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VARIOUS KINDS OF CHARNOCKITIC ROCKS FROM NE POLAND

Abstract: Charnockitic rocks from Bilwinowo, Łanowicze and Wigry boreholes have been studied with use of microprobe, geochemical and Nd and Sr isotope analyses. Investigated rocks display differences in mineral composition (especially orthopyroxenes), REE patterns, age (determined on monazite CHIME method). Probably all charnockitic rocks have different history and source of material however similarities in modal mineral composition and rock texture are visible.

Keywords: Mesoproterozoic, AMCG suite, charnockite, geochemistry, microprobe analysis, high-Al orthopyroxene, Nd isotopes, NE Poland

INTRODUCTION

Charnockitic rocks are important components of the continental crust in many Precambrian terranes. Their igneous or metamorphic origin was a topic of numerous discussions in the last two decades (Newton 1992; Kilpatrick, Ellis 1992; Duchesne, Wilmart 1997; Zhao *et al.* 1997; Kar *et al.* 2003).

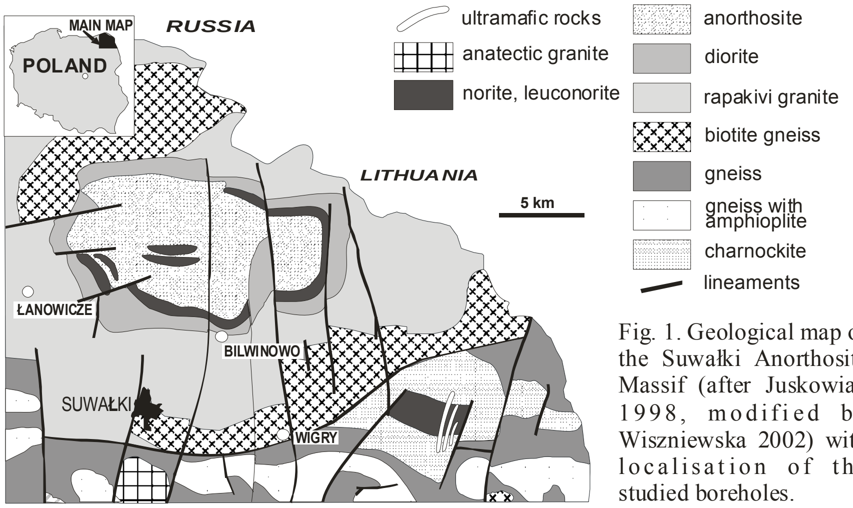

Fig. 1. Geological map of the Suwałki Anorthosite Massif (after Juskowiak 1998, modified by Wiszniewska 2002) with localisation of the studied boreholes.

Charnockitic rocks occur in different structures within the Polish part of the East European Craton and are of different origin (Ryka 1967; Bagiński *et al.* 2001), but it is needless to say that these rocks have not been studied in details yet.

This paper focuses on the selected, well documented, occurrences of charnockitic rocks from 3 drills situated in the vicinity of the Suwałki Anorthosite Massif (SAM). The selected

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drills are Bilwinowo-1, Łanowicze-1 and Wigry-1 and their location is presented on Fig. 1.

GEOLOGICAL SETTING

The Mesoproterozoic magmatism with anorthosites and porphyric granitoids, considered as anorogenic (Kubicki, Ryka 1982) and/or postcollisional (Skridlaite *et. al*. 2003) have been recognised in the Mazury Complex. Several intrusions mostly of granitic to monzonitic composition and three anorthosite massifs: Suwałki, Sejny and, Kętrzyn have been described within this area (Bagiński *et al.* 2001; Wiszniewska 2002; Skridlaite *et al*. 2003). These rocks according to their geochemical affinities defined an AMCG suite, made up of continuous series of igneous rocks ranging from anorthosite, gabbro-norite and monzodiorite through quartz monzodiorite, quartz monzonite, and granodiorite, charnockite to porphyry granite. The U-Pb zircon ages indicate that igneous activity in Mazury complex lasted from 1548 ± 7 Ma to 1513 ± 7 Ma (Dörr *et al*. 2001). These rocks have intruded in previously metamorphosed and folded crystalline basement composed of various rocks (gneisses and migmatites, amphibolites, granulites, charnockites and enderbites) of amphibolite, and granulite facies (Skridlaite, Motuza 2001). The age of the supracrustal rocks estimated by Sm-Nd whole rock method (Mansfield 1995) varies from 2.37 to 2.20 Ga (T_{DM}) and U-Pb monazite age indicates granulite metamorphism of these rocks at ca. 1.8 Ga (Bibikova *et al*. 1997).

