PALEOENVIRONMENTAL FEATURES AND BASIN EVOLUTION OF A COMPLEX VOLCANIC ARC REGION IN THE PRE-ANDEAN WESTERN GONDWANA: THE FAMATINA BELT

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INTRODUCTION

The present day Famatina System, a north-south trending orogenic entity extended between the Sierras Pampeanas and the Precordillera in northwestern Argentina (Fig. 1a) was an active volcano-sedimentary setting during the Early-Middle Ordovician. Several studies carried out during the recent years (for a review see in Durand *et al.*, 1994) consider the Famatina belt as a complex magmatic arc typical of active margins (Toselli *et al.*, 1993; Sosa Gómez & Cisterna, 1994 and references therein) which may have extended to the north into the Faja Eruptiva of the Puna and to the south into the Pampeanas Ranges in what is known as the Sierra de Paganzo and probably the Sierra de Los Llanos. According to this the Famatina System has more than 800 km in length and is exposed to different levels of erosion in the south and north. Whereas in the south the host rocks are low, medium and high grade metamorphic rocks of Pampean affinities, in the north, the host is a complex marine vulcano-sedimentary association of Lower to Middle Ordovician Age. These substrate differences might be interpreted as a progressive evolution from Island-arc complexes in the north to a predominantly active margin setting within the south. Not until recently, the Island-arc hypothesis for at least part of the evolution of the Famatina System was suggested (Mannheim & Miller, 1992). Based on sedimentary features a back-arc setting was suggested for at least part of the Ordovician successions (Clemens, 1993; Benedetto & Astini, 1993). In a regional context, Benedetto & Astini (1993) and Astini *et al.* (1995) considered the Famatina as the volcanic arc related with the accretion of the Precordillera terrane to western Gondwana, which took place in the Middle-Late Ordovician. Recent paleomagnetic data presented by Conti *et al.*, (1995) as well as faunal studies (Benedetto & Sanchez, 1994, in press) allow considering the Famatina as a partly exotic island-arc complex with connections to the well known intra-Iapetus island-arcs within the Celtic province.

NEW STUDIES

Recent surveys in the central region of the Famatina mountain belt located in western Argentina between the Precordillera and the Pampean Ranges allowed the recognition of a fairly continuous sedimentary history during the Arenig-Lower Llanvirn interval (Vaccari & Waisfeld, 1994; Albanesi & Vaccari, 1994; Toro & Brussa, 1995), which reflects the evolution of a rather complex tectonically controlled back-arc basin. Outcrops in the Cachiyuyo region include more than 2000 m of continuous section. Paleontological and sedimentological studies are still in progress but several informal members can be identified from bottom to top (Fig. 1b): a) silicified black shales with thin tuff partings, b) grey-bluish laminated shales, c) bioturbated grey sandy siltstones with calcareous fossiliferous nodules, and d) greenish-yellowish *Cruziana* rich sandstones and bioturbated siltstones with frequent coquina lenses comprise the Suri Formation, whereas e) lower red and purple silt-and sandstones, f) green volcanic breccias with tuffaceous fossiliferous siltstones and sandstones, and g) upper red and purple silt- and sandstones comprise the Los Molles Formation. Many of these members were formerly recognized as different units when studied scatterdly throughout the Famatina ranges. The succession in covered by an extensive mainly rhyolitic to intermediate volcanism of the Morado Formation correlated with the Las Planchadas Formation in the north (Mángano & Buatois, 1994). Active volcanism in the Famatina belt may have ceased after the collision of the Precordillera in the Middle-Late Ordovician, and may have been the source of the recently discovered K-bentonites in the Precordillera which occur in largely synchronous rocks.

