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TRANSTENSIVE ORIGIN OF THE ENCADENADAS-VALLIMANCA CORRIDOR (BUENOS AIRES, ARGENTINA): A REVISION AND A NEW PROPOSAL FROM SATELLITE IMAGES

ORIGEM TRANSTENSIVA DO CORREDOR ENCADENADAS-VALLIMANCA (BUENOS AIRES, ARGENTINA): UMA REVISÃO E UMA NOVA PROPOSTA A PARTIR DE IMAGENS DE SATÉLITE

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ABSTRACT - The Encadenadas-Vallimanca Corridor (EVC) corresponds to a morphostructural linear feature defining the northern boundary of the Sierra de la Ventana and Tandil hills in the Buenos Aires province. The scarcity of concluding geological studies has resulted in diverse tectonic and hydrographic interpretations regarding the genesis of the corridor. A new analysis of surface morphology, mainly derived from satellite imagery, led to the identification of a series of gentle and elongated *en échelon* left-stepping relief features or ridges with cross-sectional asymmetric flanks, having an average length of 20 km and oriented sub-latitudinally at 20° to the ENE strike of the corridor. The arrangement of these ridges reminds a tectonic scenario of right-lateral transcurrent faulting, for which, the limiting parallel faults fulfill the function of synthetic Riedel type shear. Besides, the cross-sectional asymmetry of the ridges suggests extensional normal faulting coherent with a transtensional right-lateral flower structure. Shallow seismicity of Mw 4.0 registered by the year 2016 in the proximities of the lineament could suggest recent fault activity. Also, previous gravity potential field mapping in the area seems to highlight basement anomalies underneath the sedimentary cover, coinciding with the main lineament of the Corridor. Based on all this information, the EVC is considered to be the surface expression of dextral transtensional fault activity.
Keywords: Morphotectonics. Wrench faulting. Encadenadas-Vallimanca Corridor. Far-field foreland deformation. Argentina.

RESUMO - O Corredor Encadenadas-Vallimanca (EVC) corresponde a uma feição linear morfoestrutural que define o limite norte das colinas Sierra de la Ventana e Tandil na província de Buenos Aires. A escassez de estudos geológicos concluídos resultou em diversas interpretações tectônicas e hidrográficas a respeito da gênese do corredor. Uma nova análise da morfologia da superfície, principalmente derivada de imagens de satélite, levou à identificação de uma série de características de relevo *en échelon* esquerdo suave e alongado ou cristas com flancos transversais assimétricos, tendo um comprimento médio de 20 km e inclinado a 20° para a direção ENE do corredor. O arranjo dessas cristas lembra um cenário tectônico de falha transcorrente lateral direita, para a qual as falhas paralelas limitantes cumprem a função de cisalhamento sintético do tipo Riedel. Além disso, a assimetria transversal das cristas sugere falha extensional normal coerente com uma estrutura tipo flor transtensional lateral direita. A sismicidade rasa de Mw 4.0 registrada até o ano de 2016 nas proximidades do lineamento pode sugerir atividade de falha recente. Além disso, o mapeamento prévio do campo potencial de gravidade na área parece destacar anomalias do embasamento sob a cobertura sedimentar, coincidindo com o lineamento principal do Corredor. Com base em todas essas informações, a EVC é considerada a expressão de superfície da atividade de falha transtensional dextral.
Palavras-chave: Morfotectônica. Falhas transcorrentes. Corredor Encadenadas-Vallimanca. Deformação antepaís reflexa de campo-distante. Argentina.

INTRODUCTION

The Encadenadas-Vallimanca Corridor (EVC) is a well-known major morphological feature probably the result of a structural tectonic accident that has affected the La Pampa and Buenos Aires provinces. Its main characteristic landmark is a strong lineament expressed by a depression bounded by linear margins that runs from the Utracán valley in the West to the confluence of the Vallimanca and Salado rivers in the East, covering a distance of approximately 600 km. The most notable components that make up this lineament are the ENE running valley of the Utracán river in the West, the string of large ponds or Encadenadas lagoons (the Chasilauquen, de la Sal, Epecuén, del Monte, del Venado, Cochicó, Alsina, and Inchauspe ponds) in the central part of the Cahué, Guamini and Daireaux area, and the Vallimanca river constituting the Eastern sector (Figure 1).

Due to the scarcity of field data has led to various hypotheses and controversies about its origin, available high-resolution topographic information from recent satellite imagery, covering in particular the northern limit of the Serrano Block that includes the sierras Austral (Ventana hills) and Septentrional (Tandil hills), has facilitated the identification of terrain models that highlight morph-structural features that in turn allow the construction of a new tectonic model. Of these the present work prefers to interpret the EVC as a Quaternary dextral transtensional strike-slip fault system. The support for this interpretation is based on data of detailed satellite, topographic mapping, bibliographic data from literature and available recent earthquake data.

