

# Changes in Earth's Magnetic Field are a main cause of Volcanism, Earthquakes, HGFA-seismicity & Global Warming

This is Part 2 of my Climate-Change Hypothesis → Please also read [Part 1](#), [Part 3](#) & [Part 4](#) ( alternative : [Part-1e](#) with Chapter C4)

**Abstract :**

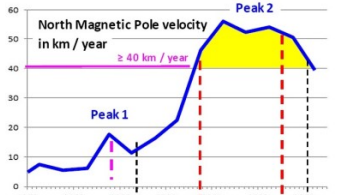
by Harry K. Hahn / Germany - 15.7.2023 - **Note : This document is not allowed for commercial use !!**

Changes in Earth's Magnetic Field seem to be a main cause of Volcanic-Eruptions on Earth ! These changes (or disturbances) in Earth's Magnetic-Field can be caused either by internal processes which take place near the Core-Mantle-Boundary (CMB), or they can be caused by external events which are strong geo-magnetic-storms caused by solar wind (space-weather). The maximum impact on volcanism, of the geomagnetic-changes caused by internal processes seems to be around +/-30%, and the maximum impact of the external events seems to be around +/-20%. There is a correlation of geo-magnetism, HGFA-seismicity, volcanism and global warming. First the geomagnetic-changes (-disturbances) seem to cause earthquakes, especially in High-Geothermal-Flux-(HGF)-areas (e.g. mid-ocean-ridges etc.), then with a delay of 1-2years Volcanism (& hydrothermal-activity, mainly in submarine-areas) is increasing, which then rises the Ocean-Heat-Content (->El-Nino-events), and eventually accelerates Global-Warming. → Please also read my [Study-1](#) which explains the causes of the El-Nino-events between 1997 and 2023 !

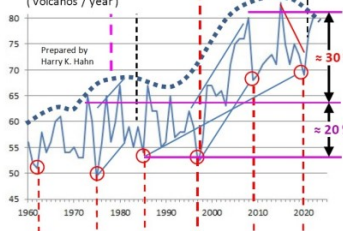
We can see a sharp rise and an elevation of the global-volcanic-activity (active volcanos per year) since around 1997, just after the sharp acceleration of the North-Magnetic Pole-shift (Pole-wander) began, around 1-2 years before. The chart of the -Worldwide Active Volcanos per Year- clearly follows a very similar trend as the chart of the North-Magnetic-Pole-Velocity (N-MPV), if a smoothed chart of the -Active Volcanos/Year- is considered (indicated by the dotted (symbolic) line above the chart). This trend is also visible if we look at Volcanism in very different regions (like South-America, Indonesia, SW-Pacific etc.).

The velocity of the North-Magnetic-Pole-shift (N-MPV) was <20km/yr before 1990 (for the last 400 years !), and it increased to >45km/yr in 1997 ! In just 7 years it more then doubled ! This fast North-Magnetic-Pole-shift is caused by an interference/interaction between two large lobes (blobs) of negative-magnetic-flux near the Earth's core-mantle-boundary (CMB), as Satellite-data of ESA's Swarm-mission showed. This fast North-Magnetic Pole-shift, which can be explained by big shifts of either fluids or electric-charge near the CMB, is a onetime-event which has increased global-volcanism by around 30% between ~1997 & 2015 (see charts), probably caused by increased pressure inside Earth's mantle, as a result of increased dynamical-processes near the CMB. Since around 2016 the N-MPV has decreased from over 50 km/yr to below 40km/yr and is further

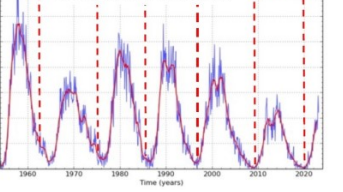
Global Volcanism is correlated with the North-Magnetic Pole-shift & Solar Cycles



worldwide active Volcanos 1960-2022 (volcanos / year)

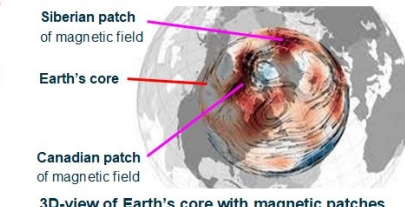


International sunspot number %; monthly mean and 13-month smoothed number

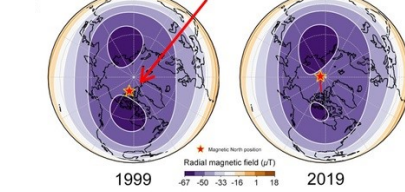


decreasing, which means that the geomagnetic-effect of the N-MPV on global volcanism will disappear in the near future ! Another effect which must be mentioned here : Strong magnetic-acceleration-patterns (magnetic-waves) which are located along the equatorial regions of the CMB, and which move around Earth's outer-core with a 7-year period seem to influence Volcanism too. The -number of active volcanos- in the Phillipines which oscillates with a ~7-year period between 0 and ~3 may be the proof for that. Further there is a clear correlation of sunspot-(solar-cycle)-minimas and Lows in the chart of the -Active Volcanos per year- which shows that Earth's Volcanism is clearly influenced by strong geomagnetic-storm-periods, or by the missing of such storm-periods ! During sunspot-minimas global volcanism clearly decreases by around 20%! Further the chart of -Total Volcanic Eruptions per year- and strong geomagnetic-storms from 1800–2023 shows that there are sharp increases in volcanic-eruptions visible, shortly after strong geomagnetic-storm-periods !

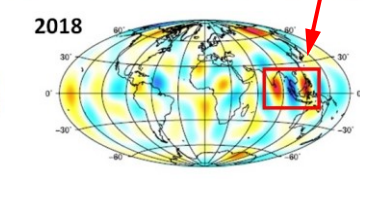
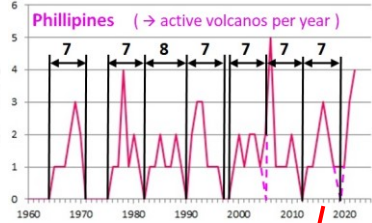
The North-Magnetic Pole-shift is caused by the interaction of 2 magnetic blobs near Earths core



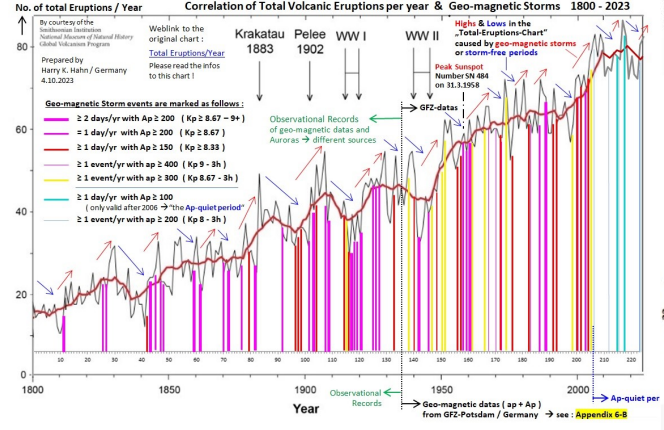
3D-view of Earth's core with magnetic patches



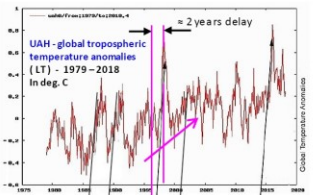
Magnetic acceleration pattern with 7yr-period causes periodic volcanism in the Phillipines ?



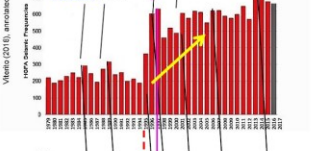
Correlation of Total Volcanic Eruptions with strong Geomagnetic storm-periods between 1800 and 2023. Eruptions rise sharply 1-2yr after geomagnetic storms



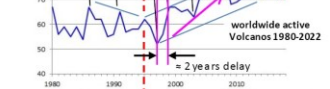
Volcanism correlates with seismicity in HGF-areas and Global Warming



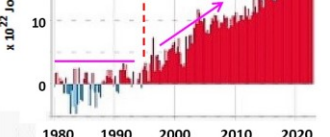
Seismicity in High-geothermal flux-areas (HGFA)



active Volcanos worldwide



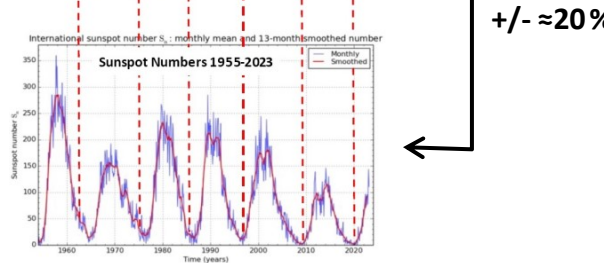
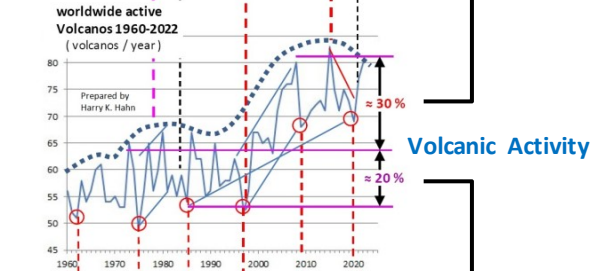
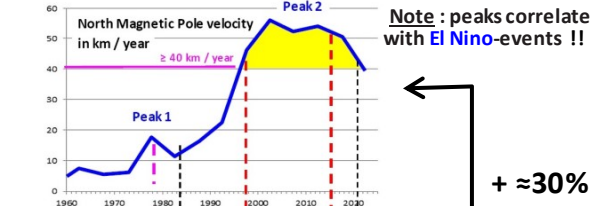
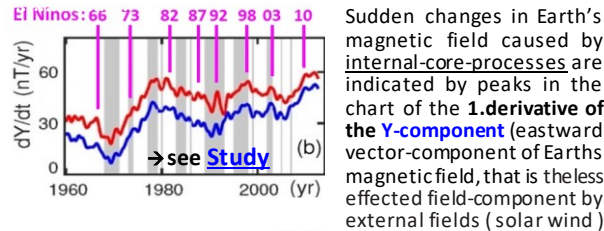
Ocean Heat Content 700 m, relative to the 1955-2006 average



**Intro :**

Changes in **Earth's Magnetic Field** seem to be a main cause of increased Volcanic-Activity on Earth !

These changes in **Earth's Magnetic-Field** can be caused either by **internal processes** which take place near the **Core-Mantle-Boundary (CMB)**, or they can be caused by **external events**, which are strong **geo-magnetic-storms** caused by **solar wind**. The maximum impact of **geo-magnetic storms** seems to be around **20%**. And the max. impact of internal-effects seems to be around **+30%**. As a major internal effect the **fast North-Magnetic Pole Shift** in the last **≈30 years** must be mentioned ! **Note :** The North Magnetic Pole moved **1300 km** in just **26 years** from **1994-2020** ! Earths Volcanic-Activity increased by **30%** in this time !



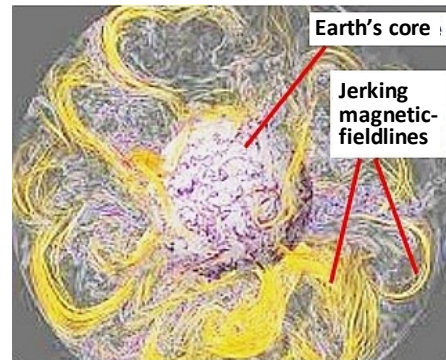
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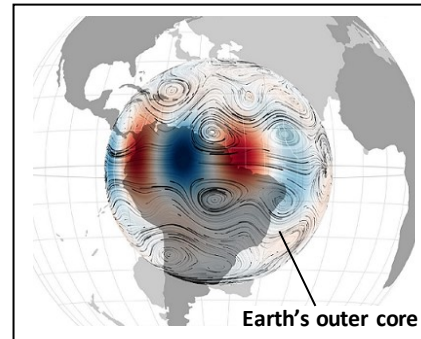
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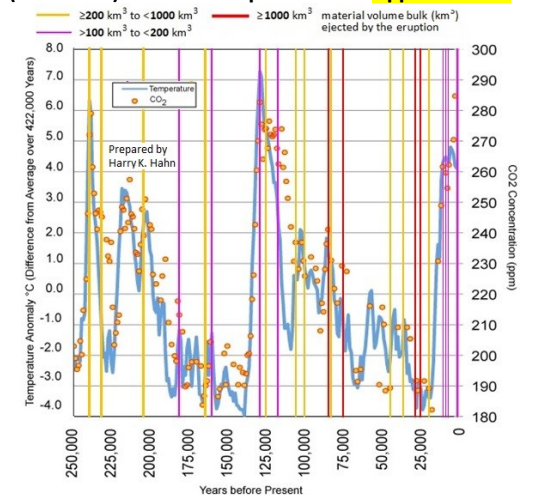
Jerking magnetic fieldlines inside Earths mantle



magnetic waves that move over Earth's Outer Core

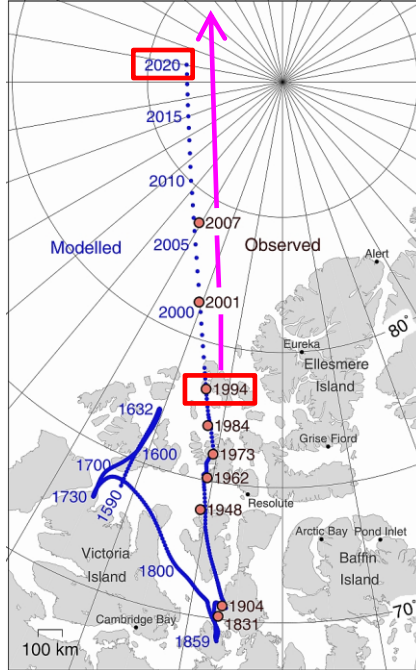


**A new hypothesis :** Interglacial-periods are caused by peak-volcanic-activity and often end with Ultra-Plinian-Eruptions with ejecta-volumes  $\geq 100 \text{ km}^3$  (= VEI  $\geq 7$ ) → see explanation in **Appendix 1-D**

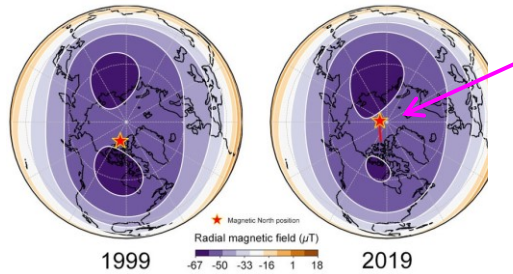


# 1 - The fast shift of the North-Magnetic-Pole seems to be responsible for increased-Volcanism & -Global Warming from ≈ 1997 - 2023

North magnetic pole positions 1590-2020



Siberian patch of magnetic field  
 Earth's core  
 Canadian patch of magnetic field  
 3D-view of Earth's core with magnetic patches



Tug between two magnetic blobs - A change in the circulation pattern of flow deep under Canada has caused a patch of magnetic field at the core-mantle-boundary to be stretched out. This weakened the Canadian patch and resulted in a fast magnetic pole shifting towards Siberia

Changes in Earth's magnetic field seem to be the main cause of volcanic eruptions on Earth!

The chart of the Worldwide Active Volcanos per Year clearly follows a very similar trend as the chart of the North Magnetic Pole Velocity (N-MPV), if we consider a smoothed chart of the Active Volcanos / Year (dotted line in the chart) → see charts below on the Left.

We can see a sharp rise & elevation of the global volcanic-activity since around 1997 just after the sharp acceleration of the North Magnetic Pole-shift began, around 1-2 years before.

Beside internal processes near the CMB inside of Earth, there are also external events that clearly influence Earth's magnetic field and with it Earth's volcanism. These are Geomagnetic storms!

(Note: A small number of volcanic eruptions may also be triggered by tidal forces caused by the Sun & Moon, which are responsible for a certain percentage of earthquakes (→ see Appendix 2).

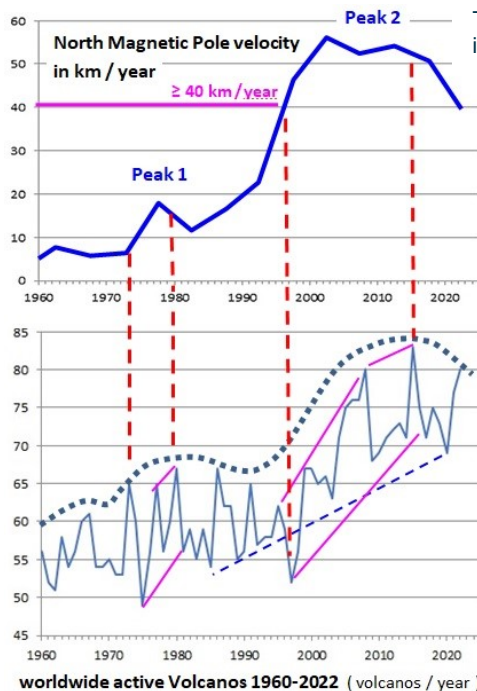
The fast shift of the North-magnetic-pole is caused by an elongating blob inside Earth's mantle

For some years now, scientists have been puzzled over the fast acceleration and fast shift of the north magnetic pole towards Siberia (Russia). Thanks, in part, to ESA's Swarm satellite mission, scientists are now more confident in the theory that magnetic blobs deep below Earth's surface which interact with each other are at the root-cause of this fast magnetic pole-shift.

