

**PROVENANCE OF CRETACEOUS–PLIOCENE CLASTIC SEDIMENTS IN THE
TÁCHIRA SADDLE, WESTERN VENEZUELA, AND IMPLICATIONS FOR
SEDIMENT DISPERSAL PATTERNS IN THE NORTHERN ANDES**

Thesis
Submitted by

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The College of Science and Engineering
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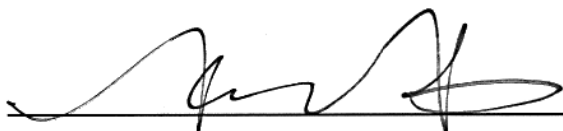
May 2016

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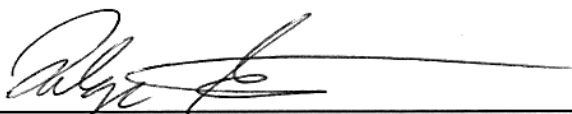
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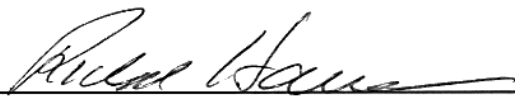
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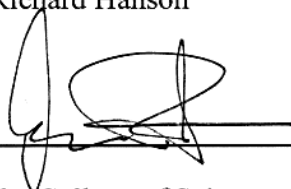
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For the College of Science and Engineering

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1. INTRODUCTION

Tectonic evolution of the northern Andes and sedimentation in the associated foreland basins are controlled by the dynamic interaction between the Caribbean plate, the South America plate, the Nazca plate, and the Arc of Panama (Dengo and Covey, 1993; Montes et al., 2005; Vincent et al., 2014). Three subparallel mountain ranges, the Western Cordillera (WC), the Central Cordillera (CC), and the Eastern Cordillera (EC), and their northern extension—the Mérida Andes (MA) and Santander Massif (SM) were formed (Fig. 1). The development of the Western and Central Cordillera was generally controlled by multiple episodes of accretion of Cretaceous arc terranes (Case et al., 1990; Cediel et al., 2003; Villagómez et al., 2011). In contrast, the uplift timing of the Eastern Cordillera and Mérida Andes ranges from Paleocene (Bayona et al., 2008) to Miocene (Cooper et al., 1995). Sedimentation and dispersal patterns in the associated basins remain poorly understood despite decades of successful hydrocarbon exploration and production in the Maracaibo, Llanos, and Barinas Basins (Fig. 1).

A regional integration of the stratigraphic record in northern South America suggests a broad similarity in early depositional history across the region (Villamil, 1999; Guzmán and Fisher, 2006). A general notion that a northward drainage system, which controlled the main sedimentation during the Tertiary, eventually migrated eastward due to the uplift of the Mérida Andes and Eastern Cordillera, is mostly accepted (Hoorn et al., 1995; Diaz de Gamero, 1996; Villamil, 1999). Recent detrital zircon analyses in the foothills of the Llanos Basin (Horton et al., 2010; Bande et al., 2012; Saylor et al., 2012) and Magdalena Valley (Bayona et al., 2008; Nie et al., 2010; Bayona et al., 2012) provide additional evidence to understand the Eastern Cordillera orogenic process and its influence on regional sedimentation. However, the role of the Mérida Andes and its interaction with the Eastern Cordillera is still under debate.

In this study, six clastic sediment samples, from Cretaceous to Pliocene strata, were collected from the Táchira Saddle area near the Barinas Basin in western Venezuela (Fig. 1). U-Pb detrital zircon geochronology and XRD mineralogical analysis were used together to document the provenance of these sediments and track their heavy mineral suite changes. Results of this study confirm the major spatial distribution of potential sediment sources for the Táchira area through time, linking the basin with the Guyana Shield to the east, the Garzon Massif to the south (Fig. 2), and the Central Cordillera to the west. Additionally, the composite detrital signatures that could be related with sediment recycling caused by uplift of the Mérida Andes and Eastern Cordillera have been identify. Sediment dispersal patterns in the region are reconstructed by comparison with similar samples from five other localities within the Magdalena Valley and Los Llanos and Maracaibo Basins.

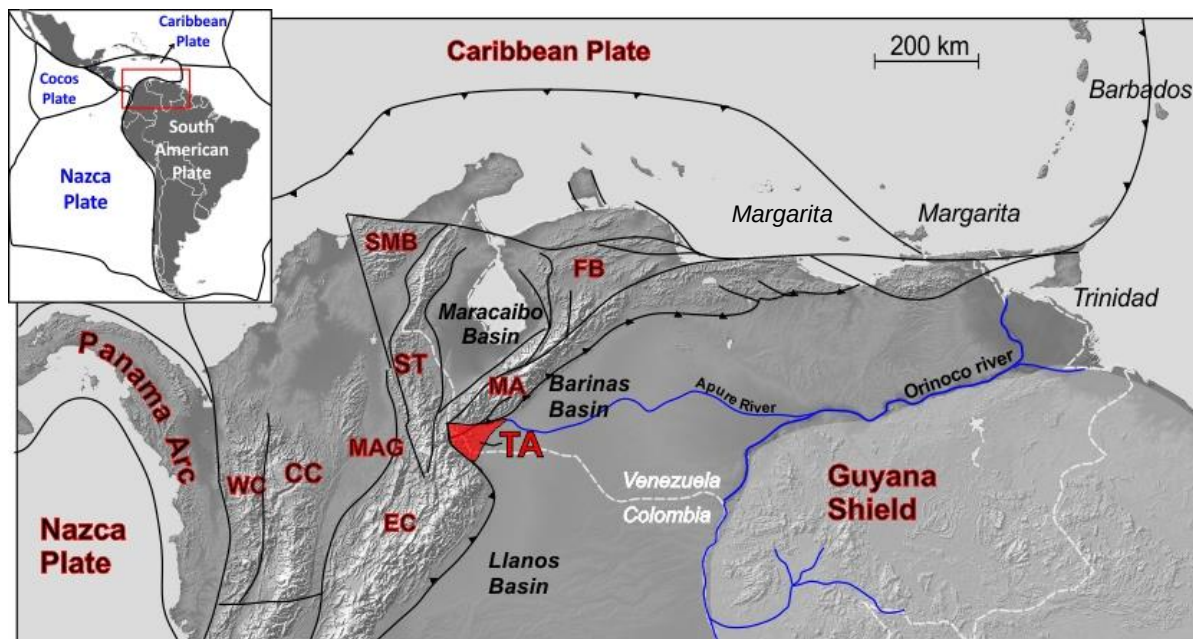


Figure 1. Major geologic features in northern South America (modified from Pindell and Barrett (1990) and Escalona and Mann (2011)). TA: Táchira Saddle, MA: Mérida Andes. EC: Eastern Cordillera, MAG: Magdalena Valley, CC: Central Cordillera, WC: Western Cordillera, SMB: Santa Marta Basin, FB: Falcon Basin, ST: Santander Massif.

Overall, detrital zircon signatures suggest (1) a transition from a Cretaceous passive margin to a Paleogene foreland basin; (2) the isolation of the Táchira Saddle from the Central Cordillera by the Oligocene; (3) a deviation of drainage systems from northward to eastward by Early Miocene; and (4) the unroofing of the Mérida Andes basement by Late Miocene-Pliocene.

2. TECTONIC FRAMEWORK AND GEOLOGICAL BACKGROUND

The northwestern portion of the South American plate is made up of the Precambrian basement of the Guyana Shield, the Andean orogenic belt containing Neoproterozoic to Late Cretaceous terranes, and a thick sedimentary cover that encompasses sediments from a Cretaceous passive margin and Cenozoic foreland basin.

Overall, the tectonic history includes at least five distinct events since the Jurassic. The first event is Late Jurassic rifting associated with the breakup of Pangea, which resulted in the separation of the North and South American plates and the Yucatán Block (Pindell and Dewey, 1982; Pindell and Barrett, 1990; Mann, 1999; Pindell et al., 2005;). This break-up was followed by the development of a Cretaceous passive margin with a long period of sedimentation and major sea level variations. By the Late Cretaceous, the passive margin sedimentation was interrupted by an eastward oblique collision of the Caribbean Plate with western Colombia, generating a deformation belt with a related foreland basin. The deformation eventually moved eastward diachronously across the northern part of the South American plate, reaching western Venezuela by the Paleocene to Early Eocene (Pindell and Barrett, 1990; Lugo and Mann, 1995; Mann and Escalona, 2011). The fourth event is the inversion of the foreland basin because of isostatic rebound as the Caribbean plate moved eastward during the Late Eocene to Late Oligocene. This movement propagated the active thrust front to the east and was responsible for the uplift of the eastern Cordillera (Dengo and Covey, 1993; Cooper et al., 1995; Mora et al., 2008; Parra et al.,

2009; Horton et al., 2010). Finally, Middle Miocene uplift of the Mérida Andes occurred due to oblique convergence of the Maracaibo tectonic block as it was thrust beneath the South American plate (Fig. 1) (Kohn et al., 1984; Case et al., 1990; Colletta et al., 1997; Montes et al., 2005; Bermúdez et al., 2011; Erikson et al., 2012; Bermúdez et al., 2017).

2.1 Tectonostratigraphy of the Táchira Saddle.

The diachronous uplifting of the Eastern Cordillera and the Mérida Andes created a topographic depression between them known as the Táchira Saddle (Macellari, 1984) (Fig. 2). The Táchira Saddle is a key feature in understanding the influence of the northern Andes orogeny on sediment dispersal patterns in northern Venezuela. The Táchira Saddle extends in an NW-SE direction and is approximately 20 km wide. Elevations range from 400 to 1500 m (Fig. 1). The area has been mapped during two oil exploration campaigns (Shaub-Gutman, 1939; Trump, 1957), and was later revisited by Macellari (1981), who documented the stratigraphy of the area and characterized the sedimentology of post-orogenic units in detail.

Overall, the Táchira Saddle consists almost entirely of highly deformed sedimentary rocks, ranging in age from Jurassic to Quaternary. In general, it can be divided into six stratigraphic sequences, each one related to a different stage in the tectonic evolution of northern South America. The first event, the Jurassic rifting, is recorded as Sequence A (Fig. 3), which filled an extensional basin and is mainly composed of intra-cratonic redbed clastic sediments interbedded with rhyolitic tuffs (La Quinta Formation) (Maze, 1984).

Sequence B (Fig. 3) is composed of Cretaceous passive margin sediments. Following the development of the rift basin and an epicontinental sea, a passive margin eventually formed and persisted throughout the entire Cretaceous (Fig. 4). Sedimentation began during an Early Cretaceous marine transgression that flooded the Guyana Shield and rift basin sediments (Garcia

Jarpa et al., 1980). The Rio Negro Formation is the initial basal clastic deposit. Next, marine carbonate shelf of the Aptian Apón Formation were deposited and is overlain by the Albian Aguardiente Formation accumulated as a transgressive shoreline sandstone (Renz, 1959); a second major transgression in the Cenomanian led to the deposition of Carbonate Platform of the Capacho Formation and the organic-rich facies of the La Luna and Mito Juan Formations, which are correlative to the Navay and Colon Formations, respectively, in the Táchira Saddle. These units are the main source rocks in the petroleum system of western Venezuela (Renz, 1959).

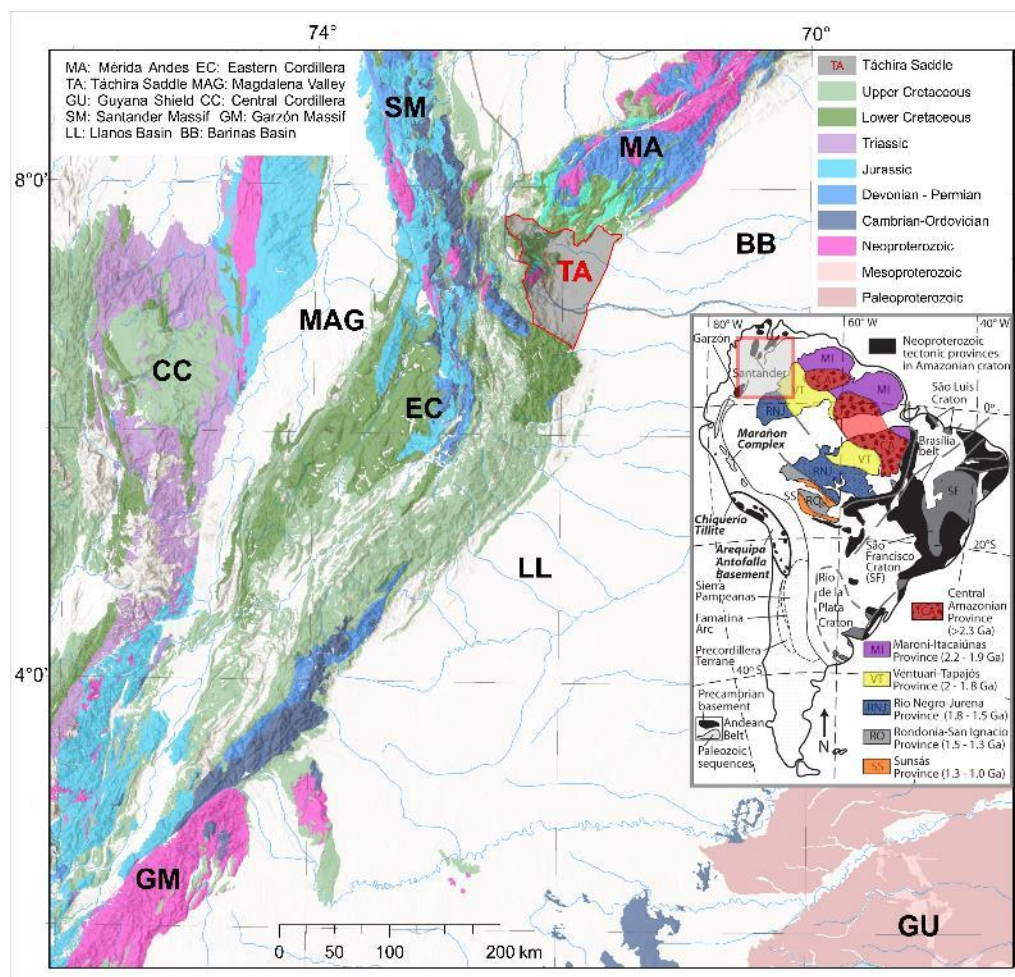


Figure 2. Geological Map of northern South America showing major Pre-Cenozoic stratigraphic units and main crystalline basement exposures (modified from Hackley et al., 2005; Gómez et al., 2007). Inset map (lower right) shows Precambrian crustal provinces of South America and the corresponding ages (Cordani et al., 2000; Chew et al., 2007). Red box in the inset map represent the location of the main figure.

The passive margin stage was interrupted in the Late Cretaceous as the Caribbean island arc on the Caribbean plate started to collide obliquely with northern South America, forming a transpressional plate boundary (Fig. 4)(Pindell and Barrett, 1990). This interaction is recorded landward by the formation of a foreland basin in the Paleocene, which is preserved in the Táchira Saddle as Sequence C. This sequence consists of shoreline sandstones and overlaying deltaic sediments of the Barco and Los Cuervos Formations (Kiser, 1989).

By the Eocene, the active thrust front related to oblique plate convergence reached western Venezuela in its continuous migration eastward (Fig. 4) An initial orogenic event was recorded in the Central Cordillera in western Colombia along with a period of rapid subsidence in the foreland basin (Villamil, 1999). The combination of these two events produced a widespread regional unconformity in the western positive areas and more accommodation space in the basins that were eventually filled by massive fluvial sandstones, which are represented by the Mirador Formation (Sequence D) on the Táchira Saddle (Kellogg, 1984; Parnaud et al., 1995; Villamil, 1999) (Fig. 3).

Between the Late Eocene and the Late Oligocene, the deformation front, called the Lara Nappes, advanced to the southeast, which combined with regional transgression during this period, increased the accommodation space in western Venezuela (Fig. 4). This episode is represented by the Sequence E, which is characterized by tidal deposits with frequent coal intervals of the Carbonera Formation. This unit can be traced into the Los Llanos basin in Colombia; however, the deposition was diachronous and the unit represents a younger period in the south (Villamil, 1999).

The uplift of the Mérida Andes mountain belt, which started in the northeast by the Middle Miocene (Case et al., 1990; Diaz de Gamero, 1996; Erikson et al., 1996; Bermúdez et al., 2011), was responsible for partitioning the depocenters in northwestern Venezuela (Fig 4). The uplift of this mountain range deviated the drainage and eventually isolated the Maracaibo and Barinas

Basins by the Early Pliocene. Fluvial and alluvial deposits, associated with rapid uplift, accumulated in the foothills of the Mérida Andes. The La Copé Formation in the Táchira Saddle represents this Sequence F. In the Alquitrana section, an anticlinal structure exposed the Mio-Pliocene fluvial-alluvial sediments of the La Cope Formation, lying uncomfortably upon folded Cretaceous to Paleogene strata (Macellari, 1981, 1984).

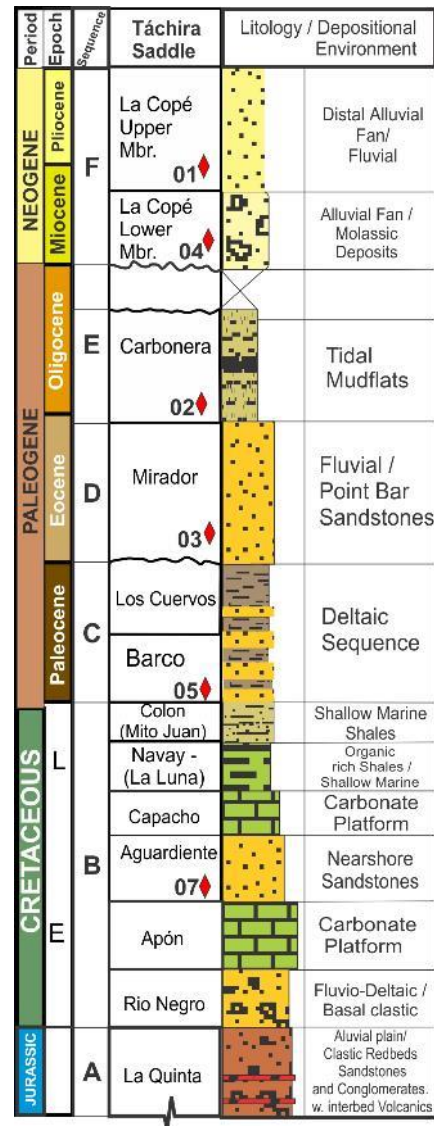


Figure 3. Stratigraphic column of Táchira Saddle, west Venezuela. (Red diamonds represent sampled strata) Modified from Macellari, (1981).

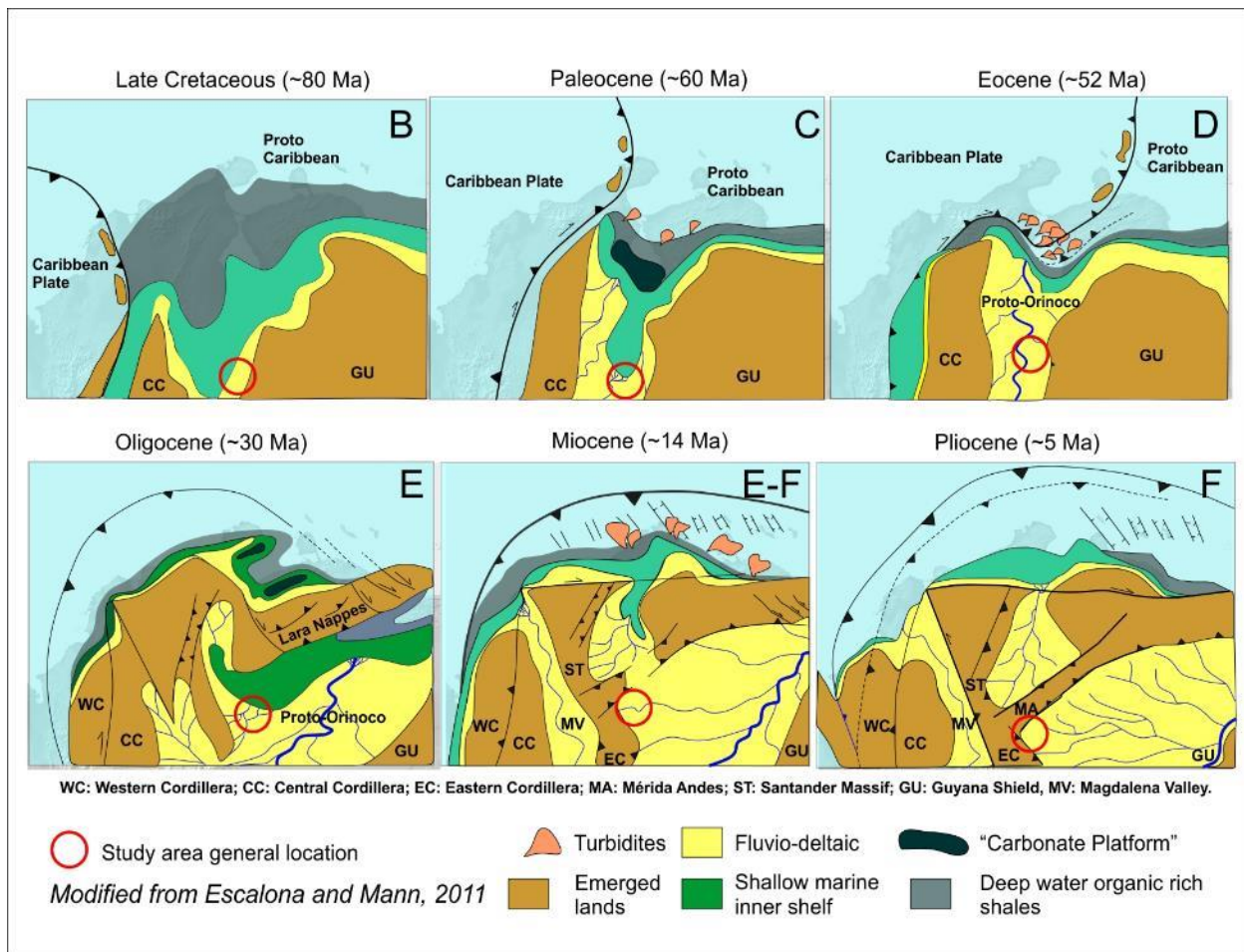


Figure 4. Tectonostratigraphic context of northern South America and the suggested location of the Táchira Saddle sediments. Letters B to F relate to the depositional sequences in the Táchira Saddle. Modified from (Escalona & Mann, 2011)

2.2 Previous insights into sediment dispersal patterns in northern South America

Earlier studies suggest that the Late Eocene to Early Miocene sedimentation of northern South America was controlled by a proto-Orinoco river, which carried sediments from the Guyana Shield and ancestral Central Cordillera into the Maracaibo Basin to the north (Dickey, 1980; Rod, 1981; Kasper and Larue, 1986; Hoorn et al., 1995; Diaz de Gamero, 1996). There are three lines of evidence for this hypothesis. First, a thick Eocene deltaic sequence is recorded in the Maracaibo Basin with the correlative massive fluvial sandstones of the Mirador Formation deposited inland

(Zambrano, 1971, Molina et al., 1993). Second, vertebrate fossils found in Late Miocene units in the western Falcon Basin (Fig. 1) correlate biogeographically with the present Orinoco River ecosystem. This correlation would imply a direct connection between the Falcon Basin and the Guyana Shield (Hoorn et al., 1995; Diaz de Gamero, 1996;). Third, provenance analysis of sandstone outcrops of the Eocene Scotland Formation exposed on Barbados Island (Xie et al., 2010) and the Eocene Pampatar Formation in Margarita island (Noguera, 2009) suggests an Eocene continental source to the west (Fig. 5). This source might be related to the Maracaibo Basin and the proto-Orinoco deltaic sediments. Later, the accretionary prism of the Caribbean arc may have displaced such sediments to their current location (Dickey, 1980; Burke et al., 1984; Kasper and Larue, 1986; Xie et al., 2010).

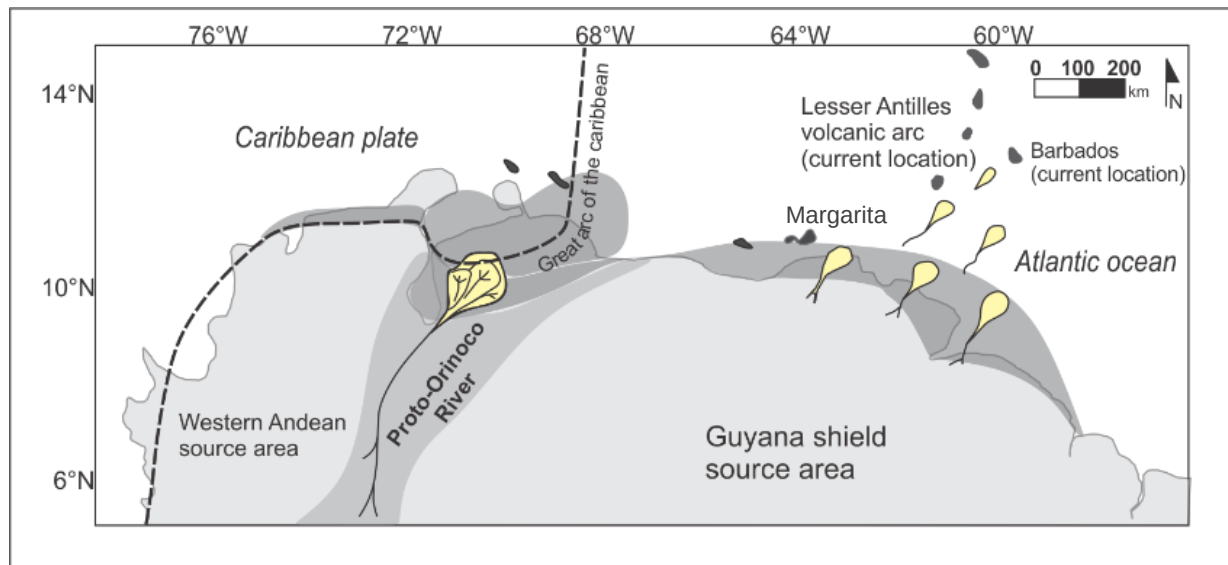


Figure 5. Sedimentation model of the Scotland Formation in the Early Eocene. Notice the big delta from the proto-Orinoco River in western Venezuela, and the displacement of these sediments eastward on the Caribbean plate to their current location on Barbados Island (after Xie et al., 2010).

However, there is stratigraphic and paleontological evidence against this hypothesis. The existence of the Early Miocene molassic deposits of the Palmar Formation on the north flank of

the Mérida Andes suggests that no major river flowed from the south to the Maracaibo Basin (Villamil, 1999). In addition, vertebrate fossils at the south end of the Falcon Basin suggest a subtidal shallow marine environment, which conflicts with the presence of major rivers crossing this area by Early Miocene (Rincón et al., 2014).

Additionally, recent studies in the Los Llanos Basin and Magdalena Valley in eastern Colombia have shown a close relation between the Andes uplift and the dynamic sedimentation patterns within the adjacent basins. U-Pb detrital zircon geochronological data from Mesozoic units show mainly Neoproterozoic to Archean ages that were probably sourced from the Guyana Shield. In contrast, Cenozoic deposits show a clear shift in age populations, displaying Paleozoic to Late Mesozoic ages indicating the influence of Andean uplift and the consequent denudation process (Bayona et al., 2008; Horton et al., 2010; Nie et al., 2010; Bande et al., 2012; Horton et al., 2015)

2.3 Potential sediment sources

The northern South American plate exposes numerous terranes with diverse lithological and geochronological characteristics that could be potential sediment sources for the Barinas and adjacent basins (Fig. 2). These terranes can be divided into three main groups: the Precambrian basement of the Guyana Shield, the Andean orogenic belt in Colombia, including the Central and Eastern Cordillera, and the Mérida Andes in Venezuela.

The Guyana Shield, the oldest geological terrane in South America, is subdivided into six major provinces accreted to an Archean nucleus (Fig.2 and 6). These provinces include 1) the *Central Amazonia* (>2.3 Ga) including the Imataca Complex in eastern Venezuela; 2) *Maroni-Itacaiúnas* (2.2-1.9 Ga) including the Pastora and Butanamo Complexes; 3) *Ventuari-Tapajós* (2.0-1.8 Ga), including Cuchivero Complex; 4) *Rio Negro-Juruena* (1.8-1.5 Ga), including the

Parguaza Granite; and the last two, the *Rondonia* (1.5–1.3 Ga.) and *Sunsas* Provinces (1.3-1.0 Ga) located further south in the eastern part of Bolivia. (Teixeira et al., 1989; Tassinari and Macambira, 1999; Cordani et al., 2000; Mendoza, 2012)(Fig. 2 and 6). These terranes have been exposed since the Paleoproterozoic, with the first depositional evidence in the Roraima Supergroup (1.87-1.3 Ga) (Santos et al., 2003). Additional geochronological studies show evidence of multiple collisional orogenic episodes and rift events along the western edge of the craton that have been overprinted by Andean orogenesis. These collisional episodes would include the Meso-Neoproterozoic Putumayo orogen (~1000 Ma) (Kroonenberg, 1982; Cordani et al., 2005; Ibañez-Mejía et al., 2015), a source for a very common detrital zircon age population in northern South America, and scattered evidence for the western equivalents of the Pan-African-Brasiliano orogeny, which is now buried beneath the Andean foreland basin (Chew et al., 2007).

The Colombian Andes include the Eastern, Central, and Western Cordilleras (Fig. 2). The Central Cordillera consists of a Paleozoic low- to medium-grade metamorphic basement (Cajamarca Complex), which records two main metamorphic events at ~ 410 to 380 Ma and 300 to 250 Ma, followed by intrusions of Permo-Triassic granites (280-230 Ma), and emplacement of Jurassic (170-150 Ma), Late Cretaceous (120-70 Ma) and Paleogene (60-40 Ma) intermediate to felsic volcanic and plutonic rocks (Toussaint and Restrepo, 1982; Aspden and McCourt, 1986; Aspden et al., 1987; Restrepo-Pace, 1992; Restrepo-Pace and Cediél, 2010; Cediél et al., 2003) (Fig. 6). Such intrusions are related to the Nazca plate subduction in western South America. Additionally, Early Paleocene intrusions and volcanic rocks related to a relatively short period of of subduction of the buoyant Caribbean Plate beneath South America have been described in the Central Cordillera and the Santa Marta Massif (Bayona et al., 2012).

The basement of the Eastern Cordillera is a Meso-Neoproterozoic granulite belt related to the Putumayo orogenic event and is divided into the Garzón Massif in the south, and the Santa Marta Complex in the north (Kroonenberg, 1982; Altenberger et al., 2012; Ibañez-Mejia et al., 2015) (Fig. 2 and 6). This belt ranges from ca. 1.25 to 1.08 Ga and is intruded by Early Paleozoic plutons such as the Floresta and Quetame massifs with reported ages in the 477-482 Ma range (Horton et al., 2010), which could be related to the Famatinian orogeny in the central Andes (Dalla Salda, 1987; Forero-Suarez, 1992; Cooper et al., 1995; Cardona et al., 2010). On top of the basement, the sedimentary cover exposes thick sequences of Jurassic to Lower Cretaceous synrift volcanic and passive margin deposits (Jaillard et al., 1990).

The Santander Massif could be considered as the northern extension of the Eastern Cordillera, and it has the same Mesoproterozoic basement, with two different groups of granitoid intrusions, emplaced in the Early Paleozoic and Late Permian (van der Lelij, 2013). A singular characteristic that could set it apart from the Eastern Cordillera potential sources is the widespread Jurassic magmatic rocks from the Santander Plutonic Group related to the break up of Pangea.

The Western Cordillera is composed of a Cretaceous tholeiitic accretionary island arc sequence (100-75 Ma), which is part of the Caribbean Large Igneous Province (Toussaint and Restrepo, 1982; Aspden and McCourt, 1986; Cedié et al., 2003). However, it is unlikely that detrital grains from this western mountain range would have directly contributed to the Táchira Saddle, as the Central Cordillera would have presented a natural barrier for sediment delivery to the Táchira Saddle.

The Mérida Andes basement is composed of two different terranes. The first is a Cambrian–Lower Ordovician metamorphic basement known as the Bella Vista Suite (500–475 Ma) (Burkley, 1976) overlain by clastic Ordovician-Silurian strata (Caparo and El Horno

Formations). The second one consists of 1.2 Ga high-grade gneiss and schist derived from sedimentary protoliths and is known as the Iglesias Complex, which is overlain by Upper Carboniferous metasedimentary rocks of the Mucuchachi Complex. These terranes are intruded by two sets of Ordovician and Devonian plutons, for instance, the Timotes Granite dated at 445.2 ± 3.9 Ma or the La Grita Diorite dated at 471.8 ± 4.0 Ma, and a set of Triassic granitoids (248-230) (van der Lelij, 2013). Detrital zircon ages for these terranes show a correlation with Paleozoic strata in the Eastern Cordillera of Colombia, which presents a wide range of ages between Neoproterozoic and Late Devonian (Dugarte, 2012).

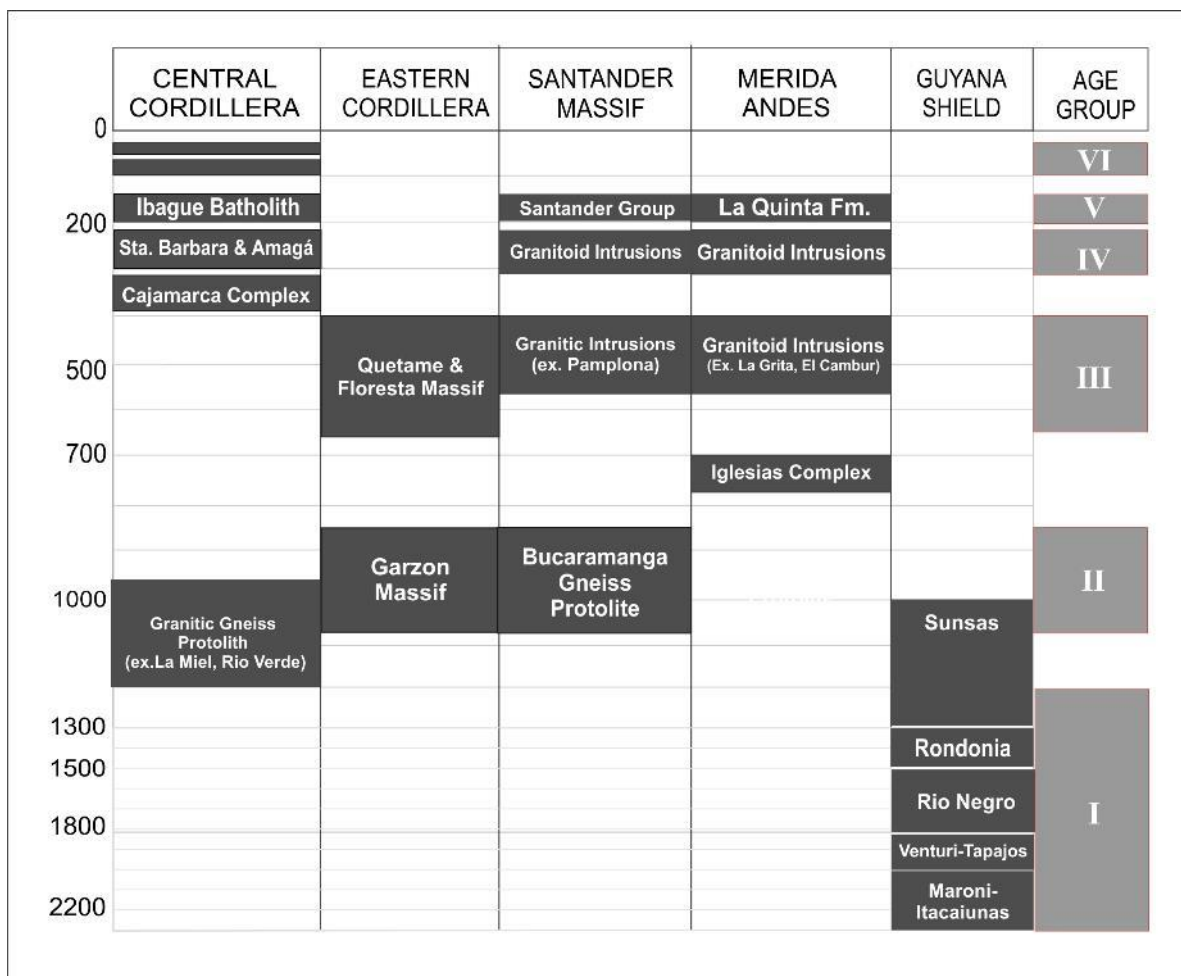


Figure 6. Compiled ages for potential sediment sources in northwestern South America (see detailed references in text)

2.4 Regional provenance studies using heavy mineral suites

Heavy mineral studies have made important contributions to the analysis of sedimentation patterns associated with tectonically active hinterlands, based on their efficacy to trace sediment transport paths as well as to constrain provenance (Morton, 1985). The zircon, tourmaline, and rutile (ZTR) index has been related to the stability of the minerals, showing higher values for cratonic sources, where most of the unstable minerals, like olivine, pyroxene, hornblende, epidote, etc. have been dissolved or altered over time by diagenetic processes (Pettijohn et al., 1987).

