Inter-Andean Cauca River Canyon

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Abstract

A section of the Cauca River canyon passing through the Department of Antioquia in northwestern Colombia is considered to be of great interest due to its geological and geomorphological characteristics, which give rise to stunning landscapes. The canyon is divided from south to north into three geomorphological segments. Erosion and accumulation processes are dominant in the first segment, highlighted in the Támesi*s* Scarp and landforms, such as Los Farallones de La Pintada. Morphotectonic features associated with the Cauca-Romeral Fault System and represented by the Cerro Bravo, El Sillón and Tusa Mounts are significant in the second segment. The third segment is characterized by fluvio-lacustrine to torrential accumulation processes and there are also evidences of neotectonic activity expressed by active mountain fronts along with seismites. This portion of the Cauca River is quite diverse and there are few places in Colombia that concentrate so much geodiversity in so few miles. Additionally, it has a high esthetic value because of the marked geomorphological contrast and the existence of panoramic landscapes.

Keywords

Canyons • Tropical mountain rivers • Recent tectonics

13.1 Introduction

The segment of the Cauca River canyon, a great geomorphological and natural heritage of the country, is located in the northwest of the country, west of the city of Medellin. It is famous for both its majestic scenery and great scientific interest.

The Cauca River rises at the *Macizo Colombiano* in southwestern Colombia and flows northward through contrasting geomorphological regions; it joins the Magdalena River and, together, they flow out into the Caribbean Sea. The segment described in this chapter is a part of the great intra-range valleys that characterize the Colombian Andes. Locally, it is an impressive depression formed by a 2000-m-deep canyon incised into extensive, well-preserved erosion surfaces of the Central Cordillera.

The Cauca River canyon can be reached by two main roads, from Medellin or from Manizales. Several towns in the region offer a variety of lodging and additional attractions, such as the historical town of Santa Fe de Antioquia.

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13.2 Geodynamic Setting

The northern part of the Colombian Andes has been formed by a complex structural converging interaction at the northwest corner of the South American continental plate, at its junction with the Nazca and Caribbean oceanic plates (Fig. 13.1). It has also been affected by regional fault systems, the product of subduction and strike slip faulting (Page 1986).

In the study area, the fault pattern is dominated by the Cauca-Romeral Fault Systems, which cross the Northern Andes from Guayaquil up to the Caribbean Sea. This SSW–NNE to S–N trending fault system is inherited from a complex sequence of accretions that occurred since the Cretaceous. At a local scale, these fault systems are represented by a series of parallel to subparallel fault segments, sometimes anastomosed (Suter et al. 2008). Between 4°N and 5°N, its kinematics changes from right-lateral in the south to left-lateral in the north (Taboada et al. 2000).

The Romeral Fault System in the east is distributed as an elongated strip of variable width, bounded on the east by the San Jerónimo Fault and on the west by the Sabanalarga Fault, whereas the Cauca, Anzá and Peque Faults are the most important of the Cauca Fault System in the west, located on the western side of the Cauca River, in the eastern foothills of the Western Cordillera. In general, they are inverse strike slip faults and many of them are considered to be active, with low to moderate activity.

13.3 Geology

Geographically, the Cauca River divides the Western and Central Cordilleras that are markedly different in terms of both lithology and ages of main rock complexes, ranging from Paleozoic to the present (Fig. 13.2).

The core of the Central Cordillera consists of Paleozoic metamorphic rocks of continental environments, such as

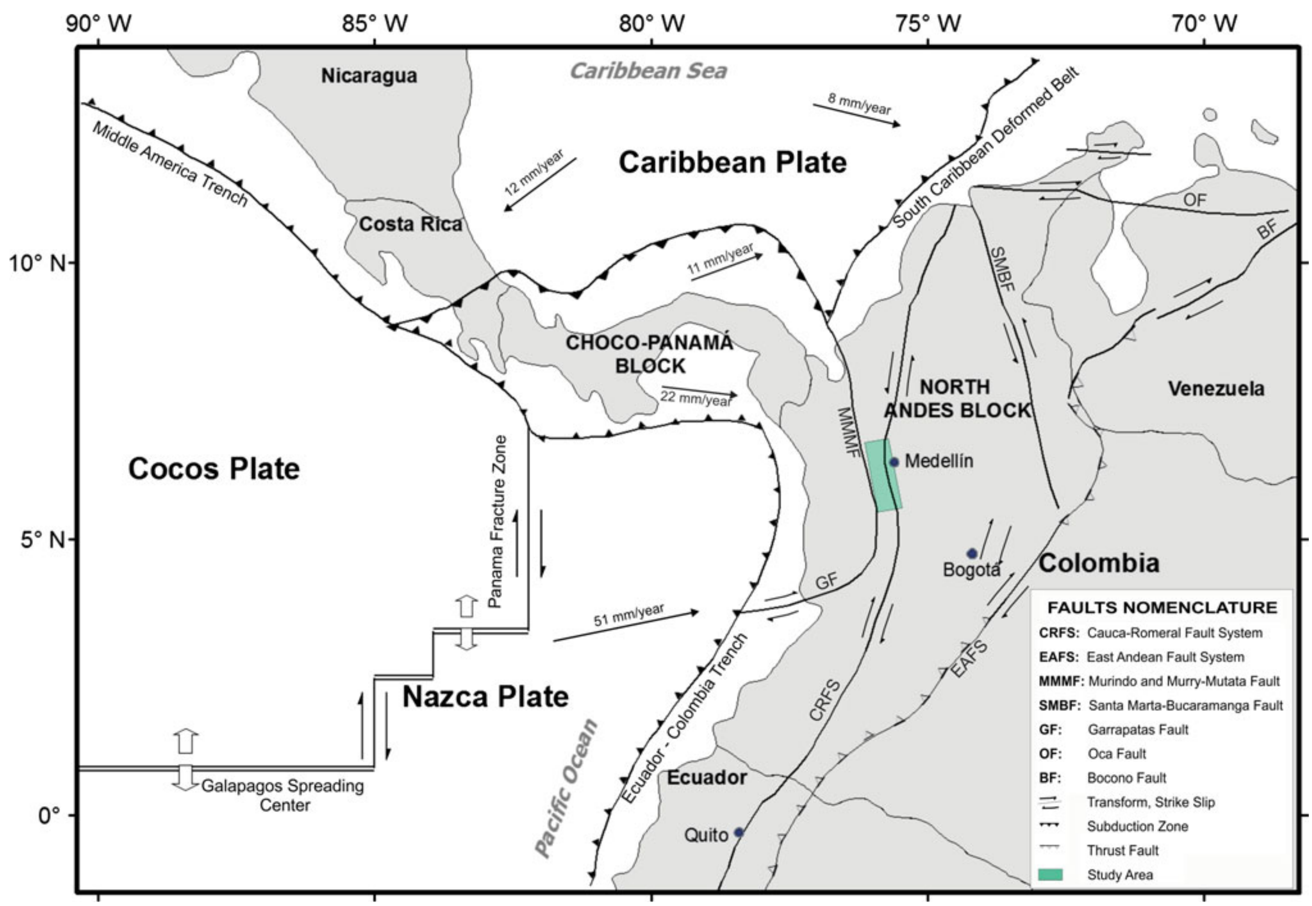


Fig. 13.1 Geodynamics of the north-western part of South America. Tectonic data modified from Rendón (2003), Monsalve and Mora (2005), Suter et al. (2008)

