AGE AND STRUCTURE OF THE OXAYA ANTICLINE: A MAJOR FEATURE OF THE MIOCENE COMPRESSIVE STRUCTURES OF NORTHERNMOST CHILE

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INTRODUCTION

The Central Andes, with an elbow shape, forms the widest and highest segment of the Andean range. DeFm and uplift of this segment are mainly controlled by Neogene shortening, broadly documented in the Sierras Subandinas, Cordillera Oriental and Altiplano (references in Baby et al., 1997). In the Cordillera Occidental, northernmost Chile (Arica latitude), recent studies have shown that the Neogene shortening is mainly represented by a system of the Miocene west-vergent structures, locally associated with syntectonic sediments (Muñoz and Charrier, 1996; García et al., 1996; Riquelme, 1998). In the Belén region this system forms a narrow thick-skinned fold and thrust belt (García et al., 1996). To the west of the Belén Belt, lesser deFm structures (folds and flexures) represent an external and late activation of the compressive system. The major structure of this less deformed region is the gentle Oxaya Anticline (O.A.), which produces an important physiographical step from 2000 to 3600 m (Fig. 1). In this paper, we describe in detail the surface geometry, kinematics and chronology of the O.A., and propose a different interpretation to that of other workers (Muñoz and Charrier, 1996; Uhlig et al., 1996).

THE DEFORMED UNITS

In the O.A. region, an extensive Oligo-Miocene cover of volcanic and sedimentary deposits overlies a substratum of more deformed Mesozoic rocks. The substratum, exposed only in the Lluta, Cardones and Azapa valleys, is essentialy formed by folded Jurassic-Lower Cretaceous sedimentary series (Livilcar Fm; Muñoz et al., 1988), which are intruded by the Late Cretaceous-Paleocene "Lluta Intrusives" (Salas et al., 1966; Muñoz and Charrier, 1996).

The Oligo-Miocene cover has been grouped in the Azapa, Oxaya, El Diablo, Zapahuira and Huaylas Fms (Salas et al., 1966; Vogel and Vila, 1980; García, 1996; Parraguez, 1998). The Azapa Fm, which consists of fluvial gravels, includes a thick lower member (•400 m), limited to the east by the Ausipar Fault (Fig. 1) and a thin upper member (0-50 m) that overlies, to the west, the lower member and to the east the Mesozoic substratum. The Oxaya Fm, which conformably overlies the Azapa Fm and locally (to east) the substratum, is the most extensive unit in the region and is entirely involved in the O.A.. It is formed by large ignimbrite sheets, interbedded with minor sediments. These sheets form a broad ~1000 m thick ignimbritic plateau of strongly competent rocks. Several K-Ar radiosotopic determinations in the Oxaya Fm, indicate an age range from 25 to 19 Ma (García et al., this symposium). In the eastern Pampa Oxaya (Fig. 1), they are overlain by fresh black basaltic-andesite of the Zapahuira Fm, that yielded K-Ar ages of 15 to 12 Ma (García, 1996; García, in prep.). The Oxaya and Zapahuira Fms are covered by the fluvial deposits of the Lower Member of the Huaylas Fm (García, 1996). The lowermost sandstones of this member and both the Oxaya and Zapahuira Fms are tilted to the East due to folding of the O.A.. They are onlaped by gravels, which upward rapidly become horizontal, defining a smooth progresive unconformity (Fig. 1). In the lowermost Huaylas Fm, Bargo and Reguero (1989) and Salinas et al. (1991) reported the presence of Early Huayquerian (9-8 Ma) mammal rests. The upper Huaylas Fm contains a thin ignimbrite dated (K-Ar on biotite) in 8.7±1.0 Ma. To the west of the O.A., the Oxaya Fm is conformably overlain by the lower sandstones and upper gravels of the El Diablo Fm (Fig. 1). The gravels contain black andesite clasts of both lithology and age identical to the Zapahuira Fm. In the Moquella region (70 km south to the O.A.), the same El Diablo gravels are conformably covered by a lava flow dated in 8.4±0.6 Ma (mean age of two K-Ar determinations; Naranjo and Paskoff, 1985; Muñoz and Sepúlveda, 1992). These data implie than deposition of the El Diablo Fm ended between ~12 and ~8.4 Ma. All the described units are locally covered, to the east and west of the Oxaya Anticline, by the Huaylas Ignimbrite, an extensive pyroclastic flow dated in 4.4±0.3 Ma (mean age of six K-Ar determinations; Naranjo and Paskoff, 1985; Gardeweg et al., this symposium).

