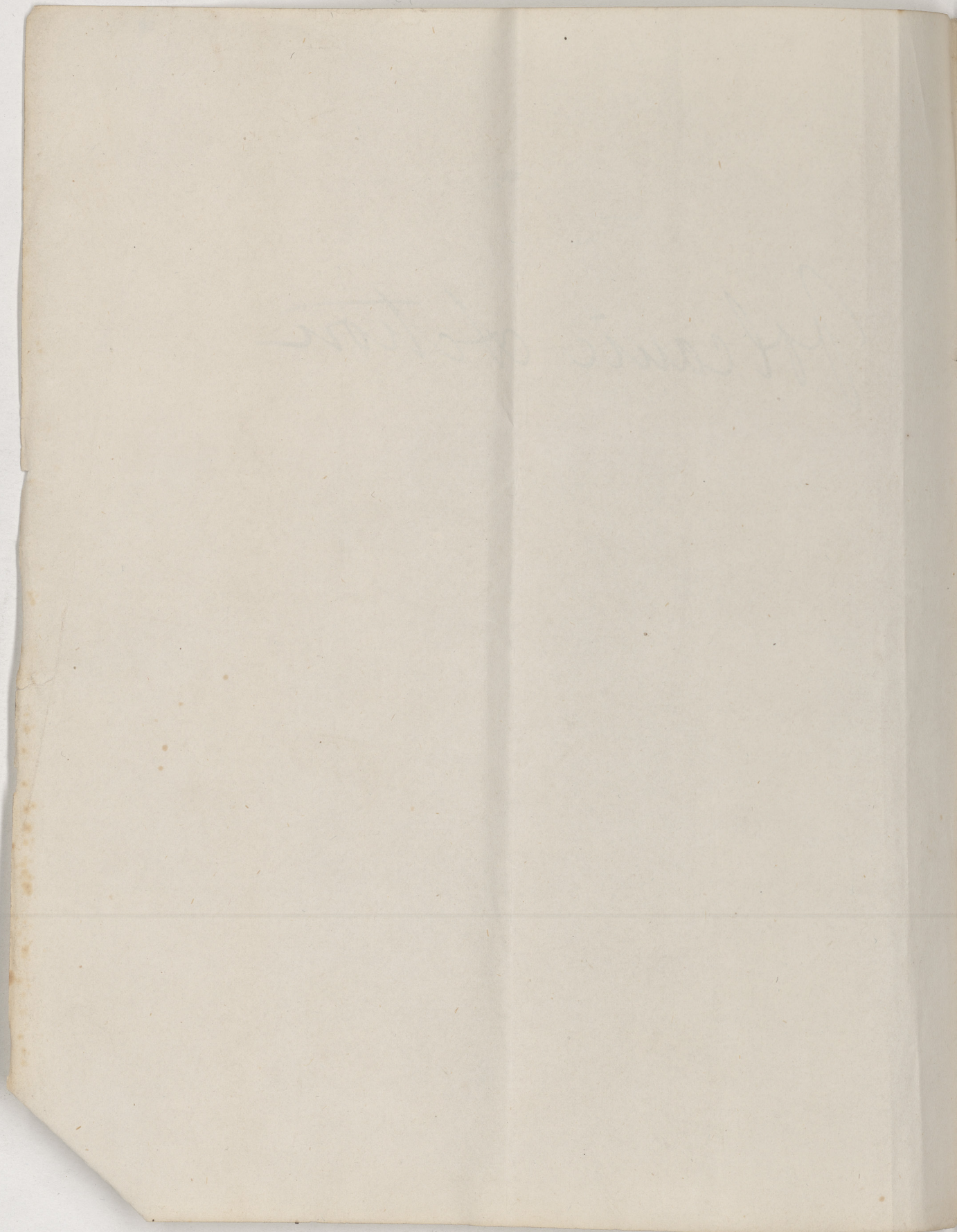


Volcanic Action



Volcanic Action

To many of my audience the title of this paper may seem strange and even inappropriate. It was my first intention to call it on fire or volcanoes. But as these would comprehend only a very small part of the effects of volcanic action. I concluded to select the latter. In the sense in which I wish it to be understood it includes the temperature of the interior of the earth the changes that go on and their effect upon the surface of the subject is a summary of nearly a collection of natural facts and hypotheses and containing one or more of conflicting statements it is difficult to reduce it to any thing like a systematic arrangement.

That order which appears most proper in my opinion is

- 1 The probable causes of volcanic action
- 2 The manner of its operation
- 3 The effects which it has produced and is now producing

This order I shall follow with a little reference to the probable particular volcanic eruption in relation to them must be familiar to every student of any course in

Volcanic Action

To many of my audience the title of this essay may seem strange and even inappropriate. It was my first intention to entitle it an essay on volcanoes. But as these would comprehend only a very small part of the effects of volcanic action I concluded to adopt the latter. In the sense in which I wish it to be understood, it includes the temperature of the interior of the earth the changes then going on and their effects upon the surface. This subject is one consisting of merely a collection of scattered facts and hypotheses, and containing one in front of conflicting statements it is difficult to reduce it to any thing like a systematic arrangement.

That order which appears most perspicuous is to consider

- 1 The probable causes of volcanic action
- 2 The manner of its operation
- 3 The effects which it has produced and is now capable of producing

This order I shall follow with as little reference as possible to particular volcanic eruptions as accounts of them must be familiar to every individual of my audience.

The causes of volcanic action have always been and probably will long continue to be involved in obscurity. This has arisen partly from the depth at which they are seated and the difficulty and danger attending their investigation and partly from the superstitious notions, which have been entertained respecting them. There has however been no scarcity of theories professing to disclose them although nearly all from the superstition which regards the volcano as the entrance of the infernal regions down to the most complicated and scientific theories of modern writers are at least extremely improbable; on this account I shall omit the greater part of them, and notice only those which are received in the present day.

The first has been termed the theory of a central Heat. It was first adopted by Buffon, who supposed that the sun was originally the only body of the solar system, but being struck obliquely by a comet which detached from it a large mass heated by the heat caused by the friction of the bodies in striking ~~and thus~~ having formed into ~~large~~ drops began to revolve round the sun and constitutes the present planets. The earth, then having thus been formed began to cool and at last having a crust having been formed upon its surface it gradually assumed its present ~~form~~ ^{appearance} although its interior still continues in its original state of liquidity.

This hypothesis although originally much admired at length fell into disrepute, and those who now ~~advocate~~ the doctrine of a central heat have rejected the greater part of Buffon's theory, and found their doctrine upon ~~less~~ ^{of probable} grounds. of these a few may be mentioned

1 That the ^{mean} temperature ^{of the earth} at the equator is some degrees below that of the atmosphere while in temperate and polar regions it is a few degrees above it, for example, at Congo, in 5° S.L. Temperature of the Earth is $= 72^{\circ}$ ~~that~~ that of the air $= 78^{\circ}$ at Havanna in 23° N, Temp E. $= 74^{\circ}$, Temp Air $= 78^{\circ}$ at Philadelphia in 40° N, Temp E. $= 54^{\circ}$ Temp Air the same at Paris, in 49° N, Temp E. $= 57^{\circ}$ Temp Air $= 51$, at Edinburgh in 56° N, Temp E. $= 47^{\circ}$ Temp Air the same at Upsal in 60° N, Temp E. $= 44^{\circ}$ Temp Air $= 43^{\circ}$ at Umeo. in 64° N Temp E. $= 37^{\circ}$ Temp Air $= 33^{\circ}$

So that in Congo the Temperature of the air is nearly 6° higher than that of the earth, at Edinburgh and ^{at Umeo} Paris they are equal, while at Umeo the temperature of the earth is 4° higher than that of the air.

2 That the temperature of the rocks at the bottom of mines is higher than that of those nearer the surface, and that after every possible inaccuracy which could arise from the breathing of mines, fires or blasting. ~~is subtracted~~ it is found that the temperature increases at the rate of 1° in every 80 or 100 feet. The temperature of the

The temperature of the air is not only
 higher than that of the earth, but
 they are equal, while at times the temperature of the air
 is higher than that of the air.
 2. That the temperature of the water at the bottom of rain
 is higher than that of the surface, and that
 after every fresh rain which would arise from
 the breathing of miners, from beating the water out of a
 tunnel that the temperature increases at the rate of
 10 or even 20 or 30 feet. The temperature of the
 air is not only higher than that of the earth, but
 they are equal, while at times the temperature of the air
 is higher than that of the air.
 at 1000 ft. air = 33° temp. = 33°
 at 1500 ft. air = 30° temp. = 30°
 at 2000 ft. air = 27° temp. = 27°
 at 2500 ft. air = 24° temp. = 24°
 at 3000 ft. air = 21° temp. = 21°
 at 3500 ft. air = 18° temp. = 18°
 at 4000 ft. air = 15° temp. = 15°
 at 4500 ft. air = 12° temp. = 12°
 at 5000 ft. air = 9° temp. = 9°
 at 5500 ft. air = 6° temp. = 6°
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 at 99000 ft. air = -555° temp. = -555°
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 at 100000 ft. air = -561° temp. = -561°

waters of Artesian wells is also found to be in proportion to the depth from which they have been obtained.