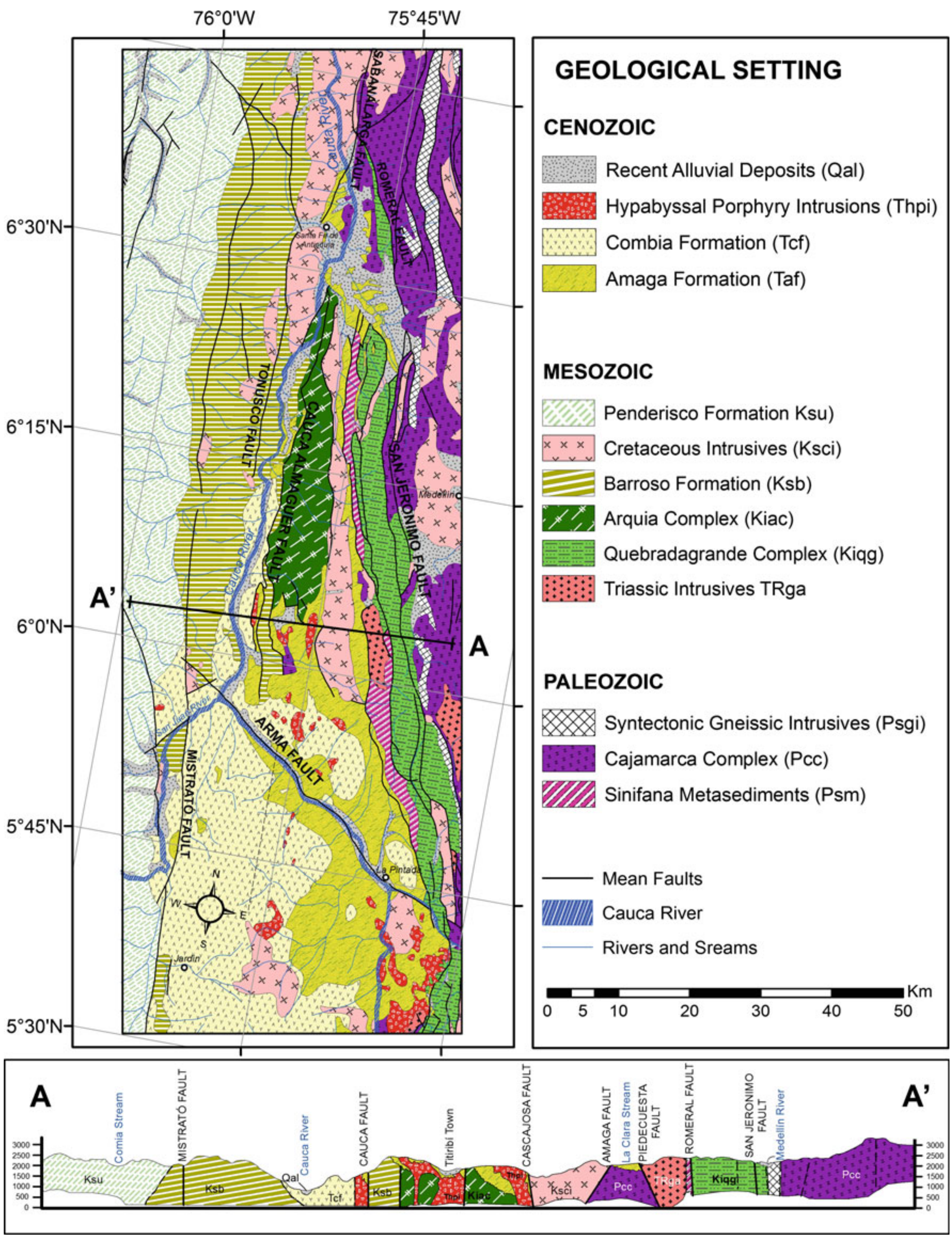


Fig. 13.2 Main geological units of the study area (Ingeominas 1990, 2001)

Sinifaná metasediments, along with schists, gneisses, quartzites, and marbles of the Cajamarca Complex. These rocks were intruded by granitic bodies, which were tectonically affected during their emplacement. During the Mesozoic, contrasted geological events occurred. Several stocks were intruded during the Triassic and this activity continued more intensely during the Cretaceous, resulting in the intrusion of the Antioquia and Sabanalarga Batholiths. Marine sedimentation in the Central Cordillera began during the Cretaceous and was followed by periods of intense seafloor volcanism, as recorded by the Quebradagrande Complex. Around the same time, the Arquía Complex appeared as a strip of medium-pressure, tectonized metamorphic rocks and related dismembered ophiolitic sequences along the Romeral Fault System (INGEOMINAS 2001).

The Barroso Formation and the Cañas Gordas Group, which contains the Penderisco Formation, represent an intense, late Cretaceous basic oceanic volcanism and constitute the oldest units of the Eastern Cordillera that are geologically separated from the Central Cordillera by the Romeral Fault System (INGEOMINAS 2001).

The Cenozoic began with the intrusion of sub-volcanic bodies of andesitic composition and porphyritic texture. Sedimentation in the Cauca River Basin was controlled by tectonics; a graben formed, resulting of pulling movements along the Romeral Fault System. Sediments from the Amagá Formation were deposited during the Neogene and are characterized by the presence of beds and lenses of coal. Lava flows and pyroclastic sequences of Combia Formation were deposited on top of these sediments, signaling the beginning of intense volcanic activity that extends to the present-day.

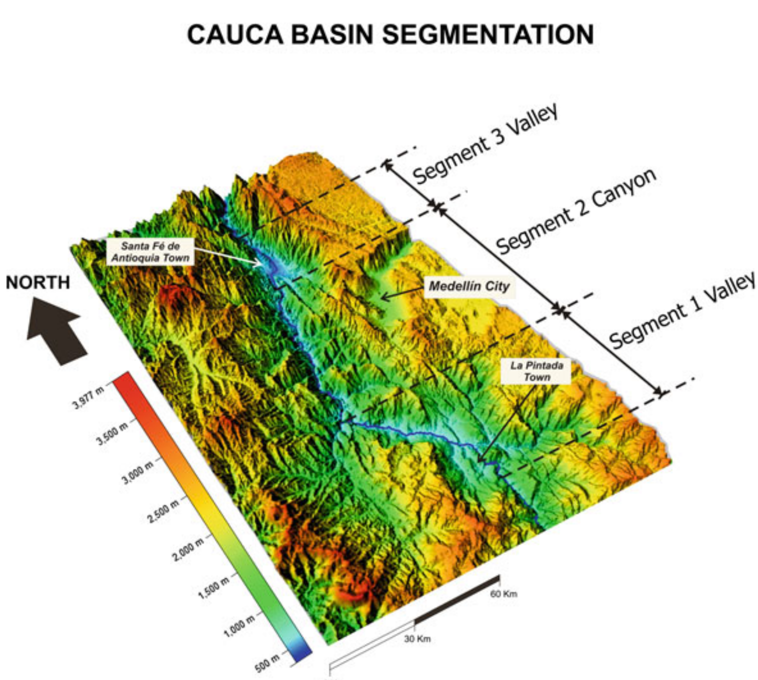
The Amagá Formation unconformably underlies the Combia Formation and is intruded by late Miocene porphyry bodies. This unit is dismembered along the Cauca River Canyon by the Cauca-Romeral Fault System, representing the clearest evidence of active tectonics at least until Late Miocene.

