行政院國家科學委員會專題研究計畫　成果報告

電漿質譜術之建立與應用（IV）：鋯石 U-Pb 定年

計畫類別：個別型計畫
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計畫主持人：鍾孫霖

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感應耦合電漿質譜術之建立與應用(IV) – 期終報告

計畫編號：NSC 92– 2116 – M – 002 - 020
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計畫主持人：台大地質科學系 鍾孫霖
計畫參與人員：溫大任、朱美妃、李皓揚（博士生）

一、中文摘要

本研究計畫為一個三年期專題計畫的延長計畫。前三年已利用新購之 Agilent (原 HP) 7500s ICP-MS 設備，建立一種利用強酸密封溶解岩石樣品、以美國地調所標準岩樣作參考標準、另加若干質量監控溶液作為內標，分析岩石中大約四十種微量元素的方法。此一分析方法具有簡單、準確、同時測量多元素等優點，能夠快速有效地分析大多數常見的岩石樣品。第四年主要開發本儀器與雷射系統之連結，應用於微小標本之原位(in-situ)微量元素含量分析和鋯石 U-Pb 定年，並配合申購 MC-ICPMS，應用於青藏高原構造演化等研究。

關鍵詞： 感應耦合電漿質譜術；微量元素分析；鋯石 U-Pb 定年；青藏高原

本研究計畫執行期間，主持人和研究生於 92 年 8 月 20 日至 92 年 8 月 31 日赴北京離子質溥儀分析中心，進行鋯石定年實驗；於 93 年 4 月 26 日至 93 年 5 月 14 日赴澳洲 Macquarie 大學 GEMOC 研究中心，進行 LA-MC-ICPMS 分析實驗。主持人和博士班研究生溫大任、碩士班研究生梁育瑄三人於 93 年 12 月 12 日至 18 日赴美國舊金山，參加 AGU 秋季大會，博士班研究生朱美妃、李皓揚兩人於 93 年 8 月 15 日至 20 日赴美國夏威夷，參加 WPGM 大會，發表論文摘要如下：

Abstracts for the WPGM Meeting, Hawaii, August 16-20, 2004

Rare Earth Element Chemistry of Apatites From the Cretaceous to Paleogene Granitoids, Southeastern Tibet

M.F. Chu (1), S.L. Chung (1), X.R. Liang (2), W.L. Griffin (3), N.J. Pearson (3), Y. Iizuka (4), X.H. Li (2), Y.Q. Zhang (2)
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Accessory minerals such as zircon and apatite occur widely in various rocks because of their wide stability in geological processes, which allow these minerals to be used as an indicator for not only igneous petrogenesis but also potentially for sedimentary source provenance. In this study, using EPMA and LA-ICP-MS composed of New Wave LUV-213 Nd-YAG laser and Agilent quadrupole ICP-MS, we measured major and trace element concentrations of apatite separates from two principal types of Cretaceous to Paleogene granitoids from SE Tibet. These are (1) the I-type Gangdese Batholith [~100-40 Ma; with SiO_2 = 50-75 wt. %, ASI= 0.78-1.12, (La/Yb)n= 2.3-14.6, (Eu/Eu*)n= 0.15-1.19, εNd(T)= -1.6 to 3.7] and (2) the S-type Nyainqentanglha magmatic belt [≥

120 Ma; SiO_2 = 66-73 wt. %, ASI= 1.07-1.30, (La/Yb)n= 6.5-23.1, (Eu/Eu*)n= 0.31-1.03, εNd(T)= -10 to -16]. Although no systematic variations are observed in major elements for apatites from the two types of granitoids, their trace elements, in particular rare earth elements (REE), have markedly differences. Apatites from the I-type rocks are highly LREE-enriched and thus show steep REE patterns [(La/Yb)n= 56-67], in contrast to those from the S-type rocks which show flat REE patterns [(La/Yb)n= 0.84-0.99]. Moreover, whereas the latter are characterized by strong negative Eu anomalies [(Eu/Eu*)n= 0.11-0.13], the former display only mild amounts of negative Eu anomalies [(Eu/Eu*)n= 0.78-0.84]. Given the fact that both I- and S-types of the Tibetan granitoids have LREE-enriched patterns, the "apparent" values of REE partition coefficients calculated by dividing REE abundances of the apatites over those of the host rocks are distinct between the two rock types. Our study indicates that REE chemistry of the apatites (1) changes between different types of the host magmas and thus may be used as a probe into igneous petrogenesis, and (2) has potential to be used as a sedimentary provenance indicator in particular when combined with *in-situ* Sr isotope determinations of these apatites to be carried out.