From these and various other facts it appears evident that the earth has a temperature within itself entirely independent of the solar rays, and that at least ~~at~~ those depths to which man has penetrated it increases with great rapidity as we descend from the surface. From these premises the advocates of this theory infer that the interior of our globe consists of an immense mass of earthy or metallic matter in a state of fusion covered by a comparatively thin solid crust and that the occasional ebullition or agitation of this fluid matter occasions all the volcanic phenomena witnessed upon the surface.

This theory however is liable to objections which in the present state of knowledge appear almost insurmountable. The experiments which have been made extend only to an insignificant depth, and though to the depth of a few thousand feet the temperature may increase it is not at all certain that at a greater distance from the surface it might diminish and finally disappear.

It has also been objected that in a body composed of earthy or metallic matter in a melted state the particles which were cooled at the surface would become heavier than those below and would consequently sink to the centre.

so that the centre instead of the surface would first become solid, and that the cooling would extend from this point to the surface, and if we suppose such a fluid to exist it should like the oceans upon the surface be influenced by the attraction of the sun and moon and consequently have tides, so that we would upon this supposition have 2 earthquakes every 24 hours.

This hypothesis is therefore although once very generally adopted is being gradually superseded by others the foundations of which rest upon Sir Humphrey Davy's discovery of the metallic bases of the alkalis and earths.

This great chemist supposed that the interior of the earth consisted of the more easily oxidized metals, and that when water by filtering through the solid crust comes in contact with these metallic substances, they immediately combine with its oxygen and during the process evolve sufficient heat to melt portions of the superincumbent rocks which together with the vapours disengaged cause volcanic phenomena. He even proceeded so far with this theory as to conjecture that the earth was originally entirely metallic but that by combination with water its surface became oxidized and the heat thus evolved, imparted to it that temperature now found to exist in its interior, and that the reason why volcanic action is not

energetic as formerly, is that as the crust became thicker water could not so easily penetrate to the metallic nucleus.

This doctrine he illustrated by the experiment of forming a small ball of those metals which have the greatest affinity for oxygen, he then breathed upon it and the moisture of the breath caused its surface to become oxidized while the ball itself became so hot that it could scarcely be touched. Whatever may be thought of the greater part of this theory it is now generally believed that volcanic action is produced by chemical action of some kind going on beneath the surface and numerous instances are adduced of iron and copper pyrites and various other minerals when placed in moist situations requiring an intense degree of heat. It has also lately been suggested that it may be produced by electricity or by the different strata of the earth's crust acting as a galvanic pile.

Both of these theories however have defects, which cannot be satisfactorily remedied, and it is not at all improbable that both may be supplanted by others, and ~~and~~ perhaps ere long may be clasped with that of Kepler who supposed the earth to be an animal whose secretory organs were slates and volcanoes the orifices through which it voided its excrements.

Having thus shortly discussed the first part of my subject the next point to be noticed is the manner in which volcanic action operates as far as this is exhibited upon the surface. In the ancient strata of the globe we find no traces of volcanic mountains such as at present exist, although volcanic action was then much more energetic, and ejected immense quantities of melted matter compared with which the lavas of modern volcanoes sink into insignificance. A detailed account of these rocks however interesting to the Geologist or Mineralogist, and although it would alone furnish ample materials for an essay, would probably here be tedious. They shall therefore be passed over as shortly as possible. The proofs of the volcanic origin of these rocks are scarcely necessary as this is admitted by every philosopher of the present day a few however may be mentioned as while they show their origin they also give an idea of the general arrangement of the rocks themselves.

These rocks have penetrated through the horizontal strata of the earth in immense shapeless masses and have elevated them into inequalities and mountain ridges and in many cases after reaching the surface they have flowed over it in different directions wherever they are in contact with other rocks they

have left traces of intense heat, thus where in contact with sandstone, lime or coal they have converted them for some distance into flint marble and anthracite or coke. They have also included and carried up with them large pieces of the rocks through which they have been forced and these remain sticking to them in the same manner as pebbles stick to wet clay. while in other places they exhibit proofs of more perfect liquefaction as where they are in contact with slate, veins have been forced from them between the laminae of the slate to considerable distances some of them not thicker than a sheet of paper.

There more ancient volcanic products have been divided into different classes according to their mineralogical characters and their relative ages as shown by the ages of the different rocks through which they have penetrated in their eruption. The first and oldest of these is granite which consists of a compoundly crystalline compound of felspar a white or light red mineral, ~~hornblende~~ ^{quartz} which is dark green brown or black and mica which usually appears in it in the form of small scales of a silver greyish or shining black colour. Granite is by far the most abundant than any other.

...left tower of interior heart, then where are connected
with substance line up oval they have connected them
for some distance with faint marks and connections
to each other, they have also indicated and connected up with
their large pieces of the rock. However, which they
have been forced and there is a serious sticking to
them in the same manner as fossils which the
most clear, visible in other places they exhibit fossils
of more perfect representation in where they are in
fact with state, because they have been from them
between the formation of the state is connected
between those of them and thicker than contact
...fossils.

There were several volcanic products there
been clustered into different classes, according to their
position, and character and their relative ages as
shown by the ages of the different rock layers which
they have penetrated in their position. The first and
best of these is granite which consists of a conglomerate
of crystalline fragments of felsic or gabbro or light red
material, which is dark green brown or black
and which is well exposed up and in the form
of small pebbles of a blue-grey or shining black color
...a paper the most abundant than any other

of the ancient igneous rocks, a circumstance which induced some of the older geologists to conjecture and even to state as certain that granite ~~was~~ is the substance of which the interior of the globe ~~is~~ composed.

The next class includes Gneiss and serpentine containing nearly of the same minerals as granite although in different proportions, but as they are neither very abundant nor generally known it would be useless to describe them.

Next in order are those called Trap rocks. Of the most common of these whinstone is a very good example. They differ from the granite in containing a larger quantity of hornblende which in many cases gives them a black or greenish appearance. Basalt which forms those beautiful columnar structures for which Fingert's cave and the Giant's Causeway have so long been celebrated belongs to this class and it is also the store house of many of the most valuable gems which are contained in local cavities in the rock in some varieties so abundantly that those containing them have been termed Amygdaloidal from the Greek Amygdala an almond ~~from~~ their fancied resemblance to an Almond cake.

The fourth class is intimately connected with those of modern origin, as they show evident traces of cones and appear to differ merely in a little.

mineralogical difference in their lavas and in greater age. There are fine examples of this class in the south of France and particularly in Auvergne, where their lavas and ashes have entombed the remains of the antediluvian mammoth hyena and rhinoceros. There are so recent that some mountains such as Aetna have been in action at this period as well as at present.

For more modern periods we generally find volcanic action connected with a cone or mountain composed of the different materials ejected by the volcano vent which is situated at the summit. They however assume different forms of which by far the most common are those resembling Aetna, Vesuvius and the Peak of Teneriffe, which are irregular cones having scattered upon their sides and at their bases smaller vents which accompany them in their eruptions and are frequently buried beneath the ashes and lavas of the principal orifice. Their internal construction is known only from sections which their own eruptions have at different times exposed. That which has furnished the most information is Mount Somma. It was originally the vent of Vesuvius which after having remained inactive from the

earliest periods of which history furnishes records, in the year 79 of the Christian era destroyed the greater part of its old cone and erected ~~that~~ ~~below~~ its modern cone leaving the remainder of Somma in the form of a precipice forming one side of Vesuvius and exhibiting an excellent section of a volcano. In it as well as in every other which can be observed, the mountain appears to consist of a perpendicular chimney, surrounded on all sides by alternating layers of ashes pumice and lava ~~which~~ resembling a number of funnels placed one within another and intersected in every direction by lower dykes or veins, supposed to have been caused by cracks and rents in the mountain becoming filled with liquid lava. Their craters are often miles in circumference the most lofty mountain however invariably having the smallest ~~extending~~ one or more small cones which continually emit vapor ashes and small quantities of lava. De La Beche thus describes Vesuvius when not in eruption.

"After ineffectual attempts to observe the workings of the fluid mass within the crater of Vesuvius at the commencement of 1829, when the mountain was somewhat active, I was fortunate enough on the 15th of February to have ascended on a calm day

when the vapors started majestically upward as they were impelled from the small cone in the middle of the great crater, and the incandescent matter in the vent was at times distinctly visible. After the more continued ebullition, there was a lull or calm succeeded by a violent explosion throwing up stones to a considerable height mixed with pieces of red-hot lava, which latter fell like lumps of soft putty upon the sides of the small cone. When the vapors cleared away the red-hot mass appeared as if in ebullition from the passage of the gaseous matter through it. The light emitted varied in intensity being greatest at the moment of the principal explosion, when a great volume of vapor suddenly forced its way through the fiery mass, starting upward with great velocity."