During the Quaternary, the high-energy morphodynamics of the Cauca River slopes and tributary watersheds, related to the Andean orogeny, generated numerous bodies of unconsolidated deposits composed of coarse materials (boulders, pebbles, gravel). These are mainly alluvial fans and slope deposits. Fluvio-lacustrine terraces are associated with ancient damming of the Cauca River and have been affected by recent tectonic activity. Some soft sediment layers show deformation structures as seismites, tilted horizons, and vertical faulting with movements less than 1 m in active mountain fronts.

13.4 Geomorphologic Setting

The central area of the Department of Antioquia is characterized by the presence of highlands embedded by two major N–S trending fault systems, Palestina in the east and Cauca-Romeral in the west. The highlands are a sequence of stepped erosion surfaces, which show a predominant southeastward tilt. The internal low relief of the highlands is a relict landscape, preserved due to low erosion rates since the late Cenozoic uplift (Page and James 1981).

The Cauca River Canyon marks the western boundary of the area where the erosion surfaces are preserved. Landforms



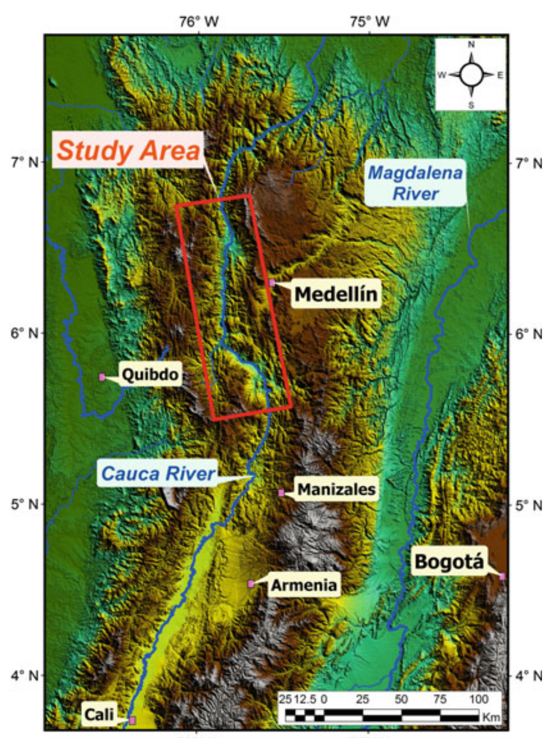


Fig. 13.3 The Cauca River basin segmentation and regional geomorphological setting

associated with intense morphodynamic processes such as slides, mud, and debris flow and intense gullying are common in the canyon slopes. It is also important to mention strong altitudinal gradients associated with abrasion zones and removal of large slope deposits.

The canyon geomorphology is complex, consisting of superimposed landscapes that have been associated with recent tectonic processes and climate variations during the Quaternary. There are noticeable morphotectonic features, such as deflected drainage systems and aligned hills and valleys. In addition, there is evidence of recent tectonic activity in the Holocene unconsolidated sediments of the Cauca River terraces (Suter et al. 2010), suggesting that earthquakes played an important role in the evolution of the landscape.

Figure 13.3 shows the regional geomorphology and a 30-m resolution DEM of the three selected sections. Several segments exhibit marked structural control, where openings and closings coincide, in many cases, with anastomosing strike slip fault traces and pull-apart structures.

13.4.1 Segment One: From Canyon to Valley

In the southeast of the area, the Cauca River incised a narrow canyon into bedrock and local relief is more than 1000 m. Deep fluvial erosion has uncovered hypabyssal rocks more resistant than their embedding sediments from the folded Tertiary sediments of the Amagá Formation and volcano-sedimentary materials of the Combia Formation (Fig. 13.4a).

Three hills formed in porphyritic rocks trending N–S, known as Los Farallones de La Pintada (Pintada Rocky Peaks) stand out as the result of the Cauca River incision (Fig. 13.4b). They are parts of ancient volcanic necks and

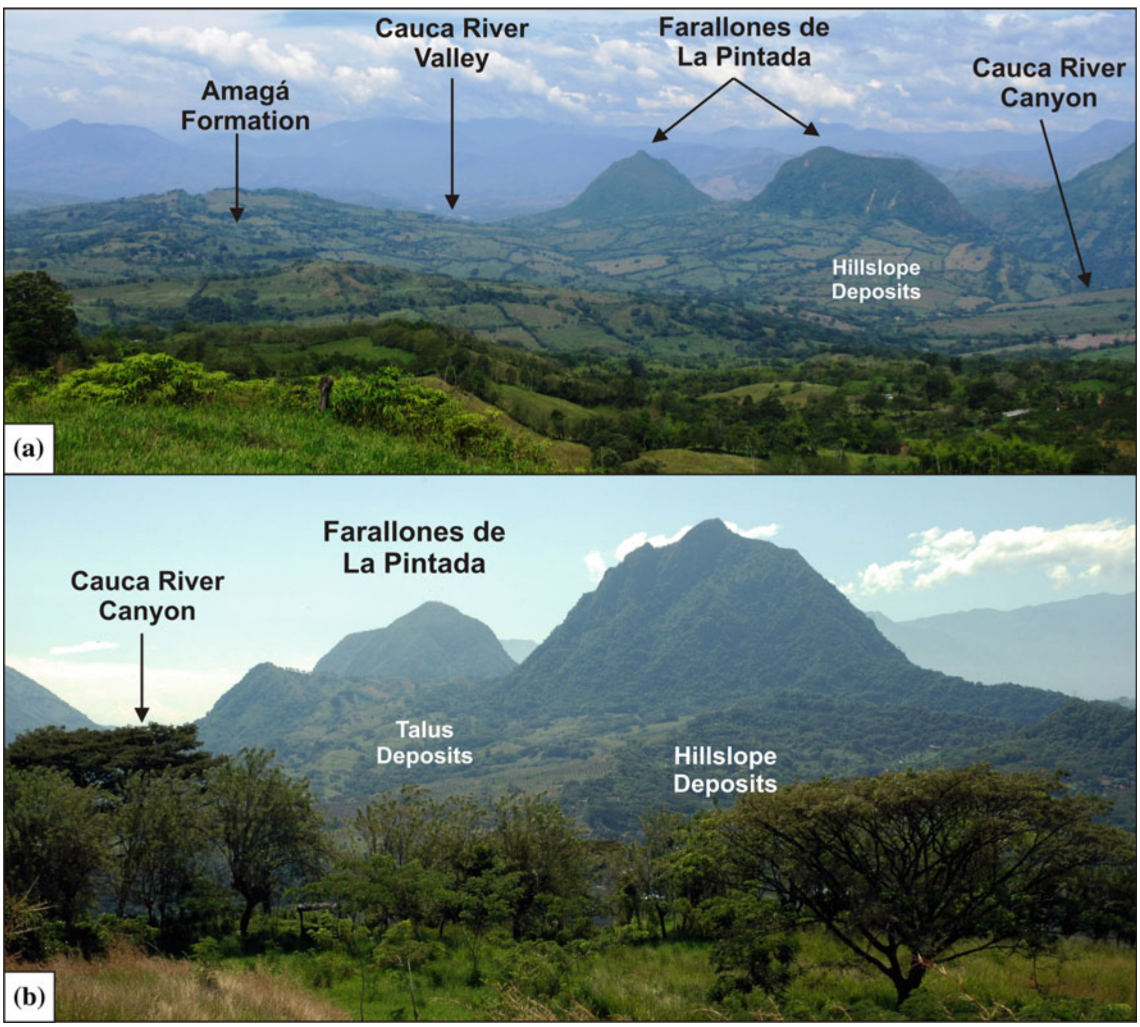


Fig. 13.4 Features of the segment 1 of the Cauca River valley and the morphology of Los Farallones de La Pintada