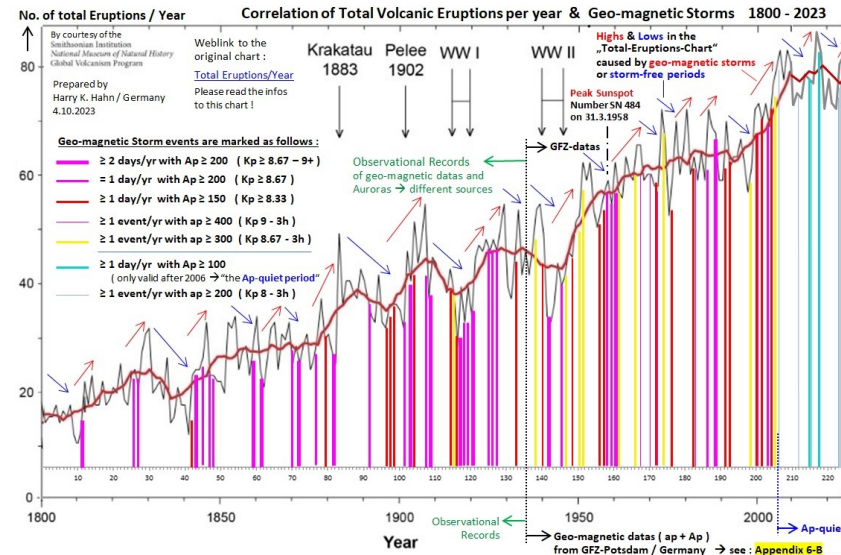
Satellite data showed that the position of the north magnetic pole is determined largely by a balance, or interference/interaction between two large lobes (blobs) of negative-magnetic-flux near the core-mantle-boundary (CMB), deep underneath of Canada.

**Note: The North-Magnetic-Pole has moved 12° towards NNW in just 26 years (1994-2020) which corresponds to the enormous distance of ≈ 1300 km in 26 years! The 400 years before it hasn't even had 25% of this velocity! It is clear that this has also caused fast mass-flows inside Earth!**

→ see map on the left → The text above was partly extracted from this : [ESA-news article](#)



## Strong Geo-magnetic storms caused by solar-wind also cause periods of increased Volcanism on Earth

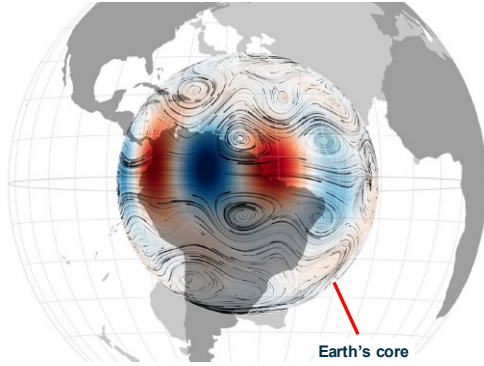


A number of studies indicate that there is a correlation of Geomagnetic storms with strong earthquakes, which then trigger volcanic-activity → see weblinks on page 5 → see also Appendix-3. I have created a Chart which indicates this correlation of Geomagnetic Storms with the worldwide Volcanic Eruptions/year for the time period 1800-2023 (→ see big image + explanation in Appendix-1-A)

How does this correlation work?: The currents generated by solar winds in the ionosphere cause magnetic-field-fluctuations on the Earth's surface, inducing electrical currents (telluric currents), which penetrate deep into the Earth, and in the presence of Earth's magnetic field, generate electromagnetic-(Lorentz-)force in the conductive crust, which can trigger the release of stress-strain-energy and can cause earthquakes and fractures in Earth's crust, which result in increased -volcanism & -hydrotherm. activity

## 2 - Short-term variations in Earth's Volcanism seem to be caused by Magnetic-Waves emitted from Earth's Core

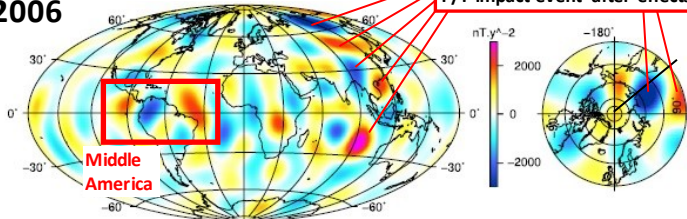
In the chart of the **worldwide active volcanos per year** we can also see **shortterm variations** in the range of around  $\approx 2-12$  years, beside the longterm trend caused by the N-MPV. **These shortterm variations in volcanic activity seem to be connected to shortterm changes of Earth's magnetic field**, caused by changing magnetic-acceleration-patterns located near the **core-mantle-boundary (CMB)**. Especially the strong magnetic pattern in the equatorial region ( under Indonesia/Phillipines ) **must be metioned here**. This pattern with a **7-year periodicity** seems to oscillate synchron with the Phillipine-volcanism (  $\rightarrow$  see image )



Scientists have discovered a completely **new type of magnetic wave that moves over the outermost part of Earth's outer core every seven years** and propagates westward at up to 1500 km a year. These magnetic waves that **oscillates every seven years** are caused by Earth's rotation, and these waves align in columns along the axis of rotation. The motion and magnetic field changes associated with these magnetic waves are strongest near the equatorial region of the core. ( **The volcanism in the Phillipines may indicate these waves !** ) The research indicates **magneto-Coriolis waves with an approximate seven-year period**. The question of the existence of similar magnetic waves that oscillate at different periods, however, remains.  $\rightarrow$  also read **Appendix-2** regarding this **7-year period** ( H.K.Hahn ) The magnetic waves are likely to be triggered by disturbances deep within Earth's fluid core, possibly related to buoyancy-plumes.  $\rightarrow$  see **News Article** about the results of ESA's swarm mission, which is mapping Earth's magnetic field,

Vertical down core magnetic field acceleration as estimated by the MCM model (Ropp et al. 2020) ; mapped at the CMB for the years 2006 and 2018

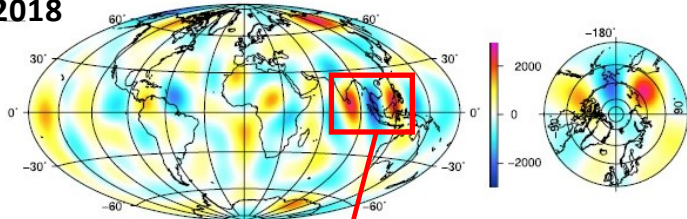
2006



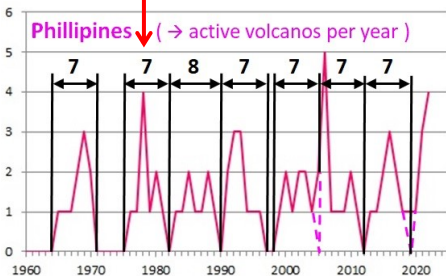
The strong magnetic-patterns between  $\approx 90^{\circ}-130^{\circ}$  E may be a result of the N-MPV and/or of P/T-impact-event after-effects

North Pole area

2018



Note the nearly precise 7 year long volcanic-activity cycles in the Phillipine-Islands ( close to Indonesia )



### Extracts from the study: Rapid Variations of Earth's Core Magnetic Field

Evidence of fast variations in the **Earth's core-field** are seen both in magnetic observatory and satellite records. The observed magnetic field above the Earth's surface results from the contribution of numerous sources located inside the Earth, such as the core and the lithosphere, or outside the Earth, such as the ionosphere and magnetosphere, which are influenced by **space-weather** (  $\rightarrow$  solar wind related to the **Solar-cycle** ).

**Note : The dominant contribution to Earth's magnetic field is by far the magnetic field generated in Earth's core.**

The Earth's magnetic field has longer time-changes, including millennial and longer Periods. The shortest changes reach sub-daily periods, in link with the rotating fluid dynamics of the fluid core. The changes observable at Earth's surface are currently between the upper limit of around 100 years and the lower limit of a few years duration.

**Note : Strong magnetic acceleration patterns are mainly located at the CMB along the equatorial regions, or at all latitudes in between the longitude-lines  $90^{\circ}$  &  $120^{\circ}$  East. Strongest accelerations are often seen under **Indonesia** or **Central (Middle) America**. These acceleration patterns have a footprint at the Earth's surface that is very large.**

The strong patterns between  $90^{\circ}$  &  $120^{\circ}$  E and in the North-pole area may be a result of the PTI (  $\rightarrow$  see below, H.Hahn )

The magnetic field induced in the conductive crust and in Earth's mantle by time varying external fields remains the major problem that makes it difficult to derivate accurate core magnetic field models, because both contributions overlap over a large range of spatial and temporal scales. Ambiguities (interferences) may also remain at the decadal period of the solar cycle (and its harmonics), and at the strong semi-annual & annual periodicities caused by ionospheric & external fields, in order to achieve a better model  $\rightarrow$  Weblink to this **Study**

The **Pacific-LLSVP** & **African LLSVP**, two big structures inside Earths mantle near the **CMB**, which are characterized by slow (seismic) shear wave velocities, may also influence the magnetic acceleration patterns. These two big **LLSVP**-structures are probably the result of the hypothetical **Permian-Triassic Impact (PTI)**, and therefore they must be **rich in iron- & carbonatites** which are very good **conductors**, and therefore react to magnetic fields. ( see **Study** )

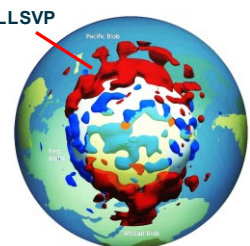
**Note : The trajectory** of the hypothetical **PTI-Impactor** was roughly following a **path between  $90^{\circ}$  &  $120^{\circ}$  E, N  $\rightarrow$  S**, when it impacted in Siberia. Thats why the strong magnetic patterns visible between  $90^{\circ}$  &  $120^{\circ}$  E, especially in the Northern-hemisphere may be the result of the primary- & secondary impacts ( Harry K. Hahn )  $\rightarrow$  see **Appendix-5** For more info about the PTI please read **Part 1** & **Part 2** of my **PTI-hypothesis**. ( or alternative: **Part 1** & **Part 2** )



Sometimes Earth's magnetic field changes rapidly -the fieldlines inside Earths mantle jerk (wave) suddenly every 3 - 12 years. This is caused by hydromagnetic waves emitted from Earth's core.  $\rightarrow$  see : **ESA-article**

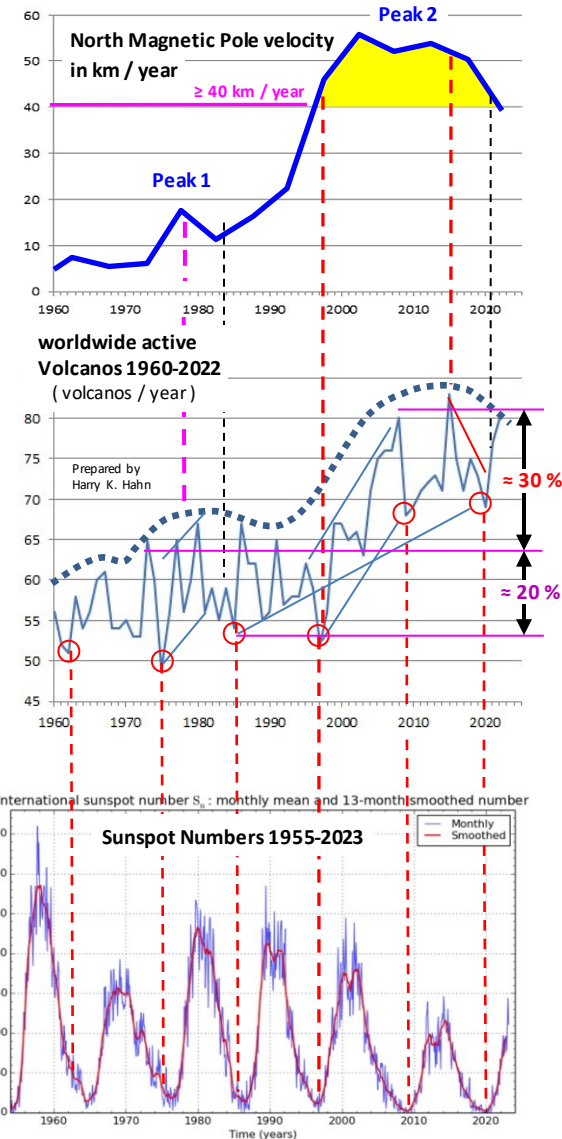
Pacific LLSVP

3D-view of the two big **LLSVPs** located near the **CMB** in Earth's mantle, the **Pacific LLSVP** and the **African LLSVP**  $\rightarrow$  see **Appendix-5**



### 3 - Volcanism is correlated to geo-magnetism, HGFA-seismicity, solar-cycles & global warming

A comparison of the 3 charts below indicates that **volcanic activity is influenced by a longterm geo-magnetic effect, the MPV, and by shortterm geo-magnetic effects, like the sunspot cycle (=space weather-activity)**. The chart of the **Worldwide Active Volcanos per Year** clearly follows a very similar trend as the chart of the **North Magnetic Pole Velocity (N-MPV)** if we consider a smoothed chart of the **Active Volcanos/Year** (dotted line). When the **MPV** reached the wide **Peak 2** with  $\geq 40$  km/year we can see a **sharp rise & elevation of the volcanic activity**. If we look at the chart of the **worldwide active volcanos per year** we clearly see **sharp rises of activity in the years 1997-99, 2003-07, 2014-15 & 2020-22** interrupted by two drops caused by **sunspot cycle** minimas. Note that we had **El Ninos** events with increased **Sea Surface-temperatures** in the years **97/98, 2003-05, 2007**



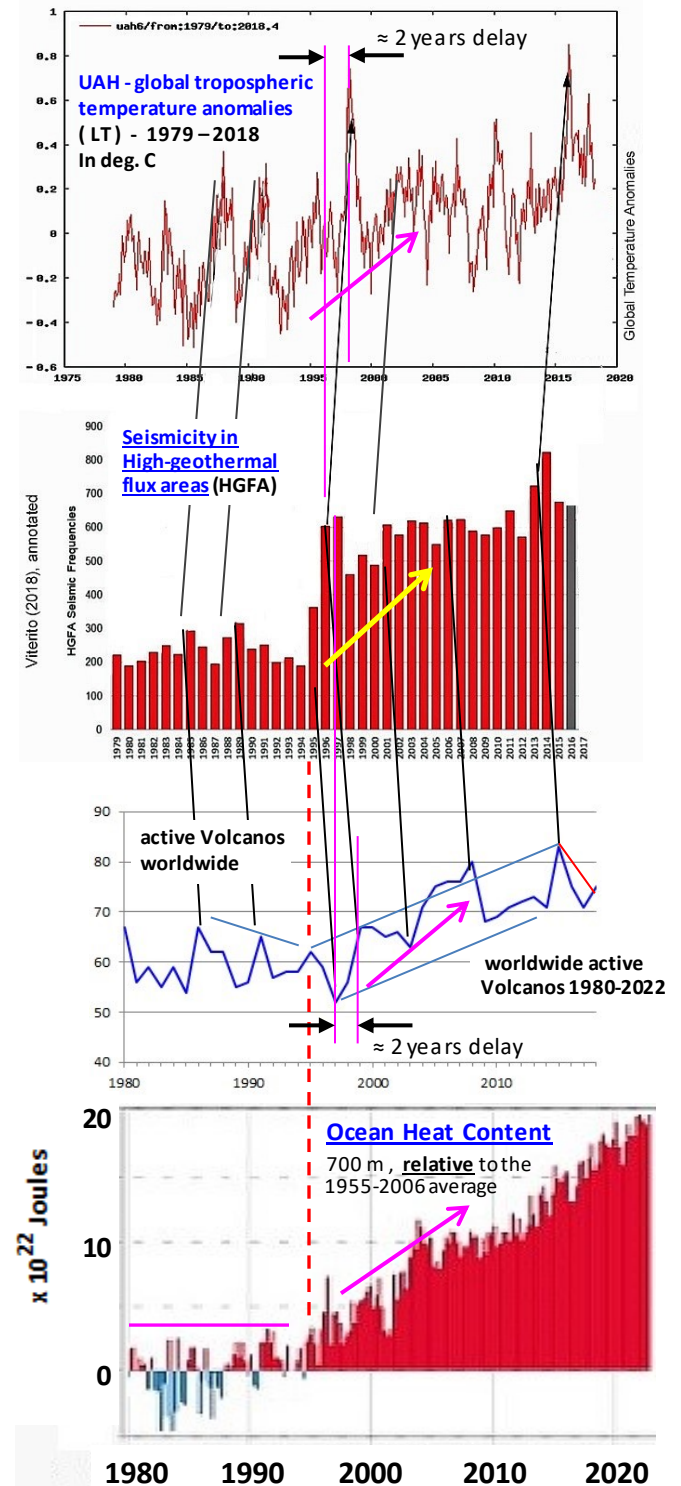
**2014-16** and a **new El Nino** episode just started in  $\approx 2022$ . The impact of the high MPV on Volcanism is  $\approx 30\%$  and that of solar cycles  $\approx 20\%$ . Further some studies show a clear **correlation of seismic activity in High-geothermal-flux-areas (HGFA) and the Global Warming** of the last few decades (see: [Study & Study-update](#))  $\rightarrow$  see charts  $\rightarrow$  **HGF-areas** are all **mid-ocean-ridge-areas** and **geothermically** active areas ( $\rightarrow$  see map in [Appendix 4](#)) It is important to note that there is a **delay of around 2 years between the seismic activity and the reaction of the global climate-system.** ( see charts on the right ).

