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ORIGINAL ARTICLE

The Somoto Grand Canyon (Nicaragua)—a Volcanic Geoheritage Site One Decade After Discovery: from Field Geological Mapping to the Promotion of a Geopark

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Abstract After its 'discovery' during field geological mapping by geologists of the Czech Geological Survey in 2004, the gorge of the Coco River in NW Nicaragua, now known as the Somoto Grand Canyon, has been turned into one of the most beautiful tourist attractions in Nicaragua. The canyon is developed in acid ignimbrites of Miocene age and is 3.5 km long and located between 13 and 14° N and 86–87° W, 12 km W of the town of Somoto. The gorge, which reaches a width of 4–10 m in its narrowest parts and a depth of up to 190 m, uncovers a range of unique pseudokarst features, such as giant erosion potholes and rock and sandy bars alternating with deep lakes. The Somoto Grand Canyon quickly became known to the public, and in 2006, it was declared a National Monument by law, and in 2007, a picture of the canyon appeared on the 50 córdobas banknote. The Somoto Grand Canyon is now considered as a famous object of geoheritage, belonging to one of the most famous sites in Nicaragua and there are aspirations that it could be included in the UNESCO Global Geopark Network, as the main geoheritage site of the planned Río Coco Geopark.

Keywords Somoto canyon · Río Coco Geopark · Nicaragua · Ignimbrite · Geoheritage

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Introduction

The interest in geoheritage- and geology-focused geotourism has increased rapidly in the last two decades, and tourism located around geological features is becoming an important source of income in many rural areas (e.g. Brocx and Semeniuk 2007; Dowling 2011). This trend is reflected and also accelerated by initiatives establishing national, European, and global geopark networks, which seek to promote and conserve the planet's geological heritage, as well as encourage sustainable research and development by the communities concerned (e.g. Zouros and McKeever 2004; Horváth and Csüllög 2013; Woo et al. 2013; Fung and Jim 2015; Rapprich et al. 2016). The Global Geopark Network includes 120 areas in 33 countries but only two areas have the status of a Global Geopark in South and Central America: Araripe Geopark in Brazil (included in November 2010) and the Grutas de Palacio Geopark in Uruguay (included in November 2011) (http://www.globalgeopark.org/). Besides this, the Latin America and Caribbean Region possess 37 natural and five mixed natural-cultural UNESCO properties (http://whc.unesco.org/en/lac/; http://www.natgeomaps.com/geotourism/) and numerous areas with various degrees of protection, many of them with a great potential for geotourism (for a definition of the term 'geotourism' see Dowling 2011).

The first attempts at nature protection in Central America were focused on establishing reserves for indigenous people in Costa Rica in the late 1930s. Recognition of the complex relationship between indigenous people and tropical forests has been paralleled by an increasing awareness of the ecological value of tropical forests and of wildlands in general. Since the late 1960s, much attention has been focused on the need to conserve the remaining wildlands in Central America for their natural and cultural values (https://www.culturalsurvival.

org/). The most significant changes relating to protected areas occurred in the 1980s and 1990s, particularly with the development of specific legislation for protected areas.

Nature protection in Nicaragua has developed over several last decades. Nicaragua has 78 protected areas that cover 22,422 km^2, which is approximately 17.3% of the nation's landmass. The National System of Protected Areas (SINAP) is administered by the Ministry of Environment and Natural Resources (MARENA). The majority of the protected areas in Nicaragua are focused on fauna and flora but there are also those where the abiotic environment (i.e. geoheritage) is principal or supplemental. All of these protected areas that cover 670.8 km^2 are situated near the Pacific coast in the Nicaraguan Volcanic Chain and mostly include active volcanoes (e.g. Hradecký and Šebesta 2007). The most famous is Masaya Volcano National Park, which was declared Nicaragua's first national park in 1979. The park is situated near the capital Managua and has an area of 54 km^2. It includes an impressive volcanic landscape of an active volcano with five craters and also volcanic caves. Other natural reserves (NR) situated in the volcanic chain are Mombacho Volcano NR, Momotombo and Momotombito NR (8500 ha), Concepción NR (2200 ha), Volcán Maderas NR (4100 ha), Volcán Cosigüina NR (12,420 ha), Télica and Rota NR (9088 ha), San Cristóbal and Casita NR (17,950 ha), Pilas and El Hoyo NR (7422 ha), and, from 2010, the Ometepe Island Biosphere Reserve (276 km^2) (http://www.nationalparks-worldwide.info/nicaragua.htm; http://www.fauna-flora.org/closerlook/ometepe-biosphere-reserve/).

Between 1997 and 2009, the Czech Geological Survey implemented several projects in Central America, undertaken in the framework of the Development Cooperation Programme of the Czech Republic funded by the Czech Government. The main emphasis was on geological studies and documentation of natural hazards in areas designated by the local partners (Hradecký 2011). These projects were implemented first of all in Nicaragua (in collaboration with the Nicaraguan Institute of Territorial Studies - INETER), and later also in El Salvador and Costa Rica, and provided a large amount of geological information (e.g. Rapprich et al. 2006, 2010; Buriánek and Hradecký 2011; Mixa et al. 2011; Žáček et al. 2011, 2012; Buriánek and Žáček 2015). At the same time, however, many of the most important results have remained unpublished with the exception of final reports and geological maps, informative brochures, and conference abstracts.

