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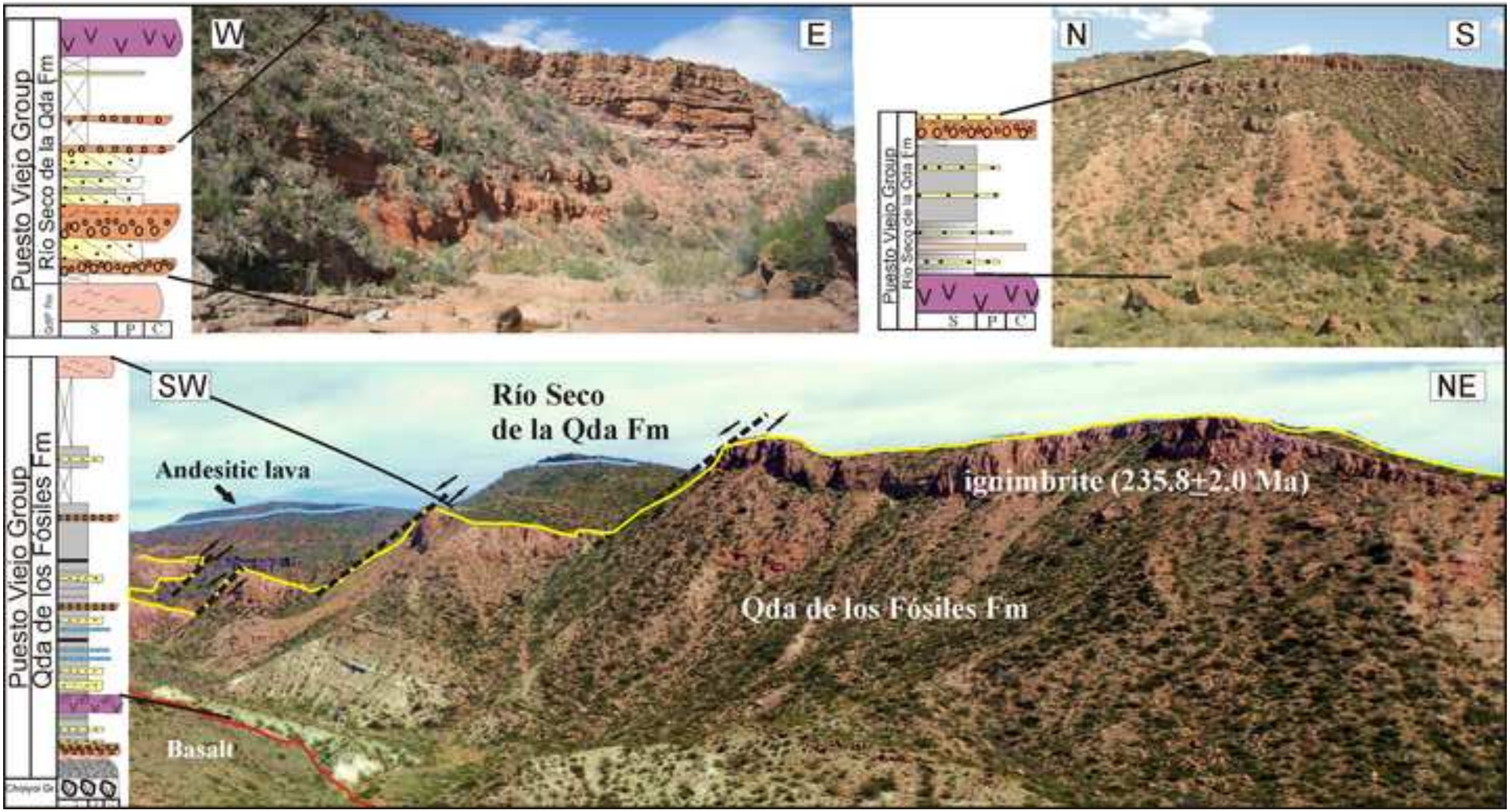
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Puesto Viejo Group
Río Seco de la Qda Fm
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Qda de los Fósiles Fm
Basalt
Puesto Viejo Group
Qda de los Fósiles Fm

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Editorial Board
Dear Sirs,

I am sending you the **Research highlights** of: *Age constraints for the Triassic Puesto Viejo Group (San Rafael depocenter, Argentina): SHRIMP U–Pb zircon dating and correlations across southern Gondwana*.

An absolute age is presented for the continental Triassic Puesto Viejo Group, Argentina.
The included tetrapods are now 10 Ma younger than by correlations with South Africa.
The validity of the South African biostratigraphic scheme for Gondwana is questioned.

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Age constraints for the Triassic Puesto Viejo Group (San Rafael depocenter, Argentina): SHRIMP U–Pb zircon dating and correlations across southern Gondwana

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ABSTRACT

The Puesto Viejo Group crops out in the San Rafael Block, southwest Mendoza, at approximately 35° S and 68°20' W. It consists of the basal mainly grayish Quebrada de los Fósiles Formation (QF) overlying by the reddish Río Seco de la Quebrada Formation (RSQ). The basal unit includes both plant remains (pleuromeians and sphenopsids) and vertebrates (scattered fish scales, dicynodont synapsids and an archosaur). In contrast, the RSQ beds have yielded only vertebrates, although a more diverse fauna. It includes cynodonts as *Cynognathus*, *Pascualognathus* and *Diademodon*, and also dicynodonts (*Vinceria* and *Kannemeyeria*). Due to the tetrapod content the bearing levels were correlated to the *Cynognathus* AZ of South Africa and thus referred to the Anisian. A SHRIMP $^{238}U/^{206}Pb$ age of 235.8 ± 2.0 Ma was obtained from a rhyolitic ignimbrite interdigitated between the QF and RSQ formations at the Quebrada de los Fósiles section. This new radio-isotopic age for the Puesto Viejo Group suggests that the tetrapod fauna in the RSQ beds was developed, instead, during the Late Triassic (early Carnian) thus ca 10 Ma later than the age attributed based only on biostratigraphic correlations. Two scenarios might explain our results. First, the *Cynognathus* AZ of South Africa is wrongly assigned to the lower Middle Triassic (Anisan) and should be considered younger in age, Late Triassic (Carnian). Second, the relative age of the *Cynognathus* AZ of South Africa is correct but the inferred range of *Cynognathus* and *Diademodon* is incorrect as they were present during the Late Triassic (Carnian) at least in South America. In any case, this new date pose serious doubts about the validity of biostratigraphic correlations based solely on tetrapod taxa, a common practice for Triassic continental successions across Gondwana.

Keywords:

Triassic vertebrates and plants

SHRIMP U–Pb zircon age

Biostratigraphic correlations

South America and South Africa

1. Introduction

In the western margin of southern South America, a series of elongated, NW–SE trending narrow rifts were developed during the Permian–Triassic times and controlled by previous Paleozoic structures (Giambiagi and Martínez, 2008). The inception of these tectonic depressions has been considered an early manifestation of the breakup of Gondwana towards the end of the Triassic and beginning of the Jurassic (Uliana and Biddle, 1988; Ramos and Kay, 1991; Barredo et al., 2012). These asymmetric half–grabens (Fig. 1) were mainly filled by continental clastic and pyroclastic sediments but also by occasional volcanic rocks. In central western Argentina, the large Ischigualasto-Villa Unión and its equivalent of the subsurface Pagancillos Basin and Cuyo Basin consist of 2000 to 6000 m continental Triassic rocks but other small basins also related to the mentioned rift system were developed in the region. Among them is the San Rafael depocenter (Fig. 1), located southern in the Mendoza Province (Strelkov and Álvarez, 1984; Kokogian et al., 1993, 1999, 2001).

During the Permian and earliest Triassic, the San Rafael region manifested an active volcanism related to the Choiyoi extensional igneous province (Kay et al., 1989; Llambías et al., 1993, Llambías and Sato, 1995; Rocha–Campos et al., 2011). The resulting Permian infilling in the San Rafael basin is complex, it includes both sedimentary and volcanic rocks (Fig. 2). Lithostratigraphically ,the infilling is divided, from base to top, into the sedimentary rocks of the Cochicó Group, the andesites and dacites of the Agua de los Burros Formation, the andesitic lavas of the Quebrada del Pimiento Formation and, finally, the rhyolites of the Cerro Carrizalito Formation (Kleiman and Japas, 2009; Rocha–Campos et al., 2011). The aeolian and fluvial sandstones and conglomerates of the Cochicó Group were related to the activity of a volcanic arc whilst the rest of the succession is considered to reflect the transitional to an intraplate tectonic regime (Kleiman and Japas, 2009). Towards the Cisuralian–Guadalupian boundary major geodynamical changes, as the lowering of the subduction velocity, produced extensional magmatism in the region with the presence of basalts and rhyolites in the upper Choiyoi succession. The extensional conditions continue during the deposition of the Triassic Puesto Viejo Group (Kleiman and Salvarredi, 2001; Kleiman and Japas, 2009) and, as occurs in the nearby Cuyo Basin (Ramos and Kay, 1991), there is a general overlap of the Choiyoi igneous province and the Triassic sedimentation suggesting a genetic relationship. A basal unconformity, attributed to the Huárpica diastrophic phase (López Gamundi et al., 1989), separates the Permian Cerro Carrizalito Formation from the Triassic Puesto Viejo Group.

The Puesto Viejo Group (Figs. 2, 3) includes sedimentary, volcaniclastic, and volcanic rocks originally mapped as the Puesto Viejo Formation by González Díaz (1964, 1966, 1972). Subsequently, the whole succession was referred to the Puesto Viejo Group by Stipanicic et al. (2007). It consists of the basal mainly grayish Quebrada de los Fósiles Formation overlying by the reddish Río Seco de la Quebrada Formation. Regional works held by Kusiak (1993) and Kleiman (1999) extended the already known Triassic outcrops and a new sedimentary analysis of the succession suggested that it was s deposited by alluvial fans and meandering rivers (Spalletti, 1994).

Regarding to the age of the Puesto Viejo Group, a recent radiometric SHRIMP U–Pb date from the underlying Cerro Carrizalito Formation (Rocha–Campos et al., 2011) indicates a $^{206}Pb/^{238}U$ age of 251.9 ± 2.7/6.6 Ma, very close to the Lopingian–Triassic boundary, thus placing the Group within the Triassic (Ogg, 2011). Early radiometric $^{40}K/^{40}Ar$ dating of ignimbrites and basalts of the Quebrada de los Fósiles Formation produced an age of 230 to 232 ± 10 Ma, and equivalent rocks from the Río Seco de la Quebrada Formation an age of 232 to 236 ± 10 Ma. These results suggested a mean age of about 232 ± 4 Ma for the igneous rocks of the Puesto Viejo Group (Valencio et al., 1975) which finally constrained the deposition of this unit to the Late-Middle Triassic. More recently, SHRIMP U–Pb ages (260.8 ± 3.2 Ma and 269.0 ± 3.2 Ma) obtained by Domeier et al. (2011) probed to be very similar to the age calculated by the same authors for the top of the Choiyoi Group (263.0 ± 2.4 Ma), thus reflecting the dating of Permian recycled zircons in the Triassic section.

