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Gabbroid intrusions of Wilhelm Archipelago, West Antarctica

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SUMMARY

The gabbroids are common representatives of Mesozoic and Tertiary plutonic rocks outcropping along the Graham Coast of the Antarctic Peninsula. Numerous gabbroid massifs were discovered on Wilhelm Archipelago and adjacent mainland near to the Ukrainian Antarctic Station “Akademik Vernadsky”. Authors present new data concerning Petermann, Anagram and Berthelot Islands gabbroid massifs collected during austral summer seasons 2017th and 2019th and in process of subsequent laboratory researches. The main goal of the researches was the clarification of geological position, peculiarities of composition and ore potential of the Wilhelm Archipelago gabbroids. It was found out that the gabbroid massifs are only small exposed parts of much more large intrusive bodies that submerged below sea level or buried under permanent snow and ice covers. The most distinctive feature of the studied gabbroids is primary magmatic layering. Its present day deep or vertical bedding was explained by regional tectonic deformations that took place in the West Antarctic region during Andean orogenesis. The layering and other petrographic features of the gabbroids indicate considerable development of crystal fractionating processes. These features as well as discovered manifestations of ore mineralisation allow to predict the presence of mafic and ultramafic cumulates with Cu-Ni sulphide or Fe-Ti-V oxide ores.

Introduction

The Mesozoic and Tertiary non-metamorphosed intrusive rocks are outcropping along the Graham Coast of Antarctic Peninsula (Burton-Jahnson and Riley, 2015). Their major representatives are the batholitic plutons composed by the granites, granodiorites, tonilites and diorites (Riley et al., 2011). Beside the acid and intermediate varieties, the common representatives of plutonic rocks are gabbroids. Several gabbroid bodies are located on the Wilhelm Archipelago and adjacent mainland coast near to the Ukrainian Antarctic Station (UAS) "Akademik Vernadsky" (Artemenko et al., 2013; Mytrokhyn et al., 2017, 2018). Their morphology, internal structure, age and relations to granite-diorite association have not been found yet. Petrology, mineralogy and chemistry of the gabbroids were not studied as well. We present new data collected during austral summer seasons 2017th and 2019th and in process of subsequent laboratory researches. This research was supported by National Antarctic Center of Ukraine in terms of target scientific-technical program of Antarctic research in 2011-2020 years. *The main goal was the clarification of geological position, peculiarities of composition and ore potential of the Wilhelm Archipelago gabbroids.*

Methods

Large-scale geological survey on the Wilhelm Archipelago was carried out by Mytrokhyn O.V. and Bakhmutov V.G. during seasonal works of 22th and 24th Ukrainian Antarctic Expedition. The photo-interpretation of Google Earth satellite imagery as well as data of previous small-scale geological mapping (Fraser, 1964; Curtis, 1966; Flemming and Thomson, 1979) were also used for conducting of geological routes and drawing upgraded geological maps. All collected samples were further studied in the laboratories of Taras Shevchenko National University of Kyiv (Institute of Geology). Thin-sections of the rocks were studied by Mytrokhyn O.V. and Mytrokhina T.V. on polarized light microscopes POLAM-RP-1. Mytrokhyn O.V. and Aleksieienko A.G. carried out electron microscopy and electron-microprobe investigations of rock-forming and Fe-Ti oxide-ore minerals using scanning electron microscope REMMA-202M equipped with energy-dispersion X-ray spectrometer «Link systems».

Results

New outcrops of gabbroids were found out on the Petermann, Anagram, Berthelot, Vedel, Roka, Cruls Islands and on the Cape Tuxen, Waddington and Girard Bays shores of mainland. Nowhere gabbroid bodies can be countered because sea water, permanent snow or ice lies upon their geological boundaries in many places. So morphology of the most gabbroid bodies is unknown and their sizes are more or less understated.

