REGIONAL BALANCED CROSS SECTION IN THE PATAGONIAN ANDES OF TIERRA DEL FUEGO (Argentina and Chile)

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INTRODUCTION

The Patagonian Andes are divided into the External and Internal Tectonic Domains. The External Tectonic Domain is characterized by structures developed in the sedimentary cover, scarce basement outcrops, low temperature deformation (usually not above green schist facies) and almost absent calcalcaline magmatism. The Internal Tectonic Domain is characterized by low to high grade polydeformed metamorphic rocks emplaced as basement thrust sheets, basic rocks with oceanic crust affinities, and abundant calcalkaline magmatism. These two descriptive domains can be mapped regionally and the boundary is a transitional zone with basement thrust and basement cored anticlines. Here I show a regional balanced cross section through the Patagonian Andes which goes from Tierra del Fuego island to the Pacific ocean (Figure 1-A). It was constructed using the fault-bend folding theory [Suppe, 1985]. The cross section presents a new interpretation linking the structures of the External and Internal domains. The rocks of the Internal domain are interpreted as alocthonous thrust sheets transported hundreds of kilometers along a basal decollement. The deformation propagates from the Internal to the External domain since Mid Cretaceous to Cenozoic.

External Domain

The External Domain is characterized by a thick folded and thrusted sedimentary cover. Fault related folds are the typical structures to the north and imbricated thrust systems to the south (Figure 1-A). The frontal folds are interpreted as fault bend folding structures related to three decollements, D1-D2 and D3 located near the top, middle and bottom of Eocene-Oligocene clastic deposits (Figure 1-B) [Cagnolatti et al., 1989; Alvarez Marrón et al., 1993]. The age of deformation of the frontal fold belt is post (S4) and can be related to a Miocene regional event of deformation. The shortening in the frontal zone is partially transfered to a back-thrust (BT) which is the limit of the frontal folds. south of this backthrust there is an imbricated system of five thrusts sheets composed of Upper Jurassic-Lower Cretaceous rocks (S1) and Upper Cretaceous rocks (S2). These thrust are related to a decollement located at the top of the Jurassic volcanics of Tobifera Formation (D4) described in surface at the Cerro Verde anticline by Klepeis [1994]. At the north edge of the imbricated thrust system, the Vicuña thrust (VT) and a back-thrust (BT) define the triangular zone described by Alvarez Marrón et al (1993). The Cerro Verde anticline (CV), affected by Quaternary strike slip faults, is the first outcrop of Tobifera Formation along the section. It is interpreted here as two stacked basement thrust sheets which are connected to the basal decollement of the orogen (D5) by a 15° ramp under the Darwin Cordillera (DC) (Figure 1-A). The shortening produced by the displacement of the basement thrust sheets along the top of Tobifera volcanics (D4) and top of Upper Cretaceous-Lower Tertiary rocks (D3) account for most of the Tertiary shortening of the fold belt east of the Deseado thrust. The Cerro Verde anticline refolds the deformed cover due to the activation of a lower decollement in the basement. This is a possible mechanism for thickening the orogenic wedge and to propagate the deformation toward the foreland during consecutive events of deformation. The fact that the low grade basement thrust sheet (BT) at the north end of Darwin Cordillera was emplaced out of sequence during the Paleocene-Eocene [Klepeis, 1994], suggest a post Mid Cretaceous (age of the main deformation in southern Darwin Cordillera) and pre Eocene event of cover deformation during Maastrichtian-Paleocene.

