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Sea level fluctuations and forced regressions in the Silurian basin in the Precordillera of Western Argentina

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Abstract: Silurian strata, as part of an Upper Ordovician to Lower Devonian siliciclastic succession, are widely distributed in the Central Precordillera of Western Argentina, but they are scarce in the Eastern Precordillera, and are not known with certainty in the Western Precordillera. The Silurian rocks are bounded at the base by an erosional unconformity that cuts Ordovician units of different age and are paraconformably overlain by Lower Devonian strata. In the Central Precordillera, the Silurian succession is represented by the Tucunuco Group, composed by the La Chilca Formation (Hirnantian to lower Wenlock) and the Los Espejos Formation (middle Wenlock to Lochkovian). These formations, which are separated by a paraconformity that coincides with a global regression, represent two regressive sequences and are interpreted as records of episodic subsidence related to an extensional regime that controlled basin geometry and infilling. In the Central Precordillera, in the San Juan River area, the Silurian is represented by the Tambolar Formation. From this area, evidence of deposition in extensional basins includes: (1) thickening-coarsening upwards successions of strata in each sequence, (2) occurrence of slumps in the middle and upper part of the Los Espejos Formation, (3) the geometry of infilling, and (4) marked north to south and east to west facies changes. Additional evidence of extensional tectonics includes the absence of Silurian strata in Western Precordillera, and tectonic boundaries separating the Central Precordillera from the Western Precordillera, and the Eastern Precordillera from the Pampeanas Ranges. It is apparent that the Silurian strata of Central Precordillera were not deposited in a foreland basin as generally proposed, but in extensional basins.

Keywords: Silurian, Argentine Precordillera, extensional tectonics.

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Introduction

Silurian shallow-water siliciclastic rocks are widespread in the Central Precordillera of the San Juan Province, Argentina, but they are not known to occur with certainty in the Western Precordillera. They also occur as allochthonous blocks mixed with a variety of Lower Devonian and pre-Silurian blocks within Lower Devonian olistostromes of the Rinconada Formation, in the Eastern Precordillera, as well as in the Los Sombreros Formation, at the western flank of the Central Precordillera (Fig. 1; Peralta 2005). The Silurian–Devonian sedimentary succession of Central Precordillera evolved as a sedimentary cycle beginning in the latest Ordovician (*Normalograptus persculptus* Chron) and ending in the Emsian–Eifelian? (Devonian) time. This succession unconformably overlies, from north to south, gradually older sedimentary units, ranging from the Upper Ordovician in the Las Aguaditas, Mogotes Azules, Cerro La Chilca and Las Chacritas sections in the north, to the Lower Ordovician limestone of the San Juan Formation in the Gualilán, Talacasto, La Invernada range, and La Dehesa range areas, as well as in the Tambolar and Pachaco sections, at the San Juan River area (Baldis & Peralta 1999). These successions are, in turn, paraconformably overlain by Carboniferous strata in Central Precordillera. It is noteworthy that Silurian strata are not known to the north of Jáchal River, like in the Guandacol, Gualcamayo and Cerro Potrerillo areas (Fig. 1), where Carboniferous strata overlie Upper Ordovician strata.

Silurian stratigraphic framework

In the Central Precordillera, the Silurian sedimentary succession is represented by the Tucunuco Group, composed of the La Chilca Formation (Hirnantian to lower Wenlock) and the Los Espejos Formation (middle Wenlock to Lochkovian) (Cuerda 1966, 1969), and its lateral equivalent, the Tambolar Formation at the San Juan River section (Fig. 1; Peralta 1990; Peralta et al. 1998, 2003). The La Chilca Formation, 85 m thick in the Jáchal River area, 20 m thick in the Talacasto section, 0.30 m in the Tambolar Pass, and 4-5 m in the Gualilán area, shows marked facies changes from east to west and from north to south. It var-