Petermann Island gabbroid intrusion (PIGI, 65°9’53’’S and 64°9’6’’W*)* exposes on the northern part of the Petermann Island (fig.1). The total area of the mapped outcrops of gabbroids is 195000 m^2. Steep slopes of the northern coast and the highest peak Clayton Hill are composed by gabbroids. On the north direction the gabbroids submerge upon the sea level. On the south PIGI is cross-cut by Upper-Cretaceous granitoid intrusion which U-Pb isotope age is 96±1 Ma. Permanent snow-ice cover partly overlaps upon intrusive contact between granitoids and gabbroids. Older age of PIGI is confirmed by numerous granitic veins in gabbroids as well as by the presence of gabbroic xenolithes in granitoids. Two generations of the mafic dykes, pre-granitic and post-granitic ones, intrude the gabbroids. At some outcrops gabbroids reveal the primary magmatic layering with rhythmic modal graded character. Each rhythm is 2-5 to 10 cm thick and consists of mesocratic and leucocratic cumulates, which gradually pass each other by increasing the content of plagioclase relative to mafic minerals. So the plagioclase content changes from 50-60% to 90% or more. The boundaries between the rhythms are linear and clear, without alterations at the margins. The thicknesses of the neighbouring rhythms are almost equal and they are stretched along the strike. Nevertheless, there are areas with a lens-layered structure where individual gabbroic layers are gradually thinning out along the strike. The layers usually dip SW subvertically or at angles greater than 75° and strike NW 330-355°. In the adjacent areas cross-bedding layering is also observed. General north-western strike of

the layering can indicate on submerged prolongation in this direction. Amphibole gabbroes, gabbro-norites and anorthosites represent petrographic diversity of PIGI. Beside accessory concentration of magnetite, ilmenite and pyrite there are manifestations of chalcopyrite and Cu-silicates in the PIGI gabbroids.

