ATLAS - IMPACT CRATERS

CREATED BY
SUNIETI BHANDARI

Centre of Geographic Sciences
COGS | nscc

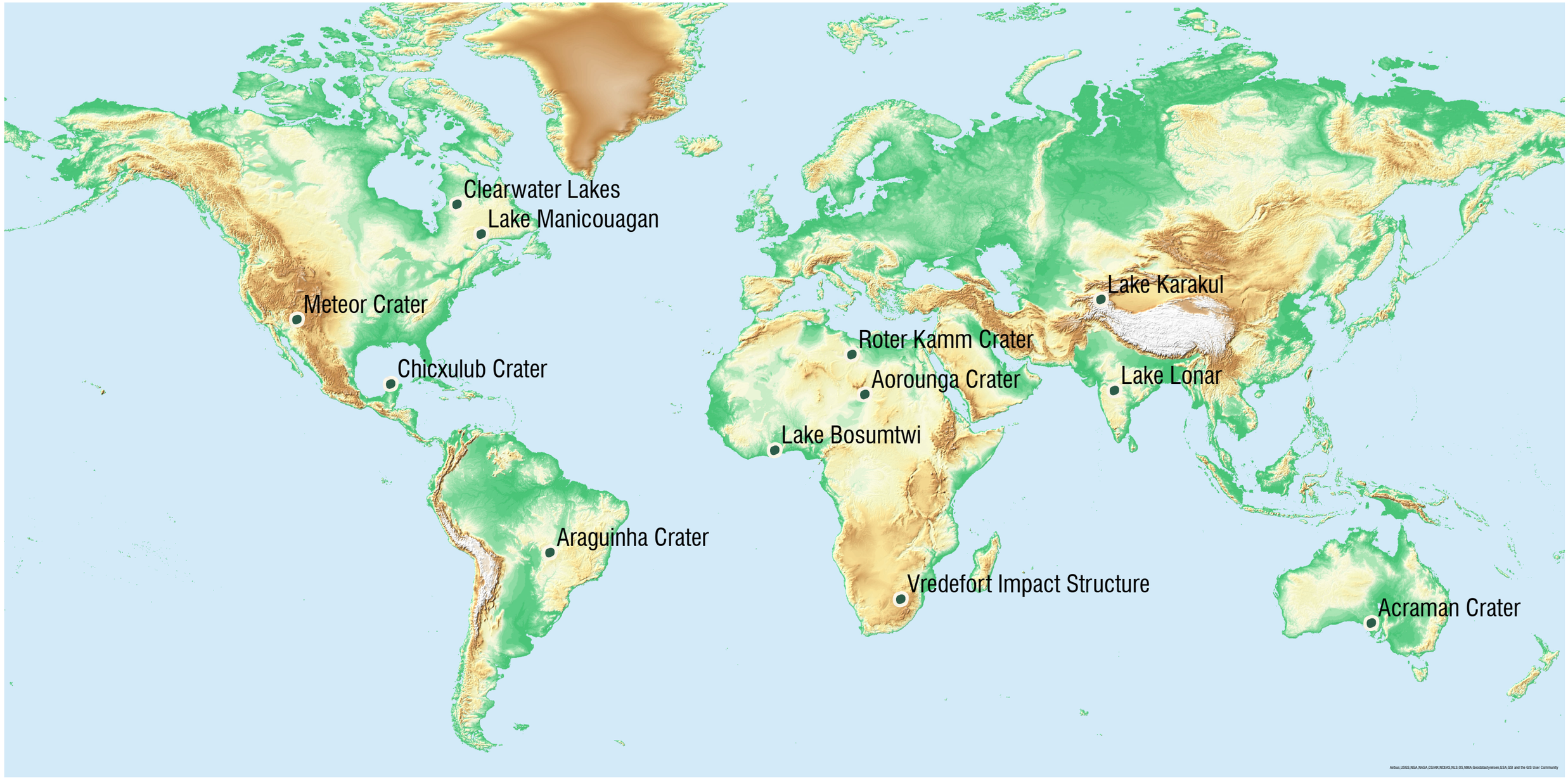
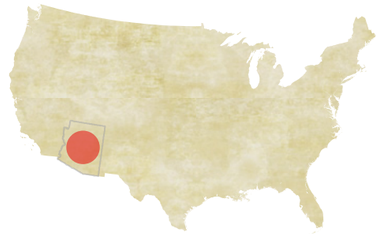


TABLE OF CONTENTS

GEOLOGICAL TIMESCALE

EON	ERA	PERIOD	EPOCH	FROM - TO (MILLIONS OF YEARS AGO)	DURATION (MILLIONS OF YEARS)
PHARENOZOIC	CENOZOIC	QUATERNARY	HOLOCENE	0.0117	0
			PLEISTOCENE	2.588	0.0117
		NEOGENE	PLIOCENE	5.3	2.588
			MIOCENE	23	5.3
		PALEOGENE	OLIGOCENE	33.9	23
			EOCENE	56	33.9
			PALEOCENE	65.5	56
	MESOZOIC	CRETACEOUS		145.5	65.5
		JURASSIC		199.6	145.5
		TRIASSIC		251	199.6
	PALEOZOIC	PERMIAN	LOPINGIAN	259.1	251
			GUADALUPIAN	272	259.1
			CISURALIAN	299	272
		CARBONIFEROUS	PENNSYLVANIAN	323.2	299
			MISSISSIPIAN	359.2	323.2
		DEVONIAN		416	359.2
		SILURIAN		443.7	416
		ORDOVICIAN		488.3	443.7
		CAMBRIAN		542	488.3
PRECAMBRIAN	PROTEROZOIC	NEO-PROTEROZOIC		1000	542
		MESO-PROTEROZOIC		1600	1000
		PALEO-PROTEROZOIC		2500	1600
	ARCHEAN	NEOARCHEAN		2800	2500
		MESOARCHEAN		3200	2800
		PALEOARCHEAN		3600	3200
		EOARCHEAN		3800	3600
	HADEAN			4600	3800

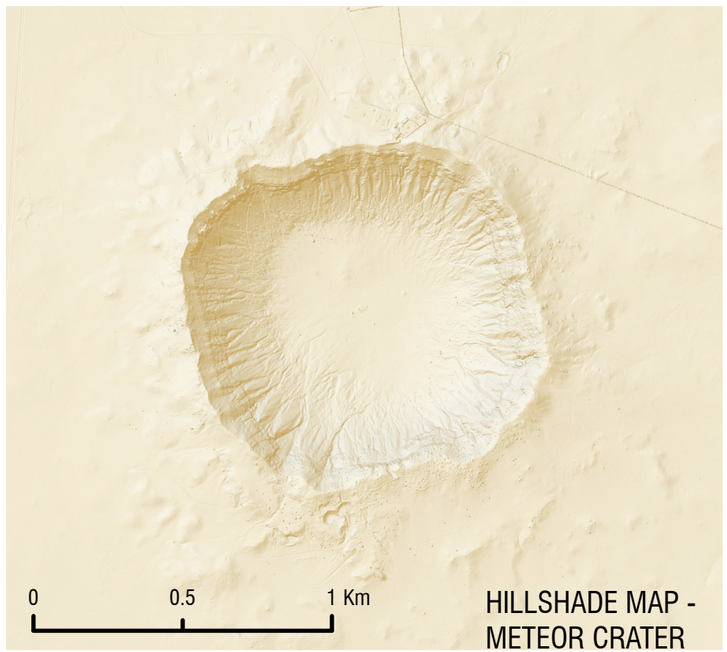
METEOR CRATER, USA



Meteor Crater is a meteorite impact crater in the desert of northern Arizona, United States. The crater was created about 50,000 years ago during the Pleistocene epoch. During this time period, the local climate of the Colorado Plateau was cooler and damper while the area was inhabited by mammoths and giant ground sloths.

Giant impact hypothesis – Is this what created the moon?

The Giant Impact Hypothesis is a prevailing theory most supported by the scientific community. It suggests that the moon was formed when a meteorite collided with Earth in its early formation stages. This Mars-sized meteorite, known as Theia, hit Earth, ejecting large chunks of the young planet's crust into space. In due time, because of gravitational pull from the remains of Theia's core, the ejected particles started fusing together and created the moon. (Nola Taylor Tillman, 2022)