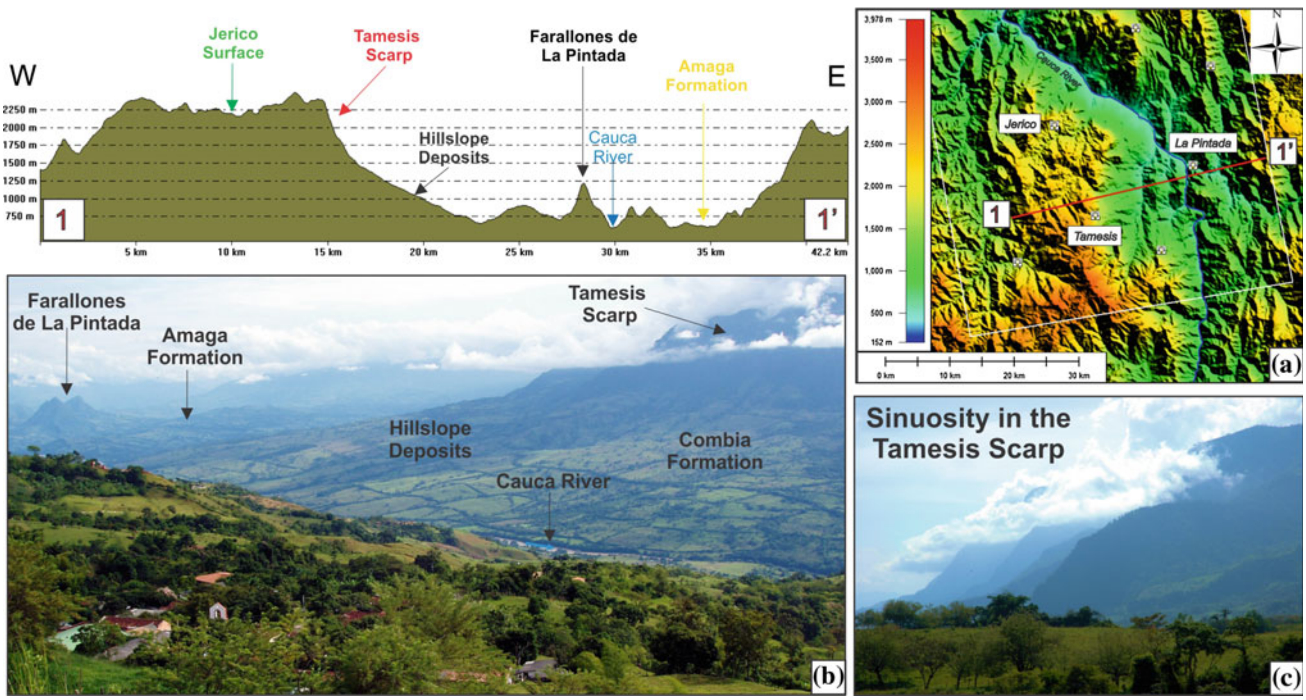


Fig. 13.5 Geomorphological profile of Segment 1 and linear valley features

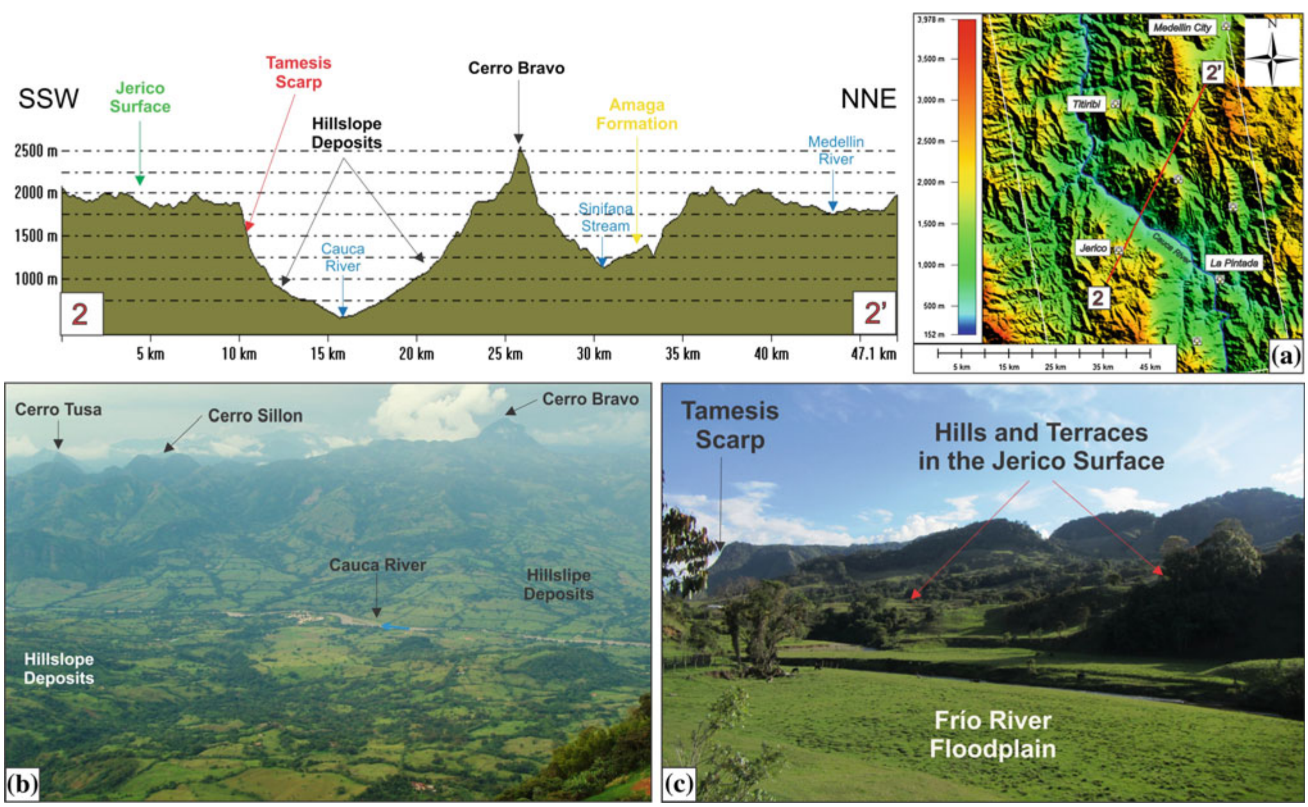


Fig. 13.6 Hill slopes of the Cauca River valley and the Jericó surface

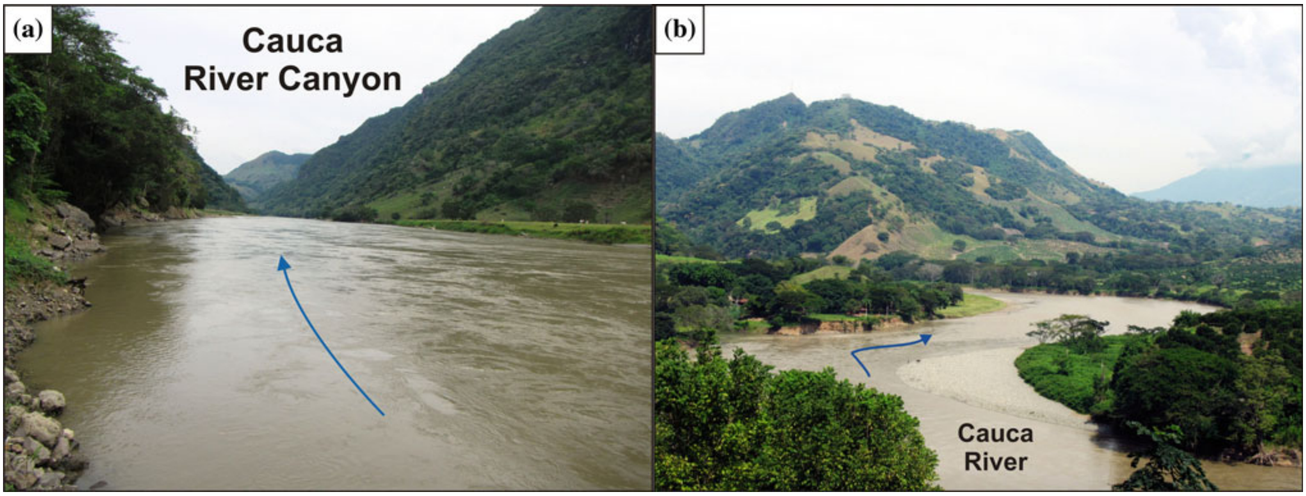


Fig. 13.7 The Cauca River Canyon in segment 2

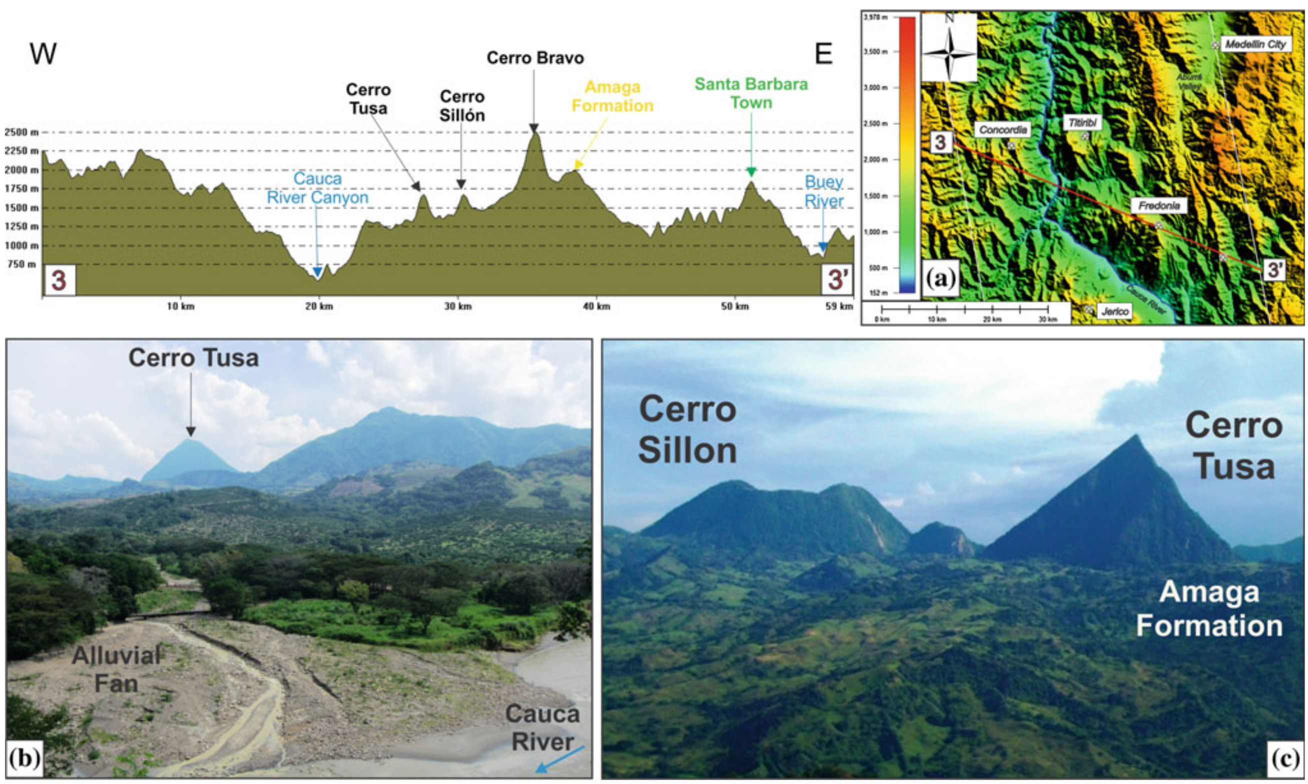


Fig. 13.8 The Cauca Basin geomorphological features in segment 2

have an abrupt morphology with high and steep slopes. Due to very active erosion produced by rapid cordillera uplift, they show little weathering. Translational slides and rock falls have contributed to the recent talus deposits west of these bodies.

There is a profound morphological change in the Cauca river valley downstream from the mouth of the Arma River. The narrow basin changes drastically to a wide, linear valley characterized by a strong structural control as exemplified in the now N50 W trending Cauca River. The course of the river in this section is related to the trace of the Arma Fault (INGEOMINAS 2001).

Characteristic features of this valley section are the broad valley floor, Los Farallones de La Pintada, and the Tamesis scarp (Fig. 13.5a). Along the base of the scarp thick slope deposits have accumulated. The sinuosity of the Tamesis