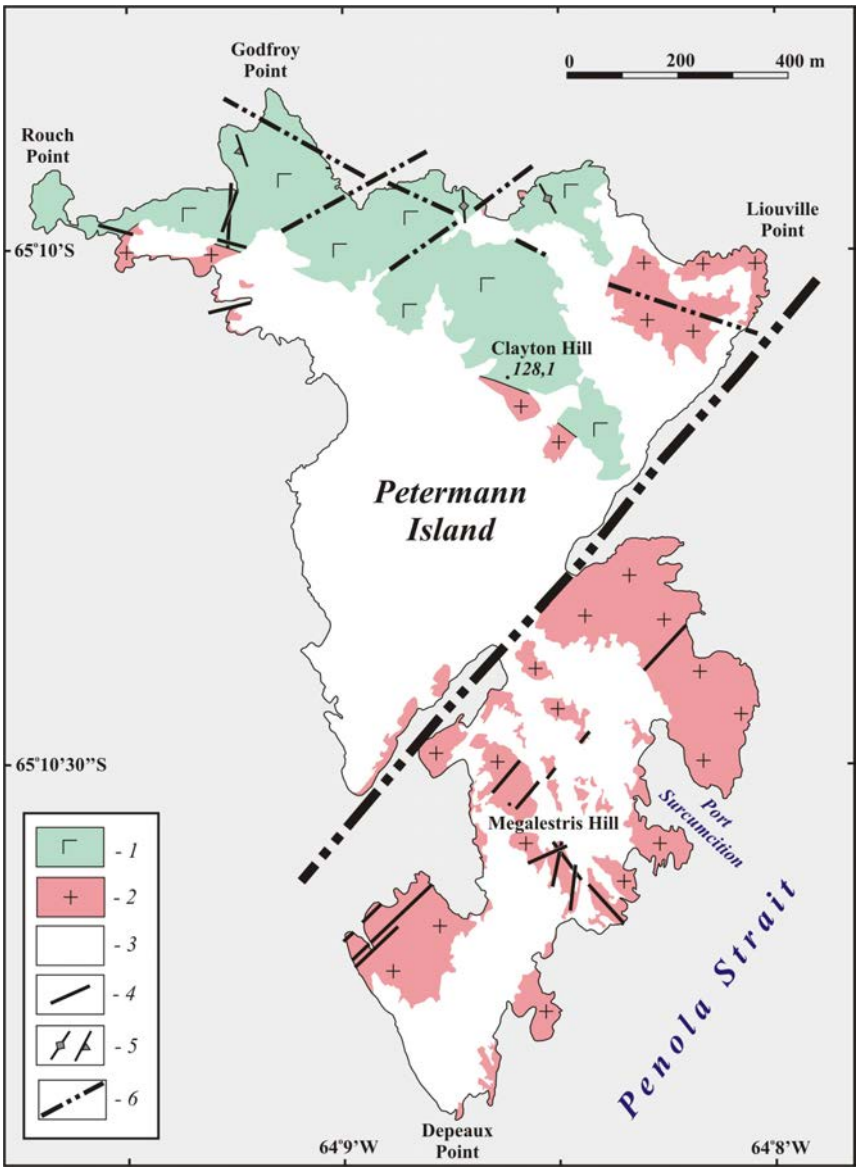

Figure 1 *Geological map of the Petermann Island. Legend: 1 – gabbroids; 2 – granitoids; 3 – snow and ice cover; 4 – mafic dykes, 5 – strike of magmatic layering with vertical and steep bedding features respectively; 6 – faults.*

Anagram Island gabbroid intrusion (AIGI) exposed on the Nob Island (65°12'11''S and 64°19'8''W) and three neighbouring unnamed islands of the Anagram group (fig.2). The gabbroids form almost all area of the Anagram Islands. Only on the north-east of the Anagram-II their outcrops are in contact with more young granitoids. Small granitic veins cross-cut the gabbroids in many other places. On the shores the gabbroids usually submerge upon the sea level. Permanent snow and ice partially cover central and south parts of the largest islands. The total area of the mapped outcrops of gabbroids is 132500 m^2. Thin rhythmical modal layering of the gabbroids exposes along north shores of Nob Island and Anagram-III. Its dip is high to vertical. The general strike agrees with north-east orientation of the islands and their promontories and inlets. Microscopic examination reveals foliate textures of the layered gabbroids which demonstrate plane-parallel orientation of cumulate minerals. Petrographic diversity of AIGI rocks includes amphibole gabbroes, olivine gabbro and gabbro-norites,

anorthosites and pyroxenites (olivine vebsterites). Typical accessory ore minerals of studied samples are Ti-V magnetite, ilmenite, pyrite and chalcopyrite.

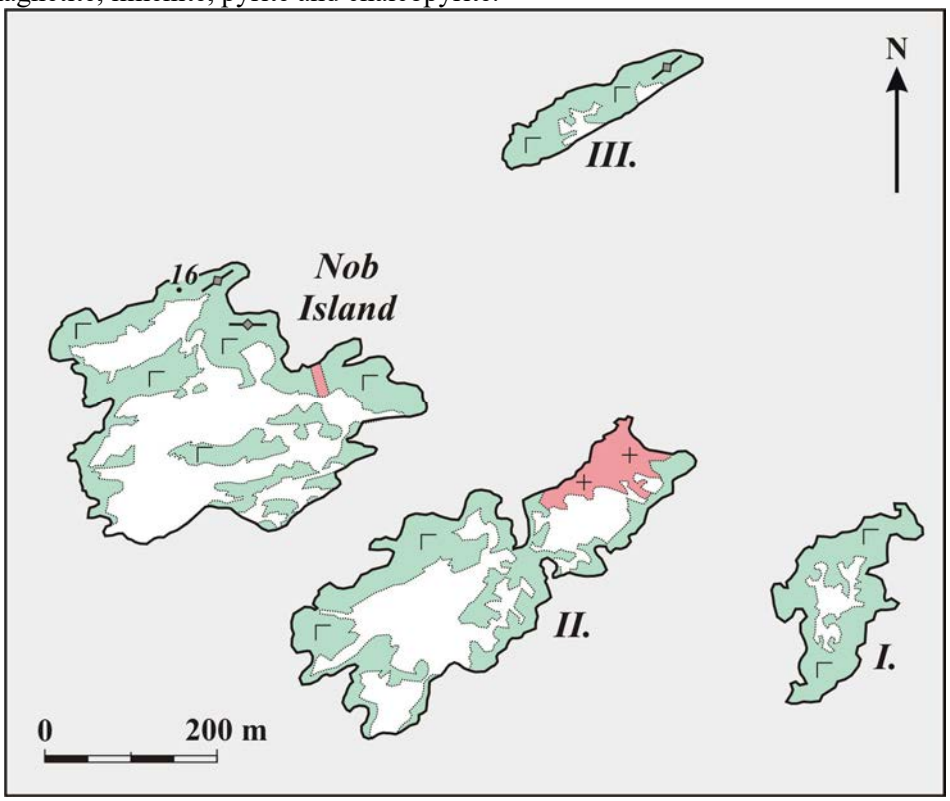

Figure 2 *Geological map of the Anagram Islands. The legend is the same as on the figure 1*

