ISSN: 2639-7455

Research Article

Earth & Environmental Science Research & Reviews

Unforeseen Connections and New Points of View to Promote Interest and Passion for Earth Sciences

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Submitted: 2023 Dec 30; **Accepted**: 2024 Jan 25; **Published**: 2024 Feb 06

Citation: Occhipinti, S. A. (2024). Unforeseen Connections and New Points of View to Promote Interest and Passion for Earth Sciences. *Earth Envi Scie Res & Rev, 7*(1), 01-07.

Abstract

This research is a first result of the initial findings of an ongoing, in-depth inquiry among scientific texts and historical documents, which are revealing surprising discoveries on the fundamental role that Earth sciences have played in shaping historical events, influencing social dynamics, and impacting culture and the arts. This perspective is often overlooked in the conventional understanding of this discipline. This research does not claim to present groundbreaking discoveries or original research but seeks to highlight a totally different aspect of Earth sciences and to present it from a completely original point of view. While it is widely acknowledged that Earth sciences play a crucial role in understanding natural phenomena, global dynamics, and natural risks and hazards; their significant contributions to addressing contemporary challenges such as global warming, extreme weather events, land consumption, and biodiversity loss are less recognized. These issues are vital for environmental protection and sustainable development. Despite this, years of teaching students of all ages, engaging them in practical activities and laboratory experiences across various Earth science fields with the aim to promote knowledge, interest and, when possible, passion for this fascinating discipline, have shown that, if communicated without passion the subject can be perceived as undeniably and inevitably boring-seen merely as a discipline dealing with stones and catastrophes, complex and complicated. This research attempts to offer a new perspective on Earth sciences by providing an effective interpretation of geological phenomena, organizing them according to a logical classification, by typology or by temporal sequence. Natural disasters, such as volcanoes or earthquakes, in some cases well known, instantaneous or long-lasting events, are portrayed as unpredictable yet indispensable causes of events that, at first glance, may seem unrelated to Earth sciences but have profoundly influenced human history and culture. This research aims to present a collection of information to educate about 'stones and catastrophes,' demonstrating how Earth sciences, through this unconventional lens, serve as a founding role of various disciplines. They promote the development of skills, both hard and soft, and stimulate curiosity, with the hope of guiding individuals towards a complex yet fascinating discipline."

Keywords: Unforeseen Connections-Natural Catastrophes and Human History

Introduction

For many years my professional career, as a science teacher, as a facilitator of workshops in schools, but above all as a geologist, has kept me committed in promoting interest in Earth Sciences among students of different ages, schools and even among the public.

This experience, which has now lasted decades, has led me to confront the various problems that meet in dealing with and proposing the contents of this discipline, so rich in suggestions, but not always loved. I have tried to make it appreciated and to instil passion, in particular in the students, towards issues that, moreover contained in the curriculum of Earth Sciences, that touch on the major environmental issues: hydrogeological instability, natural hazards, and the climate emergencies that are affecting the Earth in these years, and which inevitably lead to the UN Agenda 2030 SDGs, Sustainable Development Goals.

I have tried to raise awareness of a discipline that seems complex and complicated, and so it is in the original meaning of these terms: cumplexus, therefore "intertwined" and cumplicato, that is, "folded

together" because all the branches of the Earth Sciences are closely linked, connected, and intertwined, as they are with the: biology, chemistry, or physics. But above all, I tried to grow passion for a discipline that, due to its extension, in the space and in the time is able to develop knowledge, skills and competences that are quite exceptional and specific: in space, because it develops from the Earth's core to the boundaries of the Solar System and beyond, if it is recognized that even extrasolar planets have geological aspects to consider, and in time, because its contents unfold from the formation of the Solar System to the present day and certainly to the near future, for nearly 5 billion years.

Developing an understanding of deep time in a culture focused on the present poses a significant challenge for those dedicated to promoting Earth Sciences."

First steps towards a new point of view

In order to overcome the belief among the students that Earth Sciences is a discipline that deals with stones and catastrophes, which offers collections of minerals and rocks, collected in ancient cabinets, dusty samples, which require knowing how to classify, recognize structures and memorize the nomenclature, activities that often fail to spark curiosity and enthusiasm. Initially, simple learning objects were identified, Learning objects, sometimes banal, always made with poor materials, but which have proven to be effective in promoting the understanding of global dynamics, of natural phenomena, which may not always facilitate practical experimentation and the application of investigative methodologies, but which have managed to intrigue students of different levels of education, promoting some specific skills, also through the manipulation of materials.