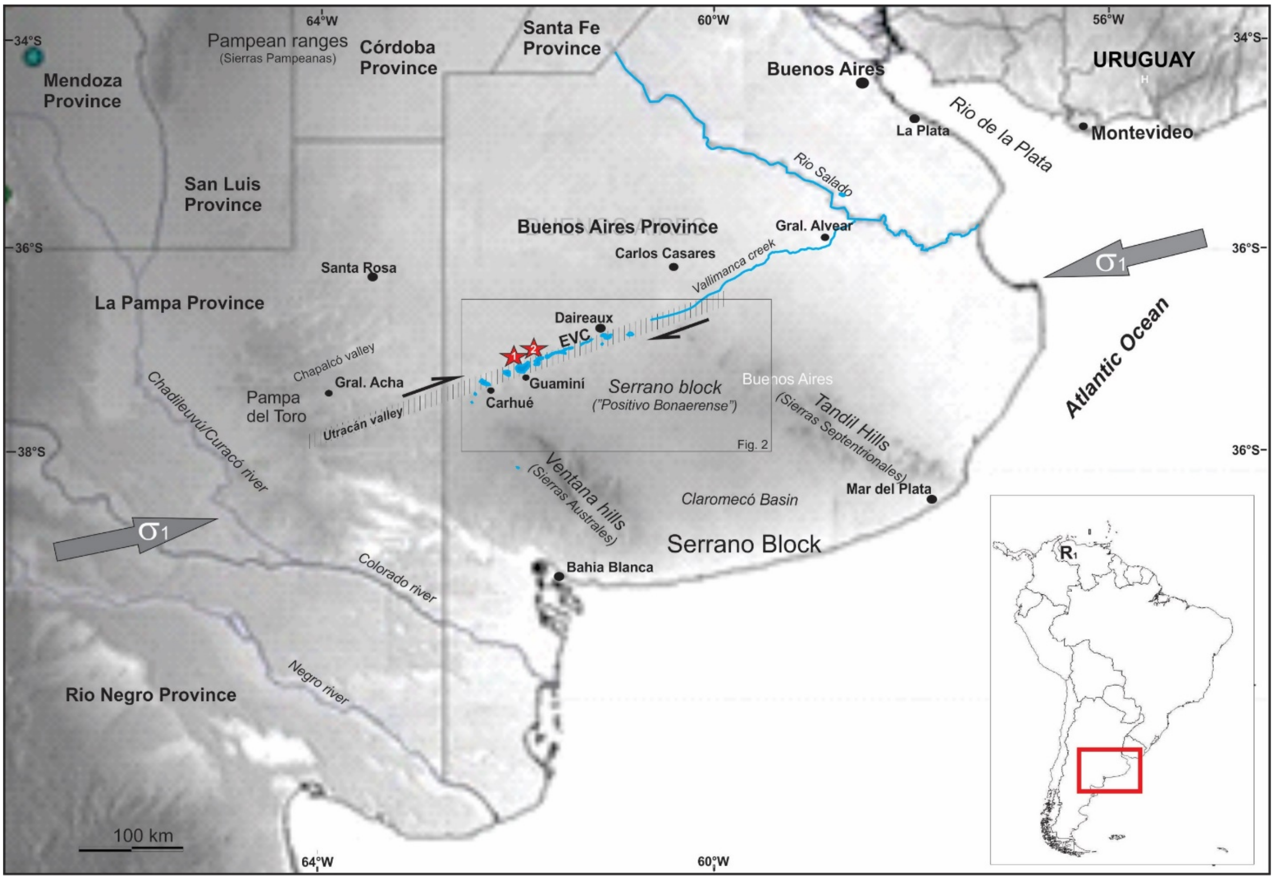

Figure 1 - General location of the Encadenadas-Vallimanca Corridor (**EVC**). The red stars indicate the epicenters of recent earthquakes: 1 and 2 in Casbas. Spatial relationship between the current Andean stress and the EVC. Solid arrows show the generalized orientation of the maximum horizontal Andean stress, and black shaded line indicates the approximate location of the EVC.

BACKGROUND

The studied region is not concerned into the previous theoretical framework and background concerned by neotectonic deformation in intracratonic or mid-plate settings for the continental interior of Argentina, on the foreland basins of the Chaco, Northern, and Southern Pampas (Costa et al., 2006; SEGEMAR, 2009, 2019). Stappenbeck (1926) considered that "cross-sectional valleys" like the Utracán valley (Terraza et al., 1981) (Figure 1) should be grabens due to their straight longitudinal outline shapes; and, Cordini (1960) maintained the same conclusion based on the linear trend and constant width of the valleys. Nevertheless, these authors did not encounter evidence that the valley sides were indeed fault escarpments. Frenguelli (1950) and Cordini (1967) associated them to a graben type or at least to fault displacement. Malagnino (1988) discarded the tectonic origin of the Utracán-Vallimanca system and considered a fluvial origin to be the most adequate. In the study of the Epecuén pond, Risso (1978) discussed both the tectonic origin as well as the fluvial origin, favoring the latter option.

Until recently most attention has been focused on the Utracán-Vallimanca creek lineament because of its strong geomorphic expression (Subsecretaría de Recursos Hídricos, 2002, INA, 2012; Niviére et al., 2010; Folguera & Zárate, 2019), specifically in the area of the Epecuén and Alsina ponds, located between Carhue and Daireaux (Figure 1). The last body was considered by Tapia (1939) and Rolleri (1975) to be the result of fluvial processes. Herrero-Ducloux (1978) assumed that the valleys were derived from lateral movements that occurred during the Upper Pliocene to the Pleistocene along pre-existing Cretaceous fault planes; but, as in the case of Linares et al. (1980), he did not explain clearly if those were directly caused by tectonics or by fault-controlled river incision. Salso (1966) described the Macachín Basin (Figure 1) as a meso-cenozoic depocenter with a regional orientation north to northwest (NNW) and south to southeast (SSE), passing through the EVC without any mention of its presence, since their interpretations favored a continuous sedimentary environment transferring water from the foothills of the Sierras Pampeanas toward the Bahia Blanca aquifers. Rolleri (1975), as also did Frenguelli (1950), stated that "the existing insights could be not enough to support the fault trace, no matter how appealing might appear their postulation to associate the mentioned hydrographic elements". And, considered instead, the linear features as the result of the overlapping of reliefs (here referred as the Serrano Block) that forced the water flux towards the Atlantic Ocean, partly draining through the enchained ponds and the Vallimanca creek system.

On the other hand, Arigós (1969) emphasized the absence of structural controls indicative of active faulting in the same region; but Yrigoyen (1975) argued the opposite when referred to the alignment of ponds and the tectonic reactivation phenomena, and he also remarked the not appearance of basement relief in the available seismic surveys as a question of scale that obscured the detection of level differences or steps. Cingolani (2005) described the **EVC** as a "transversal linear feature" (Borrello et al., 1969; Linares et al., 1980), or as a graben trending east to northeast and west to southwest, although the previous geophysical surveys failed to identify any sign of tectonic depression (Zambrano, 1974; Yrigoyen, 1975). Sellés-Martínez (1987) stated that the lineament can be related to the reactivation of fractures at the basement level, notwithstanding the lack of evidence about the associated graben; further, taken up the former ideas about their Cenozoic development from a fault, whether is dominated by a vertical displacement or more important strike-slip motion.

