The Earth is a gigantic ball of semi-molten rock,
with a heart of iron as hot as the surface of the

Sun. Titanic amounts of heat left over from its
birth and the radioactive decay of trillions of

tons of radioactive elements find no escape
but up. Currents of rock spanning thousands

of kilometers carry this energy to the surface.
Earth’s crust is the only thing in their way.

It feels solid to us, but it is only a fragile
barrier, an apple skin around a flaming behemoth.

True apocalypses can break through
and unleash eruptions tens of times

more powerful than all of our nuclear weapons
combined, subjecting the climate to centuries

worth of change in a single year, while
drowning continents in toxic ash and gases:

supervolcanoes. How big can they get?
And will they put an end to humanity?

Volcanoes

There are many types of volcanos,
from towering mountains to lava domes,

but they have two main sources:

The first is at the boundaries between tectonic
plates, the pieces of the crust that cover the

Earth like a giant jigsaw puzzle. There are seven
major tectonic plates and dozens of smaller ones,

drifting against each other at up
to 15 cm per year. This sounds slow,

but on geological timescales it is a
titanic struggle over who gets to stay

on the surface. The winning plate crumples
into a new mountain range while the loser

is shoved underneath, into an ocean of
hot rock at1300°Ct: The asthenosphere.

The temperature here is enough
to melt rock into a liquid,

but the insane pressures of all that
mass keep it a superheated solid.

Tectonic plates are usually in contact
with water for thousands of years and

absorb some of it. When they are
submerged into the hot underworld,

this water triggers chemical transformations
that allow tiny portions to melt into magma.

Liquid magma is less dense than solid rock,
so it rises to the surface in furious bubbles

that accumulate in sponge-like reservoirs right
under the crust. If enough magma accumulates,

it becomes powerful enough to pierce through the
crust – which we experience as volcanoes. This

happens under the winning plate, like a revenge
attack by the loser before it is erased forever.

The second main source of volcanoes are thought to
be mantle plumes. These are columns of abnormally

hot rock that rise all the way from the planet's
core-mantle boundary to the surface. Much less is

known about them, but in a way it is as if the
Earth's mantle has weather patterns and mantle

plumes are a little like hot air rising to form
storm clouds. Storms hundreds of millions of

years old, made of rock circulating at
a rate of a few millimetres per month.

They don't care about the motion of tectonic
plates, so they can break the crust to create

volcanoes in the middle of nowhere that stubbornly
stay active as the crust shifts around them.

The volcanic boom-meter

Scientists love to put big booms on a
scale and came up with a logarithmic

scale that measures the volume ejected during
an eruption: The Volcanic Explosivity Index,

or VEI. Simply put, it starts really
small and gets very big very quickly.

A VEI 2 eruption would fill four hundred
full Olympic swimming pools with lava.

We have around 10 of these per year.

At VEI 3 we already see devastating effects,

like the eruption of the Semeru volcano in 2021
that destroyed thousands of homes in Indonesia.

At VEI 5, we see catastrophic amounts of
materials, cubic kilometers of debris, equivalent

to an entire lake of molten rock blasted into
the air. Like the 2022 Hunga Tonga-Hunga Ha'apai

eruption that sent a shockwave around the globe
many times and created ocean-wide tsunamis.

At a VEI of 6, an eruption can change the world.
In 1883, the Indonesian island volcano Krakatoa

erupted nearly continuously over the course of
5 months. One of those eruptions blew it apart,

producing the loudest sound recorded in history,

10 trillion times louder than a rocket
taking off, heard halfway around the world.

30m high tsunamis swept away nearby populations
and so much gas and ash were released that

global temperatures cooled by nearly 0.5°C.
Red dusty sunsets followed for many years.

At VEI 7, we get Super-Colossal
eruptions, millennium-defining

events that human civilization has
only encountered a handful of times.

Mount Tambora was a 4300m high mountain
until it exploded in 1815 and released 400

times more energy than the Tsar Bomba.
140 billion tons of ash and dust were

shot halfway to space before smothering the
world's skies, turning them a sickly yellow.