Internal Domain.
The Darwin Cordillera is the most important basement outcrop in Tierra del Fuego, metamorphosed during the Upper Cretaceous as a consequence of the Mid Cretaceous compressive deformation [Kohn, 1995]. Along the profile three basement thrusts were mapped [Mingramm, 1982; Caminos et al., 1981]. Here they are interpreted as an east vergent imbricated thrust system with more than 200 km of shortening and rooted in the basal decollement (D5) at 30 km below sea level (Figure 1-A). The southern limit of Darwin Cordillera is a tectonic boundary associated with an abrupt metamorphic grade change from chlorite-biotite grade to kianyte grade along the Beagle Channel fault [Kohn,1995]. This metamorphic jump is not recognized 20 kilometers toward the east in the section because the rocks on either the north coasts of Dumas Peninsula (DP) or the south coast of the Beagle Channel (BCH) are in chlorite-biotite grade (GS in Figure 1-A). This lateral changes probably reflect variable crustal shortening and uplift along the irregular margins of the back arc basin deformed during the Mid Cretaceous. The outcrops of the Upper Jurassic volcanics (Tobifera) in depositional contact below basic rocks of the back arc basin (Tortuga Complex) along the coast of Dumas Peninsula [Suarez et al, 1985], are here interpreted as transitional crust of the north side of the back arc basin thrusted over continental crust of Darwin Cordillera. The basic rocks of Tortuga Complex are an incomplete ophiolite sequence outcroping extensively south of the Beagle Channel. They are composed by pillow lavas, sheeted dikes and gabbros representing the upper levels of the oceanic crust formed in a Mesozoic marginal basin [Suarez et al, 1985]. The metamorphism and geochemistry of these rocks support an origin related to a spreading center [Stern and Elton, 1979] but no ultrabasic rocks were found yet in the Tortuga Complex neither in the Sarmiento Complex toward the north. south of the Beagle Channel fault in Dumas Peninsula (PD) and Pasteur Peninsula (PP) several thrusts merge to a decollement located 5 kilometers below the top of the basic rocks and two more decollements are infered at the bottom and top of the Upper Jurassic-Lower Cretaceous sedimentary rocks. The southermost thrust transport Upper Jurassic-Lower Cretaceous rocks associated to the activity of a magmatic arc located on the southern margin of the basin.
It is proposed here that the basic rocks are alocthonous thrust sheets emplaced over continental crust and transported hundreds of kilometers toward the foreland along D5. Most of the deformation south of the Beagle Channel is related to a Mid Cretaceous compressive event between 87-90 Ma and 100-110 Ma [Halpern and Rex, 1972].

CONCLUSIONS

The Patagonian Andes of Tierra del Fuego are divided into an External and Internal Tectonic Domains, each one having different style of structures and rock association. The structures of the External Domain are related to four main decollements (D1-4) located in the sedimentary cover and the deformation migrates toward the foreland in at least three events of shortening during the Maastrichtian-Paleocene, Eocene and Miocene. The emplacement of basement thrusts that fold or cut the previously deformed cover is a possible mechanism for thickening the orogenic wedge and to propagate the deformation toward the foreland during consecutive events of deformation.
The structures of the Internal zone in Darwin Cordillera are basement thrusts rooted in a basal decollement (D5) located at 30 kilometers below sea level and a 15° ramp link the basal decollements of the Internal and External domains. The structures south of Darwin Cordillera are related to a basal decollement located in the oceanic crust of the back arc basin. This basic rocks are interpreted as alocthonous thrust sheets emplaced over continental crust and transported hundreds of kilometers toward the foreland. The main episode of deformation in the Internal domain is Mid Cretaceous age sustaining the general propagation of the deformation toward the foreland since then.