There is also a **delay of  $\approx 2$  years** noticeable **between the seismic-activity in the HGF-areas and the global volcanism** ( in the chart represented by **active volcanos per year** )  $\rightarrow$  see charts on the right. This delay can be explained by the time needed for magma and/or hydrothermal fluids to rise from Earth's mantle and Earth's crust to the surface, after new fractures have opened up in Earth's crust, caused by increased seismicity resulting from the mentioned geo-magnetic effects. (magnetic pole-speed & geomagnetic storms). Further it's important to note that **the distinct jump in seismic activity to a higher level in the HGF-areas**, which we see in the chart in the years **1995-1997**, was followed by a strong increase in the growing-rate of the **Ocean Heat Content** since around 1996 and followed by a strong peak in **global tropospheric-temperature-anomalies** ( $\rightarrow$  see charts on the right ).

**Here are weblinks to infos & studies that also indicate such correlations:**

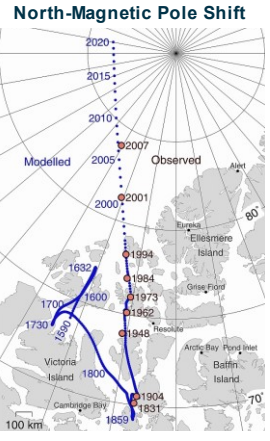
- 1.) - **Correlation between solar activity and large earthquakes worldwide**
- 2.) - **A solar-terrestrial effect influences volcanism & global seismic activity**
- 3.) - **Correlation of geomagnetic anomalies with earthquakes & solar storms**
- 4.) - **Volcanic eruptions are correlated with Solar Activity**
- 5.) - **Links of Volcanic Eruptions to Solar Activity and Solar Magnetic Field**

**More weblinks** to similar studies under [References](#) (see last pages)



# 4 - The numbers of "Active Volcanos / year" in many world-regions & worldwide clearly increased when the North-Magnetic-Pole-velocity peaked

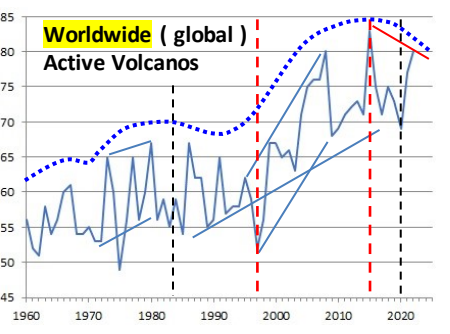
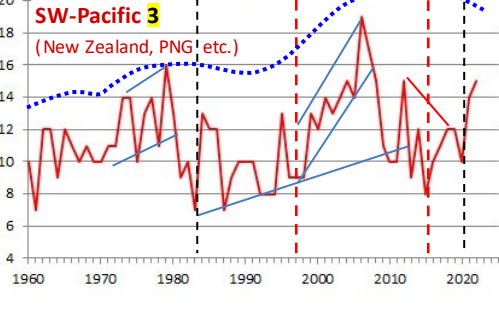
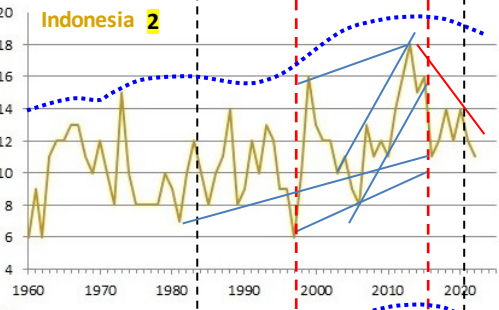
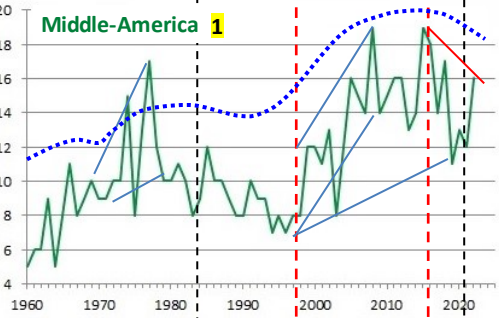
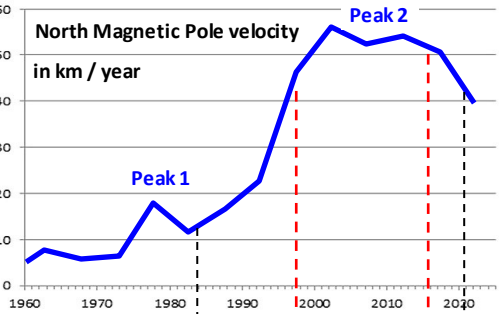
The pole-shift is caused by 2 magnetic-blobs inside of Earth  
 A change in the circulation-pattern of flow deep under Canada has caused a patch of magnetic field at the core-mantle-boundary to be stretched out. This weakened the magn.-field-patch under Canada and caused the magnetic-pole-shifting towards Siberia



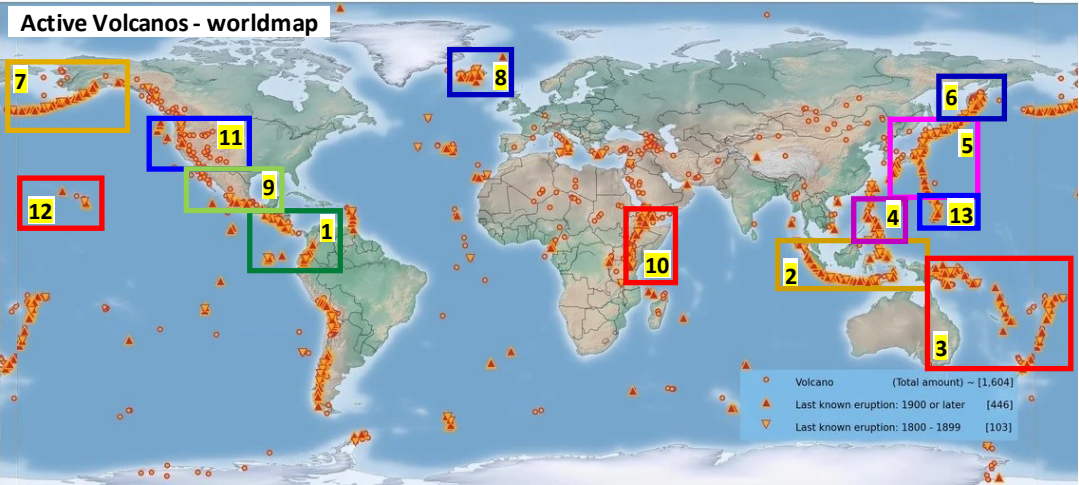
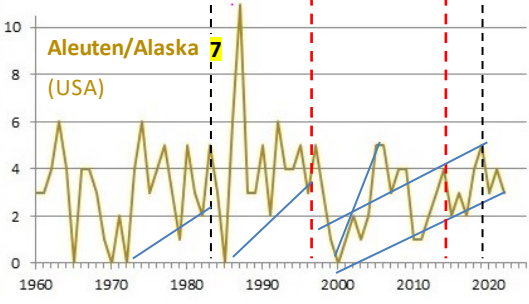
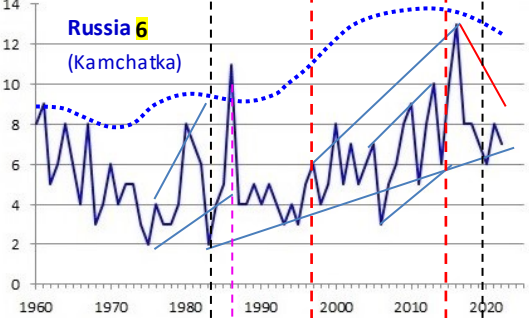
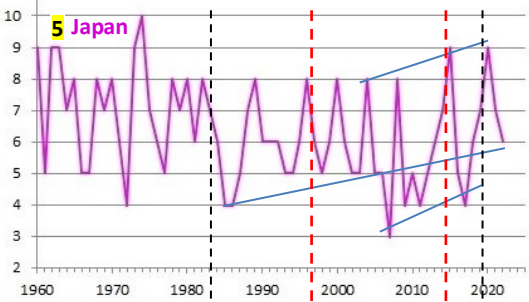
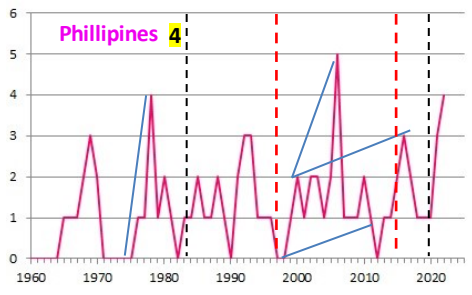
The chart of the **Worldwide Active Volcanos per Year** (see below) clearly follows a very similar trend as the chart of the **North Magnetic Pole Velocity (N-MPV)** if a smoothed chart of the **Active Volcanos/Year** is considered (dotted line over the chart (symbolic)). Increased Volcanic activity on Earth as well as increased Seismic-activity in **HGFA-areas** and increased **Ocean Heat Content** must be linked to increased **geo-magnetic**-changes in **Earth's outer core**, which resulted in the fast shifting of the north-magnetic pole towards Siberia.

When the **N-MPV** reached the wide **Peak 2** with  $\geq 40$  km/year we can see a sharp rise & elevation of the volcanic activity during the time of the **Peak-2-formation**, not only in the "worldwide"-Chart but also in many other charts which only show the active volcanos/year of selected world-regions, like Middle-America, Indonesia, SW-Pacific & Russia (Kamchatka). This means that we really look at a global phenomenon here !

If we look at the chart of the "Worldwide active volcanos per year" we clearly see sharp rises of activity in the years 1997-99, 2003-07, 2014-15 & 2020-22. We also see these sharp rises of volcanic activity in the same time-periods in the other mentioned world-regions. **Note**: The **geo-magnetic** change that is going on inside of Earth is influenced by shortterm **geo-magnetic** fluctuations caused by the **solar-cycles** (see page 4)



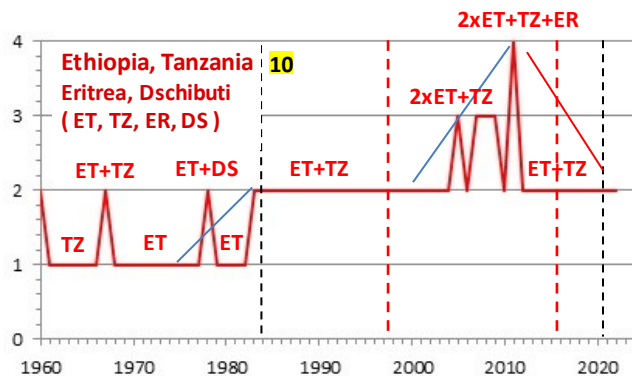
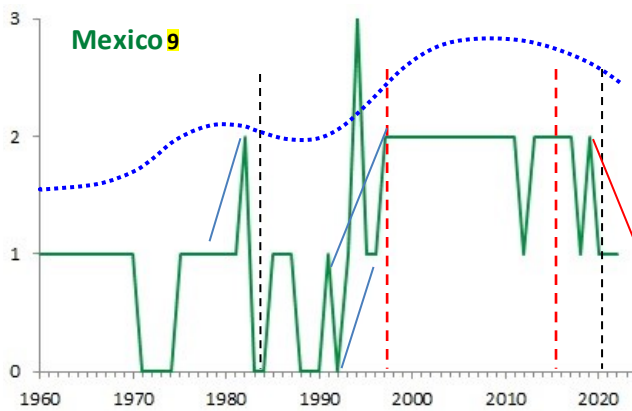
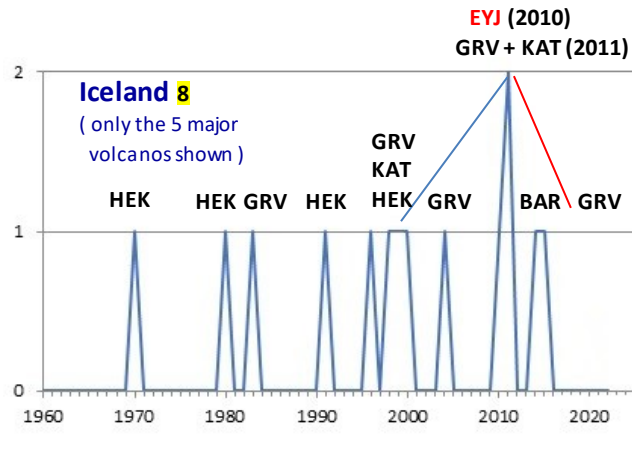
→ **Note**: the datas of the active volcanos/ per region & globally are available in **Table 1 in Appendix 6-A**



This worldmap shows the worldwide Active Volcanos. Volcanos that have been active between 1800 & 1899 are indicated by **yellow-triangles**. Volcanos that have been active 1900 or later are indicated by **red-triangles**  
 → The number of active-volcanos/year, located in the areas marked on the map, are shown in the diagrams

## 5 - The numbers of “Active Volcanos / year” in other world-regions also show increased activity in the time period 1997 - 2015

→ **Note** : the datas of the active volcanos/ per region are available in **Table 1** in **Appendix 6-A**



In four other world-regions we can also see increased volcanic activity **within the time-period 1997 – 2015** . These regions are : **Iceland, Mexico, Ethiopia+Eritrea & the Mariana Islands** This again indicates a global phenomenon !

In the timeperiod 1997-2015 the **North Magnetic-Pole-Velocity curve** reached a very high peak with a velocity of 40 km/year. The process which has caused this fast pole shift, a dynamic flow pattern inside of Earth’s mantle, must be responsible for this global phenomenon of increased volcanism, increased seismicity in HGF-areas and increased global warming (→increase in ocean heat content)

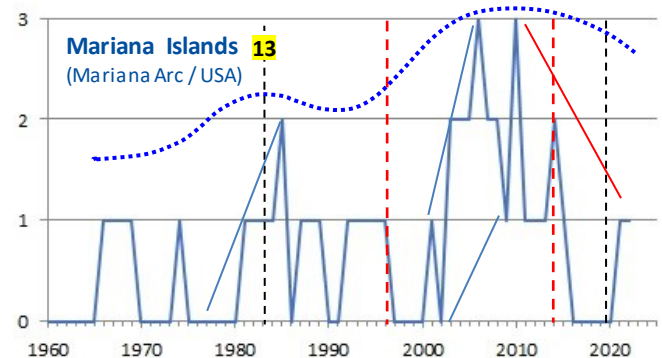
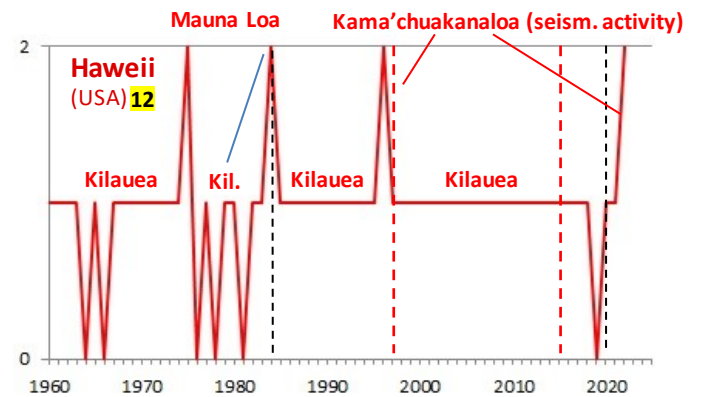
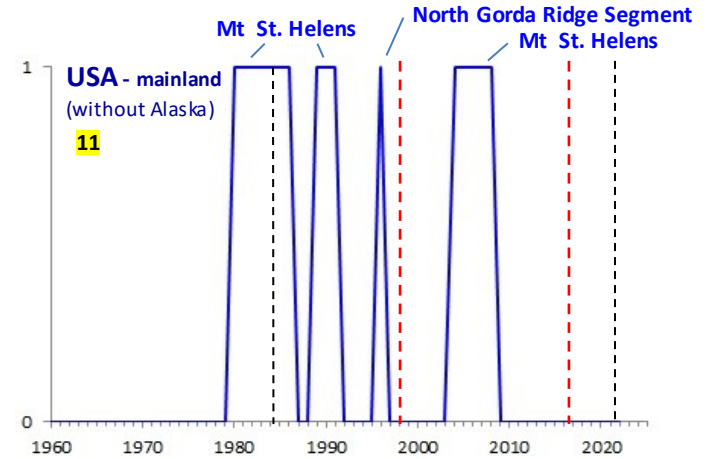
In Iceland the volcano **Eyafjallajökull** became active in **2010** after 190 years pause and the rising magma caused a big crustal displacement and a big eruption that disrupted air-traffic over NW-Europe for 6 days because of huge ash-emissions. The volcano **Katla** was active in **1999** and in **2011** after >40 years pause. And in **2021** a new eruption occurred at **Fagradalsfjall** volcano near the plate boundary in Reykjanes after 815 years pause.