The authors of this article 'discovered' and first described the gorge at the El Espino border crossing in 2004, which has been recently named the 'Somoto Grand Canyon'. The real significance of this discovery, which perhaps represents the most striking footprint of Czech geologists in Central America, appeared later when it became one of the most famous attractions in Nicaragua. The aims of this article are to provide coherent geological information about the origin, geological composition, and structure of the canyon and to describe the rapid development of the Somoto Grand Canyon as a geoheritage site connected to the growth in geotourism between 2004 and 2016. Other important aims are to promote the planned Río Coco Geopark, highlight its significance for further research, education, and geotourism, and propose recommendations for its successful and sustainable development.

Study Area

The gorge in Neogene ignimbrites, now known as the Somoto Grand Canyon or *Gran Cañón de Somoto*, is located in NW Nicaragua, between 13 and 14° N and 86–87° W, 12 km W of the town of Somoto (Fig. 1), the administrative centre of the Madriz Province, close to the El Espino border crossing with Honduras (Figs. 1, 2, and 3). The canyon was 'discovered' on 22 March 2004 during a routine geological field trip. After submission of the project results to INETER in November 2004 (final report by Novák et al. 2004; geological map by Žáček et al. 2004), rapid development of the locality began, and within several years, the site became one of the most famous places in Nicaragua, helping the growth of geotourism (and tourism in general) in Nicaragua (https://en.wikipedia.org/wiki/Somoto_Canyon_National_Monument). The geological and geomorphological data were collected mainly during field work in March–April 2004 and in April 2006. The photographs published in this paper are originals of the first and third authors, mostly taken in 2004 and 2006.

Geological Setting

The area pertains to the western part of the Eastern Chortis terrane, which represents the rifted continental margin of the North American Plate developed during Jurassic separation of the North and South American Plates (Dengo 1969; Rogers 2003; Ritchie and Finch 1985). The Guayapa fault system forms a major terrane boundary between north-easterly striking rocks in the Eastern Chortis terrane, with the basement dominated by Jurassic metasedimentary rocks, and more east-striking rocks in the Central and Northern Chortis terranes, with the basement composed mainly of Precambrian and Paleozoic metamorphic and plutonic rocks (Rogers 2003, Fig. 1).

The basement of the Eastern Chortis block in NW Nicaragua consists mainly of sub-greenschist- to greenschist-facies metamorphosed siliciclastic sediments of the Paleozoic age, called the Palacagüina Formation (Zoppis-Bracci 1957) or later the Nueva Segovia Group (Del Giudice 1960; Figge 1966, Fig. 2). These rocks are intruded by the extensive NE–SW trending Dipilto Batholith of Cretaceous age (140 ± 15 Ma; Donelly et al. 1990 using the