The paleontological content of the Puesto Viejo succession is rather diverse and has also been used to constrain its age. The tetrapods (therapsids and an archosaur) were correlated to those from the Karoo Basin of South Africa and thus the bearing-beds included in the Early–Middle Triassic interval (Bonaparte, 1966a, b, c, 1967, 1969, 1973, 1981, 1982, 2000, 2002; Abdala, 1996, 1999; Morel et al., 2001; Abdala et al., 2009; Martinelli et al. 2009; Domnanovich, 2007, 2010; Domnanovich and Marsicano, 2007, 2012; Ruban et al., 2009; Ezcurra et al., 2010; Previtera et al., 2013). The fossil plants recovered from the lower Quebrada de los Fósiles Formation have long been considered to represent an Early Triassic age (Criado Roque and Ibáñez, 1979; Ottone and García 1991; Morel and Artabe, 1994; Zavattieri and Papú, 1993; Zavattieri and Batten, 1996; Morel et al., 2001; Sepúlveda, 2001; Bonaparte, 2002; Stipanicic et al., 2002; Coturel et al., 2012; Vázquez et al., 2012). However, some authors (Zavattieri et al., 2003; Sepúlveda et al., 2007; Stipanicic et al., 2007; Gallego et al., 2009) suggested that the palynological assemblages recovered from the base of the succession (Quebrada de los Fósiles Formation) might indicate a Late Permian (Lopingian) age.

The aim of the present work is to present a new SHRIMP U–Pb zircon age obtained from an ignimbrite located approximately in the middle section of for the Puesto Viejo Group and, based on this result, to discuss the evolution of the basin infilling in a more regional context. Moreover, the new temporal frame for the deposition of the fossil-bearing beds is discussed according to previous proposals based on biostratigraphic correlations across Gondwana, mainly with the Karoo Basin of South Africa. Triassic chronostratigraphy (numerical ages and names) follows Ogg (2011) and yearly adequacies by the International Commission on Stratigraphy (Cohen et al., 2013).

2. Geological setting

Rocks of the Puesto Viejo Group crops out in the San Rafael Block, southwest of San Rafael city, approximately 35° S and 68°20' W with a general NNW–SSE strike (Fig. 2). The succession (ca 300 m in thickness) consists of synrift continental deposits interfingered with olivine basalts, andesites, and rhyolitic ignimbrites (Spalletti, 1994; Kleiman and Salvarredi, 2001). It locally and unconformably rests on Choiyoi volcanics and corresponds to the final stage of Gondwanan magmatism in the San Rafael Massif (Kleiman and Salvarredi, 2001; Kleiman and Japas, 2009). The accommodation space was controlled by fractures of NW orientation probably related to dextral strike slip movements along the megafractures of Valle Fértil–Desaguadero and Atuel (Fig. 1) (Criado Roque et al., 1981; Spalletti, 1994; Kleiman et al., 2001). Originally, González Díaz (1964, 1966, 1972) suggested that the basal section of the Triassic succession was composed of by clastic material from the Permian Agua de los Burros Formation whilst the source rock for the upper section were mostly the rhyolites of the Permian Cerro Carrizalito Formation.

Jenchen and Rosenfeld (2002) also suggested a dual provenance for the Puesto Viejo sediments, with an upper part enriched in rhyolitic components due to the occurrence of an ignimbrite at the top of the Agua de los Burros Formation. Previous sedimentological analysis of the Puesto Viejo Group succession considered it as deposited in a fluvial dominated setting where largely coexisted bed load, suspension, and washing. Acyclic factors including explosive felsic volcanic activity, tectonism, and increasing aridity controlled the evolution of these deposits and provided abundant detritus to the basin (Spalletti, 1994; Spalletti et al., 1996).

The Quebrada de los Fósiles section starts with tabular bodies of light brown to medium gray conglomerates with chaotic stratification, interbedded with fine–medium sandstones that display trough cross–stratified sets that occur as 8 m thick packages, mostly in the Río Seco de la Quebrada creek (Fig. 3). The conglomerate clasts are mainly lithics, of similar composition than that of the underlying Permian volcanic rocks (rhyolites, ignimbrites and tuffs), additionally there are poorly sorted (1 to more than 10 cm), greenish gray sandstones composed of subangular to subrounded clasts, immerse in a sandy–mudstone matrix. This basal facies association was interpreted as alluvial fans of proximal systems developed during a period in which an important fall in the base–level occurred (Spalletti, 1994). The basal section is covered by a yellowish gray ignimbrite, approximately 3 m thickness, that bears fine cristaloclasts and moderate brown volcanic lithoclasts immerse into a light gray to grayish pink aphanitic paste that contains platy glass shards of lapilli size.

Upwards, fluvial lenticular bodies of very dark red conglomerates, sabulitic sandstones and coarse–grained sandstones displaying erosional bases and trough cross–stratified sets (0.60–1 m thick) with normal grading or plane bedded beds, are present. The conglomerates include poor sorted subangular to subrounded clasts and a sandy matrix. These beds (approximately 7 m thickness) grade upwards into massive sandstones interfingered with laminated and/or wavy parallel laminated mudstones, making up about 14 m thickness packages, deposited under a low–sinuosity gravely river system. The top of this fluvial succession is truncated by a vesicular basalt mantle (9.2 m of thickness). The contact of this basalt body with the underlying unconsolidated wet sediments of the fluvial floodplain generated peperites (Fisher, 1960; Williams and McBirney, 1979; McPhie et al., 1993) (Figs. 3, 4).

The section above the basalt is characterized by low–energy deposits, consisting of flood plain with isolated channels (high–sinuosity meandering channels) and local lacustrine deposits. The channels occur as isolated, lenticular bodies, up to 3 m thickness of trough cross–stratified conglomerates and sandstones that exhibit erosive lower boundaries that progressively fining-upwards. Conglomerates are poor sorted, composed by subrounded, volcanic clasts, a medium to coarse–sandstone matrix and calcareous cement. Thick intervals dominated by massive and laminated greenish–grey mudstones, siltstones, and tuffaceous mudstones with inter–bedded organic–rich horizons having badly–preserved plant remains, characterized the floodplain facies. Well developed paleosols, evidenced by fine and dense root cast systems, are also common. Sandy tabular bodies and wedge–shaped coarsening–up siltstones interpreted to represent crevasse channel and crevasse splay deposits are scattered through the section (Figs. 3, 4). Local shallow lacustrine deposits are characterized by grayish green to very light gray shale banks, which thin limestone levels bearing stromatolite–like structures. Lacustrine horizons contain abundant silicified megaspores, ostracod impressions, and a few fish scales (Vaz Tassi et al., 2013). The fining–upward section, was interpreted as a decrease in the current energy related to the combined effect of deep denudation of the surrounding positive areas, a base level rise, and fast basin subsidence (Spalletti, 1994).

The Quebrada de los Fósiles Formation ends with ca 10 m thickness of overlapping beds of a moderate reddish orange ignimbrite, that contain the zircons analyzed herein. The ignimbrite displays abundant vitroclasts, quartz cristaloclasts and scarce moderate red lithoclasts, but also vitro– or lithoclast free zones. It is a rhyolitic, moderately welded ignimbrite, with porphyritic texture, abundant ehuedral to subhedral quartz cristaloclasts (0.25–1.5 mm), occasionally with engulfing and secondary growth, fractures are common in larger crystals and the extinction is straight. Few plagioclases (0.5 mm) displaying albite twinning are present. Lithoclasts of ignimbrites (2 mm), as well as pumice elongated fragments (fiammes) with spherulites, are also common. The glass paste contains abundant elongated vitric shards, but also platy, mono, bi and tricuspidal shards, located in areas protected by the cristaloclasts. The paste is stained by iron oxide. Lithoclasts and paste occasionally display chlorite alteration and possible prhenita (Figs. 3, 4, 5).

Stipanicic et al. (2007) suggested that the boundary between the Quebrada de los Fósiles and the Río Seco de la Quebrada formations was unconformable thus suggesting the presence of a temporal hiatus between both units. However, the contact seems more likely to be associated with an episode of normal faulting related to the synsedimentary extensional tectonics that controlled the evolution of the Triassic infilling. Therefore and according to our present analysis, the accumulation of both successions (Quebrada de los Fósiles and Rio Seco de la Quebrada) appears to be concordant and no temporal hiatuses in the sedimentation were recognized.

The Río Seco de la Quebrada Formation starts with deposits of fluvial amalgamated channel ca 8 m in thickness. They are characterized by trough cross–stratified, normal graded conglomerates that form lenticular bodies with erosional bases that pass upwards to coarse–grained sandstone with low–angle cross–stratification or horizontal lamination in sets up to 1 m thick. The conglomerates have coarse–grained sandy matrix, and are poorly sorted (1 to 10 cm in diameter), with subangular to subrounded clasts composed by rhyolitic, basaltic and/ or ignimbrite lithics, grayish green sandstone, mudstone and quartz crystal (Figs. 3, 4). Floodplain deposits characterized by laminated silstones interbedded with fine to medium massive sandstones are locally developed. This sedimentary section is covered by a dark–grey to dusky blue, fluidal, vesicular andesite, deposited as a subaerial lava flow, between 5 to 10 m in thickness. The flow is composed of abundant plagioclase microlites, interstitial iron, few andesine phenocrysts and apatite as accessory; it presents a pilotaxitic texture, and its cavities are filled by illite, quartz, microcrystalline silica, zeolites, and very fine carbonates (Figs. 3, 4).The homogeneous nature of this deposit makes it difficult to determine whether it represents a very thick, single flow event, or multiple, superimposed events. These rocks, as well as the rest of the volcanics of the Puesto Viejo Group could have originated from fissural events fed through fracture systems and, although no evidence of volcanic cones was encountered in the study area, an origin related to isolated effusive non-controlled centers is also possible.

Towards the top of the Río Seco de la Quebrada succession, 40 m of light red laminated silstones and clay silstones intercalated with thin massive tabular bodies of light gray fine to medium tuffaceous sandstones, represent the development of a low energy fluvial system. The sandstones are well sorted and make up of subrounded clasts of quartz, pale greenish green and moderate reddish orange lithics and a tuffaceous matrix. The sandstones occasionally show normal grading and low–angle cross–stratification. Tabular strata of moderate pink massive tuffs composed by fragments of pomez, plagioclase crystals, and an afanitic paste are commonly present. Upwards, tabular bodies of light red, normal grading, matrix supported conglomerates and sabulitic sandstones are present. The conglomerates are poor sorting, with rounded clasts of volcanic (rhyolities, ignimbrites and basalts) and pale green sandstone lithics, between 1 to10 cm in diameter. These deposits are interpreted as unchannelized debris flows (Figs. 3, 4).

