The Permian-Triassic Impact Event

Overview of the discoveries which were leading to the

Permian-Triassic (P/T) Impact Crater

and to

≥ 70 secondary (P/T) craters worldwide !

by Harry K. Hahn / Germany - 6.12.2018

www.permiantriassic.de → Please read my Study

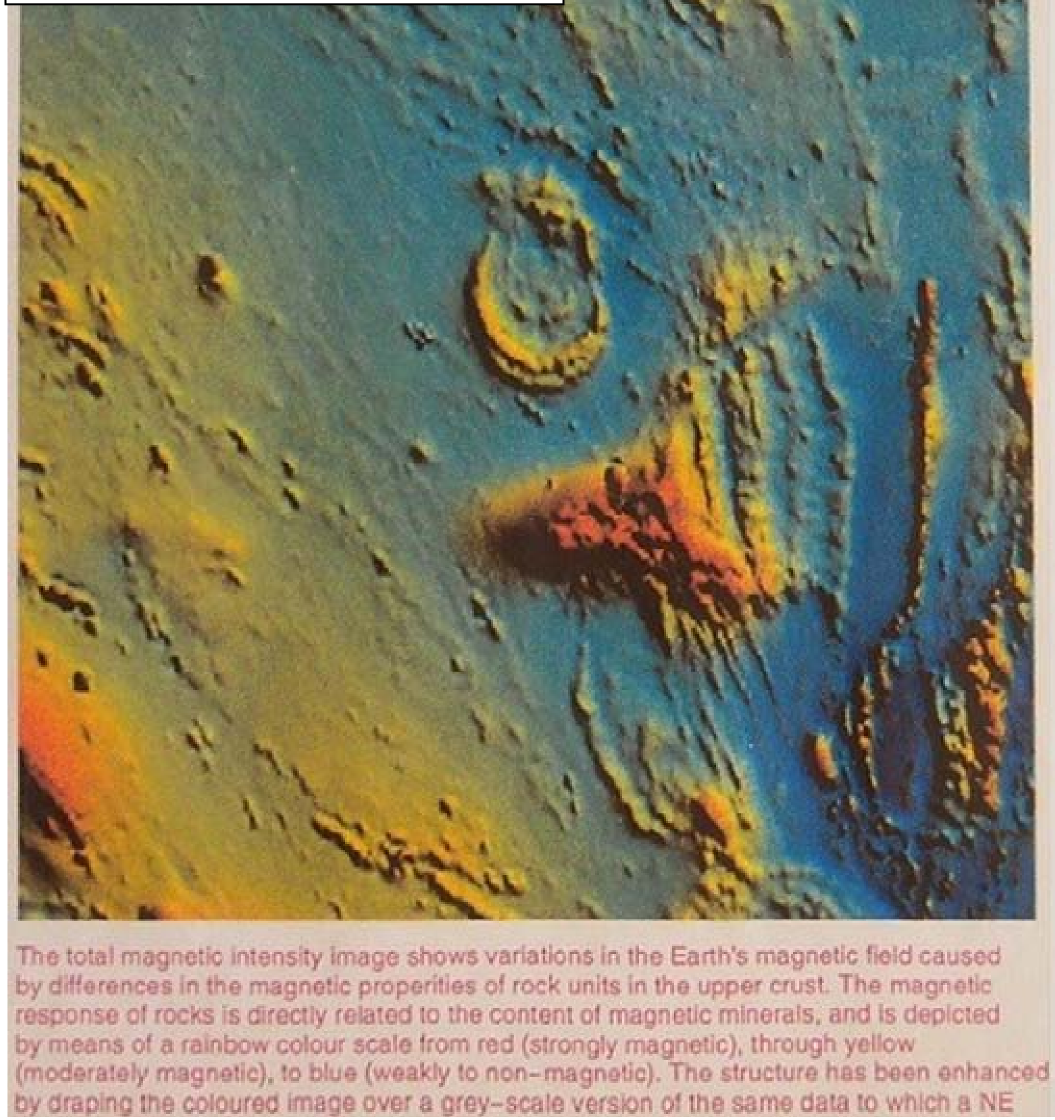
The 8 x 7 km elliptical (oblique) Warwick Crater

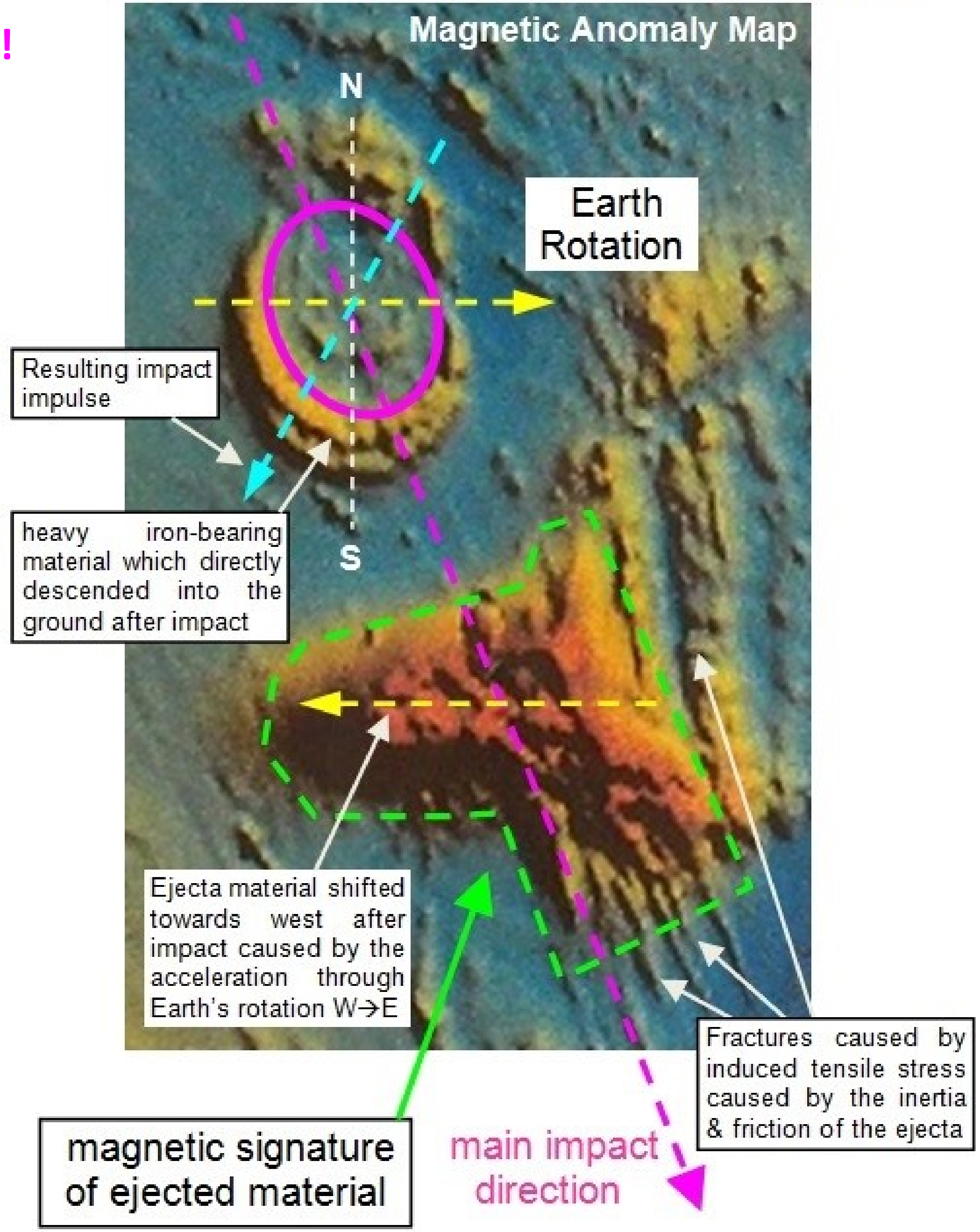
→ located near Warwick 150km SW of Brisbane/Australia

This was the first elliptical Crater which I discovered !

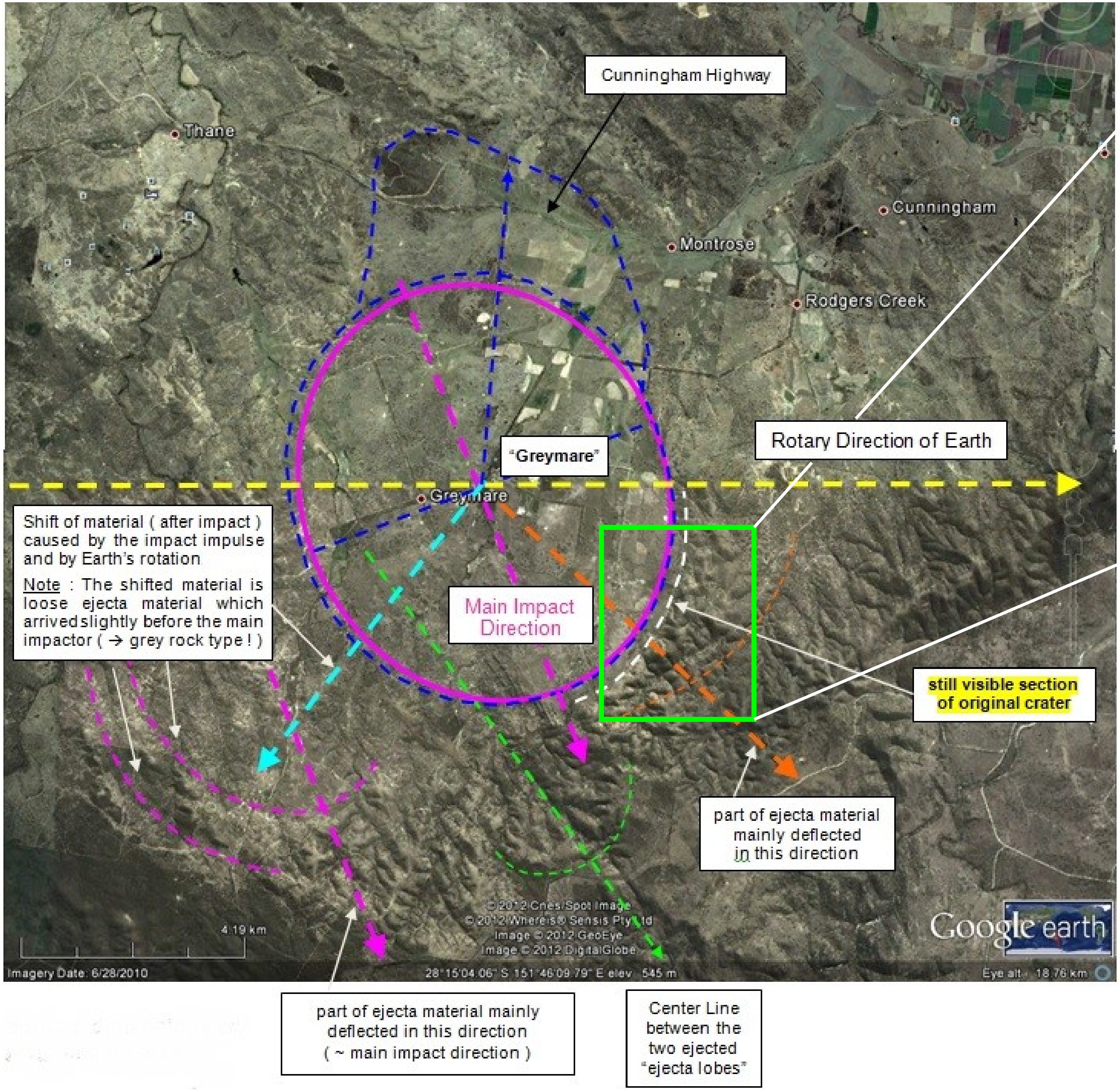
- Precise elliptical shape of the structure
- The amplified deformation towards SW was caused by Earths rotation which accelerated the impacting material

Magnetic Anomaly Map





Satellite view of the 8 x 7 km Warwick Crater / NE-Australia



visible crater-wall section

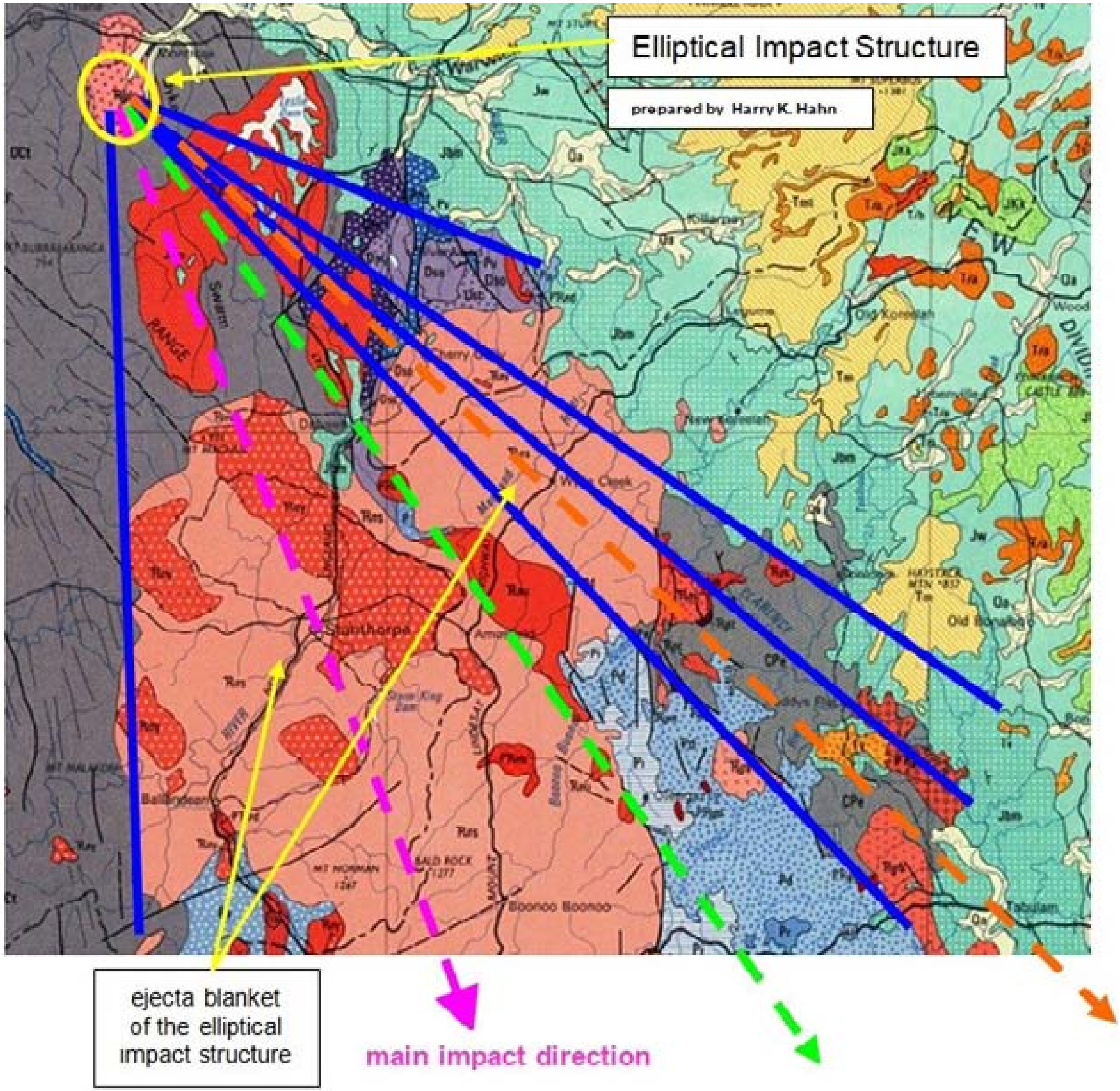
→ precise ellipse segment

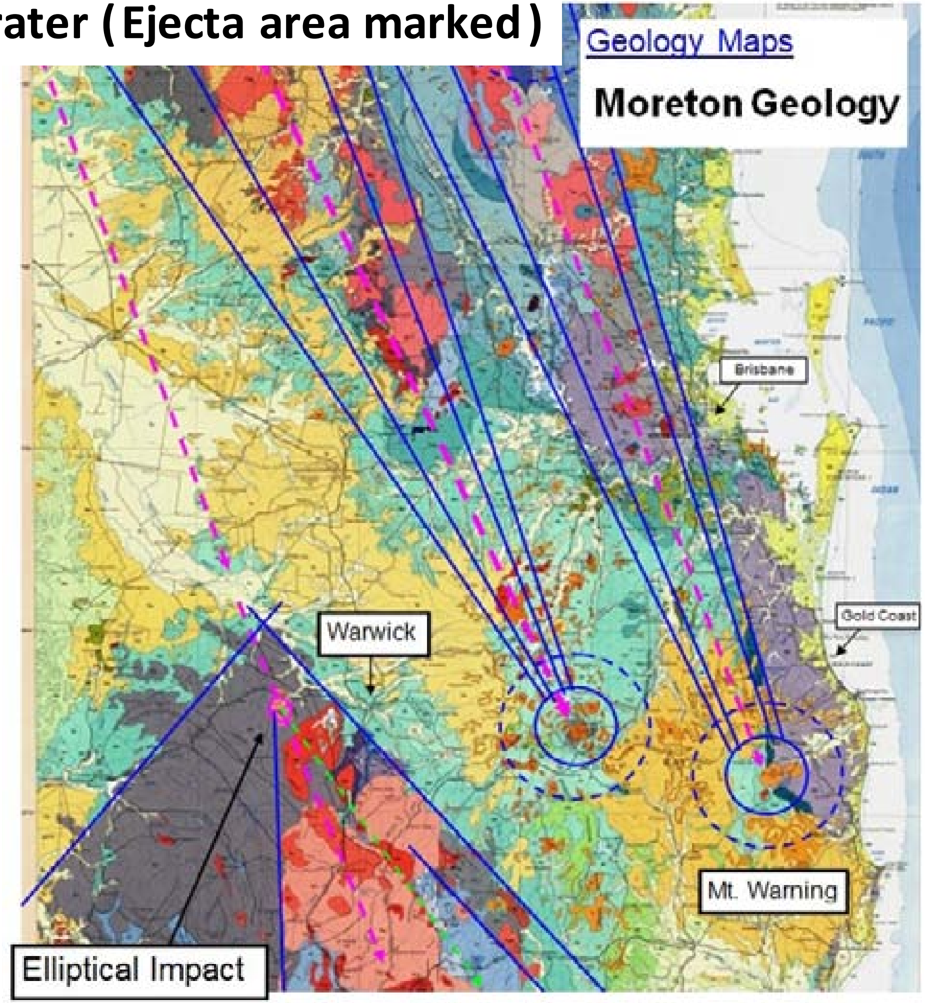
Age of Impact Crater :

~ 250 Ma (million years)

- Precise ellipse segment visible on the topographic map
  →still intact original crater-wall section

Geological Map of the surrounding area of the Warwick Crater (Ejecta area marked)



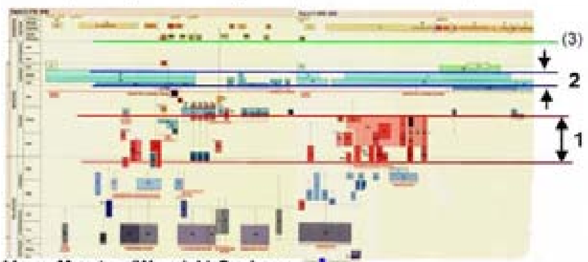


The geological map of the SE-coast of Queensland indicates two main chapters associated with the large impact event :

1.) Ejection of the red colored rock types along the East Coast of QLD at ~253 Ma. → Crystallization of this "ejecta ranges" until ~ 225 Ma

2.) A gigantic flood event triggered by magma eruption 1, ~200 Ma ago and effecting the low-lying sedimentary areas until around 160 Ma

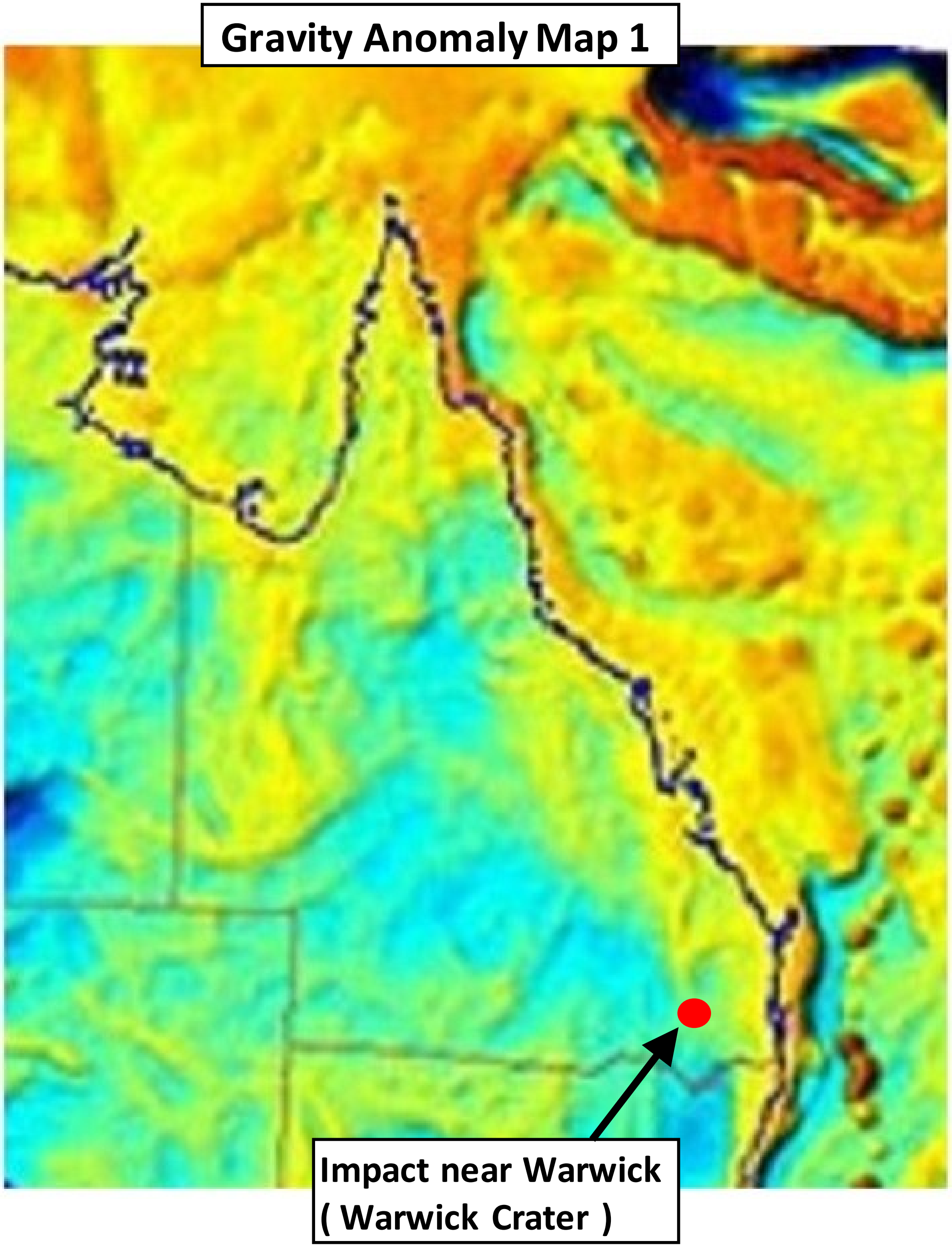
(3.) Volcanic activity initiated at around 65 Ma and lasting until ~25 Ma → probably related to magma eruptions No.5 to 8 of Cape York Crater

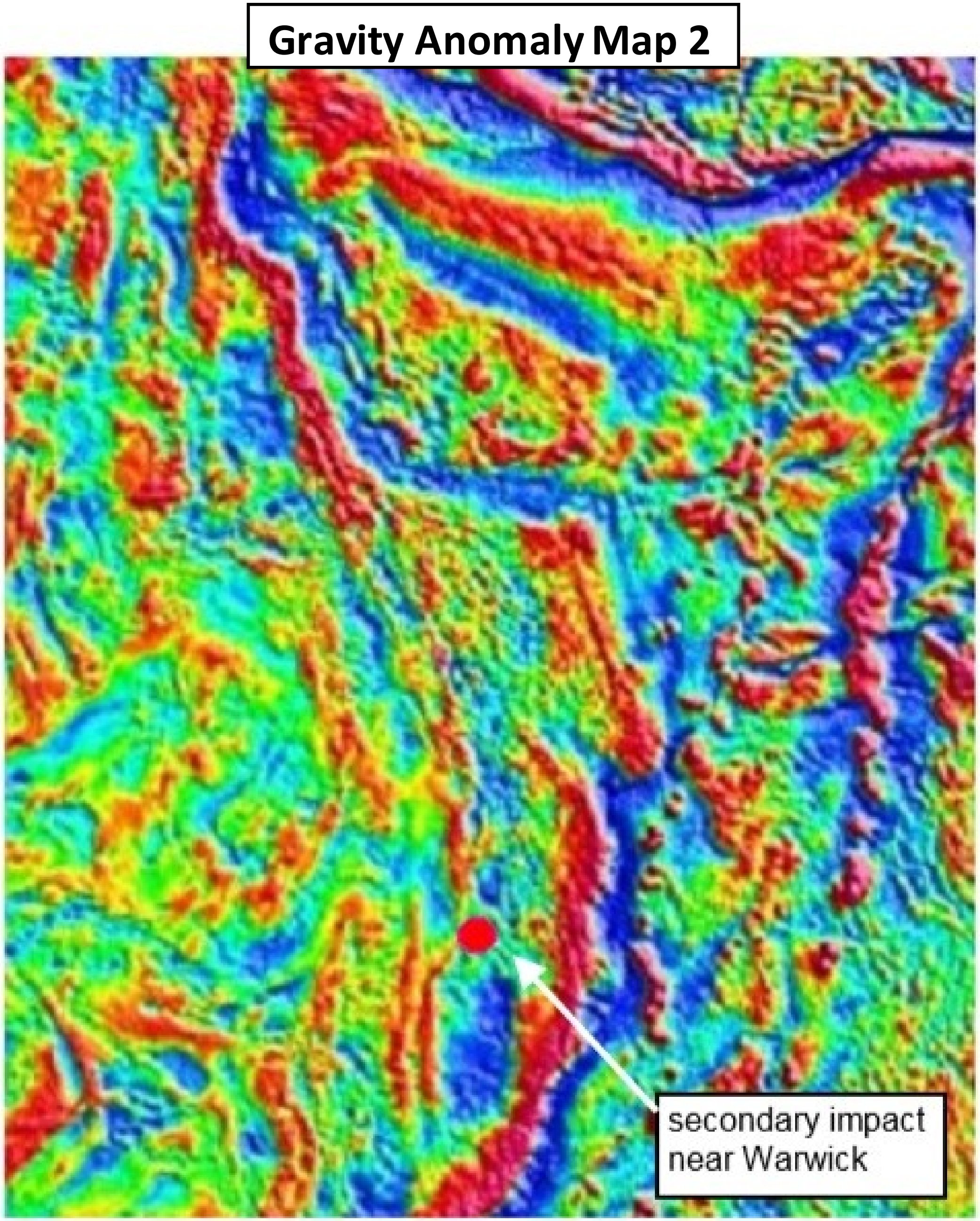


Map : Moreton (Warwick) Geology

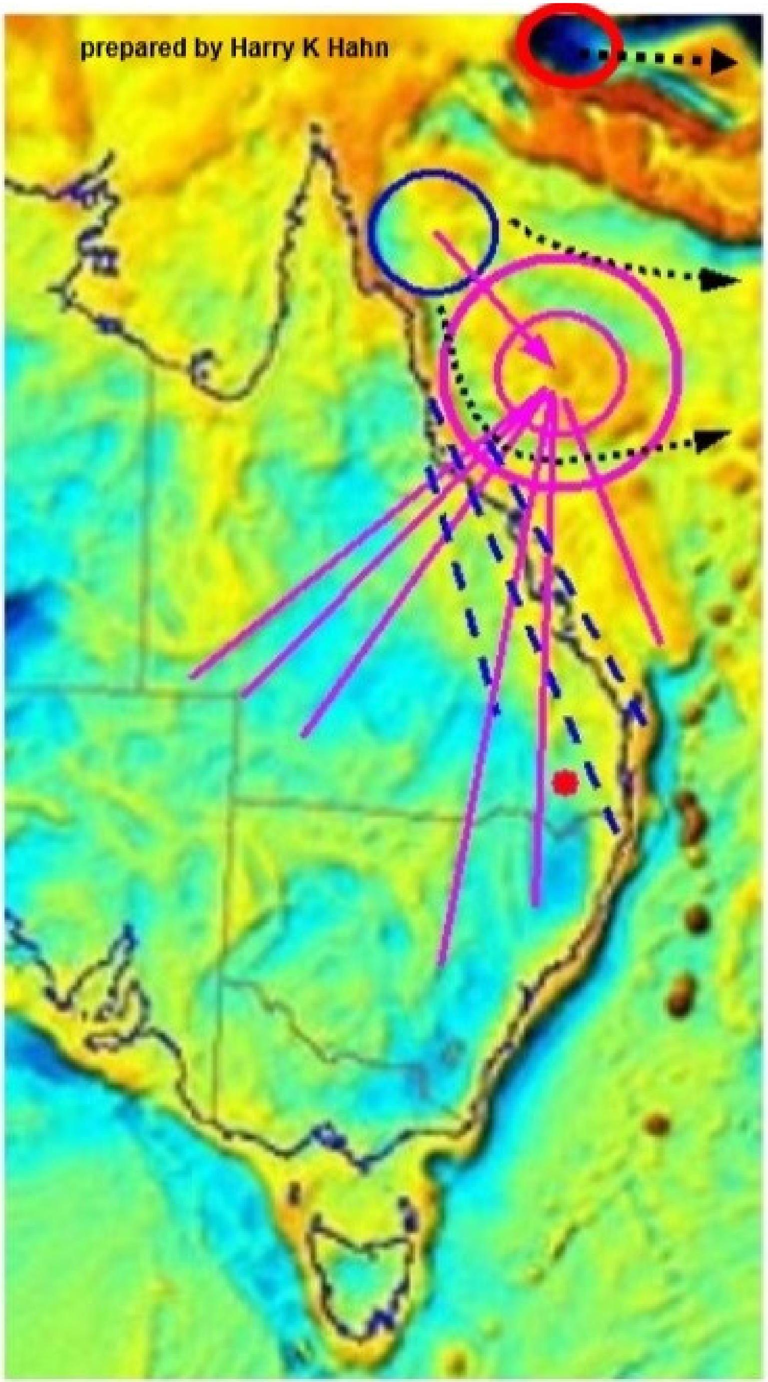
- The geological structures on the map show a precise „scattering-cone pattern“
- The grey- and the red/pink-rock types SW of Warwick arrived on the same trajectory (main impact direction)

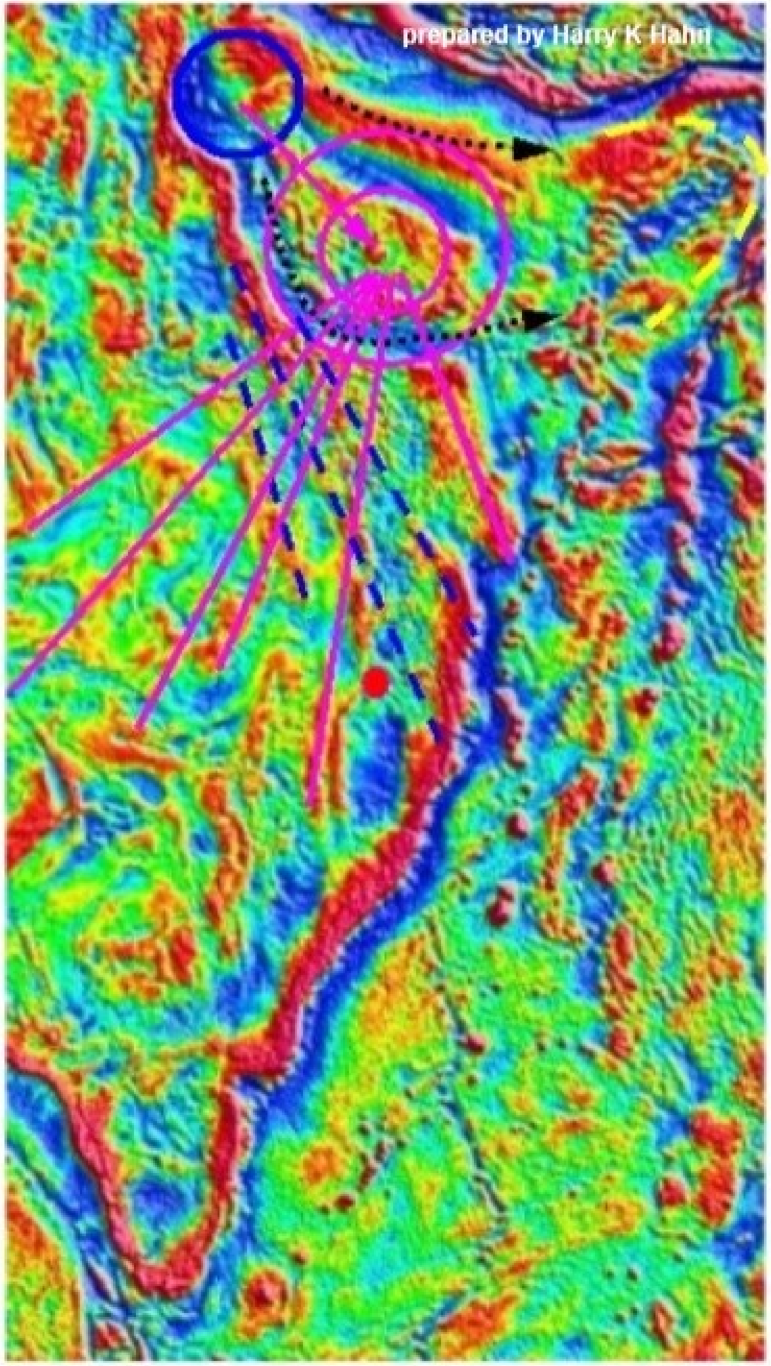
Gravity Anomaly Maps of North-East Australia (Queensland)





Gravity Anomaly Maps of North-East Australia with conspicuous structures marked





The circles and lines on the map represent a first interpretation of some conspicuous features on the gravity anomaly map

The are different conspicuous structures visible on the map, e.g. :

- a precise 120° circle-section at the continent shelf of Cape York peninsula (→ blue circle)
- There are two different ray systems visible coming from two different source areas (→ lines marked in blue & purple)
- There are large-scale flow-structures visible east of the two source-areas of the mentioned ray systems (→ probable traces of magma streams)

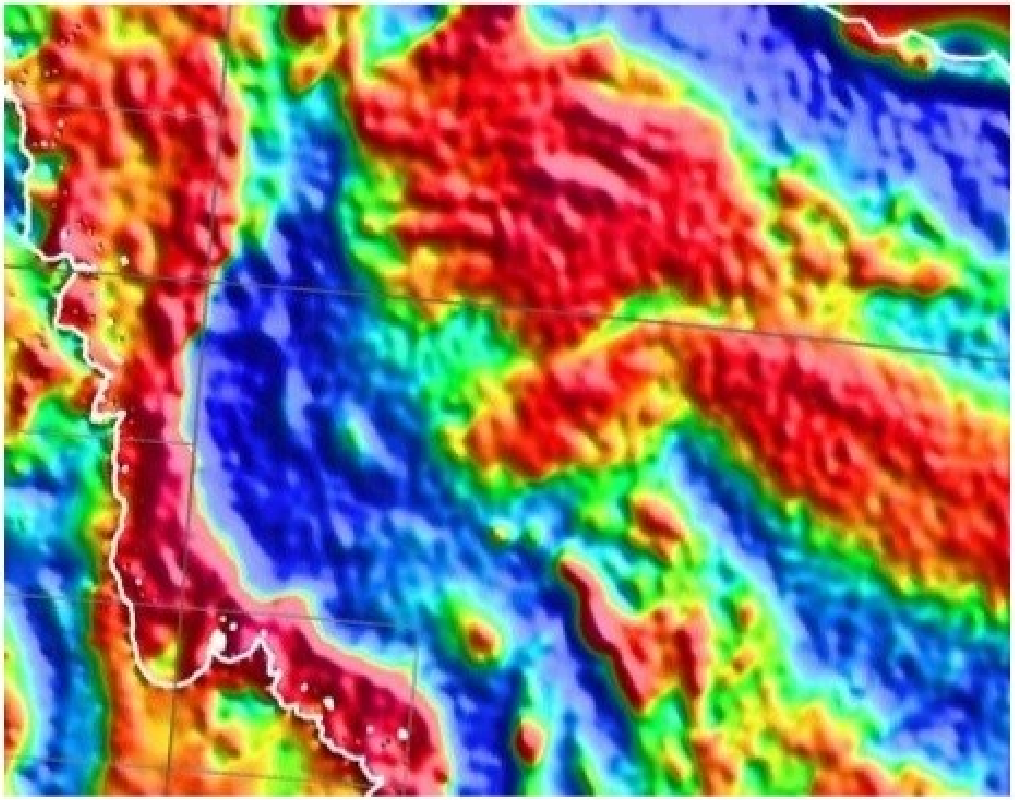
Gravity anomaly map of the Ø 320 km Cape York Crater (CYC)

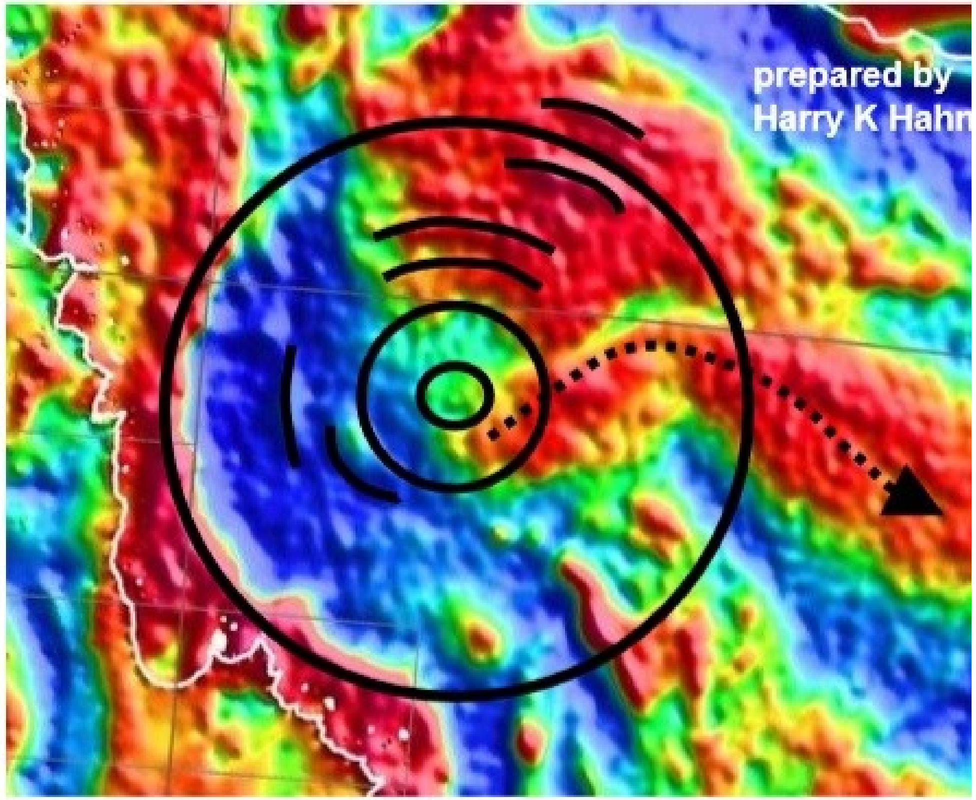
→ located on the ocean floor near the Cape Yok peninsula (NE-Australia)

This was the second Crater which I discovered ! I first believed that this is a primary crater.

