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METALLOGENY SPECIALZATION AND EROSION OF GRANITOID MASSIVE NGOCTU, KONTUM

SPECIALIZED: GEOLOGY

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PhD. DISSERTATION SUMMARY

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The work was completed at: **Vietnam Institute of Geosciences and Mineral Resources**

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INTRODUCTION

1. The necessity of the project

The magmatic formations of acid composition are quite widely distributed in the Po Co structural zone of the Kon Tum block. Many research works published in domestic and foreign journals on geological and lithological characteristics of intrusive magmatic rocks have partly elucidated the material composition and formation conditions of magmatic rocks. .

Research object is Ngoc Tu massive granitoid, distributed mainly in Ngoc Tu commune, Dak To commune, Kon Tum commune, mentioned in many works such as: Nguyen Van Trang, 1985; Nguyen Van Loc, 1998; Duong Duc Kiem, 2004; Nguyen Trung Minh, 2005; Tran Hoang Vu, 2015; Nguyen Van Niem, 2018. The surveying, geological mapping and mineral investigation in the relevant area have detected some manifestations of Au, Mo, W, Cu mineralization and geochemical anomalous fields of the soil. Sn, W and aeronautical radiation anomalies. The most recent research results of the Ministry of Science and Technology project of MONRE.2016.03.05 (Nguyen Van Niem, 2018) have partly elucidated the Mo mineralization potential of this granitoid mass. However, there has not been in-depth research to determine the ability of ore generation and the level of erosion of Ngoc Tu massive granite, as a basis for forecasting the prospect of related endogenous minerals, as well as the possibility of forming sand mines. minerals and related to Ngoc Tu massive granitoid formations.

In order to contribute to solving the above remaining problems, the PhD student has chosen the topic ***"Metallogeny specialzation and erosion of granitoid massive Ngoctu, Kontum".***

2. Research scope and object

Research scope: Granitoid massive Ngoctu formation, Kon Tum.

3. Objectives

- Clarifying the metallogeny specialzation of the granitoid massive Ngoctu, Kon Tum.

- Research and evaluate the degree of erosion of the granitoid massive Ngoctu, Kon Tum.

4. New points

On the basis of research results on geological structure, material composition, formation conditions, geochemistry, inclusion, interpretation according to modern scientific theories , the thesis has proved that granitoid massive Ngoctu has Mo, W, U mineralization specialization.

For the first time, the thesis assessed that granitoid massive Ngoctu had been eroded at a medium - low level and the element combinations typical for the upward movement were Si, K, Be, Ga, La, Li, Nb, Sc, Rb, Hf, Re, Tl, Mo, Sn, W, Th, U and the downshifted group of elements are Mg, Cd, Cu, Ti, Cr, Co, Ni, V.

5. Main points

Main point 1: Granitoid massive Ngoctu has metallogeny specialzation of Mo, W and U.

Main point 1: Granitoid massive Ngoctu has medium - low erosion and clearly shows geochemical zoning according to vertical section, characterized by the group of elements moving up as Si, K, Be, Ga, La , Li, Nb, Sc, Rb, Hf, Re, Tl, Mo, Sn, W, Th, U and shifting element group down are Mg, Cd, Cu, Ti, Cr, Co, Ni, V.

6 . Scientific significance and practical significance

Study the geochemical characteristics, geochemical lithological modules, combined with the results of the research on the oxidation - reduction environment of the rock to evaluate the metallogeny specialzation of the Ngoc Tu massive granitoid.

The application of the method of NNAmshinsky (1973) to assess the erosion depth of the granitoid mass has scientific and practical significance not only in assessing the degree of erosion of the structure with the potential to contain ore, but also basis for quantifying the mass of useful elements that are eroded, capable of creating different placer deposits or sediments, especially "ancient bed" uranium deposits in the sedimentary basins adjacent to the Ngoc Tu massive granitoid.

7 . Data

The thesis is built on 02 topics of Science and Technology of which the PhD student is the main member. During the course of participating in the project,

the researcher directly surveyed the field, took samples, studied some detailed cross-sections of Ngoc Tu, Dak To, and Kon Tum areas.

In addition to 24 samples analyzed by ICP-AES method at the Institute of Geology of the Far East (FEGI) - Russia of the NCS. The thesis also uses analysis results of 02 scientific and technological projects above, including: 22 geochemical samples by ICP - MS method for 41 elements; 05 samples of results of inclusion components to evaluate the primary magmatic environment of granitoid (over 40 analyzed samples); 03 samples of oxygen stable isotope for molybdenite rock and ore, 03 samples of U-Pb isotope analysis on zircon to determine the age of two rock types (porphyr and medium-small-grained granite); 15 microsond samples: mainly in ore minerals; 55 petrographic samples; 8 neutron activation samples for total rock and 5 neutron activation samples for single mineral; 15 mineral samples; 20 inclusive samples to determine the temperature of ore formation…

At the same time, the thesis also uses the results of analysis of Re - Os isotope (Tran Hoang Vu, 2014), stable isotope S (Tran Trong Hoa, 2005), by Nguyen Truong Giang (2001), Nguyen Quang Loc (1998) and reports in geological archives.

8 . The thesis structure

In addition to the introduction and conclusion, the thesis is structured as follows:

Chapter 1. Overview of geological and mineral features in Ngoctu, Kon Tum area.

Chapter 2. Theoretical foundations and research methods

Chapter 3. Metallogeny specialzation of the granitoid massive Ngoctu, Kon Tum

Chapter 4. Characteristics of the erosion of the granitoid massive Ngoctu, Kon Tum

9 . The place to carry out the thesis topic

The thesis was carried out and completed at the Vietnam Institute of Geosciences and Mineral Resources.

