TABULAR PLUTONS FROM THE COASTAL CORDILLERA OF COPIAPÓ-VALLENAR (27°00´-28°30 S) AND AN APPROACH TO THEIR EMPLACEMENT MECHANISMS, ATACAMA REGION, CHILE

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INTRODUCTION

Traditional methods like mapping and geochronology have been applied to the Andean Orogen over the last two decades allowing the recognition that in much of the chain an eastward migration of the magmatic focus took place (Zentilli 1974, Brook *et al*. 1986, Dallmayer 1996). In the case of the Mesozoic of Northern Chile, volcanic arcs were abandoned and uplifted allowing erosion to act and expose the plutonic roots. Whereas the study of the volcanic products of the Cenozoic modern chain permits indirect inferences about the lithospheric processes, the eroded roots of the Mesozoic arcs offer a unique opportunity to study, in the field, the processes of arc building, emplacement of magmas and their interaction with deformation and the associated processes of mineralisation. Progress made recently in the Coastal Cordillera of Taltal-Chañaral have focused the attention into the plutons themselves and their relationships with contemporary structural systems (Grocott & Wilson 1997, Wilson 1998, Wilson & Grocott 1999, Grocott & Taylor in press). These works have interpreted the plutons as tabular bodies and inferred for them roof-uplift and floor-depression emplacement mechanisms. The present contribution present some of the most relevant results of our current research, within a 130 km N-S segment of the Coastal Cordillera immediately south of Chañaral between Copiapó and Vallenar (Fig. 1), which are consistent which are consistent with findings made in the north. Current works will incorporate gravimetry and AMS studies to reach a general model for the construction of the Coastal Batholith.

REGIONAL SETTING

In the Atacama Region, the magmatic ascent during the Mesozoic was mainly focused in the current coastal range building up a multiplutonic complex that intruded a Devonian-Carboniferous basement and its related volcanic products. This complex constitutes a morphotectonic unit which is denominated Coastal Cordillera by analogy with the southern (south of 33˚ S) and northern counterpart (north of 27˚ S) where a well defined Central Valley separates it from the western ranges of the main Cordillera (Jordan *et al.* 1983, Mpodozis & Ramos 1990). The mainly sedimentary Mesozoic back-arc elements extend to the east of the Coastal Cordillera as single basins or as systems of interconnected basins, resting on a Carboniferous to Triassic basement as far as the current Chilean-Argentinean border.

PLUTONS FROM THE COPIAPO-VALLENAR AREA

(1) Three types of plutons have been recognised so far in the Coastal Cordillera of the Copiapó-Vallenar region: Multilayered mylonite bounded plutons

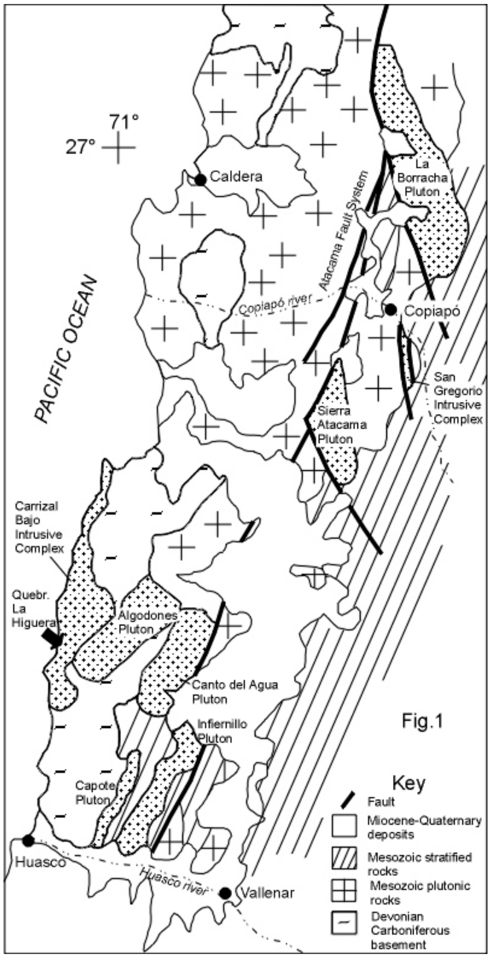
Fig.1

These plutons have parallelogram-shaped outcrops determined by the existence of syn-emplacement planar structural features. Straight borders are generally defined by one NNE-trending, sub-vertical and syn-plutonic mylonitic margin, often coinciding with a branch of the Atacama Fault System (Brown *et al.* 1993), and by other NW straight border interpreted as syn-plutonic fault (Grocott & Taylor in press). Outside non-structural borders, where layered wall rocks are well exposed, outward-dipping homoclines are often visible. Outliers of volcanic and volcaniclastic rocks in the roofs show that they are flat to gently-dipping and generally concordant. The existence of locally transgressive contacts suggest us the presence, although still unproven, of low-angle, country-rock faulting. The floors are generally unexposed. However unique outcrops at the base of the Carrizal Bajo Plutonic Complex (Welkner & Arévalo 2002) imply shallow bottom surfaces. The plutons are composite bodies internally formed by two o more distinctive, flat-lyingintrusive layers. Contacts between them are sharp, planar and generally parallel to each other and to the roof where it is exposed. Examples of these intrusives (Fig. 1) are the Infiernillo pluton (130 Ma; Gipson in prep., Valenzuela 2002), San Gregorio Intrusive Complex (111 Ma; Arévalo 1999), the La Borracha pluton (107-104 Ma, Dallmayer 1996) and the Carrizal Bajo Intrusive Complex (243-208 Ma, Welkner & Arévalo 2002).