Mexico had two constantly active volcanos without a pause from **1997 to 2011**. Before the year 1997 in average only one volcano was active per year ( except in 1994 when 3 volcanos were active and in 1982 when 2 volcanos were active )

Volcanism in the Ethiopia-Tanzania-Eritrea region reached a peak with **4** active volcanos in **2011**. It’s most active time was from **2005 to 2011**

At the **Kilauea** volcano in Hawaii the **longest major eruption in history** occurred from **1983 to 2018**

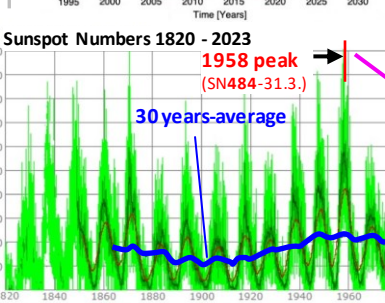
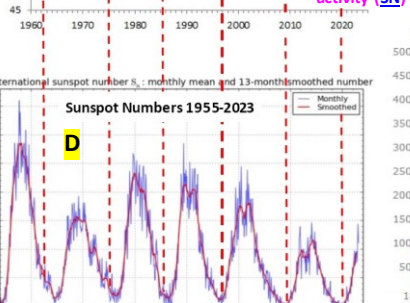
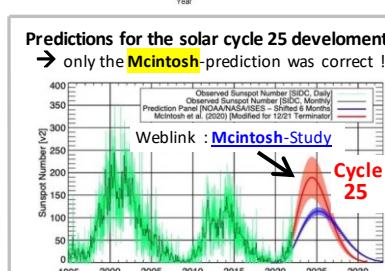
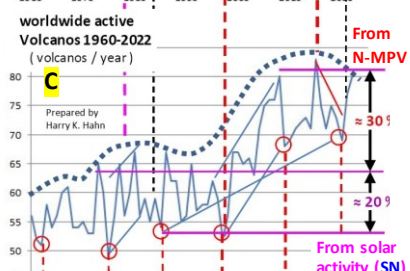
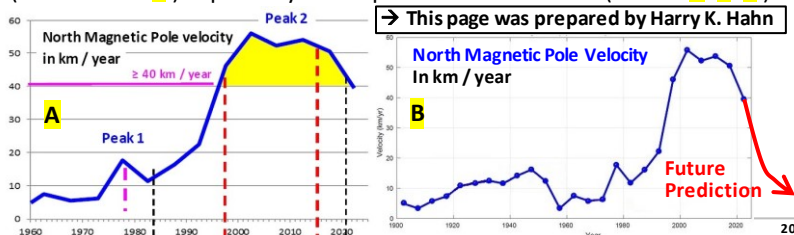
Volcanism in the Mariana Islands had a peak-time between **2003 and 2008** with **2-3** active volcanos. In the Mariana Islands new submarine lavaflores were found in 2015 together with a number of new hydrothermal vents on the ocean ground.



6 - Sunspot-minimas reduce the worldwide active volcanos and the OHC ! → To predict World's climate we must predict the future solar-activity !

As shown on page 4 there is a clear correlation between geo-magnetism, solar-cycles, HGFA-seismicity, Volcanism & Global Warming. The geo-magnetic-changes near the Earth's core-mantle-boundary, which have caused the fast shift of the North Magnetic Pole, have an impact of ≈ +30% and Geo-magnetic Storms caused by solar-cycles have an impact of ≈ +/- 20% on Global Volcanism, as Chart C (& A+D) indicate. Changes in Geo-magnetism & Solar-cycles are responsible for ≥40% of Global Warming ! See also my Study-1 !

The same flow-patterns (mass streams) inside of Earth's mantle, which cause the fast North Magnetic Pole Shift (N-MPV) ( see chart A+B ) are also responsible for increased Worldwide Volcanic Activity (chart C) and increased seismic- & geothermal-activity in HGF-areas on Earth, which caused the increased Ocean-Heat-Content (OHC) & the Global Warming (→ see Chart Y) especially in the period 1997 to 2023 (charts A+C+Y)



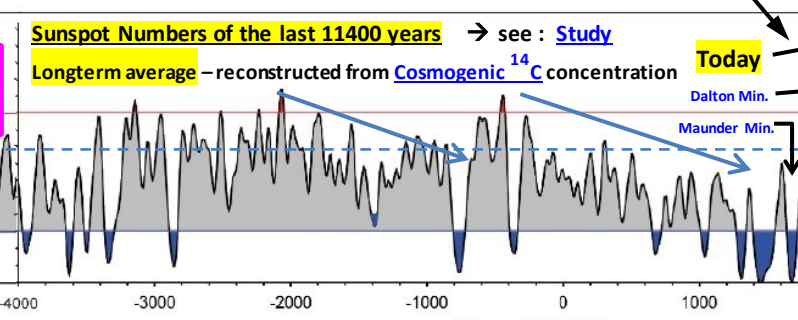
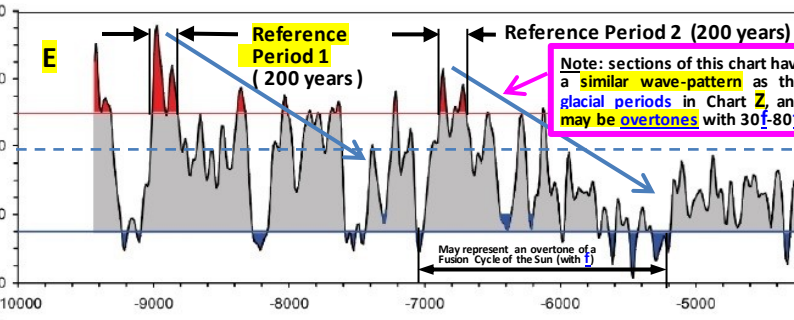
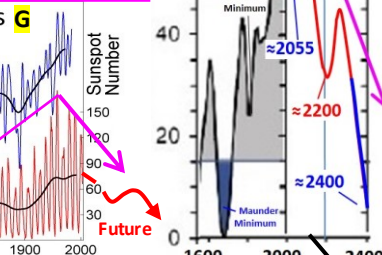
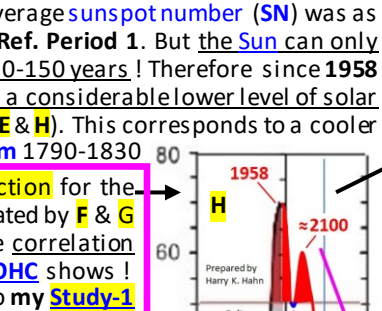
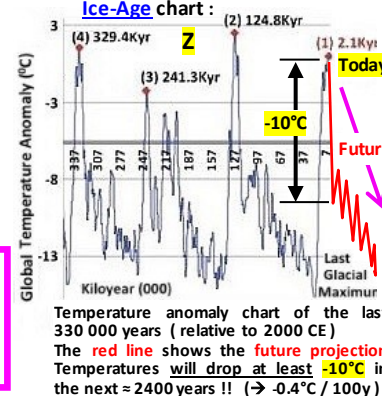
**Prediction of future Solar-Activity Volcanic Activity & Global Warming:**

In the Chart B we can see that the velocity of the North Magnetic Pole dropped below 40 km/year in ≈2022 and it will in all probably drop to ≤10 km/year in ≈2040 and then it will probably stagnate for many decades

This means the contribution of the N-MPV of ≈30% to Global Volcanism (& to geo-thermal activity +OHC) will disappear in ≈10-20 years (Chart A-C)

11000 years ago the solar activity (average sunspot number (SN) was as high as today ( see Chart E ) → see Ref. Period 1. But the Sun can only hold this high level of activity for ≈120-150 years ! Therefore since 1958 (max. SN-peak) we are on the way to a considerable lower level of solar activity with an average ≤40 SN (see E & H). This corresponds to a cooler world climate, as the Dalton Minimum 1790-1830

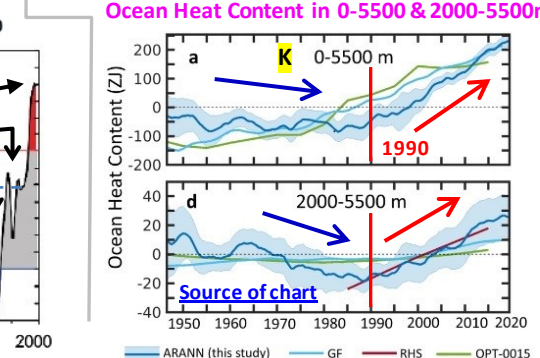
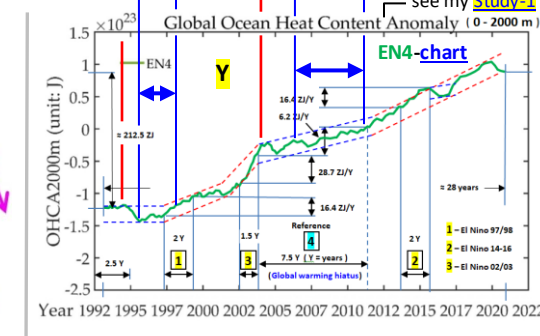
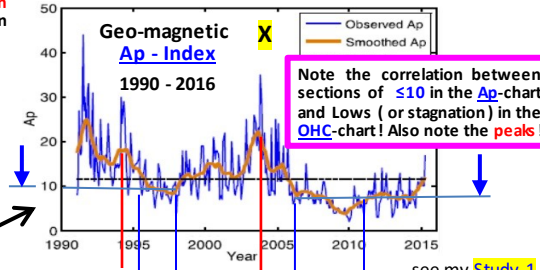
The Chart H shows my future prediction for the solar activity & SN. This is also indicated by F & G. We go to a cooler (SN)-climate as the correlation between geo-magnetic Ap-Index & OHC shows ! see Charts X & Y (& chart Z) see also my Study-1



The Ocean Heat Content in the depth-ranges 0-5500 m and 2000-5500 m did not increase in the time-period 1950-1990 !! (see chart K)  
Note : It actually dropped in that time-period especially in the depth-range 2000 - 5500 m !!

This can mean only one thing: The ocean water was heated from below, from the ocean-floor, in particular → from the HGF-areas ! in the time ≈ 1995-2023. ( → see Chart K ) Otherwise the quick warming of water in depths >2000 m can't be explained !

If heated from the surface ( caused e.g. by increased air-temperature ), then the ocean water would have needed decades if not centuries to heat up in depths 2000-5500 m !!





# Appendix 1-A : Chart which shows the Correlation of Total Volcanic Eruptions per year & Geo-magnetic Storms in the time-period 1800 - 2023

## Explanation to the Chart :

### 1.) To the visible correlation :

There is a clear correlation visible in the chart, of **sharp rises (highs)** in the "Total Volcanic Eruptions" with the **occurrence of strong geomagnetic storms** (solar storms) indicated by colored lines under the chart.

Shortly after the occurrence of a strong geomagnetic storm (period) ,or with a delay of 1-2 years, there is a sharp increase in the number of volcanic eruptions visible ! (**Highs**) ( indicated by **red arrows** )

On the other hand there is a clear correlation visible in the chart of decline-periods (**lows**) in the chart, which correlate with phases where no or very less geo-magnetic storms occurred. ( indicated by **blue arrows** )

**This correlation is strong and clearly visible in the chart !**

**Note :** Because the geo-magnetic storms first trigger earthquakes, and with a certain delay of up to  $\approx 1-2$  years the volcanic eruptions follow, the rises (peaks) follow with a slight delay after the geo-magnetic storms (storm periods)

### 2.) Geo-magnetic storm datas :

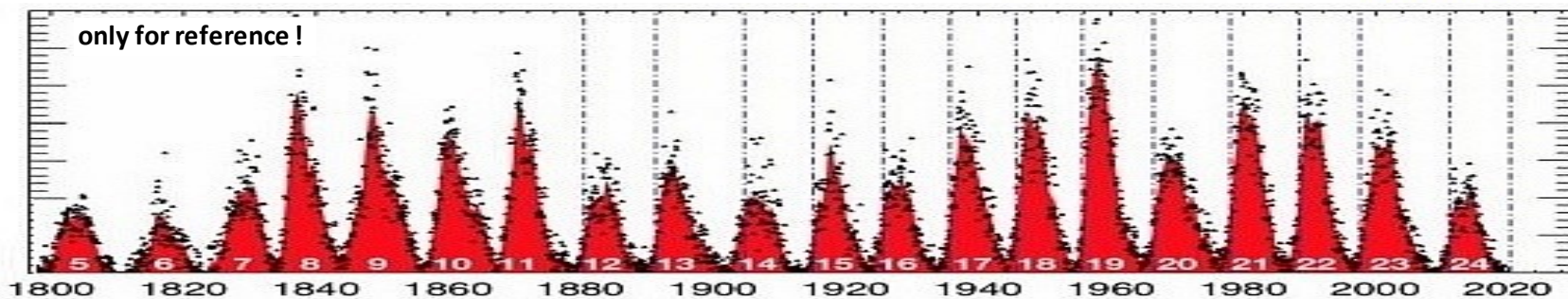
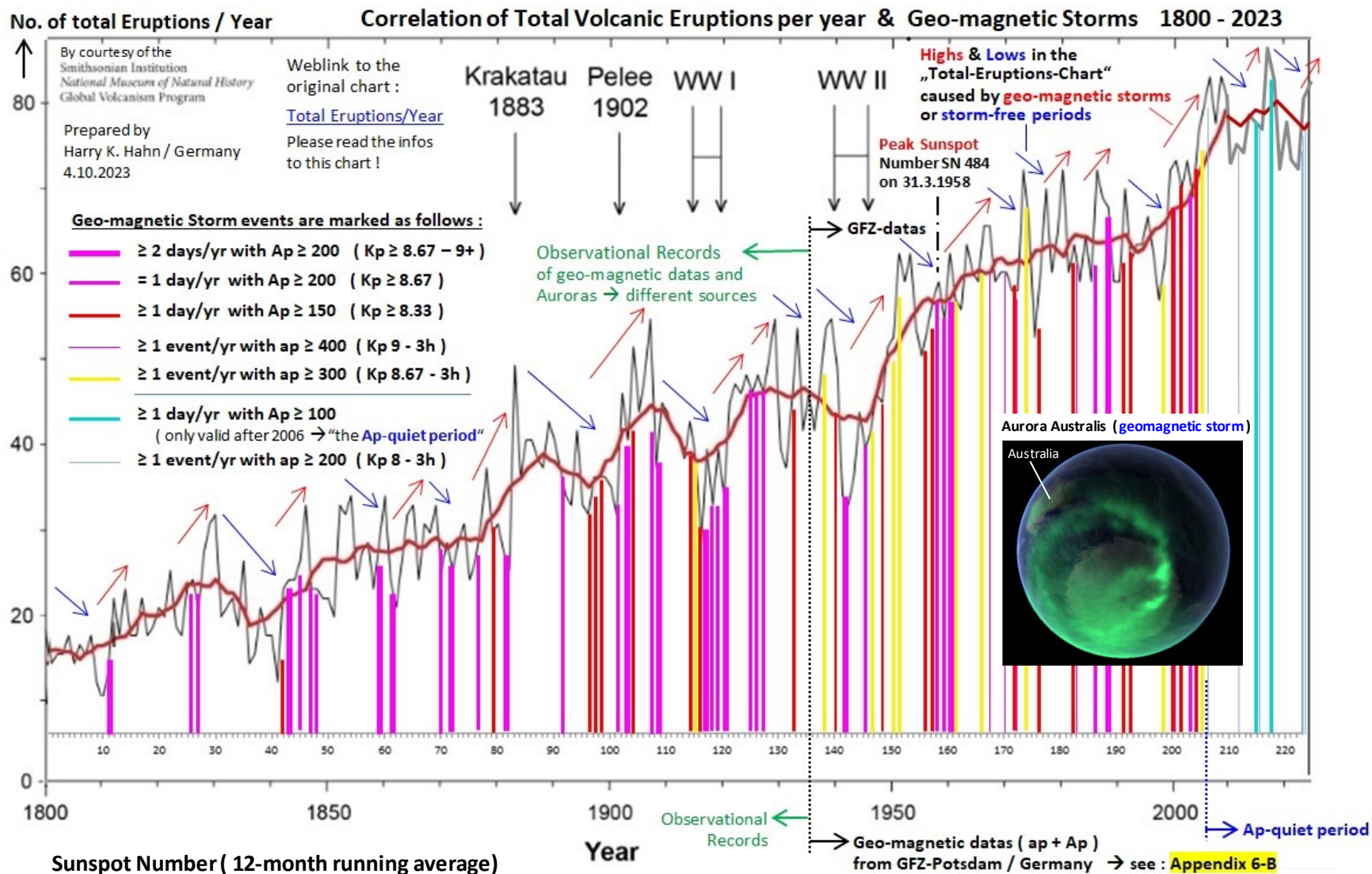
→ see **Tables 6B & 6C** in Appendix

### 3.) Volcanic Eruptions datas :

→ see **Table 6A** in the Appendix

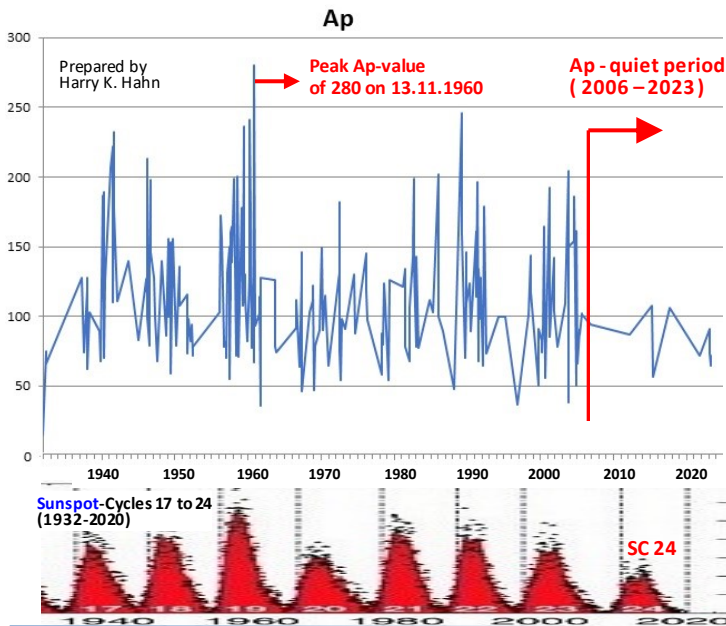
→ Also read the informations of the **Smithsonian Institution !**

see : [Total Eruptions/Year](#)



## Appendix 1-B : Longterm Prediction of future Solar Cycles and Solar Activity

Because there is a correlation of **geomagnetic storms** with earthquakes, volcanism and **hydrothermal activity**, and **Global Warming** (→ see page 5&8) we must predict the **solar cycles**:



### Geo-magnetic Storm Chart :

The chart is showing all days with at least one 3h – ap-value  $\geq 200$

The Ap-value (sum of ap1 to ap8) of these days is shown in the chart

It is clearly visible in the chart that since 2006 no days with higher Ap-values occurred anymore !!