Hoorn et al. (1995) describe the heavy mineral fraction in sediments from the Guyana Shield to consist of stable minerals such as zircon, tourmaline, and opaque phases. This stable heavy-mineral suite and the ubiquitous presence of quartz indicate a very mature sediment composition. In contrast, unstable heavy-mineral suites (epidote, garnet, chloritoid, etc.) are commonly derived from the younger orogens and have been reported in the Proterozoic Andean terranes.

A study in the Maracaibo Basin shows a correlation between the heavy-mineral assemblages and the evolution of the stratigraphic sequence in western Venezuela (Feo-Codecido, 1956). The heavy-mineral assemblages include a basic suite of zircon, tourmaline, ilmenite, and rutile, with three further categories representing the addition of increasingly complex mineral suites. The presence of staurolite, actinolite, and magnetite defines the second category, garnet and chloritoid define the third bracket, and epidote, zoisite, and clinozoisite the fourth category. In general, the younger formations tend to have more complex assemblages than the older formations.

Similarly, a regional study in the islands of Trinidad and Barbados northeast of South America shows a clear shift of heavy mineral assemblages between Cretaceous and Tertiary sediments, which has been interpreted as being related to a shift in the sediment sources connected

with the Andean orogeny and the interaction between the Caribbean and South American plates (Pindell et al., 2009; Vincent et al., 2014). Three different heavy-mineral assemblages were used in such work. The first is an ultra-stable mineral assemblage, with > 90% of translucent minerals like zircon, tourmaline, and rutile (ZTR) in the Paleogene samples. The second assemblage also contains the ultra-stable minerals but also shows the common presence (>20%) of chloritoid, staurolite, apatite, chlorite, and garnet. This assemblage is described in Upper Eocene to Middle Miocene samples. The third assemblage is characterized by <50% of ultra-stable (ZTR) minerals, with abundant epidote and chlorite (~ 40%) and a variety of other unstable minerals, including actinolite, sillimanite, kyanite, andalusite, hornblende, apatite, staurolite, chloritoid, and biotite. This assemblage is described in Late Miocene to Pliocene sediments. Moreover, potential source areas were linked to heavy mineral suites in sandstones across central and eastern Venezuela, and the islands of Trinidad and Barbados (Pindell et al., 2009). Staurolite, kyanite, and andalusite are associated with the Iglesias Complex in the Mérida Andes (Fig. 6); meanwhile, a distinctive suite of sillimanite/andalusite is more closely related to the Garzón Massif in the Eastern Cordillera and the Central Amazonia province in the Guyana Shield (Fig. 6). In a more localized study, Morton and Johnsson, (1993) examine heavy mineral assemblages in modern sediments from the Apure River in the Barinas Basin. A major difference between the assemblages coming from different sources is described between the Táchira Saddle and northern Mérida Andes. The Táchira Saddle sources show prominently ultra-stable minerals (the ZTR suite), consistent with the abundant unmetamorphosed and relative mature sedimentary sequences present in the area. In contrast, the heavy mineral assemblage coming from the northern Mérida Andes contains epidote, calcic amphibole, garnet, staurolite, and sillimanite, which reflects the presence of the high-grade gneissic Iglesias Complex

3. METHODS

Six sandstone samples were collected from outcrops of Cretaceous to Pliocene strata at La Alquitrana in the Táchira Saddle (Table 1, Fig. 7 and Appendix 3). These samples were analyzed by U-Pb detrital zircon geochronology and XRD for heavy mineral identification. Two factors make the La Alquitrana area one of the best places for the study. First, the Táchira Saddle is located between the Maracaibo and Barinas Basins and separates the Eastern Cordillera from the Mérida Andes. Second, the stratigraphic relationships in the field are clear, where the Mio-Pliocene molassic sediments of the La Copé Formation overlie uncomfortably a folded Cretaceous-Oligocene sequence (Macellari, 1984).

Table 1. Samples from Táchira Saddle (Coordinates are in UTM WGS84-19 N)					
SAMPLE	Coordinates		Unit name	Depositional age	Description
	E	N			
TA-01	792937	847733	Upper Member La Copé Formation	Mio-Pliocene	Fine-grained quartz sandstone/ distal fan-fluvial
TA-02	793648	846307	Carbonera Formation	Early Oligocene	Fine-grained micaceous sandstone/ deltaic plain
TA-03	793950	845054	Mirador Formation	Eocene	Medium-grained, cross-bedded sandstone/ main fluvial – point bar
TA-04	800561	844252	Lower Member La Copé Formation	Early Miocene	Lithic conglomerate/ proximal alluvial fan
TA-05	803141	847840	Barco Formation	Paleocene	Interbedded shale & sandstone/ deltaic plain
TA-06*	809141	847685	Lower Member La Copé Formation	Miocene	Lithic conglomerate/ proximal alluvial fan. <i>*(This sample was not used to provenance analysis because of it is oil impregnated)</i>
TA-07	823150	838737	Aguardiente Formation	Cretaceous (Albian)	Quartz sandstone/ passive margin

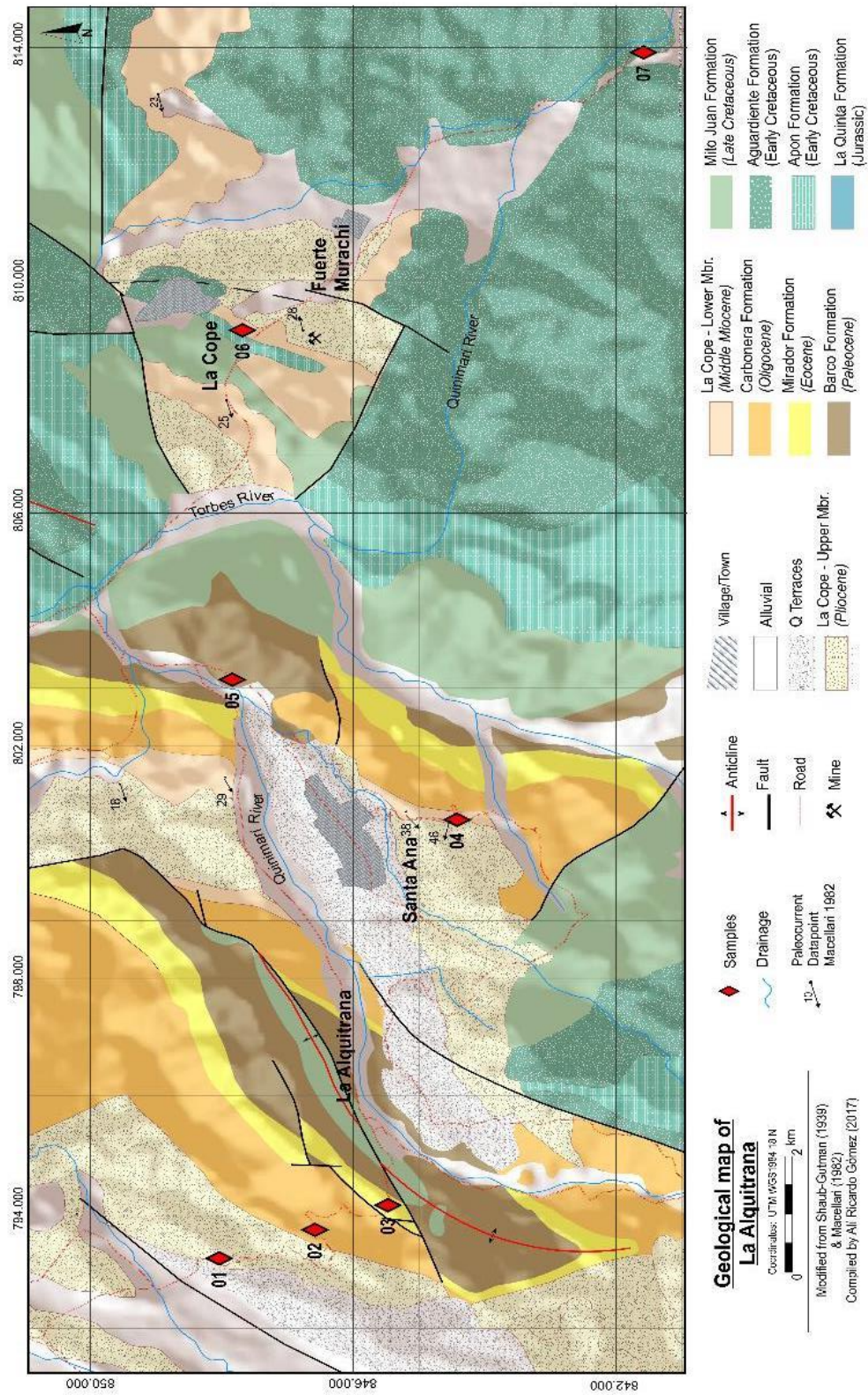


Figure 7. Geological map of Táchira Saddle showing sample locations. Arrows represent paleocurrent directions acquired by Macellari (1982) (Modified from Schaub-Gutman, 1939 and Macellari, (1982)).

3.1 Heavy mineral separation

Each sample was crushed into small pieces using a rock hammer and then ground into a fine sand-sized particles with a disc mill. Next, the sample was washed to separate the light minerals from the heavy minerals using a prospector pan. After drying, the sample was sieved to remove grains greater than 350 μm . Later, magnetic minerals were removed using a Frantz LB-1 magnetic separator in two different electromagnetic magnitudes, 1.0 Amps, and 1.5 Amps. The non-magnetic portion was used to extract zircons using heavy liquids.

In this study, the separation of heavy minerals was useful for two purposes: i) to extract detrital zircon grains for U-Pb detrital zircon geochronological analyses, and ii) to identify heavy mineral assemblages. Two types of heavy liquids were used, methylene iodide (MI) with a density of 3.325 g/cm^3 , employed to separate only zircon grains, and lithium metatungstate (LST) with a density of $\sim 2.95 \text{ g/cm}^3$, used to get the complete heavy mineral suite. The heavy fraction for U-Pb detrital zircon isotopic analyses was manually picked and examined under a binocular microscope to further remove non-zircon grains.

3.2 U-Pb Detrital Zircon Geochronology

U-Pb detrital zircon geochronological analyses were conducted at the Arizona LaserChron Center, University of Arizona, following the lab standard procedure (Gehrels et al., 2006; Gehrels et al., 2008). The separated detrital zircon grains were mounted with epoxy onto a 25-mm-diameter puck with three standards, Sri Lanka ($563.5 \pm 3.2 \text{ Ma}$), FC-1 ($1099 \pm 2 \text{ Ma}$), and R33 (419.3 Ma) (Black et al., 2003; Coyner et al., 2004). All pucks were sanded down to a depth of $\sim 20 \mu\text{m}$, cleaned, polished, and then imaged prior to isotopic analyses. All laser spots were selected using both a standard plane binocular microscope and Scanning Electron Microscope (SEM) backscatter images to avoid any cores, inclusions, and fractures (Fig. 8).

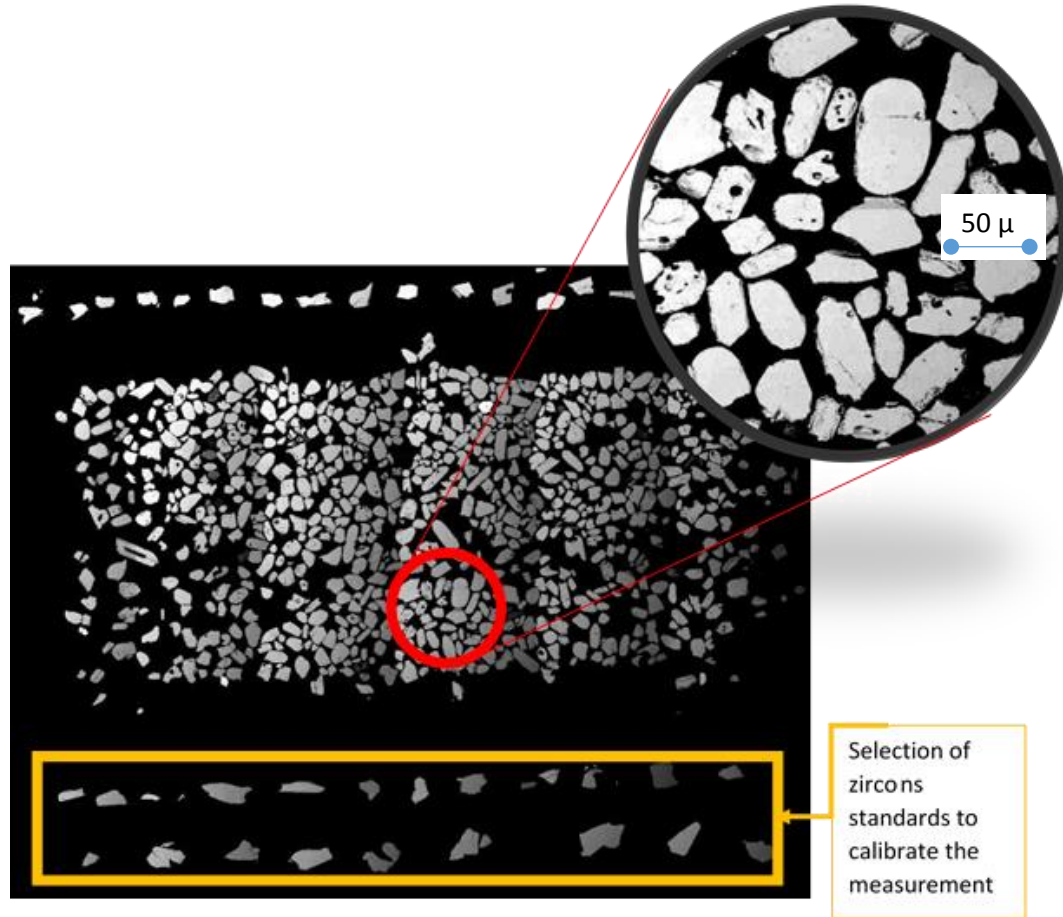


Figure 8. Backscattered electron images of selected zircon crystals used from Sample Ta-03.

The isotopic analysis was performed using a laser-ablation multi-collector that consists of a photon laser connected to an Inductively Coupled Plasma Mass Spectrometer (LA-MC-ICP-MS) (Gehrels et al., 2006; Gehrels et al., 2008). The process utilizes a Photo Machine laser that ablates the sample in a spot with a diameter of $\sim 30 \mu\text{m}$. The ablated matter is carried by helium gas to a plasma source inside the multi-collector mass spectrometer, which is capable of simultaneously measuring the U, Th, and Pb isotopic ratios. Each analysis consists of one 20-second iteration with the laser off, a 20-second iteration with the laser firing, and a 30-second delay to purge the previous

measurement and to prepare for the next grain. This results in ~90 seconds per grain and ~40 grains per hour. For each sample, we analyzed 100–300 zircon grains.

Grains that exhibit >20% discordance, >5% reverse discordance, and/or >10% uncertainty are not included in the final interpretation. Both normal and Tera-Wasserburg U-Pb Concordia diagrams are to identify discordant analysis (Fig. 9). For final results, $^{206}\text{Pb}/^{238}\text{U}$ ages are chosen for grains younger than 900 Ma, and $^{207}\text{Pb}/^{206}\text{Pb}$ ages for grains older than 900 Ma. All ages are plotted as relative age-probability diagrams using Isoplot 3.7 (Ludwig, 2003) (Fig. 10)

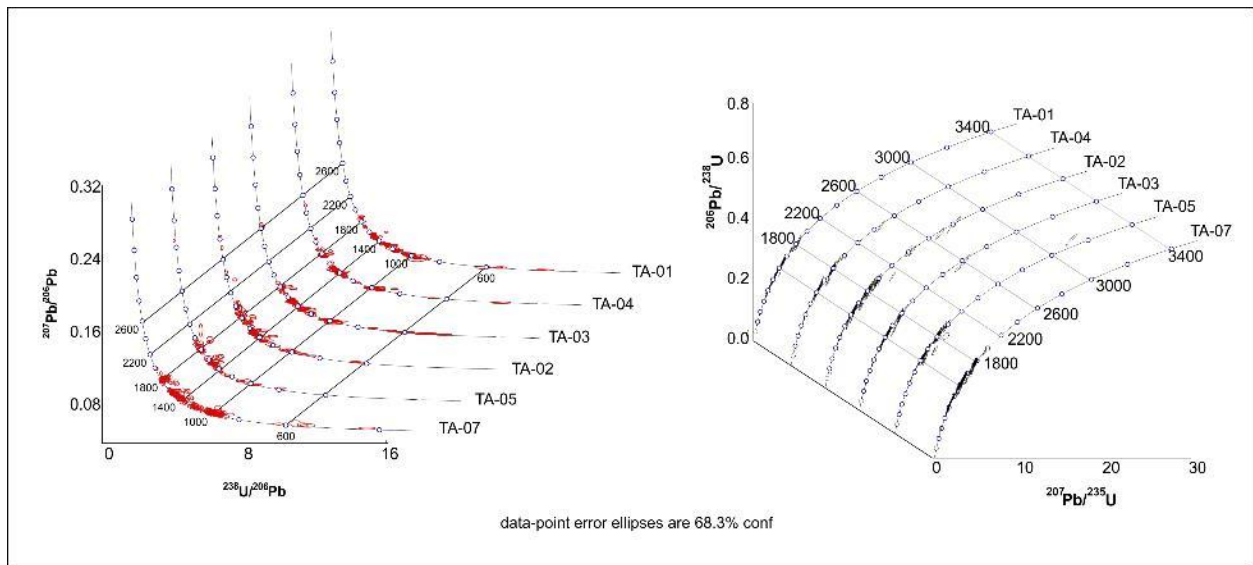


Figure 9. U-Pb detrital zircon geochronology shown on normal(right) and Tera-Wasserburg (left) Concordia plots of six sandstone samples from the Táchira Saddle.

3.3 Heavy mineral X-ray diffraction

XRD analyses were performed on the complete heavy mineral concentrate separated from the five Cenozoic samples with the idea of identifying the mineral phases throughout the sequence and recognizing potential variation in the heavy mineral suite. For each sample, 15 mg of the separated heavy mineral portion were ground into a < 150 μm fraction using a ceramic mortar. The powdered sample was loaded into a vibrating sample holder that reduced the potential for preferred

orientation effects (Sarrazin et al., 2005). The samples were analyzed at Texas Christian University using an Olympus Terra mobile XRD System with CoK α radiation and a data collection range of 10° to 55° 2 θ using a step size increment of 0.25°.

XRD synthetic patterns were analyzed using PANalytical's X'Pert High Score interpretation software. The mineralogical phases were identified by coupling the software with the PDF-2 mineral database version from the International Centre for Diffraction Data (ICDD). The relative abundance of individual mineral phases was calculated using the Reference Intensity Ratios (RIR) method, which allows calibration of an unknown sample against the standard pattern of each mineral (Chung, 1974). Any unidentified or amorphous phases are excluded from the quantification method and are not reflected in the total amount, and therefore, the quantitative result is relative and should be interpreted as relative proportions of certain heavy mineral in the samples.

4 RESULTS

4.1 U-Pb detrital zircon geochronology

Approximately 800 individual grains were analyzed from the six sandstone samples from the Cretaceous–Pliocene sequence in the Táchira Saddle area, and a total of 764 grains yield less than 20% discordance and 5% reverse discordance. The U-Pb detrital zircon ages show a wide range between Archean and Early Paleocene (2400–54 Ma). Based on the Mesozoic–Cenozoic geological framework of the northern Andes, the age results can be divided into five different age groups (Fig. 10).

Group I, which represents 64% of overall ages in all samples, is dominated by Paleo- and Mesoproterozoic ages with two main peaks at ~1800 Ma and ~1500 Ma. *Group II*, represents almost 30% of our grains with age peaks between 900–1200 Ma. *Group III* zircons have Late

Neoproterozoic to Early Paleozoic ages, including Ediacaran (550–635 Ma), Cambrian (500–540 Ma), Ordovician (450–460 Ma), and Devonian (410–420 Ma) intervals. *Group IV* is associated with Permo-Triassic ages (230–260) Ma, *Group V* is associated with Late Triassic–Jurassic ages (145–200 Ma) and *Group VI* is made up of Late Cretaceous (73–88 Ma) and Paleogene (~55 Ma) populations.

Cretaceous Aguardiente Formation

The Lower Cretaceous Aguardiente Formation (sample: Ta-07, n=275) is the oldest sample of this study. It contains mostly Precambrian ages with *Group I* being the dominant population, representing ~54% of all the grains with two peaks at 1350 and 1800 Ma. Another 44% is related to *Group II* (Fig. 10). There is also a significant scarcity of Phanerozoic ages with only 2% of the grains related with *Group III*, with Early Devonian (415 Ma) and Cambrian (539 Ma) ages.

Paleocene Barco Formation

The Paleocene Barco Formation (sample: Ta-05, n=94) shows the majority of the ages (91%) to fall within the *Group I*. This sample also shows a noticeable reduction of the *Group II* population (5%) compared with the Cretaceous Aguardiente Formation and a minor presence of Late Cretaceous peaks from *Group V* (~3%).

Eocene Mirador Formation

The Eocene Mirador Formation (sample Ta-03, n=103) shows a much more complex age distribution than the previous samples. The Precambrian ages from *Group I* (~65%) remain as the largest age group. This sample also contains all the Mesozoic and Cenozoic age groups but shows distinctive characteristics in comparison with underlying units (Fig. 10). For example, 15% of the

grains are from the age *Group II*, which represents a 10% increase from the Paleocene Barco Formation. There is also a notable number, almost 7%, of Permo-Triassic grains from *Group IV*; and another 7% is represented by Devonian to Ediacaran peaks from *Group III*. Just a few grains of Paleocene and Late Cretaceous ages are from *Group VI* (3%). Jurassic ages from *Group V* also make 3% of the population

Lower Oligocene Carbonera Formation

The Lower Oligocene Carbonera Formation (sample: *Ta-02*, n=94) shows an age distribution dominated by *Group I* with almost 90% of the grains; the rest of the grains are distributed between *Group II* ages with 8% of the population and just a few grains (~2%) of *Group III* and *Group VI* (Fig. 10).

Mio-Pliocene La Cope Formation

The distribution of both members of La Cope Formation show very contrasting age signatures. The lower Miocene sample from the lower member of La Cope Formation (sample: *Ta-04*, n=99) displays a dominant population of Proterozoic ages of *Group I* (75%) and an increased proportion of Greenville ages of *Group II* (23%) from the underlying Carbonera Formation. The rest of the grains (2%) is related to *Group III* ages. In contrast, sample *Ta-01* (n=98) from the Pliocene upper member of La Cope Formation shows dominant ages from Precambrian *Groups I* (55%) and *Group II* (~28%). There is also the reappearance of Phanerozoic peaks including a Late Triassic-Jurassic age peak from *Group V* (~8%) and early Paleozoic and Ediacaran *Group III* (~6%) grains as well as Cretaceous-Paleogene *Group VI* grains (~3%). The age distribution in this youngest sample is comparable with the Eocene Mirador Formation spectra although age *Group IV* is absent (Fig. 10).

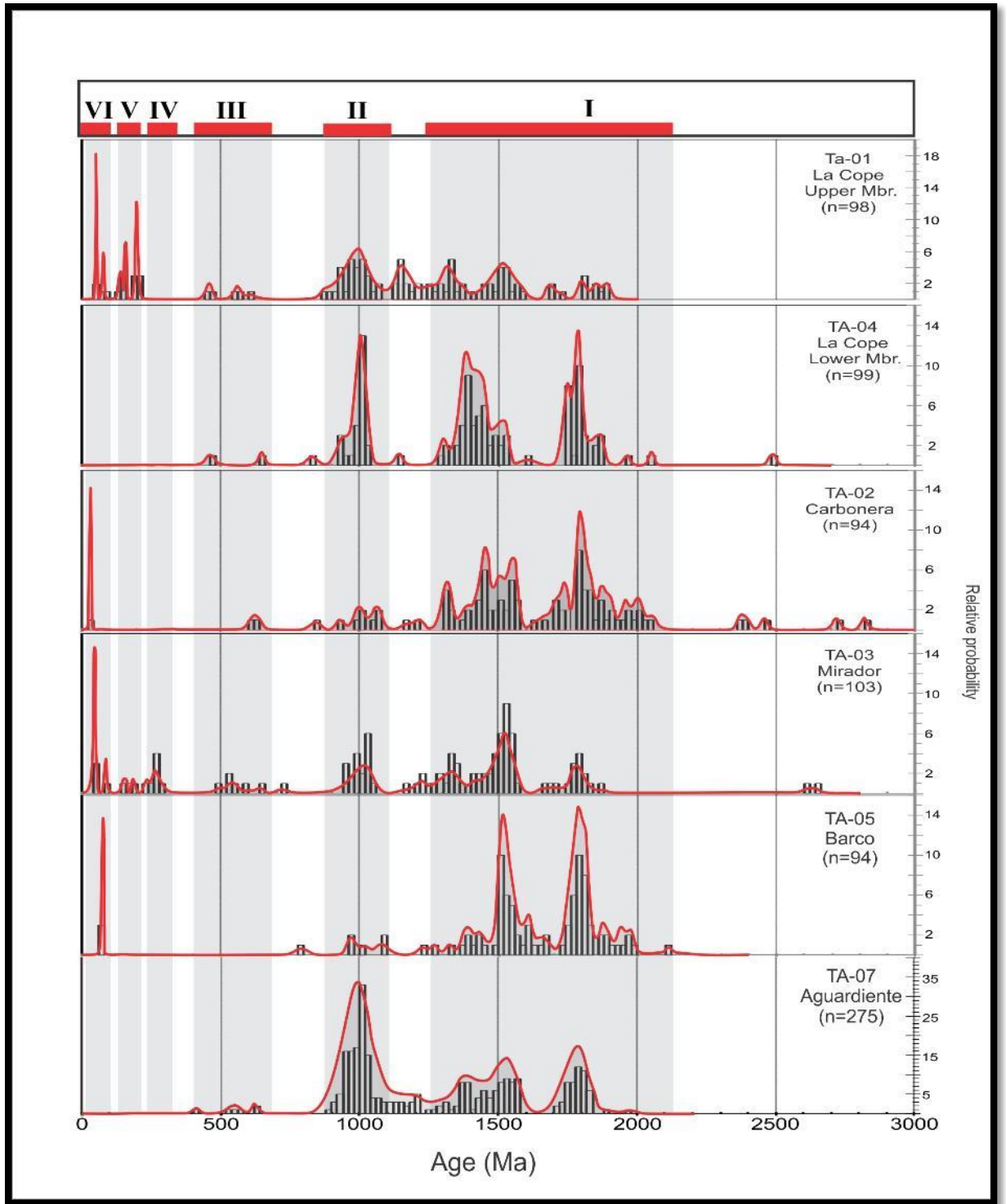


Figure 10. U-Pb detrital zircon geochronology relative probability plots of six samples from the Táchira Saddle. Roman numbers I to IV represent age groups referred in section 4.1.

4.2 X-Ray diffraction results of heavy mineral suites

Results of X-ray diffraction of the five samples show that the heavy mineral suites become gradually more variable toward the upper part of the sequence (Fig. 11). The heavy mineral suite identified in the older units of the Paleocene Barco Formation and the Eocene Mirador Formation consists of three ultra-stable minerals: quartz (Qz), zircon (Zr), and rutile (Ru). The estimated proportion in the Paleocene Barco Formation are 65% Qz, 15% Ru and 20% Zr, and in the Eocene Mirador Formation the proportions are 81% Qz, 10% Ru and 9% Zr. In the Lower Oligocene Carbonera Formation, tourmaline is incorporated into the heavy mineral suite, representing 34% of the sample. Quartz remains the major mineral phase with 60% and similar proportions of Ru (9%) and Zr (8%) are still present.

The Miocene lower member of La Cope Formation shows an increase in the Qz to 72%, and there is also the new presence of magnetite (4%) and tourmaline (16%), along with Ru (5%) and Zn (3%). Finally, the Pliocene upper member of La Cope Formation shows a different composition. This sample contains a significant proportion of staurolite (49%) and chloritoid (12%) alongside with Qz 35 % and Zr 4%; however, rutile and tourmaline are not identified in this sample.

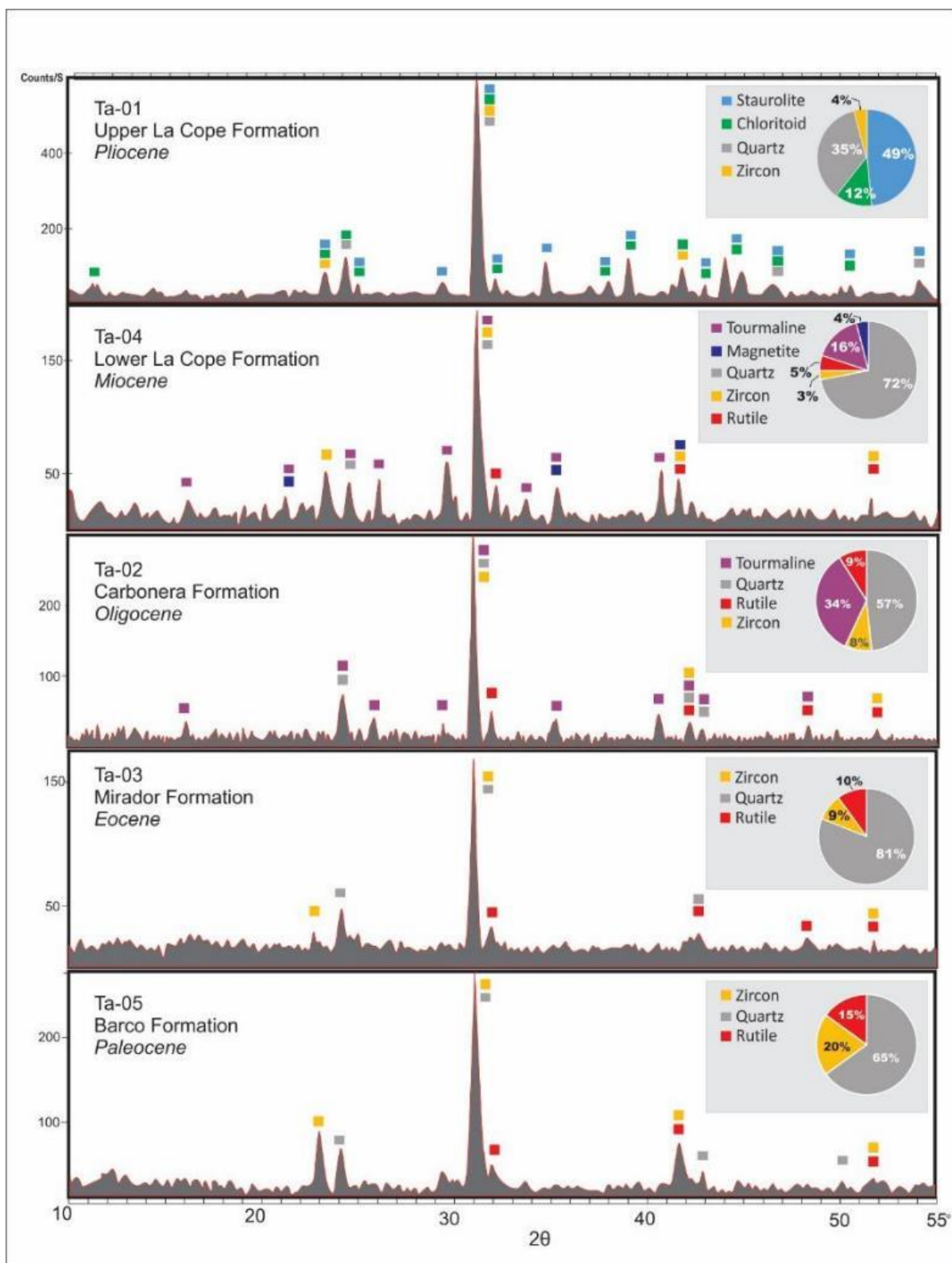


Figure 11. Diffractograms of the heavy mineral fraction of Cenozoic samples in the Táchira Saddle.

5 DISCUSSION

U-Pb detrital zircon geochronology results of the six samples from the Táchira Saddle show that sediment sources have two main characteristics. First, the Precambrian Guyana Shield terranes and the Neoproterozoic Putumayo terrains were the original sources of most zircon grains of the six samples. However, a representative proportion of Phanerozoic ages indicates the influence of the Central Cordillera terranes in the Paleocene and Eocene. Second, Oligocene and Eocene detrital zircon age spectra show comparable age signatures to Paleocene and Cretaceous samples. Such pattern could be explained by a sediment recycling process during different stages of the uplift in the Eastern Cordillera and Mérida Andes. Additionally, the XRD data demonstrate a transition from an ultra-stable heavy mineral suite to more complex heavy mineral suites towards the upper part of the sequence, including metamorphic minerals in the Pliocene samples that imply the exposure of a metamorphic basement on the Merida Andes.

5.1 Sediment provenance in the Táchira Saddle region

By comparing results to surrounding potential sources and previously published data in northern South America, the detrital zircon ages of the Táchira Saddle sediments overlap with all major potential sources (Nie et al., 2010; Xie et al., 2010; Bande et al., 2012; Horton et al. 2010, 2015; Cardona et al., 2016) but show distinctive changes in ages through time (Fig. 6).

Group I defined by Paleoproterozoic and Mesoproterozoic ages, represents the most dominant population with 67% of occurrence. These ages are generally associated with the major provinces in the Guyana Shield region. The two main peaks of this group (~1800 Ma and ~1500 Ma) can be correlated with the Venturi-Tapajos and Rio Negro provinces of the Guyana Shield. Another possible source for these ages is the recycling of previous sedimentary units, including

the Cretaceous passive margin sequence, that should have been re-exposed during the Cenozoic andean orogeny.

Group II makes up the second highest proportion of detrital zircons with 25% of the total ages. Several possible southern sources can be linked to this population. The Guyana Shield Sunsas province, located in the west edge of the Amazonian craton of Bolivia, is probably too far south to be able to reach our basin (Cordani et al., 2005). The Putumayo basement inliers scattered in the Santander Massif and the Eastern Cordillera, including the Garzón Massif, would be a closer potential source (Kroonenberg, 1982; Restrepo-Pace et al., 1997; Ibañez-Mejía et al., 2015). Another option might be sediment recycling from Paleozoic and Mesozoic strata in the Eastern Cordillera or Mérida Andes (Dugarte, 2012).

The *Group III* population could represent several episodes of Early Paleozoic intrusions in the basement of the Eastern Cordillera, Santander Massif and Merida Andes. Some modern exposures are the Quetame and Floresta massif in the Eastern Cordillera. It is also possible that some grains, including the older Ediacaran grains, were recycled from preexisting sedimentary rocks. Previous studies have reported similar detrital zircon signatures from Upper Paleozoic and Jurassic strata in the Eastern Cordillera, Merida Andes and Magdalena Valley (Horton et al., 2010; Nie et al., 2010; Dugarte, 2012; Cardona et al., 2016)

The rest of the Phanerozoic populations are related to different plutonic events that have helped shape the evolution of the northern Andes. Permo-Triassic ages of *Group IV* have been reported in the Central Cordillera as post-collisional magmatism, including plutons like the Santa Barbara batholith and Amagá stock (Fig. 6). The Late Triassic-Jurassic ages from *Group V* are related to syn-rift plutonism and volcanism on the eastern flank of the Central Cordillera recognized in the Santander Massif and the Mérida Andes. The younger age *Group VI* can be

related to the Cretaceous and Paleogene subduction and related plutonic events of the Central Cordillera terranes (~70 to 50 Ma).