3. Analytical methods and sampling

Detail mapping of the Puesto Viejo Group outcrops allowed to recognized several basalts and ignimbrite horizons (Figs. 2, 3). The ignimbrite that contains the zircons analyzed herein is intercalated between the Quebrada de los Fósiles and the Río Seco de la Quebrada formations. The ignimbrite was sampled in a vitro– or lithoclast free zone in an outcrop at the Quebrada de los Fósiles creek (Fig. 5). The zircon grains were separated from a 5 kg sample of ignimbrite. Heavy mineral fractions were concentrated and separated into 100, 150 and 250 µm size fractions by standard crushing and elutriation in the Departamento de Ciencias Geológicas de la Universidad de Buenos Aires. Zircon fractions of roughly 400 grains were handpicked in alcohol under a binocular microscope for geochronology analysis. The Zircon U–Pb analyses were made using the SHRIMP II at the Research School of Earth Sciences (RSES), The Australian National University. The standard analytical protocols described by Williams (1998) were used. A mass–filtered primary O_2^- beam was focused onto the zircons producing a spot size of approximately 20 µm in diameter. The surface was rastered for 2.5 minutes before analysis. Data acquisition was done by repeatedly stepping through the masses $^{90}Zr_2{}^{16}O$ (“reference mass 196”),

^{204}Pb, background at mass 204.04, ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{238}U, ^{232}Th and $^{238}U^{16}O$ (mass 254), for 6 scans.

The data was reduced according to that described by Williams (1998, and references therein), using the SQUID 2 Excel Macro of Ludwig (2009). The reference zircon Temora II (416.8 ± 1.3 Ma; Black et al., 2004) was the primary U–Pb geochronology calibration standards, with standard zircon SL13 (U concentration of 238 ppm; Claoué–Long et al., 1995) used to calibrate the U, Pb and Th concentrations for each session. The decay constants recommended by the IUGS Subcommission on Geochronology (as given in Steiger and Jäger, 1977) were used in the age calculations. Uncertainties given for individual U–Pb analyses (ratios and ages) are at the 1δ level, however uncertainties in the calculated weighted mean ages are reported as 95% confidence limits and include the uncertainties in the standard calibrations where appropriate. For the age calculations shown in Table 1, corrections for common Pb were made using both the measured ^{204}Pb and the relevant common Pb compositions from the Stacey and Kramers (1975) model and ^{207}Pb (for the $^{206}Pb/^{238}U$ ages) using the assumption of concordance. Concordia plots, regressions and any weighted mean age calculations were carried out using Isoplot/Ex 3.75 (Ludwig, 2012) and where relevant include the error in the standard calibration.

4. Paleontological content of the Puesto Viejo Group

The only palynological assemblage described in the Quebrada de los Fósiles Formation was recovered from the type locality (Figs. 2, 3, 4). It is characterized by a low specific diversity and high proportions of spores with sphenopsida and lycopsida affinity, which make up about 60% of the total. Disaccate pollen grains of pteridosperms (ca. 20%), together with monosulcate (ca 10%), striate (ca 5%), and inaperturate pollen grains, and pteridophytic spores are minor components of the assemblage (Ottone and García, 1991). The taxon *Aratrisporites spongeosus* Ottone and García is conspicuously represented in the assemblage. The morphogenus *Aratrisporites* Leschik emend. Playford and Dettmann, mostly includes pleuromeian microspores typical of Gondwanan Triassic palynofloras (Playford and Dettmann, 1965; Balme, 1970; Dolby and Balme, 1976; Foster, 1982; de Jersey and Raine, 1990; Balme and Foster, 1996; Zavattieri and Batten, 1996; Foster et al., 1997). Subsequent palynological analysis of the basal–most part of Quebrada de los Fósiles suggested, instead, a Permian (Lopingian) age based on the presence of *Bascanisporites undosus* Balme and Hennelly, *Brevitriletes bulliensis* (Helby ex de Jersey) de Jersey and Raine, *Leschikisporites aduncus* (Leschik) Potonié, and *Secarisporites lacunatus* (Tiwari) Backhouse, together with other striate and monosaccate pollen grains (Zavattieri et al., 2003; Sepúlveda et al., 2007; Stipanicic et al., 2007). The samples that yielded this assemblage were recovered at the Río Seco de la Quebrada creek (Fig. 2) (Sepúlveda et al., 2007) and was never figured or described. Although *B. undosus* and *S. lacunatus* are characteristic of the Permian of Gondwana (Foster, 1979; Lindström, 1996; Backhouse, 1988; Vergel, 1998; Collinson et al., 2006), *B. undosus* was also recovered from the Triassic of the Prince Charles Mountains in Antarctica (Lindström and McLoughlin, 2007). Besides, *B. bulliensis* is abundant in Permian–Triassic transition sequences in Australia and New Zealand (de Jersey and Raine, 1990), and *L. aduncus* was originally described from the Upper Triassic of Basel and is common in Triassic assemblages of India (Leschik, 1955; Tripathi et al., 2006). Striate pollen grains are common in the Lopingian–Lower Triassic transition in several Gondwanan successions but are also present in Middle to Upper Triassic horizons also in Gondwana (Zavattieri and Batten 1996).

Recently, Vázquez et al. (2012) described a microflora bearing *Aratrisporites* from the Quebrada de los Fósiles Formation at the Río Seco de la Quebrada creek. The palynological assemblage indicates a Triassic age and is comparable to that originally described by Ottone and García (1991) at the Quebrada de los Fósiles creek.

Scattered pleuromeian and equisetalean remains (Fig. 6), together with fish scales, ostracods, and spinicaudatans have been cited from the Quebrada de los Fósiles Formation (Criado Roque and Ibáñez, 1979; Morel and Artabe, 1994; Bonaparte, 2002; Stipanicic et al., 2002; Sepúlveda et al., 2007; Gallego et al., 2009; Coturel et al., 2012; Vaz Tassi et al., 2013). Petrified trunks are occasionally present in channelized facies (Fig. 6).The spinicaudatans were referred to a new species of *Cornia* Lyutkevich, a genus that is present in the Permian–Jurassic interval of Africa, India and Russia (Vaz Tassi et al., 2013).

The Quebrada de los Fósiles beds yielded scattered fragments of both large–sized and also relatively small dicynodonts together with a partial skeleton of the basal archosauromorph, *Koilamasuchus gonzalezdiazi* Ezcurra, Lecuona and Martinelli (Bonaparte, 1981, 1982; Ezcurra et al., 2010). Based on the dicynodont content, Bonaparte (1981) correlated the bearing levels with the *Lystrosaurus* AZ of South Africa. However, other authors (i.e., De Fauw, 1993; Lucas, 1998) disagree with this correlation. Thus, De Fauw (1993) assigned the large dicynodont remains to *Rechnisaurus cristarhynchus* Roy–Chowdhury from the Yerrapalli Formation of India (Roy–Chowdhury, 1970; Bandyopadhyay, 1988) and the Manda Formation of Tanzania (Cox, 1991), both referred to the Middle Triassic (Chatterjee, 1980; Jain and Roy–Chowdhury, 1987; Cox, 1991) (Fig. 7). Nevertheless, a recent revision of Quebrada de los Fósiles Formation dicynodonts, did not recognized the presence of the Indian taxon and instead considered the specimen as an indeterminate kanammeyeriform (Domnanovich, 2007, 2010; Domnanovich and Marsicano, 2007, 2012).

The Rio Seco de la Quebrada Formation has yielded a more diverse tetrapod fauna (Fig. 6) including medium sized kanemeyeriid dicynodonts, *Kanameyeria argentinensis* Bonaparte and *Vinceria* sp. (Domnanovich, 2007, 2010; Domnanovich and Marsicano, 2007, 2012), and several cynodonts as *Cynognathus crateronotus* Seeley, *Diademodon tetragonus* Seeley and *Pascualognathus polanskii* Bonaparte (Bonaparte, 1966a, b, 1969; Abdala, 1996; Martinelli et al., 2009). Based on the common presence of *Cynognathus*, the assemblage was correlated to the *Cynognathus* AZ of South Africa (Bonaparte, 1981), and thus referred to the Olenekian (i.e. Bonaparte, 1966b, 1973, 1982; Lucas, 1998) or the Anisian (Bonaparte, 1966c, 1967). More recently, Martinelli et al. (2009) suggested that the Río Seco de la Quebrada Formation fauna has a strong resemblance to the subzones B and C of the *Cynognathus* AZ of South Africa and also the Omingonde Formation of Namibia, by the common occurrence of both *Cynognathus* and *Diademodon* (Fig. 7).

5. Zircon populations and U-Pb data

Three different populations were identified based on size, color, shape, habit, and elongation under binocular microscope; the presence of fractures and inclusions was also recorded. The main morphological populations are including in: P1 (~22%) characterized by prismatic, idiomorphic, 150 and 25µ □zircons, with aspect ratios > 3:1 and abundant inclusions, some has intracrystalline fractures; P2 (~68%) with prismatic, idiomorphic, 100 to 150µ zircons, with aspect ratios of approximately 3:1 and numerous inclusions; and P3

(~10%) composed by prismatic, idiomorphic, < 100 μ zircons with aspect ratios of approximately 2:1, light-colored, very few inclusions and fractures. The external morphological study indicates that the zircon populations do not present rounded morphology and therefore it is possible to interpret them as primary and igneous in origin (Fig. 8).

Zircons extracted for U-Pb isotopic analysis are light pink to colourless, are generally anhedral but some grains do show sharp facetted terminations. Cathodoluminescence imaging reveals strong, magmatic sector zoning in most grains with oscillatory zoning towards the margins. No obvious inherited cores were observed (Fig. 9). These external morphologic and internal textures indicate an igneous origin for the zircon grains.

The SHRIMP U-Pb data show a uniform, simple population for which a weighted mean $^{206}Pb/^{238}U$ age of 235.8 ± 2.0 Ma (95% confidence limits and including the uncertainty in the standard calibration) is calculated from 24 analyses (Table 1, Fig. 9). This is interpreted to be the best estimate of the age of extrusion of this volcanic rock.

6. Discussion

6.1. Stratigraphy and tectonics

The new obtained SHRIMP$^{238}U/^{206}Pb$ age of 235.8 ± 2.0 Ma from the rhyolitic ignimbrite sampled at Quebrada de los Fósiles section (Fig. 2) is quite consistent with the previous $^{40}K/^{40}Ar$ age (236 ± 10 Ma) obtained from the same ignimbrite nearly forty years ago by Valencio et al. (1975). This result is also reinforced by other $^{40}K/^{40}Ar$ ages of 230 ± 10 Ma obtained by the same authors from the ignimbrite located at the base of the Puesto Viejo Group. The emplacement of this ignimbrite body, as well as of the basalt sills intercalated in the Puesto Viejo Group, was tectonically controlled by the main faulting evolution of the rift stage (Ramos and Kay, 1991).