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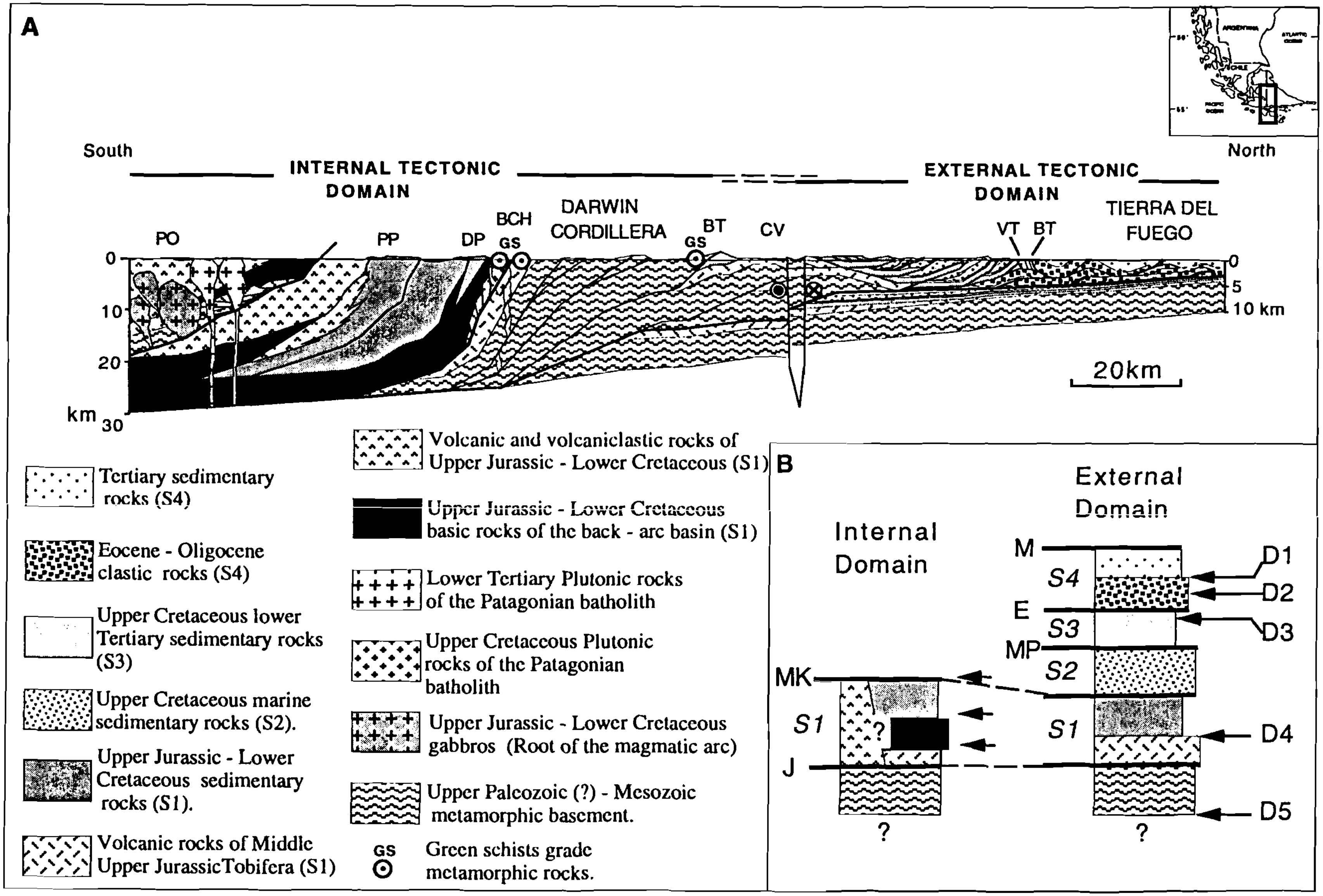
Figure 1-A Regional cross section in the Patagonian Andes of Tierra del Fuego. VT: Vicuña thrust; DT: Deseado thrust; CV: Cerro Verde anticline; BT:Basement thrust; BCH:Beagle Chanell; DP:Dumas Peninsula ; PP:Pasteur Peninsula; PO:Pacific ocean.

1-B.S1-S4:tectostratigraphic units bounded by unconformities, J:Jurassic unconformity, MK:Mid Cretaceous unconformity, MP: Maastrichian - Paleocene unconformity, E:Eocene unconformity; M:Miocene unconformity. D1-5: Decollements.


A
South
North
INTERNAL TECTONIC DOMAIN
EXTERNAL TECTONIC DOMAIN
PO
PP
DP
BCH
GS
DARWIN CORDILLERA
GS
BT
CV
VT
BT
TIERRA DEL FUEGO
0
10
20
km 30
0
5
10 km
20km
Tertiary sedimentary rocks (S4)
Eocene - Oligocene clastic rocks (S4)
Upper Cretaceous lower Tertiary sedimentary rocks (S3)
Upper Cretaceous marine sedimentary rocks (S2).
Upper Jurassic - Lower Cretaceous sedimentary rocks (S1).
Volcanic rocks of Middle Upper JurassicTobifera (S1)
Volcanic and volcaniclastic rocks of Upper Jurassic - Lower Cretaceous (S1)
Upper Jurassic - Lower Cretaceous basic rocks of the back - arc basin (S1)
Lower Tertiary Plutonic rocks of the Patagonian batholith
Upper Cretaceous Plutonic rocks of the Patagonian batholith
Upper Jurassic - Lower Cretaceous gabbros (Root of the magmatic arc)
Upper Paleozoic (?) - Mesozoic metamorphic basement.
GS
Green schists grade metamorphic rocks.
B
Internal Domain
External Domain
M
E
MP
MK
J
S4
S3
S2
S1
S1
D1
D2
D3
D4
D5
?
?