**PLIOCENE IMPACT CRATER DISCOVERED IN COLOMBIA: GEOLOGICAL, GEOPHYSICAL AND SEISMIC EVIDENCES.** J. Gómez[1], A. Ocampo[2], V. Vajda[3], J. A. García[4], A. Lindh[5], A. Scherstén[5], A. Pitzsch[6], L. Page[5], A. Ishikawa[7], K. Suzuki[8], R. S. Hori[9], M. Buitrago[10], J. A. Flores[10] and D. Barrero[11]; [1]Colombian Geological Survey, Diagonal 53 #34–53 Bogotá, Colombia (mapageo@sgc.gov.co); [2]NASA HQ, Science Mission Directorate, Washington DC 20546, US; [3]Department of Palaeobiology, Swedish Museum of Natural History, SE–104 05 Stockholm, Sweden; [3]Universidad Libre, Sociedad Astronómica ANTARES, Cali, Colombia; [5]Department of Geology, Lund University, Sweden; [6]MAX–lab, Lund University, Sweden/ Helmholtz Zentrum Berlin, Institute Methods and Instrumentation for Synchrotron Radiation Research, Berlin, Germany; [7]Department of Earth Science & Astronomy, Graduate School of Arts and Sciences, The University of Tokyo, Japan; [8]IFREE/SRRP, Japan Agency for Marine–Earth Science and Technology, Natsushima, Yokosuka 237–0061, Japan; [9]Department of Earth Science, Graduate School of Science and Engineering, Ehime University, 790–8577, Japan; and [10]Department of Geology, University of Salamanca, Spain and [11]Consultant geologist, Bogotá, Colombia.

**Introduction:** The paleontological record clearly reveals that impacts of large extra–terrestrial bodies may cause ecosystem devastation at a global scale [1], whereas smaller impacts have more local consequences depending on their size, impact angle and composition of the target rocks [2]. Approximately 190 impact structures are currently confirmed on Earth and each year a small number is added to this list but only nine verified impact craters have been detected on the South American continent despite its large area [3]. Here we provide geological and geophysical evidences of a large, buried impact crater, the Cali Crater, located in southwestern Colombia (Fig. 1) and dated as mid–Pliocene, i.e., 3.28 ± 0.07 million years [4].

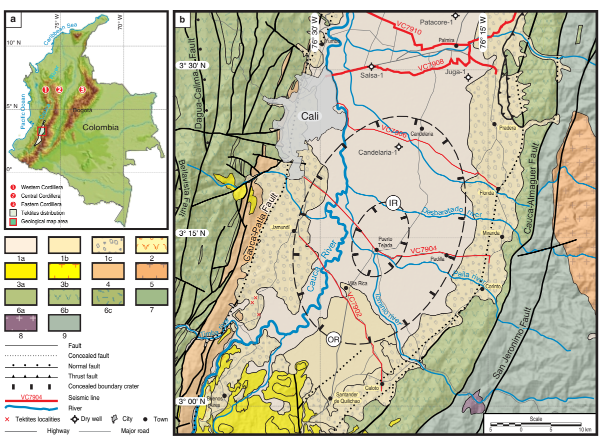


**Fig. 1.** Geological map of the Cali Crater [5]. (a) Location of the geological map area. (1) Quaternary, (1a) alluvial deposits; (1b) volcanoclastic deposits; (1c) vlluvial fans; (2) upper Pliocene volcanites; (3) Miocene, (3a) claystones, siltstones, coarse grained sandstones, conglomerates and dacitic tuffs and (3b) intrusives; (4) Eocene–Oligocene sedimentites; (5) Paleocene intrusive; (6) Upper Cretaceous, (6a) marine sedimentites, tuffs and agglomerate; (6b) Basalts and (6c) gabbros and tonalites; (7) Lower Cretaceous marine sedimentites; (8) Triassic intrusive; and (9) Permian to Cretaceous metamorphic rocks.

**The impact crater and the local geology:** The Cali Crater is located in the Cauca Sub–Basin between the Western and Central Colombian cordilleras, SE of Cali, in a geologically complex area [5]. The outer ring of the covered Cali impact crater has a major axis of 36 km and a minor axis of 26 km (Fig. 1), and the corresponding size of the inner ring is 12.7 km by 8.7 km, respectively. The basement to the east consists of Permian–Triassic and Lower Cretaceous metamorphic rocks. These are intruded by Meso–Cenozoic granitoids (Fig. 1), separated from a sliver of the Upper Cretaceous Caribbean–Colombian Oceanic Plateau (CCOP) [6]. These rocks were accreted to the active margin of South America pre–Eocene times [7], by the Cauca–Almaguer Fault. Over the CCOP basement, the Cauca Sub–Basin contains an Eocene to lower Miocene sequence, unconformably overlain by a flat–lying middle Miocene to Holocene cover (Fig. 1).

**Seismic interpretation:** Previous works in the Cauca Sub–Basin based on seismic data have shown that the Cauca Sub–Basin is a basement involved fold and thrust belt in a thick–skinned west vergent foreland style deformation, with stratigraphic evidence indicating that the Cauca Sub–Basin was deformed during Oligocene and latest Miocene [8].

