Global Impact Events are the cause for Plate Tectonics and the formation of Continents and Oceans (Part 5)

This is **Part 5** of my study. Please also see : **Parts 1 to 4 & 6** → These parts describe the Permian-Triassic Impact and its effects on Earth in more detail.

by Harry K. Hahn / Germany - **8. July 2017** - Note : Study isn't allowed for commercial use ! → Study-Documentation on : www.permiantriassic.de or here

(18.1.2022 → added page 16) (→ **higher resolution version** of study is available here : **www.archive.org** > see **Part 5_hr**)

Abstract :

The 1270 x 950 km Permian-Triassic (PT)-Impact Crater on the ocean floor of the Arctic Sea will confirm the hypothesis that Global Impact Events are the cause for plate tectonics or more precise the cause for a combination of plate tectonics and expansion tectonics ! The PT-Impact Crater in all probability was caused by a big comet or asteroid with a diameter of 60 to 200 km, and it probably collided with our planet at a very shallow angle of less than 8° near the North Pole, with an estimated low impact velocity of ≈ 8 km/s.

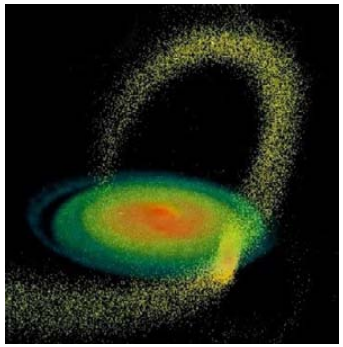
A global fracture pattern on Earth's crust was caused by this powerful impact and the ejecta of the impact, which mainly impacted in the form of powerful ejecta-rays and caused secondary-crater-chains with craters in the range of Ø100-300 km visible on different continents ! The most Impressive are the Ejecta-Rays 1 to 4 in Africa (see **Part 2** of my study)

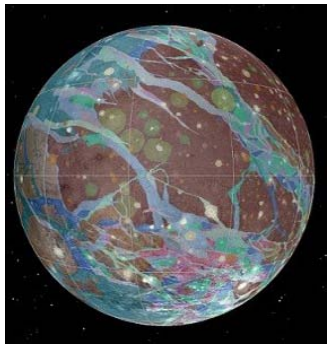
The sudden decompression of Earth's mantle, caused by the PT-Impact, triggered an expansion process in the mantle, which was caused by volatiles like H_2O, CO_2 and SO_2 in the mantle material. Earth's mantle probably consisted of a partially differentiated mixture of rock and ice (e.g. Ice-V to -XI) at the time of the PT-Impact, similar to the mantle of Jupiter's moon Callisto. The large amounts of ejected (and molten) material, caused by the PTI, partly descended in Earth's mantle and caused the African- and Pacific-LLSVP (& ULVZ) and in this way the volcanism on Earth for the last ≈250 Ma ! The PTI also started a plate tectonics process on the expanding Earth-mantle, which is still going on today.

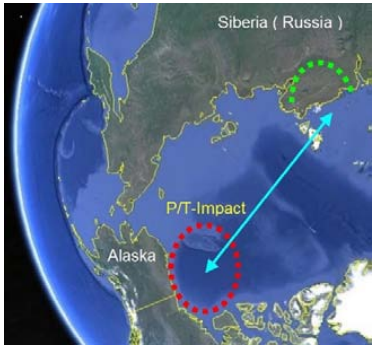
In the same way an Expansion-Tectonics- and Plate-Tectonics-process was triggered on Earth, it was initiated by an impact on other planets and moons of our Solar System as well ! There is evidence for other powerful Global Impact Events which occurred on the planets Venus, Mars and Pluto, and on Jupiter & Neptune, and on Jupiter's moon Ganymede, on Saturn's moons Enceladus & Iapetus, and on Pluto's moon Charon, and on our Moon too ! → see description of the traces of these global impact events in this Part 5 ! There is evidence that these global impact events, which occurred on the other planets and moons of our solar system, probably all took place within the last 300 million years !

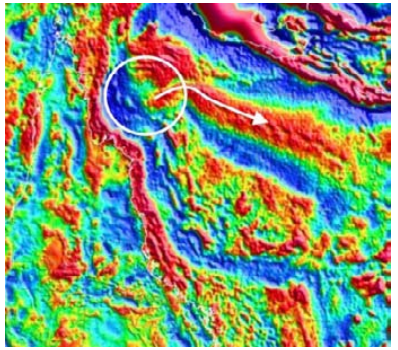
The root cause of these powerful impact events, caused by large Impactors (asteroids & comets) in the diameter range 20 - 200 km, are probably large amounts of debris located mainly close to the galactic plane of our galaxy. Tidal debris streams, probably in the range of 10 to 100 x 10^9 sun-masses, caused by dozens of galaxy-collisions over the lifetime of our galaxy, seem to be the source of the debris (asteroids & comets) distributed along the galactic plane. This dark debris-material may represent the invisible "Dark Matter" !

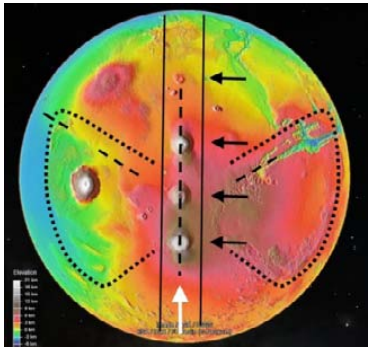
There is a distinct **62** Million year (Ma) Bio-Diversity-Cycle (or Extinction-cycle !) visible in the geological record of Earth. This extinction-cycle corresponds well to the **66** +/- **6 Ma** period for the vertical oscillation of our Solar System about the galactic plane of our galaxy ! Therefore there is an increased risk for powerful impact events all ≈33 Ma when our solar-system is crossing the galactic plane, which seems to be a kind of debris disk (similar to Saturn's Ring) consisting of a layer of large asteroid & comets ("Dark Matter" !!).











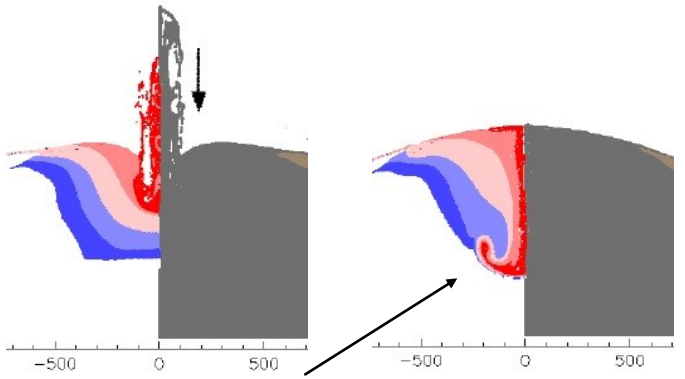
Mid of 2012 I informed ≈ 10 geologists and impact researchers (e.g. Prof. C. Koeberl, Prof. T. Kenkmann and Prof. U. Reimold) about the discovered 300 km diameter Cape-York Crater and other possible impact structures on Australia's East coast. In 2015 & 2017 I informed the above mentioned, +geologists & the head office of the UNI Karlsruhe (KIT) about the discovered PT-Impact Crater. I even went to the 16th Symposium for "Tectonics" TSK2016 in Bonn in March 2016 and distributed copies of my study about the PT-Impact. But the only answer I got so far (KIT) was : My discoveries aren't explainable with the current state of geophysics

The real cause of Earth's Plate Tectonics for the last 250 million years ! :

1.) Not mantle plumes are the primary cause of Plate Tectonics !

Global impact events, caused by powerful asteroid- or comet-impacts, are the primary driver of Plate Tectonics !

→ The **hard evidence** will be the confirmation of the Permian-Triassic (PT) Impact Crater !



This is a big mantle plume ! But it was caused by the impact of a 100km asteroid and didn't just develop out of the blue !
These images show a simulation of such an impact on the moon

Weblink: **"Numerical modelling of basin-scale impact crater formation"**
→ http://www.lpi.usra.edu/lpi/potter/publications/RossThesis.pdf
(if the weblink doesn't work: then just type-in the shown web-address in the browser)

2.) The Geo-Scientists don't know yet, that the Permian-Triassic-boundary was caused by a large asteroid- or comet impact !

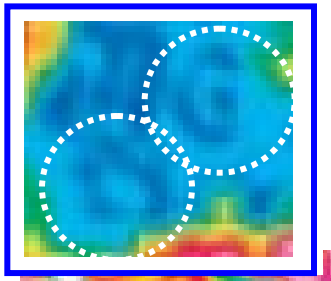
Some Geologists & Impact Researchers already speculate that a large impact Crater may have caused the P/T-boundary. But nobody has found the crater yet !

Yes there is a large Impact crater which has caused the P/T-boundary !

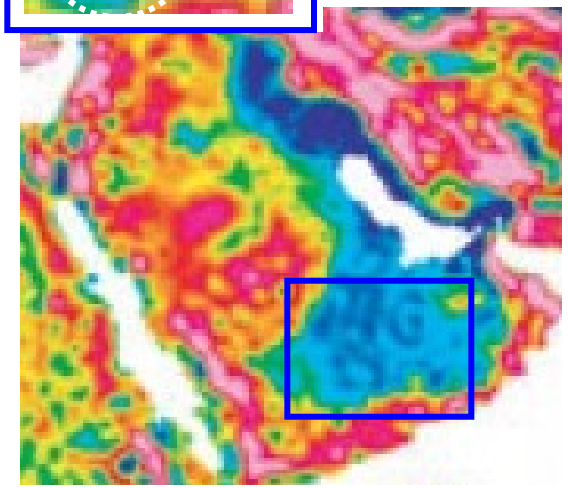
It is so large, that probably everyone has just overlooked it, because of its immense size of Ø 1270 x 950 km !! It's an elliptical crater.

You need to move up high above planet Earth to see it !

In my study I will give a detailed description of the P/T-Impact Crater !



These two large circular gravity anomaly signatures probably indicate the two impact craters which are responsible for the big oil- & gas-fields in Saudi Arabia and in the Persian Gulf.



(Eigen-GL04C free-air gravity anomaly map)

3.) The distribution of metal-ores and energy resources like crude-oil or natural gas, isn't just a coincidence ! And some mining companies probably know that !

The distribution of many mineral- & energy-resources (e.g. metal-ores, crude-oil- and natural gas) is mainly caused by big impact events !

That's why a precise knowledge of all impact structures on Earth is crucial !

And the knowledge of the P/T - Impact Event and other large Impact Events will make a big difference in future explorations, in order to find the resources which are needed for the further peaceful & prosperous development of mankind !

Mineralogical Evidence (shock-metamorphic effects in rocks) for the Permian-Triassic (PT) Impact Event which I have found :

→ Please read **Part 6** of my study : Mineralogical and Geological Evidence for the Permian-Triassic Impact Event (or alternatively here : Part 6)

→ or on my website : www.permiantriassic.de

→ or: www.permiantriassic.at

Indication and evidence for the PT- Impact Event, which is coming from existing studies :

A number of scientists specialized in impact research already proposed, that the Siberian Traps, the largest eruption of continental flood lavas on Earth, may be better explained by a large Impact than by a conventional mantle plume. Unfortunately the scientists haven't found the impact crater yet !

With my hypothesis (Parts 1 to 6) I want to proof that **Global Impact Events* are the primary cause for Plate-Tectonics** (and Expansion-Tectonics) on Earth and on other planets and moons of our solar system, and that such a Global Impact Event caused the formation of Continents and Oceans on Earth !

The hard evidence for the correctness of my hypothesis, will be the confirmation of the **Permian-Triassic (PT) Impact Crater** described in my study.

In the following I want to show now some extracts from a book written by the well-known impact researcher Prof. Dr. Christian Koeberl.
These extracts from the book show the existing indication and evidence for a Permian-Triassic (PT) Impact Crater. But no information is given for its location.

The title of the book : "Impact Markers in the Stratigraphic Record" – Authors : C. Koeberl & F. Martinez-Ruiz (ISBN : 3-540-00630-3)

Here the extracts from the book :

Page 29 : Siderophile element anomalies (e.g. enhanced Ir contents) were found at some P-Tr boundary locations (e.g., Holser et al. 1989). And recent research succeded in demonstrating the P-Tr boundary event was a much shorter event than thought. At Meishan, China, a negative excursion in the carbon isotopic composition had a duration of less than about 160,000 years and suggested that it could be the result of the impact of an icy carbon-rich comet.

Page 29 : Kaiho et al. (2001) reported sulfur isotope and chemical data for samples from the Meishan (China) Permian-Triassic (P-Tr) boundary section. They interpreted S-isotope data, as well as the occurrence of Fe- and Ni-rich particles, as evidence for a large-scale impact event that penetrated the Earth's mantle and formed a crater approximately **1000 km** in diameter.

see Study :

End-Permian catastrophe by bolide impact: Evidence of a gigantic release of sulfur from the mantle

by Kunio Kaiho, Y.Kajiwara, Yasunori Miura

A number of scientists pointed out that the Sibirian Traps cannot be the result of a mantle plume (e.g. Czamanske et al. 1998, Sharma 1997, Elkins-Tanton and Hager 2000)

Page 109 : An impact event is also supported by evidence from extraterrestrial noble gases in fullerenes found in P-Tr boundary beds in China, Japan, Hungary.

Page 109 : Because there is a similar duality of signals between likely volcanic and impact sources at the P-Tr boundary, similar to the K-T boundary, the hypothesis of Impact Researchers should be tested, which claims that the Siberian Traps could have been caused by decompression melting at the impact site. And that impact volcanism can uniquely explain the dual signals in the geological record.

Page 110 : An indicative model of Impact Researchers shows that it is possible for the volume of decompressed mantle beneath a large ~ 200 km sized crater to greatly exceed the excavated volume of the impact crater itself, primarily due to reduction of lithostatic load. Under suitable conditions of geothermal gradient, this would lead to near instantaneous melting with volumes of the order of 10^6 km^3 , similar to the characteristic volumes of LIP's.

Page 110 : And the induced large-scale vertical and horizontal thermal gradients are expected to have a long-term effect on secondary mantle flow.

Page 111 : Decompression melting may contribute more melt than conventional shock melting.

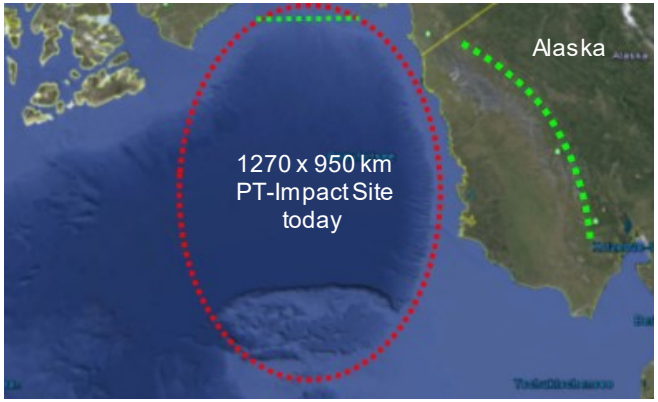
Page 111 : We propose that the Siberian Traps, which are accessible and currently under considerable scrutiny, may be better explained by a large impact than by a conventional mantle plume. The closure of a former ocean between Siberia and Mongolia, as well as amalgamation with north and south China blocks may also have been occuring during Permian-Triassic times. (→ These events were the result of the P/T-Impact Event !! → comment from Harry.K.Hahn)

Page 97 : Decompression melting must be seriously considered whenever an impact is sufficiently large to cause the transient crater depth to excavate a substantial fraction of the local crustal thickness, and thereby cause a sudden drop in lithostatic pressure beneath the crater.

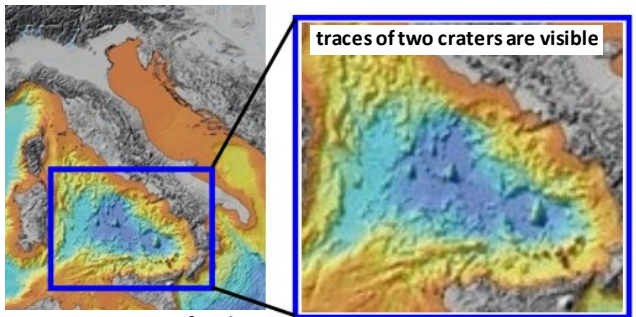
Another study which indicates a Permian-Triassic Impact Event in Australia : Raining lead around 250 mya : A smoking gun for an Australian impact origin of the Permian Extinction ; by Jim Standard & C. Austen Angell , Department of Chemistry and Biochemistry, Arizona State University, Tempe, AZ 85287

Introduction - The Permian Triassic Impact

There is evidence for an elliptical impact crater with the enormous dimensions of **1270 x 950 km** on the ocean floor of the Beaufort Sea near the north-coast of Alaska. This impact crater seems to be responsible for the Permian-Triassic Boundary, which has caused the most severe mass extinction in Earth's history, ~253 million years ago. This Permian-Triassic (PT) Impact Crater was formed by an oblique impact. That means that the impactor (an asteroid or comet) collided with our planet a very shallow angle of probably less than 8°



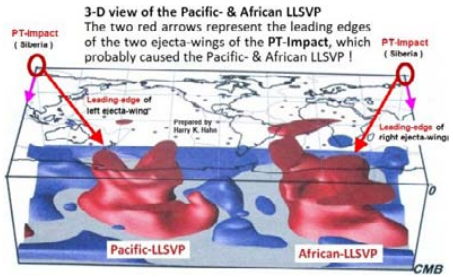
The impactor, an asteroid or a carbon-rich comet with a diameter of 60 to 200 km, impacted in the Beaufort Sea close to the north-pole and caused a gigantic butter-fly shaped ejecta blanket with two large ejecta wings which covered the majority of the northern hemisphere. Within the boundaries of this ejecta blanket many large secondary impact craters were formed by the ejecta, with crater diameters of up to 450 km. In Europe (in the mediterranean area) at least 8, but probably up to 20 such large secondary craters were formed by the impacting ejecta, which was thrown out of the PT-impact crater. These impact craters and the resulting large-scale magma (lithospheric) flow is responsible for the tectonic development of Europe during the last ~253 Ma. Two of these secondary craters (∅160 & ∅220 km), which formed the Tyrrhenian Sea north of Sicily (Italy) and which are still noticeable on topographic- & geological maps (see below), should provide the evidence to confirm the described impact scenario



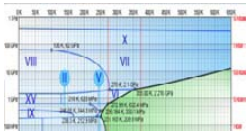
Tectonic Map of Italy

The main impulse of the PT-impact, together with the impulses and secondary craters, produced by the ejecta material, caused a global fracture pattern on Earth's crust, which was the trigger for the break-up of Pangea and for a global expansion tectonic process. This expansion tectonic process caused the dichotomy on Earth → the formation of continents and ocean basins. And it is responsible for the transport of big amounts of volatiles (mostly H_2O) from Earth's mantle to Earth's surface.
Earth's diameter increased from an estimated diameter of 6500-7500 km ~250 million years ago to a diameter of 12756 km today, with an average expansion rate of ~ 20mm/year.

The expansion of Earth's mantle probably was caused by ≥ two effects : By abrupt decompression of Earth's mantle, which led to the large-scale expansion of volatiles, especially H_2O (ice/water), in Earth's mantle. And by phase changes (transformation) of minerals and high-pressure Ice e.g. **Ice XI** & **X** caused by the thermal energy (heat) that was induced in Earth's mantle by the molten PTI-ejecta which descended in Earth's mantle and formed the African-LLSVP and the Pacific-LLSVP :



Earth's expanding mantle may be caused by a transformation of a high-pressure Ice-type, e.g. **Ice XI** with a density >> 3 to an Ice with a lower density.



The ocean basins, which represent new surface area of our planet and which formed between the old crust fragments (the continents), continuously filled up with water (H_2O) over the last ≈ 250 Ma. This water was, and still is, transported from Earth's mantle to Earth's surface through fractures caused by the PT-impact, and through the Mid-Ocean Ridges were new surface areas of planet Earth (→ the ocean floors) are continuously created

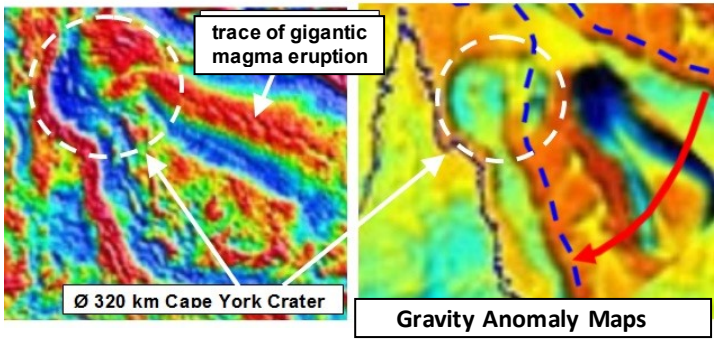
In the same way as the water was transported to the surface of our planet Earth, and in the same way the expansion tectonic process was initiated on Earth it happened on other planets and moons of our Solar System. There is evidence for other powerful global impact events which occurred on the planets Venus, Mars and Pluto, on Jupiter's moon Ganymede, on Saturn's moons Enceladus & Iapetus, on Pluto's moon Charon and on our moon The Moon's Mare are probably the result of a global impact less the 300 million years ago (see : **L1**, **L2**, **L3**, **L4**) similar as on other planets & moons These global impact events in all probability took place in the last 300 million years !

<u>But back to the Permian -Triassic (PT)-Impact !</u> :

The main impulse of the Permian-Triassic (PT)-impact on Earth initially caused a break-off of the Angara Craton from the Russian Craton and it caused a strong acceleration of the Angara Craton towards South, were China and Australia were located at that time. The following powerful south-ward movement of the Angara Craton then caused

the HP- and UHP-orogens in China, through the extreme compression which it produced in the crust fragments caught between the North China Craton & the Angara Craton. This dynamic process led to the formation of the Altaid-magmatic-fronts.

In the NE & NW of Australia, off the coast, two exceptional large craters with ~ 350-400 km diameter can be identified, which both seem to be secondary craters caused by ejecta from the PT-impact event. Here especially the Cape York impact crater located off the NE-coast of Australia must be mentioned, because it strongly influenced the tectonic development of the Pacific Plate through a number of gigantic magma eruptions.



Gravity Anomaly Maps

The stratigraphic record of the NE-coast of Australia (e.g. “Moreton Geology”) indicates the probable connection of the Cape York crater, and its secondary impact structures, with the PT-impact event. At least eight (8) gigantic magma eruptions can be assigned to the Cape York Crater, which took place within the last ~200 million years. The fifth eruption of this series of magma eruptions, which was very powerful, not only left clear visible traces on the Pacific Plate. The magma front of this eruption also moved a small cratonic block (the Colorado Plateau) deep into the north-american continent. This has caused the formation of the Rocky Mountains and the Basin & Range Province. Further, a second magma front resulting from this eruption strongly influenced the geology of Antarctica, and it separated Antarctica from Australia & South-America.

This eruption No.5 may have been triggered by extreme earthquakes, of magnitude >12 (on the Richter Scale), maybe caused by the Chicxulub Impact Event ~65 Ma ago, and could therefore be partly responsible for the extinction of the dinosaurs

The magma eruption No.6 of the Cape York crater left further distinct traces on the Pacific plate and it strongly influenced the geology of Mexico and of the Gulf of Mexico, when the magma front crossed this area. This magma front was also responsible for the formation of the Appalachians, which were created by a crust-fragment that was relocated (bended) towards the East by the magma front.

A key map for the further analysis of these magma eruptions is the NOAA ocean floor map, which shows the topography of the Pacific Plate in fine detail. This map shows all the fine traces which will lead to the confirmation of these magma eruptions, and it will help to understand the dynamic geological processes caused by these magma eruptions, e.g. the separation of New Guinea & New Zealand from Australia, and the separation of Japan from New Guinea, the formation of Indonesia, French Polynesia etc.
Another key map is a global ocean-floor-age map which shows the 1200-1600 km wide ocean-floor stripes (between 60°N & 30°S latitude) where the magma fronts moved along from west to east.
→ see detailed description in **Part 1** of my study !

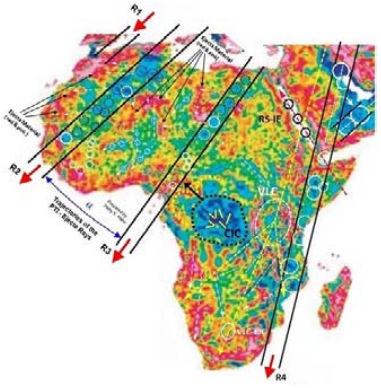
Along the NE coast of Australia there are many other secondary impact structures noticeable, which all were caused by the Cape York impact.
Other possible secondary impact craters, caused by the PT-impact event, were found in India, in Arabia and in South-America. Here the 450 x 380 km elliptical crater identified in India, which formed the Bay of Bengal, seems to be related (identical) to the large secondary crater off the NW-coast of Australia with the estimated dimension of 400 x 350 km, that is responsible for the ejection of large amounts of ejecta, rich in Platinum Group elements in a ray-like pattern on the Yilgarn Craton

A large elliptical crater with the dimensions of 840 x 630 km , found in South-America, which can be identified on topographic maps and on satellite images, may also be related to the PT-impact event. (maybe caused by ejecta ray R2)

Another largescale impact event in Africa, which also must be mentioned here, are the four chains of impact craters R1 – R4 (with probably > 10 craters per chain), formed by secondary-craters in the Ø100 to Ø300 km range, caused by PTI-ejecta rays which crossed the whole continent in slightly different angle directions ! These impact craters were caused by ejecta material which was excavated in the PT-Crater during the PT-Impact.

A gravity anomaly map of Africa provides evidence for the very powerful ejecta rays caused by the PT-Impact Event in Siberia. The traces of the Ejecta Rays R1 - R4, which caused long secondary- crater chains, are clearly visible in the form of linear negative (blue) anomalies on the Map of Africa. Craters with Ø100-300 km caused these crater chains !

Gravity Anomaly Map of Africa
showing the PTI-Ejecta Rays R1-R4



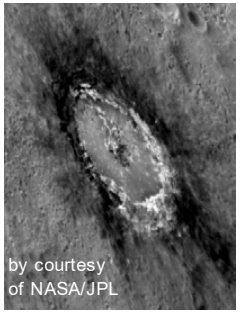
(→ Find a more detailed description of the Ejecta Rays and crater chains caused by the PT-Impact Event in the Parts 1 to 3 of my study)

My investigation points towards the strong Ejecta-Ray No. 4 along the east-coast of Africa, and the strong ejecta ray along the north-east-coast-line of Australia, which produced a number of ~Ø 300 km secondary impact craters (e.g. the Cape-York Crater), as the probable location (→the two cracks in Earth's crust) where a big part of the PT-ejecta material descended in Earth's mantle and caused the African- & the Pacific-LLSVP & ULVZ (Large Low-Shear- and Ultra-Low- Velocity Provinces) !

I believe that Earth's mantle probably consisted of a partially differentiated mixture of Rock and Ice (e.g. Ice-X or -XI) ≈ 250 million years ago, similar as the mantle of the big Jupiter moon Ganymed or Callisto. However the molten ejecta material which descended into Earth's Mantle after the impact probably caused a phase-change in the Ice towards an Ice-type with lower density and it probably produced big amounts of volatiles, which led to a constant expansion of Earth's mantle until today !

I now want to mention an interesting discovery on Mercury. The image on the right shows the ø 80 km Basho Crater on Mercury. The low-reflectance material (black) which is surrounding the crater is a form of carbon called graphite. Scientists believe it was excavated by the impact from the planet's original, ancient crust which lies deeper.

Basho Crater on Mercury



It is thought that Mercury was once covered by a crust composed of graphite, when much of the planet Mercury was still molten.

An alternative explanation would be that the carbon was brought-in by the impactor itself, for example if the impactor was a carbon-rich comet. This would be my first guess when I look at this image. However an origin from within Mercury (from Mercury's mantle) is also possible.

I mention this discovery for the following reasons :

1.) In all probability the PT-impactor was a carbon-rich comet with a diameter of 60 - 200 km.

2.) Lengai Volcano located in Tanzania within the strong ejecta ray R4 is erupting Carbonatite Lava. Carbonatites are formed essentially of carbonate. It is possible that the carbonate which formed the carbonatite lava was caused by the PT-impact, because the distribution of carbonate rocks in Europe seems to be closely related to the PT-impact event in Europe, caused by PTI-ejecta. In all probability the carbonatite was caused by carbon-rich rock material from the Carboniferous period which was excavated during the PT-Impact, and then transformed in carbonatite after the carbon-rich ejecta material impacted on Earth's surface.

The other possibility is that the carbonatite was caused by carbon material from the Impactor itself.

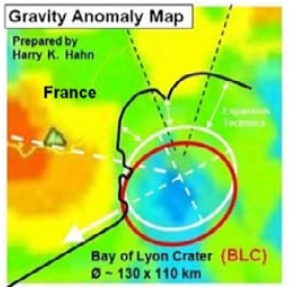
3.) The 12 km "Kola super-deep borehole" showed that at a depth > 7 km the rock in Earth's crust is saturated with Hydrogen (H_2) and H_2O which originates from deeper sources in the mantle !
It's possible that big amounts of the hydrocarbon deposits found close to impact structures may be a direct result of the thermochemical processes which are going on during & after an impact event !
(→ e.g. deposits consisting of CH_4, C_2H_6 etc.)

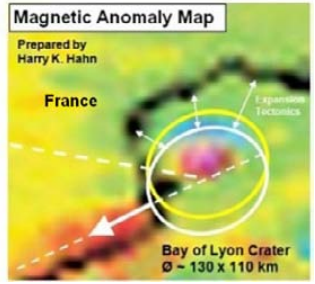
First indication for six PT - Secondary Craters ! :

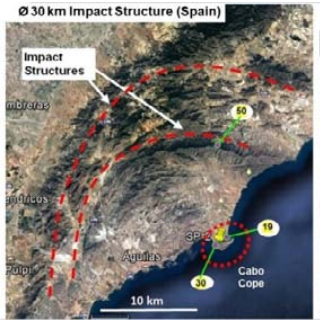
I have found indication for shock-metamorphic effects in the rock-samples of **six possible Secondary Craters** of the PT-Impact Event.
This provides the first scientific evidence for real impact structures caused by the PTI-event !

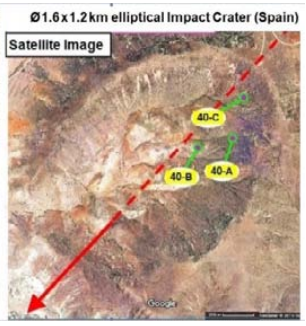
I used **Micro-Raman Spectroscopy on quartz-grains** to provide the evidence for a shock event, that in all probability was caused by the PT-Impact Shifts of the Raman peaks in quarz-samples of these six possible PT-secondary-craters indicate that the quartz-grains were shocked with a shock-pressure in the range of 20-22 GPa in some cases This is clear indication for an impact shock event !

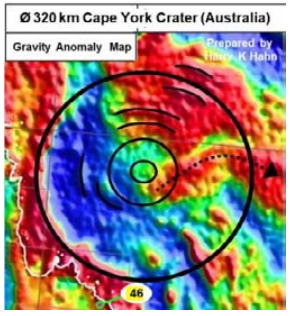
The most interesting PT-Secondary-Craters for further scientific research in Europe, to proof the PT-Impact Event, are the **Ø 130 x 110 km „Bay of Lyon Crater"** and the **Ø 30 km Impact Structure** near Puerto de Mazarron and the **Ø 1.6 x 1.2 km elliptical Impact Crater** near Rodalquilar, both in southern Spain. In Australia the most interesting PT-Secondary Craters are the **Ø 320 km Cape York Crater**, the **Ø 40 x 33 km elliptical Pilbara Crater** the **Ø 8 x 7 km elliptical Warwick Crater,** and the possible Ø 30 km Mt Warning Crater.
All these PT-Secondary Craters are unknown yet !
A detailed analysis in **Part 6** (**P6**) of my hypothesis

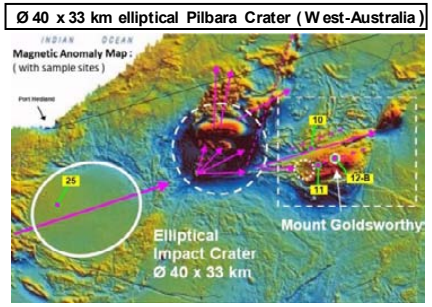






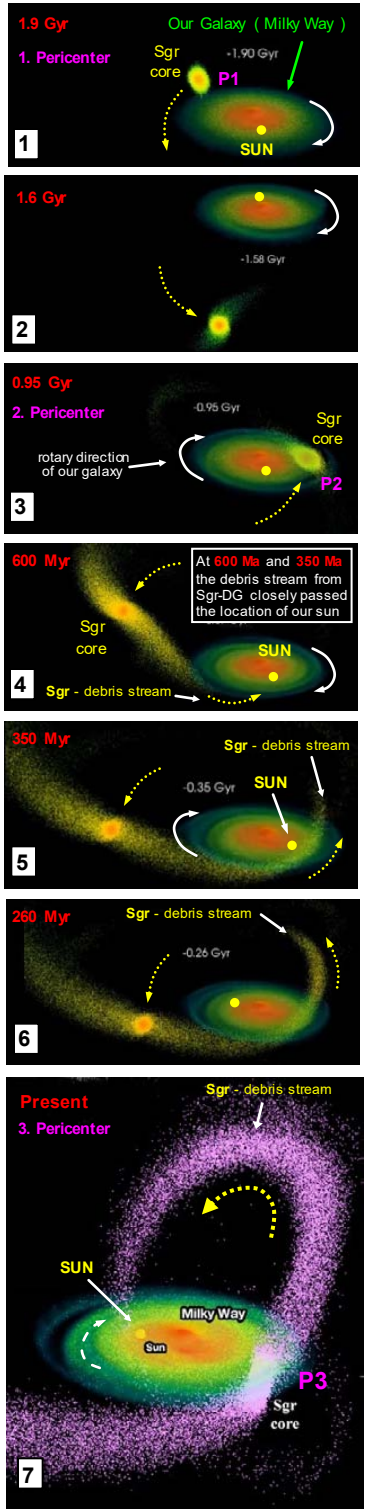




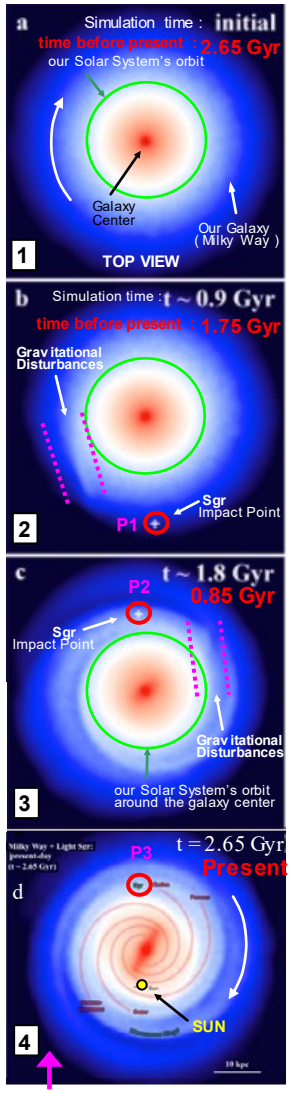


Introduction – Evidence for a fundamental cause of Global Impact Events and "Super-Continent Break-Ups"

There is strong indication that the **Sagittarius Dwarf Galaxy (Sgr-DG)**, a companion of our own galaxy (Milky Way), is responsible for "periods of global impact events" in our solar system, and in million other solar systems as well ! This means that around each **pericenter event** of the **Sgr-DG** with our own Galaxy (→ pericenter event = closest approach between the mass centers (or the collision) of both galaxies), millions of planets in our galaxy were hit by large impactors (large debris) caused by the collision of the two galaxies.



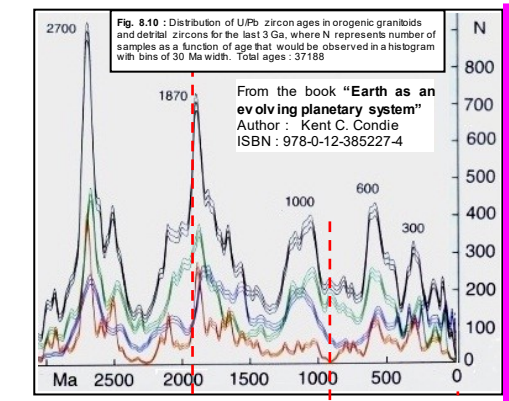
During Earth's history there were at least three (maybe even 4 or 5) of the mentioned pericenter events. The image sequence on the left shows the last three pericenter events in quick-motion (images 1 to 7 & 1 to 4). The images are extracted from a super-computer simulation of the dynamic behaviour of the two galaxies over the last 2,65 Gyr's (1 Gyr=1 billion years). The key events are the three pericenter (P)-events (collisions, or closest approaches of the two galaxies). They took place at : **P1=1,9 Gyr**, **P2=0,9 Gyr** and **P3= 0 Gyr** (now !)

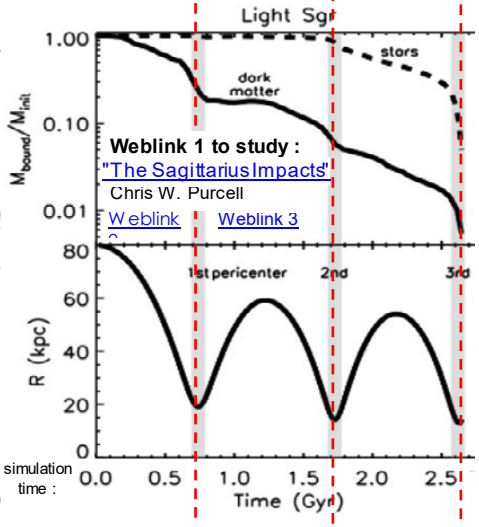


Here the weblink of the movie which shows the Dynamical Analysis of the galaxy collisions:

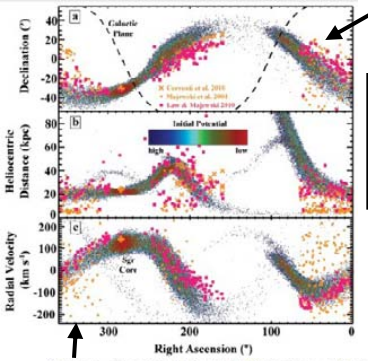
→ Movie_Dynamic_Analysis

The dynamical analysis of the three collisions (pericenters 1 to 3) of the Sagittarius Dwarf Galaxy with our own galaxy shows, that gravitational disturbances, which are caused on our galaxy disk at each collision, shear into trailing arms, which are then enhanced, strengthening the transient spiral modes of our galaxy. In other words this means that collisions of this Dwarf Galaxy with our own galaxy cause & intensify the spiral arms and spiral structure of our own galaxy. As everyone can imagine this has consequences for all solar systems located in the new created spiral arms caused (or later intensified) by these collisions ! The spiral arms created by the collisions are actually vortices of stars in which billions of solar-systems rotate around the bow-shaped center-lines of these spiral arms. And on each rotation around the center-lines of the spiral-arms the solar-systems cross the center-plane of the galaxy disk two times. (up- & down oscillation through disk)





The diagrams on the left show that there is a distinct correlation between the U/Pb **Zircon** age peaks in orogenic granitoids (& detrital zircons) on Earth and the ages / times when the Sagittarius Dwarf Galaxy (S-DG) impacted on our own galaxy (→ pericenter events **P1** & **P2**). And because there is also a correlation between the Zircon age peaks and the break-up & formation of super-continents, it can be concluded that each pericenter event with the Sagittarius Dwarf Galaxy resulted in a super-continent "break-up" & "formation" cycle (or in a shattered crust) on Earth ! These "supercontinent cycles" must be the result of strong variation of "debris-flow" in our own Galaxy, caused by the collisions (pericenters) with the S-DG, which led to times with many global impact events on the planets of our solar system, when the debris flow was high, or they led to quiet periods with low debris flow → which then allowed planets to heal fractures in their crust caused by the global impact events. In the last 600 Ma (**P3**) more global impact events occured, because there was a constant debris flow of stellar material from S-DG through our Galaxy.



The S-DG debris stream :
→ comparison of the real and simulated debris stream

Our Galaxy's (Milky Way) data :
disk (galaxy) diameter: 120000 LY
disk height : 3000 - 16000 LY*
number of stars : 100 - 300 billion
orbit period of our solar system around the galaxy center : **230 Ma**
age of our galaxy : 13.6 Ga

Sagittarius Dwarf Galaxy :
disk diameter (core) : 10000 LY
number of stars : around 1 billion
age of galaxy : approx. 13 Ga
Orbital velocity : 140 – 170 km/s

LY* = Light Year

Figure 2 - Face-on surface density visualizations of the Milky Way at four important moments during the *Light Sgr* simulation. a, Initial model. b, Immediately following first pericenter, where the white cross marks the Sgr impact point. c, Shortly after second pericentric disk crossing. d, At the present-day (corresponding to elapsed simulation time 2.65 Gyr), overlaid by a four-armed symmetric-spiral fit to the observed arms of the Milky Way as revealed by mapping neutral hydrogen[23]. The traditional view of the Milky Way as a secularly-evolving system has encouraged theoretical descriptions of quasi-stationary density-wave spirality, although the large peculiar motions of young stars in spiral arms support a more transient picture[24] (numerical evidence exists for both short-lived configurations[25] as well as more stable forms of spirality, varying with the strength of the tidal induction[26]). Dynamical analysis of each impacted Milky Way model reveals the importance of the swing amplification mechanism, in which gravitational disturbances in the stellar disk at each pericentric approach shear into trailing arms that are subsequently enhanced on small scales (even in a globally stable system), strengthening transient spiral modes.