Since 2006 only two days with an Ap-value slightly  $> 100$  occurred !!

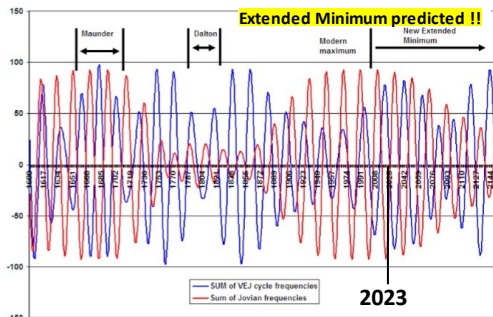
**WARNING !! :**

This fact is a clear **warning-sign** that the Sun has switched to a **lower general activity !!**

This has a **cooling effect on the World's Climate in the future !!**

Here theories for **longterm predictions of solar cycles**: „A mathematical model of the sunspot cycle...“

The model presented here is an attempt to produce a more quantitative prediction of monthly **sunspot-number forecasts** and increase the granularity of the shape of future solar cycles. The model is based primarily on a **Tidal Torque theory** proposed by Ian Wilson (2011) and **two Jovian harmonics** that account for the positioning of three Jovian planets. Wilson's theory proposes that periodic alignments of Venus and the Earth on the same or opposite sides of the Sun produce temporary solar tidal bulges. Jupiter's gravitational force acts on these bulges and either **speeds up** or **slows down** the rotation of the Sun's plasma, leading to changes in **solar activity**. The frequency of these alignments on the same side of the Sun is 22.14 yr. Wilson also shows that the strength of the tidal force depends on the heliocentric latitude of Venus and the mean distance of Jupiter from the Sun, and that **when these forces are weakest, solar minimums occur**. This happens approximately every 165.5 yr. The frequency to produce a 165.5 yr beat with 22.14 yr is 19.528 yr. These two frequencies of Venus–Earth–Jupiter (VEJ) interactions are a principle basis for the model. → Weblink to this **Study**



**Fig.:** The blue line is the interference contribution pattern for the sum of the two Venus–Earth–Jupiter (VEJ)-frequencies (19.528, 22.14), and the red line is the interference contribution for the sum of two Jovian frequencies (19.585, 21.005) to the polarity-adjusted sunspot model for the years 1600 to 2100. The periods of destructive interference during solar minimums and constructive interference during the solar maximum can be seen by inspection of these two interference patterns. At times either the VEJ or Jovian cycles can dominate.

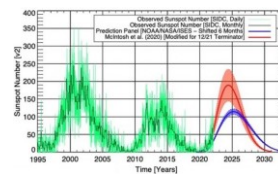
The periods of destructive interference during solar minimums and constructive interference during the solar maximum can be seen by inspection of these two interference patterns. At times either the VEJ or Jovian cycles can dominate.

**Other studies which are based on the Tidal Torque Theory:**

→ Weblinks : **Study1** , **Study2** , **Study3** , **Study4**

**Prediction of the next solar cycle :** → Weblink to **McIntosh's Study**

This theory of **Scott McIntosh** allows to predict one solar cycle precisely in advance. A relationship was found between the temporal spacing of the terminators of the 11yr-sunspot- & 22yr-magnetic cycles and the magnitude of (future) sunspot cycles.



## 1-C : Correlation of Geomagnetic Storms with Global Warming

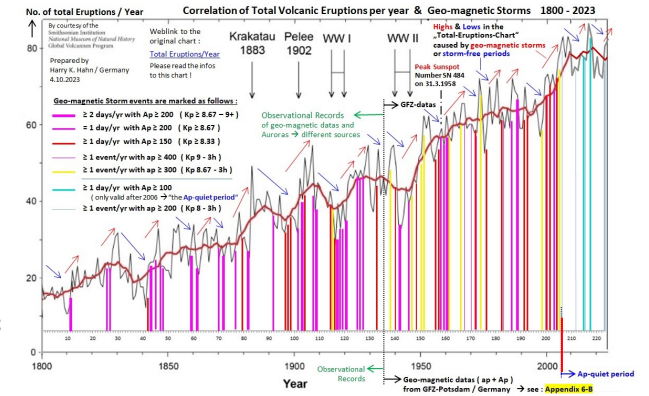
As described on the previous page there is a clear correlation visible in the chart, of sharp rises (highs) in the “Volcanic Eruptions” –worldwide, with the occurrence of mainly strong **Geomagnetic-Storms (solar storms)**, → indicated by colored lines under the Chart → see on the right

Because these **Geomagnetic Storms** probably first trigger earthquakes, mainly in the

**HGF-areas**, and then with a certain delay of  $\approx 1-2$  years the volcanic eruptions follow, the rises (peaks) in the “Volcanic Eruptions-chart” follow with a slight delay after the **geo-magnetic storms (storm periods)**.

Since  $\approx 2006$  it is noticeable that geo-magnetic storms are considerable weaker and they are rarer. These weaker geomagnetic storms are indicated by blue lines under the chart.

In the chart which shows the geomagnetic **Ap-index**, which measures the daily average storm-activity, we can see that **there is considerable less activity visible after 2006** (→ see Ap-chart on the right and below !)

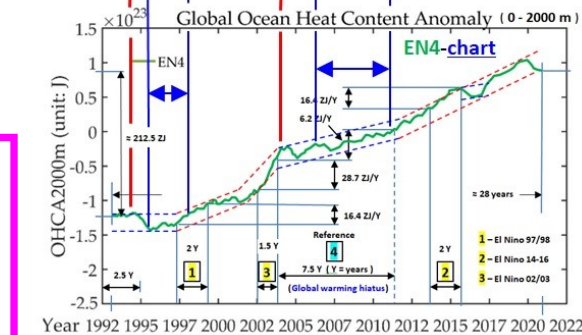
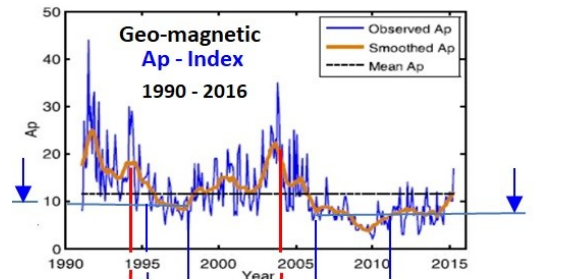
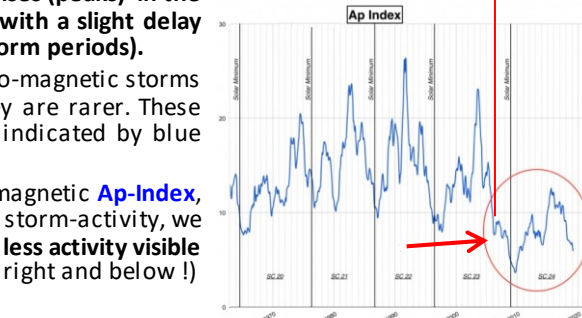


**Geo-magnetic storm-activity is effecting the World's Climate :**

The two charts on the right, the **Ap-Index** and the **Ocean-Heat-Content (→ EN4-chart)** of the last  $\approx 30$  years indicate that there is a **correlation of geomagnetic storm-activity with the Warming of the Ocean water (0-2000m)**, described by the **Ocean Heat Content**.

**Geomagnetic storm-activity** causes earthquakes, mainly in **HGF-areas** (e.g. the **mid-ocean-ridges**), which then causes increased **volcanism & hydrothermal-vent-activity**, mainly in **submarine areas**, and heats-up the ocean water in this way.

It is clearly visible in the two charts that there is a **correlation of lows with AP-values below 10** (the top chart) with **stagnation-periods (or lows)** in the **Ocean-Heat-Content chart**. And correlation of at least one major peak in the Ap-chart with a clear peak in the OHC-chart



# Appendix 1D: Interglacial-periods are caused by peak-volcanic-activity and often end by Ultra-Plinian-Eruptions with ejecta-volumes $\geq 100\text{km}^3$ -VEI $\geq 7$

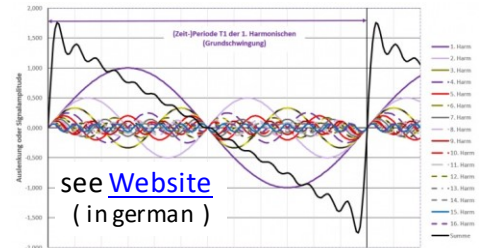
In the first part (Part 1) of my climate-hypothesis I have provided evidence, that El Ninos are caused by global hydrothermal-activity at irregular intervals. I also showed that this increased hydrothermal-activity correlates with increased volcanism, and with increased seismicity in high-hydrothermal-flux-areas. Responsible for this increased activity in all probability are increased geomagnetic changes in Earth's magnetic field, caused by geomagnetic jerks, and caused by increased solar activity (solar wind), that is probably the longterm stimulator of geomagnetic-changes

**To the Milankovitch Hypothesis:** The current hypothesis says that Milankovitch Cycles are responsible for interglacial (warm) periods and glacial (cold) periods within an ice age. **But this hypothesis doesn't provide a plausible cause for the sudden changes in global temperatures** (see chart), because the small changes in Earth's orbit eccentricity (from 0.0034 to 0.058) and in the precession and tilt of Earth's axis (of only 2.5°) over long periods of 26000 - 100000 years can't explain the strong and irregular lows (minimas) and the steep rises in the temperature chart.

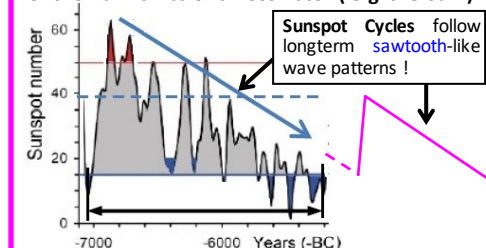
**Therefore my alternative hypothesis: Solar-Activity, Geomagnetism, Volcanism & Climate show longterm sawtooth-like-oscillations**

The solar dynamo is partially synchronized by external harmonic planetary (tidal) forcing (especially by the Jovian harmonics, caused by Venus-Earth-Jupiter (VEJ) interactions). This resonance-like effect is responsible for the  $\approx 11$  year solar cycle (sunspot-cycle), the longterm variations in the amplitudes of the solar cycles, and in the longterm solar activity in general. (see: Study1, Study2, Study3, Study4, Study5) Here the longterm solar activity follows a „sawtooth-wave“-pattern, that is visible in the longterm glacial- /interglacial-temperature chart (wave-length  $\approx 80$ -100 kyr) and that is also visible in the reconstructed solar-cycle-chart of the last 11400 years as an overtone-sawtooth-like oscillation with 30f-80f (see image on the right & chart E on page 8). Because Earth's magnetic field is influenced & stimulated by the Heliospheric magnetic field (HMF) and the solar wind, the geomagnetic activity and the climate on Earth, follows the same sawtooth-like oscillations as the solar activity! Because volcanic- & hydrothermal activity on Earth is closely connected to the geomagnetic activity!!

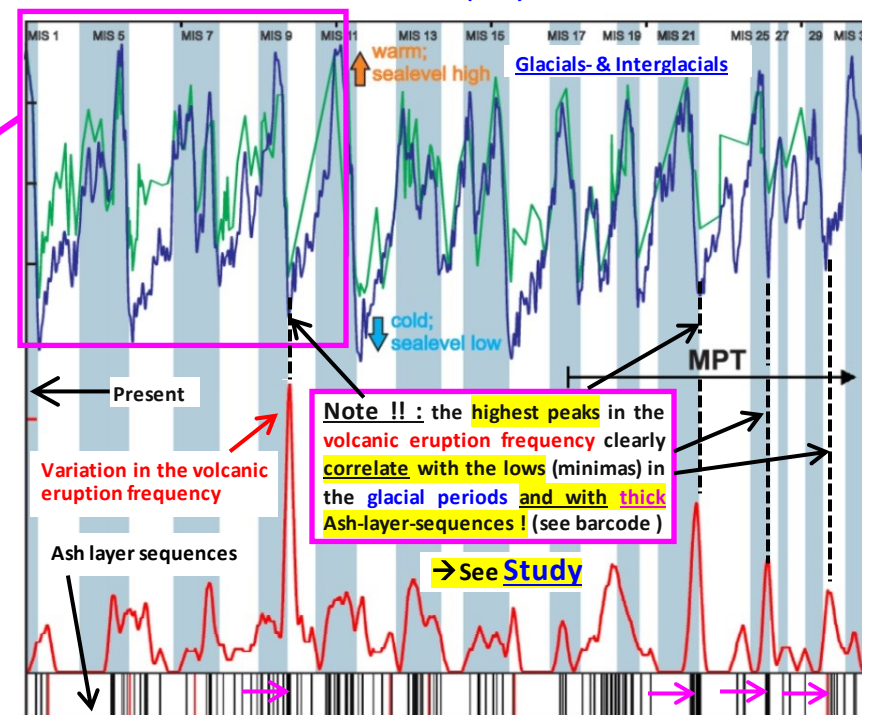
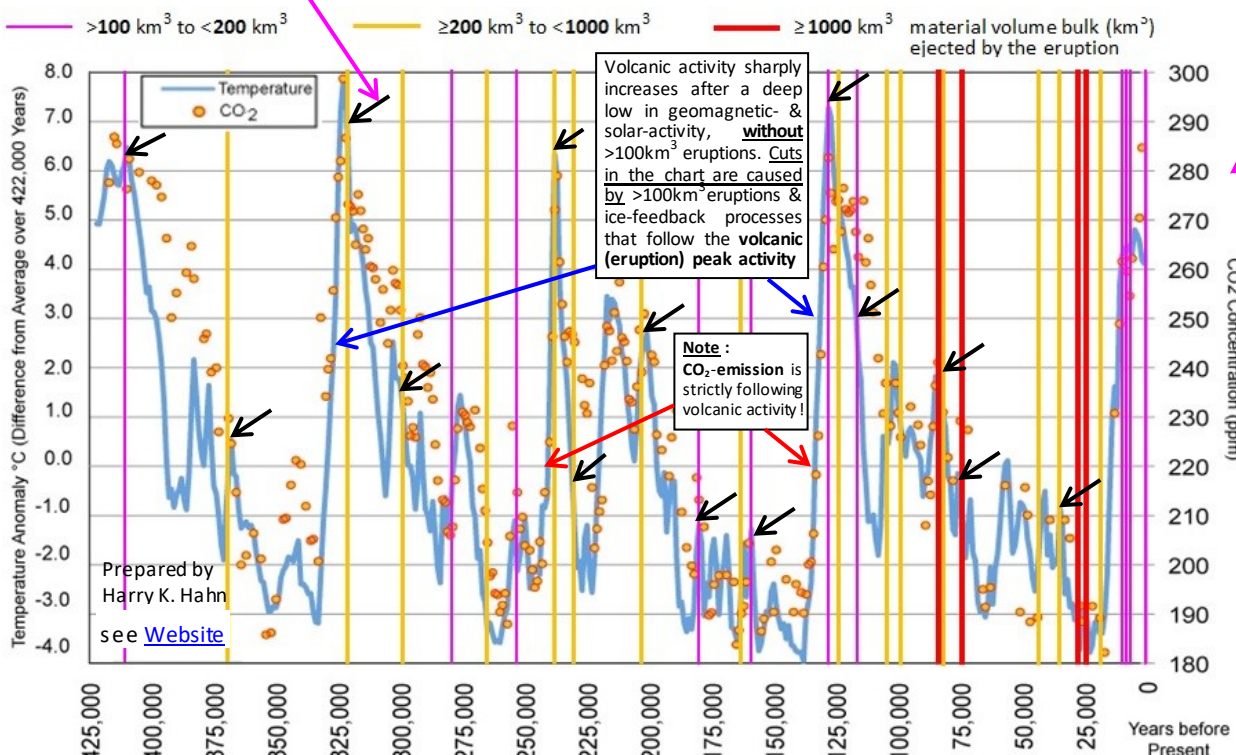
**Warning: Ultra-Plinian Eruptions seem to end interglacial-(warm)-periods. Therefore we must prepare for such a global volcanic event!**



A sawtooth wave is caused by the superposition of the harmonics of an oscillator (e.g. the Sun)



A possible Overtone-oscillation visible in the Sunspot-cycles between 7000 and 5200 BC



Changes in temperatures ( $^{18}\text{O}$ -proxy) and  $\text{CO}_2$  concentrations for the last 420000 years (from Vostok-ice-core) together with Ultra-Plinian-Eruptions shown, which have ejected bulk-material volumes  $>100\text{km}^3$  (colored lines)

Glacial and Interglacial periods, represented by  $^{18}\text{O}$ -content (green line= Hole U1437B-data & blue line= Lisiecki and Raymo 30) compared with the variation in the volcanic eruption frequency (red line  $\rightarrow$  moving average with a width of 10 kyr) and ash-layer-sequences (shown as ticks of the barcode) for the last 1.1 million years;  $\rightarrow$  Weblink to the chart-source

## Appendix 2 : Earthquakes caused by tidal forces ( gravitational forces )

Different statistical tools indicate that earthquakes are organized in time according to certain renewal intervals. These intervals ( time periods ) between earthquakes with the highest probability of their appearance are represented in the **Fourier Power Spectra** and in the **Schuster Spectra** by the highest peaks in the Spectra ( → see the diagrams further below )

There is a high correlation between **tidal events** ( tidal forces ) caused by the moon and sun.

