

# Founding Disasters

From Toba to Burckle's Comet

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Literally yours,  
the book

PS: Don't forget to breathe between chapters

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« *When you don't know where you're going, look where you come from.* »  
Wolof proverb

# Introduction

We were taught history in school. It seemed impossible to change: no one can change the past. However, science helps us understand it differently. History is not a "hard science". Etymologically, it means "investigation", and, as in all literary disciplines, it has its own internal currents and tendencies that sometimes clash.

In the twentieth century, the French "Ecole des Annales" decided to deal with the history of humans and place it before that of nations, battles, or princely genealogies. The result was a very different kind of university education, but sadly our textbooks were hardly inspired by it. The choice of their content seems to be based above all on political objectives: the teaching of recent history varies from one country to another and always aims to glorify a united nation proud of its past.

For a child attending school in France, Antiquity and the Roman Empire are summed up as a succession of battles and struggles between a few monarchs. He or she is never taught about the life of Chinese, Slavs, or Africans at that time. The Neolithic period was concentrated on the Fertile Crescent and the peoples of the Indus or Mesoamerica did not exist. As for prehistory, so many recent discoveries have shed light on it that the knowledge of a professor trained twenty years ago is partly obsolete. Indeed, hard sciences are imposing facts to some historical approximations, they bring new knowledge, and this knowledge is more and more numerous. Maybe history can change after all?

At the end of the nineteenth century, after heated debates, in front of the evidence of geology, most historians finally admitted that ice had covered Western Europe in the Stone Age. By the end of the 20th century, they bowed to the evidence of palynology and accepted that the hardwood trees of the French forests had slowly migrated from present-day China. At the beginning of our 21st century, genetics and climatology are shaking up established dogmas.

Maybe the teaching of history should be a matter of scientific updates? As children, we recited battle dates and genealogies. Our history teacher taught us: "In 105 B.C., the Roman army was defeated at Arausio by barbarians." He didn't tell us why the Cimbri, Teutons, and all the peoples from the shores of the Baltic Sea were moving south. He probably imagined that it was a migration since they were advancing with their weapons, families, and herds. But how could he have taught us that these people were fleeing repeated catastrophic floods since we only became aware of them in 2015?

# Toba

As soon as they are brought to excavate a dig site, paleontologists look for a distinguishable continuous feature: a black layer of nine meters thick in Indonesia, stretching to a few millimeters at the poles. In the chronology of sedimentary deposits, this line marks a date known to all specialists: 74,000 years BC. At that time, a gigantic volcano had erupted: it is called Toba. The ashes that gushed out of its crater covered the entire globe. Wherever we dig, their deposit forms this continuous line, the last remnant of an explosion that nearly annihilated our species.

In his colonization of the globe, man has certainly been inconsistent. He is now being accused of having damaged his planet. One can admit that, until recently, he sinned out of ignorance. The pride of Homo Sapiens-Sapiens is even more recent. We have only started considering ourselves owners of the planet for a very short time: less than three seconds if the first homo had appeared twenty-four hours ago.

Before, humans feared nature. They were afraid of it by experience. Cyclones, earthquakes, or volcanic eruptions would leave traces in our collective memory. We suffered its violence with powerlessness and incomprehension. Evil gods were invented and we started attributing these cataclysms to their anger. It brought us to our knees, then we dressed our wounds. Our survival instinct is more than mere despair. Our immense capacity to adapt put us back on our feet. Our collective intelligence helped us move forward.

In Sumbawa, the eruption of Toba was so powerful that the human species almost disappeared. We were more than a million humanoids, three thousand survived.