SAMPLES AND ANALITYCAL TECHNIQES

The studied charnockitic rocks (charnockites, opdalites and enderbites) come from both structural units mentioned above. Bilwinowo drill is situated within the outer part of SAM. Łanowicze is in the border area between SAM and crystalline basement and Wigry represent the metamorphosed basement. Charnockitic rocks in all mentioned localities display macroscopically very similar features. All are medium or coarse-grained massive, grey-greenish, not oriented or weakly oriented rocks. Under the microscope the differences are also not distinct. The studied rocks are composed of quartz + orthopyroxene + plagioclase + K feldspar + biotite ± clinopyroxene ± garnet + apatite + zircon + monazite. Antyperthinic and mesoperthitic textures are typical.

More than 170 samples were collected from the Bilwinowo, Łanowicze and Wigry drill cores. The whole rock chemical analyses including REE for 65 samples were performed at the ACME Analytical Laboratories, Vancouver. Analyses of minerals from 35 samples were obtained by use of Cameca SX-100 microprobe (Warsaw University, Faculty of Geology, for details *see* Mikulski *et al*. 2004). The $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ isotope ratios were measured in 8 samples on VG Sector 54 mass spectrometer in the Isotope Laboratory of the Institute of Geological Sciences in Warsaw (for details concerning the procedure *see* Bachliński 2000).

RESULTS

The mentioned above macroscopic and microscopic similarities of charnockitic rocks are in contrast with more detailed studies. We present here the differences in orthopyroxenes composition, REE patterns and selected isotope data to show different sources and genesis of the studied rocks.

Orthopyroxenes from the studied charnockitic rocks display variable (Fig. 2), sometimes very high Al contents what is an evidence of crystallization at high pressures (Harley, Motoyoshi 2000). The highest values in orthopyroxenes were obtained from

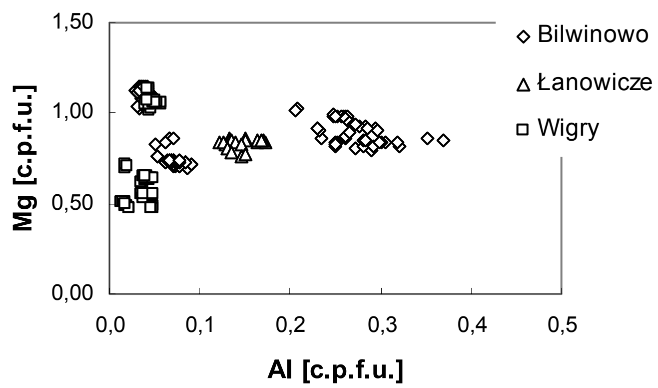

Fig. 2. Aluminium *vs*. magnesium (contents per formula unit) in pyroxenes from the studied rocks.

Bilwinowo samples where Al contents in orthopyroxenes reach 7%.

REE patterns of charnockitic rocks also show differencies (Fig. 3). REE contents in samples from the Łanowicze borehole are internally consistent while samples representing Wigry and particularly Bilwinowo show dual shape pattern with distinct positive Eu anomaly what is not present in samples from Wigry and Łanowicze. Using the ORG (ocean ridge granite) normalisation we find out that the main difference in spidegrams is in Th. Samples from Łanowicze display very distinct positive Th anomaly, these from Wigry variable anomaly (some samples display weak positive, some negative) and from Bilwinowo negative Th anomaly.

There is recognizable connection between monazite presence in studied rocks and the mentioned anomaly in the ORG spidergams. The content of monazite in the Łanowicze samples is the highest one. There is a moderate content of this mineral in Bilwinowo while in samples from Wigry monazite is very rare in some samples and pretty abundant in the others. Composition of monazite is also typical. Th and U contents in samples from Wigry is very low where monazite is rare and high where it is abundant.

Monazite presence has been used for age determination with the use of CHIME method (Suzuki, Adachi 1991). Rocks from the studied boreholes show 3 different patterns of age results.

Bilwinowo – samples show stable monazite age results 1542±20 Ma and Th contents up to 12%. Łanowicze – monazites display 2 age values, some crystals possess central parts with composition pointing out at 1850±50 Ma while most of crystals show results consistent with results from Bilwinowo borehole – 1540±30 Ma, Th contents from 4 to 7%. Wigry – the first preliminary dating points out to the monazite age ca. 1840±50 Ma.