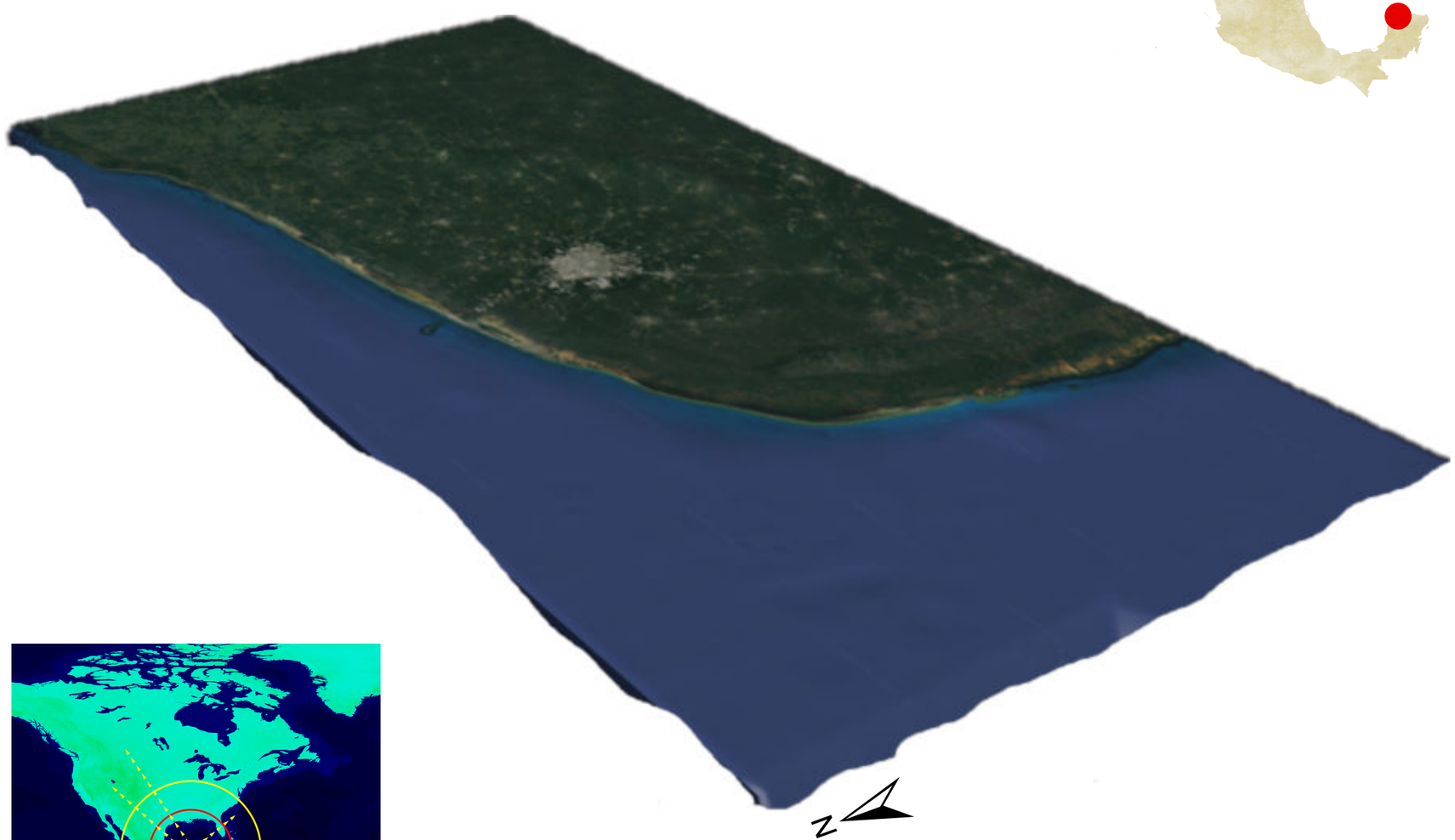
HILLSHADE MAP - METEOR CRATER

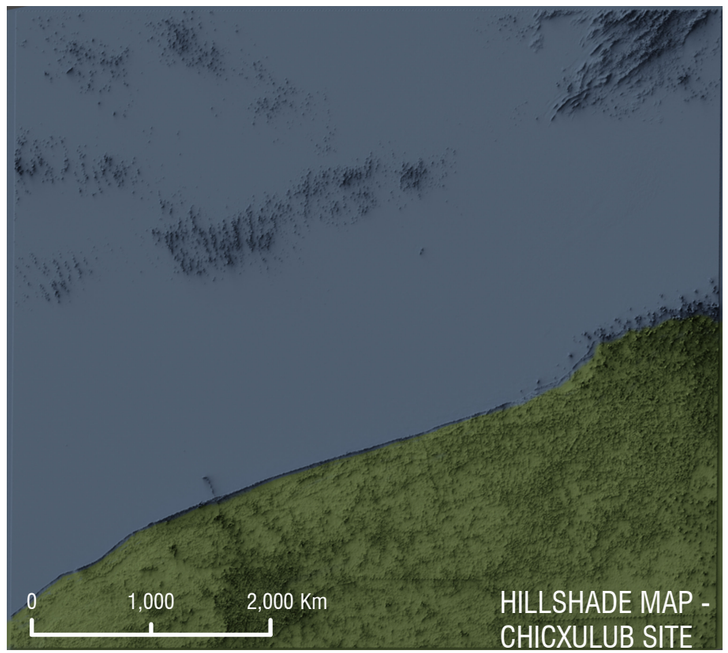
ARTISTIC REPRESENTATION OF THE COLLISION AND SUBSEQUENT FORMATION OF THE MOON

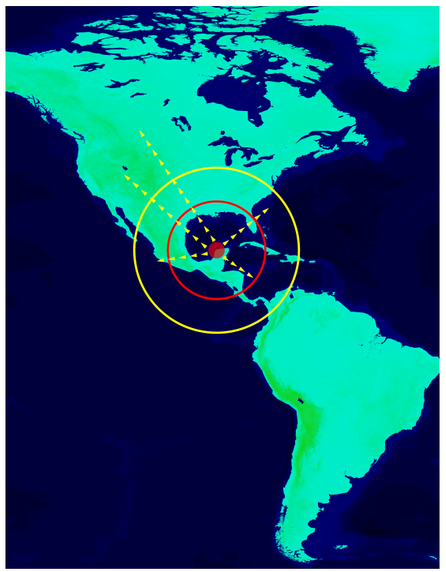
CHICXULUB CRATER, MEXICO

Chicxulub Crater, located on the Yucatan Peninsula in Mexico is a massive impact crater covering over 180 kilometres in diameter resulted from the impact around 66 million years ago.
The Chicxulub crater is mostly located on land, with a small portion extending into the Gulf of Mexico. Although not completely visible due to sediment deposition and erosion over millions of years, the circular shape of the crater still influences topography of the surrounding area.

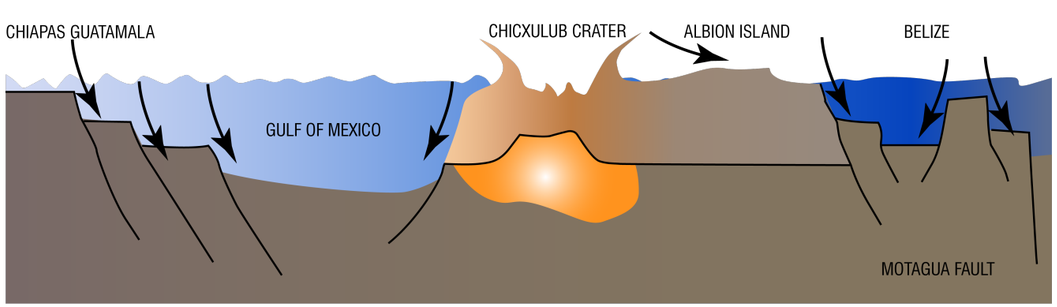
The Dinosaur killer!
The impact is considered to have caused the mass extinction event at the end of the Cretaceous period, wiping out about three-quarters of all plant and animal species including the dinosaurs on Earth (Alvarez et al., 1980). The force generated caused intercontinental destruction, tsunamis, floods, wildfires and a massive cloud of dust that blocked out the sun for months.







IMPACT SHOCK WAVES AND
AIRBLAST OF DEBRIS



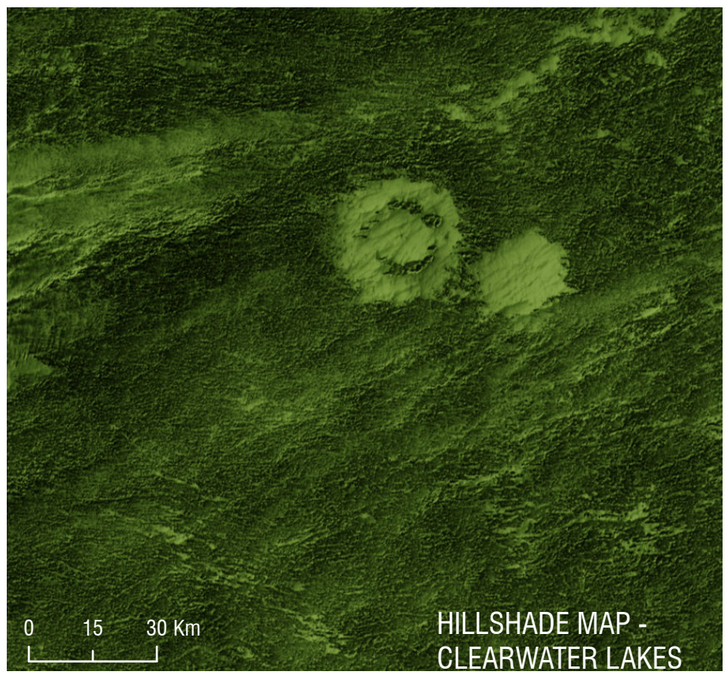
SCHEMATIC CROSS SECTION OF CHICXULUB CRATER AND SURROUNDING
PLATFORMS DISPLAYING POSSIBLE IMPACT TRIGGERED SLOPE FAILURE FEATURES

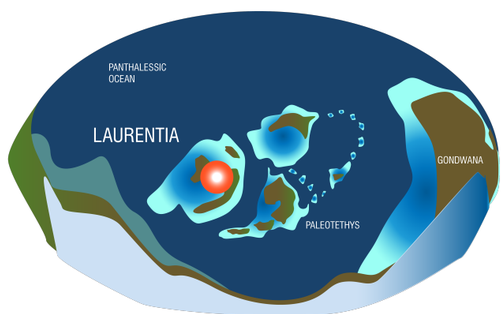
CLEARWATER LAKES, CANADA

The Clearwater Lakes are two near-circular depressions of eroded impact craters. The eastern crater is 26 kilometres in diameter while the western crater is 36 kilometres in diameter. Both are complex craters with distinct central peaks which have been formed by the gravitational collapse of crater walls and subsequent rebound of the compressed crater floor. Although a single body of water a line of islands forms a "dotted line" between the two lakes (Clearwater Lakes).

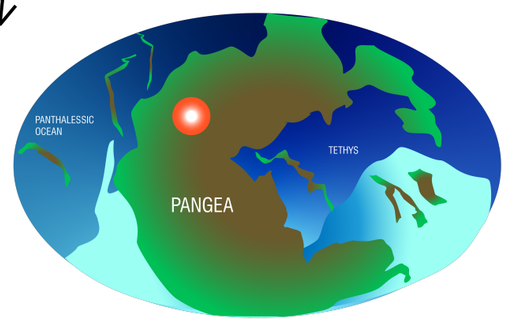
Originally, assumed to be a typical crater doublet formed by the impact of a binary asteroid, recent studies have brought out that the two impact structures represent a ‘false doublet’ struck by impacts nearly 180 million years apart (O'Dale).

There is evidence that the asteroid that created the East crater impacted a marine environment, placing the impact during the Ordovician period. The West crater, on the other hand, was created in the Permian period and impacted the landmass Pangaea (Doyle, 2015).