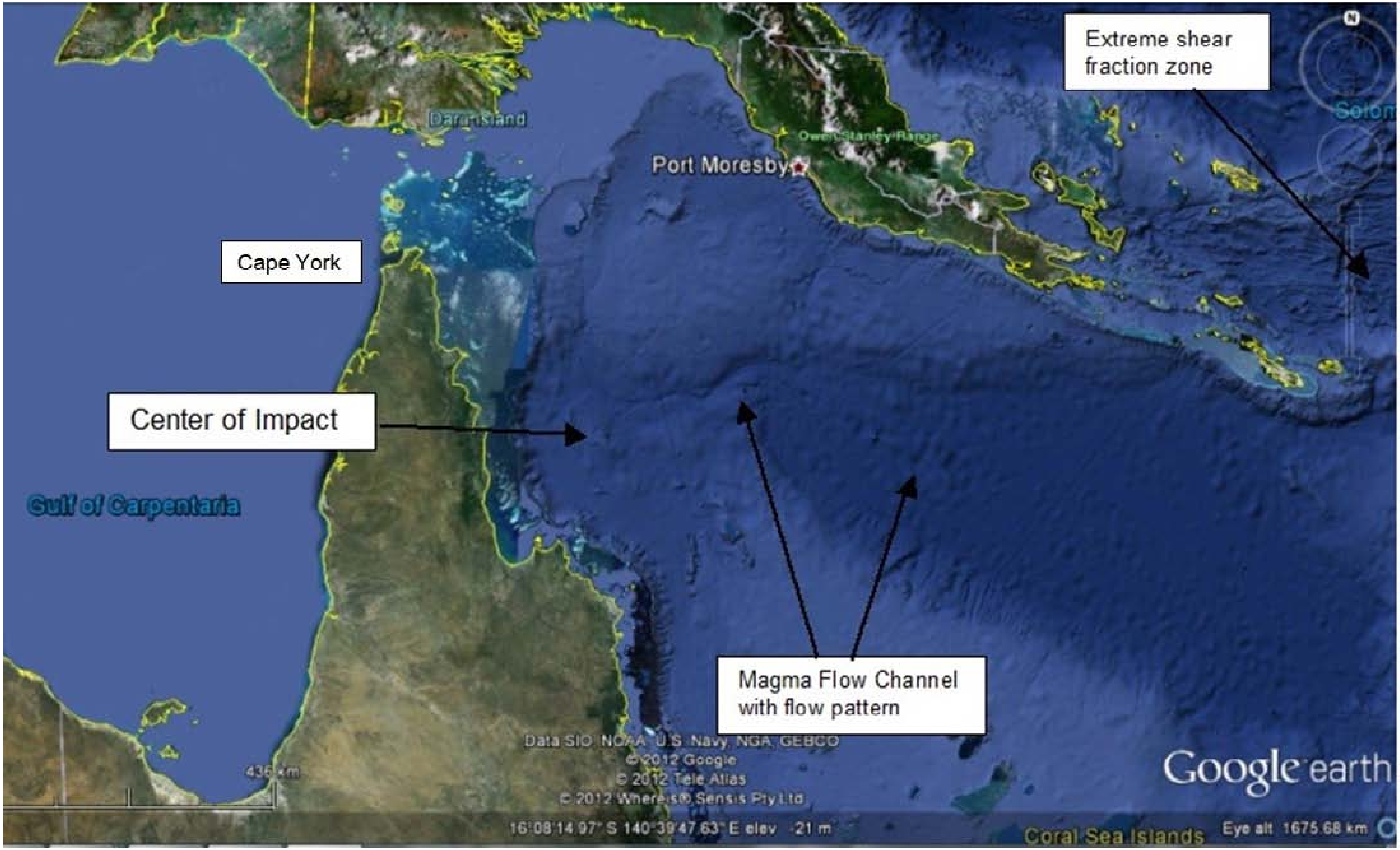
But later I came to the conclusion that it must be a large secondary crater of the PT-Impact Event.

- The gravity anomaly map shows a precise 120° circle-section at the continent shelf
- The marked circular area shows further coaxial circle-section structures (→ crater ring structures)
- There is an outflow-structure (magma flow) noticeable coming from the center of the assumed impact crater
  → This means that the impactor probably penetrated Earth's crust during the impact



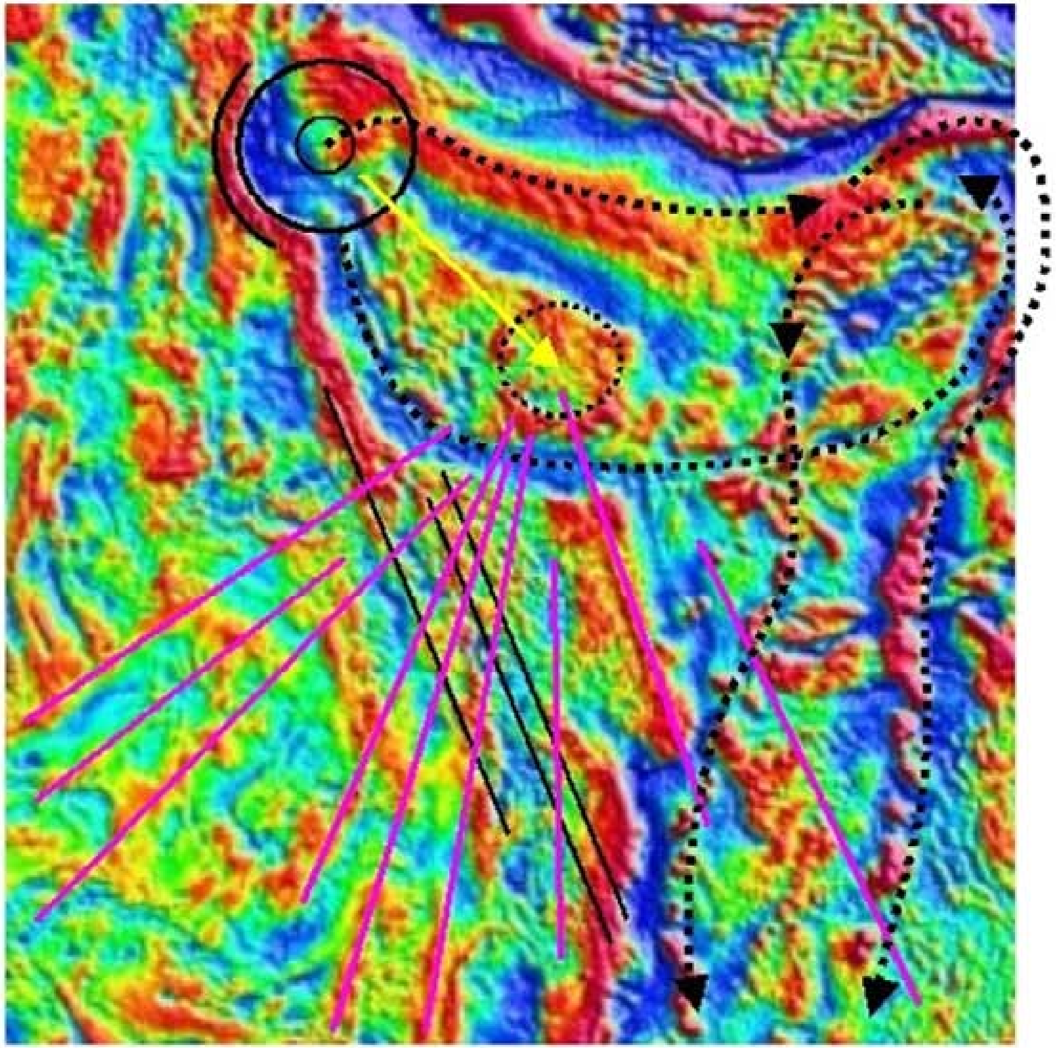


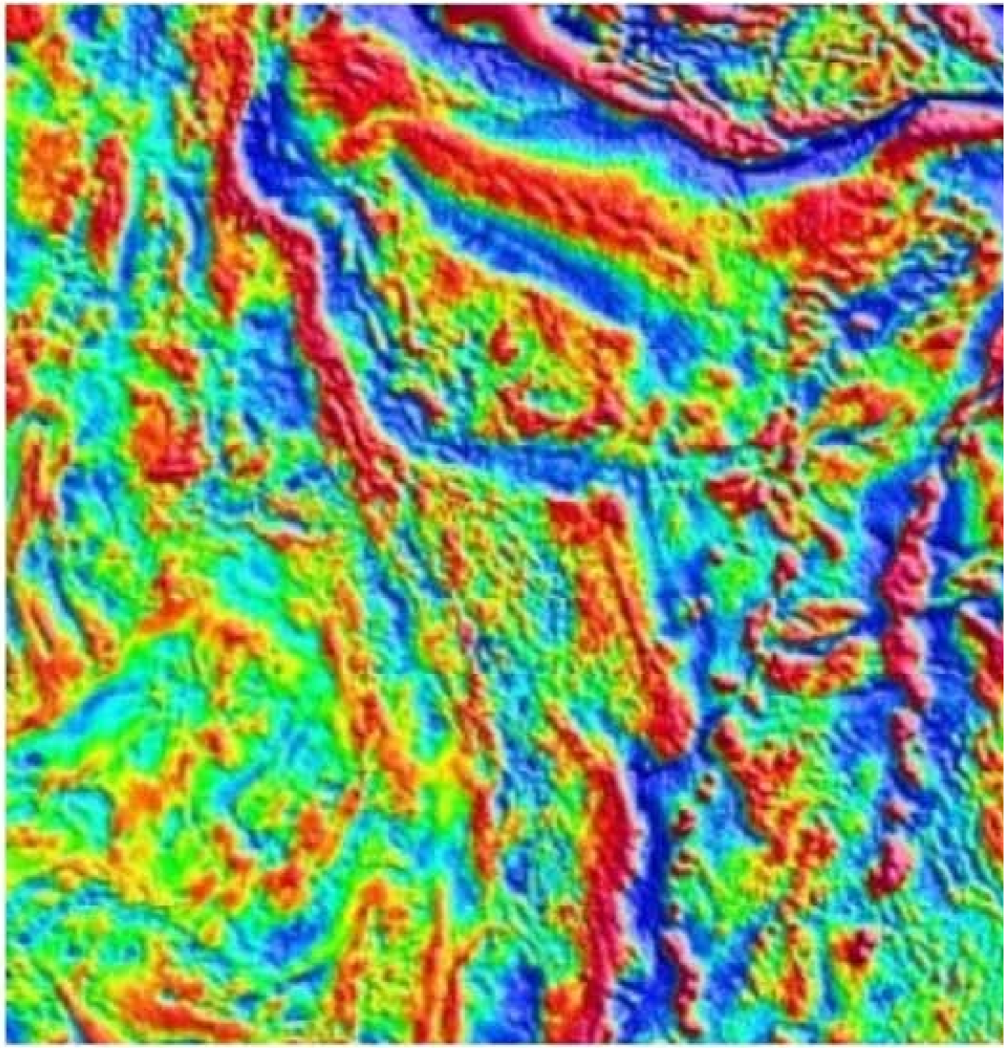
The Ø 320 km Cape York Crater shown on a satellite map with ocean floor topography



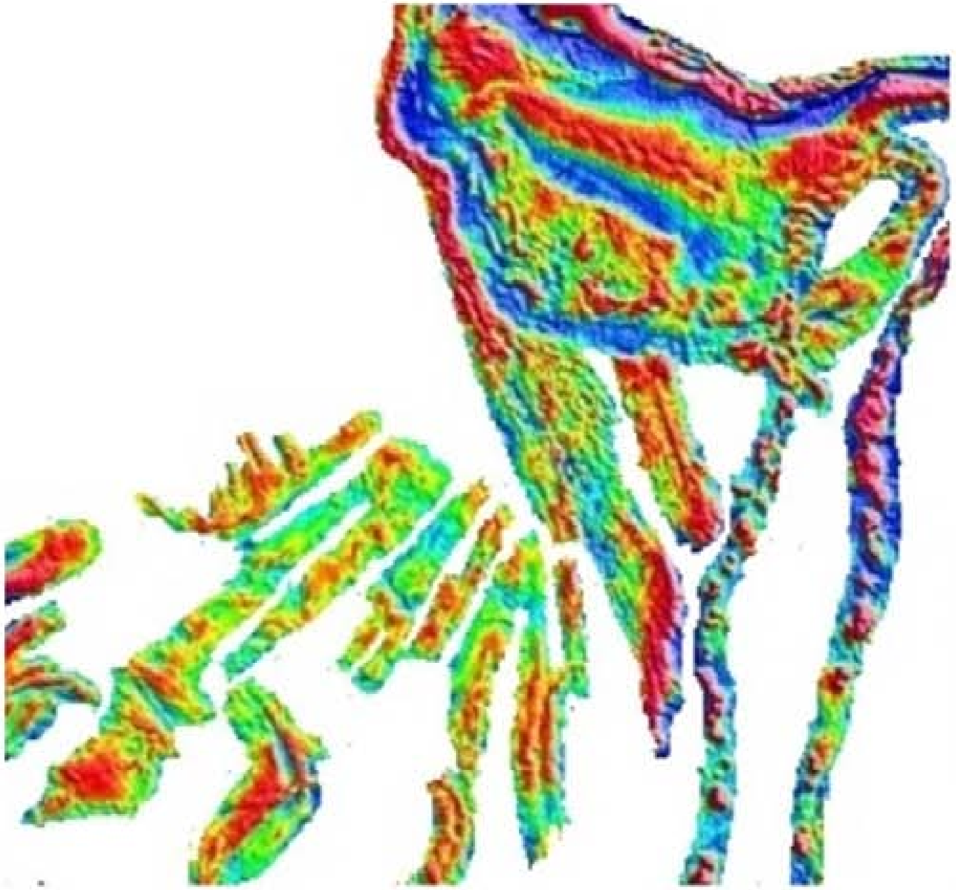
The Ø 320 km Cape York Crater & resulting structures marked on the gravity anomaly map

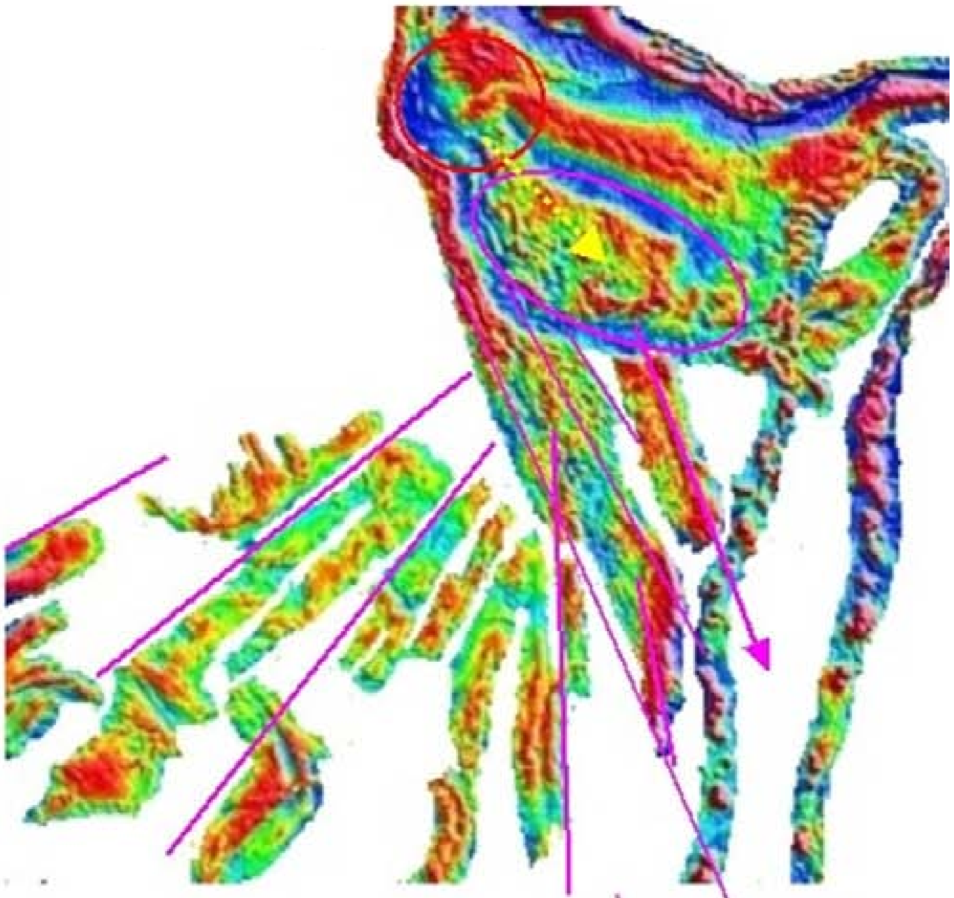
- The circle section structures at the marked impact site (full black circle)
- Two large-scale flow structures (magma flows) coming from the crater center, left visible traces (dotted arrows)
- Two different ejecta-ray systems visible, which came from two different sources (one source was the Cape York Crater (black ray system), the other source was either another crater, or impacting ejecta of the CYC caused it.





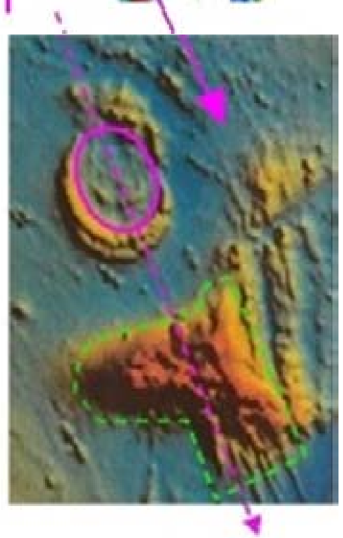
The isolated structures which all belong to the Cape York Impact Event :



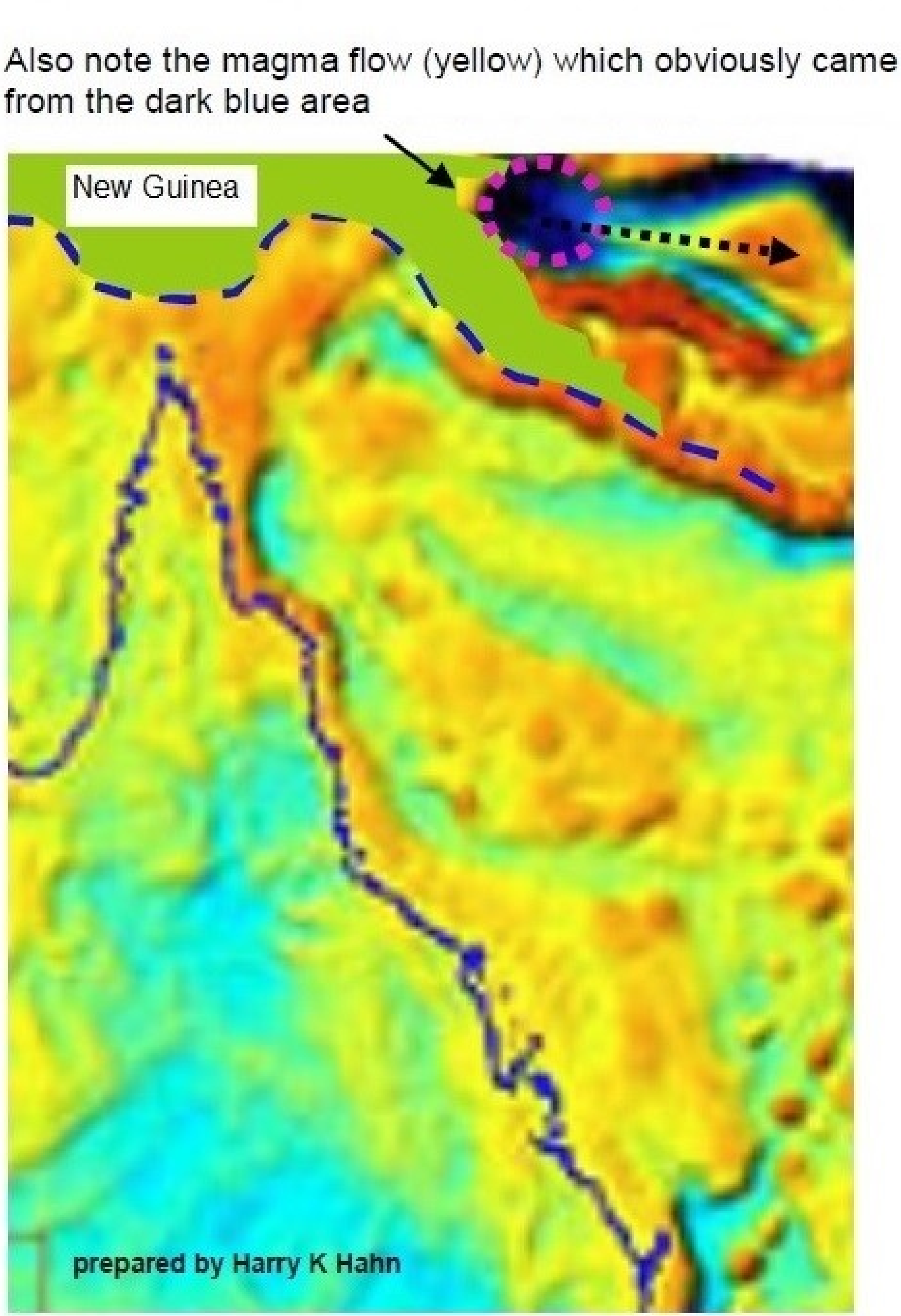


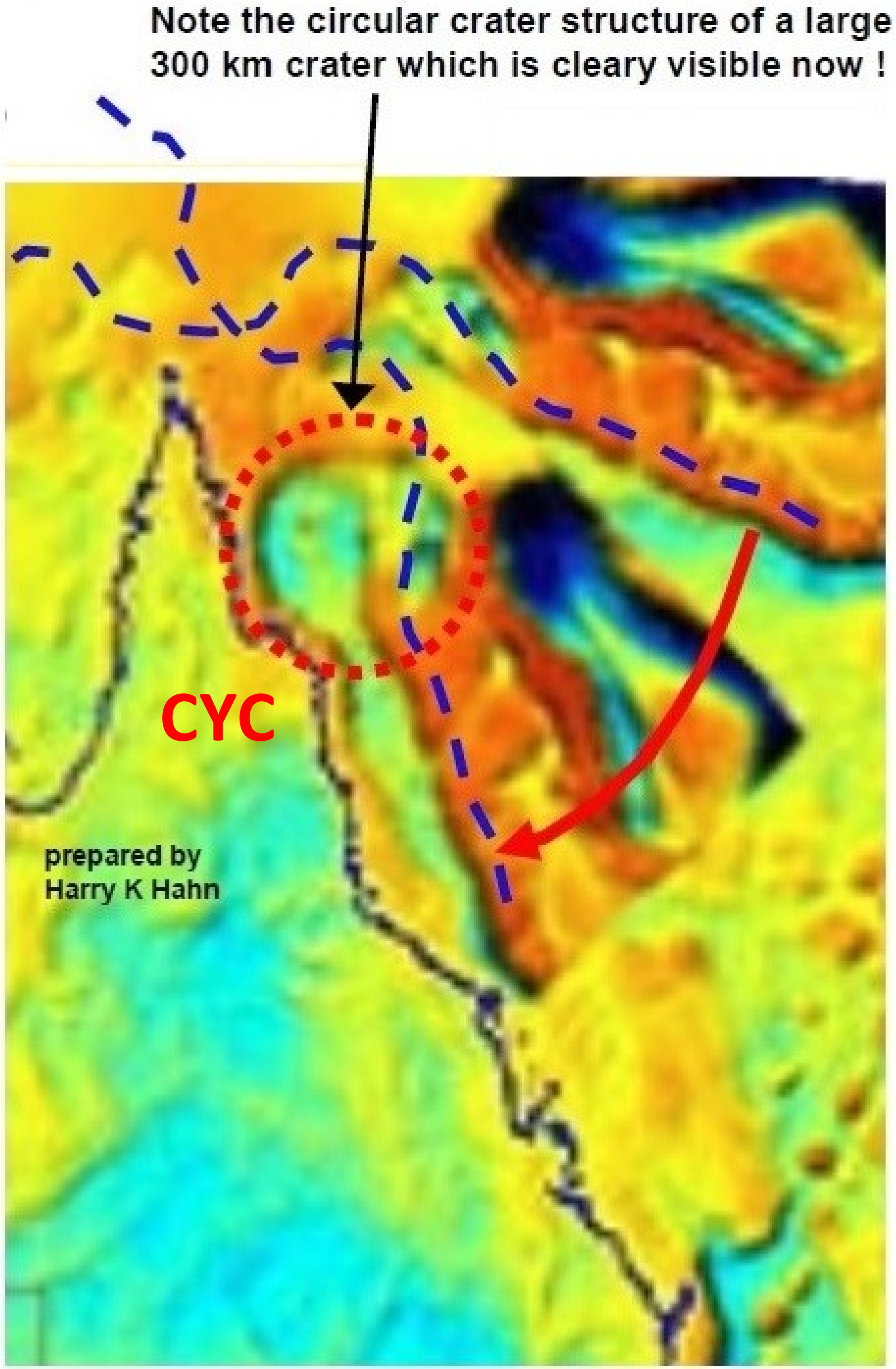
The two pink colored arrows shown in the smaller rectangular image indicate the interdependence between the assumed large impact in the North of Queensland and the assumed smaller elliptical Impact Structure in South-East Queensland.

The main impact direction of the smaller elliptical structure is identical to the direction of the thin ray structure of the larger impact structure

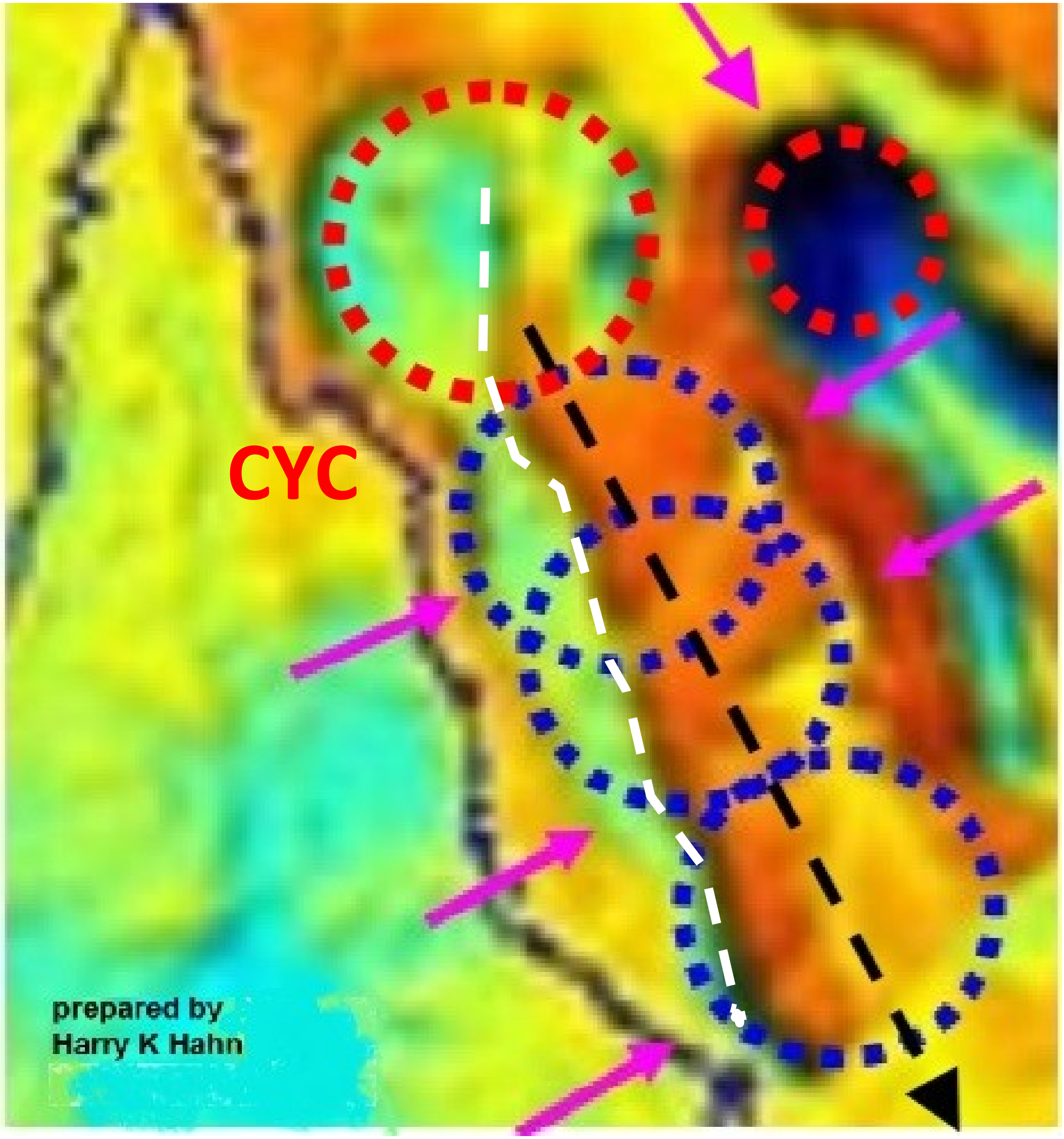


A rotation of New-Guinea by 45° towards the CY-Crater shows the original impact scenario





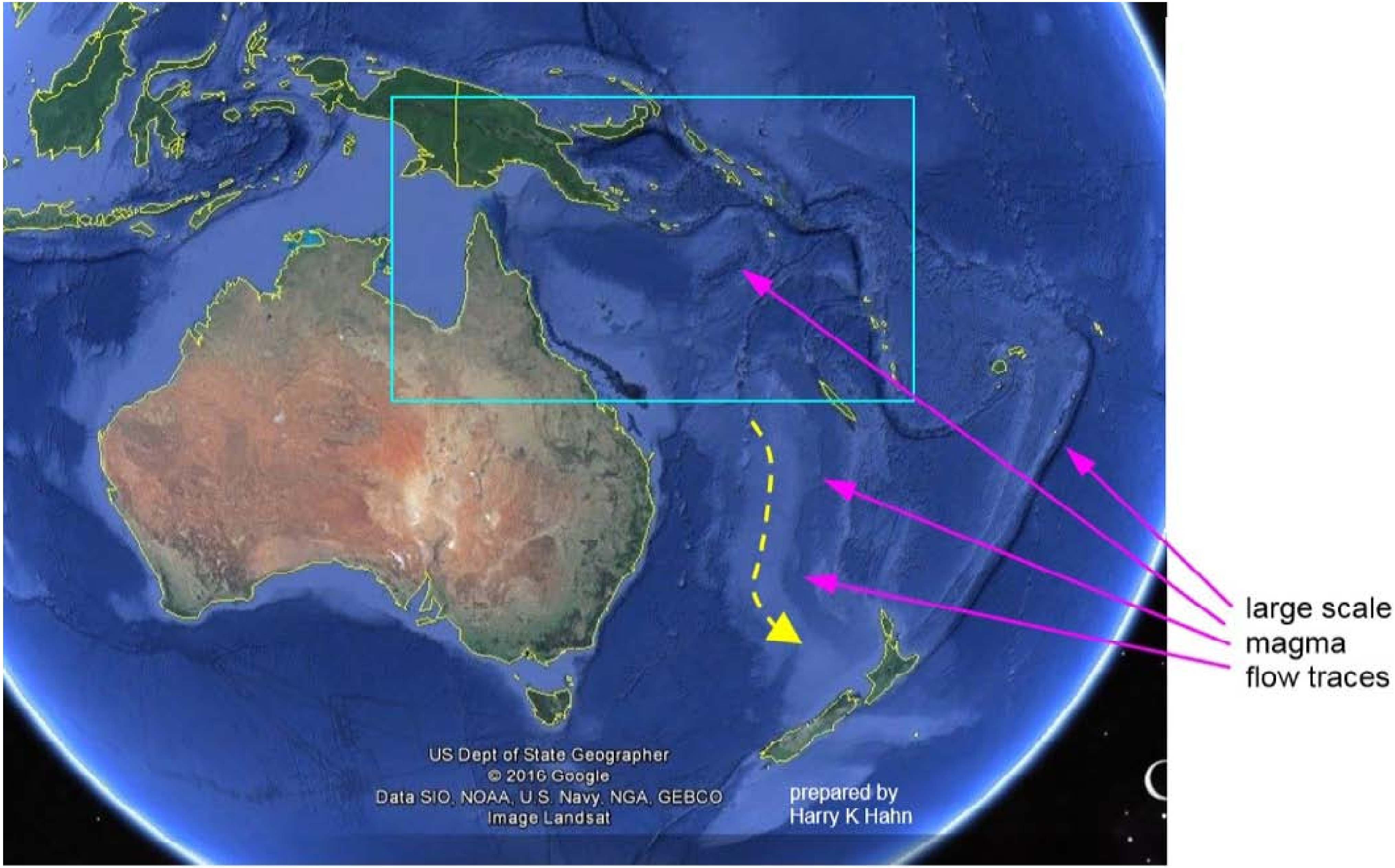
The modified gravity anomaly map indicates a crater chain which caused a crack separating Australia & New Guinea and a divergent tectonic motion



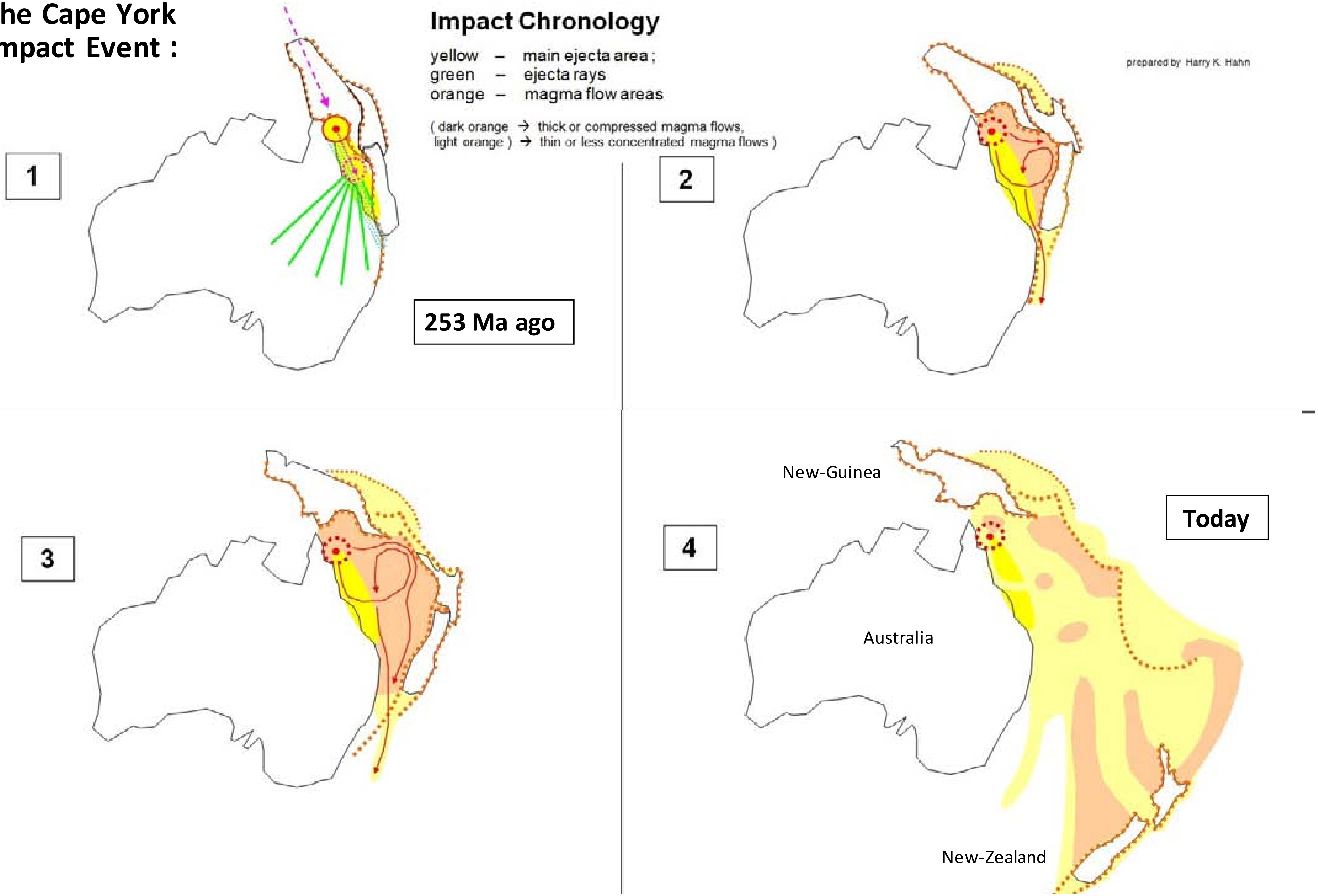
The structures visible on the modified gravity anomaly map indicate a crater chain :

- The red circle represents the Ø 320 km Cape York Crater (CYC).
- The blue circles indicate further possible impact craters with similar diameters, which originally formed a >1000 km long crater chain
- The bow-shaped border structures of the positive anomalies (orange/yellow) indicate three further craters with ≥ Ø 300 km
- The black arrow indicates the trajectory of the impactors which formed the crater chain
- The white dashed line indicates the crack in Earth's crust caused by the crater chain

The traces of the Cape York Impact Event shown on a topographic ocean floor map



The Cape York Impact Event :



An elliptical impact crater on Mars & Computer-Simulations of elliptical Impact Craters

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.