RESEARCH CONTENT

CHAPTER 1: OVERVIEW OF GEOLOGICAL AND MINERAL CHARACTERISTICS IN NGOCTU, KONTUM

1.1. Overview of the history of research

Geology in the study area has had many research works such as "Mapping and measuring" geology and mineral prospecting group sheet design scale 1:50,000" (Nguyen Quang Loc, 1998), geophysicist of Nguyen Truong Giang, (2001); "Study on the formation conditions and distribution rules of rare minerals related to magmatic activities in the Central and Central Highlands regions" (Tran Trong Hoa, 2005), "Research on mineralogy and mineral prospect forecasting Po Co structural - tectonic zone" (Duong Duc Kiem, 2006), "Study on molybdenum geochemical specialization of granitoid formations of Ba Na type in Vietnam and their Mo mineralization potential" (Nguyen Van Niem, 2018). Given that the study area is located in the Po Co zone of the "Kon Tum architecture" zone, consisting of sedimentary formations including the Tac Po Formation, the Dak Thaniang Formation, the Kon Tum Formation and magma including the Dien Binh Complex and the Hai Complex. Van, Ngoc Tu granitoid massive , Kon Tum formation .

In terms of minerals, there are molybdenum - wolframite - bitmus mineralization points and associated minerals in Dak De and Ngoc Tu.

1.2. Stratigraphy

The related distribution formations include: metamorphic formations of Tac Po Formation; Dak Honiang Formation, Kon Tum Formation , Quaternary sediments . The general geological features are as follows:

- Tac Po Formation (PR_{1-2} *tp*): Composed of 2 volumes: Volume 1: gneisbiotite, garnet biotite biotite, biotite plagiogneis, 2 mica gneiss; thin layer of amphibolite gneiss, amphibolite, pyroxene gneiss, biotite quarsite. Volume 2: 2 mica gneiss, ±small grained biotite gneiss, biotite plagiogneis, quartz - feldspar - mica schist.

- Dak Honiang Formation (PZ_1 *pt*): Composed of 2 sets: Volume 1: mainly biotite - amphibol plagiogneiss. Volume 2: Quartz slate - plagioclase - 2 mica.

- Kon Tum Formation (N_2 *kt*): Gravel, gravel, sand.

- Quaternary system (Q): Composition: sandy clay, powdery sand mixed with a little yellow grit.

1.3. Magma

Related formations include : Dien Binh Complex, Ben Giang Complex, Que Son Complex, Hai Van Complex, Ngoc Tu granitoid massive. The general geological features are as follows:

- Dien Binh Complex ($\delta\gamma OS\ db_1$) : contains diorite, quartz diorite, and hornblende biotite diorite .

- Ben Giang-Que Son Complex ($\gamma\delta PZ_3\ bg_2$): has the composition: gabrodiorite, hornblende diorite, biotite granite, medium-grained hornblende biotite granite and small-grained light-colored granite veins.

- Hai Van Complex ($\gamma aT_2\ hv$) : The composition of the massive includes phase 1: relatively dark medium to large-grained biotite granite. Phase 2: biotite granite with light colored muscovite.

- Granitoid massive Ngoctu

The object of the study is granitoid massive Ngoctu (formerly Ngok Loak), named after one of the highest peaks in the region, 16 km northwest of Dak To, with an area of about 300 km^2 . At the contact edge, the phenomenon of change and contact with the Tac Po formation causes hornification, including: quartz horn rock - feldspar, horn quartz - biotite - cordierite.

Petrographic composition includes 2 main rock groups: Group I- porphyr granite; Group II - small-medium-grained granite with transition boundary with group I.

Mineral composition features:

i) Porphyr granite has a mass structure, light to dark in color. Notably, when surveying many places, there are many spots of medium-small-grained, bright-colored granite with transitional boundaries or no clear boundaries. Major minerals : plagioclase, potassium feldspar , quartz , biotite , little muscovite , with some distorted zircon, monazite and apatite grains often associated with biotite.

ii) Small-medium-grained, light-colored, shaped granite, sometimes porphyry. Main minerals : plagioclase, potassium feldspar, quartz , biotite, muscovite , minor minerals : zircon, apatite, monazite, little sphen .

Fossil-chemical characteristics. Main element content: SiO_2 = 72.54 TiO_2 = 0.23%, Al_2O_3 = 13.65%, Fe_2O_3 = 0.84%, FeO = 1.13%, MgO = 0.35%, CaO = 0.83%, Na_2O = 2.65%, K_2O = 5.08%, total alkali (Na_2O + K_2O) = 7.19-8.41% and K_2O/Na_2O = 1.36-2.78. It shows that the massive is high siliceous granite, and belongs to the series of high-potassium lime-alkali. According to the magma environment, the mass is in a medium oxidation state with an average $Fe_2O_3/(Fe_2O_3$ +FeO) ratio of 0.47.

Distribution characteristics rare elements - traces show, quite poor strong force field elements such as Ta (1.72-4.53ppm), Nb (15.11-22.61ppm), Zr (29.81-163.57ppm) , Y (9.86-64.22ppm) and Hf (1.28-4.40ppm). Ratio K/Rb = 93.85-137.36; Rb/Sr = 4.08-9.97; Rb/Ba = 0.98-2.90. According to the tectonic classification of the plate-colliding granite (Syn-COLG)

The age of formation according to research results such as Tran Hoang Vu (2015) determining the age of U-Pb isotope is 240.5 ± 0.8 Ma and Nguyen Van Niem (2018) determining the age of U-Pb isotopic age. is 241 ± 4 Ma.n. Thus, it can be said that the Ngoc Tu massive granitoid has an absolute age of 240÷241 Ma. n, which is equivalent to the Middle Triassic (T_2).