The results of XRD analysis of the heavy mineral fraction show an increase in the variety stratigraphically upward. In the Paleogene Barco, Mirador, and Carbonera Formations, the heavy mineral suite exclusively reflects significant proportions of ultra-stable mineral including quartz, rutile, and zircon (Morton, 1985) (Fig. 11). These mature sediments with fairly simple mineralogical distributions have been related to the Guyana Shield provinces (Pindell et al., 2009). In contrast, Mio-Pliocene sediments of the La Cope Formation show affinity with metamorphic sources, demonstrated by substantial proportions of staurolite, magnetite and chloritoid, which have been related to metamorphic terranes such as the Iglesias Complex in the basement of the Mérida Andes (Case et al., 1990; Morton and Johnsson, 1993; Pindell et al., 2009).

5.2 Stratigraphic changes in detrital zircon signatures in Táchira Saddle

The detrital zircon signature of the Táchira Saddle suggests that there are at least three changes in dispersal patterns in northern South America. The first major change is the transformation of Mesozoic passive margin to a Cenozoic foreland basin configuration. The foreland basin strata record the first arrival of sediments from the Cretaceous magmatic arc of the Central Cordillera in the Early Paleocene. A second major change occurred in the Early Oligocene when the regional foreland basin that developed during the Early Paleocene was transformed into a more isolated or compartmentalized basin separated by the emerging Eastern Cordillera, Santander Massif, and the Mérida Andes, which is reflected by the disconnection of the Carbonera Formation from Central Cordillera sources. Third, uplift of the Mérida Andes and Eastern Cordillera caused recycling of old strata and culminated with the unroofing of the Mérida Andes and Santander Massif basement by the Pliocene.

5.2.1 Cretaceous - Paleocene

The predominantly Precambrian ages from Group I and II in the Cretaceous Aguardiente Formation deposited in a passive margin setting suggest that the sediments were transported directly from the Guyana Shield area. Comparable signatures have been reported in several Cretaceous samples in northern Venezuela and eastern Colombia (Noguera, 2009; Horton et al., 2010). A comparison between the Cretaceous Aguardiente Formation and Paleocene Barco Formation shows that the 1000 Ma (Grenville/Putumayo) peak changes from 44% of the grains in the Cretaceous sample to less than 10% in the Paleocene sample (Fig. 12). This change indicates that a potential exposure of a Meso-Neoproterozoic terrane occurred in the western edge of the Guyana Shield, probably a northern extension of the Sunsas province or an early exposure of the Garzón Massif by the Early Cretaceous. These terranes should have been covered by the Late Cretaceous passive margin transgression, recorded by the shale of the Mito Juan and Colon Formations, leaving a scarce signature of ~1000 Ma detrital zircons in Paleocene sediments. Another prominent change in the Paleocene signature is the initial influence from the Western Andean sources reflected by the presence of Mesozoic ages from Group VI, implying a connection with Central Cordillera terranes.

5.2.2 Eocene

Overall, the age distribution of the Eocene Mirador Formation reflects a composite signature with more mixed contributions of different sources. A noticeable feature in this sample is the distribution of peaks in all the age groups simultaneously, as well as the unique presence of Permo-Triassic ages *Group IV*, and the first appearance of Jurassic age *Group V* (Fig. 12). This signature would imply a stronger influence of the Central Cordillera terranes including the exposure of the Triassic basement. Another characteristic is that *Group I* grains remain the

dominant age population and there is a noticeable increase of the Grenville/ Putumayo population of *Group II* (15%), probably related to the exposure and recycling of the Cretaceous passive margin strata in the foothills of Central Cordillera.

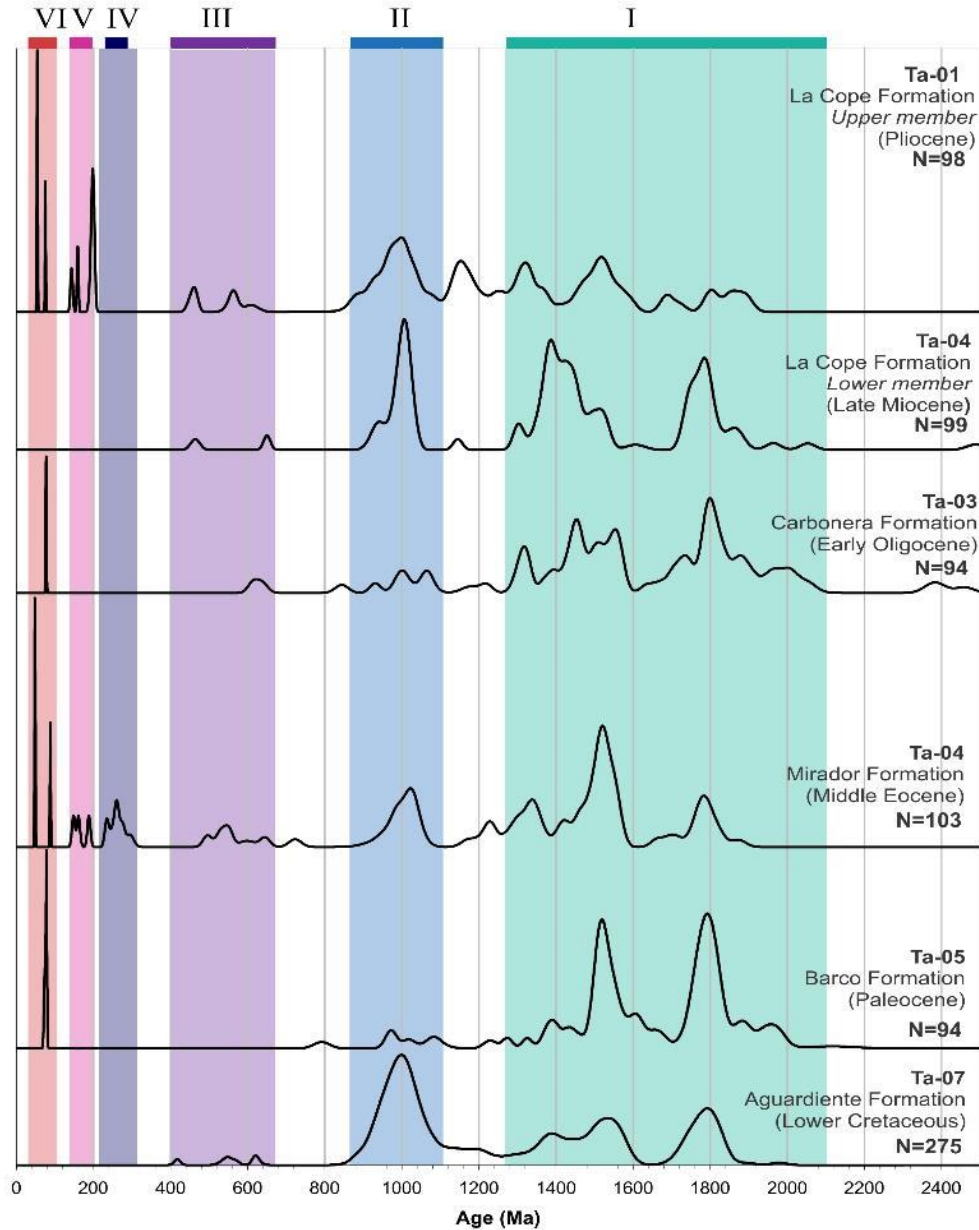


Figure 12. Normalized detrital zircon isotopic ages from the Táchira Saddle. I: Guyana Shield Provinces: Sunsas, Rondonia and Rio Negro, II: Putumayo/Grenville Eastern Cordillera Basement, III: Early Paleozoic Eastern Cordillera and Mérida basement intrusions IV: Andean Permo-Triassic Magmatism, Basement of Magdalena valley and Santander Massif. V: Jurassic Rift deposits VI: Late Cretaceous+ Paleogene intracontinental volcanism related to subduction and magmatic arc.

5.2.3 Early Oligocene

The lower Oligocene deltaic Carbonera Formation shows several variations relative to the underlying Eocene Mirador Formation. The most noticeable changes are the absence of Triassic and a Jurassic peaks (*Group IV and V*), and a comparatively lower presence (< 10%) of Putumayo population (*Group II*) (Fig. 12). These variations reflect a disconnection with western sources from the Central Cordillera, which could be evidence of an initial uplift of the Eastern Cordillera. Also, the similarity of percentage of each age groups with the Paleocene Barco Formation (Fig. 13) could imply that the Paleocene sediments were partially recycled by this initial uplifting into the Oligocene Carbonera Formation.

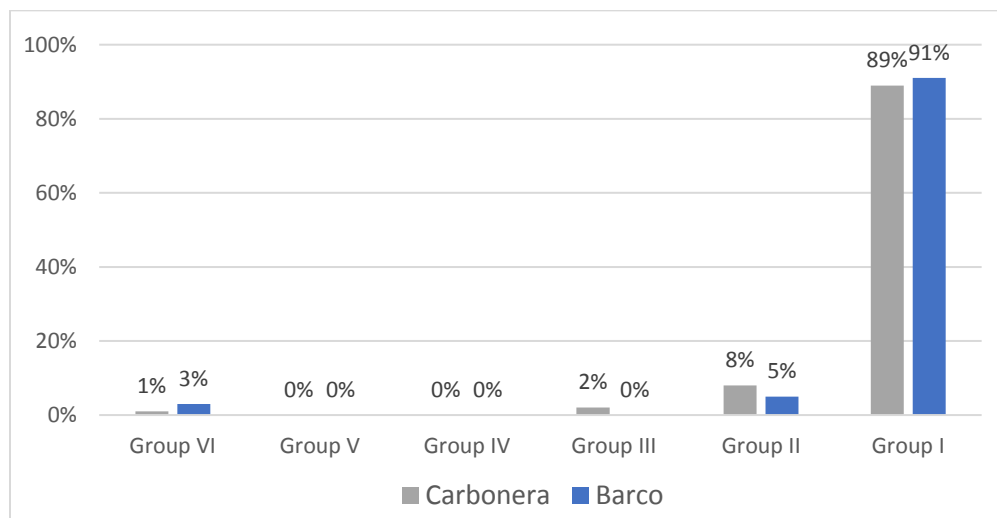


Figure 13. Comparison in group age percentage between Oligocene Carbonera Formation and Paleocene Barco Formation

5.2.4 Miocene-Pliocene

The Miocene-Pliocene La Copé Formation reveals noticeable differences between the lower and upper members of this unit, which could imply two different stages of physiographic changes. The lower conglomeratic member shows mainly Precambrian ages related to the Guyana Shield and with almost no evidence of younger Andean sources (Fig. 12). One of the biggest

differences from the underlying strata is a noticeable increase in Group II ages, and a sharper definition of the 1000 Ma peak. Such a signature could be related to the Eastern Cordillera and Merida Andes uplift, which should represent natural barriers for detritus from Triassic and Jurassic Central Cordillera terranes. In the same way, such uplifting might cause the exposure of the Meso-Neoproterozoic basement of the Eastern Cordillera that could be responsible for the increased *Group II* population. Another possible contribution to the increase in the Group II population is the re-exposure of previously deposited Paleocene and Cretaceous strata in the foothills of the Eastern Cordillera and Merida Andes. A visual comparison between the Early Miocene lower member of La Copé Formation with a combined signature of Cretaceous Aguardiente Formation plus the Paleocene Barco Formation shows broad similarities in the trimodal distribution of the major peaks and the noticeable absence of *Group V* and *VI*.

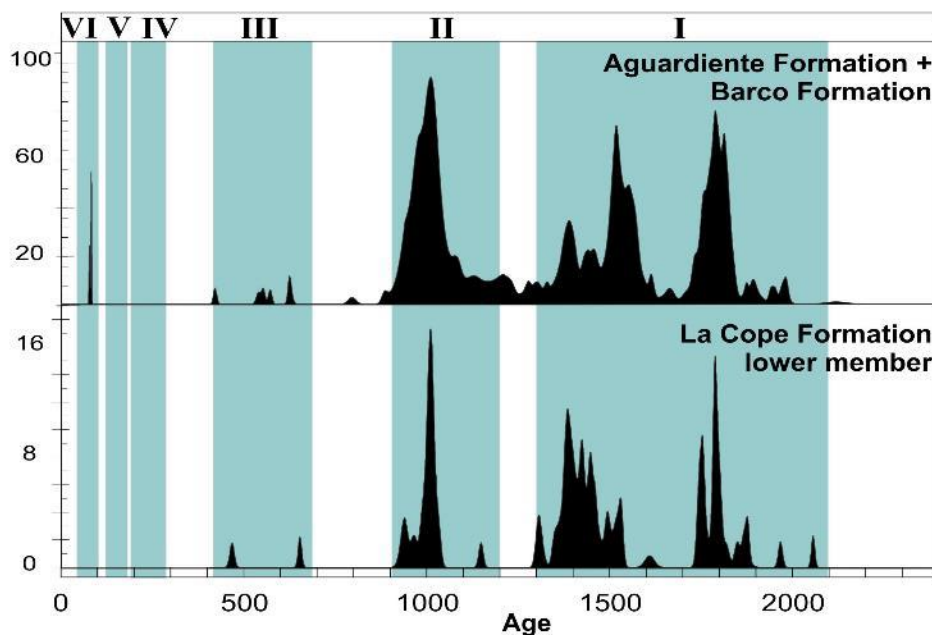


Figure 14. Comparison between the composite signature of the Cretaceous Aguardiente Formation + Paleocene Barco Formation and the lower member of the Miocene La Cope Formation.

Similarly, the upper member of the La Copé Formation seems to reflect the continuous denudation of the Mérida Andes and Eastern Cordillera by the Late Miocene-Pliocene. The resulting composite signature includes a wide range of Precambrian and Mesozoic peaks. The erosion involving the Cretaceous and Paleogene strata might have allowed the unroofing of Mérida Andes basement and caused an increase in the Jurassic ages of *Group V* associated with the Jurassic La Quinta Formation and the corresponding influx of *Group III* ages from Early Paleozoic intrusions.

Furthermore, the XRD data from the upper member of the La Copé Formation seems to confirm the denudation of the Mérida Andes basement. The representative proportion of heavy minerals such as staurolite and chloritoid that could be related to the Iglesias Complex in the basement of the Mérida Andes (Pindell et al. 2009). Additionally, sedimentological and paleocurrent data from the Táchira Saddle have shown that the Miocene-Pliocene sediments of the La Cope Formation were mainly derived from the Mérida Andes area (Macellari, 1984) implying a disconnection from the southern sources. Likewise, thermochronological data have concluded that the Mérida Andes uplift had reached its current elevation by Late Miocene (Mora et al., 2008; Parra et al., 2009; Bermúdez et al., 2017); therefore, it could be exposing the metamorphic basement by the Pliocene.

5.3 Implications on sediment dispersal patterns in northern South America

In an attempt to identify the relationship of the age populations in the Táchira saddle sediments with the ancient paleogeographical settings, a comparison between detrital zircon signatures of this study with other five localities was made. These localities include the Catatumbo Area in southern Maracaibo Basin (Localities C and F, Fig. 15) (Bayona et al., 2006; Ayala et al.,

2012); the Llanos Basin (locality D, Fig. 15) (Bayona et al., 2006; Horton et al., 2010); the Central Maracaibo Basin (locality B, Fig. 15) (Xie et al., 2010); and the Magdalena Valley (locality E, Fig. 15) (Nie et al., 2010).

In the Paleocene, the age distribution in the Táchira Saddle and Llanos Basin shows some similarities, with *Group I* as the dominant population and the presence of younger Late Cretaceous peaks from *Group VI*. However there is a noticeable difference in *Groups III, IV* and *V* which show only in the Llanos Basin samples. In contrast, the Paleocene Lisama Formation in the Magdalena Valley displays a wide range of Phanerozoic ages which would imply a bigger influence from Central Cordillera terranes and local Paleozoic sources.

In the Eocene, the main differences are reflected in the Phanerozoic population and the proportions of age *Groups IV, V* and *VI*. For example, the noticeable absence of younger peaks (<600 Ma) in the sample from the Llanos Basin was related to the position of each sample in the overall foreland basin configuration by the Eocene (Horton et al., 2010; Bande et al., 2012). Deposits from localities A, C and E could be located in the foredeep area of the basin, where they would receive more influx from eroding Triassic and Cenozoic terranes of the Central Cordillera. In contrast, the deposits from the Los Llanos Basin were farther east in the distal zone of the basin, presumably close to the forebulge, preventing the sediments from the Central Cordillera to reach these deposits (Horton et al., 2010; Bande et al., 2012).

In the Early Oligocene, the detrital sample from the Mugrosa Formation in Magdalena Valley shows very distinctive distributions (localities E, Fig. 15). This sample have a stronger influence from the Central Cordillera with age populations from the *Groups IV, V* and *VI*. These differences with the Táchira Saddle sample would imply a separation between the Magdalena Valley and the Táchira Saddle by the initial uplifting of the Eastern Cordillera (Nie et al., 2010;

Ayala et al., 2012; Horton et al., 2015). Also, by comparing the Carbonera Formation sample from the Llanos Basin (Locality D, Fig. 15), some broad similarities might imply a similar paleogeographic configuration. These similarities include the bimodal distribution of *Group I*, the relatively small population of Putumayo grains of *Group II*, and fewer grains with Late Cretaceous ages of *Group VI*. Additionally, the Carbonera Formation in southern Maracaibo Basin (Locality F, Fig. 15) shows a contrasting distribution as well; the *Group I* population is relatively lower, which would imply a lower influence of Guyana Shield terranes; there is also a noticeable population of Jurassic grains, related to the Santander Massif uplift (Ayala et al., 2012).

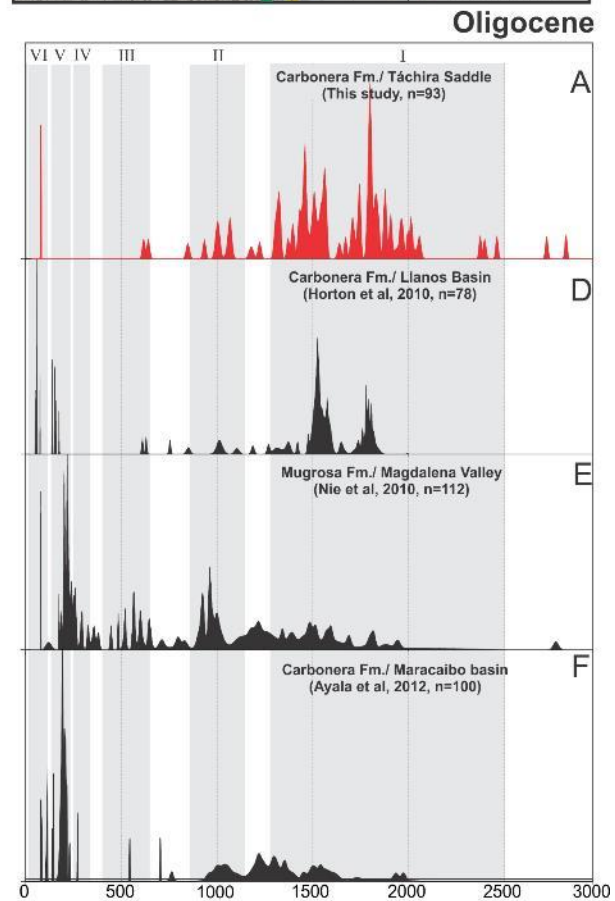
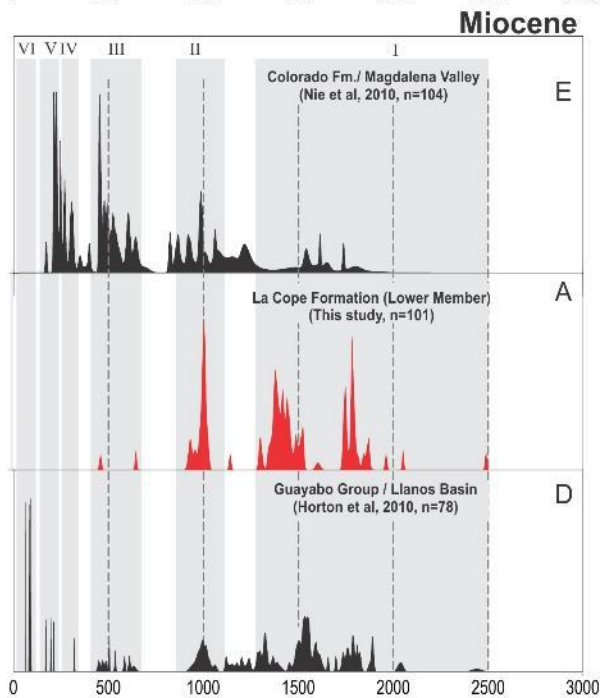
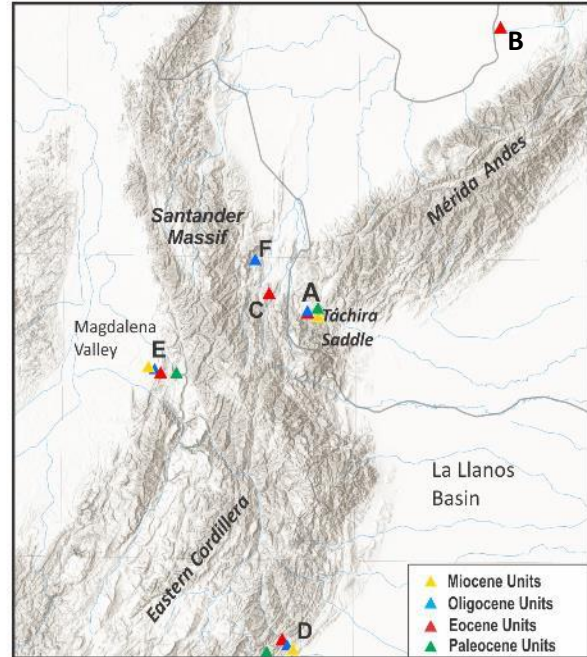
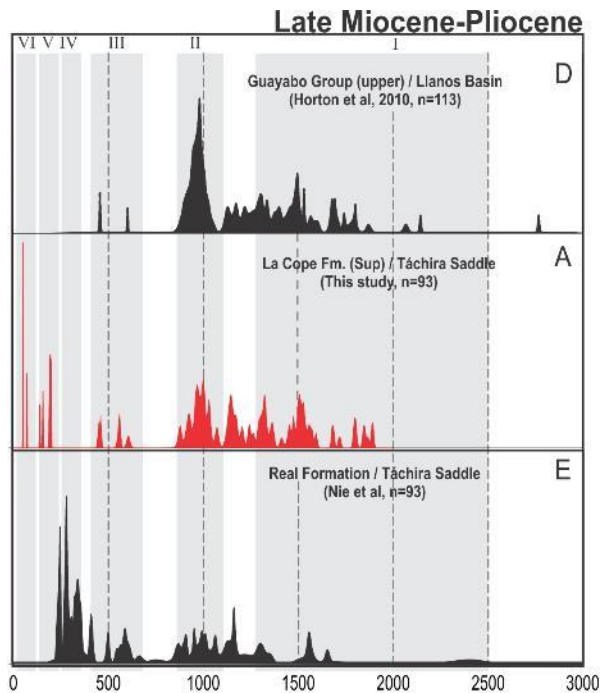
The compartmentalization of basins in the Early Oligocene caused by the uplifting of the Eastern Cordillera and Santander Massif would contrast with the idea of a major fluvial system by Late Oligocene–Early Miocene, as proposed by previous studies (Rod, 1981; Kasper and Larue, 1986; Hoorn et al., 1995; Diaz de Gamero, 1996; Villamil, 1999). The initial uplifting of the Eastern Cordillera and Santander Massif would act as topographic barrier, and consequently deviate the northward course of the proposed Proto-Orinoco River to the east.

By the Early Miocene, the lower member of the La Copé Formation shows a noticeable absence of Mesozoic grains, which contrast strongly with the signatures of the Colorado Formation in the Magdalena Valley and the Guayabo Group in the Llanos Basin. The Colorado Formation shows a noticeable population of Triassic and Jurassic ages from *Group IV* and *V*, related to the Central Cordillera and Santander Massif terranes (Nie et al., 2010). Similarly the lower Guayabo Group mostly shows the presence of mostly all the age groups, including Paleocene, Cretaceous and Jurassic grains of *Groups V and VI*. This composite signature could imply a new connection with Central Cordillera terranes; however, this distribution was interpreted as a result of recycling of previous Paleogene strata by Horton et al. (2010) and Bande et al., (2012). In the same way,

such a process could have happened in the Miocene sediments from the Táchira Saddle, with the difference that the denudation includes the Paleocene and Cretaceous strata.

Finally, comparison of the Pliocene sediments of the La Copé Formation in the Táchira Saddle and the Guayabo Group in the Llanos Basin (localities D, Fig. 15) makes changes in the Phanerozoic age groups noticeable. In the Guayabo Group sample, a major Putumayo peak is the main difference along with the absence of any Mesozoic age. This signature was proposed to be a product of the denudation of the Cretaceous passive margin sediments along with the exposure of the Proterozoic basement in the eastern Cordillera (Bande et al 2011). In contrast, the presence of a younger population in the Pliocene sediments in the Táchira Saddle suggests a different set of sources in our study area, implying an independent sedimentation, with intense denudation of the Mérida Andes and Santander Massif, exposing the metamorphic basement and the Jurassic rocks of La Quinta Formation and the Santander Group.

Moreover, noticeable differences are also found in the age distributions between the Magdalena Valley and Táchira Saddle. These differences are reflected by the high concentration of Permo-Triassic ages in the Magdalena Valley, indicating a bigger influence from Central Cordillera terranes (Nie et al., 2010). This dissimilarity suggests a disconnection of both basins by the Pliocene.



- A: Táchira Saddle (This study)
 B: Maracaibo Basin (Xie *et al.* 2010)
 C: Southern Maracaibo basin (Bayona *et al.* 2012)
 D: Los Llanos Basin (Horton *et al.* 2010)
 E: Magdalena Valley (Nie *et al.* 2010)
 F: Catacumbo basin (Ayala *et al.* 2012)

Figure 15. Detrital zircon age distribution comparison of Táchira Saddle and previous studies in surrounding localities (Continued in next page).

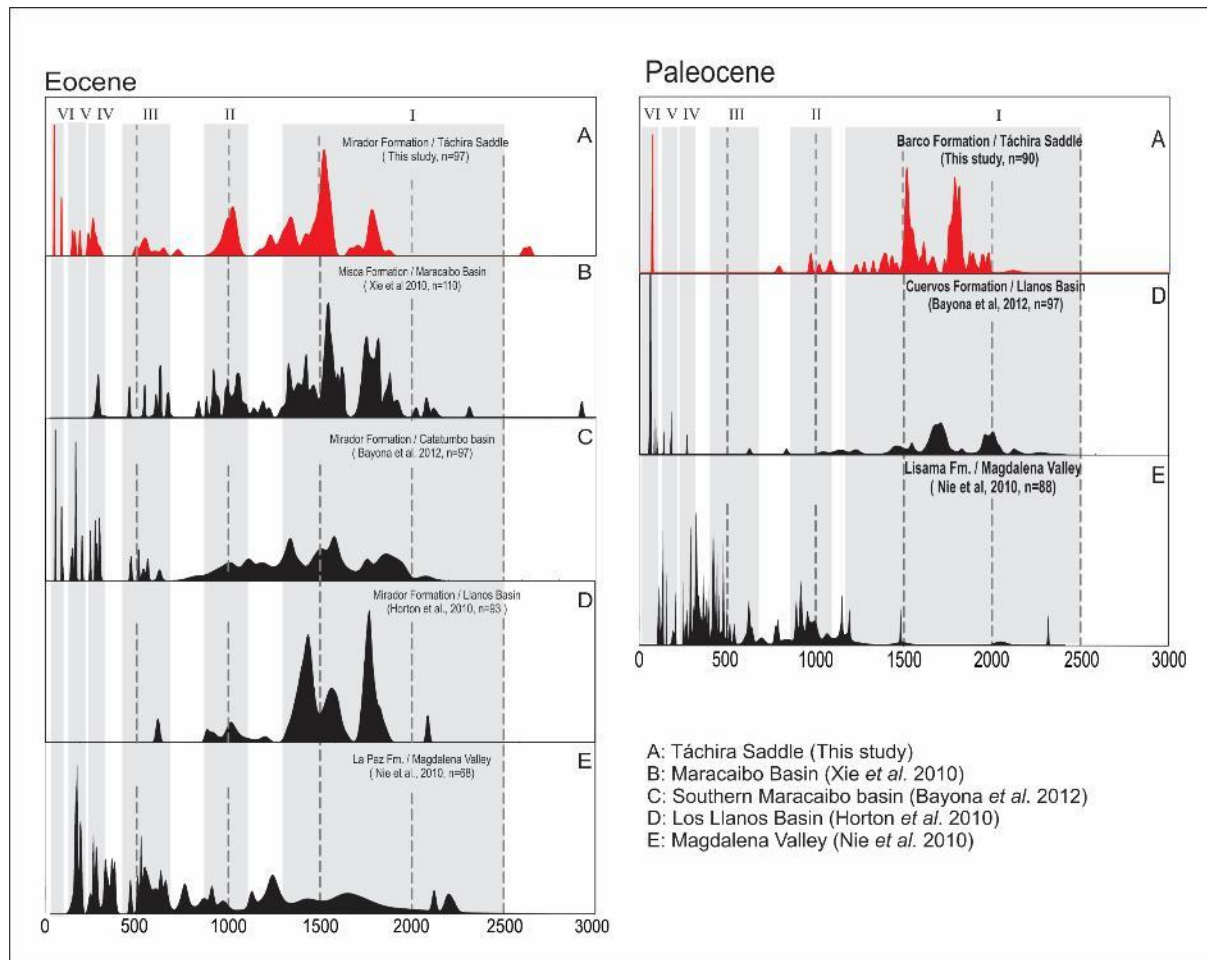


Figure 15 (cont.) Detrital zircon age distribution comparison of Táchira Saddle and previous studies in surrounding localities.

5.4 Regional tectono-sedimentary evolution model

Comparing detrital signatures in the Cenozoic sequence in the Táchira Saddle and surrounding basins suggests five different stages of basin evolution (Fig. 16). The first stage is an initial configuration of a Paleocene foreland basin with the Central Cordillera to the west and the Guyana Shield to the east (Fig. 16A). The Táchira Saddle region is part of a deltaic environment receiving sediment input from both Central Cordillera and the Guyana Shield.

During the second stage, the advancing deformation wedge of the Central Cordillera continues in the development of the foreland basin (Fig. 16 B). At this time, the flexural load of the Central Cordillera creates the depositional space for an axial proto-Orinoco fluvial system flowing northward and carrying sediments from both sides of the basin including the Triassic terranes exposed by the advance of the Central Cordillera deformation wedge. The fluvial sandstones of Mirador Formation in the Táchira Saddle area are located close to this axial fluvial system in the foredeep area. The flexural deformation is also reflected further east basin by the exposure of a forebulge that initially isolated the Llanos region from the input of Central Cordillera (Bande et al., 2012).

The third stage is the eastward propagation of the deformation front, which generates the initial uplift of the Eastern Cordillera and Santander Massif during the Early Oligocene (Fig. 16 C). The new topographic feature isolated the Magdalena Valley and the Llanos Basin from the Táchira Saddle region. Paleogene strata were being recycled and sediment redeposited in the foothills of the Eastern Cordillera. During this stage, the northward Paleo-Orinoco fluvial system was deviated to the northeast.

By the Early to Middle Miocene, the initial uplift of the Mérida Andes is recorded by the denudation of Mesozoic strata (Fig. 16 D). The deformation wedge of the Eastern Cordillera continued to advance eastward, causing re-exposure of Paleogene sediments in the Llanos basin.

During the fifth stage, uplift and denudation of the Mérida Andes intensified leading to exposure of Jurassic deposits and the metamorphic basement complex by the Late Miocene-Pliocene (Fig. 16 E). Similar unroofing processes also happened in the Eastern Cordillera, exposing the Mesozoic sequence and some inliers of the Paleozoic and Proterozoic basement.

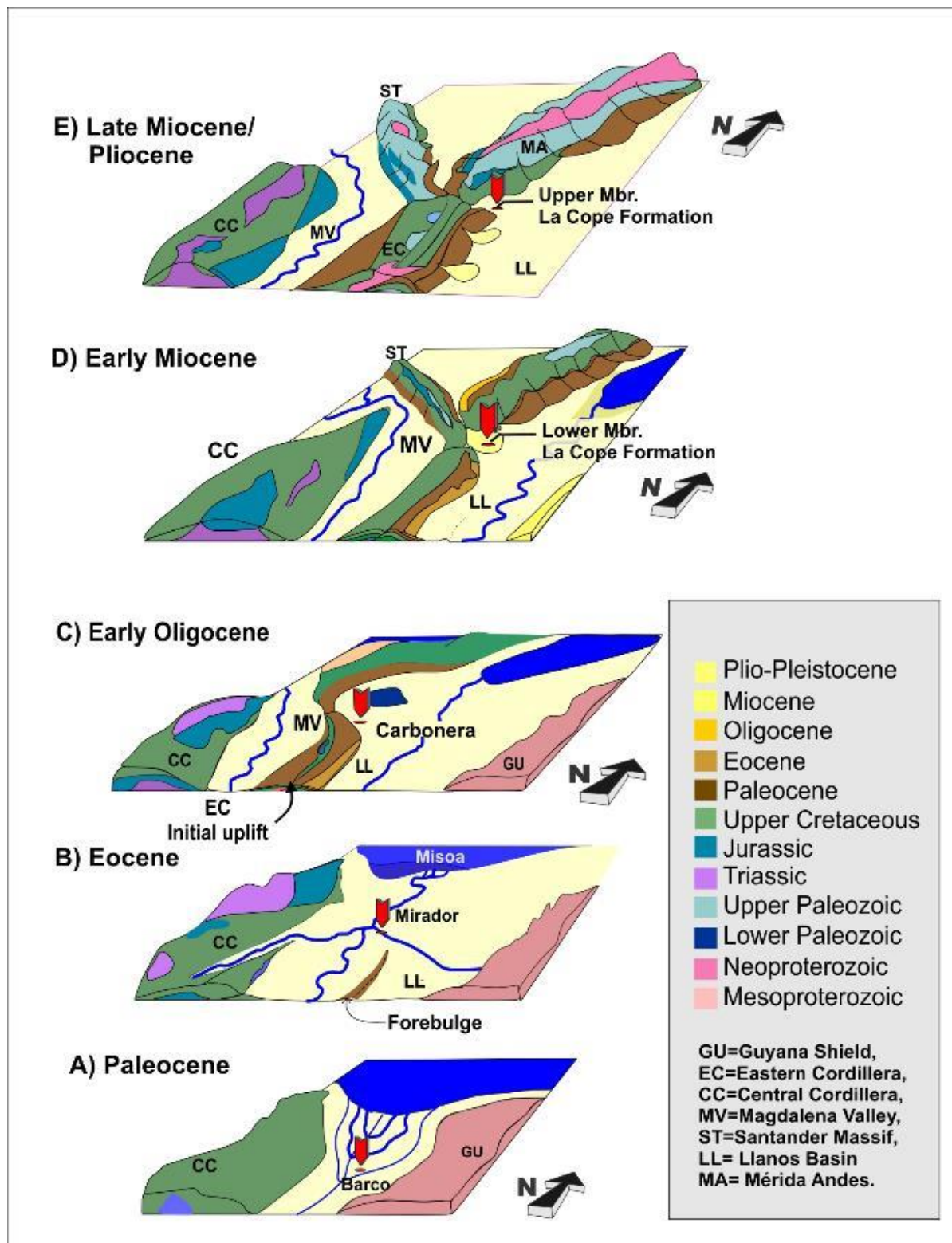


Figure 16. Diagram with paleogeographic reconstructions from Cretaceous to Pliocene showing a proposed location and potential sediment sources of Táchira Saddle deposits.

6 CONCLUSIONS

The main conclusions of this study are listed below:

1. Results from the U-Pb detrital zircon geochronology shows that the main sources of sediments in the Táchira Saddle were originally the Precambrian Guyana Shield provinces and Meso-Neoproterozoic Putumayo terranes in the western edge of the craton. Smaller proportions of Mesozoic ages from the Central Cordillera were deposited prior to the uplifting of the Eastern Cordillera by the Oligocene.
2. The detrital zircon age spectra from the Oligocene Carbonera Formation and lower Member of La Copé Formation show comparable signatures with underlying Paleocene and Cretaceous samples. Such patterns could be a consequence of a sediment recycling process during the uplift in the Eastern Cordillera and Mérida Andes combined with the exposed Neoproterozoic basement of the Eastern Cordillera.
3. The uplift of the Eastern Cordillera and Santander Massif by Early Oligocene is likely to be responsible for deviation to the east of the Proto-Orinoco River, somewhat earlier than proposed by previous authors.
4. Complementary XRD analysis reflects a change in the maturity of the sediments in the Táchira Saddle. Paleogene sediments reflect ultra-stable minerals such as zircons, tourmaline, and rutile. In contrast, a less stable mineralogy characterizes the Mio-Pliocene sediments, including metamorphic species such as staurolite and chloritoid. These results, along with the presence of a notable population of Jurassic zircon grains in the upper Member of La Cope Formation, imply the unroofing of the metamorphic Mérida Andes basement.