Correlations across the nearby Cuyo Basin were traditionally based on lithological comparisons and bioestratigraphy, based on fossil plants (Yrigoyen and Stover, 1970; Strelkov and Álvarez, 1984; Spalletti et al., 1999). However, recent SHRIMP U–Pb zircon data from the Cerro Puntudo (Mancuso et al., 2010), Rincón Blanco (Barredo et al., 2012) and Cacheuta (Ávila et al., 2006; Spalletti et al., 2008) depocenters (Fig. 1), together with K–Ar data from the Paramillos de Uspallata (Massabie, 1986), improved the definition of reliable chronostratigrafic horizons across the basin. In the Cerro Puntudo depocenter (San Juan Province), crops out a ca. 900 m thick Triassic section where a tuff close to the middle section has yielded an age of 243.8 ± 1.9 Ma (Anisian) (Mancuso et al., 2010). Southern of these outcrops, the Rincón Blanco depocenter is developed towards the west of Sierra del Tontal, also in the San Juan Province. The Triassic infilling is separated into the Rincón Blanco Group and, the overlying Marachemil Unit. Recent dates obtained from the whole succession placed the Rincon Blanco Group in the Anisian-Ladinian interval and the Marachemil section into the Carnian (Barredo et al., 2012). The Triassic outcrops in the Paramillos de Uspallata (north of Mendoza Province) are lithoestratigraphically included, from base to top, in the Paramillo, Agua de la Zorra, Portezuelo Bayo, and Los Colorados formations. A basalt sill interlayered within the Portezuelo Bayo Formation yielded a $^{40}K/^{40}Ar$ age of 235 ± 10 Ma and 240 ± 10 Ma, referring this unit to the Ladinian-Carnian interval (Massabie, 1986; Linares, 2007; Ottone et al., 2011). In the southern most outcrops of the Cuyo Basin at the Cacheuta depocenter (west of Mendoza Province) the succession corresponds to, from base to top, the Río Mendoza, Cerro de las Cabras, Potrerillos, Cacheuta, and Río Blanco formations. An ignimbrite interlayered within the upper part of the Río Mendoza Formation yielded an age of 243 ± 5 Ma, referring this unit to the Anisian (Ávila et al., 2006), whilst recent ages from tuffs located at the base of the Potrerillos Formation (230.3 ± 2.3 Ma, 239.7 ± 2.2 Ma and 239.2 ± 4.5 Ma) places it in the late Ladinian-Carnian interval (Spalletti et al., 2008). Accordingly, the Cuyo Basin infilling was recently divided into three tectonosequences separated by unconformities, all associated with regional extensional pulses (Barredo et al., 2012). The first rifting pulse occurred in the Anisian (synrift I) characterized by the deposition of alluvial, fluvial and lacustrine facies recognized at Rincón Blanco (246.4 ± 1.1 Ma), Cerro Puntudo (243.8 ± 1.9 Ma) and Cacheuta (243 ± 5 Ma) depocenters (Fig. 1). The second cycle (synrift II) is also characterized by alluvial, fluvial and lacustrine deposits but developed under a more humid climate c. This second tectonosequence was recognized in the Rincón Blanco depocenter (Corral de Piedra Formation, 239.5 ± 1.9 Ma), at Paramillos de Uspallata (Portezuelo Bayo Formation, 235 ± 10 Ma and 240 ± 10 Ma) and in the Cacheuta depocenter (Potrerillos Formation, 230.3 ± 2.3 Ma, 239.7 ± 2.2 Ma and 239.2 ± 4.5 Ma) and its deposition was constrained to the late Ladinian-early Carnian interval (Barredo et al., 2012) (Fig. 1). Finally a third stage of rifting (synrift III) was preliminary identified in the Rincón Blanco through. This is represented by the alluvial and fluvial sediments developed under semiarid conditions included in the Marachemil Unit. A SHRIMP U–Pb zircon age (230.3 ± 1.5 Ma) obtained for this succession constrains this last synrift pulse in the Cuyo Basin to the late Carnian (Barredo et al., 2012) (Fig. 1).

According to the previous discussion, the new sedimentological analysis of the Puesto Viejo Group together with the new absolute date obtained were used to compared the Triassic infilling of the Basin with the tectono-sequences described by Barredo et al. (2012). As a result, we consider that the whole Puesto Viejo succession corresponds to a unique extensional pulse correlated to the synrift II, constrained in the present case to the late Ladinian-early Carnian interval and characterized by alluvial, fluvial and lake deposits under relatively humid climatic conditions.

6.2. Biostratigraphy: faunal and floral correlations

As previously mentioned, an Early Triassic age for the lower part of the Puesto Viejo Group has long been accepted by most paleobotanists, even though, a Late Permian age was suggested for the lowermost section of the succession. The paleoflora of the Puesto Viejo Group is restricted to the lower part of the Quebrada de los Fósiles Formation. This unit yielded scattered horizons with parautochtonous compressions and/or impressions of sphenopsids and small pleuromeians, and rare, poorly preserved gymnosperm trunks preserved in fluvial channel deposits. The palynoflora is scarce, low specific, and dominated by spores of pleuromeians and sphenopsids (Ottone and García, 1991). When compared with the typical corystosperm-rich Middle to Late Triassic assemblages of Argentina (Zamuner et al., 2001), the mega– and microflora from the Puesto Viejo succession is less diverse and quite different. The relatively paucity of the Puesto Viejo paleoflora, was partially explained due to its supposed older age, and related with the presence of a stressed environment affected by the latest Choiyoi volcanic activity in the region (Spalletti et al., 2003). However, considering the new SHRIMP U–Pb zircon age provided herein, it is evident that the distinct characteristics of the Puesto Viejo paleoflora cannot be related to its older age when compared with the more extensively known Triassic paleofloras from other Argentinian basins. Therefore, the impoverish character of the Puesto Viejo paleoflora could be related with the instability of the landscape due to extensive volcanism during its deposition, as has also been proposed for other Triassic successions controlled by volcanic processes (Domnanovich and Marsicano, 2006). Pteridospems, conifers, cycadales and ginkgoales, that are common in the rest of the Argentine Triassic (Zamuner et al., 2001), composed a type of vegetation that need time and certain stability to progress. The fact that these plants were recorded only by a relatively low percentage of pollen grains suggests that their development could be strongly affected by the local volcanism. Little pleuromeians and sphenopsids, adapted to rapid grow, probably acted as opportunistic or pioneering plants in the stressed environments (Retallack, 1975, 1997) as probably was the case of the lower portion of the Puesto Viejo succession.

As mentioned above, the Middle Triassic age (Anisian) based on the tetrapod content of the Río Seco de la Quebrada Formation fauna has long been sustained on the common occurrence of both *Cynognathus* and *Diademodon* with the *Cynognathus* AZ of South Africa. The three subzones (A, B and C from oldest to youngest) were based mainly on the different temnospondyl amphibian content of the *Cynognathus* AZ of the Karoo Basin (Hancox et al., 1995; Shishkin et al., 1995; Abdala et al., 2005) (Fig. 7). The subzone A, with *Cynognathus*, the trirachodontid *Langbergia* Abdala, Neveling and Welman and a new taxon with allotherian–like postcanines, is attributed to the late Olenekian (Abdala et al., 2007). The subzone B, with *Cynognathus*, *Diademodon*, the trirachodontid *Trirachodon* Seeley, *Lumkuia* Hopson and Kitching and *Bolotridon* Coad, is referred to the early Anisian

(Kitching, 1995; Hopson and Kitching, 2001). The subzone C, with *Cynognathus*, *Diademodon* and the trirachodontid *Cricodon* Crompton is considered late Anisian (Hancox, 2000; Hancox and Rubidge, 2001; Damiani and Hancox, 2003; Abdala et al., 2005). According to Martinelli et al. (2009) the Río Seco de la Quebrada Formation can be correlated more specifically with subzones B and C however, the presence of traversodontids in the Argentinian beds represents an important difference with the South African faunas.

The new SHRIMP U–Pb age presented herein for the ignimbrite emplaced at the top of the Quebrada de los Fósiles Formation suggests that the tetrapod fauna of the Río Seco de la Quebrada Formation was developed, in contrast to previous propositions, during the Late Triassic (early Carnian) thus ca 10 Ma later than the age attributed to the *Cynognathus* AZ of South Africa. As previously discussed, the whole Puesto Viejo succession is considered herein to be part of the same sinrift pulse, thus the Quebrada de los Fósiles Formation is consider to be not older than Middle Triassic (Ladinian).

Two scenarios could explain our results. First, the *Cynognathus* AZ of South Africa is wrongly assigned to the lower Middle Triassic (Anisan) and should be considered younger in age, Late Triassic (Carnian). Second, the relative age of the *Cynognathus* AZ of South Africa is correct but the inferred range of *Cynognathus* and *Diademodon* is incorrect as they were present during the Late Triassic (Carnian) at least in South America. Whatever scenario is correct, it can only be falsified if an absolute date is obtained for the *Cynognathus*-bearing levels in the Karoo Basin, a succession devoid of radio-isotopic dates until now.

This new radio-isotopic age for the Puesto Viejo fauna pose serious doubts about validity of the biostratigraphic correlations across Gondwana that has been largely based on direct co-generic comparisons of therapsid taxa. In this context, the therapsids of the *Cynognathus* AZ of South Africa has been used to attribute beds from other African basins (Omingonde Fm. of Namibia, Manda Fm. of Tanzania, the lower N'Tawere Fm. of Zambia), Australia (Wianamata Group), India (Yerrapalli Fm.) and Argentina (Puesto Viejo Group) to the Middle Triassic, more specifically to the late Anisian (see Rubidge, 2005). The new scenario present herein constitutes solid evidence to contest against previous assignations to the Middle Triassic (Anisian) of several continental deposits across southern Gondwana based solely on biostigraphic controls (Fig. 7).

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FIGURE CAPTIONS

Fig. 1. Triassic rift basins of central-western Argentina with location of San Rafael depocenter, Bermejo Basin, and depocenters of the large Cuyo Basin, cited in the text (modified from Barredo et al., 2012).

Fig. 2. Locatity and geologic map of the studied area with location of sampled ignimbrite.

Fig. 3. Simplified geological section of the Puesto Viejo Group with emplacement of sampled ignimbrite and depositional environments.

Fig. 4. Río Seco de la Quebrada Formation at Quebrada del Durazno, basal and upper sections (above left and right respectively), and Quebrada de los Fósiles Formation in the type locality with sampled ignimbrite (below).

Fig. 5. Rhyolitic ignimbrite sampled at Quebrada de los Fósiles section: a) and b) general views, c) detail, d) thin section (parallel nicols), showing subhedral cristaloclasts of quartz immersed in a glass paste with abundant vitreous shards. Scale bar = 8 cm in c), 200 µm in d).

Fig. 6. Fossils from the Puesto Viejo Group: a) pleuromeian impression, b) cynodont bone (left femur), c) undetermined trunk, d) sphenopsid impression; except b), all captions from the Quebrada de los Fósiles Formation. Scale bar = 10 mm in a), 15 mm in c).

Fig. 7. Stratigraphic range of the *Cynognathus* AZ subzones (A, B and C) in the Karoo Basin, and the Lower-Middle Triassic stratigraphic units of southern Africa, Australia India, and the Puesto Viejo Group. Dashed lines indicate ranges based only on biostratigraphic correlations. Star indicates our SHRIMP U–Pb zircon age of 235.8 ± 2.0 Ma.

Fig. 8. Zircon populations separated from the rhyolitic ignimbrite sampled at Quebrada de los Fósiles. All zircons are prismatic and idiomorphic but with variable aspect ratios: a) (P1) > 3:1; b) (P2) 3:1, (P3) 2:1.

Fig. 9. a)-c) CL images with spots and ages of the dated zircons and, d) U/Pb concordia ages obtained from the rhyolitic ignimbrite sampled at Quebrada de los Fósiles.