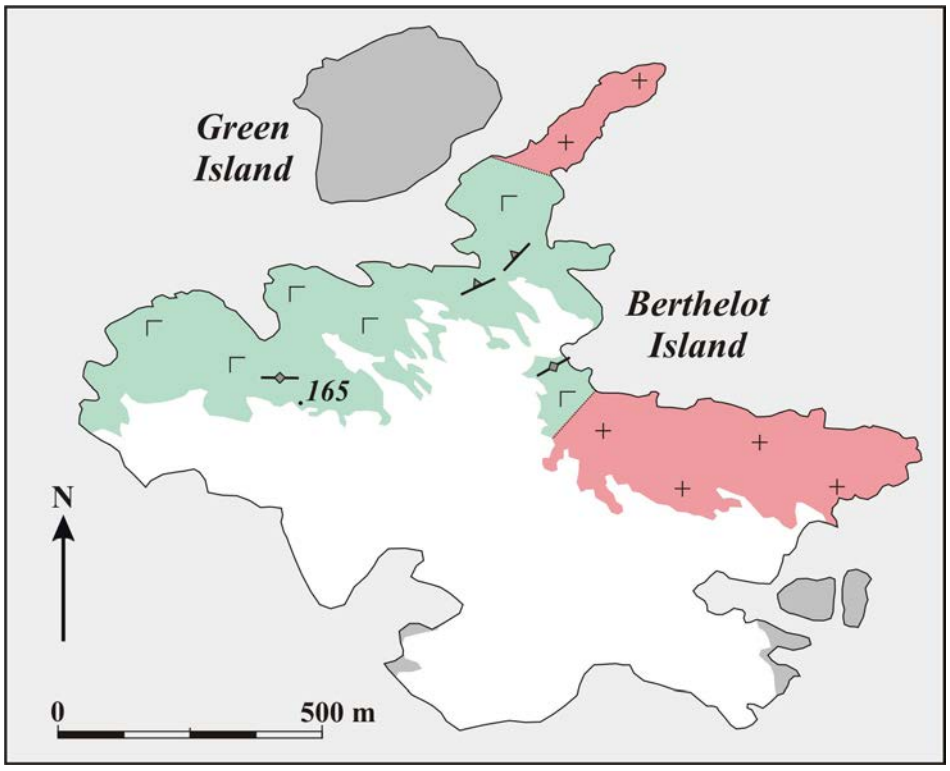

Figure 3 *Geological map of the Berthelot Island. The legend is the same as on the figure 1*

Berthelot Island gabbroid intrusion (BIGI) exposed on the west part of the largest island of Berthelot group (65°19’50,5’’S; 64°9’13,3’’W), fig.3. The mapped outcrops of gabbroids occupy area around

90000 m^2. On the north-east they are intruded by granitoids. In the central part of the island their contact with granitoids is under the ice and moraine deposits. On the east and west shores the gabbroids submerge upon the sea level. In the north direction the prolongation of the BIGI is assumed on the Green Island. The last one is the Antarctic Special Protected Area and was not studied in geological respect. In many places the gabboids demonstrate spectacular examples of magmatic layering. Vertical dips change on high north-west ones in the north direction. BIGI petrographic diversity represents olivine gabbro, gabbro-norites and anorthosites. The gabbroids contain accessory concentrations of Ti-magnetite, ilmenite, pyrrotite, pyrite and chalcopyrite. Also Cr-Fe-spinellides were firstly discovered by authors in the studied samples of gabbroids.

Conclusions

1. Numerous gabbroid massifs of Wilhelm Archipelago are only small exposed parts of much larger intrusive bodies that submerged below sea level or buried under permanent snow and ice covers.
2. The most distinctive feature of the studied gabbroid massif is primary magmatic layering. Its present day deep or vertical bedding can be explained by regional tectonic deformations that took place on the West Antarctic during Andean orogenesis.
3. The layering and other petrographic features of the gabbroids indicate considerable development of crystal fractionating processes. These features as well as discovered manifestations of ore mineralisation allow to predict the presence of mafic and ultramafic bottom cumulates with Cu-Ni sulphide or Fe-Ti-V oxide ores.

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