This succession can be interpreted as the progressive filling of a back-arc basin with provenance from both foreland and arc derived sources (Fig. 1c). The first stage involved a rapidly subsiding trough reflecting the inception of initial thermal subsidence. This stage is characterized by starved-basin graptolitic black shales with minor marly hemipelagic beds. After a lag-period the succession shallowed upward indicating high sediment rates and decreasing accommodation space. Several stack-up shorefaces develop in a recurrent pattern dominated by storm-influenced environments and prograding volcanic-volcaniclastic wedges. Rapid facies associations shifts indicate a narrow shelf with predominantly high gradients, subjected to periodical base level drops, herein mostly related to local tectonic activity. Final stages of deposition, recorded in the Los Molles Fm, involved subaerial and marginal marine environments with prograding volcanic aprons and periodical emergence with short-life transgressions also driven by active tectonics (relative sea-level changes).

Throughout the Arenig and possibly culminating in the Early-Mid Llanvirn increasing volcanic activity took place. Silicified chonites and white-yellowish laminated and graded tuff horizons firstly appear in the *B. deflexus* Zone (Toro & Brussa, 1995). Increasing coarse volcaniclastics and volcanic breccias are common in the upper part of the Suri Fm., where they alternate with coarse shallow marine clastics and coquina layers. In most of the Los Molles Fm., they are interbedded with pink cross-bedded tidally influenced sandstones (herring-bone stratification) with abundant features of subaerial exposure and variegated shales with scarce fauna. Minor transgressive levels with abundant brachiopods (*Paralenorthis* and *Famatinorthis*, see Benedetto, 1994) seldom occur. The volcaniclastic beds yield trough and planar cross-beds. The coarsening and thickening upward trend reflects an increasing gradient typical of volcanic aprons and high gradient shelfal environments adjacent to volcanic or Island-arc complexes. As previously recognized (Mángano & Buatois, 1995), in the upper part of the succession, the low diversity faunal composition with unusually large individuals, the unstable paleocommunity structure and the low diversity *Cruziana* assemblage suggest the existence of extremely stressful environments.

Paleocurrents and sandstone composition indicate a double provenance. Most of the quartz-rich sandstones were derived from the east and are related to stable cratonal sources and subordinated recycled orogen. The volcanic source was located to the west and most of the paleocurrents measured in cross-beds show progradation toward the east-northeast. Most of the volcanic breccias and pyroclastics are derived from andesitic volcanism with minor felsic and basaltic components.

The available paleomagnetic data (Conti *et al.*, 1995), the faunal similarities to those of other island-arc complexes (Mángano y Buatois, 1992), and the predominance of Celtic mid-Iapetus brachiopods (Benedetto, 1994; Benedetto & Sanchez, in press) reveal a possible early stage island-arc setting. On the contrary, most of the features in the Arenig-Early Llanvirn suggest a back-arc environment. If a true island-arc complex developed in the early Famatinian history then it should have accreted to western Gondwana previous to the Precordillera terrane accretion in the Middle-Late Ordovician. Magmatic composition and isotopic relationships support an initial volcanic arc setting with no influence of continental crust contamination and a later collisional stage with acid peraluminous magmas generated by crustal anatexis intruding the Ordovician succession (Mannheim, 1993). Hence, it can be suggested that we should expect to find either two magmatic arcs in western Gondwana or, in the case of successively developed opposite dipping subduction, two superimposed or amalgamated magmatic arcs of slightly different ages in the context of the Famatina ranges (Fig. 1d).

CONCLUSIONS

Available sedimentological data in the central region of the Famatina belt shows a fairly continuous sedimentary record with no evident breaks through the Arenig and possibly the Lower Llanvirn. The inception of frequent sandy layers and volcaniclastic debris in an open-marine starved-basin with black shales indicates the initial closure of the basin, which was originally considered as a back-arc trough with a twofold provenance, from a volcanic arc to the west and from a cratonal region to the present east. However, new paleomagnetic and faunal data suggest a probable early stage volcanic-arc setting as suggested from its magmatism, which still remains to be demonstrated on a sedimentological ground.