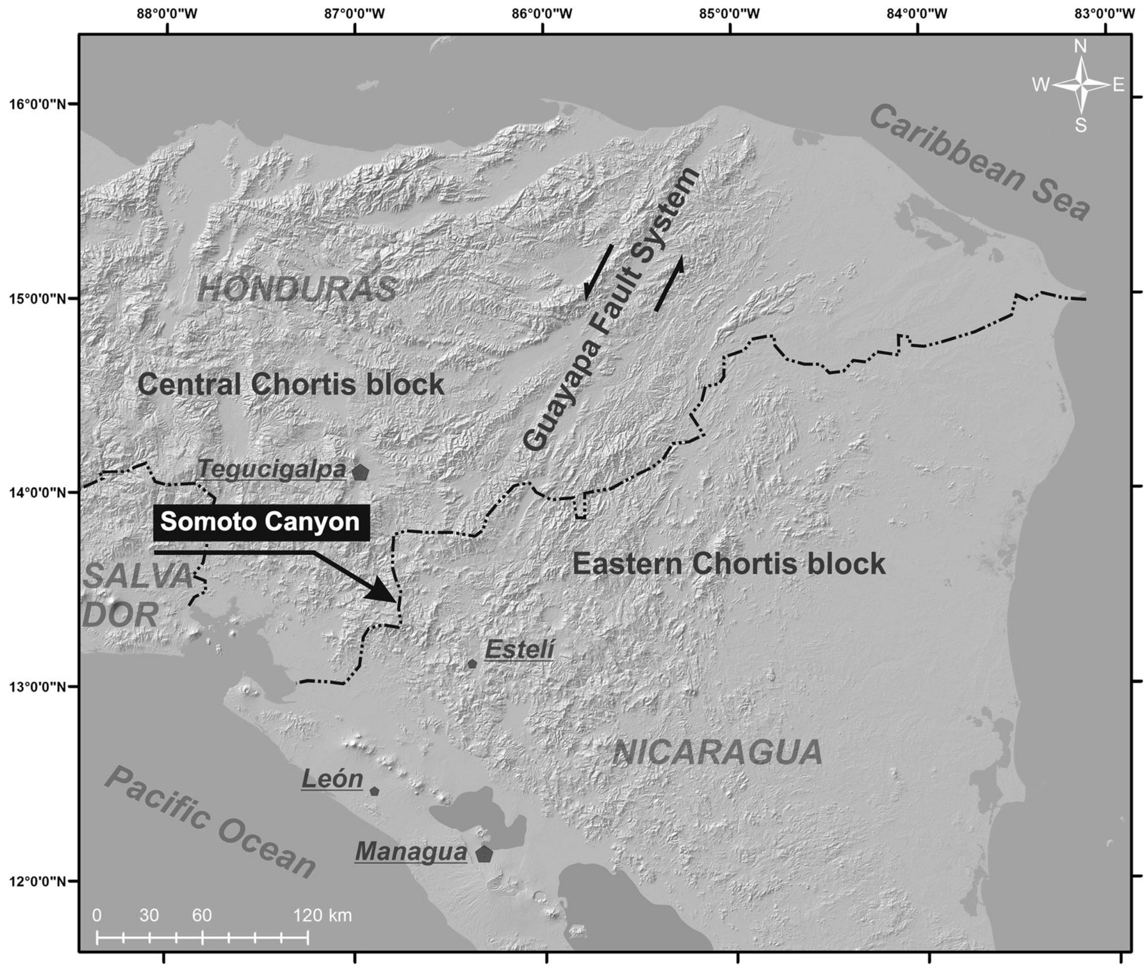


Fig. 1 General view of a part of Central America with the principal geotectonic units and with the location of the Somoto Grand Canyon

Rb–Sr whole-rock method). The batholith is composed of diorites, granodiorites, and granites and is surrounded by a contact aureole up to several kilometres wide (Buriánek and Žáček 2015). The following unit, the Totogalpa Group (Del Giudice 1960), represents siliciclastic red-bed type sediments, which filled local depressions on the eroded surface and reach a thickness of up to ~150 m. Williams and McBirney (1969) proposed an Oligocene to Middle Miocene age for this unit but direct paleontological evidence is absent due to strong oxidization of the sediments.

The intensive volcanic activity started in the Neogene. Williams and McBirney (1969) first reported rhyolite ignimbrites containing lithics and 'black glass' from the Somoto and El Espino area. Hradecký (2006) correlates the Neogene ignimbrites throughout Central America and introduces the new name Somoto Group for a group of pyroclastic rocks in the vicinity of Somoto, which partially corresponds to the previously defined Coyol Group. The accumulation of acidic ignimbrites of Miocene age up to ~500 m thick is typical for a wide area of NW Nicaragua and adjacent areas in Honduras (Hradecký 2006). Below the sequence of ignimbrites occurs a sequence of dominantly basaltic andesite ('lower andesite') up to ~1000 m thick, which belongs to the Matagalpa Group, correlated in Honduras with the Metapán Group of Oligocene to early Miocene age (Garayar 1971).

The K–Ar radiometric data for the acidic ignimbrites of northern Nicaragua published by the Parsons Corporation (1972) range between 12.8–15.2 and 18.6–19.1 Ma (Weyl 1980). A sample of rhyodacitic ignimbrite taken in 2006 from the bottom of the canyon and dated using a conventional K–Ar method yielded an age of 13.89 ± 0.74 Ma (Žáček et al. 2008, Fig. 4). The results of geochronology indicate that the ignimbrites of the Somoto Group deposited during multi-stage explosive activity between ~13 and 19 Ma correspond to the early–middle Miocene ages of Serravalian–Burdigalian.

Geology of the Somoto Canyon

The profiles in the canyon itself and its surroundings clearly illustrate the complex structure of the ignimbrite with embedded andesite lavas and andesitic breccia ('upper andesite')

