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Blueschists and eclogites of the Lhasa terrain - are they a result of oceanic subduction, deep transpressional thrusting or of both processes?

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The P-T evolution of major terrains of NE Gondwana is critical to understand growth, formation and subsequent uplift of the Himalaya and Tibetan plateau during Cenozoic times. It has long been assumed that the Lhasa terrain in southwestern China, bounded by the Banggong-Nujiang suture zone in the north and the Indus-Yarlung suture zone in the south, was a uniform block of NE Gondwana, separated from Gondwana during the early Jurassic and accreted to Eurasia during the Cretaceous. This model, however, does hardly account for early Mesozoic extensively crustal-derived magmatism, mafic-ultramafic nappes and late Permian eclogites within the Lhasa terrain. Alternatively, models proposing additional suture zones within the Lhasa terrain were recently presented. However, garnet-bearing blueschist and eclogite, recently recognized within the Lhasa terrain, could contribute to distinguish between various geodynamic models considering different collisional settings. These rocks were found structurally beneath meta-basalt and altered gabbro coexisting with limestone, quartzite, and white-mica schist. Permian fossils were discovered within these (meta)sediments during preliminary mapping.

One of these newly detected high-pressure rocks occurring about 60 km NE of Lhasa was investigated in detail. The sample consists of some percent of corroded garnet situated in a matrix of amphibole, white-mica, epidote, chlorite and quartz. Accessory phases are rutile, ilmenite, titanite, omphacite and albite. Grains of matrix amphibole and phengite as well as garnet within the studied rock were found to be chemically zoned. From core to rim, matrix amphibole changes from glaucophane, through Na-Ca amphibole to Ca amphibole composition. The Si contents of potassic white-mica decrease from core (Si per formula unit (pfu): 3.50-3.51) towards the rim (Si: 3.25 pfu). Garnet is concentrically zoned ranging from $Alm_{62}Gro_{14}Py_{5}Spes_{19}$ (core) to $Alm_{73}Gro_{14}Py_{9}Spes_{3}$ (rim). Epidote compositions range between 0.42 and 0.76 Fe^{3+} pfu. Rutile and clinopyroxene ($Acm_{35}Jad_{25}Di_{30}Hed_{10}$) were observed to be exclusively enclosed in garnet whereas albite and titanite occur only in the matrix. Epidote and differently composed amphibole (e.g., barroisite) also occur as inclusions in garnet.

The reconstruction of the P-T evolution of the investigated sample was attempted by applying conventional geothermobarometry but also by calculating a P-T isochemical diagram (pseudosection) for the P-T range 4-28 kbar and 250-650°C. However, the observed minerals are broadly in disequilibrium complicating this reconstruction. According to the P-T pseudosection, the garnet was formed at P-T conditions located in the field of the garnet amphibolite facies (stage I, about 600°C). This event was preceded at lower temperatures by a medium to high-pressure event (pre-stage I = assemblage of inclusion minerals in garnet) leading, for instance, to the formation of acmite-jadeite-rich clinopyroxene. The formation of glaucophane and phengite of the rock matrix postdated stage I either as a result of isobaric cooling or possibly even by pressure increase to blueschist facies conditions (stage II). The final metamorphic stage III, characterized by Ca-amphibole, albite and Si-poor phengite, resulted from pressure release to greenschist-amphibolite facies conditions.

The derived unusual metamorphic evolution (rather an anti-clockwise P-T path) does not fit a simple Permian - Early Mesozoic subduction event in order to explain the existing blueschists and eclogites. We assume an additional process in a transpressional setting along a major suture zone (strike-slip fault zone) in the Lhasa terrain where basic rocks from a mid-crustal level (stage I) were thrust to deep levels (stage II) and subsequently exhumed (stage III).