This approach has become necessary even though we are living in a historical moment in which catastrophic events are repeated with dramatic frequency which, although falling within the cyclical "normality" of geological dynamics, are the cause of extraordinary tragedies; the use of these objects proves to be effective every time, in particular to make it clear that Earth Sciences are an exciting and certainly not boring discipline, capable of developing fundamental concepts of cause-effect relationships or complexity, just as Thomas Kuhn in his work The Structure of Scientific Revolutions (1962) defined Plate Tectonics: A profoundly revolutionary theory – a new paradigm "because it forced us to rethink almost all the great themes of geology, from tectonics to orogeny to biogeography".

But in many science curricula in various school systems, the study of these phenomena volcanic buildings and their types, seismic waves and their magnitude, are proposed as separate entities, disconnected from global dynamics, from the Theory of Plate Tectonics; they reappear, in a completely marginal way, as an effect of the action of convergence or divergence at the edges of the plates and not as an integral part of the global dynamics, which give reason for their existence. The perception is often that the Earth Sciences are made up of fragmented contents, dramatically guilty of events that mark the history of humanity and of our lives, but devoid of scientific contents, when instead they constitute a unicum closely connected by causal links, in a system that sees branches of Geosciences intertwined with all scientific disciplines, but also with many humanities, in a complex and interconnected system, in space and time. This vision severely limits its appeal, interest, desire to discover, to deepen, to research: to passion.

A transversal and interconnected vision of all disciplines, both scientific and non-scientific, and therefore also of Earth Sciences is needed; it is necessary to develop connections, manage information in an effective way, allowing, for example, the understanding of the close intertwining that binds the historical events of the 20th century and the discoveries that have contributed to build the puzzle of knowledge that has allowed to assemble a global dynamic model, the Theory of Plate Tectonics.

In a different historical context, many discoveries would not have had the opportunity to be born, grow and develop, to elaborate theories, to build complex systems. But the opposite relationship is also true: knowledge, discoveries and even scientific events have radically changed history, and perhaps have also acted on other cultural and social fields.

Obviously, this different point of view in the Earth sciences cannot replace the basic knowledge of geological phenomena: plate tectonics in general, natural hazards, the atmosphere, and the hydrosphere, which constitute the bases without which it is difficult to recognize cause-effect relationships or of complexity. The entire history of the Earth, since its formation, is the result of countless geological events, volcanic eruptions, earthquakes, meteorites, landslides, faults: catastrophic events that have caused radical transformations of the natural environment, both geological and biological, which may have taken millions of years, such as an orogeny or the opening of a rift, or just a few moments, such as an earthquake.

The aim of this research is to help people understand the complexity and uniqueness of the Earth System and global dynamics, through a sequence of cause-and-effect relationships, concepts that are clear to geoscientists but little and poorly understood due to the transmissive teaching of schools in many countries.

A different organization of discovery and learning paths, built through logical steps and historical connections, can make us discover how Earth sciences can represent a founding nucleus for the understanding of past and recent historical or cultural events, sometimes predictable and known, sometimes completely unforeseen. These are events, relationships, and connections known to many, especially geoscientists; in fact, the aim is not to surprise with great revelations but only to try to organize in time, type and effects a sequence of events that would otherwise risk taking on an anecdotal aspect, certainly interesting but not very effective if the goal is to provide a different point of view of the Earth Sciences, that makes them more fascinating for those who find them boring and unattractive, more meaningful and fundamental for those who find them marginal in the vast context of the sciences.

Unforeseen Connections Between Volcans And Humanity

It is well known that volcanoes, and especially the products of their eruptions, have played a fundamental role in Earth's history. They are responsible not only for fundamental actions on the activation of plate tectonics but also for the contribution of many elements and chemical compounds, such as water vapor and carbon dioxide, cause for the greenhouse effect and therefore for the habitability of our planet. Additionally, volcanoes have contributed nutrients that have made the Earth's crust fertile. They have been the cause of mass extinctions and climate change, and perhaps also played a role in the formation of the first organic molecules.

However, eruptions throughout geological and historical eras have had varying consequences, some predictable and others unpredictable. In the following lines, we will present some examples of these consequences, drawn from a much broader range of cases that will be explored in a more detailed publication."