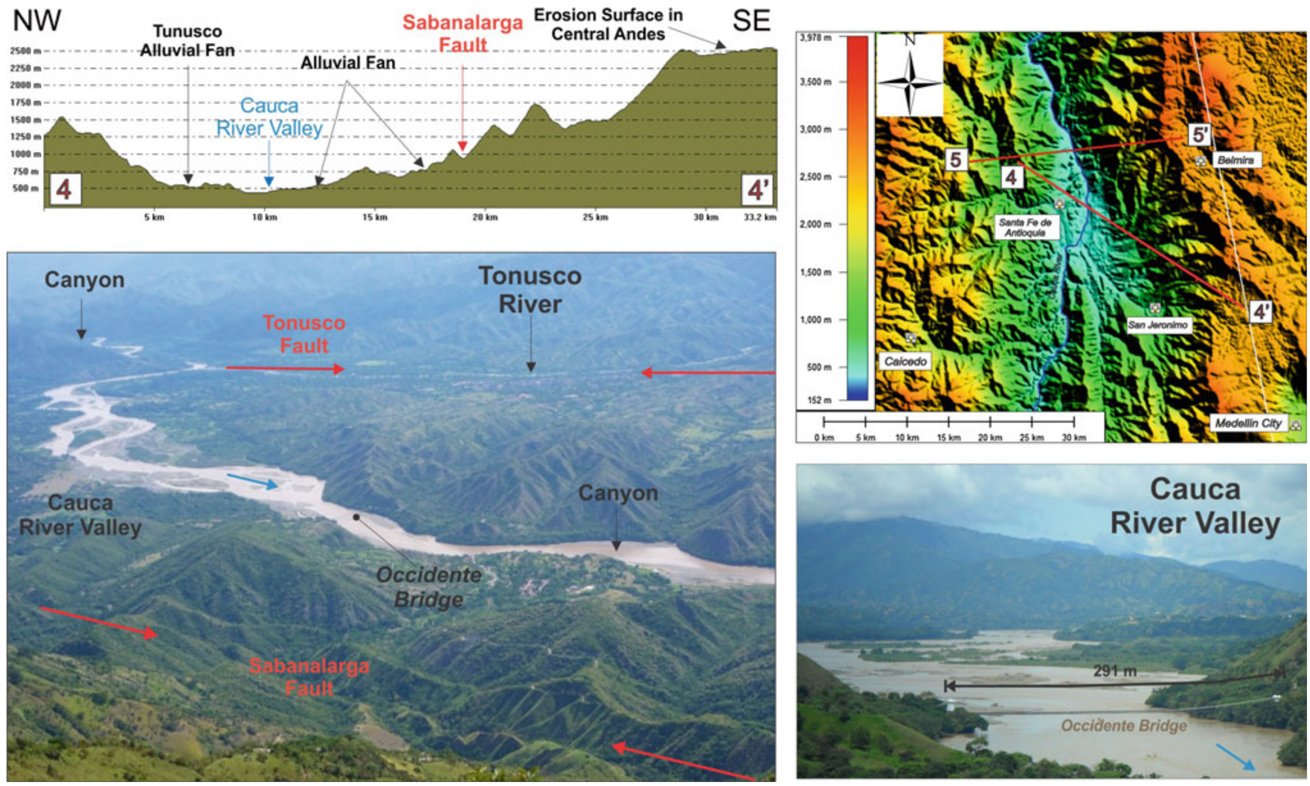


Fig. 13.9 The broad section of the Cauca River valley and its morphotectonic features. Cross section 5–5′ is presented on Fig. 13.11

scarp results from progressive erosion that has formed horseshoes and pediments as the evidence of enlargement of the valley and escarpment retreat (Fig. 13.5b, c).

The Cauca River valley width is about 20 km and it has a significant relative relief of 1300 m (Fig. 13.6a; Profile 2–2′). Likewise, the highest isolated hill is 2,500 m high and it is known as Cerro Bravo (Fig. 13.6b), which evidences the magnitude of Neogene volcanism that have occurred and significant erosion and exhumation rates in the basin.

Both hillslopes of the Cauca River are covered by slope deposits that consist of thick mud and debris flow materials, eroded by various tributaries. This erosion has exposed decametric-sized boulders from the base of the escarpment to the distal area near the Cauca River. These bodies could not have traveled over such long distances due to their volume. It is therefore suggested that they are remnants of the evolution and erosive retreat of the vertical talus that composed the Támesis Scarp.

The Jericó surface is a highland cut across an accumulation of volcanoclastic sediments of the Combia Formation. This surface has suffered less incision than the slopes of the Cauca River. Nevertheless, it shows a low hilly relief, which provides evidence of inverted relief given by multiple levels of alluvial terraces of the Frío River valley (Fig. 13.6c).

13.4.2 Segment Two: From Valley to Canyon

The Cauca River drastically changes its trend from the mouth of the San Juan River in the Peñalisa village, where it again becomes a canyon with strong N–S trend, controlled by the course of the Cauca-Romeral Fault System. In this section, the river narrows to a deep canyon with changeable extent from hundreds of meters to 10 km. Furthermore, its relative relief is higher than 2000 m.

The overall hydraulic behavior of the river is given by a straight pattern with high incision and abrasion rates (Fig. 13.7a). The river cuts into bedrock and accumulation of alluvial deposits is unusual. However, as the river flows north, the canyon widens and the channel tends toward a meandering behavior, with deposits of gravel-sized sediments, marked lateral erosion and toe scour (Fig. 13.7b). Another feature of the canyon is the extensive alluvial fans from most of the tributaries, which have higher gradients and torrential behavior. Toward the Cauca River valley floor they merge into one, gently sloping surface. Figure 13.8 shows fans of the Sinifaná and Amagá Rivers, with several dissected terrace levels.

Furthermore, various rocky hills and peaks protrude in the landscape. The most representative are known as El Sillón and Tusa mounts, the latter with an amazing geometric pyramidal morphology, which used to be used for rituals and worship by the natives who inhabited the region. Currently, Cerro Tusa is one of the most important and widely recognized landforms within the geomorphological and archaeological heritage of Colombia and it is considered as one of the largest natural pyramids in the world.

Profile 3–3′ (Fig. 13.8) identifies the westward tilting of the Amagá Formation and rocky andesite porphyry hills with striking geometric shapes, which protrude among sedimentary rocks. The intrusion of these hypabyssal rocks of the Combia Formation into the sandstone strata is a part of the Neogene magmatism in northwestern Colombia.

13.4.3 Segment Three: From Canyon to Valley Again

This section is characterized by a broad valley, in which there is a sizeable accumulation of alluvial materials, along with torrential and fluvio-lacustrine deposits. In this area, there are no rock outcrops, in contrast to what was observed in the previous segments. The Cauca River undergoes a noticeable change, turning eastward after passing the mouth of the Tonusco River. In addition, its bed expands to reach a width of about 1 km.

Undoubtedly, this large valley presents the most notorious morphotectonic features associated with recently active