Table 1. Summary of SHRIMP U–Pb zircon data for Puesto Viejo Group sample.

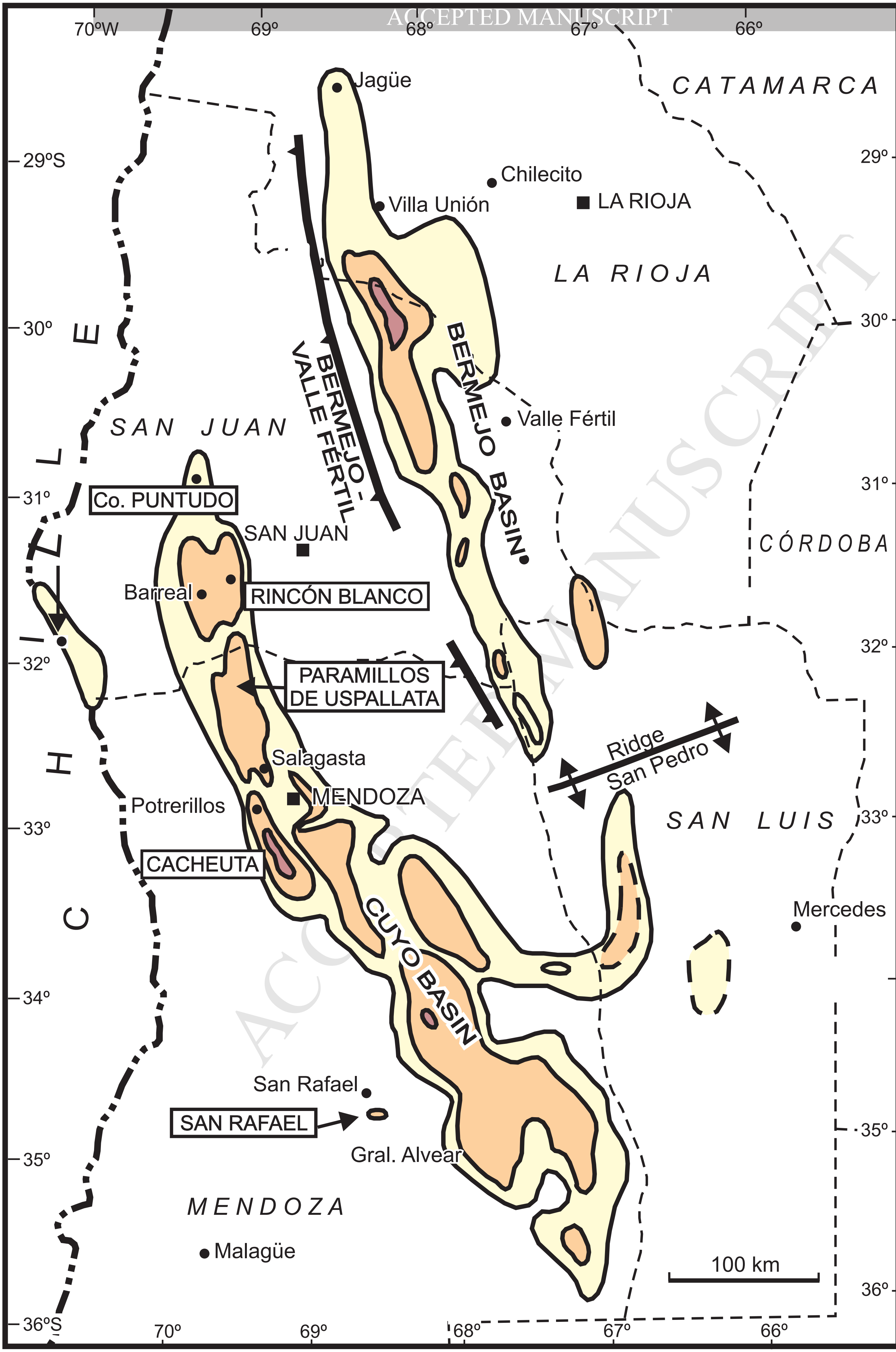
Grain.Spot	% $^{206}Pb_c$	ppm U	ppm Th	$^{232}Th/^{238}U$	±%	(1) ppm $^{206}Pb^*$	(1) $^{206}Pb/^{238}U$ Age		(2) $^{206}Pb/^{238}U$ Age		(1) $^{207}Pb/^{206}Pb$ Age		% Discordant	Total 238U/206Pb	±%	Total 207Pb/206Pb	±%	(1) $^{207}Pb^*/^{206}Pb^*$	±%	(1) $^{207}Pb^*/^{235}U$	±%	(1) $^{206}Pb^*/^{238}U$	±%	err corr
3.2	0.21	42	19	0.46	1.55	1.3	234	±6	234	±6	206	±107	-14	27.00	2.4	0.0525	3.1	0.05023	4.6	0.256	5.2	0.0369	2.4	0.5
4.2	0.32	27	11	0.43	0.61	0.9	237	±4	237	±4	321	±93	+27	26.65	1.5	0.0535	3.8	0.05282	4.1	0.273	4.4	0.0375	1.5	0.3
5.2	--	49	22	0.46	0.45	1.5	232	±3	231	±3	286	±93	+19	27.37	1.4	0.0506	3.1	0.05202	4.0	0.262	4.3	0.0366	1.4	0.3
6.2	0.10	148	73	0.51	1.96	4.6	228	±7	228	±7	152	±92	-51	27.74	2.9	0.0515	3.1	0.04908	3.9	0.243	4.9	0.0359	2.9	0.6
7.2	0.09	89	34	0.39	0.36	2.9	236	±4	236	±4	219	±64	-8	26.75	1.8	0.0517	2.2	0.05052	2.8	0.260	3.3	0.0373	1.8	0.5
8.2	--	28	9	0.35	0.65	0.9	235	±4	236	±5	149	±99	-59	26.86	1.9	0.0497	4.0	0.04903	4.2	0.251	4.7	0.0372	1.9	0.4
9.2	0.40	46	22	0.50	0.44	1.5	237	±3	237	±3	284	±95	+17	26.65	1.4	0.0541	2.9	0.05198	4.2	0.268	4.4	0.0374	1.4	0.3
10.2	0.11	73	32	0.44	0.38	2.4	237	±4	237	±5	318	±70	+26	26.73	1.9	0.0518	2.5	0.05275	3.1	0.272	3.6	0.0375	1.9	0.5
11.2	0.29	51	26	0.53	0.42	1.6	232	±3	231	±3	317	±67	+27	27.31	1.4	0.0531	2.9	0.05273	3.0	0.266	3.3	0.0366	1.4	0.4
13.2	0.61	27	10	0.40	0.65	0.9	237	±6	237	±6	279	±160	+15	26.52	2.7	0.0558	4.1	0.05186	7.0	0.268	7.5	0.0375	2.7	0.4
14.2	--	41	18	0.45	0.49	1.3	230	±6	231	±6	140	±82	-66	27.49	2.5	0.0493	3.3	0.04883	3.5	0.245	4.3	0.0363	2.5	0.6
15.2	--	35	13	0.40	0.56	1.1	235	±5	235	±5	175	±85	-35	26.97	2.0	0.0501	3.5	0.04957	3.7	0.253	4.2	0.0371	2.0	0.5
16.2	0.23	60	31	0.53	0.39	1.9	239	±3	238	±3	308	±62	+23	26.49	1.3	0.0528	2.6	0.05251	2.7	0.273	3.0	0.0377	1.3	0.4
17.2	0.46	28	11	0.42	0.59	0.9	234	±3	234	±4	245	±178	+4	26.88	1.5	0.0545	5.7	0.05109	7.7	0.261	7.9	0.0370	1.5	0.2
18.2	--	33	15	0.48	0.54	1.1	236	±5	236	±5	208	±91	-14	26.79	2.0	0.0508	3.7	0.05029	3.9	0.259	4.4	0.0373	2.0	0.5
19.2	0.42	145	71	0.51	0.26	4.7	236	±4	236	±4	251	±68	+6	26.71	1.6	0.0542	1.7	0.05122	3.0	0.263	3.4	0.0373	1.6	0.5
20.2	0.03	165	87	0.54	0.23	5.4	240	±5	239	±5	291	±92	+18	26.44	2.0	0.0512	3.7	0.05213	4.0	0.272	4.5	0.0379	2.0	0.4
21.2	--	47	16	0.34	0.51	1.5	239	±3	239	±3	252	±92	+5	26.51	1.4	0.0499	3.0	0.05125	4.0	0.267	4.2	0.0378	1.4	0.3
22.2	0.29	53	17	0.33	0.50	1.7	234	±5	233	±5	389	±81	+41	27.14	2.3	0.0532	2.8	0.05444	3.6	0.277	4.3	0.0369	2.3	0.5
24.2	0.04	61	25	0.42	0.41	2.0	240	±4	240	±4	243	±61	+1	26.35	1.7	0.0513	2.6	0.05105	2.7	0.267	3.2	0.0379	1.7	0.5
26.1	0.20	138	53	0.40	0.28	4.4	234	±4	234	±4	198	±65	-19	26.96	1.7	0.0525	1.7	0.05007	2.8	0.255	3.3	0.0370	1.7	0.5
27.1	0.02	76	54	0.73	1.40	2.5	238	±3	238	±3	186	±71	-28	26.58	1.3	0.0511	2.3	0.04981	3.0	0.258	3.3	0.0376	1.3	0.4
28.1	0.22	54	20	0.38	0.46	1.8	239	±7	240	±7	94.0	±141	-157	26.34	2.8	0.0528	2.7	0.04789	5.9	0.249	6.6	0.0377	2.8	0.4
29.1	0.46	162	55	0.35	0.28	5.2	238	±4	237	±4	391	±38	+40	26.61	1.6	0.0546	1.7	0.05449	1.7	0.282	2.3	0.0376	1.6	0.7

Errors are 1-sigma; Pb_c and Pb^* indicate the common and radiogenic portions, respectively.

Error in Standard calibration was 0.33% (not included in above errors but required when comparing data from different mounts).

(1) Common Pb corrected using measured ^{204}Pb.