Other volcanic vents present a low and broken appearance sometimes forming lakes or bays, and appear either to be very recent or to have been broken to pieces by their own eruptions. They have in almost every instance a deep gorge or ravine in one of their sides through which lava seems to have flowed. The Isle of Palma in the canaries affords a good instance of this class. In its centre is a large circular cavity 6 miles in diameter surrounded by a

When the vapor started rapidly upward as they were
expelled from the small can in the middle of the group
water, and the consequent reaction in the water was
at times almost visible. After the more continued
elaboration there was a half an hour necessary for a
violent explosion through which water to a considerable
depth mixed with pieces of coal - but lower which but
it fell like bunches of soft foam upon the water of the
small can. When the vapor ceased every one red but
bunch appeared as if in collision from the escape of
the power we enter through it. The light continued again
in intensity being greater at the moment of the first
explosion which was of course of more sudden
by forced its way through the few scraps, starting upward
with great velocity.

Other reactions were present as low could be
seen upon some specimens forming like a large and
explosive when the very least of the water was broken
to pieces by their own explosion. They burnt in almost
every instance except one a certain number of them
which through which seems to have passed
the whole of them in the same case of explosion
of this class, and its center is a deep red
an empty bottle in the experiment described above

precipice so steep that the valley is altogether inaccessible except through the ravine which was before mentioned as a characteristic of these volcanoes, ~~and~~ its exterior slopes gently on all sides to the sea the whole island being composed of volcanic matter.

Another kind of which there appears to be only a solitary example occurs in the Island of Hawaii or Owhyee in the Sandwich Islands. This island having a surface of 4000 square miles is entirely volcanic and is covered with small cones most of which are extinct Its interior rises in two peaks about 15,000 feet above the level of the sea upon one of which the volcano is situated. It is thus described by Mr Ellis. "We expected to have seen a mountain with a broad base and rough indented sides, composed of loose slabs or hard shavings of lava and whose summit would have presented a rough wall of scoriae forming the rim of a mighty caldron but instead of this we found ourselves on the edge of a steep precipice with a vast plain before us 15 or 16 miles in circumference and sunk from 2 to 400 feet below the original level. The surface of this plain was uneven and strewed over with loose stones and volcanic rocks and in the centre of it was the great crater at a distance of a mile and a half

present water at a distance of a mile and a half
and volcanic rocks end in the center of it even the
plain was narrower and almost over north
1500 feet below the original level. The surface of the
is 1000 miles in circumference and 1000 miles in
length. The deep fissures with a west plain before us
California had a number of these volcanic mountains on the
west side of the range forming the rim of a great
basin and volcanic mountains would have been extinct or
distant hills, compared of some steep or direct descent of a
been a mountain with a broad base and a sharp top.
It is then described by Mr. Ellis "the expected to have
if the sea were over of which the first course is a continuation
from the two peaks, about 1500 feet above the level
with small cones and of which one extinct and the other
face of the sphere is a central volcanic cone is equal
for the 2 mountains I observed. The volcanic basin is now
the example seen in the island of Hawaii. The Pacific
the other kind of which these appear to be volcanic
composed of volcanic matter.
quartz and all rocks to the sea the volcanic matter being
as a consequence of these volcanoes, and the volcanic
except through the same which even before recent times
preserved in deep that the valley is still the same.

from the place where we were standing. We walked on to the north end of the ridge, where the precipice being steep, a descent to the plain below seemed practicable. After walking some distance over the sunken plain which in several places sounded hollow under our feet we at length came to the edge of the great crater where a spectacle sublime and even appalling presented itself. Immediately before us yawned an immense gulf, in the form of a crescent about 2 miles in length from north east to south west, nearly a mile wide and apparently 800 feet deep, the bottom was covered with lava and the south west and northern parts of it were one vast flood of burning matter in a state of terrific ebullition. 51 conical islands of varied form and size containing so many craters, rose either round the edge or from the surface of the burning lake. Twenty two constantly emitted columns of grey smoke or pyramids of brilliant flame, and several of them at the same time vomited from their ignited mouths streams of lava which rolled in blazing torrents down their rough indented sides into the boiling mass below.

There appeared to be no traces of lava having flowed from this crater, which indeed from the depth to which it was sunk below the level of

the surrounding plain would have been almost impossible. It appears therefore to have been a great reservoir probably communicating by subterranean channels with the smaller volcanoes upon different parts of the island.

A fourth class which are comparatively insignificant are the mud volcanoes found in some parts of South America and Asia. They are mounds, sometimes of considerable size, composed of clay having a small crater from which vapor and balls of mud sometimes containing bitumen are emitted. They appear to be vents for the products of chemical changes produced by water at small depths.

Although volcanic forces are constantly acting yet they occasionally assume in particular volcanoes an unusual state of activity produced either by its own coming some obstacle which has for a time prevented it from propelling its products to the surface, or meeting with some substance eminently calculated to increase its violence. When this occurs, the volcano is said to be in Eruption.

The eruptions of volcanoes usually occur at long intervals. In Hawaii there intervals have been so long that for ages before the eruption which destroyed

the numerous specimens which have been
collected. It appears therefore to have been a species
which probably occurred in early tertiary times
with the smaller vertebrates upon different parts of the
land.

At South Cliff which is a prominent outcrop
on the land between the river and the sea, I have
found in some parts of the cliff a large number
of small shells of the same kind as those
which I have found in the other parts of the
cliff. These are certainly the same as those
which I have found in the other parts of the
cliff. They are certainly the same as those
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cliff.

Pompeii & Herculaneum its crater was a plain overgrown with trees and brushwood and after that event before its next eruption it was long a pasture for cattle. On the other hand eruptions when they do occur have been known to last for many years with almost unrelenting violence.

Eruptions are usually preceded by subterranean sound Earthquakes the stopping of Springs and ~~these~~ changes in their mineral properties and sometimes by electrical phenomena. They are commenced by the discharge of a great quantity of ashes and vapor from the volcano the former principally derived from the matter which has accumulated in the volcanic chimney and the latter consisting of Nitric & Sulphurous acid sulphureted Hydrogen and other gases produced by the chemical changes proceeding beneath. In most eruptions this prelude to the more destructive substances ejected is represented as rising in the form of a wide spreading tree illuminated by bright balls of liquid lava and vivid flashes of lightning. After rising to a great height it moves slowly away in the direction of the prevailing wind and scatters a shower of light stones sand and ashes over areas sometimes extending to the distance of hundreds of miles from the volcano.

This is followed by the discharge of lava which is the great and almost only production of modern volcanic action. It rarely issues from the summit of the cone as before it has attained that height the hydrostatic pressure of so high a column of a very heavy fluid, is insufficient to burst the walls in which it is contained.

When it issues from the mountain it is uniformly fluid of the consistence of honey so heavy that large stones when thrown upon it float along upon its surface, and emitting an intense light. As it moves to a greater distance from the point whence it issues its colour becomes dim it flows more slowly and a crust being formed upon its surface and cracked by the motion of the fluid below, it is soon covered with a crust of light porous matter called Scoriae, ~~and~~ until at length it resembles an immense current of Blachsmith's crucibles moving slowly forward and in this state persons may walk upon its surface and the inhabitants of houses or villages to which it appears to approach have full opportunity to escape. An anecdote is related of some Italian peasants who perceived a current in this state flowing towards their village and being apprehensive of the consequences, covered themselves with blankets and rolled boldly forth.

It is followed by the discharge of two which is the
great and almost only foundation of modern navigation
bottom. It rarely rises from the summit of the cone as
before it has attained that height the topography is such
that no high or extensive of a low level, but is only
sufficient to break the water in which it is contained.
When it rises from the mountain it is accompanied by
the craters of three or four that large ones when
known upon a foot which upon its surface, coral
something on surface light up it rises to a greater or
less from the point where it rises to a lower level
than it flows from that point and is not being formed
upon its surface and ended by the action of the fluid
below, it is soon covered with a coat of light brown
matter called brown sand and at length it resembles
an immense cavern of blackish earthy matter
shaly formed and in this state it remains until
upon its surface and the substance of brown
volcanic the subject of volcanic the surface being full
of a porous and is related to
More volcanic phenomena are concerned in current
in this state flowing towards the valleys and
being whirling in the current, and
the volcanic matter which is the subject of the

with pick axes and crowbars to break through the
crust of the lava on the opposite side and thus give
it a new direction, but unfortunately the inhabitants of
another village found that this expedient would turn
the lava upon them and they accordingly attacked the
labours and obliged them to leave their village to its
fate. Although lava soon begins to move exceedingly
slowly its motion is perceptible for months after its ejection
and it in large quantity it often retains its heat for
nearly half a century. Thus when Humboldt visited
Mount Jorullo 26 years after its eruption a cinder could
be lighted in the crevices of the lava a few inches from
the surface. When lava cools in the open air its sur-
face as before stated emits of light from service but there
parts which are near the bottom of the current or in
clikes or veins in the interior of the mountain are hard
heavy and sometimes hence a crystalline appearance
often resembling the trap and other older rocks so much
that some writers are inclined to believe that the only
difference is that that the one claps have been cooled
under water or in the interior of the earth, while the
others have undergone the same process in the open
air. The country in which its now being con-
sidered volcanic action appears to have been must

with fresh water could explain the fresh through the
ground of the lower in the opposite side and then again
it is more probable, but not impossible, that the water
under the large forest that the fresh water would be
the same as the lower and the surrounding would be the
same and obliged them to leave their water to it
of the fresh water now begins to move
towards the surface of the earth for months of its existence
and it is large quantity of fresh water to be sent for
recently built a canal in the same place which would
be built in the same place of the lower a few miles from
the surface. When lower water is the same as the
one in before stated amount of fresh water from the lower
part which are seen the bottom of the current or in
other or lower in the center of the mountain are seen
heavy sand and stones because of the fresh water
then resembling the fresh water and other water as well
but more water are abundant to believe that the only
difference is that that the fresh water has been under
under water in the center of the earth, while the
other lower water is the same as the fresh water in the open
river. The current in which it is seen even
which is not even a distance of a few miles from the

emerged during the period of Fluvy is Iceland. One
of the eruptions of Hecla in this island continued for 7 years
and Skapten Jökul another of its volcanoes in an eruption
which lasted 2 years commencing in June 1783 ejected
the greatest quantity of lava ever known to be produced by
one eruption. It flowed in two streams one 40 and the
other 50 miles in length and about 15 or 16 in extreme
breadth their average depth on level ground being 100
feet, while in valleys and lakes which it covered it was
much greater. Many geologists have attached so much
importance to this eruption, that they have triumphantly
defied anyone to give an instance of a greater area
having been covered by Granite or other ancient ig-
neous rocks which can be proved to be the products of
one eruption.