1.3.3. Assist

On the study area, fault systems develop in three systems: northwest - southeast, northeast - southwest and sub-meridian. They play a major role in creating the geological structure of the area.

1.3.4. Mineral

In the study area, there are some manifestations of molybdenum - wolframite - bitmus mineralization and associated minerals in the area. Dakde and Ngoctu.

CHAPTER 2: THEORETICAL BASIS AND RESEARCH METHODS

2.1. Theoretical basis

2.1. 1 . Geochemical specialization and metallogeny specialzation

** Geochemical specialization and metallogeny specialzation*

According to Iu.V. Kazitryn et al. (1975): Geochemical specialization of rocks is the relative increase or decrease in the ore elemental content relative to their Clark value.

According to the "Geological Dictionary". 2 episodes. M. Nedra, 1978 : The geochemical specialization of magma is the characteristic of magma with a higher concentration of distributed elements (positive geochemical specialization) or lower (negative geochemical specialization) than the Clark value.

According to the "Geological Dictionary". 2 episodes. M. Nedra, 1978 **:** *Magmatic metallogeny specialzation* is a special case of magmatic rock geochemical specialization, which involves only the metallic components associated with ore deposits. Some authors also add to the term metallogeny specialzation as the sum of the processes that make magma ore-forming, ending with the formation of ore deposits.

According to IE Smorchkov , "On defining the concept of magmatic rock metallogeny specialzation " in: *Magma metallogeny specialzation* is the ability to form ore of magma, that is, the existence of a set of factors that cause a heterogeneous disturbance. material in the magma chamber, concentrating the elements in separate zones in the chamber, as well as separating the ore matter from the silicate solution.

VSEGEI Open Geological Dictionary: *Metallogenic specialization* is a set (a set of) dominant minerals, specific to a geological object or a certain geological process, for example, , ore node or region, geological formation, a geological period, etc

The metallogeny specialzation of magmatic rocks often coincides with their geochemical specialization. In order to evaluate the metallogeny specialzation of the magmatic complex, the geochemical premise for mineral prospect is used - qualitative and quantitative characteristics of magmatic rocks, indicating their ability to create deposits. The direct premise is the

distribution of ore elements specific to the mine type, the indirect premise is the element composition characteristics, including the content and distribution characteristics of rock-forming elements and trace elements. amount not involved in the ore composition.

The geochemical method to determine the metallogeny specialzation of magma objects can be used in the following three directions:

a) Clarifying the ore-forming geochemical characteristics of the research object on the basis of statistical analysis of chemical element content and other geochemical parameters. Multicomponent statistical analysis allows to show the main manifestation of ore geochemical trends on the basis of consistent trends in the behavior of ore-forming elements and associated elements, as well as to assess the degree of affect the chemical changes of the system. It is thus possible to identify the processes that lead to ore formation (for example, sulfide ores) and the type of ore involved, and the areas where they may be concentrated can be predicted.

b) Detecting the anomalous content of ore elements in the rock and delineating the anomaly;

c) Establishing the laws of ore and accompanying elements variation in time and space, allowing to build a model of the ore formation process in relation to the lithological model of the object. Of most practical importance is the geochemical specialization of the magma phases.

Based on the behavior characteristics of the elements, compounds (and metals) in rocks when their average concentrations exceed the clark content (AAGolovin, 2000) the clark factor was used to calculate the coefficient. Elemental concentration (Ktt) for geochemical and metallogeny specialzation n levels as follows: $0.7 < Ktt < 1.5$ - no geochemical specialization; $Ktt > 1.5$ - has positive geochemical specialization and < 0.7 - negative geochemical specialization.

- Using the method of Permiakov (1983) calculate the fossil modulus according to the atomic mass of the rock-forming elements.

- Concentration index (cstt) of granitoid elements according to (Kozlov VD, 1985).

- Along with some mineralization charts based on the comparison of elemental content ratios, including: Correlation chart Cao-Na_2-K_2O (according to VT Pokalov, 1973) related to Cu- Mo, Mo, W-Mo, Sn; Rb-Sc and V-Ni diagrams (according to Meinert, 1995) related to the metallogeny specialzation Mo, Sn, W, Zn, Cu, Au; the graph of Fe_2O_3 /FeO-SiO_2 (according to Ryan D. Taylor, 2010) related to molybdenum porphyr, copper porphyr and Sn; correlation between Ba-Rb-Sr (according to Twist and Kleeman, 1989) related to Sn-W-Mo mineralogy granite, differentiated granite, etc…. Correlation chart of Mg^+, K^+, Na^+ (according to V. Sattran, 1977) related to mineralization of Mo, Sn, Au according to oxidation - reduction state (according to Blevin, 2004).

* *Oxidation-reduction properties and ore-forming ability of granitoids :*

- Based on the classification of ilmenite and magnetite series of graintoids according to Tsuesue and Ishihara (1972).

- Based on the correlation Fe^{2+} - Fe^{3+} according to Blevin. PL, (2004) for graintoid rocks.

- Based on the researches of Henderson, focus on studying multivalent trace element groups to determine the redox state of magma.