## ***Volcano with a Caldera***

It all starts with a column of magma rising from the bowels of the earth. Often, this molten rock stops a few hundred kilometers below the surface. It can stagnate there for millennia. Sometimes it continues its way to the surface: it is the eruption. When the magma column does not open, it forms a hot spot that melts the surrounding minerals. In the intimacy of the earth's crust, an underground lake is formed. This reservoir of heat-melted rock is slowly growing. On the surface, we see nothing. No suspicious heat to alert us. No earthquake is shaking our seismographs. A few kilometers underground, the lake of magma is growing. Its content is so slimy, so thick, that it traps gases. In some thousand years, the pressure becomes colossal. When it increases too much, an explosion occurs. Its energy is gigantic, smashing the vault of the underground lake. The crater can be up to 100 kilometers in diameter. The accumulated pressure triggers eruptions one hundred to one thousand times more powerful than those of traditional volcanoes.

The last caldera volcano that exploded was relatively small. Its eruption began on September 2, 1991, in the Philippines. The Pinatubo killed only a thousand people, ejected only a billion cubic meters of rock, its caldera was only 2.5 km in diameter and its explosion did not even cool the earth by one degree for two years.

Toba had a completely different dimension. Its caldera reached 80 km. Its explosion nearly destroyed the human species.

The eruption lasted nearly two weeks. 8,000 billion tons of sprayed rock were spit out into space and 10 billion tons of sulfuric acid accompanied them. The explosion was so violent that it propelled the whole thing beyond the troposphere into the stratospheric ozone layer. Fortunately, Sumbawa is under the regime of trade winds. The immense cloud,

composed of the 8 million tons of ash that rose every second from the mouth of the volcano, was pushed westward. The Southern Trade Winds initially prevented them from crossing the equator. From 6,000 meters above sea level, strong winds from the upper atmosphere scattered the ashes, mainly to the north and east.

The atmosphere, north of the equator, was filled with a thick layer of volcanic dust. These slowly spread. In two months, they covered the entire globe. Our "blue planet" turned brown. Toba's ejections revolved around it, forming a dense opaque layer. The ashes blocked 80% of the sun's rays. Sulfuric acid combined with ozone to create a perfect screen. No more solar rays reached the earth's soil. The night settled down, continuously. After two years, it was completely dark. Then, little by little, the survivors began to distinguish the sun. It took six years to see it in broad daylight.

Meanwhile, on earth, an intense cold was setting in. The terrible volcanic winter was getting worse. Ocean temperatures were decreasing by 3 to 3.5°C. Terrestrial ones plunged: the Northern Hemisphere's temperate regions suffered a drop from 15°C to 17°C. By accentuating a climatic cooling in progress, the eruption of Toba had instantly provoked a glaciation: the Würm Glaciation.

It was the largest volcanic explosion of the last 100,000 years. It profoundly affected all living things.

Plant photosynthesis decreases by 85% when light intensity drops by 10%. It also decreases as temperatures plunge. With 80% of the sun's rays blocked, photosynthesis became practically zero. It destroyed the tropical forests. In temperate zones, most deciduous trees died and only half of the evergreens survived. In the seas, plankton became rare. In the Indian Ocean, five million square kilometers of underwater life were devastated. The monsoon weakened considerably. The intertropical zone experienced a devastating drought. Herbivores, following the disappearance of their grasslands, perished by the millions. In the absence of their usual prey, the carnivores devoured each other. Homo sapiens disappeared almost completely.

South of the equator, the trade winds had protected the troposphere from ash clouds and the thermal mass of the oceans prevented temperatures from falling too violently. The gorillas and bonobos north of the equator disappeared; in the south, those of Katanga survived. In East Central Africa, some hominids adapted to the cold.

Below the equator, on the high plains of East Africa, grew shrub ferns, plant species that had already experienced the rigors of ice ages during their evolution, they withstood a drop in temperature of 7°C. As there had been fewer ashes in this region because of the trade winds, the rivers were less polluted by ashes. The great depth of the East African lakes diluted the acid rain sufficiently to keep the surface water almost potable. There, mammals whose dens were deep caves shivered, but they survived. Among them, some Homo Sapiens managed to survive below those conditions, thanks to their use of fire and a lot of furs.