The ashes and cinders as they have been called
which are ~~thrown~~ discharged by volcanoes are merely
fragments of hardened lava carried off from the sur-
face of the liquid matter in the chimney or from
the rim of the crater by the rising upward of gases
and therefore deserve no particular notice.

There are upon the present continents about 200
volcanoes of which America contains 116 Asia 66
and Europe 13. none having yet been discovered in

Apica, except the Peak of Teneriffe in the Canaries which is sometimes reckoned as belonging to it. A great number of them are ^{apparently} extinct although it is not at all improbable that they may yet revive and the periods at which they have been in action are entirely unknown. As a great number are situated in America and only of recent discovery and of the history of the remainder with the exception of a few in Europe nothing is known claiming a greater antiquity than 1 or 200 years. A great number of volcanoes are also supposed to exist beneath the waters of the ocean, as frequent accounts have been given by seamen of vapour and flame issuing from the sea and portions of the water appearing discoloured and in a state of ebullition, while ~~whales~~ have occasionally appeared above the surface presenting all the phenomena of volcanoes. As an instance of these I may mention an Island which was thrown up off the coast of Sicily in 1831. It was 3 miles in circumference and 200 feet high and in the spot where it arose the round. hags on the previous year were more than 100 fathoms. It was however swept away by the sea in 3 months after its appearance.

Before leaving this part of the subject one very remarkable circumstance must be noticed.

This is that volcanic action appears always to have
acted in certain lines, extending in different directions
over the surface of the globe, and from this peculiarly arises
the disposition of mountains in ranges or chains. For in
stances of this we need not go beyond Nova Scotia where
the granite and trap respectively form long lines extend-
ing along the Atlantic coast and the shores of the Bay
of Fundy. The present volcanoes also occur in this man-
ner and their line which as it includes most of the
volcanoes may be called the great volcanic band
of the earth, extends from Terra del Fuego along the An-
des and rocky mountains as far as the Aleutian Isles
in Russian America here it crosses to the coast of Asia
and proceeding along the Japan Philippine and Moluc-
ca Islands through Borneo Java and Sumatra ends
at Borneo Island in the Bay of Bengal. Another
line by some thought to be connected with the for-
mer commences at the Caspian Sea proceeds along
the coasts of the Black Sea and the Mediterranean
and ends in the Azores. The countries along which this
line extends throughout its whole course contain nu-
merous volcanoes hot and sulphur springs and are
subject to earthquakes. These volcanic lines
appear to have frequently changed. Nova Scotia

It is that volcanic action appears always to have
acted in certain lines, extending in different directions
over the surface of the globe and from the present day
the direction of mountain ranges or chains. The in-
fluences of this are not yet fully understood, but it is
the opinion of some that volcanic forces have extended
and along the Atlantic coast and the shores of the Bay
of Mexico. The present volcanic also occur in this
area and their true extent is not in doubt. The
volcanoes which are collected the great volcanic belt
of the earth, extends from the del Fuero along the
coast and rocky mountains as far as the Atlantic. The
volcanic influence here it refers to the coast of Asia
and proceeding along the Pacific. Volcanic and volcanic
are located through some of the most fertile
of the volcanic belt in the Bay of Bengal. Another
line of volcanic thought to be connected with the for-
mer volcanic belt the Pacific has passed along
the coast of the Black Sea and the Mediterranean
and ends in the Alps. The volcanic belt which the
line extends throughout its whole course. Volcanic
forces volcanic but not volcanic. The volcanic line
subject to earthquakes. These volcanic lines
appear to have frequently changed. Other bodies

as well as a great part of the East coast of North America
were included in one of them at the time when the Granito
and Trap were ejected, and of its power at these periods it
has left lasting records not only in the great masses of the rocks
just mentioned but in the fractured and shattered condition
in which it has left our ^{slates} sandstones and coal measures.
The Andes however furnish an instance of long perman-
ence in one line for their modern volcanoes have burst
through Basalt, Porphyries and other Trap rocks of
which a great part of that mountain chain is composed

Earthquakes are sometimes preceded by sudden
gusts of wind followed by dead calms and sometimes

The next operation of volcanic action is the Earthquake and this though it does not present such beautiful or sublime phenomena as the ~~earthquake~~ volcano extends over a far greater area is far more frequent and produces much more real change upon the surface of our planet.

Earthquakes are supposed to be produced by gases disengaged by chemical action which being pent up in subterranean cavities, at length acquire sufficient expansive force to burst through the strata of the earth or pass between their layers and thus communicate a vibratory motion in the same manner as when the end of a carpet is raised from a floor and then suddenly brought down, an undulatory movement proceeds from the disturbed extremity to the other. And this motion continues until the elastic fluids by which it is produced find some means of escape are absorbed by water or form a cavity sufficiently large to contain them under a moderate degree of pressure. It is also probable that some earthquakes may be produced by melted lava pouring up from beneath without finding a vent by which it may be carried to the surface.

Earthquakes are sometimes preceded by sudden gusts of wind followed by dead calms a redoubt of

they supposed to be produced by the disengagement of dense vapours from the soil sounds resembling the rolling of cannon or distant discharges of artillery, and when they occur in the neighbourhood of volcanoes these always seem to be affected, sometimes showing unusual activity and at others altogether ceasing their customary discharges.

The earthquake itself consists in a motion of the strata of the earth either vertically in an undulating or circular direction. The undulatory motion is most destructive to buildings while the circular when it occurs in a town produces the most whimsical effects throwing down ^{a number} ~~some~~ houses and perhaps leaving one in the midst of them perfectly uninjured.

The effects of earthquakes are numerous but nearly all may be classed under the heads of Permanent and momentary elevation. The latter of these occurs in every earthquake the former ~~is~~ ^{are} comparatively rare, numerous instances of it however are known, such that which occurred in Chili in 1822 in Cutch in 1819 which have already been mentioned before this society and in one in the ^{Philippine Isles in} 1816 and another in 1814 in the former of which a mass of rock 4 miles in circumference and in the latter a similar body 3000 feet high were raised above the level of the sea. Except

however in instances such as there where the sea coast affords certain evidence it is extremely difficult to estimate the extent of displacement. Temporary elevation produces a great variety of effects some of which may be interesting. Rivers flow back upon their sources and hence the channels changed, lakes become dry and new lakes are formed. Hills and mountains are sent long pipes and chains of immense depth are produced sometimes straight and in other radiating from a centre like the cracks in a pane of glass which has been broken by a blow upon its centre. Immense waves flow over the land causing temporary inundations. Another effect for which it is difficult to account is the formation of great numbers of circular cavities which throw out water and sand and when examined after the earthquake are found to be funnel-shaped ending in a straight perpendicular tube.

Earthquakes often extend over great areas, thus that of Lisbon in 1755 extended with different degrees of intensity over almost the whole of Europe, & the north of Africa, and was even felt in the West Indies and from the immense disturbances in the ocean which it produced the principal shocks are supposed to have occurred beneath the Atlantic.

The vibrations of the strata in this earthquake from the relative times at which they were felt in particular places are supposed to have travelled at the rate of 20 miles in a minute.

More than 50 great and destructive earthquakes have occurred within the last 500 years besides thousands of lesser oscillations and as ^{scarcely any} part of the earth has been exempt from them we may safely infer judging from the relative extent of land and water that 3 subterranean earthquakes occur for every one terrestrial, a conclusion which is confirmed by the frequent occurrence of irregularities in the tides and unusual movements in the water of particular sea ports which cannot otherwise be accounted for. And from these considerations it has been ascertained though with what truth it would be difficult to determine that an earthquake occurs in some part of the world every 24 hours.

The collection of the strata in this neighborhood from the
relative times at which they were laid in particular
places are supposed to have travelled at the rate of 20
miles in a century.

Other than 20 feet and strata are deposited here
occurred within the last 10 years. Indeed thousands of
feet of strata are laid on the part of the earth which
has been formed from them are now being deposited from
the relative extent of land and water that is subsiding
entirely. There is every one terrestrial or extraneous
which is confirmed by the frequent occurrence of it.
In the center of the island and around mountains in
the center of the island. Indeed, around other
there is accounted for. It is not from the surrounding
it has been expected that it will be true that it
would be difficult to determine that our conclusions
be in some part of the world every 20 years.