The Tambora volcan eruption - April 1815

The case of Tambora represents the best-known example of a "year without a summer", due to the complexity of the events unleashed by its eruption in 1815. For this reason, it is presented separately from a historical timeline, which will be respected in subsequent examples. Between April 5 and 15, 1815, the Tambora volcano on the island of Sumbawa in Indonesia, erupted, spewing large amounts of volcanic ash into the upper layers of the atmosphere. The eruption was 10 times more powerful than the subsequent one of Krakatoa; moreover, the Soufrière volcano on the island of Saint Vincent in the Caribbean in 1812, and the Mayon in the Philippines in 1814, had already erupted abundant dust into the atmosphere, whose sulphur compounds have been found in the ice of Greenland and have been attributed to the same age. As is always the case after major volcanic eruptions, the global temperature dropped as sunlight struggled to pass through the atmosphere clouded by ash and dust.

These phenomena overlapped with the Dalton Minimum, a period of low sunspot numbers and consequent low solar activity from about 1790 to 1830, during which the sun is believed to have emitted less energy. At that time, moreover, the Little Ice Age was still underway, the general cooling period of the planet that, from 1600 lasted until at least 1850. The year 1816 will therefore be defined as the year without summer, but its consequences will continue for the following months, triggering events that conditioned human history and culture. During this eruption, severe anomalies in the summer weather destroyed crops in Europe and North America. People were hit by great poverty; farmers faced great hardship and many cattle died. Large storms, abnormal rainfall and flooding of major European rivers are attributed to the eruption of Tambora, which was also the cause of dirty snow in Hungary. Also in Italy, due to the ash present in the atmosphere, red snow fell for about a year. Food riots occurred in Britain and France, and grain warehouses were looted.

These climatic conditions and the widespread lack of food prompted many inhabitants of the Italian peninsula to emigrate to America in the hope of finding a better world: in October 1816 the authorities of the Duchy of Genoa noticed a considerable increase in applications for passports to the Americas in the port registers. However, when migrants reached U.S. shores, they discovered that weather conditions had caused poverty and hunger. Many historians cite the year without a summer as the main reason for the "conquest" of the American West The following year, a group of English writers engaged in the Grand Tour stopped to spend the summer at Villa Diodati near Geneva, which had been rented by Lord Byron. Mary Shelley and John Polidori reunited, along with other guests who, unable to spend their days on the lake due to bad weather, decide to challenge each other to write the scariest novel. Two of these tales became exemplary works for the genre of gothic horror, notably Mary Shelley's Frankenstein and John Polidori's Dracula the Vampire, which was the first modern vampire-based tale. Children's literature was also indirectly influenced by the eruption of Tambora. The Brothers Grimm published the first unabridged edition in 1815, a collection they called Fables of the Hearth, many of which were set in cold and certainly unwelcoming climates.

The lack of fodder inspired Baron Karl Drais to look for new means of horseless transport, leading to the invention of the Dandy horse or velocipede, the prototype of the modern bicycle and giving a decisive impetus to subsequent motorized means of personal transport. Also in 1815, another historical event deserves to be remembered for its possible relationship with the eruption of Tambora and the climatic consequences: the defeat of Napoleon at the Battle of Waterloo. His war strategy was to move his troops quickly on the battlefield to defeat the enemy army, but in that particularly rainy year, on the night before the battle, numerous storms of great violence swept over the countryside where Napoleon's troops were camped. The rains made the ground muddy and the French cavalry, generally Napoleon's winning weapon, could not move because of the mud and the artillery was ineffective because of the muddy terrain.

These, like others, are hypotheses and not certainties, but it is interesting to think that a volcano on the other side of the earth may have conditioned the history of Europe.

Painting will also be affected in some way: the high levels of ash in the atmosphere made the sunsets of that year spectacular, with red and yellow colours, linked to the refraction effects produced by atmospheric dust, which are found in the paintings of J.M.W. Turner. Also, in 1832 the Babuyan Claro volcano in the Philippines lit up the skies of Turner’s works with the red and yellow that Turner painted. Equally well-known is the link between the eruption of the Indonesian volcano Krakatoa in 1883. It was one of the largest volcanic eruptions in history: it developed a power of 200 megatons, expelling about 21 cubic kilometres of rock, ash, and pumice stone. In this case it was the Norwegian painter Edvard Munch who was struck by the colours of the sky and in his various

reproductions of "The Scream", the constant and colourful sky with its oblique stripes accentuates the anguish aroused by looking at the screaming figure.