IMPACT ON EAST CLEARWATER LAKE DURING THE LATE ORDOVICIAN (~ 450 MILLION YEARS AGO)



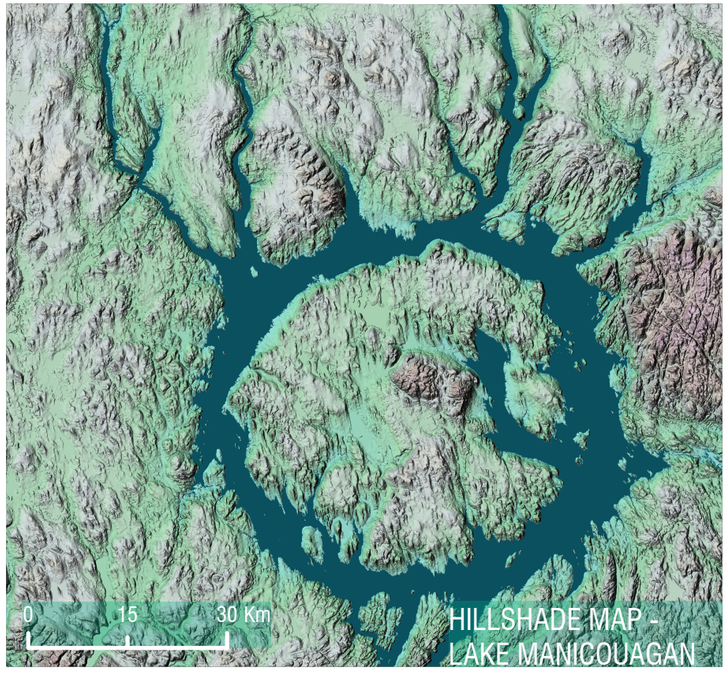
IMPACT ON WEST CLEARWATER LAKE DURING THE EARLY PERMIAN (~ 285 MILLION YEARS AGO)

ARTISTIC DEPICTION OF COLLISIONS RESPONSIBLE FOR CREATING THE TWO CRATER LAKES

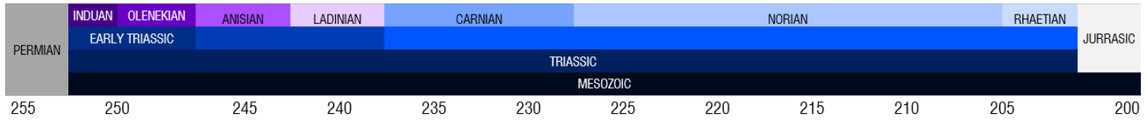
LAKE MANICOUAGAN, CANADA

Lake Manicouagan is an impact crater lake dating back to 212 million years ago, in the Late Triassic period.
The lake and the island in the middle of the crater cover an area of 1,942 square kilometres. Visible from space, it is often called the "eye of Quebec". It is the Earth's sixth-largest confirmed impact structure and Mount Babel which lies in the middle of the crater, is understood to have formed by the post-impact uplift (Manicouagan Reservoir).

Part of a Multiple Impact event?
Manicouagan crater may have been part of a multiple impact which also formed the Rochechouart impact structure in France, the Saint Martin crater in Manitoba, the Obolon' crater in Ukraine, and the Red Wing crater in North Dakota. This impact may have been responsible for a mass extinction of roughly 60% of all species (Manicouagan Impact Structure, Quebec, 2001).



BLENDER RENDERED HILLSHADE OF LAKE MANICOUAGAN

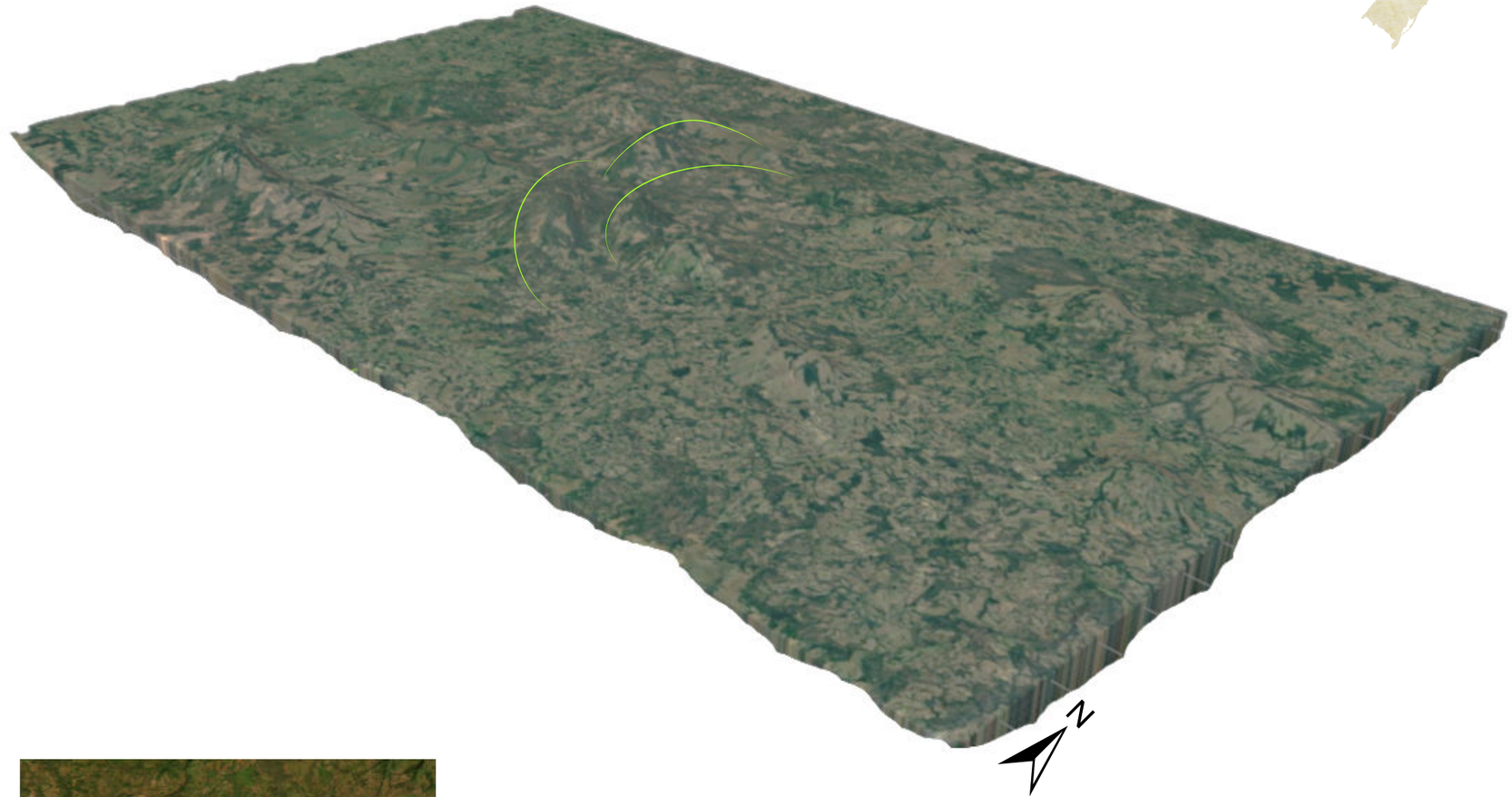


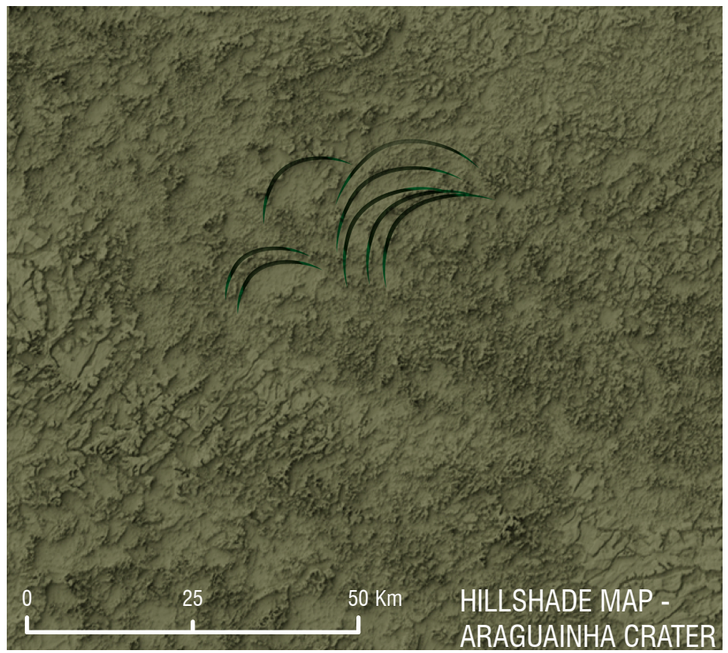
SUBDIVISION OF THE TRIASSIC

ARAGUAINHA CRATER, BRAZIL

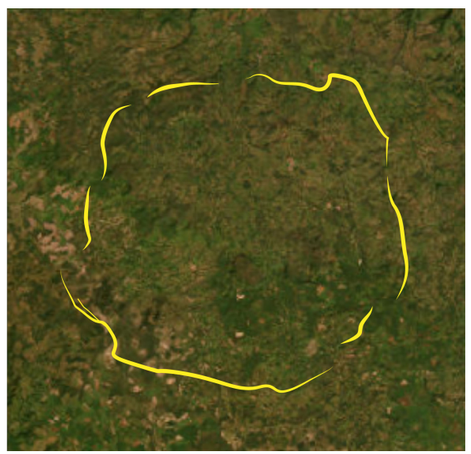
The Araguainha crater is the largest known impact crater in South America and measures around 40 kilometres. The impact is estimated to have occurred around 250 million years ago, during which the region was under the estuarine waters of the Parana Basin.
Most of the kinetic energy transferred from the collision was converted into thermal energy, which vapourised and melted the uppermost surface of the basin over a radius of several kilometres. A mammoth dent has been left by the meteorite collision and although most of the crater has been eroded, impact is still visible as folds created on ground.

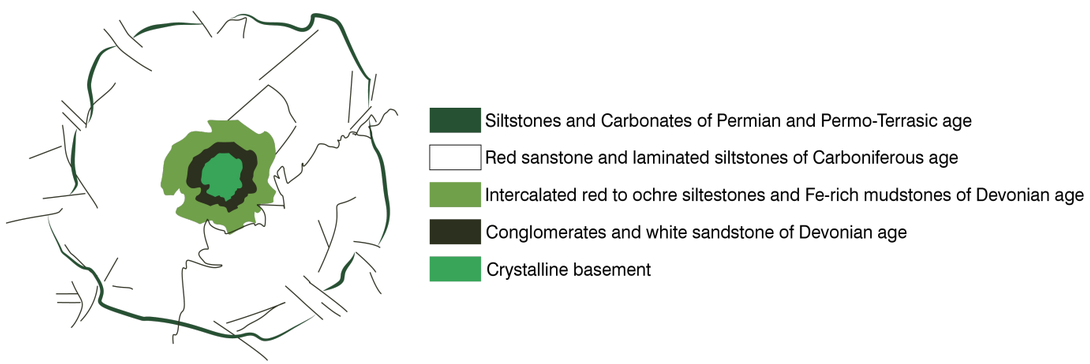
The Great Dying
Araguainha is estimated to have occured in the Permo-Triassic boundary and could be one of the causes of the Permian–Triassic catastrophe. Also known as the Late Permian extinction event or the Great Dying, it erased 90% of marine species from Earth.