Another of the manifestations of volcanic action is that which is displayed in hot springs. All springs except those particularly called Hot Springs are supposed to indicate pretty nearly the ^{mean} temperature of the country in which they are found. Hot Springs however have a temperature ~~far~~ exceeding this standard and often exceeding the boiling point of water and generally contain a quantity of mineral matter. They exist in great numbers in every volcanic country although they are in many cases found altogether disconnected with volcanoes.

The most remarkable are those which are intermittent, of this kind the Geysers of Iceland furnish a good example. They are found at the foot of Mount Heccla. The water issues from a small pipe in the centre of a basin-shaped cavity incrustated with minerals deposited by the water. Their eruptions occur at short intervals and are presaged by subterranean noises and followed by the discharge of steam. The principal Geyser is thus described by Dr J. M^r Lewis "The sound was repeated irregularly and rapidly and I heard just given the alarm to my companions who were at a little distance when the water after heaving several times suddenly rose from the middle of the basin in a

large column accompanied by clouds of steam. At the height of 10 or 12 feet. The column seemed as if it burst and subsiding down produced a wave which caused the water to overflow the basin in considerable quantities after the first propulsion the water was thrown up again to the height of 15 feet. There was now a succession of jets to the number of 18, none of which appeared to me to exceed 50 feet in height. After the last jet which was the most furious the water suddenly left the basin and sunk into the pipe to the depth of 10 feet, but afterwards rose gradually, when sufficiently high the temperature was observed and found to be 208°F. The Geysers have been assigned to two causes both of which suppose ^{water} them to pass over heated lava, ~~but which~~ is by no means improbable, but neither can satisfactorily explain all the phenomena.

The first was proposed by Sir J Herschel who supposes them to be produced in the same way ~~that~~ jets of water are formed by heating the stem of a tobacco pipe to red-
ness and pouring water into the bowl. In this case the sudden production of steam at the part which is hot forces water from the extremity of the stem and drives the unexpanded part back into the bowl, this flowing

back the phenomenon is repeated until the water is exhausted or the pipe cooled. This is applied to the eyes by supplying their waters to pipes run red hot but have while proceeding through subterranean pipes as in the diagram.



The second explanation is that the water being contained in a cavity such as A and steam rising from the cracks B becomes encased at the top of the cavity until ~~it~~ by its expansive force it forces the water below the level of the pipe C and then it rises up driving the water before it.



I have now reached the last part of my subject, the effects which volcanic action has produced and is now capable of producing. From what has been stated in the previous part of the essay it will be evident that dry land is not that solid unmovable thing which it is often supposed to be it has been again and again elevated and depressed at the sport of volcanic action, and there is scarcely a part of the surface of our globe which does not bear evidence of having ~~been~~ experienced hundreds of alternate elevations and depressions. It is to this power too to which we are indebted for nearly all the mountains and hills with which our continents are ~~decorated~~ covered, for many of the rocks and metals of every day use in the furnace of ~~the earth~~, and even for those crystals and gems, which from the regularity and order of their structure seem rather the work of fairy artists, than the products of that power which produces the earthquakes and volcanoes.

But while it is admitted by all that these effects have in former ages been produced there is a great difference of opinion with respect to what volcanic action can now produce. This differ-

ance of opinion cannot be better illustrated than by comparing the statements of De la Beche and Lyell both of whom are considered good authorities ^{in modern geology} and they express pretty nearly the two opposing opinions.

De la Beche in concluding his chapter on volcanoes says, "If we now withdraw ourselves from the turmoil of earthquakes and volcanoes, and come to measure them by ~~their~~ effects which they have produced upon our imaginations, we shall find that the real changes they cause on the earth's surface are comparatively small and quite unaccountable with those theories which propose to account for the elevation of vast mountain ranges, and for ~~gradual~~ sudden dislocations of strata by catastrophes of no greater importance than a modern earthquake." The following is the opinion of Lyell. "If by a continued series of elevatory movements those masses now forming in the interior of the earth shall hereafter be brought up to the surface, in the same manner as sedimentary marine strata in the course of ages have been upheaved to the summits of the loftiest mountains, it is not difficult to conceive what perplexing problems may be presented to the

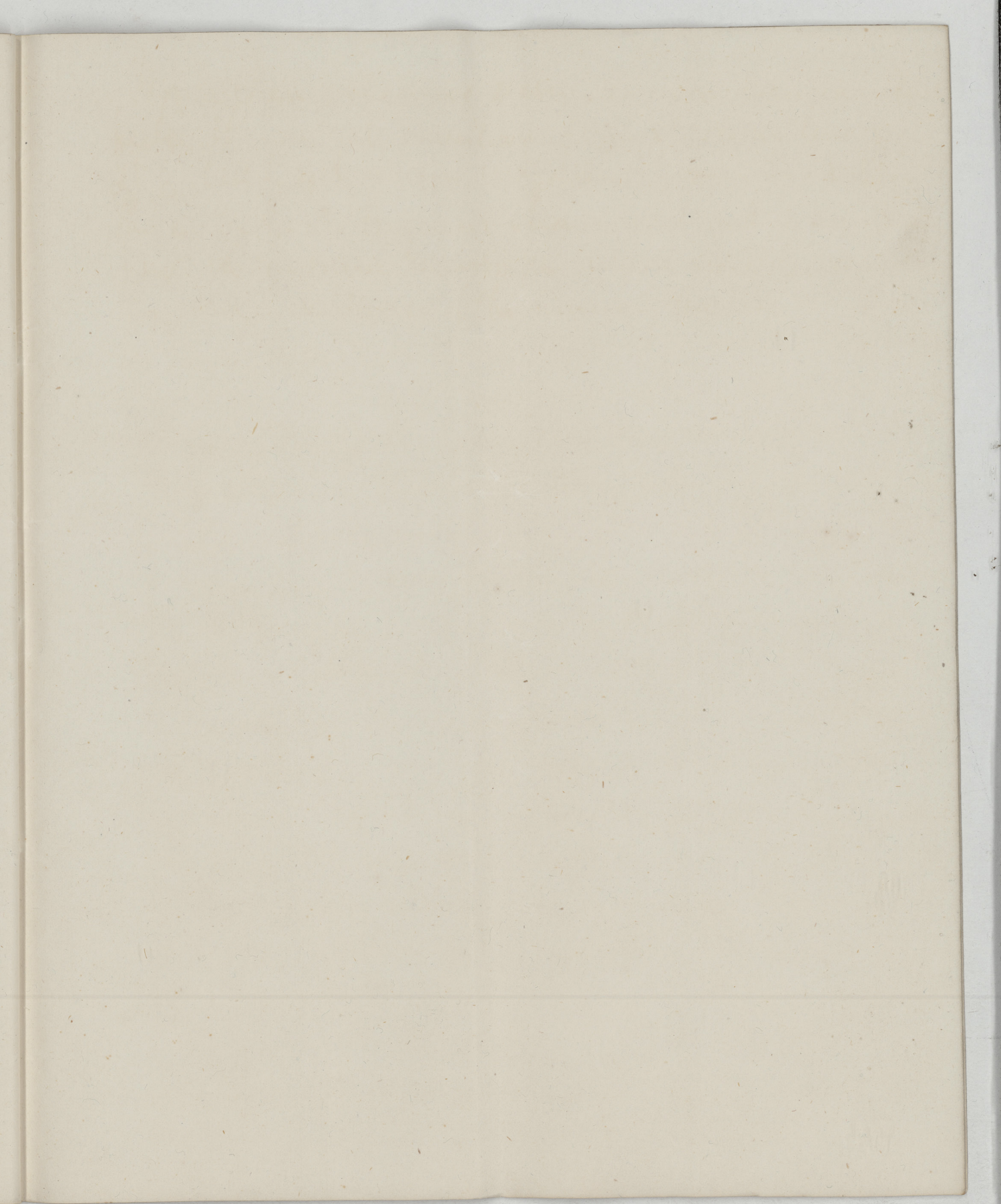
geologist. He may then study in some mountain chain the very rocks produced at several miles beneath the Atles Iceland or Iver, in the time of Leibnitz, and draw from them the same conclusion which that philosopher derived from certain igneous products of high antiquity. For he conceived our globe to have been for an indefinite period in the state of a cornet without an ocean and alike uninhabitable by aquatic and Terrestrial animals."