The unconsolidated nature of the sedimentary cover in the area (Frenguelli, 1950; Fidalgo et al., 1975), the anthropogenic changes, and the rapid vegetation growth conspire against the preservation of pristine conditions of outcrops, making difficult to identify discontinuous deformation features whose existence could decisively indicate the fault development. However, San Cristóbal (1984) reported on some sedimentary outcrops with microstructures like "slickensides with striae" and cracks along the region between the La Pampa and Buenos Aires provinces; particularly noting at north from the Carhué pond the existence of slickenside surfaces (without spatial arrangements) that suggest tectonic activity after the Miocene period.

THE ENCADENADAS-VALLIMANCA CORRIDOR (EVC)

The **EVC** is a geological feature corresponding to a corridor of nearly 20 km width and 200 km length, limited to the south by the rectilinear edges of the aligned ponds between Gral. Acha town (La Pampa province) to the Lagunas Encadenadas complex and its continuation to the Vallimanca river near Gral. Alvear town (Buenos Aires province) in the East. To the north, the EVC is limited by a system of narrow and elongated ponds located in the surroundings of Daireaux town (Figure 1).

The "Lagunas Encadenadas" system drains from ENE to WSW (Kruse & Laurencena, 2005; Geraldi et al., 2016) as evidenced by intrapampean relictic medanes, with altitudes stepping from 110 m a.s.l in the Alsina pond to 97 m a.s.l. in the Epecuén pond during normal water conditions. The system of enchained ponds follows a structural ENE lineament named "*Lineamiento de Vallimanca*" by Kostadinoff et al. (2001) and Kostadinoff (2007), or "*Lineación Utracán-Vallimanca*" by Sellés-Martínez (1987) extending from the valley of Utracán in the La Pampa province to the headwater of the Vallimanca creek in the Buenos Aires province (Figure 1). This feature can be considered as the prolongation of the incised transverse valleys in the Pampa platform (Nivière et al., 2013; Folguera & Zárate, 2019), trending N70º E to N85º E (Herrero-Ducloux, 1983; Vogt et al., 2010).

The outcropping stratigraphic record in the EVC is only represented by modern sediments (Malagnino, 1989; Contreras et al., 2018). Salso (1966) used soil drilling wells located near Carhué to describe a thickness of approximately

100 m of Pampean sediments presumably of Plio-Pleistocene age, overlying over at least 60 m of Oligo-Miocene Macachín Formation, but without exposing the basement. The sedimentary deposits capping the landforms were named as "The Invasive Medane" by Groeber (1936) without making the distinction of any typological description (see more details in Tripaldi & Forman, 2007; Zárate & Tripaldi, 2012; Tripaldi & Zárate, 2014). It covers a vast region that includes a large portion of the Buenos Aires province, the southern parts of the Cordoba and Santa Fe provinces, and the eastern portion of the La Pampa province (Figure 2). Within this sedimentary environment, Iriondo (1999) identified some isolated locations with longitudinal and parabolic medanes, the same that were studied by Malagnino (1988, 1989) in terms of their most representative typology, morphometry, source areas of clastic constituents, areal extent and time of deposition, to determine the Pleistocene-to-present geomorphological evolution under desert to hyper-desert low temperature conditions.