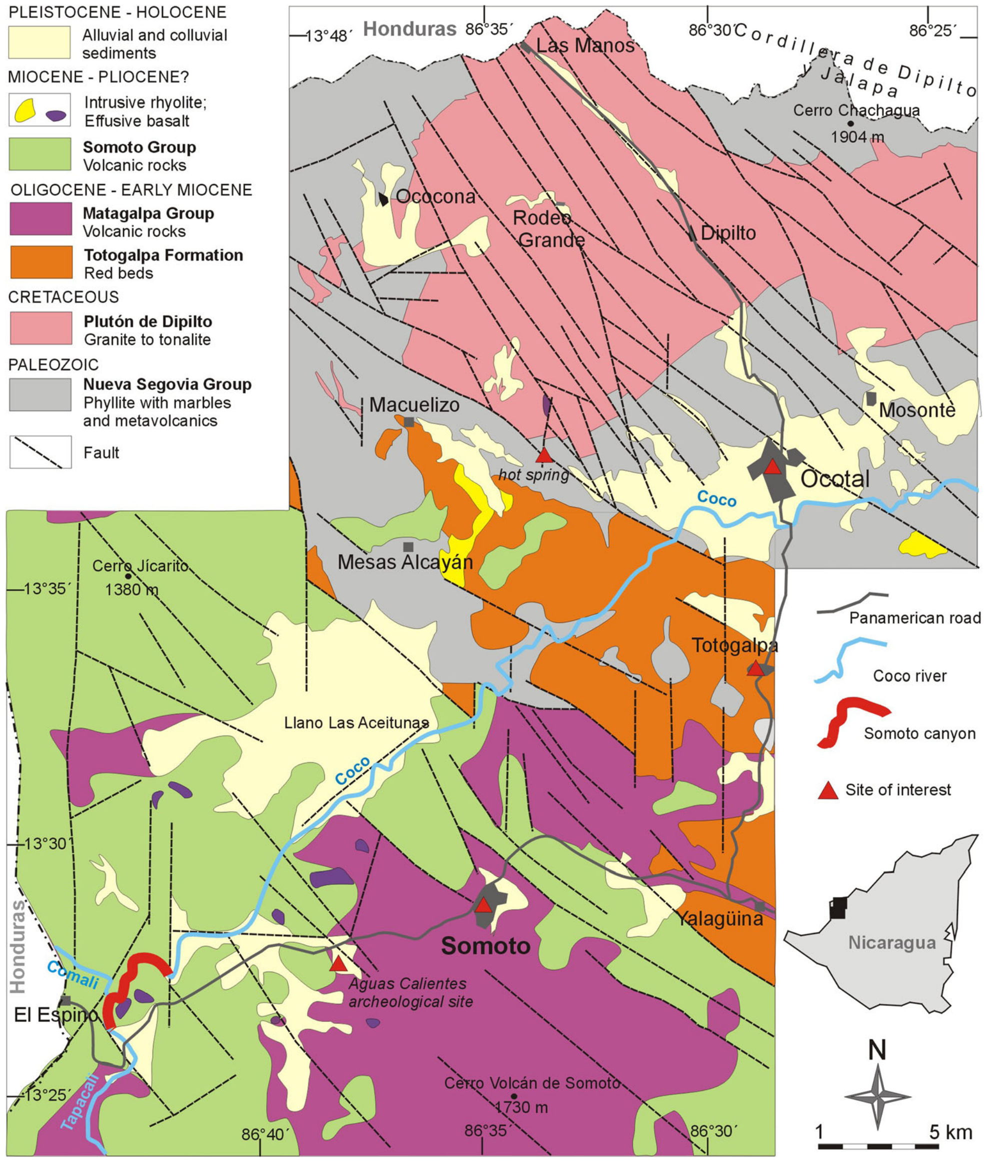


Fig. 2 Geological map of NW Nicaragua, based on 1:50,000 geological maps by Žáček et al. (2004) and Žáček and Hradecký (2005)

(Fig. 4). Generally, the lower part of the ignimbrite sequence in the vicinity of the canyon is composed of welded ignimbrite, whereas the upper parts are composed of poorly welded ignimbrites with a 'tuff-like' appearance deposited during several flow pulses. The ignimbrite that prevails at the bottom of the canyon is massive, fine-grained, usually without apparent stratification, but sometimes with a fluidal structure, greyish to pinkish, and more or less fractured (Fig. 5). The exposed surfaces contain frequent rounded to irregular cavities of uncertain origin, up to several centimetres in diameter as well as light-coloured lithic fragments. Under the microscope, the groundmass is glassy, slightly devitrified, sometimes fluidal but often randomly oriented. The rock has a vitroclastic structure, contains millimetre–centimetre-sized clasts of acidic rocks, in addition to glass shards and fragmented phenocrysts of alkali feldspars and quartz. Biotite and amphibole can occur as accessory minerals. Welded ignimbrites with a typical eutaxitic structure, rich in fiamme, were also observed in the exposures in the vicinity of the canyon where they also occur as pebbles in fluvial gravels. The ignimbrites are sharply bounded from andesitic breccia in the NW by a significant NE–SW trending fault, ~200 m upstream of the Comali River. Welded coarse-grained to blocky andesitic breccia, with abundant nests and veinlets of red, yellow to whitish jasper, is exposed in the river bedrock. This is the reason for the occurrence of andesitic breccia and multi-coloured jaspers in the fluvial gravels of the Somoto Canyon. As a result of the youngest volcanic activity of a supposed Pliocene age, several small basaltic cones and dykes are scattered in the vicinity of the canyon. Pleistocene fluvial sediments are preserved in

Fig. 3 Narrow section of the Somoto Canyon characterized by lakes alternating with gravel banks (March, 2006)

paleoterraces, and Holocene to recent fluvial sediments are preserved in the lowermost part of the canyon.

Geomorphology

The Somoto Grand Canyon is ~3500 m long but reaches a total length of ~5400 m if the additional ~1900 m part of the Tapacalí River is included. The western end of the canyon lies at the confluence of the Tapacalí and Comali rivers at ~640 m a.s.l., which join to form the Coco River (also known as Segovia, Wangki, or Wanks) which represents the longest river in Central America. The eastern limit of the canyon lies at an altitude of ~620 m a.s.l., where it springs into Valle El Guayabo, a tectonic depression filled by Quaternary fluvial sediments (Figs. 6, 7, and 8). The Somoto Grand Canyon has the character of an entrenched meander. It represents an antecedent type of valley cutting the 'Fila El Alto' mountain ridge (~800–900 m a.s.l.), dominated by the Cerro Nacascolo (950 m a.s.l.), which formed the ancient surface (Fig. 4). In its narrowest part, the canyon is approximately 350 m wide between the upper edges but only 4–10 m wide at the bottom (Fig. 3). The slopes of the canyon are about 190 m high in total, whereas the vertical walls proper reach up to 100 m. The canyon displays plenty of unique geomorphic features, which developed due to backward and downward erosion, corrosion, or evorsion. These features include erosion potholes, water pockets, pseudokarst lapiés, rock bars, and waterfalls (Fig. 9). Turbulent flash flood-related water flow carrying boulders, pebbles, and sand acted as an abrasion agent. During Hurricane Mitch in December 1998 (e.g. Kepert 2006 and references therein), which affected large areas of Central America and caused major damage, the last catastrophic flash food occurred in the canyon, and its consequences are still clearly visible on the walls of the canyon. The canyon walls are up to ~15 m above the recent level, depending on the width of the canyon, without vegetation, and the rock is very fresh due to abrasion during floods (Figs. 8 and 10).