Preliminary data obtained from Nd isotopes show for all samples from Bilwinowo and Łanowicze negative $\varepsilon_{Nd}(1550)$ and positive $\varepsilon_{Sr}(1550)$ values what could indicate that the continental crust took role in their genesis.

CONCLUSIONS

Taking into account the data presented above (and macroscopic and microscopic studies not presented here) we can conclude that all three types of charnockitic rocks show distinct differences.

1. Al contents in the studied orthopyroxenes indicate that the conditions of crystallization (pressure) vary from fairly low in Wigry, medium in Łanowicze to polybaric (low and high pressure) in Bilwinowo.

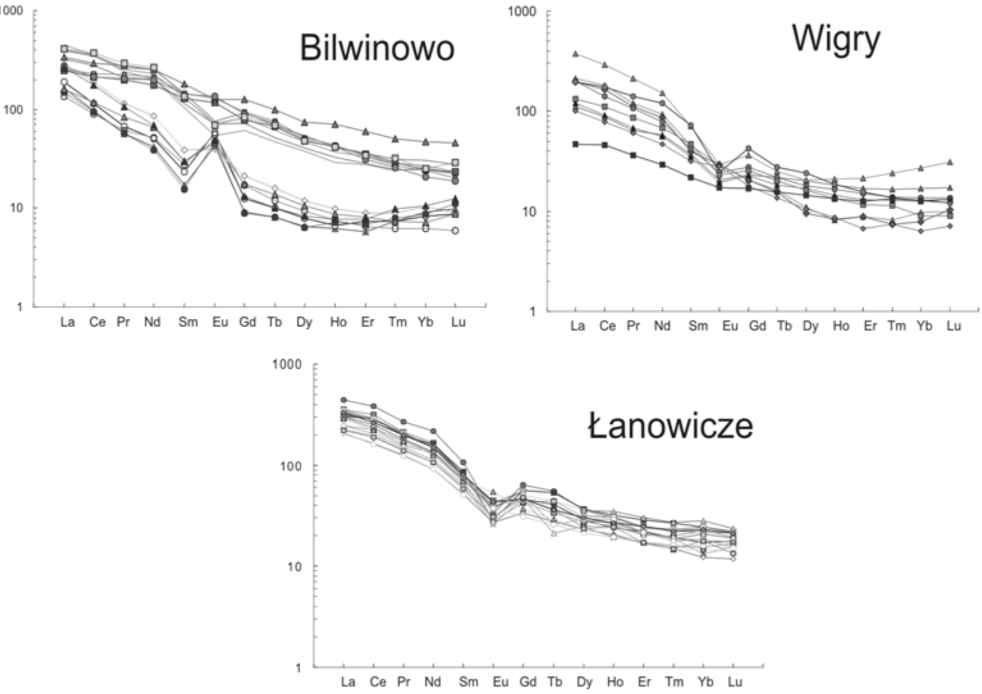

Fig. 3. REE distribution in the studied rocks. Normalisation after Sun, McDonought 1989.

2. REE distribution pattern of Bilwinowo displays picture similar to that we can find in migmatized rocks (Fourcade *et al*. 1992). Dual shape could be explained by the process of injection of molten country rock material into the solidifying magma chamber. The heat of the intrusion produced partial melting and migmatization (Duchesne, Wilmart 1997). REE distribution in Łanowicze is very consistent what could be an evidence for homogeneous magma with high REE contents. Charnockitic (and country metamorphic rocks) from Wigry show different pattern resulting from a mixture of several rock types but having generally similar pattern what when connected with the fact that charnockites in this bore-hole are situated within metamorphic rocks could lead to conclusion that charnockites could be genetically connected with migmatitic gneisses being the main constituent of the Wigry drillcore.

3. The CHIME age determination on monazites show that age results from Bilwinowo rocks are with a good agreement with SAM age determination. A connection between these rocks being constituents of the AMCG suite have already been presented (Baginski, Krzemińska 2004). The dual monazite age (1542 and 1840 Ma) obtained in Łanowicze indicates that charnockites could have been generated in the same event as the SAM formation. We also assume that magma for these rocks have been generated in dry conditions by the SAM heat influence and that the potential source could be metamorphic rocks of 1850 Ma being the main constituent of crystalline basement at that age. CHIME age determinations in Wigry are very preliminary and require more monazite dating, but taking into account position of charnockitic rocks within the drill-core and geochemistry of charnockites and adjacent rocks we could point out that possible mechanism of charnockites formation could be generation of small quantities of charnockitic melt by partial melting of mafic gneisses in granulite facies conditions.

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