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APPENDICES

I. U-Pb Detrital zircon geochronology data tables

TA-01. La Cope formation. Upper member (Late Miocene-Pliocene)

U	206Pb	U/Th	206Pb*	±	207Pb*	±	206Pb*	±	error	206Pb*	±	207Pb*	±	206Pb*	±	Best age	±	Conc
(ppm)	204Pb		207Pb*	(%)	235U*	(%)	238U	(%)	corr.	238U*	(Ma)	235U	(Ma)	207Pb*	(Ma)	(Ma)	(Ma)	(%)
539	15089	2.2	20.9975	1.3	0.0553	2.3	0.0084	1.9	0.84	54.1	1.0	54.6	1.2	80.6	30.1	54.1	1.0	98.9
278	7064	1.5	21.0841	3.1	0.0557	3.8	0.0085	2.2	0.58	54.7	1.2	55.0	2.0	70.9	73.1	54.7	1.2	99.3
309	9398	1.5	21.5854	1.8	0.0756	3.2	0.0118	2.6	0.82	75.9	1.9	74.0	2.3	14.7	43.6	75.9	1.9	102.5
96	68794	1.3	20.4139	2.6	0.1525	3.5	0.0226	2.4	0.68	143.9	3.4	144.1	4.7	147.2	60.2	143.9	3.4	99.9
313	17059	1.9	20.1682	0.9	0.1716	1.9	0.0251	1.6	0.86	159.8	2.5	160.8	2.8	175.5	22.0	159.8	2.5	99.4
151	17471	0.8	20.0286	1.5	0.2120	3.1	0.0308	2.7	0.87	195.5	5.2	195.2	5.5	191.7	35.9	195.5	5.2	100.2
341	5793	0.4	20.5791	1.1	0.2066	2.8	0.0308	2.5	0.91	195.8	4.8	190.7	4.8	128.3	26.6	195.8	4.8	102.7
249	11085	1.7	20.2794	1.3	0.2120	2.4	0.0312	2.0	0.83	197.9	3.9	195.2	4.2	162.6	30.8	197.9	3.9	101.4
143	7742	1.5	19.9607	1.8	0.2187	2.9	0.0317	2.3	0.78	200.9	4.6	200.8	5.4	199.6	42.7	200.9	4.6	100.1
284	43185	1.6	20.1685	0.8	0.2173	1.9	0.0318	1.7	0.89	201.7	3.3	199.6	3.4	175.4	19.7	201.7	3.3	101.0
336	48292	1.8	17.6236	0.9	0.5699	2.5	0.0728	2.4	0.94	453.2	10.3	457.9	9.3	481.5	19.7	453.2	10.3	94.1
280	2282350	1.5	17.5491	0.8	0.5868	2.0	0.0747	1.8	0.91	464.4	8.2	468.9	7.6	490.9	18.5	464.4	8.2	94.6
209	137928	2.0	16.8011	1.3	0.7422	3.2	0.0904	2.9	0.91	558.1	15.3	563.7	13.6	586.2	28.3	558.1	15.3	95.2
1761	686386	12.6	16.8636	0.8	0.7478	2.2	0.0915	2.0	0.92	564.2	10.9	566.9	9.5	578.1	18.4	564.2	10.9	97.6
47	6530	0.1	16.7719	2.2	0.8153	4.0	0.0992	3.4	0.84	609.6	19.6	605.4	18.3	589.9	47.0	609.6	19.6	103.3
91	15409	1.2	14.4451	1.1	1.3913	2.7	0.1458	2.5	0.92	877.1	20.5	885.2	16.1	905.5	22.5	877.1	20.5	96.9
109	59742	1.1	14.4238	0.7	1.4054	2.1	0.1470	2.0	0.95	884.2	16.2	891.2	12.3	908.5	13.7	884.2	16.2	97.3
210	29324	1.2	14.3888	0.9	1.5059	2.3	0.1571	2.2	0.92	940.9	18.9	932.8	14.3	913.6	18.6	913.6	18.6	103.0
185	63528	2.6	14.3096	0.9	1.5405	2.6	0.1599	2.4	0.94	956.1	21.6	946.7	15.9	924.9	17.7	924.9	17.7	103.4
452	380822	7.3	14.2841	0.8	1.5032	2.4	0.1557	2.2	0.94	933.0	19.5	931.7	14.6	928.6	16.5	928.6	16.5	100.5
5	2500	2.9	14.2687	4.7	1.5389	8.9	0.1593	7.6	0.85	952.6	67.5	946.1	55.0	930.8	95.7	930.8	95.7	102.3
76	7974	2.1	14.2197	0.8	1.5988	3.4	0.1649	3.3	0.97	983.9	30.3	969.7	21.3	937.8	15.7	937.8	15.7	104.9
171	155716	2.0	14.0884	0.8	1.5806	2.1	0.1615	1.9	0.92	965.1	17.5	962.6	13.2	956.8	17.1	956.8	17.1	100.9
213	26448	2.7	14.0468	0.8	1.6459	2.4	0.1677	2.3	0.94	999.3	21.4	988.0	15.5	962.9	16.8	962.9	16.8	103.8
401	407815	2.7	14.0288	0.9	1.6459	3.0	0.1675	2.8	0.95	998.1	26.1	988.0	18.7	965.5	18.5	965.5	18.5	103.4
117	19808	4.6	14.0102	0.8	1.6242	2.9	0.1650	2.8	0.96	984.7	25.5	979.6	18.2	968.2	15.8	968.2	15.8	101.7
121	12500	3.7	13.9728	0.8	1.6893	2.1	0.1712	2.0	0.92	1018.7	18.5	1004.5	13.6	973.7	16.9	973.7	16.9	104.6
139	42883	2.1	13.9331	0.8	1.6822	1.9	0.1700	1.8	0.91	1012.1	16.5	1001.8	12.4	979.4	16.8	979.4	16.8	103.3
159	52169	2.2	13.9221	0.9	1.5534	2.1	0.1569	1.9	0.92	939.3	16.9	951.9	13.1	981.1	17.3	981.1	17.3	95.7
83	14510	1.8	13.8973	0.9	1.6904	2.8	0.1704	2.6	0.94	1014.2	24.6	1004.9	17.7	984.7	19.1	984.7	19.1	103.0
139	76080	4.1	13.8218	0.8	1.6846	1.9	0.1689	1.8	0.92	1005.9	16.5	1002.7	12.3	995.8	15.6	995.8	15.6	101.0
87	69053	1.1	13.8172	0.8	1.6856	2.6	0.1689	2.4	0.95	1006.1	22.5	1003.1	16.3	996.5	16.5	996.5	16.5	101.0
167	15686	3.0	13.7812	0.8	1.7169	2.5	0.1716	2.3	0.94	1020.9	21.9	1014.9	15.8	1001.7	16.6	1001.7	16.6	101.9

325	180208	3.1	13.7441	0.7	1.6702	1.9	0.1665	1.8	0.93	992.7	16.4	997.3	12.1	1007.2	14.0	1007.2	14.0	98.6
388	95411	2.3	13.7420	0.7	1.6423	1.8	0.1637	1.7	0.92	977.2	15.4	986.6	11.7	1007.5	14.5	1007.5	14.5	97.0
308	55589	37.4	13.7368	0.8	1.6759	2.3	0.1670	2.2	0.94	995.4	20.3	999.4	14.8	1008.3	15.6	1008.3	15.6	98.7
107	124290	2.2	13.6683	0.9	1.7756	3.3	0.1760	3.2	0.96	1045.2	30.5	1036.6	21.4	1018.4	18.3	1018.4	18.3	102.6
81	253293	1.7	13.5717	0.9	1.7046	3.3	0.1678	3.2	0.97	999.9	29.6	1010.3	21.2	1032.8	17.3	1032.8	17.3	96.8
161	63869	1.6	13.5599	0.8	1.7951	2.4	0.1765	2.3	0.94	1048.1	22.1	1043.7	15.8	1034.5	16.5	1034.5	16.5	101.3
178	32311	4.0	13.5590	0.7	1.7554	2.3	0.1726	2.2	0.95	1026.5	21.0	1029.2	15.0	1034.7	14.2	1034.7	14.2	99.2
93	44887	3.5	13.5058	1.0	1.6977	3.1	0.1663	2.9	0.95	991.6	26.9	1007.6	19.8	1042.6	20.3	1042.6	20.3	95.1
122	37790	1.4	13.3123	0.9	1.7885	2.5	0.1727	2.3	0.93	1026.9	22.3	1041.3	16.4	1071.7	18.1	1071.7	18.1	95.8
128	131344	1.7	13.2582	0.9	1.8689	3.2	0.1797	3.1	0.96	1065.4	30.0	1070.1	21.0	1079.8	17.3	1079.8	17.3	98.7
33	8093	1.6	12.9493	1.3	2.0933	3.8	0.1966	3.6	0.94	1157.0	37.9	1146.6	26.1	1127.0	25.3	1127.0	25.3	102.7
109	30740	3.3	12.9098	1.0	2.0921	2.6	0.1959	2.4	0.93	1153.2	25.9	1146.2	18.2	1133.1	20.0	1133.1	20.0	101.8
111	30425	2.0	12.8605	0.9	2.1574	2.9	0.2012	2.8	0.95	1181.9	29.9	1167.4	20.1	1140.7	17.1	1140.7	17.1	103.6
86	36935	3.4	12.8144	1.0	2.1404	3.4	0.1989	3.3	0.96	1169.6	34.9	1162.0	23.5	1147.8	19.1	1147.8	19.1	101.9
143	184583	3.3	12.7963	0.9	2.0697	2.7	0.1921	2.5	0.95	1132.6	26.2	1138.8	18.3	1150.6	17.3	1150.6	17.3	98.4
212	568779	1.7	12.7697	0.8	2.1248	2.5	0.1968	2.3	0.95	1158.1	24.6	1156.9	16.9	1154.7	15.7	1154.7	15.7	100.3
49	28950	2.4	12.7669	1.1	2.0274	3.0	0.1877	2.8	0.93	1109.0	28.6	1124.7	20.6	1155.2	22.3	1155.2	22.3	96.0
217	43669	2.0	12.6687	0.9	2.1207	2.5	0.1949	2.4	0.94	1147.6	24.8	1155.6	17.4	1170.5	17.7	1170.5	17.7	98.0
91	174242	1.4	12.6451	1.0	2.1528	2.7	0.1974	2.5	0.94	1161.5	27.1	1165.9	18.9	1174.2	19.0	1174.2	19.0	98.9
96	12197	4.5	12.5950	0.7	2.1942	2.7	0.2004	2.6	0.96	1177.7	27.6	1179.2	18.6	1182.1	14.4	1182.1	14.4	99.6
110	53269	2.2	12.4384	1.0	2.1889	3.0	0.1975	2.8	0.95	1161.7	30.1	1177.5	20.8	1206.7	19.0	1206.7	19.0	96.3
129	183206	1.9	12.4163	1.0	2.3937	2.6	0.2156	2.4	0.93	1258.3	27.6	1240.7	18.6	1210.2	18.8	1210.2	18.8	104.0
200	141429	3.4	12.1970	0.8	2.3796	2.3	0.2105	2.1	0.93	1231.5	23.9	1236.5	16.3	1245.2	15.9	1245.2	15.9	98.9
385	95930	2.2	12.1809	0.9	2.2914	2.9	0.2024	2.7	0.95	1188.4	29.4	1209.6	20.2	1247.8	17.8	1247.8	17.8	95.2
124	45206	1.6	12.0511	0.7	2.5027	2.7	0.2187	2.6	0.96	1275.2	29.7	1272.8	19.4	1268.8	14.6	1268.8	14.6	100.5
79	78312	1.6	11.8960	0.9	2.3623	5.0	0.2038	4.9	0.99	1195.8	53.6	1231.3	35.5	1294.0	16.7	1294.0	16.7	92.4
138	1003451	3.4	11.8776	0.8	2.5513	2.7	0.2198	2.5	0.96	1280.7	29.4	1286.8	19.4	1297.0	15.3	1297.0	15.3	98.7
134	17193	2.0	11.8097	0.6	2.7444	2.2	0.2351	2.1	0.96	1361.0	26.3	1340.6	16.6	1308.1	12.1	1308.1	12.1	104.0
34	32254	1.7	11.7282	0.7	2.5646	4.3	0.2181	4.2	0.98	1272.1	48.3	1290.6	31.1	1321.5	14.5	1321.5	14.5	96.3
97	304751	1.1	11.7258	1.0	2.5588	2.6	0.2176	2.4	0.92	1269.2	27.2	1289.0	18.7	1321.9	19.1	1321.9	19.1	96.0
254	57856	1.5	11.7041	0.9	2.5922	2.4	0.2200	2.2	0.93	1282.1	25.7	1298.4	17.4	1325.5	16.8	1325.5	16.8	96.7
132	875353	1.9	11.6660	0.7	2.6930	1.9	0.2279	1.8	0.94	1323.2	21.7	1326.5	14.3	1331.8	13.1	1331.8	13.1	99.4
144	127485	2.2	11.6610	1.1	2.6618	2.5	0.2251	2.3	0.90	1308.8	26.7	1317.9	18.5	1332.7	21.1	1332.7	21.1	98.2
31	10858	3.7	11.5359	1.3	2.7876	3.5	0.2332	3.3	0.93	1351.4	40.0	1352.2	26.3	1353.5	24.8	1353.5	24.8	99.8
67	11871	2.5	11.4775	0.9	2.8430	2.9	0.2367	2.8	0.96	1369.3	34.3	1367.0	21.9	1363.3	16.5	1363.3	16.5	100.4
234	62101	1.3	11.4210	0.8	2.8277	2.2	0.2342	2.1	0.93	1356.6	25.5	1362.9	16.8	1372.8	15.6	1372.8	15.6	98.8
193	50056	2.2	11.1628	1.0	3.0408	2.5	0.2462	2.3	0.92	1418.8	29.8	1417.9	19.5	1416.6	19.3	1416.6	19.3	100.2
71	24481	1.2	10.9630	0.9	3.2668	2.8	0.2597	2.6	0.94	1488.5	35.1	1473.2	21.8	1451.1	18.0	1451.1	18.0	102.6
224	59833	1.8	10.9145	0.7	3.1963	2.4	0.2530	2.3	0.95	1454.0	29.6	1456.3	18.4	1459.5	13.6	1459.5	13.6	99.6
151	67176	2.3	10.8114	0.8	3.4391	2.2	0.2697	2.1	0.94	1539.1	28.9	1513.4	17.7	1477.5	14.8	1477.5	14.8	104.2
216	176506	1.1	10.7996	0.6	3.2126	2.1	0.2516	2.0	0.96	1446.9	26.2	1460.2	16.3	1479.6	11.5	1479.6	11.5	97.8

478	170509	2.3	10.6920	0.8	3.0882	2.4	0.2395	2.3	0.94	1384.0	28.1	1429.8	18.4	1498.6	15.2	1498.6	15.2	92.4
39	14069	1.5	10.6590	1.0	3.4038	3.3	0.2631	3.2	0.96	1505.9	43.0	1505.3	26.2	1504.4	18.0	1504.4	18.0	100.1
67	35593	1.2	10.6384	0.9	3.4357	2.8	0.2651	2.7	0.95	1515.8	36.6	1512.6	22.4	1508.1	16.4	1508.1	16.4	100.5
152	41237	2.3	10.6213	0.9	3.4841	2.1	0.2684	1.9	0.91	1532.6	26.3	1523.6	16.8	1511.1	17.1	1511.1	17.1	101.4
75	18872	0.8	10.5989	0.9	3.3208	2.7	0.2553	2.5	0.95	1465.6	33.2	1486.0	20.9	1515.1	16.1	1515.1	16.1	96.7
60	112620	2.1	10.5633	0.9	3.4476	2.8	0.2641	2.6	0.94	1510.9	35.3	1515.3	21.9	1521.4	17.3	1521.4	17.3	99.3
377	2076517	2.7	10.5082	0.7	3.5321	2.0	0.2692	1.9	0.93	1536.7	25.3	1534.4	15.7	1531.3	13.5	1531.3	13.5	100.4
403	478061	3.0	10.4977	0.9	3.4789	2.2	0.2649	2.0	0.92	1514.7	27.2	1522.4	17.3	1533.2	16.3	1533.2	16.3	98.8
103	35628	1.0	10.4709	0.9	3.4850	2.4	0.2647	2.2	0.92	1513.6	29.9	1523.8	18.9	1538.0	17.2	1538.0	17.2	98.4
58	71665	1.8	10.3788	0.9	3.6262	3.1	0.2730	2.9	0.95	1555.8	40.3	1555.3	24.4	1554.6	17.6	1554.6	17.6	100.1
105	287286	2.0	10.3291	0.7	3.5285	3.9	0.2643	3.9	0.98	1512.0	51.9	1533.6	31.0	1563.6	13.7	1563.6	13.7	96.7
159	97899	3.8	10.2532	0.7	3.6282	1.7	0.2698	1.5	0.92	1539.8	21.0	1555.7	13.3	1577.4	12.2	1577.4	12.2	97.6
535	135645	2.1	10.1426	0.7	3.0094	2.1	0.2214	2.0	0.94	1289.1	23.3	1410.0	16.1	1597.7	13.2	1597.7	13.2	80.7
163	109592	1.8	9.6809	0.6	4.3151	2.2	0.3030	2.1	0.96	1706.0	31.3	1696.3	17.9	1684.2	10.6	1684.2	10.6	101.3
184	11723682	1.9	9.6554	0.7	4.2709	2.6	0.2991	2.5	0.96	1686.8	37.5	1687.8	21.7	1689.0	13.5	1689.0	13.5	99.9
240	121077	2.4	9.4886	0.7	4.4471	2.1	0.3060	2.0	0.94	1721.2	30.5	1721.2	17.8	1721.1	13.3	1721.1	13.3	100.0
225	157777	2.3	9.0813	0.7	4.6583	2.2	0.3068	2.1	0.95	1725.0	31.4	1759.8	18.2	1801.3	12.0	1801.3	12.0	95.8
139	158180	1.5	9.0801	0.9	4.8813	2.7	0.3215	2.6	0.94	1796.8	40.2	1799.0	22.9	1801.6	16.2	1801.6	16.2	99.7
213	83671	3.1	9.0597	0.8	4.8507	2.4	0.3187	2.3	0.94	1783.5	35.3	1793.7	20.3	1805.6	14.7	1805.6	14.7	98.8
121	33377	1.8	8.8392	0.7	5.3263	2.2	0.3415	2.1	0.95	1893.7	34.8	1873.1	19.0	1850.3	12.1	1850.3	12.1	102.3
167	40001	1.0	8.8362	0.8	5.0399	2.8	0.3230	2.7	0.96	1804.3	42.2	1826.0	23.7	1850.9	14.7	1850.9	14.7	97.5
219	321878	1.2	8.7448	0.8	5.0983	2.3	0.3234	2.1	0.93	1806.1	33.4	1835.8	19.3	1869.7	14.9	1869.7	14.9	96.6
151	160872	1.0	8.6305	0.7	5.1727	2.3	0.3238	2.1	0.95	1808.2	33.7	1848.1	19.2	1893.4	12.7	1893.4	12.7	95.5
183	68993	1.1	8.6196	0.6	5.1710	4.5	0.3233	4.5	0.99	1805.7	70.4	1847.9	38.4	1895.7	10.6	1895.7	10.6	95.3

TA-02. Carbonera Formation (Early Oligocene)

U	206Pb	U/Th	206Pb*	±	207Pb*	±	206Pb*	±	error	206Pb*	±	207Pb*	±	206Pb*	±	Best age	±	Conc
(ppm)	204Pb		207Pb*	(%)	235U*	(%)	238U	(%)	corr.	238U*	(Ma)	235U	(Ma)	207Pb*	(Ma)	(Ma)	(Ma)	(%)
456	318197	1.7	20.3864	0.9	0.0814	2.3	0.0120	2.1	0.91	77.1	1.6	79.4	1.7	150.3	21.7	77.1	1.6	97.1
338	156155	1.9	16.4021	0.8	0.8404	2.5	0.1000	2.3	0.94	614.3	13.6	619.4	11.4	638.1	17.9	614.3	13.6	96.3
170	45653	2.0	16.2022	0.8	0.8859	2.4	0.1041	2.3	0.95	638.4	14.1	644.2	11.7	664.4	16.3	638.4	14.1	96.1
156	197440	11.5	14.6035	0.8	1.3221	2.3	0.1400	2.2	0.95	844.8	17.4	855.4	13.4	883.0	15.7	844.8	17.4	95.7
126	767039	2.6	14.2617	0.7	1.4622	2.9	0.1512	2.9	0.97	907.9	24.3	914.9	17.8	931.8	14.2	931.8	14.2	97.4
83	111315	2.1	13.8359	0.9	1.6306	3.6	0.1636	3.5	0.97	976.9	31.9	982.1	22.8	993.7	17.4	993.7	17.4	98.3
76	35656	0.9	13.7605	1.1	1.6434	3.0	0.1640	2.8	0.93	979.1	25.2	987.0	18.7	1004.8	21.4	1004.8	21.4	97.4
56	29760	3.5	13.7593	0.8	1.6923	3.3	0.1689	3.1	0.97	1005.9	29.3	1005.6	20.7	1005.0	16.9	1005.0	16.9	100.1
12	15814	4.7	13.3922	1.4	1.7840	4.6	0.1733	4.4	0.95	1030.2	41.4	1039.7	29.7	1059.7	27.5	1059.7	27.5	97.2
184	17088	2.8	13.3759	0.8	1.7556	2.8	0.1703	2.6	0.95	1013.8	24.7	1029.2	17.8	1062.1	16.5	1062.1	16.5	95.5

111	20518	1.3	13.3365	0.8	1.8954	2.9	0.1833	2.8	0.96	1085.2	28.3	1079.5	19.5	1068.0	15.8	1068.0	15.8	101.6
28	425761	0.4	12.6319	1.1	2.1958	4.5	0.2012	4.3	0.97	1181.6	46.6	1179.7	31.2	1176.3	22.5	1176.3	22.5	100.5
115	47428	3.0	12.3557	0.8	2.3731	3.4	0.2127	3.2	0.97	1243.0	36.7	1234.5	23.9	1219.8	16.1	1219.8	16.1	101.9
65	37667	2.3	11.8362	0.8	2.7177	2.8	0.2333	2.7	0.96	1351.7	32.7	1333.3	20.7	1303.8	15.2	1303.8	15.2	103.7
20	69459	1.8	11.8331	0.9	2.6691	3.4	0.2291	3.3	0.96	1329.6	39.8	1320.0	25.4	1304.3	17.7	1304.3	17.7	101.9
78	172897	1.4	11.7608	1.0	2.6933	3.9	0.2297	3.8	0.97	1333.1	45.3	1326.6	28.9	1316.2	19.8	1316.2	19.8	101.3
181	53778	2.7	11.7447	0.7	2.4832	2.5	0.2115	2.4	0.96	1236.9	26.8	1267.2	18.1	1318.8	14.3	1318.8	14.3	93.8
91	23061	3.0	11.7283	0.7	2.7464	2.7	0.2336	2.6	0.97	1353.4	31.3	1341.1	19.8	1321.5	13.5	1321.5	13.5	102.4
216	109975	1.6	11.6908	0.6	2.6592	2.4	0.2255	2.3	0.96	1310.7	27.6	1317.2	17.8	1327.7	12.3	1327.7	12.3	98.7
103	422630	1.7	11.4468	0.7	2.9729	2.6	0.2468	2.5	0.96	1422.0	31.7	1400.7	19.6	1368.5	13.5	1368.5	13.5	103.9
227	34005	1.7	11.3168	0.7	2.6749	2.2	0.2195	2.1	0.94	1279.5	24.0	1321.5	16.2	1390.4	14.0	1390.4	14.0	92.0
77	37214	2.0	11.2812	0.8	3.0620	3.0	0.2505	2.9	0.97	1441.2	38.0	1423.2	23.3	1396.4	14.8	1396.4	14.8	103.2
78	295315	1.7	11.1060	0.8	2.5496	3.9	0.2054	3.8	0.98	1204.1	41.5	1286.3	28.2	1426.4	16.0	1426.4	16.0	84.4
410	671900	2.7	11.0931	0.7	2.9271	2.5	0.2355	2.4	0.96	1363.3	30.0	1389.0	19.2	1428.6	13.0	1428.6	13.0	95.4
105	24422	2.1	11.0460	1.3	3.0899	2.9	0.2475	2.6	0.90	1425.8	33.1	1430.2	22.1	1436.7	24.3	1436.7	24.3	99.2
108	37941	1.6	10.9987	0.8	3.0410	3.3	0.2426	3.2	0.97	1400.1	40.8	1418.0	25.5	1444.9	14.9	1444.9	14.9	96.9
285	1135921	2.5	10.9890	0.8	3.1008	2.2	0.2471	2.1	0.94	1423.7	26.9	1432.9	17.2	1446.6	14.9	1446.6	14.9	98.4
60	26015	0.8	10.9333	0.7	3.2623	2.7	0.2587	2.6	0.97	1483.1	34.2	1472.1	20.7	1456.3	13.0	1456.3	13.0	101.8
146	234788	2.3	10.9331	0.6	3.1421	2.5	0.2492	2.4	0.97	1434.1	31.3	1443.1	19.4	1456.3	12.0	1456.3	12.0	98.5
232	331540	2.4	10.9289	0.8	3.1150	2.6	0.2469	2.5	0.96	1422.5	32.3	1436.4	20.3	1457.0	14.3	1457.0	14.3	97.6
208	115978	2.3	10.9187	0.6	3.1517	2.0	0.2496	1.9	0.96	1436.3	25.1	1445.4	15.6	1458.8	10.5	1458.8	10.5	98.5
37	9825	1.1	10.8807	1.0	3.2896	3.7	0.2596	3.6	0.96	1487.8	47.4	1478.6	28.8	1465.4	18.5	1465.4	18.5	101.5
54	12365	0.6	10.8353	1.0	3.2906	3.6	0.2586	3.5	0.96	1482.7	46.2	1478.8	28.2	1473.4	18.5	1473.4	18.5	100.6
32	13138	0.7	10.7245	1.0	3.4939	4.1	0.2718	4.0	0.97	1549.7	54.5	1525.8	32.2	1492.8	18.7	1492.8	18.7	103.8
58	11686	1.4	10.7108	0.9	3.4285	3.0	0.2663	2.9	0.96	1522.2	38.6	1511.0	23.4	1495.3	16.4	1495.3	16.4	101.8
74	54128	2.3	10.6584	0.7	3.5886	2.3	0.2774	2.2	0.95	1578.3	30.9	1547.0	18.4	1504.5	13.6	1504.5	13.6	104.9
75	24536	1.0	10.6470	0.7	3.3969	3.8	0.2623	3.7	0.98	1501.6	49.5	1503.7	29.6	1506.6	14.0	1506.6	14.0	99.7
53	18652	1.1	10.6093	0.8	3.5412	3.4	0.2725	3.3	0.97	1553.4	45.8	1536.5	27.1	1513.3	15.9	1513.3	15.9	102.7
74	2500858	1.9	10.5678	0.9	3.4327	3.2	0.2631	3.1	0.96	1505.7	41.6	1511.9	25.3	1520.6	16.9	1520.6	16.9	99.0
174	219113	2.0	10.5102	0.8	3.5384	2.4	0.2697	2.3	0.95	1539.4	31.3	1535.8	19.1	1530.9	14.4	1530.9	14.4	100.6
262	3545693	1.6	10.4564	0.7	3.4162	2.7	0.2591	2.6	0.96	1485.1	34.6	1508.1	21.3	1540.6	13.4	1540.6	13.4	96.4
156	134448	2.9	10.4498	0.7	3.4153	2.9	0.2588	2.8	0.97	1483.9	37.1	1507.9	22.7	1541.8	13.5	1541.8	13.5	96.2
318	56920	2.1	10.3815	0.7	3.5713	2.4	0.2689	2.3	0.95	1535.2	31.2	1543.2	19.0	1554.1	13.4	1554.1	13.4	98.8
403	33662	1.6	10.3801	0.7	3.0516	4.2	0.2297	4.2	0.99	1333.1	50.2	1420.6	32.3	1554.4	12.8	1554.4	12.8	85.8
137	74606	0.9	10.3626	0.8	3.2807	2.6	0.2466	2.5	0.96	1420.7	32.0	1476.5	20.4	1557.5	14.5	1557.5	14.5	91.2
104	33110	2.2	10.3294	0.7	3.6488	2.6	0.2734	2.5	0.96	1557.8	35.2	1560.2	21.1	1563.6	13.6	1563.6	13.6	99.6
125	258966	1.4	10.3194	0.7	3.5422	2.5	0.2651	2.4	0.96	1515.9	32.8	1536.7	20.0	1565.4	12.9	1565.4	12.9	96.8
314	71311	2.1	10.3068	0.8	3.2814	2.5	0.2453	2.4	0.95	1414.2	30.4	1476.7	19.6	1567.7	14.3	1567.7	14.3	90.2
306	160873	2.4	9.9318	0.9	3.7732	2.4	0.2718	2.2	0.92	1549.9	30.4	1587.1	19.2	1636.8	17.0	1636.8	17.0	94.7
196	178598	1.3	9.7599	0.7	4.0966	2.4	0.2900	2.3	0.96	1641.4	32.7	1653.6	19.2	1669.1	12.6	1669.1	12.6	98.3
66	15604	1.6	9.5901	0.9	4.3416	3.6	0.3020	3.5	0.97	1701.1	52.2	1701.3	29.8	1701.5	16.5	1701.5	16.5	100.0

111	181201	1.5	9.5703	0.7	4.3820	2.6	0.3042	2.5	0.96	1711.9	37.5	1709.0	21.5	1705.3	13.5	1705.3	13.5	100.4
112	64232	1.1	9.5130	0.9	4.0122	2.3	0.2768	2.1	0.92	1575.3	29.9	1636.7	18.8	1716.4	16.3	1716.4	16.3	91.8
124	42651	1.7	9.4059	0.7	4.5516	2.7	0.3105	2.6	0.96	1743.2	39.4	1740.5	22.3	1737.2	13.1	1737.2	13.1	100.3
95	73239	1.3	9.3995	0.8	4.4954	3.1	0.3065	3.0	0.97	1723.3	44.8	1730.1	25.4	1738.4	14.0	1738.4	14.0	99.1
149	1368311	1.9	9.3836	0.9	4.0870	2.6	0.2781	2.5	0.94	1582.0	34.8	1651.7	21.6	1741.5	17.0	1741.5	17.0	90.8
148	203922	0.9	9.3670	0.5	4.4184	2.4	0.3002	2.4	0.98	1692.1	35.2	1715.8	20.0	1744.8	9.1	1744.8	9.1	97.0
118	89684	1.3	9.1781	0.6	4.6799	2.8	0.3115	2.7	0.97	1748.2	41.4	1763.6	23.2	1782.0	11.8	1782.0	11.8	98.1
122	172336	4.5	9.1482	0.6	4.7707	2.6	0.3165	2.5	0.97	1772.8	38.6	1779.8	21.6	1788.0	11.7	1788.0	11.7	99.2
93	768249	2.1	9.1165	0.8	4.8098	2.4	0.3180	2.3	0.95	1780.0	35.6	1786.6	20.3	1794.3	14.0	1794.3	14.0	99.2
42	52783	1.1	9.1163	0.7	4.9829	3.2	0.3295	3.1	0.98	1835.7	50.2	1816.4	27.3	1794.3	13.0	1794.3	13.0	102.3
199	114864	2.4	9.1149	0.6	4.8076	2.1	0.3178	2.0	0.96	1779.1	31.4	1786.2	17.7	1794.6	10.7	1794.6	10.7	99.1
203	69150	2.1	9.1028	0.8	4.0657	3.1	0.2684	3.0	0.97	1532.8	41.4	1647.4	25.5	1797.0	14.0	1797.0	14.0	85.3
93	681794	1.9	9.1010	0.8	4.9285	2.0	0.3253	1.8	0.92	1815.6	29.1	1807.2	16.9	1797.4	14.0	1797.4	14.0	101.0
70	54521	1.2	9.0947	0.8	4.9485	3.0	0.3264	2.9	0.96	1820.9	45.3	1810.6	25.0	1798.6	14.6	1798.6	14.6	101.2
102	41328	2.1	9.0871	0.7	4.9164	2.9	0.3240	2.8	0.97	1809.3	43.7	1805.1	24.2	1800.2	13.6	1800.2	13.6	100.5
89	851170	1.5	9.0775	0.7	4.9776	2.6	0.3277	2.5	0.96	1827.3	39.1	1815.5	21.6	1802.1	12.5	1802.1	12.5	101.4
79	46577	1.4	9.0761	0.8	4.9705	2.8	0.3272	2.7	0.96	1824.7	43.0	1814.3	23.9	1802.4	15.0	1802.4	15.0	101.2
193	97804	2.0	9.0154	0.7	4.8351	2.6	0.3161	2.5	0.96	1770.9	38.5	1791.0	21.7	1814.6	12.6	1814.6	12.6	97.6
215	325773	1.7	8.9739	0.6	4.9825	2.3	0.3243	2.2	0.96	1810.6	34.8	1816.4	19.4	1822.9	11.0	1822.9	11.0	99.3
71	1432974	1.9	8.9555	0.8	5.2054	3.1	0.3381	3.0	0.96	1877.5	49.0	1853.5	26.6	1826.6	15.4	1826.6	15.4	102.8
72	214467	1.2	8.9247	0.8	5.0458	2.8	0.3266	2.7	0.96	1821.9	42.4	1827.0	23.7	1832.9	14.8	1832.9	14.8	99.4
116	10951	1.7	8.9176	0.7	4.1750	3.1	0.2700	3.0	0.97	1540.9	41.0	1669.1	25.2	1834.3	12.9	1834.3	12.9	84.0
273	366036	2.1	8.8705	0.7	4.7362	2.8	0.3047	2.7	0.97	1714.6	41.0	1773.7	23.6	1843.9	12.4	1843.9	12.4	93.0
86	44559	1.2	8.7348	0.9	5.2385	3.2	0.3319	3.1	0.96	1847.4	49.6	1858.9	27.4	1871.8	15.9	1871.8	15.9	98.7
128	79550	1.5	8.7301	0.7	5.4703	2.9	0.3464	2.8	0.97	1917.2	46.6	1895.9	24.8	1872.7	12.4	1872.7	12.4	102.4
84	69412	0.9	8.7085	0.6	5.4257	2.8	0.3427	2.7	0.98	1899.6	44.7	1888.9	23.9	1877.2	10.9	1877.2	10.9	101.2
47	75523	1.4	8.6794	0.9	5.5814	3.3	0.3513	3.2	0.96	1941.0	53.7	1913.2	28.8	1883.2	16.9	1883.2	16.9	103.1
288	298878	1.1	8.5881	0.7	5.3192	2.4	0.3313	2.4	0.96	1844.8	37.7	1872.0	20.9	1902.3	12.0	1902.3	12.0	97.0
284	53828	1.5	8.5624	0.6	4.8799	2.4	0.3030	2.4	0.97	1706.4	35.3	1798.8	20.5	1907.6	11.1	1907.6	11.1	89.4
125	15552	1.2	8.4468	1.7	5.1587	3.2	0.3160	2.7	0.85	1770.3	41.5	1845.8	27.0	1932.0	30.3	1932.0	30.3	91.6
67	37495	1.2	8.3340	0.7	5.9389	2.8	0.3590	2.7	0.97	1977.3	45.7	1966.9	24.0	1956.1	11.9	1956.1	11.9	101.1
91	5682	1.9	8.3003	1.7	5.5482	3.0	0.3340	2.5	0.82	1857.7	39.7	1908.1	25.8	1963.3	30.5	1963.3	30.5	94.6
46	32074	2.2	8.2823	0.7	5.9282	3.2	0.3561	3.2	0.98	1963.7	53.8	1965.4	28.2	1967.2	11.9	1967.2	11.9	99.8
81	65530	1.2	8.1583	0.6	6.0432	3.2	0.3576	3.1	0.98	1970.7	52.9	1982.1	27.7	1994.0	10.8	1994.0	10.8	98.8
117	21390	2.9	8.0841	0.6	5.7833	3.0	0.3391	2.9	0.98	1882.3	47.9	1943.9	26.0	2010.2	11.1	2010.2	11.1	93.6
30	26929	1.0	8.0685	0.9	6.1604	3.8	0.3605	3.7	0.97	1984.5	62.5	1998.8	33.0	2013.7	16.7	2013.7	16.7	98.6
71	9485	1.0	7.9600	2.0	6.0168	3.1	0.3474	2.5	0.78	1922.0	40.8	1978.3	27.4	2037.7	34.7	2037.7	34.7	94.3
146	12816	1.3	7.8790	0.8	6.3094	2.7	0.3605	2.6	0.95	1984.8	43.9	2019.8	23.7	2055.7	14.9	2055.7	14.9	96.5
71	35490	1.1	6.5630	0.7	7.7761	3.0	0.3701	2.9	0.97	2030.1	50.9	2205.4	27.0	2372.7	11.8	2372.7	11.8	85.6
52	109364	1.3	6.4744	0.8	9.6703	2.9	0.4541	2.8	0.96	2413.4	55.5	2403.9	26.5	2395.8	13.8	2395.8	13.8	100.7
98	75614	1.6	6.2335	0.7	10.0851	2.9	0.4559	2.8	0.97	2421.6	57.3	2442.6	27.0	2460.1	11.9	2460.1	11.9	98.4

77	167114	1.0	5.3342	0.8	13.2650	2.6	0.5132	2.5	0.96	2670.2	53.6	2698.7	24.2	2720.1	12.4	2720.1	12.4	98.2
198	2476917	1.3	5.0158	0.7	14.8856	3.5	0.5415	3.5	0.98	2789.8	78.2	2808.0	33.5	2821.0	11.2	2821.0	11.2	98.9

TA-03. Mirador Formation (Eocene).

