

Geochemical evolution of granitic continental crust: A comparative study among Paleoproterozoic and Phanerozoic representatives

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論文目次

TABLE OF CONTENTS

Abstract 19

Preface 22

Acknowledgement 23

Part A. OVERVIEWS 26

 CHAPTER 1. SIGNIFICANCE OF CONTINENTAL CRUST 26

 1.1 EARTH'S CONTINENTAL CRUST 26

 1.2 ORIGIN OF THE CRUST AND CRUSTAL PARADOX 27

 1.3 TEMPORAL COMPOSITIONAL EVOLUTION 29

 1.4 ROLE OF THE CONTINENTAL CRUST IN THE SOLAR SYSTEM 29

 1.5 ROLE OF THE CONTINENTAL CRUST IN THE EARTH 30

 1.6 CRUSTAL GROWTH AND EVOLUTION RECORD 31

 CHAPTER 2. GRANITES AND GRANITOIDS: CLASSIC AND CURRENT TOPIC 35

 2.1 GRANITOIDS: DEFINITION 35

 2.2 CLASSIFICATION OF GRANITOIDS 35

 2.3 GRANITIC ZIRCON AS A TIMETRACER 38

 CHAPTER 3. PURPOSE OF THIS STUDY 43

Part B. INDIVIDUAL STUDIES 52

 CHAPTER 1. CRUSTAL EVOLUTION OF THE PALEOPROTEROZOIC UBENDIAN BELT (SW TANZANIA) WESTERN MARGIN: A CENTRAL AFRICAN SHIELD AMALGAMATION TALE .. 52

 ABSTRACT 52

 1.1. INTRODUCTION 53

 1.2. GEOLOGICAL BACKGROUND 54

 1.3. METHODS 63

| | | |
|---|-----|-----|
| 1.4. RESULTS | 69 | |
| 1.5. DISCUSSION | 78 | |
| 1.6. CONCLUSIONS | 86 | |
| REFERENCES | 87 | |
| CHAPTER 2. LATE PALEOZOIC–EARLY MESOZOIC GRANITOIDS IN THE KHANGAY–KHENTEY BASIN, CENTRAL MONGOLIA: IMPLICATION FOR THE TECTONIC EVOLUTION OF THE MONGOL–OKHOTSK OCEAN MARGIN | | 129 |
| ABSTRACT | 129 | |
| 2.1. INTRODUCTION | 130 | |
| 2.2. REGIONAL AND LOCAL GEOLOGY | 131 | |
| 2.3. METHODS | 134 | |
| 2.4. RESULTS | 135 | |
| 2.5. DISCUSSION | 140 | |
| 2.6. CONCLUSIONS | 148 | |
| REFERENCES | 148 | |
| CHAPTER 3. LATE PERMIAN S-, I-TYPE MAGMATISM IN THE MIDDLE GOBI VOLCANOPLUTONIC BELT, MONGOLIA: CONSTRAINTS FOR AGE, PETROGENESIS, AND TECTONIC SETTING | | 182 |
| ABSTRACT | 182 | |
| 3.1. INTRODUCTION | 182 | |
| 3.2. GEOLOGICAL BACKGROUND..... | 183 | |
| 3.3. RESULTS | 186 | |
| 3.4. DISCUSSION | 188 | |
| 3.5. CONCLUSIONS | 194 | |
| REFERENCES | 194 | |
| CHAPTER 4. CRETACEOUS TO MIOCENE NW PACIFIC PLATE KINEMATIC CONSTRAINTS: PALEOMAGNETISM AND AR–AR GEOCHRONOLOGY IN THE MINEOKA OPHIOLITE MÉLANGE (JAPAN) | | 214 |
| ABSTRACT | 214 | |
| 4.1. INTRODUCTION | 215 | |
| 4.2. GEOLOGICAL SETTING..... | 216 | |
| 4.3. SAMPLING SITES AND LITHOLOGICAL VARIATIONS..... | 225 | |
| 4.4. PALEOMAGNETISM | 228 | |
| 4.5. $^{40}\text{Ar}/^{39}\text{Ar}$ AGES | 232 | |
| 4.6. DISCUSSION | 233 | |
| 4.7. CONCLUSIONS | 240 | |
| REFERENCES | 241 | |
| Part C. COMPARISON OF THE OROGENIC REPRESENTATIVES..... | 272 | |

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|--|-----|
| CHAPTER 1. COMPARISON OF THE CRUSTAL GROWTH PATTERN: IMPLICATION TO THE SPATIAL-TEMPORAL EVOLUTION | 272 |
| 1.1. INTRODUCTION | 272 |
| 1.2. METHOD | 273 |
| 1.3. CRUSTAL GROWTH IN THE CENTRAL AFRICAN SHIELD..... | 275 |
| 1.4. CRUSTAL GROWTH IN THE CENTRAL ASIAN OROGENIC BELT..... | 282 |
| 1.5. DISCUSSION..... | 287 |
| 1.6. CONCLUSION..... | 292 |
| CHAPTER 2. SUMMARY AND PERSPECTIVES | 307 |
| REFERENCES | 310 |