### ***How many Survivors?***

At a very distant time, the photosynthesis of plants had allowed the earth's atmosphere to saturate with oxygen, to the detriment of certain living beings that could not tolerate this gas. Symbioses took place. Some anaerobic organisms merged with others, which supported oxygen. The mitochondria, in particular, were poisoned. They found welcoming cells and adapted their DNA to multiply simultaneously as their host cell. Every cell in every mammal is home to them. They are responsible for the transformation of organic molecules into energy. During human reproduction, they are only transmitted by ova, so the mitochondrial

DNA of a human is strictly identical to that of its mother. By studying family trees, we were able to prove that all the mitochondria in our cells come from the same strains. All are from sub-Saharan Africa.

It is difficult to determine the exact number of survivors of the Toba eruption. The official theory is that only Homo Sapiens survived, under the equator, in Ethiopia, Kenya and Tanzania. More recent genetic studies have shown that some Neanderthal, Denisova and Flores men also resisted the freezing cold and the scarcity of food in the absolute urgency and fear of this sky turning dark. However, it is Homo Sapiens who survived in greater numbers. According to the hypotheses adopted, the survivors were between 40 (Harpending, 1993) and 10,000 (Ambrose, 1998). The most commonly accepted estimate is that there were 500 Sapiens women of childbearing age, hence 3,000 survivors, and about 100 Neanderthals and Denisovas. From a population of about 500,000 women before the eruption, just 500 were to be the ancestors of all humanity.

In other words: 99.7% of humans would have died, essentially dying of cold and hunger. Across the land as a whole, plants and animals disappeared in similar proportions. For example, mitochondrial DNA analysis of today's chimpanzees has shown that they all come from two strains. One was located in the highlands of Uganda and the other came from the eastern Democratic Republic of Congo, south of the equator. After this cataclysm, the great apes began westward migrations towards the forests of Central Africa.

Homo Sapiens went in all directions, his greatest migration went north. In the course of his conquest of the world's lands, he – as a couple- will prove again and again the superiority of his creative abilities, discovering new sources of food, new strategies, new processes, and new tools. The survivors first colonized East Africa and then dispersed. But the aggressive attitude that underpinned the conquest of territories by hominids differed fundamentally from the placid migration of the great apes.

### ***Conquering the World, again***

Starting from the Great Lakes, some Homo Sapiens followed the line of the highlands, from south to north, from Kenya to Ethiopia. Vegetation and fauna were recovering. He went up the Nile and crossed the Sinai Peninsula. Then it turned east and spread across the globe. As time went by, the quality of its tools improved. His clothes became more effective. His mastery of fire set him apart. The more we follow its trail in its conquering expansion to the north, the more refined its technology becomes. Having left Africa after Toba, Homo Sapiens adapted to all situations. It took him forty thousand years to extend his territory to every corner of the world. No other mammal has ever been able to demonstrate such amazing adaptability. He came from south of the equator, he was nevertheless able to create a civilization based on the migrations of reindeer towards the Arctic Circle; he delighted in sweet larvae, he learned how to kill sharks with a harpoon; he lived by hunting and gathering, he was going to plant millions of square kilometers of grasses.

Within a few years, hominids had gone from a thriving species to an endangered species. Then, within a few millennia, their ability to adapt enabled them to become conquerors. A few more tens of millennia and the inventive genius of humans would dominate all the mammals of the world.

## ***What if Toba Erupted Today?***

Apart from asteroid falls, most of the abrupt changes in climate over the last few millennia have been due to volcanic activity and all the important ones were the work of caldera volcanoes. Fortunately, caldera volcanoes remain very scarce. There have been a few eruptions in the last 100,000 years. For instance, in 1815, the eruption of Tambora had triggered a "year without summer"; 3,650 years ago, the island of Santorini exploded, putting an instant end to Cretan civilization.

