PLIOCENE IMPACT CRATER DISCOVERED IN COLOMBIA - PETROLOGICAL EVIDENCES.

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Introduction: The paleontological record clearly reveals that impacts of large extra-terrestrial bodies may cause ecosystem devastation at a global scale [1, 2]. Approximately 200 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 evidence of a large, buried impact crater, the Cali Crater, located in western Colombia (Fig. 1) and dated to mid-Pliocene, i.e., 3.28 ± 0.07 million years.

Methodology: A large number of rock samples, including impactites were collected and studied from the Cauca Basin with the following methods: optical microscopy, scanning electron microscopy, energy-dispersive X-ray analyses (EDS), major- and trace-element (including High Siderophile Elements, HSE) analyses by ICP-AES and ICP-MS respectively, $^{40}Ar/^{39}Ar$ geochronology, and X-ray absorption spectroscopy [4]. The crater was investigated by geophysical methods including gravimetry and seismic profiling. Herein we focus on the petrological results.

The impact crater and the geology of the area: The newly discovered impact crater is located in the Cauca Sub-Basin between the Western and Central Colombian Cordillera, SE of Cali, in a geologically complex area [5]. We have named the crater "Cali" based on its location close to the city Cali. The outer ring of the covered impact crater has major axis of 36 km and a minor axis of 26 km.

Petrological evidence of asteroid impact: Several hundred rock samples and thin sections were studied in order to characterize the impactites (Figures 1–2), which include suevites, impact melt rocks, polymict impact breccias, shocked minerals (quartz and feldspar) and tektites. Some samples contain black to dark brown glass, nearly opaque in thin sections [4]. The glass is compositionally heterogeneous with app roximately 90 wt% FeO, 4 wt% SiO_2 and 2 wt% Al_2O_3.

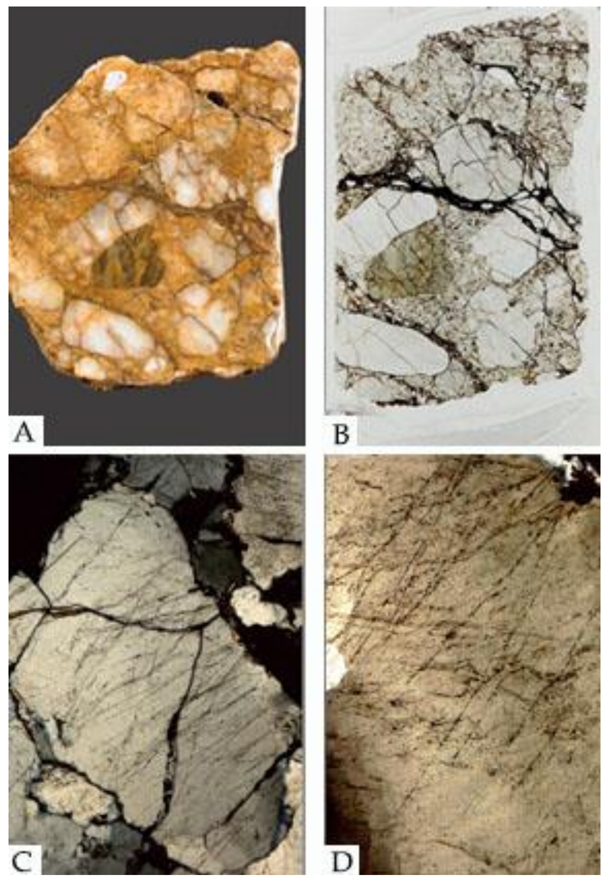

Figure 1. Clast supported impact breccia characterized by strongly deformed and fractured quartz pebbles. Black glass surrounds individual pebbles and fills internal fractures. **(A)** Cut surface **(B)** Plain light thin-section. **(C–D)** Micrograph showing quartz grains influenced by high-pressure.