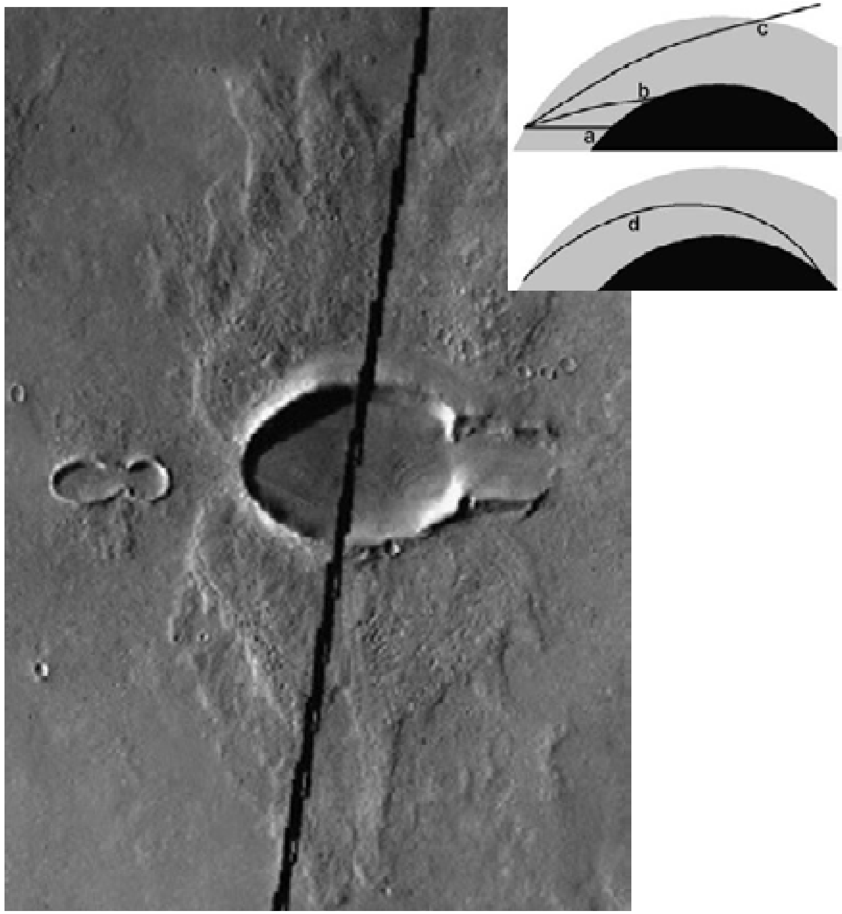


Fig. 1. A large (7.5 × 10.0 km) elliptical crater with a smaller elliptical crater (2.0 × 3.0 km) lying 12.5 km directly uprange (to the left). 'Butterfly'-pattern ejecta occur around both craters. (Mosaic of THEMIS daytime IR images.) North is up.

Fig. 2. Atmospheric flight trajectories for asteroids (top) and a moonlet (bottom) in

The transition from circular to elliptical impact craters

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

2. Model Setup

[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,

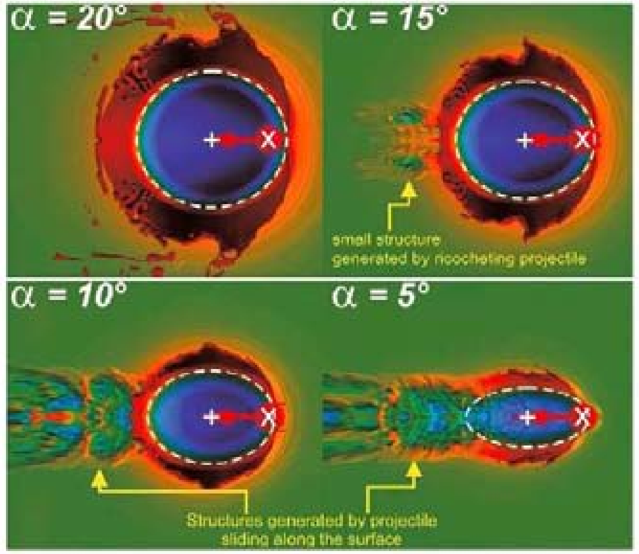
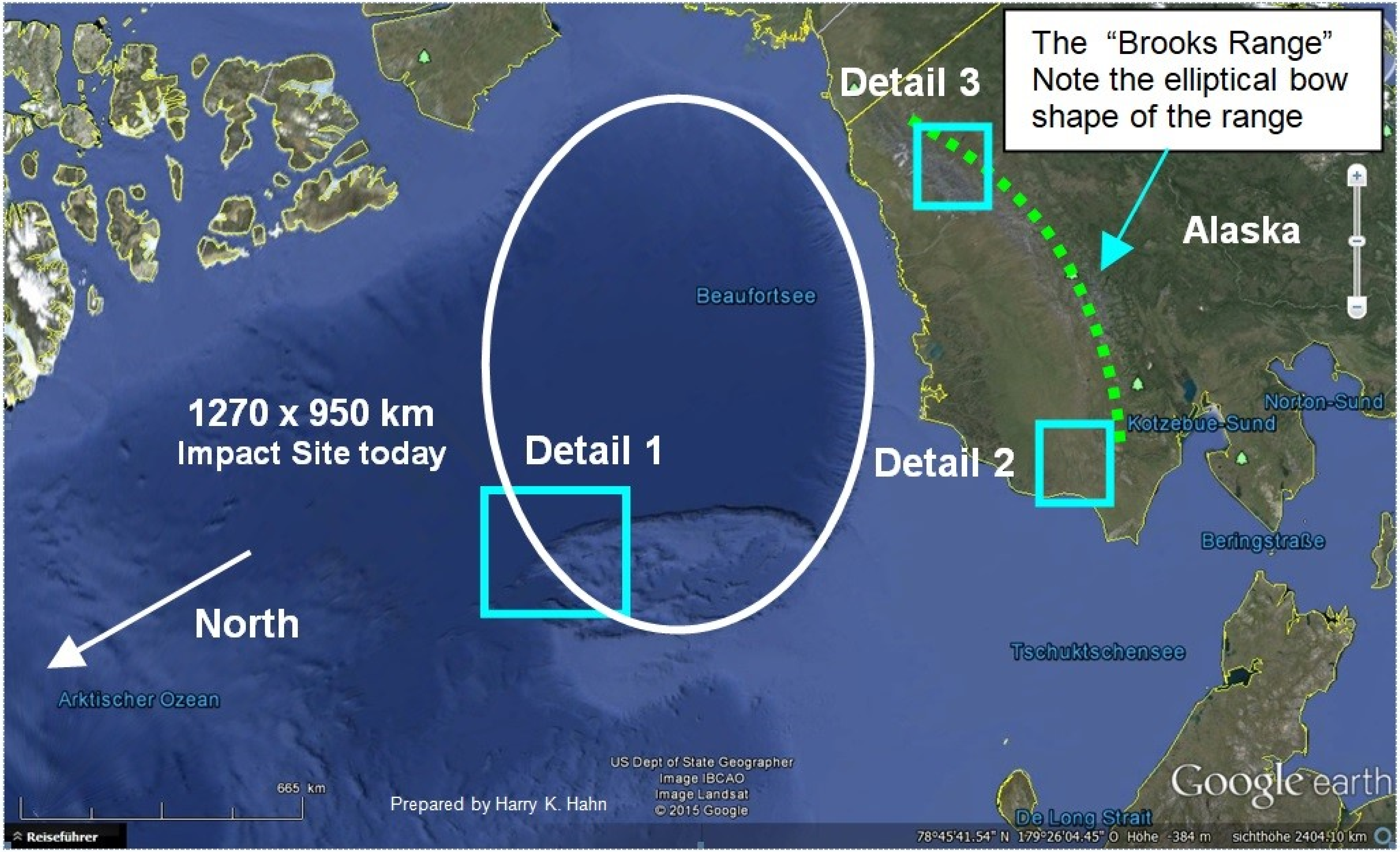


Figure 2. Influence of the impact angle on crater shape. Impact of a 5 km sized projectile at 8 km/s and low impact angles α (friction coefficient $f = 0.3$; no cohesion). The dashed white line marks the inner boundary of the crater cavity just before the onset of crater modification (measured at the 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 Permian-Triassic Impact Crater is an elliptical Crater located north of Alaska

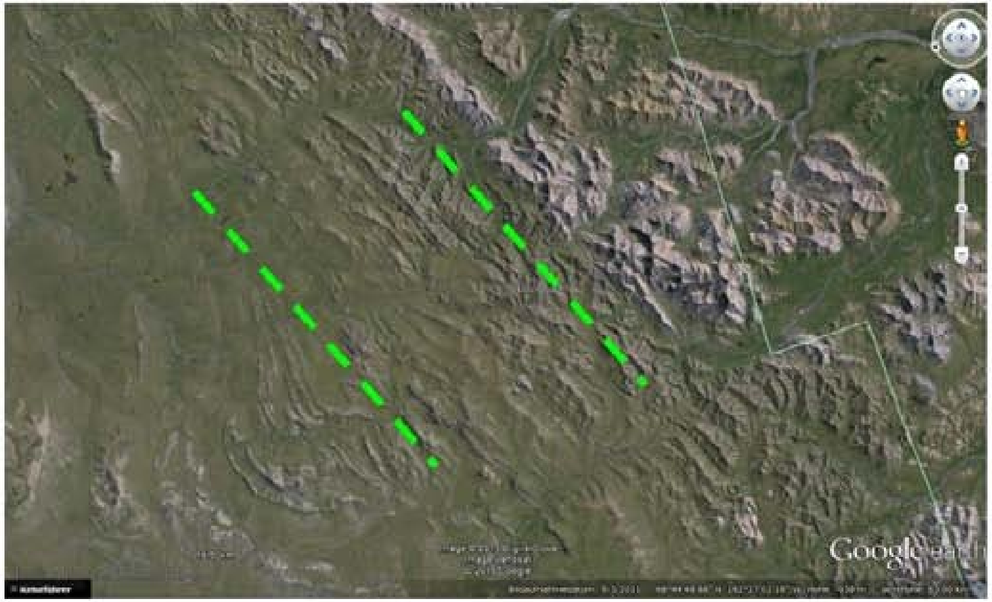
The asteroid or comet who caused it had a diameter of **60** to **150 km** and it impacted in a shallow angle < 10°

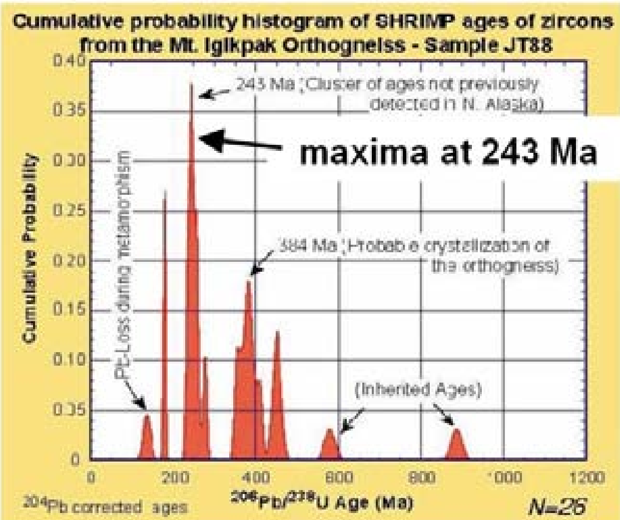


Structures on the ocean-floor and on the Brooks Range provide further evidence for the Impact

Detail 1 : Remaining section of crater-wall visible. Structures on the crater floor indicate the angle of the escaping ejecta.

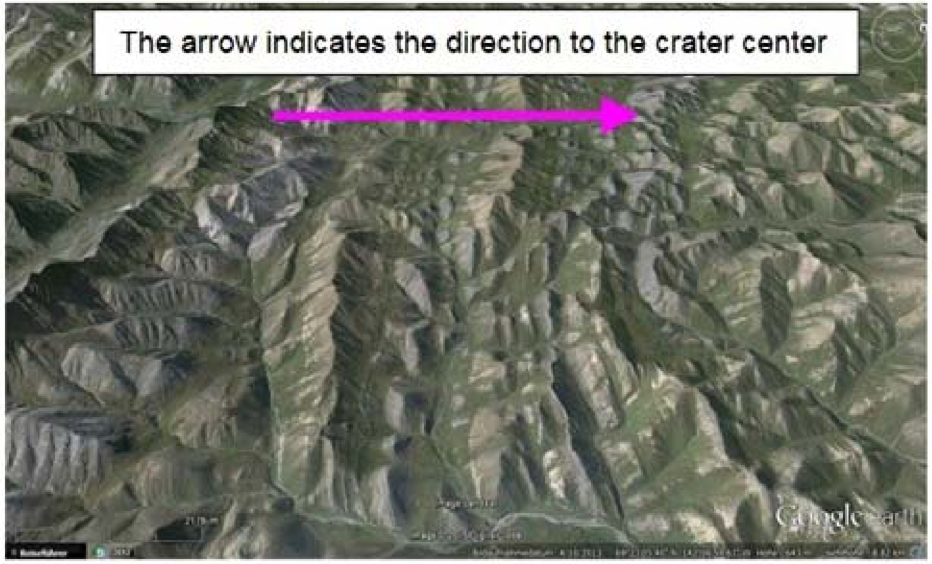
Detail 2 : This section of the Brooks Range also indicates the escape angle of the ejecta. It's similar (but opposite) to Detail 1



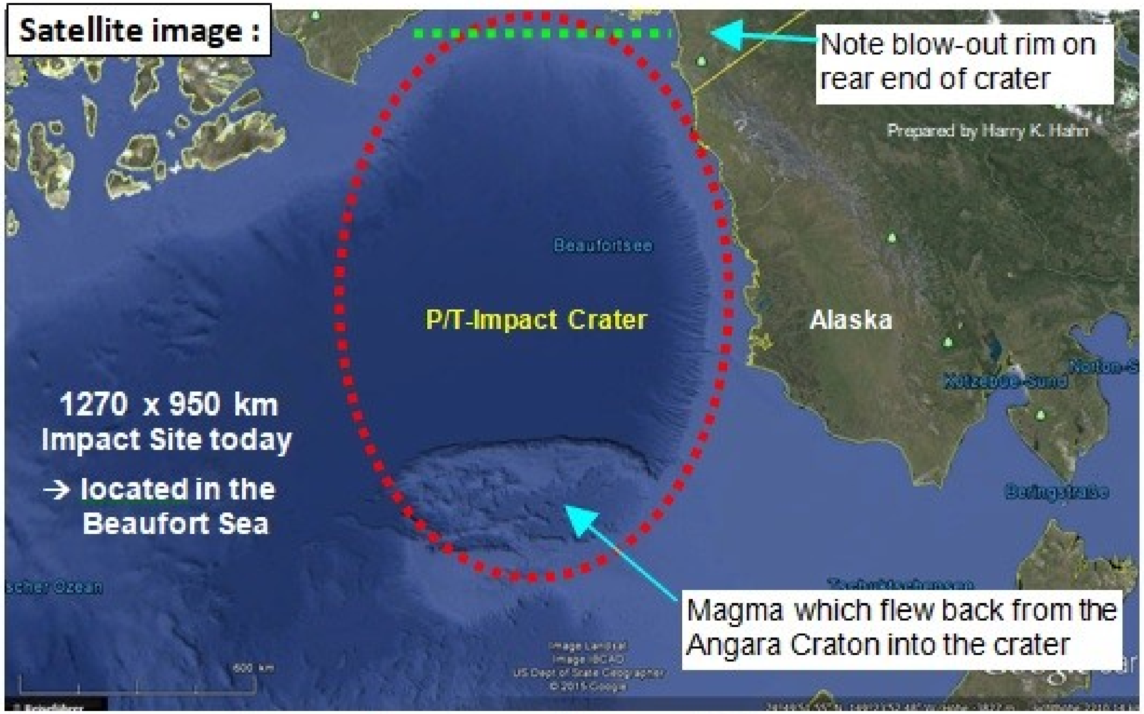


see : [Zircon Analysis of Rocks from the Brooks Range](#) (from Jaime Toro, Dep. Geology, WV) : With SHRIMP-RG analyzed rims and cores of 15 zircon crystals indicate 206Pb/238U ages range from 137 to 887 Ma with **histogram maximas at 243 & 384 Ma.**

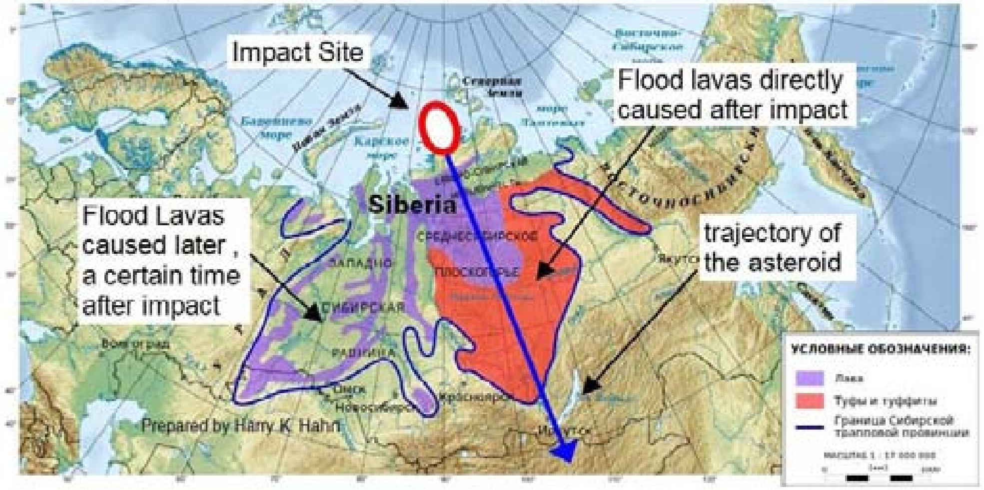
Detail 3 : The Brooks Range formed through compression of the crust surrounding the impact crater , which was caused by the extreme shockwaves of the impact event.
Note the linear structure of the mountain ridges and the rock layers which are tilted in a defined angle towards the crater center.



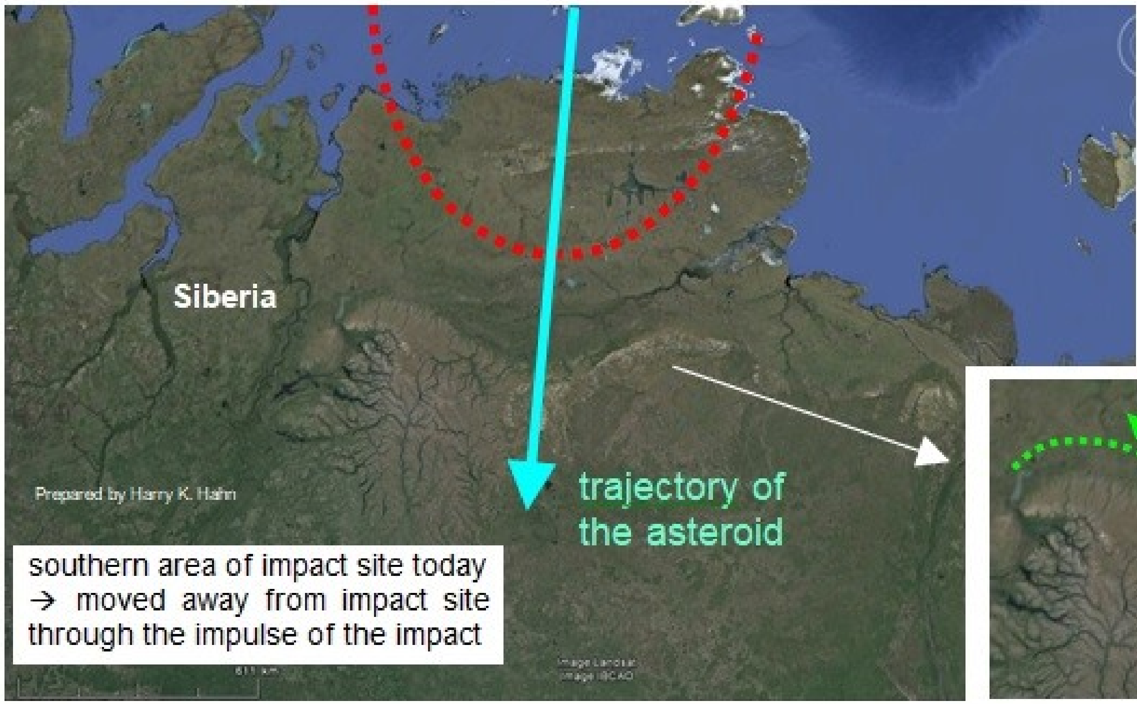
Shape and location of the Siberian Traps confirm the P/T – Impact Crater's position



The flood lavas caused by the impact: The Siberian Traps



The tongue-shaped outline of the Siberian Traps confirms that the proposed location of the P/T-crater is correct. The tip of the „red tongue-shaped area" indicates the trajectory of the impactor.



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

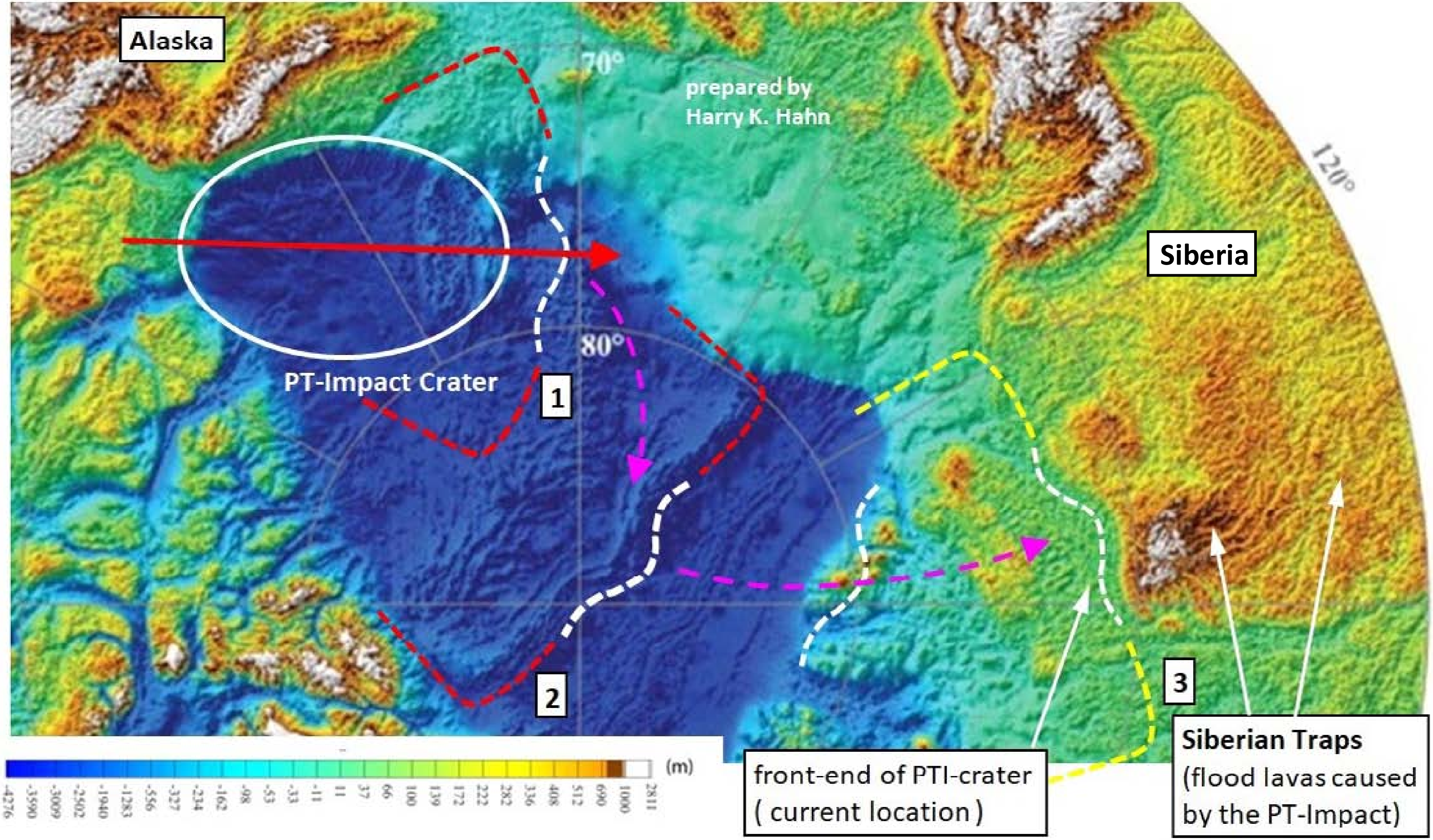
Structural Evidence for the P/T-Crater :

- Perfect elliptical outline of the Beaufort Sea Basin (open to one side)
- Bow-shape of Brooks Range fits to elliptical basin on the ocean floor.
- Age of Brooks Range ≥ 243 Ma (→ crystalization age ~ P/T-boundary)
- Tongue-shaped outline of the main section of the Siberian Traps fits to proposed location of the P/T-Crater
- The bow-shaped edge of the northern end of the Siberian Traps indicates the main direction of the ejecta which was ejected during impact (→ the Siberian Traps are mainly ejecta material !)
- The structure of the P/T Crater corresponds to a simulated impact

The topography provides further structural evidence for the P/T-Impact Event

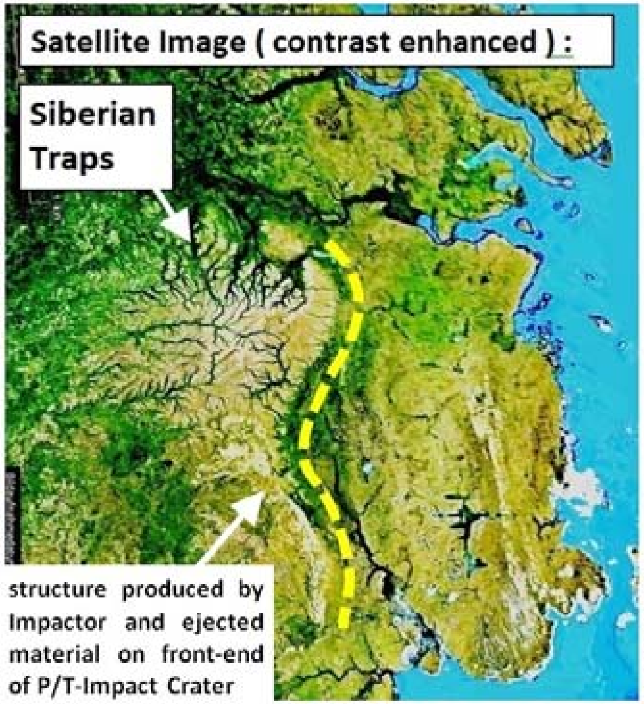
There are clear topographic traces visible in order to identify the front-end of the crater and its tectonic motion

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

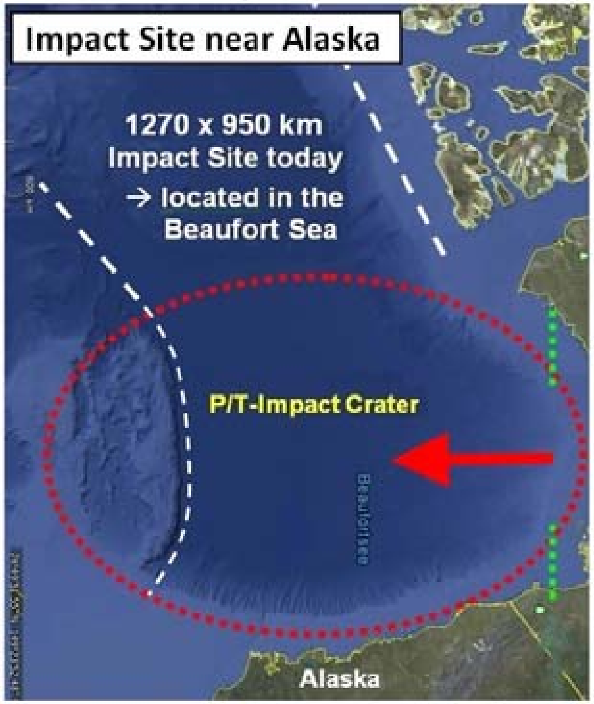


The topography of the real P/T-impact Crater is nearly identical to the topography of a simulated elliptical impact crater

Satellite Image (contrast enhanced) :

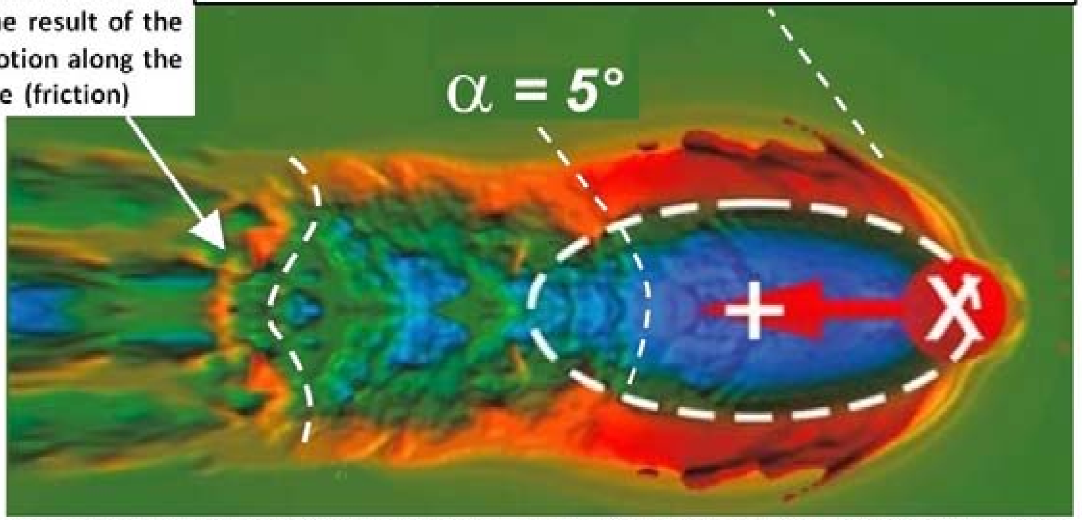


Impact Site near Alaska



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 :

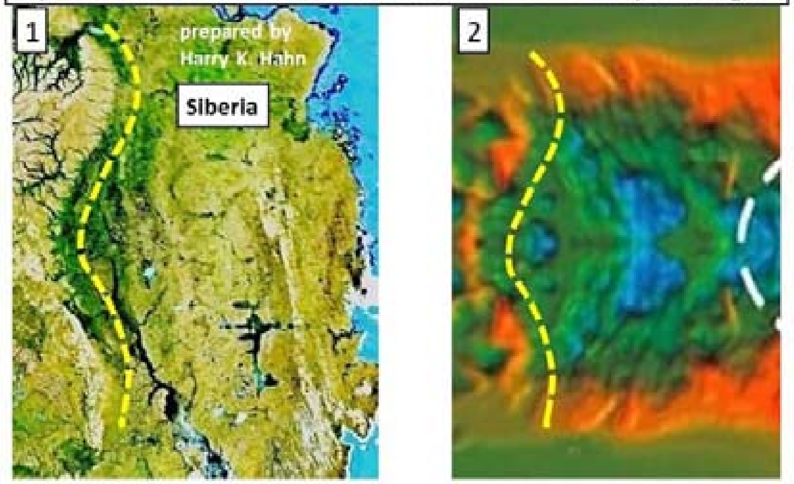


Early reflections of shock and rarefaction waves in the projectile prevent plastic deformation in the upper part of the body. The strong pressure gradient in the projectile suggests fragmentation of the projectile would likely occur.

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.

Note the similarity of the structures on the front-end of the Real- & Simulated-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

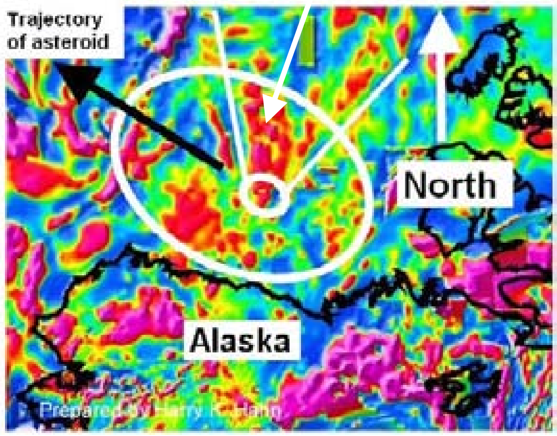


Topographic map

Magnetic Anomaly Map

Note the cone-shaped structure !

Note the cone-shaped Ejecta blanket (red) coming from the impact center



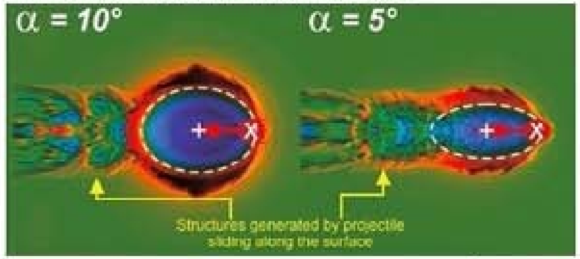
To the crater formation of the Ø1270 x 950 km P/T-Impact Crater

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 mostly forward directed 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 chapter 4**)

Reasons why it is difficult to find mineralogical evidence for the PTI

- **Because impact velocity was relatively low → probably ≤ 8 km/s and the impact angle was only 5 - 7° → resulting shock pressure was relatively low at the P/T Impact Site.**
- **Therefore the volume of molten rock, caused by the impactor, was probably less than 10 % of that, caused in a vertical impact**
- **Impact velocities & impact pressures at secondary impact sites of P/T-ejecta were even smaller than at the P/T – impact site**
- **The above mentioned impact conditions are the reason for the difficulty to find clear impact markers in the stratigraphic record (e.g. impact breccia, suevite, diaplectic glass, PDF's etc.)**

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

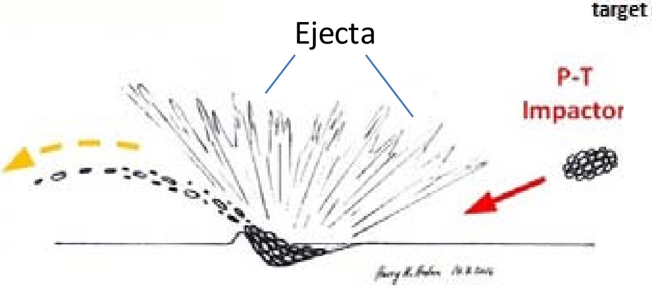
Dirk Elbeshausen,[1] Kai Wünnemann,[1] and Gareth S. Collins[2]

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].

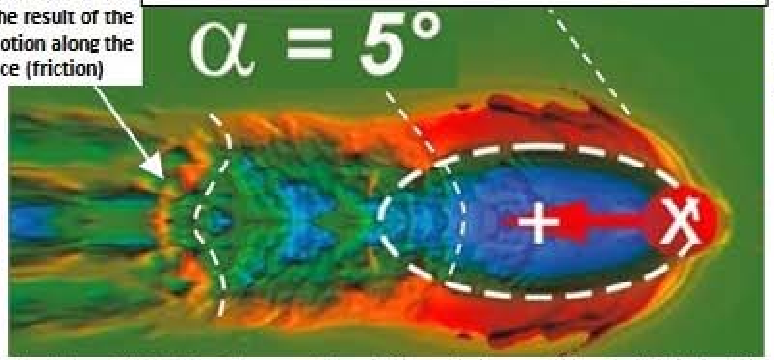
[6] In all simulations, we assume terrestrial gravity conditions ($g = 9.81$ m/s^2) and resolve the projectile by 16–24 cells per projectile radius. We varied the impact angle α in a range between 90° (vertical impact) and 5°. The primary focus of this study was on low impact angles ($\alpha < 30°$),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

Side View of the P/T Impact :



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 :

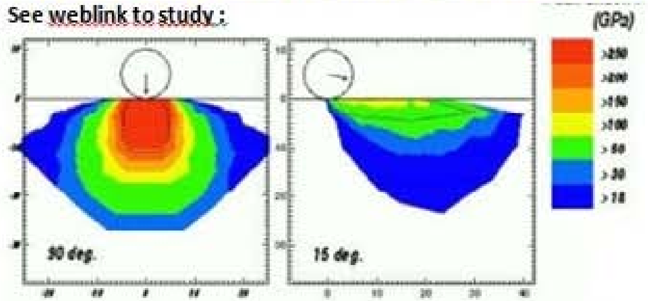


Early reflections of shock and rarefaction waves in the projectile prevent plastic deformation in the upper part of the body. The strong pressure gradient in the projectile suggests fragmentation of the projectile would likely occur.

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.