HILLSHADE MAP - ARAGUAINHA CRATER





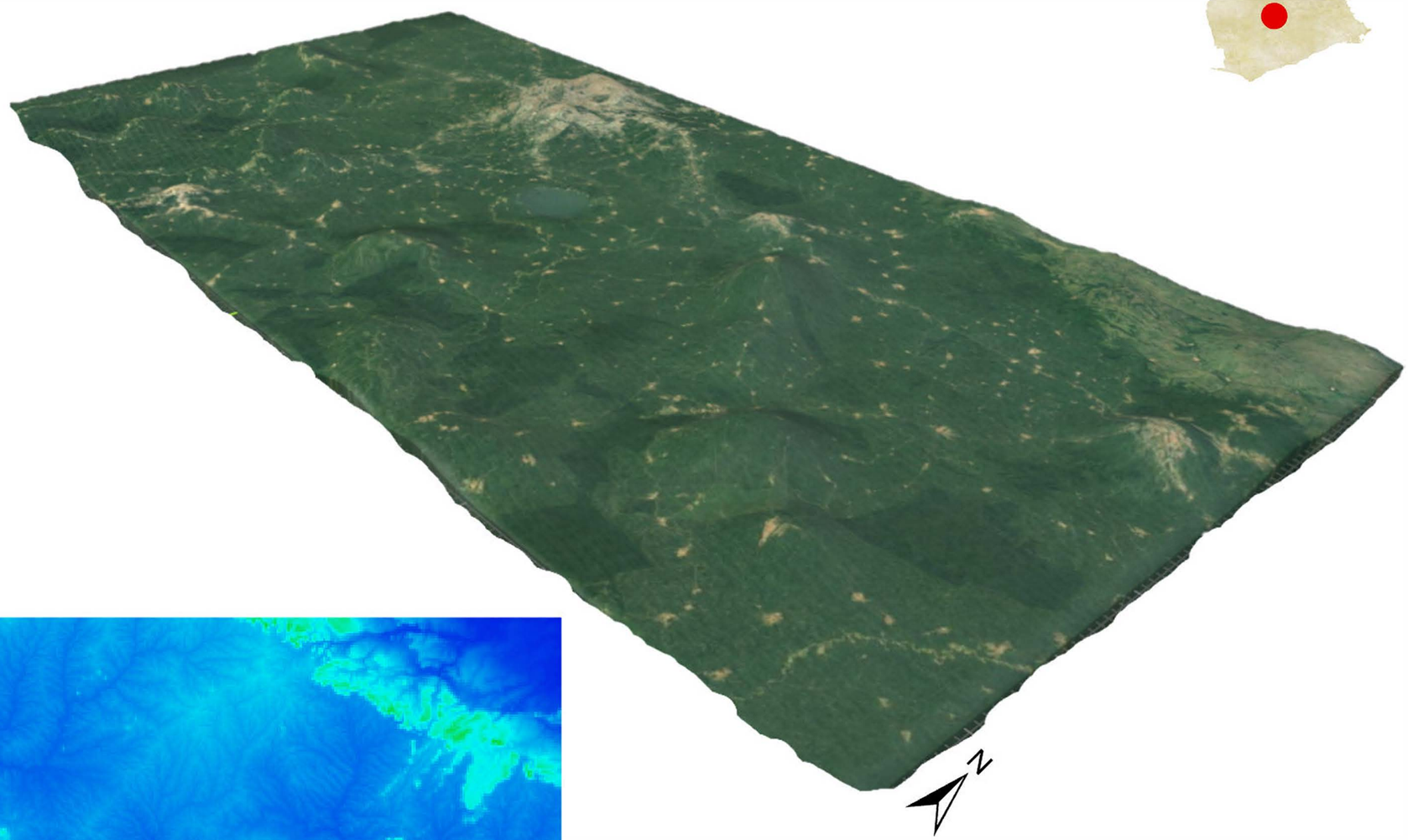
GEOLOGICAL MAP OF ARAGUAINHA SHOWING LAYERS PULLED OUT FROM THE CRUST DURING THE IMPACT

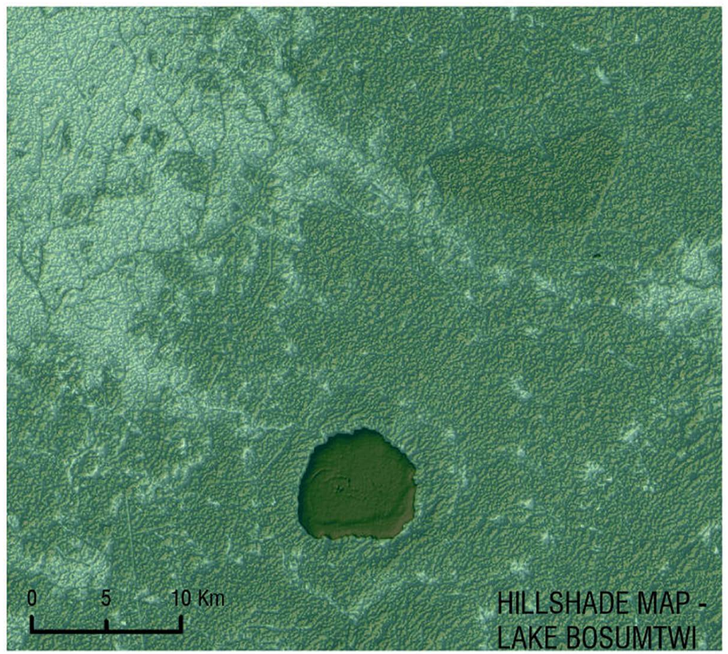
LAKE BOSUMTWI, GHANA

The Bosumtwi crater in Ghana is a complex meteorite impact structure formed around 1.07 million years ago in the Pleistocene period. What is fascinating about this structure is that the feature rises 300 metres above the level of the lake and is characterised by a steep and faulted rim (Bosumtwi Impact Crater, Ghana: A Remote Sensing Investigation).

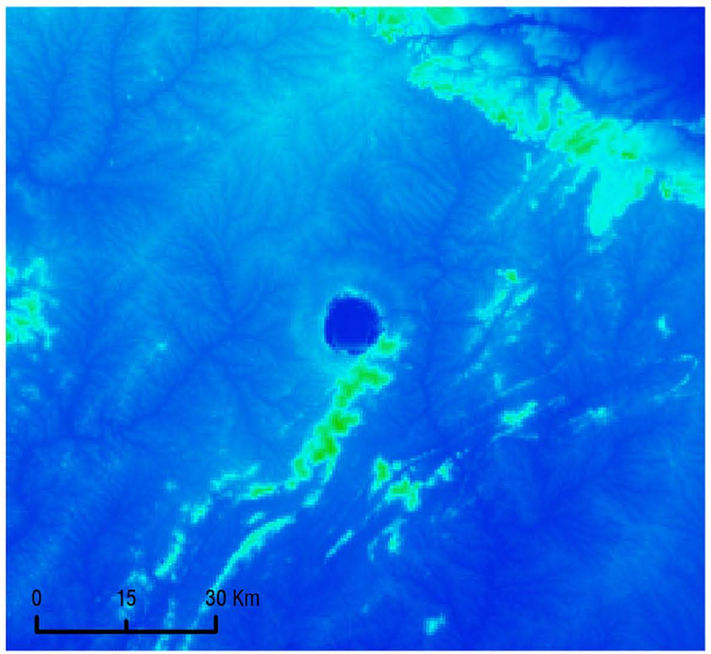
Lake Bosumtwi, the only natural lake in Ghana is situated within the circular depression of this ancient impact crater. The lake is said to have formed by the collection of rainwater in the depression caused by the impact (Lake Bosomtwe Biosphere Reserve, Ghana).

The crater is partly eroded and lies in dense rainforests which makes on-site studies difficult but has at the same time allowed it to remain well preserved. Debris, believed to be from this impact, has been found in the neighbouring country of Côte d'Ivoire, and in deep-sea sediments west of Africa.