Figure S2 - The time evolution of bound mass and orbital radius in each simulated Sgr infall. Most mass loss occurs near the pericentric passages, marked by shaded bands. The dark halos in these satellite models both follow NFW density profiles with a scale length of 4.9 kpc for *Light Sgr*. We account for the mass loss that would have occurred between virial-radius infall and our initial Galactocentric radius of 80 kpc by truncating the Sgr progenitor mass at the instantaneous Jacobi tidal radius at that position, *i.e.* $r_t = 23.2$ kpc for the *Light Sgr* model. The total mass enclosed within this radius is $M_{Sgr} = 1.37 \times 10^{10}\ M_\odot$ for the *Light* model. These masses agree well with the pre-disruption mass estimates based on the stellar kinematics of the observed Sgr core and debris stream[9]. Implicit in our model is that the infall into the halo was recent enough that the first pericenter crossing modeled here was indeed the first close passage experienced by this satellite.

Figure 3 – The observed Sgr tidal debris stream and remnant core in comparison to our *Light Sgr* simulation, in equatorial coordinates. a, Declination versus right ascension. b, Heliocentric distance versus right ascension. c, Radial velocity versus right ascension. Simulated particles are colored according to their initial potential energy, and the orange points are data from 2MASS M-giant stars[27] and SDSS red-clump stars[28] (marked by squares and crosses respectively, thick crosses denote canonical values for the remnant core[2,12]). The pink points are 2MASS M-giants identified as likely stream members[8]. The present-day location of the simulated remnant and tidal arms are similar to those observed. Combining this with observational constraints on the dispersion ($\sigma \sim 10 - 15$ km s^{-1}), breadth ($8 - 10$ kpc)[27], and length of the observed debris stream provides some legitimacy for our model.

Introduction - Evidence for a 62 +/- 3 Ma Cycle in Bio-Diversity on Earth, caused by big Impact Events

There is strong analytical evidence for a **62 +/- 3 Ma** cycle in Fossil Diversity (or Bio-Diversity). Sharp cuts in the bio-diversityon Earth clearly occur within **approx. 20 Ma (Myr) long extinction periods**. These sharp cuts all happen within the declining phases of the **62-Ma (Myr) cycle** (→ see sin-wave diagram **1c**).
Currently we live at the end of such an extinction period or declining phase of the 62-Ma cycle which is still going on for another 3 to 5 million years !! But it is obvious that there wasn't a similar sharp cut yet, in the current cycle, if compared with the past 8 cycles !

Note that in 6 of the past 8 cycles **at least 70%** of all marine species became extinct !!! (diagram 3). And in all 8 cycles the minimum percentage of extinct species was 40 %. However the current cycle doesn't show any cut in Bio-Diversity worth mentioning !! Have we just been very lucky ?, or is the cause of the sharp cuts in bio-diversity just a bit late in the current cycle which is still going on ?? Note : In cycles 5 and 8 a sharp cut occurred right at the end of each cycle ! (corresponds to eruptions & craters in Diagr. 2)

There are indicators in diagram 2 & 3 that the sharp cuts in bio-diversity may be caused by periods of large impact events. Note in **Diagram 2** the 5 large eruption events (which could have been caused by big impacts), which occurred within or very close to cycles 1 & 5-8, and the two large impact events in cycle 5 & 8 ! → also see **Diagram 3** !
It would be important to produce a more extensive and precise diagram to the age and size of large impact events & large eruption events with information to age tolerances !

The most plausible cause for the 62 +/- 3 Ma period "Big impact cycles" is **the periodic crossing of the galactic plane by our Solar System**. The galactic plane may be full of debris (asteroids & comets) similar to the debris in Saturn's Ring-plane. The **62 +/- 3 Ma** Bio-Diversity cycle is in good agreement with the **66 +/- 6 Ma** period for the vertical oscillation of our Solar System about the plane of our galaxy ! Note that it seems that the last crossing of the galactic plane occurred **≤ 3 Ma ago !,** which is approx. 5 to 7 Ma after mid of the calculated extinction cycle !! → see weblinks : 1.) Weblink Study 1 2.) Weblink Study 2

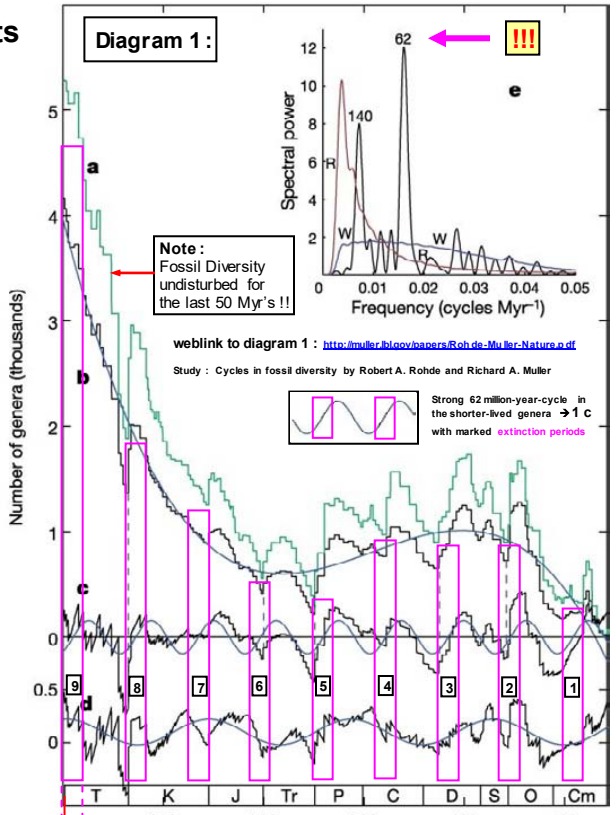
"Cycles in Fossil Diversity"
by Robert A. Rohde and Richard A. Muller
Weblink to Study : http://muller.lbl.gov/papers/Rohde-Muller-Nature.pdf

Diagram 1e : Shows the Fourier Spectrum of the short-term variations of the bio-diversity on Earth. The Fourier Spectrum is dominated by a **strong spectral peak with period 62 +/- 3 Myr.** The **sin wave** corresponding to this cycle is shown in **Fig. 1c** where it accounts for 35% of variance.

Diagram 1e also shows a second spectral peak with period 140 +/- 15 Myr.

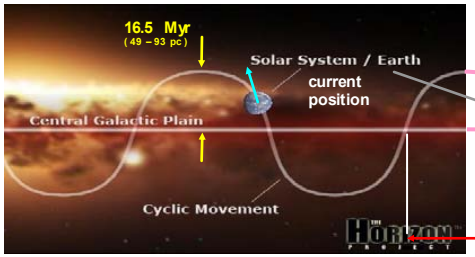
The 62-Myr cycle is very significant.
By contrast the 140 Myr cycle can plausibly result from random processes.

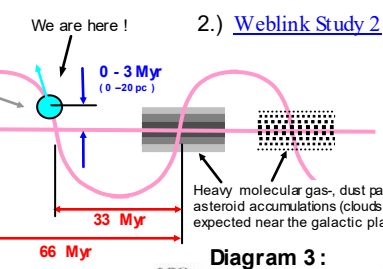
Although no explanation exists, the 62-Myr cycle is not a subtle signal. It is evident even in the raw data (Fig. 1a), dominant in the short-lived genera (Fig. 2) and strongly confirmed by statistical analysis. It implies that **an unknown periodic process** has been **having a significant impact on Earth's environment** throughout the Phanerozoic. The author considers the following physical processes : periodic comet showers triggered by a companion star or a planet X or by the oscillations of our solar system up- and down the galactic plane every 52-74 Myr or by periodic crossings of spiral arms, or periodic mantle plume cycles & volcanism cycles, or longterm solar cycles.



full web-addresses
1.) http://www.nature.com/nature/journal/v316/n6030/abs/316706a0.html
2.) http://www.nature.com/nature/journal/v314/n6006/abs/314073a0.html

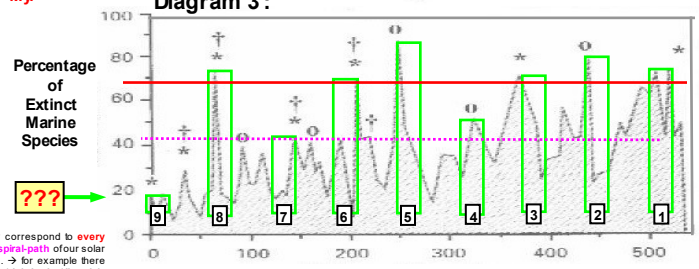
3 - extinction period left	~ 3 - 5 million years
2 – extinction period	approx. 20 million years
1 - fossil diversity cycle	62 +/- 3 million years

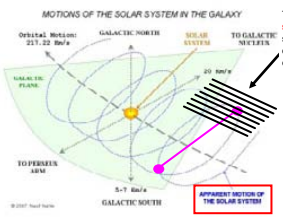




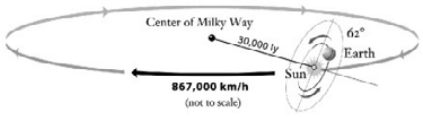
Large well-dated Impact Craters
Diagnostic evidence of Impact
documented Iridium Spikes

Diagram 3 :





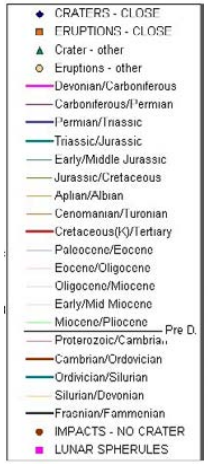
The logical reason why large impact events mainly correspond to **every second crossing** of the galactic plane could be the **spiral-path** of our solar system on it's way around the center of our galaxy. → for example there could be **a "heavy dust- & asteroid accumulation (debris ring)" mainly on one side of the spiral path and less on the other side** ! (see image)



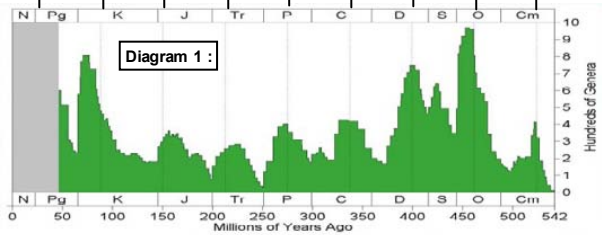
weblink to diagram 3 : Weblink Diagram 3
Study : Impacts and Mass Extinctions by Michael R. Rampino :
Weblink : http://adsabs.harvard.edu/full/1996EM%26P...72.441R

prepared by Harry K. Hahn , 29-9-2013

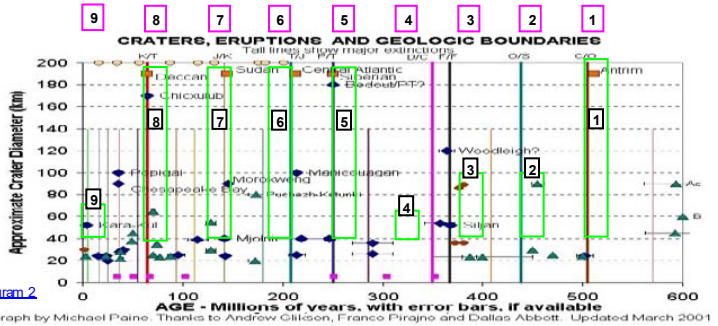
Diagram 2 :



weblink to diagram 2 : Weblink Diagram 2



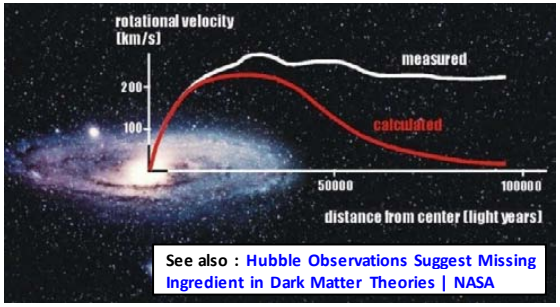
Fossil Diversity. All 13,682 short-lived (< 45 Myr) genera listed by Sepkoski are plotted. The dotted lines are spaced 62 Myr. (Rohde & Muller, Nature, vol 434, 208-210, 10 March 2005)



Graph by Michael Paine. Thanks to Andrew Glikson, Franco Pirajno and Dallas Abbott. Updated March 2001

A new hypothesis to Dark Matter: Interstellar -Asteroids and -Comets caused by Galaxy-Collisons are the invisible matter !

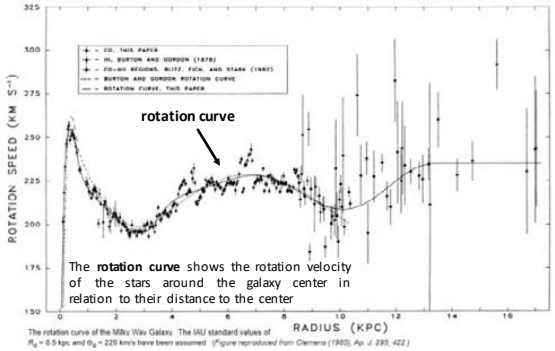
Dark Matter is exactly what its definition says ! : It is dark matter with a low albedo ! I am talking about Asteroids and Comets which are nearly invisible when they are far away from the sun. There is indication coming from different directions which shows us that we are totally underestimating the amount of asteroids - and comet-like objects which move through interstellar space ! In 2017 the first **Interstellar Asteroid** "**Oumuamua**" was discovered. In 2019 the first **Interstellar Comet** **2I/Borisov** was discovered. These small dark objects are very hard to detect !, because they move very fast. Old elliptical galaxies don't seem to have dark matter (**see: Study**). All younger spiral galaxies seem to be the result of collisions and fusions of two or more galaxies, which have produced gigantic tidal debris streams that were distributed along the spiral arms, and in the long term along the galactic planes. Collision simulations show that the spiral structures are caused by collisions ! (**see : Study2**) And there is indication that all bipolar planetary nebulae are the result of direct star-collisions (**Study3, Study4**)



See also : Hubble Observations Suggest Missing Ingredient in Dark Matter Theories | NASA

The curve on the left shows the Measured Rotation Curve (white) and the Calculated Rotation Curve (red) of stars in a typical spiral galaxy. It shows the rotation velocity of the stars around the galaxy center in relation to their distance to the center. In regards to the visible (luminous) matter which we can see, the rotation speed of stars further away from the center should drop rapidly (red curve). But it doesn't !! That's why astro-physicists developed the idea of dark (invisible) matter that must be distributed between the stars further away from the center (in the socalled galaxy corona) in order to explain the much to high measured rotation speed of stars here.

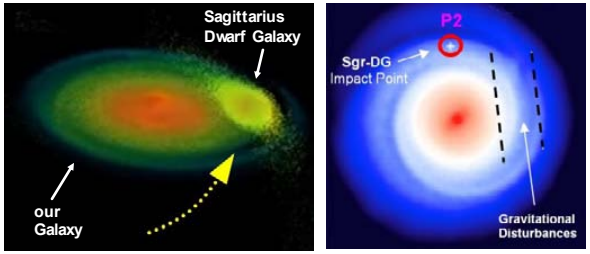
In my opinion this "Dark Matter" can simply be explained by dark matter that consists of „dark debris (asteroids & comets)" caused by galaxy collision. Spiral-Galaxies are the result of collisions & fusions of two or more galaxies ! Old Elliptical- (not collided) Galaxies don't seem to contain dark matter ! → **see Study :** https://arxiv.org/abs/1303.6896



The curve shows the total rotation curve. It has contributions from the spherical *galactic bulge* and the *disk*, but these contributions do not make up the entire curve, so another contribution called the *corona* must exist. The corona is not evident in anything we can see. so-called *luminous matter*, so it must be due to some form of *dark matter*

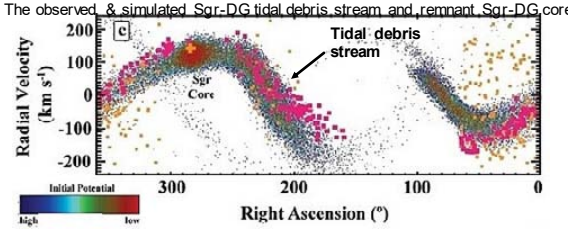
Old Elliptical Galaxies are not the result of many collisions like spiral galaxies ! A simulation of collisions of our own Galaxy with the Sagittarius Dwarf Galaxy (Sgr-DG) shows that gigantic tidal debris streams move through the areas, during collisions, where dark matter is expected. If we consider this tidal debris mass streams to be mainly asteroid- & comet-streams caused by billions of star-collisons then we can explain the mysterious dark matter (see images below left). A proof for this hypothesis may be bi-polar planetary nebulas located in the galactic plane of our galaxy which are aligned with the same 'collision vector'

The collision of the **Sagittarius Dwarf Galaxy** with our own galaxy caused debris streams **>10^{10}** sun-masses and gravitational disturbances, which enhanced the spiral modes (structure) of our galaxy. **see animation** → Movie_Dynamic Analysis



Weblink to study which analyses the collision : http://arxiv.org/abs/1109.2918

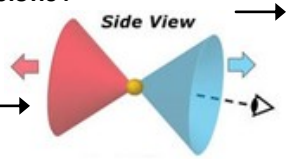
The observed & simulated Sgr-DG tidal debris stream and remnant Sgr-DG core



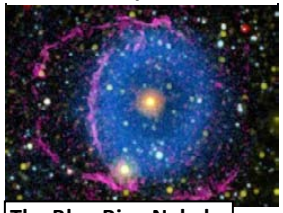
Bi-polar Nebulas are caused by collisions :

The **Blue Ring Nebula** is a cloud in space composed of debris & gas from two stars that collided and merged into one star. → **see images** → (**see: Study**) This Nebula represents the bi-polar planetary nebula type ! Another study to bi-polar planetary nebulas In our galaxy's central bulge showed that they have their long axes mostly aligned along the disk-plane of our galaxy !! This is a first proof for my hypothesis that bi-polar Planetary Nebulas are the result of star-collisions !! **Because stars mainly move ≈parallel to the galactic-plane their collision-vectors will have a similar direction !**

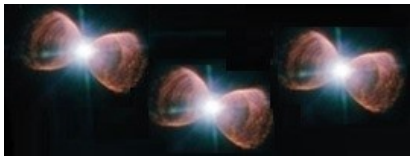
see weblink : Aligned Nebulae (ESO)
https://www.eso.org/public/news/eso1338/



a similar bi-polar Nebula

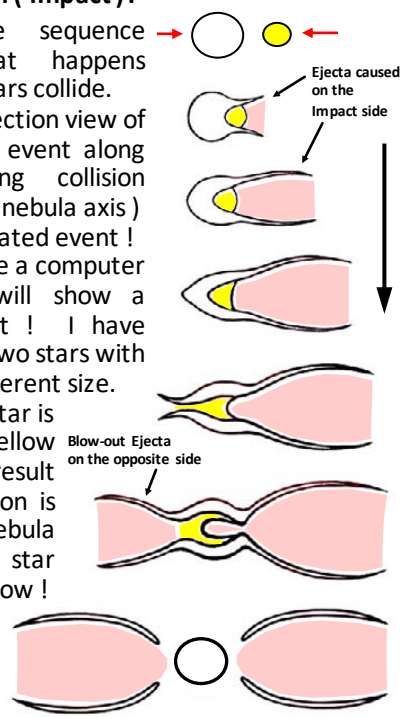


The Blue Ring Nebula

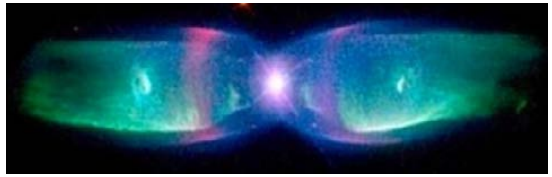


Star-Collision (-Impact) :

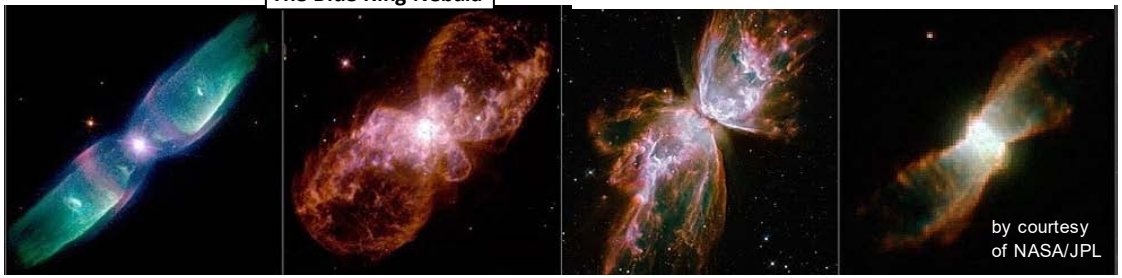
This image sequence shows what happens when two stars collide.
It shows a section view of the collision event along the resulting collision vector (long nebula axis)
It is an estimated event !
But I am sure a computer simulation will show a similar result ! I have considered two stars with slightly differerent size.
The smaller star is marked in yellow color. The result of the collision is a bi-polar nebula and a fused star as shown below !



The resulting nebula looks like two rocket-nozzles !



The images below show some bi-polar Nebulas



Introduction - Oblique Impact Craters & Impact Structures formed by several Impactors

Prepared by Harry K. Hahn

To understand what happens when an asteroid or comet impacts on a planetary body, here a few examples of oblique impact craters and impact structures formed by several impactors (→ impactors which broke apart) :

Here we don't consider the case where the impact angle is 90° and a simple circular impact crater is formed.

The following images show what happens if an impactor (asteroid of comet) impacts on the surface of a planet or moon in a shallow angle, and what impact structures are formed by impactors which break apart just before impact

The following facts of such "oblique impacts" with a shallow impact angle should be kept in mind :

1.) An elliptical impact crater is formed during impact

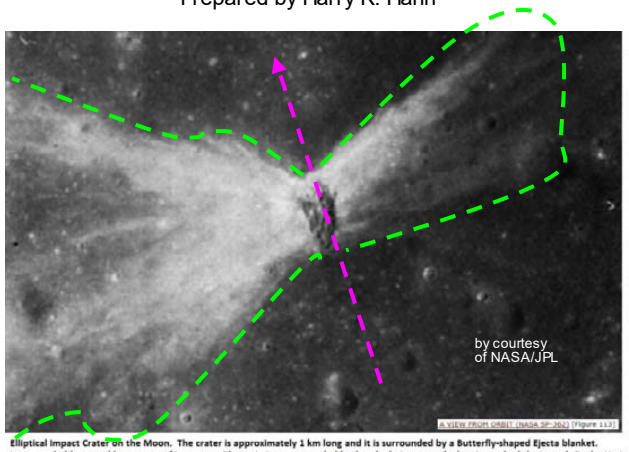
2.) Oblique impacts (2) produce a butterfly-shaped ejecta blanket with two mostly forward directed wings

3.) The ejecta blanket is formed by multiple ejecta lobes

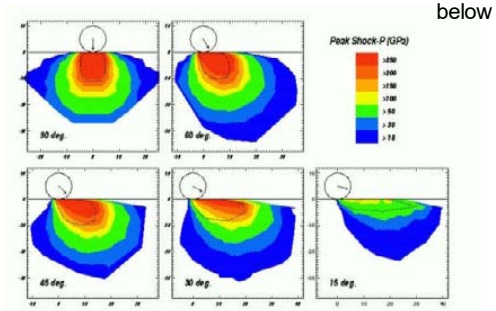
4.) The smaller the impact angle the more ejecta is thrown out without being melted → see below

5.) There is often a blow-out rim on the rear end of the crater visible. (the crater has a flat end)

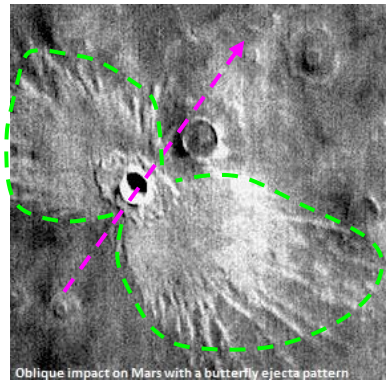
6.) At multiple impact craters "ejecta strings" along the borders between the separate shock fronts are caused (accumulation of ejecta along lines)



Elliptical Impact Crater on the Moon. The crater is approximately 1 km long and it is surrounded by a Butterfly-shaped Ejecta blanket. It was probably caused by a group of impactors. The main impactor probably already desintegrated when it reached the moon's Roche Limit

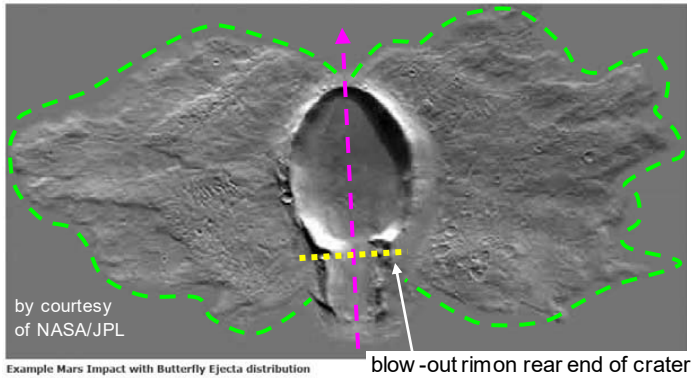


In the range of shock pressures at which most materials of geologic interest melt or begin to vaporize, we find that the volume of impact melt decreases by at most 20% for impacts from 90° down to 45°. Below 45°, however, the amount of melt in the target decreases rapidly with impact angle. Compared to the vertical case, the reduction in volume of melt is about 50% for impacts at 30° and more than 90% for a 15° impact. These estimates do not include possible melting due to shear heating, which can contribute to the amount of melt production especially in very oblique impacts.



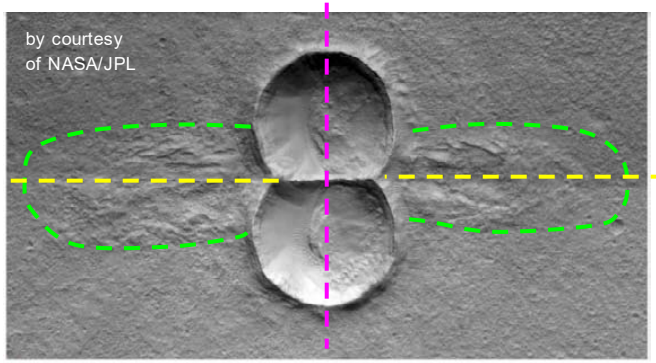
Oblique impact on Mars with a butterfly ejecta pattern

Imaging of the surface areas of our solar system's terrestrial planets and moons has show that approximately 5% of all craters are created during low angle of incidence [oblique] impacts. These events create a set of recognizable characteristics: oval shape, butterfly ejecta pattern, "no-fly" ejecta area up field, and "blow-out" rim down field. These are sometime seen in a "train" of craters, where the impactor had been fragmented to a stream of individual components due to atmospheric disruption or Roche tidal disruption prior impact

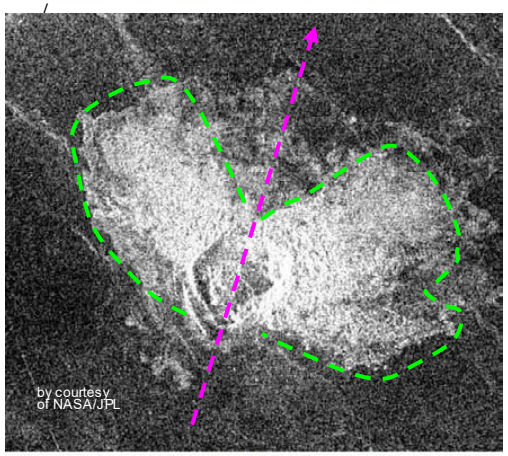


Example Mars Impact with Butterfly Ejecta distribution
Credit: NASA / JPL / ASU / mosaic by Emily Lakdawalla

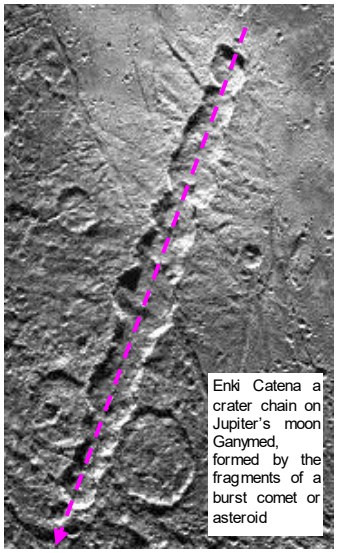
Owing to the atmospheric drag, a string of fragmented impactors would differentiate during decent, with the larger bodies tending to travel further than smaller ones.
We call special attention to the work of Schultz and Stickle (Lost Impacts), which explains how shallow angle of incidence (oblique) impacts generate "impact" structures that are significantly different from the classic, better understood, crater planforms. We proposed the Saginaw impacts to have been at an angle of less than 5 degrees - nearly tangential. The craters generated would manifest



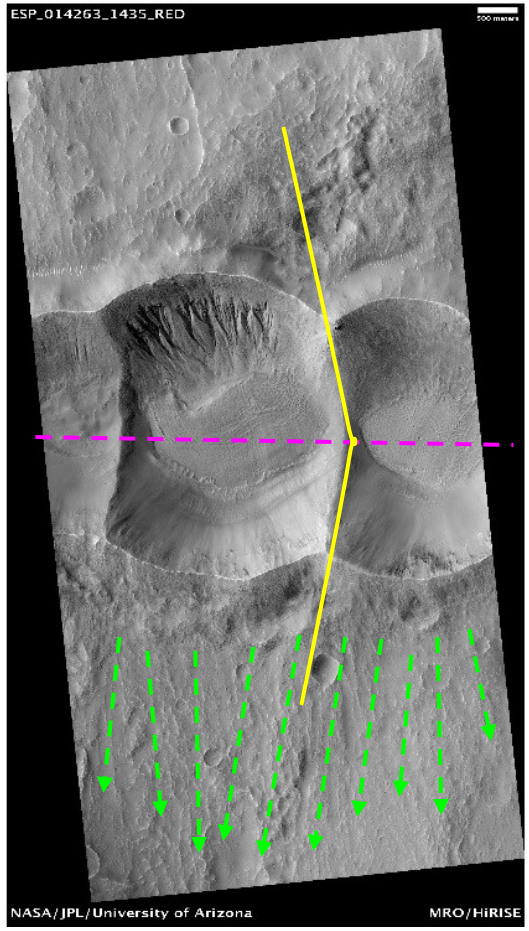
22. On to Mars next - this image shows a remarkable double crater with a shared rim and North-South trending ejecta deposits. These two craters must have formed simultaneously. Image acquired in February, 2011 by NASA's High Resolution Imaging Science Experiment (HiRISE), a camera on board the Mars Reconnaissance Orbiter (MRO). (NASA/JPL/University of Arizona)



A 50 km wide radar image showing an 8 km diameter impact crater on Venus. The asymmetric distribution of the bright ejecta indicates that this crater was formed by an oblique impact, by a approx. 200 m object arriving from the south at a speed of maybe 20 km/s.

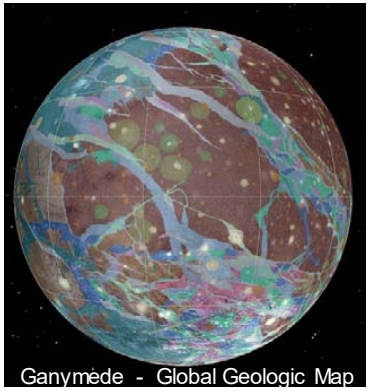


Enki Catena a crater chain on Jupiter's moon Ganymed, formed by the fragments of a burst comet or asteroid



Introduction : The cause of global Expansion Tectonics : A global impact event and a mantle that contains volatiles, in particular water/-ice

High concentrations of volatiles in the mantle of certain planets & moons may be the driving force for their rapid expansion , after a global impact event has caused extensive fractures in their crust. → The global impact event and the fractures in the crust are the trigger, which initiate the expansion of the planet or moon through abrupt decompression of the mantle. Then the volatiles in their mantle e.g. **CO_2, H_2, SO_2, H_2S… → but especially H_2O (ice)** cause the rapid expansion of the mantle, and the formation of ice-crusts, oceans & atmospheres on the surface. → as seen on Earth, Mars, Ganymede, Enceladus & Pluto etc. (see this study !). The **H_2O** may be present in different shells of high-pressure-Ice (e.g. Ice-X & -XI) or present as water in the mantle, and it may go through a phase-transition, e.g. towards an Ice-type with a lower density, after the impact event !


Ganymede - Global Geologic Map

Jupiter's moon Ganymede is definitely one of the most obvious examples of global expansion tectonics. **It is easy noticeable that the (old) brown colored areas represent fragments of a sphere which drifted away from each other !** The fragments of these shattered (older & smaller) sphere seem to get pulled apart from each other by an expanding sphere (→ the expanding mantle) underneath. The cause of the fractures in the old (brown-colored) crust and the trigger of the expansion tectonics was a global impact event ! (see page 20 in this study !) And the substance which is driving the obvious expansion of the moon must be **H_2O** ! Because the mantle of Ganymede mostly consists of Water & Ice in the state of different high pressure Ice-types (**I – XI?**) ! (see diagram & P.20) The expansion only slightly increases the moon's moment of inertia

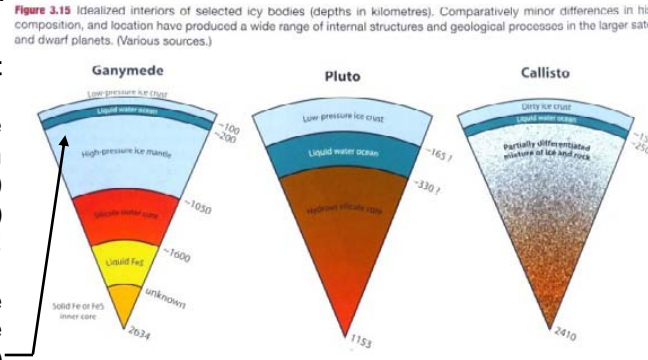


Figure 3.15 Idealized interiors of selected icy bodies (depths in kilometres). Comparatively minor differences in history, composition, and location have produced a wide range of internal structures and geological processes in the larger satellites and dwarf planets. (Various sources.)

Inner structure of Ganymede, Pluto & Callisto

Table 2.5 : Average Chemical Composition in % of Continental and Oceanic Crust

	Continental Crust				Oceanic Crust
	Upper	Middle	Lower	Total	
SiO_2	66.3	63.5	53.4	60.6	50.5
TiO_2	0.64	0.69	0.82	0.72	1.6
Al_2O_3	15.4	15.0	16.9	15.9	15.3
FeOT	5.04	6.02	8.57	6.71	10.4
MgO	2.48	3.59	7.24	4.66	7.58
MnO	0.10	0.10	0.10	0.10	0.19
CaO	3.59	5.25	9.59	6.41	11.3
Na_2O	3.27	3.39	2.65	3.07	2.68
K_2O	2.80	2.30	0.61	1.81	0.11
P_2O_5	0.15	0.15	0.10	0.13	0.2

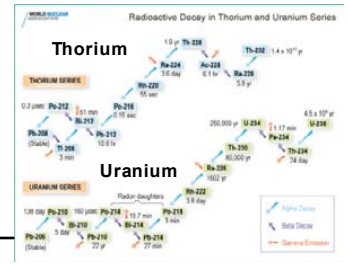
Composition of Earth's mantle in weight percent

Element	Amount	Compound	Amount
O	44.8		
Mg	22.8	SiO_2	46
Si	21.5	MgO	37.8
Fe	5.8	FeO	7.5
Ca	2.3	Al_2O_3	4.2
Al	2.2	CaO	3.2

Important indicators which support the Expansion Tectonics Hypothesis (→ see description below) :

1) Earth's mantle contains **0,5 – 2 wt% H_2O** . But because the mass of water (**H_2O**) in the mantle is poorly constraint, the real value could be much higher !
2) A comparison of Earth's mantle with the mantle of other planetary bodies with high concentrations of H_2O on their surfaces (see diagram), indicates that the **wt% of H_2O** in Earth's mantle maybe considerably under-estimated !
3) Different analyses indicate that Earth's radius is expanding with 4 to 15 mm/y This means Earths diameter increased by **2000-7500 km** in the last **250 Ma !**
4) The 12 km "Kola super-deep Borehole" showed that at depths >7 km the **rock is extremely fractured** and **saturated with H_2O & Hydrogen** from deeper sources !
5) The **H_2O** in Earth's mantle may be super-critical & behave like a gas (Study1, http://)
6) **Helium-3** and **Tritium** detected on Mauna Loa / Hawaii indicate the production of Hydrogen-3 (**Tritium**) by ternary fission in Earths core. **See :** https://books.google

Other interesting information: Study1, Study2, Study3, Study4, Study5, Study6 Study8, Study9



The number of atoms increases during radioactive decay !!

Hypothesis : → **A scenario for the expansion of a mantle, which is causing Global Expansion Tectonics :**

1.) First we consider a crust of a planet or moon which is stable (→ undamaged by big impacts) for a long time period (> 200 Ma). Underneath this stable crust, which is acting like the wall of a pressure vessel, volatiles accumulate within the mantle material over a long time. These volatiles may be produced by different processes inside the mantle. At the beginning the mantle material of the planet or moon contains these volatile components in a dissolved state. However pressure and temperature in the mantle increase over time, because more and more volatiles accumulate within the mantle material, and because radioactive decay is constantly adding heat. The solubilities of the volatiles depend on pressure, temperature and the composition of the mantle material. When solubility decreases below volatile concentration, the volatiles will start to exsolve and start to expand the mantle-material

2.) At this point the mantle material is super-saturated with these volatiles. And with further increasing pressure within the mantle material, finally the point will be reached where the pressure in the mantle exceeds the pressure caused by the lithostatic load (weight) of the crust. This is the point when tensile stress will start to build up inside the crust material of the planet or moon, which allows the pressure within the mantle to increase even further ! (→ like in a pressure vessel). This build-up of stress in the crust can go so far, that the crust is close to fracturing through tensile stress ! In this state the crust will be very vulnerable to impact events !! The extremely fractured rock found at depths >7 km maybe proof of this !! (Note that Earth's mantle contains at least 0,5 - 2 % H_2O !)

3.) If one or more large impactors are hitting the crust of the planet or moon in this state, the fracturing of the crust will be particularly extensive because it was already close to fracturing through increased tensile stress. And as soon as the crust is fractured by the impact(s) the mantle material will start to expand rapidly. Because volatile solubility in the mantle material (magma) decreases through the rapid pressure drop in the mantle, caused by the fracturing of the crust, more and more gas will exsolve !! And the mantle expands faster and faster because of the expanding mantle material. Heat from the impact event is contributing to this process !

4.) A self-accelerating process is initiated which only stops when a new equilibrium is reached between the decreased pressure in the mantle and the pressure produced by the new (thinner) overlying crust, which is caused mainly by gravity and not by the constraint of a closed spherical shell (a pressure vessel wall) anymore. Because of the expansion the mantle-density dropped considerably

Expansion Tectonic Earth models :

From James Maxlow & other geologists and geo-physicists which support this Theory :

Web-Links : L1, L2+L3, L4, L5, L6, L7+L8, L9, L10

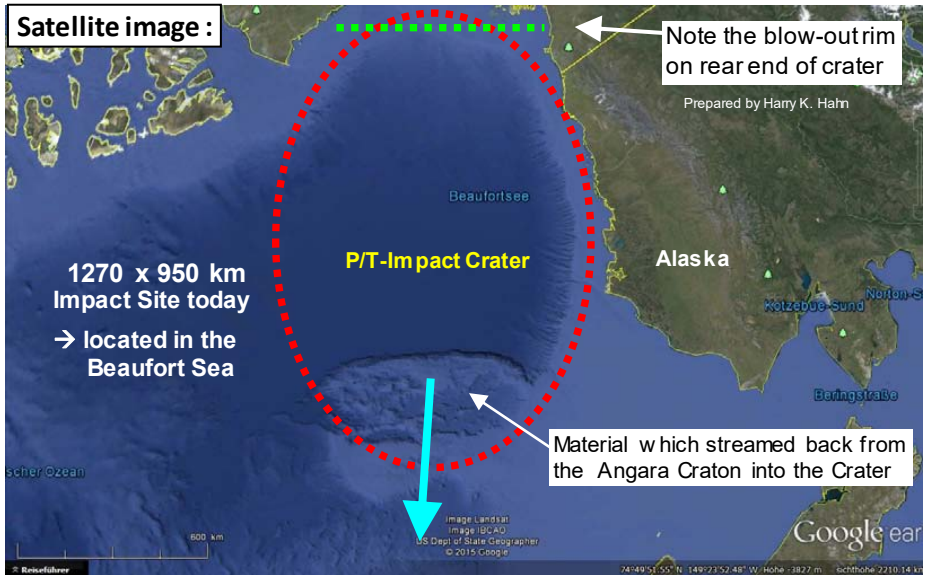
Present-day major heat-producing isotopes

Isotope	Heat release [W/kg isotope]	Half-life [years]	Mean mantle concentration [kg isotope/kg mantle]	Heat release [W/kg mantle]
^{238}U	9.46×10^{-5}	4.47×10^{9}	30.8×10^{-9}	2.91×10^{-13}
^{235}U	5.69×10^{-4}	7.04×10^{8}	0.22×10^{-9}	1.25×10^{-13}
^{232}Th	2.64×10^{-5}	1.40×10^{10}	124×10^{-9}	3.27×10^{-12}
^{40}K	2.92×10^{-5}	1.25×10^{9}	36.9×10^{-9}	1.08×10^{-12}

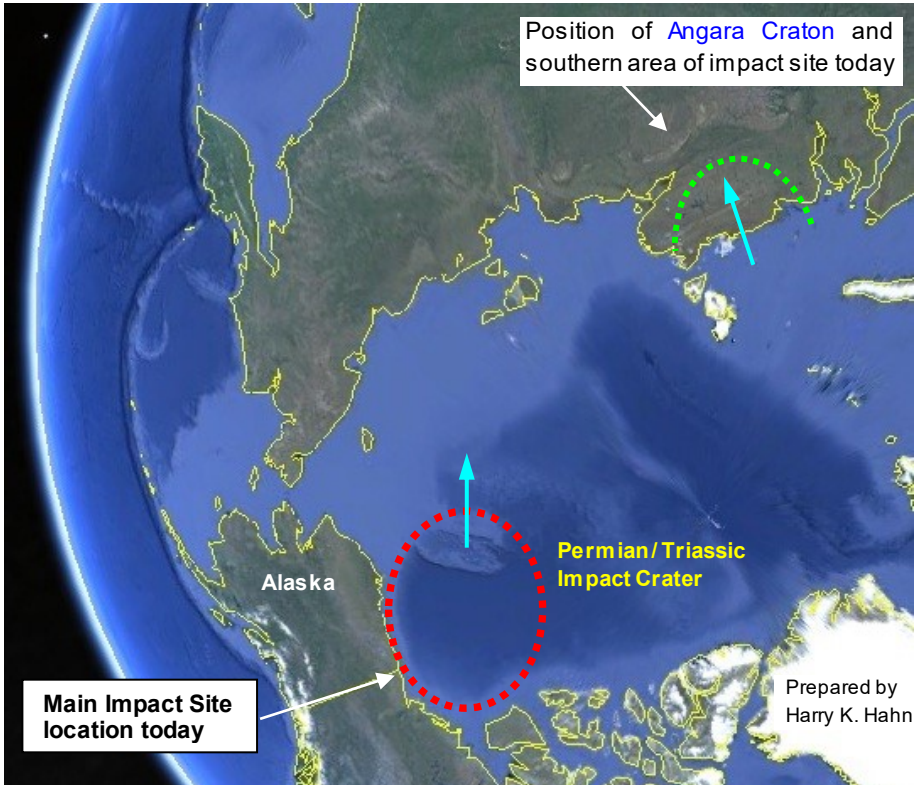
The Permian-Triassic Impact Event : A Comet or Asteroid collided with Earth and caused a 1270 x 950 km elliptical Crater

The asteroid or comet had a diameter in the range of ≥ 60 to 200 km, and it caused the most severe impact event and mass extinction known in Earth history 253 Ma ago. This event caused the Permian-Triassic boundary [1], associated with the most extensive mass extinction of marine species and terrestrial vertebrates and plants. And it caused the largest eruption of "continental" flood lavas, the Siberian Traps.