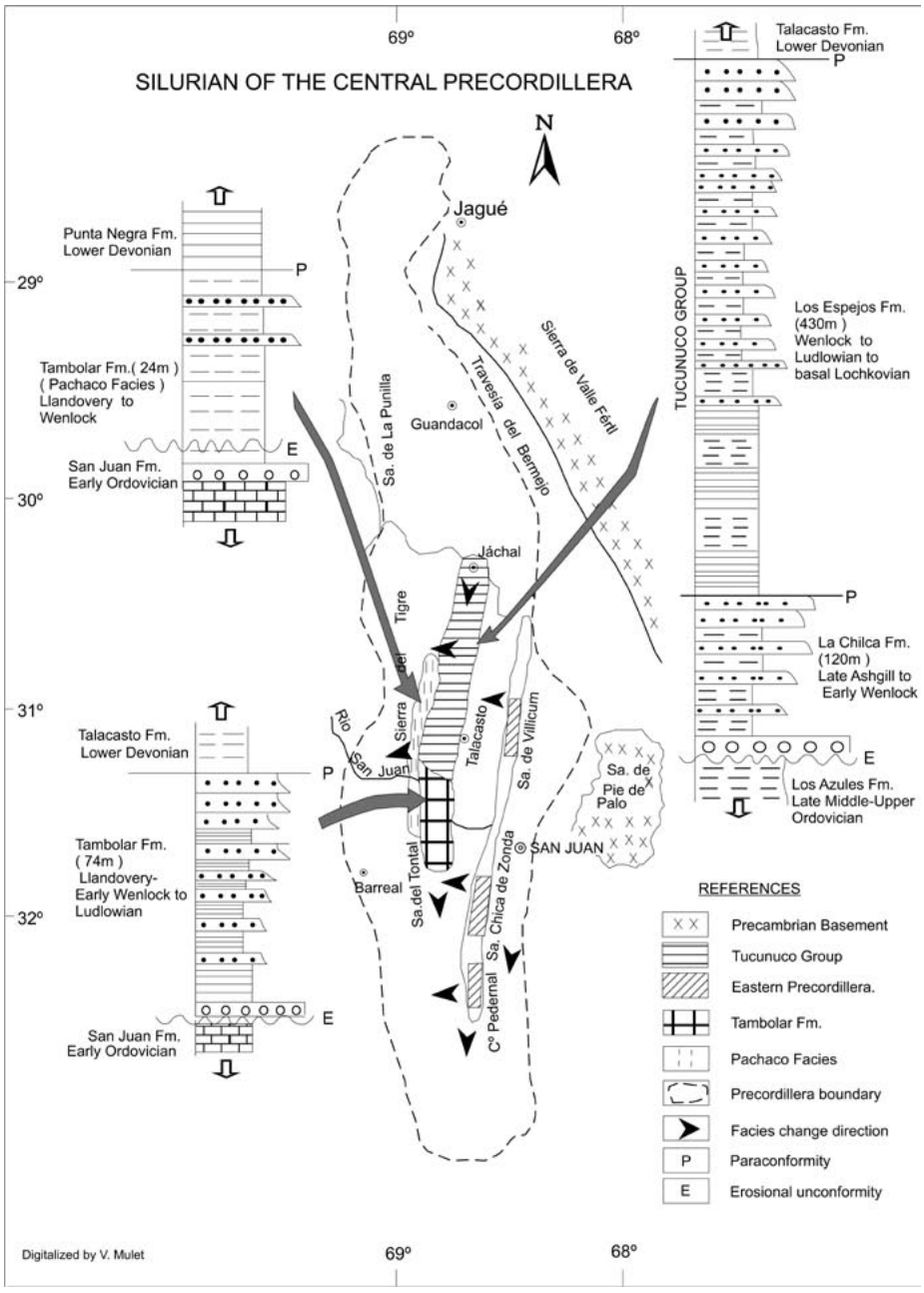

Fig. 1. Index map showing the geographical distribution of Silurian type sections, from the Jáchal River to the San Juan River areas, in the Central Precordillera of the San Juan Province (modified from Peralta et al. 2003). See stratigraphic explanation in the text.