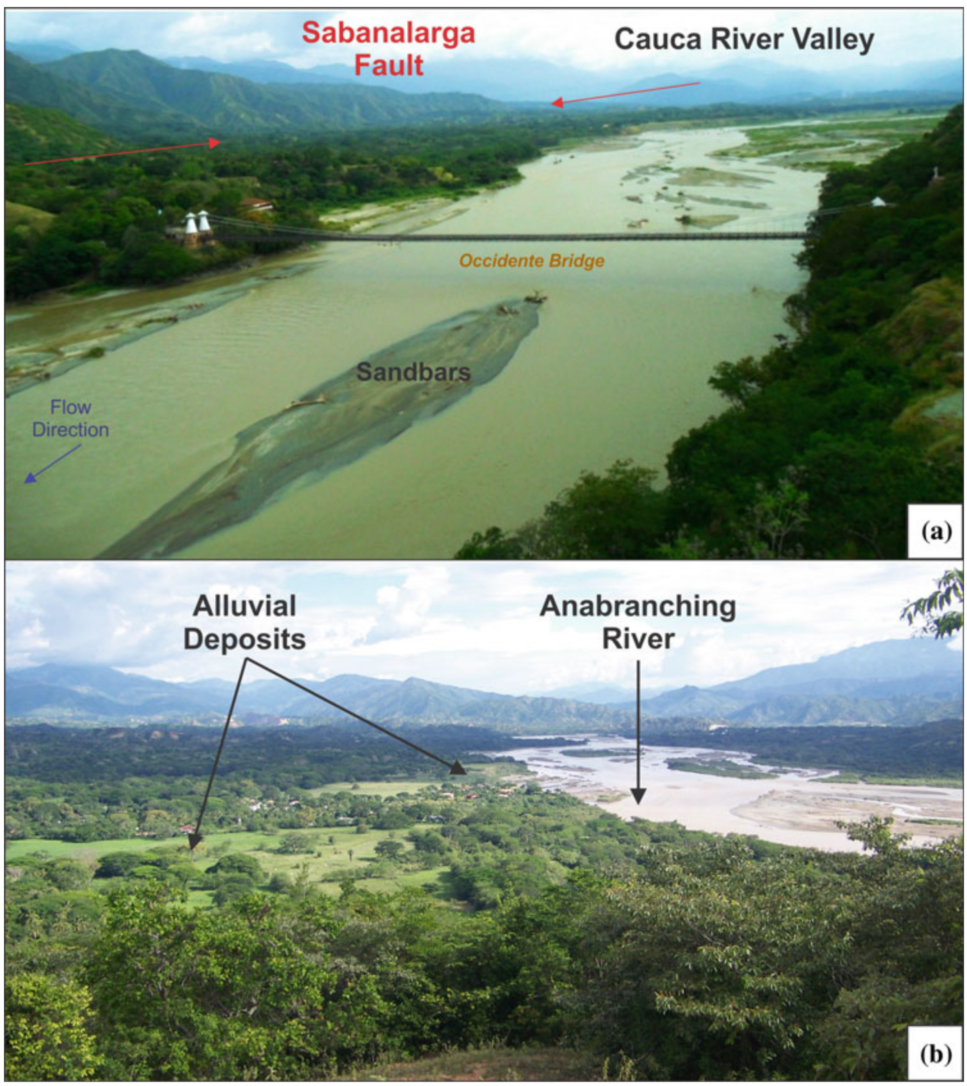


Fig. 13.10 Alluvial deposits and the amplitude of the Cauca River valley in segment

faults west of Medellin. The landscape is dominated by the mountain front of the Sabanalarga Fault (Fig. 13.10a), the marked fault lineament of the Tonusco River, and the trace of satellite faults associated with the Cauca Fault System (Fig. 13.9).

This sector of the Department of Antioquia, and especially the town of Santa Fe, due to its auriferous wealth and tropical dry climate has been favored among post-conquest settlers. Santa Fe is one of the oldest towns found by Spaniards in this part of the country. It has well-preserved colonial architecture and churches that are considered an important part of the country's cultural and historical heritage. Furthermore, the Puente de Occidente is a 291-m-long bridge, built between 1887 and 1895 and at that time considered as the largest wooden suspension bridge worldwide (Figs. 13.9c and 13.10a).

In this segment, the Cauca River channel has an anabranching pattern, with many sand and gravel oversized bars, in which informal gold panning has been carried out since Colonial times (Fig. 13.10b). In this portion of the basin, recent silt deposits on both banks of the river, suggesting a calm depositional environment, are possibly related with a fluvial-lacustrine regime. These fine deposits are not resistant to erosion and have been rapidly entrenched by the river. Recent studies indicate that their origin may be associated to the Cauca River damming by mega-landslides generated by earthquakes and/or instability of rock slopes further downstream. It is also important to mention the evidence of neotectonic activity determined from morphotectonic features and the displacement of recent deposits, liquefaction phenomena and seismites on the silt terraces in the surroundings of the towns of Santa Fe de Antioquia and Olaya.

The Cauca Basin again changes its morphology after crossing the Occidente Bridge and once again becomes a deep and narrow canyon until it leaves the northern foothills of the Cordillera Central. About 100 km downstream from this segment, there are impressive morphotectonic features related to faults such as straight mountain fronts and triangular facets (Fig. 13.11). Furthermore, it is possible to identify aligned saddles and considerably dissected alluvial fans, such as the one left by the Tahamí Stream in the town of Sucre.

The morphology in this segment of the valley is characterized by mountain ranges on both sides of the river. The lower is located in the bottom of the valley and shows low

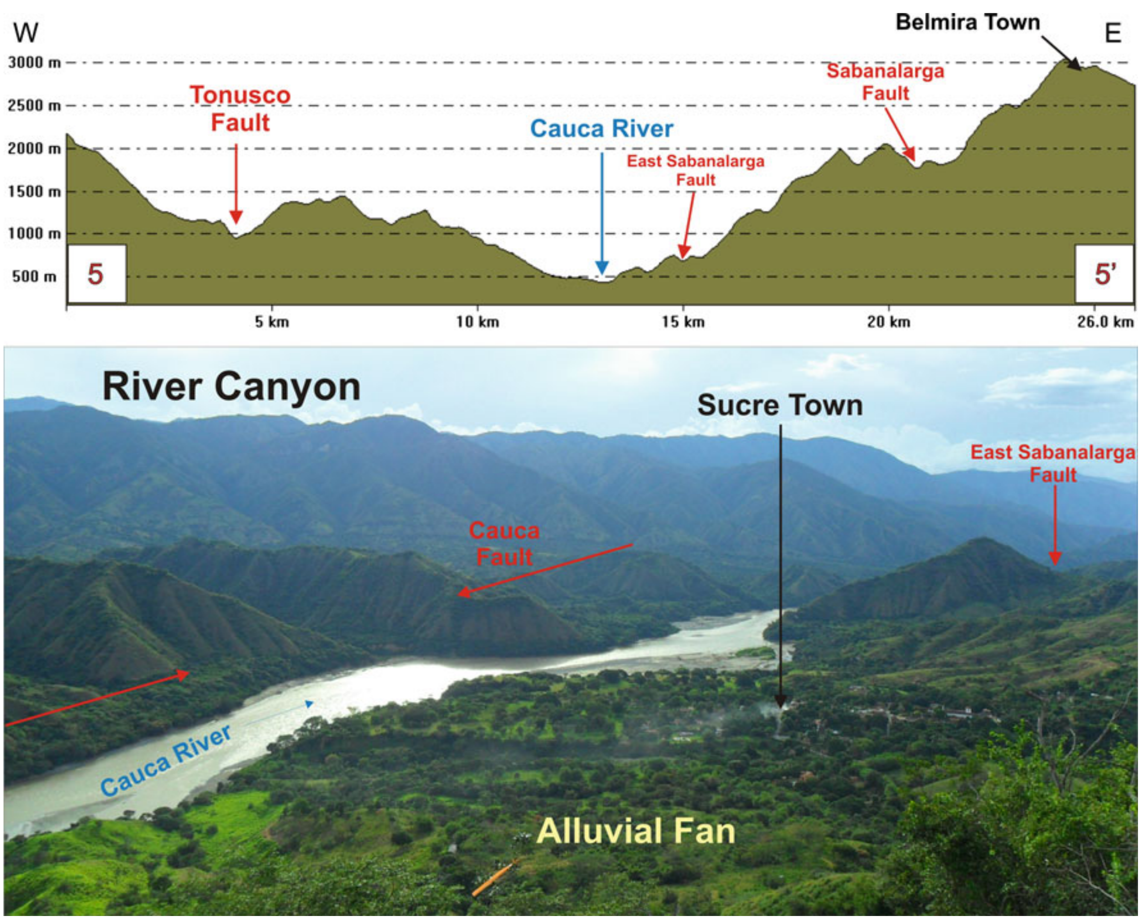


Fig. 13.11 Features of the Cauca River canyon downstream from the Occidente Bridge