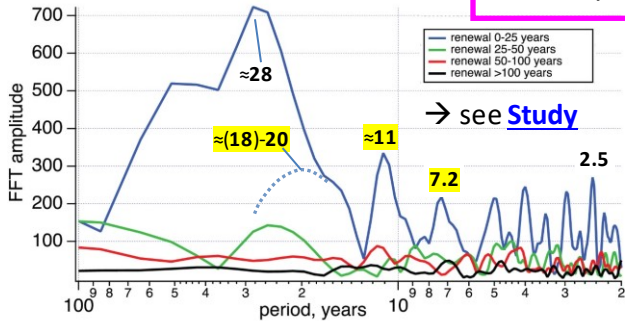
I want to contribute here an example of a powerful earthquake which surely was triggered by a maximal tidal stress amplitude. The **M 7.6 Gölcük-earthquake** from **17.8.1999** in Turkey which occurred just **6 days after the solar eclipse from 11.8.1999**. Note that the **core-shadow** (→gravity force vectors of moon and sun in line) moved ≈ **20 minutes** precisely along the **North Anatolian fault**, probably the crucial fact here !



Satellite map of Turkey with tectonic fault lines

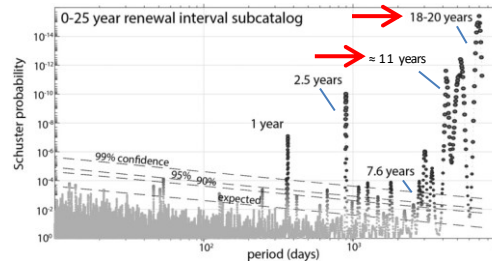
and tectonic earthquakes, and earthquakes in the **mid-ocean-ridge-areas** (=HGF-areas). Tidal stress caused by Sun & Moon, is superimposed on tectonic-stress and plays a triggering role for such earthquakes. Strong earthquakes ( ≥M7), such as the 2011 Tohoku-Oki-earthquake often occur near the maximal tidal stress amplitude. The **M 7.6 Gölcük-earthquake** from 17.8.99 in Turkey which occurred just 6 days after a **solar-eclipse** was also caused by maximal tidal stress ! Beside daily- and ≈14-day-tidal periodicities which are caused by Earth's rotation and by the moon's orbit-period, there is also one longterm tidal periodicity caused by the moon, which seems to be presented by the **18-20 year peak** in the Schuster-(Fourier-) Spectra This periodicity probably is caused by the **18 year Saros-period**. Because after a **solar-eclipse** Earth, Sun & Moon reach the same geometry, after one **Saros-period** and a similar **solar-eclipse** (tidal event) follows. →**Studies** about tidal triggers: **Study1, Study2, Study3**

**Note**: The strong **11-year peak** in the spectra is caused by the **11-year solar-cycle**. And the big **7.2 year peak** & other peaks with shorter periods (e.g. 2.5) probably are caused by the described **magnetic waves** emitted from **Earth's core**. Changes in **Earth's magnetic field** caused by these factors trigger **earthquakes+ volcanism**



Fourier spectra results - complementary to the Schuster spectra

Time series of annual earthquake productivity for different renewal interval subcatalogs. Indicating power at frequencies which are also identified in the Schuster-spectra. For example the strong peaks at 2.5, 7.2, 11 & 20 years and other resolved peaks at 3, 4, 5 and 28 years ( for the **1-25 year** catalog )

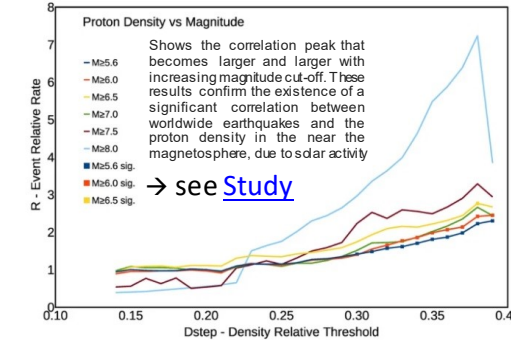


Schuster spectra for 1-25 year subcatalog of earthquakes

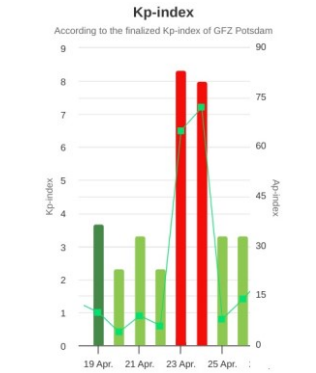
The logarithmic diagram of the Schuster probability for the subcatalog of earthquake events with the renewal interval of 1-25 years shows a number of strong peaks. For example at 1, 2.5, 7.6 and 18-20 years periods (with >99% confidence)

## Appendix 3: Earthquakes (& Volcanism) caused by Geomagnetic storms

Large earthquakes occurring worldwide have long been recognized to be non-Poisson distributed, so involving some **large scale correlation mechanism**, which could be **internal** &/or **external** to the Earth. **Clear correlation was found between increased proton density, during solar-cycle maximas & during geomagn. Storms (solar storms), and the occurrence of earthquakes with magnitude > M 5.6.**



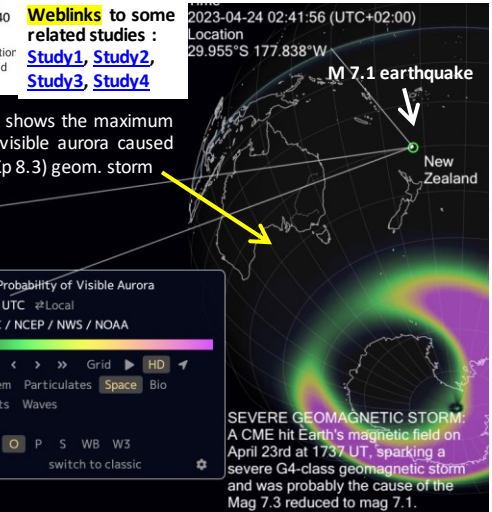
Plots of the Event Relative Rate R as a function of the normalized proton density, and for the condition 1Dy BT (earthquakes occurring within 24 h from the value of density decreasing below the threshold value). Colour indicates different lower cut-off magnitudes in the catalogue



Kp-index of the geomagnetic storm on 23.4. to 24.4.2023

The currents generated by solar winds in the ionosphere cause magnetic field fluctuation on the Earth's surface, inducing electrical currents, which penetrate into the Earth and, in the presence of Earth's magnetic field, generate electromagnetic (Lorentz) force, which can trigger the release of stress strain energy and can cause earthquakes and fractures in Earth's crust.

The map below shows the **aurora australis** caused by a **G4-geomagnetic storm on 23.4.2023** & the location of a **M 7.1 earthquake** in the **Kermadec-Arc** that occurred ≈ **7 hours** after the start of the storm. The probability for **>M7 earthquakes** in this 8h-period was only **1:180**

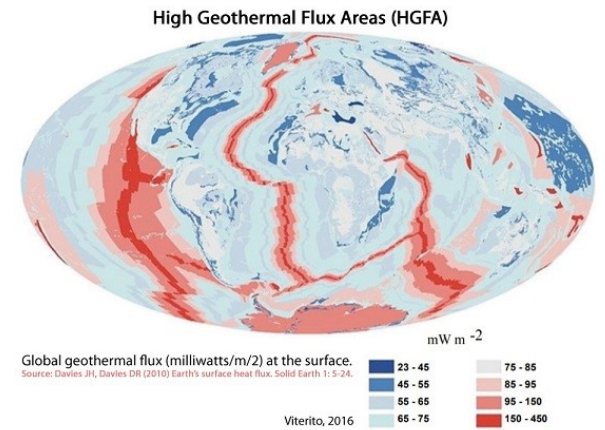


## Appendix 4: High Geothermal Flux Areas ( HGFA ) – World Map

**Note**:

**HGF-areas** are all **mid-ocean-ridge-areas** and the **geo-thermally active areas**

( → see map )

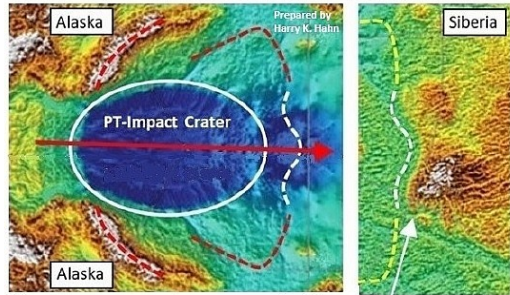


Global geothermal flux (milliwatts/m<sup>2</sup>) at the surface. Source: Davies JH, Davies DR (2010) Earth's surface heat flux. Solid Earth 1: 5-24. Viterito, 2016

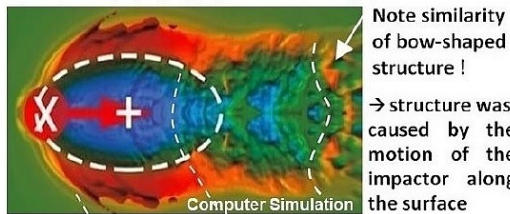
# Appendix 5 : To the probable cause of the Pacific-LLSVP & African-LLSVP inside of Earth's mantle

There are two large structures noticeable in Earth's mantle, the **Pacific-LLSVP** & the **African LLSVP**, which are characterized by slow (seismic) shear wave velocities and which in all probability consist of much hotter material (~4000°K) than the surrounding mantle material (~2000°K). These two large LLSVP's extend laterally and vertically for thousands of kilometers from the core-mantle boundary (CMB). There is strong indication that the hypothetical **Permian-Triassic Impact (PT-I)** and the ejecta that was caused by this enormous impact-event are responsible for the formation of these two big LLSVPs inside of Earth's mantle. (see study: **Part 1**)

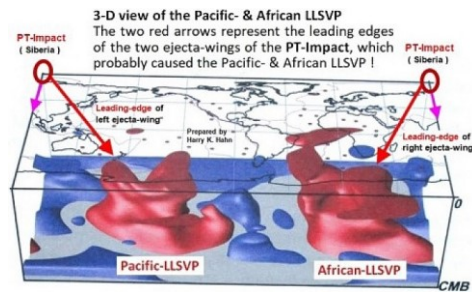
## The Ø 1270 x 950 km Permian-Triassic Crater



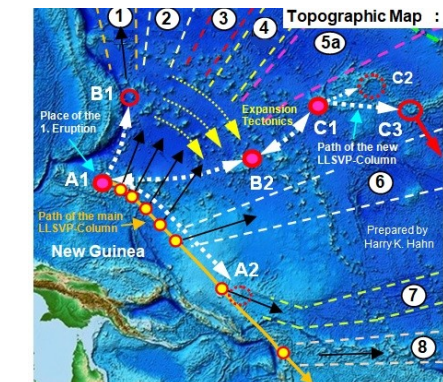
PT- crater topography (symmetrical image)



Note similarity of bow-shaped structure!  
→ structure was caused by the motion of the impactor along the surface



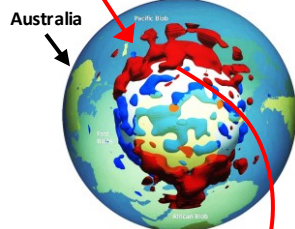
3-D view of the Pacific- & African LLSVP  
The two red arrows represent the leading edges of the two ejecta-wings of the PT-Impact, which probably caused the Pacific- & African LLSVP!



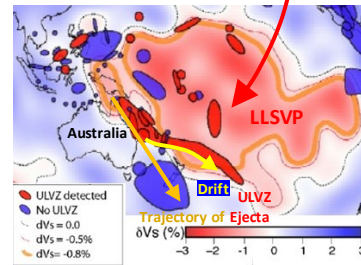
Topographic Map : 5a



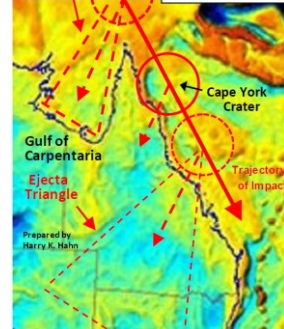
3D-view of the two big LLSVPs located near the CMB in Earth's mantle, the Pacific LLSVP and the African LLSVP



the Pacific-LLSVP



Cape-York Impact-Crater-Chain  
East Australia Gravity Anomaly Map



In all probability the powerful Ejecta-masses of the leading-edges of the two ejecta-wings of the PT-I together with large secondary impactors descended deep into Earth's mantle and caused the 2 LLSVP's.

Because the impactor that caused the PTI was either a carbon- & iron-rich-asteroid or -comet we can assume that the two LLSVPs caused by the PTI-ejecta also contain a considerable share of Iron and Carbon in the form of various minerals, for example in the form of molten carbonate minerals (→ that have an electrical conductivity that is exceeding the one of any mantle-phase → see Study ).

Therefore the Pacific-LLSVP & African LLSVP may also influence the magnetic acceleration patterns near the CMB and the North-pole-shift, described on the first pages of this study, because the LLSVPs are probably rich in iron- & carbonatites which are very good conductors, and therefore react to magnetic fields & telluric-currents caused by Earth's magnetic field & by strong geomagnetic-storms ( solar wind ).

**Note :** The trajectory of the hypothetical PTI-Impactor was roughly following a path North to South between the longitudes 90° & 120° E, when it impacted in Siberia. That's why the strong magnetic patterns visible between 90° & 120° E near the CMB ( as described on page 3 ), especially in the Northern-hemisphere may be the result of the primary- & secondary-impacts of the PTI !

The 2D-map of the Pacific-LLSVP on the left shows that especially the ULVZ at the core mantle boundary (CMB) within the Pacific-LLSVP is mainly orientated along the path where the leading edge of the left ejecta wing of the PTI probably impacted. Because this ULVZ has a distinct chemical signature there is a high probability that the ULVZ is a direct result of ejecta of the PTI which descended to the CMB in this area. This path where the leading-edge of the left-ejecta wing of the PTI impacted is noticeable on a gravity-anomaly-map as a chain of large secondary-craters ( → see image on the bottom left )

The powerful Ø 320 km Cape-York secondary-Impact (CYC) probably formed a channel in Earth's mantle which connected the Pacific-LLSVP / ULVZ that was caused by the PTI with the surface. Through this channel in the mantle ≥ 8 large-scale magma eruptions probably occurred over the last ~200 Ma, which are probably responsible for a number of big LIP's on the Pacific Plate ( e.g. the Ontong LIP ).

→ see explanation in : **Part 1** and **Part 2** of my PTI-hypothesis. ( alternative links : **Part 1** & **Part 2** )

More info about my PT-I Hypothesis [here](http://www.permiantriassic.de) : [www.permiantriassic.de](http://www.permiantriassic.de) or here [www.permiantriassic.at](http://www.permiantriassic.at)

The topographic-map on the left shows the path of the source of the mentioned magma eruptions, which is part of the Pacific-LLSVP ( → the yellow dots on the orange arrow ). Today it is probably located in the area of the Fiji-islands. **Note :** There is a high probability that another such large-scale magma eruption ( as described in **Part 1** of my PTI-hypothesis ) will take place probably somewhere in the surrounding area of the Fiji-islands. The trigger for such a large-scale eruption, which can cause a large LIP, may be an extreme seismic-shock-wave that runs through Earth's mantle. Such an extreme seismic shock-wave can be caused by a large asteroid-impact. For example the Chicxulub-Impact in Mexico which killed the Dinosaurs ≈ 66 million years ago probably triggered a global seismic shock-wave of > RS-magnitude 12, that was 1000 times more powerful than the strongest earthquake ever measured (RS-magnitude 9 ). The massive eruption that caused the Deccan-Traps, a large LIP in India at the same time ≈66 million years ago, probably was triggered by the global seismic shockwave of the Ø 180 km Chicxulub Impact.