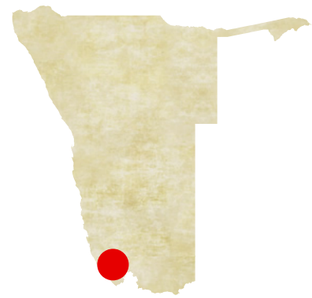


HILLSHADE MAP - LAKE BOSUMTWI



BATHYMETRIC MAP OF LAKE BOSUMTWI

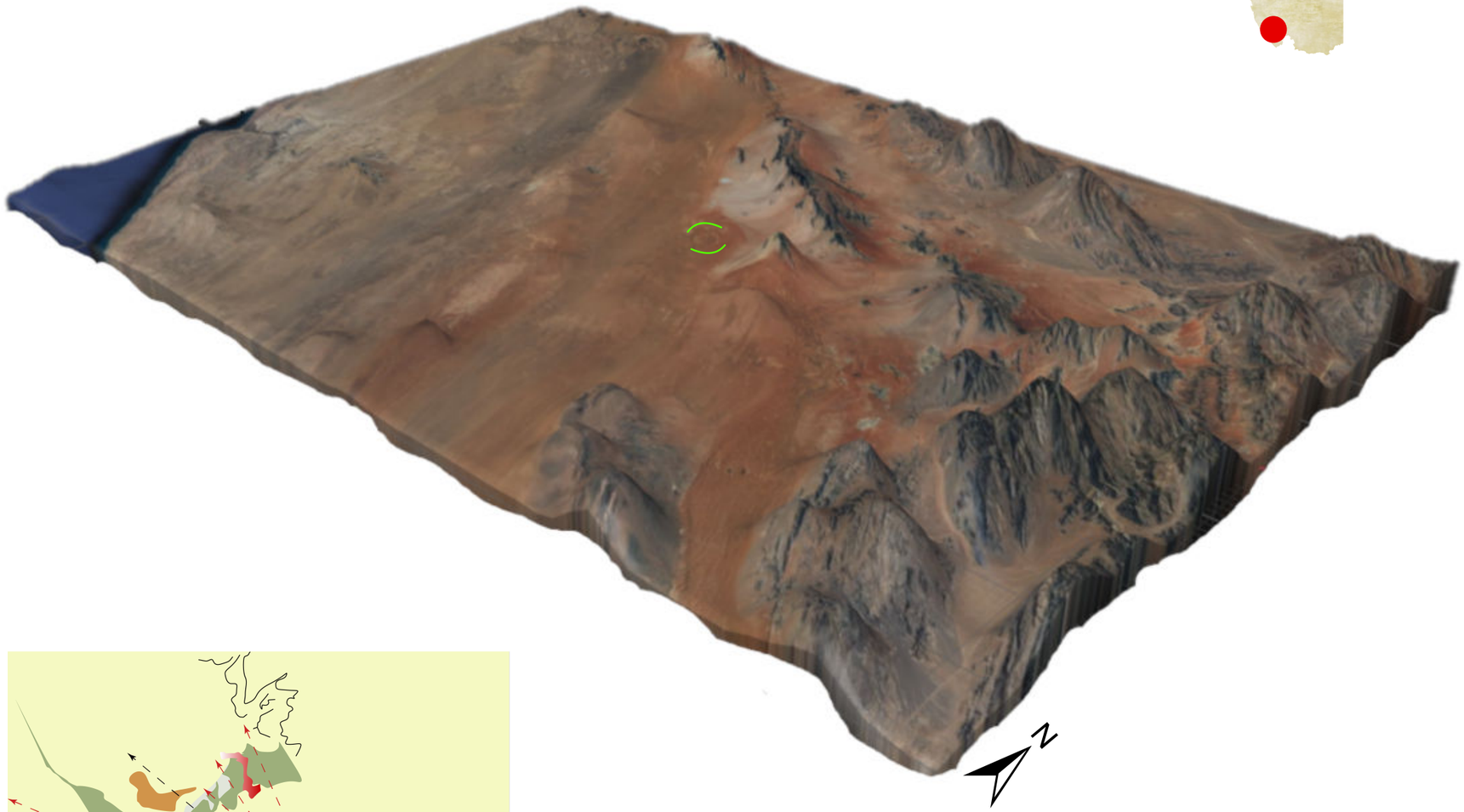
ROTER KAMM, NAMIBIA

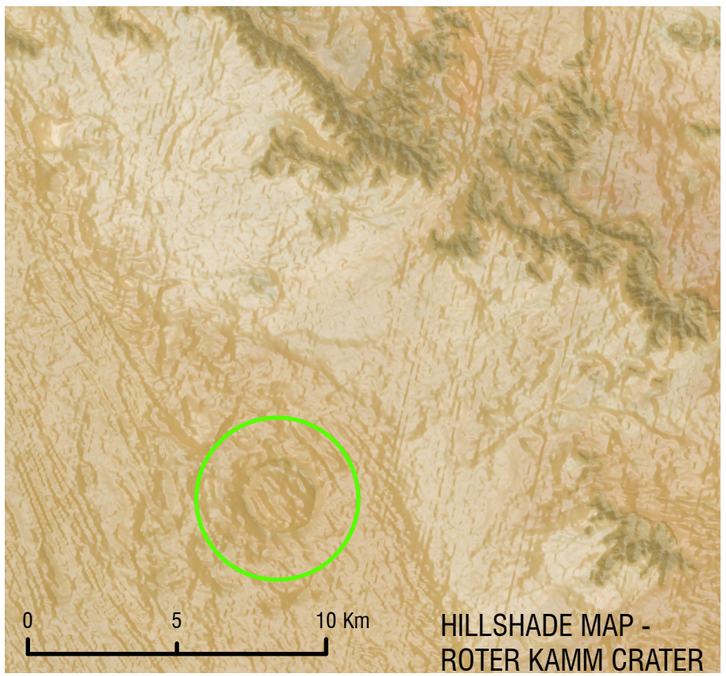


Roter Kamm is a meteorite crater, located in the Namib Desert. The crater is 2.5 kilometres in diameter and 130 metres deep. The meteorite that created this circular feature, hit the Earth about 5 million years ago, placing the impact in the Pliocene. The crater has an exposed surface, but its original floor lies at least 100 metres below the sand deposits.

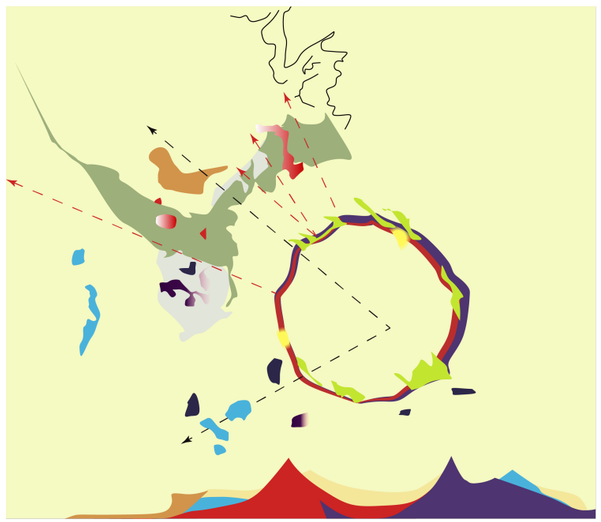
Studies into the crater suggest that it was formed in a two-layer target region with a heavily intruded basement. No parts of this meteorite that struck Roter Kamm have been found, however, there is evidence of post-impact hydrothermal activity, which suggests that the meteorite completely vapourised upon impact.

Regardless of this crater being heavily piled up with sand, it is still one of the best-exposed impact craters on Earth due to the rocky terrain and little rainfall in the region.





HILLSHADE MAP - ROTER KAMM CRATER



PRE IMPACT LITHOLOGY

- Sossus Sand Formation (Pliocene)
- Tsandab Sandstone Formation (Miocene)
- Light blue limestone (Neoproterozoic)
- Couse grained luecocatic gneiss (Mesooproterozoic)
- Couse grained biotite gneiss (Mesooproterozoic)

IMPACT AND POST IMPACT LITHOLOGY

- Mobile Dunes
- Vegetatice sand dunes (Pliocene to today)
- Sand with ejecta
- Sand with large biotite gneiss ejecta
- Sand with small ejecta
- Calcrete
- Pegogenic Calcrete
- Large ejecta

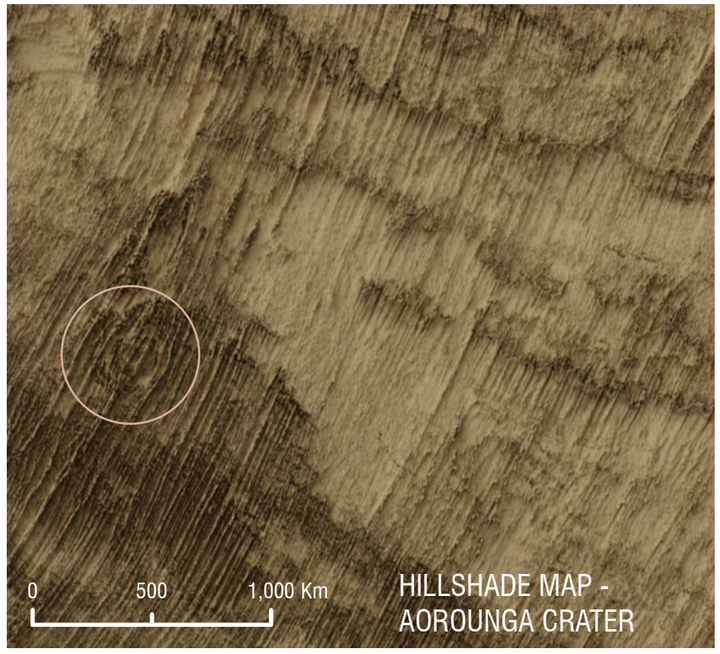
IMPACT EJECTA ORIENTATION OF ROTER KAMM

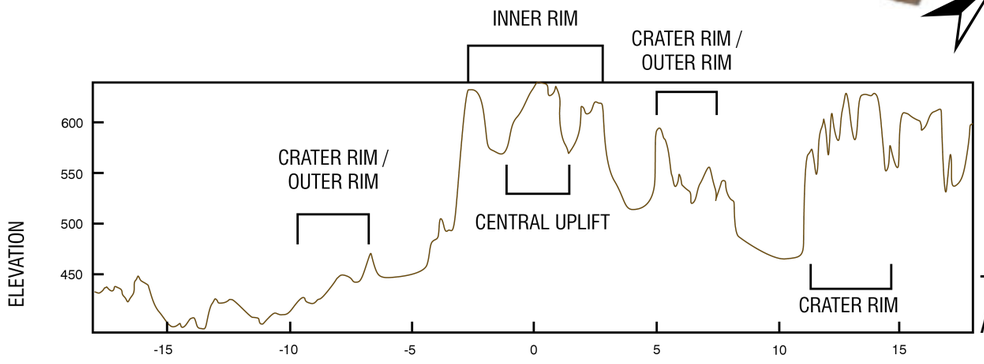
AOROUNGA CRATER, CHAD

The Aorounga Crater is a large impact crater located in the Sahara Desert in northern Chad. Estimated to be around 345 million years old, it measures approximately 17 kilometres in diameter and is surrounded by a distinctive ring of hills and ridges formed by the rebound of the Earth's crust after the impact.

A 1994 research considered that Aorounga belonged to a set of three craters formed by the same impact event.

The original crater was buried in sand and underwent partial erosion forming the current ring-like appearance. Called the Yardangs, they lend this crater its unique appearance and characterized by their elongated, streamlined shape which has been sculpted by the winds eroding and depositing sand in this region over thousands of years. Yardangs can reach heights of up to 30 meters and extend several kilometres in length (Landsat 9 Image of Aorounga Crater, 2022).