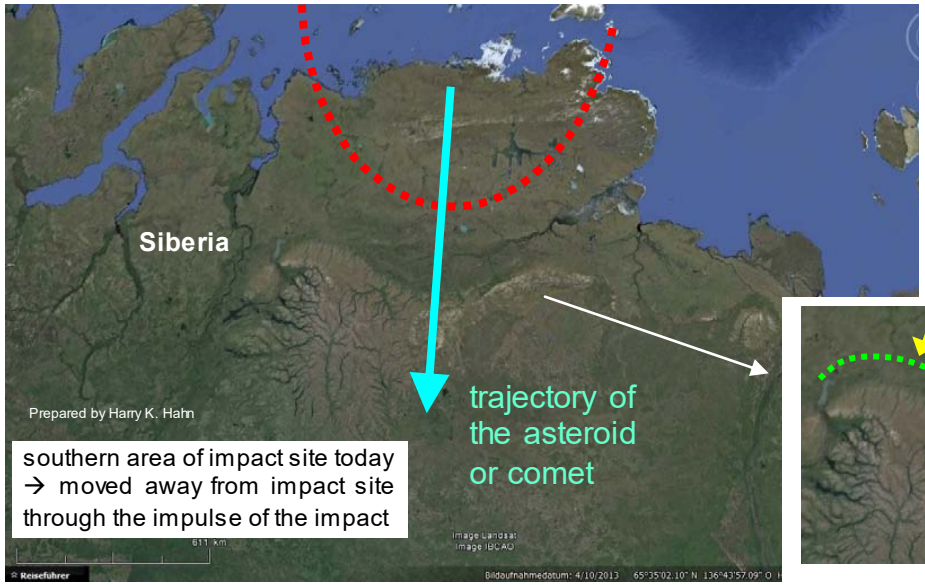
The following images and explanations describe the impact event and its effects on our planet Earth during the ~ 253 million years from this event. As everyone can imagine, this powerful impact event completely reshaped our Earth's appearance !



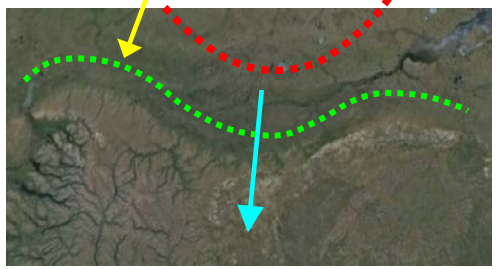
The two images on the left show the remains of the impact site as it appears today.
The main impact site is located in the Beaufort Sea close to the coast of Alaska. Another part of the impact crater which moved away from the impact site through the impulse of the impacting asteroid is located in Siberia
By moving the two locations together the impact scene becomes evident.



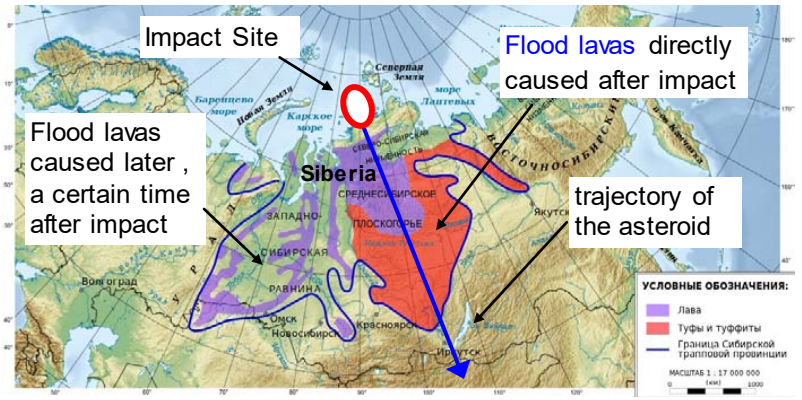
→ Here 3 informative **movies about the P/T-Event** : PT_Movie 1 ; PT_Movie 2 ; PT_Movie 3



Note the bow-shape of the northern edge of the flood-lava formation
→ similar to bow-waves produced by ships !



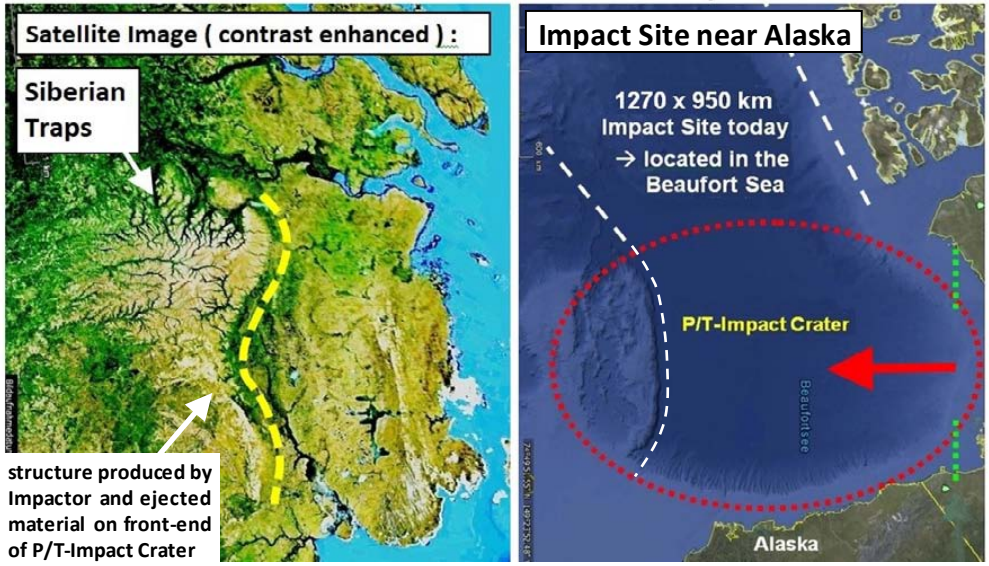
The flood lavas caused by the impact : The Siberian Traps



To the crater formation of the Ø 1270 x 950 km Permian-Triassic (PT) - Impact Crater

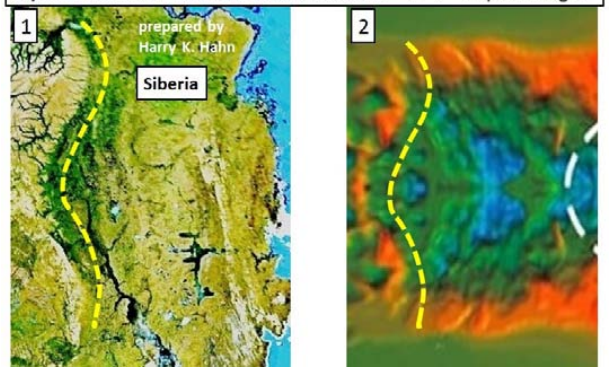
There is close correlation between the topography of the real P/T-impact crater and the topography of a simulated elliptical impact crater with similar properties (ellipticity, impact angle, impact velocity, target surface etc.). **The PT- impactor probably had an impact velocity of around 8 km/sec. And the impact angle probably was in the range of around 5 to 7 degrees.**
Therefore the PT-impact was a "**low-velocity impact**" of a large asteroid or comet in the diameter range of 60 to 200 km, at a very shallow angle. During impact the lower part of the impactor was decelerated by shearing along the surface, while the fragmented upper part of the impactor continued its motion nearly unaffected. The fragmented upper part of the impactor, together with a very large volume of partly molten excavated rock material was ejected in a very large butterfly-shaped ejecta blanket. This ejecta blanket which included many large secondary impactors (→ fragments of the P/T-impactor + ejecta), produced a number of secondary crater chains with crater diameters of 100-250 km, and a number of very large secondary craters with diameters of >300 km (e.g. Bengal Bay Crater, Cape York Crater, Pantanal Crater, etc.). There is strong indication that these impact crater chains are responsible for the major fractures in Earth's crust, which led to the break-up of Pangea. (→ e.g. the **crater chains R1 to R4 → see Part 2 of Study**)

The real structure of the Permian Triassic Impact crater area



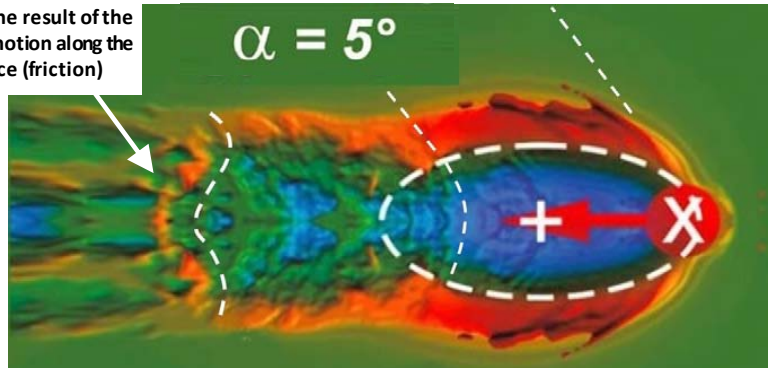
structure produced by Impactor and ejected material on front-end of P/T-Impact Crater

Compare → impact structures on front-end of crater :
1.) Reality : Satellite image **Siberia** (contrast enhanced)
2.) Simulation : front-end structure at ~ 5 - 7° impact angle



The secondary structures at the front-end of the crater are the result of the projectile motion along the target surface (friction)

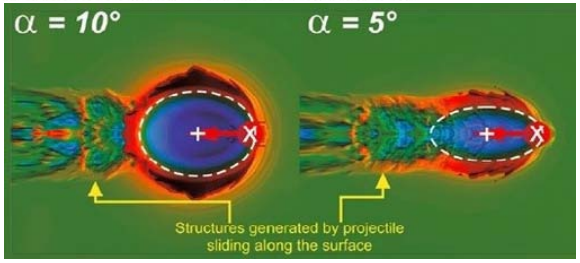
Simulated Impact Structure of a 5° oblique Impact :



Early reflections of shock and rarefaction waves in the projectile prevent plastic deformation in the upper part of the body. The strong pressure gradient in the projectile suggests fragmentation of the projectile would likely occur.

In this case, the lower part of the projectile is decelerated by shearing along the surface while the upper part continues its motion nearly unaffected.

Figure 2. Influence of the impact angle on crater shape. Impact of a 5 km sized projectile at 8 km/s and low impact angles α (friction coefficient $f = 0.3$; no cohesion). The dashed white line marks the inner boundary of the crater cavity just before the onset of crater modification (measured at the preimpact surface). The cross (X) indicates the contact point of the projectile with the target, the "+" marks the geometric center of the crater. The secondary structures close to the left crater rim are the result of the projectile motion along the target surface (friction) and indicate a very oblique impact angle. The color contours denote the elevation where green represents the initial level of the target, blue represents topography below, and red above the target level.



The transition from circular to elliptical impact craters

Dirk Elbeshausen,[1] Kai Wünnemann,[1] and Gareth S. Collins[2]

2. Model Setup

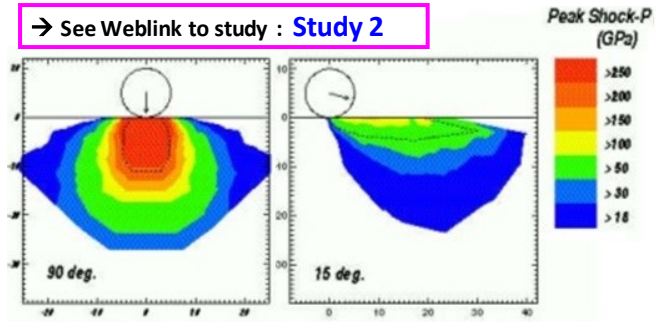
→ Weblink to Study : Study 1

[5] To investigate crater formation for shallow-angle impacts, we have carried out a series of 3-D simulations with the hydrocode iSALE-3D [*Elbeshausen and Wünnemann*, 2011; *Elbeshausen et al.*, 2009]. This code uses finite difference and finite volume techniques on a Cartesian staggered mesh. It follows an Implicit Continuous-fluid Eulerian and Arbitrary Lagrangian-Eulerian (ICE'd ALE) approach, as described in *Harlow and Amsden* [1971] and *Hirt et al.* [1974], to solve the Navier-Stokes equations in a compressible manner. Hence, the kinematic description of motion can be either Lagrangian (where the mesh deforms according to the nodal velocities) or Eulerian (where mesh is fixed in space) or a mixture of both. Due to large deformations and shearing of matter that occur in particular during oblique impacts, the Eulerian approach is more appropriate for the given study [e.g., *Collins et al.*, 2013]. The Eulerian kinematic description requires the reconstruction of interfaces between matter and the free surface (or different types of materials which was not considered in this study as target and projectile were assumed to consist of the same material) to enable a precise calculation of material flows. For the interface reconstruction, it is beneficial to use an adaptive approach coupled with a volume-of-fluid technique [*Benson*, 2002; *Hirt and Nichols*, 1981; *Gueyffier et al.*, 1999] as described in *Elbeshausen and Wünnemann* [2011]. The code has been successfully validated against laboratory experiments and benchmarked against other numerical impact models [e.g., *Davison et al.*, 2011; *Pierazzo et al.*, 2008].

[6] In all simulations, we assume terrestrial gravity conditions ($g = 9.81$ m/s^2) and resolve the projectile by 16–24 cells per projectile radius. We varied the impact angle α in a range between 90° (vertical impact) and 5°. The primary focus of this study was on low impact angles ($\alpha < 30°$), since we expected the transition from circular to elliptical craters in this range. We used impact velocities of $U = 8$ km/s, 12 km/s,

The diagrams below show that the maximum shock pressure is drastically reduced in an oblique impact at 15° impact angle compared to the vertical impact case. The reduction in volume of melt is ≥ 90% for a 15° impact ! (This estimate does not include possible melting due to shear heating).
That means the PT-Impact has ejected large volumes of unmelted rock !

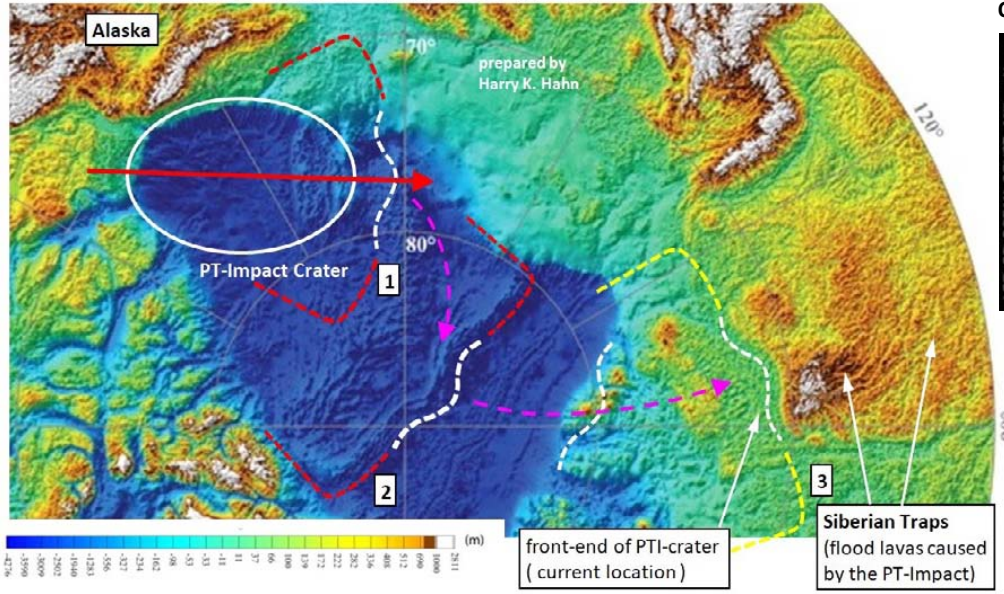
→ See Weblink to study : Study 2



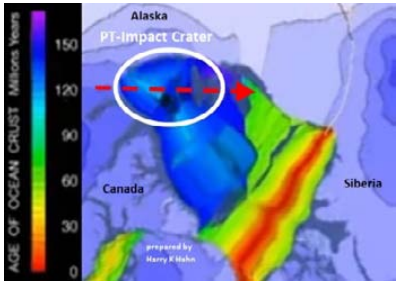
Large-scale structures caused by the PT – Impact , visible on different Maps

Polar-Projection of PT-Impact Area – Topographic Map

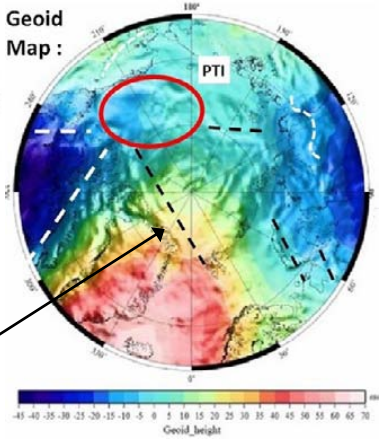
→ the motion of the front-end of the PTI-crater over time is indicated



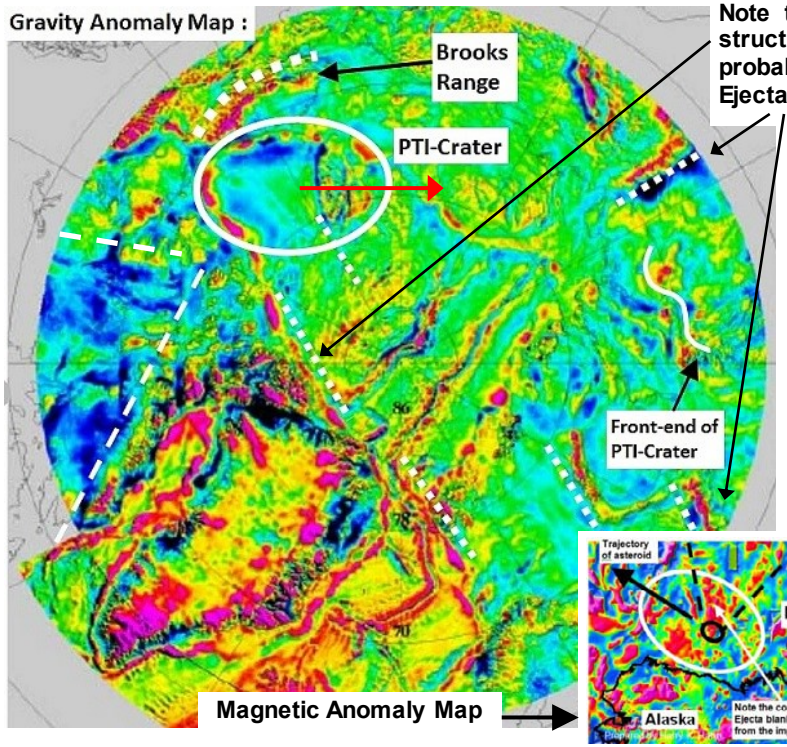
Ocean-Floor Age Map of PT-Impact Area



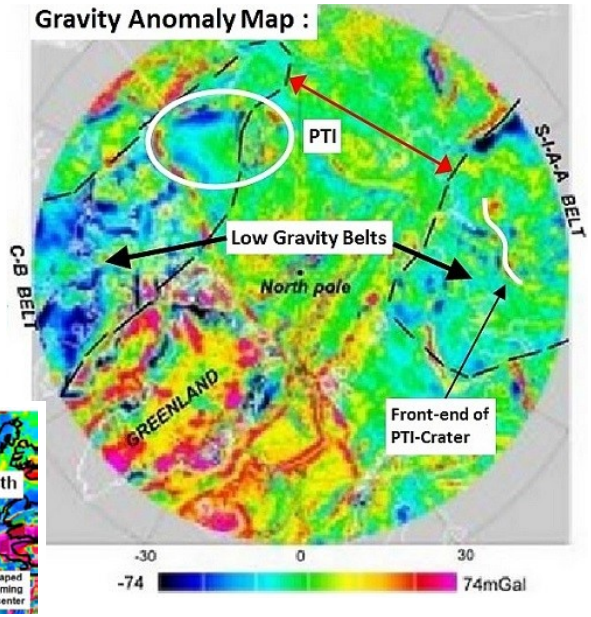
Geoid Map :



Gravity Anomaly- and Geoid Maps also indicate the PT- Impact



Note the indicated linear structures on the maps, probably caused by large Ejecta-rays & -blankets



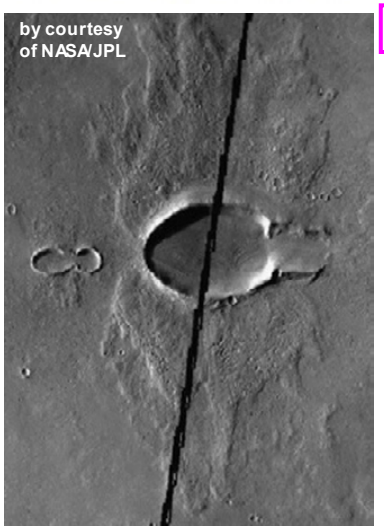
There is an interesting example of an elliptical Crater on Mars with the dimensions of 10 x 7.5 km, which in all probability was caused by a small Mars-orbiting moonlet whose orbit tidally decayed, because it came to close to the marsian atmosphere. It probably impacted in a very shallow angle ≤ 5° (see trajectory-**d** at the image below) with a relative slow velocity of less than 5 km/s .

The impactor which caused the P/T-Impact Crater on Earth probably also was a small moonlet, which was caught be Earth's gravity and was orbiting around Earth, before its orbit tidally decayed in Earth's atmosphere, and it finally **impacted at a shallow angle of ≤ 8° with an impact velocity of probably less than 8 km/s**. This would explain the elliptical Crater, the visible ejecta-ray structures the Siberian Traps and the triggered Expansion Tectonics.

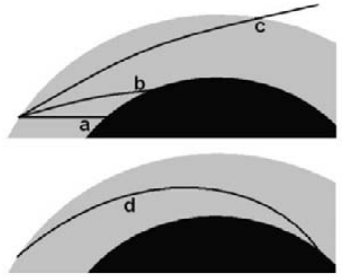
On the origin of a double, oblique impact on Mars

J.E. Chappelow [a,b,*], R.R. Herrick [b]

A double, oblique impact feature north of Olympus Mons provides a unique opportunity to investigate the event that formed it. The sizes of the craters, their ellipticity, shapes of ejecta blankets, separation from each other, and positions relative to each other, all give us information about the event. Coupling this information with an existing model of meteoritic flight through an atmosphere allows us to test several possible scenarios for the event (object type and origin, pre-entry trajectory, atmospheric trajectory, prevailing atmospheric density). We find it highly improbable that the impactor was simply an extra-martian asteroid or comet. We also find that it is unlikely to have been a double-asteroid or a tidally fractured one, but is more likely to have been a Mars-orbiting moonlet whose orbit tidally decayed, and that denser atmospheric conditions than today's may have prevailed when it impacted.



→ Study : Weblink1, Weblink2



The trajectory (**d**) of the asteroid that caused the elliptical impact on Mars and the trajectory of the impactor that caused the PT-Impact were similar !

Fig. 1. A large (7.5 × 10.0 km) elliptical crater with a smaller elliptical crater (2.0 × 3.0 km) lying 12.5 km directly uprange (to the left). 'Butterfly'-pattern ejecta occur around both craters. (Mosaic of THEMIS daytime IR images.) North is up.

Fig. 2. Atmospheric flight trajectories for asteroids (top) and a moonlet (bottom) in the martian atmosphere, as discussed in the text. Both are radially exaggerated.

To the evolution of the PT – Impact Event, and the effects of the impact on Earth's crust

The PT_3-Impact was an oblique impact. This means the impactor, a large asteroid or a comet, with ~ 60 to 200 km diameter, impacted on our planet in a very shallow angle. The impact angle was probably < 8°. Therefore the impact, which took place close to the north-pole, produced a large butterfly-shaped ejecta blanket, originating at the impact site and spreading over the majority of Earth's surface area. ⟶

→ The butterfly-shaped outline of the ejecta blanket (marked in red) is shown on the map in FIG. 1

The tectonic map on the left (FIG 3), a polar projection shows the present situation. The two maps on the right side show the situation directly at the time of the PT-Impact, and at ~ 150 Ma after the PT-impact.

Because of the immense size of the impactor, the ejecta blanket which resulted from the impact, covered nearly Earth's complete surface, and it produced very large secondary impacts. Most of these secondary impacts were distributed within this butterfly-shaped ejecta pattern, and many secondary impact craters formed along distinct ejecta rays (e.g. ejecta rays R1 to R4), which have their starting point at the PT-Impact Crater.

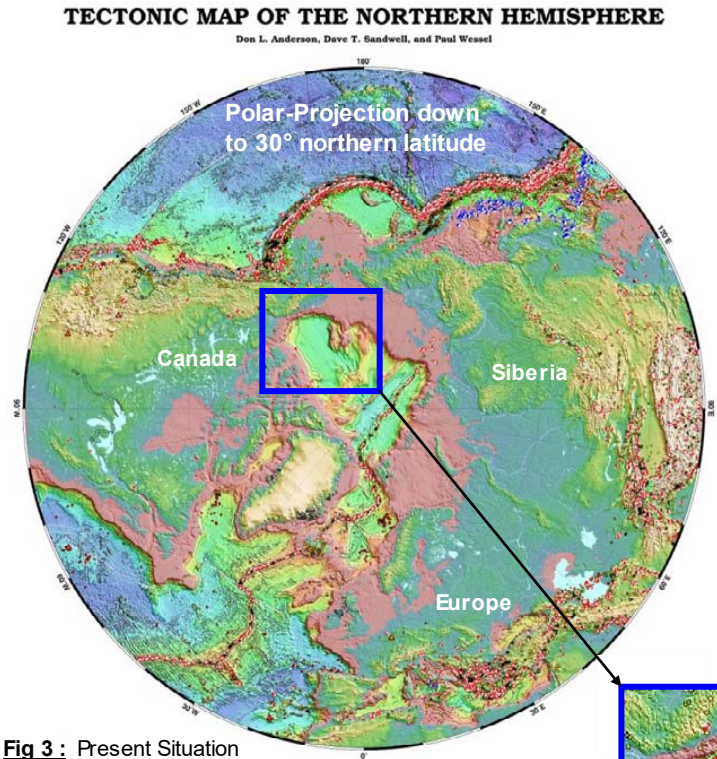
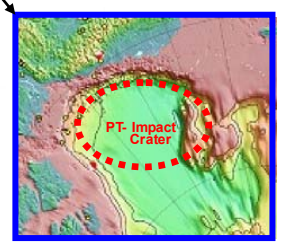
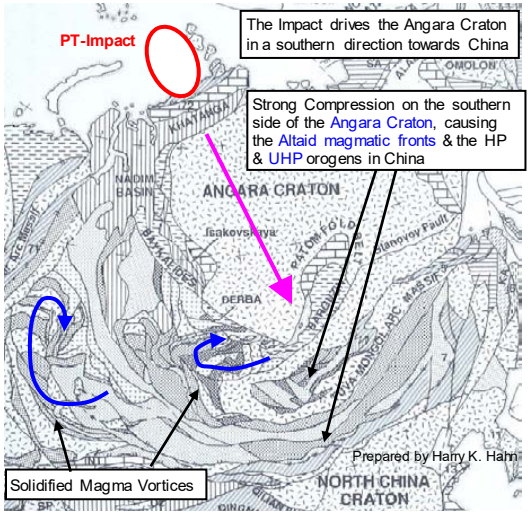


Fig 3 : Present Situation



Detail of Impact Site



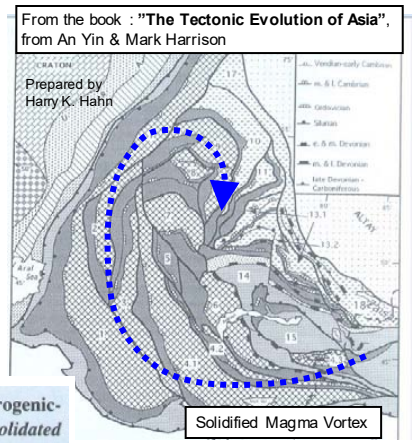


Figure 21.6. Paleotectonic map of Asia showing the primary orogenic-collage components mentioned in the text. *Precambrian consolidated*

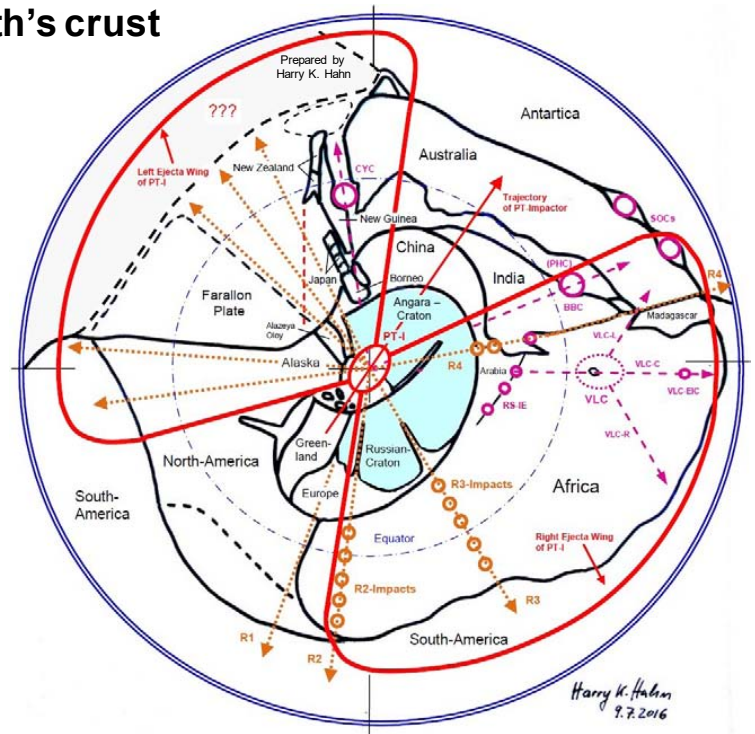


Fig 1 : Polar-Projection of Earth's complete surface area at the time of Impact centred on the PT-Impact Crater. **Earth diameter : ~6500-7500 km**

Fig 1 : A Polar-Projection centred on the PT-Impact Site (→ center point corresponds approx. to the North-Pole too). The map shows Earth's complete surface area and the positions of Earth's continents as they probably were located at the time of impact. The area which was most effected by the PT-Impact is located within the butterfly-shaped ejecta blanket (red) Most secondary impacts (marked in pink & orange) and ejecta rays are also located within this area.

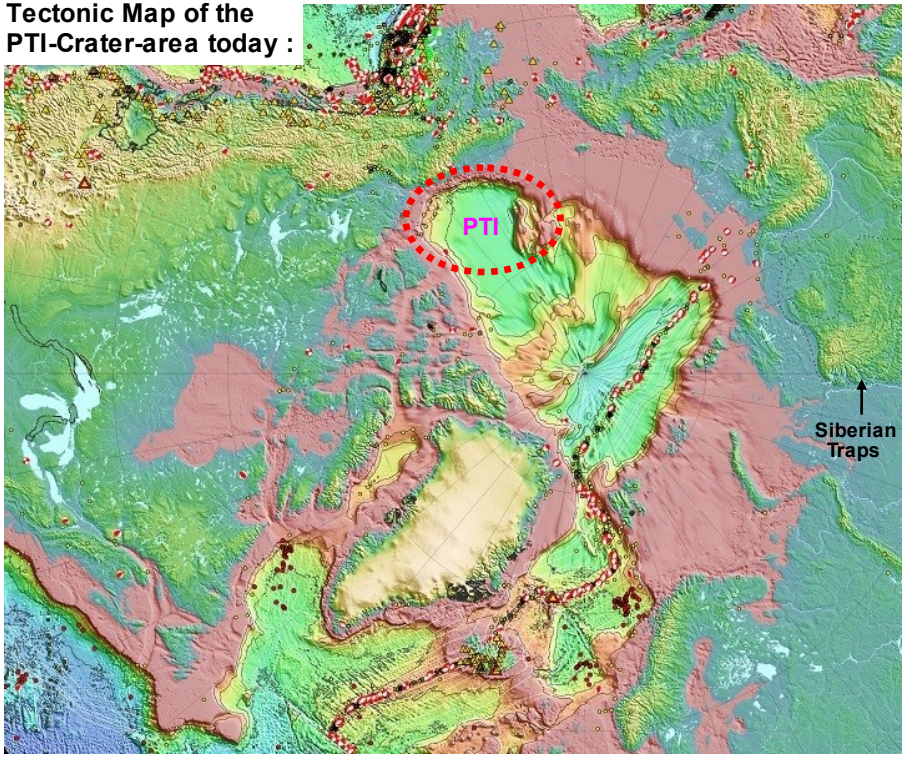
Fig 2 : Polar-Projection down to 30° N ~100 Ma ago, Ø **Earth : ~ 10000 km**

Fig 2 : A Polar-Projection of the North-Pole area down to approx. 30° northern latitude , showing the scene at a time between the PT-Impact and today. All following considerations in this study are based on a smaller Earth before the impact and on strong Expansion Tectonics after the impact, because all maps used for the analysis indicate Expansion Tectonics !!

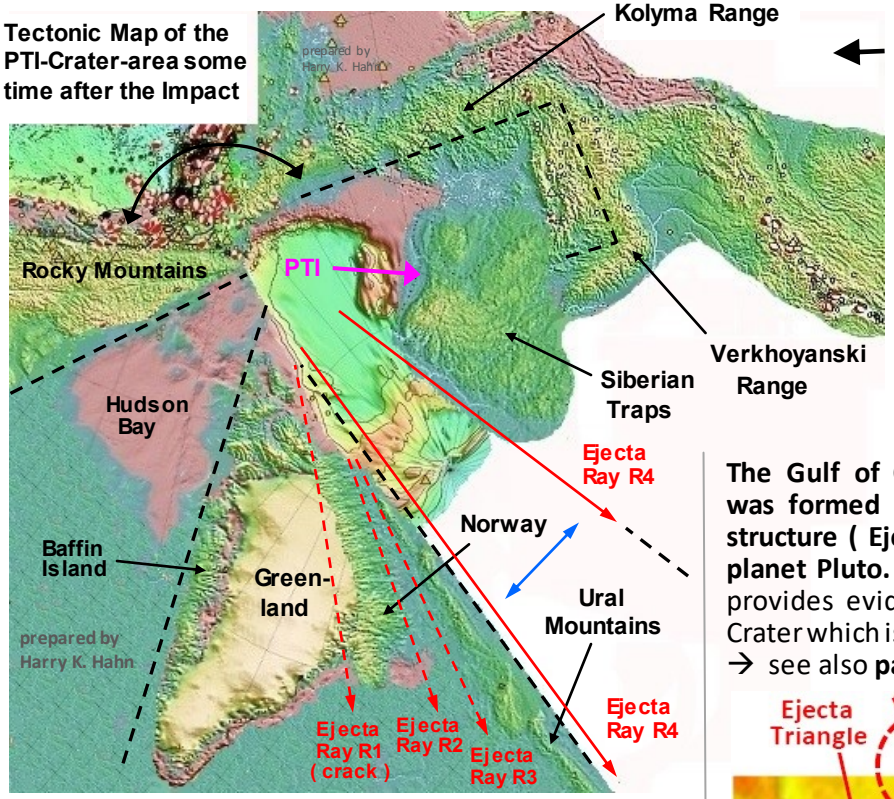
A re-constructed Tectonic Map of the Ø 1270 x 950 km Permian-Triassic Crater-area a certain time after the Impact Event

I have re-arranged some key-areas of the Tectonic- (Topographic-) Map of the PTI-Crater-area to provide a clearer picture of the deformations which the PT-Impact caused on Earth's crust. This will make it a bit easier for Tectono-physicists (Geo-physicists) to confirm and accept the existence of the PT-Crater and the Expansion Tectonis process that obviously was triggered by this Impact Event !

Tectonic Map of the PTI-Crater-area today :



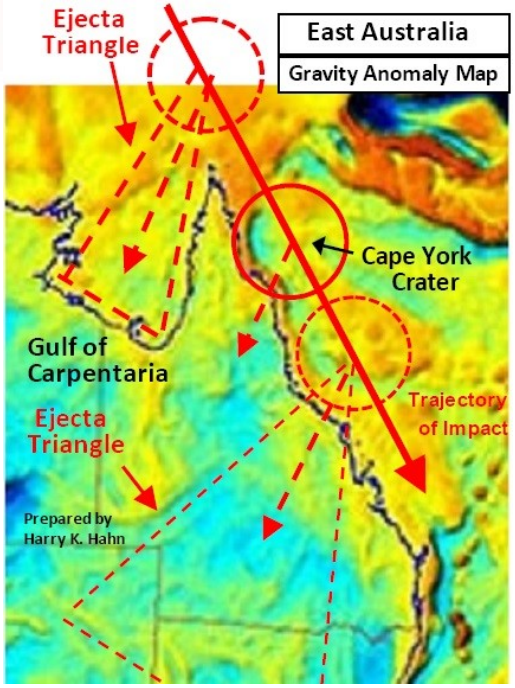
Tectonic Map of the PTI-Crater-area some time after the Impact



→ Page added on **18.1.2022**

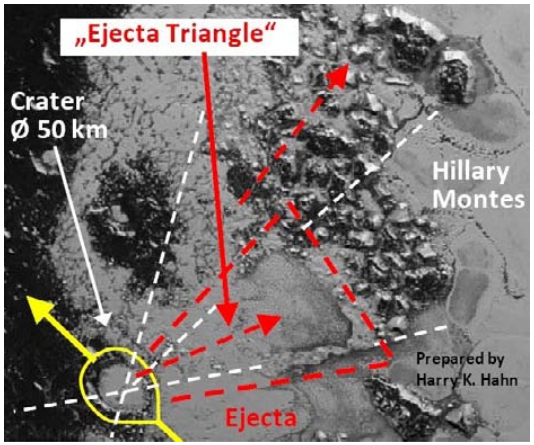
The manipulated tectonic-(topographic-) map on the left shows the PT-Impact area as it probably looked a certain time after the Impact The Hudson Bay (CA) and the Kolyma Range in Siberia were caused by ejecta-lobes of the PTI, which show the same ejecta triangle structure as an impact on planet Pluto and as two other secondary impacts caused by the PTI (see below)

The Gulf of Carpentaria in NE-Australia was formed by a similar ejecta-impact-structure (Ejecta-Triangle) as visible on planet Pluto. → This **"Ejecta Triangle"** provides evidence for another ≈ 300 km Crater which is hidden on the ocean floor. → see also **page 13** in **Part 2** (or: **Part-2**)



Other shallow Impacts which caused „"Ejecta-Triangles" :

A Ø 50 km Crater on planet Pluto caused a large „Triangular Ejecta Impact Structure"

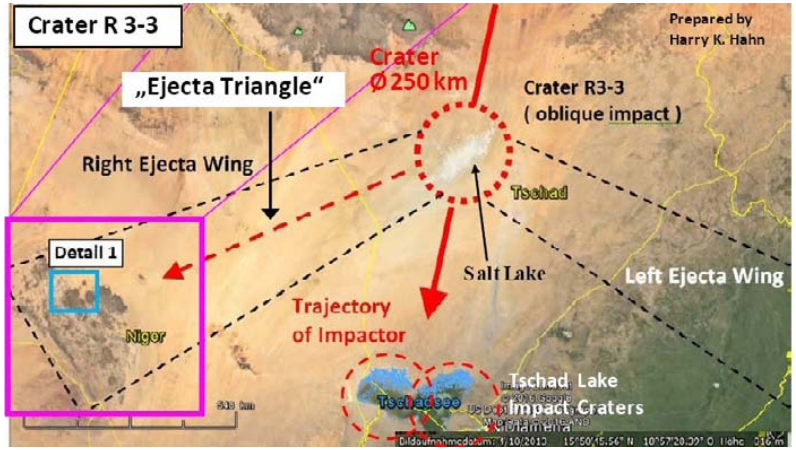


A shallow (oblique) Impact Event on **Pluto**, less than 100 million years ago, formed **Hillary Montes** at the border line of **Sputnik Planum**.