U	206Pb	U/Th	206Pb*	±	207Pb*	±	206Pb*	±	error	206Pb*	±	207Pb*	±	206Pb*	±	Best age	±	Conc
(ppm)	204Pb		207Pb*	(%)	235U*	(%)	238U	(%)	corr.	238U*	(Ma)	235U	(Ma)	207Pb*	(Ma)	(Ma)	(Ma)	(%)
497	9798	1.8	21.1673	1.4	0.0488	2.7	0.0075	2.3	0.86	48.1	1.1	48.4	1.3	61.5	33.3	48.1	1.1	99.5
141	761	2.5	20.4053	6.4	0.0514	7.3	0.0076	3.6	0.49	48.9	1.7	50.9	3.6	148.2	150.0	48.9	1.7	96.0
841	42505	7.4	20.8043	0.9	0.0911	2.2	0.0137	2.0	0.91	88.0	1.7	88.5	1.9	102.6	21.3	88.0	1.7	99.4
121	3945	1.5	20.9257	2.0	0.1538	3.4	0.0233	2.8	0.82	148.8	4.1	145.3	4.6	88.8	46.4	148.8	4.1	102.4
185	12626	1.4	20.6636	1.7	0.1690	3.2	0.0253	2.7	0.85	161.3	4.3	158.6	4.7	118.6	39.5	161.3	4.3	101.7
233	28905	1.3	19.8875	1.1	0.2057	2.5	0.0297	2.2	0.89	188.5	4.1	189.9	4.3	208.1	25.9	188.5	4.1	99.2
471	272803	8.0	19.4419	0.8	0.2624	2.4	0.0370	2.2	0.94	234.2	5.2	236.6	5.0	260.4	18.1	234.2	5.2	99.0
431	24729	1.0	19.6392	1.2	0.2764	3.6	0.0394	3.4	0.94	248.9	8.3	247.8	7.9	237.1	27.5	248.9	8.3	100.5
174	8957	1.6	19.9370	1.2	0.2852	2.9	0.0412	2.6	0.91	260.5	6.6	254.8	6.4	202.3	27.4	260.5	6.6	102.3
285	145905	1.2	19.1961	1.3	0.2970	2.8	0.0413	2.5	0.89	261.2	6.4	264.0	6.5	289.5	29.0	261.2	6.4	98.9
180	229324	1.4	19.0994	1.4	0.3155	2.8	0.0437	2.4	0.86	275.8	6.5	278.4	6.8	301.1	32.8	275.8	6.5	99.0
79	7925	1.2	19.3730	1.7	0.3322	4.1	0.0467	3.7	0.91	294.1	10.7	291.2	10.4	268.5	38.8	294.1	10.7	101.0
285	16755	2.3	17.4407	0.9	0.6320	2.5	0.0799	2.4	0.93	495.8	11.2	497.4	9.9	504.5	19.7	495.8	11.2	98.3
275	738310	1.8	17.1362	0.9	0.6911	2.7	0.0859	2.5	0.94	531.2	12.8	533.5	11.1	543.2	19.8	531.2	12.8	97.8
142	34786	1.2	17.0629	0.9	0.7022	3.5	0.0869	3.4	0.97	537.2	17.4	540.1	14.6	552.5	18.7	537.2	17.4	97.2
1619	169650	4.9	17.1007	0.7	0.7208	2.2	0.0894	2.1	0.95	552.0	11.0	551.2	9.3	547.7	15.3	552.0	11.0	100.8
815	103227	7.3	16.6551	0.8	0.8049	3.7	0.0972	3.6	0.97	598.1	20.5	599.6	16.7	605.1	18.1	598.1	20.5	98.9
630	158017	2.7	16.2316	0.8	0.8943	2.3	0.1053	2.2	0.94	645.3	13.5	648.7	11.2	660.5	16.9	645.3	13.5	97.7
162	91337	1.0	15.5210	0.7	1.0547	2.5	0.1187	2.4	0.96	723.2	16.4	731.2	13.0	755.7	14.4	723.2	16.4	95.7
25	4896	2.9	14.1998	1.7	1.5768	5.7	0.1624	5.4	0.96	970.0	48.8	961.1	35.2	940.8	33.9	940.8	33.9	103.1
15	4484	6.7	14.1263	2.2	1.5737	5.7	0.1612	5.3	0.92	963.6	47.3	959.9	35.5	951.3	44.8	951.3	44.8	101.3
96	22725	3.1	14.1078	0.9	1.5575	4.2	0.1594	4.1	0.98	953.2	36.3	953.5	26.0	954.0	18.9	954.0	18.9	99.9
814	69189	3.7	13.9122	0.7	1.4685	2.2	0.1482	2.1	0.95	890.7	17.4	917.5	13.3	982.5	14.3	982.5	14.3	90.7
70	18482	1.6	13.9044	0.8	1.6317	4.1	0.1646	4.0	0.98	982.0	36.8	982.5	26.0	983.7	17.1	983.7	17.1	99.8
150	21154	2.5	13.8716	1.0	1.6252	5.2	0.1635	5.1	0.98	976.3	46.5	980.0	32.9	988.5	20.6	988.5	20.6	98.8
403	63336	3.1	13.8182	0.8	1.6798	2.6	0.1683	2.5	0.95	1003.0	23.1	1000.9	16.6	996.3	15.8	996.3	15.8	100.7
146	20745	3.2	13.7538	0.8	1.6147	3.5	0.1611	3.4	0.97	962.7	30.5	975.9	22.0	1005.8	16.7	1005.8	16.7	95.7
357	1634785	2.7	13.6630	0.8	1.6988	3.2	0.1683	3.1	0.97	1003.0	29.1	1008.1	20.7	1019.2	16.2	1019.2	16.2	98.4
86	121588	1.8	13.6506	0.8	1.7090	3.5	0.1692	3.4	0.97	1007.7	31.6	1011.9	22.4	1021.1	17.1	1021.1	17.1	98.7
116	17964	2.8	13.6207	0.8	1.7547	2.8	0.1733	2.7	0.96	1030.5	25.6	1028.9	18.1	1025.5	15.3	1025.5	15.3	100.5
103	149708	1.2	13.6034	0.9	1.7020	3.3	0.1679	3.1	0.96	1000.7	29.0	1009.3	20.8	1028.1	18.4	1028.1	18.4	97.3
85	19497	2.1	13.5821	0.8	1.6974	2.9	0.1672	2.7	0.96	996.7	25.4	1007.6	18.3	1031.2	16.4	1031.2	16.4	96.7

179	278764	2.5	13.5624	1.0	1.7351	3.3	0.1707	3.2	0.96	1015.8	29.6	1021.7	21.2	1034.2	19.6	1034.2	19.6	98.2
48	12602	2.6	13.5313	1.1	1.7691	4.1	0.1736	4.0	0.96	1032.0	37.9	1034.2	26.8	1038.8	23.1	1038.8	23.1	99.3
73	12116	1.5	13.4981	1.1	1.8292	3.5	0.1791	3.3	0.95	1061.9	32.7	1056.0	23.1	1043.8	22.5	1043.8	22.5	101.7
201	38770	1.7	12.6654	0.9	2.2063	3.1	0.2027	2.9	0.95	1189.6	31.6	1183.1	21.3	1171.0	18.4	1171.0	18.4	101.6
105	19037	2.6	12.4434	1.0	2.3165	3.5	0.2091	3.3	0.96	1223.8	37.0	1217.4	24.5	1205.9	18.8	1205.9	18.8	101.5
297	146163	5.0	12.3222	0.7	2.2576	2.9	0.2018	2.8	0.97	1184.8	30.2	1199.2	20.3	1225.2	14.4	1225.2	14.4	96.7
83	92528	1.6	12.2857	0.8	2.2954	3.1	0.2045	3.0	0.97	1199.6	33.0	1210.9	22.0	1231.0	15.5	1231.0	15.5	97.4
144	170384	1.9	12.2246	0.9	2.2999	2.7	0.2039	2.6	0.95	1196.3	28.4	1212.3	19.4	1240.8	17.3	1240.8	17.3	96.4
84	35863	1.7	12.0313	0.8	2.4874	3.4	0.2171	3.3	0.97	1266.3	37.9	1268.4	24.5	1271.9	14.8	1271.9	14.8	99.6
180	24493	0.5	11.9009	0.8	2.6947	3.1	0.2326	2.9	0.97	1348.0	35.8	1327.0	22.6	1293.2	15.6	1293.2	15.6	104.2
218	39371	2.1	11.8638	0.9	2.6403	2.8	0.2272	2.6	0.94	1319.7	31.2	1312.0	20.4	1299.2	17.6	1299.2	17.6	101.6
136	35156	2.2	11.8286	0.8	2.6447	3.1	0.2269	3.0	0.97	1318.2	36.0	1313.2	23.0	1305.0	15.1	1305.0	15.1	101.0
87	74957	1.8	11.7273	1.1	2.3897	3.2	0.2033	3.0	0.94	1192.8	33.0	1239.5	23.0	1321.7	20.7	1321.7	20.7	90.2
77	110084	1.5	11.6822	1.0	2.6749	3.6	0.2266	3.5	0.96	1316.8	41.1	1321.5	26.5	1329.2	18.8	1329.2	18.8	99.1
433	564653	1.6	11.6733	0.8	2.6938	2.8	0.2281	2.7	0.95	1324.3	31.8	1326.8	20.6	1330.6	16.3	1330.6	16.3	99.5
555	165538	1.0	11.6623	0.7	2.7175	2.5	0.2299	2.4	0.96	1333.7	28.8	1333.2	18.5	1332.4	13.8	1332.4	13.8	100.1
308	156555	2.2	11.5946	0.7	2.6996	2.6	0.2270	2.5	0.96	1318.8	29.8	1328.4	19.2	1343.7	13.7	1343.7	13.7	98.2
162	43449	1.9	11.5387	0.9	2.8488	3.3	0.2384	3.2	0.96	1378.4	39.3	1368.5	24.8	1353.0	17.6	1353.0	17.6	101.9
115	132194	0.6	11.5339	0.7	2.6413	5.1	0.2209	5.1	0.99	1286.9	58.9	1312.2	37.6	1353.8	14.3	1353.8	14.3	95.1
342	435263	3.0	11.4481	0.9	2.8965	2.7	0.2405	2.6	0.95	1389.3	31.9	1381.0	20.4	1368.2	16.8	1368.2	16.8	101.5
64	21448	2.8	11.1954	0.8	3.0482	4.1	0.2475	4.0	0.98	1425.6	50.8	1419.8	31.0	1411.1	15.4	1411.1	15.4	101.0
19	8540	3.6	11.1889	1.3	2.9994	4.9	0.2434	4.8	0.96	1404.3	60.2	1407.5	37.6	1412.2	24.8	1412.2	24.8	99.4
139	92399	2.0	11.1300	1.0	3.0179	2.8	0.2436	2.6	0.94	1405.4	33.5	1412.1	21.5	1422.3	18.4	1422.3	18.4	98.8
567	323962	3.3	11.0966	0.8	3.0578	2.3	0.2461	2.2	0.95	1418.3	28.2	1422.2	17.9	1428.0	14.6	1428.0	14.6	99.3
132	542211	1.3	10.9300	0.8	3.1293	2.7	0.2481	2.6	0.96	1428.5	33.1	1439.9	20.7	1456.8	14.7	1456.8	14.7	98.1
132	23262	2.3	10.9220	0.8	3.1231	2.8	0.2474	2.7	0.96	1425.0	34.9	1438.4	21.9	1458.2	15.0	1458.2	15.0	97.7
102	17738	1.4	10.8597	0.8	3.2253	2.8	0.2540	2.7	0.96	1459.2	35.3	1463.3	21.9	1469.1	15.7	1469.1	15.7	99.3
183	50079	2.7	10.8478	0.7	3.2132	2.3	0.2528	2.2	0.95	1452.9	28.7	1460.4	18.0	1471.2	14.2	1471.2	14.2	98.8
513	102936	3.1	10.7375	0.7	3.4926	2.5	0.2720	2.4	0.96	1550.9	33.4	1525.5	20.0	1490.6	13.6	1490.6	13.6	104.0
60	76841	2.0	10.7354	0.8	3.4523	3.7	0.2688	3.6	0.98	1534.7	49.7	1516.4	29.3	1490.9	14.6	1490.9	14.6	102.9
293	79502	1.9	10.7080	0.7	3.3363	2.2	0.2591	2.1	0.95	1485.3	28.4	1489.6	17.6	1495.8	13.0	1495.8	13.0	99.3
16	46342	0.7	10.6859	1.2	3.3883	5.5	0.2626	5.4	0.98	1503.1	71.7	1501.7	43.0	1499.7	22.9	1499.7	22.9	100.2
46	27534	0.9	10.6804	1.0	3.5712	4.1	0.2766	4.0	0.97	1574.4	56.2	1543.1	32.8	1500.6	18.5	1500.6	18.5	104.9
247	828242	1.9	10.6193	0.8	3.5087	2.7	0.2702	2.6	0.96	1542.0	36.0	1529.2	21.6	1511.5	14.9	1511.5	14.9	102.0
33	12081	0.6	10.5989	0.9	3.3690	4.1	0.2590	4.0	0.98	1484.6	52.8	1497.2	32.0	1515.1	17.0	1515.1	17.0	98.0
184	34040	1.0	10.5960	0.8	3.6233	2.9	0.2784	2.8	0.96	1583.5	38.7	1554.7	22.8	1515.6	14.8	1515.6	14.8	104.5
98	41585	0.9	10.5913	0.7	3.4539	2.7	0.2653	2.6	0.96	1517.0	35.8	1516.8	21.6	1516.5	13.9	1516.5	13.9	100.0
70	246301	1.3	10.5854	0.8	3.4314	3.3	0.2634	3.2	0.97	1507.4	42.7	1511.6	25.8	1517.5	15.0	1517.5	15.0	99.3
190	84552	1.1	10.5707	0.6	3.4069	2.7	0.2612	2.7	0.97	1496.0	35.7	1506.0	21.5	1520.1	11.7	1520.1	11.7	98.4
121	21910	0.9	10.5699	0.8	3.4849	3.0	0.2671	2.9	0.96	1526.3	39.9	1523.8	24.0	1520.3	15.4	1520.3	15.4	100.4
63	83298	1.2	10.5659	1.0	3.3953	3.4	0.2602	3.3	0.96	1490.8	43.8	1503.3	26.9	1521.0	18.1	1521.0	18.1	98.0

107	24899	2.4	10.5652	0.9	3.3910	4.0	0.2598	4.0	0.98	1489.0	52.6	1502.3	31.8	1521.1	16.4	1521.1	16.4	97.9
86	13497	1.1	10.5596	0.7	3.4503	4.0	0.2642	3.9	0.98	1511.5	52.5	1515.9	31.2	1522.1	13.4	1522.1	13.4	99.3
153	39410	1.5	10.5511	0.7	3.5734	2.4	0.2735	2.3	0.96	1558.3	31.8	1543.6	19.1	1523.6	13.3	1523.6	13.3	102.3
395	97202	1.7	10.5310	0.7	3.4358	2.6	0.2624	2.5	0.96	1502.2	34.0	1512.6	20.7	1527.2	13.5	1527.2	13.5	98.4
193	147582	0.7	10.4987	0.9	3.4122	2.7	0.2598	2.5	0.94	1488.9	33.3	1507.2	20.8	1533.0	16.4	1533.0	16.4	97.1
116	35577	1.2	10.4912	0.8	3.5206	3.4	0.2679	3.3	0.97	1530.0	44.5	1531.8	26.5	1534.3	14.5	1534.3	14.5	99.7
458	144299	2.6	10.4180	0.8	3.5512	2.5	0.2683	2.3	0.95	1532.3	31.9	1538.7	19.6	1547.5	15.0	1547.5	15.0	99.0
425	165129	2.7	10.3926	0.9	3.5883	2.9	0.2705	2.7	0.95	1543.2	37.1	1547.0	22.7	1552.1	17.2	1552.1	17.2	99.4
96	15833	1.0	10.3919	0.8	3.4793	3.4	0.2622	3.2	0.97	1501.3	43.5	1522.5	26.5	1552.2	15.8	1552.2	15.8	96.7
224	59597	2.1	10.3899	0.7	3.5849	2.3	0.2701	2.2	0.95	1541.5	29.8	1546.2	18.2	1552.6	13.3	1552.6	13.3	99.3
466	173062	2.7	10.3856	0.7	3.5523	2.4	0.2676	2.3	0.95	1528.5	31.3	1538.9	19.1	1553.4	13.6	1553.4	13.6	98.4
339	151570	1.7	10.3839	0.8	3.5835	2.5	0.2699	2.4	0.94	1540.2	32.4	1545.9	19.9	1553.7	15.7	1553.7	15.7	99.1
143	379645	0.8	10.3112	0.8	3.6074	3.5	0.2698	3.4	0.97	1539.7	46.0	1551.2	27.4	1566.9	14.9	1566.9	14.9	98.3
157	40398	2.2	9.7929	0.8	4.0867	2.5	0.2903	2.4	0.95	1642.8	35.0	1651.7	20.7	1662.9	14.4	1662.9	14.4	98.8
218	50511	1.7	9.6269	0.8	4.4324	3.1	0.3095	3.0	0.96	1738.1	45.6	1718.4	25.7	1694.5	15.1	1694.5	15.1	102.6
135	48279	1.7	9.5137	0.8	4.4952	2.5	0.3102	2.4	0.95	1741.5	35.9	1730.1	20.7	1716.2	14.9	1716.2	14.9	101.5
86	119184	1.4	9.3031	0.8	4.7549	3.2	0.3208	3.1	0.97	1793.8	48.0	1777.0	26.6	1757.3	14.9	1757.3	14.9	102.1
102	56528	1.3	9.2483	1.2	4.7705	4.1	0.3200	4.0	0.95	1789.6	61.8	1779.7	34.8	1768.1	22.6	1768.1	22.6	101.2
344	23148	1.2	9.2366	0.7	3.8800	3.9	0.2599	3.8	0.98	1489.4	50.9	1609.5	31.4	1770.4	12.5	1770.4	12.5	84.1
229	330905	2.3	9.2110	0.7	4.6220	2.9	0.3088	2.8	0.97	1734.6	43.1	1753.2	24.3	1775.5	12.1	1775.5	12.1	97.7
175	127399	0.8	9.1737	0.8	4.8181	2.9	0.3206	2.8	0.97	1792.5	43.9	1788.1	24.4	1782.9	13.8	1782.9	13.8	100.5
221	2653249	1.3	9.1459	0.9	4.8736	2.9	0.3233	2.8	0.95	1805.7	43.5	1797.7	24.4	1788.4	16.2	1788.4	16.2	101.0
104	69616	0.8	9.1450	0.7	4.6737	4.8	0.3100	4.7	0.99	1740.6	72.2	1762.5	40.1	1788.6	13.4	1788.6	13.4	97.3
219	63584	1.4	9.1245	0.8	4.8115	3.0	0.3184	2.9	0.97	1782.0	45.2	1786.9	25.3	1792.7	14.2	1792.7	14.2	99.4
169	95264	0.8	9.0380	0.8	4.8669	2.8	0.3190	2.7	0.96	1785.0	41.6	1796.6	23.4	1810.0	14.5	1810.0	14.5	98.6
116	1320546	1.2	9.0367	0.8	4.4060	6.9	0.2888	6.9	0.99	1635.4	99.7	1713.5	57.5	1810.3	14.1	1810.3	14.1	90.3
385	36700	1.9	8.9484	0.9	4.7131	2.8	0.3059	2.6	0.95	1720.4	39.6	1769.6	23.1	1828.1	15.6	1828.1	15.6	94.1
160	53897	1.5	8.7190	1.0	5.3342	3.1	0.3373	2.9	0.95	1873.7	47.5	1874.4	26.3	1875.0	17.3	1875.0	17.3	99.9
401	173092	3.7	5.6887	0.8	11.4157	2.3	0.4710	2.2	0.94	2487.9	44.6	2557.7	21.5	2613.5	12.9	2613.5	12.9	95.2
78	86454	2.6	5.5883	0.7	12.2556	3.2	0.4967	3.1	0.97	2599.7	66.0	2624.2	29.7	2643.1	11.7	2643.1	11.7	98.4

Ta-04. La Copé Formation, Lower member (Early Miocene)

U	206Pb	U/Th	206Pb*	±	207Pb*	±	206Pb*	±	error	206Pb*	±	207Pb*	±	206Pb*	±	Best age	±	Conc
(ppm)	204Pb		207Pb*	(%)	235U*	(%)	238U	(%)	corr.	238U*	(Ma)	235U	(Ma)	207Pb*	(Ma)	(Ma)	(Ma)	(%)
122	31582	1.1	17.8028	1.2	0.5788	3.0	0.0747	2.8	0.92	464.6	12.4	463.7	11.2	459.1	26.4	464.6	12.4	101.2
398	609308	2.6	16.3842	0.6	0.8931	1.7	0.1061	1.6	0.94	650.2	9.9	648.0	8.1	640.5	12.0	650.2	9.9	101.5
44	113713	2.5	14.2597	1.1	1.5028	3.3	0.1554	3.1	0.95	931.3	27.3	931.5	20.3	932.1	21.8	932.1	21.8	99.9
305	192892	3.1	14.2458	0.9	1.4991	2.4	0.1549	2.2	0.92	928.3	19.3	930.0	14.7	934.1	19.0	934.1	19.0	99.4
184	20441	1.2	14.2221	0.7	1.5054	2.0	0.1553	1.8	0.93	930.5	15.9	932.6	12.1	937.5	15.4	937.5	15.4	99.3
30	10540	5.1	14.0685	1.1	1.6470	3.3	0.1680	3.1	0.94	1001.3	28.8	988.4	20.9	959.7	23.1	959.7	23.1	104.3
169	122118	2.8	14.0453	0.8	1.5570	2.4	0.1586	2.3	0.95	949.0	20.4	953.3	15.1	963.1	16.0	963.1	16.0	98.5
133	18886	3.1	13.9118	0.6	1.6650	2.3	0.1680	2.2	0.96	1001.1	20.3	995.3	14.5	982.6	12.8	982.6	12.8	101.9
305	54932	2.2	13.8762	0.7	1.6514	1.9	0.1662	1.8	0.93	991.1	16.6	990.1	12.2	987.8	14.1	987.8	14.1	100.3
183	25230	3.1	13.8101	0.7	1.6701	1.9	0.1673	1.7	0.92	997.1	16.0	997.2	11.9	997.5	14.7	997.5	14.7	100.0
71	65841	1.6	13.8000	1.1	1.7263	2.6	0.1728	2.3	0.91	1027.4	22.1	1018.4	16.4	999.0	21.5	999.0	21.5	102.8
486	195882	4.1	13.7923	0.8	1.6922	1.6	0.1693	1.4	0.87	1008.1	12.7	1005.6	9.9	1000.1	15.4	1000.1	15.4	100.8
33	190543	3.6	13.7723	1.0	1.5634	3.6	0.1562	3.5	0.96	935.4	30.5	955.8	22.5	1003.1	19.4	1003.1	19.4	93.3
108	42163	2.8	13.7657	0.8	1.7555	2.7	0.1753	2.6	0.96	1041.1	24.8	1029.2	17.4	1004.0	15.5	1004.0	15.5	103.7
296	104352	4.5	13.7466	0.7	1.7344	1.7	0.1729	1.6	0.92	1028.2	15.3	1021.4	11.3	1006.8	13.7	1006.8	13.7	102.1
238	72285	2.9	13.7456	0.7	1.7002	2.1	0.1695	1.9	0.95	1009.3	18.2	1008.6	13.1	1007.0	13.4	1007.0	13.4	100.2
69	44043	3.5	13.7391	0.8	1.6745	2.8	0.1669	2.7	0.96	994.8	25.2	998.9	18.1	1007.9	15.7	1007.9	15.7	98.7
94	266612	2.0	13.7363	0.9	1.6559	3.1	0.1650	3.0	0.96	984.3	27.1	991.8	19.6	1008.4	17.6	1008.4	17.6	97.6
126	23647	2.4	13.7328	0.9	1.6582	2.4	0.1652	2.2	0.93	985.4	20.5	992.7	15.3	1008.9	17.7	1008.9	17.7	97.7
96	14771	2.9	13.7276	1.0	1.6929	3.0	0.1685	2.8	0.95	1004.1	26.4	1005.9	19.1	1009.6	19.6	1009.6	19.6	99.5
121	20327	3.9	13.7264	0.9	1.7234	3.1	0.1716	2.9	0.95	1020.8	27.6	1017.3	19.7	1009.8	18.6	1009.8	18.6	101.1
104	83760	2.5	13.7227	0.7	1.6418	2.5	0.1634	2.4	0.96	975.7	21.5	986.4	15.7	1010.4	14.7	1010.4	14.7	96.6
156	54031	4.1	13.7047	0.7	1.7480	2.6	0.1737	2.5	0.96	1032.7	23.6	1026.4	16.7	1013.0	14.6	1013.0	14.6	101.9
287	219881	3.0	13.6928	0.7	1.6997	2.5	0.1688	2.4	0.96	1005.5	22.6	1008.4	16.1	1014.8	13.6	1014.8	13.6	99.1
168	51053	4.1	13.6116	0.8	1.7074	1.8	0.1686	1.6	0.89	1004.2	14.5	1011.3	11.2	1026.8	15.9	1026.8	15.9	97.8
235	1299376	2.3	13.5931	0.6	1.7146	1.9	0.1690	1.8	0.94	1006.8	17.0	1014.0	12.4	1029.6	12.8	1029.6	12.8	97.8
259	43461	3.2	12.8295	0.6	2.0835	2.4	0.1939	2.4	0.97	1142.3	24.7	1143.4	16.7	1145.5	12.1	1145.5	12.1	99.7
126	22882	2.5	11.8617	0.7	2.6504	2.3	0.2280	2.2	0.95	1324.1	26.8	1314.8	17.3	1299.6	13.6	1299.6	13.6	101.9
111	37762	2.7	11.8303	0.7	2.6753	2.0	0.2295	1.8	0.94	1332.1	22.1	1321.7	14.5	1304.7	13.2	1304.7	13.2	102.1
195	45519	1.6	11.7876	0.9	2.6126	2.0	0.2234	1.8	0.90	1299.6	21.3	1304.2	14.8	1311.8	17.3	1311.8	17.3	99.1
71	34405	1.3	11.5897	0.6	2.8471	2.9	0.2393	2.9	0.98	1383.1	35.8	1368.0	22.1	1344.5	12.4	1344.5	12.4	102.9
156	45985	3.0	11.5336	0.6	2.7095	2.3	0.2266	2.2	0.96	1316.9	26.7	1331.1	17.3	1353.9	12.3	1353.9	12.3	97.3
151	113066	2.7	11.4822	0.6	2.8590	1.9	0.2381	1.8	0.95	1376.7	22.2	1371.2	14.2	1362.5	11.7	1362.5	11.7	101.0
73	45348	1.7	11.4217	0.7	2.9429	2.8	0.2438	2.7	0.97	1406.4	33.8	1393.0	21.0	1372.7	13.8	1372.7	13.8	102.5
89	443877	1.2	11.4113	0.6	2.8602	2.7	0.2367	2.6	0.97	1369.6	32.2	1371.5	20.2	1374.4	11.5	1374.4	11.5	99.7
67	12175	1.5	11.4089	0.8	3.0176	2.5	0.2497	2.4	0.95	1436.9	30.6	1412.1	19.1	1374.8	15.5	1374.8	15.5	104.5
142	25852	2.6	11.3719	0.6	3.0095	1.9	0.2482	1.8	0.95	1429.2	22.6	1410.0	14.1	1381.1	10.9	1381.1	10.9	103.5

97	15168	2.2	11.3704	0.7	2.9141	2.7	0.2403	2.6	0.97	1388.3	32.6	1385.6	20.5	1381.3	13.5	1381.3	13.5	100.5
73	34913	1.6	11.3692	0.8	2.9295	2.9	0.2416	2.8	0.96	1394.8	34.6	1389.6	21.7	1381.5	15.0	1381.5	15.0	101.0
78	47689	2.0	11.3457	0.8	2.9199	3.2	0.2403	3.1	0.97	1388.1	38.4	1387.1	24.0	1385.5	14.6	1385.5	14.6	100.2
315	345890	1.5	11.3286	0.8	2.9161	2.7	0.2396	2.6	0.96	1384.6	32.3	1386.1	20.4	1388.4	14.5	1388.4	14.5	99.7
140	75959	2.0	11.3278	0.6	2.9118	2.2	0.2392	2.1	0.95	1382.7	25.8	1385.0	16.4	1388.5	12.4	1388.5	12.4	99.6
57	30449	1.4	11.2901	0.7	2.9410	4.3	0.2408	4.2	0.99	1391.0	52.6	1392.5	32.4	1394.9	14.0	1394.9	14.0	99.7
138	40091	2.7	11.2834	0.8	2.9654	2.7	0.2427	2.6	0.95	1400.6	32.3	1398.8	20.5	1396.1	15.5	1396.1	15.5	100.3
111	46571	1.9	11.2684	0.7	2.9405	2.7	0.2403	2.7	0.97	1388.3	33.1	1392.4	20.8	1398.6	13.4	1398.6	13.4	99.3
317	70396	2.8	11.2297	0.7	2.9541	1.9	0.2406	1.8	0.93	1389.8	21.9	1395.9	14.3	1405.2	13.6	1405.2	13.6	98.9
74	93436	1.9	11.2291	0.9	2.9686	3.0	0.2418	2.9	0.95	1395.9	35.8	1399.6	22.8	1405.3	18.0	1405.3	18.0	99.3
57	98088	2.3	11.1784	0.9	3.0355	3.9	0.2461	3.8	0.97	1418.3	47.8	1416.6	29.6	1414.0	17.7	1414.0	17.7	100.3
69	53228	1.8	11.1635	0.7	3.0249	3.1	0.2449	3.0	0.97	1412.2	37.8	1413.9	23.4	1416.5	14.1	1416.5	14.1	99.7
321	70740	1.9	11.1419	0.7	3.0807	2.1	0.2489	2.0	0.94	1433.0	25.1	1427.9	15.9	1420.2	13.1	1420.2	13.1	100.9
145	74050	2.0	11.1362	0.7	3.1261	2.3	0.2525	2.2	0.96	1451.3	28.3	1439.1	17.6	1421.2	12.9	1421.2	12.9	102.1
173	95745	2.1	11.1252	0.7	3.1085	2.4	0.2508	2.3	0.96	1442.7	30.2	1434.8	18.7	1423.1	13.0	1423.1	13.0	101.4
310	25733	1.8	11.1008	0.7	2.7589	2.9	0.2221	2.9	0.97	1293.1	33.5	1344.5	21.9	1427.3	13.0	1427.3	13.0	90.6
76	175109	1.5	11.0807	0.8	3.0407	3.7	0.2444	3.6	0.97	1409.3	45.4	1417.9	28.2	1430.7	16.0	1430.7	16.0	98.5
155	47502	2.2	11.0221	0.6	3.1257	2.4	0.2499	2.3	0.96	1437.8	29.2	1439.0	18.1	1440.9	11.8	1440.9	11.8	99.8
1019	269529	3.0	11.0072	0.7	3.2506	1.7	0.2595	1.5	0.92	1487.3	20.3	1469.3	12.9	1443.4	12.4	1443.4	12.4	103.0
62	15603	1.2	11.0030	0.8	3.2376	3.5	0.2584	3.4	0.97	1481.5	45.0	1466.2	27.2	1444.2	15.9	1444.2	15.9	102.6
135	62054	2.3	10.9883	0.8	3.1939	2.6	0.2545	2.5	0.95	1461.8	32.1	1455.7	20.0	1446.7	15.2	1446.7	15.2	101.0
87	984552	2.3	10.9792	0.6	3.1215	2.1	0.2486	2.0	0.96	1431.1	26.0	1438.0	16.2	1448.3	10.6	1448.3	10.6	98.8
355	96488	1.3	10.9246	0.5	3.1177	1.7	0.2470	1.6	0.96	1423.1	20.7	1437.1	13.0	1457.8	9.0	1457.8	9.0	97.6
44	24130	1.2	10.9053	0.9	3.3486	5.2	0.2648	5.1	0.98	1514.6	69.4	1492.5	40.9	1461.1	18.0	1461.1	18.0	103.7
31	7546	2.0	10.8805	0.9	3.3185	4.9	0.2619	4.8	0.98	1499.4	64.8	1485.4	38.5	1465.5	17.2	1465.5	17.2	102.3
14	9122	0.4	10.7822	1.4	3.4376	6.5	0.2688	6.4	0.98	1534.8	86.8	1513.0	51.2	1482.7	26.6	1482.7	26.6	103.5
70	97247	1.6	10.7461	0.7	3.3190	2.8	0.2587	2.7	0.97	1483.1	36.4	1485.5	22.2	1489.0	14.0	1489.0	14.0	99.6
280	102090	2.3	10.7246	0.7	3.4285	2.5	0.2667	2.4	0.96	1523.9	33.1	1510.9	19.8	1492.8	12.6	1492.8	12.6	102.1
51	157499	0.6	10.6530	0.7	3.4580	3.5	0.2672	3.4	0.98	1526.4	45.9	1517.7	27.2	1505.5	13.9	1505.5	13.9	101.4
99	44350	1.3	10.5951	0.6	3.5819	2.7	0.2752	2.6	0.97	1567.4	36.4	1545.5	21.4	1515.8	12.0	1515.8	12.0	103.4
50	15954	1.3	10.5565	0.9	3.4676	3.4	0.2655	3.3	0.96	1517.9	44.0	1519.9	26.6	1522.7	17.1	1522.7	17.1	99.7
219	816324	2.5	10.5318	0.6	3.4946	2.0	0.2669	1.9	0.95	1525.2	25.3	1526.0	15.5	1527.1	12.0	1527.1	12.0	99.9
212	247469	2.7	10.5162	0.6	3.4884	1.8	0.2661	1.8	0.95	1520.8	23.8	1524.6	14.6	1529.9	10.8	1529.9	10.8	99.4
44	25408	1.3	10.0942	1.4	3.7794	3.7	0.2767	3.4	0.93	1574.7	47.3	1588.4	29.4	1606.6	25.9	1606.6	25.9	98.0
201	4643244	1.5	9.3856	0.7	4.6250	1.8	0.3148	1.7	0.92	1764.4	26.0	1753.8	15.3	1741.1	13.3	1741.1	13.3	101.3
133	39590	2.1	9.3853	0.8	4.5304	2.4	0.3084	2.2	0.95	1732.7	34.1	1736.6	19.7	1741.2	13.9	1741.2	13.9	99.5
238	197618	2.6	9.3729	0.7	4.4357	1.9	0.3015	1.7	0.94	1698.9	26.1	1719.0	15.5	1743.6	12.0	1743.6	12.0	97.4
194	82324	1.3	9.3501	0.7	4.3814	2.2	0.2971	2.1	0.95	1677.0	30.7	1708.8	18.0	1748.1	11.9	1748.1	11.9	95.9
69	24493	1.5	9.3465	0.7	4.7099	3.3	0.3193	3.2	0.98	1786.2	50.2	1769.0	27.6	1748.8	13.3	1748.8	13.3	102.1
343	603630	2.2	9.3277	0.4	4.4477	2.3	0.3009	2.3	0.98	1695.7	34.1	1721.3	19.3	1752.5	7.6	1752.5	7.6	96.8
213	153062	1.8	9.3007	0.7	4.5205	2.2	0.3049	2.0	0.95	1715.7	30.9	1734.7	17.9	1757.8	12.4	1757.8	12.4	97.6

107	41899	1.0	9.2936	0.8	4.7096	2.5	0.3174	2.4	0.95	1777.2	37.5	1769.0	21.2	1759.2	14.0	1759.2	14.0	101.0
202	100945	2.4	9.2106	0.7	4.8563	2.0	0.3244	1.9	0.94	1811.2	29.8	1794.7	16.8	1775.5	12.0	1775.5	12.0	102.0
263	102773	1.6	9.1696	0.5	4.8284	1.9	0.3211	1.8	0.97	1795.1	28.7	1789.9	15.9	1783.7	8.8	1783.7	8.8	100.6
202	70095	1.0	9.1661	0.6	4.8670	1.6	0.3236	1.5	0.94	1807.1	22.9	1796.6	13.1	1784.4	10.0	1784.4	10.0	101.3
176	373926	1.6	9.1649	0.5	4.8500	1.9	0.3224	1.9	0.96	1801.3	29.4	1793.6	16.4	1784.6	9.6	1784.6	9.6	100.9
115	126105	1.2	9.1645	0.8	4.9938	2.8	0.3319	2.7	0.96	1847.7	43.4	1818.3	23.8	1784.7	13.8	1784.7	13.8	103.5
247	127807	1.6	9.1492	0.6	4.5866	1.6	0.3043	1.5	0.92	1712.8	22.6	1746.8	13.5	1787.8	11.3	1787.8	11.3	95.8
247	899327	3.6	9.1469	0.6	4.6704	2.0	0.3098	1.9	0.95	1739.9	28.2	1761.9	16.3	1788.2	11.2	1788.2	11.2	97.3
231	118857	1.1	9.1394	0.7	4.7732	2.2	0.3164	2.0	0.95	1772.1	31.6	1780.2	18.1	1789.7	12.8	1789.7	12.8	99.0
81	81634	1.4	9.1366	0.8	4.9136	3.0	0.3256	2.9	0.96	1817.0	45.3	1804.6	25.0	1790.3	14.2	1790.3	14.2	101.5
117	38660	1.8	9.1101	0.6	4.9902	2.7	0.3297	2.6	0.98	1837.0	41.6	1817.7	22.6	1795.5	10.6	1795.5	10.6	102.3
165	75661	1.3	9.0836	0.5	4.9160	2.2	0.3239	2.1	0.97	1808.6	33.4	1805.0	18.4	1800.9	9.7	1800.9	9.7	100.4
50	61259	0.9	9.0742	0.9	4.8596	3.7	0.3198	3.6	0.97	1788.9	55.9	1795.3	31.1	1802.7	16.1	1802.7	16.1	99.2
274	59141	2.2	9.0000	0.8	4.9242	1.9	0.3214	1.7	0.90	1796.7	27.0	1806.4	16.2	1817.6	15.4	1817.6	15.4	98.8
262	26424	1.8	8.8623	0.8	5.0239	2.1	0.3229	2.0	0.93	1803.9	31.3	1823.4	18.1	1845.6	14.0	1845.6	14.0	97.7
159	59077	1.4	8.7641	0.7	5.4628	2.0	0.3472	1.9	0.94	1921.4	31.2	1894.8	17.2	1865.7	12.4	1865.7	12.4	103.0
196	8847	1.3	8.7624	1.6	5.0243	2.9	0.3193	2.4	0.84	1786.3	37.8	1823.4	24.4	1866.1	28.3	1866.1	28.3	95.7
186	132245	1.8	8.7181	0.5	5.5668	2.2	0.3520	2.1	0.97	1944.1	35.3	1911.0	18.6	1875.2	9.2	1875.2	9.2	103.7
377	1528325	0.9	8.2948	0.7	5.9613	1.8	0.3586	1.7	0.93	1975.7	28.8	1970.2	15.8	1964.5	11.9	1964.5	11.9	100.6
552	637755	0.8	7.8881	0.5	6.3177	1.5	0.3614	1.4	0.93	1989.0	23.5	2020.9	12.9	2053.7	9.6	2053.7	9.6	96.8
160	89249	1.3	6.1262	0.6	10.3998	2.7	0.4621	2.6	0.97	2448.7	53.7	2471.0	25.1	2489.4	10.8	2489.4	10.8	98.4

TA-05. Barco Formation (Paleocene).

