Devonian-Carboniferous retro-eclogite (blueschist) boulders from the Cordillera de la Costa accretionary complex (41°S), Chile: Tectonic similarities to high grade blueschists of the California Coast Ranges, USA

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Introduction

High pressure relative to temperature (high P/T) blueschist minerals, such as glaucophane and lawsonite have long been recognized as widely distributed, but rare, constituents of the Coastal accretionary complex (Western Series) which together with the Eastern Series (high T/P) forms a paired metamorphic belt[1].

In the large, nearly continuous exposure in the Coastal Range between latitude 38°S and 42°S, in the portion of the Western Series referred to locally as the Bahia Mansa Metamorphic Complex (BMMC) (figure 1), the predominant ages from abundant ⁴⁰Ar-³⁹Ar dating range from Permian to Triassic [2]. Carboniferous dates from this zone are scarce and are related primarily to anomalous coarse crystalline blueschists from the Los Pabilos/Cuesta Brava area at 41 °S [3; 4]. Because the blueschist/amphibolites are encountered as surficial boulders or clasts in young, semi-consolidated sediment, their exact relationship to the in situ basement complex is somewhat inconclusive.

Nonetheless, ⁴⁰Ar-³⁹Ar ages and petrographic aspects of the coarse blueschist boulders preserve an earlier (Devonian-Carboniferous) history of high P/T metamorphism of eclogite and epidote ± garnet amphibolites, likely formed during initiation of subduction [5]. This was followed by static blueschist metamorphism in a decreasing thermal gradient accompanied by fluid infiltration and serpentinite diapirism. The high P/T blueschist event was followed by incorporation into upper levels of the voluminous accretionary complex which developed during the major metamorphic-deformational
event (Permian-Triassic) recorded in present exhumed exposures of the BMMC in the Cordillera de la Costa [5]. We focus here primarily on the genesis of a sample of the rare coarse blueschist boulders from the Los Pabilos area with relict omphacite plus garnet which indicate the early presence of eclogite in addition to the much more abundant remnants of hornblende assemblage (figure 2).

$^{40}\text{Ar}^{39}\text{Ar}$ dating and mineral analyses of the retro-eclogite/amphibolite assemblages

Recent $^{40}\text{Ar}^{39}\text{Ar}$ dating and electron microprobe analyses of minerals from the coarse blueschist boulders provide evidence that relict eclogite minerals (omphacite + garnet) coexisted in textural equilibrium during the earliest phase of metamorphism at $>361$ Ma [5]. $^{40}\text{Ar}^{39}\text{Ar}$ analyses of relict hornblende and white mica in garnet amphibolite suggests a two stage early retrograde path from eclogite facies metamorphism ($>361$ Ma) followed by blueschist metamorphism ($325$ to $308$ Ma) [5]. Initial retrograde metamorphism of the eclogite is thought to have followed a counterclockwise P-T-t path similar to that of boulders with early assemblages of garnet amphibolite [3, 4]. Coexisting omphacitic pyroxene and garnet exchange equilibria suggest metamorphic conditions for eclogite facies metamorphism of $550 \pm 30$ °C at pressures exceeding $1.32 \pm 0.04$ GPa, well within the field of high P/T subduction zone metamorphism [5]. The omphacite is often in textural equilibrium with hornblende (figure 2). Although dating of hornblende in the retro-eclogite sample was not attempted, a similar hornblende from a garnet amphibolite sample provides an $^{40}\text{Ar}^{39}\text{Ar}$ age of $361 \pm 1.7$ Ma, which we interpret as the time of cooling below the argon blocking temperature (~450 °C) of hornblende (figure 3) [5]. White mica in textural equilibrium with glaucophane and replacing the garnet amphibolite assemblage from the same rock and another similar sample gives dates of $325 \pm 1.1$ Ma and $\approx 320$ Ma respectively which we interpret as indicating cooling below the white mica Ar closure temperature. This evidence suggests that high pressure relative to temperature (high P/T) subduction zone type metamorphism in the block was thus established by $361$ Ma (late Devonian) and maintained at least into the late Carboniferous (circa $304$ Ma).

Tectonic similarities to high grade blueschist blocks of the California Coast Ranges, USA

Retro-eclogite/amphibolite blocks in varying stages of replacement by blueschist facies assemblages are widely distributed in the Franciscan complex that underlies most of the California Coast Ranges of the USA. In northern California, where they are most abundant, the high grade blueschists exhibit the following general characteristics in common with the retro-eclogite/amphibolite blocks from Los Pabilos: (1) they are older than the main body of the in situ accretionary complex [6, 7], (2) they are higher grade, more coarsely crystalline, and contain relict minerals not in equilibrium with the in situ complex, (3) unlike most of the in situ rocks, the high grade blueschist blocks followed a
counterclockwise P-T-t path, and (4) they are often associated with serpentinite and structurally distinct from the rest of the complex [7].

In California, where the coarse blueschist has been extensively studied, it is evident that the eclogite/amphibolite metamorphism in the blocks predates the development of the regional fabric and even depositional age of much of the in situ Franciscan Complex. They have therefore been differentiated from the rest of the Franciscan as “tectonic blocks”. The late Jurassic high P/T eclogite-amphibolite facies metamorphism in the high grade blueschists of the Franciscan subduction complex is widely interpreted as having formed during the inception of Franciscan subduction [7].

The eclogite metamorphism in the Cordillera de la Costa of Chile may, as in the California Coast Ranges, date the approximate inception of subduction and formation of the Coast Range accretionary complex in south-central Chile. It may also have been the initial stage in the development of the associated North Patagonian/Nahuelbuta batholith.

References
Figure 1 Regional map of Bahia Mansa Metamorphic Complex, Chile

Figure 2 Photomicrograph of retro-eclogite (blueschist). Coexisting omphacite + garnet ± hornblende (Hb)

Figure 3 Inferred temperature-pressure-time (P-T-t) path for Los Pabilos retro-eclogite (blueschist).