THE OXAYA ANTICLINE

The O.A. is a gentle and west-vergent assymetric fold, well exposed in the western part of the Pampa Oxaya, and mainly formed by ignimbrites of the Oxaya Fm (Fig. 1). Along strike (N30W) it can followed for ~50 km. The structure smoothly plunges to the south, whereas to the north it evolves to a

N20W trending monoclinal flexure (Fig. 1). The greater amplitude of the O.A. is observed in the proximity of the Azapa valley (section of Fig. 1), where the structure causes a change in altitude of ~1600 m. Extrapolating eastward the regional slope (1-2°W) of the top of the Oxaya Fm in the Central Depression, a 1100-1200 m vertical offset is obtained for the hinge region (Fig. 1). In this region, the assymetry of the fold is better observed: the western limb dips 12-18°, the eastern limb dips 7-8°. The anticline is also associated with a very open frontal syncline (Fig. 1). In the hinge zone of the O.A., buckling and strong competence of the rocks of the Oxaya Fm has caused normal faulting and grabens, wich are locally filled by the Huaylas Ignimbrite.

The O.A. was produced by the propagation and reactivation of an ancient thrust. This structure, the Ausipar Fault (Salas et al., 1966; Muñoz and Charrier, 1996; Parraguez, 1998), only exposes its trace in the Lluta valley. The Ausipar Fault dips 40-55°E in the floor of the valley where it juxtaposes the substratum with the lower Azapa Fm. Higher up it evolves to a subhorizontal thrust that propagates into the upper Azapa and lower Oxaya Fms and deforms the upper Oxaya Fm (Fig. 1). The existence of the lower Azapa Fm westward of the Ausipar Fault, and its absence to the east (over the substratum), indicate a major period of complexe faulting prior to the generation of the O.A.. This period is constrained between the deposition of the lower and upper members of the Azapa Fm, during the Oligocene.

AGE OF FOLDING

We here consider the ages of the non-folded and folded units in the flanks of the O.A.. On the eastern limb, the tilted lowermost Huaylas Fm (9-8 Ma) is unconformably covered by horizontal gravels, which have intercalated a 8.7±1.0 Ma ignimbrite. If we consider the analitycal error of this age, then its minimum age can be regarded as 7.7 Ma. Therefore, the age interval for folding in this area is between 9 and 7.7 Ma. On the western limb of the frontal syncline, the El Diablo and Oxaya Fms dip very gently to the west. The minimum age of the El Diablo Fm implies that folding occurred after ~12-8.4 Ma. In addition, the Huaylas Ignimbrite (~4.4 Ma) overlies the El Diablo Fm with strong erosion unconformity (Fig. 1) and also covers the anticline. Thus, the geometric relationships in the western side of the O.A. indicate that folding took place after ~12-8.4 Ma and much earlier than 4.4 Ma. This last interval of age is wider than that the one obtained at the eastern border of the anticline, but is very consistent, and contraints also the folding to the Late Miocene (~9-7.7 Ma).

CONCLUSIONS

The O.A. formed in the Late Miocene (~9-7.7 Ma). It was generated by the propagation and reactivation of the Ausipar Fault in a compresional environment. The O.A. representes an external and late activation, under conditions of lesser strain, of the Miocene west-vergent compressive system of the northernmost Chilean Andes (Arica latitude).

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