There was no summer the following year, crops
died and over a hundred thousand people perished.

This is the dreadful potential of volcanic
eruptions, with famines across the other

side of the world and even centuries-long
cold periods being attributed to them.

Ok. But what is a supervolcano?

The term "Super volcano" is a media invention
and not a scientific term. The main issue with

them is that not every eruption from
a supervolcano is a super eruption.

What makes super volcanoes special is that
they have been waiting to erupt for hundreds

of thousands of years. Pressure builds up in
colossal magma reservoirs several kilometers deep,

until it becomes strong enough to lift
the rock above it by several meters.

Rocks crack under the pressure, until they finally
give way and billions of tons of gas and ash blast

out at supersonic speed. An insane explosion
of at least a thousand cubic kilometers that

impacts every corner of the globe. And yet, that
is only a small portion of the magma reservoir.

Super eruptions are like a boiling pot of water
popping its lid off and spilling a bit off the

top. Afterwards the ground collapses into
the void left behind, forming a hole called

a caldera. Under this caldera, pressure starts
building again until the volcano gathers enough

energy for another supereruption – but this
could take hundreds of thousands of years.

It is estimated that one of the few
volcanoes capable of supereruptions

on Earth could cause a catastrophic eruption every

17,000 years on average. That would make them far
more frequent than comparable asteroid impacts..

The most recent super-eruption is the Oruanui
eruption 26,500 years ago in New Zealand.

With the force of dozens of billions of tons of
TNT, a Mount Everest- sized pile of explosives,

a huge portion of the landscape was
scooped out and thrown into the atmosphere.

It left behind a caldera spanning 20km and
it caused the entire Southern Hemisphere

to undergo a period of abrupt cooling. Though
among super-eruptions, it is a mere firework.

The Lake Toba eruption of 74,000 years ago
was a much more significant turning point

in history. It released a gargantuan 5300 cubic
kilometers of material, enough to blanket parts

of South Asia in 15 cm of ash and trigger
a rapid 4°C drop in global temperatures.

It’s possible that the volcanic winter lasted
ten years, followed by worldwide droughts for

centuries. Earth's climate might have
not recovered for a thousand years.

The largest volcanic events we know
of were not really huge explosions,

but floods of millions of cubic kilometers of
lava. The grand finale were the Siberian Traps

around 250 million years ago, a continuous
release of lava for two million years.

They raised the ocean temperatures to over 40°C,
which caused the Permian–Triassic extinction,

killing over 90% of all species. Earth's surface
needed 9 million years to recover. These sorts

of eruptions don't change the climate:
they are the climate. But thankfully,

we haven't seen anything even remotely close
to that scale in many millions of years.

So. Should you be scared of super-volcanoes?
Definitely not. They've been used to frighten

many people and are overhyped as an unavoidable
apocalypse. The most famous one, Yellowstone,

will erupt again, but they will
be relatively small eruptions.

Natural disasters for sure, but not enough to
devastate the US or come close to ending humanity.

The chance of a VEI 8 eruption in the
next few hundred years is less than 2%

and more importantly, it would
not come as a sudden surprise.

However, less powerful but more
frequent eruptions can also do

serious damage to our civilizations and
are in many ways a much greater concern.

So we must watch for slow changes in
magma reservoirs, like ground swelling

and temperature increases, to get an early
warning that can save the lives of people

living the closest to a volcano. And there's time
to develop solutions that can remove sulfur and

ash from the stratosphere to eliminate the root
cause of the climate disruption we've seen from

previous eruptions. Who knows, maybe we'll even
be able to turn this force of destruction into

an agent for good by exploiting the geothermal
energy held in their giant magma reservoirs.

We've done this work for so many other disasters
and we are already doing things we could only

have dreamed about decades ago, like sending a
probe to perform our first asteroid redirection

test. With determination, humanity really
can solve anything. So while deep below us

an angry hell is churning and waiting for
its moment, you can sleep well tonight.

Learning how we can get ahead of catastrophes like
climate change and supervolcanoes is interesting,

but can also be challenging. Maybe you still
feel like you don't really understand how

most of the science behind it works. And on
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