Figure 1: the Tambora eruption

Figure 2: The typical colours of Turner's painting

Figure 3: The Dandy horse

The Toba Volcan eruption 75.000 to 70.000 years B.C.

Between 75,000 and 70,000 years ago, under Lake Toba, located on the island of Sumatra, a supervulcano erupted that was probably the largest eruptive event of the last 25 million years and made the climate of the planet already affected by the Wurmian glaciation even harsher. The catastrophic eruption produced 800 cubic kilometres of ash into the atmosphere, triggering plummeting global temperatures. Perhaps one of the peaks of the Wurmian glaciation, called Tahoe, was a consequence of the super eruption of Toba. These huge amounts of aerosols in the atmosphere decreased sunlight by 25 to 90 percent. In these climatic conditions, some molecular data attest to a decline in the population of Homo sapiens, an evolutionary bottleneck that sees a drastic reduction in the population and therefore a restart from the few survivors of the cataclysm. According to this theory, such an event left very serious consequences throughout the world's ecosystem at the time, bringing many organisms to the brink of extinction.

The human community in East Africa, which is thought to have been one of the largest of the period, naturally suffered the impact of the volcanic eruption, the consequences of which lasted several years and were so severe that they seem to have brought man to the brink of extinction. According to a much-debated theory, the Toba catastrophe was mainly responsible for the reduction of the species of human beings that populated the planet to a few thousand specimens: Homo erectus began a slow decline that lasted about 40 thousand years, mainly due to competition with Homo sapiens for the search for food. Specimens of H. erectus were larger and stronger than those of H. sapiens, but they were less intelligent. Homo sapiens was able to adapt even to complex scenarios thanks to the possibility of elaborating ideas and being able to communicate them in a simple and effective way to their peers. This bottleneck that has limited the number of individuals in the human population could partly explain the low genetic variability in our species. Homo erectus disappeared from Asia about 30,000 years ago, although some of their descendants seem to have survived on the island of Flores in Indonesia, which also probably disappeared due to an eruption, that of the Flores volcano.

The Thera volcan eruption 1456 B.C.

Around 1456 BC a catastrophic explosion of the Thera volcano, on the present-day island of Santorini, in the Cyclades archipelago, led to the almost complete destruction of the island. Plato recounted the dramatic and sudden eruption, although it was likely preceded by numerous premonitory tremors for a few weeks.

The volcanic activity, which prompted the population to flee Thera and seek refuge in Crete, began with a paroxysmal phase featuring a shower of pink pumice, renowned on the island, followed by a subsequent explosion: a jet of compressed materials and superheated gases that reached the stratosphere."

The explosion triggered a tsunami in the Aegean Sea that devastated coastal regions; recently, a group of Greek geologists identified traces of those gigantic waves on the coasts of Turkey which propagated across the Aegean Sea in just two hours, while an ash fallout over a large area up to the coast of Anatolia impacting ancient cities and contributing to climate change." Santorini was a naval base of the Minoan Empire and the date of the destruction of Thera, with the consequent tsunami seems to coincide with that of the progressive disappearance of the Minoan civilization that was prospering thanks to trade, and its supremacy in the Mediterranean, with the consequent rise of Mycenae.

The Mycenaean civilization was a dominated by a warrior aristocracy that extended its dominion over Crete, the centre of the Minoan civilization, weakened by the eruption of Santorini. Recent scientific studies have dated the explosion to 1645 BC. While some scholars argue that there is a significant gap between the natural catastrophe and the decline of the Minoan civilization, it is clear that the volcanic eruption and ensuing tsunami significantly impacted coastal cities, which were major ports, contributing to

the civilization's decline."

The event in Santorini also coincides chronologically with some episodes narrated in the Bible, the 10 plagues of Egypt: volcanic ash may have blocked sunlight causing the plague of darkness and acid rain; a consequent increase in precipitation and humidity may have favoured the development of locusts; the proliferation in the waters of toxic algae, the Oscillatoria rubescens, which at death make the water red and poor in oxygen, may have forced the frogs to leave the water in which they lived, the uncontrolled proliferation of flies and other insects, which would lead to the next two plagues: livestock deaths and ulcers on animals and humans. Environmental conditions may have favoured the development of Clavicex purpurea in rye, the so-called "ergot" with which breads were produced, reserved for first-born males and for this reason they would have been the first to fall victim.