- Based on the composition of the primary body applied in primary granite types (containing CO_2, H_2O). The samples were analyzed on Raman equipment (thermochemical geochemical method) to clarify the primary magma geochemical environment characterized by oxidizing properties, favorable for mineralization. .

2.1.2. Theoretical basis for studying the level of granitoid erosion

The assessment of the degree of erosion of the granitoid mass under study has an important meaning in assessing the degree of erosion of the ore-containing structure as well as the possibility of the existence of ore in the deep part, thereby orienting the search method system. mine discovery related to the operation of ore magma system.

In general, the granitoid intrusive magmatic blocks can be very roughly divided into the following parts (Figure 2.1):

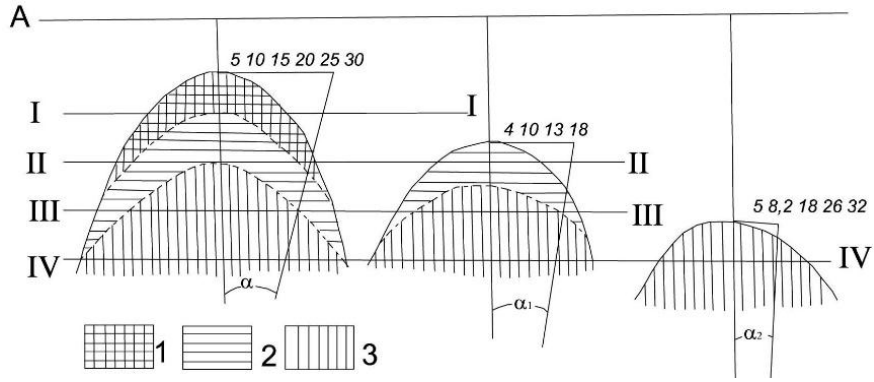


Figure 2.1: Cross-sectional model of erosion levels of granitoid intrusive bodies
1- aplite granite, 2- porphyric granite, 3- medium-small-grained granite. I-IV- wear levels; AD- neck surface; α- angle between the upward shift (U) and vertical axis

The method of assessing the degree of erosion of magma blocks has been studied and experimented by Soviet geochemists for specific granitoid magma blocks in the Russian Federation. The results of that research are currently being used as a theoretical basis for geological research and investigation, searching and discovering minerals in Russia.

The degree of erosion of the intrusive mass is evaluated on the basis of geological, petrographic and geochemical data, reflecting the zoning of the

intrusive mass. For example, where there are many large-grained porphyric granites as well as many obtuses of the penetrated rock are areas of low erosion. On the contrary, where granite has a uniform grain structure, the composition is quite stable, it cannot be stuck, it is a place where it is strongly eroded.

Based on the concept that the initial composition of the magma is homogeneous and formed under the same conditions to compare the erosion rate of the intrusive masses. Thus, the deeper down, the more homogeneous and similar the composition of the granitoid mass is to the original solution. On that basis, Bondarenko VN and Verkhovskaya proposed to use statistical methods to determine the degree of erosion of the intrusive mass (compared to the top dome) of the intrusive blocks. .

Model for quantitative determination of erosion depth N.N Amshinski, 1973

- Based on the initial composition of the magma volume is homogeneous and formed under the same conditions to compare the erosion rate of the intrusive masses. Thus, the deeper down, the more homogeneous and similar the composition of the granitoid mass is to the original solution.

- Based on the composition of major and minor minerals in the block to assess the zoning depth of blocks.

- Based on the average content (X), deviation (S^2) and content variation (V) of rock-forming oxides along with the regular distribution of rock-forming elements and the allowable fossil zoning coefficient calculate vertical zonal gradient according to depth (K1, K2, K3, K4) . These ratios are called geochemical vertical zoning coefficients. Determine the set of elements "shifting up" such as Si, K, Li, Nb, La, Y, W, Be, Sn, Mo, Rb, U, Th... and the set of elements "shifting down" like Fe, Ti, V, Cr, Ni, Co, Zn.

- Based on ratios between "upshift" and "downshift" sub-elements. In the geochemical subdivision, the granitoid block is divided into 4 parts: the top

dome, the upper part, the middle part and the deep part, the height difference of each part is 400m. Each part is characterized by the value K1, K2, K3, K_2O/MgO, Nb/Y, Yb/Co, Nb/V… In which the ratio Nb/V > 4 corresponds to the apical arch, eroded. low, Nb/V ≈2, corresponding to the upper part of the block and often have ore-like manifestations, Nb/V ≈1,2 is typical for the middle part, and Nb/V < 1 only occurs in the deep zone without ore of the granitoid mass . Specifically, Nb/V > 4 in granitoid is typical for low erosion, Rb/V < 1 is for low part of granite and contains no ores, etc.

Based on the ratio between the indicator elements K_2O/MgO, Nb/Y and Yb/Co of shallow facies granitoid (10.0 – 0.8 – 1.5); average depth (4.0 – 0.4 – 1.0); deep generals (2.0 – 0.3 – 0.3).

2.2. Research Methods

2 . 2.1. Synthesize, analyze and systematize documents

The PhD student has consulted, collected and synthesized various types of documents related to the research content of the thesis, including: Geological and mineral mapping works with the scale 1:200,000; ratio 1: 50,000; Projects, topics and thematic reports on magma, geochemistry, geophysics, stratigraphy, mineralogy; In-depth works and articles published in domestic and foreign journals.