U	206Pb	U/Th	206Pb*	±	207Pb*	±	206Pb*	±	error	206Pb*	±	207Pb*	±	206Pb*	±	Best age	±	Conc
(ppm)	204Pb		207Pb*	(%)	235U*	(%)	238U	(%)	corr.	238U*	(Ma)	235U	(Ma)	207Pb*	(Ma)	(Ma)	(Ma)	(%)
154	15290	3.3	20.7159	2.5	0.0758	3.8	0.0114	2.9	0.76	73.0	2.1	74.2	2.7	112.6	58.9	73.0	2.1	98.4
1581	29399	1.8	20.3099	0.8	0.0824	3.0	0.0121	2.9	0.96	77.7	2.2	80.4	2.3	159.2	19.4	77.7	2.2	96.7
322	3425	1.3	21.4969	2.9	0.0785	3.6	0.0122	2.1	0.58	78.5	1.6	76.8	2.7	24.6	69.9	78.5	1.6	102.2
191	45351	1.5	14.8180	1.0	1.2171	3.0	0.1308	2.9	0.95	792.5	21.3	808.5	16.8	852.8	20.0	792.5	21.3	92.9
90	103011	2.4	13.9827	0.8	1.6067	3.2	0.1629	3.1	0.97	973.1	27.7	972.8	19.8	972.2	16.0	972.2	16.0	100.1
187	65829	0.8	13.9808	0.7	1.5383	1.8	0.1560	1.7	0.92	934.4	14.8	945.8	11.4	972.5	14.6	972.5	14.6	96.1
196	110340	1.8	13.6648	0.8	1.7594	2.5	0.1744	2.4	0.94	1036.2	22.8	1030.6	16.3	1018.9	16.7	1018.9	16.7	101.7
246	24090	2.5	13.2351	1.6	1.8098	2.7	0.1737	2.1	0.80	1032.6	20.4	1049.0	17.6	1083.3	32.6	1083.3	32.6	95.3
64	28132	1.2	13.2330	0.9	1.9506	3.1	0.1872	3.0	0.96	1106.2	30.0	1098.6	20.7	1083.7	18.1	1083.7	18.1	102.1
68	84738	1.5	12.2927	0.9	2.3734	4.1	0.2116	4.0	0.98	1237.3	44.5	1234.6	29.0	1229.9	17.6	1229.9	17.6	100.6
158	23184	1.4	12.0154	0.7	2.6362	1.9	0.2297	1.8	0.94	1333.1	22.0	1310.8	14.3	1274.5	13.4	1274.5	13.4	104.6
275	125894	2.0	11.7013	0.6	2.7737	2.0	0.2354	1.9	0.95	1362.7	23.6	1348.5	15.1	1326.0	12.5	1326.0	12.5	102.8
96	799232	1.0	11.4259	0.8	2.9141	2.0	0.2415	1.8	0.92	1394.4	22.8	1385.6	14.9	1372.0	15.0	1372.0	15.0	101.6

248	90630	2.1	11.3439	0.8	2.9748	2.5	0.2447	2.4	0.95	1411.3	30.6	1401.2	19.3	1385.8	14.8	1385.8	14.8	101.8
92	29304	2.0	11.2993	0.8	3.0402	3.1	0.2491	3.0	0.96	1434.1	38.1	1417.8	23.5	1393.4	15.6	1393.4	15.6	102.9
185	59439	1.7	11.2442	0.7	2.9251	2.8	0.2385	2.7	0.97	1379.1	33.7	1388.4	21.2	1402.7	13.4	1402.7	13.4	98.3
312	129854	2.2	11.1021	0.6	3.1540	2.7	0.2540	2.6	0.97	1458.8	33.7	1446.0	20.5	1427.1	12.0	1427.1	12.0	102.2
507	113058	3.5	11.0420	0.7	3.0140	2.1	0.2414	2.0	0.95	1393.8	24.6	1411.2	15.8	1437.4	12.5	1437.4	12.5	97.0
245	25602	2.5	10.9276	0.8	3.1787	2.5	0.2519	2.3	0.95	1448.4	30.3	1452.0	19.0	1457.2	14.8	1457.2	14.8	99.4
34	16720	1.4	10.7372	1.1	3.2676	4.9	0.2545	4.8	0.97	1461.4	62.4	1473.4	38.1	1490.6	20.7	1490.6	20.7	98.0
220	37883	2.5	10.6692	0.8	3.4165	2.7	0.2644	2.6	0.96	1512.2	35.3	1508.2	21.4	1502.6	14.6	1502.6	14.6	100.6
121	41088	0.9	10.6579	0.7	3.3527	2.4	0.2592	2.3	0.96	1485.6	31.2	1493.4	19.1	1504.6	12.6	1504.6	12.6	98.7
168	39591	0.7	10.6544	0.7	3.3325	2.3	0.2575	2.2	0.95	1477.1	29.0	1488.7	18.0	1505.2	13.7	1505.2	13.7	98.1
90	86515	1.3	10.6187	0.7	3.4738	2.7	0.2675	2.6	0.97	1528.3	35.2	1521.3	21.1	1511.6	13.0	1511.6	13.0	101.1
71	26595	1.3	10.6078	0.7	3.6093	2.4	0.2777	2.3	0.95	1579.7	32.8	1551.6	19.5	1513.5	13.7	1513.5	13.7	104.4
152	26243	1.1	10.6037	0.7	3.6043	2.7	0.2772	2.6	0.97	1577.2	36.4	1550.5	21.4	1514.2	12.7	1514.2	12.7	104.2
130	45761	1.2	10.6034	0.5	3.5539	3.0	0.2733	3.0	0.98	1557.6	41.0	1539.3	23.9	1514.3	10.1	1514.3	10.1	102.9
27	8783	0.6	10.5999	0.9	3.3455	4.0	0.2572	3.9	0.97	1475.5	51.2	1491.7	31.2	1514.9	17.6	1514.9	17.6	97.4
223	71396	1.4	10.5820	0.7	3.5300	2.2	0.2709	2.1	0.95	1545.5	29.2	1534.0	17.6	1518.1	12.7	1518.1	12.7	101.8
543	79535	2.8	10.5810	0.6	3.5720	1.7	0.2741	1.6	0.94	1561.7	21.7	1543.3	13.2	1518.3	11.1	1518.3	11.1	102.9
161	63832	1.2	10.5598	0.6	3.5628	2.8	0.2729	2.7	0.98	1555.3	37.8	1541.3	22.2	1522.1	11.1	1522.1	11.1	102.2
124	88185	0.8	10.5530	0.9	3.4981	2.6	0.2677	2.5	0.94	1529.3	33.7	1526.8	20.7	1523.3	16.2	1523.3	16.2	100.4
203	87350	1.4	10.5438	0.8	3.6024	2.0	0.2755	1.8	0.92	1568.5	25.6	1550.1	16.0	1524.9	15.1	1524.9	15.1	102.9
489	550521	2.8	10.5218	0.8	3.3952	2.7	0.2591	2.6	0.96	1485.2	34.6	1503.3	21.4	1528.9	14.8	1528.9	14.8	97.1
104	45013	0.9	10.5088	0.7	3.5199	2.7	0.2683	2.6	0.96	1532.0	35.2	1531.7	21.3	1531.2	14.1	1531.2	14.1	100.1
166	164401	1.7	10.4853	0.6	3.4650	2.4	0.2635	2.3	0.96	1507.7	30.7	1519.3	18.7	1535.4	12.1	1535.4	12.1	98.2
148	30205	0.7	10.4455	0.8	3.4587	2.3	0.2620	2.1	0.93	1500.2	28.6	1517.9	18.1	1542.6	15.9	1542.6	15.9	97.3
470	1477847	3.6	10.4338	0.7	3.5511	2.1	0.2687	2.0	0.95	1534.3	26.7	1538.7	16.3	1544.7	12.3	1544.7	12.3	99.3
566	19818	2.6	10.3980	0.7	3.1279	2.6	0.2359	2.5	0.96	1365.3	30.7	1439.6	20.0	1551.1	13.6	1551.1	13.6	88.0
169	83654	2.7	10.3952	0.7	3.6003	2.6	0.2714	2.5	0.96	1548.1	33.9	1549.6	20.4	1551.6	13.8	1551.6	13.8	99.8
85	168543	0.9	10.3642	0.8	3.6109	2.4	0.2714	2.3	0.94	1548.0	31.4	1551.9	19.3	1557.2	15.8	1557.2	15.8	99.4
401	869900	4.1	10.3053	0.8	3.6812	2.1	0.2751	2.0	0.94	1566.8	27.9	1567.3	17.1	1567.9	14.2	1567.9	14.2	99.9
25	10448	0.6	10.2777	0.9	3.4677	4.7	0.2585	4.6	0.98	1482.1	60.6	1519.9	36.7	1573.0	16.3	1573.0	16.3	94.2
127	69331	1.9	10.1744	0.7	3.9276	2.7	0.2898	2.6	0.96	1640.6	37.2	1619.4	21.7	1591.8	14.0	1591.8	14.0	103.1
55	9065	2.5	10.1132	0.8	3.7813	3.1	0.2774	3.0	0.96	1578.0	41.8	1588.8	24.9	1603.1	15.7	1603.1	15.7	98.4
222	78055	1.3	10.0696	0.6	3.9239	2.1	0.2866	2.1	0.96	1624.3	29.5	1618.6	17.3	1611.2	10.5	1611.2	10.5	100.8
206	118647	2.0	10.0397	0.7	3.8864	2.4	0.2830	2.3	0.96	1606.4	32.6	1610.9	19.3	1616.7	12.7	1616.7	12.7	99.4
38	3051	0.9	9.9785	1.9	3.9323	4.7	0.2846	4.3	0.91	1614.4	60.8	1620.3	37.7	1628.1	35.0	1628.1	35.0	99.2
157	7784	1.8	9.8576	1.7	3.3871	3.5	0.2422	3.1	0.88	1397.9	38.5	1501.4	27.3	1650.7	30.8	1650.7	30.8	84.7
240	4472	2.2	9.7922	1.2	3.5587	3.0	0.2527	2.8	0.93	1452.6	36.6	1540.4	24.1	1663.0	21.3	1663.0	21.3	87.3
291	9267	1.3	9.7620	1.3	3.3302	3.4	0.2358	3.1	0.92	1364.7	38.3	1488.2	26.4	1668.7	24.5	1668.7	24.5	81.8
231	487889	1.8	9.4449	0.6	4.5996	2.0	0.3151	1.9	0.95	1765.7	28.8	1749.2	16.3	1729.6	10.9	1729.6	10.9	102.1
175	41745	2.5	9.3276	0.6	4.7826	2.1	0.3235	2.0	0.95	1807.0	30.9	1781.9	17.3	1752.5	11.4	1752.5	11.4	103.1
350	93778	2.6	9.3196	0.6	4.5453	2.2	0.3072	2.1	0.96	1727.0	32.1	1739.3	18.3	1754.1	10.6	1754.1	10.6	98.5

243	298815	2.1	9.3124	0.8	4.6180	2.6	0.3119	2.5	0.96	1750.0	38.5	1752.5	22.0	1755.5	14.3	1755.5	14.3	99.7
98	92280	1.8	9.2828	0.8	4.8109	3.5	0.3239	3.4	0.97	1808.7	54.3	1786.8	29.7	1761.3	14.7	1761.3	14.7	102.7
204	201731	1.0	9.2581	0.6	4.7576	2.1	0.3195	2.0	0.96	1787.1	31.2	1777.4	17.5	1766.2	11.0	1766.2	11.0	101.2
225	155463	2.4	9.2461	0.9	4.9087	3.0	0.3292	2.8	0.95	1834.4	44.9	1803.8	25.0	1768.5	17.2	1768.5	17.2	103.7
183	20104752	1.9	9.2276	0.7	4.7530	2.4	0.3181	2.3	0.95	1780.4	36.3	1776.6	20.6	1772.2	13.5	1772.2	13.5	100.5
167	24080	1.7	9.2138	0.7	4.7684	2.2	0.3186	2.1	0.95	1783.1	32.2	1779.3	18.2	1774.9	12.2	1774.9	12.2	100.5
310	338758	1.5	9.2095	0.6	4.8857	2.3	0.3263	2.2	0.97	1820.6	35.6	1799.8	19.6	1775.8	11.0	1775.8	11.0	102.5
208	98495	2.6	9.1703	0.5	4.9680	1.9	0.3304	1.9	0.96	1840.4	29.9	1813.9	16.5	1783.6	9.8	1783.6	9.8	103.2
545	237495	44.4	9.1680	0.6	4.8110	2.1	0.3199	2.0	0.95	1789.2	31.4	1786.8	17.7	1784.0	11.7	1784.0	11.7	100.3
242	2667944	1.3	9.1602	0.7	4.9501	2.3	0.3289	2.2	0.95	1832.9	34.5	1810.8	19.3	1785.6	13.6	1785.6	13.6	102.7
235	61526	2.3	9.1579	0.4	4.9139	1.9	0.3264	1.8	0.97	1820.8	29.0	1804.6	15.9	1786.0	8.0	1786.0	8.0	101.9
179	103017	1.7	9.1384	0.6	4.8440	2.8	0.3210	2.7	0.97	1794.8	42.8	1792.6	23.6	1789.9	11.7	1789.9	11.7	100.3
161	97274	2.0	9.1321	0.5	4.9283	2.2	0.3264	2.1	0.97	1821.0	33.0	1807.1	18.2	1791.2	10.0	1791.2	10.0	101.7
187	28769	0.9	9.1318	0.7	4.7337	2.4	0.3135	2.3	0.96	1758.0	34.9	1773.2	19.9	1791.2	12.6	1791.2	12.6	98.1
97	29618	1.0	9.0993	0.7	4.9374	2.6	0.3258	2.5	0.96	1818.2	39.2	1808.7	21.7	1797.7	12.3	1797.7	12.3	101.1
229	421782	1.4	9.0975	0.6	5.0103	2.0	0.3306	1.9	0.95	1841.2	30.5	1821.1	17.0	1798.1	11.4	1798.1	11.4	102.4
361	25305	0.7	9.0964	0.6	4.6410	1.9	0.3062	1.8	0.94	1721.9	26.8	1756.7	15.7	1798.3	11.5	1798.3	11.5	95.8
152	28002	1.7	9.0878	0.7	5.1348	3.1	0.3384	3.1	0.98	1879.2	50.0	1841.9	26.7	1800.0	12.6	1800.0	12.6	104.4
184	32904	1.2	9.0411	0.7	4.9989	2.7	0.3278	2.6	0.97	1827.7	41.0	1819.1	22.5	1809.4	12.4	1809.4	12.4	101.0
154	98973	1.4	9.0376	0.6	4.9539	2.5	0.3247	2.4	0.97	1812.7	38.0	1811.5	21.0	1810.1	10.8	1810.1	10.8	100.1
144	105621	0.8	9.0339	0.5	5.1020	2.0	0.3343	2.0	0.97	1859.1	32.0	1836.4	17.4	1810.8	9.4	1810.8	9.4	102.7
73	30029	1.6	9.0271	0.7	5.0976	3.8	0.3337	3.7	0.98	1856.5	59.9	1835.7	32.1	1812.2	12.9	1812.2	12.9	102.4
184	57671	1.3	9.0204	0.5	4.8511	2.5	0.3174	2.4	0.98	1776.9	37.7	1793.8	20.9	1813.5	9.5	1813.5	9.5	98.0
100	43625	1.5	9.0045	0.6	4.9161	2.5	0.3211	2.4	0.97	1794.9	38.3	1805.0	21.3	1816.8	11.6	1816.8	11.6	98.8
56	32864	1.0	8.9967	0.8	4.9792	2.9	0.3249	2.7	0.96	1813.6	43.5	1815.8	24.3	1818.3	15.3	1818.3	15.3	99.7
135	39815	1.3	8.9707	0.5	5.0472	2.9	0.3284	2.8	0.98	1830.5	45.0	1827.3	24.3	1823.6	9.1	1823.6	9.1	100.4
189	3400989	1.9	8.9685	0.6	5.0464	2.5	0.3282	2.5	0.97	1829.9	39.1	1827.1	21.5	1824.0	11.8	1824.0	11.8	100.3
291	32006	0.8	8.9045	0.7	4.8702	2.0	0.3145	1.8	0.93	1762.9	28.5	1797.1	16.7	1837.0	12.8	1837.0	12.8	96.0
118	161089	1.4	8.7659	1.1	5.4409	3.4	0.3459	3.2	0.95	1915.0	52.7	1891.3	28.8	1865.4	19.1	1865.4	19.1	102.7
136	88414	1.5	8.7281	0.6	5.1561	4.1	0.3264	4.0	0.99	1820.9	63.9	1845.4	34.6	1873.2	10.2	1873.2	10.2	97.2
130	67547	1.3	8.6595	0.7	5.5045	2.4	0.3457	2.3	0.95	1914.1	38.4	1901.3	20.9	1887.4	13.3	1887.4	13.3	101.4
96	571468	1.3	8.6231	0.8	5.7499	3.0	0.3596	2.9	0.96	1980.3	49.2	1938.9	26.0	1894.9	15.1	1894.9	15.1	104.5
185	6383	1.1	8.5415	1.3	5.2050	3.0	0.3224	2.7	0.89	1801.7	41.7	1853.4	25.3	1912.0	24.1	1912.0	24.1	94.2
146	4279	1.1	8.4123	0.6	4.5330	2.4	0.2766	2.3	0.97	1574.1	32.5	1737.1	20.0	1939.3	11.0	1939.3	11.0	81.2
282	70798	1.6	8.3599	0.6	5.9103	1.9	0.3584	1.7	0.94	1974.4	29.6	1962.8	16.1	1950.5	11.4	1950.5	11.4	101.2
455	5832	1.1	8.2907	2.1	4.6060	4.2	0.2770	3.6	0.86	1576.0	50.6	1750.4	35.0	1965.4	37.8	1965.4	37.8	80.2
161	21762	1.5	8.2642	0.7	5.7978	2.2	0.3475	2.1	0.94	1922.7	34.8	1946.1	19.2	1971.1	13.1	1971.1	13.1	97.5
118	107824	1.1	8.2128	0.6	6.1539	2.7	0.3666	2.6	0.98	2013.2	45.6	1997.9	23.6	1982.2	10.4	1982.2	10.4	101.6
225	2767	1.4	7.6029	3.5	5.8835	4.2	0.3244	2.3	0.55	1811.3	36.4	1958.8	36.2	2118.4	61.0	2118.4	61.0	85.5
266	131369	1.1	4.3476	0.5	20.4175	2.1	0.6438	2.1	0.97	3203.9	52.0	3111.3	20.6	3052.1	8.1	3052.1	8.1	105.0

TA-07. Aguardiente Formation (Cretaceous)

U	206Pb	U/Th	206Pb*	±	207Pb*	±	206Pb*	±	error	206Pb*	±	207Pb*	±	206Pb*	±	Best age	±	Conc
(ppm)	204Pb		207Pb*	(%)	235U*	(%)	238U	(%)	corr.	238U*	(Ma)	235U	(Ma)	207Pb*	(Ma)	(Ma)	(Ma)	(%)
140	37799	0.7	18.0455	1.6	0.5112	2.7	0.0669	2.2	0.81	417.5	8.9	419.3	9.3	429.0	35.0	417.5	8.9	97.3
64	28121	2.9	17.1099	2.1	0.6989	3.2	0.0867	2.4	0.75	536.1	12.1	538.1	13.2	546.5	46.1	536.1	12.1	98.1
82	30366	1.1	16.7329	1.7	0.7331	2.5	0.0890	1.8	0.73	549.4	9.6	558.4	10.8	595.0	37.3	549.4	9.6	92.3
13	50678	2.4	16.5165	4.0	0.7693	4.4	0.0922	1.8	0.42	568.3	10.0	579.4	19.5	623.1	86.7	568.3	10.0	91.2
228	92983	1.3	16.5723	1.2	0.8409	1.9	0.1011	1.4	0.75	620.7	8.2	619.7	8.6	615.8	26.6	620.7	8.2	100.8
753	71837	1.7	16.6152	0.9	0.8429	2.2	0.1016	2.0	0.91	623.6	12.1	620.7	10.3	610.2	19.6	623.6	12.1	102.2
63	96977	2.6	14.6593	1.9	1.3789	2.7	0.1466	1.9	0.70	881.9	15.3	880.0	15.7	875.1	39.5	881.9	15.3	100.8
178	65029	3.4	14.4721	1.6	1.4638	2.6	0.1536	2.0	0.78	921.4	17.3	915.6	15.7	901.7	33.8	901.7	33.8	102.2
67	62766	2.1	14.4082	1.7	1.4727	2.7	0.1539	2.1	0.78	922.7	18.1	919.2	16.4	910.8	35.2	910.8	35.2	101.3
71	104045	2.7	14.3499	1.5	1.4973	2.5	0.1558	2.0	0.79	933.6	17.4	929.3	15.4	919.2	31.8	919.2	31.8	101.6
182	234435	3.5	14.3086	1.2	1.5052	2.1	0.1562	1.8	0.83	935.7	15.2	932.5	12.9	925.0	24.3	925.0	24.3	101.1
37	88550	1.5	14.2365	2.0	1.5278	3.0	0.1577	2.3	0.75	944.2	19.8	941.6	18.4	935.5	40.5	935.5	40.5	100.9
82	67871	3.9	14.2261	2.0	1.5046	2.5	0.1552	1.5	0.61	930.3	13.2	932.3	15.2	936.9	40.6	936.9	40.6	99.3
436	8046160	1.2	14.2219	1.2	1.5158	2.5	0.1563	2.2	0.88	936.4	19.4	936.8	15.5	937.5	25.0	937.5	25.0	99.9
128	244753	2.7	14.2134	1.6	1.5460	2.4	0.1594	1.9	0.77	953.2	16.5	948.9	15.0	938.7	32.0	938.7	32.0	101.5
130	2019552	3.9	14.1794	1.3	1.5214	2.1	0.1565	1.7	0.80	937.0	14.8	939.0	12.9	943.7	25.8	943.7	25.8	99.3
43	44215	1.7	14.1715	1.8	1.4847	2.7	0.1526	2.0	0.74	915.5	16.8	924.2	16.2	944.8	36.8	944.8	36.8	96.9
105	115576	4.2	14.1562	1.4	1.5355	2.7	0.1577	2.3	0.85	943.7	20.3	944.7	16.7	947.0	29.2	947.0	29.2	99.7
23	98583	1.5	14.1548	2.6	1.4954	3.3	0.1535	2.0	0.60	920.6	17.0	928.5	20.1	947.2	54.1	947.2	54.1	97.2
163	144417	2.4	14.1440	1.5	1.5352	2.6	0.1575	2.1	0.82	942.8	18.4	944.6	15.8	948.8	30.1	948.8	30.1	99.4
229	256646	6.1	14.1430	1.4	1.5527	2.3	0.1593	1.9	0.81	952.7	16.7	951.6	14.5	949.0	28.3	949.0	28.3	100.4
344	2409345	4.4	14.1411	1.2	1.3768	2.4	0.1412	2.1	0.87	851.5	16.8	879.1	14.3	949.2	25.0	949.2	25.0	89.7
72	103994	3.4	14.1380	1.5	1.5010	2.2	0.1539	1.6	0.72	922.8	13.6	930.8	13.4	949.7	31.1	949.7	31.1	97.2
45	36164	3.4	14.1273	1.8	1.5039	2.3	0.1541	1.4	0.63	923.9	12.4	932.0	13.9	951.2	36.1	951.2	36.1	97.1
35	26940	2.7	14.1185	1.9	1.5748	2.9	0.1613	2.2	0.76	963.8	20.0	960.3	18.3	952.5	39.4	952.5	39.4	101.2
330	273175	4.2	14.0895	1.3	1.6301	2.2	0.1666	1.8	0.82	993.2	16.7	981.9	14.0	956.7	26.4	956.7	26.4	103.8
152	161471	1.5	14.0787	1.4	1.5541	2.3	0.1587	1.8	0.80	949.5	16.2	952.1	14.2	958.2	28.5	958.2	28.5	99.1
37	41127	2.4	14.0787	2.1	1.4875	2.9	0.1519	1.9	0.68	911.5	16.5	925.3	17.4	958.2	43.3	958.2	43.3	95.1
54	964133	2.0	14.0762	1.6	1.5821	2.7	0.1615	2.2	0.81	965.2	19.6	963.2	16.9	958.6	33.0	958.6	33.0	100.7
107	130768	3.4	14.0755	1.2	1.5466	2.3	0.1579	1.9	0.85	945.0	16.8	949.2	13.9	958.7	24.6	958.7	24.6	98.6
148	98093	2.8	14.0716	1.5	1.4985	2.3	0.1529	1.7	0.75	917.4	14.6	929.8	13.8	959.3	30.8	959.3	30.8	95.6
53	204086	2.7	14.0579	2.1	1.5625	2.7	0.1593	1.7	0.62	952.9	14.7	955.5	16.7	961.3	43.3	961.3	43.3	99.1
76	45364	2.7	14.0162	1.9	1.6153	2.9	0.1642	2.2	0.77	980.1	20.2	976.2	18.2	967.3	38.1	967.3	38.1	101.3
133	157982	3.1	14.0144	1.6	1.6670	2.4	0.1694	1.8	0.75	1009.0	17.0	996.0	15.3	967.6	32.3	967.6	32.3	104.3
19	25022	2.9	14.0113	2.5	1.5130	3.4	0.1537	2.3	0.67	921.9	19.7	935.6	20.9	968.0	51.9	968.0	51.9	95.2
97	246150	3.8	14.0111	1.3	1.6553	2.3	0.1682	1.9	0.82	1002.2	17.6	991.6	14.6	968.1	26.6	968.1	26.6	103.5
92	194880	2.8	14.0098	1.6	1.5176	2.5	0.1542	1.8	0.74	924.5	15.8	937.5	15.1	968.3	33.6	968.3	33.6	95.5

13	72870	3.6	14.0005	2.4	1.5366	3.5	0.1560	2.5	0.72	934.7	21.7	945.2	21.3	969.6	48.9	969.6	48.9	96.4
43	55388	1.1	13.9951	2.1	1.5321	3.0	0.1555	2.2	0.72	931.8	18.9	943.3	18.7	970.4	43.5	970.4	43.5	96.0
80	167421	2.1	13.9947	1.5	1.6227	2.6	0.1647	2.1	0.81	982.9	19.3	979.0	16.4	970.5	31.1	970.5	31.1	101.3
57	27470	2.1	13.9895	1.9	1.6221	2.7	0.1646	1.9	0.71	982.2	17.5	978.8	17.0	971.2	38.9	971.2	38.9	101.1
107	65334	5.1	13.9835	1.5	1.5740	2.4	0.1596	1.9	0.78	954.7	16.4	960.0	14.8	972.1	30.7	972.1	30.7	98.2
60	1373489	1.9	13.9775	1.9	1.5912	2.6	0.1613	1.7	0.67	964.0	15.6	966.8	16.3	973.0	39.6	973.0	39.6	99.1
73	79377	5.5	13.9744	1.7	1.5893	2.8	0.1611	2.2	0.80	962.7	20.1	966.0	17.5	973.5	34.2	973.5	34.2	98.9
98	90089	3.7	13.9578	1.5	1.5551	2.4	0.1574	1.9	0.78	942.4	16.3	952.5	14.7	975.8	30.0	975.8	30.0	96.6
98	26742	2.9	13.9556	1.5	1.6218	2.4	0.1641	1.8	0.77	979.8	16.7	978.7	15.0	976.2	31.3	976.2	31.3	100.4
39	98941	2.2	13.9344	1.8	1.5326	2.6	0.1549	1.9	0.72	928.3	16.4	943.6	16.2	979.3	37.2	979.3	37.2	94.8
54	57863	1.7	13.9240	1.5	1.5406	2.4	0.1556	1.9	0.78	932.1	16.5	946.7	15.1	980.8	31.5	980.8	31.5	95.0
296	205979	2.4	13.9154	1.0	1.6888	2.4	0.1704	2.2	0.91	1014.6	21.0	1004.3	15.6	982.1	20.2	982.1	20.2	103.3
22	81318	1.5	13.8955	2.0	1.5184	3.0	0.1530	2.2	0.73	917.9	18.8	937.8	18.3	985.0	41.4	985.0	41.4	93.2
84	75046	3.5	13.8784	1.7	1.6710	2.4	0.1682	1.7	0.71	1002.2	15.8	997.6	15.2	987.5	34.0	987.5	34.0	101.5
113	55553	2.1	13.8723	1.8	1.6392	2.9	0.1649	2.2	0.77	984.1	20.2	985.4	18.1	988.4	37.3	988.4	37.3	99.6
50	92180	2.6	13.8684	1.8	1.5444	2.6	0.1553	1.9	0.73	930.8	16.5	948.2	16.0	989.0	35.8	989.0	35.8	94.1
108	50866	4.5	13.8662	1.9	1.6204	2.6	0.1630	1.9	0.71	973.2	16.9	978.1	16.6	989.2	37.8	989.2	37.8	98.4
95	95017	5.0	13.8530	1.2	1.6800	2.2	0.1688	1.8	0.83	1005.4	16.8	1001.0	13.9	991.2	24.7	991.2	24.7	101.4
114	79149	2.5	13.8432	1.6	1.6867	2.4	0.1693	1.8	0.74	1008.5	16.6	1003.5	15.2	992.6	32.5	992.6	32.5	101.6
55	71308	4.3	13.8422	1.8	1.6541	2.8	0.1661	2.1	0.76	990.4	19.6	991.1	17.9	992.8	37.6	992.8	37.6	99.8
302	95340	3.4	13.8401	1.3	1.6793	2.3	0.1686	1.9	0.82	1004.2	17.8	1000.7	14.8	993.1	26.7	993.1	26.7	101.1
46	32754	3.8	13.8364	1.8	1.6494	2.6	0.1655	1.9	0.72	987.4	17.3	989.3	16.6	993.6	37.2	993.6	37.2	99.4
78	31538	3.1	13.8328	1.3	1.6313	2.0	0.1637	1.4	0.73	977.1	13.1	982.4	12.4	994.2	27.3	994.2	27.3	98.3
78	69999	1.4	13.8268	1.6	1.6332	2.4	0.1638	1.8	0.76	977.8	16.5	983.1	15.1	995.1	31.6	995.1	31.6	98.3
35	29126	4.3	13.8185	1.7	1.6988	2.8	0.1703	2.2	0.78	1013.5	20.3	1008.1	17.8	996.3	35.4	996.3	35.4	101.7
81	336520	4.6	13.8091	1.7	1.6632	2.5	0.1666	1.8	0.73	993.2	16.9	994.6	15.9	997.6	34.8	997.6	34.8	99.6
165	143217	3.9	13.8058	1.2	1.6614	2.1	0.1664	1.7	0.82	992.0	15.5	993.9	13.0	998.1	23.9	998.1	23.9	99.4
64	91593	3.0	13.7873	1.5	1.6804	2.5	0.1680	2.0	0.79	1001.3	18.3	1001.1	16.0	1000.8	31.2	1000.8	31.2	100.0
37	31311	2.8	13.7790	2.0	1.6720	2.7	0.1671	1.8	0.68	996.1	17.0	997.9	17.2	1002.1	40.0	1002.1	40.0	99.4
126	88750	5.2	13.7782	1.5	1.6889	2.4	0.1688	1.9	0.78	1005.3	17.3	1004.4	15.3	1002.2	30.5	1002.2	30.5	100.3
272	73270	3.2	13.7772	0.9	1.6966	1.9	0.1695	1.7	0.87	1009.5	15.5	1007.3	12.2	1002.3	19.2	1002.3	19.2	100.7
63	201970	3.7	13.7702	1.4	1.6862	2.2	0.1684	1.7	0.77	1003.3	15.8	1003.3	14.1	1003.4	28.8	1003.4	28.8	100.0
20	56283	0.7	13.7659	2.0	1.6819	2.9	0.1679	2.1	0.71	1000.6	19.3	1001.7	18.6	1004.0	41.4	1004.0	41.4	99.7
53	106365	3.2	13.7646	1.9	1.6276	2.6	0.1625	1.9	0.70	970.5	16.7	980.9	16.6	1004.2	38.1	1004.2	38.1	96.6
152	109959	1.8	13.7624	1.3	1.6706	2.4	0.1667	2.0	0.84	994.2	18.3	997.4	15.0	1004.5	25.8	1004.5	25.8	99.0
85	28225	1.9	13.7608	1.5	1.6290	2.4	0.1626	1.8	0.78	971.1	16.5	981.5	14.8	1004.8	29.9	1004.8	29.9	96.6
56	48739	1.9	13.7607	1.6	1.6377	2.6	0.1634	2.0	0.78	975.9	18.3	984.8	16.2	1004.8	32.6	1004.8	32.6	97.1
155	111205	3.3	13.7523	1.5	1.5557	2.3	0.1552	1.7	0.74	929.8	14.5	952.7	14.0	1006.0	31.0	1006.0	31.0	92.4
141	107504	3.8	13.7511	1.4	1.6481	2.3	0.1644	1.8	0.79	981.0	16.3	988.8	14.3	1006.2	28.2	1006.2	28.2	97.5
50	192840	2.5	13.7494	2.0	1.6355	2.5	0.1631	1.4	0.58	974.0	13.0	984.0	15.7	1006.4	41.3	1006.4	41.3	96.8
54	70643	2.2	13.7396	1.6	1.7091	2.7	0.1703	2.2	0.82	1013.8	20.7	1012.0	17.3	1007.9	31.6	1007.9	31.6	100.6