(2) Common Pb corrected by assuming $^{206}Pb/^{238}U$-$^{207}Pb/^{235}U$ age-concordance



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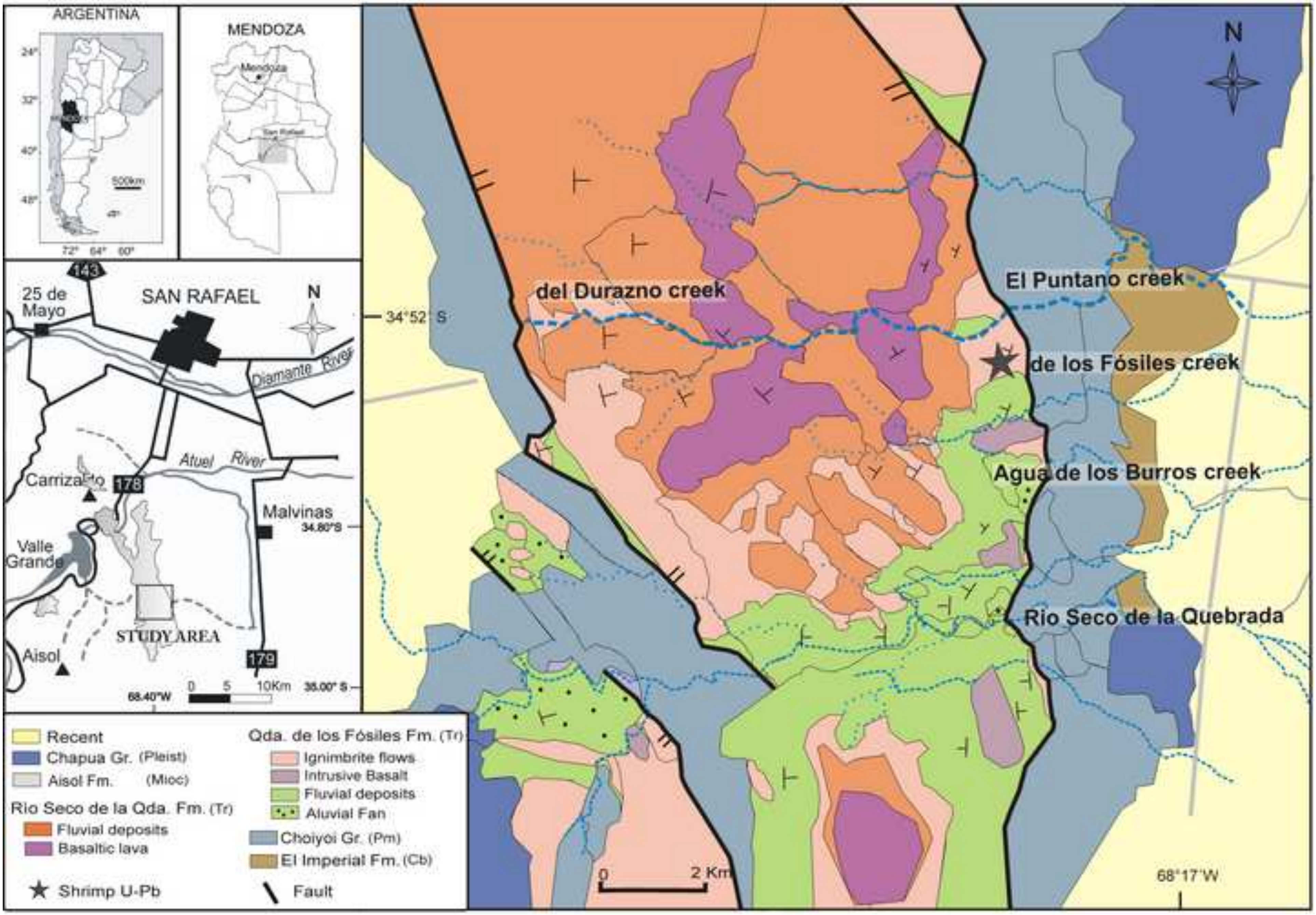
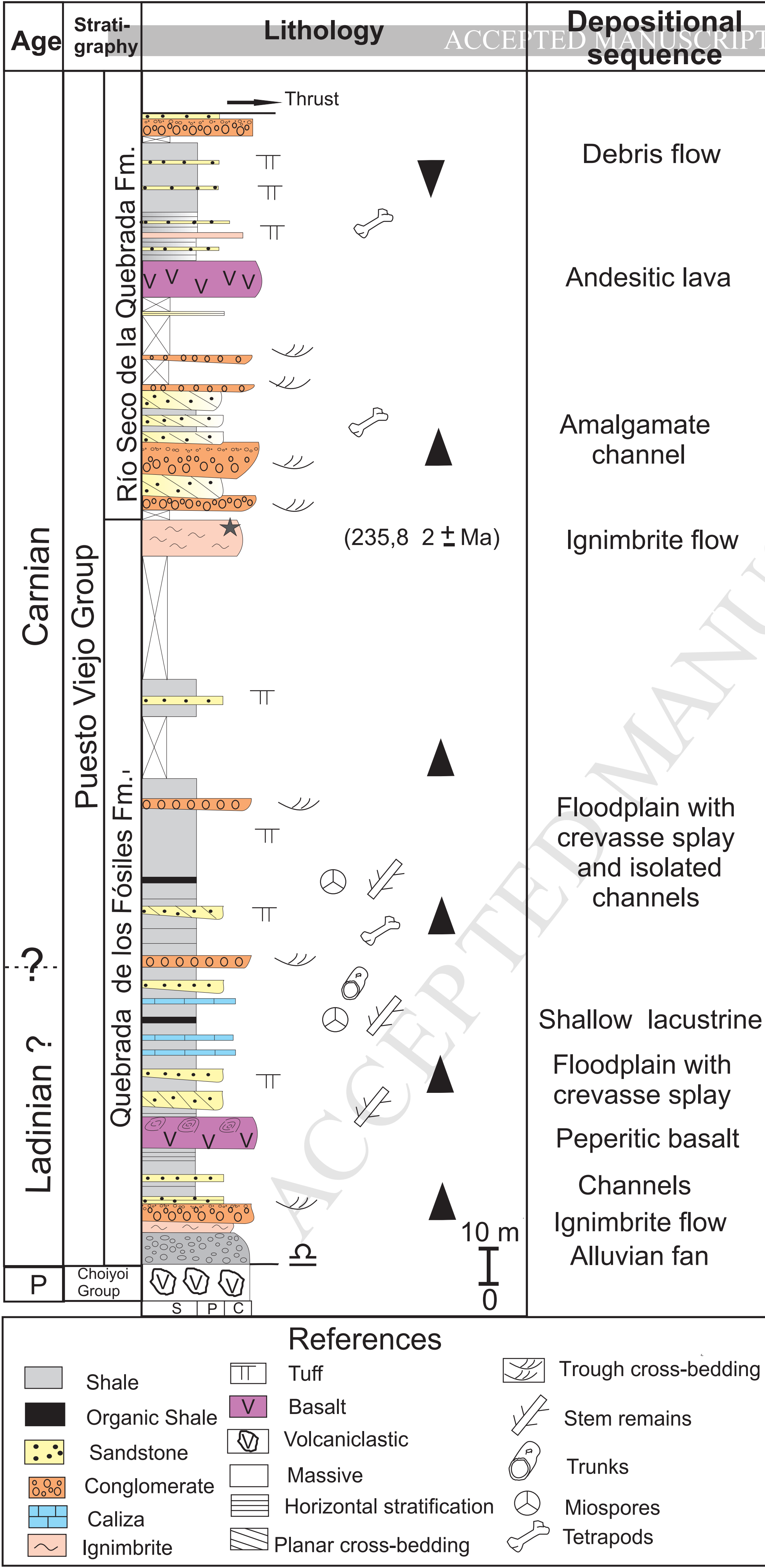
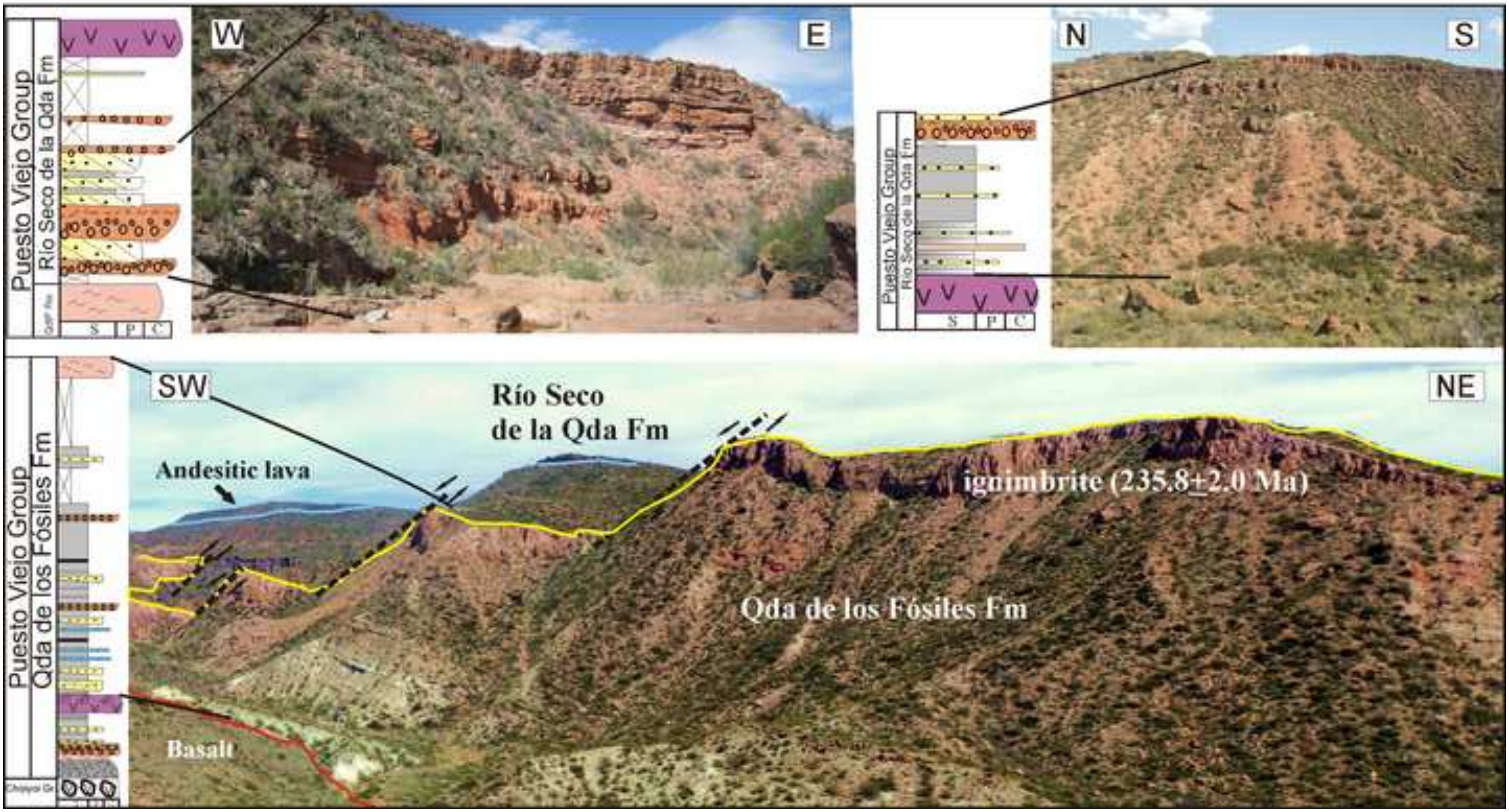
Jagüe
CATAMARCA
Chilecito
Villa Unión
LA RIOJA
LA RIOJA
BERMEJO - VALLE FÉRTIL
BERMEJO BASIN
Valle Fértil
SAN JUAN
CHILE
Co. PUNTUDO
SAN JUAN
CÓRDOBA
Barreal
RINCÓN BLANCO
PARAMILLOS DE USPALLATA
Ridge San Pedro
Salagasta
MENDOZA
Potrerillos
SAN LUIS
CACHEUTA
CUYO BASIN
Mercedes
San Rafael
SAN RAFAEL
Gral. Alvear
MENDOZA
Malagüe
100 km