2.2.2. Closer to the field , taking all kinds of samples for analysis.

Research and evaluate the results achieved and survive after processing existing documents. The field survey method includes the following steps:

- Collecting sample forms such as bedrock geochemistry, petrology, facies mineralogy, inclusions, samples of fluid concentration in related total rocks for analysis as a basis for in-depth research on geochemical characteristics and geochemical-geological environment, in order to solve the content of geochemical specialization; Next, study the ore zonation of the area showing mineralization.

On the basis of geological structure and topography-geomorphology of granitoid massive Ngoctu, the researcher has collected elevation data of geochemical samples and diversified into 3 groups of elevations: 1 - upper zone (1000m) 14 samples ; 2 – middle zone (850m) 15 acres; 3 – lower zone (700m) 16 samples, serving to calculate the erosion of the massive.

2.2.3. Analytical method system

+ Analysis of lithology, facies mineralogy: to clarify the petrographic composition of primary rock and of metamorphic rock, ore mineral composition and their relationship.

+ Analysis of silicate chemistry, adding data for rock composition determination, as well as other studies.

+ The system of geochemical analysis methods of rock and ore includes:

- 46 ICP-MS samples with 41 parameters (Mo, Ta, Nb, Cu, Pb, Zn, Bi, Sn, W, U, Cd, Ag, Zr, V, Cr, ...)

- 24 ICP-AES samples for total granite and ranges with mineralization to ensure the determination of the relevant ore-forming element content at concentrations higher than analytical sensitivity.

- 40 samples of inclusion composition CO_2 , H_2S , SO_2, H_2O , CH_4 , some key elements (Fe, K, Na...) in the granitoid to determine the redox environment of rock, predicting the favorable level of magma volume in the process of mobilizing ore-forming material resources.

- 15 microsond samples to determine minerals and composition of some trace elements (Ni, Co, Mn, U...) in molybdenite, pyrite in molipdenite ore zone/related variation zone.

- 8 samples of neutron activation for total rock and 5 samples of neutron activation for single mineral to determine the content of elements in minerals in mineral bodies, in granitoid rocks, U, REE components....

- 20 inclusion samples to determine the temperature of ore formation.

2.2. 4 . Process data and interpret results

The geochemical sample set is diversified according to the petrographic composition of the rock and according to 3 elevations (1000m, 850m, 700m) and uses a system of statistical methods to establish the parameters of the

distribution of elements and calculate them. concentration coefficient (Ktt) and parameters explaining the metallogeny specialzation and the of erosion of the granitoid mass according to the methods mentioned above.

Using specialized software such as Mapinfo, grapher, mathematica, excel functions... to calculate, build and display maps, diagrams, charts, geochemical correlations, geological cross-sections - localization, standard models.

CHAPTER 3 : METALLOGENY SPECIALZATION OF THE GRANITOID MASSIVE NGOCTU, KONTUM

3.1. Metallogeny specialzation of granitoid massive Ngoctu on the basis of geochemical specialization study

For pophyr granite, according to the calculation results, it is characterized by a group of elements with positive geochemical specialization (Ktt ≥ 1.5) including: Cs(45,68) Re(23,68) W(3,34) U(3.25) Sn(2.75) Pb(2.46) Rb(2,19) Th(2.05) Be(1.73) Li(1.70) Mo(1.58) .

Elements with concentration coefficients close to Clark's value (1.5 > Ktt ≥ 0.7) include: Ga (1.01) Ce (1,00) As (0.95) Nb(0.85) Zn (0.83) Ta(0.82) La(0.80) Cu(0.79) Ni (0.79).

The remaining group of elements with low concentration coefficient Ktt < 0.7 (negative specialization) is Zr(0.69) Sc(0.68) Ge(0.67) Y(0.61) Sr(0, 39) Ba(0.38) Co (0.29) V(0.28) Cd(0.20).

Correlation analysis of chemical elements shows that, in granite porphyry, there are 5 closely correlated groups as follows (Figure 3.1):

Group 1: **Sn**-Zn-**Mo**-**U**-**W**-Cu Group 2: **Li** - **Cs** - **Rb** - **Tl** .

Group 3: **Be** -Ga- **Re** -Nd-Cr-Ni Group 4: **Pb**-La-Sc-Hf-**Th**

Group 5: Ba-Ce-Co-Sr-V-Cd-Y

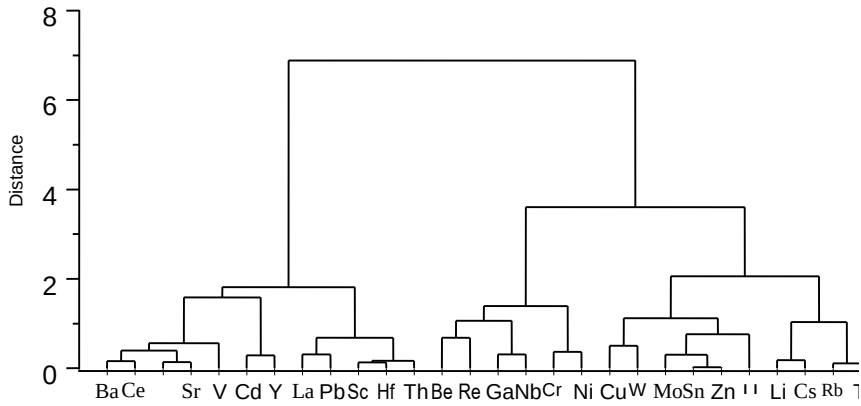


Figure 3.1: Correlation analysis of the content of elements

In small-medium-grained granite , the element combination has a positive geochemical specialization: Cs(45,72) Re(17,63) U(4.81) Mo(3.47) Pb (2,98) W (2.88) Rb (2,14) Sn (1.95) Cu (1,66).