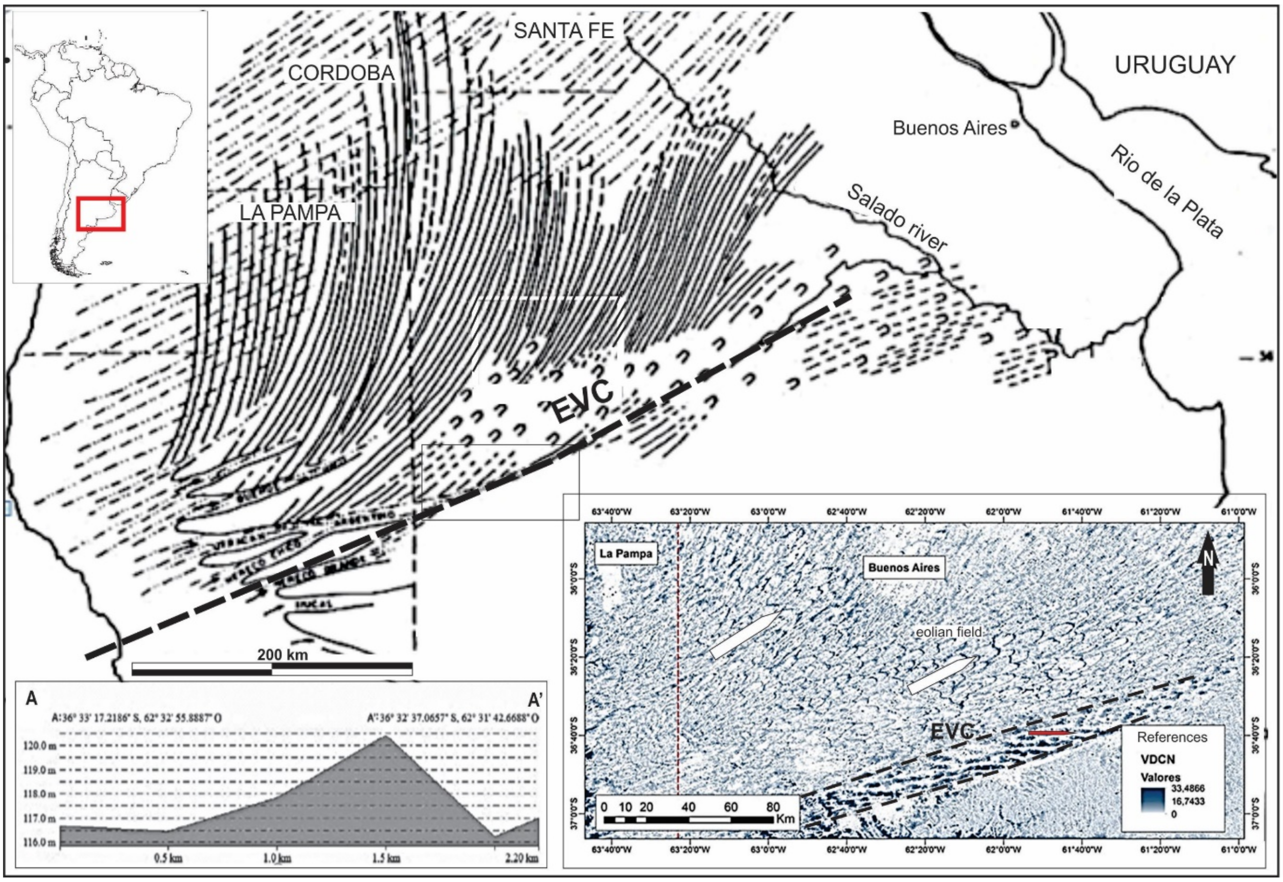

Figure 2 - Map showing the orientation of eolian palaeoforms and their relationships with the riverine flood models for the Buenos Aires province with the approximate position of the EVC (taken from Malagnino, 1989). *Right insert*: Lower to Middle Holocene parabolic medanes detected through VDCN based on a SRTM 3 arc/sec image (taken from Contreras et al., 2018) where the difference in patterns between the dune field and the reliefs related to the EVC is highlighted. *Left insert*: Topographic profile of a parabolic dune estimated from a SRTM 3 arc/sec image showing NE wind transport.

An earlier topographic analysis by Malagnino (1988) showed asymmetrical flanked ridges with the northern slopes steeper than southern faces. Isla et al. (2007) referred to this array of ridges as the Daireaux eolian corridor, there establishing a difference between the northern parabolic medanes and the longitudinal medanes field (Malagnino, 1988).

These dunes (Lancaster, 2009), are typical of semiarid conditions, in which occasional humidity favors the growth of discontinuous grasses and shrubs in the basal margins that serve as sediment traps, thus holding sand to preserve the landforms (Paladino et al., 2017). Moreover, blowout depressions appear in the central zone surrounded by the dome and the horns or parabolic dunes. In plain view, it is possible to distinguish dunes with crescentic-elongated or tuning fork shapes, whose arms (or horns) point toward the wind direction of provenance in this case, being unidirectional and striking NNE-SSW (Figure 2). Contreras et al. (2018) performed the detection and delimitation of the field of dunes by means of a Digital Elevation

Model from Shuttle Radar Topography Mission 3 arc/sec images, obtained from the United States Geological Survey. Contreras et al. (2018) performed topographic profiles through the use of SRTM images, which were subsequently compared with the results in the field showing asymmetric flanks, of which, those arranged toward the direction of wind transport (windward) are more inclined with respect to the leeward flanks (Figure 2).

The filling of eolian sediments coming from the SW and flowing toward the ENE is associated to a peneplain region that covers the La Pampa (Tripaldi et al., 2014) and Buenos Aires provinces that extents until the southern part of the Santa Fe province. These medane fields are characterized by the profusion of elongated and parabolic dunes intercalated with water bodies such as ponds (Figure 2). Iriondo (1999) and Iriondo et al. (2009) called them the “Pampean Sand Sea” and postulated their origin to be related to humid and arid alternating episodes during the Upper Quaternary period: In the Pleistocene humid period (65 to 36 kyr B.P.) were common the flood plain fluvial networks; and, in the Holocene arid period (3.5-1.4 kyr B.P.), extensive eolian sheets composed of coarse sandy silts and fine silty sands with 10-12 m and 5 m thickness covered areas of the regional plain.

Results of a gravimetric and ground magnetic surveys in the NW Buenos Aires province conducted by Kostadinoff (2007) suggest the presence of tectonic blocks as a semi-positive area in the basement that separates the Claromeco and Chacoparanaense depocenters (Chebli et al., 1999), located to the north of the Trenque Lauquén-La Zanja Station (Figure 3). Gravimetric minima between Sundblat and Salliqueló towns can be attributed to rock volumes of underlying Paleozoic units of up to 4000 m in thickness. Minima along an N-S zone from González Moreno to Guaminí towns achieve 160 km in longitude and 75 km in average width. Also, the variations of magnetic field anomalies by Kostadinoff (2007) approximately coincide with the EVC. Although this author did not make emphasis on structural features deductible from the geophysics, it is possible to infer a not properly displayed pattern of interruption for the anomalies matching the EV**C** position (Figure 3).

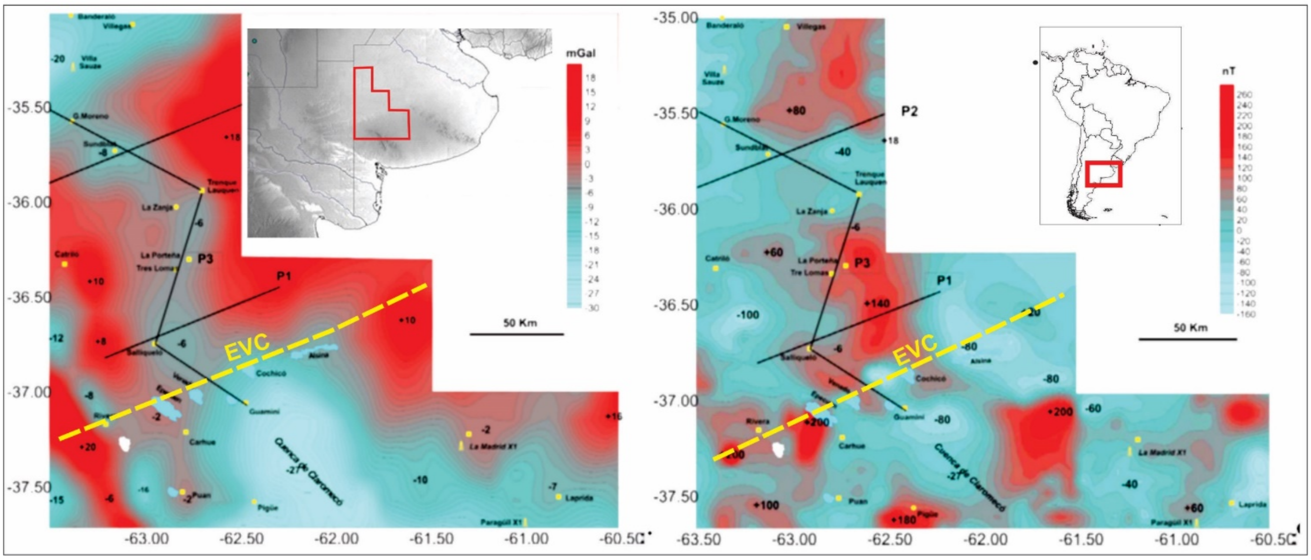

Figure 3 - *Left*: Bouguer gravity anomaly map with isolines each 1 mGal. *Right:* Terrestrial gravity anomaly map with isolines each 20 nanoTeslas (from Kostadinoff, 2007).