The earth revolves around the sun in a continually changing orbit, from a perfect circle to an elongated ellipse, in fifty thousand years. 76,000 years after the eruption of Toba, our planet is much closer to its star. It is currently spinning practically in a circle: it is more heated. The globe also rotates on itself, around an inclined axis passing through its two poles. The inclination of this axis of rotation relative to the sun means that today, summers are less hot in the northern hemisphere and winters are less cold. And we are not in a glacial age.

If the Toba caldera volcano were to explode now, the impact would be quite different. The volcano would project billions of tons of ejections into the stratosphere. A thick layer of ashes and sulfuric acid would form, which would mask the sun. Average temperatures on earth would only drop by 10°C. After ten years, this global cooling would be only two degrees. Rainfall would decrease by about 45% for several years. Those who have financial means could endure this sudden cold: they would buy warmer clothes, consume more heating and pay dearly for fresh water and food. To give a more concrete order of magnitude: an inhabitant of Naples will have to live for two years as in winter in Montreal and then, for about ten years, as someone living in Hamburg, Germany. Two years of continuous night and intense cold will affect his morale. The intense dust that will be everywhere, even in his bronchial tubes, may weigh him down. Some ash damage will complicate things: house roofs will collapse under the weight, power lines too. Traffic conditions will become... difficult. The pipes are likely less insulated in Naples than in Montreal: they will burst. There will be an insufficient number of Italian snowplows. Stress could be hard to bear but there will be no danger for this Neapolitan's survival: the cold will not kill him. The person who lives in Moscow today is likely to have more difficulty adapting to a temperature drop of about 15 degrees. He will perhaps rush to the option of climate emigration towards the south.

The position of Earth relative to the sun is much more favorable than it was 76,000 years ago. So, what would kill men in large numbers is not the cold but hunger.

## ***The Major Risk is Starvation***

Seven billion people weigh considerably more on our planet today. Under the optimal conditions we know, one billion people are already considered to be undernourished. If the Toba eruption were to occur today, plants would suffer considerably. Rainfall would drop by 45% and our huge cereal and fruit tree plantations would be wiped out. Decreasing temperatures would cause the disappearance of evergreen broad-leaved trees. Virtually all tropical trees would perish. The herbs would not survive for lack of photosynthesis. Rainfalls would become rare but very acidic. Freshwater resources would decrease considerably, also affecting our farms. Deciduous trees would be decimated.

After two years without sun, vegetation would start springing again. Herbs will grow back first, their photosynthesis is weaker than that of trees. The cold will have wiped out the forests, canceling out the cooling effect of their evapotranspiration. Around the 40th parallel, hunting will be reduced, and harvests very poor. However, the world's population has mainly

concentrated in temperate zones. The large northern hardwoods will have been frozen. Those in the intertropical zone will not have endured the cold. Then the earth will present to the sun large areas of grass and young growing trees. It will absorb more energy from its rays than it does today. At the poles, ice soiled by dust will capture more than it reflects. The climate will warm up. And then the climate will balance again: after a few decades, plants will refresh the earth while new ice will mirror the sun's rays. Our star will heat us less and we should finally experience a global cooling of 3 to 5 °C. It's significant, but it has nothing to do with the cataclysm that the Eruption caused 76,000 years ago.

The explosion, today, of a volcano the size of Toba would affect the climate less. Nevertheless, it would still result in a very high mortality rate, mainly due to famine. Computer simulations are incredibly complex. Scientists put forward a wide variety of figures. They often cite the simplest number to remember, one of the low hypotheses: one billion dead.

### ***Are there any Other Volcanoes with Caldera?***

We do not know if one or more volcanoes are hiding under the oceans, but we do know that a super-volcano exists before our eyes. We all know it because on its surface lies one of the most famous natural parks in the United States of America. It is potentially more powerful than Toba. Paleontologists discovered its huge size in 1990. It is the caldera volcano of Yellowstone.