(2) Single-layered, mylonite bounded plutons

The plutons have subvertical rounded walls. They have elliptical to semi-elliptical outcrops with NE to NNE long axes. Often, specially where the walls juxtapose the plutonic rocks with sedimentary or volcanic panels, mylonitised shear zones are developed. No clear outliers of countryrock at the top of the plutons are exposed indicating erosion of most of the intrusive roofs. The Canto del Agua dioritic pluton exposes at its eastern border panels of older shallowly dipping, hornfelsified-andesitic rocks as remains of flat-lying roof. The plutons are internally homogeneous suggesting that they are probably formed by only one single layer although the possibility of erosion of other facies cannot be ruled out. Examples of these intrusives are the Algodones pluton (197-192 Ma, Arévalo & Welkner in prep.), the Sierra Atacama pluton (111-104 Ma, Arévalo in prep.) and the Canto del Agua pluton (155-150 Ma; Arévalo & Welkner in prep.).

(3) Single-layered plutons unrelated to mylonites

These correspond to minor scale, single layer intrusives with well defined floors and roofs, steep sides and no mylonitic envelopes. Generally they are emplaced within flat lying surfaces like basement-cover interfaces (Capote pluton, 189 Ma; Valenzuela 2002) or internal sedimentary contacts (Los Puntudos diorite; Arévalo & Welkner in prep.).

3-D GEOMETRY AND AN APPROACH TO EMPLACEMENT MECHANISMS

No research has been done so far to determine the geometry in depth of these plutons. However. characteristics such as shallow-dipping roofs, steep sides, flat lying internal interfaces between plutonic layers and shallow plutonic floors are all consistent with flat-lying tabular pluton geometry (Vigneresse 1995, Cruden 1998). In the case of the multilayered plutons the pluton-down sense of shear indicators within synplutonic mylonitic rocks in the walls and down-warping of primary structures in the host rocks toward the mylonitic envelop and the pluton are consistent and imply a floor depression emplacement mechanism. The presence of outward dipping homoclines in well layered country rock around these plutons is somehow inconsistent with the latter mechanism. Although it is a matter of current research two explanations are possible: (1) vertical bending of the upper plutonic layers as a result of an upward doming of the pluton roof due to a drop in the space-creation rate producing a subsequent rising in the magma pressure or (2) syn/late stage tectonic folding. Cruden (1998) evaluated the mechanisms by which Cordilleran plutons depressed their floors utilising two possible end models: the cantilever and the piston model which differ in the existence of vertical shear within one single wall (cantilever) or all around the pluton border (piston). In the light of the evidence given the multilayered plutons were emplaced mostly through the operation of the Cantilever mode of floor depression. In the case of single layered intrusives, the pluton-up sense of shear within mylonitised walls and the existence of open synclines outside and parallel to plutonic margins imply emplacement via roof-uplift for most of them. Explanations for the absence of layering exhibited by the pluton types 2 and 3 are matters for further research. One possibility could invoque the tendency of magma to favour lateral propagation to create single sheets rather than layered complexes in a scenario of increasing overburden thickness (Roman-Berdiel *et al.* 1995). On the other hand, removal of putative upper layers by erosion should not be discarded. This latter case seems to be the situation of the San Gregorio Intrusive Complex where complete panels of a shallow layers have been removed by erosion during inflation of a deeper layer via dip-slip of bounding faults

DYKE ASCENT OF MAGMAS

Dykes are well known as the most efficient way to feed upper crustal plutons (Petford 1996). In the Copiapó-Vallenar zone dykes of basic to intermediate composition cross cut the intrusives and their hosting rocks throughout the region. However places where demonstrable spatial linkages between tabular bodies and vertical dykes are scarce. One exceptional place is Quebrada La Higuera (Fig. 1) where deep incision of the valley allows to see a complete section of the Carrizal Bajo Intrusive Complex. Along this valley a stack of four compositionally distinct plutonic sheets are exposed. Interfaces between each layer are defined by sharp contacts or by horizon of intrusion breccias (Welkner & Arévalo 2002). The lower most sheet is a homogeneous diorite exposed throughout on a marine terrace. La Higuera valley has deeply eroded this terrace exposing at the base of the dioritic layer windows of strongly deformed biotite schists from a Permo-Triassic basement cross cut by a pervasive andesitic to dacitic dyke swarm. The absence of these minor intrusives in the upper plate implies that the dykes expanded upward to feed the horizontal body. Additionally the existence of vertical shear surfaces parallel to the dykes and ductile shear bands as dyke walls indicate that some of these bodies also acted as structurally active channels to feed and to eventually create space for the upper layers.

CONCLUSIONS

In the Copiapó-Vallenar region three type of plutons have been identified: multilayered mylonite bounded plutons, single layered mylonite bounded plutons and single-layered plutons unrelated to mylonites,

(1) Characteristics such as shallow dipping roofs, flat lying internal interface between layers and shallow plutonic floors are consistent with flat-lying tabular geometry,
(2) The tabular character and the existence of marginal, synplutonic, dip-slip ductile shear zones, implies that the intrusions were emplaced by roof-uplift or floor-depression,
(3) Clear evidence of dyke ascent of magma is exposed at the Quebrada La Higuera.

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