國立東華大學自然資源與環境學系

碩士論文

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萬榮地區構造地塊之岩石成因與全岩地化研究

Metamorphic Petrogenesis and Whole-rock Geochemistry of Tectonic Blocks in the Wanjung Area, Eastern Taiwan

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摘　要

綠輝石與透輝石共生現象為單斜輝石降溫時經離溶作用(exsolution)而形成，依全球文獻該共生現象常見於高壓變質岩。大南澳變質雜岩玉里帶是台灣唯一出露高壓變質礦物的區域，且屬高壓變質礦物之一的綠輝石僅出露於萬榮構造地塊，其產狀、溫壓制約與年代仍然不明確。地塊岩石主要為蛇紋岩，尚有含綠輝石變質岩、角閃石鈉長石岩，蛇紋岩體圍岩則為鐵鎂質片岩。本研究新發現之含綠輝石岩位於蛇紋岩體下部，其岩性具連續變化，由深色至淺綠分別為綠輝石角閃石岩、角閃石綠輝石岩、斜黝簾綠輝石岩。經岩象觀察，含綠輝石岩中綠輝石與角閃石含量成反比，且綠輝石與透輝石呈互長關係。三種含綠輝石岩主要元素成份差異頗大，但標準化之稀土元素分佈型態卻呈現一致，銪正異常隱示原岩可能為富斜長石堆晶岩。含綠輝石岩至少記錄三個變質階段，M1 為假形幔部的陽起石為主，M2 為假形邊部與變質分異條帶角閃石邊部之韭閃石，變質分異條帶角閃石 Al_2O_3 與 TiO_2 的邊部含量皆較核部高，同時輔以角閃石等值線計算，結果指示含綠輝石岩經歷一增溫增壓階段，其變質溫壓可達 490℃，8Kbar。由於綠輝石[M3]較角閃石晚生成，因此其中一階段之變質溫壓路徑(P-T path)可能呈逆時針方向。

蛇紋岩、角閃石鈉長石岩與鐵鎂質片岩之角閃石亦具成份環帶。蛇紋岩中角閃石核部為韭閃石，邊部為透閃石；角閃石鈉長石岩之角閃石核部則為韭閃石-淡閃石、鎂角閃石，邊部為陽起石；鐵鎂質片岩角閃石核部為凍藍閃石，邊部為陽起石，其元素矽、鎂變化趨勢與角閃石鈉長石岩角閃石環帶相似。經 Perple_X 計算之相平衡視剖面圖顯示岩石經歷一減溫減壓過程，鐵鎂質片岩變質溫壓範圍為 445-475℃，6-8Kbar，然片岩中含生長型環帶的石榴子石，推估變質度可達角閃岩相，角閃石鈉長石岩則為 375-440℃，6.7Kbar。

據全岩地化數據，含綠輝石岩與鄰近鐵鎂質片岩的原岩為不同源，且角閃石成份變化和相平衡視剖面圖亦顯示含綠輝石岩與鐵鎂質片岩歷經不同之變質溫壓演化。

[關鍵字] 綠輝石、固溶間隙、角閃石、構造地塊、萬榮、玉里帶

Abstract

The Yuli Belt is the only unit that exposes HP/LT metamorphic rocks in Taiwan. In addition to the glaucophane found in the Juisui area, omphacite represents another HP index mineral and occurs mainly in the Wanjung serpentinite tectonic block. However, due to lack of detailed studies, the nature, origin, age, and implications of the Wanjung omphacite-bearing rocks remain unclear. This study describes a new outcrop in which omphacite-rich rocks occur within the lower part of the Wanjung serpentinite block. In this locality, an in-situ pod shows a rock sequence ranging from massive omphacite-rich rocks to banded and foliated amphibole-rich metabasites. This block contains various rock layers with gradual to sharp boundaries. The omphacite-bearing rocks also contain chlorite, clinozoisite, albite, titanite, calcic amphibole, and phlogopite. The banded amphibole-rich metabasites contain similar minerals but with higher proportion of calcic amphibole, which occurs as very large porphyroclasts in some cases. XRF analyses of omphacite-bearing rocks reveal a significant variation in major element composition (especially CaO and Al_2O_3) across the studied in-situ block. However, ICP-MS analyses show high consistency in the chondrite-normalized trace element patterns in the same rock samples, implying a co-genetic source of origin. It seems that the omphacite-bearing rocks could have been metamorphosed from a protolith of gabbroic plagioclase cumulate.

BSE imaging and EPMA mapping data reveal that omphacite contains diopside lamellae or lobes. Petrographic features and mineral compositions indicate that the relation between omphacite and diopside might represent a miscibility gap caused by exsolution from cooling. The observed omphacite-diopside compositional gap varies slightly from sample to sample of different mineral modes, but is consistent with some miscibility gaps reported in previous studies. This is the first discovery of this kind of unusual rock assemblage and texture in Taiwan. We have applied multi-equilibrium thermobarometry (the Perple_X software) to constrain the metamorphic conditions of the studied block and associated rocks. Three stages of metamorphism are reconstructed on the basis of petrographic criteria. M1 stage is represented by actinolite in the interior of a large amphibole pseudomorph (porphyroclast) in the omphacite-bearing rocks. M2 stage is by amphiboles in the segregated bands, and M3 is by omphacite-diopside intergrowth in the massive samples. The inferred P-T path, via computed pseudosections and amphibole isopleths, appears to be a counter-clockwise one. The M2 stage is about 490 ℃ and 8 kbar, but the M1 and M3 is less quantitatively constrained due to lack of suitable assemblages.

Keywords: omphacite, diopside, miscibility gap, geochemistry, Wanjung, Yuli Belt