The Pampean plain, covering the Buenos Aires and La Pampa provinces, has been traditionally considered to be seismically inactive in contrast with the active Andean system associated with the subduction of the Nazca plate under the South American plate (Assumpção et al., 2016; Rossello et al., 2020). However, two moderate earthquakes with magnitudes close to 4.0 magnitude (Richter scale) and epicenters at the SW of the Buenos Aires province (Figure 1) were registered in 2016 by the INPRES (2019):

On August 10^{th}, 2016, 21:01 ART, an earthquake with magnitude 3.7 degrees and hypocenter estimated at a depth of 32 km, was perceived by inhabitants of Guaminí locality (Figure 1, 4). The INPRES (2019) published details of this shake on its Website and mapped it in red which means “felt”. The epicenter was located at 424 km SW from Buenos Aires and 70 km S from Trenque Lauquen town. At Modified Mercalli scale, the intensity was II to III (“very weak to weak”) around Casbas and Laguna Alsina localities, which means that was quite noticeably by persons indoors, especially on upper floors of buildings, but it did not cause any infrastructural damage.

On November 7th, 2016, 07:17 ART, another earthquake with magnitude 4.0 degrees and hypocenter estimated at 14.6 km depth, was perceived again in the same area and the epicenter was located at 30 km NEE of Casbas town (Figure 4). The INPRES report situated the shake at 167 km E from Santa Rosa town (La Pampa province), 420 km SW from Buenos Aires, and 66 km SE from Trenque Lauquen.

Unfortunately, there is no available information on the focal mechanisms and fault plane orientations that would be essential to contribute to the determination of the EVC kinematics. Perhaps this lack of data is due to the fact that they do not exist or until now have not been constructed.

These data would be most relevant for validating the activity and type of movement on the controlling faults of the EVC, and for elucidating whether we deal with a pure strike-slip phenomenon or a rift system associated with a regional-scale extensional regime. These earthquakes could be related to the EVC for their proximity, but other not yet defined basement discontinuities are capable of reactivation despite being located away from typically seismic areas (Nivière et al., 2013; Reuber & Mann, 2019; Rossello et al., 2020). The referred magnitude and depth have no direct strong incidence in inducing surficial deformation, but the softness of the sedimentary cover could be easily accommodated on the underlying fractured basement.

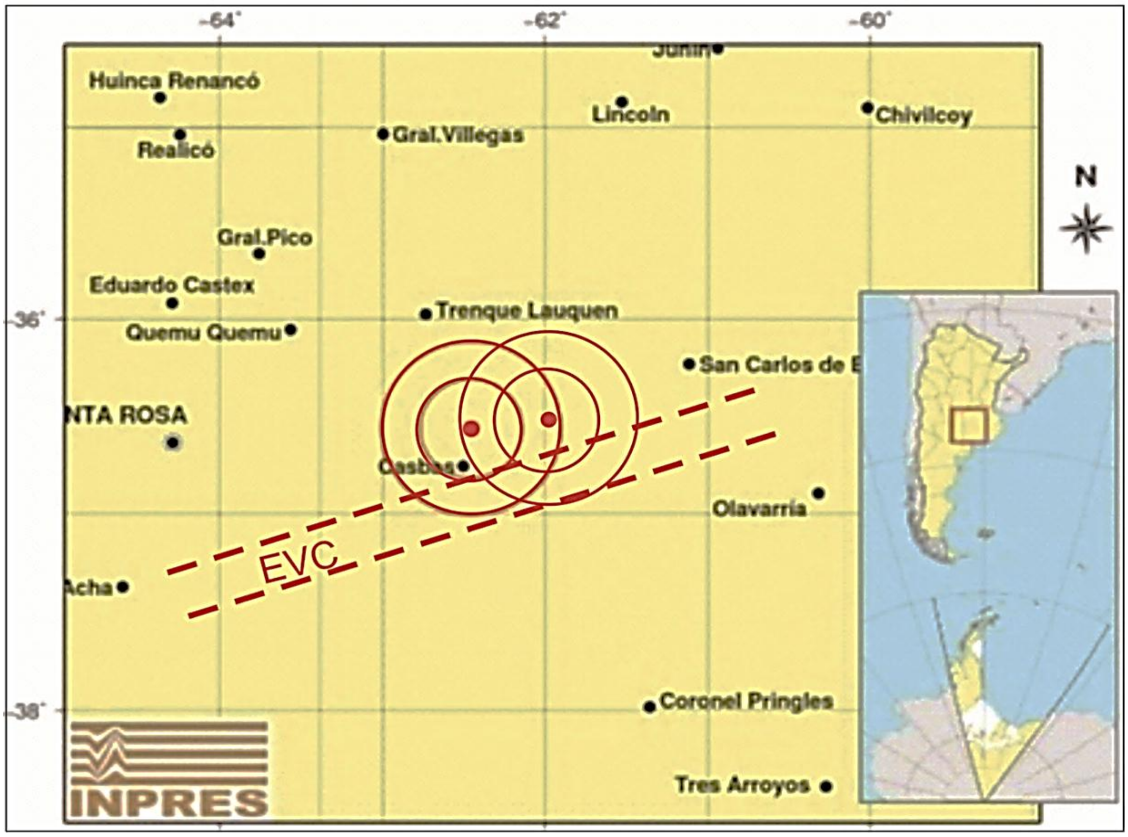

Figure 4 - Modified print screen from the INPRES (2019) with the location of the earthquakes occurred by 2016. Red circles indicate the epicentral locations near Casbas town.