Yellowstone Park covers one million hectares in the U.S. state of Wyoming. The ground is relatively flat, it was chopped by the passage of glaciers in ancient times. You can walk there without imagining that you are walking on a volcano. The caldera is located a few kilometers underground and the landscape does not evoke the steep cliffs of a volcano. It's because everything is excessive. On the horizon, one can see small reliefs about thirty meters high: these are the lips of the crater. The park's postcards often present Old Faithful, a geyser that spits at 55 meters high with great regularity. The wonderful colors of the lake at Grand Prismatic Spring make charming pictures. Everything there seems idyllic. Sometimes an intense thermal activity collapses a path, it is immediately closed to the public. Tourists walk around, enthusiastic, their cameras loaded with immortal memories.

But men are mortal.

Beneath the tourist's sandals lies the largest volcano in the world. In the middle of the caldera, the earth rises continuously at the imperceptible speed of one meter every 75 years. 8,000 meters below, the magma chamber is under high pressure. In the magma at 1,500 °C, the gases are compressed. Five kilometers below the surface, the earth's crust is still at a temperature of 350°C. This volcano is active, devilishly active! Approximately 100 low-intensity tremors shake the soil each year, and this number is increasing. Fumaroles, hot springs, and geysers are all expressions of underground activity. Far below the surface, NASA's infrared cameras have discerned a gigantic caldera of at least 90 km by 30 km. It would therefore be comparable to that of Toba.

Unless extrapolating on the statistics of the last three explosions, it is impossible to predict when the next Yellowstone eruption will take place. We only know that it will be cataclysmic and change the aspect of the world. Man is nothing much when the earth triggers the power of a caldera volcano.

As extraordinary and diverse as it was, the evolution of "Man, the standing mammal" came to an abrupt halt 76,000 years ago when Toba abruptly killed almost all the descendants of Homo Erectus. Scientists call this moment "the evolution's bottleneck". This

near extinction of our species simplifies our family tree: among the 3,000 survivors in the heart of Africa, all had the same morphological characteristics. They all walked the same way, shared the same skin and hair color, all knew how to talk and how to control fire: a stunning simplification for paleontologists!

At the end of a few million years of evolution, a tiny branch of the lineage of the great apes had given birth to a million diverse hominids with contrasting knowledge, lost in the vastness of the globe when a sudden colossal burst of lava, stones, and ashes had summed up everything to three tiny groups of individuals. Practically all the hominids in the world were dead, except our ancestors.

We left the Paleolithic period and entered protohistory. The human species was reborn from a few Toba survivors.

## Further information

The power of Toba is equivalent to the simultaneous eruption of 300 volcanoes such as Pinatubo (1991); or 3,000 simultaneous explosions of (traditional) volcanoes the size of Mount Saint Helens. The quantity of ejecta projected by the Toba eruption in 74000 BC could have covered all of the land that emerged from a mattress more than a meter thick.

The ice age triggered by the Toba eruption is called the "Würm Ice Age". This climate change didn't end until 12,000 years ago, at the end of the Younger Dryas, when the Holocene began.

In 1815, the Tambora erupted on the island of Sumbawa, Indonesia. In the northern hemisphere, the temperatures fell so that stones burst in the August frost in New England, Canada and Western Europe. The world did not know a summer in 1816. A terrible famine developed in Bengal; Foci of cholera appeared and spread; there has occurred the first major cholera epidemic in history. The famine sparked great social movements across Europe. Revolutions multiplied in Spain, Germany, Greece, Eastern Europe, Romania, Italy and Latin America.

In the summer of 1783, the Laki erupted in Iceland. Its clouds cooled the Earth, they were followed by a dry fog which covered Europe. The harvests were abysmal. Hunger became so pervasive that it is known to be one of the main causes of the French Revolution of 1789.