SiO_2 and Al_2O_3 are always present [4], but in varying amounts. Na_2O, K_2O, CaO and more rarely TiO_2 occur among the less abundant oxides in the glass. The glass is partly devitrified into limonite or goethite. Irregular, angular lithic fragments occur in the glass Figure 2). They are moderately to heavily altered and include both felsic and mafic rocks, e.g. dolerite with preserved ophitic texture and medium-grained, unidentified plutonic rocks [4]. The lithic fragments also include recognizable mineral fragments such as quartz, feldspar, mica, albite in form of maskelynite, andradite and epidote. Interestingly, grossular-rich garnet (Ca-Al garnet) occurs [4], indicating high metamorphic pressure. The angularity, compositional variability and distribution of the clast fragments imply that they did not form *in situ* but were rather emplaced into a high-density melt and that the glassy material could not have been precipitated from a solution. The penetration of a melt with a composition similar to andradite-garnet into µm-sized networks in quartz crystals cannot easily be explained in any other way than by shock-fracturing of the host quartz crystal followed by introduction of an impact melt of a composition foreign to all normal terrestrial magmas. The fragmentary character of many crystals in the melt is opposed to the generally euhedral to subhedral crystals formed in crystallizing magmas. We contend that the fine intergrowth of angular rutile and titanite in straight bands through fractured iron oxide has formed from shock metamorphism. Some of the impactites further enclose grains of quartz exposed to high pressure while strongly deformed and fractured quartz pebbles characterize other clast-supported impact breccias (Figure 2). The combination of lithic fragments in this odd glass melt most certainly results from an impact of an extra terrestrial body and we argue that the Ca-rich melt has formed from calcareous target rocks with Al and Si contributions from argillitic or arenitic rocks.

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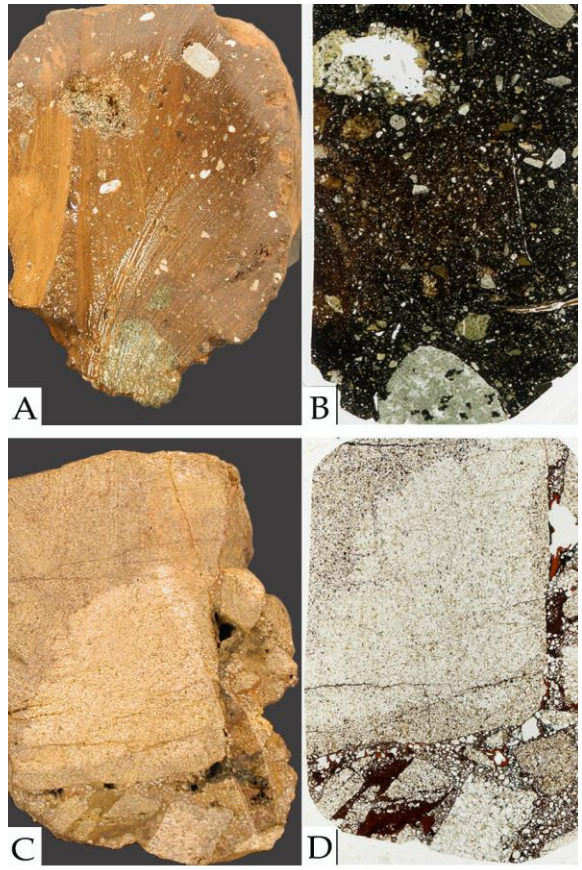

Figure. 2. (A) Impact melt rock, cut surface of sample, red stained due to its high Fe-content. The individual, irregular lithic fragments are clearly visible. **(B)** Plain light thin-section sections showing the black to dark brown glass with irregular, angular litho-fragments. **(C-D)** Clast supported impact breccias dominated by quartz–rich sandstone clasts. Glass occurs along clast boundaries. **(C)** Cut surface **(D)** Plain light thin-section (note the glass around angular and sub-angular polymict fragments)**.**