New age and geochemical constraints for the origin of the Linzizong volcanic successions, southern Tibet

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The Linzizong volcanic successions emplaced in the Lhasa terrane, southern Tibet are generally considered as products of northward subduction of the Neo-Tethyan slab underneath Asia that resulted in an Andean-type convergent margin before the India-Asia collision. Here we report new $^{40}Ar/^{39}Ar$ dating and geochemical data to better constrain the tempo-spatial distribution, petrogenesis and geodynamic significance of the Linzizong volcanic rocks. The results show two major episodes of eruptions, namely, a Cretaceous episode occurring dominantly in the northern Lhasa terrane from ~110 to 70 Ma and in the area around Lhasa city in the south at ~90 Ma, and an Paleogene episode erupting only in the southern part of the Lhasa terrane from ~60 to 45 Ma. These data allow us to re-evaluate the geologic context of the so-called Linzizong volcanic successions that are re-defined as comprising the younger episode. The Paleogene successions consist essentially of calc-alkaline rocks ranging from basalt to rhyolite, associated with a shoshonitic suite emplaced in the Linzhou area, ~50 km north of the Lhasa city. Our data furthermore suggest a southward migration and intensification of the volcanism marked by magmatic "flare-ups" around ~50-45 Ma, which we interpret as products of the ending phase of the Neo-Tethyan subduction in the early stage of the India-Asia collision because the overall geochemical characteristics of the volcanic successions are comparable to those of the arc lavas from modern subduction zones. This

would require rollback and steepening of the Neo-Tethyan slab, a process that could have intensified corner flow in the mantle wedge and caused significant partial melting. To account for the generation of the Cretaceous and more widespread episode of volcanism, more detailed studies are needed so that different models, such as Cretaceous low-angle subduction of the Neo-Tethyan slab in the south and lithospheric deformation following the Triassic-Jurassic suturing between the Lhasa and Qiangtang terranes in the north, may be better constrained.

Abstracts for the AGU Fall Meeting, San Francisco, Dec. 12-17, 2004
Detrital zircon study along the Tsangpo River, SE Tibet

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The interactions among tectonic uplift, river erosion and alluvial deposition are fundamental processes that shape the landscape of the Himalayan-Tibetan orogen since its creation from early Cenozoic time. To better understand these processes around the eastern Himalayan Syntaxis, we conducted a study by systematic sampling riverbank sediments along the Tsangpo River, SE Tibet. Detrital zircons separated from the sediments were subjected to U-Pb dating by the SHRIMP II at the Beijing SHRIMP Center and then *in-situ* measurements of Hf isotope ratios using LA-MC-ICPMS at GEMOC. These results, together with U-Pb ages and Hf isotope data that we recently obtained for the Transhimalayan plutonic and surrounding basement rocks, allow a more quantitative examination of the provenance or "protosource" areas for the river sediments. Consequently, the percentage inputs from these source areas can be estimated. Our study indicates that, before the Tsangpo River flows into the Namche Barwa Syntaxis of the eastern Himalayas where the River forms a 180\deg Big Bend gorge and crosscuts the Himalayan sequences, the Gangdese batholith that crops out just north of the River appear to be an overwhelming source accounting for $\sim$50 \% of the bank sediments. The Tethyan Himalayan sequences south of the River are the second important source, with an input of $\sim$25 \%. The proportion of sediment supply changes after the River enters the Big Bend gorge and turns to south: $\sim$25 \% of detrital zircons are derived from the Greater Himalayas so that the input from the Tethyan Himalayas decreases ($<$ 10 \%) despite those from the Gangdese batholith remains high ($\sim$40 \%). Comparing with the sediment budget of the Brahmaputra River in the downstream based on literature Sr, Nd and Os isotope information, which suggests dominant ($\sim$90-60 \%) but subordinate ($\sim$10-40 \%) contributions by the (Greater and Lesser) Himalayan and Tibetan (including Tethyan Himalayan) rocks, respectively, the change is interpreted to be a result of focused erosion along the Tsangpo-Brahmaputra river system that behaves as one of the most active mountain rivers on Earth.

下列為本計畫執行以來，已/將發表的相關研究成果：

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