The Cali impact crater shows a relative small negative anomaly caused by the low–density sedimentary cover. In order to precise the nature of this negative anomaly, uninterpreted seismic lines to the E and SE of Cali were obtained from the Colombian Agencia Nacional de Hydrocarburos (ANH).

The Cauca Sub–Basin was divided in seven unconformity stratigraphic sequences [8] for the seismic line VC7910 and Candelaria–1 well drilled in 1965. This provides a unique stratigraphic control for the 106 km through the crater, providing a new 2D seismic interpretation of the lines VC7906, VC7904 and VC7902 (Fig. 2).

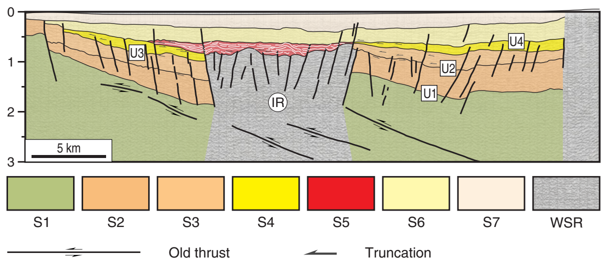


**Fig. 2.** Interpreted seismic line VC7904 from Cauca Sub–Basin showing structural style, regional unconformities, seismic sequences and geometry of the Cali Crater. Vertical scale is two–way travel time in seconds. (U1) Sub–Eocene unconformity; (U2) Sub–Oligocene unconformity; (U3) Sub–Miocene unconformity; (U4) Sub–upper Pliocene unconformity; (IR) Inner ring and (WSR) Without Seismic Resolution.

Sequence S1 shows Upper Cretaceous rocks of oceanic affinity including ultramafic complexes, gabbros associated with tonalites, basalts, dacites and rhyolites associated with sedimentary rocks of marine origin. Sequence S2 corresponds to the lower Eocene Chimborazo Formation composed of by coarse conglomerates interbedded with reddish muddy sandstones and siltstones overlain by cyclothems of quartz sandstones, siltstones, mudstones, shales and coal of the basal Oligocene Guachinte Formation. Sequence S3 is the Ferreira Formation, which consists of upward thinning units of quartz conglomeratic sandstones, quartz sandstones, fossiliferous sandstones, coal seams and shales. Sequence S4 comprises the Miocene La Paila Formation predominantly composed of lithic sandstones and polymictic conglomerates interbedding with dacitic tuffs. This is in the southern part represented by the coeval Esmita Formation composed of black siltstones, dark clays, gray to green sandstones, carbonaceous shales and quartz conglomerates.

Within the impact basin a new seismic sequence (S5) was identified, which is consistent with the age of 3.3–3.25 Ma for the tektites [4] (Fig. 2). Importantly, sequence S5 was not found in any seismic line to the north or south of the Cauca–Patía Basin, supporting the impact origin for S5. From seismic evidence, the extraterrestrial body that formed the Cali crater affected the Paila, Esmita and Guachinte formations, and possibly the Ferreira Formation, which together make up the target rock.

Sequence S6 includes the sandstones, conglomerates, and diatomaceous deposits of the Zarzal Formation and agglomerates and tuffaceous deposits of the Popayán Formation. Eventually, sequence S7 is the youngest sedimentary sequence that unconformably overlies and conceals the older sequences of the Cauca Sub–Basin.

It is worth to note that in the seismic lines VC7906, VC7904 and VC7902, the basement–involved fold and thrust belt seen in the seismic lines VC7908 and VC7910 is lacking. By contrast, a symmetrical pattern of normal faults with downward and inward displacements is observed along the edges of these seismic lines (Fig. 2), characteristic of large basin structures. Furthermore, other two distinctive features of large impact structures are the structural disruptions, with no coherent seismic reflector in the central zone, the Inner Ring (Fig. 2). In addition, continuous reflectors, not affected by the impact (pre–existing old thrust), are present beneath the disrupted zone (Fig. 2).

Substantiating our discovery of the Cali impact crater, stereomicroscope analysis of the cuttings of the Candelaria–1 well showed the occurrence of microspherules in the layer at a depth of 1,500–1,750 feet (~457–533 m). The microspherules occur within sequence S5, which is interpreted as the crater fill deposits. The seismic lines VC7906, VC7904 and VC7902 reveal another important structural feature. Based on morphotectonic and paleoseismic evidence, the present elliptical shape of the Cali impact crater could be explained by Holocene tectonic activity [9]. Consequently, the present elliptical shape of the Cali impact crater could be explained by this horizontal movement still being active during the Holocene [9].

As a final geological consideration, the Dagua–Calima Fault is a normal fault (huge land–slide) that could have been formed by the Cali asteroid impact at 3.3 Ma. Its current position north of Cali impact crater could be explained by the displacement of the Western Cordillera along of the Cauca–Patia Fault with strike–slip fault, right–lateral offset. The Dagua–Calima Fault is the only normal fault in Colombian Andes that is characterized by strike–slip faults and thrust faults [5].

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