ies from fine-grained sandstone in the Las Aguaditas, La Chilca hill, Talacasto, and Gualilán sections to bioturbated mudstone in the La Invernada range, Tambolar and Pachaco sections. The unit is interpreted as a typical shallow-water, storm-dominated sequence (Peralta 1990; Astini & Piovano 1992), possibly related to a global sea level change. A conspicuous cherty pebbly conglomerate (Figs. 1, 2), no more than 0.50 m thick, occurs at its base, as well as at the base of the Tambolar Formation, in which the chert pebbles come from the Early Ordovician limestone of the San Juan Formation (Marchese 1972). This conglomerate, related to the transgressive Hirnantian post-glacial sea level rise, is paraconformably overlain by bioturbated mudstone bearing graptolites of the *Normalograptus persculptus*, *Parakidograptus accuminatus*, and *Atavograptus atavus* zones (Cuerda et al. 1988). Upwards, the mudstone gradually intercalates with siltstone and fine-grained sandstone, which predominate toward the upper part of the formation. Well developed hummocky cross stratification and abundant trace fossils of the *Cruziana* Ichnofacies, represented by *Planolites-Paleophycus-Zoophycus-Chondrites* ichnoguild (Peralta 1990), are present.

The siltstone levels bear *Monograptus priodon* (Bronn) indicating a correlation with the late Llandovery–early Wenlock (Kerlleñevich & Cuerda 1986). The La Chilca Formation is paraconformably overlain (flooding surface) by the basal pelites of the Los Espejos Formation (Peralta 1990). The latter is gradually succeeded upward by fine-grained sandstone, which

