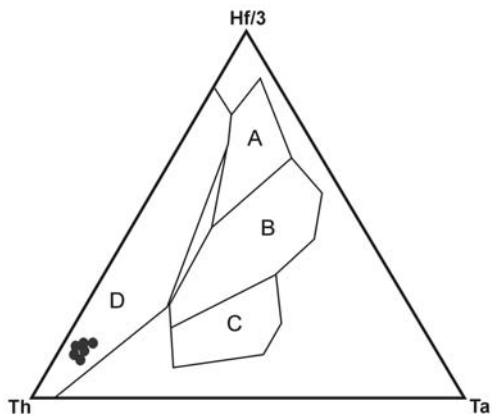


Fig. 4. Th-Hf-Ta discrimination diagram (after Wood, 1980). A – N-type MORB, E – E-type MORB and within-plate tholeiites, C – alkaline within-plate basalts; D – volcanic-arc basalts. Black circles – studied rocks from the Pieniny Mts.

Th-Hf-Ta discrimination diagram (Fig. 4) suggests volcanic arc setting of the magma generation environment. However, isotope data should be included in more detailed discussion on magma genesis.

REFERENCES

- BIRKENMAJER K., 1958: Nowe dane o geologii skał magmowych okolic Szczawnicy. *Prace Muzeum Ziemi*, 1: 89-112.
- BIRKENMAJER K., 2003: Post-collisional Late Middle Miocene (Sarmatian) Pieniny Volcanic Arc, Western Carpathians. *Bulletin of the Polish Academy of Sciences, Earth Sciences*, 51: 79-89.
- BIRKENMAJER K., PECSKAY Z., 1999: K-Ar dating of the Miocene andesite intrusions, Pieniny Mts., West Carpathians, Poland. *Biulletin of the Polish Academy of Sciences, Earth Sciences*, 47: 155-169.
- BOYNTON W. V., 1984: Geochemistry of rare earth elements: meteorite studies. In: P. Henderson (Ed.), *Rare Earth Element Geochemistry*, Elsevier, Amsterdam, 63-114.
- MAŁKOWSKI S., 1924: Andezyty okolic Pienin. *Prace Państwowego Instytutu Geologicznego* 1: 3-67.
- MAŁKOWSKI S., 1958: Przejawy wulkanizmu w dziejach geologicznych okolic Pienin. *Prace Muzeum Ziemi*, 1: 105-113.
- MAŁOSZEWSKI S., 1958: Anomalie magnetyczne w Pieninach. *Prace Muzeum Ziemi*, 1: 113-129.
- MICHALIK A., 1963: Z badań nad strefami pomagmowych przemian andezytów w Pieninach. *Kwartalnik Geologiczny*, 7: 721-722.
- PYRGIES W., MICHALIK M., 1998: Contact effects of the Pieniny andesites on the surrounding sedimentary rocks. In: *Carpathian-Balkan Geological Association XVI Congress, Abstracts*, Vienna, 502.
- SUN S. S., McDONOUGH W. F., 1989: Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. In: A. D. Saunders & M. J. Norry (Eds.), *Magmatism in the Ocean basins. Geological Society Special Publications*, 42: 313-345.
- SZELIGA W., MICHALIK M., 2003: Contact metamorphism and hydrothermal alterations around andesite intrusion of the Jarmuta hill, Pieniny (Poland). *Mineralia Slovaca*, 35: 31-35.
- WOOD D. A., 1980: The application of a Th-Hf-Ta diagram to problems of tectonomagmatic classification and to establishing the nature of crustal contamination of basaltic lavas of the British Tertiary volcanic province. *Earth Planet. Sci. Lett.*, 50: 11-30.
- WOJCIECHOWSKI J., 1950: Złoto rodzime i minerały towarzyszące w żyłach kruszcowej pod Szczawnicą. *Acta Geologica Polonica*, 1/2: 143-149.
- WOJCIECHOWSKI J., 1955: O żyłach kruszcowych w okolicy Szczawnicy. *Biuletyn Instytutu Geologicznego*, 101: 3-63.
- YOUSSEF M. M., 1978: Large-scale geological survey of the Mt. Wzar andesites, Pieniny Mts., Poland. *Studia Geologica Polonica*, 66: 1-30.
- ZEUSCHNER L., 1833: Geognostische Reise in die Karpathen. *Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde*, 1833, 316-319.
- ZEUSCHNER L., 1835: Geognostische Beschreibung von Szczawnica und Szlachtowa. *Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde*, 1835, 636-666.