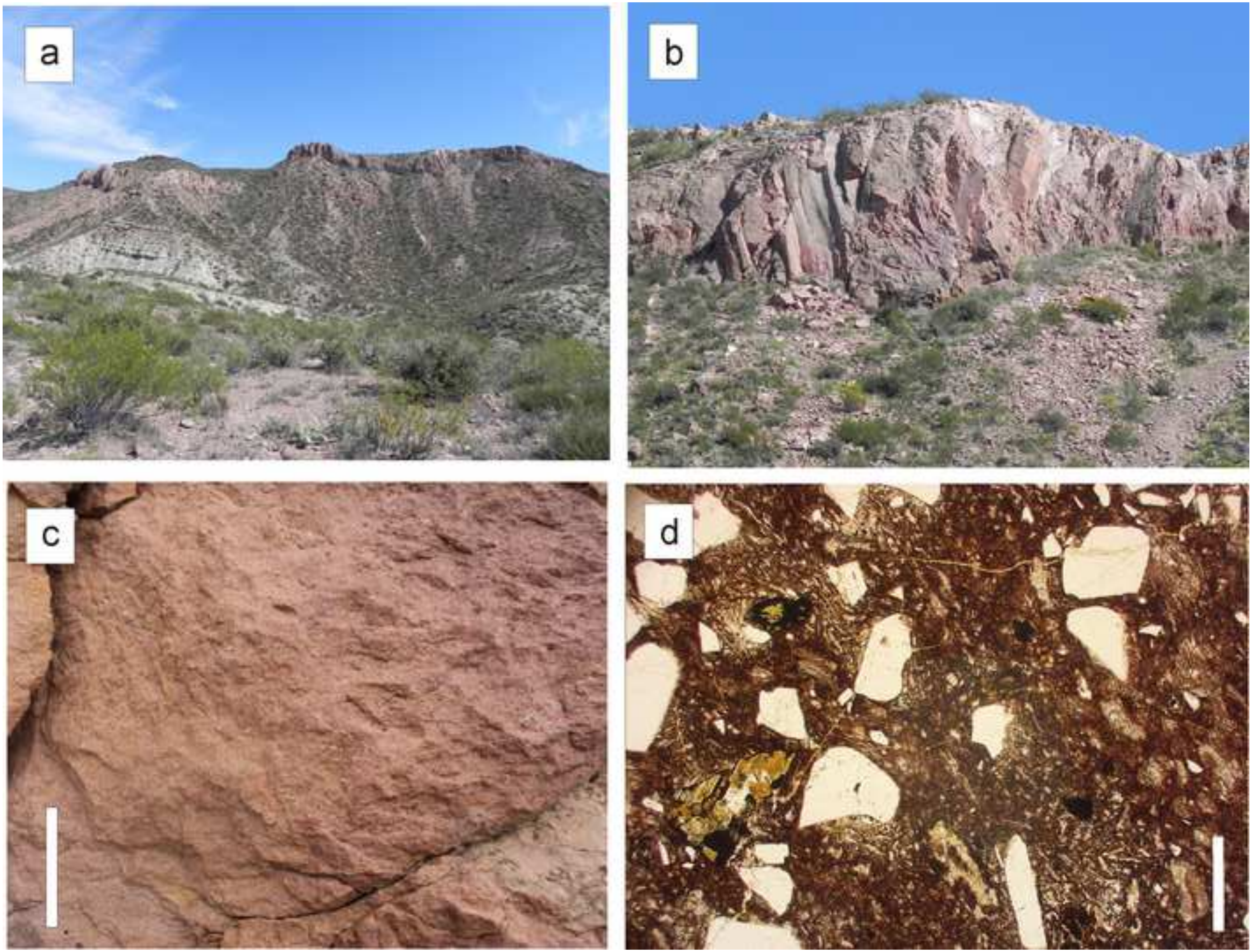
ARGENTINA
MENDOZA
Mendoza
San Rafael
500km
25 de Mayo
SAN RAFAEL
N
Diamante River
Atuel River
Carrizalito
Malvinas
Valle Grande
STUDY AREA
Aisol
143
178
179
34.80°S
35.00° S
68.40°W
0 5 10Km
34°52' S
del Durazno creek
El Puntano creek
de los Fósiles creek
Agua de los Burros creek
Rio Seco de la Quebrada
0 2 Km
68°17'W
Recent
Chapua Gr. (Pleist)
Aisol Fm. (Mioc)
Rio Seco de la Qda. Fm. (Tr)
Fluvial deposits
Basaltic lava
Shrimp U-Pb
Qda. de los Fósiles Fm. (Tr)
Ignimbrite flows
Intrusive Basalt
Fluvial deposits
Aluvial Fan
Choiyoi Gr. (Pm)
El Imperial Fm. (Cb)
Fault

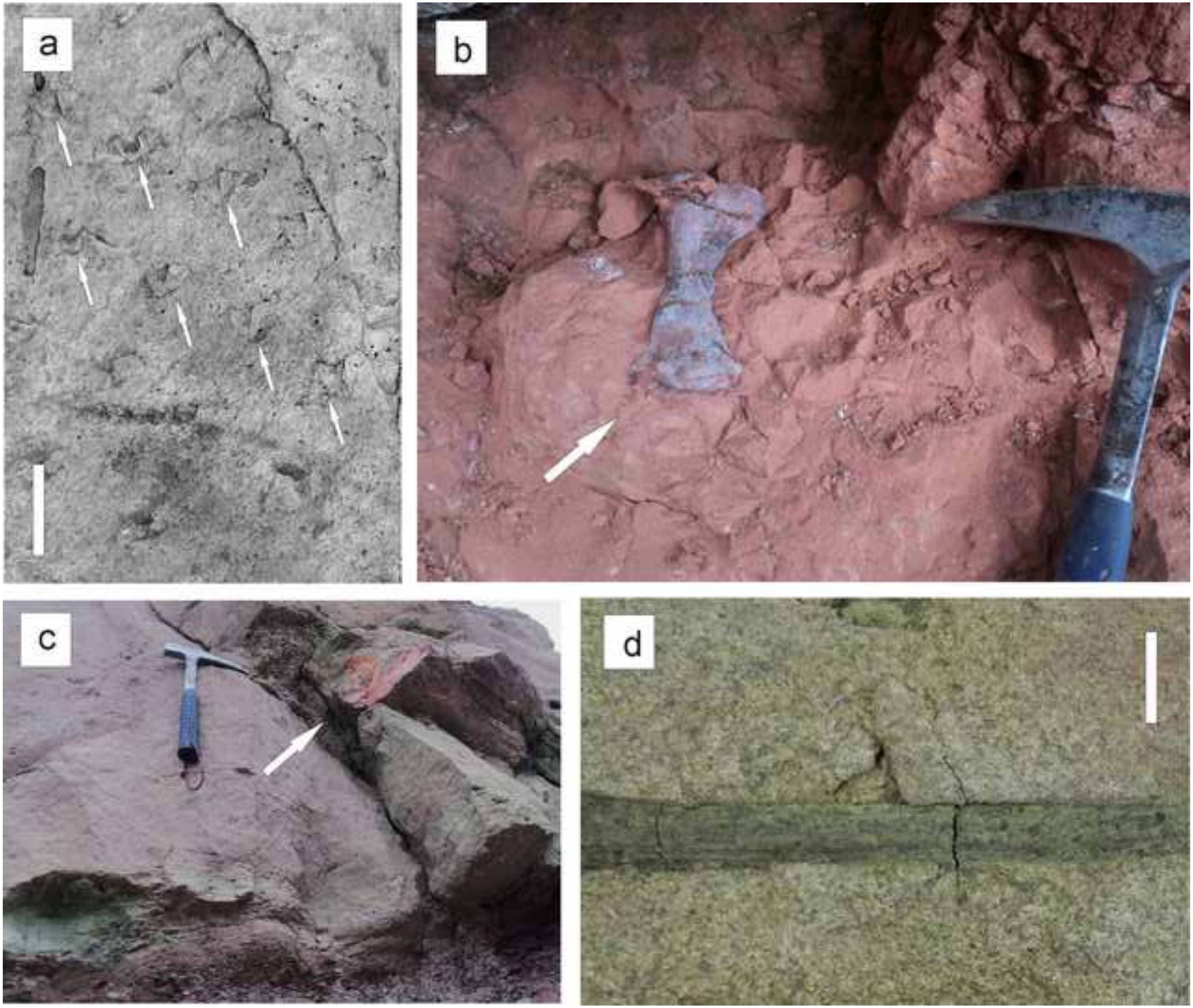


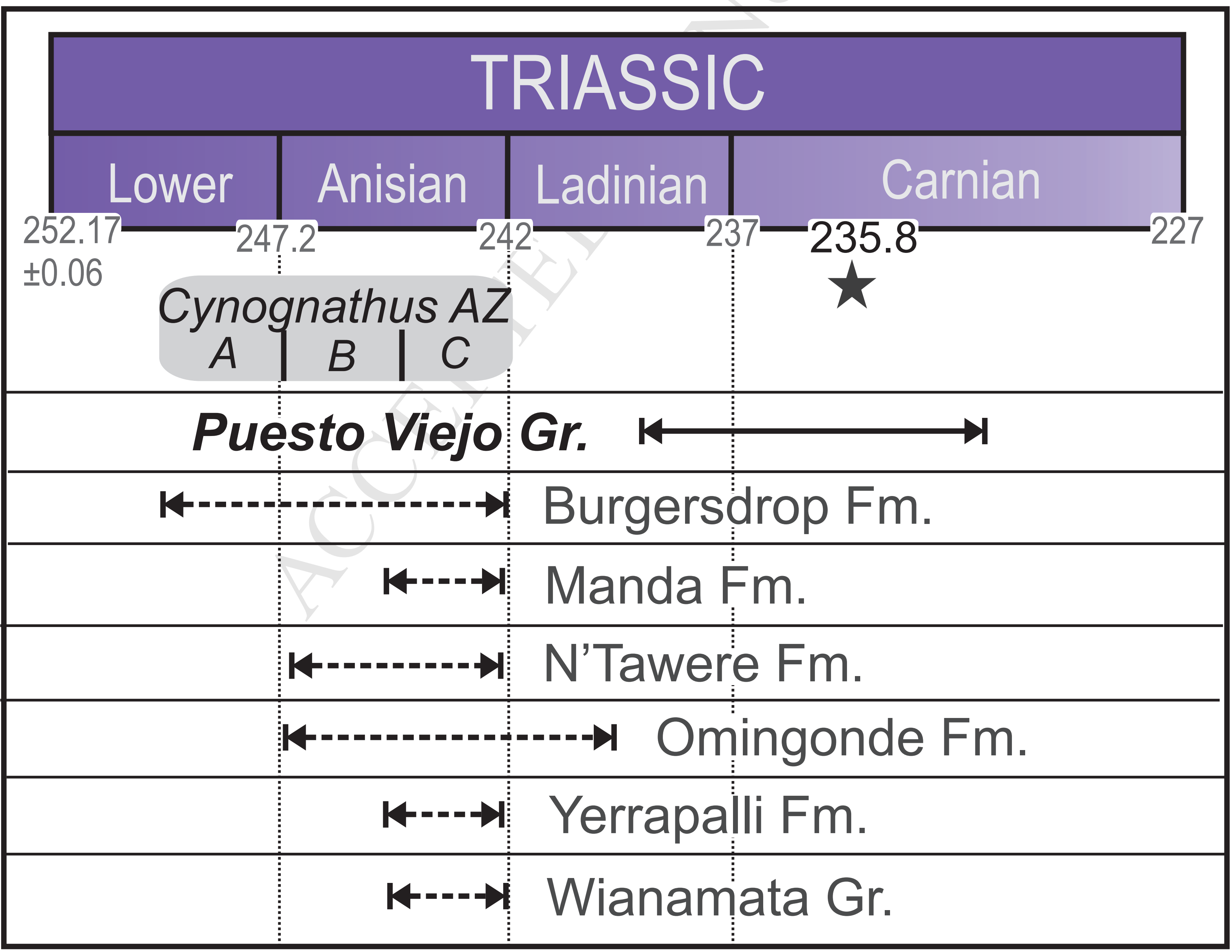
Age
Strati-graphy
Lithology
Depositional sequence
Thrust
Debris flow
Andesitic lava
Amalgamate channel
(235,8 2 ± Ma)
Ignimbrite flow
Floodplain with crevasse splay and isolated channels
Shallow lacustrine
Floodplain with crevasse splay
Peperitic basalt
Channels
Ignimbrite flow
Alluvian fan
Carnian
?
Ladinian ?
P
Puesto Viejo Group
Río Seco de la Quebrada Fm.
Quebrada de los Fósiles Fm.
Choiyoi Group
10 m
0
S
P
C
References
Shale
Organic Shale
Sandstone
Conglomerate
Caliza
Ignimbrite
Tuff
Basalt
Volcaniclastic
Massive
Horizontal stratification
Planar cross-bedding
Trough cross-bedding
Stem remains
Trunks
Miospores
Tetrapods