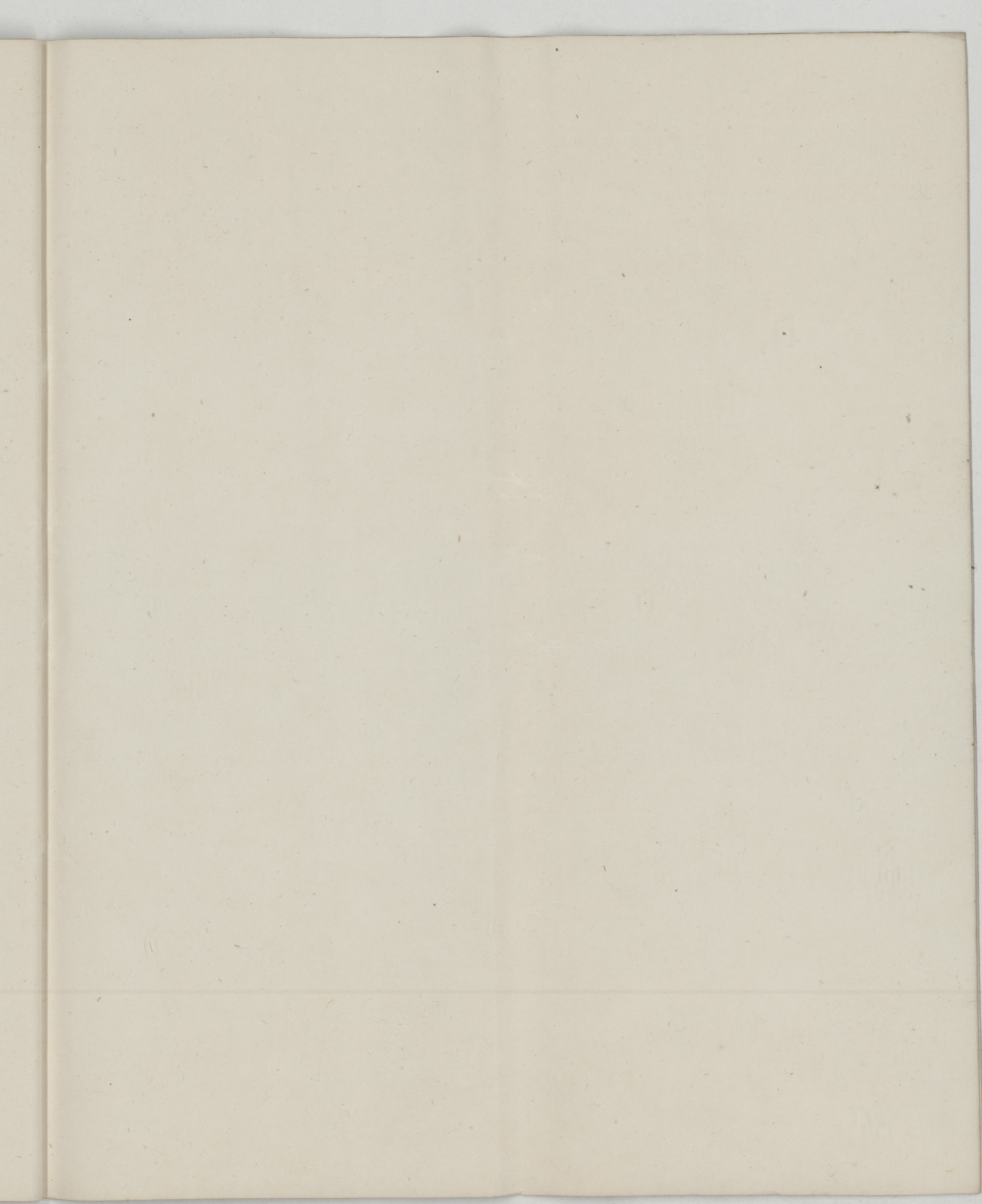
When such contradictory statements as these are generally authors of acknowledged merit, it appears almost in vain to attempt forming any definite conclusion. The truth however seems to be that volcanic action does not now produce so many surface-changes as formerly. yet this gives scarcely any data from which we can infer the extent of its operation in the interior. For it is exceedingly probable that we ought to consider volcanoes as merely openings to the furnaces in action below. Even the surface changes however are by no means inconsiderable and I am certain that if those which have occurred within the last 600 years could be summed up into one view it would astonish any one not exceedingly well acquainted with the subject.

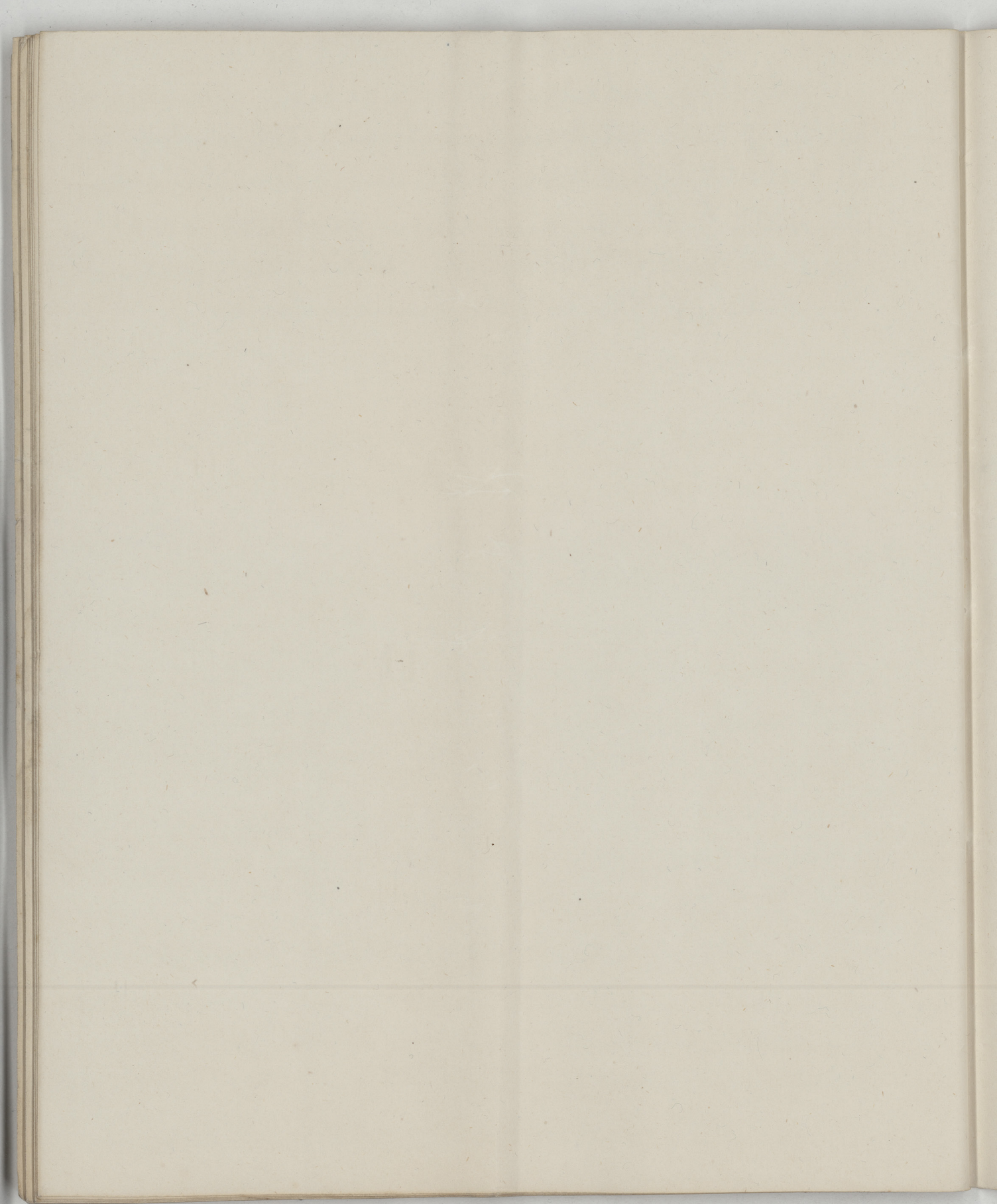
...the most likely in some instances
...the very best of the world at present
...the of which is better, in the time of
...and closer than the same
...that should be taken from certain
...of high quality. In the case of our
...we are confident that in the state
...we can see and while we
...by a private and personal
...I have been extremely interested in these
...of acknowledged merit, it is our
...in order to attempt forming any definite
...The truth however seems to be that we
...two that we have not many more
...formerly, yet the given cases are
...which are even more the extent of its
...the interior for it is especially probable that
...right to consider. However, on the
...to the former in order to be. Even the
...changes have been made in the
...and I am certain that if there were
...within the last 20 years could be
...into one we can it would not
...especially well represented with the