In the lowermost part of the canyon, ~1000 m long, there is a relatively wide alluvial plain filled with fluvial gravels (Fig. 8). The attractive parts of the canyon are situated upstream of point 'A' near the main entry known as 'Valle De Sonís', towards a 'fallen block' at point 'C' (compare Fig. 4). The river cuts into welded ignimbrites between points 'A' and 'B', which form continuous outcrops on both sides of the river ~500 m upstream, and no fluvial sediments are preserved. The river here forms a long continuous lake where local guides offer ship tours, but it is also walkable along the shore with difficulty (Fig. 10). The second part begins at point 'B' where the long lake ends and continues about ~600 m upstream. The canyon narrows to a width of 4–10 m before a sharp curve to the SSE; the walls are completely vertical (Fig. 3). The bottom is formed by dry areas with a highly irregular rocky outcrops and gravel banks, which alternate with small but deep lakes. The last lake is approximately 100 m long and up to 9 m deep (Hradecký et al. 2009) and ends before a sharp curve to the SW at the place where an approximately 3-m block of ignimbrite has fallen. This block forms a natural dam with a small waterfall.

This section is the most attractive for tourists, despite the fact that it is not walkable at all, and one has to swim to reach it. The local guides take tourists on improvised 'tube tours'. Further upstream to the confluence of the Tapacalí and Comali rivers, the canyon is still ~1400 m long. The canyon walls gradually decrease, the floor is again filled with fluvial sediments, and fallen blocks and tree trunks are frequently found. Gravel bars alternate with small lakes; however, towards the confluence, the sediments gradually disappear, and there are rocky outcrops of light-coloured poorly welded rhyolitic ignimbrite at the bottom (Fig. 11). A smaller canyon, about 1900 m long, continues as a narrow and relatively smaller gorge upriver from the Tapacalí with its outfall near the village of La Ceiba and upriver from the Comali.

Geohazards

Flash floods represent a potential hazard for tourists during the rainy season or in cases of storms or extreme weather. During

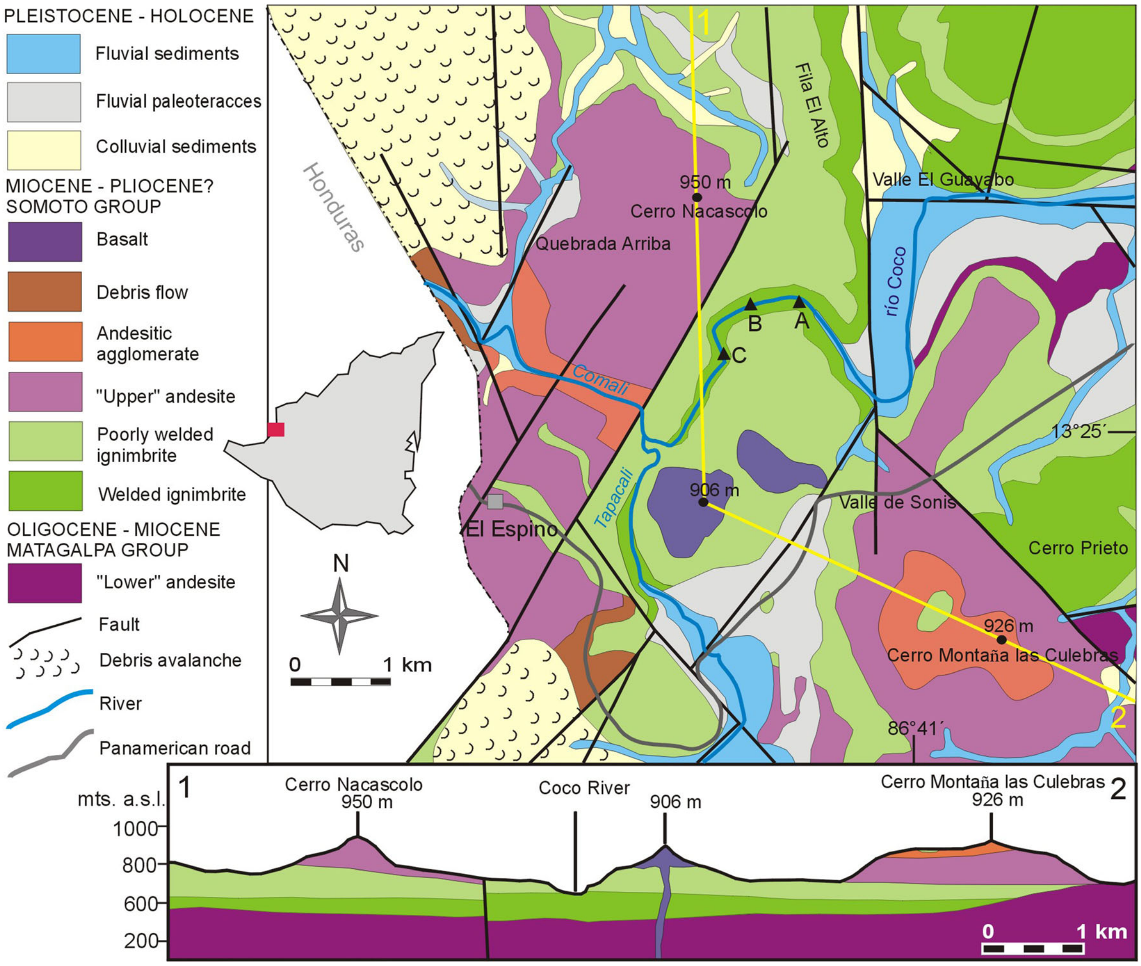


Fig. 4 Detailed geological map and cross sections *1–2* of the Somoto Grand Canyon (based on a 1:50,000 map by Žáček et al. 2004). The points *A*, *B*, and *C* show the places in the canyon discussed in the text

Hurricane Mitch in 1998, the water level increased by up to ~15 m in the narrow parts of the canyon (Fig. 12, see also Fig. 8).