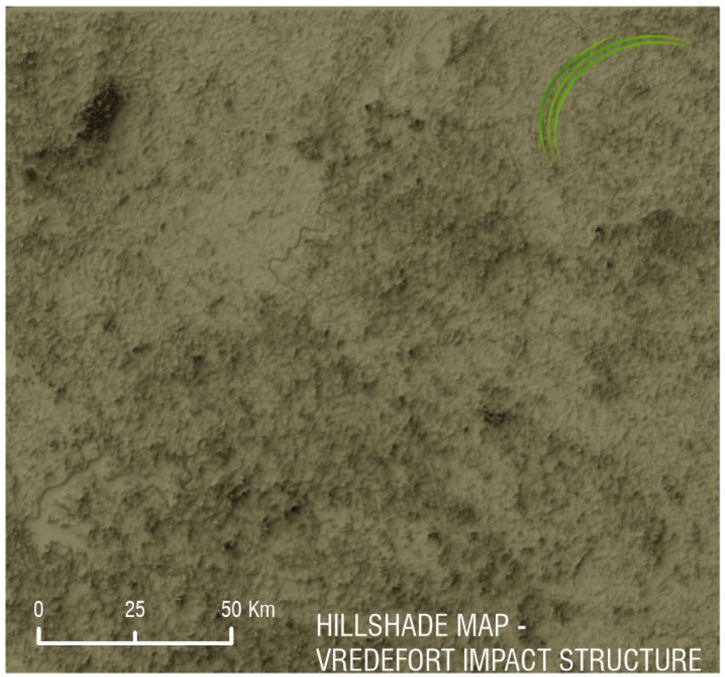
TOPGRAPHIC PROFILE IN THE NORTH SOUTH DIRECTION ACROSS AOROUNGA CRATER

VREDEFORT IMPACT STRUCTURE, SOUTH AFRICA

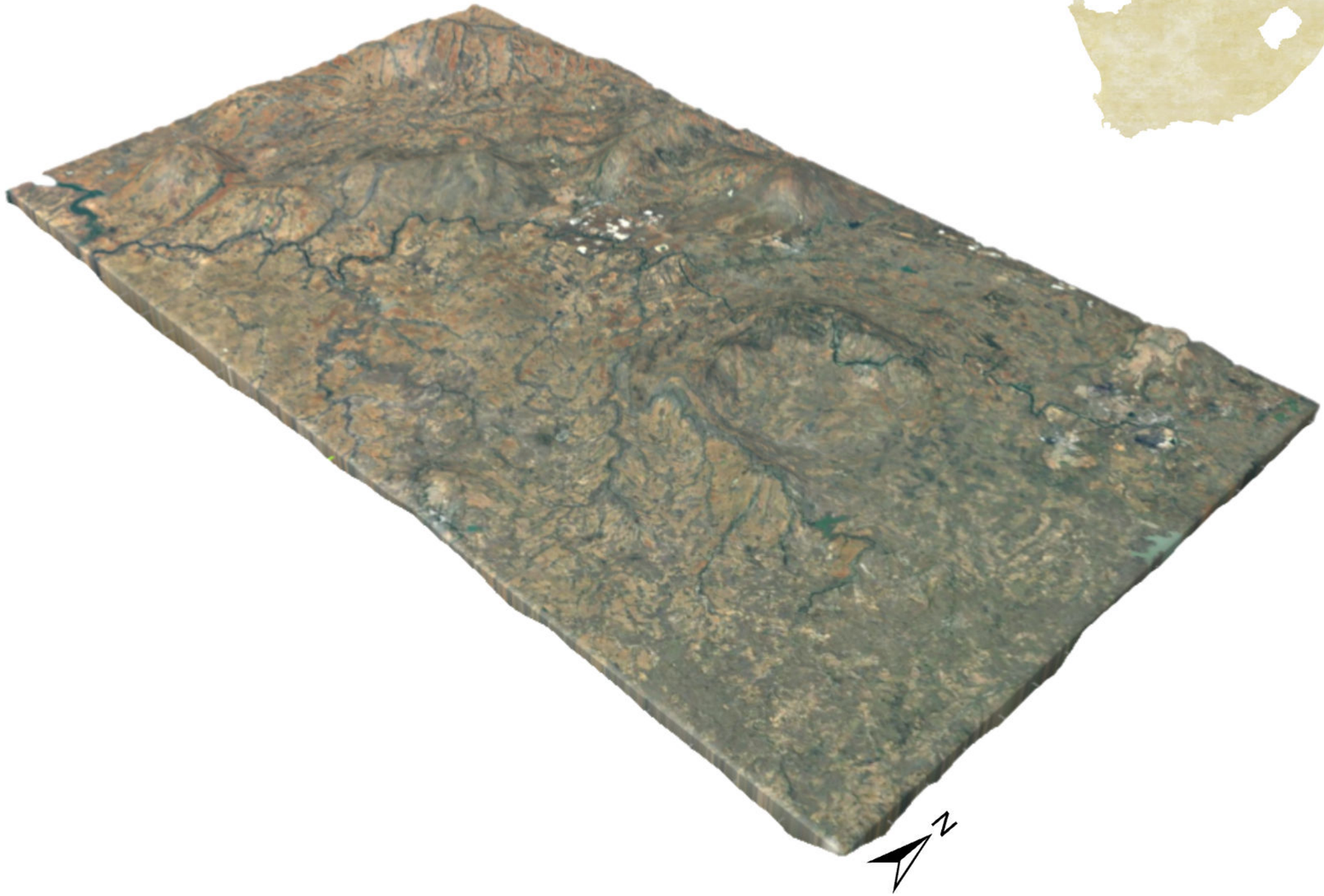
The Vredefort impact structure is one of the oldest and the largest verified impacts on Earth. Located in Free State, South Africa, this crater was formed by an asteroid collision about two billion years ago in the Paleoproterozoic Era. The Witwatersrand Basin, Ventersdorp Lavas and the Transvaal Supergroup were hugely distorted by this collision, the effects of which are visible to date.

Vredefort is one of the few multiple-ringed impact structures on Earth as they get destroyed by geological progressions of erosion and tectonic movements.

Only an eroded deformed underlying bedrock remains of the original crater. The force from the uplift of the impact caused a 25 kilometres section of Earth's crust to twist out. The upended rock features generated concentric outlines around the impact site, still visible today. The central dome called the Vredefort Dome measures about 90 kilometres across and was only observed in June 2018 by Landsat 8 (Vredefort Crater).



HILLSHADE MAP -
VREDEFORT IMPACT STRUCTURE



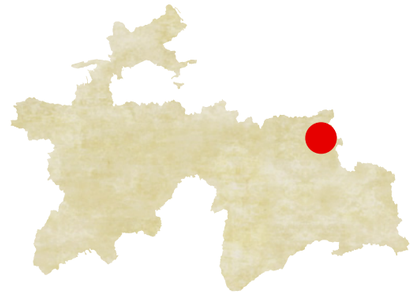
A SCHEMATIC DIAGRAM OF A CROSS-SECTION THROUGH THE VREDEFORT IMPACT STRUCTURE
AND HOW IT DISTORTED THE CONTEMPORARY GEOLOGICAL STRUCTURES