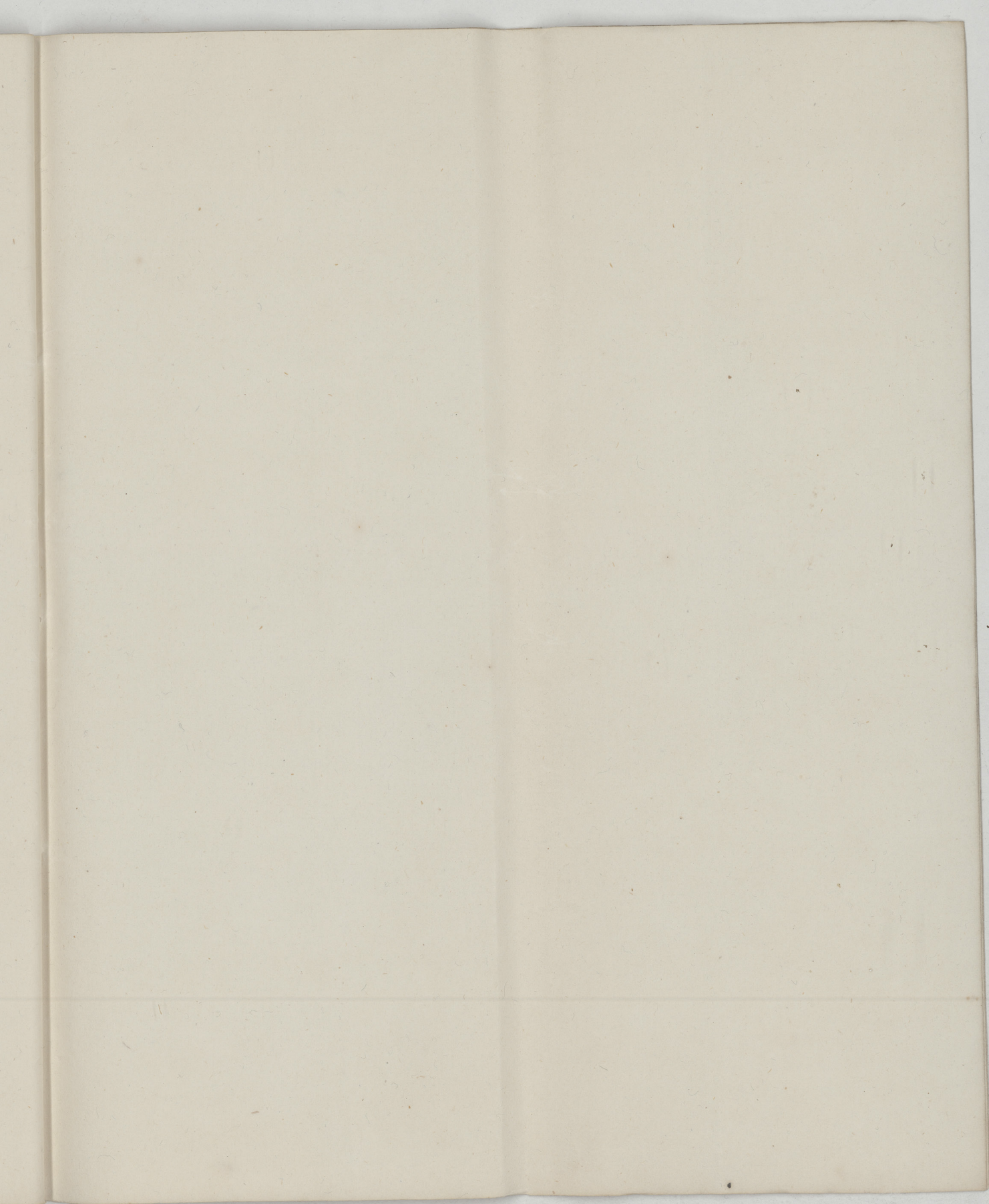
While then volcanic action is now comparatively feeble it may yet awaken from its slumber and it probably yet retains sufficient power to reduce the earth to its original chaos and act a conspicuous part in the final catastrophe which shall terminate the earthly existence of the human species.

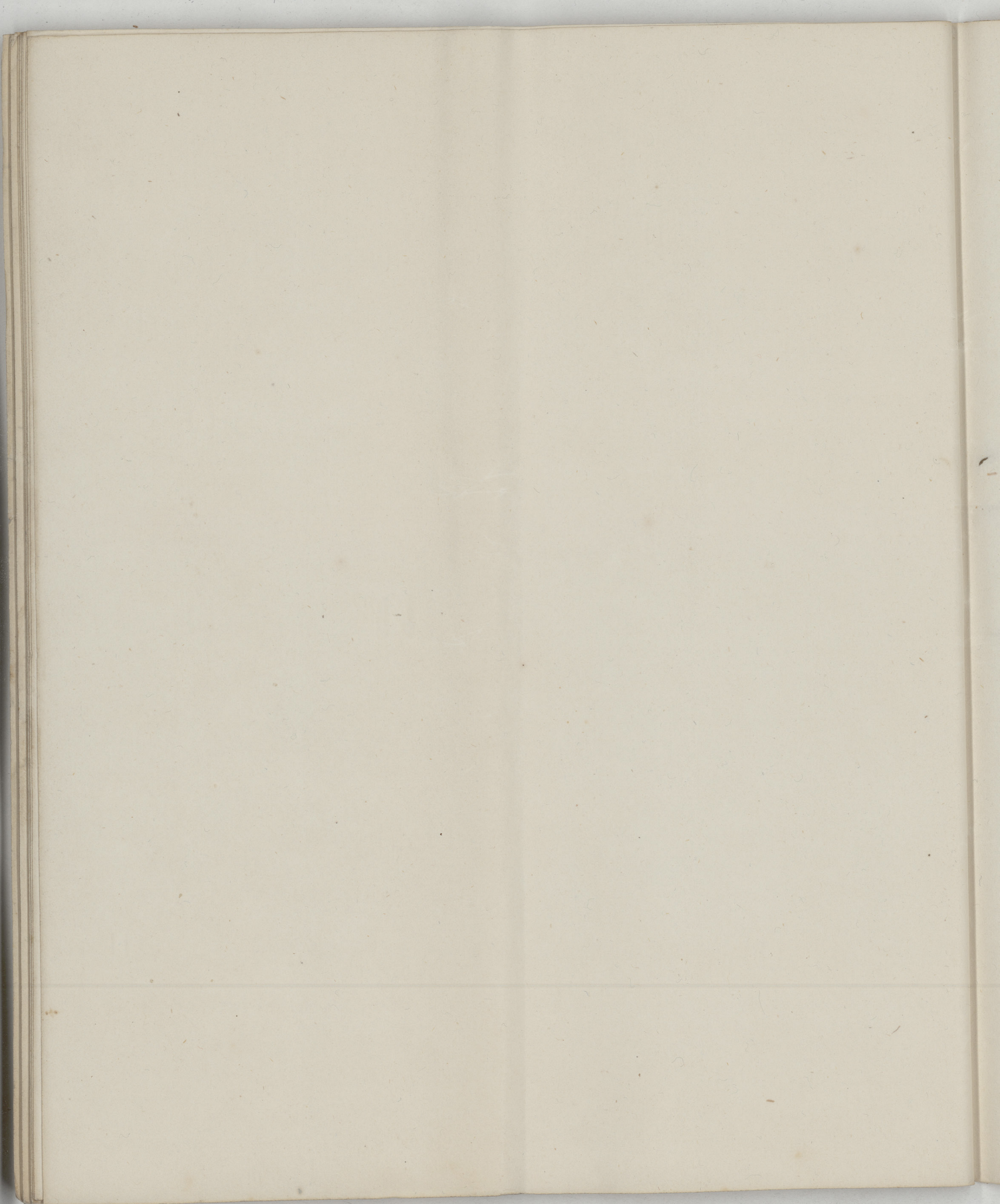
While there is no section to show
it is not yet known from the
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the south to the westward there is a
part in the fossil which shall be
the early existence of the human species.

