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東亞岩石圈張裂作用之板塊運動機制與地球化學性質演化

(1/3)

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摘要：

本計畫第一年的工作完成赴越南南部採集地函捕獲岩，並完成該樣本與先前所獲得之澎湖地函捕獲岩樣本之準備與岩象學觀察工作。其後赴澳洲麥覺理大學(Macquarie University)地球與行星科學系GEMOC研究中心進行澎湖樣本和部份越南樣本的雷射同位素分析工作。期間並與日本學者合作獲得衣索匹亞(Ethiopia)南部境內東非裂谷地函捕獲岩樣本，以進行雷射鋨(Os)同位素分析之測試工作。而後者所獲致之成果，已完成摘要投稿至第15屆Goldschmidt地球化學研討會，並將於九十四年五月二十一日於美國愛德華州(Idaho)的Moscow口頭發表。由澎湖地函捕獲岩的礦物地球化學成份亦已獲致初步台灣海峽下方地溫梯度的推測。

Abstract:

The composition and structure of the upper 100-150 km (lithosphere) beneath the SE Asia is currently unknown, but is an important link in understanding the evolution of the Earth's crust between continental China and the plate collision region beneath Taiwan. The Penghu Islands are made up of basaltic volcanics that contain fragments of xenoliths of the underlying mantle. Mineral chemistry of mantle xenoliths will allow the calculation of the geothermal gradient (increase in temperature with depth). This geotherm is the key to providing a spatial framework to locate the depths of other mantle rock types and so define the structure of this mantle domain.

Original aims:

(1) To use geochemical data from mantle xenoliths to define the geothermal gradient beneath the SE China continental margin in Miocene times (beneath the Penghu Islands).
(2) To use geochemical data from spinel lherzolites to define the geochemical features of the lithospheric mantle beneath the region.
(3) To establish a firm basis to define the architecture and evolution of the upper mantle beneath SE China.

Results:

Fieldwork at Penghu Islands, Taiwan was done before the approval of this project. Geochemical results (as described bellow) derived from the spinel peridotites collected in the fieldwork have revealed the geothermal gradient and geochemical characteristics of the sub-continental lithospheric mantle (SCLM) beneath the Taiwan Strait, SE China in Miocene times. This result fulfils the *first* and *second* original aims of this project. In addition, the fieldwork to southern Vietnam was very successful and an excellent first sampling was achieved (the details please refer to the separate report attached). Moreover, I found abundant sulfides hosted in some mantle xenoliths on Penghu Islands, and these are ideal for *in situ* Re-Os isotope analysis although samples from southern Vietnam did not have many sulfides. Recent developments in the *in situ* analysis of the Re-Os system in sulfide phases allow us to unravel complexity and improve the interpretation of the age information in the mantle xenoliths, which provides direct and critical constraints on evolution of the SCLM. It satisfies the *third* original aim of the

project. Meanwhile, through cooperation with Japanese geoscientist, Dr. Ryuichi Shinjo, mantle xenolith samples from southern Ethiopian, East Africa have been provided for the *in situ* Re-Os isotope analysis. Description of results is given below:

Petrography and mineral geochemistry:

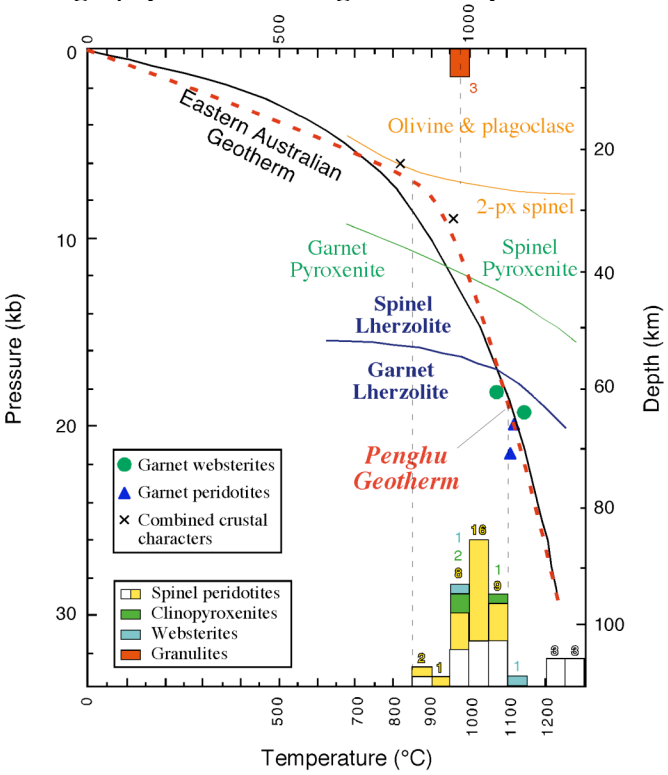

Fig 1. Penghu geotherm constrained by crustal, spinel-bearing and garnet-bearing xenoliths.

The xenoliths from Penghu Islands are dominantly spinel peridotites with minor spinel pyroxenites. Most peridotites have fine to coarse-grained porphyroclastic or equigranular microstructures; some are foliated, and many show textural disequilibrium with clinopyroxene exsolution lamellae in orthopyroxenes, spinel exsolution in clinopyroxenes, and strained clinopyroxene grains coexisting with strain-free clinopyroxene neoblasts. These peridotites range from relatively fertile compositions, with 10-20 vol.% clinopyroxene (cpx), to depleted compositions with <5 vol.% cpx. Whereas rare Kueipi xenoliths contain amphibole and/or apatite, most Tungchiyu xenoliths contain amphibole, reflecting modal metasomatism. They also show complex episodes of fluid inclusions in ortho- and clinopyroxene pophyroblasts, indicating at least two different episodes of metasomatism. Zoning of orthopyroxenes from high-Ca cores to low-Ca rims suggests some of these peridotites represent upwelling of deeper mantle materials. The equilibration temperatures range from 880°C to 1250°C. Combining the reported data of crustal and garnte-bearing xenoliths, with equilibrium temperature result estimated from this study, a local geotherm is proposed that is similar to that beneath eastern Australia (Fig. 1). Their major-element data show that some of the lithospheric mantle beneath this region is quite refractory. The Fo contents of olivines in spinel peridotites range from 89.0 to 91.7, but most fall between 90.0 and 91.0; Mg# of olivine is correlated with Cr# (0.11~0.55) in spinel. It suggests that some of the lithospheric

mantle beneath this region may possibly be Proterozoic, as old as mantle xenoliths from several nearby mainland localities. At least two types of metasomatism are reflected in the trace element patterns of clinopyroxenes. High La/Yb and low Ti/Eu ratios indicate carbonatitic metasomatism, which the GEMOC database shows to be typical for many extensional settings worldwide. The other metasomatic signature is characteristic of silicate melt interaction. Apparently this result is consistent with petrographic observation for these mantle xenoliths.

Composition of sulfides:

Some spinel peridotites and pyroxenites contain sulfide inclusions large enough to be laser-probed (≧ 50 micron). Nearly all sulfide grains from the Kueipi locality consist of interfingered Ni-rich and Fe-rich monosulfide solid solutions (MSS), with an outer rim of chalcopyrite. Those from the Tungchiyu islet mostly have Fe-rich MSS cores, surrounded by Ni-rich MSS and a Co-rich rim. These sulfides have high bulk cobalt contents (up to 8 wt.%) and Ni/Co ratios lower than the chondritic value. Trace-element patterns of the Tungchiyu sulfides are flat and similar to that of sulfide liquid, or MSS crystallized from such liquid after separation from residual MSS. Similar high-Co sulfides from the Slave Craton, Canada are interpreted as derived from the lower mantle. The occurrence of these unique Co-rich sulfides in the Penghu Islands may shed light on the involvement of the deeper mantle in geodynamic processes in East Asia.