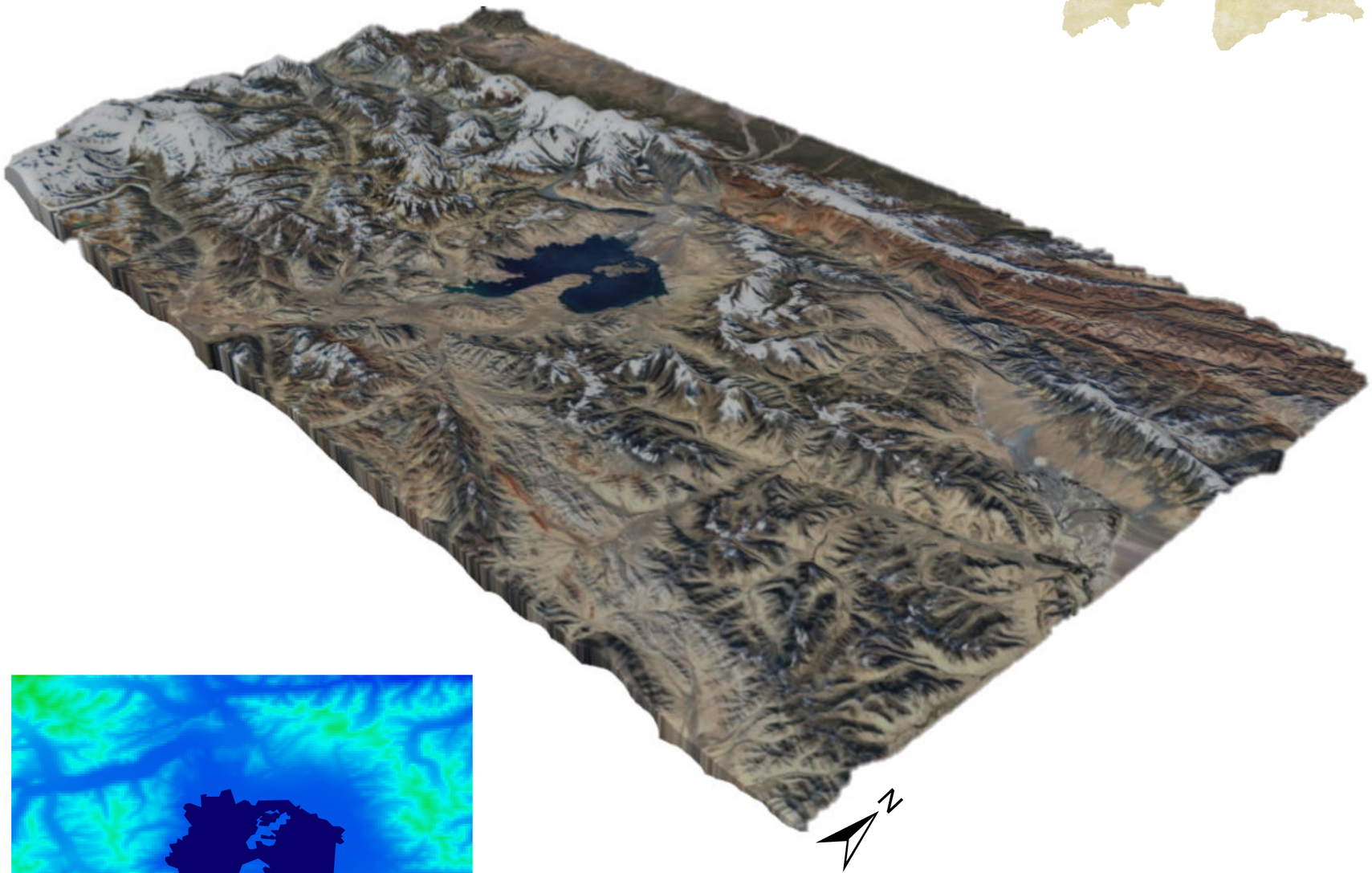
KARAKUL CRATER, TAJIKISTAN

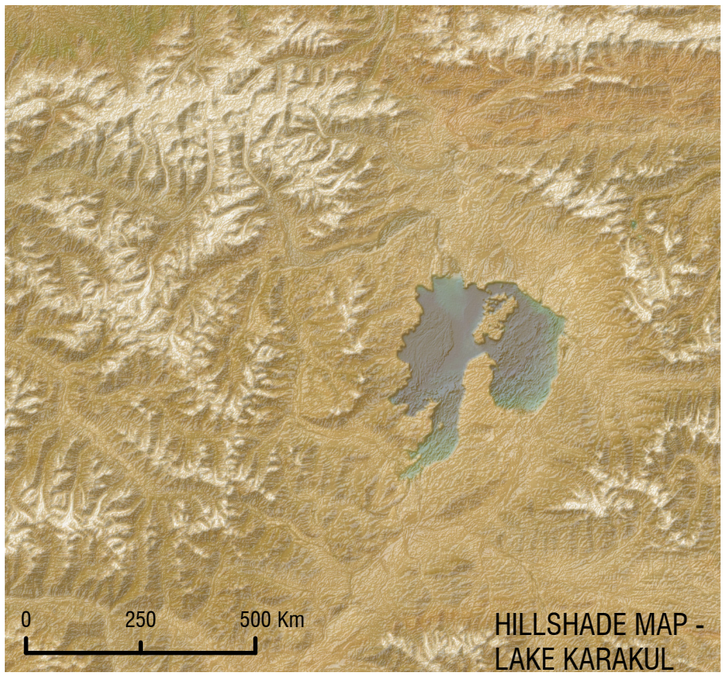
Karakul Impact Structure is a 52 kilometres circular depression of an impact crater located in the Tajik National Park in the Pamir Mountains in Tajikistan. The Earth Impact Database (EID) lists it as one of the largest complex craters and estimates its age at about 5 million years which puts it in the Pliocene age making it younger than the India-Asia collision. Not surprisingly, sitting atop the Roof of the World, aka the Pamirs, it is also the highest impact crater.

An endorheic lake lies within this depression with two basins separated by a central uplift forming an island and peninsula in the middle part. The crater is one of the few places that offer the possibility to investigate how meteorite impacts and tectonic activity interacted with one another and their subsequent consequences on the geography of the region.

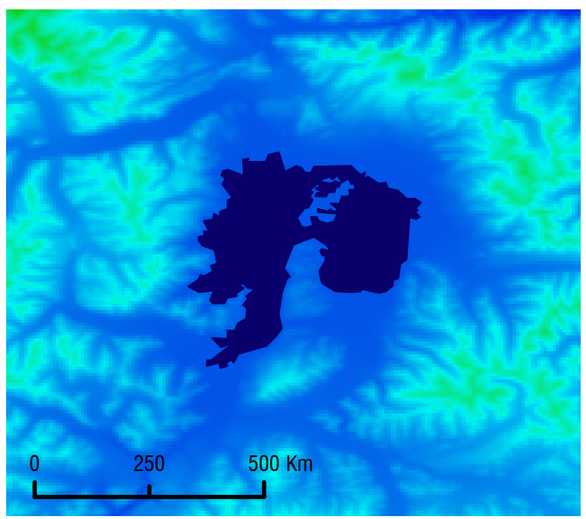
What is most fascinating is that the impact structure was first discovered around 1987 while studying imagery taken from space.







HILLSHADE MAP - LAKE KARAKUL



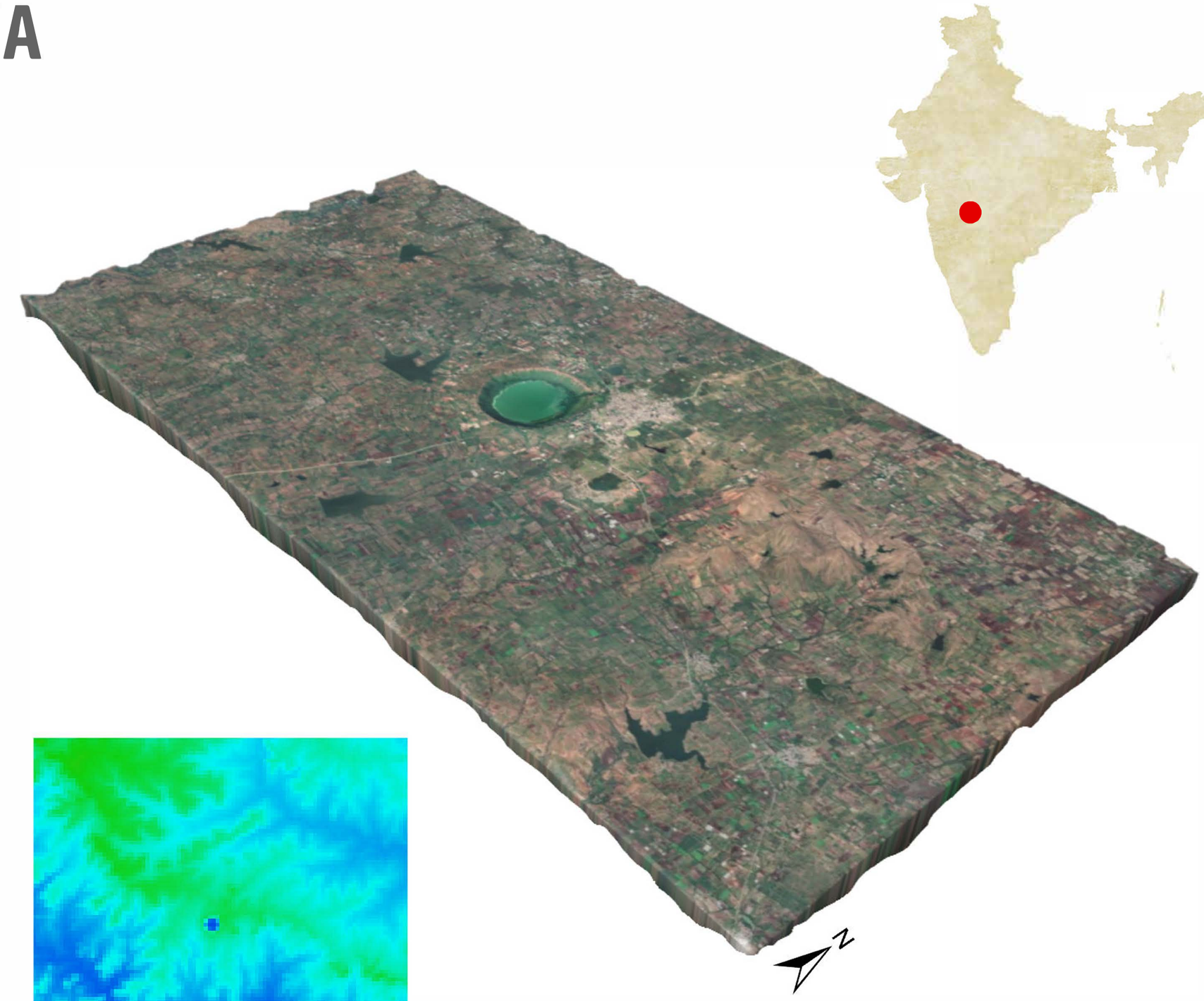
BATHYMETRIC MAP OF LAKE KARAKUL

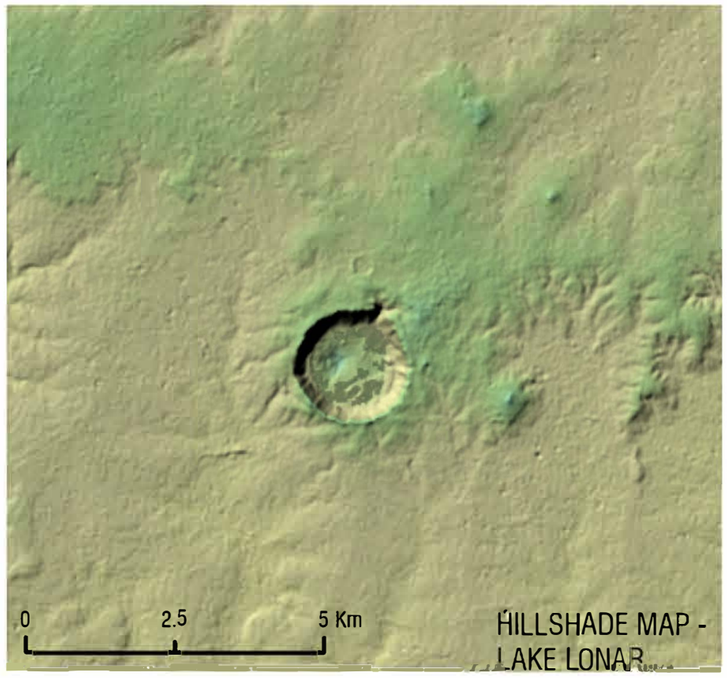
LAKE LONAR, INDIA

Lake Lonar, also known as Lonar crater, is a saline, soda lake, located in Maharashtra, India. It was created by a meteorite impact during the Pleistocene Epoch and is one of only four known hyper-velocity impact craters in basaltic rock anywhere on Earth. The meteor crater rim is about 1.8 kilometres and forms part of the younger impact craters with an estimated age of about 576,000 ± 47,000 years.

A 2019 study found that the minerals in the lake were very similar to the minerals found in the moon rocks brought back during the Apollo Program. It is one of the best-preserved impact structures formed in continental flood basalts and provides a unique opportunity to study the processes of impact cratering in basaltic targets.

Additionally, researchers across the globe also conduct many studies on the lake owing to the biological nitrogen fixation discovered in the lake in 2007 (Lonar Lake).