Fig. 5 Massive ignimbrite with a fluidal structure at the bottom of the canyon

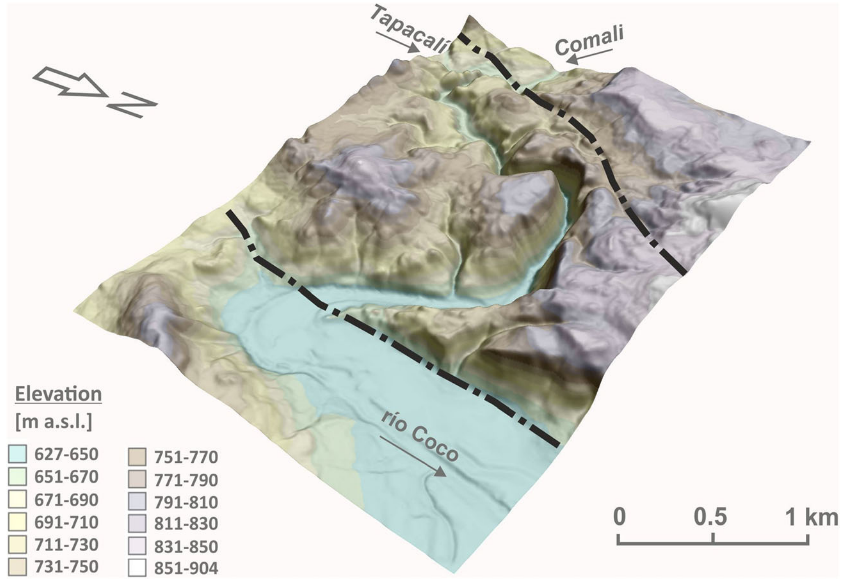
Erosion and aggradation of gravel are potentially dangerous phenomena downstream of the Somoto Canyon and in other watercourses. During Hurricane Mitch, the banks along with the Coco River were eroded and the village of Valle El Guayabo was destroyed. The new village, called Guayabo Nuevo (Santa Soledad), is now situated above the floodplain.

Rockfall represents a potential hazard for visitors to the canyon, and it can be dangerous in relation to seismicity or extreme weather conditions.

Landslide accumulations occupy a large area along the border with Honduras. Small-scale landslides can be triggered by heavy rainfall in steep slopes formed by poorly consolidated rocks and larger landslides by seismicity.

Seismicity represents a potential hazard because the area of the Somoto Canyon is affected by intense multistage tectonic activity. The dominant NE–SW to N–S and the NW–SE fault systems reflect the overall tectonic image of the area, which is characterized by an extension regime (Figs. 4 and 6). NE–SW (N–S) faults exhibit mostly sinistral kinematics, disrupt the NW–SE faults, and are probably still active. These faults at

Fig. 6 Digital elevation model of the Somoto Canyon with the principal faults (compare Fig. 7). The same N–S trending fault cutting the Fila El Alto ridge is shown in Fig. 7



El Espino are accompanied by extensive landslides reaching the Tapacalí and Comali river valleys, probably provoked by seismicity (Žáček et al. 2004, Fig. 4). At the end of 1953, eyewitnesses observed the growth of the 'cerritos', hillocks originated during long-lasting seismic activity (according to articles in the newspapers La Noticia on December 10, 1953 and La Prensa on January 6, 1954). The mentioned hillocks developed near the state border with Honduras crossing the El Espino and were considered as manifestations of volcanic activity. They actually represent either lateral ridges produced by a large-scale landslide or more likely extrusions of soft rocks along the young faults. The yellow-green colour of the surrounding tuffs, however, was not caused by "sulphur in the vicinity of volcanic centres" as the newspapers speculated, but represents the colour of the weathered rock.

Development of the Geoheritage Status

The example of the Somoto Grand Canyon can demonstrate how quickly a 'recently discovered' geological phenomenon can be introduced to the public as geoheritage and then developed. The canyon was discovered "for the rest of the world" during routine geological mapping in March 2004 (Novák et al. 2004; Žáček et al. 2004); however, it was known about for a long time before, and the local people called it Namancambre or La Estrechura (Fig. 11). Local authorities, however, had no idea that such a unique natural phenomenon is situated in their region with such a great potential for tourism. After the final report and geological maps were submitted to INETER, the Nicaraguan authorities quickly recognized the importance of the discovery. The development of the infrastructure was apparent as soon as March 2006, when car access to the canyon was made possible following the building

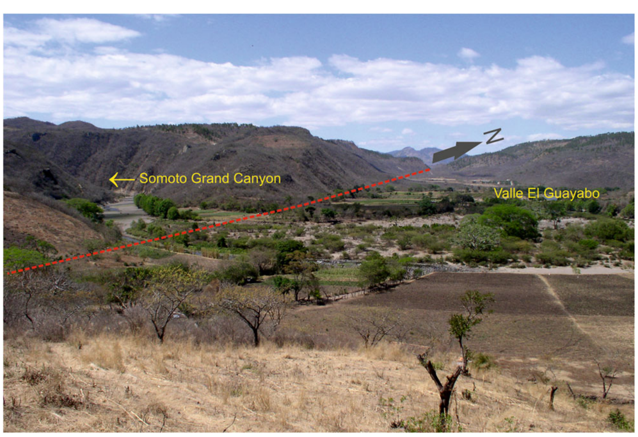


Fig. 7 A tectonic depression of Valle El Guayabo filled with fluvial sediment. The floodplain narrows towards the west where the river leaves the Somoto Canyon. The course of the N–S trending normal fault cutting the Fila El Alto ridge is shown