The Okmok volcan eruption 43 B.C.

In 43 B.C., the eruption of the Okmok volcano in Alaska caused, as often happens, a sharp drop in temperatures, resulting in famines in many parts of the Earth.

Due to the abundance of available documents, it is known that the eruption had significant consequences on the social and political context of Mediterranean societies during this period: in particular, the sharp reduction in temperatures caused severe famines. The period following the assassination of Julius Caesar, on the Ides of March 44 B.C. C., is described as a two-year period characterized by unusually cold weather, poor agricultural yields, famine, and political instability in the Mediterranean area.

This period marked the beginning of a 17-year struggle, which led to the end of Republican Rome in 27 B.C.E. and the collapse of the Egyptian Ptolemaic kingdom. It culminated in the rise of the Roman Empire, a new form of political authority that fundamentally altered the course of history."

The Samalas volcan eruption - 1257 AD

The 1257 eruption of the Samalas volcano, located in Indonesia on the island of Lombok, was one of the most violent eruptions of the last 7,000 years, eight times more powerful than the Krakatoa explosion in 1883, ten times more powerful than the Tambora eruption of 1815.

As is normally the case with volcanic eruptions that produce large amounts of dust and ash in the atmosphere, the climate has changed, and temperatures have dropped. In 1258 in Europe the crops did not ripen due to the cold, famine killed a third of the population of London. Around 10,500 skeletons have been found in the Spitalfields market area and St Mary's Spital Hospital, but the remains suggest the presence of over 18,000 bodies. Until recently, it was believed that the cause was the Black Death outbreak, but references to the great famine of 1257-58 have been found in documentary evidence, particularly in Babad Lombok, a 13th-century Javanese text written on palm leaves that tells of a "phenomenal eruption" that profoundly changed the climate of the time.

The Laki volcan eruption- June 8th, 1783
Laki is a volcano in southern Iceland. A series of phreatomagmatic explosions erupted 14 kmc of basalt from a huge linear crater. Throughout the entire eruptive episode, which concluded in February 1784, volcanic ash reached a height of 15 kilometres and dispersed throughout the northern hemisphere.

Volcanic gases formed what became known as the Laki haze over Europe, a toxic blue fog, which hung in the skies for months. Contaminated grazing killed more than 50% of the Iceland's livestock, causing a famine that claimed the lives of more than 20,000 inhabitants. The following winter was extremely harsh: in Central Europe there was heavy snowfall; the aftermath of the eruption did not cease when the cloud dissipated.

In 1785 the climatic conditions that affected France changed with and warmer climate that favoured agriculture, generating an abundance of crops and a fall in the prices of products.

But in the following years, agricultural production was penalized by summer drought, excessive cold in winter and violent hailstorms that devastated crops. In this context of famine, the French Revolution broke out in 1789. These climatic alterations were described and commented on in European newspapers, but no one linked them to the eruption of the Laki craters except Benjamin Franklin, at a scientific assembly held in December 1784.

Unforeseen Connections Between Earthquakes and Humanity

The impacts of earthquakes on society, people, buildings, and the economy are always inevitably dramatic. Their outcomes can vary, depending on the level of attention that populations and their governments have paid to complying with anti-seismic criteria for constructing buildings. But some earthquakes and their aftermath, especially when tsunamis are triggered, inevitably result in devastating effects. In the case of earthquakes, it has been more difficult to discover unexpected connections, since the dramatic effects overshadow any positive outcomes. The loss of human lives, the destruction of goods, including historical buildings, certainly cannot represent a positive event, but sometimes they can have, in once again unpredictable areas, impacts on the social and cultural history of humankind. In this case as well, only a few examples are presented from the collected data; as mentioned, the logic followed is the timeline, although the dimensions and effects could be very different.

The Troy earthquake, 1300 BC

Greece and the Aegean Sea were hit by a series of earthquakes from 1225 to 1175. In addition, a significant climate change was taking place that led to a severe drought: in the entire eastern Mediterranean region, between the late thirteenth century and the early twelfth century BC, fertile lands turned into deserts, leading to severe famines. Troy, already weakened by this food crisis, was

hit by several earthquakes: particularly the level of the city that is identified with phase VI, attributable to the thirteenth century BC and which was probably that of Priam, was not destroyed by invaders, but by an earthquake; the earthquake may have facilitated the conquest by the enemies.