The element combination with a concentration coefficient close to Clark's value includes: Be (1.27) As (1.01) Th (0.94) Ga (0.86).

The element combination with negative geochemical specialization is: Li (0.68) Ge(0.55) Ta(0.52) Nb(0.52) Sc(0.42) Y(0.42) V(0.40) Zn (0.39) Ce (0.38) La(0.32) Zr(0.31) Sr(0.29) Ba(0.23) Cd(0.20).

The main difference between medium-small-grained granite compared to porphyric granite is that in the combination of elements with a positive geochemical specialization, Cu has the appearance of Cu and the absence of Th, Be, and Li. At the same time, the main ore-forming elements such as Pb, Mo, and U have a higher concentration coefficient than that of porphyr granite.

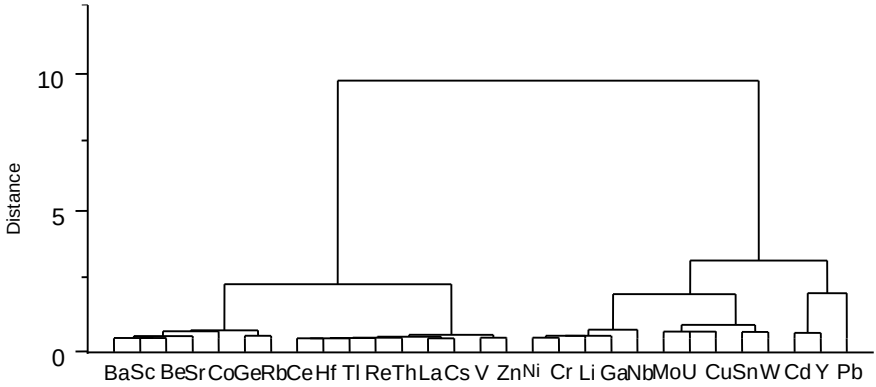


Figure 3.2: Correlation analysis of the content of elements

Correlation analysis of chemical elements shows that in medium-small-grained granite, there are 5 closely correlated groups as follows:

Group 1: **Pb** -Cd-Y; Group 2: **Mo** - **U** - **Cu** - **Sn** - **W**

Group 3: Ni-Cr-Li-Ga-Nb; Group 4: Ce-Hf-Tl- **Re** -Th-La- **Cs** -V-Zn

Group 5: Ba-Sc-Be-Sr-Co-Ge- **Rb**

There is a variation of Nb and V: in porphyr granite, Nb is Ktt = 0.85 and in the reduction of medium-small-grained granite is Ktt = 0.52. In contrast, porphyr V granite is Ktt = 0.28 and increases to medium-small-grained granite is Ktt 0.40. This reflects the trend of zoning according to the process of magmatic activity intruding on Ngoc Tu massive.

With Re (Ktt ≥ 17) often present in molybdenite and wolframite, up to 1.8% content, which is an accompanying useful component, is recovered during the treatment of Mo ore.

Cesium (Cs) (Ktt≥45) has close geochemical behavior with Rb, K and Tl, significant in ilmenite, monazite, minerals of U. In greizen wolframite, the average content can reach 0.06 %Cs.

Based on the above results, it can be concluded that *the Ngoc Tu massive granites have geochemical specialization Mo, U, W, Sn.*

3.2. Metallogeny specialzation of granitoid massive Ngoctu on the basis of study of fossil data

- With the calculation results based on the main element according to the method of Permiakov (1983), it shows that: silicon q = 0.75÷0.78, calcium c = 0.03 ÷ 0.08, alkalinity a = 0.76 ÷ 0.94, iron degree f = 0.70÷0.91, alkaline type n = 0.27÷0.39. Thus, the Ngoc Tu massive granites mainly has the potential to generate W, Mo and fluorite

- Based on the oxidation - reduction chart (Fe_2O_3/FeO) - (Rb/St) (Blevin, 2004) shows that granite is an oxidizing environment and capable of generating W-Mo minerals.

- Based on the correlation chart between Cao - Na_2O - K_2O (according to VT Pokalov, 1973), Ngoc Tu massive granitoid here is characterized by Mo

mineralization and in molybdenum porphyr, Cu porphyr with granitoid (according to Ryan D. Taylor, 2010).

- Based on the correlation chart between Ba-Rb-Sr (according to Twist and Kleeman, 1989), Ngoc Tu massive granitoid is related to the mineralization ability of Sn-W-Mo.

3.3. Oxidation - reduction environment of granitoid massive Ngoctu

* According to the correlation between Fe and the difference index (DI) or the correlation between Fe -Ti, granitoid massive Ngoctu also leaves the magnetite field, corresponding to the oxidized granite type. This granite has a mineral content of magnetite from 0.23 to 0.57 and ilmenite from 0.11 to 0.53.

According to the high Fe_2O_3/FeO ratio, usually > 0.5 and the oxidation - reduction state according to Blevin. PL, (2004) , Ngoc Tu massive granite exhibits both moderate and strong oxidizing environments.