An ejecta-lobe (wing) from the impact-crater produced an Ejecta-Impact-Structure with a precise triangular shape ! (→ red lines) (→ see : Pluto Images)

A big ≈ Ø 250 km Crater in Ejecta Ray R3 shows an „Ejecta Triangle"

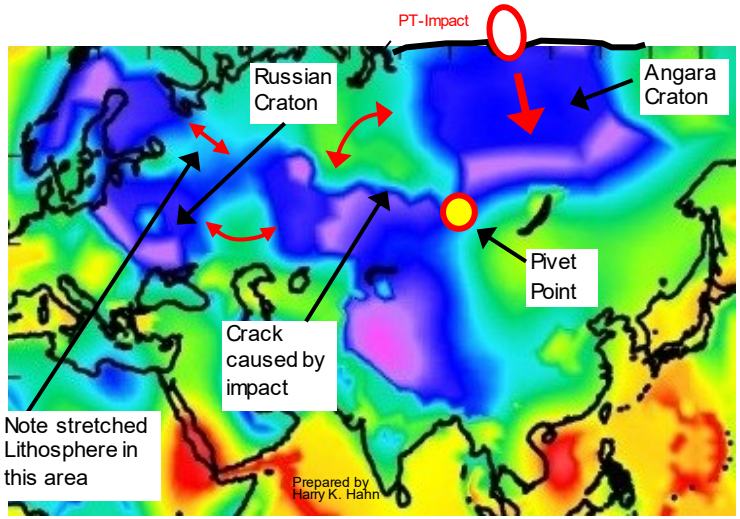
The gravity anomaly map and satellite images show a similar "Ejecta-Impact-structure" as on Pluto → in N-Australia, caused by the Crater **R3-3**



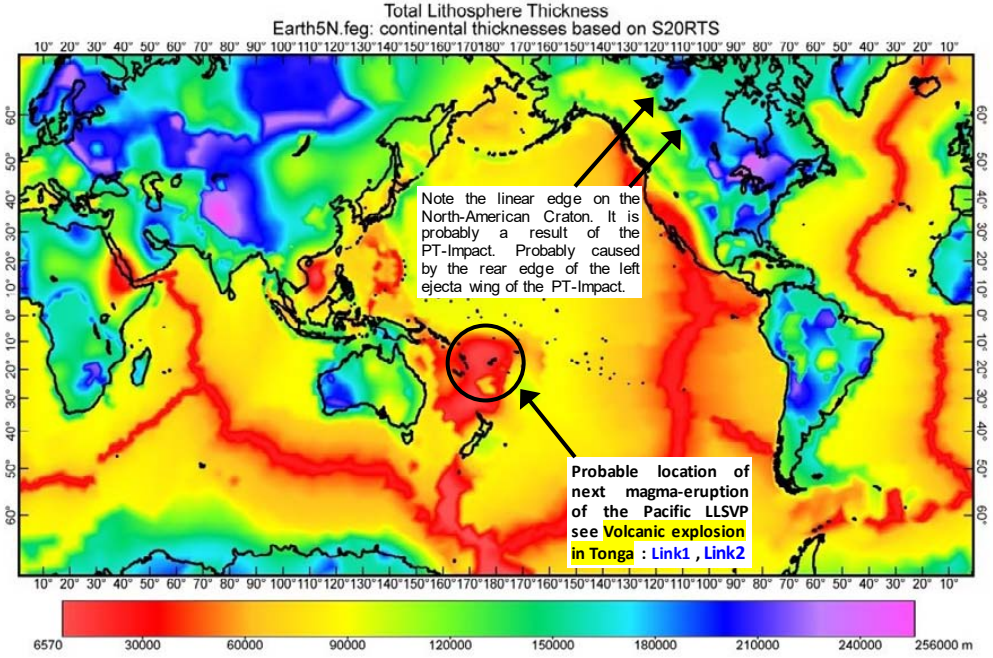
The tectonic evolution after the PT – Impact Event

Prepared by Harry K. Hahn

As already mentioned on the previous page, all the following considerations are based on a smaller Earth with ~Ø 6500-7500 km before the impact, and on strong Expansion Tectonics after the impact. Because all maps used for the analysis indicate that the PT_2-Impact triggered strong Expansion tectonics on Earth which is probably still going on today. (→There is certainly much more expansion than subduction going on today !)



Model of total lithosphere thickness. A composite of continental thicknesses scaled from vertical-S-wave upper-mantle travel-time-anomalies and an age-dependent model in the ocean basins.
See following Weblink: http://peterbird.name/publications/2008_torque_balances/012_total_lithosphere-Earth5N.jpg



An important key-map for the analysis :

On the lefthand side a composite of continental thicknesses scaled from vertical-S-wave upper-mantle travel-time-anomalies combined with an age-dependent model of ocean basins is shown.

The map shows that there was originally a complete Eurasian Craton. However this large Eurasian Craton was hit by the asteroid ~253 Ma ago and broke apart through the immense shear- & bending stress which was induced into the Craton by the Impact Impulse.

The physical description of the impact event :

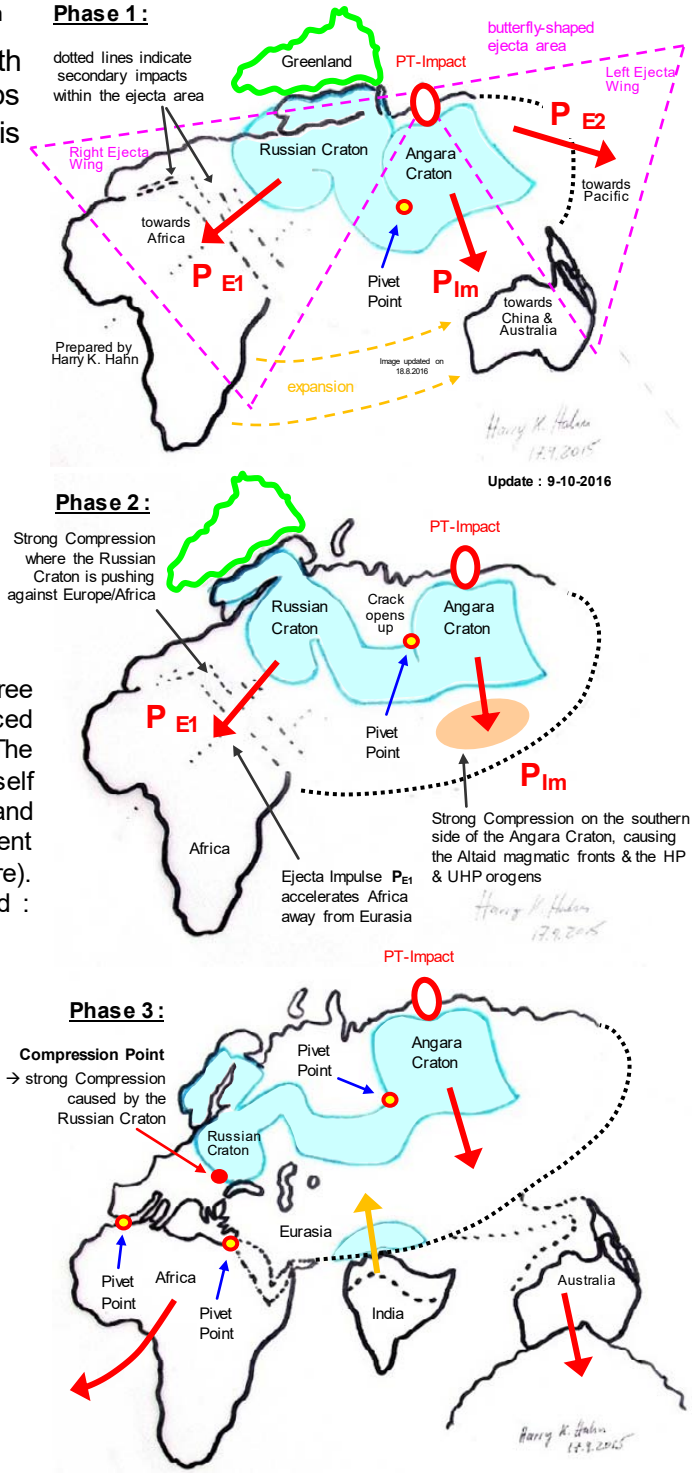
The PT_3-Impact event can roughly be divided into three phases which I will describe in the following :

Phase 1 : The impact produced three main impulses which were induced into the surrounding Lithosphere. The impulse P_{IM} from the Impactor itself and the two Ejecta-Impulses P_{E1} and P_{E2} which all accelerated different areas of Eart's crust (lithosphere). The following formula can be applied :

$$P_{Total} = P_{IM} + P_{E1} + P_{E2}$$

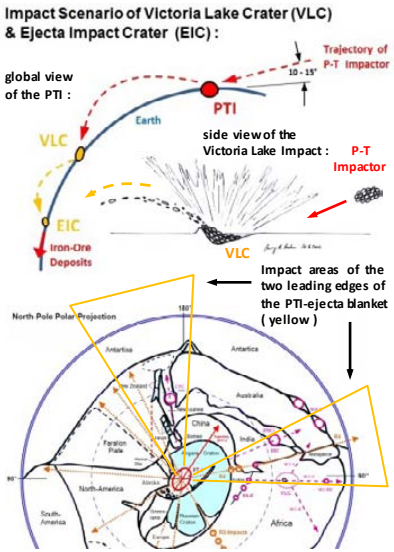
Phase 2 : The accelerated sections of Earth's Crust (e.g. the Angara & Russian Cratons, which rotated around a common pivot point) then later produced immense compression stress further away, where they collided with other thick crust areas.

Phase 3 : The further tectonics is more complex , because of complex interaction between different areas of Earth's crust. The begin of phase 3 is roughly described in the image on the right-hand side.



The Pacific - LLSVP, which is responsible for the magma eruptions, and the African - LLSVP were caused by the PT-I:

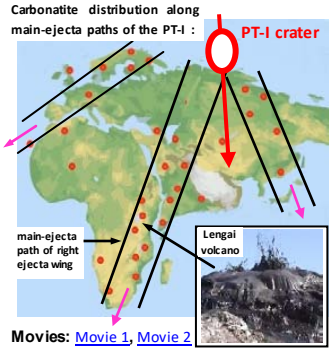
There is strong indication that the **Permian-Triassic Impact (PT-I)** and the ejecta rays which were caused by this enormous impact are responsible for the formation of the two main **LLSVPs** (Large low-shear-velocity provinces) inside Earth's mantle. These two large structures, which are characterized by slow (seismic) shear wave velocities and which consist of much hotter material (~4000°K) than the surrounding mantle material (~2000°K), extend laterally and vertically for thousands of kilometers from the core-mantle boundary. In all probability the remains of large secondary impactors and the powerful ejecta of the leading edges of the two ejecta-wings of the PT-I descended deep into Earth's Mantle and caused the **LLSVP's** as a result.



The diagram on the left shows the shallow (oblique) impact of the PT-Impactor which probably had a diameter of around **~60 to 200 km**. It also shows a side view of the **Victoria Lake Impact** (crater) (→**VLC**) which was caused by a large secondary impactor ejected from the PTI-crater. Part of the ejecta from the VLC was ejected forward in impact direction where it formed another secondary crater, the EIC. The rest (the majority) of the VLC-ejecta was again ejected in a butterfly-ejecta-pattern. Traces of "forward-ejecta", which always seems to be dense & ductile metal-bearing material, are also visible near the CYC- and PHC (BBC)-craters.

The majority of the ejecta from the PTI-crater was ejected in the form of a gigantic butterfly-shaped ejecta blanket. Where the leading edges of the two ejecta wings of this butterfly-ejecta blanket impacted on Earth's crust (in the yellow marked areas) extensive fractures (new continent borders) were formed

The north-polar-projection of Earth, shown on the left shows Earth at P/T boundary time

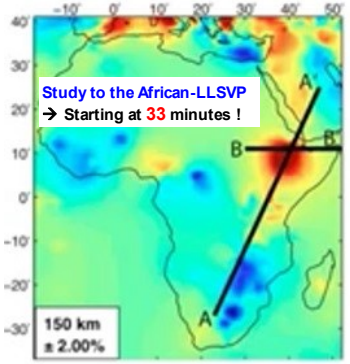


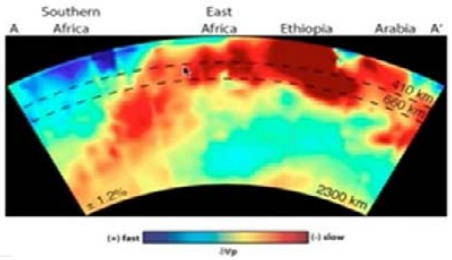
Movies: Movie 1, Movie 2

see: Study about Carbonatite Lava

A large part of the ejected material and a number of big secondary impactors impacted in these two yellow marked areas. → see also larger map in the chapter: **"Earth at the time of the PT-Impact Event"**

The world map on the left shows the distribution of **Carbonatites** in Africa & Eurasia. I have rearranged the position & orientation of Africa, Europe and India so as they were just after the PT-Impact 253 Ma ago (→original map, Le Bas 1987). **It is clearly visible that the carbonatites are mainly located along the paths where the leading edges of the ejecta wings of the PTI impacted !!** This is especially clear for the impact path of the leading edge of the right ejecta wing along the east-coast of Africa (→ ejecta ray R4 & VLC-ray). Because the Carbonatites are probably derived from Earth's lower mantle, we can conclude that the shock-wave of the PT-impact, or PTI-ejecta descenting into the mantle, brought carbonatites from the lower mantle to the surface, or the carbonatites were brought-in by the impactor itself! Lengai Volcano in Tanzania still erupts Carbonatite-Lava today! (→ from the African LLSVP!)





The two images on the bottom left side show a section view of the **African-LLSVP**. The section view A – A' runs from the Arabian Peninsula through the African Rift Valley and the Victoria Lake (VLC) area towards South-Africa. The section view runs essentially along the same path where the leading edge of the right ejecta wing of the PTI impacted.

It is clearly visible that the main structure of the African **LLSVP** is orientated along the same path as the impacting right leading edge of the PTI-ejecta.

(→ LLSVP = red, orange & yellow area in the section view A – A'). The images are from a study of Andy Nyblade which used **African-Array Data**. He claims that evidences indicate that the African LLSVP is a thermochemical whole-mantle-structure without a separation in the 410-660 km region.

The same principles applies for the **Pacific LLSVP**

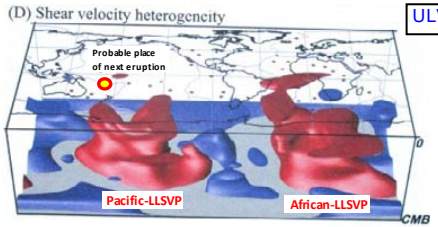
The two maps on the top right side show that especially the **ULVZ** at the **core mantle boundary (CMB)** within the Pacific LLSVP is mainly orientated along the path where the leading edge of the left ejecta wing of the PTI impacted. Because this ULVZ has a distinct chemical signature there is a high probability that the **ULVZ** is a direct result of ejecta of the PTI which descented to the CMB in this area.

Note: it seems that the Cape York Impact produced a permanent channel in the mantle which connects the Pacific-LLSVP/ULVZ with the surface. Through this channel in the mantle ≥8 violent magma eruptions occurred over the last ~200 Ma causing a number of big **LIP's** on the Pacific Plate (e.g. the **Ontong LIP**)

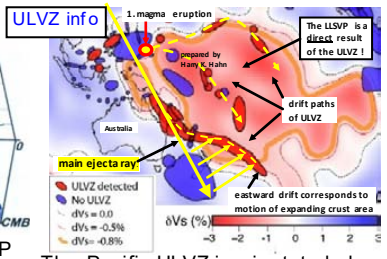
Warning: There is a high probability that another such violent magma eruption will occur !! My study indicates that the next magma eruption will take place near the **Fiji-islands** → see image on the right which shows the path of the source (outflow channel positions = yellow dots) of the magma eruptions. It seems the Pacific LLSVP is due for an eruption soon ! The solid upward pointing column at the top-end of the LLSVP, near the **Fiji's** may indicate the coming eruption (& mass extinction !). The vertical expansion rate of this column must be measured !!!

Note: All volcanos of the **Pacific Fire Ring** and all other volcanos on Earth can be explained by the Permian-Triassic Impact ! They are all located in the (fractured) crust areas which were directly caused by the ejecta of the PT-I !! The magma (molten mantle material) which causes these volcanos, in all probability is exclusively a result of the impact of ejecta & secondary impactors from the PTI !!!

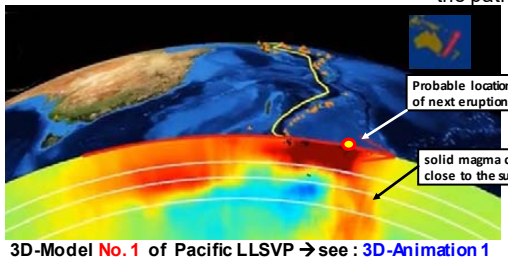
Therefore a revised model for **Earth's mantle** is required, which must consider a much higher share of volatiles, e.g. H_2O & CO_2 within the mantle material



A 3-D view of the Pacific- & African LLSVP and the probable location of the next eruption

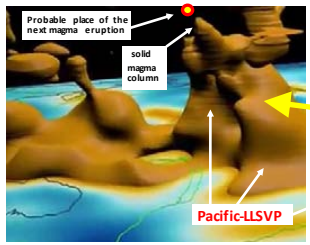


The Pacific-ULVZ is orientated along the path of a main ejecta ray of the PTI



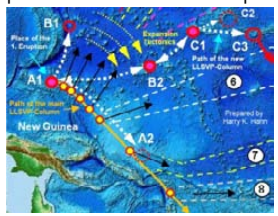
3D-Model No. 1 of Pacific LLSVP → see: 3D-Animation 1

3D-Model No. 2 of Pacific LLSVP → see: 3D-Animation 2

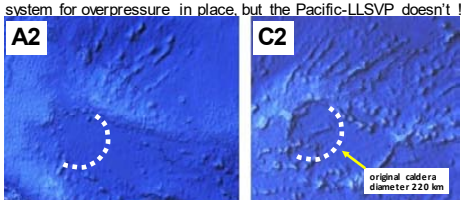


3D-view of Pacific-LLSVP with the possible location of next eruption

This 3-D Animation shows the African-LLSVP has a large vent system for overpressure in place, but the Pacific-LLSVP doesn't !



Path of the magma eruption source (→ yellow dots). A2, B1&B2, C1-C3 represent drift-off-copies & remains of the first magma-eruption-zone A1

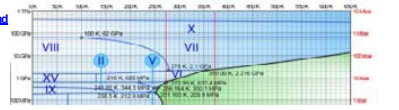


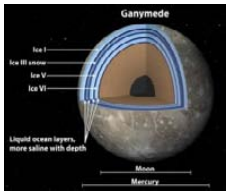
These two different ocean floor areas A2 & C2 which are thousands of km apart represent the same structure !!

These "drift-off-copies" are an image of the first magma eruption which took place on position A1 ! These nearly identical structures, from two different crust layers (?), probably show the remains of a burst shield-volcano with a base Ø ~450 km and a caldera Ø ~220 km.

An alternative model for Earth's mantle is required !! Earth's mantle in all probability contains much more volatiles, especially H_2O, than currently believed ! Similar to **Ganymede**, Earth's mantle may contain a high share of high-pressure ice, e.g. **Ice X** & **Ice XI**, probably mixed with silicate material like in Callisto's mantle and other materials. H_2O may also be stored in materials like **Ringwoodite** etc.

Ringwoodite in Diamond



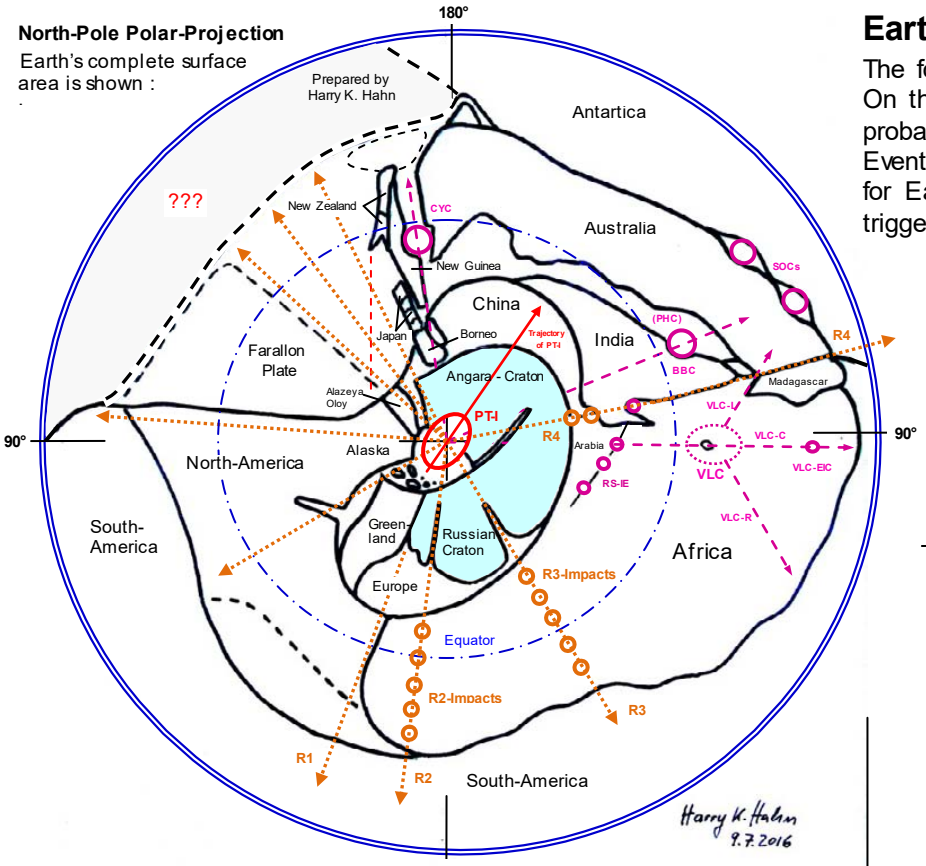


Earth at the time of the PT-Impact Event

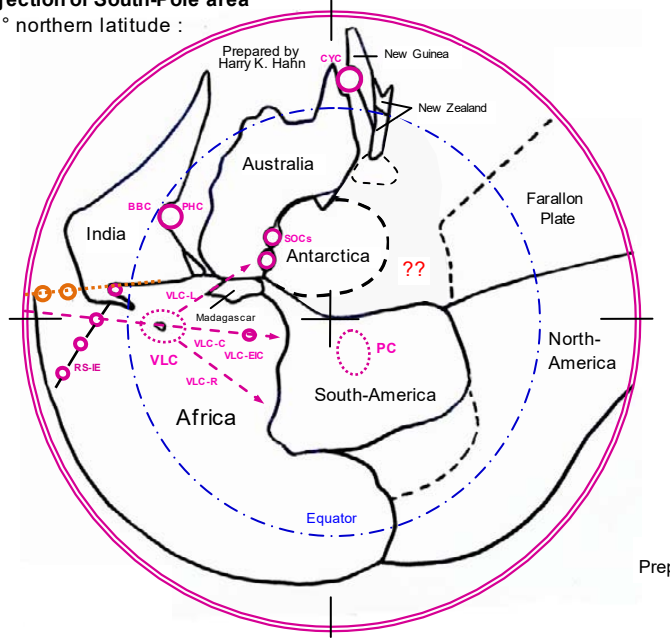
Prepared by Harry K. Hahn

The following maps show how our planet Earth probably looked at the time of the Permian-Triassic (PT)-Impact On these maps, the arrangement of Earth's continents at PTI-time is based on impact structures which in all probability were caused by the PT-Impact Event (especially the CYC-, the BBC/PHC- and the VLC-Impact Event & the Ejecta Rays (crater chains) R1-R4 were used as a reference). And an Expansion Tectonics model for Earth was used as base for these maps. The PT-Impact Event caused the shown fracture pattern, which triggered an expansion tectonics process on Earth. → **Earth's Ø** at the time of the PT-Impact : **~ 6500-7500 km**

North-Pole Polar-Projection
Earth's complete surface area is shown :



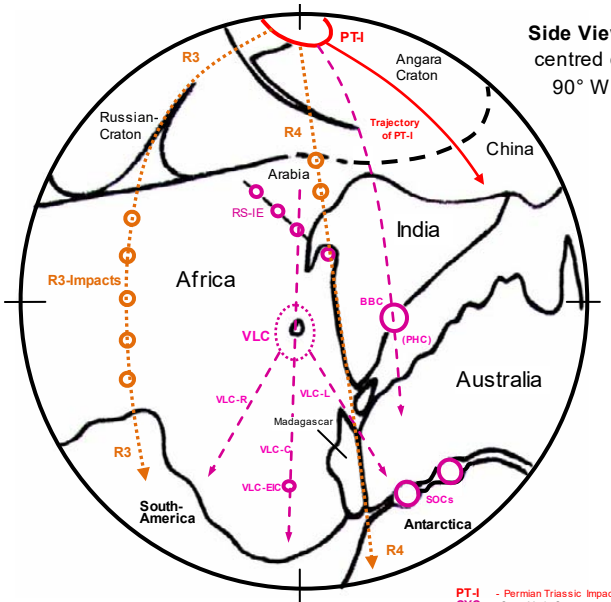
Polar-Projection of South-Pole area
up to ~ 45° northern latitude :

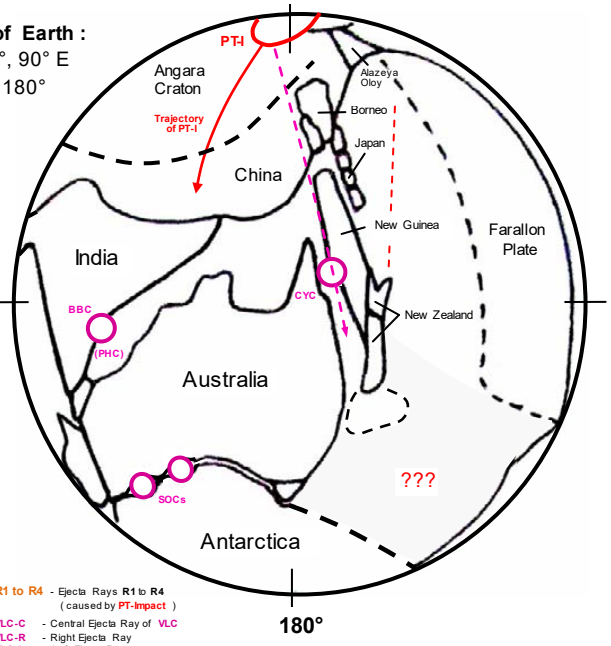


Prepared by Harry K. Hahn

Update : 9-10-2016

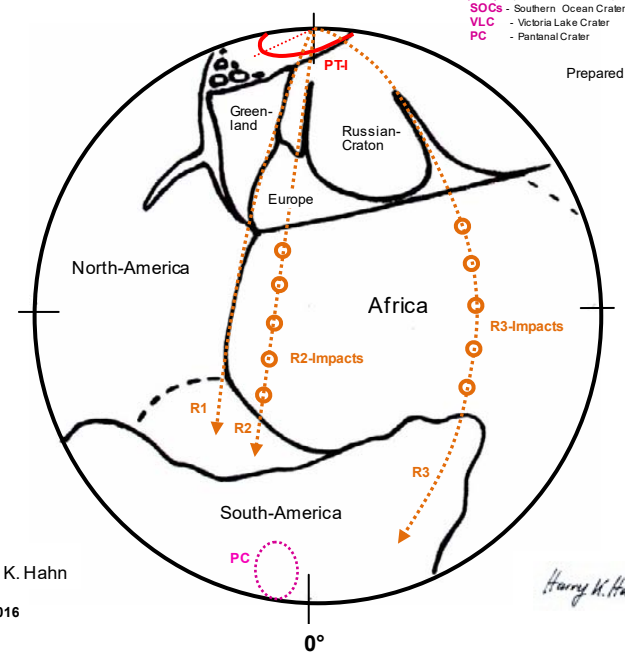
Side Views of Earth :
centred on 0°, 90° E
90° W and 180°



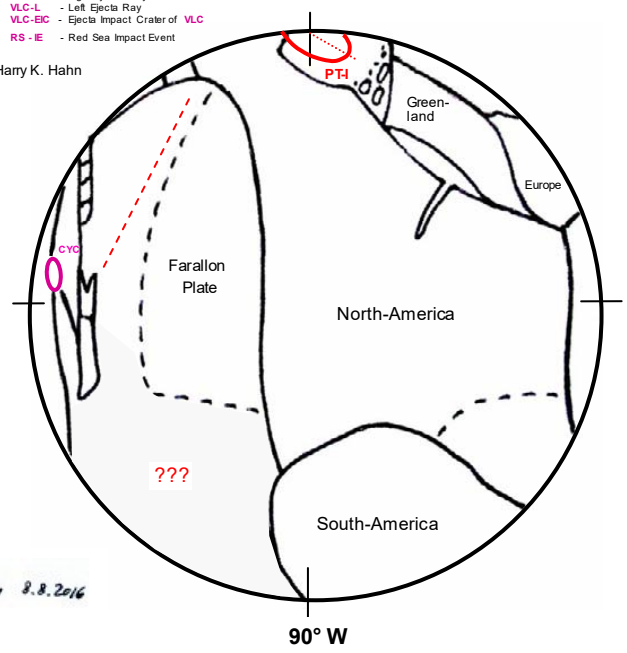


PT-I	- Permian Triassic Impact	**R1 to R4**	- Ejecta Rays **R1** to **R4** (caused by **PT-Impact**)
CYC	- Cape York Crater	**VLC-C**	- Central Ejecta Ray of **VLC**
BBC	- Bengal Bay Crater	**VLC-R**	- Right Ejecta Ray
(PHC)	- (Port Hedland Crater)	**VLC-L**	- Left Ejecta Ray
SOCs	- Southern Ocean Craters	**VLC-EIC**	- Ejecta Impact Crater of **VLC**
VLC	- Victoria Lake Crater	**RS - IE**	- Red Sea Impact Event
PC	- Pantanal Crater		

Prepared by Harry K. Hahn



Harry K. Hahn 9.8.2016

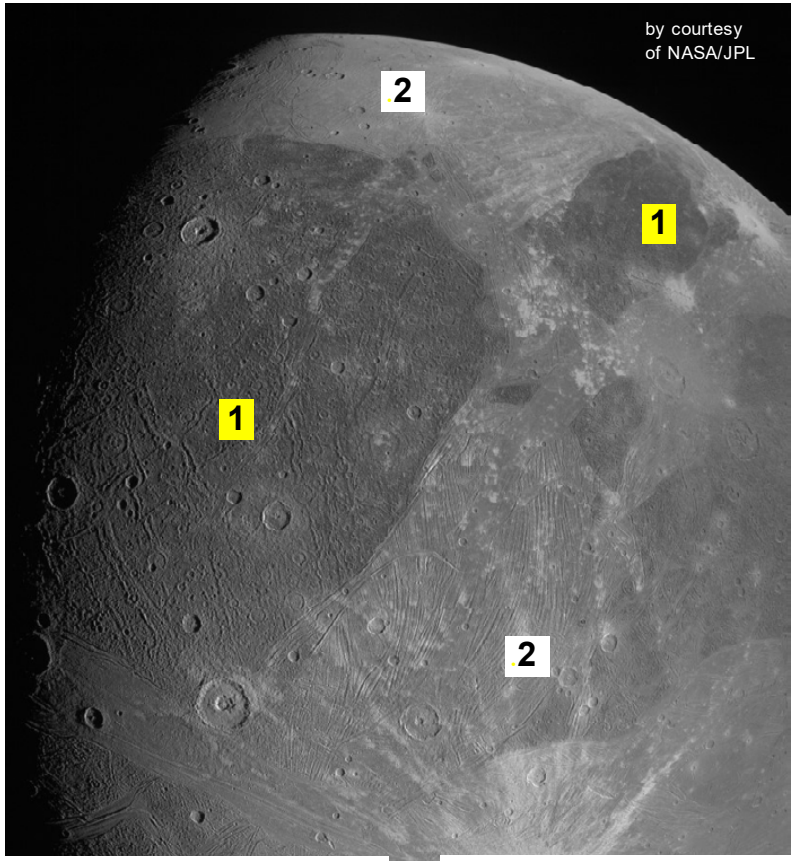


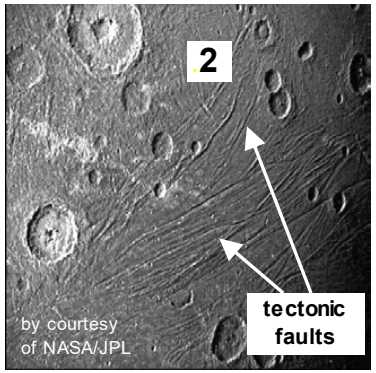
Ganymede will help us to understand the Expansion Tectonics Process on Earth caused by the PT -Impact Event

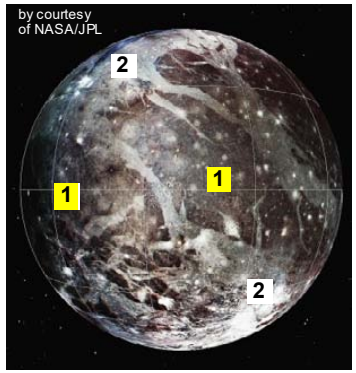
Similar to Earth Jupiter's moon Ganymede shows Expansion Tectonics over it's whole surface area. Looking on Ganymede's geological map then it is very obvious that the brown colored areas represent fragments of a sphere which are slowly drifting away from each other. It is undeniable that the moon's mantle has expanded !

A new sharp image of Jupiter's moon Ganymede was made by NASA's **Juno** spacecraft during its June 7, 2021, flyby, from a distance of only 1038 km. **The image shows clearly distinct dark and bright terrain, and long structural features possibly linked to tectonic faults. Ganymede's surface is composed of two types of terrain :**

1.) Dark old regions, saturated with impact craters and currently dated to four billion years ago, cover about one third of it. These dark regions contain clays and organic materials that could indicate the composition of the impactors from which Jupiters moons accreted. (→ on the geological map the old regions are indicated in brown color).



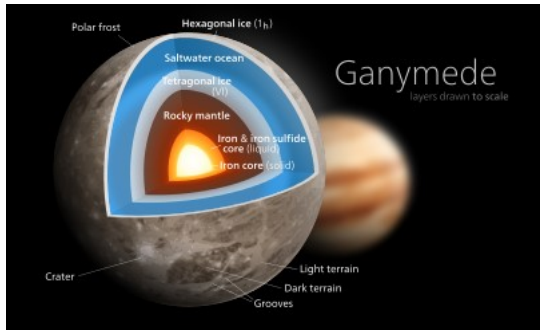


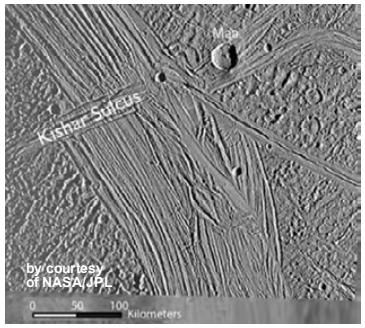


2.) Brighter and younger regions, crosscut by extensive grooves and ridges, cover the other two thirths of the moon's surface. The cause of the light terrain's disrupted geology was likely the result of tectonic activity.

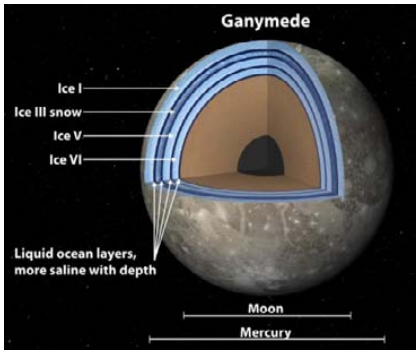
Water ice seems to be present everywhere on Ganymede's surface, with a mass fraction of 50–90% :

The bright grooved regions (areas) have a more icy composition than the dark regions. The modern view is that these brigth grooved regions are mainly tectonic in nature. Cryovolcanism is thought to have played only a minor role. Scientists believe that in the past Ganymede may have passed through one or more Laplace-like resonances (episodes of eccentricity excitations of its orbit), and that this probably caused significant tidal heating of the interior of Ganymede. The formation of the grooved terrain may be a result of one or more such tidal heating episodes. The scientists think that this tidal heating episodes may have caused an expansion of Ganymede's mantle caused by thermal expansion and phase transitions in the high-pressure ice which forms Ganymede's mantle. But there is also the possibility that the Gilgamesh Impact and other Impacts have caused the mantle expansion (Harry K. Hahn)





Tiamat Sulcus region of Ganymede showing Strike-slip tectonics



Internal Structure

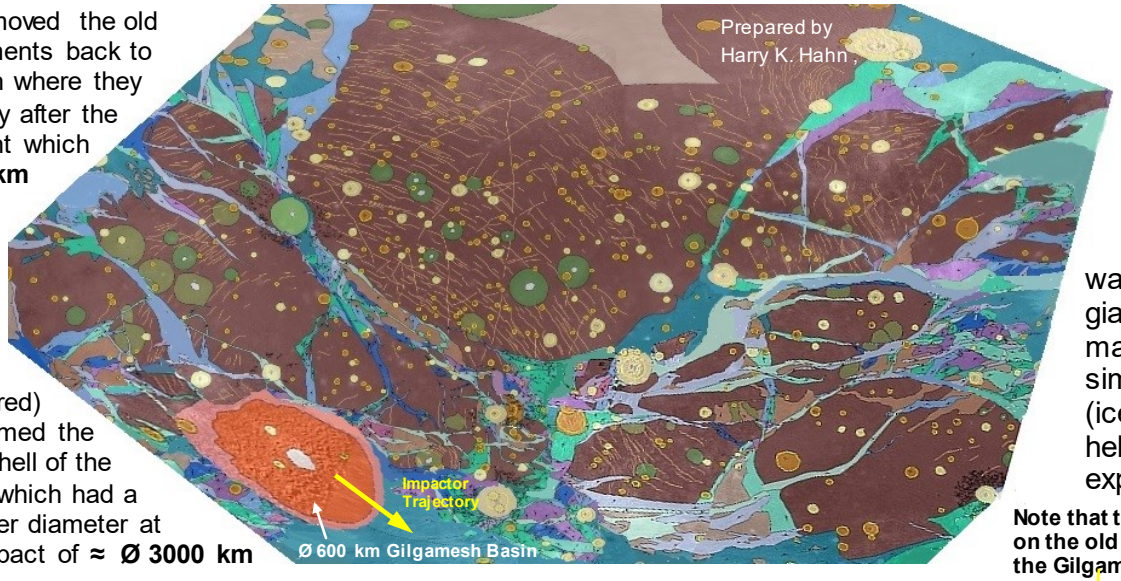
Jupiter's largest moon Ganymede (**Ø 5150 km**) is composed of approximately equal amounts of silicate rock and water. It appears to be fully differentiated, with an internal structure consisting of an iron-sulfide–iron core, a silicate mantle and outer layers of water ice and liquid water, which may contain more water than all of Earth's oceans combined. The precise thicknesses of the different layers in the interior of Ganymede depend on the assumed composition of silicates (fraction of olivine and pyroxene) and the amount of sulfur in the core.

The average density of Ganymede, 1.936 g/cm^3, suggests a composition of about equal parts rocky material and mostly water ices (→ see info to : Water-Ice-types). Beside water ice there are various non-water materials on Ganymede's surface present : carbon dioxide, sulfur dioxide and, possibly, cyanogen, hydrogen sulfate and various organic compounds. The *Galileo* space probe has also found magnesium sulfate ($MgSO_4$) and, possibly, sodium sulfate (Na_2SO_4) on Ganymede's surface. These salts may originate from the subsurface ocean. Ganymede has a thin oxygen atmosphere that includes O, O_2, and possibly O_3 (ozone). Atomic hydrogen is a minor atmospheric constituent. The oxygen is thought to be produced when water ice on Ganymede's surface is split into hydrogen and oxygen by radiation, with hydrogen then being more rapidly lost due to its low atomic mass. Thermolysis of water (→ water molecules split into hydrogen & oxgen at **T > 2200° C**), where the required heat is provided by impacts, could be another possibility ! (comment by Harry K. Hahn). Ganymede is the only moon known to have a magnetic field. This causes auroras to glow around the moon's north and south poles.

The surface of Jupiter's moon Ganymede seems to be the result of Expansion Tectonics caused by a Global Impact Event

Jupiter moon Ganymede (**Ø 5150 km**) shows indication for a global Expansion Tectonics process. Looking at Ganymede's geological map then it seems to be obvious that the brown colored (old crust-) areas represent fragments of a sphere which are slowly drifting away from each other. It's obvious that an expansion process was started at a certain point of time and the fragments of the old smaller spherical shell (brown) got slowly pulled apart by an expanding mantle underneath ! Having a close look at the pattern of the "expanding cracks" between the old brown-colored crust fragments, than it seems that one global impact event was the initial trigger for the break-up of Ganymede's old spherical shell (→ the brown-colored surface area)! This global impact event not only provided the impact energy and the required shock-waves to shatter Ganymede's crust in one single event. It also provided the energy & conditions which started the massive mantle-expansion of Ganymede. My new analysis indicates that the **Ø 600 km Gilgamesh Impact Basin** (pages 23-26, 78, 163, 214 in this PDF) and the impact energy and fracture pattern caused by this global impact event in all probability triggered the obvious expansion tectonics process on Jupiter's moon Ganymede ! Because there are strong similarities to the PT-Impact Event on Earth : → e.g. crater (impact basin) size ≈ 1/10 to 1/5 of the planet's (moon's) Ø, the impact angle was ≤ 15°, a massive expansion tectonics was triggered (started) by the giant impact, and a surface & mantle which seems to have a similar structure (→ high water (ice) content) Ganymede will help to understand the similar expansion tectonics on Earth !

