RECONSTRUCTION OF TECTONOTHERMAL HISTORY OF THE SOUTHWESTERN HIGHLAND COMPLEX, SRI LANKA: IMPLICATION OF INTERNAL TEXTURES AND GEOCHRONOLOGY OF ZIRCON AND MONAZITE

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INTRODUCTION

The high-grade terrain of Sri Lanka linked to the South India, Madagascar, East Africa, and Antarctica according to the proposed models of the Gondwana supercontinent. The multi-thermal histories before, during, and after the Gondwana amalgamation are not well established in the region. There are numerous research works especially in the Central Highland Complex, Sri Lanka, Madagascar, South India, and Antarctica. However, the Southwestern Highland Complex was not well studied. According to the previous studies, the Southwestern Highland Complex closely related to the Androyan Complex of Madagascar and Kerala Khondolite Belt of South India. However, the Chronological histories are not well established. Moreover, the most of the minerals have been reprinted completely during the intense Pan-African metamorphism. According to the previous studies of the region especially in the Central Highland Complex it has been shown that the Pan-African repeated thermal events have occurred and peak metamorphism is ultra-high temperature metamorphism, and the major metamorphism is granulite grade metamorphism. According to the chronological information in zircon and monazite in the nearby Gondwana crustal units, the older thermal events have been recognized, especially during 1.9–1.7 Ga. The recent publications in the Central Highland Complex have shown the one metamorphic event using a double subduction, oceanic floor exhumation, and collisional suture model to describe Pan-African metamorphism. However, the idea of the existence of metamorphic events prior to Pan-African metamorphism cannot be discarded in which the Highland Complex is regarded as a distinct crustal block. Many researchers have shown that zircon can record the older ages and thermal histories. In high-grade terrains the most of the major rock forming minerals get recrystallized or overprinted by the intense recent thermal event because of the closure temperature of those minerals are lower than the metamorphic temperature and partial melting can take place in rocks containing hydrous minerals like mica and amphibole. The second most important accessory mineral that preserves such older thermal histories is monazite. Monazite can be used in conjugation with zircon geochronology to define those thermal histories. Therefore, my main target of the doctoral program is to study the petrological, internal textural variation of zircon and monazite, and establish a clear chronological relationship among the Southwestern Highland Complex, the Central Highland Complex, Southeast Madagascar, and South India.

METHODOLOGY AND ANALYTICAL PROCEDURE

To achieve this purpose during the doctoral degree program, I studied the metamorphic rocks of the Southwestern Highland Complex of Sri Lanka. Mainly I studied garnet-biotite gneiss, garnet-biotite-cordierite gneiss, hornblende-bearing charnockitic gneiss, and charnockitic gneiss. Following the previous studies, I have constructed the thermal gradient in the study area. I used two geothermometers based on ideal and non-ideal mixing of Fe and Mg in garnet and biotite. I studied internal textures of both zircon and monazite in the rocks samples and geochronology. I used the backscattered electron images of both minerals and cathodoluminescence images of zircon to identify the zones and domains. After observing those internal textures, my next step was geochronological work. In this case, I use LA-ICP-MS for zircon U-Pb age dating in Hiroshima University. With the help of National Museum of Science and Nature, Japan, I established the U-Th-total Pb chemical age dating in EPMA for monazite age dating.

RESULTS

The collected rock samples show the mineral assemblages of the major metamorphism such as garnet + biotite + orthopyroxene + clinopyroxene + sillimanite + cordierite. The results show the temperature is decreasing from east to west of the area as similar to the thermal gradients proposed by the previous studies. However, I found that the isothermal contours are much more complex in pattern. The zircons in the garnet-biotite gneiss and garnet-biotite-cordierite gneiss show a wide diversity of internal textures. I observed detrital cores with transgressive textures and oscillatory zones. Morphology of detrital cores varies from rounded to subhedral and/ euhedral shapes. Then most of those detrital cores are overgrown by one to three generations. In rare cases, five generations were observed. Charnockitic gneisses generally show simple core and thin-rim textures, some inherited cores, and rarely, several growth generations. In both garnet-biotite gneiss and charnockitic gneiss show detrital core absent zircon grains. The detailed cathodoluminescence images revealed they have several growth generations shown by typical metamorphic internal textures like radial zones, planner banded zones, and fir-tree textures. Monazite shows four types of internal textures such as core-rim zoned, inherited core-bearing, complexly zoned, and oscillatory zoned. Using the chemical maps and backscattered electron images, I identified several domains in those monazites. According to LA-ICP-MS, I found six ranges of ages in zircon; range 1, 3380–3220 Ma; range 2, 2730–2660 Ma; range 3, 2650–2490 Ma; range 4, 2220–2170 Ma; range 5, 1900–1700 Ma; range 6, 630–500 Ma. Detrital cores in garnet-biotite gneiss show range 1 to 5. Range 1 to 4 are overgrown by overgrowth generation belongs to range 5 and 6. The Th/U ratios of most of the overgrowths in range 5 and all the overgrowths in range 6 show less than 0.1. The detrital core absent zircon grains with typical metamorphic internal textures show the age in range 6. The U-Th-total Pb chemical age dating of monazite showed four groups of ages: Group I of 1830–1648, 1766±140, 1788±30; Group II of 803±99, 679±99 Ma; Group III of ages in a range between 550–485 Ma, 533±22, 481±42; and Group IV of ages in a range between 470–430 Ma, 470±45, 433±14. Group II to IV can be considered as one event within the error range.

DISCUSSION AND CONCLUSION

The isothermal contours are much more complex in a pattern which may indicate the effect of the regional metamorphism, collisional deformations, and interlayered rocks. According to the internal textures and geochronology of the zircon and monazites I came into several discussions and conclusions. The detrital zircon cores and Proterozoic sediments came from several unidentified Achaean to Proterozoic igneous sources. Later intensive thermal events caused changes of internal textures of zircon and two to five overgrowth generations. First five ranges in zircon represent the ages of several Precambrian sources and their ages. Overgrowths with age range of 1900–1700 Ma may have formed by a thermal event prior to 630–500 Ma. The overgrowths and detrital-core-free zircons with the ages in the range of 630–500 Ma may have formed by the latest Pan-African metamorphism. Among the four types of monazites, inherited core-bearing, complexly zoned, and oscillatory-zoned types were new observation for Sri Lankan monazites. The preserved older monazite domains confirm a metamorphic event during 1900–1700 Ma as observed as overgrowths in range 5 of zircon. The ages of group II to IV overlapped within the error, which can be identified that repeated thermal events and long period of thermal activities during the latest metamorphism. Two possible interpretations for crustal formation for the Southwestern Highland Complex are proposed using the data presented in this study: 1) the Southwestern Highland Complex formed ad a single collisional event; 2) the Southwestern Highland Complex formed as two collisional events. However, the two collisional model is more consistent with the complex internal textures and chronology of zircon and monazite. Age data of the Southwestern Highland Complex shows a close geochronological relationship with the South India (Kerala Khondolite Belt) and Androyan Complex of Madagascar. The close relationship among the Southwestern Highland Complex and nearest Gondwana fragments in the proposed model on Gondwana supercontinent is confirmed by the chronological data in the present study and the published data.