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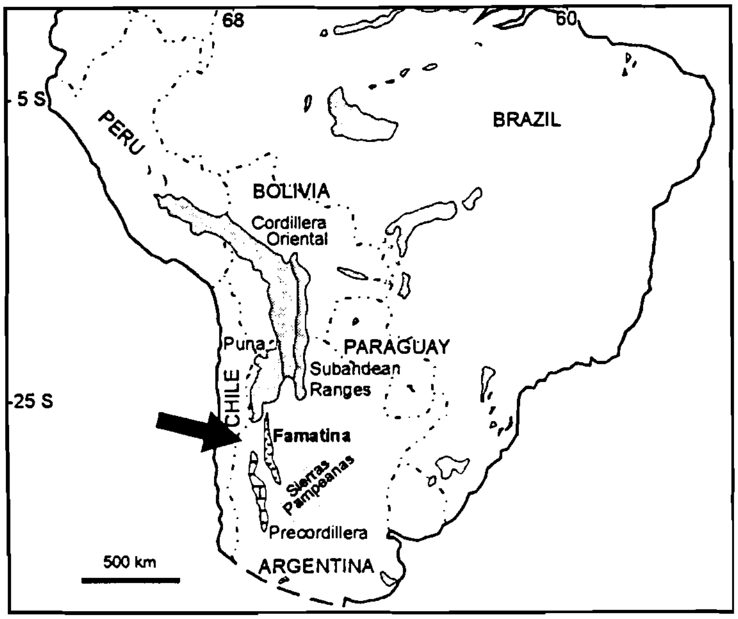

Fig. 1a: Location map of the Famatina System in the context

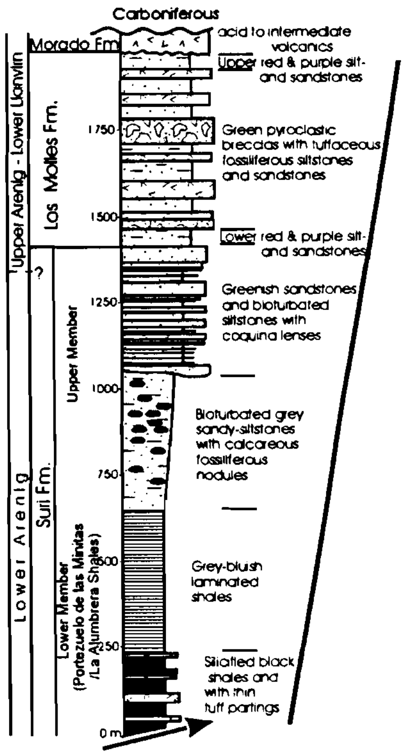

Fig. 1b: columnar log of the Lower Ordovician strata of the

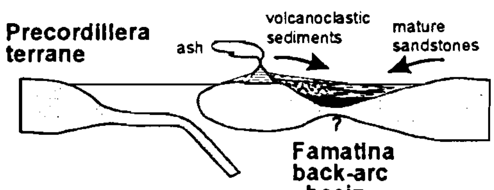

Fig. 1c: depositional model for the evolution of the Famatina basin fill with a twofold provenance from

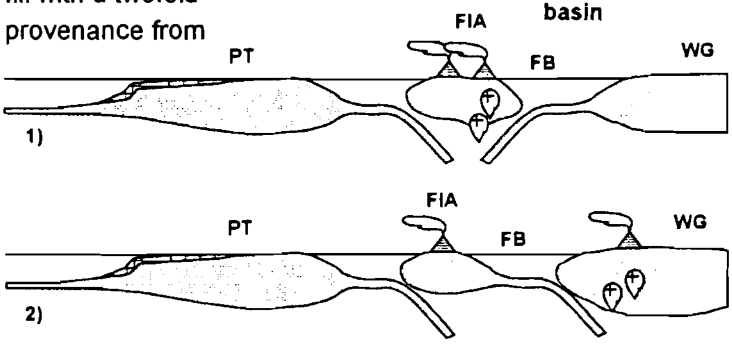

Fig 1d: Schematic diagrams of the two possible settings for the Famatina island-arc (FIA) hypothesis. PT:Precordillera terrane, WG: Western Gondwana, PB:represents the hypothetical Famatina basin depocenter. In 1) the two magmatic arcs are amalgamated in the same