Summary

The formation of the Earth's continental crust and its evolution through time is elusive. In the Earth's history, Paleoproterozoic and Phanerozoic are important eras in terms of enormous production of granitoids. In order to understand the growth pattern of the two representative eras, the author investigated the spatial-temporal impacts of mantle-derived melt adding to the preexisting continental crust based on comparative case studies. As a Paleoproterozoic representative, the Ubendian Belt–Bangweulu Block of East Africa was chosen for geochemical and geochronological reconnaissance. Although the paucity of reliable radiogenic ages and geochemical data in the continental basement terranes hampered understanding the amalgamation history of the shield, new zircon U–Pb geochronology and whole-rock trace-element geochemistry of granitoids revealed that an extensive magmatism occurred between 1.89 and 1.85 Ga in a slab-failure tectonic setting and it can be responsible for global detrital zircon record peak. The ~1.9 Ga metagranitoids contain zircons with negative Hf isotope compositions, indicating the existence of the enriched mantle source. On the other hand, the Central Asian Orogenic Belt (CAOB), as a Phanerozoic representative, shows a different growth pattern. Although the CAOB has long been considered as a venue of the high production of the newly-formed radiogenic continental crust. In order to evaluate this issue, metagranitoids of the Mongol–Okhotsk Belt—one of the youngest segments of the CAOB—were also investigated. Newly obtained U–Pb zircon ages identified three magmatic events at ~296, ~280, and ~230 Ma. Geochemical features inferred that those three granitic plutons were generated along the active continental margin where the Mongol–Okhotsk oceanic plate subducted. In addition, both S- and I-type granitoids with their volcanic equivalents, and gabbro-diorite plutons were emplaced between ~ 265 and ~250 Ma in an intra-oceanic arc setting. The precursor of the S-, and I-type granitoids were mostly likely metagraywacke, and metabasalt of old accretionary complex, respectively. Overall the Mongol–Okhotsk Belt granitoids are characterized by positive Hf zircon and whole-rock Nd isotope marking their radiogenic source.

To understand the crustal growth pattern on a larger scale, the author made a comprehensive comparisons of the Hf zircon data in literature from the Central African Shield and CAOB. Hf isotope evolution of the Central

African Shield exhibits a crustal array – cratonic lower crust and lithospheric mantle were attached to the subducting plate, and became involved in collision. In contrast, zircons from major orogenic segments of the CAO B show an isotopic evolution shifting from the crustal values to the depleted mantle values in descending order of time. This isotopic evolution pattern attributed to continuous intra-oceanic subduction that removes the lower continental crust and lithospheric mantle. Estimation on radiogenic versus crustal portions of the CAO B inferred that the Early–Middle Paleozoic time-slice consists of 20% of the reworked crust, 60% of the mixed crust, and 20% of the radiogenic crust. Moreover Late Paleozoic to Early Mesozoic time-slice was composed 20% of the reworked crust, 50% of the mixed crust, and 30% of the radiogenic newly-formed crust, which yield a 10% increase of the radiogenic crust and suggest that during the Phanerozoic pre-existing crust was a dominant constituent. The comparative study offer an insight into crustal growth mode: episodic in the Paleoproterozoic and steady-state in the Phanerozoic. The recognition of these disparate Hf isotopic characters in two global-scale orogenic systems of different eras offers a new insight into feedback between magma source and tectonic activity and a difference in the melt generation models during these times.

論文審査の結果の要旨

本論文は、地球史においてもっとも大陸成長が活発であったとされる古原生代と顕生代（中・古生代）について、中央アフリカ楕状地と中央アジア造山帯の花崗岩体に着目し、岩石学・地球化学・地球年代学を組み合わせた手法による総合的比較研究によって大陸地殻の進化パターン的一般化を試みた。著者は古原生代の大陸地殻成長の一例として、タンザニア西端タンガニーカ湖東部の花崗岩に着目し、多数の岩石試料の全岩主要微量化学組成とそれに含まれる火成ジルコンのウラン鉛局所年代及び局所ハフニウム同位体比を系統的に調べ、約 19 億年前から約 6 億年前までの地史と地殻進化を復元した。とりわけ、従来バングウェウル地塊とウベンディアン造山帯として区別されてきたタンザニア西端の先カンブリア時代の基盤岩類の地球化学的特徴と形成年代が両地質ユニットで共通すること、約 19 億年前のコロンビア超大陸縁辺のマグマ活動でバングウェウル地塊が大きく成長したこと、バングウェウル地塊が約 6 億年前のゴンドワナ超大陸を形成する際にタンザニア地塊に衝突し、中央アフリカ楕状地が安定化したこと、さらに約 6 億年前の造山運動の影響が局所的にしか残っていないこと、を明らかにした。これらの結果は中央アフリカ楕状地の理解を深め、その成果の一部は筆頭著者論文として国際誌に掲載され最多ダウンロードなど大きな反響を得た。一方、著者は顕生代の大陸地殻成長の典型例として、モンゴルの複数の花崗岩体を解析し、約 3 億年前から 2 億年前の大陸地殻成長とその構造場を明らかにした。結果の一部は現在、国際誌 2 編で査読中である。本論文は、時代が大きく異なる 2 つの地域のケーススタディーに加えて、既存のジルコンの局所ハフニウム同位体比のデータベースを構築し、地理情報システムを駆使することで大陸地殻の形成年代・ハフニウム同位体比の進化を地図としても描画することに成功した。さらに、上述の大陸地殻進化の研究の他にも複課題として房総半島に産する古第三紀の海洋底玄武岩の古地磁気をもちいたプレートキネマティクス解析を行い、筆頭著者として国際誌に成果発表している。

以上の研究成果及び業績は、自立して研究活動を行うに必要・十分な高度の研究能力と学識を有することを示している。したがって、提出の博士論文を博士（理学）の学位論文として合格と認める。