* Fluid composition in primary inclusions from porphyry granite to medium-small-grained granite shows:

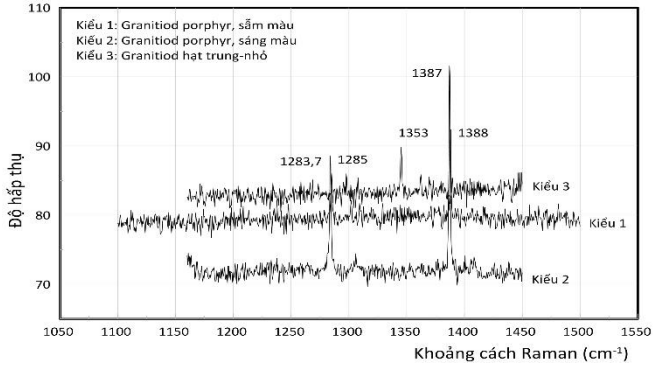
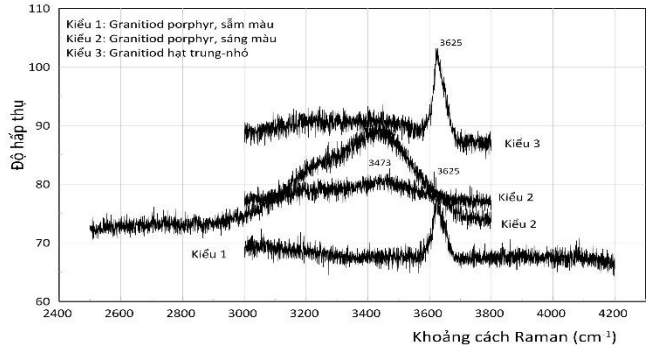


Figure 3.3: Raman spectrum of primary inclusions in quartz minerals containing CO_2 density 0.23-0.35g/cm^3 and spectral range 1283.7cm^{-1} to 1387 cm^{-1} . H_2O -containing quartz minerals, the spectral range is 3575cm^{-1} to 3625cm^{-1} .



The primary inclusion component Raman spectrum of fluorapatite $(Ca_5(PO_4)_3F$ surrounded by quartz crystals has a spectral range of 464, 963.2 cm^{-1} to 429, 465, 965 cm^{-1}.

In the mass , there is an increase in the composition and concentration of fluids in the primary inclusions, specifically rich in CO_2, H_2O, which clearly shows the oxidizing nature of the rock (Yves Moussallam, 2016).

The Ngoc Tu granitoid massive has a medium to strong oxidizing environment, so it is a favorable condition for the mineralization of Mo, W.

3.4. Mineralization characteristics related to granitoid massive Ngoctu

Molybdenite mineralization point at Ngoc Tu quarry

The mineralization point is located in Ngoc Tu quarry area, in light-colored large-grained porphyr granite. Mineralization of olipdenite and wolframite penetrates into sub-cracks in granite along with sericitization, chloritization, and quartzization superimposed transformation zones .

Major ore minerals include: wolframite, molybdenite, sheelite; minor minerals include: chalcopyrite, arsenopyrite, galenobismutin, pyrotin, galenite; Vein minerals: turmalin, quartz, chlorite, fluorite, sericite...

Elemental content in the ore: Mo=59.86%; S=39.32%; Pb = 0.22% heat assimilation of ore inclusions from 200 - 250 ^oC with a high density of liquid - gas inclusions (liquid composition accounts for 80-90%, gaseous components are 10-20%) .

Molybdenite mineralization point Dak Manh

Molybdenum mineralization point, Dak Manh area, Dak Ro Nga commune has the vascular form (traditional core - molybdenite, molybdenite from small granular to large scale) that cuts through porphyric granite .

Major ore minerals include: molybdenite, sheelite; minor minerals include: chalcopyrite, arsenopyrite, galenobismutin, pyrotin, galenite; Vein minerals: turmalin, quartz, chlorite, fluorite, sericite...

The vascular change zone has also encountered galenite, minerals rich in rare earths, Th, U (orthite, xenotim, monazite - these minerals are unknown magmatic or secondary source), Nb-rich rutile, Mn-rich ilmenite, especially encounter very fine grained protozoan uraninite with radioactive minerals .

Elemental content in the ore: Mo = 0.314%, Cu = 0.0501 %, W = 0.1446%, Re = 0.06 ppm , heat assimilation of the ore inclusions from 203 - 250^{o}C.

- The oxygen isotope characteristics of hydrothermal quartz and muscovite in the quartz - molybdenite - sheelite ore zone have the value (δO^{18}= 9.1 - 12.8‰) equivalent to the Ngoc Tu granitoid.

The results of Re - Os isotope analysis on molybdenite minerals of Tran Hoang Vu (2014) give the age of 238±1.7 million years. Compared with the results of isotopic age analysis by the U-Pb method on zircon 240.51±0.8 Ma and 239.0±1.5Ma for granitoid massive Ngoctu, it shows that molyblene ore is formed. a little later, at the end of the Ngoc Tu magma activity.

Thus, synthesizing research results of geochemical specialization and mineralogenic potential and redox environment of granitoid massive Ngoctu shows that this mass has ***Mo, W and U metallogeny specialzation.***

CHAPTER 4: CHARACTERISTICS OF THE EROSION OF THE GRANITOID MASSIVE NGOCTU, KON TUM

4.1.1 . Architectural features of rock structure and variation of mineral content according to high levels

To evaluate the degree of erosion of granitoid massive Ngoctu, the thesis has divided the bedrock samples into 3 groups according to the absolute altitude ranges of 1150-950, 950-750m and 750-650m.

The actual survey results show that: from the absolute height of 651m to 1150m, mainly light porphyr granite, porphyr grains have irregular sizes, the length of plagioclase grains ranges from 1cm to 4cm, sometimes 6cm.