Image 1 : I have moved the old (brown) crust-fragments back to the original position where they were located shortly after the Global Impact Event which caused the **Ø 600 km "Gilgamesh" Impact Basin**



This manipulated Geological Map of **Ganymede** clearly shows that the old (brown-colored) crust fragments formed the original spherical shell of the moon Ganymede, which had a considerable smaller diameter at the time of the impact of **≈ Ø 3000 km**

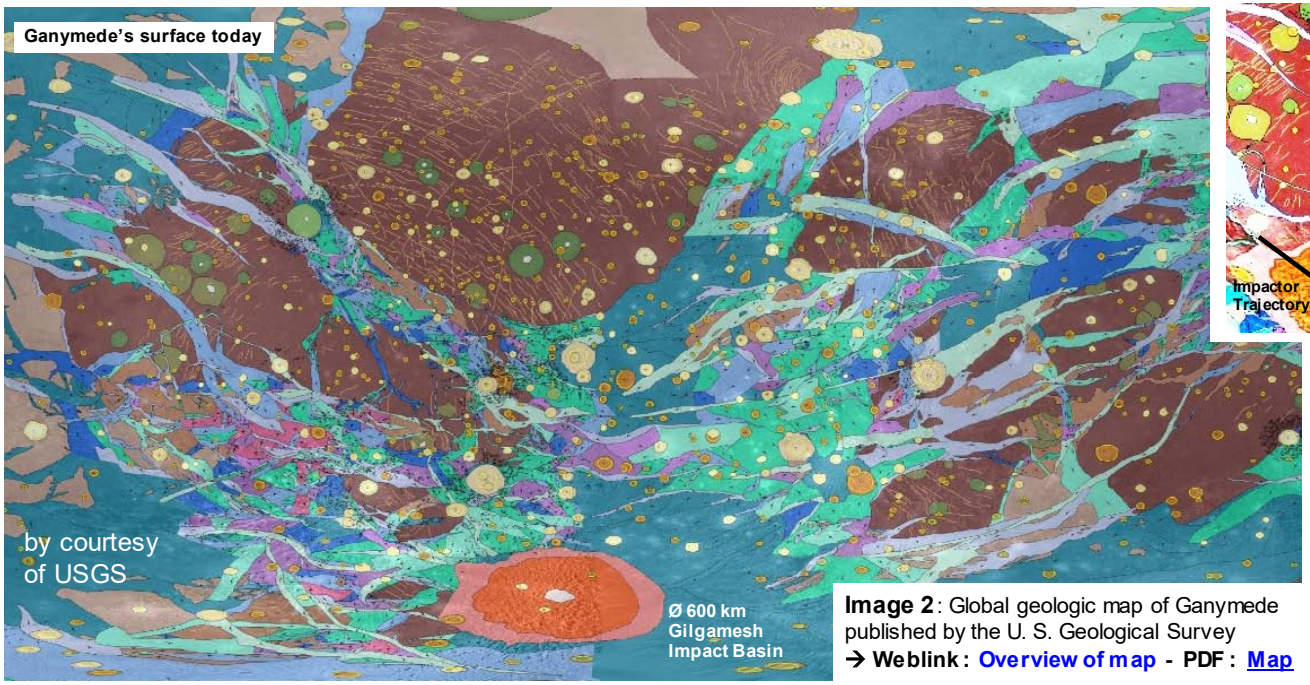
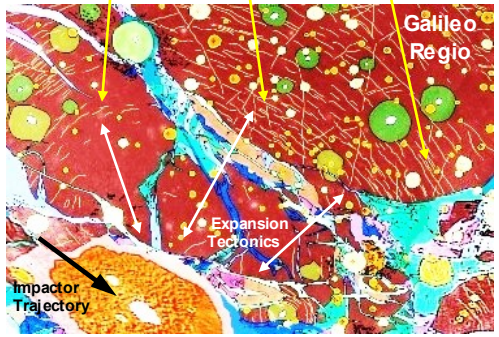


Image 2: Global geologic map of Ganymede published by the U. S. Geological Survey
→ **Weblink : Overview of map - PDF : Map**

Note that these concentric sets of fractures on the old crust-fragments were caused by the Gilgamesh-Impact ! (→ my analysis !)

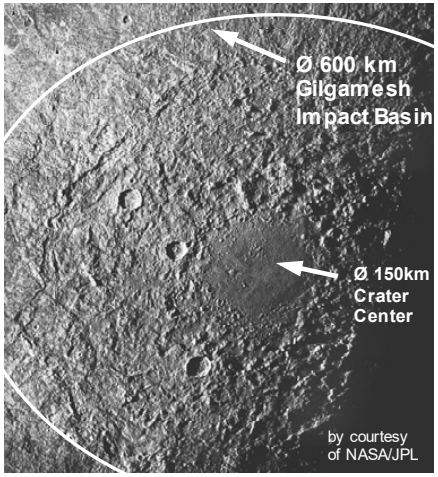


According to the Geological Map these curved furrows (fractures) were caused by large impact(s) into a relatively thin brittle lithosphere during the Nicholsonian period

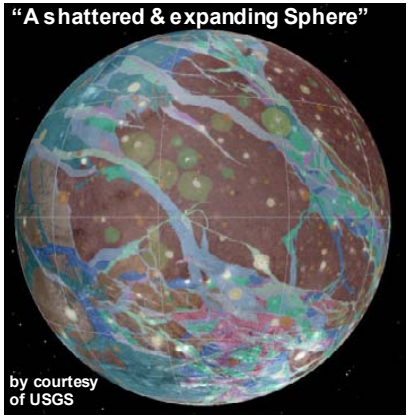
Near-infrared & UV-spectral analysis

Water ice exists everywhere on the surface of Ganymede with a mass fraction of 50–90%. Strong water-ice absorption bands are present.

Interesting Weblinks : Ganymede Geology
Rotating Geological Map : **GEO Animation**, Link2 : Rotation Animation 2



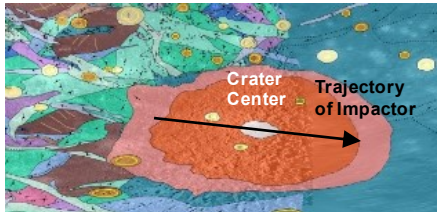
Different structural features indicate the Impactor's trajectory (→ **see next page !**)



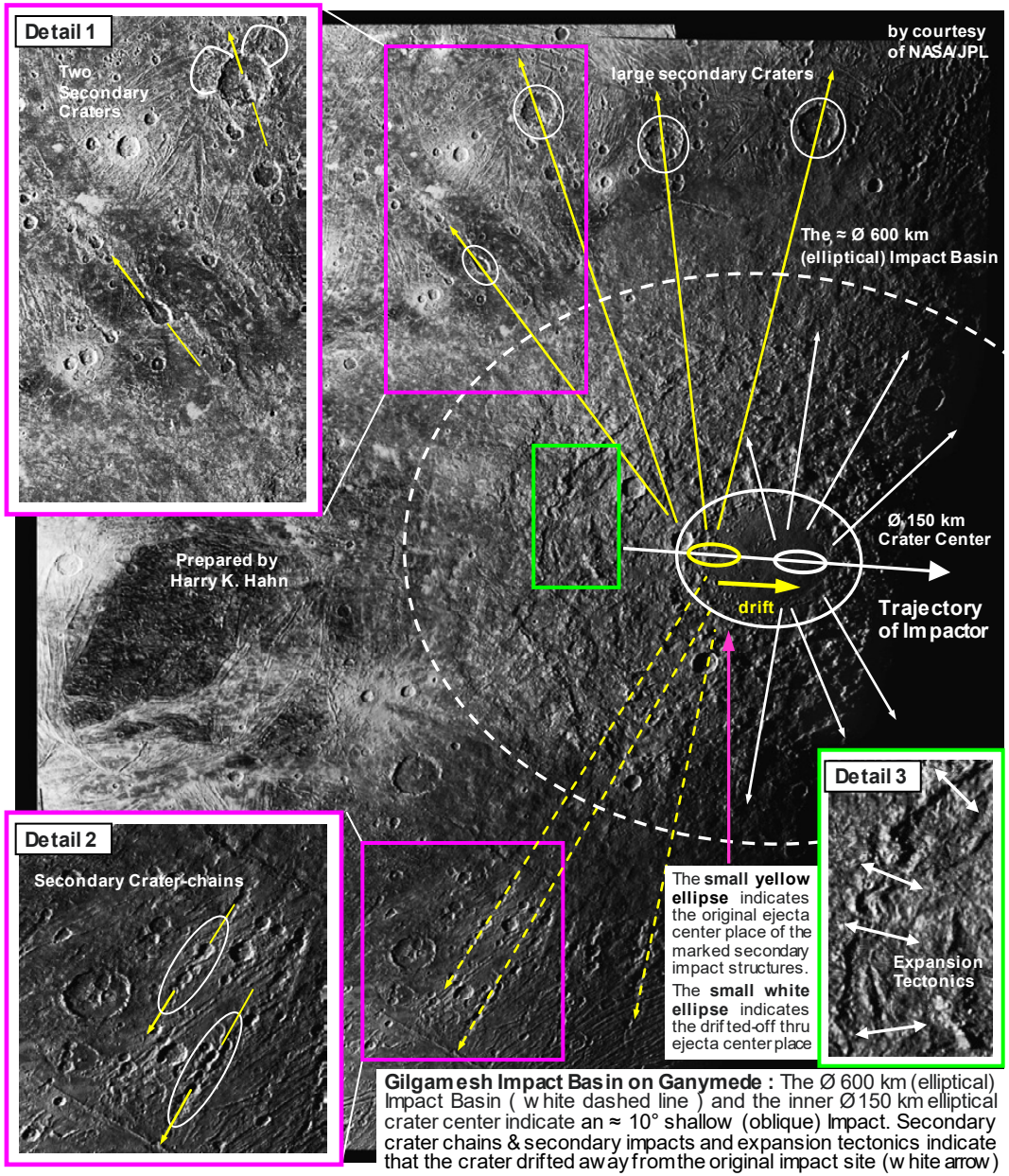
Global Geological Map of Ganymede

The Gilgamesh Impact, a large shallow Impact, fractured Ganymed's crust and caused Expansion Tectonics in the mantle

There is strong indication that the **Ø 600 km elliptical Gilgamesh Impact Basin** is responsible for the global fracture pattern that shattered the old and smaller spherical shell (dark regions) of Jupiter's moon Ganymede, and that this giant Impact started an Expansion Tectonics process in Ganymed's mantle, which slowly pulled apart the old crust fragments by an expanding mantle underneath. Similar as on Earth (→ the PT-Impact Crater) this giant oblique (shallow) Impact obviously caused the "tectonic plates" (the fragments of the old crust) and the Expansion Tectonics process on Ganymede. Beside the extreme seismic shock waves and the secondary impact structures (crater chains & big secondary craters) caused during the impact, also the powerful tangential impulse induced into Ganymed's crust and mantle by the giant shallow impact, together with the induced impact heat, must have been the decisive factors for the global fracture pattern.
Secondary Crater-chains and large Secondary Craters caused by the Gilgamesh Impact clearly indicate that the **Gilgamesh Crater** slowly drifted away from the original impact site into the direction of the original impact impulse (= trajectory of the impactor). Further indication comes from expansion tectonics structures on the rear-end of the impact basin. (→ see left image !)
The real drift of the crater may exceed > 1000 km !



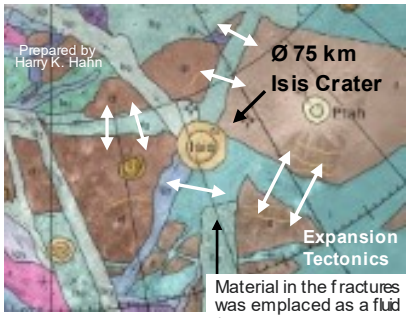
Geological map of the Gilgamesh Impact Basin
The Ø 600 km impact basin is marked in orange



Gilgamesh Impact Basin on Ganymede : The Ø 600 km (elliptical) Impact Basin (white dashed line) and the inner Ø 150 km elliptical crater center indicate an ≈ 10° shallow (oblique) Impact. Secondary crater chains & secondary impacts and expansion tectonics indicate that the crater drifted away from the original impact site (white arrow)

Ganymede's Isis Crater and an old Crater on Earth caused tectonic plates

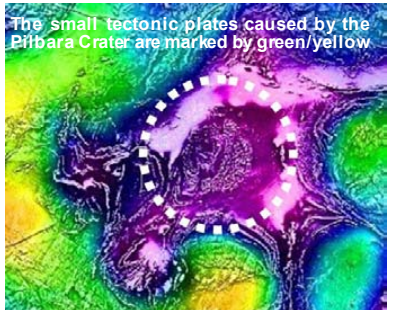
Another interesting crater on Ganymede, the **Ø 75 km Isis Crater**, also seems to have caused "plate tectonics" in a smaller scale on Ganymede. The image and the geological map of Ganymed's Isis Crater and its surrounding area indicate that a small tectonic plate on Ganymede (→ brown-colored on the geological map) obviously was fractured by the Isis Impact (Crater) and the fragments of this old plate then drifted apart after the impact.
A very similar impact crater which fractured Earth's crust ≈ 3 Ga ago also exists on Earth !



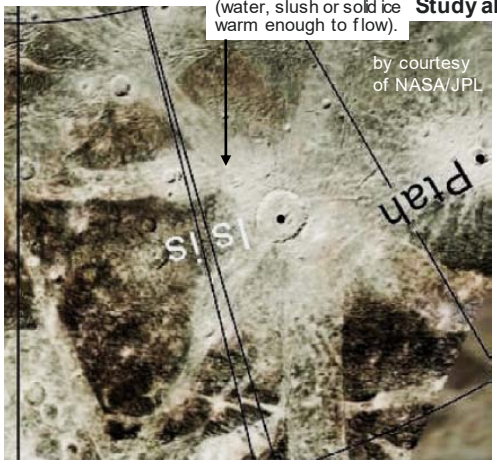
Material in the fractures was emplaced as a fluid (water, slush or solid ice warm enough to flow).

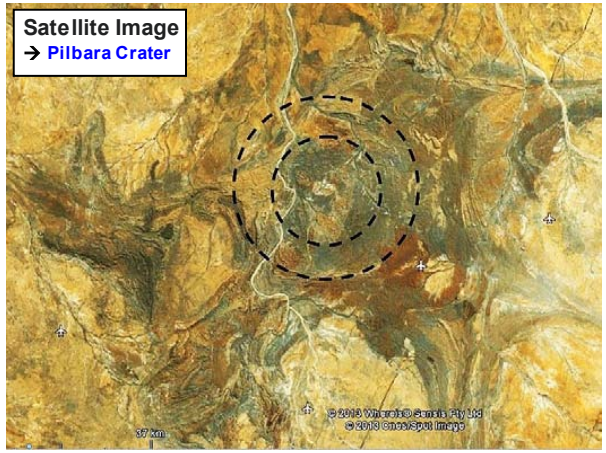
On the Pilbara Craton in NW-Australia there is a similar, yet unknown !, impact scenario visible where an impact crater obviously has fractured Earth's young crust and caused tectonic plates !

Weblinks to my study → : Link 1 ; Link 2



Study also available on : www.permiantriassic.de / www.permiantriassic.at





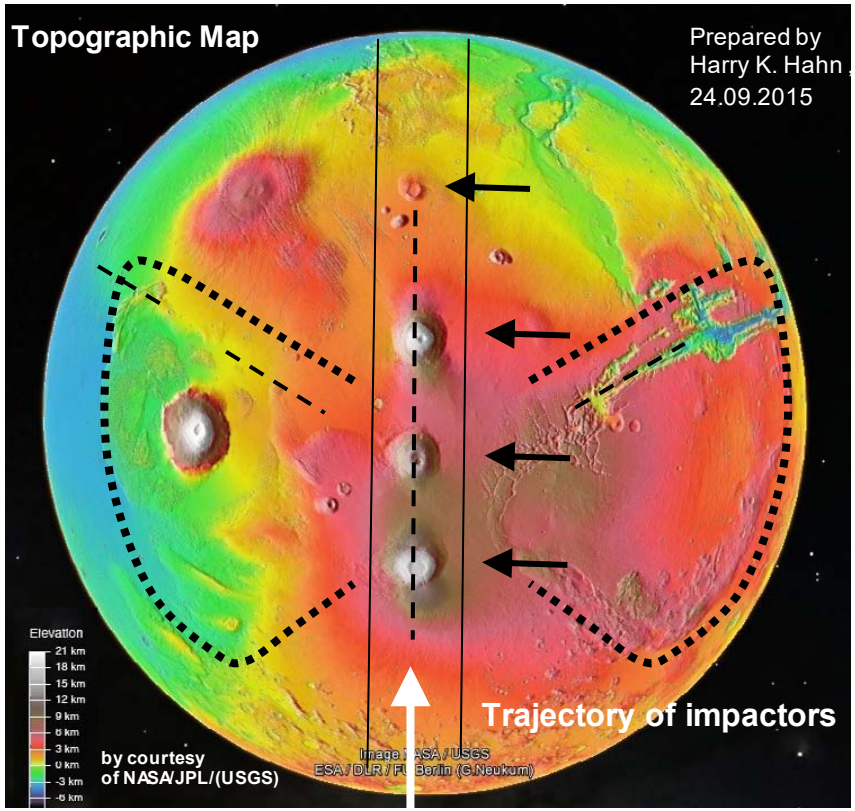
There is strong indication for a global impact event on Mars that probably happened less than 250 Ma ago

This global impact event produced at least four large impact craters of up to 600 km diameter which fractured the crust of Mars and triggered global expansion tectonics. The former oceans and ocean basins of Mars are a result of this event.

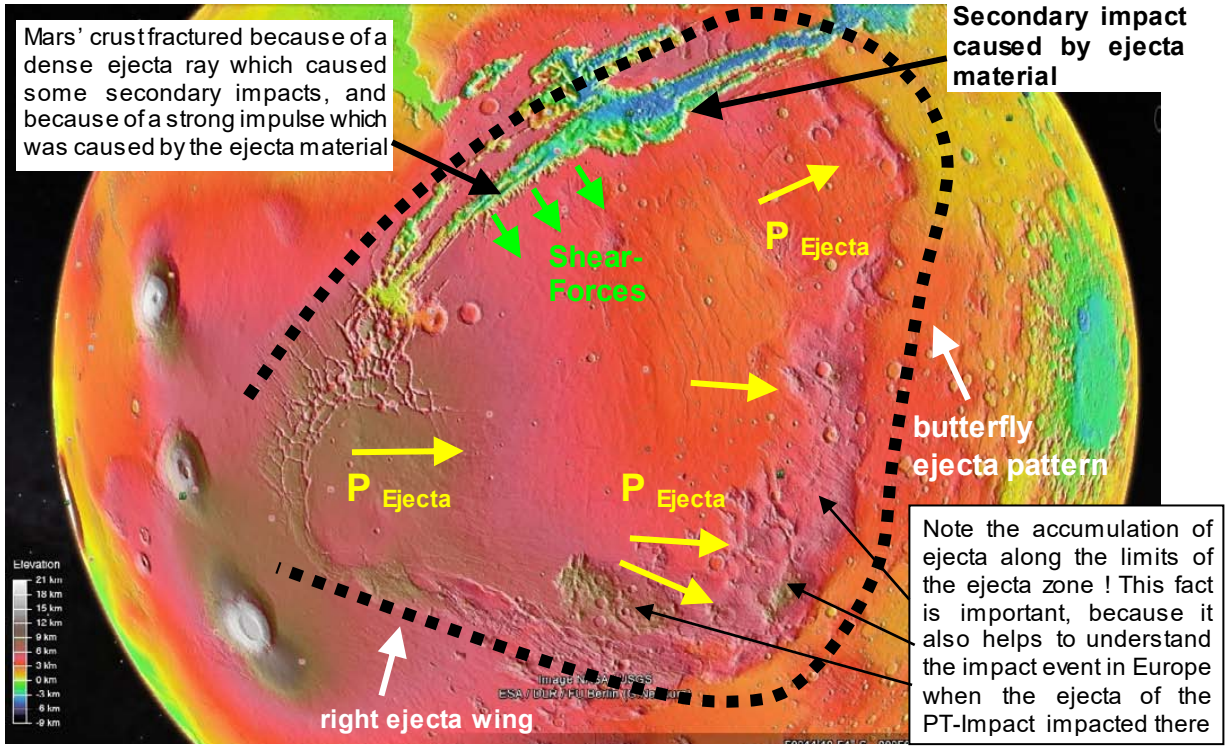
The dichotomy on Mars, extreme volcanism and the ancient oceans & water erosion on Mars are a direct result of the impact event. The water which filled the developing ocean-basins on Mars was brought to the surface in the process of global expansion tectonics started by the impact, and through the extreme volcanism that followed the impact event and that was going on for millions of years

The impactors which produced the impact craters probably had a diameter in the range of 20 to 50 km each.

The impact was an oblique impact which means that the impactors arrived in a shallow impact angle probably < 30° in regards to the surface. This is indicated by the ejecta pattern of the impact. The following images give a first explanation of the impact event :



This image clearly shows that the shield volcanos of the Tharsis Montes region are the result of a global impact event. There is fourth smaller shield volcano which lies a bit further up. All four structures lie on one precise line !
This is strong indication for an impact event, because impactors of a collapsed comet or asteroid always arrive on one straight line because they share a common orbit.



This image shows a classical butterfly-shaped ejecta pattern on the righthand side of the impactor chain. From the shape of the ejecta pattern the trajectory of the impactors becomes obvious, because a butterfly-ejecta pattern is always wider in the direction in which the impactor(s) travelled before impact → **see introduction**

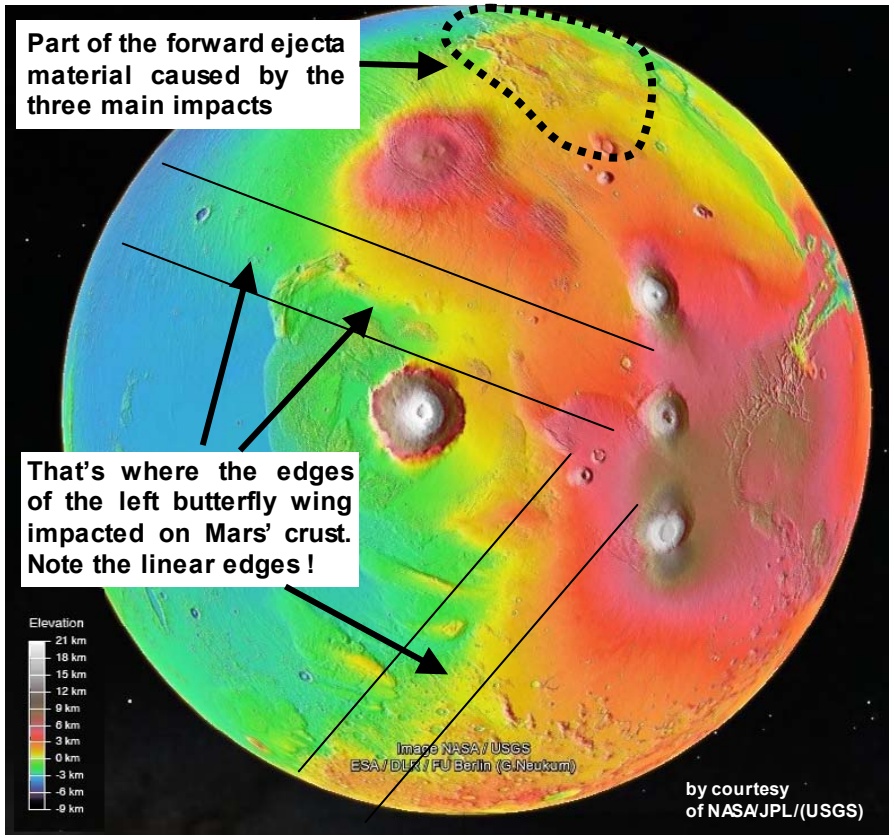
Regarding the accumulation of the ejecta material the following must be said :
Because of the nearly simultaneous impact of the three main impactors there were three spherical shock waves developing around the three craters. And along the nearly plane meeting zones of the shock waves the ejecta was forced to accumulate along straight lines. → **see Examples of double & triple impact in the Introduction !**

The dichotomy on Mars → the clear difference in the topography between the northern and southern hemisphere of Mars, and the formation of the large ocean basins Utopia Planitia & Arcadia Planitia is a direct result of this global impact event !

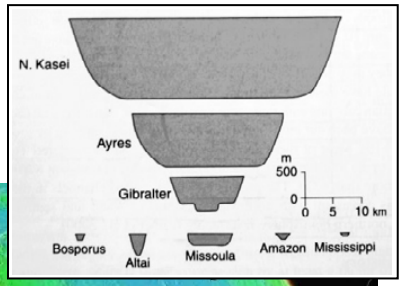
Because there was strong expansion tectonics going on, which was triggered by the global impact event, the area which is marked in blue on the map (→ deepest area !) is mainly new (additional) surface area of the planet !! Please compare this global impact event on Mars with the one on the Jupiter moon Ganymede (see study !) and with the PT-Impact Event. These impact events are very similar !

The left side of the butterfly-shaped ejecta pattern (→ the left wing) caused straight fractures in the crust of Mars, similar as it happened on the right side, caused by the right wing of the ejecta, were the impact impulse of the ejecta and secondary craters fractured the crust in a straight line and caused the gigantic Valles Marineris Canyon, which stretches over a distance of 2400 km !
But on the left side the crust completely broke apart and strong Expansion Tectonics quickly began to form the new ocean basins.

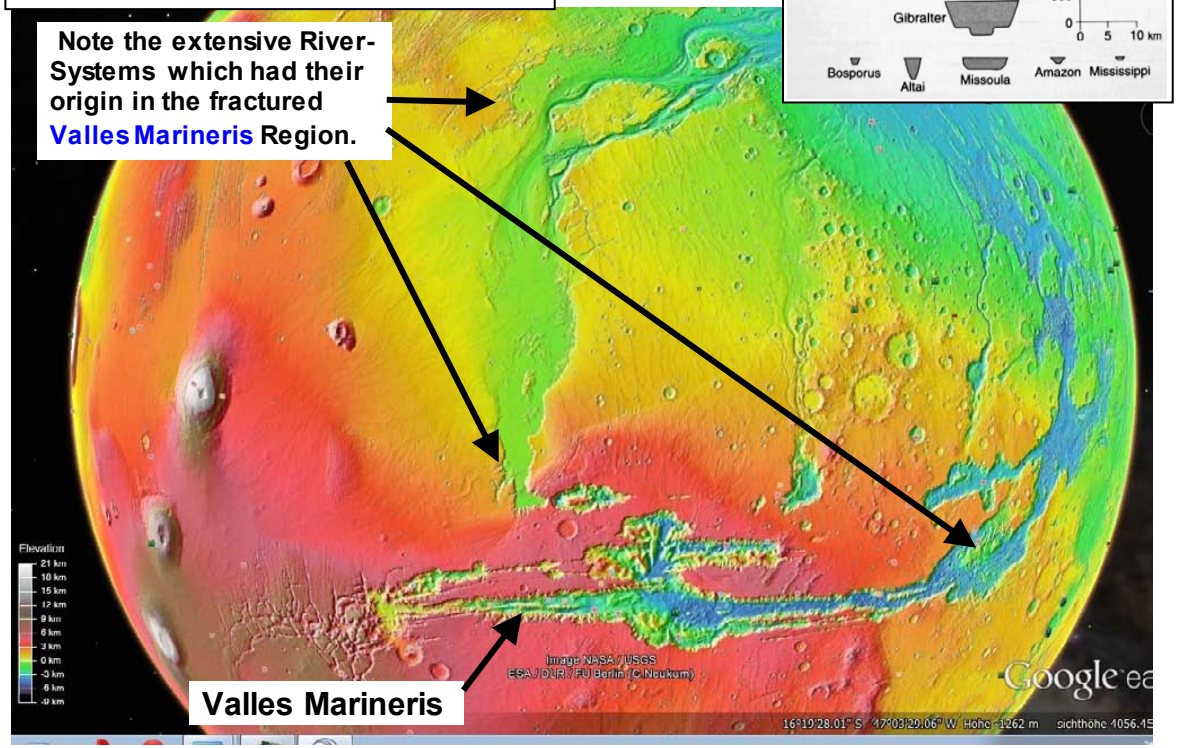
It is also easy visible that large amounts of water came from the Valles Marineris Region ! Which means that the water came from the interior of the planet ! It was water which was contained in the magma, probably in a super-saturated state. And when the planetary crust fractured it was released because of the rapid drop of pressure in the uncovered (fractured) mantle regions.
The maximum filling of the ocean basins probably happened when the expansion tectonics was in full swing.



Compare the biggest flood channels on Mars Kasei Valles & Ayres with the largest flood channels on Earth !!!



MARS GEOLOGY:
Rotating Globe Geology : see → weblink



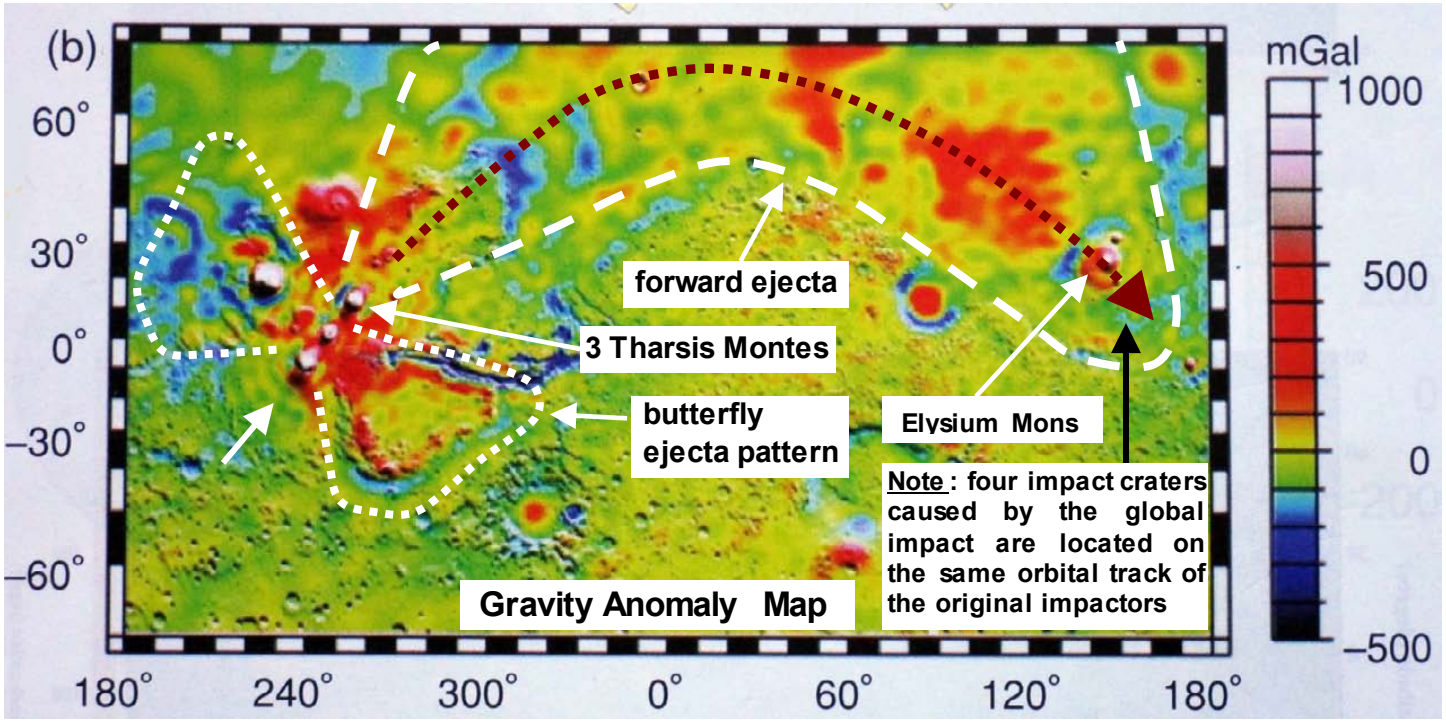
The strong concentration of the ejecta mass along the wing edges of the butterfly-ejecta pattern cut the complete crust of Mars along the edges of the ejecta blanket and formed the ocean basins Utopia Planitia & Arcadia

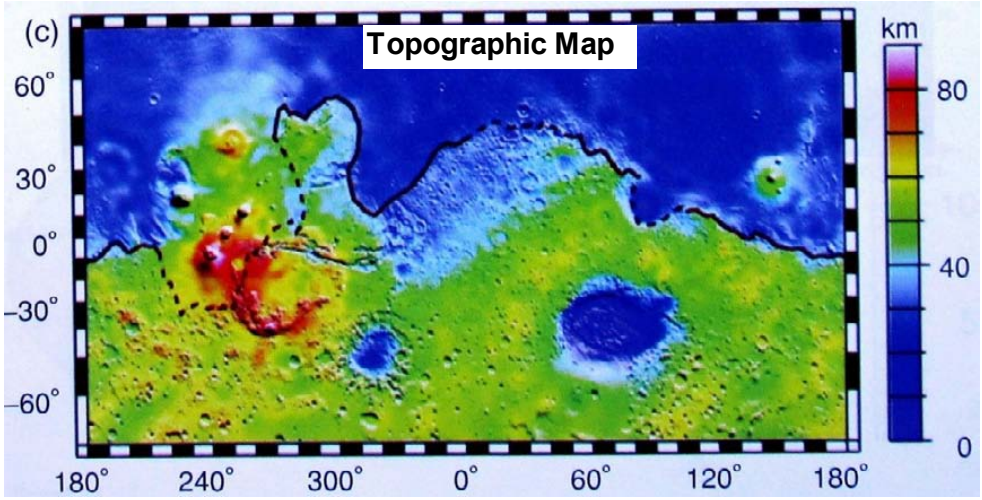
This ocean basins began to fill with water, coming out of Mars' mantle, shortly after the impact and the start of expansion tectonics

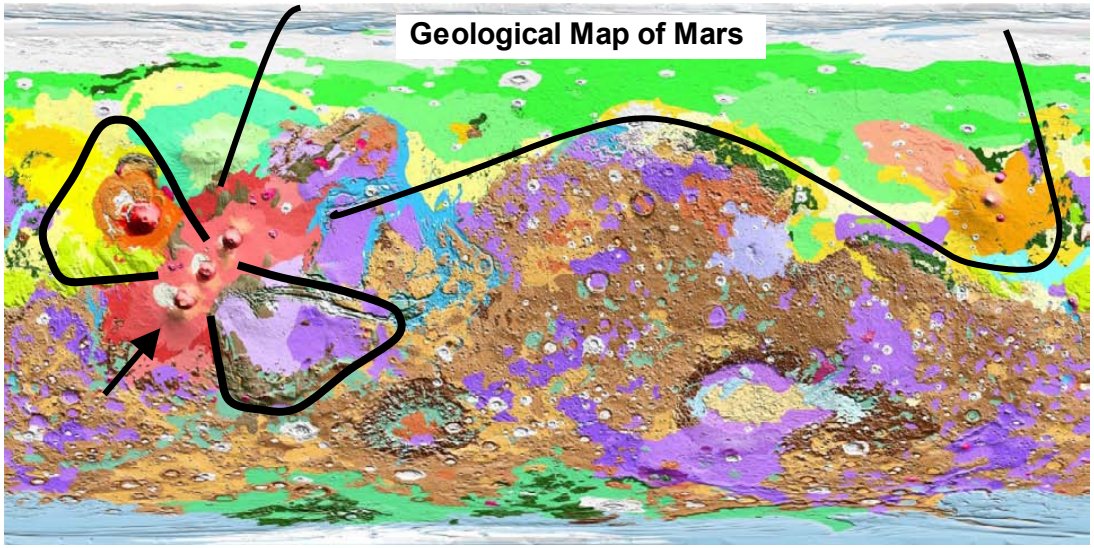
The maps on the righthand side show the full extension of the butterfly- and forward- ejecta blankets. Because there was expansion tectonics going on in the last 100-200 Ma, the forward ejecta area was probably much smaller at the time of impact. Elysium Mons was caused by the impact of the fourth Impactor from the Impactor-group (on the same orbit)!

The topographic map on the bottom shows the dichotomy border-line on Mars' crust along which the crust was cracked & cut open by the ejecta

And the geological map nicely inllustrates the massive geological changes on Mars' surface, caused by this global impact event.





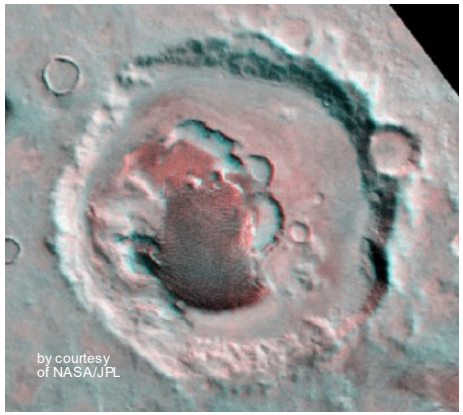


Mars' large shield volcanos are not the result of hotspots, they are the result of large impacts !

The large shield volcanos of the Tharsis Montes region are the result of an impact event of global scale, caused by the nearly simultaneous impact of at least three large impactors ! They are not the product of so called hotspots. The three Tharsis Montes shield volcanos, and probably Elysium Mons as well, where caused by the fragments of a large asteroid or comet which probably broke apart just before impact !

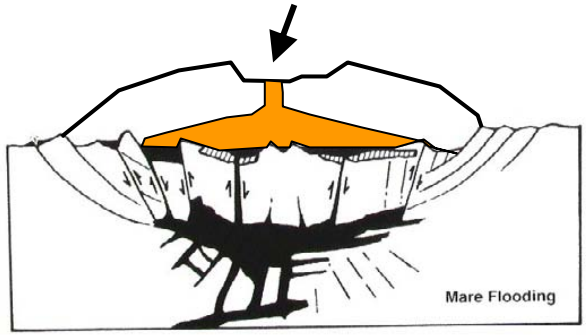
The two images below show how volcanic domes grow above large impact craters. This happens when the fractures under the crater, which result from the impact, are so extensive and deep that magma from the mantle can rise.

Then the conditions are given that shield volcanos like the large shield volcanos of the Tharsis Montes region on Mars, Ascraeus Mons, Pavonis Mons, Arsia Mons and Elysium Mons can form. Olympus Mons the largest shield volcano is probably also the direct result of an impactor or it is the result of impacting ejecta from the Tharsis Montes impacts.



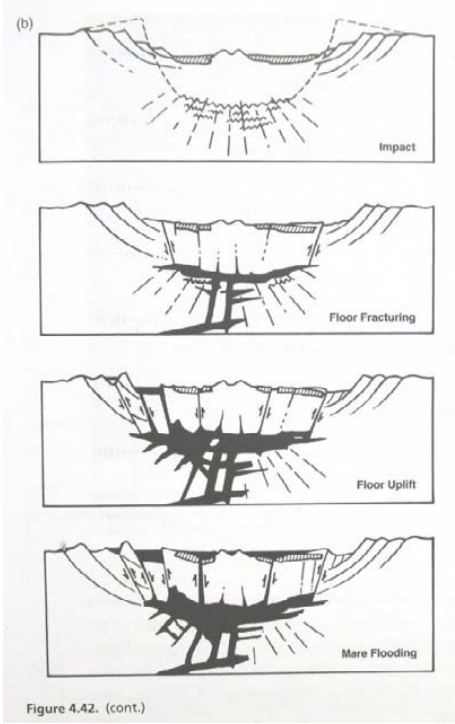
As these two examples of craters with dome structures, formed by magma outflow, clearly demonstrate, big impacts can cause large shield volcanos

Shield Volcano grown above an impact crater

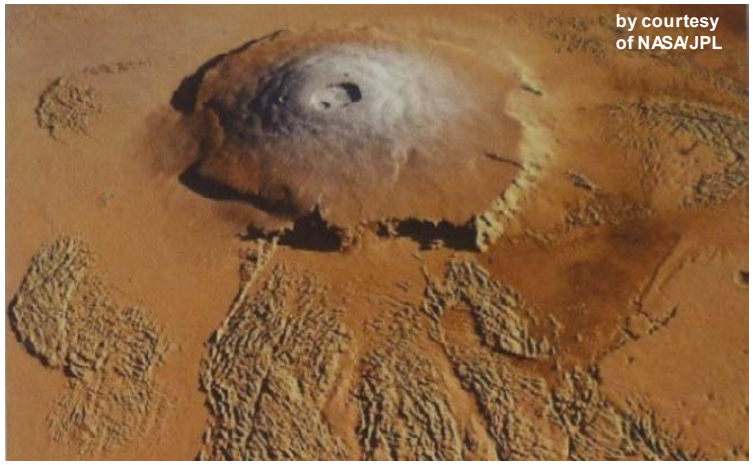


A crater with a fractured floor and massive outflow of magma can form a large shield volcano which rises high above the crater

Fracturing of the crater floor of a large impact crater, and later flooding of the crater with magma flowing out of the cracks

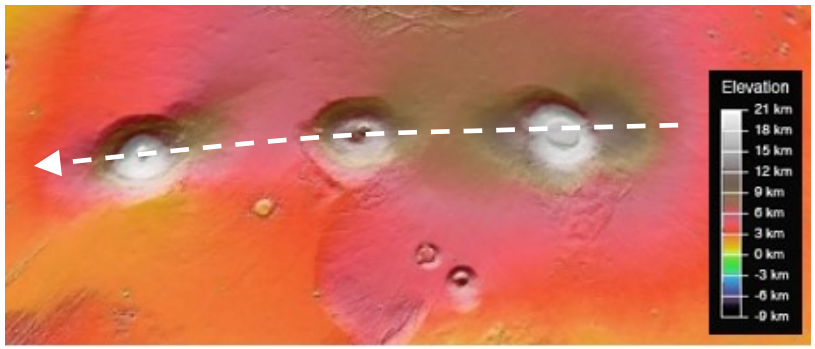


From : **Planetary Geomorphology**,
Ronald Greeley, ISBN : 978-0-521-86711-5



The shield volcano Olympus Moons is 23 km high and 600 km in diameter, and it is bordered by an escarpment up to 10 km high, at the foot, from which a series of lobate deposits (ejecta lobes ?) extend for hundreds of kilometers.