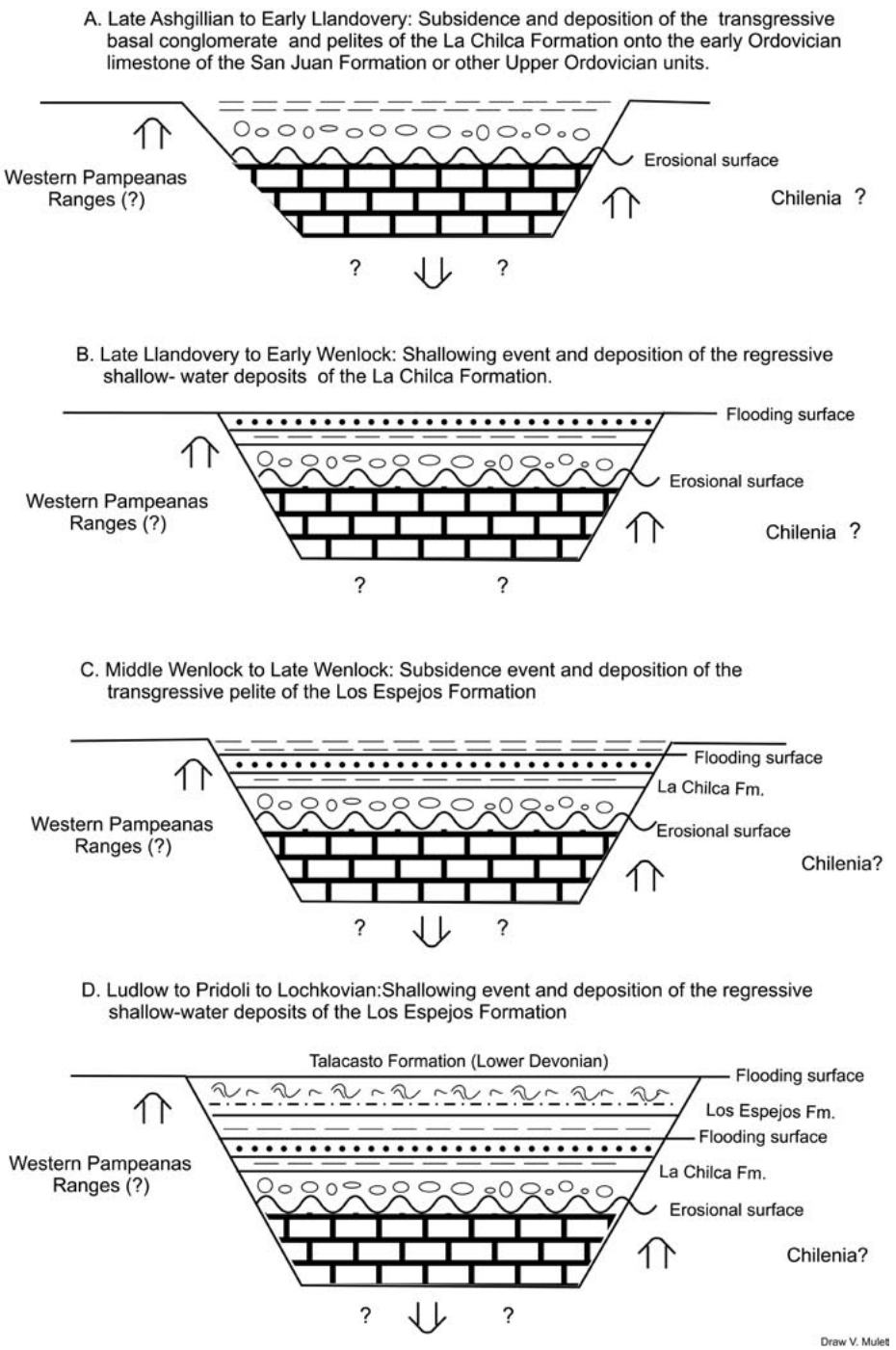

Fig. 2. Schematic cross sections (not to scale) showing the tectosedimentary evolution during which both the La Chilca and Los Espejos formations evolved as result of "yo-yo" type tectonics in an extensional basin.

in the middle and upper part of the formation bear *Saetograptus argentinus* (Cuerda) and *Monograptus uncinatus* var. *notouninatus* (Cuerda), indicating a Ludlow age (Cuerda 1969). More recently, Albanesi (*in* Peralta et al. 2003) recorded conodonts of the *Kokelella variabilis variabilis* Zone in the middle part of the Los Espejos Formation, indicating a Gorstian (Ludlow) age. Most of the sandstone beds show hummocky cross stratification and contain shell coquinas composed mainly of brachiopods, although bivalves, trilobites, corals, and crinoids also occur. Synsedimentary deformation structures, such as slumps and load casts, occur in the middle and upper part of the Los Espejos Formation (Peralta 1990; Astini & Maretto 1996), which is 270 m thick to the south of the Jáchal River, 170 m thick in the Talacasto range, and 150 m thick in the La Dehesa range. This formation shows north to south and east to west facies changes similar to those of the La Chilca Formation, and its deposits also are reworked in the olistostrome of the Lower Devonian Los Sombreros (western flank of the Central Precordillera), and Rinconada (Eastern Precordillera) formations (Peralta 2005).

Tectosedimentary evolution

The strata of the La Chilca Formation began to form during a subsidence event that resulted in deposition of its lower transgressive (post-glacial) deposits. A forced regression, likely due to basin uplift, and coupled with a global sea level rise, resulted

in a coarsening upwards succession (Fig. 2). A phosphate-rich, bioturbated sandstone, representing a sea level lowstand, is present to the top of the La Chilca Formation. This formation is paraconformably overlain by the basal transgressive pelites of the Los Espejos Formation. As indicated by low rate of sedimentation and high rate of bioturbation, the pelites are related to the maximum flooding stage. Upsection, the Los Espejos Formation is composed of gradually coarser sediments, with frequent synsedimentary deformation structures in the middle and upper parts, indicating basin instability. The thickening and coarsening upwards section of the La Chilca and Los Espejos formations, respectively, indicate two shallowing events, during which sediment accumulation could naturally produce regressive sequences. However, such shallowing upwards successions could also be the result of tilting of the basin due to extensional tectonics. The Central Precordillera includes a thick Lower Cambrian to Middle Ordovician carbonate succession that serves as basement for the Middle–Upper Ordovician and Silurian successions, which is clearly defined between the Jáchal River and San Juan River areas. The absence of Silurian strata above the carbonate basement north of Jáchal River and south of San Juan River may be the result of tectonic activity in Devonian time, when the olistostromes of the Los Sombreros and Rinconada formations were deposited (Peralta 2005).

Concluding remarks

The La Chilca and Los Espejos formations are both regressive thickening-coarsening upward sequences, and are bounded by paraconformities interpreted as flooding surfaces. These two regressive sequences are interpreted in terms of forced regressions resulting from "yo-yo" type tectonics that produced westward and northward tilting of the Central Precordillera block, which in turn was bounded to the east and west by major faults. This tilting produced the uplift of the Tambolar high in the San Juan River area and subsidence in the Jáchal River area, as demonstrated by northward increase in thickness. In this way, while the gross pattern of sea level fluctuations is of tectonic origin, some traces of a more global pattern also are present.

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