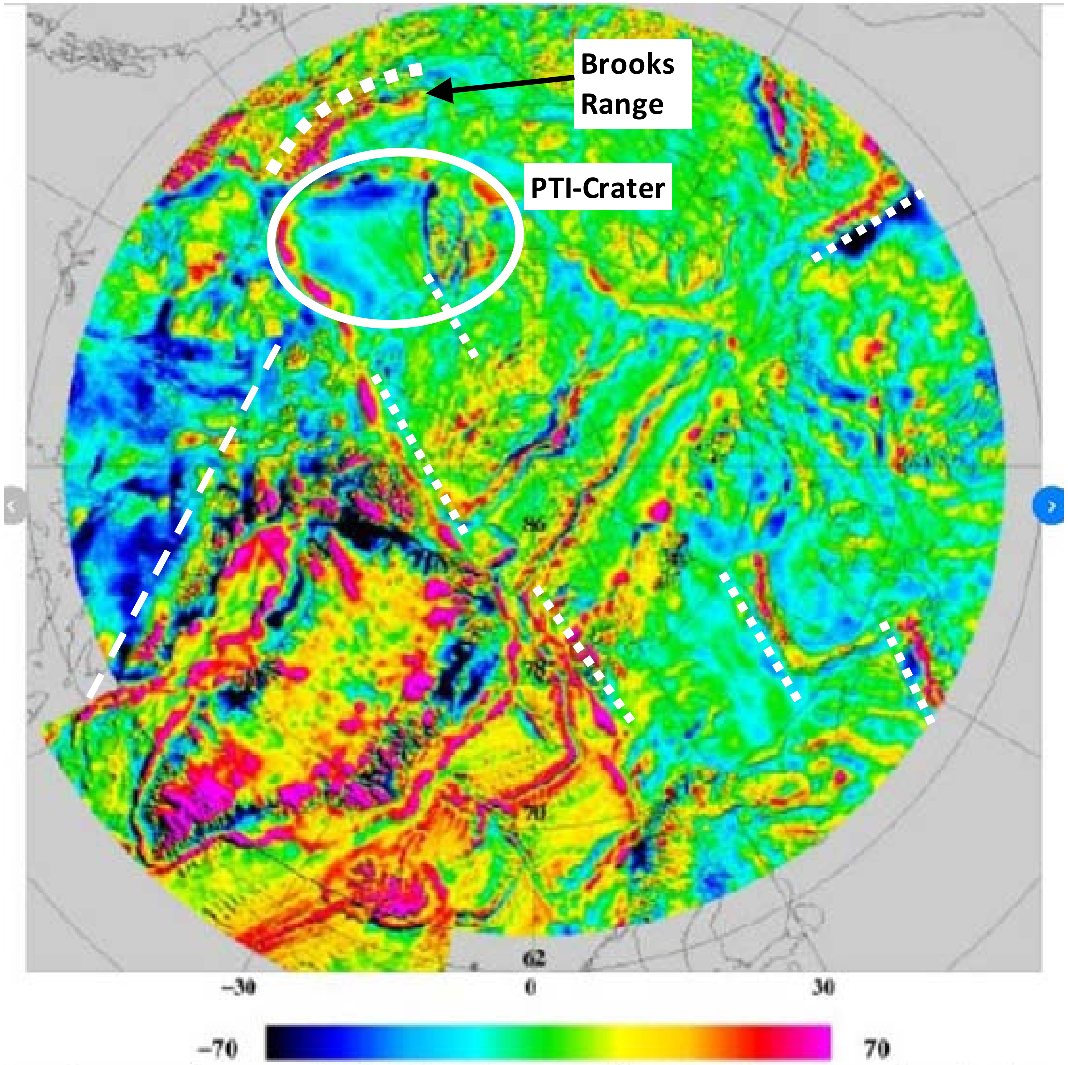
The diagrams below show that the maximum shock pressure is drastically reduced in an oblique impact at 15° impact angle compared to the vertical impact case. The reduction in volume of melt is ≥ 90% for a 15° impact !
(This estimate does not include possible melting due to shear heating).
That means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

See weblink to study :



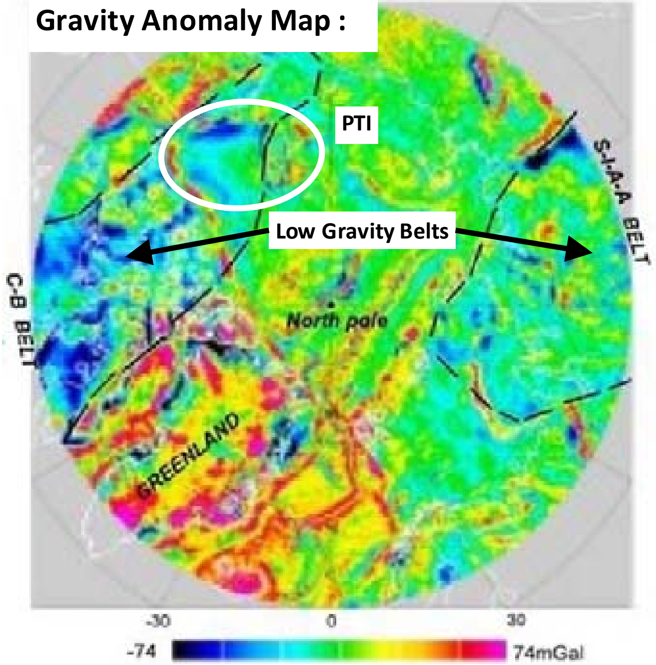
Gravity Anomaly Map of the PTI – Crater

The P/T-Impact Crater, the Brooks Range and a number of linear structures can be identified as gravity anomaly structures, resulting directly from the P/T impact event.

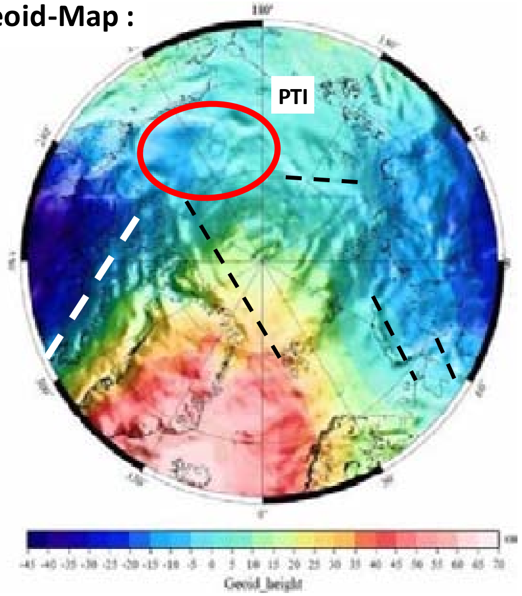


Arctic Gravity project free-air anomaly grid, mGal. The data is compiled from major airborne surveys, surface, icebreaker

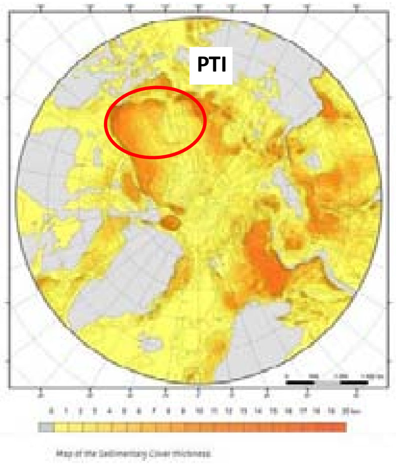
→ Polar-Projection of Arctic area :



Geoid-Map :



Sediment-Map :



Arctic gravity anomaly map (left) and geoid anomaly map (right). Both extracted from Forsberg et al. (2006) and www.esa.int/esaLP/SEMMNBAATME_index_2.html. Note that the two low-gravity belts are connected in the Arctic Ocean, which is best seen in the geoid map. The GRACE gravity map shows the geoid anomalies, which reflect mainly the Earth's surface topography (local high-gravity anomalies in the mountain regions) and the mantle inhomogeneity (large-scale low and high anomalies). The observed gravity field provides us with insight into intriguing tectonic features of the mantle. The high-gravity regions all coincide with the tectonically most active regions in Meso-Cenozoic time. The regions are commonly underlain by slow mantle at shallow depth (above 350 km) except for the

The P/T – Impact Crater shown on the Tectonic Map & Ocean-Floor-Age Map

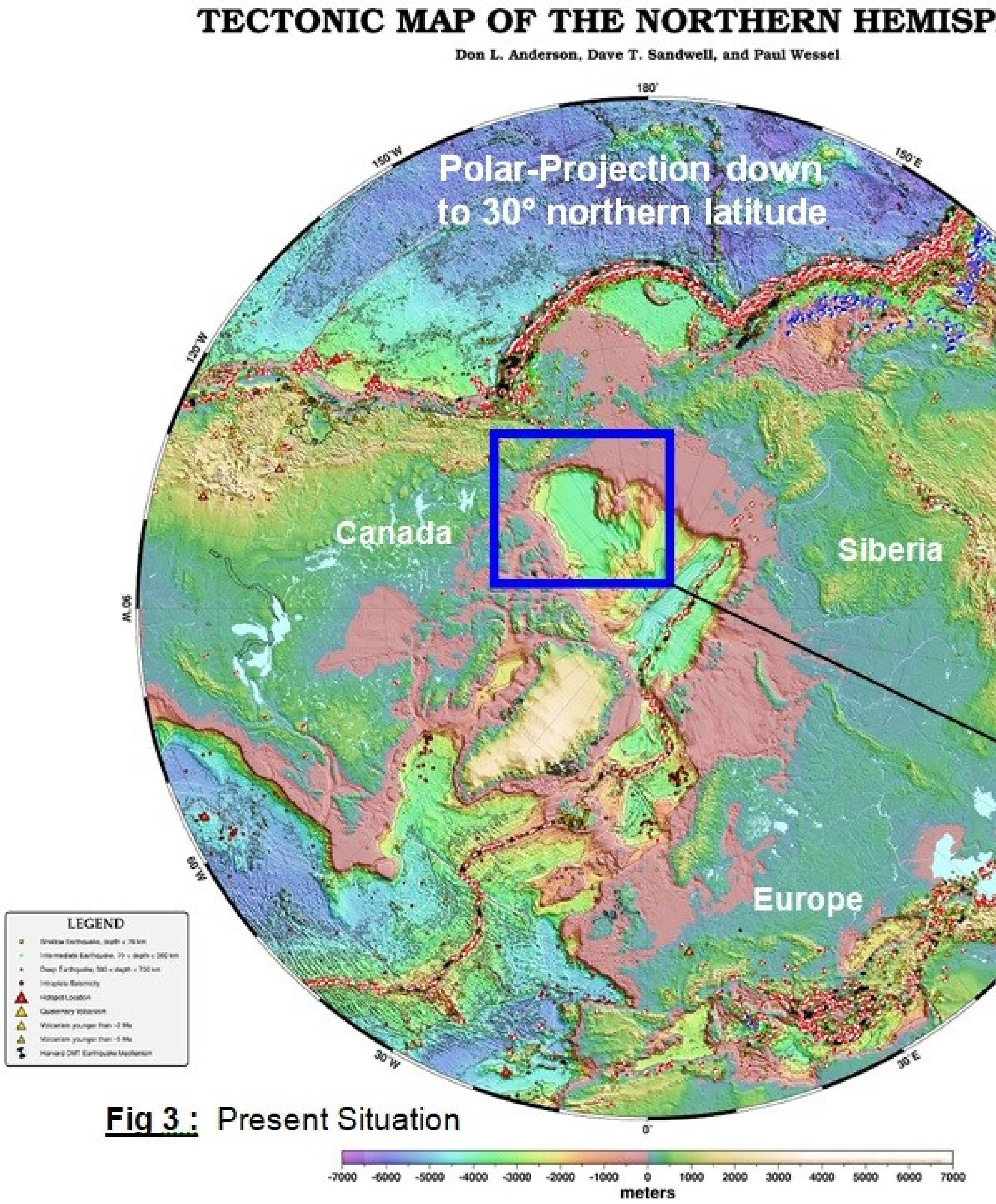
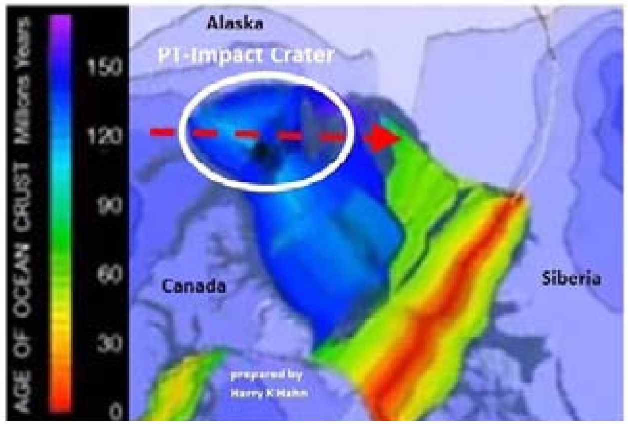
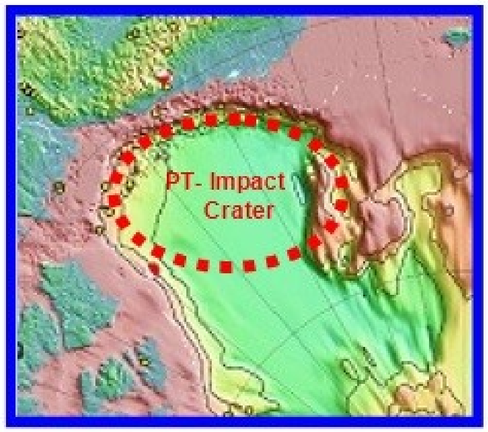


Fig 3 : Present Situation

Ocean-Floor Age Map of PT-Impact Area



Detail of Impact Site



Polar Projection of the P/T – Impact Event with the positions of Earth's continents as they probably were located at the time of the impact

→ Note the butterfly-shaped ejecta blanket (orange) and the secondary craters caused by the P/T-Impact.

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.

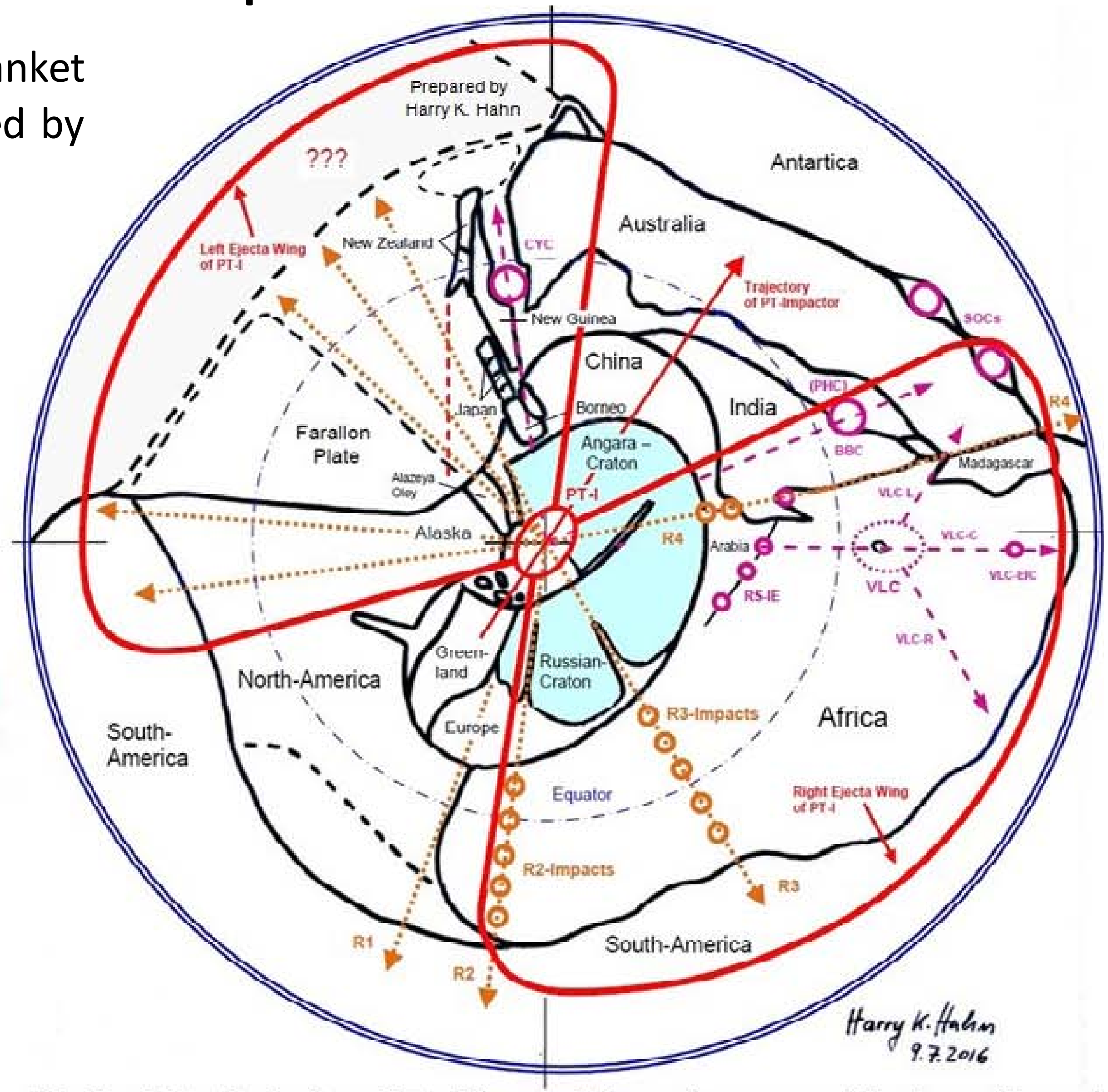


Fig 1 : Polar-Projection of Earth's complete surface area at the time of Impact centred on the PT-Impact Crater. **Earth diameter : ~6500-7500 km**

The impact area as it appeared around 100 Ma ago

→ North-America and Siberia are drifting apart from each other, caused by the dynamic impuls from the impact and caused by an expanding Earth !

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 !

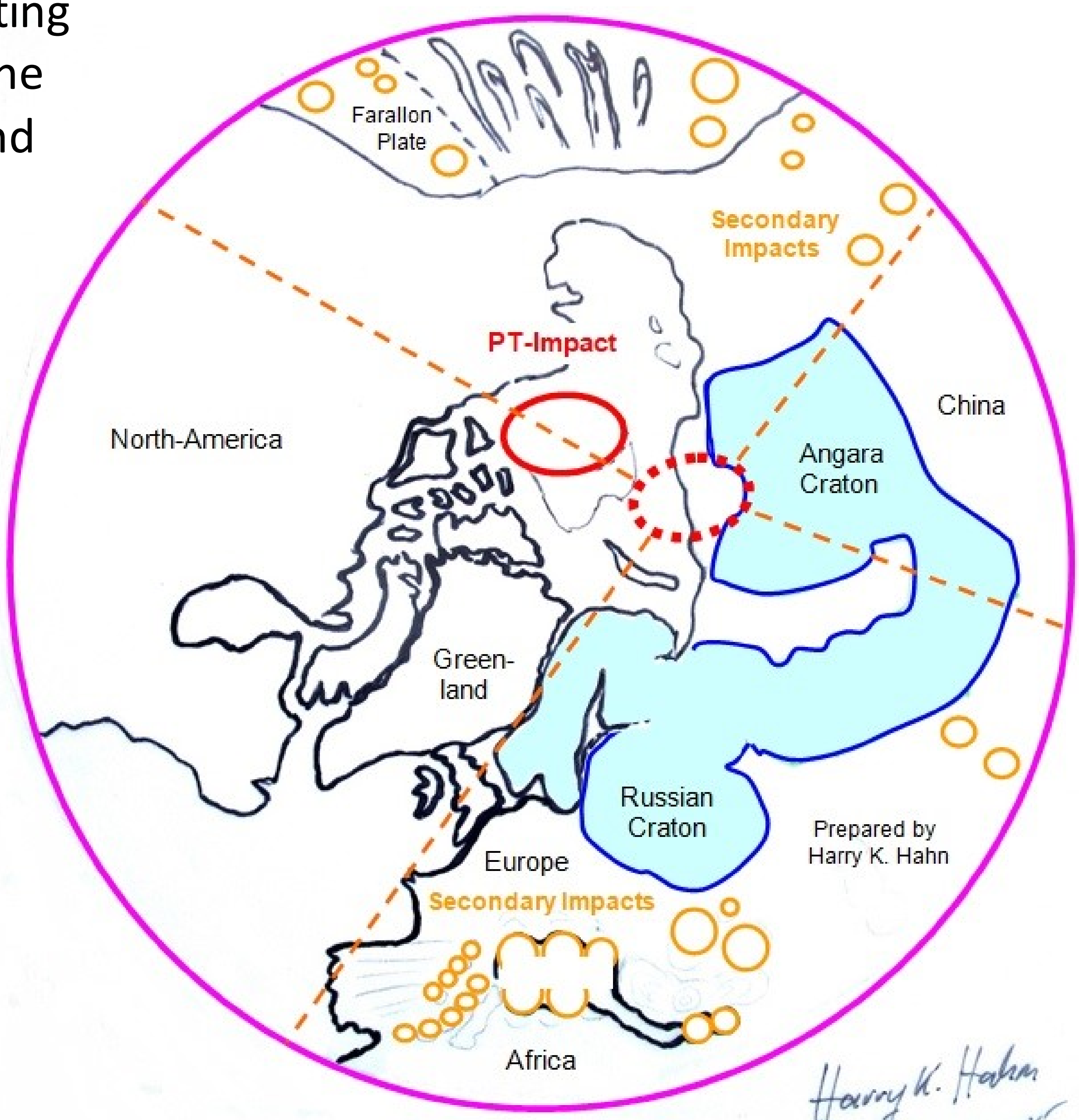
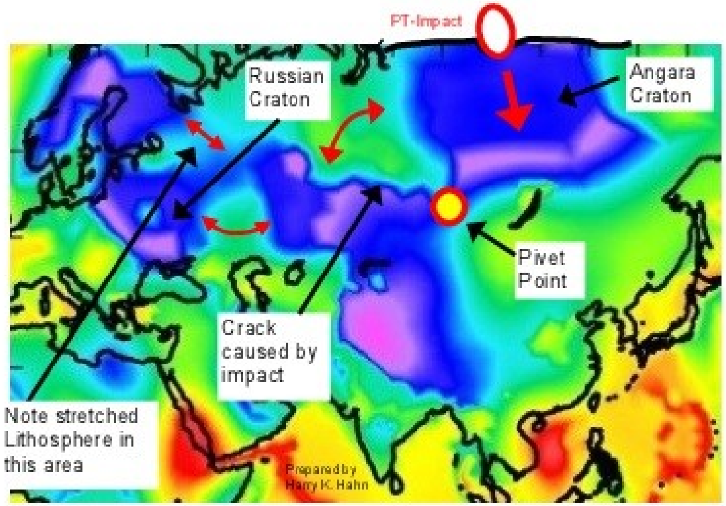


Fig 2 : Polar-Projection down to 30° N
~100 Ma ago, Ø **Earth : ~ 10000 km**

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 PT₂-Impact triggered strong Expansion tectonics on Earth which is probably still going on today. (→There is certainly much more expansion than subduction going on even today !)



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.

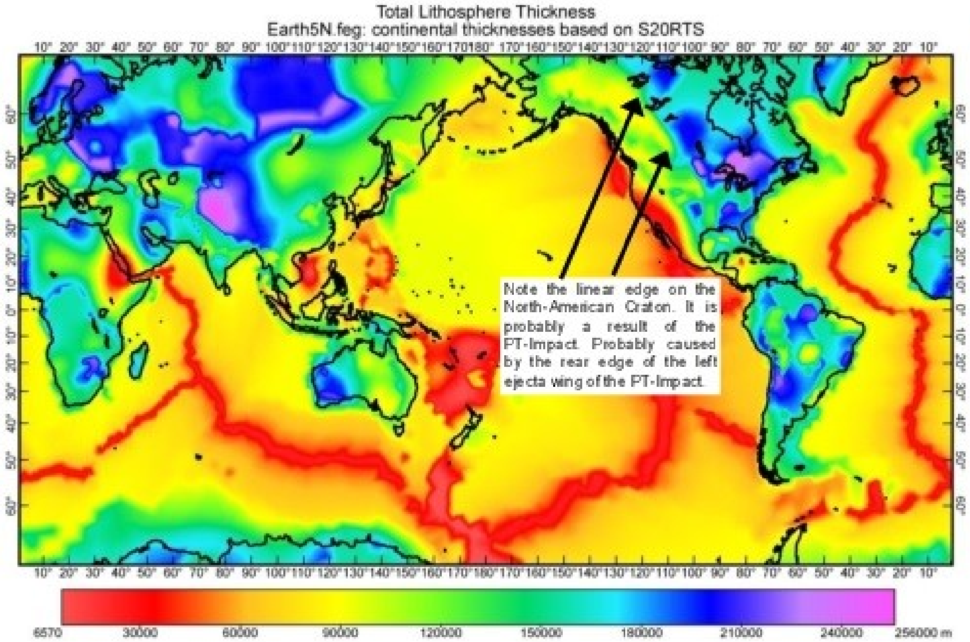
Model of total lithosphere thickness. A composite of continental thicknesses scaled from vertical-S-wave upper-mantle travel-time-anomalies and an age-dependent model in the ocean basins.
See following Weblink : http://peterbird.name/publications/2008_torque_balances/012_total_lithosphere-Earth5N.jpg

The physical description of the impact event :

The PT₃-Impact event can roughly be divided into three phases which I will describe in the following :

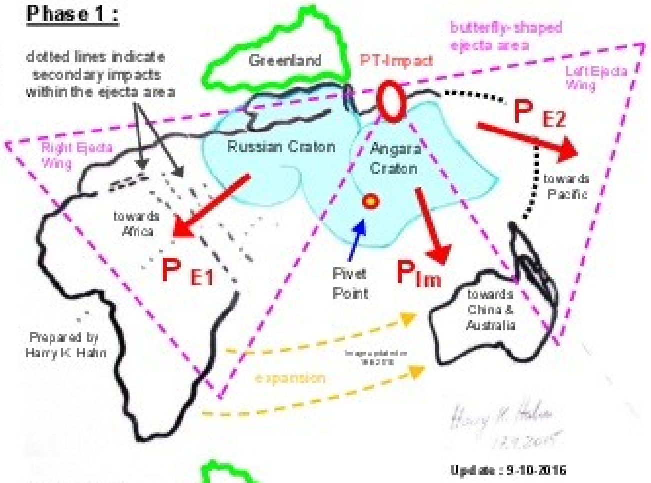
Phase 1 : The impact produced three main impulses which were induced into the surrounding Lithosphere. The impulse P_{IM} from the Impactor itself and the two Ejecta-Impulses P_{E1} and P_{E2} which all accelerated different areas of Eart's crust (lithosphere). The following formula can be applied :

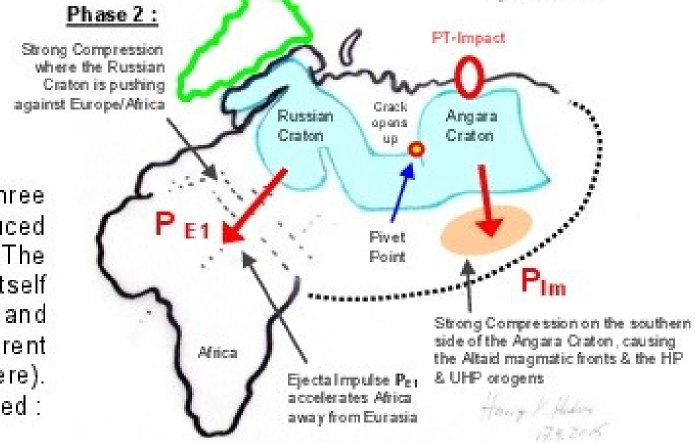
$$P_{Total} = P_{IM} + P_{E1} + P_{E2}$$

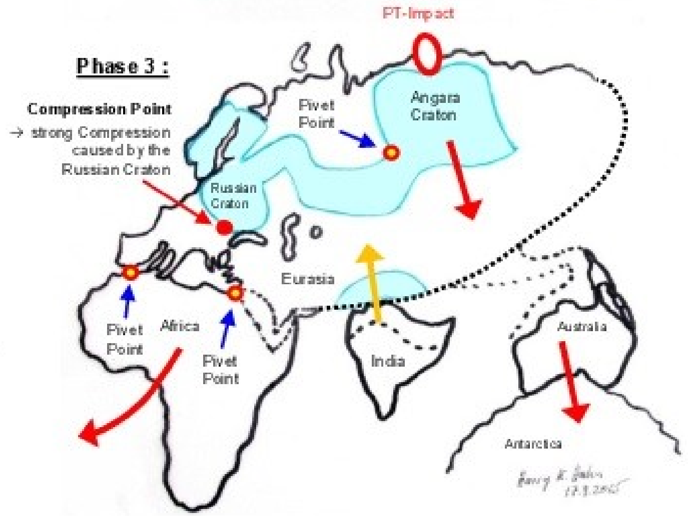


Phase 2 : The accelerated sections of Earth's Crust (e.g. the Angara & Russian Cratons, which rotated around a common pivot point) then later produced immense compression stress further away, where they collided with other thick crust areas.

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.



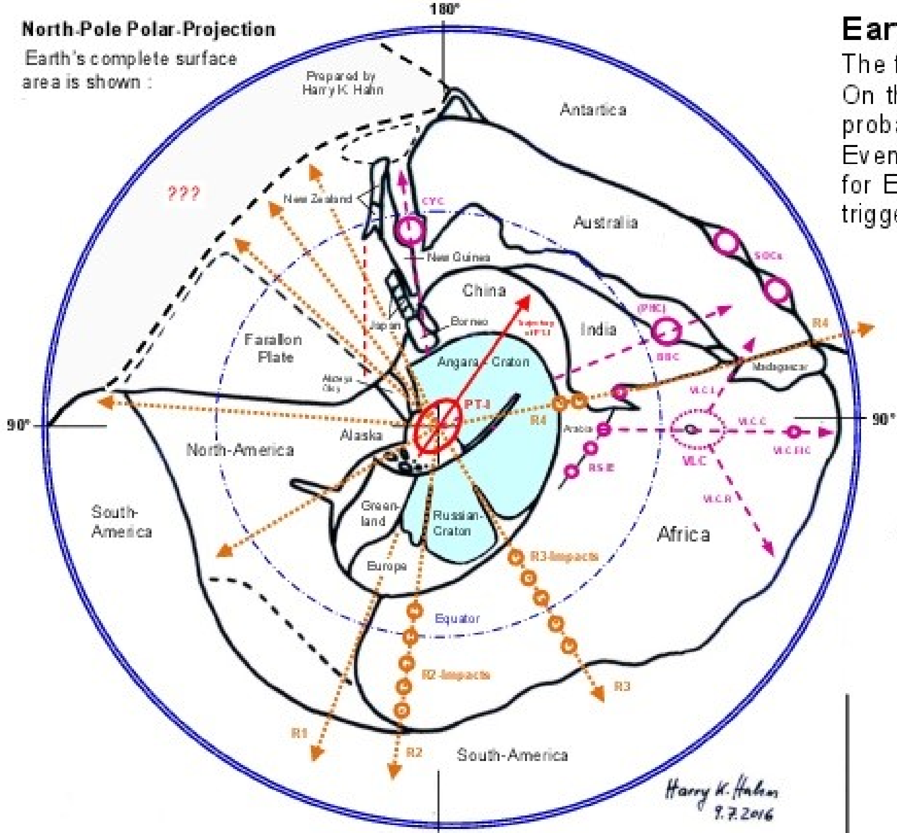


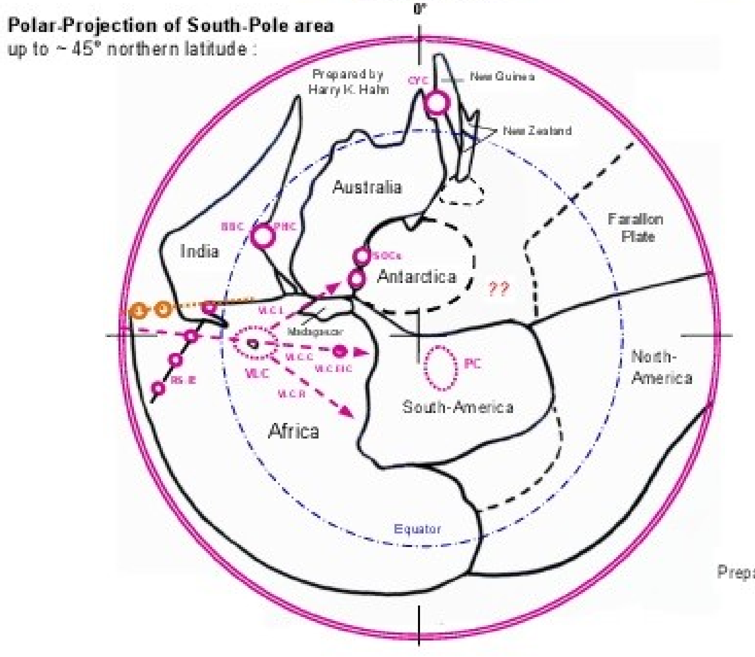


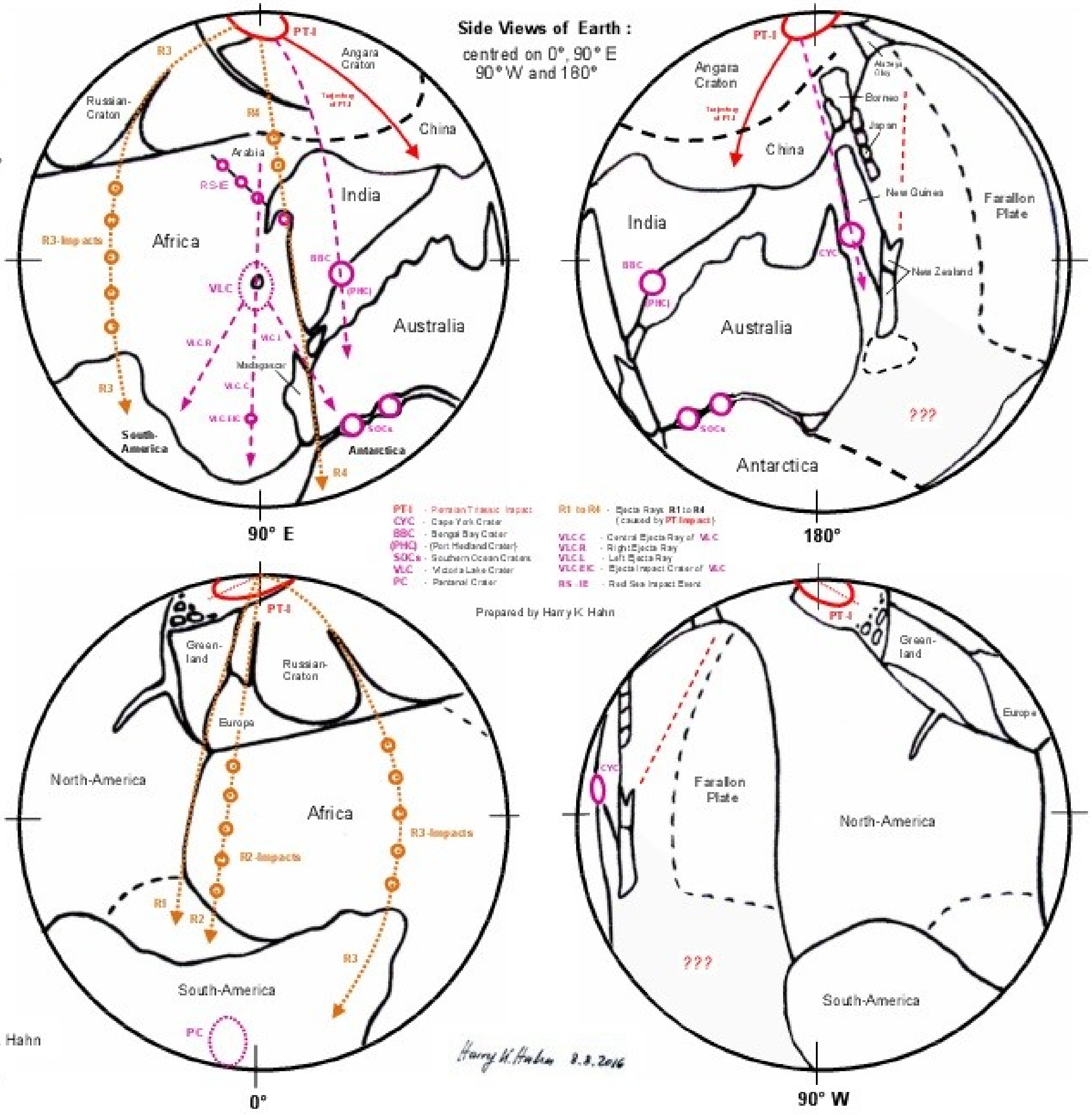
Earth at the time of the PT-Impact Event