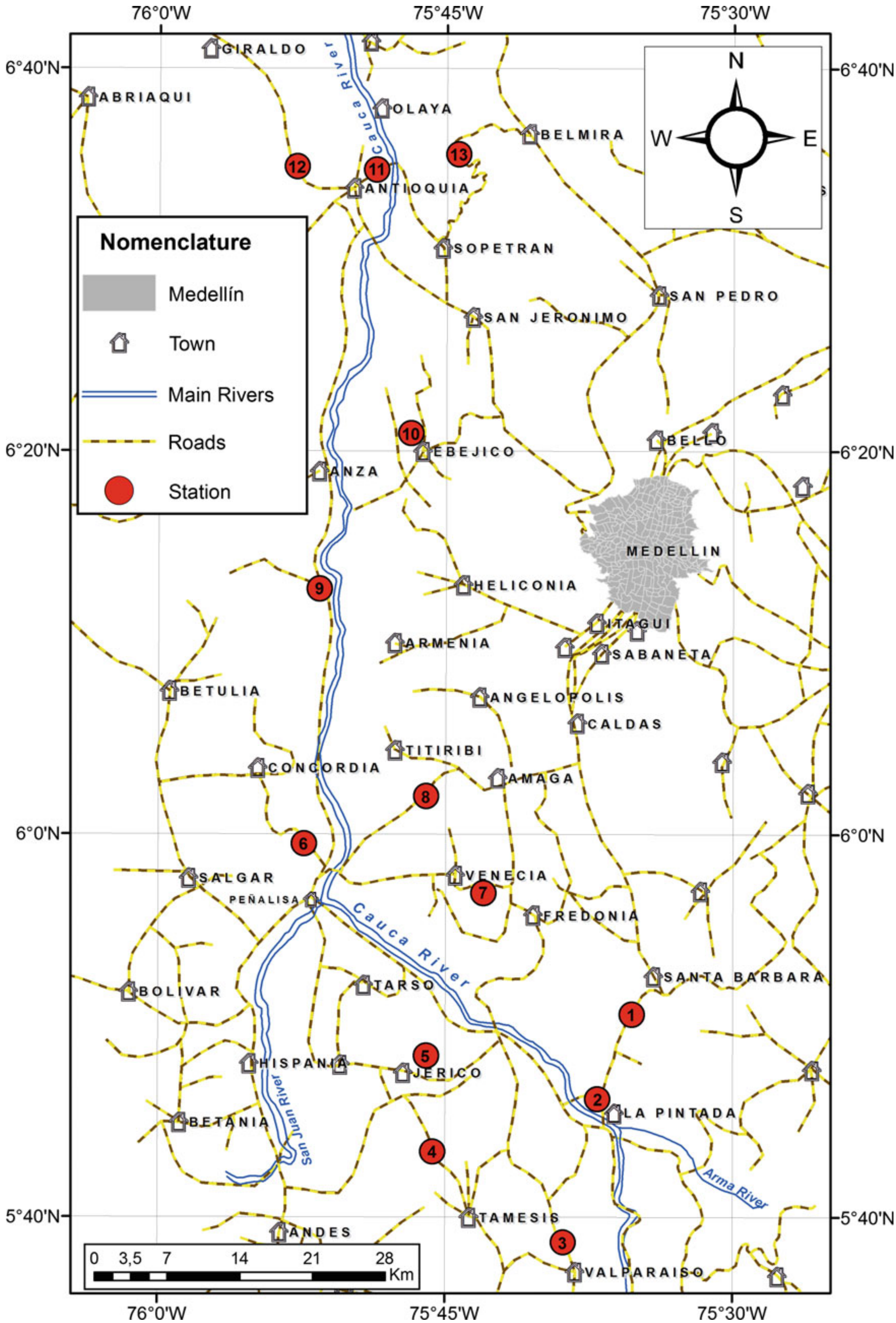


Fig. 13.12 Itinerary and proposed geomorphosites

Table 13.1 Location of points of interest for observing the landscape

Stop	Longitude (W)	Latitude (N)	Locality	Landscapes
1	75°35′ 17.06″	5°50′ 39.17″	Midway between Santa Bárbara and La Pintada	Segment 1 of the Cauca River Valley, Támesis Scarp and Amagá Formation
2	75°36′ 54.25″	5°45′ 40.17″	La Pintada	Segment 1 of the Cauca River Valley, *Farallones de la Pintada*
3	75°38′ 48.91″	5°38′ 40.38″	Midway between La Pintada and Valparaiso	*Farallones de La Pintada*, Amagá Formation and Támesis Scarp
4	75°45′ 26.48″	5°43′ 29.21″	Támesis to Jericó	Segment 1 of the Cauca River Valley, Támesis Scarp, Jerico Surface and Frio River waterfall
5	75°45′ 53.50″	5°47′ 38.93″	Puerto Arturo-Jericó Highway	Segment 1 of the Cauca River Valley, Tamesis Scarp and Combia Formation
6	75°52′ 23.25″	5°59′ 26.93″	Road to Concordia	Segment 2 of the Cauca River Canyon, mouth of the San Juan River and the Romeral Fault System
7	75°43′ 26.01″	5°57′ 14.433″	Venecia	Segment 2 of the Cauca River Canyon and Cerro Tusa climbing
8	75°46′ 06.20″	6°02′ 9.15″	La Siria-Bolombolo Highway	Hypabyssal porphyry intrusion and Amagá Formation
9	75°51′ 28.30″	6°12′ 59.14″	Peñalisa to Anza road	Segment 2 of the Cauca River Canyon and alluvial fans
10	75°45′ 59.92″	6°20′ 12.43″	Quebrada Seca-Ebéjico	Cauca-Romeral Fault System
11	75°49′ 50.48″	6°33′ 43.01″	Santa Fe de Antioquia	Segment 3 of the Cauca Cauca River Valley and Occidente Bridge
12	75°52′ 51.44″	6°34′ 49.16″	Antioquia-Giraldo Highway	Segment 3 of the Cauca Cauca River Valley and Cauca-Romeral Fault System
13	75°44′ 12.95″	6°35′ 30.25″	Llanadas	Segment 3 of the Cauca Cauca River Valley, Tonusco River and Cauca-Romeral Fault System

edges and ridges; the higher is situated over 3000 m a.s.l. and constitutes the flank of the erosion surface remnants in the Central Cordillera. This marked contrast can be interpreted as the differential action of individual faults within the Cauca-Romeral Fault System during uplift of the Cordillera, as well as the result of erosion and intense Cauca River incision in response to the recent pulses of uplift.

13.5 Proposed Geotouristic Itinerary

In order to appreciate the landscapes of each segment, the following itinerary from Medellin is proposed (Fig. 13.12). The recommended circuit would take 2 days and include sites listed in Table 13.1.

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