The composition of porphyr granite is mainly plagioclase, the background is quartz, plagioclase, potassium feldspar, biotite and muscovite. Common auxiliary minerals are ortite, monassite, zircon, sphen (little) and ore minerals. In porphyr granite, hybrid rock formations have been detected.

The mineral composition shows that, according to the vertical section, from bottom to top there is an increase in plagioclase, potassium feldspar, monazite and a gradual decrease in apatite and ortite content.

The decreasing content of the secondary minerals apatite and ortite reflects the regular decrease of Ca in the rock from bottom to top.

This shows that there is a vertical zoning of minerals in the granitoid mass and from bottom to top there is a unidirectional variation of rock-forming minerals and minor minerals.

4.2.2 . Characteristics of the fossilized and geochemical vertical zoning of granitoid

On the basis of calculation of rock-forming elements, it is found that according to high levels, there is a vertical variation of content from bottom to top as follows:

Uptrend : SiO_2 content increased from 71.38 at 700m to 72.65 at 875m and reached 72.75 at 1050m high. The K_2O content increased from 4.97 $\rightarrow$5.07 to $\rightarrow$5.41. Similarly, there is also an increasing trend that the content of Fe_2O_3 : 0.75 $\rightarrow$0.79 $\rightarrow$1.27.

Downtrend : Components showing a downtrend include MgO, FeO, Al_2O_3 and TiO_2. In which the MgO content decreased sequentially from 0.36 to →0.35 →0.29; FeO decreased from 1.28 to 1.22 and to 0.96.

There was no obvious trend in the content fluctuations in the CaO, Na_2O, MnO and P_2O_5 components .

Thus, the granitoid massive Ngoctu has a fossilized characteristic by a combination of oxides moving up as SiO_2, K_2O and Fe_2O_3 and moving down as MgO, FeO, Al_2O_3 and TiO_2.

Monitoring the variation of the average content of trace elements according to high levels shows:

The elements that move up include: Be, Ga, La, Li, Nb, Sc, Rb, Hf, Re, Tl, Mo, Sn, W, Th, U.

The elements that move down include: Cd, Cu, Cr, Co, Ni, V.

The element group that does not show the tendency to change the rule according to the depth levels is (10 elements): As, Ba, Ce, Ge, Pb, Sr, Ta, Y, Zn, Cs

The regular distribution of rock-forming elements and the fossil zoning coefficient allows to calculate the vertical zonal gradient for 1km of depth.

According to the ratio between the indicator elements including K_2O/MgO, Nb/Y, Yb/Co (14.42 - 1.31 - 2.42), the Ngoc Tu granitoid corresponds to the shallow facies granitoid. Similarly, the ratio Nb/V = 2.18, of Yb/Co = 2.42 and at the same time, in fact the geological samples taken also correspond to the expression levels of quartz-molybdenite fossil ores containing U. Thus, this result is completely consistent and corresponds to the low-medium erosion zone containing rare metal mineralization.

Thus, on the basis of the results of actual survey and study of the material composition of the Ngoc Tu granitoid mentioned above, it can be concluded that: granitoid massive Ngoctu ***has medium - low erosion and is clearly visible. features of geochemical zoning according to the vertical section, characterized by the group of elements moving up are Si, K, Be, Ga, La, Li, Nb, Sc, Rb, Hf, Re, Tl, Mo, Sn, W , Th, U and downshifted element groups are Mg, Cd, Cu, Ti, Cr, Co, Ni, V.***

CONCLUSION AND RECOMMENDATION

Conclusion

The research results of the thesis have clarified the mineraloogenesis and the degree of erosion of the Ngoc Tu massive granitoid, Kon Tum. In there:

1. Research results on geochemical specialization, magma redox environment and related mineralization show that Ngoc Tu massive granitoid has Mo, W and U mineralization properties.

2. The Ngoctu massive granitoid corresponds to shallow intrusive facies and medium-low mass erosion, which is represented by the following characteristics:

- There are signs of zoning according to the vertical section from top to bottom according to rock composition. The upper part is porphyric granite, large-grained, accompanied by obtuse, the lower part is medium-small-grained granite.

- There is a variation of rock-forming minerals and auxiliary minerals with depth, from bottom to top the content of minerals plagioclase, potassium feldspar, monazite increases and the content of apatite and ortite decreases.

- There is a geochemical vertical zoning, in which the element group moving up is Si, K, Be, Ga, La, Li, Nb, Sc, Rb, Hf, Re, Tl, Mo, Sn, W, Th, U and the downshifted element group are Mg, Cd, Cu, Ti, Cr, Co, Ni, V.

- K2O/MgO ratios; Nb/; Yb/Co; The Nb/V and the variation in the content of the elements shifted up, showing that the mass corresponds to the shallow intrusive facies and the medium-low erosion rate.

Recommendation

The research results of the thesis show that Ngoctu massive granitoid has metallogeny specialzation with Mo, W, U. Although the molybdenite-containing sheelite and uraninite mineralization expression has been detected, the search should not be carried out. Search for them within the

massive because the dome of the top of this massive is almost completely eroded.

At the same time, with the level of mass erosion as determined by the thesis, there will be a large amount of soil and rock being eroded, washed away, dissolved elements with high mobility (such as U) and brought into the sedimentary environment. accumulate. Under favorable conditions, they can concentrate to form deposits of mineral deposits. Studying the level of erosion of granitoid massives and calculating and predicting the amount of uranium dissolved and put into the bare soil environment by Russian scientists, they have predicted and discovered uranium deposits of "ancient heart" type. which on the surface has almost no anomalies. Therefore, in mineral forecasting research, this issue should be kept in mind.

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