In-situ Os isotope analysis of sulfides from Penghu Islands:

Preliminary results show that $^{187}Os/^{188}Os$ ratios of most sulfides are unradiogenic and range from 0.1061~0.1249. High $^{187}Re/^{188}Os$ (0.12~1.07) leads to negative T_{MA} model ages and indicates that sulfides from Penghu peridotites and pyroxenites have recently experienced three types of disturbance in their Os isotopic systematics: (1) addition of Re with no apparent addition of Os, or only of lithospheric Os with low $^{187}Os/^{188}Os$; (2) addition of Re, and of Os with an isotopic composition near the present-day primitive upper mantle; (3) addition of radiogenic Os, but little or no Re. The highly radiogenic Os in (3) could be derived from lithospheric sources such as pyroxenites or subducted basalts, and the transporting medium may have been an oxidising fluid derived from a subducting slab beneath the area. Processes (2) and (3) involve the introduction of Os that is radiogenic relative to that expected in old SCLM; in this case neither T_{MA} nor T_{RD} model ages may date specific events, except perhaps in the case of rare low-Re/Os sulfides. However, T_{RD} model ages will still provide minimum estimates for the age of the SCLM, whether the sulfides originally are residual from melt-depletion events or deposited from metasomatic fluids derived from the asthenosphere. The T_{RD} model ages of the Penghu sulfides with the best analytical precision range from 0.70 to 2.64 Ga, with a major peak between 1.5-1.2 Ga, and the T_{RD} model ages derived for the low-Re/Os component of the mixing lines are all in the range 1.9-2.3 Ga. These data require that parts of the SCLM beneath the Taiwan Straits have been segregated from the convecting mantle since at least mid-Proterozoic time, and some portions may have formed as early as the late Archean.

In-situ Os isotope analysis of sulfides from southern Ethiopian

The Os isotope compositions of sulfides in spinel lherzolites hosted by Quaternary alkali basalts from NE of the Turkana Depression, S. Ethiopia, reveal the presence of Proterozoic subcontinental lithospheric mantle (SCLM) beneath the continental rift setting in East Africa. Most of the sulfides have subchondritic $^{187}Os/^{188}Os$ (<0.129). A large range in $^{187}Re/^{188}Os$ (0.003-0.309) suggests recent addition of Re, perhaps reflecting the Paleogene mantle plume activity, which not only caused the East Africa Rift but also significantly perturbed the SCLM in the region. Sulfides with low $^{187}Re/^{188}Os$ (<0.075; Griffin et al., 2002) yield similar T_{MA} and T_{RD} model ages of 1.1±0.2 Ga, interpreted as the depletion age of the SCLM beneath the region. Re-Os mixing lines defined by sulfides in single samples give an initial $^{187}Os/^{188}Os$ (0.1184) consistent with formation of some volumes of the SCLM at ~1.3 Ga. T_{RD} model ages of sulfides can provide minimum estimates for the SCLM age and record later metasomatic events. All model ages of the sulfides suggest a main SCLM depletion age at 1.1 Ga with a later metasomatic event at 0.4-0.5 Ga. A few older ages (1.5-1.8 Ga) suggest the presence of older parts of the SCLM, but no Archean model ages were found. The SCLM depletion age of 1.1 Ga is consistent with the known Meso-Neoproterozoic crustal evolution event of the East African Orogen (Stern, 2002), and the 0.4-0.5 Ga may be related to closing stages of the Paleozoic Pan-Africa orogeny. The sulfide Re-Os data show that Proterozoic SCLM has survived the extensive continental rifting due to the mantle plume.

An abstract regarding Os isotope results of sulfides from southern Ethiopia have been finished and submitted to 15th Goldschmidt Conference at Moscow, Idaho, USA. It was accepted as oral presentation and will be presented on May 21 (the details please refer to the separate report attached). A manuscript about Penghu sulfides is preparing.

Publications:

Conference abstract (refereed):

Wang, K.L., O'Reilly, S.Y., Griffin, W.L., Pearson, N.J., Shinjo, R., and Matsumura , R., 2005. Proterozoic mantle lithosphere beneath the East African Rift (Southern Ethiopia): In situ Re-Os evidence. Geochim. Cosmochim. Acta, 69/10S, A284.