KINEMATIC MODEL TO THE EVC

The dunes with crescentic-elongated or tuning fork shapes, whose arms (or horns) point toward the wind direction of provenance in this case, being unidirectional and striking NNE-SSW (Figure 2). In the present work, this distinction results inconvenient because the sub-latitudinal trend of the topographic ridge arrangements markedly differs from the eolian advance in direction ENE (Malagnino, 1988; Iriondo, 1997, 1999; Iriondo et al., 2009; Paladino et al., 2017).

Transverse cross-sections across the EVC reveal the asymmetrical flanks of the ridges of which the northern face have gentler dip than their southern steep flanks.

In contrast, in the case of the medanes, the gentler flanks are set to the southern flanks (Figure 2). Through analysis of digital topography models with 3601 x 3601 pixels of spatial resolution, derived from 1 arc-second SRTM (Shuttle Radar Topography Mission) satellite imagery, it was possible to recognize an array of low-reliefs *en échelon* left-stepping ridges within the EVC in roughly sub-latitudinal arrangements, limited to the Corridor reaching heights between 100 and 120 m a.s.l. Those ridges can be identified trending toward E from Daireaux locality to the Inchauspe pond (Figure 5) where achieve 2 km width and 20 km length, and level differences of risers of steps and valleys by 5-10 m.

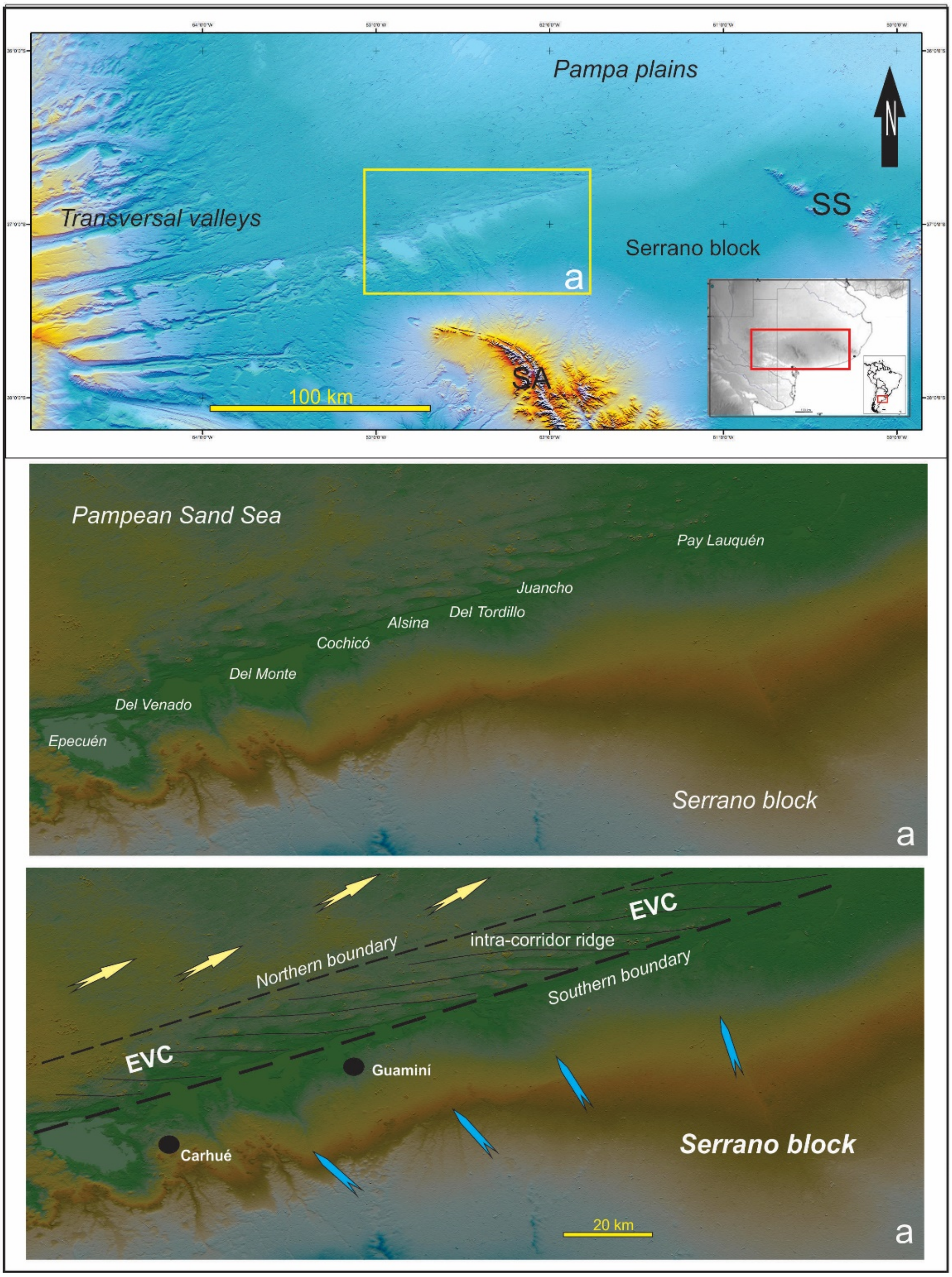

Figure 5 - Regional topography model extracted from SRTM (30 m) satellite imagery, with a general view of the **EVC** and the internal shallow relieves. Yellow arrows: wind direction. Blue arrows: fluvial runoff.

The discrepancy between the eolian and the EVC patterns has a clear relevance for the subsequent analysis. The configuration of the EVC is interpreted (looking west) as evidence of clockwise tilting of the fault bounded ridges (Figure 6). These bonding faults are thought to be subordinate extensional Sintectic Riedel – type faults, associated to the major EVC bounding faults and are thus an expression of the kinematics of the simple shear model in the sense of Moody & Hill (1956) (Figure 6).