Tharsis Montes Region :

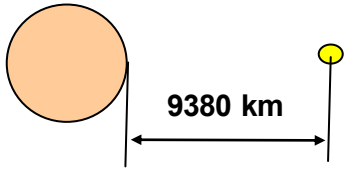


These three shield volcanos represent three major impact craters (impact sides) caused by the global impact event on Mars

Mars moon Phobos provides further evidence for the described global impact event on Mars

Mars moon Phobos is covered with parallel grooves which can only be created by a very large impact event on Mars. These grooves which were formed by parallel chains of secondary impactors are very dense on Phobos leading apex but completely missing on its trailing apex. This is strong evidence that a global impact event occured on Mars.

Note that the distance between Mars and Phobos is around 9400 km !



To give an impression of the distance which the ejecta from Mars travelled to produce the grooves : Phobos orbits Mars in an average distance of 9380 km !!

from Page 27 :

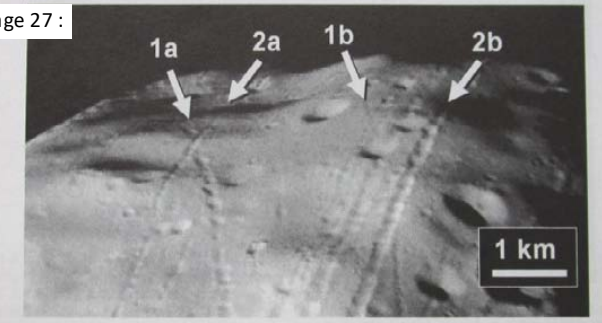


Fig. 6. The two parallel grooves 1a and 1b are cut by grooves 2a and 2b, respectively, indicating that the groove family represented by 2a and 2b is younger. From image h6906_0000.nd2. Image credit: ESA/DLR/FUB.

Secondary impact chains from primary craters on Mars

The final hypothesis, that the grooves of Phobos are secondary impact crater chains from impacts on Mars, is explained in more detail in Figure 17. Unlike all of the other ideas, the pattern of grooves on Phobos almost exactly matches that predicted by theory (Fig. 12). On this hypothesis, each groove family originates from a large impact on Mars and is composed of radial (effectively parallel at the distance of Phobos) coalesced crater chains. These would, therefore, create the parallel plane intersections observed, each family having a different orientation, but the motion of Phobos would ensure that the plane passing through the leading apex of Mars would also pass through the centre of Phobos. This idea is also the only one that explains why each groove family covers only one hemisphere of Phobos, and also why the groove families are of different ages. The 'zone of avoidance' at the trailing apex of Phobos ties in exactly with what this hypothesis predicts: this is the only location that ejecta from Mars cannot reach because Phobos' forward motion in its orbit exceeds the ejecta velocity.

from Page 37 :

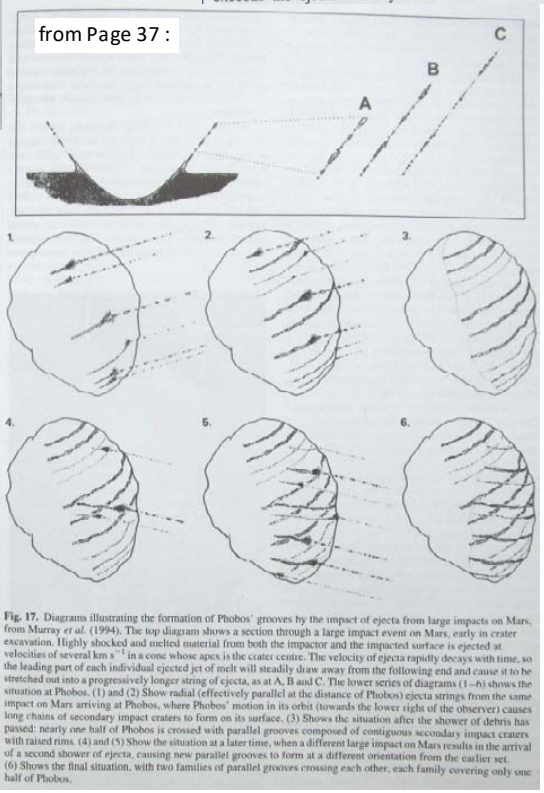


Fig. 17. Diagrams illustrating the formation of Phobos' grooves by the impact of ejecta from large impacts on Mars, from Murray *et al.* (1994). The top diagram shows a section through a large impact event on Mars, early in crater excavation. Highly shocked and melted material from both the impactor and the impacted surface is ejected at velocities of several km s^{-1} in a cone whose apex is the crater centre. The velocity of ejecta rapidly decays with time, so the leading part of each individual ejected jet of melt will steadily draw away from the following end and cause it to be stretched out into a progressively longer string of ejecta, as at A, B and C. The lower series of diagrams (1–6) shows the situation at Phobos. (1) and (2) Show radial (effectively parallel at the distance of Phobos) ejecta strings from the same impact on Mars arriving at Phobos, where Phobos' motion in its orbit (towards the lower right of the observer) causes long chains of secondary impact craters to form on its surface. (3) Shows the situation after the shower of debris has passed: nearly one half of Phobos is crossed with parallel grooves composed of contiguous secondary impact craters with raised rims. (4) and (5) Show the situation at a later time, when a different large impact on Mars results in the arrival of a second shower of ejecta, causing new parallel grooves to form at a different orientation from the earlier set. (6) Shows the final situation, with two families of parallel grooves crossing each other, each family covering only one half of Phobos.

from Page 34 :

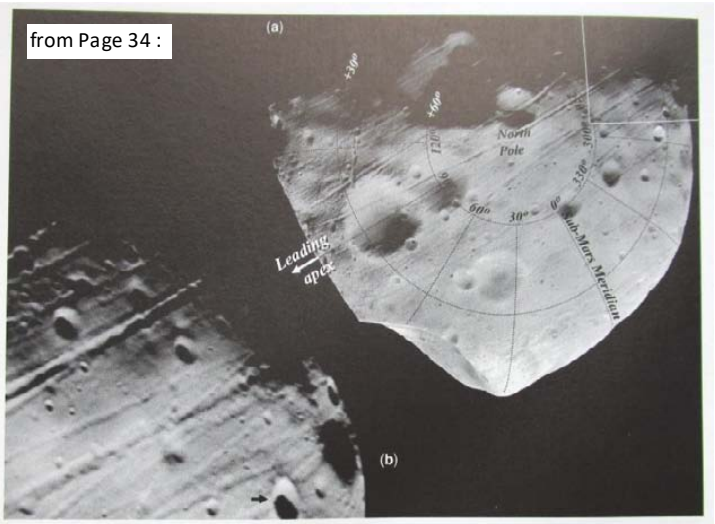


Fig. 14. (**a**) (Top right) Image h3310_0000.nd2 centred close to the north pole, dominated by the subparallel striations and crater chains of family A, the most complete groove family on Phobos that covers most of the northern hemisphere. Note that some individual grooves run unbroken for nearly 180° of latitude, and that the central groove of this family passes close to both the north pole and the leading apex. The tightly spaced grooves appear very straight and linear, but the super-resolution image (**b**, lower left) of the area in the box at top right shows that they comprise contiguous pits with raised rims (image h3310_sr2_0006). The top right-hand image is about 23 km left to right. Image credit: ESA/DLR/FUB.

From **„Martian Geomorphology“**, M.R.Balme, A.S.Bargery, ISBN : 978-1-86239-330-1

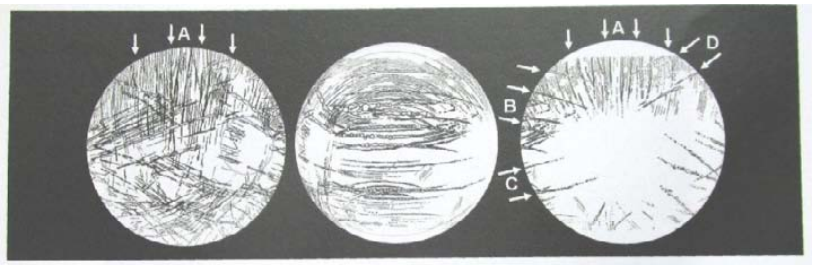


Fig. 7. (Top) Orthographic projections of groove positions on Phobos centred on (left) the leading apex (0° latitude, 90° longitude), (centre) the sub-Mars point and (right) the trailing apex. Note that grooves appear straight and in groups of parallel families when viewed from the leading and trailing apex (left and right). Four prominent families were named by Thomas *et al.* (1979); family A (the most prominent and numerous), B and D are marked. Also, note that all grooves become parallel along the sub-Mars meridian.

from Page 28 :

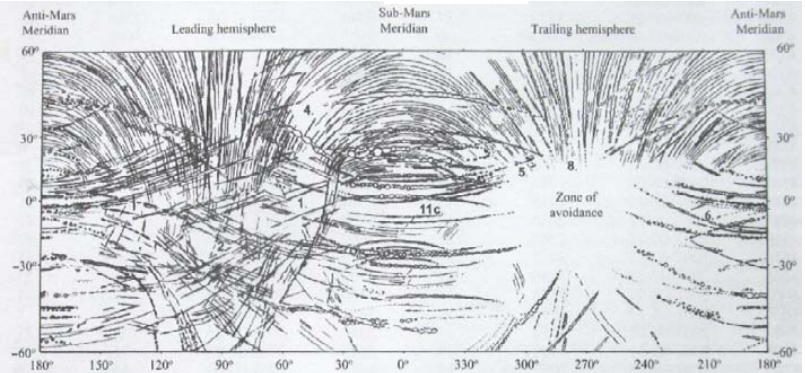
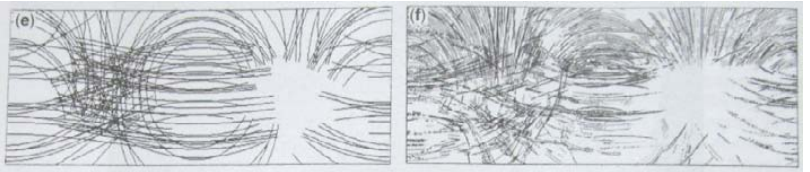


Fig. 1. Sketch map of grooves on the surface of Phobos derived from HRSC *Mars Express*, *Viking* and MGS (*Mars Global Surveyor*) images. A Mercator projection between −60° and +60° is used, and locations and orientations of features were assembled using crater positions from an existing control network (Duxbury & Callahan 1989). (1) Marks the centre of Stickney crater, the largest on Phobos; other numbers (2, 4, 5, 8 and 11c) refer to the approximate centres of figures in the text. Note that grooves become parallel along the sub-Mars and anti-Mars meridians (0° and 180°), and that there is a 'zone of avoidance' around which all grooves fade out and disappear surrounding the trailing apex (0° latitude, 270° longitude). The leading apex (0° latitude, 90° longitude) is characterized by groove families crossing each other at all orientations.

from Page 24



from Page 32

(**e**) (Lower left) Predicted secondary crater chain orientations from impacts at 12 different latitudes on Mars, chosen to match those seen on Phobos. Note the resemblance between this model and the map of grooves at the bottom. The model is simplified as a spherical Phobos, so does not fit the real situation as well as if it were modelled as a triaxial ellipsoid; nevertheless, the resemblance between theory and model illustrated in (**e**) is strong. (**f**) (Bottom right) Map of Phobos' grooves from HRSC images.

Remnant massifs of the highland - lowland (dichotomy) boundary , probably are the result of a global Impact Event

The obtained absolut ages for the most recent resurfacing periods of these massifs (→ the covering of these massifs by large amounts of volcanic material) indicate that the global impact event may have happened in the range of **50 to 200 Ma** ago. It also seems that the volcanic material (the volcanic ash) which periodically covered these massifs contained large amounts of volatiles (probably mostly water), which evaporated within a certain time and caused big landslides etc., because of "volatile-activity"

The relatively smooth-appearance mantling deposit blankets most parts of the study area and overlies lowland plains and footslope aprons as well as the smoothly convex remnant massifs. It is prominent where landslide scars and small-scaled depressions, such as obliterated impact craters, form local catchment areas (Fig. 9d). At over-steepened walls, mantling material accumulates at the footslope and reaches backwards uphill. Remnant crests marked by a central segmented ridge (Fig. 6a) often exhibit an overlying mantling material that terminates on both sides of the crest. This suggests the retreat of the covering material either by atmospheric loss of volatiles or by downwasting through slumping or creep at steep locations (Figs 6b, c & 7). Some of the displacement of a mantling layer occurs as glide flows, as indicated by polygonal sheets and circumferential ridges (Fig. 6b).

The mantling deposit is (a) superimposed on the remnant massif and (b) often detached from the

Remnant massifs of the highland–lowland boundary are either autochthonous, that is, they represent erosional remnants of highland material as suggested by geological mapping work (Scott & Tanaka 1986; Tanaka *et al.* 2005*a*) and earlier discussions (Sharp 1973; Carr & Schaber 1977; Squyres 1979; Lucchitta 1984; Carr 2001), or they form uplifted crustal material as suggested for the southern hemispheric circum-Hellas and Argyre Planitiae remnants, as mapped by Greeley *et al.* (2006) (cf. question marks in Fig. 4). Alternatively, an allochthonous origin is conceivable although less likely, that is, emplacement by impact processes, similar to alternative explanations for the southern hemispheric remnant-apron features (e.g. Crown *et al.* 1992; Greeley *et al.* 2006).

Age constraints

For age determination, crater-size frequency distributions for nine lobate debris aprons were derived from undeformed impact craters. The obtained absolute ages provide proxies for the most recent resurfacing period and give some insight into the early past of apron formation or modification. Ages are in the range of 10–50 Ma, with early traces dating back to 100 Ma and up to 200 Ma ago (Table 4 & Fig. 12). Old ages for #9 are old signatures in the terrain covered by debris aprons; such older impact craters are partially filled by debris-apron material. Segmentation and stair-stepped frequency curves indicate multiple resurfacing events. Shallow branches of frequency curves strongly suggest the continuation of denudation and/or resurfacing and obliteration of older impact craters. Individual branches indicate a clear phase at 50 Ma ago and some modification process dating back to 10–20 Ma ago. It cannot completely

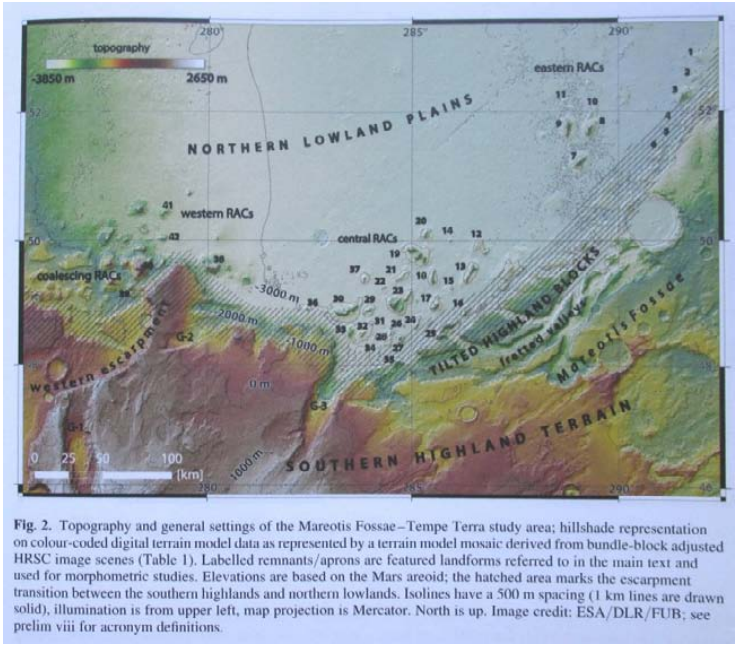


Fig. 2. Topography and general settings of the Mareotis Fossae–Tempe Terra study area; hillshade representation on colour-coded digital terrain model data as represented by a terrain model mosaic derived from bundle-block adjusted HRSC image scenes (Table 1). Labelled remnants/aprons are featured landforms referred to in the main text and used for morphometric studies. Elevations are based on the Mars areoid; the hatched area marks the escarpment transition between the southern highlands and northern lowlands. Isolines have a 500 m spacing (1 km lines are drawn solid), illumination is from upper left, map projection is Mercator. North is up. Image credit: ESA/DLR/FUB; see prelim viii for acronym definitions.

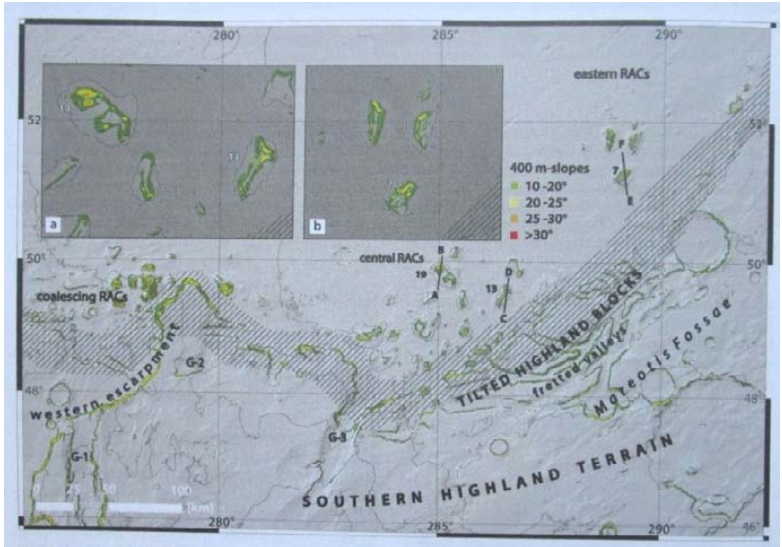


Fig. 5. Map in a hillshade-relief representation with superimposed slope data of remnant massifs and debris aprons. Slope data have been derived from 400 × 400 m digital terrain model data to avoid low-frequency noise. Locations of profiles are marked in the overview map, insets (a) and (b) show details of RAC features 7, 13 and 19 where topographical profiles are located. North is up in all images.

From **„Martian Geomorphology"**, M.R.Balme, A.S.Bargery, ISBN : 978-1-86239-330-1

from Page 49 to 60

Note the fluid-like appearance of the cover material of the massif!

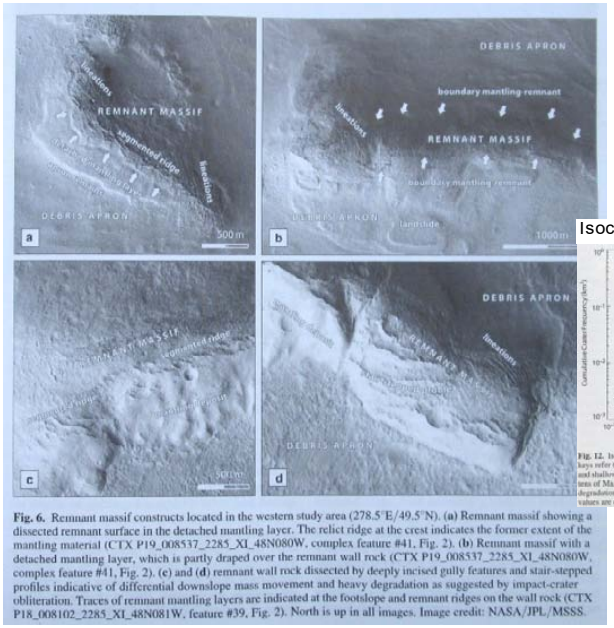


Fig. 6. Remnant massif constructs located in the western study area (278.5°E/49.5°N). (a) Remnant massif showing a dissected remnant surface in the detached mantling layer. The relict ridge at the crest indicates the former extent of the mantling material (CTX P19_008537_2285_XI_48N080W, complex feature #41, Fig. 2). (b) Remnant massif with a detached mantling layer, which is partly draped over the remnant wall rock (CTX P19_008537_2285_XI_48N080W, complex feature #41, Fig. 2). (c) and (d) remnant wall rock dissected by deeply incised gully features and stair-stepped profiles indicative of differential downslope mass movement and heavy degradation as suggested by impact-crater obliteration. Traces of remnant mantling layers are indicated at the footslope and remnant ridges on the wall rock (CTX P18_008102_2285_XI_48N081W, feature #39, Fig. 2). North is up in all images. Image credit: NASA/JPL/MSSS.

Isochrones & crater-size frequency measurements

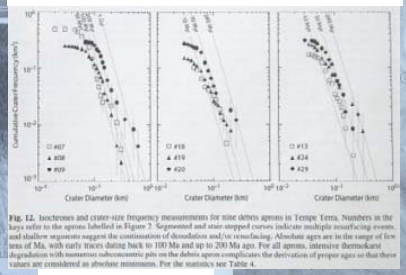


Fig. 12. Isochrones and crater-size frequency measurements for nine debris aprons in Tempe Terra. Numbers in the keys refer to the aprons labelled in Figure 7. Segmented and stair-stepped curves indicate multiple resurfacing events, and shallow segments suggest the continuation of denudation and/or resurfacing. Absolute ages are in the range of few tens of Ma, with early traces dating back to 100 Ma and up to 200 Ma ago. For all aprons, intensive thermokarst degradation with numerous subconcentric pits on the debris apron complicates the derivation of proper ages so that these values are considered as absolute minimums. For the statistics see Table 4.

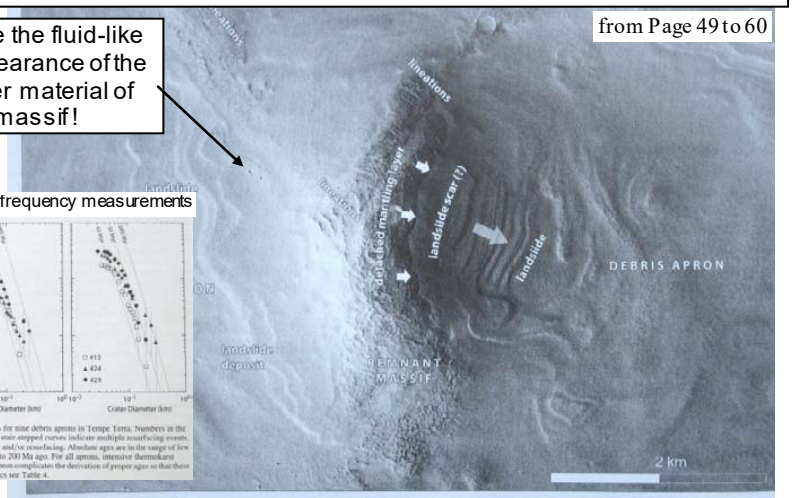


Fig. 7. Complex remnant-apron construct showing several episodes of resurfacing, as indicated by an old landslide scar, obliterated impact craters, parallel surface lineations and several younger phases of deformation of mantling deposits leading to landslides and accumulation on, as well as reworking in, lobate aprons. The mantling deposit is detached from the remnant massif (P19_008537_2285_XI 48N080W, feature #41, Fig. 2). North is up. Image credit: NASA/JPL/MSSS.

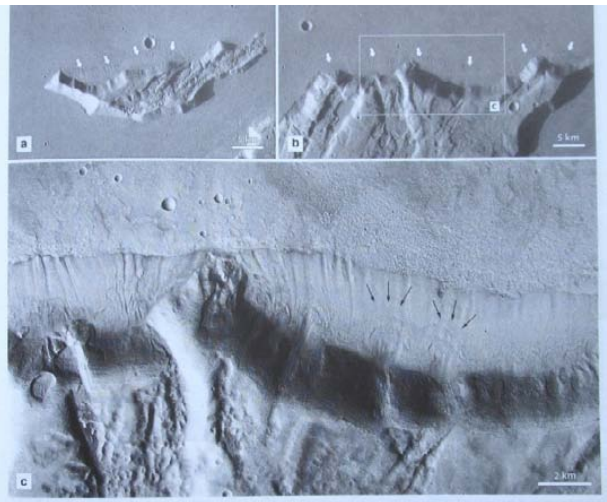


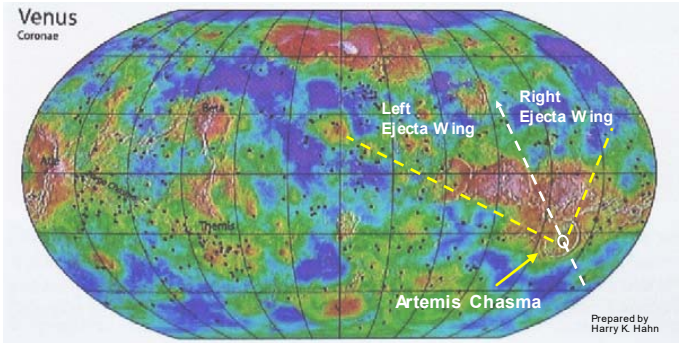
Fig. 10. Lobate debris aprons at isolated remnants in western Tempe Terra. The distribution and dimensions of lobate debris aprons in this more southern part are different from features located in more northern locations of Tempe Terra (Fig. 11). (a) Massif at 35.36°N with lobate debris aprons (white arrows) on the northern side, but not on the southern side (detail of HRSC image h5081_0000; centre at 35.36°N and 268.65°E; north is up, illumination is from the west/left). (b) Remnant highland massif with marginal lobate debris apron (white arrows). Lineations on lobate debris apron are parallel to the inferred flow direction (detail of HRSC image h5081_0000; centre at 35.0°N and 267.9°E; north is up, illumination is from the west/left). (c) Detailed view of lobate debris apron shown in (b); a convoluted or undulating pattern in plan view characterizes the texture of the upper (southern) parts of the apron. The position of lobes (e.g. black arrows) are controlled by indentations of the southern scarp (detail of CTX image P17_007852_2154; north is up, illumination from the SW/lower left). Image credit: ESA/DLR/FUB and NASA/JPL/MSSS.

Planet Venus and Earth's Moon also show traces of Global Impact Events and Expansion Tectonics

Venus

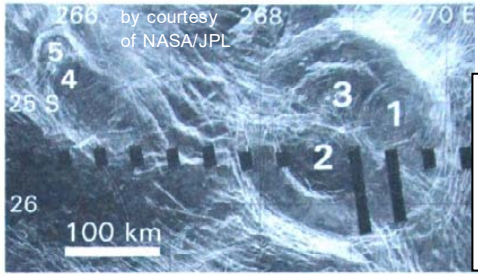
Prepared by Harry K. Hahn , 24.09.2015

Conventional interpretations assign Venus a volcanotectonic surface pocked only by ~1000 small impact craters. But this is incorrect ! Much of venusian plains are full of 100-600 km circular structures. And there are dozens of circular basins reaching up to 2500 km in diameter. All these circular structures are impact structures ! And the larger ones with > 1000 km diameter are responsible for triggering extensive expansion tectonics on Venus.
The hard evidence for this statement will be Artemis Chasma, which was caused by the oblique impact of a large impactor > ø 20 km with an orbit inclination > 45° (→ probably an Oort Cloud- or Sgr-DG- Comet or -Asteroid) !!



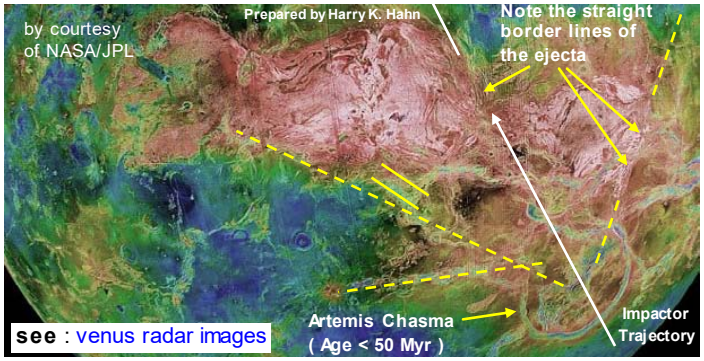
Topographic Map of Venus with coronae marked (→ black dots)

I recommend to read the article : **"An alternative Venus"** from Warren B. Hamilton in the book : **"Plates, Plumes and Planetary Processes"** : ISBN 978-0-8137-2430-0



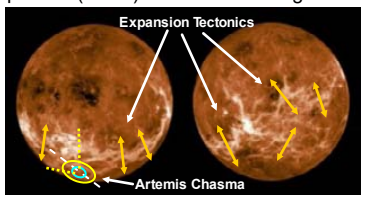
Note the nearly linear border line between coronae 2 & 3 !! Both coronae grew nearly simultanously !! These are impact structures !

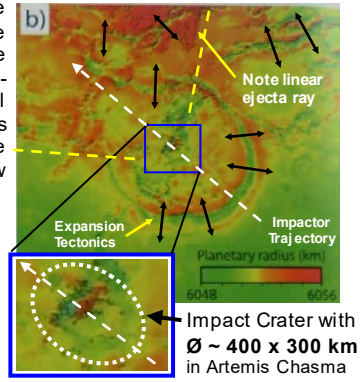
From all the **Coronae** structures shown on the image only a smaller structure (Elza Crater) is conventionally assigned an impact origin. However all these coronae structures are impact structures !! The large 200 km coronae (Herv or Coronae) is actually cut by 3 nested craters from almost simultaneous impacts (by fragments of a comet or asteroid), of which 1 cuts 2, which cuts 3 !



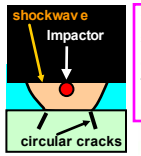
Topographic Map centered at 90° longitude (Magellan datas)

Artemis Chasma is not a structure (coronae) which was caused by a mantle plume (current theory) ! Artemis Chasma definitely was caused by an impact !!
There are a number of clear visible trendlines which mark the outline of the buttlerfly ejecta-blanket of this olique impact !! And it is clear that the impact- and the ejecta-impulses triggered global Expansion Tectonics on Venus, which is noticeable as a belt-like global fracture pattern (white) on the radar image below



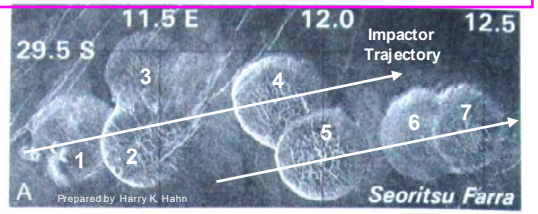


Impact Crater with **Ø ~ 400 x 300 km** in Artemis Chasma

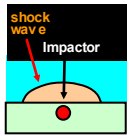


Coronae and **Pancake Domes** are definitely all impact structures ! Here coronae are probably the result of a powerfull atmospheric shockwave which causes a dent in the crust which then leads to the circular fracture pattern. And Pancake domes result from spherical shockwaves raising from under the ground

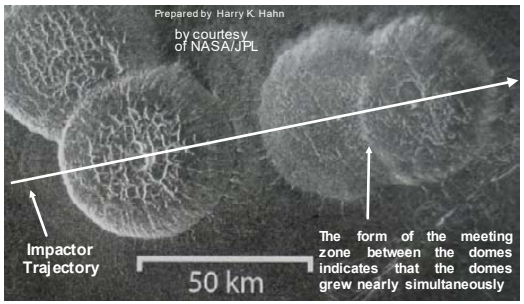
The image above describes how a Coronae is caused by the spherical shockwave caused in the very dense Venus Atmosphere The crust is dented and a circular crack pattern is the result



These plain features commonly regarded as volcanoes that appear instead to be of impact origins. (A) Chain of low **Pancake Domes** which show eastward-younging cookie-cutter superpositions, not magmatic-interference patterns !, and that are probably constructs of impacts in soft sediments by fragments of a comet or asteroid which was disrupted by Venus' gravity.

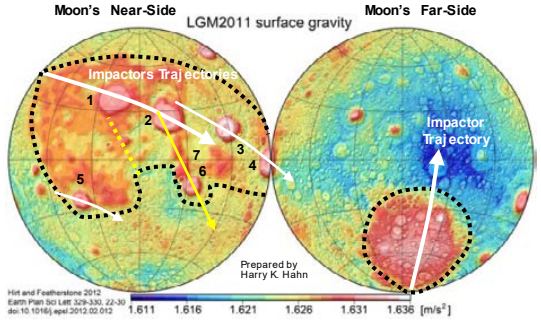


This image above shows how the shockwave of an impactor which hit the ground causes a Pancake Dome The very dense Venus Atmosphere prevents the ejecta from flying away.



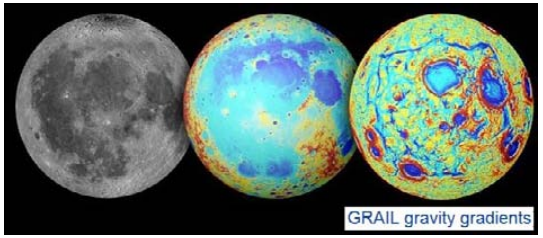
Earth's Moon

The gravity anomaly maps of Earth's Moon indicates at least one global impact event which triggered Expansion Tectonics on the Moon. This impact event caused the Mare areas on the near-side of the Moon. Another big impact event caused a circular area of Ø1500 km on Moon's far-side which comprises a handfull 200 km craters (Leibnitz- & Apollo-crater etc)

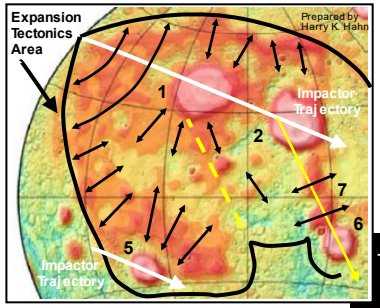


The global impact event

The global impact event on Moon's near-side was caused by at least 5 large impactors, probably fragments of an asteroid, with Ø 10 - 60 km each ! These impactors caused the base craters **No.1 - 7** with the diameters : 600, 550, 420, 530, 320, 330 and 220 km, which then produced most of Moons flood-lava filled Mare. →

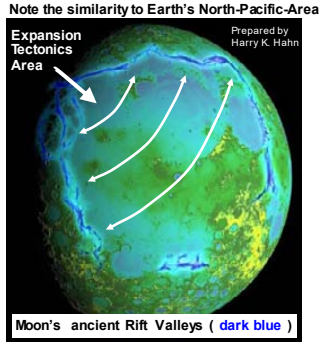


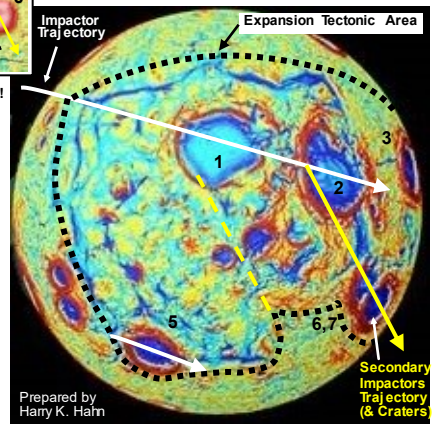
The Mare formed by the impact craters No. 1 - 7 :
Mare 1 – 7 : Imbrium , Serenitatis , Crisium , Smythii , Humorum Nectaris , Asperitatis → the last two Mare are secondary craters !



Expansion Tectonics on the Moon :
The nearly simultanous impact of the mentioned ≥5 impactors caused an extensive fracture pattern on Moon's near-side. Similar as on Earth, volatiles in the mantle must then have been the driving force for the following expansion of Moon's mantle. These volatiles must have been in a super-saturated state at the time after the impact when Expansion Tectonics began. Because of their size the impactors may have been a result of the P-T Impact or of the 1. or 2. Sgr-DG pericenter event

Note the similarity to Earth's North-Pacific-Area !





The Great Red Spot (GRS) on Jupiter and the big Dark Spots on Neptune are Impact-Sites of large Asteroid- or Comet Impacts !

A photograph from 1879 clearly shows how large the **Great Red Spot** of Jupiter was 140 years ago. It had a longish shape with a length of 40000 km ! Today it is only 15000 km long. **Since 1880 the GRS constantly shrank** from a long elliptical shape of 40000 km length to a short ellipse of 15000 km length. It's illusory to believe that a 40000km long storm can exist without a gigantic heat source on the 18000km deeper mantle surface. In all probability **the assumed heat source responsible for the GRS was caused by an impact** of a number of impactors, asteroid -or comet-fragments, on the same latitude of Jupiter, similar as it happened in 1994 when fragments of Comet Shoemaker-Levy-9 impacted on Jupiter ! But the Impact that caused the **GRS** was probably ≥1000 times more powerful and was caused by impactors in the Ø 10 – 30 km range. A similar impact occurred on Neptune just before 1989.

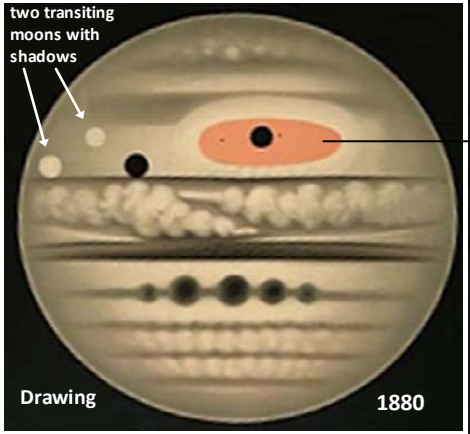
Length of GRS in the past

1880 -- 40,000 km

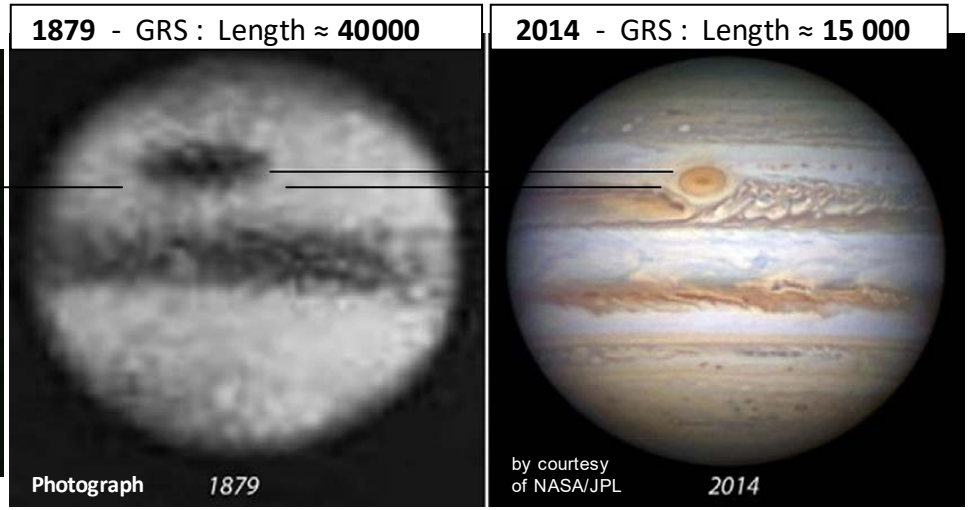
2003 Feb – 18,420 km
2005 Apr – 18,000 km
2010 Sep – 17,624 km
2013 Jan – 16,954 km
2013 Sep – 15,894 km
2013 Dec – 15,302 km

The Great Red Spot (GRS) on Jupiter must be the result of a multiple Impact Event

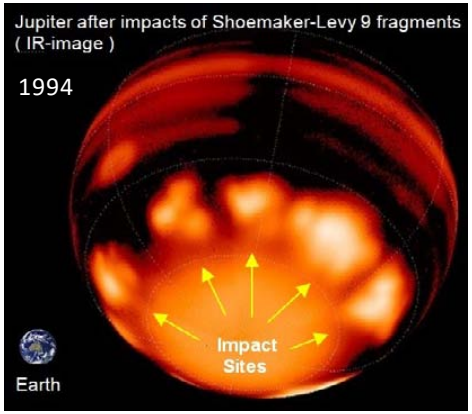
Historical datas show that the **Great Red Spot** was nearly three times as long as it is today. It had a > 40000 km longish elliptical shape, which probably was the result of a number of impacts on the same latitude, caused e.g. by a collapsed comet, similar as it happened 1994 when the collapsed Shoemaker-Levy 9 comet impacted on Jupiter → see images below.
Cassinis observation in 1665-1677 probably show a different spot caused by a different impact
All observations after 1880 when the gigantic spot was observed first, show a shrinking spot ! This is strong indication for a heat source (impact site) in the deeper mantle which is constantly shrinking ! A **photo from 1879** shows the gigantic longish **GRS** shortly after the Impact event !