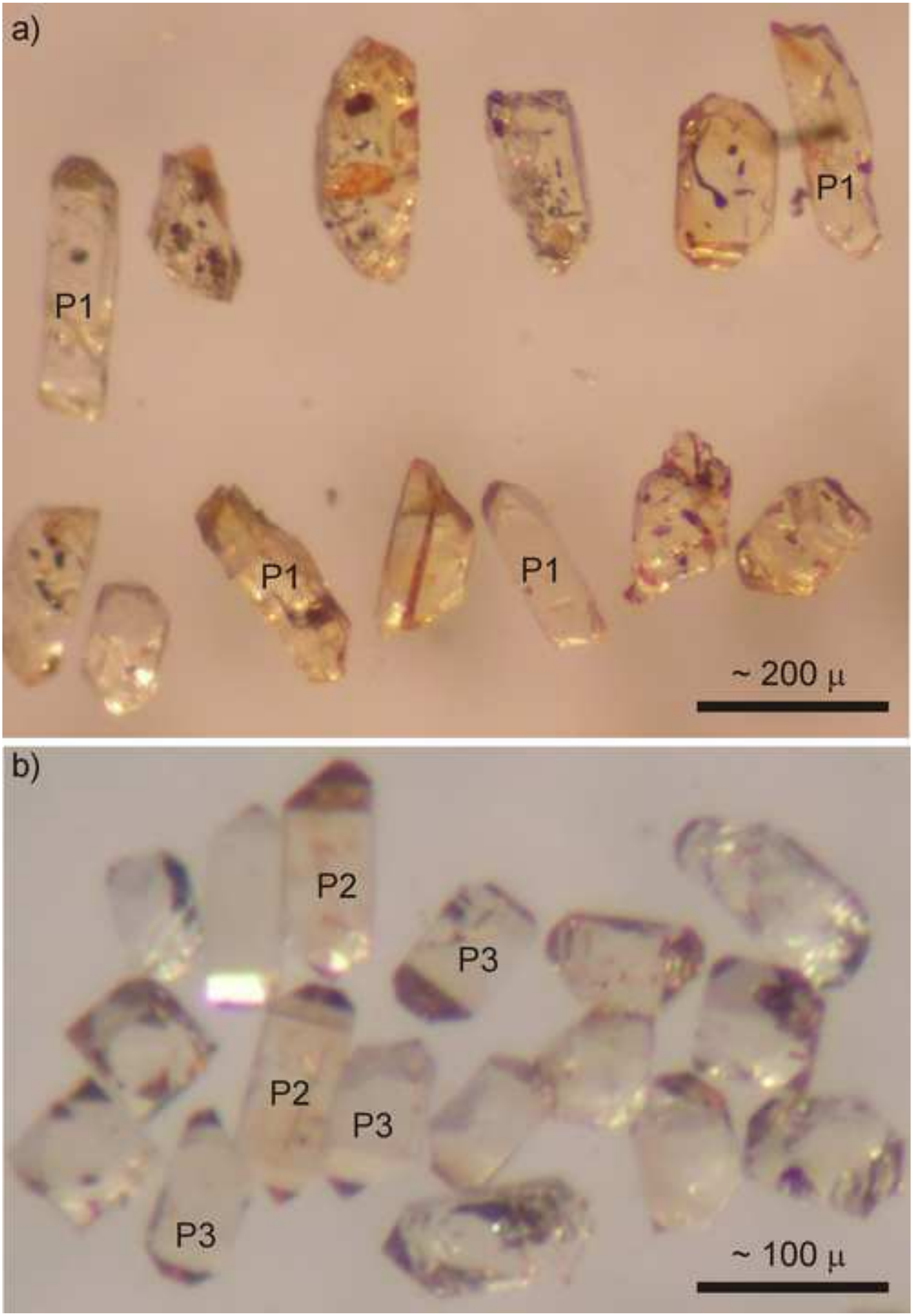
W
E
N
S
Puesto Viejo Group
Río Seco de la Qda Fm
SW
NE
Río Seco
de la Qda Fm
Andesitic lava
ignimbrite (235.8±2.0 Ma)
Qda de los Fósiles Fm
Basalt
Puesto Viejo Group
Qda de los Fósiles Fm

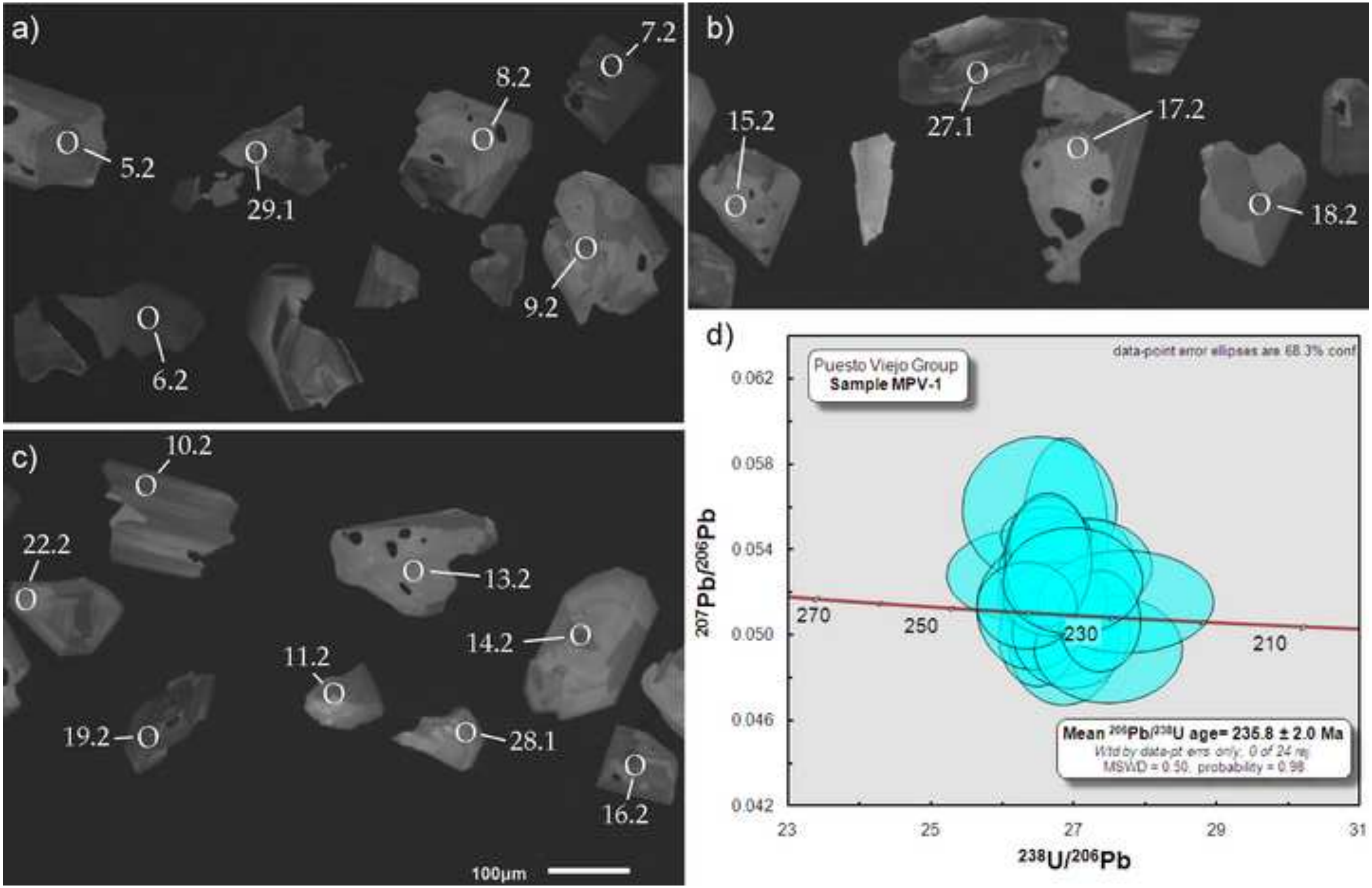

a
b
c
d


a
b
c
d



TRIASSIC
Lower
Anisian
Ladinian
Carnian
252.17 ±0.06
247.2
242
237
235.8
227
Cynognathus AZ
A
B
C
Puesto Viejo Gr.
Burgersdrop Fm.
Manda Fm.
N'Tawere Fm.
Omingonde Fm.
Yerrapalli Fm.
Wianamata Gr.


a)
P1
P1
P1
P1
~ 200 μ
b)
P2
P3
P2
P3
P3
~ 100 μ


a)
7.2
8.2
5.2
29.1
9.2
6.2
b)
15.2
27.1
17.2
18.2
c)
10.2
22.2
13.2
14.2
11.2
19.2
28.1
16.2
100µm
d)
data-point error ellipses are 68.3% conf
Puesto Viejo Group
Sample MPV-1
0.062
0.058
0.054
0.050
0.046
0.042
270
250
230
210
Mean $^{206}Pb/^{238}U$ age= 235.8 ± 2.0 Ma
Wtd by data-pt errs only, 0 of 24 rej.
MSWD = 0.50, probability = 0.98
23
25
27
29
31
$^{207}Pb/^{206}Pb$
$^{238}U/^{206}Pb$