Fig. 8 The floodplain of the Coco River developed in the lowermost part of the canyon close to Valle El Guayabo. Note the zone washed out during Hurricane Mitch

Fig. 9 A deep lake and the giant eversion pots developed in massive welded ignimbrite in the canyon, near point B (see Fig. 4)

Fig. 11 An indigenous woman washing clothes at the confluence of the Tapacalí (*right*) and Comali rivers in April 2004. The exposed rock is whitish, poorly welded ignimbrite. Downstream the river bears the name Coco River (Río Coco, Wanks, Wangki, or Segovia) and represents the longest river in Central America

of a new road. The local community already offered boat trips on the lake in the lower part of the canyon, and then local amateur guides began offering tube trips to the parts of the canyon inaccessible on foot (Fig. 13).

In December 2006, the canyon was declared a National Monument by law (Act 605, Fig. 14), with a protected area of 170.3 ha and an outer protective zone of 473.4 ha in total.

The process of creating the Río Coco Geopark also began in 2006. Local authorities and Nicaraguan governmental organizations were the main actors in this process, which was coordinated by Martina Pásková, an expert in sustainable tourism and ethnoecology from the Ministry of Environment of the Czech Republic. The common goal was to create the Río Coco Geopark followed by its integration into the Global Geoparks Network assisted by UNESCO as a Central American pilot project (Pásková and Hradecký 2014). The preparation process included many meetings on regional and national levels, desk top and field research, design of the possible institutional structure, and a plan for the education of local people and sustainable development-based geotourism and landscape heritage protection (see interview with Martina Pásková (https://www.youtube.com/watch?v=1Gnlm_Y-e3w) and Pásková and Hradecký 2014).

In September 2007, the National Bank issued a banknote with a nominal value of 50 córdobas with a picture of the canyon on the reverse side (Fig. 15), and in October 2009, a modified version of the banknote with the canyon was issued and is still valid today. The year after, the geology of the Somoto Grand Canyon was presented during the Geological Congress of Central America held in Costa Rica (Žáček et al. 2008). The Czech Geological Survey in collaboration with the Ministry of Environment of the Czech Republic published an informative brochure in 2009 about the geology of the canyon in English and Spanish (Hradecký et al. 2009).

The potential of indigenous knowledge for the sustainability of geotourism for the planned Río Coco Geopark was studied by Martina Pásková. Findings of this work showed that the indigenous people of Chorotega origin mainly populate four municipalities in the proposed Río Coco Geopark.

Fig. 10 The Somoto Canyon with a deep lake inside the ignimbrite outcrops. Note the massive, non-stratified structure of the ignimbrite with vertical fractures and fresh rock without vegetation

Fig. 12 The lower part of the Somoto Canyon with the lake also shown in Figs. 10 and 13. The zone of fresh rock without vegetation shows the water level during Hurricane Mitch

Fig. 13 The local community has been offering services to tourist and boat trips on the lake from March 2006

Evidence of their indigenous knowledge mainly includes rites used in agriculture and medicine, management of sacred sites, pre-Colombian petroglyphs, and archaeological sites, handing down of legends, and know-how of various handicrafts. As noted by Pásková (2015), modern science sensibly combined with the traditional indigenous knowledge can essentially contribute to the sustainability of the development of the Río Coco Geopark and can also positively impact the identity of the local indigenous people and their indigenous knowledge.

From around 2005, tourism in the canyon has been organized by local community action groups, and a variety of amateur and several professional guides, organized into local cooperatives, offer canyon trips in various forms i.e. on foot, on horseback with a view of the canyon, by boat or 'tube trips', or simply swimming, including the possibility of camping and meals (http://www.somotocanyontours.org/; https://treehuggers.cafeluzyluna.org/2016/11/14/somoto-canyon/; http://namancambretours.nicaragua-info.com/; https://vianica.com/attraction/141/somoto-canyon). The statistics from April 2012 show that in the period between

Fig. 14 An information board placed by the main road to Somoto in May 2010

2005 and 2011, between 11,000 and 15,000 paying visitors visited the Somoto Grand Canyon per year, and 25 official guides from the local community offered their services (http://www.actiweb.es/canon_somoto/). The number of visitors over the last few years has increased to 'several tens of thousands' annually, with 40,000 visitors being estimated in 2016 (Marcio Ariel Rivas Núñez, mayor of Somoto town, oral communication).

The project of the Río Coco Geopark has recently been promoted by a group of local professionals from Somoto (Bueno de Frutos ed. 2014; https://geoparqueriococo.wordpress.com/) with the intention of submitting a nomination document for inclusion as a UNESCO Global Geopark in 2017.

Conclusions and Recommendations

A brief overview of the evolution of the canyon has been established. During the intense Late Miocene volcanic activity (~13–19 Ma ago), an up to ~500-m-thick accumulation of acidic ignimbrites was deposited, associated with minor andesite lavas and basic pyroclastic rocks. The source of such complex volcanism is linked to large calderas situated outside the Somoto territory (Cas and Wright 1987; Ehrenborg 1996; Hradecký 2006). The youngest post-caldera volcanic activity produced small basaltic volcanoes of probable Late Miocene or even Pliocene age.