**Appendix 6-A : Table 1 : worldwide Active Volcanos / & -Eruptions per year - Datas from the [Smithsonian Volcanism Program](#) ( left side of table )**

→ active volcanos per year were separated into selected regions ( right side of table ) → **to see all volcanos of a certain year clic on the year** ( left column )

Year	Eruptions Started (New)	Eruptions Ended	Eruptions Total	Volcanos Active (globally)	Countries	VEI <= 2	VEI 3	VEI 4	VEI 5	VEI 6	Active Volcanos per year - separated into selected regions													Ethiopia, Tanzania, Eritrea, Dschibut		
											Indonesia	Ecuador, Colombia, Guatemala, Costa Rica, El Salvador, Nicaragua	Papua New Guinea, New Zealand, Tonga, Australia, Samoa, Vanuatu	Japan	Russia (Kamchatka)	Aleuten + Alaska (USA)	Phillippines	Indonesia + Phillipines	Iceland (5 major volcanos) BAR, EYJ, GRV, HEK, KAT	Mariana Islands (USA)	North-America (USA without Alaska)	Hawaii	Mexico		all others	
1960	35	18	58	56	20	26	9	0	0	0	6	5	10	9	8	3	0	6	0	0	0	1	1	11	2	
1961	32	25	56	52	21	27	5	0	0	0	9	6	7	5	9	3	0	9	0	0	0	1	1	10	1	
1962	29	21	52	51	17	24	5	0	0	0	6	5	12	9	5	4	0	6	0	0	0	1	1	6	1	
1963	40	27	64	58	20	31	8	0	1	0	11	9	12	9	6	6	0	11	0	0	0	1	1	2	1	
1964	29	29	58	54	21	27	1	1	0	0	12	5	9	7	8	4	0	12	0	0	0	0	1	7	1	
1965	34	27	60	56	24	27	6	1	0	0	12	8	12	8	6	0	1	13	0	0	0	1	1	6	1	
1966	35	32	63	60	23	24	9	2	0	0	13	11	11	5	4	4	1	14	0	1	0	0	1	8	1	
1967	43	31	66	61	24	37	6	0	0	0	13	8	10	5	8	4	1	14	0	1	0	1	1	7	2	
1968	32	29	58	54	22	24	7	1	0	0	11	9	11	8	3	3	2	13	0	1	0	1	1	3	1	
1969	32	29	57	54	22	30	2	0	0	0	10	10	10	7	4	1	3	13	0	1	0	1	1	5	1	
1970	34	25	57	55	23	28	6	0	0	0	12	9	10	8	6	0	2	14	1	0	0	1	1	5	1	
1971	32	28	56	53	20	27	5	0	0	0	10	9	11	6	4	2	0	10	0	0	0	1	0	9	1	
1972	30	22	55	53	22	25	5	0	0	0	8	10	11	4	5	0	0	8	0	0	0	1	0	13	1	
1973	41	29	69	65	21	35	5	1	0	0	15	10	13	9	5	4	0	15	0	0	0	1	0	5	1	
1974	27	32	64	60	19	22	4	1	0	0	10	15	14	10	3	6	0	10	0	1	0	1	0	-1	1	
1975	23	16	52	49	22	21	1	1	0	0	8	8	10	7	2	3	0	8	0	0	0	2	1	7	1	
1976	29	23	61	56	23	27	1	1	0	0	8	13	13	6	4	4	1	9	0	0	0	0	1	5	1	
1977	39	35	73	65	26	35	4	0	0	0	8	17	14	5	3	5	1	9	0	0	0	1	1	9	1	
1978	25	22	58	56	22	23	2	0	0	0	8	12	11	8	3	3	4	12	0	0	0	0	1	4	2	
1979	32	24	65	60	22	28	4	0	0	0	10	10	16	7	4	1	1	11	0	0	0	1	1	8	1	
1980	41	36	74	67	25	31	9	0	1	0	9	10	13	8	8	5	2	11	1	0	1	1	1	8	1	
1981	29	24	60	56	24	22	5	2	0	0	7	11	9	6	7	3	1	8	0	1	1	0	1	8	1	
1982	32	35	64	59	22	27	3	1	1	0	10	10	10	8	6	2	0	10	0	1	1	1	2	7	1	
1983	32	24	58	55	20	25	6	1	0	0	12	8	7	7	2	5	1	13	1	1	1	1	0	8	2	
1984	33	29	64	59	23	28	5	0	0	0	10	9	13	6	4	3	1	11	0	1	1	2	0	7	2	
1985	27	25	60	54	25	22	5	0	0	0	8	12	12	4	5	0	2	10	0	2	1	1	1	4	2	
1986	41	38	75	67	28	32	6	3	0	0	10	10	12	4	11	6	1	11	0	0	1	1	1	8	2	
1987	32	23	64	62	23	29	3	0	0	0	11	10	7	5	4	11	1	12	0	1	0	1	1	8	2	
1988	27	30	64	62	24	23	4	0	0	0	14	9	9	7	4	3	2	16	0	1	0	1	0	10	2	
1989	25	26	57	55	24	23	2	0	0	0	8	8	10	8	5	3	1	9	0	1	1	1	0	7	2	
1990	30	27	60	56	22	23	6	1	0	0	9	8	10	6	4	5	0	9	0	0	0	1	1	0	10	2
1991	37	29	67	65	27	31	4	0	1	1	12	10	10	6	5	2	2	14	1	0	1	1	1	13	2	
1992	27	24	61	57	24	24	2	1	0	0	10	6	8	6	4	6	3	13	0	1	0	1	0	7	2	
1993	27	28	60	58	24	25	1	1	0	0	13	9	8	5	3	4	3	16	0	1	0	1	1	8	2	
1994	33	27	62	58	22	28	4	1	0	0	12	7	8	5	4	4	1	13	0	1	0	1	3	10	2	
1995	33	36	65	62	29	29	4	0	0	0	9	8	12	6	3	5	1	10	0	1	0	1	1	11	2	
1996	35	26	61	59	23	29	6	0	0	0	9	7	9	8	5	3	1	10	1	1	1	2	1	10	2	
1997	26	25	56	52	23	22	4	0	0	0	6	8	9	6	6	5	0	6	0	0	0	1	2	7	2	
1998	32	23	59	56	24	27	5	0	0	0	10	8	9	5	4	3	0	10	1	0	0	1	2	12	2	
1999	39	31	70	67	26	34	4	1	0	0	16	12	13	6	5	1	1	17	1	0	0	1	2	8	2	
2000	39	38	75	67	29	34	4	1	0	0	13	12	12	8	8	0	2	15	0	0	0	1	2	7	2	
2001	33	36	70	65	26	27	6	0	0	0	12	7	11	6	5	1	1	13	0	1	0	1	2	9	2	
2002	41	34	74	66	25	36	3	2	0	0	12	13	13	5	7	2	2	14	0	0	0	1	2	7	2	
2003	29	32	65	63	25	24	5	0	0	0	10	8	13	5	5	1	2	12	0	2	0	1	2	10	2	
2004	49	42	81	71	27	41	7	1	0	0	11	12	15	8	6	2	1	12	1	2	1	1	2	8	2	
2005	46	38	83	75	28	39	7	0	0	0	9	16	14	5	7	5	2	11	0	2	1	1	2	8	3	
2006	44	41	86	76	29	39	4	1	0	0	8	15	19	5	3	5	5	13	0	3	1	1	2	7	2	
2007	36	38	81	76	29	30	6	0	0	0	13	14	17	3	5	3	1	14	0	2	1	1	2	11	3	
2008	45	39	86	80	28	36	6	3	0	0	11	19	15	8	6	4	1	12	0	2	1	1	2	7	3	
2009	31	31	75	68	25	28	2	1	0	0	12	14	11	4	8	4	1	13	0	1	0	1	2	7	3	
2010	33	37	77	69	24	21	10	2	0	0	11	15	10	5	9	1	2	13	1	3	0	1	2	8	2	
2011	36	36	76	71	28	31	2	2	1	0	14	16	10	4	5	1	1	15	2	1	0	1	2	12	4	
2012	41	38	81	72	27	36	5	0	0	0	16	16	15	5	8	2	0	16	0	1	0	1	1	5	2	
2013	37	42	80	73	29	29	7	1	0	0	18	13	9	6	10	3	1	19	0	1	0	1	2	7	2	
2014	41	33	79	71	31	30	8	3	0	0	15	14	12	7	6	4	1	16	1	2	0	1	2	5	2	
2015	44	40	90	83	31	37	5	2	0	0	16	19	8	9	10	2	2	18	1	1	0	1	2	11	2	
2016	36	45	86	75	28	30	6	0	0	0	11	18	10	5	13	3	3	14	0	0	0	1	2	7	2	
2017	33	31	74	71	29	26	6	1	0	0	12	14	11	4	8	2	2	14	0	0	0	1	2	13	2	
2018	37	32	80	75	28	31	6	0	0	0	14	17	12	6	8	4	1	15	0	0	0	1	1	9	2	
2019	27	29	75	73	28	22	3	2	0	0	12	11	12	7	7	5	1	13	0	0	0	0	2	14	2	
2020	28	25	74	69	29	22	4	2	0	0	14	13	10	9	6	3	1	15	1	0	0	1	1	9	2	
2021	34	31	83	77	30	31	1	1	1	0	12	12	14	7	8	4	3	15	0	1	0	1	1	12	2	
2022	33	35	85	80	28	32	1	0	0	0	11	16	15	6	7	3	4	15	0	1	0	1	1	12	2	
2023 (7.9.23)	16	17	66	65	28						10		11		13	5	5	3	1					2	Ethiopia +Tanzania	











**Appendix 6-C: Table 3: List of Geo-magnetic Storms in the time period 1800 – 2023 , mainly based on observational reports ( visible Auroras etc. )**

Year	month-day(s)	DST-value ( in nT )	-dH (nT) from Kakioka	Solar Flare class	Kp-index (before 1932 estimated)	Aurora oval visibility overhead/low-latitude (estimated)	Aurora observation reported from these locations	Effects of solarstorm	Comments	weblinks (more info)		
1811	12-15				9+	≈35°/≈25° (?)	South-& North-Carolina, Havana/Caribbean(?),Jerusalem (?)	possible connection with the strong M7.4-8.6 Intraplate-Earthquake in New Madrid/Missouri (USA) on 16-12-1811	from distant cities & ships (in the Tropics) a Red-Aurora was seen in the night-sky, one day before the big Earthquake	<a href="#">more info (page 46)</a>	<a href="#">more info2 (see Light)</a>	
1826	3-29				9-	≤50° / ≈40°	Manchester		rainbow-like arc aurora, stretching across the midheaven	<a href="#">more info</a>	-	
1827	9-25				9-	≤50° / ≈40°	Charleston, Norfolk, Switzerland Holland, Paris		brilliant bright arc aurora was visible in the northern sky in Charleston, aurora also seen in Central Europe	<a href="#">more info</a>	<a href="#">more info2</a>	
1842	2-24				≈8	≈50° / ≈40°	Alford (Lincolnshire) UK		brilliant aurora with streamers seen in Alford	<a href="#">more info</a>	-	
1843	4-19				9+	≤ 45°/≈23°	Mexico, Scotland	magnetic disturbances measured in Makerstoun Scotland	sporadic aurora observed in Mexico on 19 April 1843 other bright aurora seen on March 20&28 in Manchester	<a href="#">more info</a>	<a href="#">more info2</a>	
1845	12-29				9-	≤50° / ≈40°	Valencia (Spain)		sporadic red aurora observed in Spain on 29 December 1845	<a href="#">more info</a>		
1847	10-24 11-17				9 (24.10)	≈45° / ≈35°	San Fernando (Spain) Cartagena, Coruna (Spain),UK 17.11.	strong magnetic storm reported from Helsinki (23/24.10) at the same time great magnetic disturbances (17.11.)	extraordinary display of aurora borealis observed in Cambridge	<a href="#">more info</a>	<a href="#">more info2</a>	
1848	10-18 11-17	-900 (28.8.)			9	≈45° / ≈35°	Valladolid (Spain) - 18.10. Cartagena, Coruna (Spain),UK 17.11.	strong magnetic storm reported from Helsinki (17/18.11) value of a geomag. Storm from 28/29.8.1848 : -900nT	red bright aurora in NNW, color became white later (18.10.) Aurora arc from NNW to NNE, colors: white, green, yellow 17.11.	<a href="#">more info</a>	<a href="#">more info2</a>	<a href="#">more info3</a>
1859	8-28 9-2 to 9-4	-1760			9+	41° / 20°	Hawaii, Cuba, Mexico, Italy, Washington, London	disabled telegraph network from New York to Washington brilliant radiations of different colored light filled the sky	"Carrington Event", big floods of 1861-62 in California indicate: a strong El Nino may have been caused by the solar-storm !	<a href="#">more info</a>	<a href="#">more info2</a>	
1862	12-14				9+	≤44°/≈34°	Virginia, Gulf States (USA)		brilliant aurora borealis seen by civil war soldiers in Virginia possible bright aurora with streamers seen in the gulf states	<a href="#">weblink1</a>	-	
1870	10 -14 & 24				9-	≈45° / ≈35°	New York, Cleveland, Cincinnati (24.10.)	magn. disturbance reported from Melbourne Observatory (Australia) and on other places in the north. Hemisphere	unusual bright and brilliant aurora was observed on 24.10. in Cleveland & Cincinnati. It lasted two days !	<a href="#">weblink1</a>	-	
1872	2-4/5	-830			9+	≈45°/≈21° - north ≈23° (?) -south	Paris, Havana, Cuba Rio de Janeiro (4.2.)		A possible case of a low latitude sporadic aurora another bright aurora was visible on 18.8.1872	<a href="#">weblink1</a>	<a href="#">more info</a>	<a href="#">more info3</a>
1872	8-18				9-	≤45°/≈35°	New York		the best auroral display that occurred in the present generation	<a href="#">weblink1</a>	-	-
1875	Sept.						Martinique Island (magnetic Phenomena observed)	the telegraph chief at Fort de France/Martinique observed that each of the Sept. 1875 earthquakes was preceded by a marked disturbance of the electric telegraph needles		<a href="#">more info</a>	-	
1877	5-28				9-	≤45°/≈35°	New York	telegraph lines were effected from Boston, Baltimore, Philadelphia & Washington DC	bright wavering aroras with streamers seen in New York arched aurora that moved halfway to the zenith, visible in NY	<a href="#">weblink1</a>	-	
1880	8-12				≈8	≈50° / ≈40°	daytime aurora borealis in USA	disruption of telegraph-lines in Connecticut/USA	Current was induced in lines. Batteries had to be removed.	<a href="#">weblink1</a>	-	
1882	4-16/17 11-17/18				9+ ≈9	42°/≈30° - north ≈40°/30° - south	overhead in Chicago & Goulburn/AU England: aurora crossed sky (16/17.4)	strong disruption of telegraph systems, Telegraph lines between Chicago & Milwaukee worked without batteries	a moon-like aurora crossed sky in England, bright aurora of crimson (red) color seen 60° high in Goulburn/NSW Australia	<a href="#">more info</a>	<a href="#">weblink1</a>	<a href="#">more info2</a>
1892	2-13				9-	≈45°/≈35°	Cleveland, Lousville, Detroit, Milwaukee		Was described as the -most wonderful exposition- ever seen on american soil, visible from Iowa to the Atlantic-coast	<a href="#">weblink1</a>	-	-
1897	4-23 / 7-30 8-19 / 12-20				≈8	≈50° / ≈40°	Williams Bay (USA)	<b>Note:</b> a telegraph operator noticed 22.5.1897 a few seconds before an earthquake an unusual signal on a telegraph device	bright aurora arcs with streamers observed at the Yerkes-Observatory in Williams-Bay (USA) 23.4, 30.7, 19.8. & 20.12.	<a href="#">more info (page1-2)</a>	<a href="#">more info2 (earthquake)</a>	
1898	9-9 & 9-10				≈8	≈50° / ≈40°	reported from Haslemere (UK) Williams-Bay (USA)	disruption of telegraph systems reported from Chicago, Tennessee, Washington by daytime-aurora, Tennessee and Omaha (USA) --> daytime aurora	voltage of ≈ 280 V was induced into the telegraph wires very bright auroras with streamers reported from UK 9.9/10.9. other bright auroras at Williams Bay on 16.1., 14.3, 3.5, 2-15.9.	<a href="#">more info</a>	<a href="#">more info2 (page2-4)</a>	
1899	2-11&15 / 5-1 6-28&29				≈8	≈50° / ≈40°	Williams Bay (USA)		bright aurora arcs with streamers observed at the Yerkes-Observatory in Williams-Bay (USA) 11+15.2, 1.5., 28+29.6.	<a href="#">more info (page5-6)</a>	-	
1901	9-10 9-26				≈6	≈60° / ≈52°	Scotland (10. Sept 1901), Canada, Finland	Remark : The worldwide hot climate in 1901 may indicate an El Nino event in 1901-02	beautiful display of curtains of Aurora borealis observed in Rusnes/Sanday near Kirkwall (Nature Journal No. 1665)	<a href="#">more info</a>		
1902	Oct.				9-	≤50° / ≈40°	Spain (Pyrenees mountains)		pink & red Aurora observed on a few occations	<a href="#">more info</a>		
1903	≈10-30 11-1 (& 7-29)	-531			9+	≈44°/≈34° (north) ≈35°/≈30° (south)	Ireland, Scotland, Chicago, Colorado, overhead Aurora in Duluth & NSW-Australia	disruption of Western Union- & New York telegraph systems & transatlantic sea-cables, swiss street-cars disabled, another strong geom. Storm on 29.7.	Geom. storm during <u>sun</u> cycle minimum measured in France, telegraph disruption in Mexico, Geom. storm reported from East-Asia, in Chicago telegraph lines up to 675 V were measured	<a href="#">more info</a>		
1905	3-2 & 3-3				≈8	≈50° / ≈40°	Chicago & Sioux City (USA)	Electrical disturbances on Chicago- & Sioux City telegraph systems reported		<a href="#">weblink1 (2.3.1905)</a>	-	