Right-lateral motion of a strike slip fault at a right step over gives rise to extensional bends characterized by zones of subsidence, local normal faults, and pull apart basins. On extensional duplexes, normal faults accommodate the vertical motion, creating negative relief. The surface consists of *en échelon* and/or braided segments probably inherited from previously formed Riedel shears. In cross-section the displacements are dominantly reverse or normal in type depending on whether the overall fault geometry is transpressional (*i.e*. with a component of shortening) or transtensional (with a component of extension). As the faults tend to join downwards onto a single strand in basement, the geometry has led to these being termed flower structure. Strike-slip fault zones with dominantly reverse component are known as positive flowers, and those with dominantly normal offsets are known as negative flowers (Figure 6).

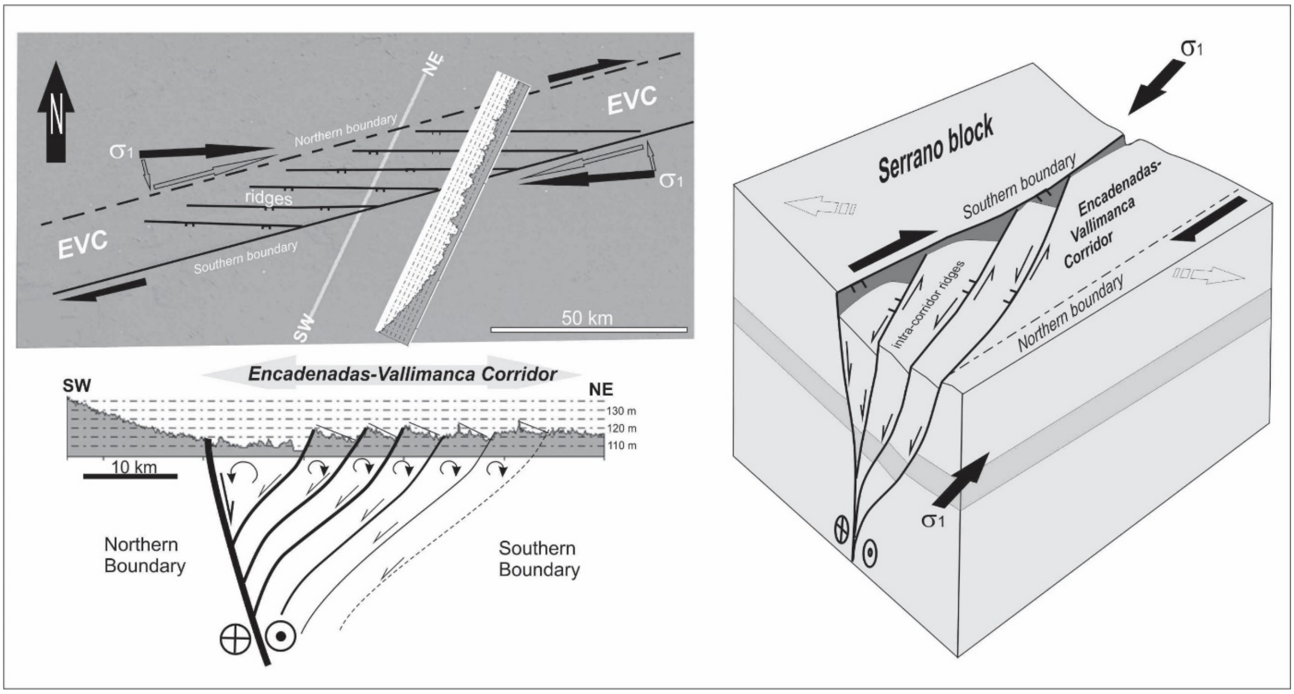

Figure 6 - Structural interpretation in plain view (SRTM) of the central EVC, and SW-NE topographic cross section (yellow line) with a scheme of the tilted blocks bounded by Riedel Type subordinated faults. Black arrows (□$_1$) in the image represent the horizontal principal stress. Simplified scheme of the relationship between the stress field and the dextral wrenching, with the development of a negative (extensional) flower structure from associated Riedel-type synthetic normal faults bounding intra-corridor ridges (adapted from Woodcock & Fisher 1986).

The identification of such structures, particularly where positive and negative flowers are developed on different segments of the same fault, are regarded as reliable indicators of strike-slip. The Riedel shears are normally the first subsidiary fractures to occur and generally build the most prominent set. They develop at an acute angle, typically 10-20° clockwise to a dextral main fault, anticlockwise to a sinistral strike-slip fault. They often form an *en échelon* and overstepping array synthetic to the main fault; they evolve as a sequence of linked displacement surfaces. Their acute angle with the fault points in the direction of the relative sense of movement on the main fault (Riedel, 1929; Woodcock & Fischer, 1986, Davis et al., 1999).

Linares et al. (1980), through analysis of ERTS satellite images, recognized a principal lineament and a secondary structure at 20º, interpreted by them as second order strike-slip faults with respect to the main fault, coinciding with the model proposed by Moody & Hill (1956) for right-lateral transcurrent systems. Even though the horizontal relative displacement was not estimated, they suggested that it was very small as not vertical unevenness was observed when passed through Macachín basin. The same opinion was maintained by Sellés-Martínez (1986).

This *échelon* parallel left stepping faulting is rather reminiscent of a rigid domino or bookshelf structural arrangement. The formation of Riedel's faulting occurs from an early initial phase in the development of a strike-slip fault system controlling on the development of flower structures (Woodcock & Fischer, 1986; Cunningham & Mann, 2007).

The oblique ridges are considered the surficial expression of synthetic Riedel shears (is that is has the same sense of movements as the controlling main fault) bounding the internal blocks of a negative flower structure. Consequently, these ridges are an evidence of the Quaternary activity of secondary faults. But, any determination of the Quaternary slip rate of the master strike slip fault (ENE-WSW), in order to create such distinctive relief, is at the present time impossible to determine. Complementary field data like the microtectonic San Cristobal´s (1984) observations, could endorse these interpretations. The strike-slip faults with dominating brittle deformation in the subsurface basement frequently propagate upward into the sedimentary cover including unconsolidated sediments (Rossello, 2001; Cunningham & Mann, 2007).