In 1453, the Kuwae erupted. Earth's climate cooled down three degrees. Ashes covered the sky above Constantinople. The sun made it take on a bloody red color. The population, which was besieged by the Turks, would have interpreted this phenomenon as a very bad omen. Folks would have fled at nightfall, leaving the gate of Kerkopoporta open. The Ottomans would therefore have crossed its impassable walls without striking a blow. It was the end of the Byzantine Empire.

In 1258, a caldera volcano exploded in Indonesia on the island of Lombok. The eruptive plume rose to 43,000 meters, the ash cloud obscured the moon. It has been the biggest volcanic eruption of the last millennium. Chinese and English temperature readings allow to locate it in January 1258. The rains and cold were particularly intense, which triggered immense famines (a third of the inhabitants of London died of hunger). An epidemic of murrain attacked the herds of sheep, the prolonged frost killed the cows. Iceland was cut off by the ice. A plague appeared immediately and, after a harsh winter, spread from April 1259; from the Middle East to Europe, the epidemic decimated the population. The Mongolian army entered Baghdad but, for lack of food, stopped its conquest of eastern Europe. The intense cold that resulted from this eruption caused the planet's cooling to accelerate towards the Little Ice Age.

If the last two eruptions of caldera volcanoes, Pinatubo (1991) and Tambora (1815) were lethal, it was mainly indirectly: they triggered the prolonged installation of the climatic phenomenon of El Nino. A severe drought followed in the tropics (Gagan, 1995), the volume of precipitation having halved (Pittcock, 1989), causing severe famines.

Harwell (1984) studied the impact of temperature on tree death. He did not take into account the impact of sulfur-containing acid rain. Nonetheless his work sheds light on the impact of a variation in the Earth's average temperatures of a few degrees on plants:

If temperatures dropped by 3 ° C for 5 years, the biomass of trees in temperate zones would decrease by 25% and the forest would regain its volume after about fifty years. In the case of grassy ecosystems, a drop in temperature of 3 ° C would decrease biomass by 9%.

In the event of a drop in temperature of 6 ° C, the biomass would drop by 80% and only regain 50% of its initial volume after 50 years.

If temperatures were to decrease by 9 ° C for 5 years, 90% of the biomass would be destroyed, only 33% of the initial mass would be found after 50 years. And grassy systems would see their biomass decrease by 51%. (In Europe, the Toba eruption cooled the land by 16 ° C!).

Fossils of hundreds of dead mammals have been found, killed by an eruption of Yellowstone 10 million years ago: their lungs had been lacerated by volcanic dust, they had died from coughing out their blood.

Yellowstone has already erupted 1.8, then 1.2 then 0.64 million years ago. During this last explosion, the volcano had ejected 2,500 billion cubic meters of magma (almost as much as Toba: 2,800 billion).

A caldera volcano only slightly smaller in size is found in New Zealand, below Lake Taupo. He is watched like milk on fire. It has erupted roughly every nine hundred years (for 27,000 years), but it has been 1,700 years since it exploded.

Of Toba only one large lake remains, on the surface. In the depths of the earth, in the same place, a new caldera volcano is being reborn. It has experienced a few severe earthquakes (up to magnitude 9 on the Richter scale) but does not seem to worry vulcanologists.

In 2012, an active caldera 13 km in diameter was discovered, a few kilometers from the city of Naples (Italy), its lake of molten rock is still growing.

This is not an established rule, yet it seems that eruptions of caldera volcanoes are so powerful that they always induce associated eruptions or earthquakes (sometimes over 10,000 km apart).

Homo floresiensis has also survived Toba but has remained, indefinitely, in the forest of the Indonesian island of Flores, until its extinction around 16,000 BC. The eruption of Toba would have put an end to practically all the other lines of Homo erectus, including those of which we recently discovered skeletons (Morocco, Georgia, China, Mongolia...). Hopefully archaeologists will uncover other species of Homo that survived Toba. Geneticists have discovered that Denisovans also descended from Homo erectus.