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**





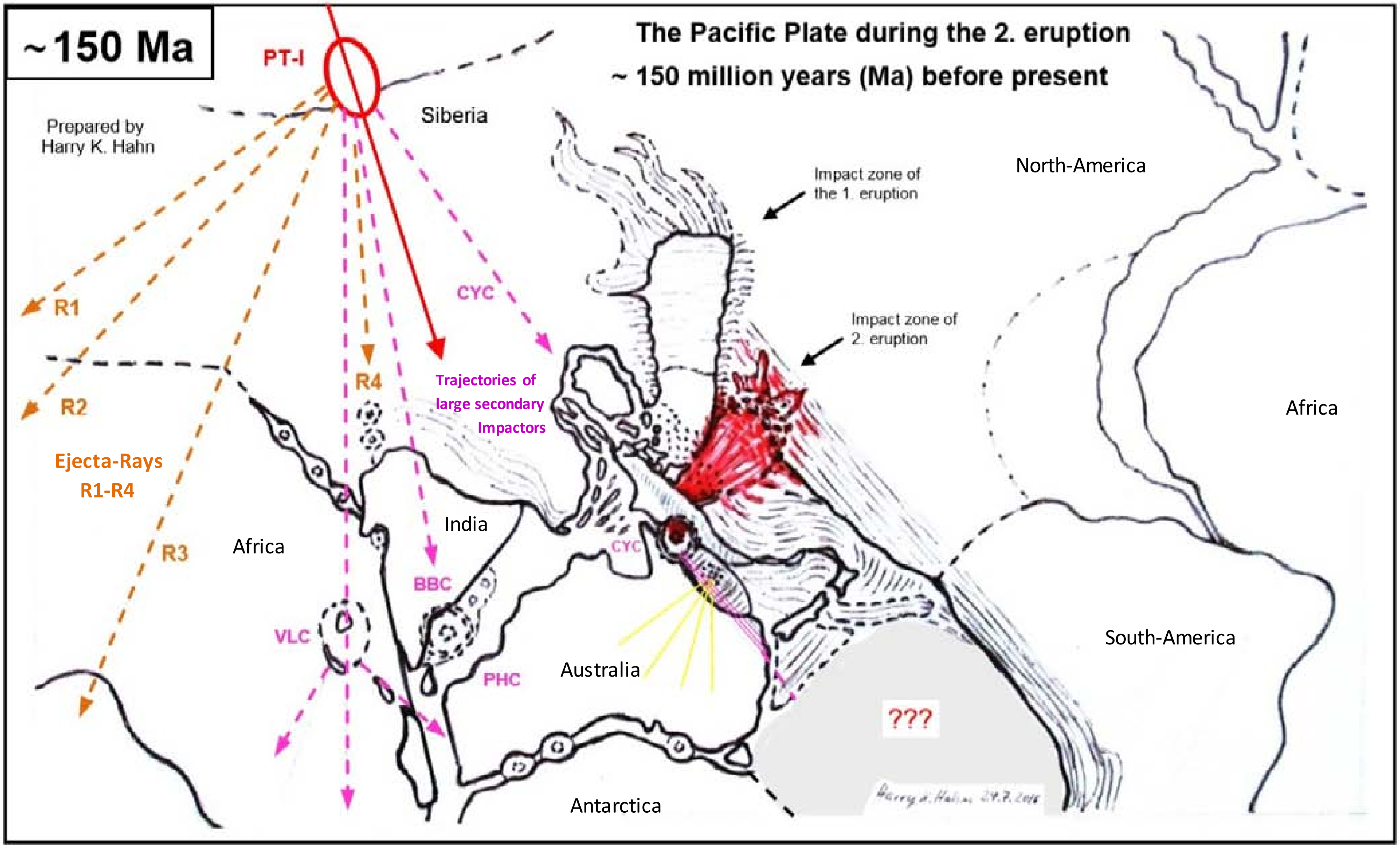


Prepared by Harry K. Hahn

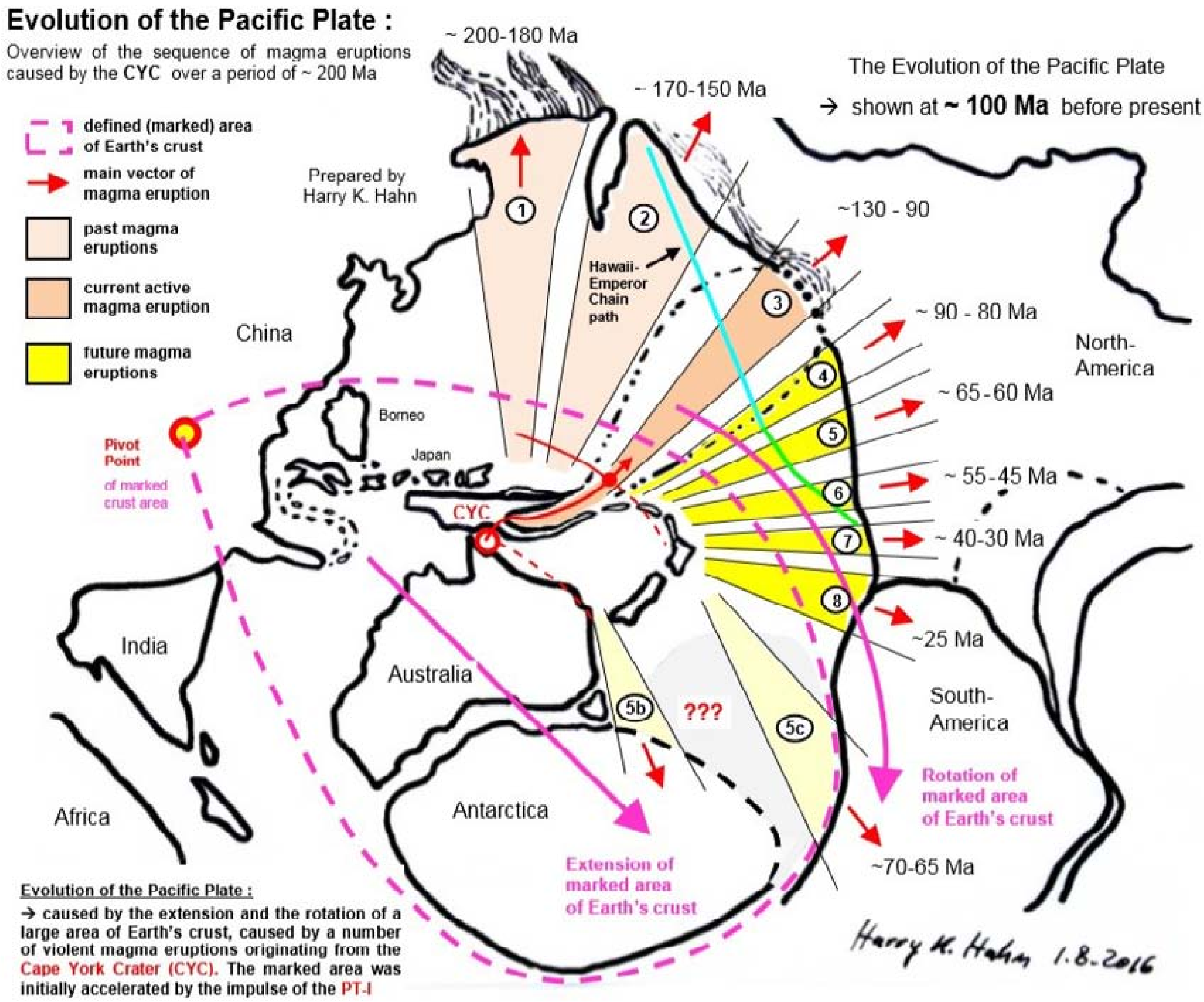
Update: 9-10-2016

The Pacific Region 150 Ma ago, after the 2. magma eruption of the Cape York Crater

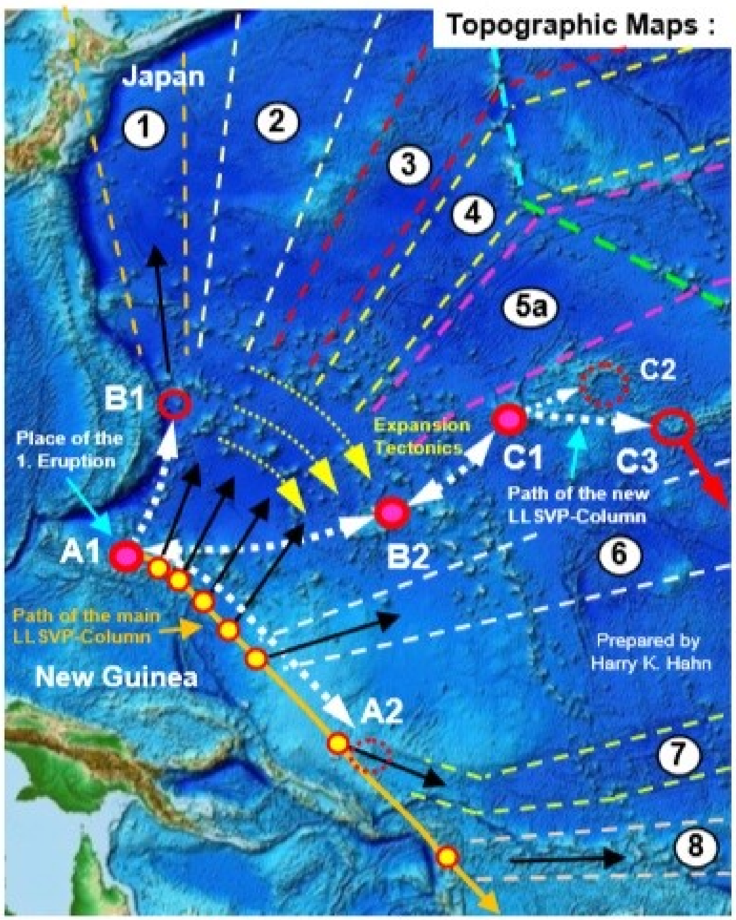
→ After the P/T-Impact Event the Cape York Crater erupted at least eight times large amounts of magma



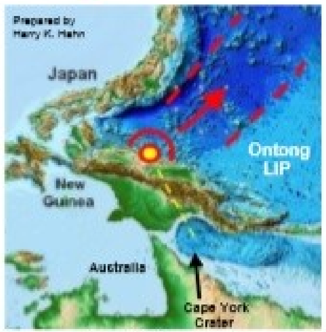
Expansion Tectonics amplified by magma eruptions from the CY-Crater caused the Pacific Plate



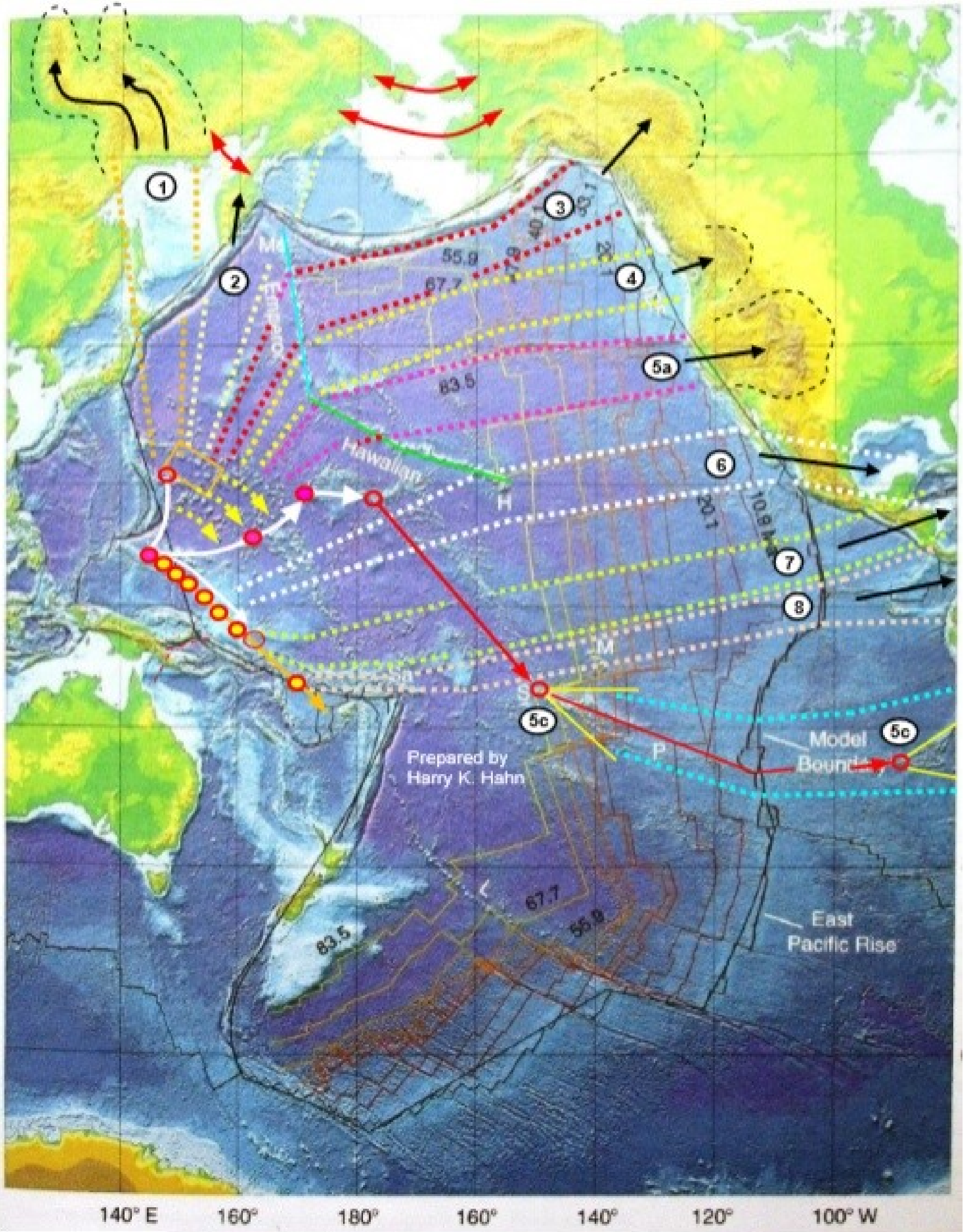
The topography of the Pacific Region shows the traces (& tracks) of ≥ 8 eruptions from the CY-Crater



Source Area
Path of Source Area
Eruption Path
Eruption No.
Drift-off copies of source area 1
A2, B1-2,C1-C3 : Chronological order (age) of the "Drift-off-copies" of source area 1 (A1)



The small map on the right shows the situation around the **3.** or **4.** magma eruption The eruptions started on the north-coast of New Guinea

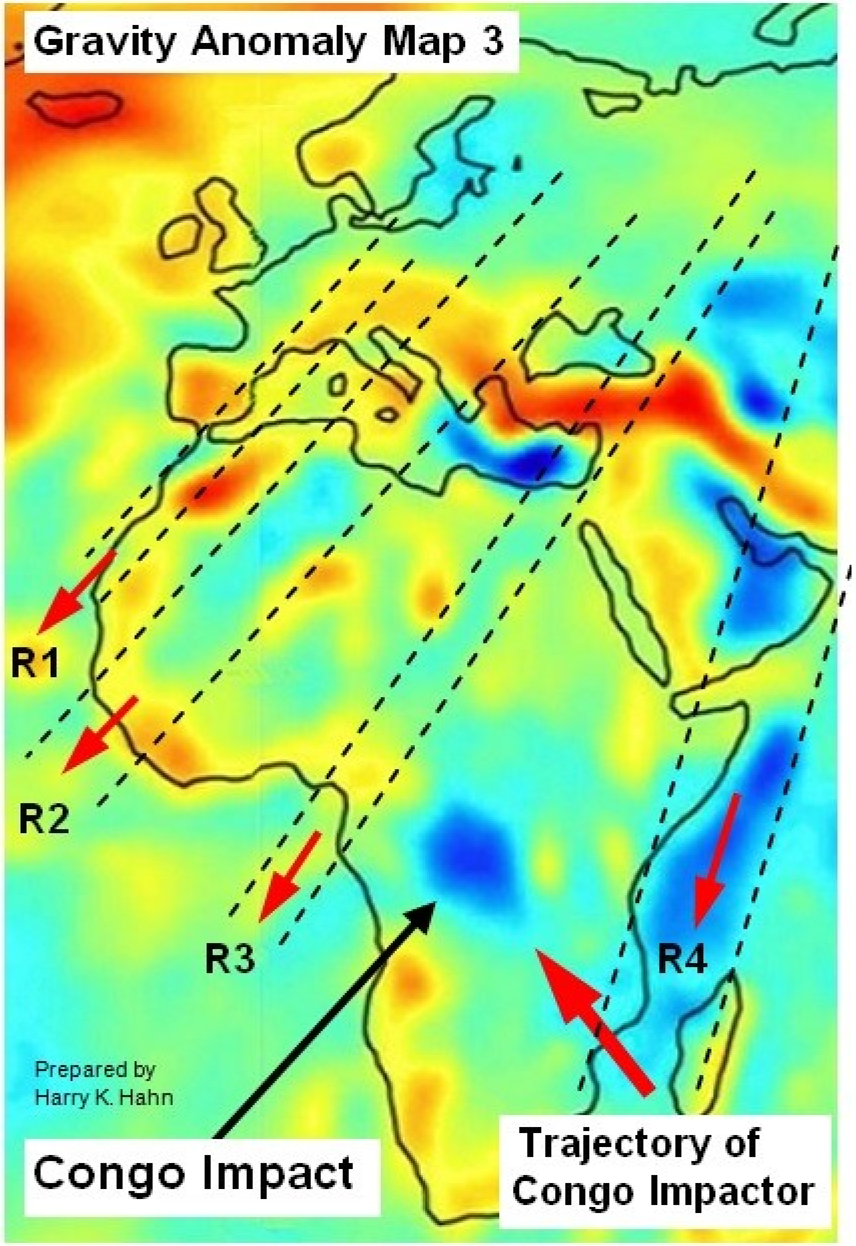


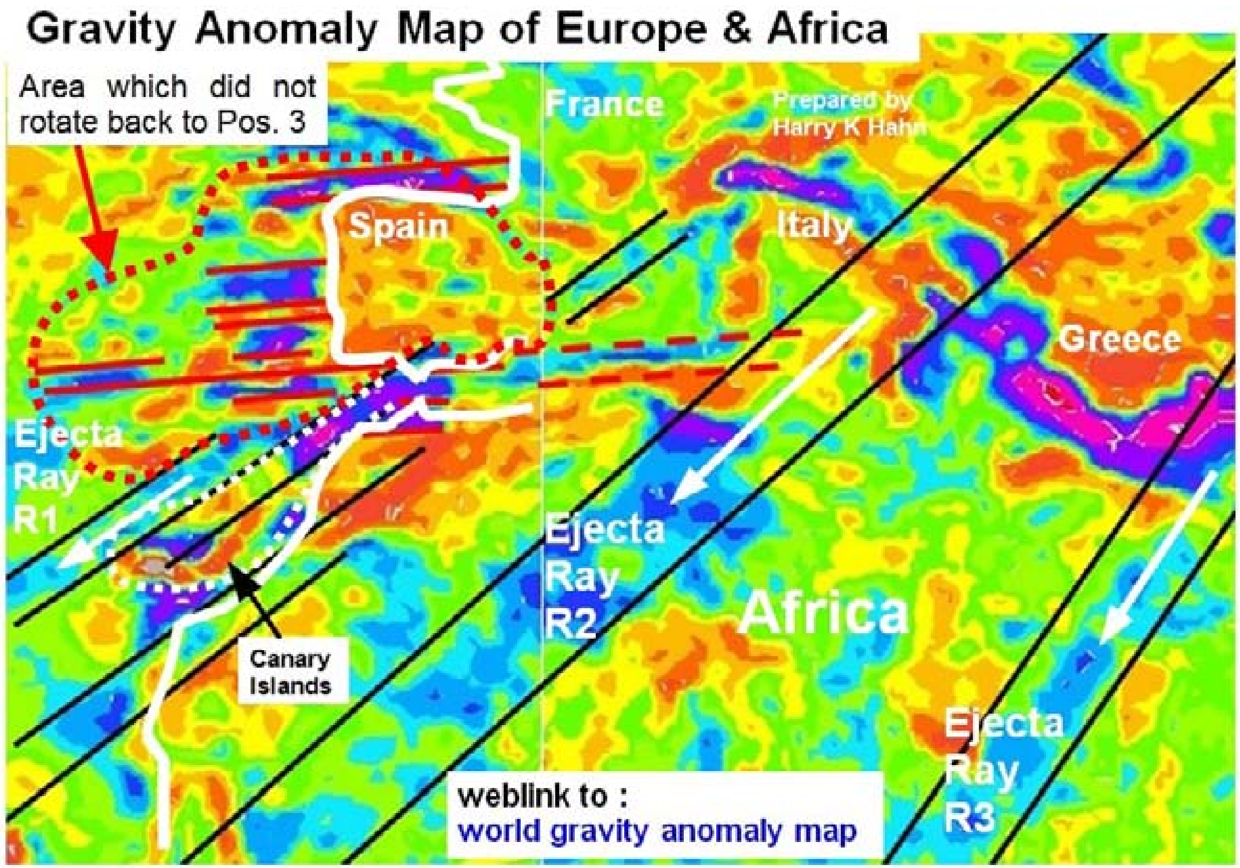
The larger map above shows the path of the source of the magma eruptions (yellow dots on orange arrow). Today it is located near the Fiji-islands. The source, a LLSVP resulting from the PTI- & CYC-Impact, has formed another LLSVP-column (B2) after the 1.eruption

Gravity Anomaly Map of Europe & Africa

→ **blue** and **green** areas are **negative anomalies** → **red** and **orange** areas are **positive anomalies**

There are sets of linear structures (negative anomalies) visible which represent ejecta ray structures from the P/T-Impact



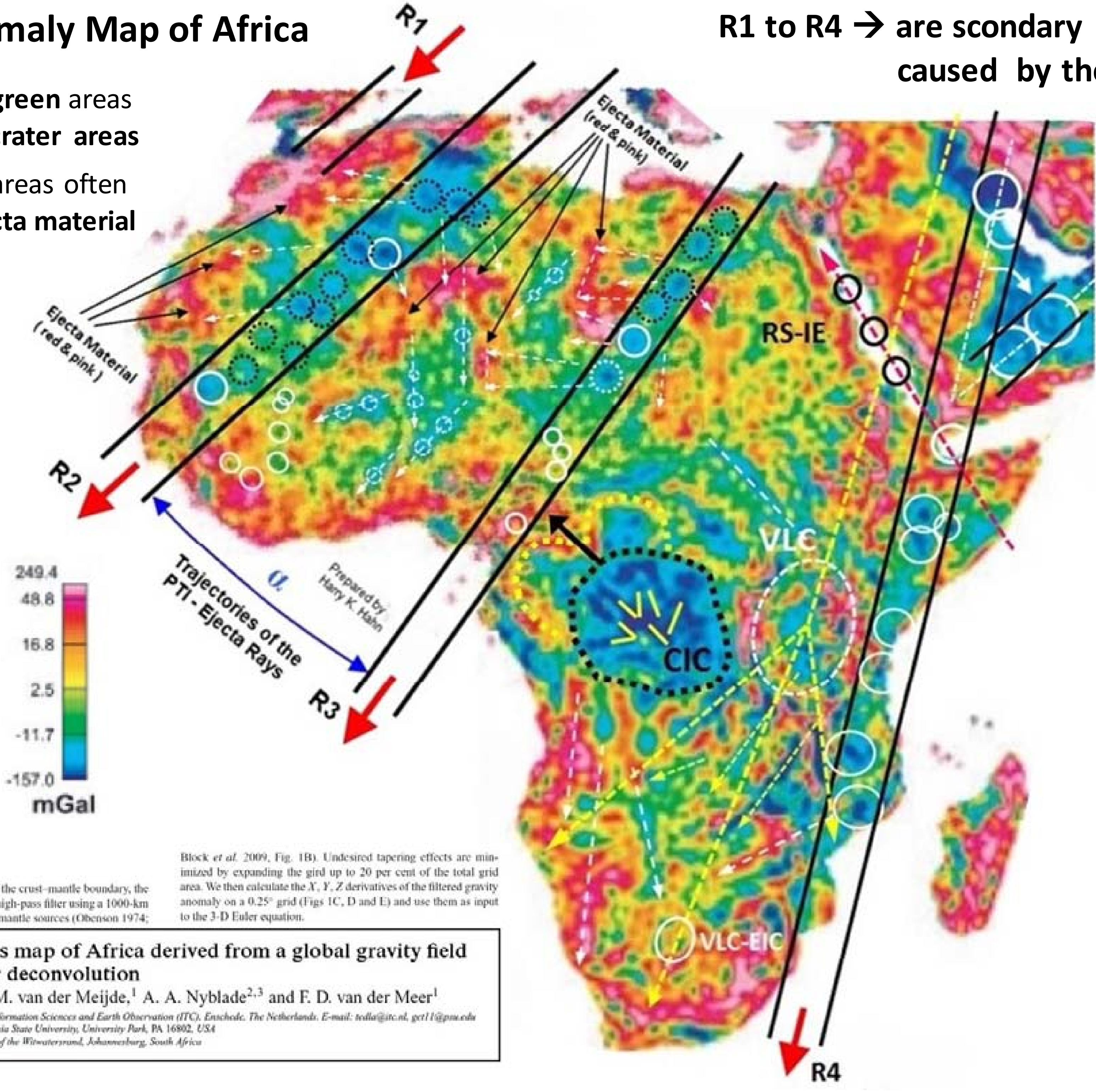


Gravity Anomaly Map of Africa

→ the **blue** and **green** areas show **impact-crater areas**

→ **red** and **pink** areas often represent **ejecta material**

R1 to R4 → are scondary crater chains caused by the P/T Impact



3 METHODOLOGY

As our main interest is the depth of the crust–mantle boundary, the gravity data are first subjected to a high-pass filter using a 1000-km cut-off wavelength to remove deep mantle sources (Obenson 1974;

Block *et al.* 2009, Fig. 1B). Undesired tapering effects are minimized by expanding the gird up to 20 per cent of the total grid area. We then calculate the *X*, *Y*, *Z* derivatives of the filtered gravity anomaly on a 0.25° grid (Figs 1C, D and E) and use them as input to the 3-D Euler equation.

A crustal thickness map of Africa derived from a global gravity field model using Euler deconvolution

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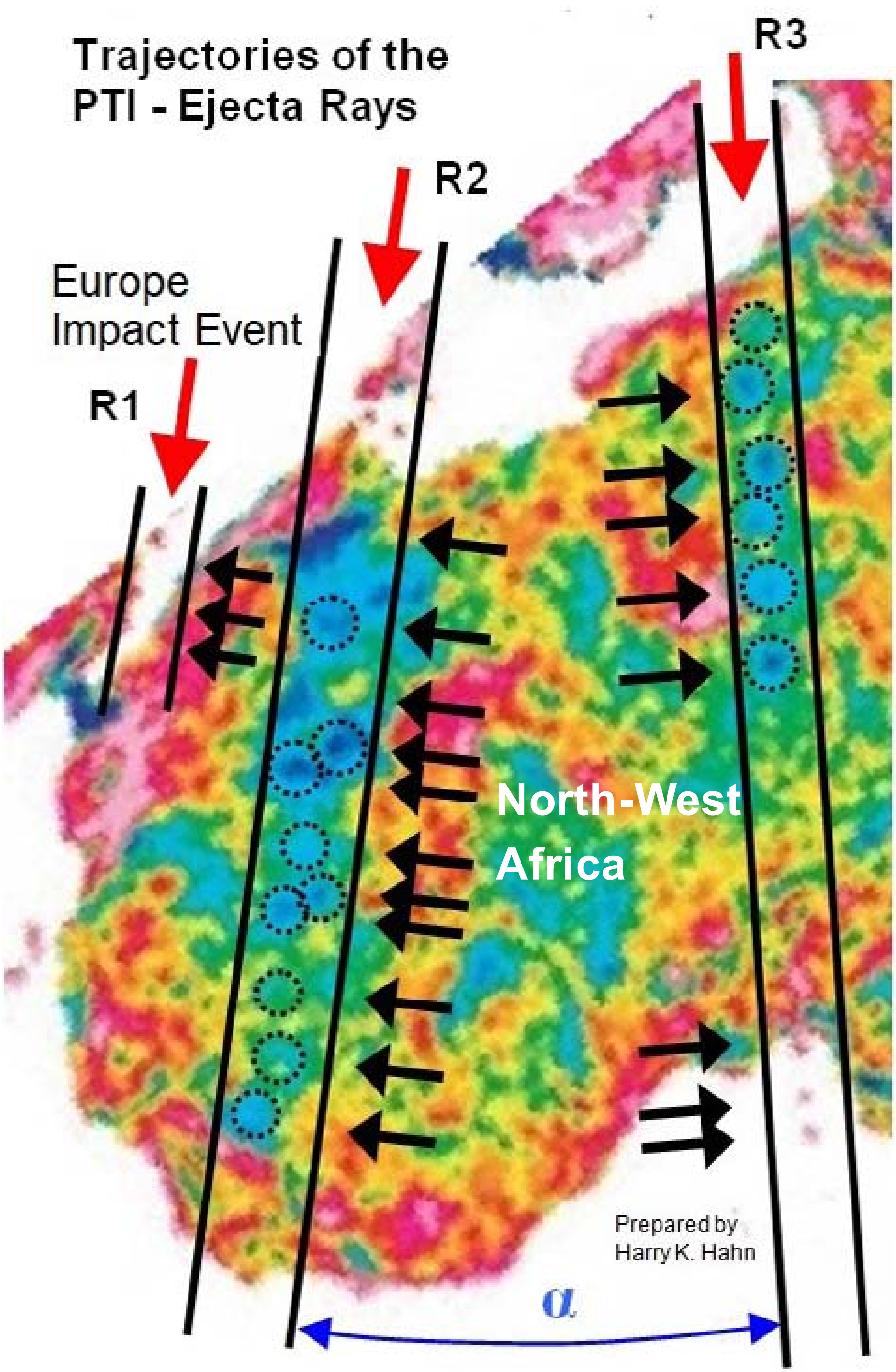
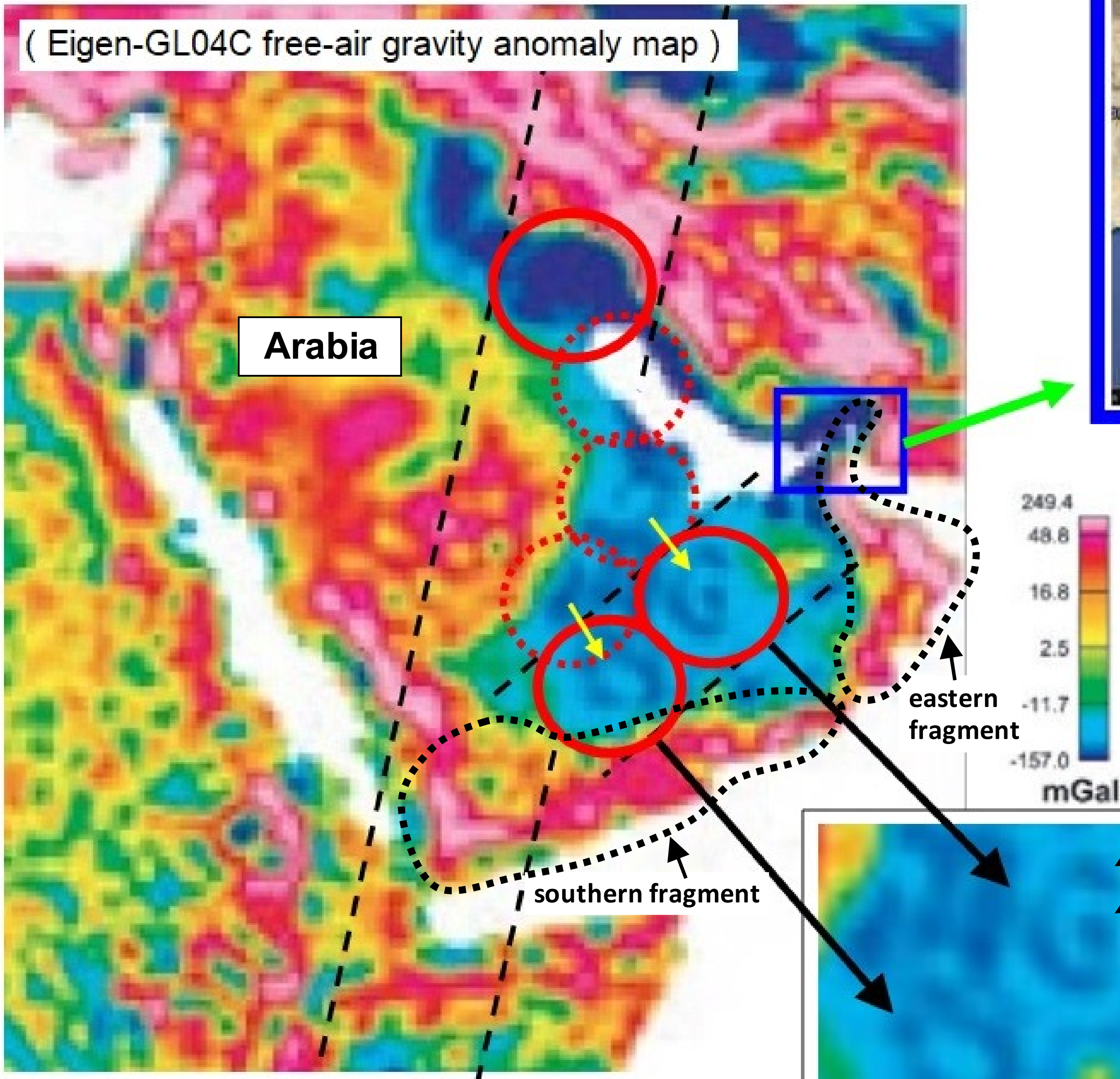
[2]*Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA*
[3]*School of Geosciences, The University of the Witwatersrand, Johannesburg, South Africa*

Ejecta Rays R2 and R3 → Secondary Impact Craters (crater chains) are indicated by circles :

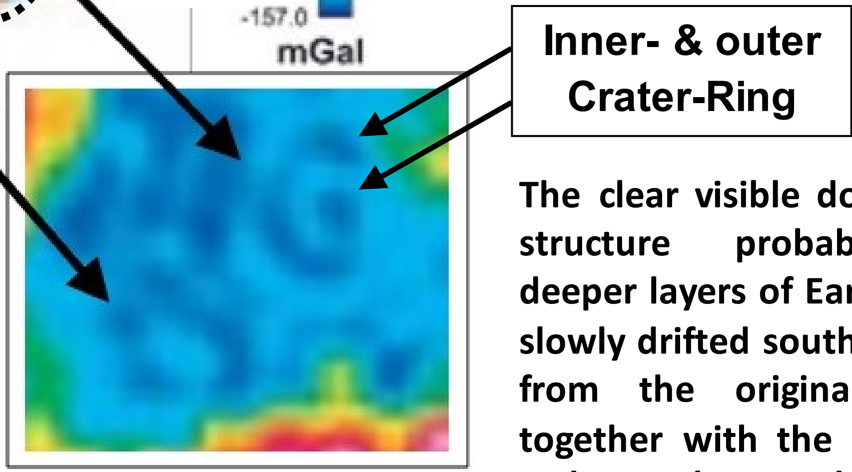


Oilfields North Africa Map :

A number of large craters caused by Ejecta Ray R4 are responsible for the formation of Arabia's Oil-fields



The gravity anomaly map shows that four large impact craters separated (cracked) the Arabian Peninsula into three crust-fragments The Southern Fragment is only connected on ist western end to the Arabian Shield area. The Eastern Fragment is only connected on ist northern tip to the Eurasian Plate.



The clear visible double-ring crater structure probably represents deeper layers of Earth's crust which slowly drifted south-eastward away from the original impact site, together with the lithosphere and asthenosphere underneath.

The Geological Map indicates the original orientation of the crust-fragments which were caused by the PTI-event

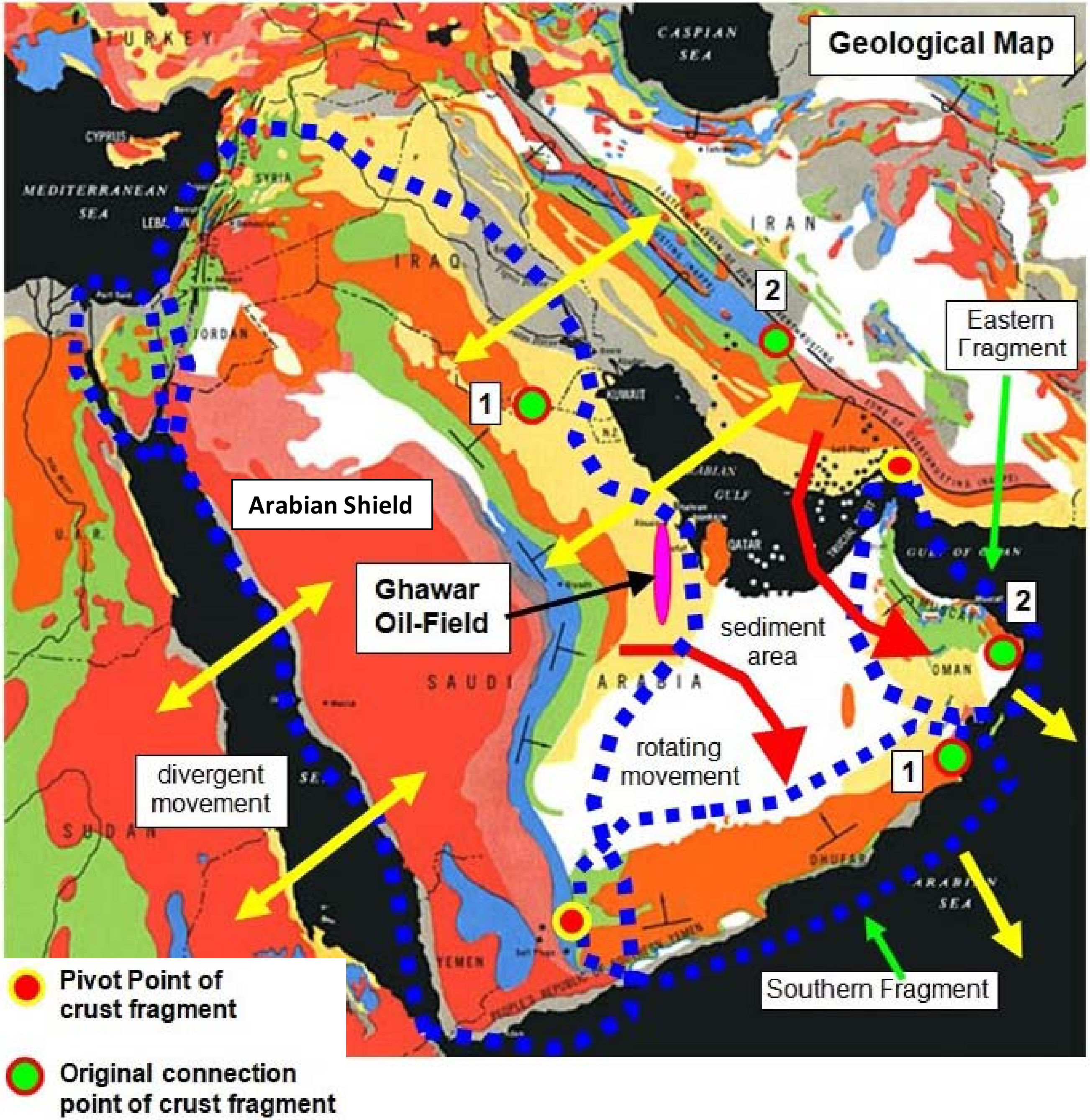
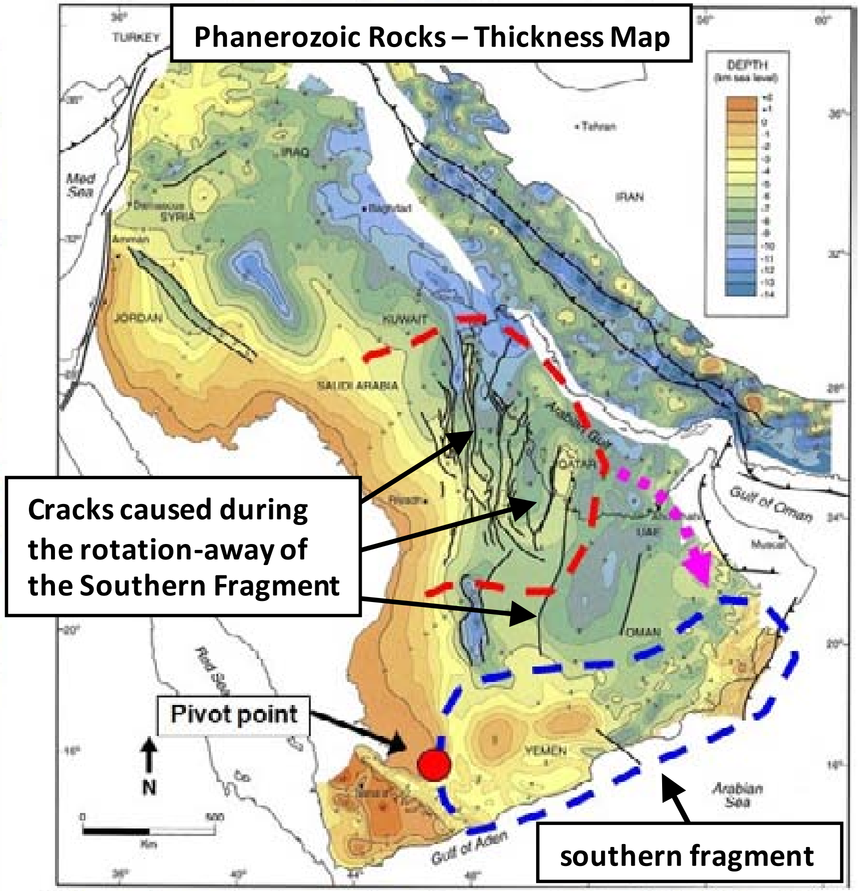


Fig. 2. Preliminary basement depth map of the Arabian Plate, showing th increasing thickness of Phanerozoic -Rocks away from the exposure of Precambrian rocks in the Arabian Shield.