The canyon and recent river network started to form in the Pleistocene (~2.6 Ma ago) and has developed through the Holocene. Originally, the Coco River meandered in a relatively flat basin; the river most probably drained the same area as it does now. Due to activity of the Guayapa Fault System and the subsequent extension in its SW terminal part, the transtensional wrench-fault basin of Valle El Guayabo dramatically lowered the local base level and caused rapid down cutting of the Coco River channel in the predefined meander trace. Competent ignimbrite beds conserve the original paleosurface as well as the erosion forms and steep slopes. As was shown in 1998 during Hurricane Mitch, turbulent water flow carrying boulders and sand related to flash flood flow can still gradually modify the canyon morphology and distribution of fluvial sediments.

The most important character of this natural site is the genetic type of rock in which the canyon is developed. In many cases in the world, deep narrow canyons are developed in carbonates, limestones, dolomites, and calcareous loess. In Somoto, these are acidic volcanic rocks and ignimbrites. While the origin of similar morphological forms in carbonates is primarily the result of the dissolution (karstification) of rocks, in ignimbrites, it originated through a combination of tectonic features and river erosion.

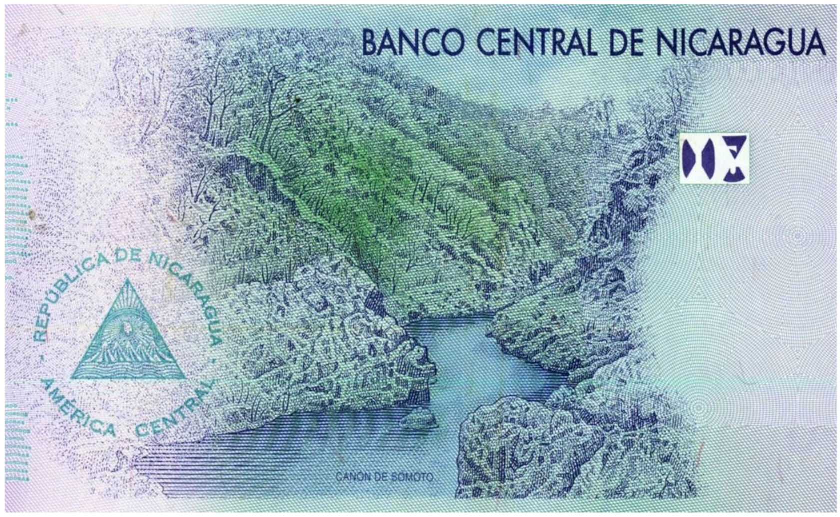


Fig. 15 The picture of the Somoto Canyon on the 50 córdobas banknote issued in 2007

As demonstrated here, the Somoto Grand Canyon has become a famous geoheritage site during a single decade, and domestic and foreign visitors have discovered this remote region of NW Nicaragua. Previously, tourist attractions in Nicaragua were mainly focused on active volcanoes, historic towns, and destinations on the Pacific coast. The popularity of the Somoto Grand Canyon is now contributing to the economic development of the wider region (Pásková and Hradecký 2014). Currently, an application to be included in the UNESCO Geopark Network is under preparation (Bueno de Frutos 2014; Pásková 2015). The planned Río Coco Geopark has an area of 967.55 km^2 (or 1602 km^2 after Pásková 2015) and includes the Somoto Grand Canyon as the most important geoheritage site and 11 smaller geosites situated in five municipalities: Somoto, San Lucas, Totogalpa, San José de Cusmapa, and Las Sabanas (https://geoparqueriococo.wordpress.com/). They include not only natural geosites such as rock exposures, caves, and waterfalls but also pre-Colombian archaeological sites and petroglyphs (Aguas Calientes, Icalupe), and indigenous municipalities of the Chorotega people in San José de Cusmapa, San Lucas, Totogalpa, and Telpaneca.

Geologists from the Czech Geological Survey (Petr Hradecký and Tomáš Hroch) last visited Somoto in November 2016, the visit being organized by the IGG-CIGEO of UNAN (Instituto de Geología y Geofísica, Ciencias Geológicas, Universidad Nacional Autónoma de Nicaragua). During a short excursion, together with employees from the Town Hall, the main subject of discussion was close cooperation for the development of the Río Coco Geopark.

In conclusion, the following observations can be made:

- There is an intensively working group of Nicaraguan professionals in Somoto and the IGG-CIGEO of UNAN, who intend to submit a proposal document for a Río Coco Global Geopark to UNESCO in 2017.
- Information on the geological structure (geological map of Žáček et al. 2004 and informative poster) is available in the main entrance of the information centre of the Somoto Canyon National Monument. Informative brochures are also available in Spanish and English (Hradecký et al. 2009).
- Most local guides can only provide basic geological information; hence, capacity building for guides in the Somoto Canyon area and in the proposed Global Geopark is highly recommended.
- Further professional field investigation of the geology (petrology, mineralogy, geochronology, tectonics, etc) and geomorphology is necessary for the provision of appropriate geological information for the whole area of the proposed Global Geopark, including for the description of individual geosites, which is still lacking. Continued collaboration between the IGG CIGEO of UNAN and the Czech Geological Survey, with its detailed geological experience of the region, would be an appropriate way to effectively develop this necessary knowledge and documentation.

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