HILLSHADE MAP - LAKE LONAR

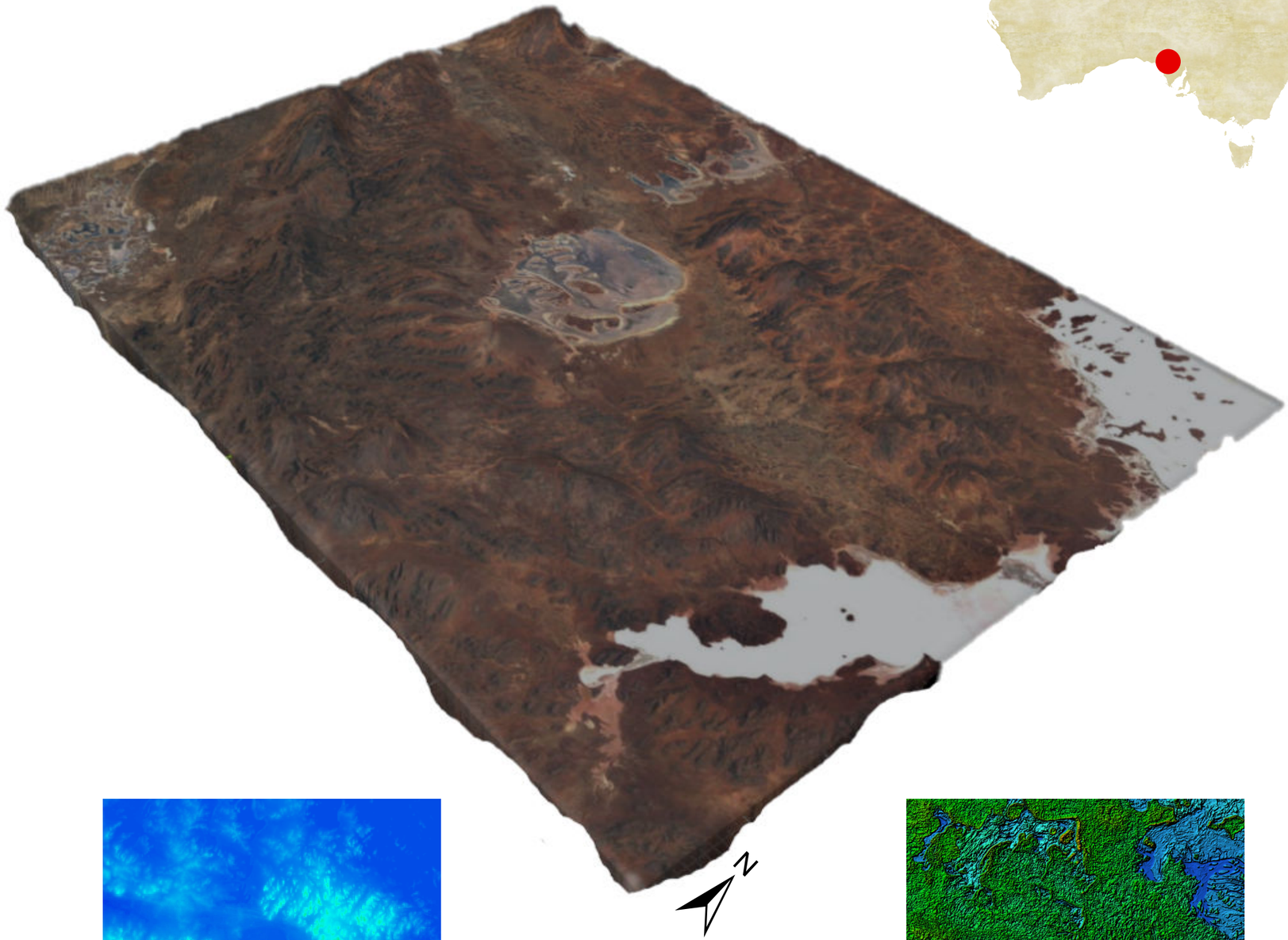
BATHYMETRIC MAP OF LAKE LONAR

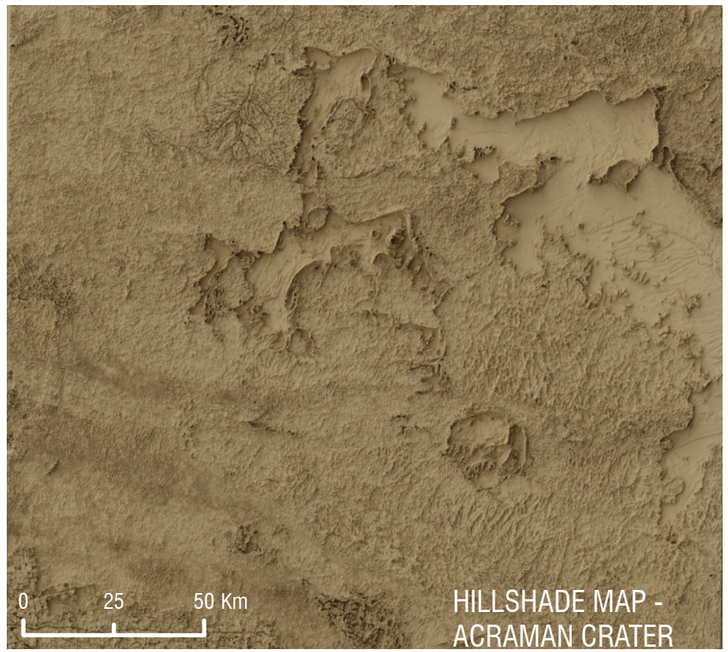
ACRAMAN CRATER, AUSTRALIA

The Acraman crater is a massive geological feature located in the South Australian outback. It is considered one of the most well-preserved impact craters on Earth, and it is estimated to be around 590 million years old. The crater measures roughly 90 kilometres in diameter, making it one of the largest known impact structures on the planet.

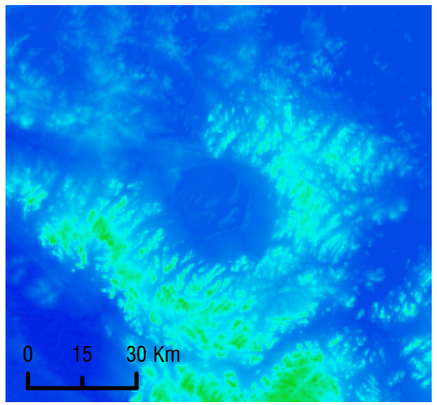
The asteroid that formed this crater is estimated to be around 5 to 10 kilometres in diameter, and it is believed to have been travelling at a speed of 15 to 20 km per second. The event is approximated to have occurred during the Proterozoic era, when the Earth was undergoing significant geological and biological changes.

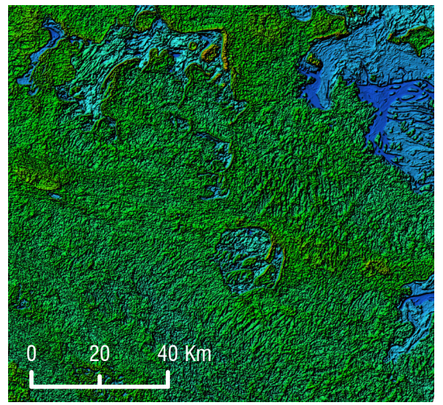
Lying between rocky outcrops and hills, the crater is still visible as a depression in the landscape, surrounded by a ring of elevated terrain that marks the outer edge of the impact structure.





HILLSHADE MAP - ACRAMAN CRATER





BATHYMETRY AND SHADED RELIEF MAPS - ACRAMAN CRATER

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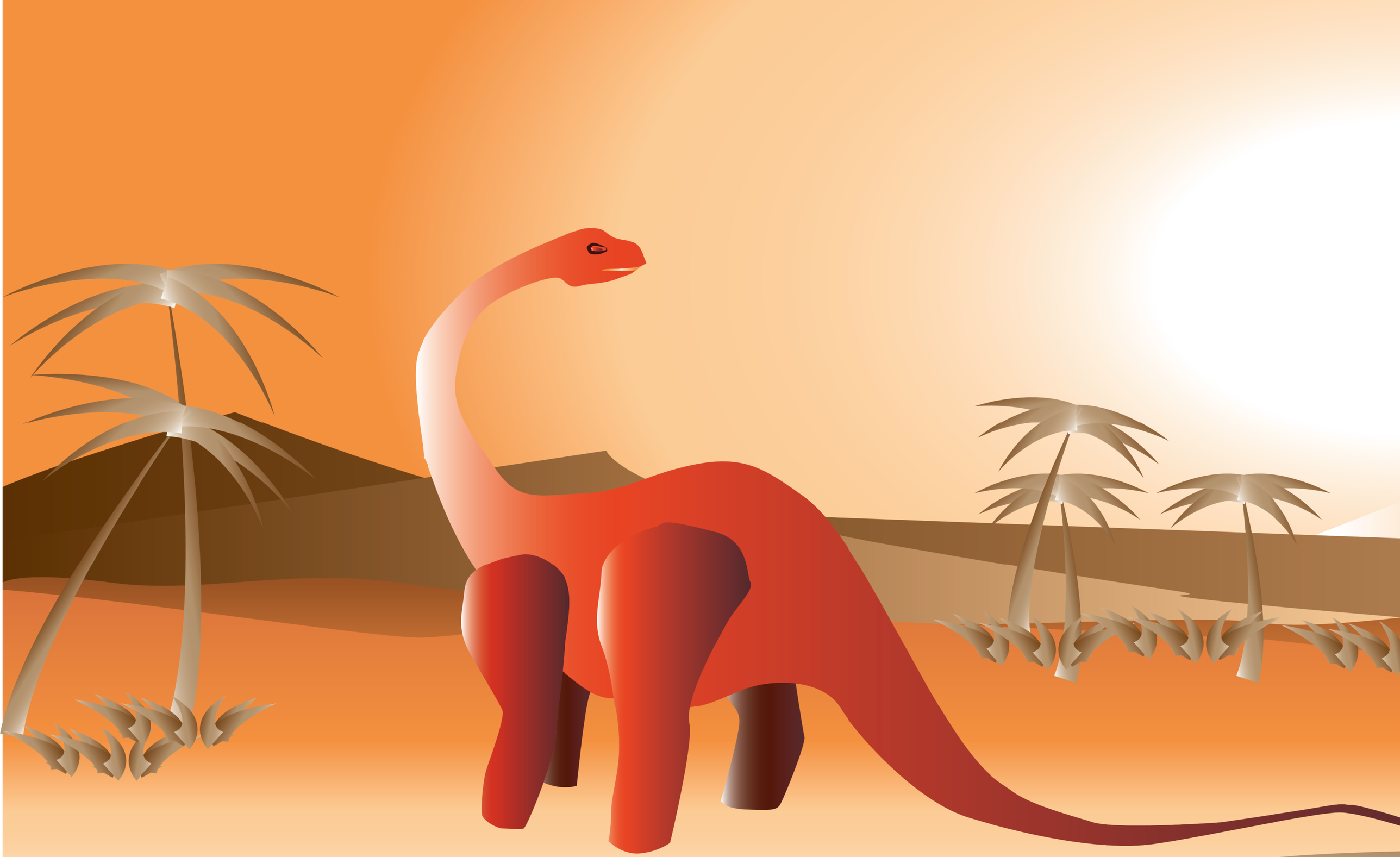
SOFTWARE CREDITS:

1. Cartography - ArcGIS Pro
2. Hillshades & 3D - Blender
3. Artwork – Adobe Illustrator

COVER DESIGN & ARTWORK CREDITS:

S. B. (n.d.). Digital Art. [Adobe Illustrator]



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The product is unedited, unverified and intended for educational purposes only.
Cartography by Sunieti Bhandari, 2023