Another aspect of the negative flower structural model is that the string of ponds that is so well visible on the satellite imagery is being situated on the external side of the main fault lineament. Depressions would be generated at the junction of the Riedel faults with the main controlling fault and inside the controlling fault (Figure 6). A possible explanation for the depressions containing the ponds could be that a North-directed drainage originating in the South has been blocked by a ridge or fault scarp related to the EVC.

DISCUSSION

The most striking feature of the EVC is its location in excess of 1000 km inboard of the Nazca-South America margin, matching the maximum horizontal stress orientation derived from plate convergence (Figure 1). In the regional framework, one of the processes capable of producing widespread deformation in the upper plate and advancing inland for more than 600 km, is the Chilean-Pampean flat slab segment related to the subduction of the Juan Fernandez Ridge (Nazca plate), between 29ºS and 34ºS (Cahill & Isacks, 1992, Introcaso et al., 1992, Anderson et al., 2007, Alvarado et al., 2007, Ammirati et al., 2016, and references therein). From the tectonic point of view, the Pacific margin of South America is subjected to compression since the Mesozoic when the Nazca-South America convergence established a sub-latitudinal deformation regime (Brooks et al., 2003; Sperner et al., 2003; Cobbold et al., 2005; Costa et al., 2006; Guzmán et al., 2007). The revised and updated compilation of focal mechanisms in intraplate South America shows that horizontal compressional stresses predominate, not only in the Andean foreland belt, but also in mid-plate areas of the continent (Assumpção et al., 2016; Rossello et al., 2020). The cited works allow assuming the current maximum horizontal stress orientation for the Pampean region with an azimuth of 80º, which is slightly oblique with respect to the EVC, putting in evidence the right-lateral component of the wrench faulting (Figure 5). Particularly, the low-angle spatial relationship between the Andean stress field and the EVC, determines the existence of an extensional component of the right-lateral transcurrent structure (Moody & Hill 1956). Consequently, the transverse reliefs oriented sub-latitudinally inside the **EVC** should be controlled by subordinate "Riedel Type" synthetic normal faults responsible for developing a transtensional asymmetrical negative flower (Woodcock & Fisher, 1986; Rossello, 2001), whose southern boundary represents the principal fault flank, while the northern boundary is less marked (Figure 6). The marginal faults bounding the EVC as well as the array of obliquely trending *en échelon* ridges of its interior can be identified at a regional scale quite easily from SRTM imagery (Figure 6). Shallow underlying basement rocks of the northern boundary of the Sierras Australes seem to enhance the surface expression of topographic features (Salso, 1966; Zambrano, 1974; Yrigoyen, 1975).

The EVC appears between 36ºS - 37ºS and 60ºW - 64ºW (Figure 1), trending ENE, and can be placed separating the eastern prolongation of two distinctive regional tectonic domains, at north the Chilean-Pampean flat slab domain and at south the normal subduction domain. The right lateral EVC involves basement levels and suggests the flow of crustal material farther east, possibly facilitating the widening of Cenozoic depocenters located in the Atlantic margin such as those documented by Rossello et al. (2017). Richardson et al. (2013) argued that the increased coupling between the subducting flat slab and the overriding plate beneath the Andean Cordillera at 32ºS resulted in the propagation of Neogene and Quaternary crustal deformation eastward to the Rio de la Plata craton (Rossello et al., 2020). In this sense, the EVC located far East could constitute the prolongation of a major slab discontinuity zone. Regional differences in mid-plate flexural loads and the opposite stresses associated with the push of the Atlantic ridge may represent additional contributions to the far-field tectonic forces explaining the deformation in the intracratonic domain (Cobbold et al., 2007; Folguera & Zárate, 2019; Reuber & Mann, 2019).

CONCLUSIONS

The interpretation of relevant morph-tectonic features recognizable through terrain analysis, complemented with surface and subsurface data from existing literature and recent earthquake reports, allowed to consider the EVC as an active geological morph-structure. Regarding the two tectonic possibilities for the explanation of the major lineaments that define the EVC: 1) a graben or rift structure, or 2) a transtensional strike-slip principal fault zone, our preference is for the latter and we have consequently worked out a model that responds to it putting a great deal of emphasis on the function of synthetic Riedel shears as the predominant feature that facilitates the model of a negative flower structure.

The EVC is limited by the alignment of a succession of discrete longitudinal depressions enclosing elongated left-stepping gentle ridges with 20 km length and 2 km width. This array, different from the regional medanes trend, as its different geomorphological expression of the ridges and closeness with recent earthquakes, suggest a neotectonic origin controlled by the development of an extensional dextral transcurrent system.

Topographical transverse cross-sections to the EVC evidenced asymmetrical flanks of the inner elongated ridge, here interpreted to be the surface expression of tilting along subordinate Riedel-type normal faulting, composing a negative flower structure typical of transtensional environments. For this reason, the former name "Vallimanca Graben" used by the pioneers in the description of this lineament (Stappenbeck, 1926; Cordini, 1960, 1967; Zambrano, 1974; Yrigoyen, 1975) reemerges as its logical identity. The morphological scenario corresponds to a topographic depression more accentuated towards the southern limit that has exerted a strong control on the water surface drainage network. The pattern of a belt of *en échelon* left stepping ridges associated with normal compound in the region of the ponds supports the dextral wrenching kinematics for a long distance of 150 - 200 km. Striking is the fact that mid-resolution imagery like the used in the present work highlights the mentioned morph-structure.

The EVC does affect quaternary sediments that still maintain their morphological expression as ribs with their asymmetric flanks, whose age is considered modern, although present time activity of the fault system should be additionally addressed through micro-topographic and paleoseismological approaches, among other disciplines.

The occurrence of seismicity near the morph-structure, the proven neotectonics in the area possibly extending far west to the Southern Central Andes, and the proximity of EVC to the most populated region in Argentina justifies also the undertaking of dedicated as detailed geophysical surveys and instrumentation and permanent monitoring accompanying geological research.

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