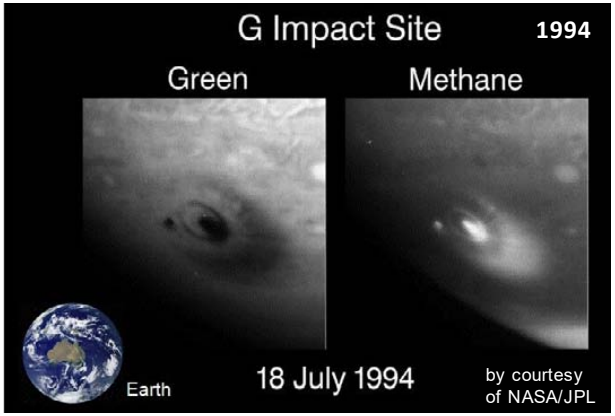


Drawing from E. Trouvelt 1880; A photo from 1879 of Jupiter from Anne Clerk's Book → see : Weblink



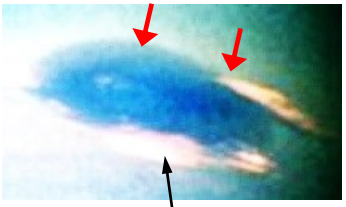
Fragments of **Comet Shoemaker–Levy 9** impacted on Jupiter in **July 1994**, 21 distinct impacts of comet fragments were observed. The largest G-Fragment Ø **1 - 2 km** caused a giant dark spot Ø 12000 km and released an energy equivalent to 6,000,000 MT TNT (600 times the world's complete nuclear arsenal !) → **see weblink :** **Shoemaker-Levy-9** and some **movies :** movie 01 , movie 02 , movie 03 , movie 04

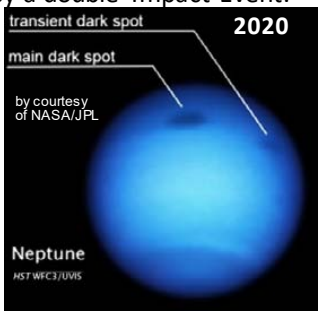


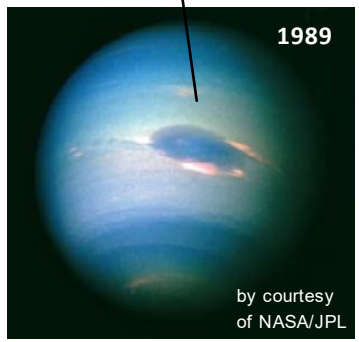


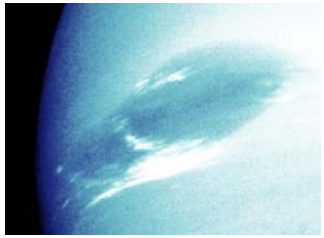
The big Dark Spots on Neptune are Impact Sites !

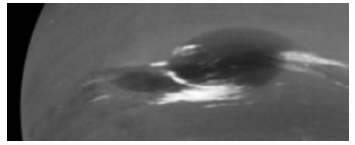
The **Great Dark Spot** that was observed by spaceprobe **Voyager 2** in 1989 had a size of **13000 x 6600 km**.
The scientists believed that this spot (GDS-89) was just a hole in the methane cover of Neptune. But a close look at the spot shows that there were two rotating cloud systems side by side ! Only a physical reason like two strong heat sources on the deeper mantle surface caused by a double impact could cause such an impossible weather system. 2020 the Hubble Telescope observed **two spots**, which probably were also caused by a double Impact Event.

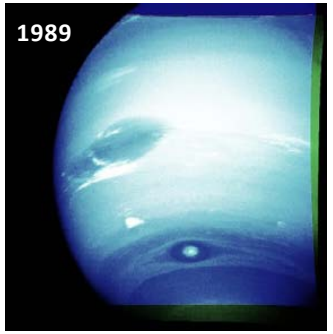


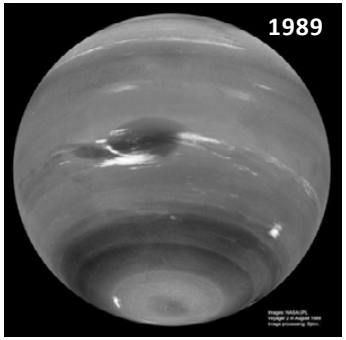












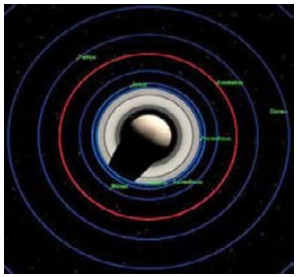
Enceladus, a moon of Saturn, shows evidence of a Global Impact Event, which probably happened < 200 Ma ago

Enceladus was hit by a large impactor, with a diameter in the range of 10 to 40 km on it's leading hemisphere. This caused an impact crater (a circular impact structure) with an outer diameter of approx. 350 km and an inner diameter of approx. 200 km. This happend in the geological recent past, probably less than 200 Ma ago.

The current believe is that the so called Tiger Stripes in the southern pole area are caused by tidal pull from Saturn's gravity. But this is incorrect ! The tiger strips are the result of largescale global deformation on the small Saturn Moon Enceladus caused by the yet unknown global impact event.

This impact event not only caused a global fracture pattern. It also caused expansion tectonics on the moon and largescale cryo-volcanism in the southern hemisphere, which is still going on today. The jets coming out of the cryo-volcanos mainly contain water out of the upper mantle of the moon

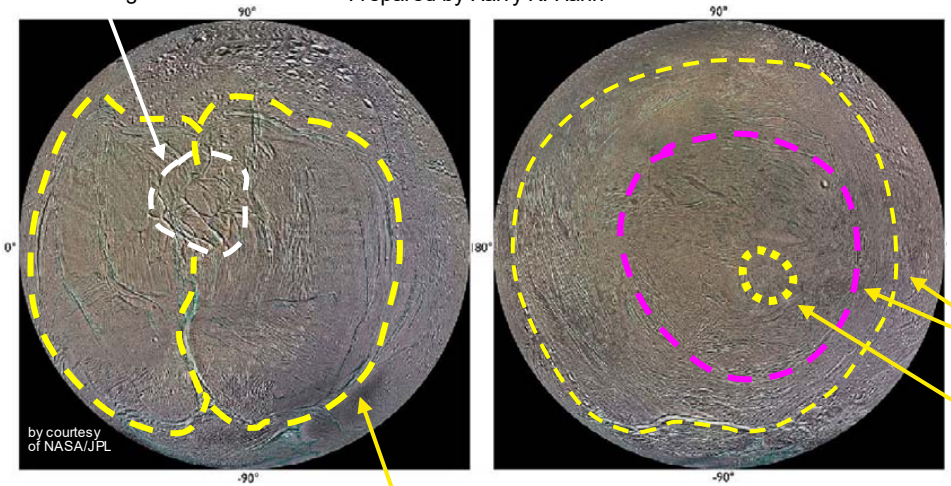
Diameter : 503 to 513 km
Orbital Period : 1.37 days
Semi-major axis : 237948 km
(orbit around Saturn)
Inclination : 0.019°
(to Saturn's equator)
Orbital velocity : around 12 km/s
Rotation Period : synchronous
(always faces same side to Saturn)



Enceladus's orbit (marked in red) from above Saturn's north pole

Chaos Region

Prepared by Harry K. Hahn



Trailing Hemisphere

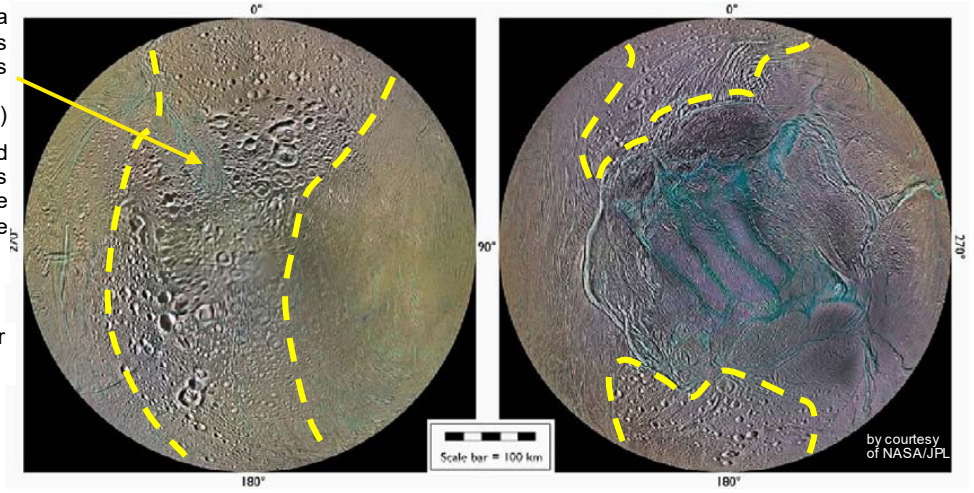
Leading Hemisphere

Old surface area with many craters only within this belt-shaped area (see yellow lines)

The belt with old surface area is terminating on the borders of the Tiger Strips Area

Outer & inner impact area

assumed Center of Impact



Northern Hemisphere

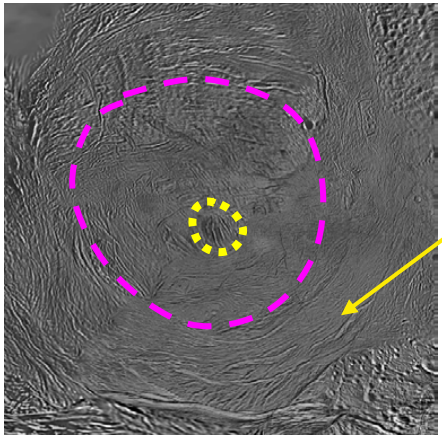
Southern Hemisphere

two kidney-shaped "tectonic-plates" caused by the impact shockwave

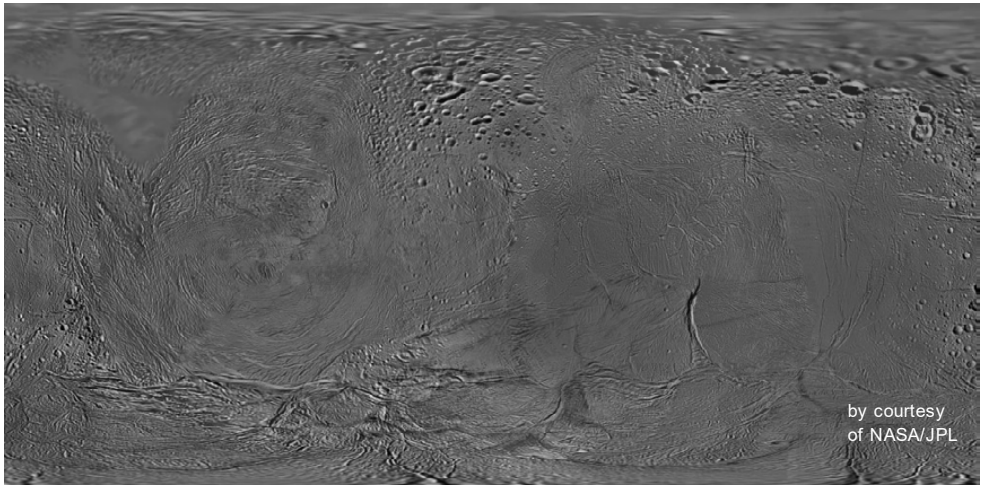
Detail view of the chaos region near the center of the Trailing Hemisphere.

This is where the peak of the shockwave, which travelled through the deep mantle, hit the trailing hemisphere from the inside. The two kidney-shaped "tectonic-plates" on the trailing hemisphere indicate that the shockwave travelled around a solid core before focusing in a peak area on the trailing side

Detail view of the inner impact area

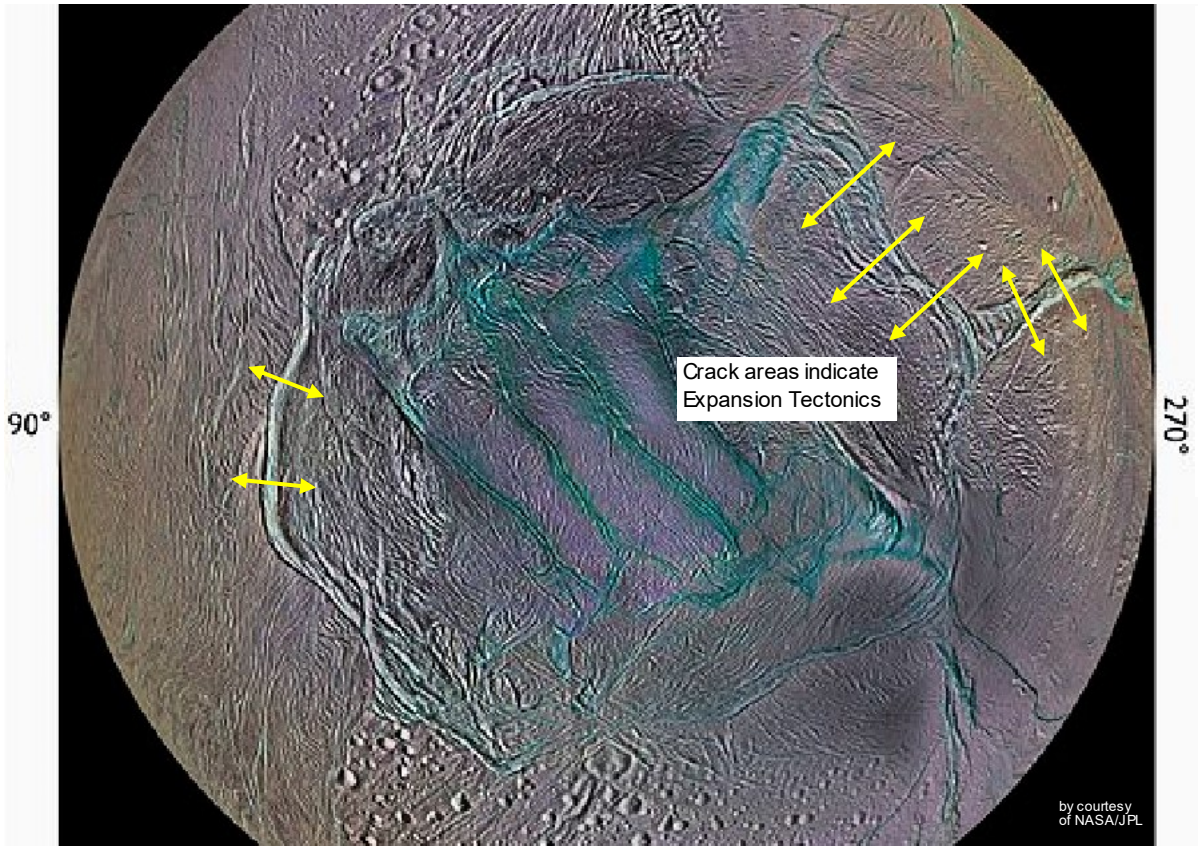


Note the circular structures !



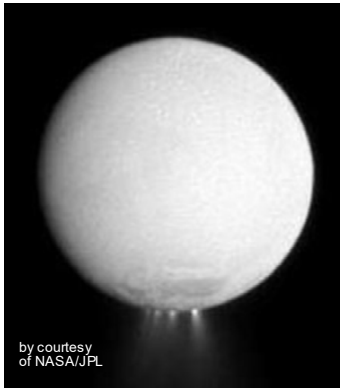
The “Tiger Strips” on Enceladus are the result of the described Global Impact Event

Prepared by Harry K. Hahn , 24.09.2015



Detail view of the Tiger Strips area on Enceladus Southern Hemisphere

The Tiger Stripes on Enceladus southpole-area are the result of the largescale impact event and the following global deformation of the moon. The global deformation of Enceladus was caused by the shockwave which was triggered by the impact. This shockwave travelled through the interior of the moon and caused large scale fracture patterns on the leading- and trailing hemisphere. However a belt between the leading- and trailing hemisphere survived mostly without damage, with exception of the Tiger Stripes area. But because there is strong indication of Expansion Tectonics in this Tiger Strips area, it can be concluded that the whole moon expanded considerably after the impact ! And it seems that the expansion of the moon is still going on. The wide crack areas and the ongoing cryovolcanism are indicators for this ! The expansion of the moon must be driven by the mantle-volatiles ejected by the jets.



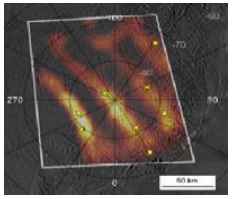
Jets of water and ice shooting up from “the Tiger Stripes” on Enceladus. The volcanoes along the fractures are known as cryovolcanos, meaning "volcanoes of ice". The jets are mostly water, they also contain ammonia, methane, carbon dioxide, nitrogen, and trace amounts of hydrocarbons as well as solid material including sodium chloride crystals and ice particles.
The jets (or plumes) at Enceladus seem similar in chemical makeup to comets (according to NASA scientists).
There is evidence for a large south polar subsurface ocean of liquid water within Enceladus with a thickness of around 10 km.

The Tiger Stripes (Enceladus) → From Wikipedia

The stripes are spaced approximately 35 kilometers apart. The ends of each tiger stripe differ in appearance between the anti-Saturnian and sub-Saturnian hemisphere. On the anti-Saturnian hemisphere, the stripes terminate in hook-shaped bends, while the sub-Saturnian tips bifurcate dendritically.
Virtually no impact craters have been found on or near the tiger stripes, suggesting a very young surface age. Surface age estimates based on crater counting yielded an **age of 4–100 million** years assuming a lunar-like cratering flux and 0.5-1 million years assuming a constant cratering flux

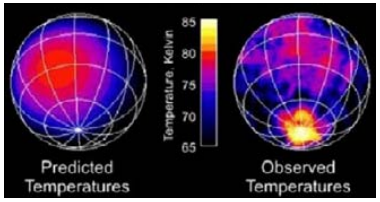
IImages from the ISS camera onboard *Cassini* revealed the 4 tiger stripes to be a series of sub-parallel, linear depressions flanked on each side by low ridges. On average, each tiger stripe depression is 130 kilometers long, 2 kilometers wide, and 500 m deep. The flanking ridges are, on average, 100 meters tall and 2–4 kilometers wide. Given their appearance and their geologic setting within a heavily tectonically deformed region, the tiger stripes are likely to be tectonic fractures. However, their correlation with internal heat and a large, water vapor plume suggests that tiger stripes might be the result of fissures in Enceladus' lithosphere.

Researchers modeled eruptions on Saturn's moon Enceladus as **uniform curtains** along prominent fractures that stretch across the icy moon's south pole. **(→ Compare this to the Mid-Ocean-Ridges on Earth ! → comment by Harry K. Hahn)**
The scientists found that brightness enhancements appear as optical illusions in places where the viewer is looking through a "fold" in the curtain. The folds exist because the fractures in Enceladus' surface are more wavy than perfectly straight. The researchers think this optical illusion is responsible for most -- but not all -- of what appear to be individual jets. Some discrete jets are still required to explain Cassini's observations.



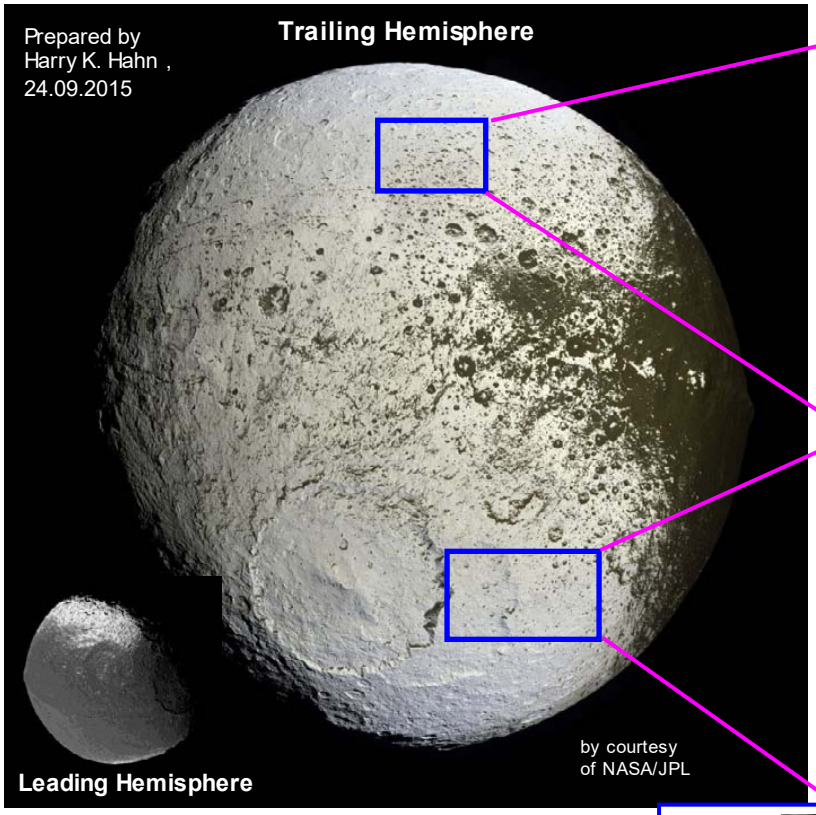
The fractures are much warmer than surrounding area

Enceladus heat color map



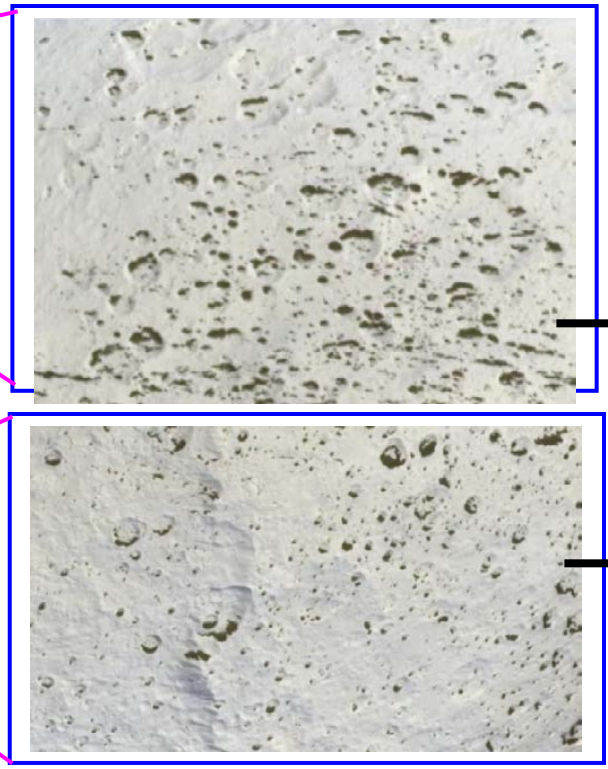
The icy surface on Saturn Moon Iapetus originates from a large cryo-volcano which is the result of a Global Impact

The analysis of NASA, that Iapetus had originally a complete icy surface which was covered with dark material, is incorrect !
It is the opposite way ! Iapetus had originally a rocky surface which was covered by ice from a very large cryo-volcano, resulting from a global impact. This impact formed the ∅ 580 km Turgis Impact Basin. And the equatorial ridge may be the result of the water-loss of the mantle region of Iapetus caused by the cryo-volcanism.

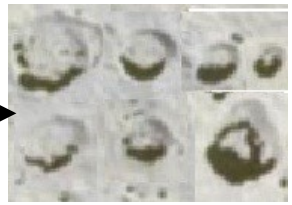


The following explanation will provide the hard evidences for this statement !!

Diameter : **1470** km
Orbital Period : 79,32 days
Semi-major axis : 3 560 820 km
(orbit around Saturn)
Inclination : 15,47°
(to Saturn's equator)
Orbital velocity : around 3,26 km/s
Rotation Period : 79,3 d synchronous
(always faces same side to Saturn)

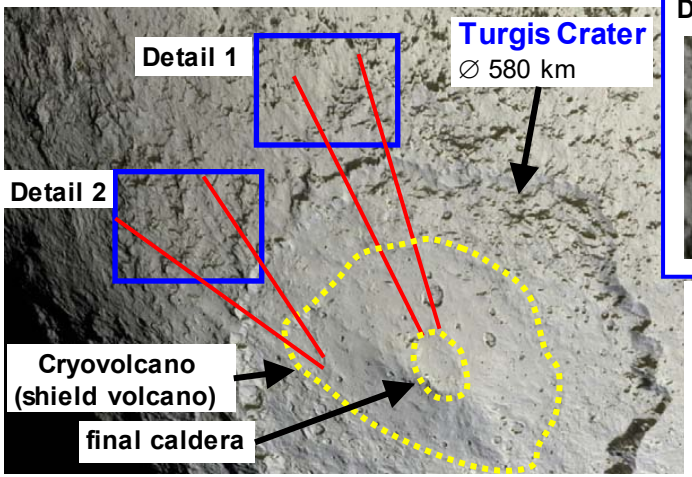


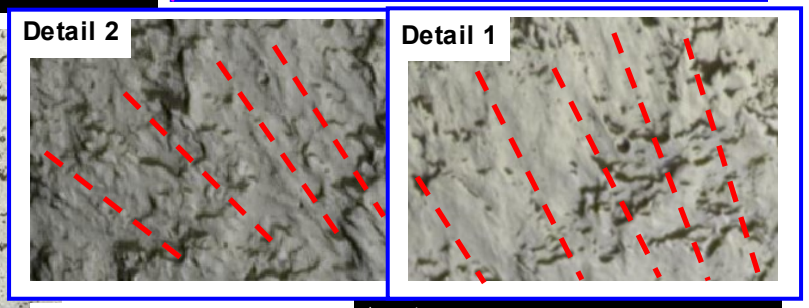
Note the appearance of the craters from the selected areas in the northern- and in the southern hemisphere !!



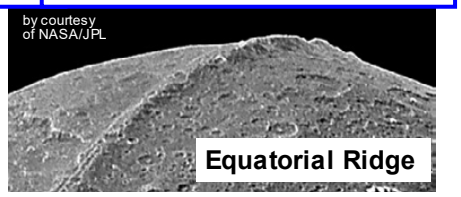
It is easy noticable that the dark areas in the craters must be caused by melting (sublimation) of the ice which covers a dark rocky surface !!

It is always the area of the craters which faces towards the sun, where there is no ice-cover ! This can only mean, we are talking about a thin ice cover on a rocky surface !! And this thin ice cover (< 100 m ?) has sublimated away from the sun-facing rocky surface areas of Iapetus !!





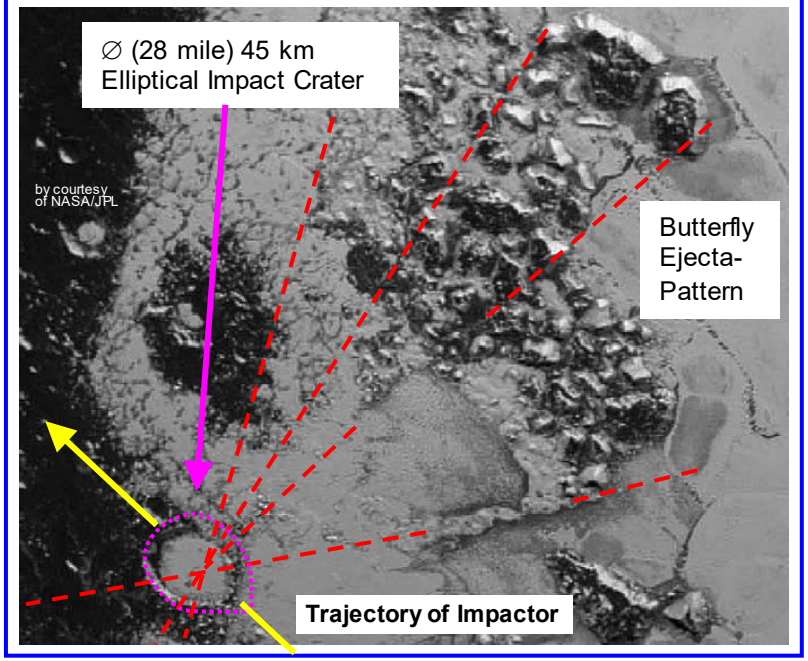
The low coefficient of friction (0.1-0.3) of the Iapetus ice avalanches is probably caused by heat coming from the impact area (warm ice)



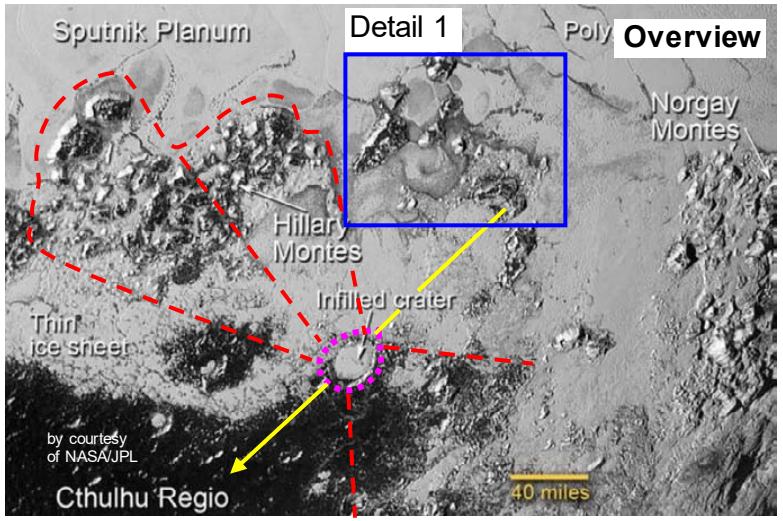
The ice-cover on Iapetus with high probability came from a large cryo-volcano in the Center of the Turgis Crater, which means that the Turgis Crater is responsible for the ice cover on Iapetus Trend-lines in the ice formations around the crater indicate that the ice came from the marked cryo-volcano area. And the equatorial ridge therefore may be the result, of either the impact shockwave, the water-loss in the mantle & tidal forces or a result of a combination of them

9a On Pluto the "heart-shaped" region & Sputnik Planum were formed by a complex global impact event

There are different geological formations around Sputnik Planum, which indicate an impact origin. Sputnik Planum itself seems to be the result of several big impacts which caused a large fracture and led to expansion tectonics and volatiles rising from the mantle to Pluto's surface in this area



The image below shows an overview of the surface features around the Hillary Montes where the small elliptical crater with butterfly-ejecta pattern is visible



The mountain areas around Sputnik Planum, e.g. Hillary Montes and Norgay Montes, are the result of a multiple Impact event. With high probability the fragments of a burst comet or asteroid formed these mountains, when they impacted on Pluto.

The image on the lefthand side shows clear trend-lines in the Hillary Montes region which all originate in an approx. 28 mile (45 km) wide crater, which is infilled with ice now Hillary Montes at the border line of Sputnik Planum probably formed less than 100 million years ago as a result of this impact event. (see also : Pluto images from NASA) "This is one of the youngest surfaces we've ever seen in the solar system," said Jeff Moore (from the Geology, Geophysics and Imaging Team (GGI) / NASA)

"Because Pluto cannot be heated by gravitational interactions with a larger planetary body, some other process must be generating the mountainous landscape" said the GGI deputy team leader John Spencer.

And he is right ! The mountains were formed by a complex multiple impact event !
The small 28 mile wide crater is only part of a much larger impact event !

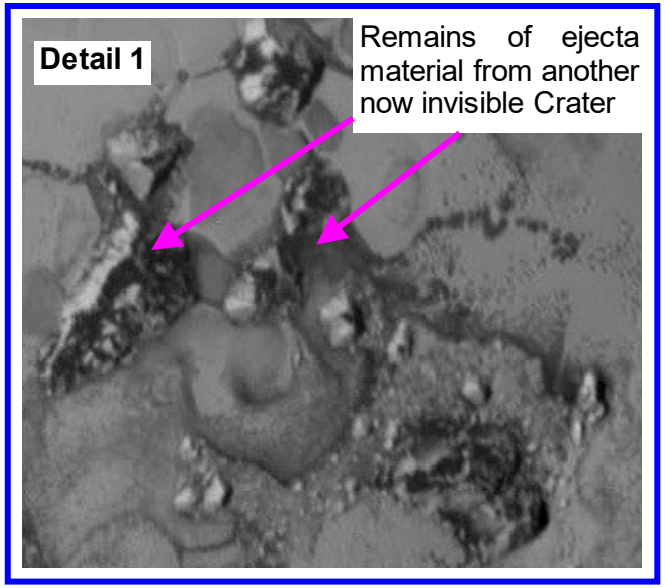
From the slightly elliptical shape of this crater the trajectory of the impactor can be determined. The trajectory of the impactor and the arrangement and position of the butterfly-ejecta of this oblique impact crater give indication about the possible position of further impact craters and ejecta areas which all belong to this complex impact event.

The area "Detail 1" (marked in blue on the left image) seems to contain remains of ejecta from a similar impact as the one described above (shown on the two images on the lefthand side)

However most of the ejecta of this impact is not visible anymore, either because it is located under the "sea level" of the "Sputnik Planum Ocean" now, or because it may have melted in the aftermath of the impact.

But it seems that there are more traces of this "impact crater" are visible on the other side of the "frozen Sputnik Planum Ocean" !!

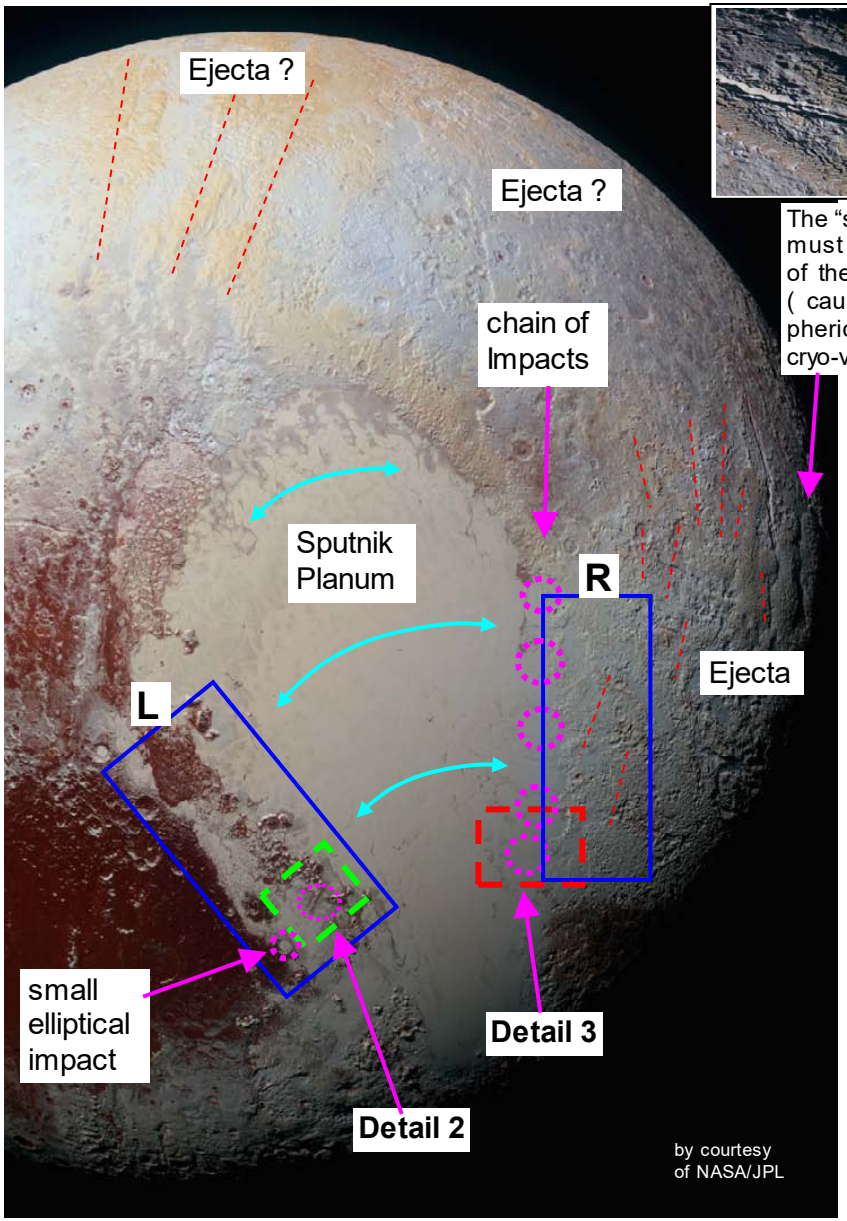
→ **See next page**

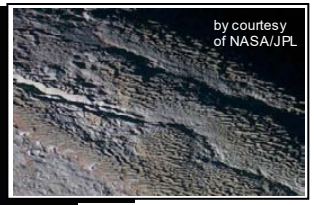


A chain of impacts seems to have caused a large fracture in Pluto's crust, which then led to expansion tectonics

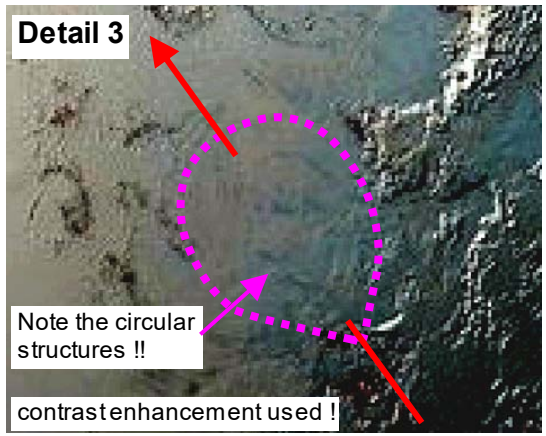
Along the linear sides in the East and West of Sputnik Planum there are structures visible which indicate the impact of several impactors. (the two linear sides are marked with blue boxes). On the west side (marked with L) the already mentioned small elliptical impact is visible. And on the east side (marked with R) structures are noticable which indicate **4 to 5 large impact craters with diameters in the range of ∅ 70 to ∅ 100 km.**

These impact craters are all flooded and infilled with ice and only indirectly visible through circular structures in the ice (→ e.g. see Detail 3). It seems that these impact craters led to expansion tectonics which formed Sputnik Planum and led to the outflow of H_2O, N_2 and other volatiles from the mantle.

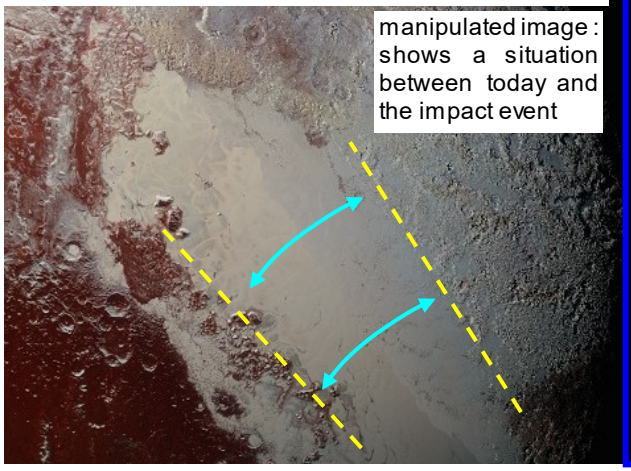


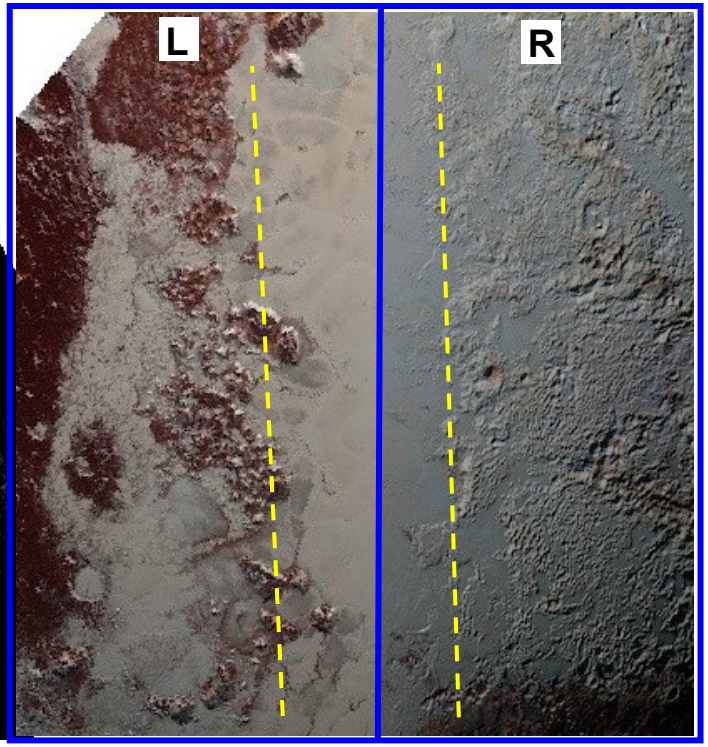


The "snakeskin area" must also be a result of the impact event. (caused by atmos-pheric flow or by cryo-volcanism)



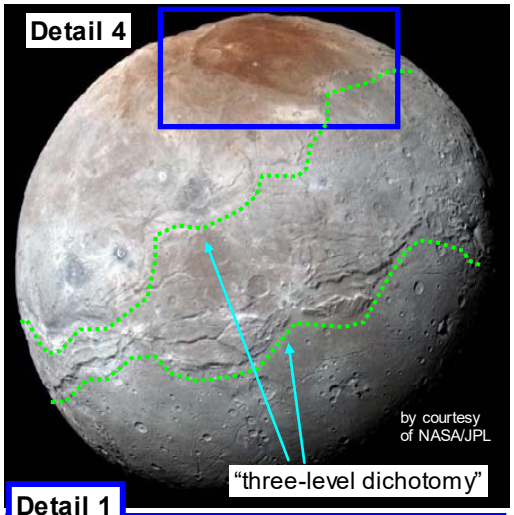
At the time of the impact the areas of detail 2 and detail 3 (or L & R) were one and the same area, before expansion tectonics set in and slowly moved the two sides (yellow lines) away from each other (see below !). Remains of the crater structure are only visible in detail 3. The slightly later formed small elliptical impact on the west site probably overprinted the remains of the larger crater indicated in detail 2 & 3.