63	185914	4.5	13.7200	1.4	1.6970	2.5	0.1689	2.1	0.83	1005.9	19.3	1007.4	15.9	1010.8	27.9	1010.8	27.9	99.5
130	67418	1.8	13.7182	1.2	1.6711	2.1	0.1663	1.7	0.81	991.5	16.0	997.6	13.6	1011.0	25.2	1011.0	25.2	98.1
61	76060	3.2	13.7142	1.4	1.6866	2.3	0.1678	1.8	0.80	999.8	16.9	1003.5	14.6	1011.6	28.1	1011.6	28.1	98.8
81	51616	3.4	13.7114	1.4	1.6538	2.5	0.1645	2.0	0.81	981.5	18.5	991.0	15.8	1012.0	29.3	1012.0	29.3	97.0
45	140289	4.9	13.7052	1.8	1.6865	2.9	0.1676	2.2	0.76	999.1	20.3	1003.4	18.3	1013.0	37.5	1013.0	37.5	98.6
432	92600	5.8	13.7021	1.3	1.7044	2.6	0.1694	2.2	0.85	1008.7	20.7	1010.2	16.6	1013.4	27.3	1013.4	27.3	99.5
114	82796	5.5	13.7010	1.3	1.7460	2.1	0.1735	1.6	0.77	1031.4	15.3	1025.7	13.5	1013.6	27.0	1013.6	27.0	101.8
146	99187	4.6	13.6989	1.3	1.7067	2.5	0.1696	2.1	0.85	1009.7	19.6	1011.0	15.9	1013.9	26.8	1013.9	26.8	99.6
79	64304	3.2	13.6948	1.7	1.6682	2.8	0.1657	2.1	0.78	988.3	19.6	996.5	17.5	1014.5	35.3	1014.5	35.3	97.4
31	53466	3.2	13.6921	2.1	1.7051	2.9	0.1693	2.0	0.70	1008.4	18.7	1010.4	18.4	1014.9	41.5	1014.9	41.5	99.4
119	823524	2.2	13.6847	1.8	1.7201	2.6	0.1707	2.0	0.74	1016.1	18.4	1016.1	16.9	1016.0	35.7	1016.0	35.7	100.0
78	68689	3.6	13.6741	1.7	1.6636	2.9	0.1650	2.3	0.80	984.4	20.9	994.8	18.1	1017.6	34.5	1017.6	34.5	96.7
33	35339	4.7	13.6741	2.3	1.6879	2.9	0.1674	1.7	0.59	997.7	15.5	1004.0	18.2	1017.6	47.0	1017.6	47.0	98.1
78	35852	2.6	13.6729	1.7	1.6349	2.6	0.1621	1.9	0.74	968.6	17.1	983.7	16.1	1017.7	34.7	1017.7	34.7	95.2
36	3478247	4.1	13.6722	1.4	1.7510	2.3	0.1736	1.8	0.79	1032.1	17.4	1027.5	14.9	1017.8	28.7	1017.8	28.7	101.4
125	152930	3.7	13.6633	1.4	1.6981	2.4	0.1683	2.0	0.81	1002.6	18.4	1007.8	15.6	1019.2	28.9	1019.2	28.9	98.4
67	90981	2.0	13.6601	1.7	1.6624	2.6	0.1647	1.9	0.75	982.8	17.7	994.3	16.5	1019.6	34.9	1019.6	34.9	96.4
175	129768	3.3	13.6586	1.4	1.6775	2.2	0.1662	1.7	0.76	991.0	15.4	1000.0	14.1	1019.9	29.3	1019.9	29.3	97.2
271	213121	8.3	13.6586	1.4	1.5139	2.4	0.1500	1.9	0.80	900.8	15.9	936.0	14.4	1019.9	28.4	1019.9	28.4	88.3
36	37771	4.3	13.6539	2.2	1.7006	2.9	0.1684	1.9	0.66	1003.3	18.0	1008.8	18.8	1020.6	44.6	1020.6	44.6	98.3
46	157333	2.9	13.6525	1.7	1.6957	2.6	0.1679	2.0	0.77	1000.6	18.7	1006.9	16.7	1020.8	33.7	1020.8	33.7	98.0
32	155533	2.1	13.6496	2.1	1.6423	3.0	0.1626	2.1	0.70	971.1	19.0	986.6	19.0	1021.2	43.3	1021.2	43.3	95.1
49	26482	2.6	13.6460	1.9	1.6650	2.8	0.1648	2.1	0.74	983.3	18.9	995.3	17.7	1021.7	38.0	1021.7	38.0	96.2
60	112143	2.5	13.6451	1.7	1.6681	2.7	0.1651	2.1	0.78	985.0	18.8	996.5	16.8	1021.9	33.8	1021.9	33.8	96.4
64	51623	2.3	13.6409	2.1	1.5793	2.8	0.1562	1.8	0.65	935.9	15.8	962.1	17.3	1022.5	43.0	1022.5	43.0	91.5
75	53822	3.9	13.6345	1.8	1.6346	2.6	0.1616	1.9	0.73	965.9	17.2	983.6	16.6	1023.4	36.6	1023.4	36.6	94.4
37	34060	1.9	13.6110	1.7	1.6713	2.5	0.1650	1.8	0.73	984.4	16.9	997.7	16.1	1026.9	35.0	1026.9	35.0	95.9
226	73457	5.5	13.6064	1.6	1.6761	2.4	0.1654	1.7	0.73	986.7	16.0	999.5	15.3	1027.6	33.3	1027.6	33.3	96.0
39	44920	3.1	13.5959	2.3	1.5916	3.4	0.1569	2.5	0.74	939.8	22.3	966.9	21.4	1029.2	46.6	1029.2	46.6	91.3
36	71849	2.6	13.5896	1.7	1.6745	2.3	0.1650	1.7	0.71	984.7	15.1	998.9	14.9	1030.1	33.5	1030.1	33.5	95.6
117	66884	3.0	13.5651	1.5	1.7284	2.5	0.1700	2.1	0.81	1012.4	19.2	1019.2	16.2	1033.8	29.6	1033.8	29.6	97.9
167	753464	4.2	13.5457	1.5	1.7461	2.2	0.1715	1.6	0.72	1020.6	15.0	1025.7	14.2	1036.6	30.9	1036.6	30.9	98.5
150	55180	3.0	13.5327	1.4	1.7075	2.4	0.1676	2.0	0.81	998.8	18.3	1011.4	15.6	1038.6	28.9	1038.6	28.9	96.2
94	46800	6.4	13.5320	1.4	1.8409	2.5	0.1807	2.0	0.82	1070.7	19.8	1060.2	16.2	1038.7	28.7	1038.7	28.7	103.1
43	46165	4.6	13.5224	1.8	1.7353	2.6	0.1702	1.9	0.72	1013.1	17.8	1021.7	17.0	1040.1	37.1	1040.1	37.1	97.4
24	40965	4.2	13.4488	2.7	1.7336	3.6	0.1691	2.4	0.67	1007.1	22.5	1021.1	23.1	1051.2	53.6	1051.2	53.6	95.8
288	140113	5.8	13.4321	1.3	1.7209	2.3	0.1676	1.9	0.81	999.1	17.3	1016.4	14.8	1053.7	27.1	1053.7	27.1	94.8
186	160915	2.1	13.4236	1.3	1.6708	2.2	0.1627	1.8	0.80	971.5	15.8	997.5	13.9	1054.9	26.2	1054.9	26.2	92.1
501	59958	4.2	13.3277	1.5	1.6612	2.8	0.1606	2.3	0.83	960.0	20.6	993.9	17.5	1069.4	30.6	1069.4	30.6	89.8
250	92875	5.7	13.3195	1.2	1.7877	2.1	0.1727	1.8	0.82	1027.0	16.7	1041.0	13.9	1070.6	24.4	1070.6	24.4	95.9
49	74903	3.4	13.3166	2.2	1.7871	3.2	0.1726	2.4	0.74	1026.4	22.5	1040.8	20.9	1071.0	43.6	1071.0	43.6	95.8

127	93577	3.6	13.2984	1.1	1.8847	1.8	0.1818	1.4	0.78	1076.7	14.1	1075.7	12.1	1073.8	22.8	1073.8	22.8	100.3
175	143126	4.0	13.2485	1.2	1.8200	2.2	0.1749	1.8	0.84	1039.0	17.3	1052.7	14.1	1081.3	23.6	1081.3	23.6	96.1
19	22127	1.1	13.2111	2.6	1.8120	3.1	0.1736	1.6	0.51	1032.0	15.0	1049.8	20.1	1087.0	52.8	1087.0	52.8	94.9
75	114519	2.2	13.2025	2.1	1.7787	2.7	0.1703	1.6	0.61	1013.8	15.3	1037.7	17.2	1088.3	41.9	1088.3	41.9	93.2
185	119980	7.4	13.1022	1.5	1.8764	2.4	0.1783	1.9	0.77	1057.7	18.2	1072.8	16.0	1103.6	30.5	1103.6	30.5	95.8
127	272380	4.2	13.0252	1.5	2.0544	2.2	0.1941	1.6	0.75	1143.4	17.2	1133.8	15.0	1115.3	29.0	1115.3	29.0	102.5
135	144164	4.1	13.0229	1.5	1.9742	2.3	0.1865	1.7	0.77	1102.2	17.7	1106.8	15.4	1115.7	29.3	1115.7	29.3	98.8
114	71484	1.4	12.9829	3.0	1.6666	3.5	0.1569	1.9	0.54	939.7	16.7	995.9	22.3	1121.8	59.0	1121.8	59.0	83.8
133	1975753	3.0	12.9452	1.5	2.1028	2.2	0.1974	1.6	0.75	1161.5	17.4	1149.7	15.1	1127.6	29.1	1127.6	29.1	103.0
195	84093	2.8	12.9122	1.2	2.0616	2.0	0.1931	1.6	0.81	1138.0	17.0	1136.2	13.7	1132.7	23.1	1132.7	23.1	100.5
63	186191	3.6	12.8499	1.9	1.9900	2.7	0.1855	2.0	0.72	1096.7	20.0	1112.1	18.6	1142.3	37.7	1142.3	37.7	96.0
275	243230	3.6	12.8045	1.3	2.0309	2.1	0.1886	1.7	0.79	1113.8	17.3	1125.9	14.5	1149.3	25.8	1149.3	25.8	96.9
38	48851	4.2	12.7507	2.0	2.0615	2.6	0.1906	1.8	0.67	1124.9	18.2	1136.1	18.1	1157.7	38.9	1157.7	38.9	97.2
122	80383	4.7	12.7144	1.5	2.1192	2.5	0.1954	2.0	0.80	1150.7	21.2	1155.1	17.3	1163.3	29.5	1163.3	29.5	98.9
169	57349	3.3	12.6555	1.7	2.0464	2.8	0.1878	2.2	0.80	1109.6	22.8	1131.1	19.0	1172.6	32.8	1172.6	32.8	94.6
152	86221	3.3	12.5958	1.6	2.1483	2.5	0.1963	1.9	0.76	1155.1	20.2	1164.5	17.5	1181.9	32.5	1181.9	32.5	97.7
367	179825	2.5	12.5575	1.3	2.2941	2.5	0.2089	2.1	0.86	1223.2	23.9	1210.5	17.7	1188.0	25.4	1188.0	25.4	103.0
180	226343	3.9	12.5349	1.6	2.1960	2.4	0.1996	1.8	0.75	1173.4	19.3	1179.8	16.9	1191.5	31.9	1191.5	31.9	98.5
131	131789	3.9	12.4348	1.1	2.2721	2.2	0.2049	1.9	0.86	1201.6	20.6	1203.7	15.4	1207.3	21.8	1207.3	21.8	99.5
79	75529	1.8	12.4316	1.6	2.2610	2.6	0.2039	2.0	0.79	1196.0	22.2	1200.2	18.2	1207.8	31.1	1207.8	31.1	99.0
285	68486	7.6	12.3992	1.5	2.1883	2.6	0.1968	2.1	0.81	1158.0	22.0	1177.3	17.8	1212.9	29.4	1212.9	29.4	95.5
164	69045	3.5	12.3714	1.8	2.1947	2.9	0.1969	2.3	0.79	1158.7	24.8	1179.4	20.6	1217.3	35.2	1217.3	35.2	95.2
115	51730	1.3	12.3585	1.6	2.2645	2.6	0.2030	2.0	0.77	1191.3	21.4	1201.3	18.0	1219.4	32.0	1219.4	32.0	97.7
39	50479	2.5	12.1852	1.9	2.2730	2.7	0.2009	2.0	0.72	1180.0	21.2	1204.0	19.2	1247.1	36.9	1247.1	36.9	94.6
113	123110	2.7	12.0990	1.3	2.3646	2.2	0.2075	1.8	0.81	1215.5	19.5	1232.0	15.5	1261.0	24.8	1261.0	24.8	96.4
92	188768	2.3	11.9591	1.5	2.5893	2.7	0.2246	2.2	0.83	1306.0	26.2	1297.6	19.6	1283.7	29.0	1283.7	29.0	101.7
95	208277	3.5	11.8935	1.7	2.5893	2.7	0.2234	2.1	0.78	1299.6	24.3	1297.6	19.5	1294.4	32.7	1294.4	32.7	100.4
126	92514	3.2	11.8589	1.1	2.5633	1.7	0.2205	1.3	0.77	1284.3	15.6	1290.2	12.7	1300.0	21.5	1300.0	21.5	98.8
68	271896	2.4	11.8574	1.6	2.7068	2.3	0.2328	1.7	0.73	1349.0	20.3	1330.3	16.9	1300.3	30.3	1300.3	30.3	103.7
145	131189	4.4	11.8062	1.5	2.5702	2.2	0.2201	1.7	0.75	1282.3	19.4	1292.2	16.2	1308.7	28.2	1308.7	28.2	98.0
61	62383	3.6	11.6252	1.3	2.6806	2.3	0.2260	1.9	0.83	1313.6	22.9	1323.1	17.1	1338.6	24.6	1338.6	24.6	98.1
134	107657	3.4	11.5690	1.4	2.5912	2.5	0.2174	2.0	0.81	1268.2	22.9	1298.2	18.0	1348.0	27.6	1348.0	27.6	94.1
152	116605	4.4	11.5418	1.4	2.7414	2.0	0.2295	1.5	0.72	1331.8	17.6	1339.7	15.2	1352.5	27.6	1352.5	27.6	98.5
64	83765	2.1	11.4768	1.6	2.8140	2.7	0.2342	2.3	0.82	1356.6	27.5	1359.3	20.5	1363.4	30.1	1363.4	30.1	99.5
71	74557	1.6	11.4705	1.4	2.7962	2.5	0.2326	2.1	0.83	1348.2	25.0	1354.5	18.7	1364.5	27.1	1364.5	27.1	98.8
72	58531	2.5	11.4098	1.3	2.9074	2.1	0.2406	1.7	0.79	1389.8	21.2	1383.9	16.1	1374.7	24.9	1374.7	24.9	101.1
69	80616	1.2	11.3987	1.6	2.8158	2.4	0.2328	1.7	0.72	1349.1	20.7	1359.8	17.7	1376.5	31.6	1376.5	31.6	98.0
15	33956	2.3	11.3854	2.0	2.8747	2.5	0.2374	1.5	0.59	1373.1	18.4	1375.3	18.9	1378.8	38.9	1378.8	38.9	99.6
70	153526	2.1	11.3824	1.4	2.8418	2.5	0.2346	2.1	0.83	1358.5	25.7	1366.6	19.0	1379.3	27.4	1379.3	27.4	98.5
146	119947	1.9	11.3803	1.1	2.6699	2.3	0.2204	2.1	0.89	1283.8	24.2	1320.2	17.2	1379.7	20.4	1379.7	20.4	93.1
54	62337	1.6	11.3637	1.5	2.7608	2.2	0.2275	1.7	0.75	1321.6	20.0	1345.0	16.5	1382.4	28.0	1382.4	28.0	95.6

197	113060	3.0	11.3347	1.1	2.8780	2.0	0.2366	1.6	0.84	1368.9	20.3	1376.2	14.8	1387.4	20.6	1387.4	20.6	98.7
63	84532	2.7	11.3277	1.9	2.8752	3.0	0.2362	2.3	0.78	1367.0	28.9	1375.4	22.6	1388.6	35.8	1388.6	35.8	98.4
64	62280	1.9	11.3167	1.4	2.9690	2.1	0.2437	1.5	0.73	1405.8	19.6	1399.7	16.1	1390.4	27.7	1390.4	27.7	101.1
32	132728	1.8	11.3077	1.8	2.8562	3.0	0.2342	2.4	0.80	1356.7	29.4	1370.4	22.5	1391.9	34.2	1391.9	34.2	97.5
54	88611	2.6	11.2915	1.4	2.9193	2.1	0.2391	1.6	0.75	1381.9	19.3	1386.9	15.8	1394.7	26.7	1394.7	26.7	99.1
70	2961375	2.0	11.2694	1.0	2.8116	1.8	0.2298	1.5	0.82	1333.5	17.8	1358.6	13.4	1398.4	19.5	1398.4	19.5	95.4
157	278916	1.4	11.2626	1.4	2.5046	2.0	0.2046	1.4	0.71	1199.9	15.2	1273.4	14.3	1399.6	26.7	1399.6	26.7	85.7
67	100932	2.3	11.1963	1.4	2.8380	2.4	0.2305	1.9	0.80	1336.9	23.0	1365.7	17.8	1410.9	27.2	1410.9	27.2	94.8
58	120097	1.5	11.1427	1.7	2.5715	2.5	0.2078	1.8	0.72	1217.2	20.3	1292.6	18.5	1420.1	33.3	1420.1	33.3	85.7
97	57580	2.7	11.1406	1.1	2.9079	2.0	0.2350	1.6	0.82	1360.4	19.7	1384.0	14.9	1420.4	21.8	1420.4	21.8	95.8
79	57811	2.0	11.0660	1.2	3.1294	2.1	0.2512	1.8	0.83	1444.5	23.0	1440.0	16.5	1433.3	22.7	1433.3	22.7	100.8
110	203612	2.9	11.0348	1.5	3.0984	2.4	0.2480	1.9	0.79	1428.0	24.7	1432.3	18.8	1438.7	28.6	1438.7	28.6	99.3
224	158755	1.7	11.0092	1.2	2.9556	2.4	0.2360	2.1	0.87	1365.8	25.4	1396.3	18.0	1443.1	22.5	1443.1	22.5	94.6
102	149916	2.8	10.9780	1.4	3.1172	2.5	0.2482	2.1	0.82	1429.1	26.3	1436.9	19.2	1448.5	27.2	1448.5	27.2	98.7
90	214514	4.2	10.9672	1.3	3.1378	2.2	0.2496	1.8	0.80	1436.3	22.5	1442.0	16.9	1450.4	25.1	1450.4	25.1	99.0
97	75181	2.1	10.9467	1.1	3.0150	2.2	0.2394	1.9	0.87	1383.4	24.2	1411.4	17.1	1453.9	21.2	1453.9	21.2	95.2
42	226256	2.0	10.9411	2.1	3.1303	2.8	0.2484	1.9	0.67	1430.2	23.8	1440.2	21.3	1454.9	39.1	1454.9	39.1	98.3
20	30465	1.4	10.9366	1.7	3.2092	2.5	0.2546	1.9	0.75	1461.9	24.6	1459.4	19.4	1455.7	31.7	1455.7	31.7	100.4
17	48859	1.9	10.8964	2.1	3.1918	2.9	0.2522	2.0	0.69	1450.0	26.3	1455.2	22.6	1462.7	40.0	1462.7	40.0	99.1
48	198963	1.2	10.8874	1.3	3.2131	2.2	0.2537	1.8	0.81	1457.6	23.2	1460.3	17.1	1464.3	24.8	1464.3	24.8	99.5
37	118590	1.9	10.8428	1.5	3.1941	2.5	0.2512	2.0	0.80	1444.6	26.2	1455.7	19.5	1472.1	28.7	1472.1	28.7	98.1
12	25720	1.8	10.8005	3.5	2.8067	4.2	0.2199	2.3	0.55	1281.1	26.5	1357.3	31.3	1479.5	66.4	1479.5	66.4	86.6
69	236364	1.4	10.7613	1.5	3.3971	2.2	0.2651	1.5	0.71	1516.1	20.6	1503.7	16.9	1486.3	29.0	1486.3	29.0	102.0
213	56198	2.9	10.7428	1.5	2.9652	2.4	0.2310	1.9	0.78	1339.9	22.6	1398.7	18.3	1489.6	28.6	1489.6	28.6	89.9
123	84711	5.2	10.7049	1.4	3.2727	2.3	0.2541	1.8	0.80	1459.5	24.0	1474.6	17.8	1496.3	25.8	1496.3	25.8	97.5
49	91744	2.3	10.7036	1.5	3.1689	2.3	0.2460	1.7	0.73	1417.8	21.1	1449.6	17.5	1496.5	29.0	1496.5	29.0	94.7
249	284540	3.2	10.6999	1.2	3.1694	2.0	0.2460	1.6	0.82	1417.6	20.7	1449.7	15.4	1497.2	21.8	1497.2	21.8	94.7
98	108850	1.5	10.6974	1.6	3.3409	2.8	0.2592	2.4	0.83	1485.8	31.4	1490.7	22.3	1497.6	30.1	1497.6	30.1	99.2
149	1804133	1.7	10.6615	1.1	3.4958	2.3	0.2703	1.9	0.86	1542.4	26.7	1526.3	17.8	1504.0	21.7	1504.0	21.7	102.6
30	39956	1.0	10.6437	1.7	3.2473	2.6	0.2507	1.9	0.75	1442.0	24.6	1468.5	19.8	1507.1	32.1	1507.1	32.1	95.7
69	68799	1.8	10.6297	1.3	3.3094	2.3	0.2551	2.0	0.84	1464.9	25.7	1483.3	18.2	1509.6	24.0	1509.6	24.0	97.0
35	58787	1.2	10.6230	1.4	3.3779	2.3	0.2603	1.8	0.78	1491.1	24.3	1499.3	18.2	1510.8	27.3	1510.8	27.3	98.7
116	166472	1.6	10.6090	1.6	3.3790	2.5	0.2600	1.9	0.75	1489.8	24.8	1499.5	19.4	1513.3	30.9	1513.3	30.9	98.4
191	140551	1.3	10.5911	1.3	3.4476	2.7	0.2648	2.3	0.87	1514.5	31.5	1515.3	21.2	1516.5	25.4	1516.5	25.4	99.9
146	81677	2.4	10.5820	1.5	3.5004	2.6	0.2686	2.1	0.82	1533.9	28.6	1527.3	20.2	1518.1	27.7	1518.1	27.7	101.0
177	101236	3.9	10.5762	1.3	3.5127	2.1	0.2694	1.6	0.77	1538.0	22.0	1530.1	16.4	1519.2	24.8	1519.2	24.8	101.2
30	37391	1.5	10.5528	1.3	3.4358	2.1	0.2630	1.7	0.80	1505.0	22.7	1512.6	16.7	1523.3	24.3	1523.3	24.3	98.8
168	238119	2.0	10.5497	1.4	3.5404	2.2	0.2709	1.6	0.76	1545.3	22.5	1536.3	17.1	1523.9	26.5	1523.9	26.5	101.4
96	130217	3.6	10.5451	1.5	3.4850	2.7	0.2665	2.3	0.83	1523.2	30.8	1523.8	21.5	1524.7	28.3	1524.7	28.3	99.9
95	137482	1.3	10.5222	1.4	3.4718	1.9	0.2649	1.3	0.67	1515.1	17.4	1520.8	15.1	1528.8	26.7	1528.8	26.7	99.1
20	43890	0.4	10.5066	1.5	3.4679	2.5	0.2643	2.0	0.81	1511.6	27.6	1519.9	19.8	1531.6	27.5	1531.6	27.5	98.7

140	154043	1.5	10.5028	1.4	3.1918	2.5	0.2431	2.1	0.84	1403.0	26.6	1455.2	19.4	1532.3	25.6	1532.3	25.6	91.6
85	161729	1.9	10.4822	1.6	3.4443	2.5	0.2618	1.9	0.76	1499.3	25.4	1514.6	19.6	1536.0	30.2	1536.0	30.2	97.6
159	105808	3.2	10.4787	1.2	3.5618	2.3	0.2707	1.9	0.84	1544.3	26.7	1541.1	18.3	1536.6	23.5	1536.6	23.5	100.5
30	182405	1.8	10.4780	1.6	3.5677	2.3	0.2711	1.7	0.73	1546.5	23.5	1542.4	18.6	1536.7	30.1	1536.7	30.1	100.6
52	47041	1.1	10.4236	1.3	3.3972	1.9	0.2568	1.4	0.74	1473.6	18.8	1503.8	15.2	1546.5	24.7	1546.5	24.7	95.3
138	93005	3.8	10.4014	1.4	3.4952	2.5	0.2637	2.1	0.83	1508.6	28.0	1526.1	19.9	1550.5	26.6	1550.5	26.6	97.3
208	131578	1.5	10.3963	1.4	2.8293	2.7	0.2133	2.2	0.84	1246.5	25.4	1363.3	19.9	1551.4	26.9	1551.4	26.9	80.3
396	66428	3.2	10.3836	1.6	3.5170	2.9	0.2649	2.5	0.85	1514.7	33.8	1531.0	23.3	1553.7	29.1	1553.7	29.1	97.5
163	224786	3.1	10.3770	1.5	3.6300	2.2	0.2732	1.7	0.74	1557.0	23.1	1556.1	17.9	1554.9	28.2	1554.9	28.2	100.1
134	141100	2.3	10.3749	1.8	3.2764	2.6	0.2465	1.9	0.73	1420.6	23.8	1475.5	19.9	1555.3	32.9	1555.3	32.9	91.3
38	78009	1.2	10.3656	1.4	3.4534	2.6	0.2596	2.2	0.84	1487.9	29.0	1516.7	20.4	1557.0	26.3	1557.0	26.3	95.6
264	163489	2.6	10.3559	1.3	3.6626	2.2	0.2751	1.9	0.83	1566.6	25.8	1563.3	17.9	1558.7	23.5	1558.7	23.5	100.5
214	215426	2.3	10.3357	1.3	3.2216	2.4	0.2415	2.1	0.84	1394.5	25.8	1462.4	19.0	1562.4	24.9	1562.4	24.9	89.3
99	191183	1.1	10.3256	1.3	2.9197	2.2	0.2187	1.9	0.83	1274.8	21.5	1387.0	17.0	1564.2	23.6	1564.2	23.6	81.5
187	58664	3.5	10.3246	1.3	3.6150	2.4	0.2707	2.0	0.85	1544.3	27.9	1552.8	19.1	1564.4	24.1	1564.4	24.1	98.7
22	43248	1.9	10.3212	1.7	3.4977	2.6	0.2618	2.0	0.77	1499.2	26.8	1526.7	20.6	1565.0	31.5	1565.0	31.5	95.8
423	1912447	3.8	10.3121	1.2	3.6438	2.1	0.2725	1.7	0.80	1553.6	23.0	1559.1	16.6	1566.7	23.2	1566.7	23.2	99.2
285	52806	1.5	10.3116	1.4	3.2869	2.4	0.2458	1.9	0.81	1416.8	24.2	1477.9	18.3	1566.8	26.0	1566.8	26.0	90.4
92	69375	1.6	10.2945	1.3	3.7277	2.4	0.2783	1.9	0.82	1582.9	27.1	1577.3	18.8	1569.9	25.2	1569.9	25.2	100.8
107	150208	1.6	10.2532	1.3	3.0986	2.4	0.2304	2.0	0.83	1336.7	23.7	1432.3	18.1	1577.4	24.6	1577.4	24.6	84.7
218	178232	3.1	10.2439	1.3	3.6403	2.8	0.2705	2.4	0.88	1543.1	33.5	1558.4	22.1	1579.1	24.9	1579.1	24.9	97.7
111	244100	1.8	9.5587	1.4	4.4666	2.2	0.3097	1.7	0.78	1739.0	26.6	1724.8	18.6	1707.6	26.0	1707.6	26.0	101.8
92	71376	1.1	9.5523	1.4	3.5995	2.6	0.2494	2.2	0.83	1435.3	27.9	1549.4	20.7	1708.8	26.6	1708.8	26.6	84.0
159	244255	0.9	9.4488	1.3	3.8444	2.4	0.2635	2.0	0.84	1507.5	27.3	1602.1	19.6	1728.8	24.5	1728.8	24.5	87.2
138	56308	1.5	9.4243	1.2	4.0053	2.3	0.2738	1.9	0.85	1559.9	26.9	1635.3	18.6	1733.6	22.2	1733.6	22.2	90.0
58	59294	1.9	9.4108	1.2	4.5030	2.1	0.3073	1.7	0.83	1727.6	26.3	1731.5	17.5	1736.2	21.7	1736.2	21.7	99.5
213	90644	1.9	9.3786	1.4	4.5199	2.3	0.3074	1.8	0.78	1728.1	26.8	1734.6	18.8	1742.5	25.9	1742.5	25.9	99.2
48	69124	1.2	9.3621	1.5	3.7286	2.4	0.2532	1.9	0.78	1454.8	24.9	1577.5	19.6	1745.7	28.0	1745.7	28.0	83.3
159	108716	1.8	9.3533	1.1	4.5072	2.0	0.3057	1.6	0.84	1719.8	24.8	1732.3	16.3	1747.5	19.6	1747.5	19.6	98.4
96	54016	2.3	9.3357	1.3	4.7642	2.2	0.3226	1.8	0.82	1802.3	28.1	1778.6	18.3	1750.9	23.0	1750.9	23.0	102.9
124	76309	2.1	9.3353	1.5	4.5396	2.4	0.3074	1.9	0.79	1727.7	28.6	1738.3	20.0	1751.0	27.2	1751.0	27.2	98.7
120	182666	2.4	9.3153	1.4	4.7525	2.5	0.3211	2.0	0.82	1795.0	32.0	1776.6	20.9	1754.9	26.0	1754.9	26.0	102.3
46	187160	3.3	9.3146	1.4	4.5443	2.3	0.3070	1.9	0.79	1725.9	28.0	1739.1	19.5	1755.0	26.1	1755.0	26.1	98.3
82	133990	3.0	9.3132	1.5	4.5964	2.4	0.3105	1.9	0.79	1743.0	29.1	1748.6	20.1	1755.3	27.1	1755.3	27.1	99.3
102	150951	1.4	9.2853	1.5	4.5478	2.3	0.3063	1.7	0.75	1722.3	25.7	1739.8	18.8	1760.8	27.3	1760.8	27.3	97.8
73	104145	2.5	9.2694	1.3	4.7489	2.2	0.3193	1.8	0.80	1786.1	27.6	1775.9	18.5	1763.9	24.2	1763.9	24.2	101.3
215	129693	1.7	9.2426	1.4	4.3035	2.5	0.2885	2.0	0.82	1633.9	28.9	1694.0	20.2	1769.2	25.8	1769.2	25.8	92.4
115	959927	1.5	9.2275	1.3	4.6690	2.1	0.3125	1.7	0.79	1752.8	26.1	1761.7	18.0	1772.2	23.9	1772.2	23.9	98.9
95	236286	3.0	9.2152	1.2	4.7278	2.2	0.3160	1.9	0.85	1770.1	28.7	1772.2	18.4	1774.7	21.4	1774.7	21.4	99.7
61	133770	1.2	9.2115	1.3	4.8132	2.4	0.3216	2.0	0.82	1797.4	30.8	1787.2	20.0	1775.4	24.5	1775.4	24.5	101.2
68	62013	1.7	9.2066	1.3	4.7914	2.1	0.3199	1.6	0.78	1789.4	25.7	1783.4	17.7	1776.4	24.3	1776.4	24.3	100.7

107	239316	1.3	9.1895	1.5	4.3770	2.4	0.2917	1.9	0.77	1650.1	27.0	1708.0	19.9	1779.7	28.2	1779.7	28.2	92.7
57	132995	1.3	9.1799	1.5	4.7484	2.4	0.3161	1.8	0.77	1770.9	28.6	1775.8	20.0	1781.7	27.5	1781.7	27.5	99.4
96	50047	2.1	9.1742	1.2	4.7079	2.0	0.3133	1.7	0.82	1756.7	25.5	1768.7	17.0	1782.8	21.1	1782.8	21.1	98.5
190	55362	2.2	9.1732	1.7	4.2778	2.9	0.2846	2.3	0.82	1614.5	33.4	1689.1	23.6	1783.0	30.3	1783.0	30.3	90.6
103	124153	2.0	9.1642	1.4	4.2633	2.1	0.2834	1.6	0.75	1608.3	22.1	1686.3	17.0	1784.8	24.9	1784.8	24.9	90.1
144	5079551	2.4	9.1632	1.6	4.7570	2.8	0.3161	2.3	0.82	1770.8	35.9	1777.3	23.8	1785.0	29.9	1785.0	29.9	99.2
217	90282	3.7	9.1503	1.0	4.6738	2.0	0.3102	1.7	0.86	1741.5	26.0	1762.6	16.7	1787.5	18.7	1787.5	18.7	97.4
57	628216	2.0	9.1472	1.3	4.7529	2.2	0.3153	1.7	0.81	1766.8	27.0	1776.6	18.2	1788.2	23.4	1788.2	23.4	98.8
100	85577	1.9	9.1404	1.4	4.7429	2.2	0.3144	1.7	0.78	1762.4	26.4	1774.9	18.5	1789.5	25.3	1789.5	25.3	98.5
133	75824	2.9	9.1289	1.3	4.8054	1.8	0.3182	1.3	0.71	1780.7	20.1	1785.8	15.3	1791.8	23.3	1791.8	23.3	99.4
172	126770	2.2	9.1175	1.1	4.8099	2.3	0.3181	2.0	0.88	1780.2	31.0	1786.6	19.0	1794.1	19.2	1794.1	19.2	99.2
91	54298	2.3	9.1123	1.1	4.6381	2.3	0.3065	2.0	0.87	1723.6	29.9	1756.1	19.1	1795.1	20.8	1795.1	20.8	96.0
227	221274	2.6	9.0951	1.2	4.3594	2.2	0.2876	1.8	0.83	1629.3	26.3	1704.7	18.1	1798.5	22.0	1798.5	22.0	90.6
44	101075	2.7	9.0829	1.4	4.7737	2.6	0.3145	2.2	0.84	1762.7	33.3	1780.3	21.7	1801.0	25.7	1801.0	25.7	97.9
85	119220	1.2	9.0824	1.6	4.8028	2.5	0.3164	1.9	0.77	1772.0	29.2	1785.4	20.7	1801.1	28.8	1801.1	28.8	98.4
257	125434	8.0	9.0602	1.3	4.3669	2.1	0.2870	1.6	0.78	1626.3	23.5	1706.1	17.3	1805.5	23.8	1805.5	23.8	90.1
62	171316	1.8	9.0401	1.4	4.7124	2.3	0.3090	1.8	0.79	1735.6	27.8	1769.4	19.4	1809.6	25.8	1809.6	25.8	95.9
98	236642	2.0	9.0349	1.3	4.8781	2.3	0.3197	1.9	0.82	1788.0	30.1	1798.5	19.7	1810.6	24.0	1810.6	24.0	98.8
62	81056	2.3	9.0241	1.7	4.8761	2.6	0.3191	2.0	0.77	1785.5	31.2	1798.1	21.9	1812.8	30.3	1812.8	30.3	98.5
80	69303	2.3	9.0227	1.1	4.7258	2.1	0.3092	1.8	0.85	1737.0	27.6	1771.8	17.9	1813.1	20.6	1813.1	20.6	95.8
178	165030	1.9	9.0198	1.2	4.6860	2.3	0.3066	1.9	0.84	1723.7	29.3	1764.7	19.3	1813.7	22.6	1813.7	22.6	95.0
120	299711	1.7	9.0006	1.2	4.7658	2.1	0.3111	1.7	0.81	1746.1	25.5	1778.9	17.3	1817.5	22.1	1817.5	22.1	96.1
95	175481	2.1	9.0003	1.3	4.8698	2.1	0.3179	1.7	0.80	1779.4	25.8	1797.0	17.5	1817.6	22.8	1817.6	22.8	97.9
169	102363	2.1	8.9953	1.2	4.8696	2.0	0.3177	1.6	0.82	1778.5	25.6	1797.0	17.0	1818.6	21.2	1818.6	21.2	97.8
179	207440	1.7	8.9777	1.2	4.8330	2.0	0.3147	1.7	0.83	1763.7	26.1	1790.7	17.2	1822.2	20.9	1822.2	20.9	96.8
139	98322	2.0	8.9709	1.3	4.3584	2.4	0.2836	2.0	0.84	1609.3	28.7	1704.5	19.9	1823.5	24.0	1823.5	24.0	88.3
31	7708911	1.1	8.9560	1.3	4.9203	2.0	0.3196	1.6	0.78	1787.8	24.6	1805.7	17.0	1826.5	22.7	1826.5	22.7	97.9
103	87706	2.2	8.9325	1.2	4.6302	2.2	0.3000	1.8	0.83	1691.1	27.5	1754.7	18.6	1831.3	22.6	1831.3	22.6	92.3
97	244080	1.3	8.9264	1.4	4.2889	2.9	0.2777	2.5	0.87	1579.6	35.5	1691.2	24.0	1832.5	26.1	1832.5	26.1	86.2
87	244278	1.9	8.9163	1.2	4.4790	2.1	0.2896	1.7	0.82	1639.7	25.0	1727.1	17.5	1834.6	22.1	1834.6	22.1	89.4
187	452089	2.0	8.6218	1.3	5.1563	2.0	0.3224	1.6	0.78	1801.6	24.8	1845.4	17.2	1895.2	22.8	1895.2	22.8	95.1
63	181435	2.5	8.2254	1.1	5.8614	2.2	0.3497	1.9	0.86	1933.0	31.0	1955.5	18.7	1979.4	19.3	1979.4	19.3	97.7

II. X-Ray Diffraction data

In the following section we present the specifications of the XRD equipment and the diffractograms and the results from each one of the samples.