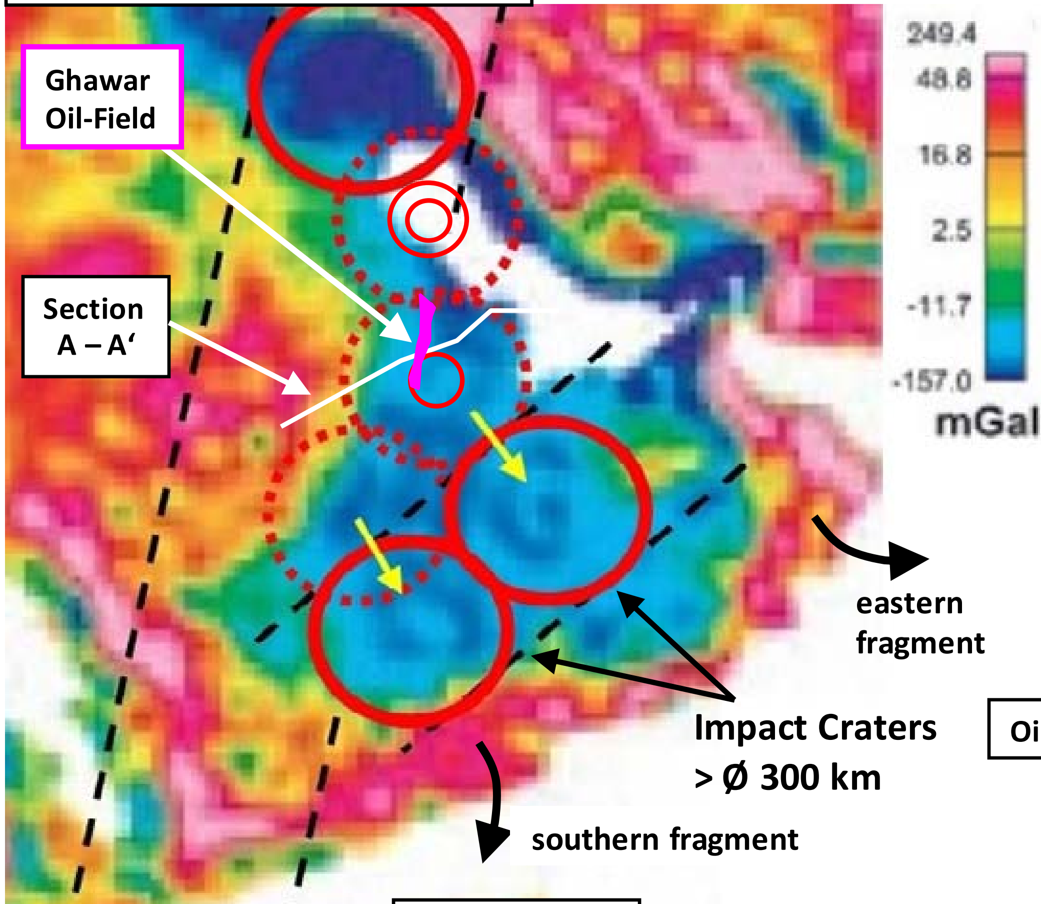


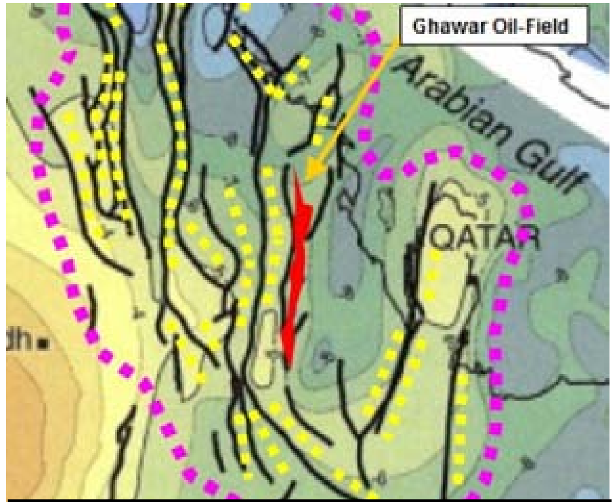
The red marked area is still part of the original Arabian Shield. The extensive fractures in this area were probably caused by the impacts (secondary impacts from the PT-impact) and by divergent movement of the crust fragments.

The cracks in the Phanerozoic Base-Rocks indicate the motion and separation of the Southern Fragment. Along one of these cracks the largest known oil-field (Ghawar) formed. H_2, H_2O & CH_4 released from deep layers of Earth's crust probably supported the development of the large oil-field.

The large oil-fields of Saudi-Arabia are a result of the environment and the divergent tectonic motion caused by the (P/T) Impact Event

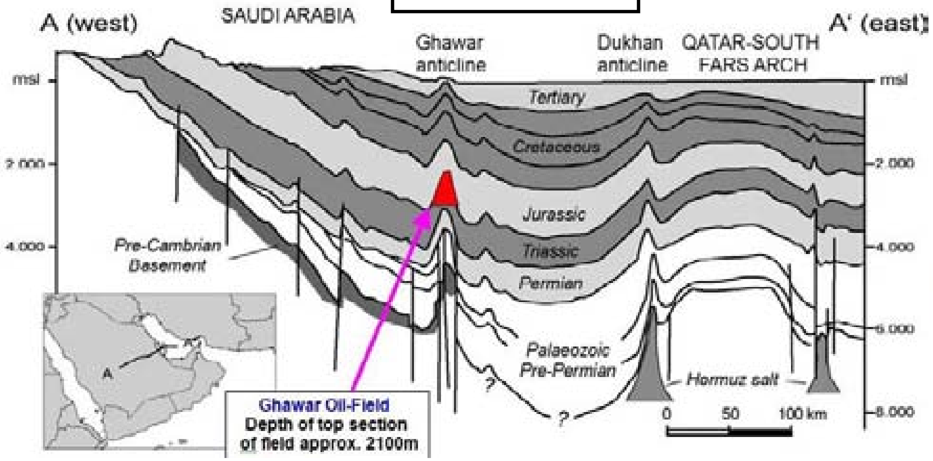
Gravity Anomaly Map –Arabia



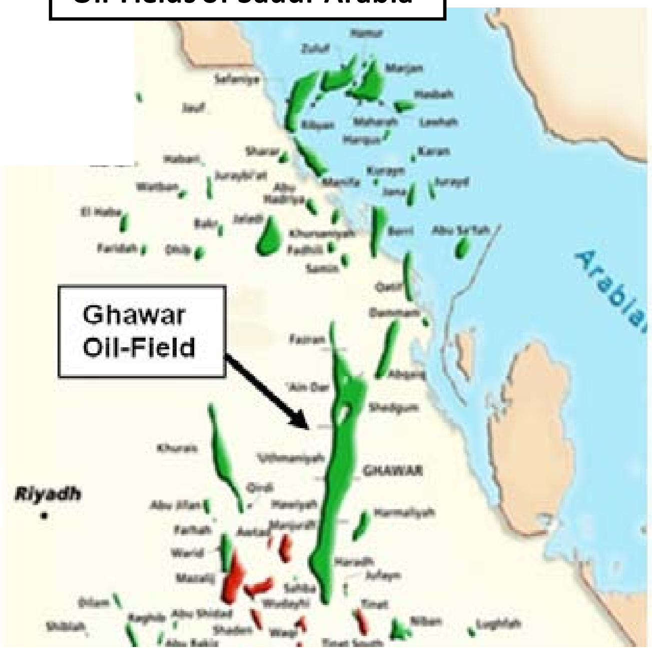


Cracks in the Phanerozoic rocks are linked to the formation of the large oil-fields

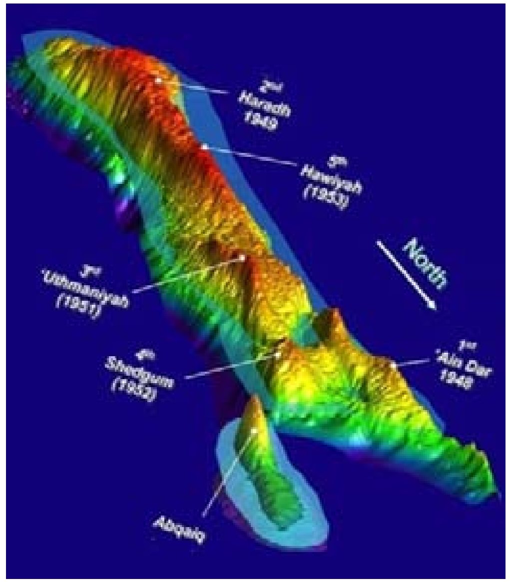
Section A – A'



Oil-Fields of Saudi-Arabia



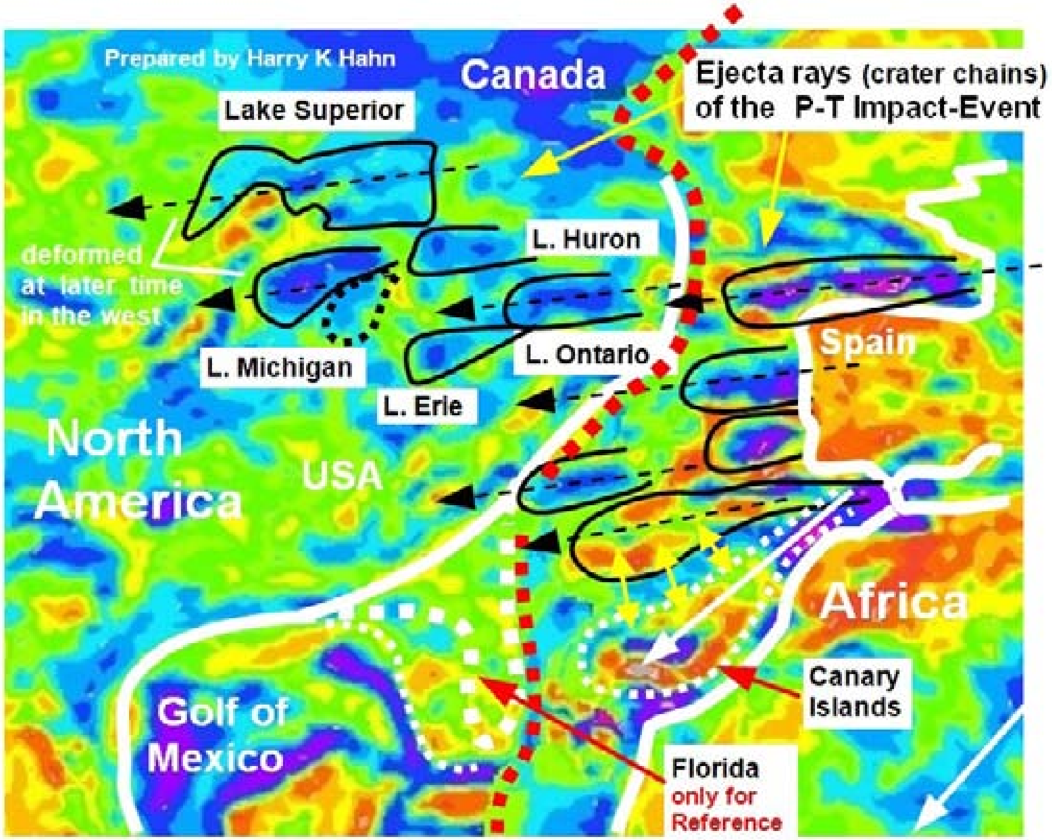
3D view of Ghawar Oil-Field :



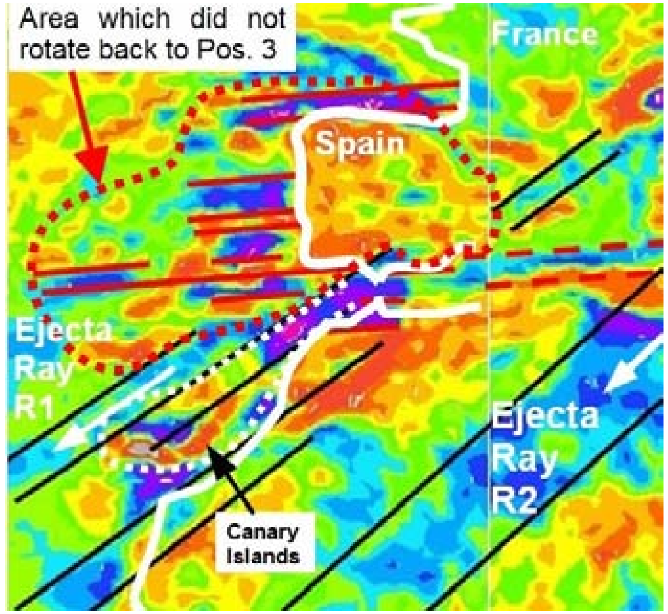
Linear gravity anomalies in Europe, North-Africa & -America indicate PTI-ejecta-ray structures

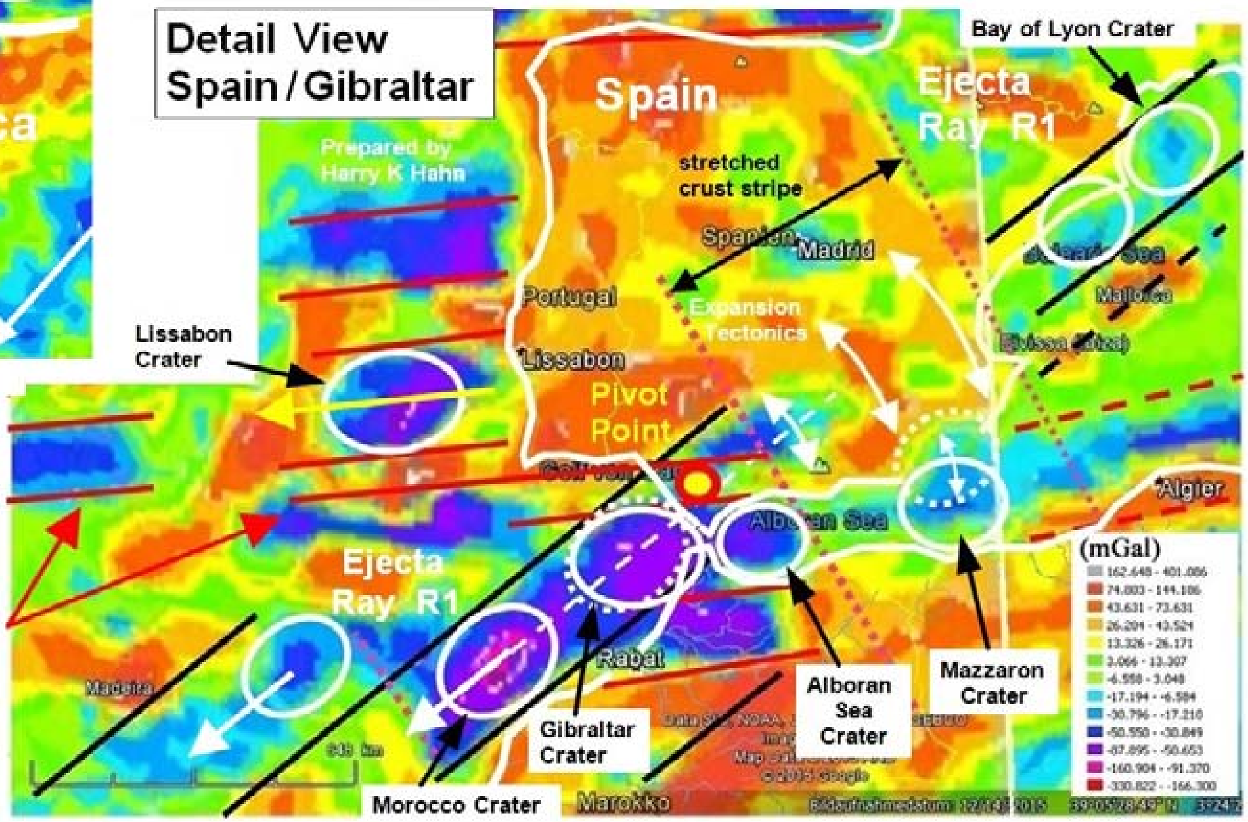
→ the Great Lakes in USA are probably also a result of impacting ejecta from the PTI.

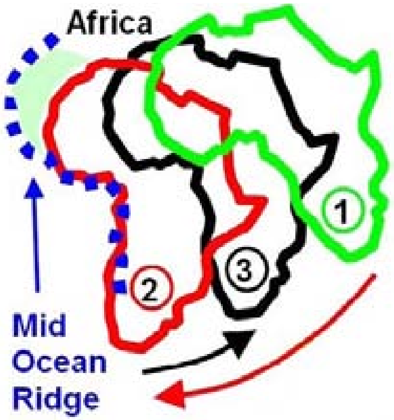
Gravity Anomaly Map showing Europe & North-America (with Great Lakes marked) ~200 Ma ago



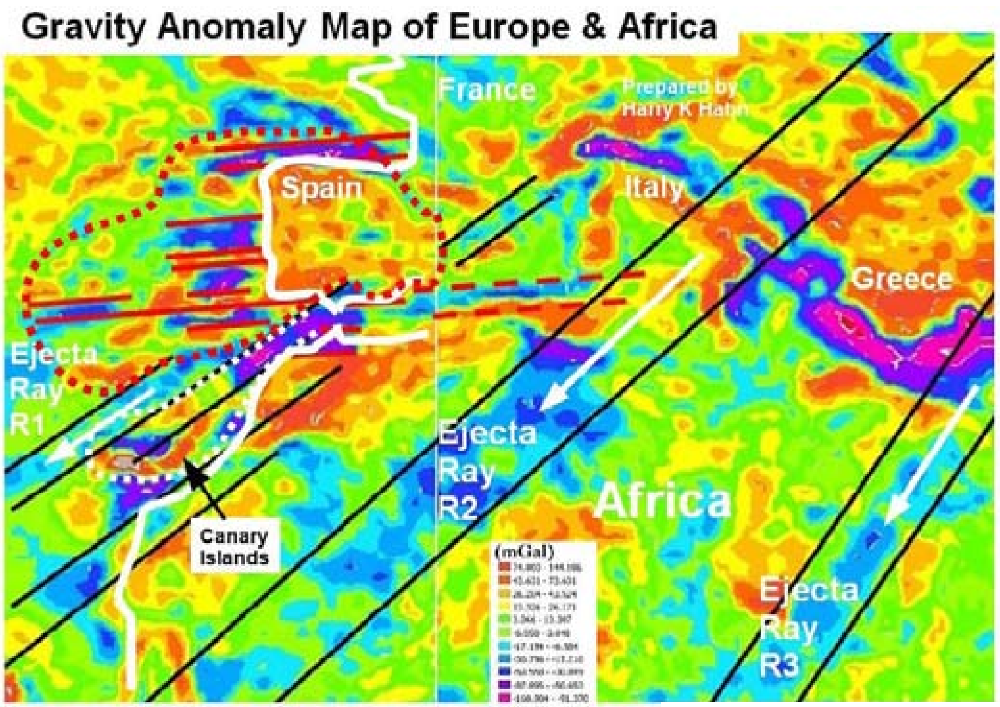
Caused by the impulse of the Ejecta Rays R1–R4 the African Plate rotated from **position 1** to **position 2** (→ see sketch). But because Africa was still connected to Eurasia it later rotated back to **position 3.** But the majority of Spain and the ocean floor west from Spain did not rotate back to position 3 anymore.





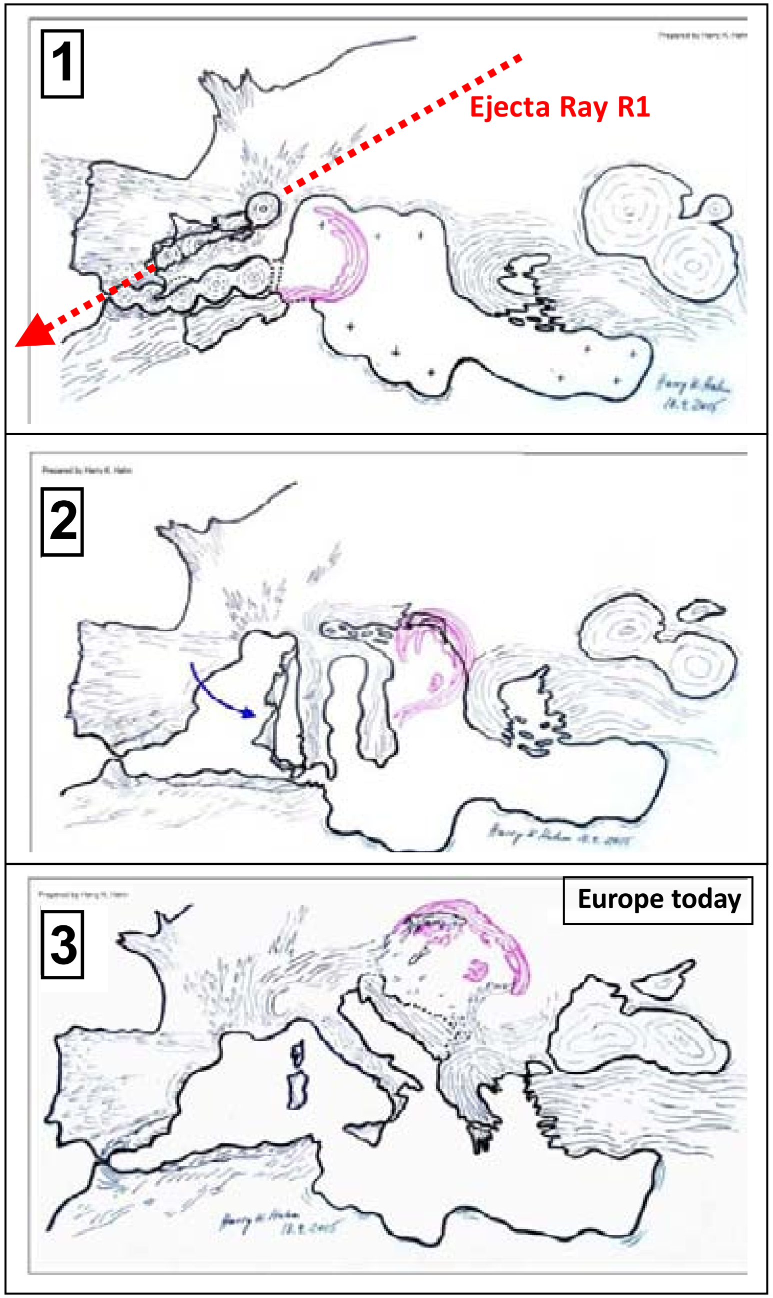


The set of gravity anomalies marked by the **red lines** indicates the crust area which <u>did not</u> rotate back to Pos 3



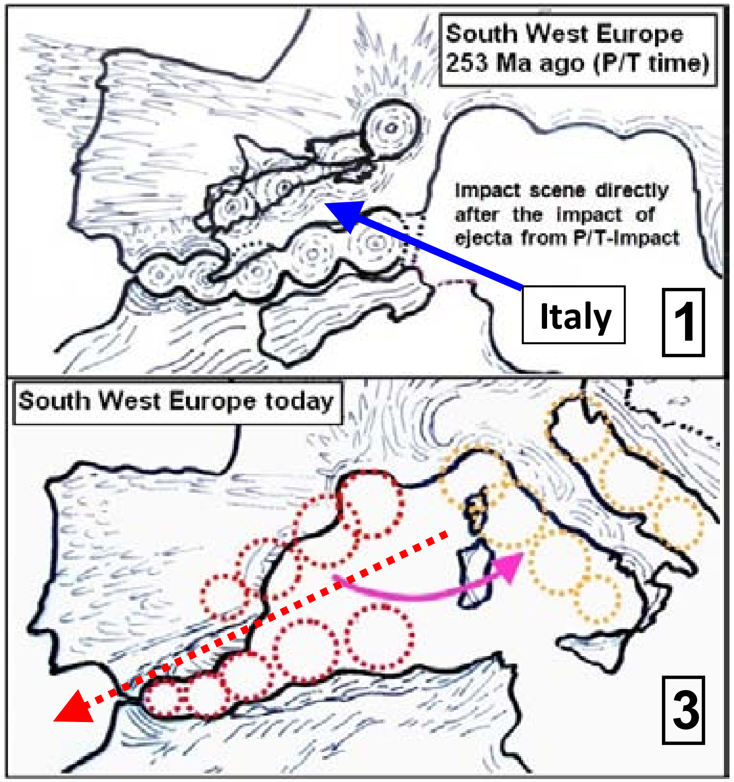
Tectonic Evolution of Europe after the P/T-Impact

→ the linear blue areas on the gravity anomaly map (on the left) indicate the impact crater chains caused by the P/T-Ejecta



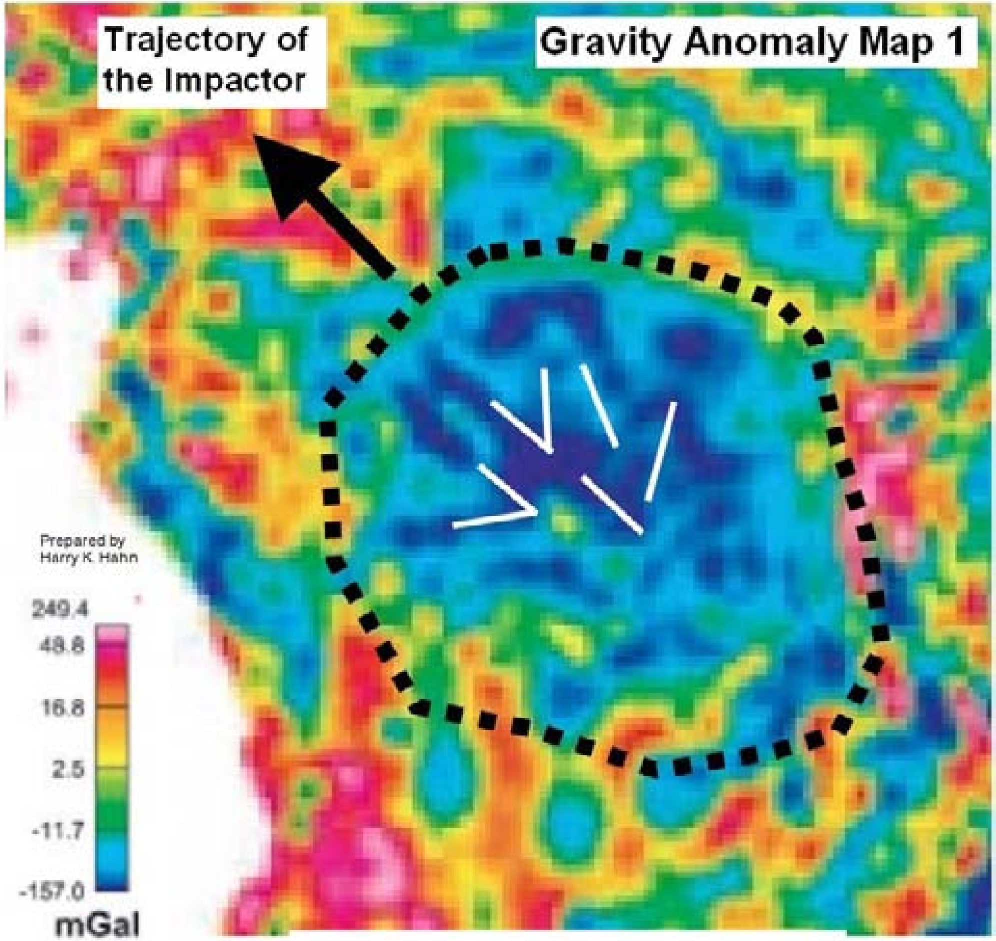
Tectonic evolution of Europe after the impact of the P/T-Ejecta Ray R1 :

The drawings No. 1 to 3 show were ejecta material (thrown out of the P/T Impact Crater) impacted in Europe ~253 million years ago. This ejecta material (impactors with Ø10-20 km) formed chains of secondary craters with Ø150-200 km. These craters formed the original ocean basins.



A multiple Impact Structure with the dimensions 1200 x 850 km has formed the Congo Basin

→ the complex impact structure probably was formed by a large comet or asteroid which collapsed just before impact



(A) EIGEN-GL04C free-air anomaly,

3 METHODOLOGY

As our main interest is the depth of the crust–mantle boundary, the gravity data are first subjected to a high-pass filter using a 1000-km cut-off wavelength to remove deep mantle sources (Obenson 1974; Block *et al.* 2009, Fig. 1B). Undesired tapering effects are minimized by expanding the gird up to 20 per cent of the total grid area. We then calculate the *X*, *Y*, *Z* derivatives of the filtered gravity anomaly on a 0.25° grid (Figs 1C, D and E) and use them as input to the 3-D Euler equation.

A crustal thickness map of Africa derived from a global gravity field model using Euler deconvolution

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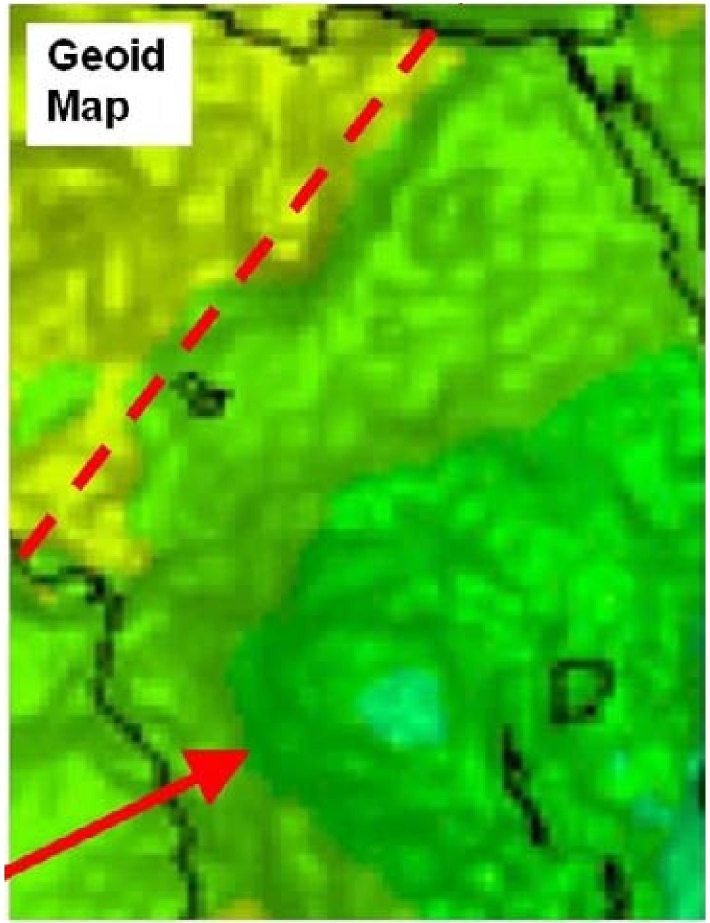
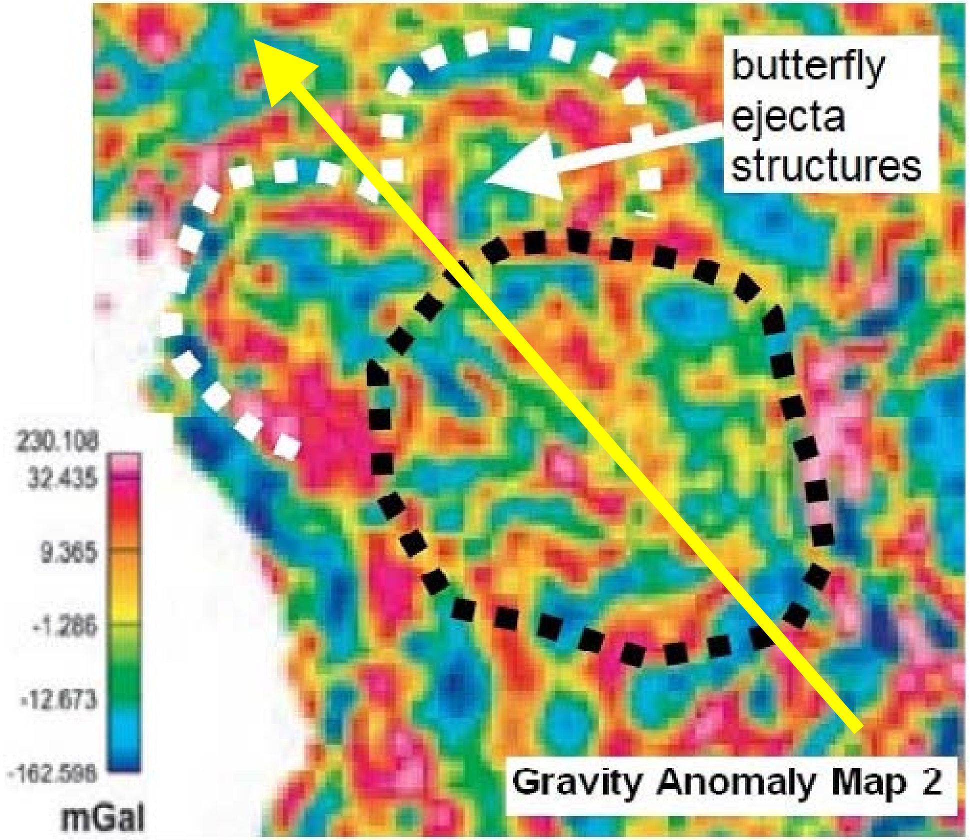
[2]*Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA*
[3]*School of Geosciences, The University of the Witwatersrand, Johannesburg, South Africa*



Geoid deformation caused by the Congo Impact Crater

The impulse of the Congo Impact in all probability caused the final break-up of Gondwana

→ under consideration of a sudden induced impulse into Earth's crust the impact probably happened 200-150 Ma ago



(B) High-pass filtered gravity anomaly map

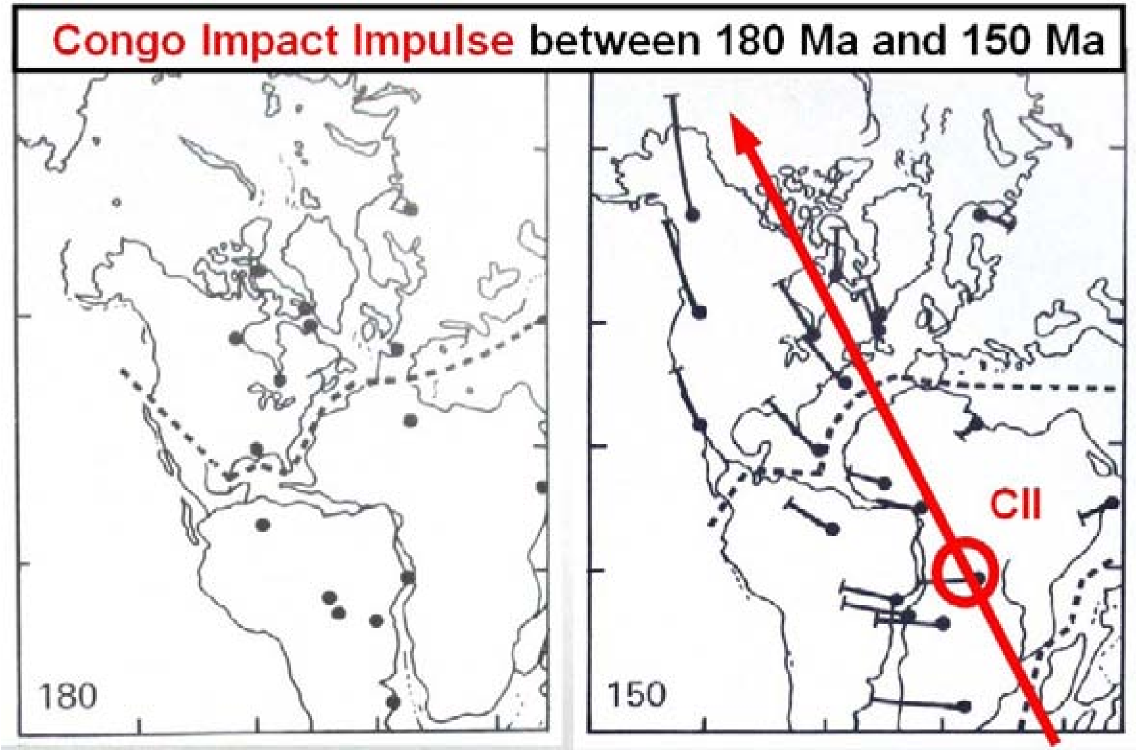
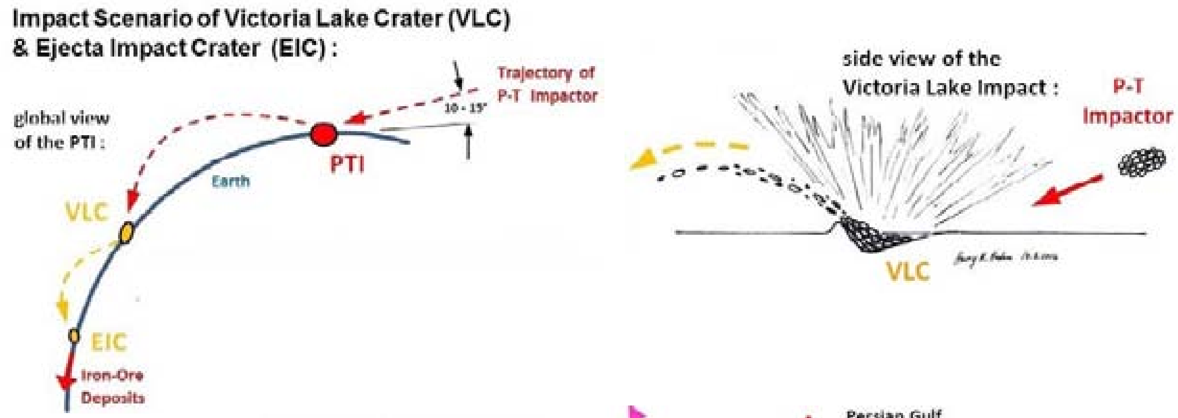
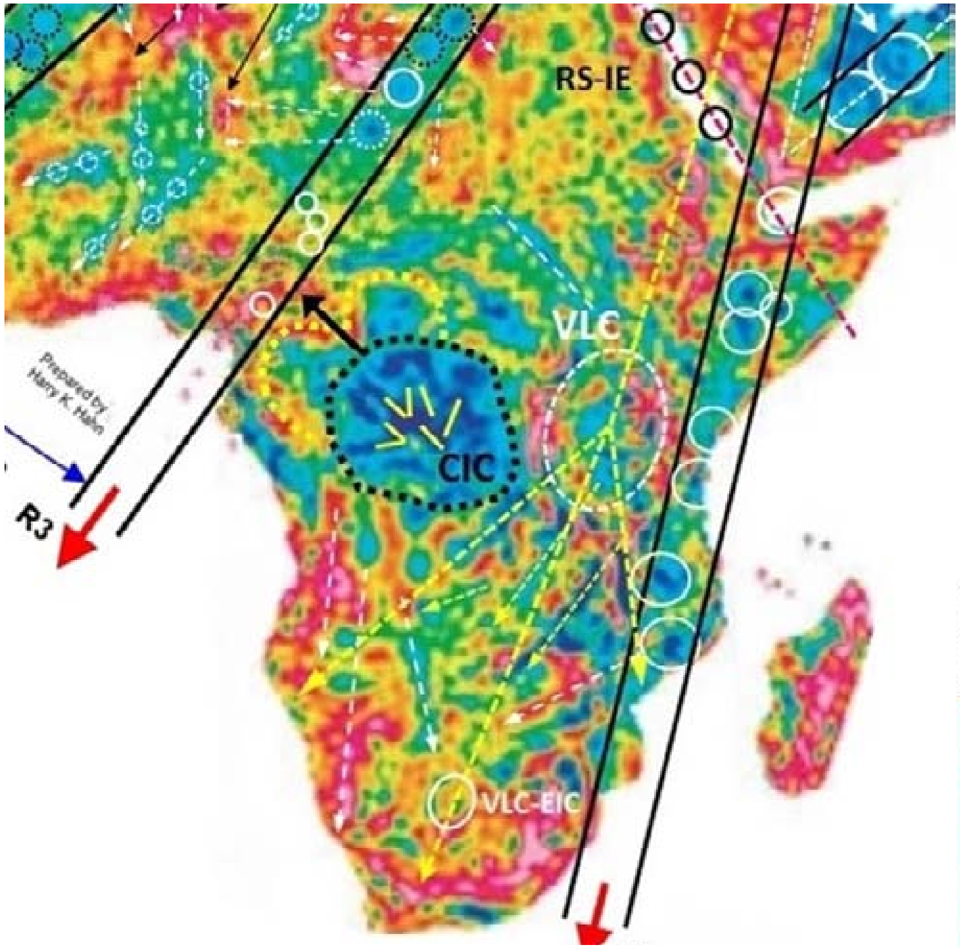