Later the seventh city was rebuilt, which was destroyed around 1190-1180 BC by a fire following a siege, probably by the sea peoples and not by the Mycenaeans, who were already in a strong social crisis.

The Noto earthquake, 11 January 1693

Eastern Sicily is one of the most seismic areas in Italy. Already in 1169, a strong earthquake was recorded in this area, which caused at least ten thousand victims and destroyed entire cities. In 1693 a terrible seismic sequence flattened approximately seventy cities in south-eastern Sicily, in the area from Catania to Ragusa, and particularly the Val di Noto. The earthquake had a heavy impact on the social structure of cities, also due to the high number of victims, about 60,000. In Catania at least 12,000 people died. Following the earthquake, however, the Val di Noto underwent a reconstruction process that will see the birth of a historical heritage of great value, one of Italy's most stunning examples of Baroque architecture.

Noto will become a stone garden due to the beauty of its new buildings and Catania will be rebuilt according to a new architectural and urban plan, with completely new road layouts. Noto has been a UNESCO site since 2002.

Figure 4: The Baroque architecture in Noto

Figure 5: The Lisbon earthquake

The Lisbon earthquake November 1st, 1755

Lisbon was devastated by an earthquake, with its epicentre approximately 200 km off the Portuguese coast, which caused a tsunami with waves up to 20 meters high that reached and destroyed the city centre. Lisbon was a city still heavily conditioned and controlled by the Holy Inquisition, which attributed the earthquake to God's response to the "spread of heresies and lasciviousness," and as revenge for the massacre of the Indians by Portuguese soldiers. But after the emergency phase, a radical reconstruction transformed Lisbon, a process that made it a more resistant, orderly, and modern city; The ancient medieval and Arab alleys were transformed into a modern city. The new buildings were designed using state-of-the-art anti-seismic techniques: to simulate the effects of the earthquake, cavalry was galloped close to the houses causing vibrations. Finally, it was possible to contain the influence of the church and the aristocracy and to promote the economic development of the city. The reconstruction after the terrible earthquake caused a great socio-cultural upheaval, which would transform Lisbon, the seat of medieval obscurantism, into the cradle of modern rationalism, owing to the presence and influence of Voltaire.

Unforeseen Connections Between Magnetic Field Inversion and Humanity

Changes in the magnetic field may also have caused widespread climate upheaval resulting in extinctions. Research suggests that a weak magnetic field could lead to severe climate impacts: ionizing radiation can cause significant damage to the ozone layer, allowing ultraviolet rays to penetrate, altering the way the Sun's energy is absorbed by the atmosphere. A strongly ionized atmosphere could also have generated bright auroras around the world and produced frequent electrical storms. A relatively recent and brief polarity reversal, the Laschamps excursion, which occurred between 41,000 and 42,000 years ago, could for example be related to changes that occurred on Earth at that time. During this period, Australia's megafauna began to go extinct, as did European

Neanderthals: their decline may have been accelerated by climate change in their ecosystems. Another significant event during this period is the appearance of rock art created by Homo sapiens in various locations around the world. The first examples of the use of red ochre date back to this period: researchers hypothesize that it had a function of protection from the sun's rays, a practice still present in a modern indigenous population in Namibia.

Conclusions

Numerous other unpredictable connections between natural, geological, astronomical events and humanity have been acknowledged: for example, we can recall the fall of the meteorite of The and the collapse of the walls of Jericho. Of great relevance is the relationship between the formation of the Great Rift Valley, which began about ten million years ago, which led to a progressive drying up of the easternmost territories of the African continent, fragmenting the rainforest and then replacing it with grasslands and savannahs, and the development of Australopithecus afarensis, which fossils are found mainly in the Rift Valley. Endowed with bipedalism, a broader vision, efficient body cooling, in socially complex groups, a mixed diet rich in animal proteins developed to the advantage of Austrohalopithecus robustus, whose fossil traces are found mainly in the deposits of the nearby highlands.

Finally, the unpredictable but more than certain connections between climate change and human history; another work will be dedicated to this, in progress, but even more documented.

This different approach to Earth Sciences, while not entirely new, is often underutilized in teaching and communication practices: it can represent a fundamental resource to bring students and less experts closer to this discipline, to discover its importance, not only as a science of "stones and catastrophes", but as a founding node of events that have determined the formation and evolution of the Earth, of its abiotic and biotic components, but above all of humanity.

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