1908	9-11				9-	≈45°/≈35°	Washington	disruption of telegraph systems	bright pink-colored (energetic) aurora with streamers, often reaching up to the zenith, observed in Washington	<a href="#">weblink1 (12.9.1908)</a>	-	
1909	9-24/25	-595		probably ≥X10	9+	≈35°/≈20°	Japan, Maine (USA) (Singapore?)	disruption of telegraph systems in Boston, Chicago, Tennessee and in transatlantic sea-cable reported, disruptions also in telegraph systems in Europe	voltage of up to ≈500 V was induced into the telegraph wires, geomagn. disturbance was compared with events from 1803 & 1882 (it was a daytime aurora in Chicago)	<a href="#">more info</a>		
1915	6-17				9-	≈45°/≈35°	Flagstaff (Lowell Observatory) (Arizona/USA)	eastern telegraph circuits interrupted (USA), only east- & west-cables were effected and these wires were heavily surcharged, electrical disturbances in the western states	bright aurora with streamers observed in Flagstaff, some streamers reached almost to the zenith, was bright for a few hours, aurora reached from 25° west to 45° east	<a href="#">weblink1</a>		
1916	8-25/26				≈7	≤50° / ≤40°	Minneapolis,	telephone & telegraph services in the East & West of the USA were seriously disrupted (between Chicago & Minneapolis), 75 V were induced in the cables	bright night-sky in Minneapolis,	<a href="#">weblink1</a>		
1917	8-8 8-21				9- ≥6	≈50° / ≈40°	Algonquin/Canada	telegraph & telephone communications to Chicago from Pittsburg, Omaha, Buffalo & Philadelphia stopped.	arc aurora with streamers observed in Algonquin/CA on 21.8 telegraph networks around New York area were disrupted too	<a href="#">weblink1</a>	<a href="#">more info</a>	
1918	3-7				9+	≤40°/≤30°	Washington (overhead aurora) Illinois, Tampa/Florida, Texas	telegraph lines from New York to Buffalo were disrupted motors/generators providing electricity were effected too	bright overhead aurora with streamers observed in Washington and Duluth, another bright aurora on 21.3.1918	<a href="#">more info</a>	<a href="#">weblink1</a>	<a href="#">more info2</a>
1919	1-31 8-11 10-1				9	≤50° / ≤40°	St. Petersburg (overh. Aurora, 31.1.) Denver (11.8.), New York, Omaha (1.10)	telegraph disruptions along Atlantic seaboard as far south as Georgia & Kansas (11.8.), disruption of telegraph systems in Minnesota & NW-states	31.1.: brilliant flaming auroras were observed in the night 11.8.: in Denver aurora visible in northern sky	<a href="#">weblink1</a>		
1920	3-22				9	≤44°/≤34°	New York, Atlanta	disruption of telegraph cables of the American Telegr. Co. Undersea cables were disrupted and stopped working too	flashing and wavering auroras were seen in the northern sky from New York, aurora with streamers seen in Atlanta	<a href="#">weblink1</a>		
1921	5-13 to 5-15	-907 +/- 132			9+	≤34° / ≤24° (north) ≈33° / -13° (south)	visible in east-USA, Caribbean, and in Samoa (confirmed !), overhead aurora in California	substantial damage to overhead and underwater telegraph equipment in USA, Europe and in the southern hemisphere, sparked many electrical fires	induced (telluric) ground currents probably were larger than from the 1989 superstorm, Auroras created brightly lit night skies in eastern USA, credible Aurora-report from Samoa	<a href="#">more info</a>	<a href="#">weblink1</a>	
1926	1-26 3-9				9	≈45° / ≈35°	Salzburg/Austria (9.3.)	telegraph systems throughout the country were disrupted all over the country down south to New Orleans (26.1.)	120 to 150 V were induced in telegraph cables (USA)-26.1. bright red aurora visible from Austria/Salzburg	<a href="#">weblink1</a>	-	
1927	2-24 4-14 7-21 10-12				9- (24.2.) ≥7 (12.10)	≈50° / ≈40° (24.2.)	Geneva/Switzerland (24.2.) Berlin (12.10.)	telegraph systems disrupted, Winnipeg to Montreal 14.4. telegraph systems disrupted, New York to Mid-West 21.7. disruption of telegraph networks in northern states 12.10.	bright red aurora visible from Geneva 100 V were induced into telegraph cables 12.10. disrupted shortwave radio systems to the north, Berlin 12.10. Berlin: glow of Aurora Borealis was visible on 12.10.	<a href="#">weblink1</a>	-	
1928	7-7/8		486		9-	≈45°/≈35°	Sydney, Geelong (Australia)	disruption of telegraph system all over USA caused by earth-currents resulting from the geomagnetic storm	7.July.1928 in Sydney: green&blue aurora with bright white streamers against a red glowing sky visible	<a href="#">weblink1</a>		
1932	5-29/30				9-	≤45°/≤35°	Cleveland, New Mexico, Geneva	radio- & telegraph systems were disrupted by magn. Storm	two wide bands of pale white light appeared in the sky (photo)	<a href="#">more info</a>	<a href="#">weblink1</a>	<a href="#">more info2</a>
1938	1-17 1-22 to 1-25	-336	490/509		8+ 9-	≤ 45°/≈30°	Sicily, Portugal, Bermuda, Southern California	electrical disturbances, short wave radio systems were interfered, 3 geom. Storms, 2 great aurora storms, 4 SSCs	The "Fatima Storm" Jan. 22-25, great Aurora display in Europe, USA & South-Australia, another geom. Storm on 16.4.1938	<a href="#">more info</a>	<a href="#">weblink1</a>	
1941	9-18/19		604		9+	≤ 40°/≈20°	Florida (18.9.), Washington, New Mexico	"geomagnetic flash" reported, disruption of telegraph- & short wave radio systems, another magn. Storm on 6. July	18.09.1941, most brilliant aurora display ever seen in Washington (energetic pink aurora), even seen in Florida	<a href="#">weblink1</a>	<a href="#">more info</a>	
1943	8-30/31				8+	≈40°/≈30°	Delaware/Ohio	radio communication between Europe and USA was seriously disturbed (3.9.)	brilliant aurora during sunspot-minimum visible at Perkins-Observatory/Ohio, aurora with streamers covered northern sky	<a href="#">more info</a>	<a href="#">weblink1</a>	
1946	2-7 3-25 & 3-28	-512 (23.3.)	462		8+ 9-	≈40°/≈30° (north & south)	New York (overhead-7.2.), Scotland Canberra 30.3., Cambridge 28.9.	radio disruption reported from Bombay, Lisbon, Cairo & Singapore, & worldwide on 3.2.(until 15.2.) on 26.3.	brilliant waving overhead aurora seen in New York on 7.2. and 26.7., aurora with bright streamers (colors red & green)	<a href="#">weblink1</a>	<a href="#">more info</a>	<a href="#">more info2</a>
1949	1-25/26 5-12	-530(?)	407 (24.1.)	3+ (1949)	9- 9-	≤45°/≤30°	Adelaide (Australia)-12.5.	complete blackout in India shortwave-radio services, shut-down of radio- & Sea-cable communication on 26.1.	24.01.1949 (-dH-value), sudden-commencement-type Storm 12.5.: bright pink aurora seen from Adelaide	<a href="#">more info</a>	<a href="#">more info2</a>	<a href="#">more info3</a>
1950	2-20 3-19				9- 7+	≤45°/≤35°	Sydney (Australia)	disruption of worldwide radio communication (21.2.1950)	red glowing aurora seen from Sydney in the South on 19. March	<a href="#">weblink1</a>	-	<a href="#">more info3</a>
1956	2-24				8+	≤ 54°/≈35°	one overhead aurora visible in South-England	strong solar cosmic rays measured during a strong solar proton event	extremely high ground level (telluric current) enhancement auroras visible on 8 nights (low latitude) in South-England (54°)	<a href="#">weblink1</a>		
1957	1-21/22 9-13		486 (13.9.)		9- 9-	≤ 54°/≈35°	South-England (13.9.), France (23.1.) Chicago (4.9.), Los Angeles (13.9.)	strong solar storms measured (13.9.), spectacular fade-out of radio signals worldwide (16.4.)	highest auroral activity for at least two centuries (NASA) auroras visible on 30 nights (low latitude) in South-England (54°)	<a href="#">weblink1</a>		
1958	2-11	-425	617/472		9	≤ 45°/≈23°	Havana, Los Angeles, New Mexico Washington, across Europe	strong geomagn. storm, most communication systems were disrupted for a few hours, blackout in Toronto, SSC	telegraph cables over the North Atlantic became a 2650V battery, auroras visible on 16 nights in South-England (54°)	<a href="#">more info</a>	<a href="#">weblink1</a>	
1960	11-12/13		417		9+	≤40°/≤30°	Western Europe, Atlantic overhead in France	widespread radio disruption	12.11.1960 (-dH-value), active arc aurora with streamers, sometimes brilliant red flaming curtains	<a href="#">weblink1</a>	<a href="#">more info</a>	
1967	5-25/26		509		9	≤45°/≤35°	England, Northern France, W-Atlantic, Washington	strong geomagnetic storm measured	25.5.1967 (-dH-value), brilliant aurora bands with streamers colored in red, violet & green	<a href="#">more info</a>	<a href="#">more info2</a>	<a href="#">weblink1</a>

1969	3-24				8	≈45°/≈30°	Eastern USA, New York to Louisiana		mostly red aurora with green and yellow colors	<a href="#">weblink1</a>		
1972	8-4	-450 to -486		X20	9	≤45°/≤35°	Illinois to Colorado Bilbao/Spain	disruption of electrical- & communication networks & satellites, DST-value may have surpassed -1600 nT	series of strong solar flares (peak class 20), fastest CME-transit ever recorded, 4 X-flares, strong geom. Induced currents (GICs)	<a href="#">weblink1</a>		
1974	7-5/6				9-	≤50° / ≤40°	Chicago, Ohio, Michigan, Omaha	strong geomagnetic storm measured	brilliant green- & yellow-colored aurora was visible over Chicago	<a href="#">more info</a>	<a href="#">more info2</a>	<a href="#">weblink1</a>
1982	7-13/14	-330	630	3B/X7.1	9	≤45°/≤35°	Bermuda, Sardinia, Malta, Australia Michigan, Ontario, Atlantic, UK	the geom. storm from 13.7. produced a localized (around Japan) short-lived (1.5h) deep depression of geom. H-comp.	13.7.1982 (-dH-value), aurora borealis observed in the Mediterranean region	<a href="#">more info</a>	<a href="#">more info2</a>	
1989	3-13/14	-589	644	X8	9+	≤ 40°/≈20°	Florida, Honduras, Caribbean Wales: overhead aurora	caused the collapse of the Hydro-Quebec Power grid in seconds (protection relays tripped in a cascade), widespread effects on power systems	on 13. March the strongest geom. Storm of the last century struck Earth with intense auroras ,(-dH-value: date : 13.3. ), another X4.5-flare was caused 2 days earlier,10. March 89)	<a href="#">more info</a>		
1991	3-24/25 6-5 11-8/9		503		9- 9- 9-	≤45°/≤30°	Texas, Pennsylvania, California (9.11) Graz (Hungary)-24.3.	around half of the energy output of the 1989 event, worst mag. Storm since 1989	24.3.91 (-dH-value), in Northern USA aurora covered whole sky active flaming pulsing aurora seen in Graz (24.3.)	<a href="#">more info</a>	<a href="#">weblink1</a>	.
1992	5-9/10		426		9-	≤55°/≤45°	North Dakota, south. Scotland		9.5.1992 (-dH-value), aurora with bright streamers	<a href="#">more info</a>		
1995	4- 7/8 (10- 18/20)				8 7-	≈50° / ≈40°	Denmark, Northern England & Detroit (18/19.10.);North Dakota, Scotland & Midlands in UK (7.4.)		brightest aurora seen all over the sky in North Dakota 7.4. and all over Scotland down to the english midlands	<a href="#">more info</a>		
1996	10-22/23				7+	≈50° / ≈40°	North Dakota		23.10.1996 - Ap-index 38 & Kp-max=7+ active moving, waving & pulsating Aurora observed in Dakota	<a href="#">more info</a>	<a href="#">more info2</a>	
1998	5-4 9-25	-216 (soho) -207 (soho)			9- 8+	≤50° / ≤40°	Chicago, Detroit, Boston (4.5.) Dakota (USA) in Sept./Oct.		active moving, waving & pulsating Aurora observed in Dakota	<a href="#">more info</a>	<a href="#">more info2</a>	<a href="#">more info3</a>
1999	10-22	-237 (soho)			8	≈50° / ≈40°				<a href="#">more info</a>	<a href="#">weblink3</a>	
2000	4-6/7 7-15 8-11/12 9-17	-321 (soho) -301 -237 (soho) -201 (soho)		X5.7 (14.7.)	9- 9 8- 8+	≤45°/≤35°		minor satellite- & power transformer damage worldwide associated solar particle event was 4.th largest since 1967 (15.7.2000)	DST-value from 14/15. July, G5-storm, "Bastille Day storm"	<a href="#">more info</a>	<a href="#">more info2</a>	<a href="#">weblink1</a>
2001	3-31 4-11	-377 (soho) -251 (soho)	477		9- 8+	≤45°/≤30°	Texas, California, Florida	fast moving CME triggered vivid aurora in Nov. 2001	red aurora visible on 6. April was caused by X20 flare, but the majority of the solar storm missed the Earth	<a href="#">more info</a>	.	
2003	10-29 to 11-2	-353   -383	423		9	≤45°/≤30°	Texas, Mediterranean countries, (South Africa?)	3 strong geom. Storms from 29.10-2.11 ->"Halloween Storm" 12 transformers in South Africa were disabled by the storm	3 geom. Storms between 29.10 and 2.11. overlapped each other DST-values : -151, -353 & -383, storm of a X45 flare missed Earth	<a href="#">more info</a>	<a href="#">weblink1</a>	.
2003	11-20	-533	415 (20.11.)		9-	≤40°/≤25°	Florida, South Australia	extreme radio blackout was caused on 4. Nov. 2003	on 4th of Nov. a powerful X34 flare was detected	<a href="#">weblink1</a>	<a href="#">weblink3</a>	
2004	7-25/26 11-4 to 11-10		460 (7.11.)		8 9-	≤45°/≤35° (25.7.)	25.7.: Michigan, California, New York 7.11.: Alabama, Ohio			<a href="#">weblink1</a>		
2005	5-15		401 (15.5.)		8+	(GFZ-Potsdam data)		big solar storm caused large-scale atmospheric ionization	20. Jan 05			
2013	3-17				7-	(GFZ-Potsdam data)						
2013	6-1				7	(GFZ-Potsdam data)						
2013	10-2				8-	(GFZ-Potsdam data)						
2014	2-19				6+	(GFZ-Potsdam data)						
2015	3-17				8-	(GFZ-Potsdam data)		St. Patrick's Day storm:				
2017	9-8			X8.2	8+	(GFZ-Potsdam data)						
2022	2-3			M1.1	5	(GFZ-Potsdam data)		CME ended up as shock-driving magnetic cloud (MC)	3. February: 39 starlink satellites lost in solar-storm	<a href="#">more info</a>		
2022	9-30				4	(GFZ-Potsdam data)	Tasmania	bright aurora visible in Tasmania		<a href="#">more info</a>		
2023	2-10/11			X1.1	4	(GFZ-Potsdam data)		temporary radio blackout in South America		<a href="#">more info</a>		
2023	2-16/17			X2.2	5	(GFZ-Potsdam data)	New York, Idaho (predicted)	temporary radio blackout on sunlit side of Earth		<a href="#">more info</a>		
2023	2-27				7-	(GFZ-Potsdam data)				-		
2023	3-3			X2.1	4	(GFZ-Potsdam data)		caused a shortwave radio blackout in N- & S-America		<a href="#">more info</a>		
2023	3-24				8	(GFZ-Potsdam data)		see GFZ-data table - Appendix 6-B		-		
2023	4-23/24				8+	(GFZ-Potsdam data)	South Australia,NSW & WA		24. April : bright Aurora visible across southern Australia	<a href="#">more info</a>		

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