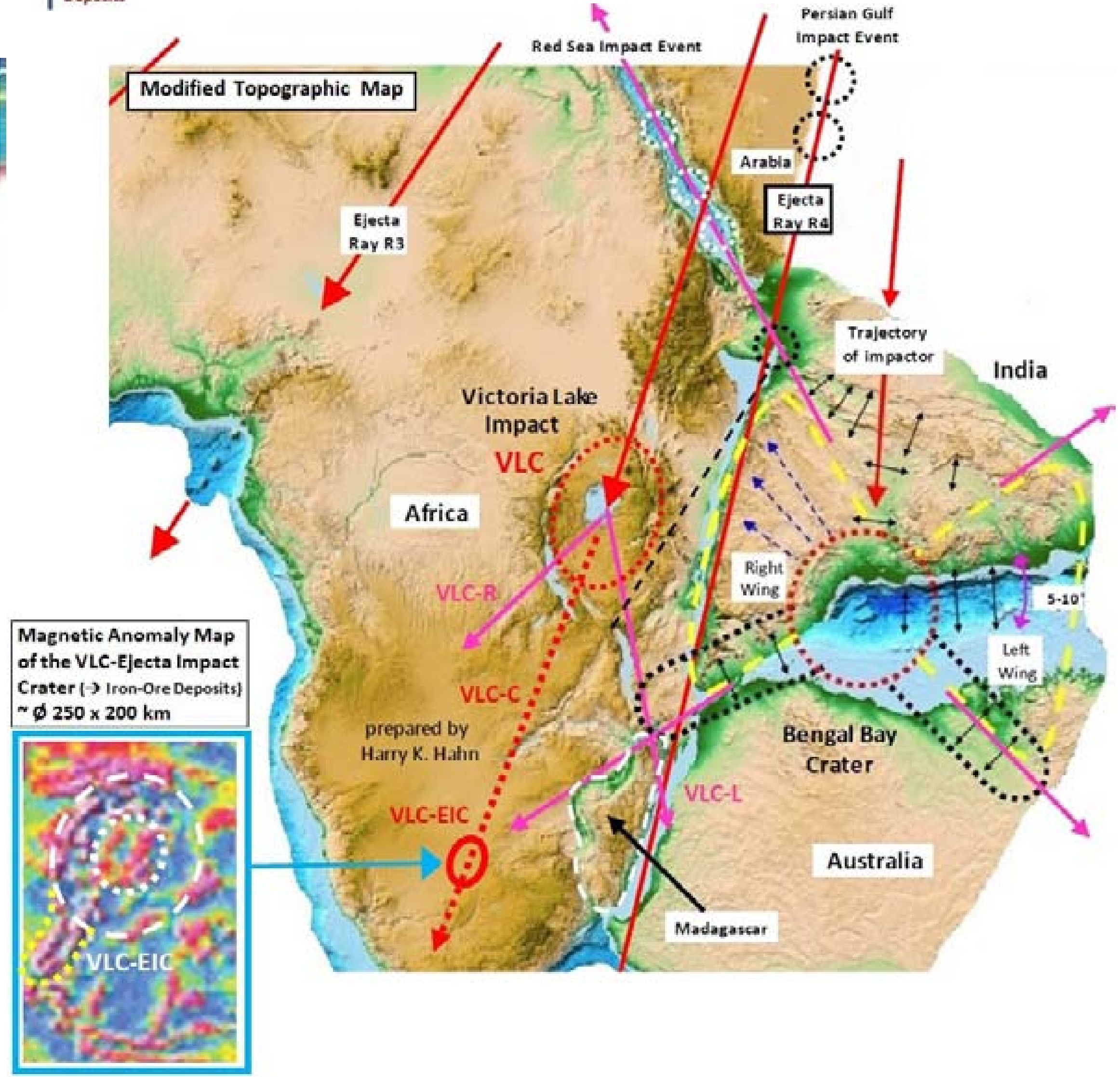
Fig. 5.8 Reconstruction of plates around the Atlantic from 180 Ma to present in a fixed hotspot frame of reference (redrawn from Morgan, 1983, with permission from Elsevier).

Orientation of the African-, Indian- and Australian-Plate at the time of the (P/T) Impact Event

→ the orientation of the continental plates as shown on the topographic map, is based on identified ejecta-ray-structures

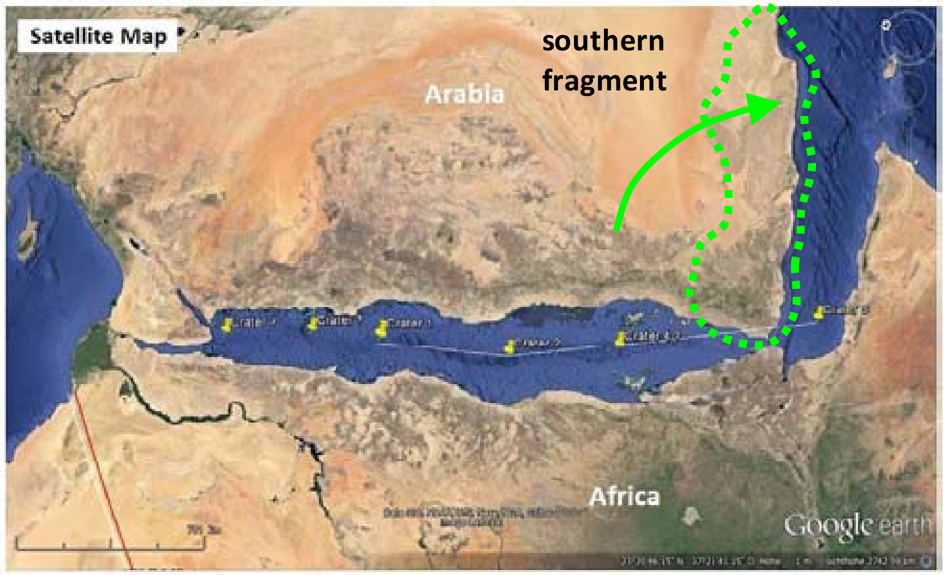






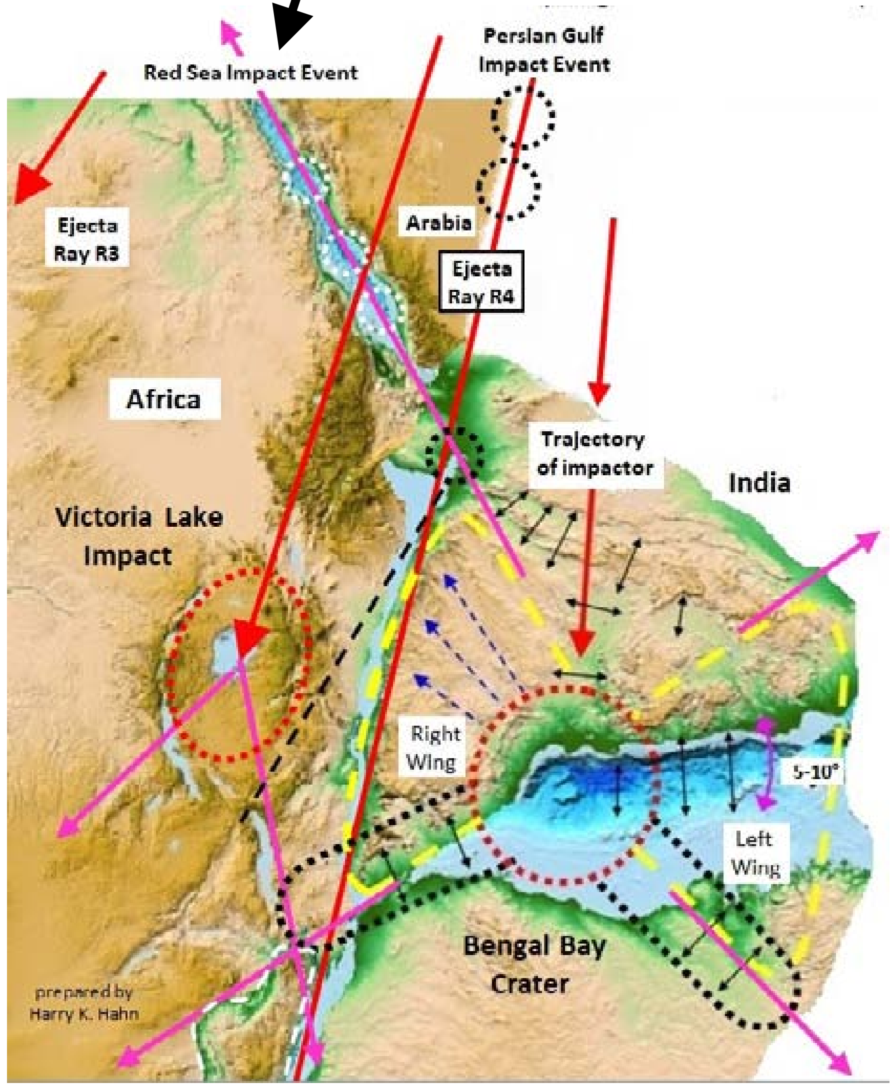
The Red Sea "Rift-Area" was caused by a Crater Chain of ≥ 3 craters with Ø 100 to 150 km

→ Along the coast-lines of the Red Sea many secondary impact structures from the craters can be identified



The Red Sea Impact Event occurred from SE to NW

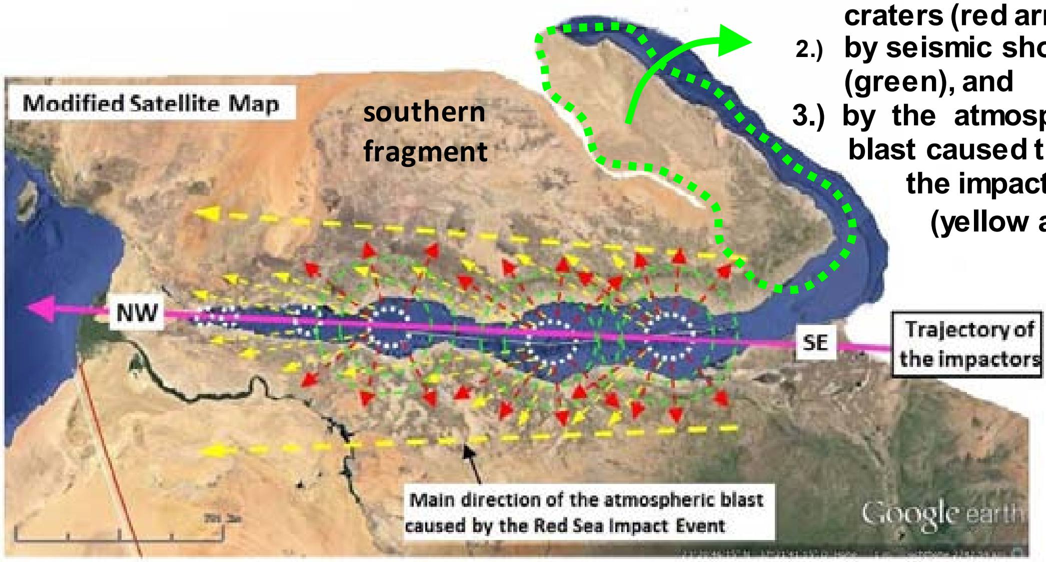
It seems that large secondary impactors which were ejected by the Bengal Bay Crater have caused the crater chain and the resulting crack & rift-area which has formed the Red Sea



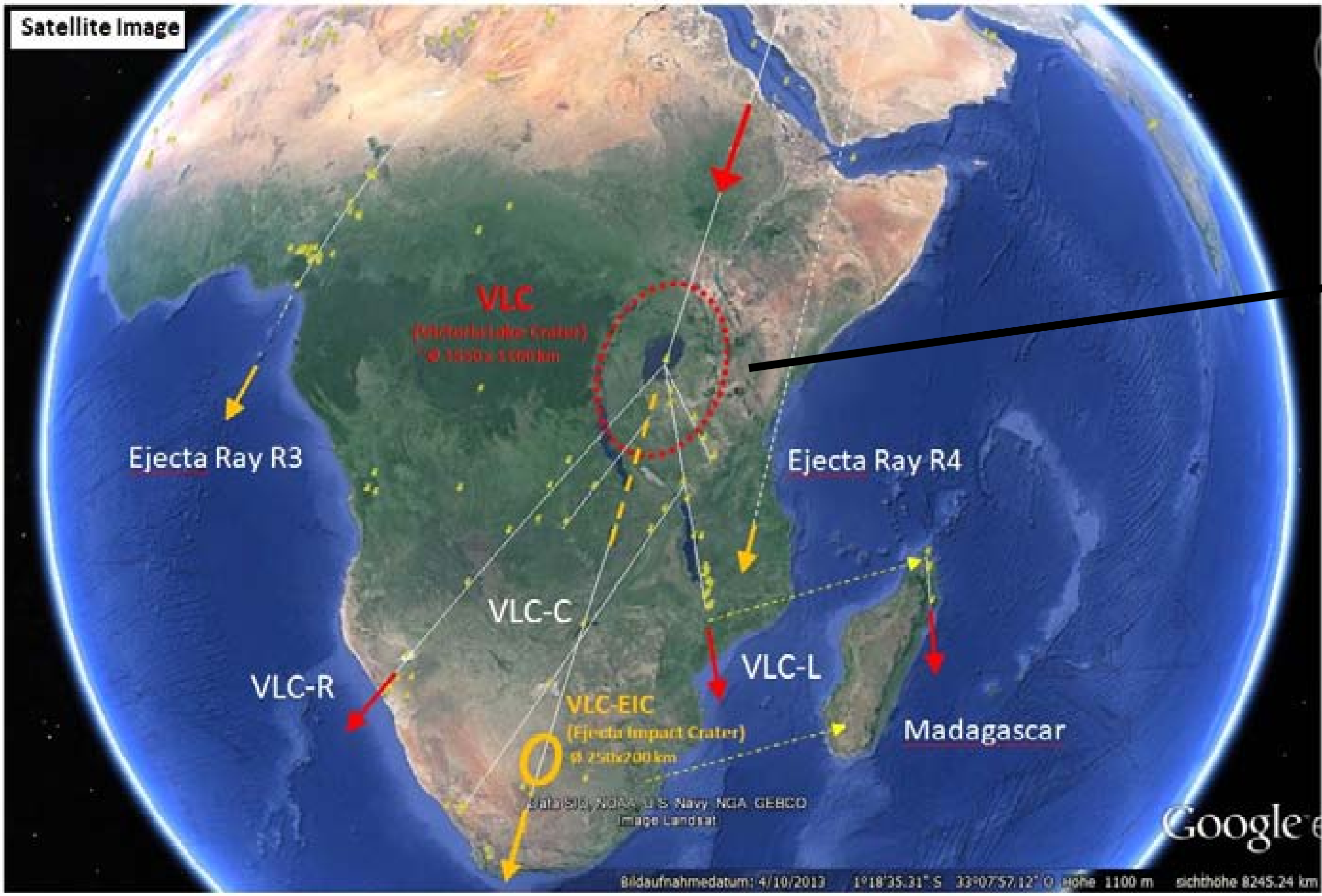
The modified satellite map shows the impact area some time after the impact

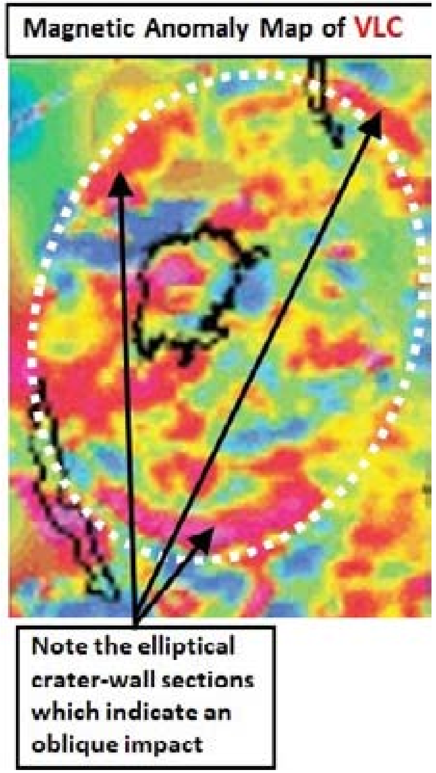
The secondary impact structures were formed by three effects :

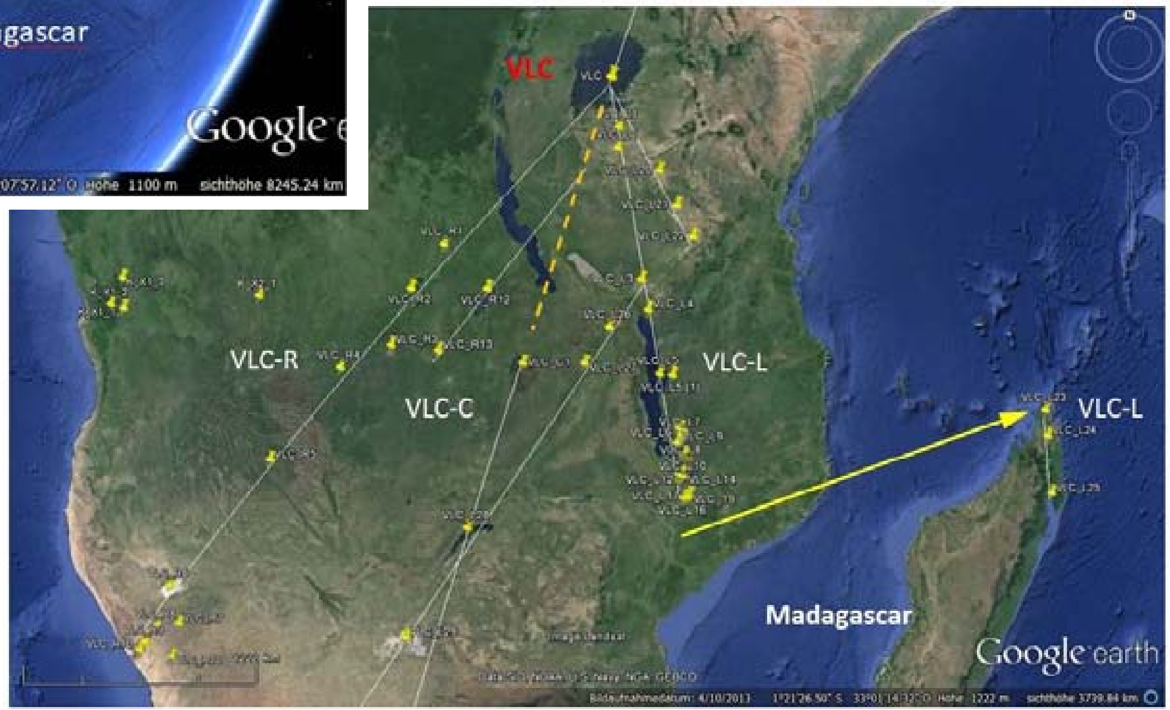
1.) by the ejecta from the craters (red arrows)
2.) by seismic shock-waves (green), and
3.) by the atmospheric blast caused through the impact event (yellow arrows)



The Victoria Lake Crater (VLC) → A result of Ejecta-Ray R4 of the PTI







The Victoria Lake Impact (VLC) produced two strong "ejecta wings" or ejecta rays (**VLC-R & VLC-L**) and a Central Ejecta Ray (**VLC-**C) which caused the Iron-Ore Deposits in South-Africa
→ see Ejecta Impact Crater (**EIC**).

The crater-wall sections (red) indicated on a Magnetic Anomaly Map, and fitting in a perfect ellipse, are a first proof for the VLC.

The impact of ejecta from the Victoria Lake Crater caused the Iron-ore deposits in South-Africa

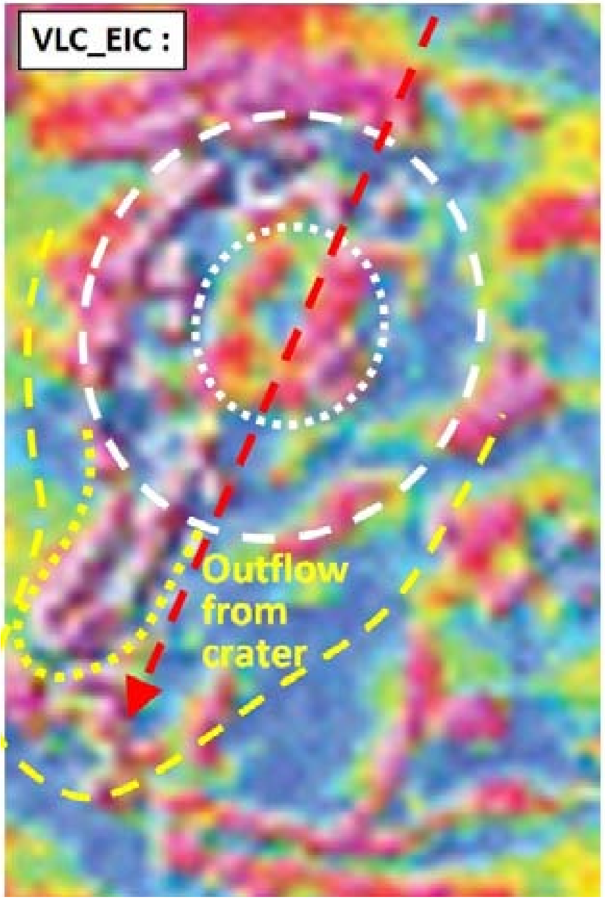
→ The **Ejecta Impact Crater (EIC)** , caused by the iron-rich ejecta of the Victoria Lake Crater (& PTI) was partly filled with molten ejecta-material which then flow in a south-westward direction out of the crater.

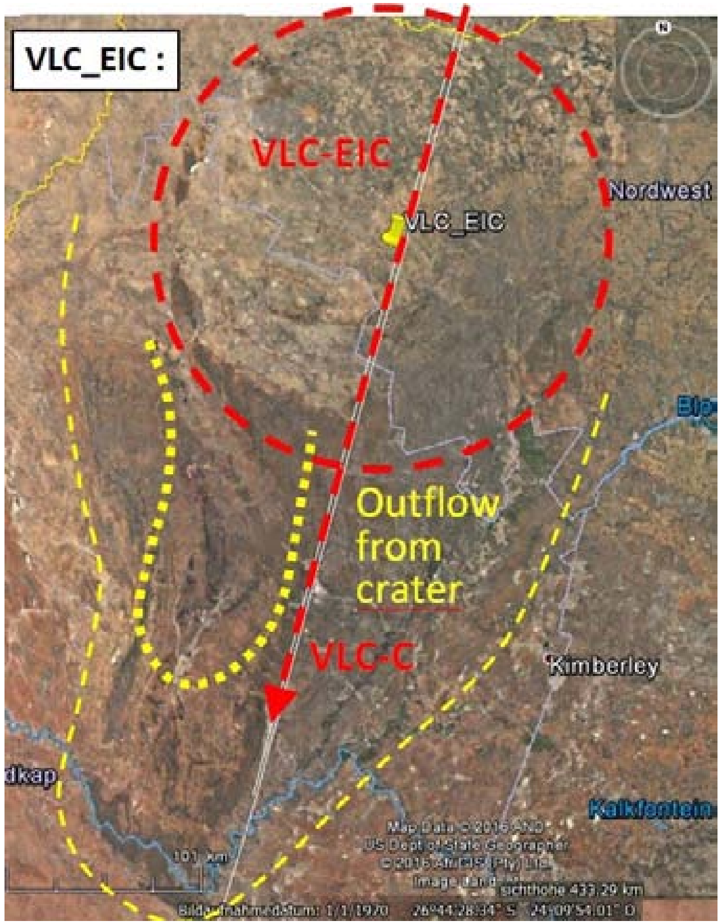
→ see tongue-shaped flow-structure near Kathu (Iron-ore mines)

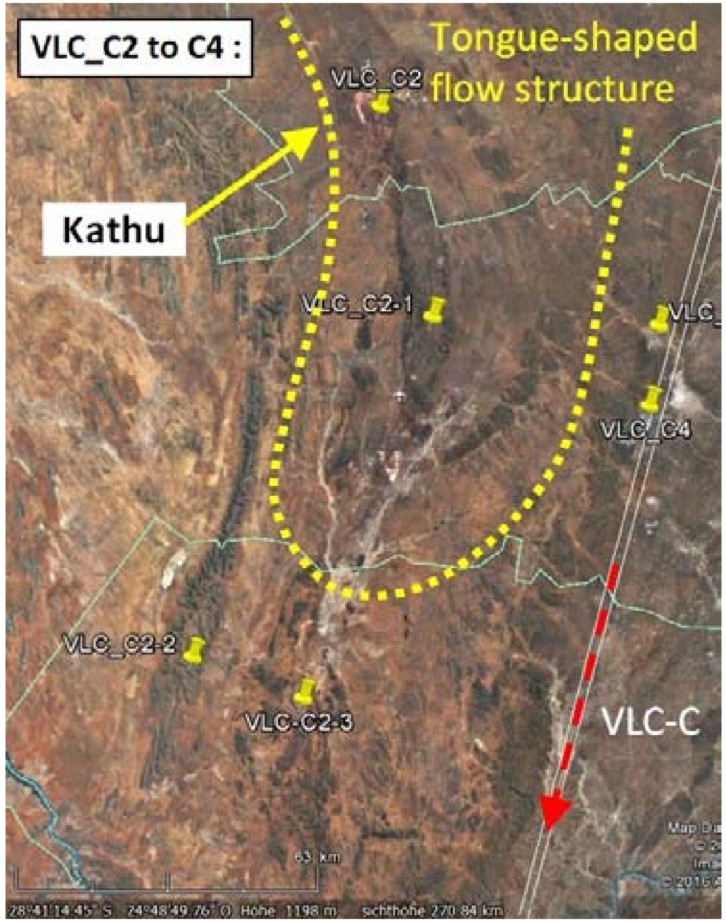
VLC-C2 : Kathu : → Iron-Ore Mines :
e.g. Sishen Mine 30km from Kathu is one of the largest Iron-Ore Mines in the world. Lump ore is extracted from a large Hematite ore body hosted by a Lake Superior-type banded iron formation (BIF) called Kuruman Formation (see also → manganese field). The lump to fine ratio of the Sishen ore is 60:40. The ore body measures approximately 14km long, 3.2km wide and 400m deep.

VLC-C2-1 : Postmasburg : → Iron-Ore (Hematite), Manganese Ore, Diamonds, Asbestos

Magnetic Anomaly Map of EIC

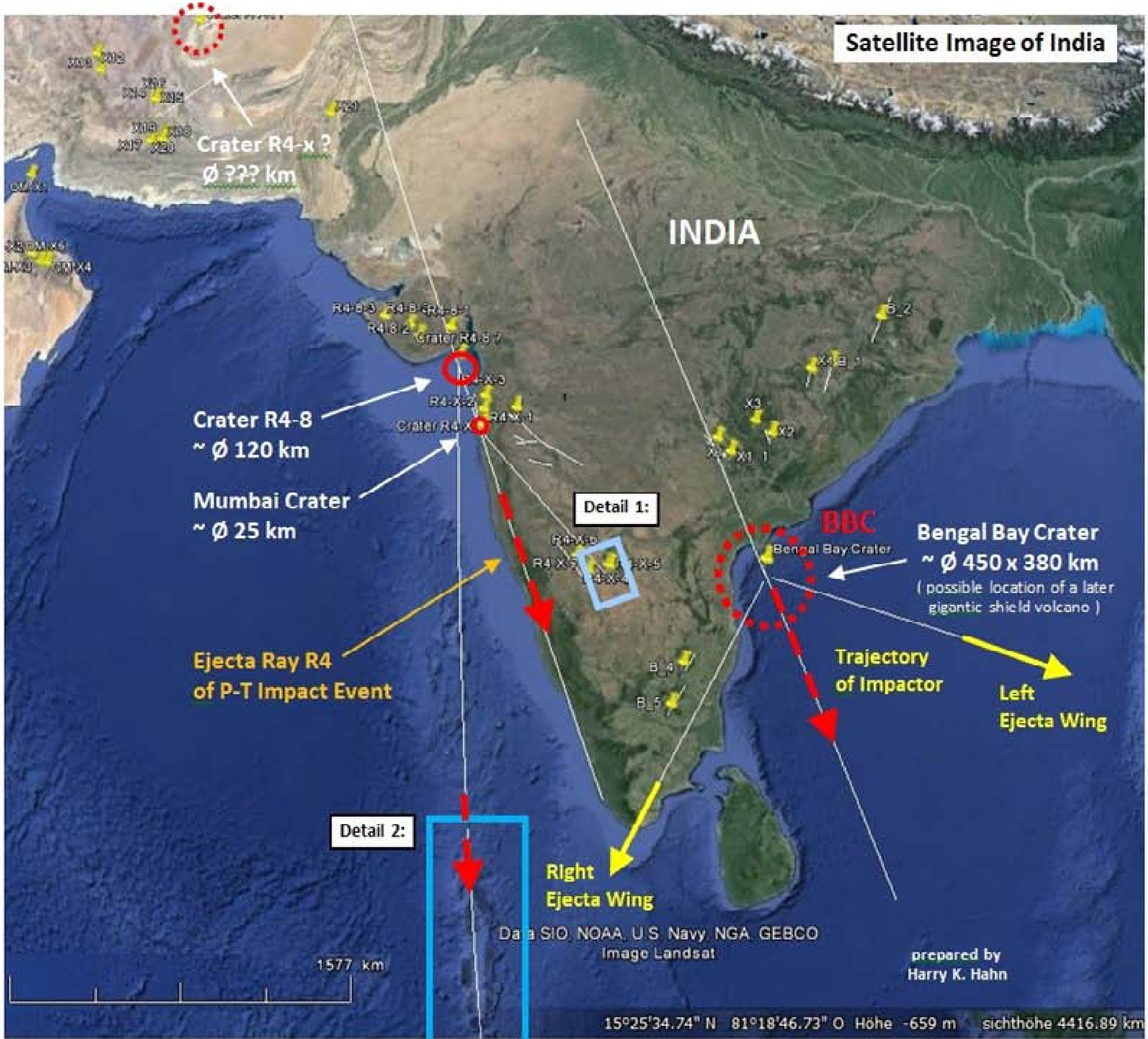


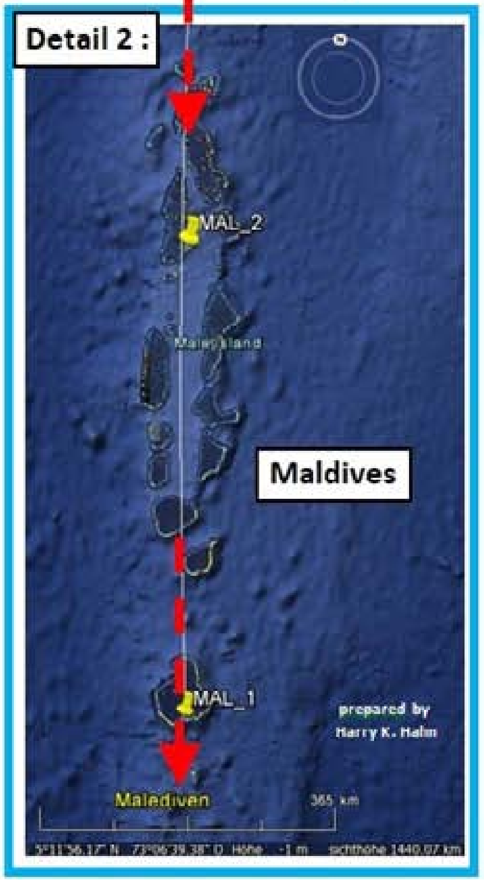




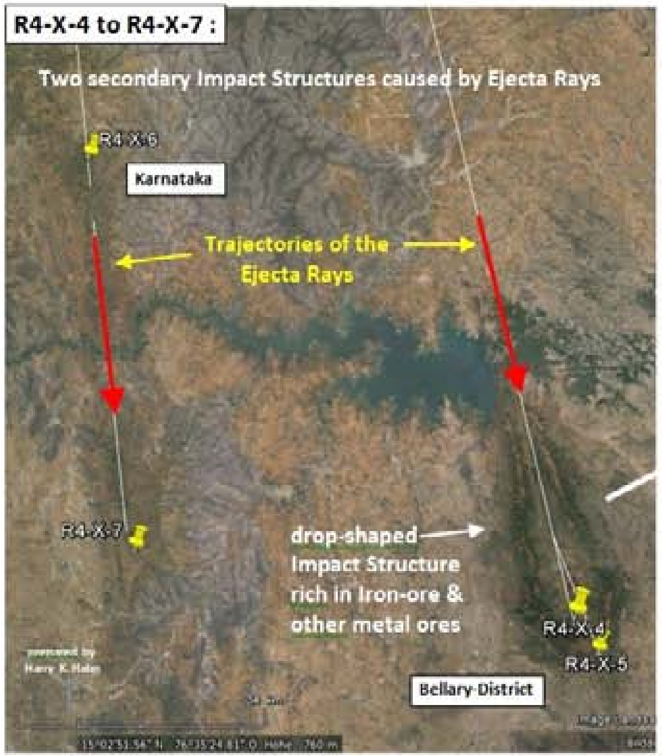
Ejecta from the PTI-Crater has formed the linear west-coast of India and the Bengal Bay Crater

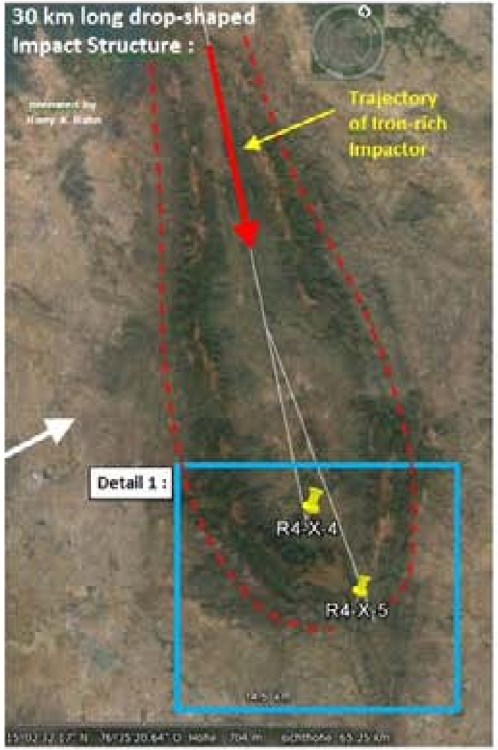
→ The Iron-ore deposits near Sandur and the Maldives are secondary impact structures of the **Ejecta Ray R4**

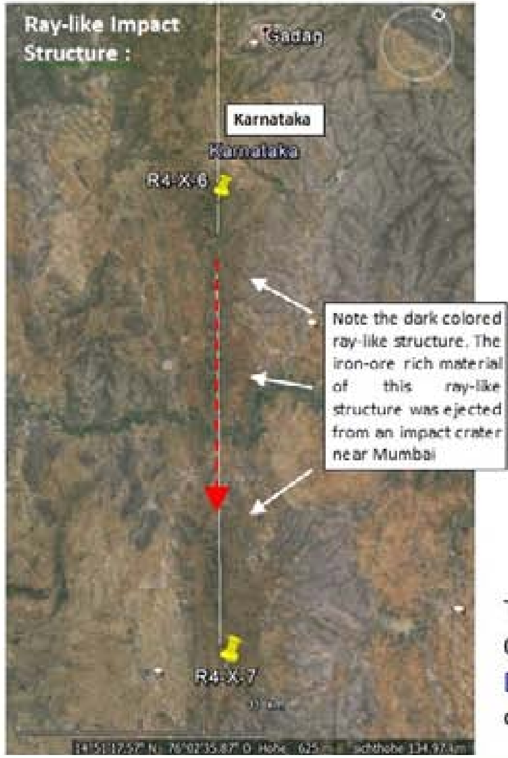




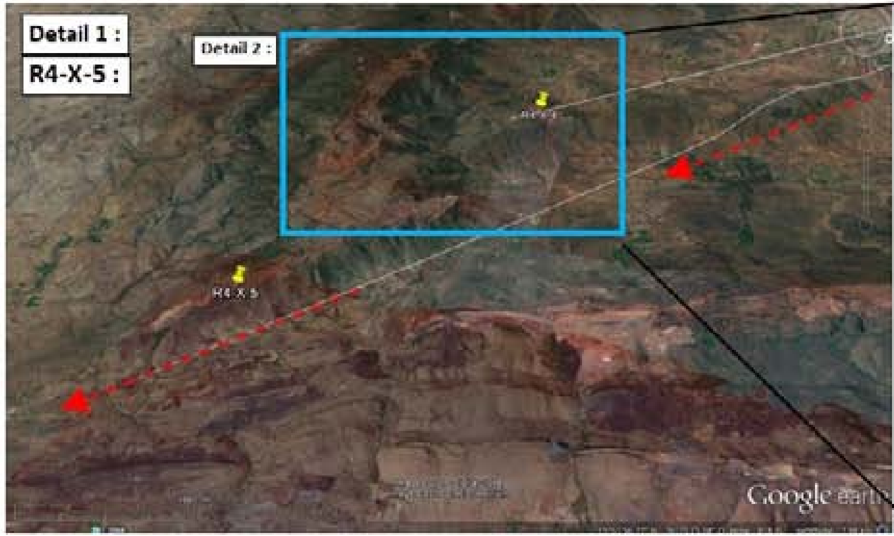
India's Iron-Ore-Reserves are the result of Secondary Impacts caused by ejecta from the Mumbai Crater, the BBC and the P-T Impact Crater in general







There is clear indication that the Iron-Ore Deposits near Sandur in the Ballari District are ejecta material which is originating in the Mumbai Impact Crater



The drop-shape of the mountain range around Sandur (→ iron-ore deposits), its exact orientation and the visible ejecta ray near Gadag lead to the bay near Mumbai.