The equipment used to perform the XRD analyses was an OLYMPUS TERRA Portable X-Ray Diffraction /X-Ray Fluorescence instrument (Fig. I). This equipment is located in the petroleum reservoir lab in the Geology Department at Texas Christian University. This instrument has a Cobalt anode as X-ray source with a 240-mm diameter goniometer, allowing it to measure in a 2θ range between 5° – 55° .



Fig I. Olympus Terra Portable X-Ray Diffraction/Fluorescence instrument

The specification and measurement conditions are listed below:

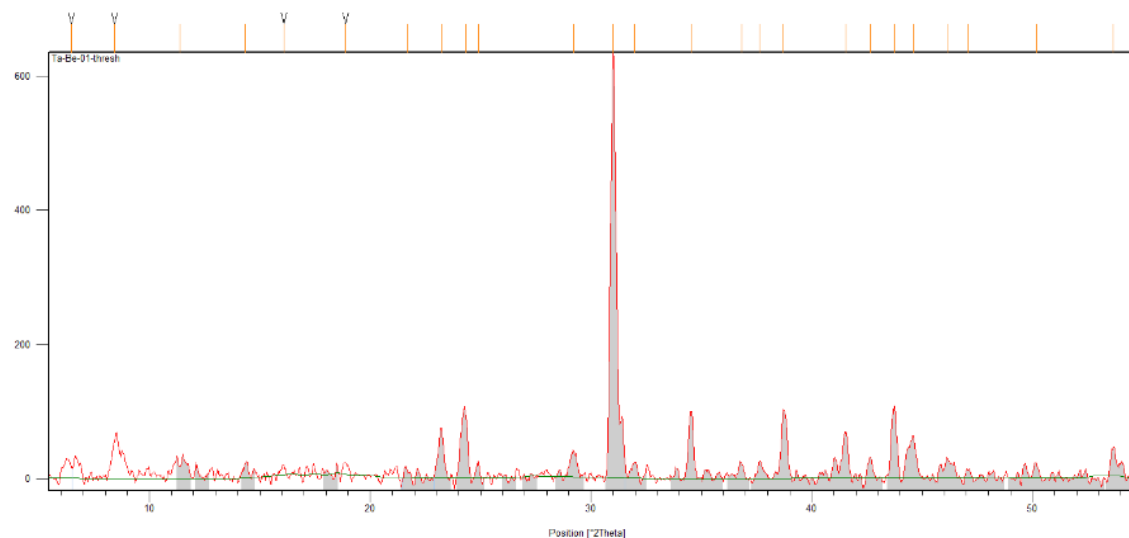
Geometry:

Terra-211 axisX = 1120.47 axisY = 129 axisZ = 1235.13 sensorAngle1 = 29.9852

• Raw Data Origin (scan) (.MDI)	Jade ASCII
• Scan Axis	Gonio
• Start Position [2θ .]	5.0000
• End Position [2θ .]	54.9200
• Step Size [2θ .]	0.0400
• Scan Step Time [s]	1.0000
• Offset [2θ .]	0.0000
• Divergence Slit Type	Fixed
• Divergence Slit Size [$^\circ$]	1.0000
• Specimen Length [mm]	10.00

• Receiving Slit Size [mm]	0.1000
• Measurement Temperature [$^\circ\text{C}$]	25.00
• Anode Material	Co
• K-Alpha1 [$\text{\AA}$]	1.78901
• K-Alpha2 [$\text{\AA}$]	1.79290
• K-Beta [$\text{\AA}$]	1.62083
• K-A2 / K-A1 Ratio	0.50000
• Generator Settings	0 mA, 0 kV
• Goniometer Radius [mm]	240.00
• Dist. Focus-Diverg. Slit [mm]	91.00

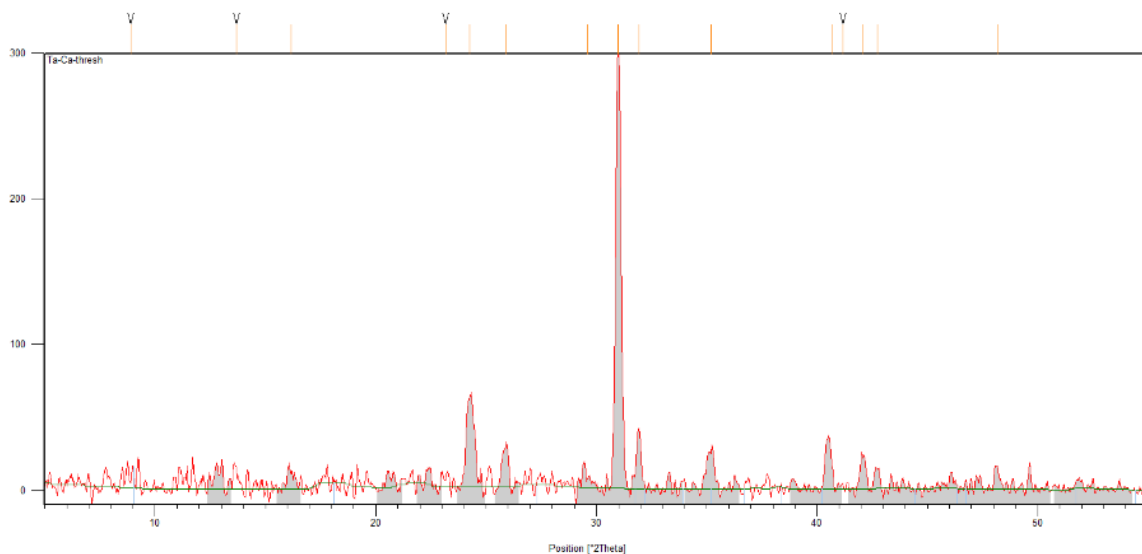
TA-01. La Cope Formation, Upper Member.



Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]	Matched by
6.4651	20.99	0.6298	15.87463	3.29	
8.4215	59.17	0.3149	12.19137	9.28	Cl
11.3879	24.48	0.4723	9.02239	3.84	Sr
14.3316	20.97	0.2362	7.17607	3.29	
16.0933	15.93	0.3363	6.39489	2.50	
18.8972	24.15	0.1607	5.45284	3.79	
21.6685	13.11	0.2362	4.76224	2.06	Cl
23.2210	72.95	0.3149	4.44780	11.44	St, Cl, Zr
24.3442	89.95	0.3936	4.24548	14.10	Cl, Qz
24.9001	25.76	0.1968	4.15215	4.04	St, Cl
29.2301	37.04	0.3149	3.54764	5.81	St
31.0085	637.82	0.3542	3.34874	100.00	St, Zr, Qz
31.9789	23.72	0.2362	3.24966	3.72	St, Cl
34.5494	101.33	0.3149	3.01446	15.89	St
36.8217	22.91	0.2362	2.83430	3.59	St
37.6276	24.27	0.3149	2.77572	3.81	St, Cl
38.6903	96.26	0.3149	2.70228	15.09	St, Cl
41.5538	69.22	0.3542	2.52348	10.85	Cl, Zr
42.6479	31.55	0.2362	2.46164	4.95	Cl, Qz
43.7448	108.27	0.3542	2.40283	16.98	St, Cl
44.6119	61.30	0.4723	2.35845	9.61	St, Cl
46.1836	24.67	0.4723	2.28236	3.87	St, Cl, Qz
47.0982	12.99	0.2362	2.24049	2.04	Cl, Qz
50.1744	22.08	0.2880	2.10969	3.46	St, Cl
53.6721	58.40	0.2345	1.98289	9.16	St, Qz

Ref. Code	Score	Compound Name	Scale Factor
01-079-2197	51	Staurolite	0.158
01-083-1362	26	Chloritoid	0.154
01-083-0539	63	Quartz	0.984
01-081-0588	33	Zircon	0.172

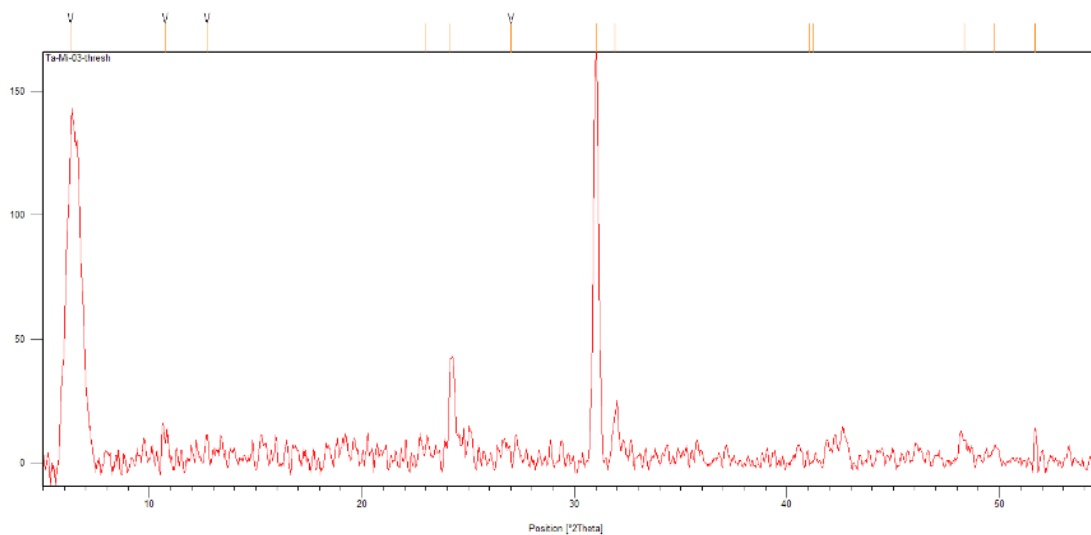
TA-02 Carbonera Formation.



Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]	Matched by
8.8981	9.71	0.7872	11.53957	3.24	
13.7034	11.17	0.3936	7.50339	3.73	
16.1730	12.20	0.6298	6.36359	4.08	Tml.
23.1603	9.67	1.6339	4.45930	3.23	
23.1603	9.67	1.6339	4.45930	3.23	
24.2482	61.93	0.3936	4.26203	20.69	Qz, Tml.
25.8829	27.54	0.3149	3.99703	9.20	Tml
29.5759	7.52	0.4723	3.50707	2.51	
30.9884	299.28	0.3149	3.35086	100.00	Qz. Tml.
31.9450	40.13	0.3149	3.25302	13.41	Rutile, Tml.
35.1850	25.96	0.4723	2.96168	8.68	Tml.
40.6773	17.44	0.3936	2.57548	5.83	Tml.
41.1600	4.00	0.0900	2.54656	1.34	
42.0867	23.29	0.2362	2.49295	7.78	Qz. Tml. Rutile
42.7231	13.98	0.2362	2.45751	4.67	Tml.
48.1630	14.40	0.2880	2.19222	4.81	

Ref. Code	Score	Compound Name	Scale Factor
01-083-0539	62	Quartz	0.938
01-076-1939	52	Rutile	0.151
01-074-1731	28	Tourmaline	0.132

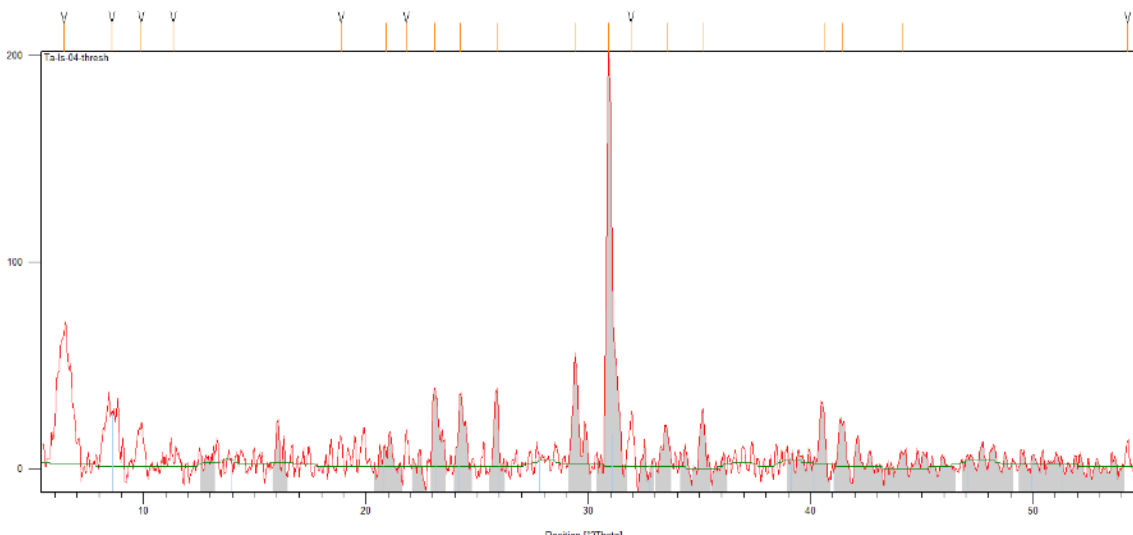
TA-03. Mirador Formation.



Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]	Matched by
6.2928	131.51	0.7085	16.30896	79.44	-
10.7205	9.61	0.3149	9.58227	5.80	
12.7115	10.38	0.1574	8.08623	6.27	
22.9600	3.00	0.0900	4.49767	1.81	Zr
24.1671	41.87	0.2755	4.27612	25.29	Qz
31.0036	165.54	0.3149	3.34926	100.00	Qz, Zr
31.9099	18.37	0.2362	3.25650	11.10	Ru
41.0400	1.00	0.0900	2.55368	0.60	Zr
48.3342	9.27	0.4723	2.18650	5.60	Ru
49.7405	6.19	0.4723	2.12845	3.74	Qz
51.6819	14.05	0.1920	2.05221	8.48	Ru

Ref. Code	Score	Compound Name	Scale Factor
01-083-0539	60	Quartz	1.005
01-076-0317	29	Rutile	0.140
01-081-0591	17	Zircon	0.153

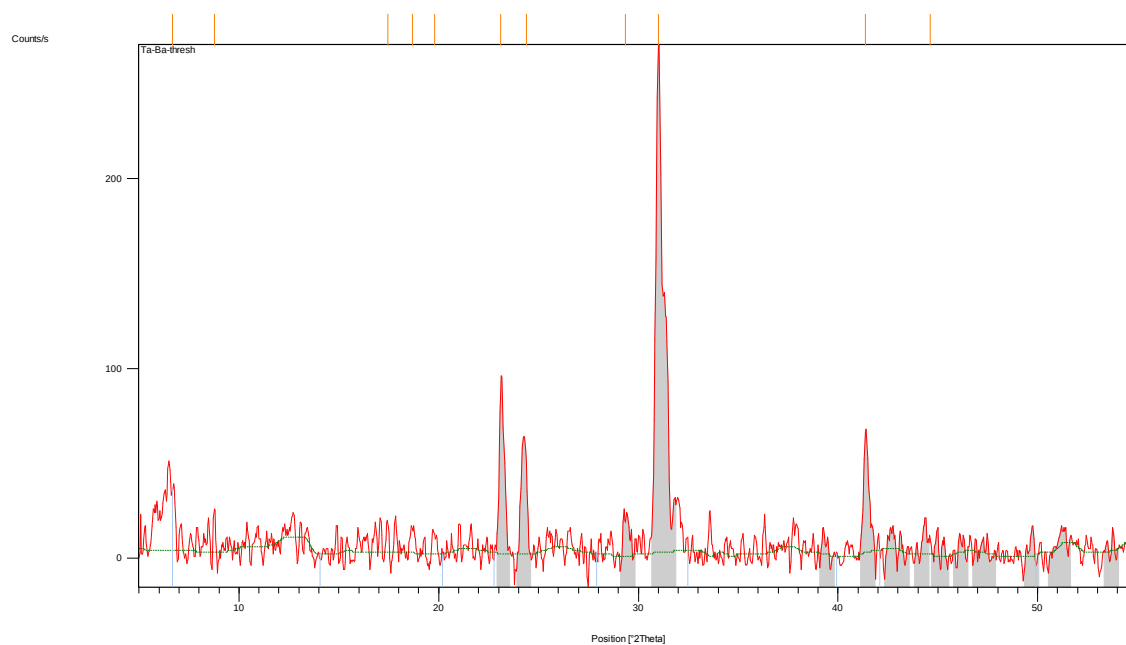
TA-04 La Cope Formation, Lower Member.



Pos. [°2 θ .]	Height [cts]	FWHM [°2 θ .]	d-spacing [Å]	Rel. Int. [%]	Matched by
6.4157	66.15	0.7085	15.99684	33.55	
8.5755	28.37	0.6298	11.97278	14.39	
9.8882	20.19	0.3149	10.38653	10.24	
11.3488	5.56	0.6298	9.05334	2.82	
18.8842	14.31	0.1968	5.45657	7.26	
20.9135	9.02	0.4723	4.93217	4.57	
21.8283	15.42	0.1574	4.72782	7.82	Tour
23.1112	38.84	0.3149	4.46864	19.70	Zr
24.2250	32.88	0.3149	4.26604	16.68	Tour, Qz
25.8954	38.03	0.2755	3.99513	19.29	Tour
29.4034	51.50	0.2362	3.52719	26.12	Ru
30.9096	197.17	0.2362	3.35920	100.00	Qz, Zr
31.9205	24.87	0.2362	3.25546	12.61	Ru
33.5421	17.39	0.3149	3.10227	8.82	Tour
35.1918	25.77	0.2755	2.96113	13.07	Mag, Tour
40.6395	16.34	0.2755	2.57777	8.29	
41.4164	21.83	0.3149	2.53148	11.07	Tour
44.1558	8.00	0.2362	2.38157	4.06	Mag, Zr
54.2463	11.74	0.2880	1.96204	5.95	Ru, Tour

Ref. Code	Score	Compound Name	Scale Factor
01-071-1167	45	Anatase	0.283
01-086-1342	28	Magnetite	0.116
01-081-0588	23	Zircon	0.162
01-086-1572	24	Tourmaline	0.161
01-083-2465	43	Quartz	0.512
01-080-0390	29	Magnetite	0.109

Ta-05. Barco Formation



Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]	Matched by
6.6655	31.92	0.3936	15.39787	11.91	
8.7636	23.11	0.1181	11.71627	8.62	
17.4422	16.85	0.1574	5.90374	6.29	
18.6990	13.31	0.2362	5.51013	4.96	
19.7918	10.50	0.2362	5.20866	3.92	
23.1156	92.74	0.1968	4.46780	34.60	Zr
24.3947	49.69	0.3542	4.23683	18.54	Qz
29.3688	21.07	0.3149	3.53125	7.86	Ru
31.0051	267.99	0.2755	3.34910	100.00	Qz, Zr
41.3814	63.99	0.3936	2.53353	23.88	Zr
44.6297	7.44	1.1520	2.35585	2.78	Ru

Ref. Code	Score	Compound Name	Scale Factor
01-078-1252	65	Quartz	1.010
01-081-0588	37	Zircon	0.420
01-076-0326	21	Rutile	0.211

III. Field work and sample location descriptions

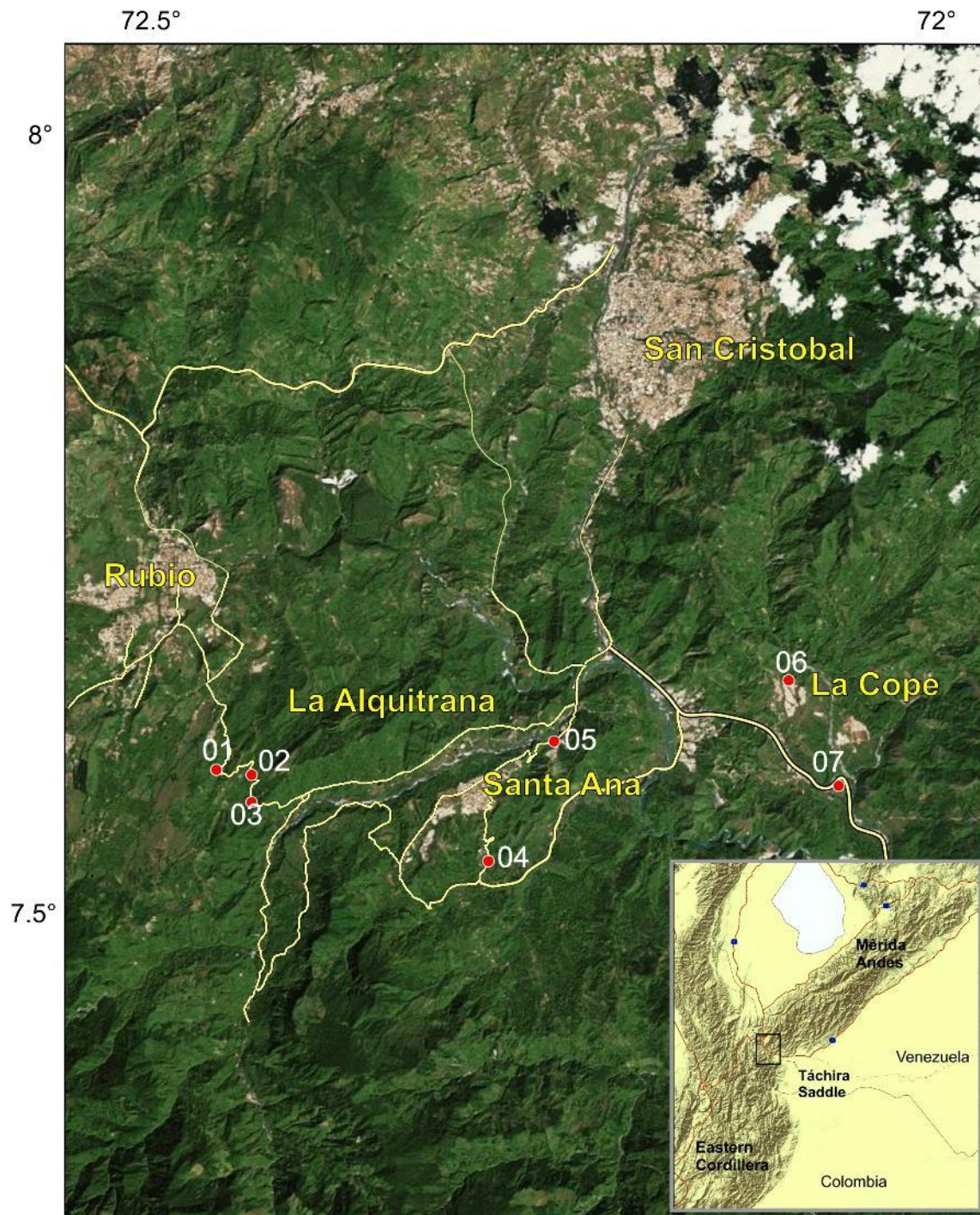


Figure I. Location map of Táchira Saddle showing principal roads and field stations.

Station 1. La Alquitrana Sector, a road cut on the way to Rubio. [N 847733 E 792937]:

Geological Unit: La Cope Formation, Upper Member.

Stratigraphic age: Mio-Pliocene

Sample: Ta-01

Description.

Road cut is on the western side of the road, exposed behind a house. A Quaternary polymictic conglomerate with tabular-shaped sandstone boulders overlies a coarse-grained, poorly cemented, lithic sandstone with a silty matrix that belongs to the upper member of the La Cope Formation. The boundary is presented as paleosol relicts preserved in a folded red oxidized horizon. We collected 3 kg of sample from the underlying sandstone.

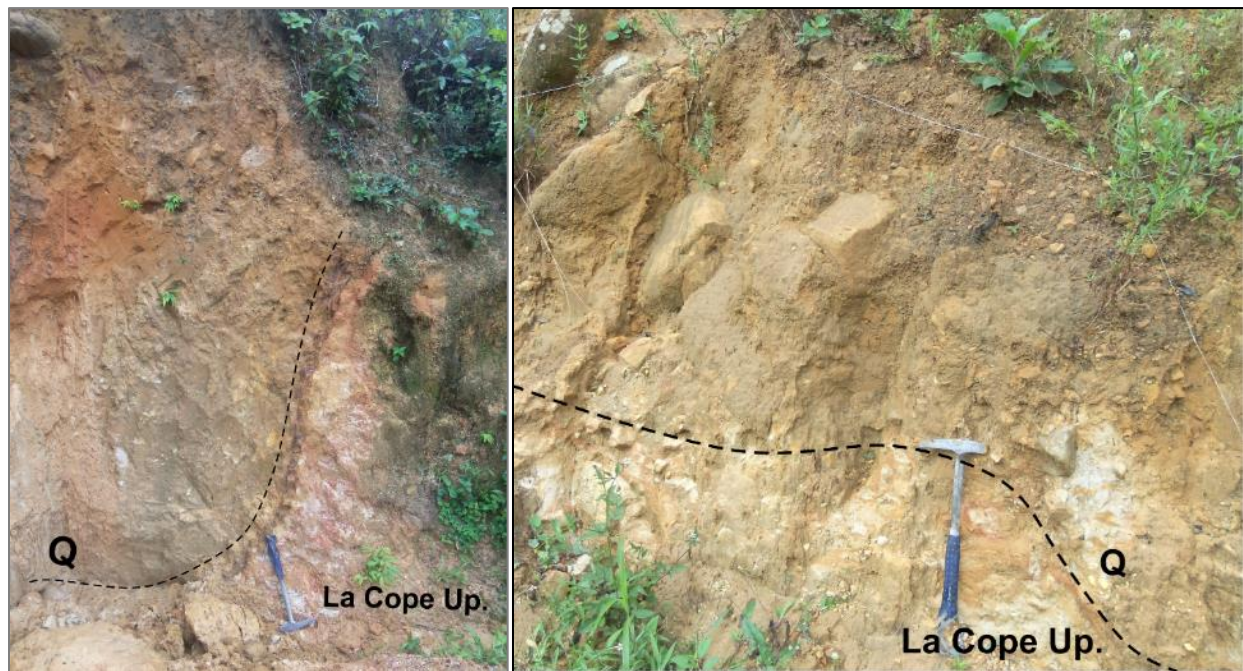


Figure. II. Road cut exposing a poorly cemented sandstone from the upper member of the La Cope Fm.

Station 2. La Alquitrana Sector, a road cut on the way to Rubio. [N 846307; E 793648]

Geological Unit: Carbonera Formation.

Stratigraphic age: Oligocene

Sample: Ta-02

Description

A road cut in the northern side of the road exposes a 15-m-wide by 4-m-high cliff of gray sandstone strata, poorly cemented with a very homogeneous fine-grained texture. The layers have a general orientation N60E 60N. Some of the layers shows flaser bedding and intercalation of dark brown layers of clay ~2-cm-thick. The sandstone is protected by a 1-cm-thick black crust of weathered material. The clay intervals are slightly oxidized, and have a red\dark brown color. 10 kg of the fresh gray sandstone were collected to perform the analysis.



Figure III. Outcrop of Carbonera Formation sandstone. Notice the flaser interstratification in the left picture.

Station 3. La Alquitrana Sector, a road cut on the way to Rubio. [N 845054; E 793950]

Geological Unit: Mirador Formation.

Stratigraphic age: Eocene

Sample: Ta-03

Description

A 100-m-wide by 30-m-high cliff of sandstone is exposed on the north side of the road. Massive sandstone strata have well-cemented grains with a homogeneous medium grain size and light gray color. The Outcrop shows cross bedding and some cemented burrows. The strata have a general orientation N70E 82N and are highly fractured, with at least two generations of faults. Normal faults are generally oriented N30W 81S and the second group of faults with oriented N42E 20 N, presenting relative inverse movement. 10 kg of the sample were collected from this outcrop.



Figure IV. Outcrop of sandstones of Mirador Formation.



Figure V Outcrop of sandstones of Mirador Formation. Left: Picture showing the displacement of conjugated faults. Right: close-up of the cross-bedding

Station 4. Santa Ana de Táchira. Road to La Blanquita village. [N 844252; E 800561]

Geological Unit: La Copé Formation. Lower Member

Stratigraphic age: Middle Miocene

Sample: Ta-04

Description:

In the southern hills of the town Santa Ana del Táchira, there is a small road that connects with La Blanquita village. 1.5 km from Santa Ana there is a road cut to the left side of the road that exposes a white conglomerate with rounded clasts that vary in diameter between 2–8 cm. The conglomerate is oligomictic with the smaller clasts composed of mostly quartz and gray chert, with the larger ones being commonly white chert. There is no apparent textural arrangement or fabric orientation in the conglomerate, but the clasts are well cemented into a fine-grained matrix. Between the conglomerate strata, there are some sandstone lenses of white, coarse-grained, poorly cemented and well sorted sandstone. 10 kg of this white sandstone were collected for the analysis.



Figure VI. Outcrop of conglomerate of lower member of La Cope Formation, near Santa Ana de Táchira.

Station 5. Santa Ana de Táchira. Main road. [N 847840; E 809141]

Geological Unit: Barco Formation.

Stratigraphic age: Paleocene

Sample: Ta-05

Description:

In the main road of Santa Ana, near to the northern exit of town, close to the river, there is a road cut that exposes an intercalation of shales and sandstones of dark brown color. This layer has a general orientation of N68E 64N. The sandstone layers have an average thickness of 10 cm with gray color and homogeneous fine grain size. The shale layers are fragile and splintering, with a dark gray color and with an averages thickness <10 mm. Cross-stratification structures were observed in some sandstone strata where 5 kg of the sandstone were collected.



Fig. VII. Outcrops of Barco Formation in the main road of Santa Ana del Táchira.

Station 6. Abandoned Asphalt mine near La Cope. [N 847685; E 809141]

Geological Unit: La Copé Formation.

Stratigraphic age: Mio-Pliocene

Sample: N/A

Description.

Old asphalt mine close to La Copé town on the road between San Cristobal and Santo Domingo.

The mine front exposed multiple strata of a polymictic conglomerate with clasts of black limestone, black and white chert and quartz, with diameters between 2 cm and 8 cm. The sandstone matrix is well cemented and saturated in oil. The layers have an orientation of approximately N34W45S, becoming more horizontal to the top of the mine. Two kilograms of this conglomerate were collected. However, the sample was not used because of the analysis for the extra treatment necessary to remove the oil.



Fig. VIII. Outcrops of La Cope Formation in abandoned asphalt mine in La Cope.

Station 7. The highway between Santo Domingo and San Cristobal. [N 847685; E 809141]

Geological Unit: Aguardiente Formation

Stratigraphic age: Lower Cretaceous

Sample: Ta-07

Description.

A road cut in the highway between Santo Domingo and San Cristobal, where a 50-m-wide and 30-m-high cliff exposes a sequence of massive quartz-feldspar sandstone, well cemented with a medium to fine grain size, presenting large scale cross-bedding structures of ~15 m long. Strata thickness varies between 10 to 1 m, occasionally with interbedded dark shale in layers between 1 to 5 cm thick and showing large scale cross-bedding structures. General Orientation of the layers is N10°E 35°N.



Fig. IX. Outcrop of Aguardiente Formation in San Cristobal – Santo Domingo Highway.

VITA

Ali Ricardo Gomez-Ramos was born on September 3rd of 1984, in Caracas, Venezuela. He is the only son of Nilsen de la Trinidad Gomez-Ramos. Graduated from high school at Colegio Fe y Alegría 'La Rinconada' in 2002. After surfing around different career paths, he received a Bachelor degree in Geological Engineering from Universidad Central de Venezuela in Caracas, in 2012. During his undergrad experience, he assumed responsibilities as a Research Assistant in the Geology and Petrology Lab 330, and Teaching Assistant in Sedimentology and Field Methods. He was also part of different student organizations, as the Photography club, the Student Geoscience Foundation, and captain of the School of Geology and Geophysics soccer team.

After graduation, he worked in the Venezuelan Seismological Research Institute (FUNVISIS), from 2012 to 2015, where he developed a regional geological mapping project of northern Venezuela and participated with interdisciplinary teams in several natural hazard assessments around the country. In January 2013, he received an offer from Universidad Central de Venezuela to be part of their academic staff as an adjunct professor in introductory geology and sedimentology academic units. In August 2015, he decided to quit both of his jobs and move abroad to pursue a Master degree in Texas Christian University, in Fort Worth, Texas.

Starting in August 2017, he will pursue doctoral studies working within the Conjugate Basins, Tectonics, and Hydrocarbons Consortium in the Department of Earth and Atmospheric Sciences at University of Houston

ABSTRACT

PROVENANCE OF CENOZOIC CLASTIC SEDIMENTS IN THE TÁCHIRA SADDLE, WESTERN VENEZUELA, AND IMPLICATIONS FOR SEDIMENT DISPERSAL PATTERNS IN THE NORTHERN ANDES

Ali Ricardo Gomez, MS, 2017
School of Geology, Energy & the Environment
Texas Christian University

Thesis Advisor: Dr. Xiangyang Xie
Committee Members: Dr. Helge Alsleben and Dr. Richard Hanson

Northwestern South America is highly deformed due to the transpressive plate boundary associated with complex interactions between the Caribbean plate, the South American plate, the Nazca plate and the Panama arc. Previous studies suggest that the Cenozoic uplift of the Mérida Andes and Eastern Cordillera of Colombia affected sediment dispersal patterns in the region, shifting from a Paleocene foreland basin configuration to the modern isolated basins. Well-exposed Cretaceous to Pliocene strata in the Táchira Saddle provide a unique opportunity to test proposed sediment dispersal patterns in the region. U-Pb detrital zircon geochronology and supplementary XRD heavy mineral data are used together to document the provenance of the Táchira Saddle sediments and refine the sediment dispersal patterns in the region. Results from the U-Pb detrital zircon geochronology show that there are six age groups recorded in these samples. Two groups are related to the Precambrian Guyana shield terranes and Putumayo basement in the Eastern Cordillera, and four groups are related to different magmatic episodes occurring during the Andean orogenic process. The transition between the Cretaceous passive margin and the Paleocene foreland basin and the initial uplift of the Eastern Cordillera and the uplift of the Mérida Andes by the Early Miocene were also recorded in the Táchira saddle detrital zircon signature.