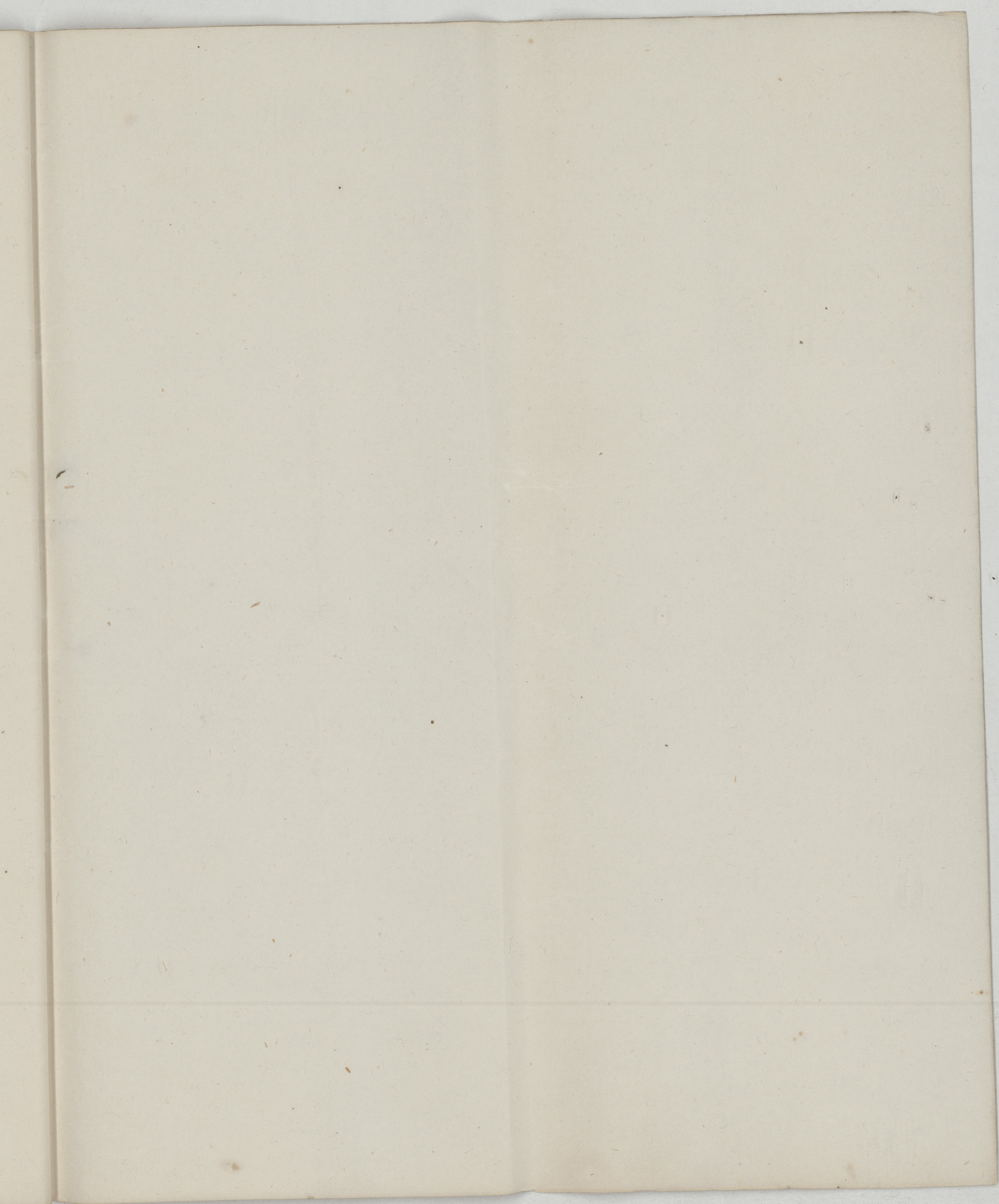


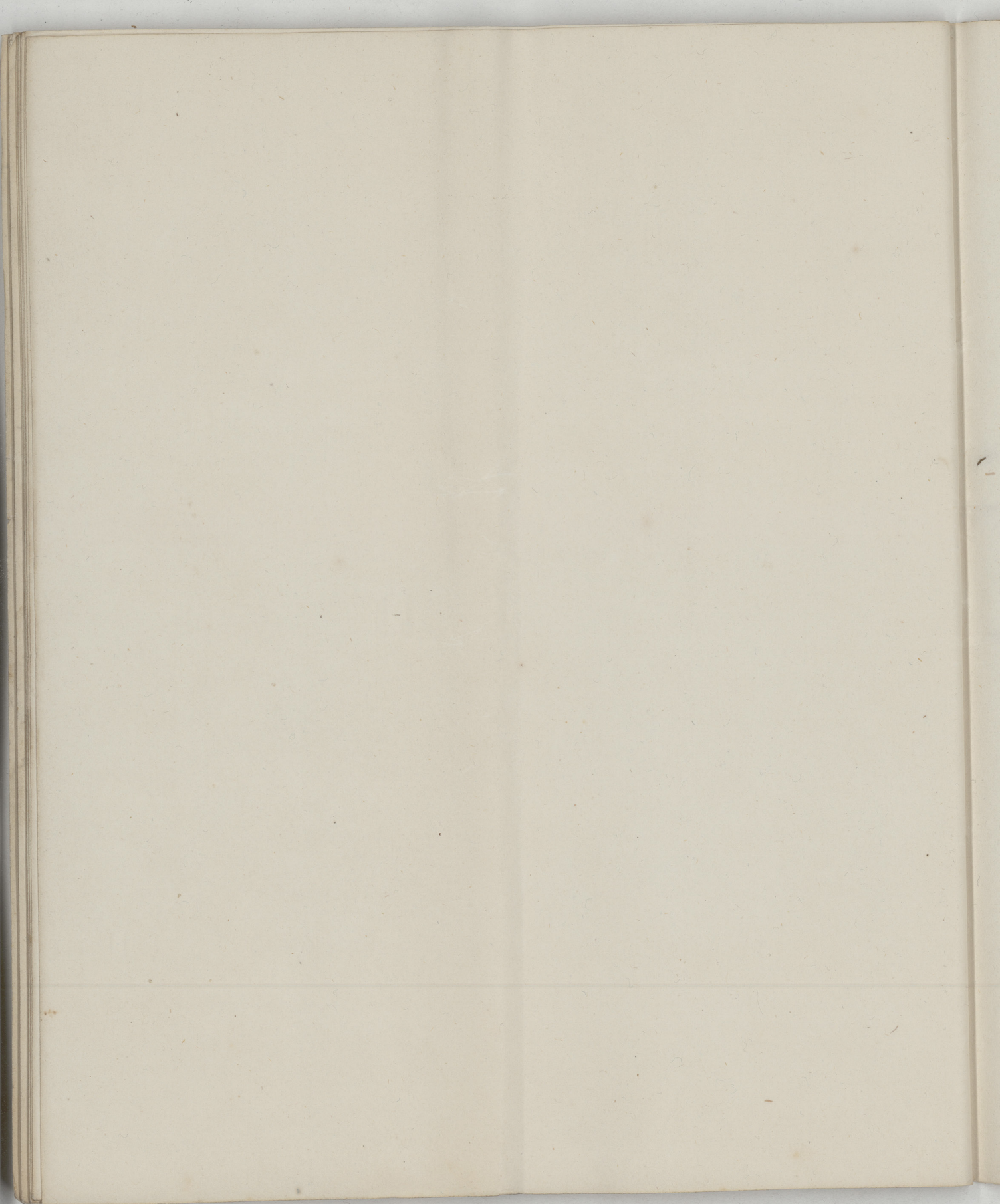


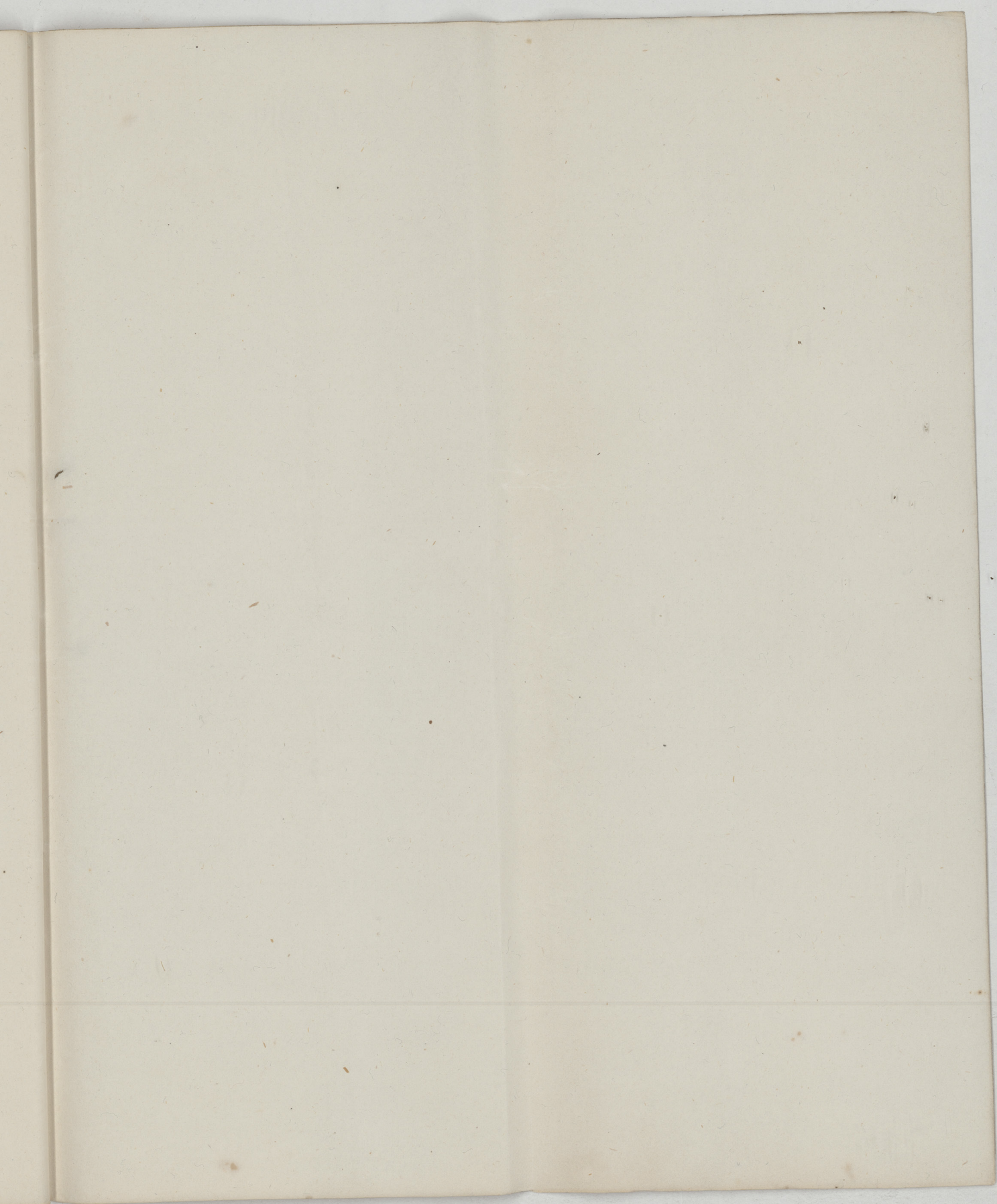












Volcanoes.

Volcanoes.