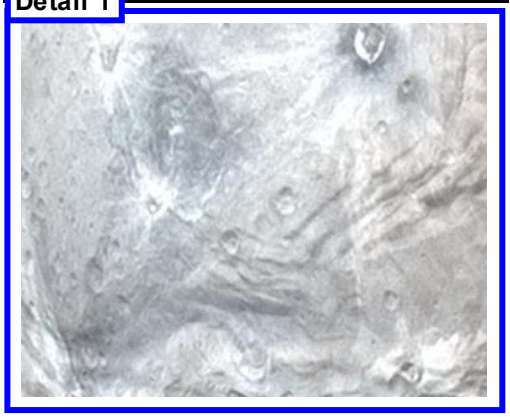


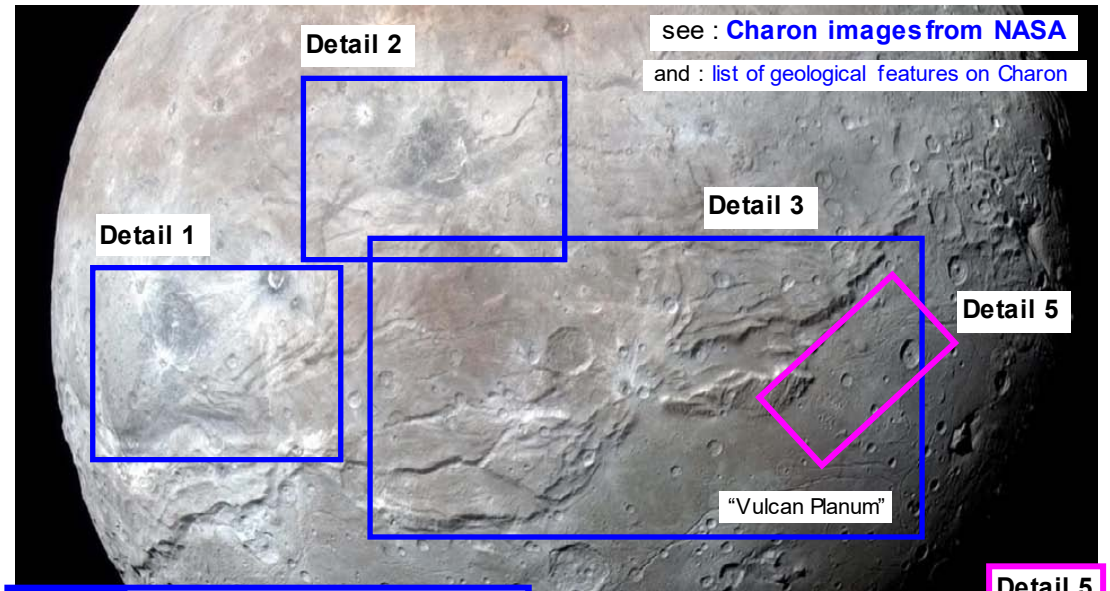


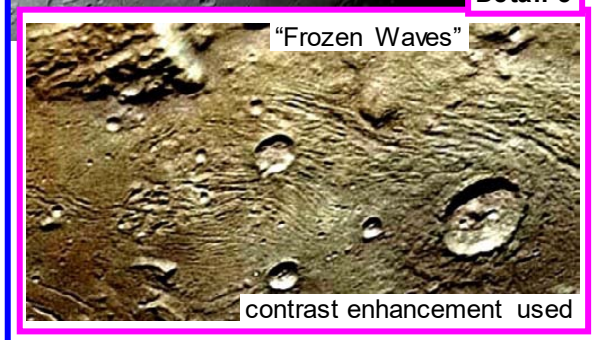
9b The fracture belts on Charon are caused by Comet Impacts, which formed craters in the diameter range ∅60-110 km

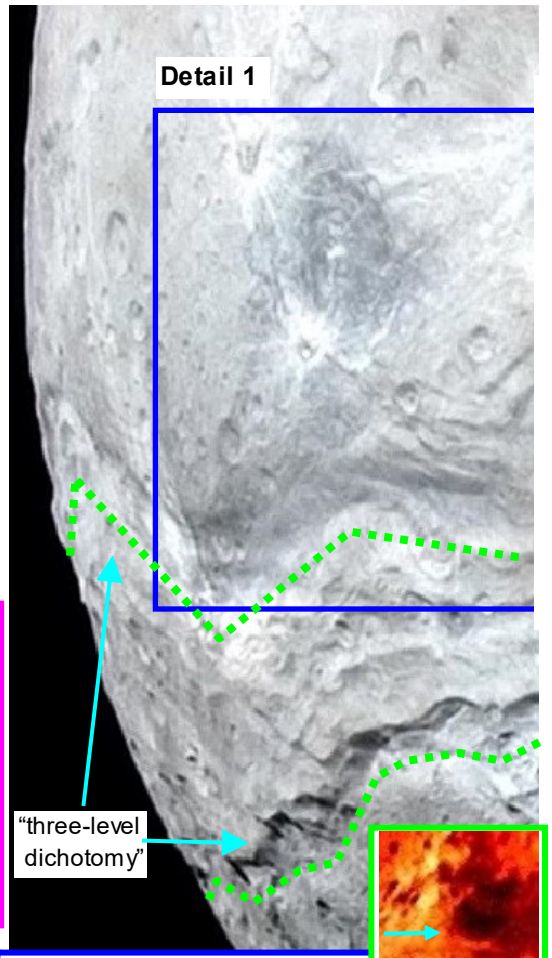
A number of large impact craters, probably caused by high velocity comets, are responsible for the fracturing of **Pluto Moon** Charon's crust. The cracks which resulted from these impacts not only caused the extensive canyon systems on Charon, they also triggered global expansion tectonics on Charon. There is a "three-level dichotomy" visible on Charon which probably was caused by two global impact events, which happened at different times.

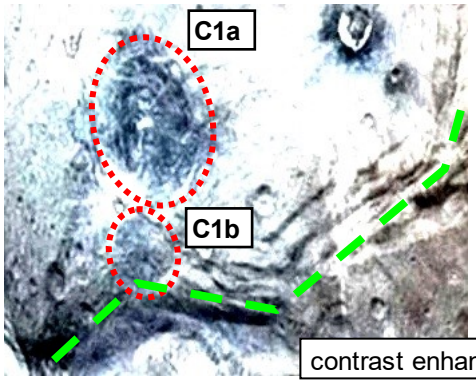


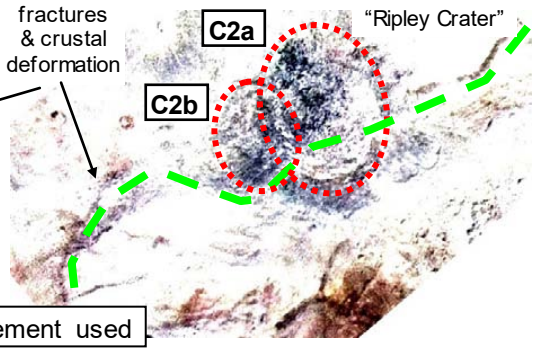




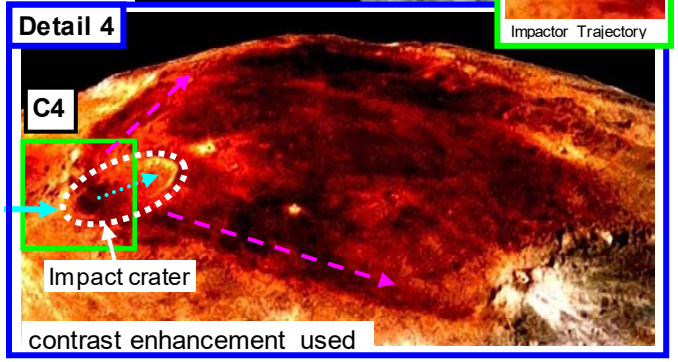






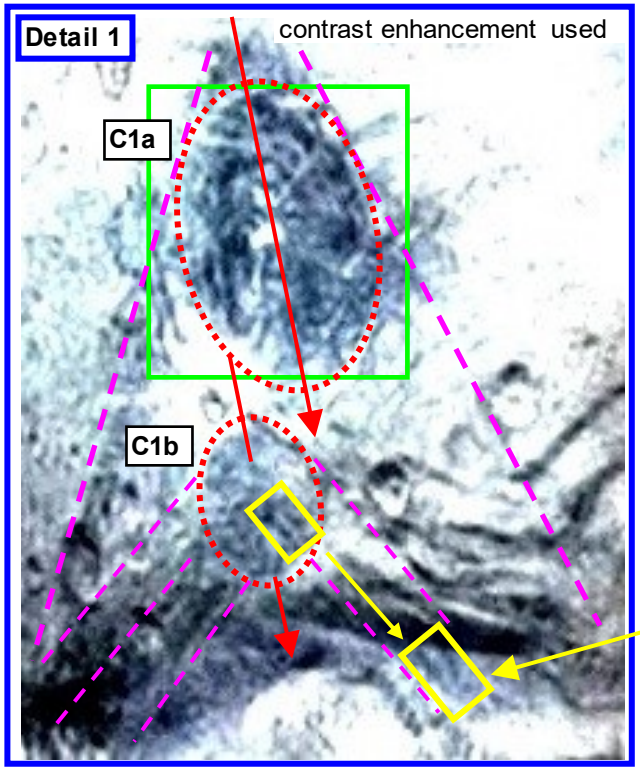


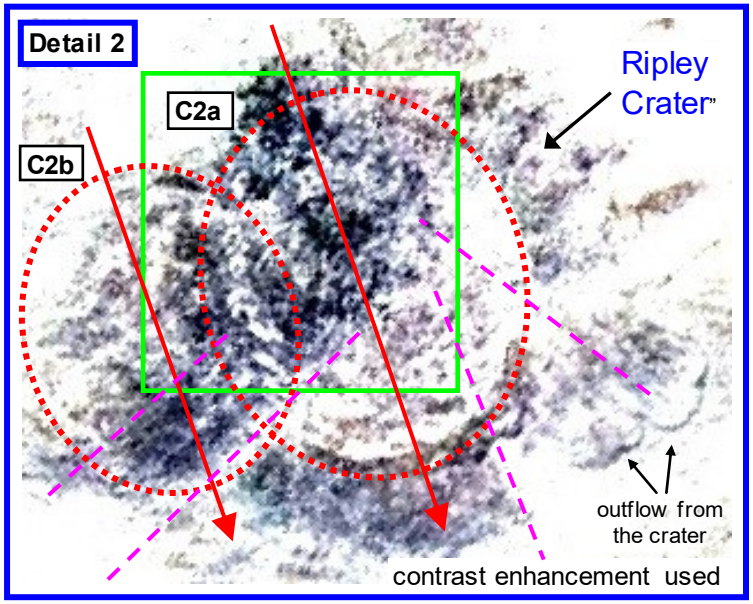
The Impact Craters visible in Details 1 & 2 were probably caused by comet fragments. These impacts are responsible for the fractures and the crustal deformation shown in the Details 1 & 2, which triggered global expansion tectonics and led to the "first dichotomy level". The dark surface markings in the north polar region are probably also the result of a big (carbon-rich) comet impact. See marks & description in Detail 4

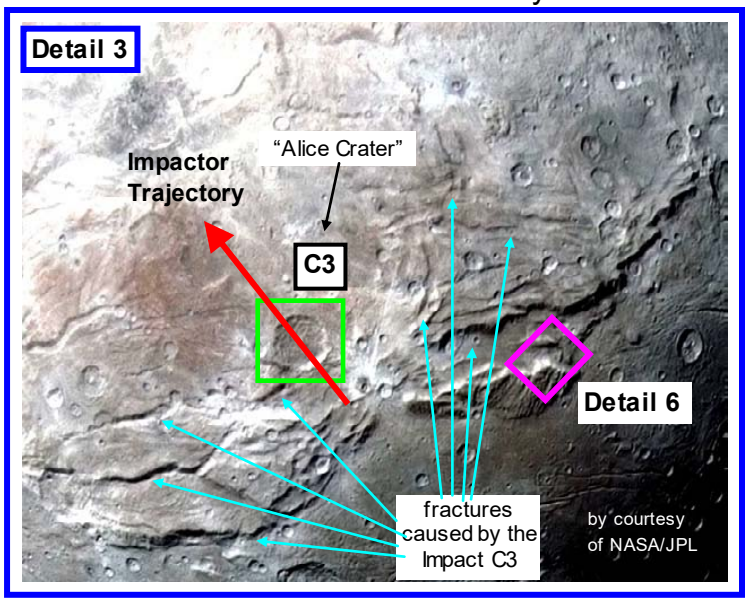


The "three-level-dichotomy" on Charon is a result of expansion tectonics, triggered by impact-induced fractures

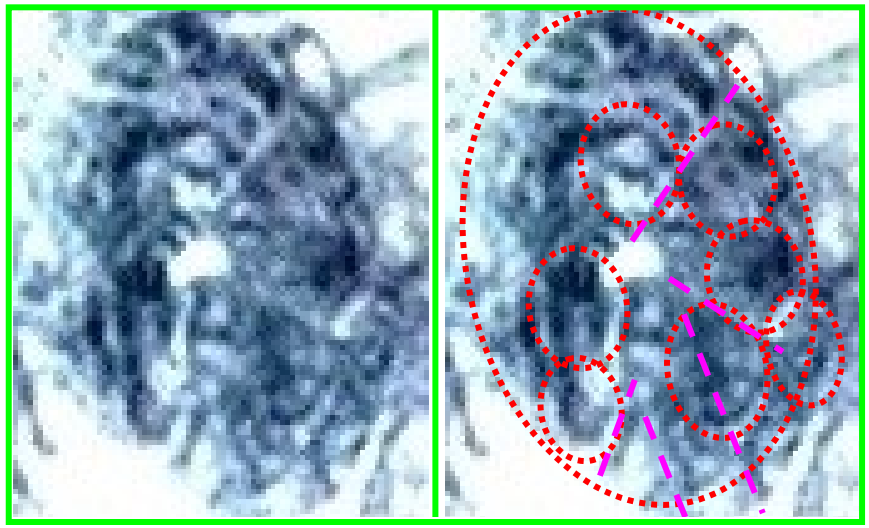
The "first dichotomy level" noticeable on Charon was caused by at least two simultaneous impact events which occured 350 km apart from each other Each of these two impact events not only produced two distinctive crater areas, which again were formed by several (> 10 (comet) fragments). It also caused extensive fractures and deformations in Charon's crust, which triggered global expansion tectonics and led to this "first dichotomy event".

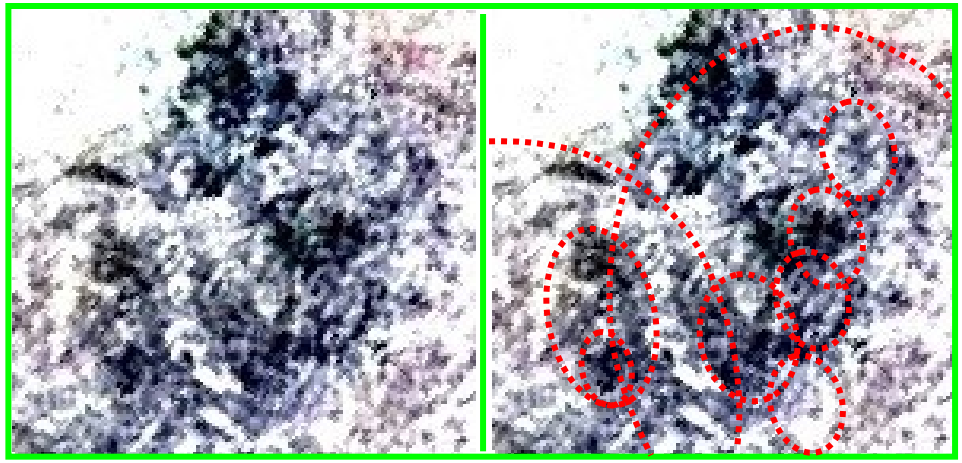




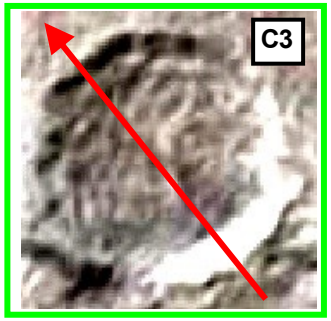


The two sections of the twin ejecta ray (→ yellow boxes) , belonging together, were separated by crustal deformation





The "second dichotomy level" noticeable on Charon was also caused by at least one (or more) large Impact event(s) which led to another intensive episod of global expansion tectonics, which formed the young "Vulcan Planum" area on Charon.
Crater C3, which is probably also the result of a (burst) comet impact, is responsible for the majority of the fractures shown in Detail 3 ! This can be read from the fracture pattern and the trajectory of the comet which produced the impact crater (Alice Crater). The smooth Vulcan Planum is the result of expansion tectonics triggered by the fractrures, which brought large amounts of H_2O- & NH_3-rich material to the surface.



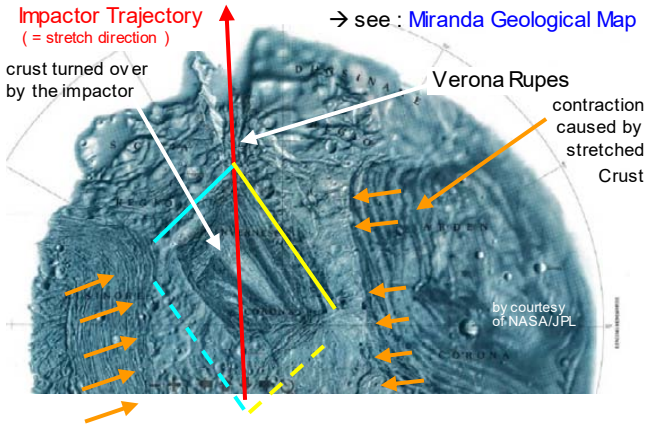
Detail 6 shows landslides probably caused by water-rich material, which probably was deposited by cryovolcanism.
A result of expansion textonics !

Epilogue :

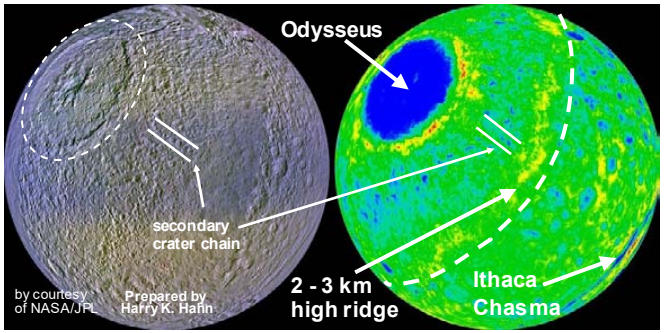
At first a few words to some other planets and moons which need to be analysed under consideration of the new acquired knowledge about global impact events.

There are many structures noticeable on other planets and moons which seem to be traces of global impact events, but they are not recognized as such yet ! That's why planetary scientists must continue the work which I started with this study !!

For example on Uranus moon **Miranda** there is an impact structure visible, which obviously was caused by a powerful "gazing shot" !
A large impactor seems to have "scratched" along Miranda's surface and has "turned-over" a certain area of Miranda's crust in slow motion (→ like a skin-lobe is cut and turned over by a sharp knife).
This caused the triangular-shaped feature on Miranda's surface, which actually shows the deeper layers of Miranda's crust, and it also caused the 5 km deep "Verona Rupes" fault-scarp.
Because of the forcefull stretching of Miranda's crust in the triangular shaped area, contraction was caused in perpendicular direction to the impactor trajectory right and left of the stretched area. This caused the bow-shaped "rift-valleys" (cracks) right and left of the "triangular gash" which also show deeper layers of Miranda's crust.

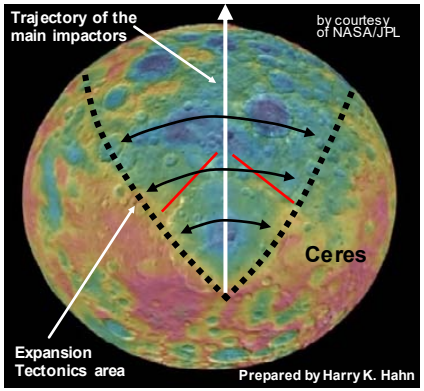


Or Saturn's moon **Tethys** with the dominant feature, the 8-kilometer-deep and 440-kilometer-wide Odysseus impact basin. This moon can help to better understand global impact events.
For example the visible 2-3 km high (equatorial) ridge (yellow) may be a tectonic (shock) feature related to the impact event or it may be a deposit formed when the ejecta blasted out of Odysseus, and fell back onto the surface at high velocity. Between the ridge and Odysseus, the surface is scoured & pockmarked, and there are clear visible secondary crater chains in this area. At bottom right can be seen the globe-circling trench Ithaca Chasma, formed as part of Tethys stretched apart.



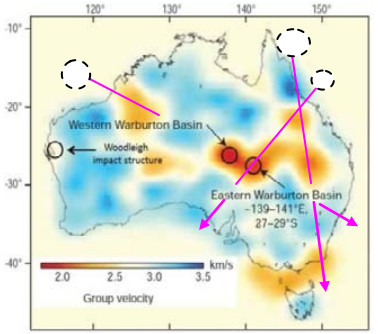
→ see also : animated rotation of Tethys

Or the dwarf planet **Ceres** : Similar as on Earth's Moon, Expansion Tectonics was triggered on Ceres by a global impact event, which was caused by several impactors which impacted simultanously



Like on Earth's Moon volatiles in the mantle, e.g. H_2O (→ in a super-saturated state) must have caused the expansion tectonics visible on Ceres. An indication for that maybe Ahuna Mons which in all probability resulted from cryovolcanic activity

There are still many other large-scale impact structures on Earth which need to be properly analysed, in order to figure out the correct tectonic model for Earth before & after the PT-Impact Event → e.g. the East- & West-Warburton Impact Basins.



→ see image on the left !
There are two craters which formed the East- & West Warburton Basins approx. 300-360 Ma ago (estimated diameter Ø 100-200km each)

Weblinks :
News Article 1 , News Article 2
East-Warburton Basin
Eromanga Basin
(Woodleigh Crater)

However this work must be carried out by experienced planetary scientists & geologists now, together with the analysis of all planets and moons

Because we need to know the root causes of all global impact events which took place in our Solar System and we need to find all impact structures !!

After reading this study about global impact events
What practical measures should be taken ??

1.) The first and most important measure must be the continuation of the research work, regarding global impact events and their causes & effects, which was started with this study here !

Scientists from many different disciplines must take on the challenge to find further evidence for the global impact structures described in this study

2.) Rock samples from all new impact craters and impact structures described in this study (Part 1-4) should be collected and analyzed.

3.) After the confirmation of the P/T-impact crater and related secondary impact structures a new analysis & simulation of the tectonic processes in Earth's past, in the last 253 Ma, must be done !

4.) Then the cause of the expansion tectonic process, which obviously was triggered by the P/T-impact, must be found. And because there are other planets & moons in our solar system where expansion tectonic processes were triggered by a global impact event, a teamwork of scientists from different areas is required.
To find the driving physical / chemical process for the mantle expansion visible on different planets and moons, a close collaboration of planetary scientists, geophysicists, geologists, chemists and physicists (especially with expertise in fission research and high-pressure / high-temperature material research) ls required.

5.) A more precise and more detailed computer analysis of the collisions (pericenter events) of the Sagittarius Dwarf Galaxy with our galaxy must be done. In all probability debris- (mass) streams resulting from these collisions are the cause of periods of violent global impact events in our solar system ! That's why it is important to find out the exact composition, extension & the effects of the debris streams, caused by these collisions, on our solar system !!! The starting point of this analysis should be the study from Mr Chris Purcell
Important ! : Especially the effects and the position of the leading tidal tail of the **Sgr-DG** in the past (-300Ma) & in the future must be studied !!

6.) Because the distribution of metal-ores and energy resources, like crude oil or natural gas in Earth's crust, is mainly caused and defined by large (global) impact events, knowledge of the precise location and size of all impact craters on Earth is crucial for future explorations of ore deposits, and especially for the exploration and discovery of new large oil- and gas-deposits !!

Good knowledge of all large impact structures on Earth will make a big difference in future explorations, in order to find these important energy- and ore- deposits for mankind !!

Especially the correlation of big impact craters with the formation and the development of large oil-fields & gas-fields must be precisely analysed !! It seems that in particular the impact-related tectonic motion of crust fragments and magma streams, which were created during large impact events, are an important condition for the development of large oil- and gas deposits !!

This correlation must be studied & analysed !

Having seen and analyzed the Permian-Triassic Impact and the global destruction which it caused :

THE FOLLOWING WARNING MUST BE GIVEN :

We must consider different worst case scenarios in regards to one or more impactors (asteroids or comets) which are on a collision course with our planet Earth !!! And we must find solutions, and build and install suitable defence technology in space, in order to deflect the impactors of all assumed worst case scenarios away from Earth !!!

Possible Worst Case Scenarios to consider !! :

1.) Accumulations of Asteroids and/or Comets with a density like in the Asteroid Belt are approaching from deep space and they are on a collision course with Earth, having velocities up to 100 km/s !!

2.) Up to 10 Asteroids in the diameter range of ø 10–40 km with velocities of 20-100 km/s are on a collision course with Earth and all are arriving at the same time !! Pre-Warning Time < 18 months !!!

3.) A large Asteroid with ø 200 km and a velocity of 100 km/s is approaching from deep space (from outside the solar system !!) and is on a collision course with Earth. Pre-Warning Time < 2 years !!!

As long as we don't exactly know what astro-physical processes have caused the global impact events within the last 300 million years, described in this study, we must take sufficient precautions !! in this violent and merciless universe !!

Because if we don't do so !!, Mankind and most other species on Earth could go extinct within a very short time !!, just like the Dinosaurs !!!

There are already some ideas and plans for the realization of technology to deflect small asteroids.

But every idea or plan which I have seen so far regarding the deflection of an asteroid or comet is far away from being able to cope with one of the described worst case scenarios !

If we are very lucky we could survive Worst Case Scenario 1.) But only if all asteroids or comets > Ø 10 – 20 km would miss our planet Earth !

Because we are not able to deflect such large impactors yet !!! We just don't have the required defense capability and technology to do that !

I have made an own assessment, and I found a few suitable defense strategies which are able to cope with large impactors, up to Ø 200 km !!

However these strategies only work if the required technology is installed in space (in defined locations in our solar system !) and if we are ready (well trained !!) to use this technology. And it would only be possible to cope with high-velocity Asteroids or Comets (with velocities >30-40 km/s) if the technology is installed with maximum rocket performance which is possible and if it would be installed on many locations in our solar system !!!

It would probably take at least 20 years to design, build and install such a defense system and it would probably cost ≥ US$ 100 billion !

However if all members of the UNO cooperate in the effort to build such a defense system for our planet Earth, then it shouldn't be a problem to finance it !!! And it also should't be a problem to

convince the UNO members to invest in such a defense system for our planet Earth !!

Because this is really the only possible insurance against a global impact event and the extinction of mankind and the total destruction of our world !!

And we shouldn't wait until the devil comes around the corner ! Fast and smart action is required !

How such a defense system for our planet Earth could look like is described in my following study :

→ see Weblink : "To the deflection of asteroids in the diameter range of 5 to 200 Km"

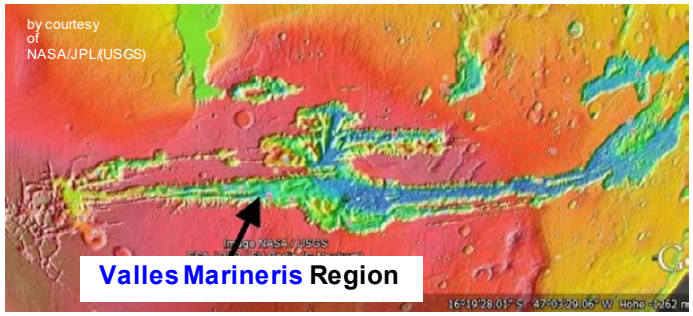
(This study will also be available at **www.vixra.org** soon. Just type-in my author-name in the search field and press enter. Then you will find the study.)

The interested readers should also have a look at the following Wikipedia page :

→ Asteroid Impact Avoidance Strategies

The strategies and the technology described in my above mentioned study : **"To the deflection of asteroids in the diameter range of 5 to 200 Km"** can also be used for doing Terra-Forming on Mars and on other planets & moons

With the described asteroid deflection strategies it would be possible to carry out controlled impacts of asteroids in the 10-20 km diameter range on Mars and on other planets & moons !!



The Valles Marineris is a deep 2400 km long Canyon on Mars probably caused by a crack in the crust of Mars. **Note :** Mars' ocean water came out of the mantle here !

An action plan for Terra-Forming on Mars :

In order to create an additional "Second Earth" for Mankind we should perform Terraforming on Mars as quick as possible before the settlement starts !! With a controlled impact series of probably 3 to 4 asteroids in the Ø 10-20 km range a large crack in the crust of Mars could easily be produced.

Alternatively a few 50 MT Fusion-Bombs located in 10km deep drill-holes can be used to achieve this.

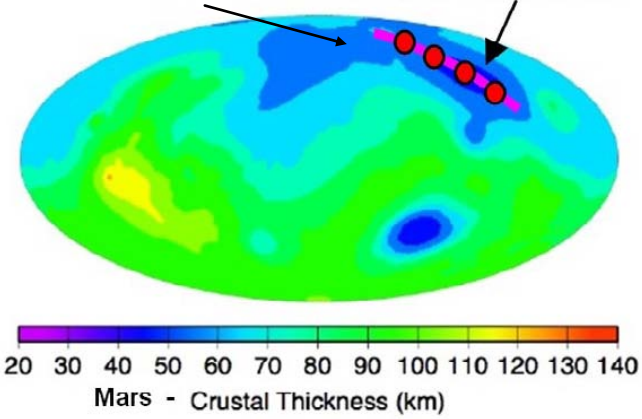
In order to achieve the crack with the smallest possible impactor diameter & energy expense, the optimum area for the intended crack would be the thinnest crust area of Mars. This is in the center area of the northern lowland (→ the former ocean floor on Mars) Here the crust is only 40 km thick!

A large crack in this area should cause large amounts of volatiles (e.g. H_2O) to rise up to the surface, similar as it happened in Valles Marineris. This would quickly produce a small ocean near the crack and a thicker atmosphere, which would improve the living-conditions on Mars considerably!

Such a Terra-Forming project should first be tested on another planet or moon which is located further away from Earth, and which is not a primary target for human settlements. It could be tested for example on Jupiter's moon Ganymede.

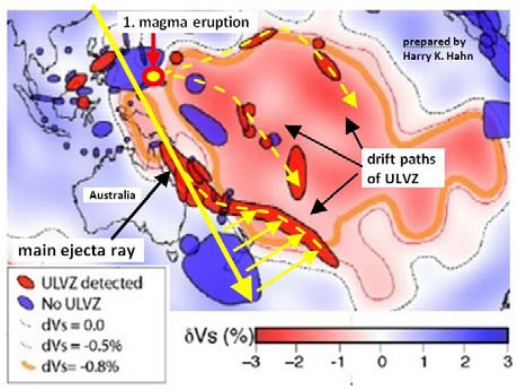
From this crack large amounts of salt-water from Mars' mantle can fill up the old ocean basin !

Ø 10-20 km impactors produce a crater chain which causes a crack



A few words to the dangerous Pacific-LLSVP :

An essential new discovery in comparison to the first edition of my study is the fact that the Pacific Plate and the expansion tectonics process which has formed it, is the result of ≥ 8 gigantic magma eruptions in the west pacific region over the last 200 Ma. These magma eruptions were caused by the Pacific-LLSVP-(ULVZ), which in all probability is a direct result of impacting ejecta of the PTI !



Further new discoveries were the Victoria Lake Impact event, the Canary Islands Impact event, the localization of the "Bay of Lyon" Crater, the correct position & orientation of the Indian Plate, Madagascar and South-America at the time of the PTI-event and some other new interdependencies.

Regarding the described magma eruptions in the West Pacific the following **Warning** must be given :

With high probability another magma eruption will take place in the west pacific region ! In all probability it will occur in proximity to the Fiji Islands. When it will happen is difficult to say ! Therefore the mantle area below the Fiji region must be examined with seismic tomography in more detail, e.g. the vertical velocity of the magma flow under the Fiji region must be measured ! **see Part 1**

Note that a new mass extinction, caused by another gigantic magma eruption of the Pacific-LLSVP, can begin at any time ! Within a short time period such a largescale magma eruption could kill up to 60% of all

species on Earth ! Like the other eruptions in the past it will cause an oceanic anoxic event (like the OAE-1a & OAE-2 and PETM (Paleocene-Eocene Thermal Maximum.), which will release vast amounts of CO_2, H_2S etc. into the oceans and will kill up to 60% of all marine species. Largescale explosive volcanism with vast amounts of CO_2 released will be a result too (e.g. see Ajupa Island)

It could begin in a few years, or it may not happen in the next million years. But in all probability it will happen sometime within the next ~5 million years ! A solid column at the top end of the Pacific LLSVP near Fiji, which is located close to the surface, may be an indication of the next due magma eruption !

And there seems to be a connection between these magma eruption events in the west pacific region and the **62 Ma bio-diversity cycle** on Earth (→ Extinction-cycle with two half periods of ≈31 Ma)

In all probability some of these violent magma eruptions were triggered by extreme earthquakes, e.g. caused by impact events, like the Chicxulub-Impact in Mexico. Like a punch which triggers an eruption of the contents of a heated Coke-bottle, the shock waves of an extreme earthquake may finally trigger a magma eruption from the Pacific-LLSVP (→ caused by a sudden pressure spike) !

But to make it clear : We are looking at two different periodic cycles here !

The periodic magma eruptions of the Pacific-LLSVP are caused by thermochemical processes which are going on inside the LLSVP & ULVZ. There seem to be longterm thermochemical processes at work with cycle lengths of 10 - 30 Ma (million years).
(→ the cycle length seems to decrease over time)

Please note : It may also be the case that a large amount of superheated mantle-water streams out of the Mid-Ocean-Range-crevices before a magma eruption starts, causing in this way climate change and sea-level rise !! see weblink to : → **News Article**

And the final stage of this cycle, the magma eruption, can be triggered by an outer shock event
The 62 Myr Bio-Diversity Cycle (or 62 Ma Extinction-cycle !) is caused by a precise periodic astronomical event going on for at least 500 Ma !
In all probability it is caused by the periodic crossing of the galactic plane by our solar system every 31 Ma. Every second crossing of the galactic plane seems to be particularly dangerous, because it has produced a worldwide mass extinction every time for the last 8 (62 Ma)-cycles !

6 of this 8 crossings caused a mass extinction each time, killing ≥ 70 % of all marine species on Earth !
Because our solar system moves along a spiral path around the galactic center, at every second crossing our solar system crosses the same ring area of the galactic plane, which in all probability is densely packed with debris resulting from collisions of our Galaxy with the Sagittarius Dwarf Galaxy (Sgr-DG).

And to point this out : Our solar-system is currently crossing the galactic plane in this obviously dangerous ring-area ! We know that the last world-wide extinction took place 65 Ma ago !
Therefore the next worldwide extinction event seems to be overdue and can happen at any time ! Maybe we just haven't passed the dense debris-layer yet !

By the way : This assumed debris-ring (or debris accumulation) may be the cause of the Oort Cloud (→ the source area of comets !) around our solar system, and the densely packed debris ring(s) in the galactic plane (similar to Saturns ring) may offer an alternative to explain the Dark Matter problem !!

Looking at the other global impact events which I have discovered on the planets Venus, Mars & Pluto, and on the moons Ganymede & Charon, which all indicate orbit inclinations ≥ 40° for the original orbit of the impactors (comets or asteroids), then it certainly must be taken into consideration that the impactors came from outside our solar system !!
→ either from the Oort Cloud, or from the assumed debris ring (layer) in the galactic plane !

Because these global impact events probably all occurred within the last ~250 Ma, we must expect large impactors which are coming with high velocity from deep space !

As long as we don't exactly know the physical process which has caused the global impact events within the last 300 million years, described in this study, we must take sufficient precautions !!
Because we are not able to deflect such large impactors yet ! We just don't have the required defence capability and technology to do that !

Therefore an asteroid- & comet deflection system must be built which protects our planet!

I have made an own assessment, and I found a few suitable defence strategies which are able to cope with large impactors, up to Ø 200 km !!

How such a defence system for our planet Earth could look like is described in my following study :

See : → "To the deflection of asteroids in the diameter range of 5 to 200 Km"

It will probably take at least 20 years to design, build and install such a defence system and it would probably cost ≥ US$ 100 billion ! But it is our responsibility to build such a system !

It is also our task & responsibility to settle on our neighbour planet Mars as soon as possible, and to establish an independent civilisation on Mars, which doesn't need support from Earth to survive !

This is the only way to make sure that our advanced technological civilisation will survive in the case of a global impact event on Earth, caused by a large impactor coming from deep space, or in the case of another gigantic magma eruption caused by the Pacific LLSVP !

We may be able to build a defence system against a large impact on Earth. However it's not possible to build a defence system against a gigantic magma eruption coming from Earth's mantle !!

That's why the development of nuclear drives for spaceships must be accelerated. We need much more payload capacity ! Instead of just being able to lift 10 tons into orbit, we need payload capacities of thousands of tons to really make progress in establishing settlements on Mars and on other planets and moons. If we shift our focus to the development of nuclear driven spacecraft we can achieve this within a few decades !

Please note that 10 kg enriched Uranium contain as much energy as thousands of tons of rocket fuel ! We already have enough fuel (enriched uranium) to build hundreds of spaceships with payload capacities ≥ 1000 tons ! The weapons industry worldwide must be redirected to build such large spaceships, and the space-technology which we need for the colonization of Mars, instead of ever-increasing the weapons-piles on Earth !
We must shift our focus !

At last a few words to our political leaders :

The G20 & UNO must set a new framework, so that "resource wars" can't happen anymore !

Therefore I suggest an **action plan** and **a number of global regulations** with the following goals :

1.) To secure and explore the **required resources for mankind** far in advance before they are needed

2.) To define which resources should be extracted first and which ones should be put on hold, in order to minimize the environmental impact of the mining industry, in particular regarding very sensitive natural environments.

3.) Altogether there should be a **longterm planning** for a secure and environmental friendly resource exploitation worldwide.

Speculation on commodity markets must be restricted by setting bandwidths for trading.

Commodity prices must be forced into defined bandwidths to provide stability for world's economy.

A worldwide analysis of all available mineral- and energy- resources and -reserves must be carried out under control of the UNO and G20.

A precise projection of the resource needs for the next 30 years must be done, and a 30 Year plan for food-, water-, energy- and mineral resources supply for mankind must be set up.

Because the next 30 years will be the most challenging time in human history, with maximum resource consumption !

→ see Part 4 of my study for further information

4.) Mining industries which are critical for the resource supply for mankind should be under observation and protection of the UNO & UNSC.
(for example the crude oil exploration industry)

5.) More food and energy reserves (oil & gas) must be kept in stock during the coming very low sun-spot-cycle minima, in which cold Winters and shortened harvest seasons must be expected !!
see following links : link_1 , link_2 , link_3 , link_4

6.) The population growth in the fastest growing countries must be reduced as quickly as possible with the financial help from the G20 & UNO.

And much more irrigated farmland is required !!

A Top-Down Approach is required to reduce resource consumption ! First it must be defined how much resources can be used over the next 30 years. Then all key-industries must get limits for the use of resources, which they shouldn't exceed !

We need to refocus ! We must start many international projects where all members of the UNO & G20 work together to achieve a better and saver life for all people, a healthy environment and in general a good and positive vision for mankind !

One of these positive visions must be the **realization of a constant settlement of mankind on Mars**, realized by the G8, G20 and the UNO !

Other important visions for mankind must be :

That we really must get serious now about the **Protection of the remaining Rainforests on Earth** otherwise they will be gone in 10 years and with it millions of species ! The rich countries must pay for achieving this goal !

The rainforests are the lungs and filters of our atmosphere, and they reduce climate change !!!

And we must get serious about removing the plastic waste from the rivers and oceans !

The source of plastic waste which ends up in the world's oceans is plastic-waste which gets dumped in rivers and flood-areas.
This happens especially in highly populated asian countries and in India. The ten biggest rivers in this area transport ≈ 70-80% of the plastic waste into the world's oceans !

Especially the monsoon-rain and the following floods transport all plastic waste from the once- a-year flooded areas into the worlds oceans !

To prevent this pollution the authorities in these countries must define dumping-sites for waste on higher flood-save areas, and there must be high penalties for dumping waste elsewhere.

Cleaning up the oceans with specialized machines won't work. The task is just to big !!

The root-cause must be eliminated, which is the dumping of waste in rivers and flood-areas !!

It's high time to get serious on all this tasks !

The Author : **Harry K. Hahn** - 8.7.2017

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17. J.I.Lunine : **Earth Evolution of a Habitable World** ; 2013 , Cambridge University Press, ISBN : 978-0-521-85001-8

Interesting Online Documents & Websites :

Note : If weblinks don't work, then type-in or copy the shown web-address directly in your internet browser, or search with titel & author !

Images of **Rock-samples & Sample sites** of some of the described impact structures can be found on these websites : www.permiantriassic.at or www.permiantriassic.de

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→ **Clic on the images to run the animation !! :**
→ http://www.isale-code.de/redmine/projects/isale/wiki/Media
(Especially watch the 3. animation !! clic on the thirth image !)

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From Prof. Jeffrey Kenney from Yale University
→ **See also the following animation :** https://www.youtube.com/watch?v=1keSq3Wg024

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Documentation of my Permian-Triassic Impact Hypothesis :

Weblinks to my PT-Impact Hypothesis :

Here the weblinks to the Parts 1 to 6 of my hypothesis → They are available on **vixra.org** and on **archive.org**

Weblinks to my studies on → vixra.org :

Part 1 : https://vixra.org/abs/2012.0210
Part 2 : https://vixra.org/abs/2101.0052
Part 3 : https://vixra.org/abs/2101.0096
Part 4 : https://vixra.org/abs/2101.0067
Part 5 : https://vixra.org/abs/2101.0127
Part 6 : https://vixra.org/abs/2104.0099 → **see also :** Part 6b

Weblinks to my studies on → archive.org

Study-Part 1
Study-Part 2
Study-Part 3
Study-Part 4
Study-Part 5
Study-Part 6 **and :** Study-Part 6b

You can also find all parts of my hypothesis on my website : www.permiantriassic.de or alternatively here : www.permiantriassic.at

→ See links on the main-page or under "Documents for Download"

Note : **The weblinks to Raman spectroscopy analyses of rock samples which I have collected at, or near, secondary impact-craters & structures of the PT-Impact, which indicate shock-metamorphic effects (in particular) in quartz grains, can all be found in Part 6 of my hypothesis :**

→ **See Part 6 :** https://vixra.org/abs/2104.0099 **or** Study-Part 6 (→ or find this document alternatively on my website)

or go on my website to : → **"Mineralogical Evidence"**

→ **On my website you can also find photos of all samples sites and all rock samples which I have collected**