This leads to the logical conclusion that the bay of Mumbai must be caused by an Impact Crater, which was formed by an iron-rich impactor probably originating from the PT-Impact Event. (this can be concluded from the probable trajectory of the Impactor which caused the Mumbai Impact Crater)

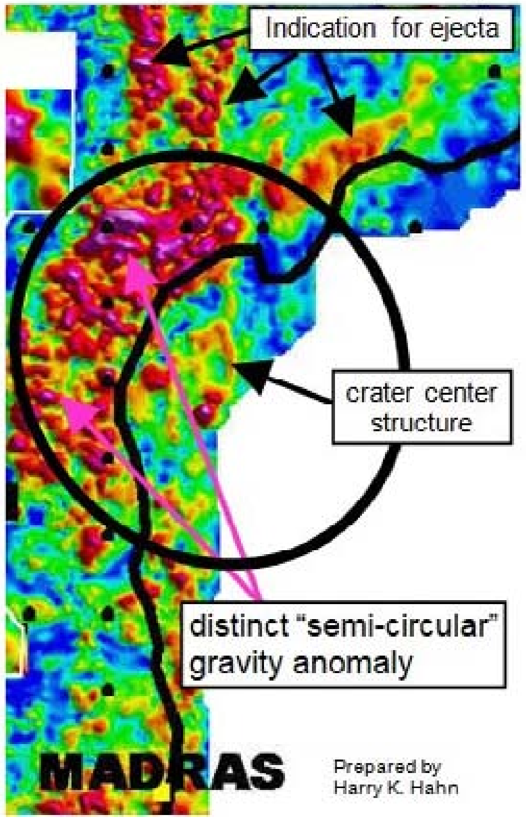
Ballari District is rich in mineral resources. It contains 25% of India's Iron ore reserves. It has both metallic and non-metallic minerals. The metallic minerals include iron ore, manganese ore, redoxide, gold, copper and lead. The non-metallic minerals include andalusite, asbestos, corundum, clay, dolomite, limestone, limekankan, moulding sand, quartz, soap stone, granite and red ochre.

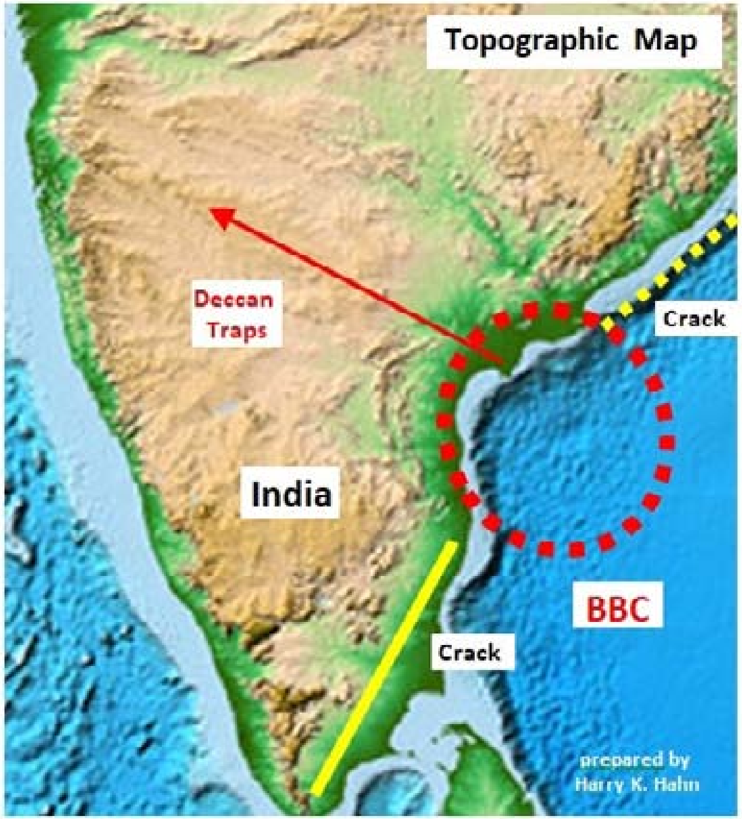
A Ø 450 x 380 km elliptical Impact Crater has formed the Bengal Bay in India

→ This impact crater which seems to be a large secondary crater of the P/T-Impact Event probably started the break-off of India from Australia starting around 250 Ma ago. Strong Ejecta Rays of the Ø450x380 km crater caused cracks in Earth's crust which defined the linear eastern coast-lines.

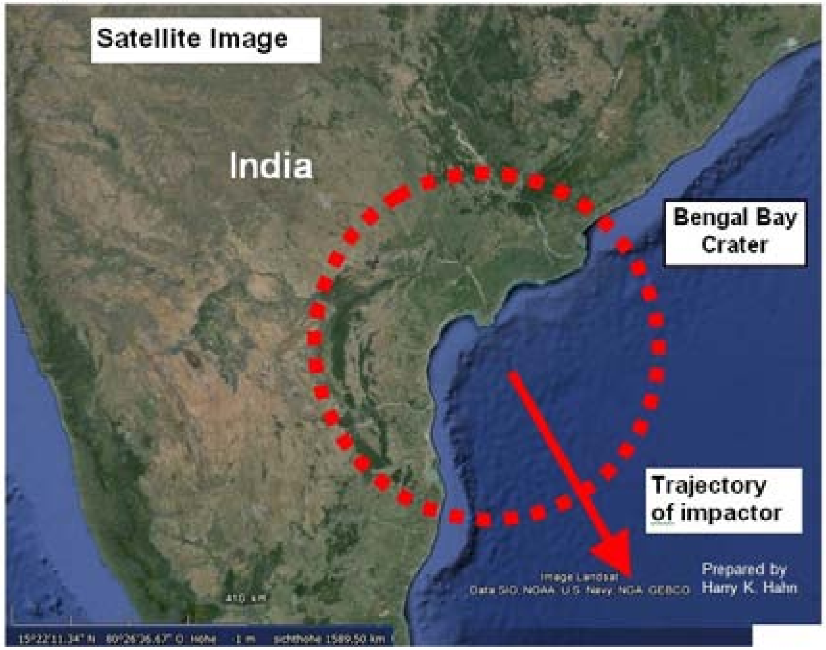
This was the thirth Crater which I discovered. Directly after that I discovered the PT-Crater on Google Earth

Gravity Anomaly Map



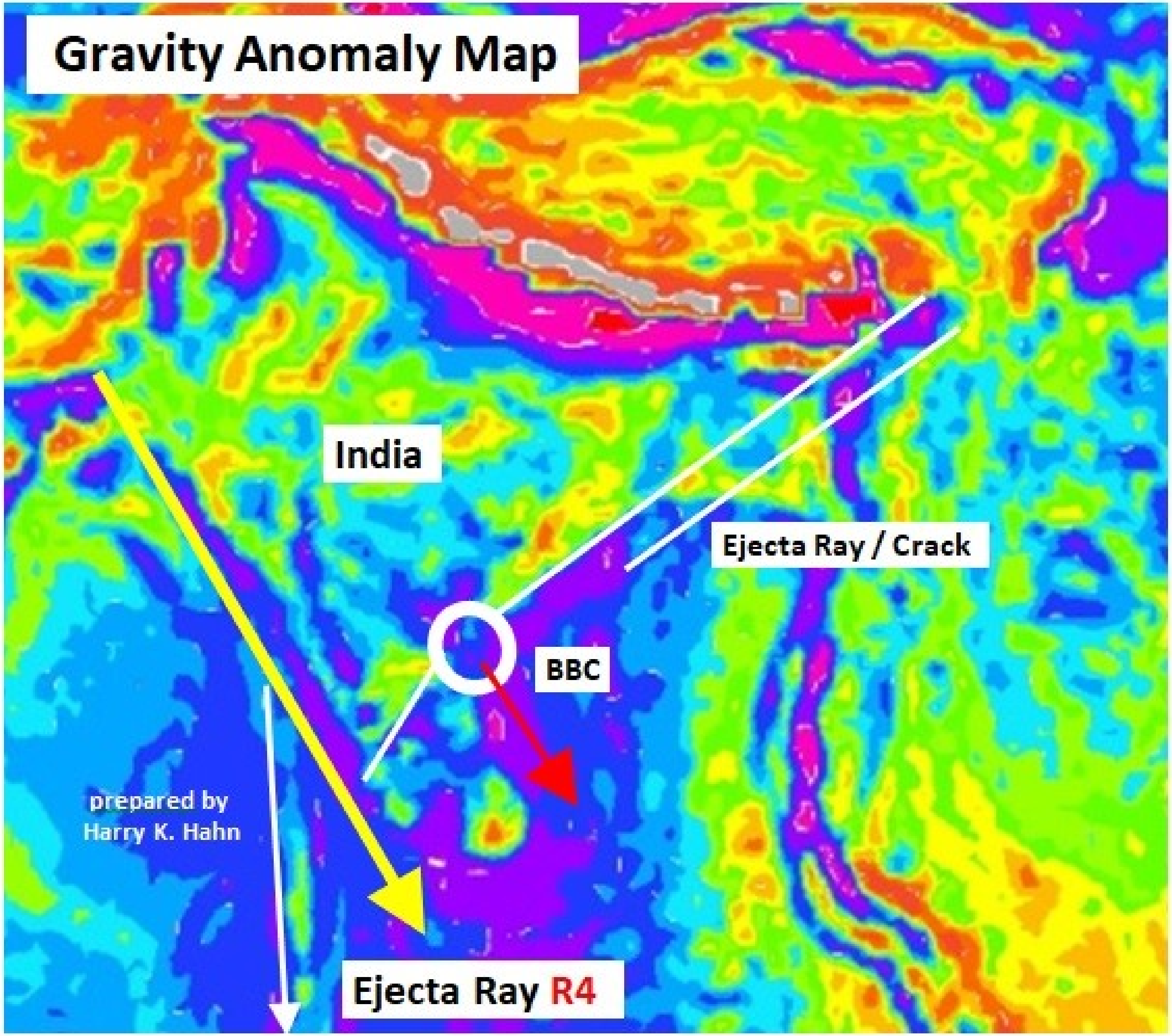


Elliptical crater ∅ 450 x 380 km in India



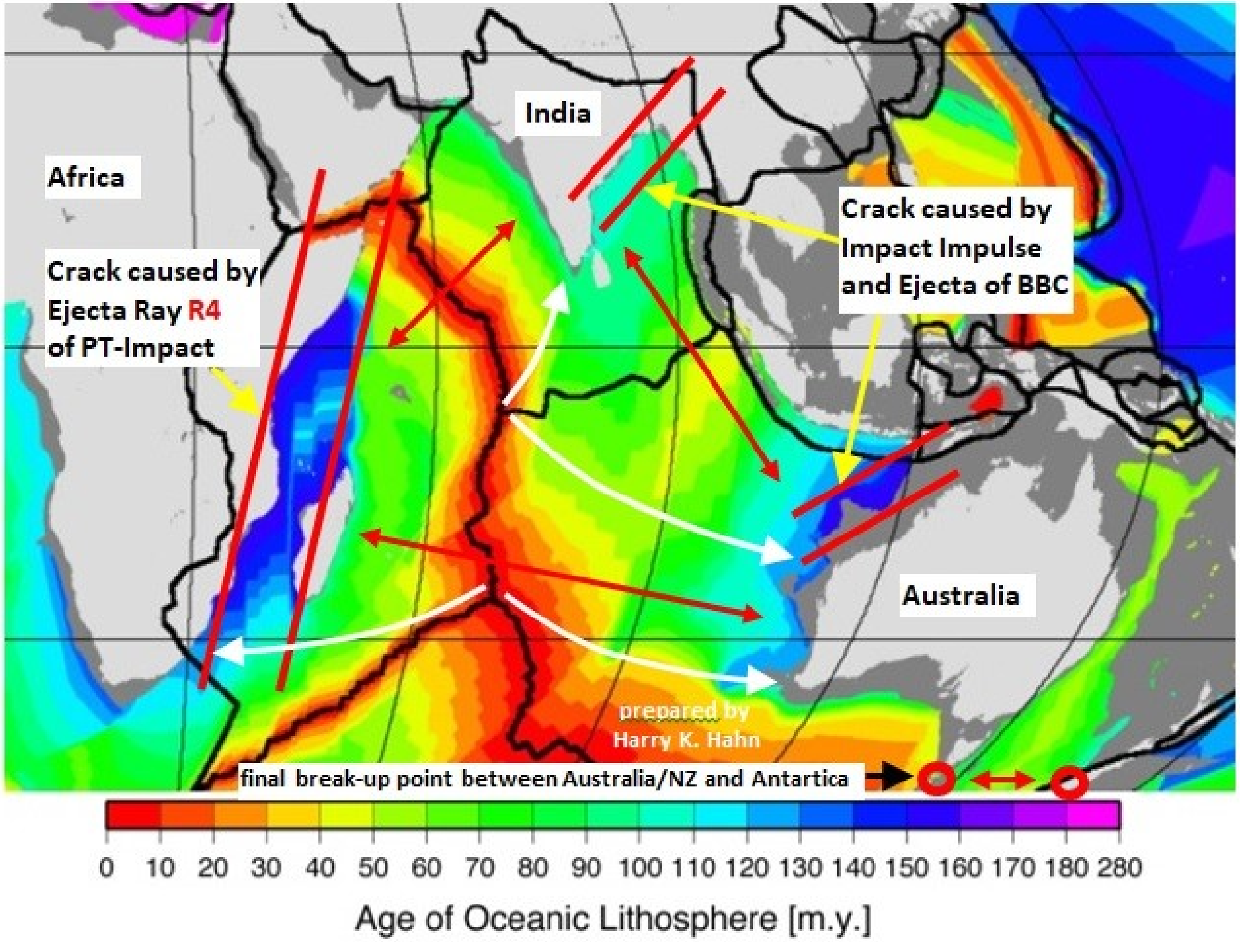
The gravity anomaly map of India clearly shows the linear impact track of Ejecta Ray R4

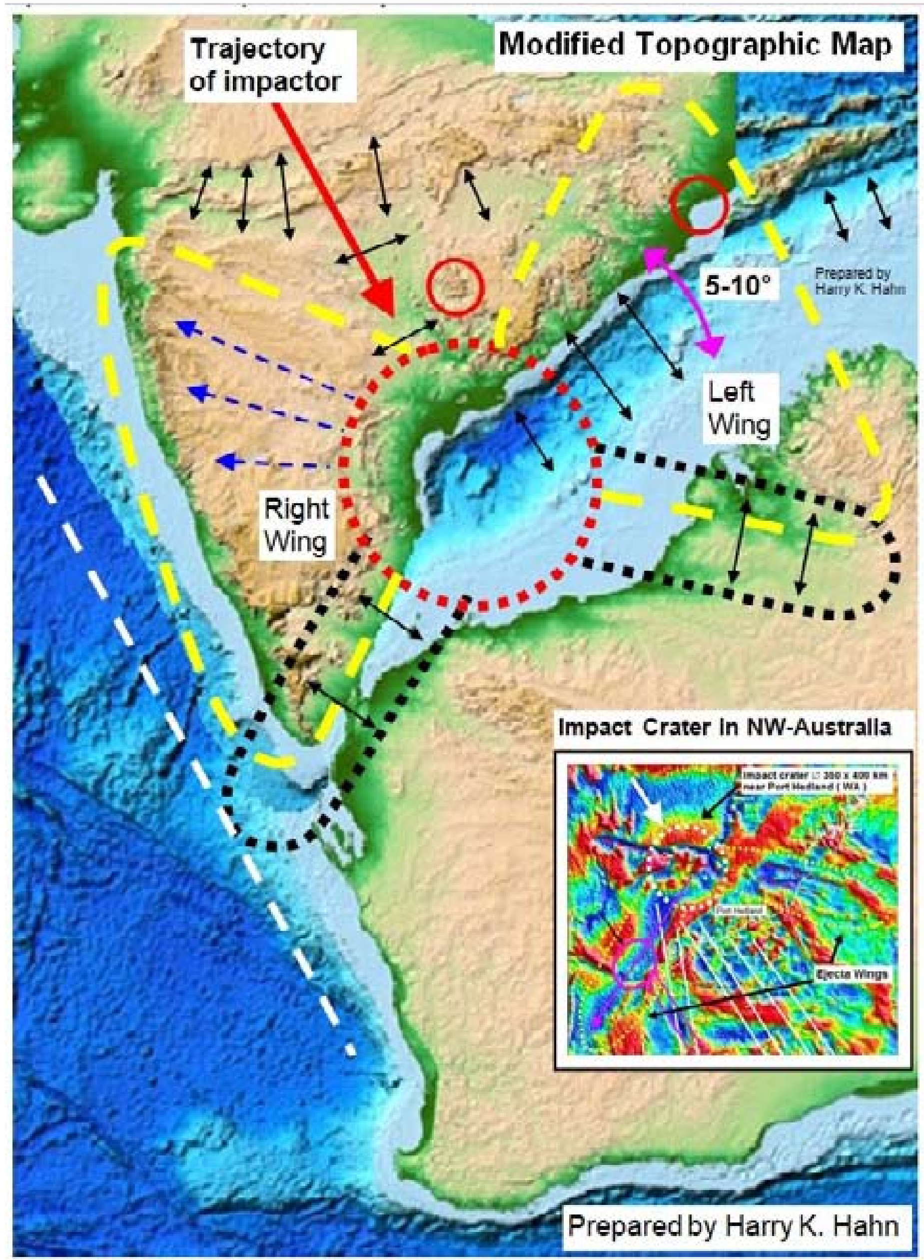
→ The negative (blue-colored) linear gravity anomaly along the west-coast of India is a result of **Ejecta Ray R4** from the P/T-Impact Crater. And the negative linear gravity anomaly east of the **Bengal Bay Crater (BBC)** was caused by a strong ejecta ray which was ejected by the Bengal Bay Crater (BBC).



The separation of India and Australia from Africa was caused by Ejecta Ray R4 (→from PTI)

The powerful **Ejecta Ray R4** caused an immense crack in the Super-Continent Pangea which **defined the eastern border of the African Plate** on one side **and the western border of the Indian Plate** and the **Australian Plate** on the other side. Another large crack in Pangea's crust was caused by the Bengal Bay Impact which defined India's western border & Australia's NW border and started their separation

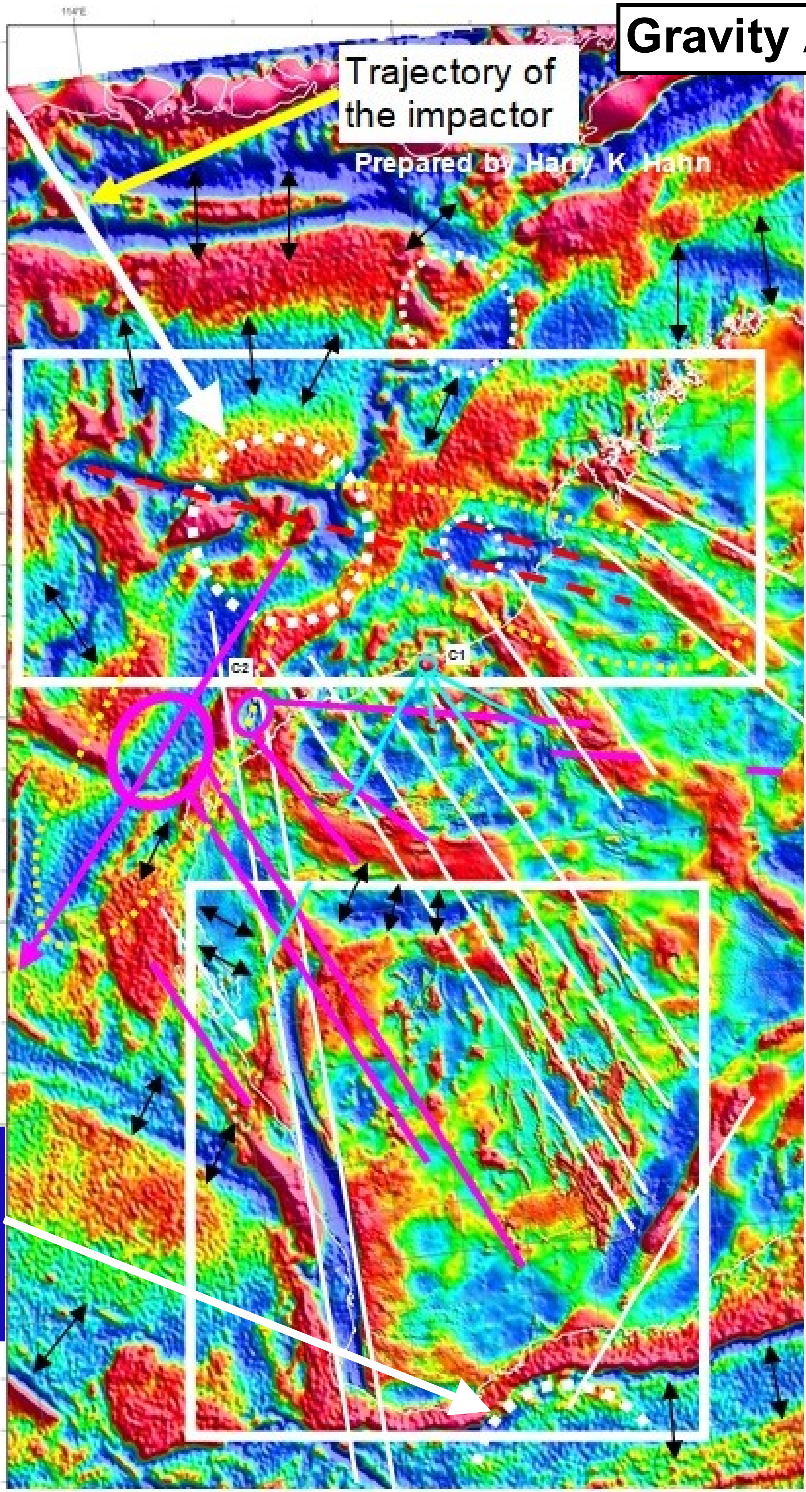


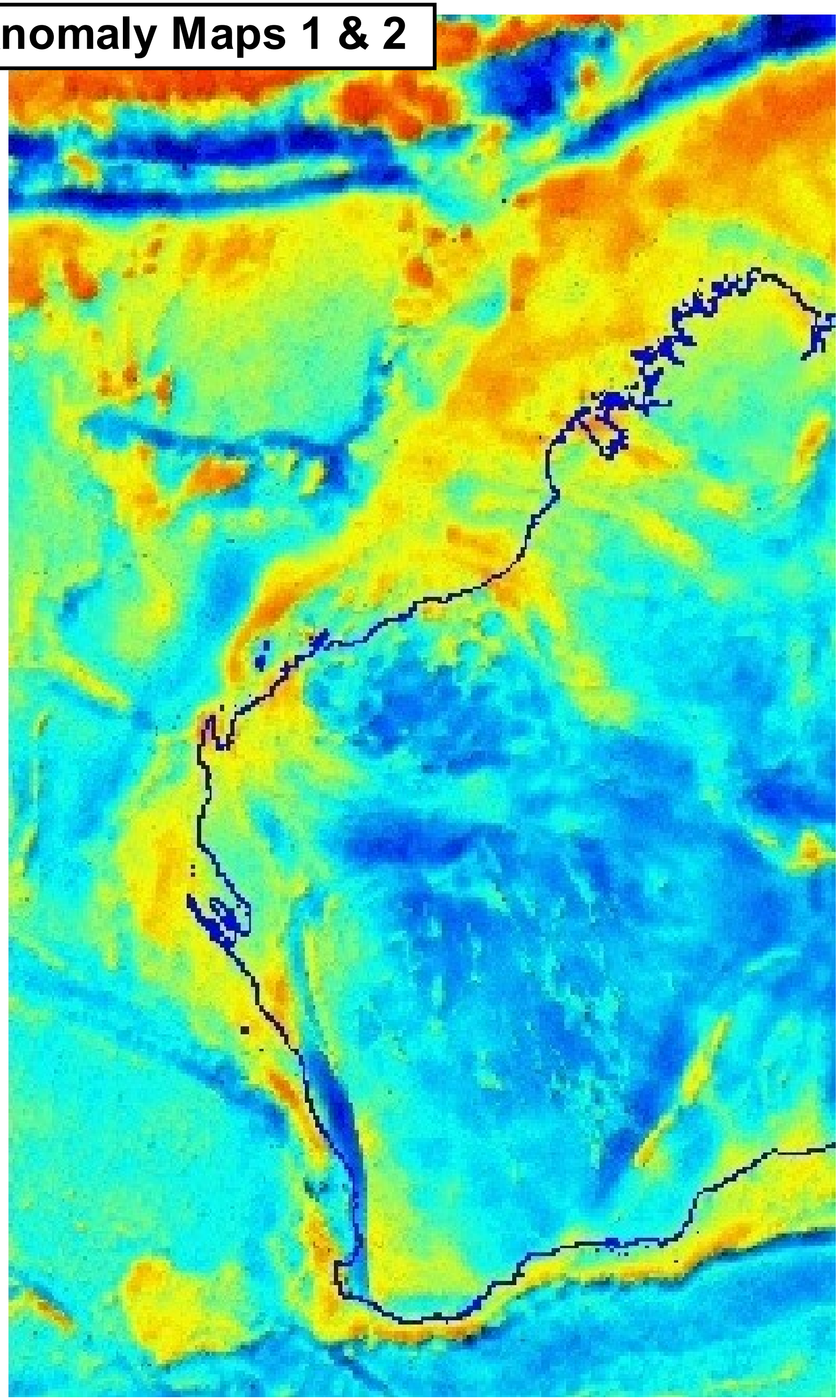


A Ø 400 x 350 km Impact Crater in NW-Australia :

The shown gravity anomaly structure was caused by the same crater which formed the Bengal Bay in India !

Gravity Anomaly Maps 1 & 2

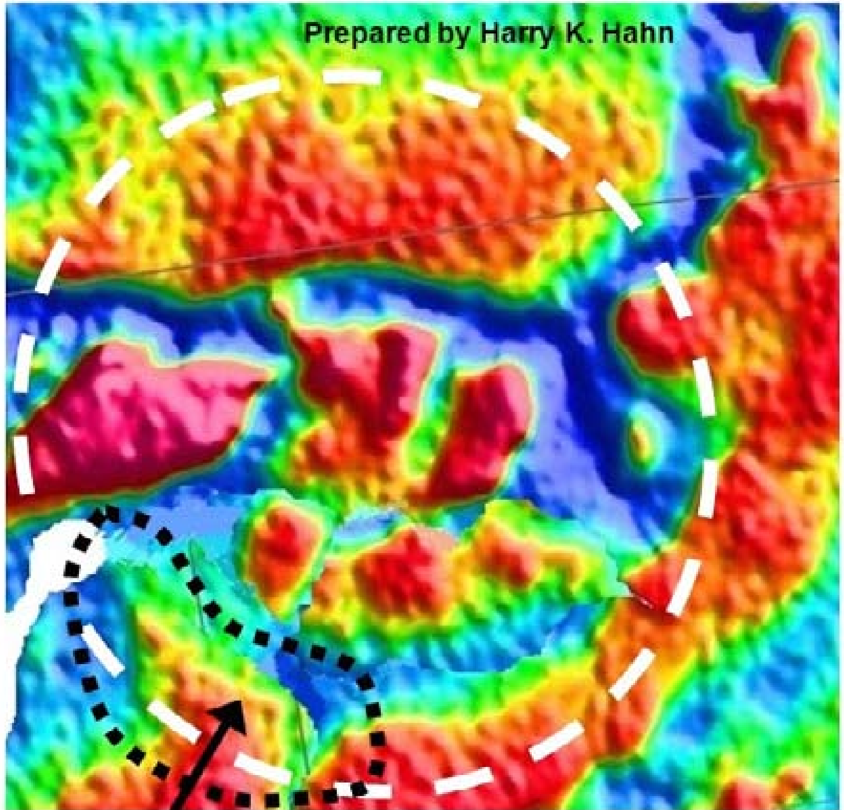




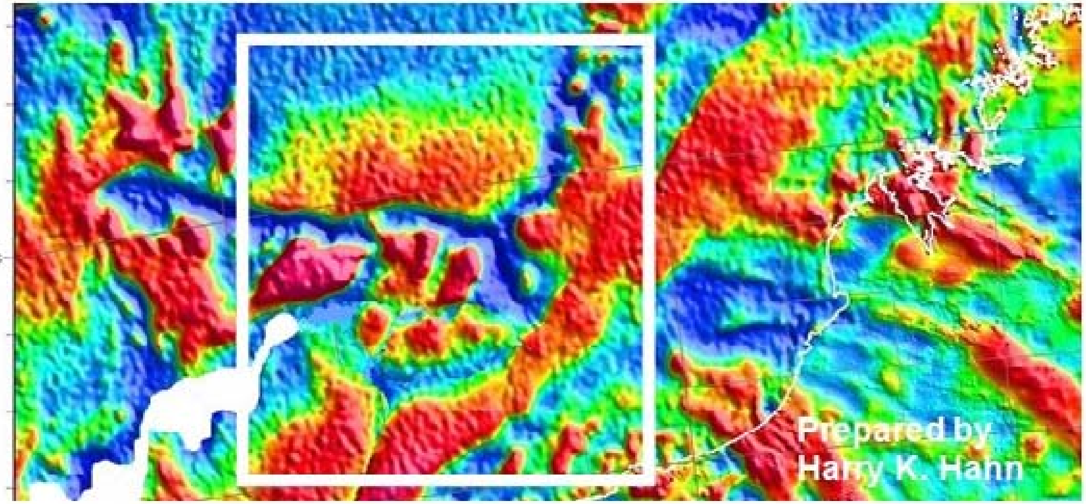
Gravity Anomalies also indicate **a Ø 420 km Crater** in South-West Australia

The gravity anomaly structure of the Ø 400 x 350 km Impact Crater in NW-Australia :

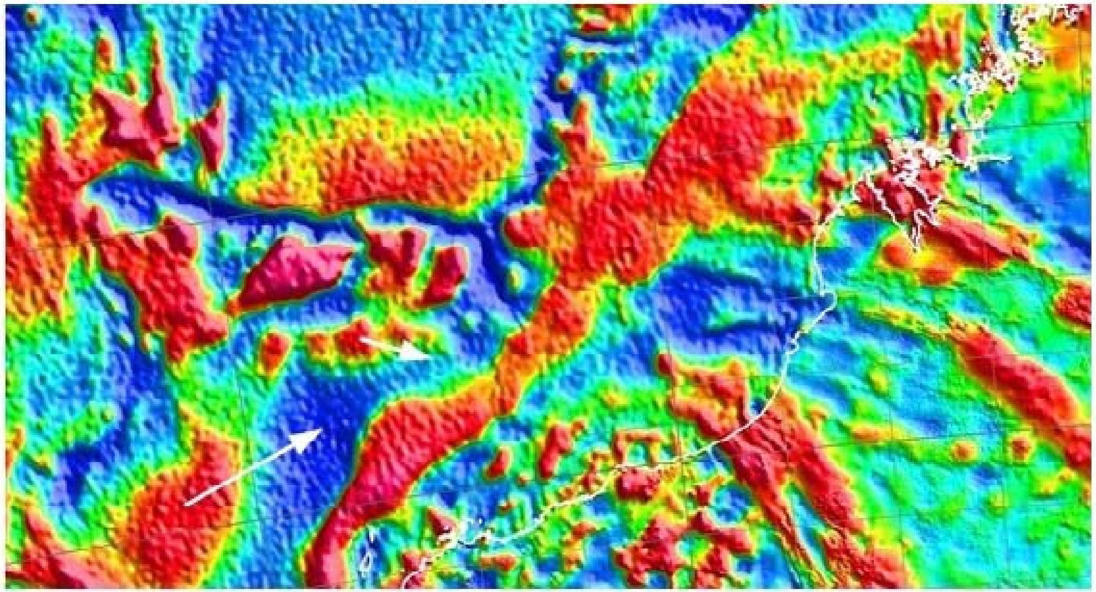
Elliptical Impact Crater ∅ 400 x 350 km



Note the precise crater-wall shape on the marked fragment !



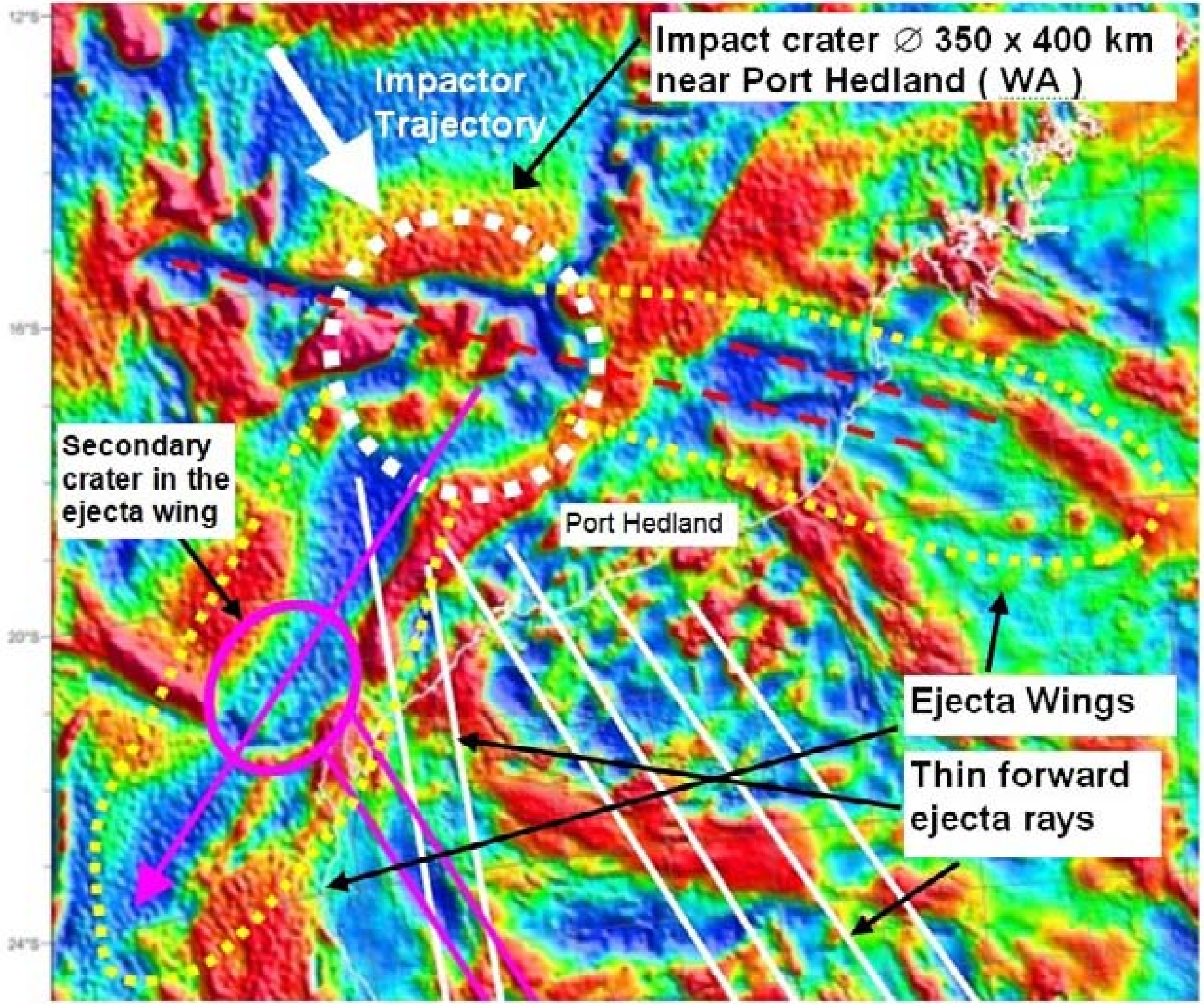
This image is manipulated and shows the crater roughly in it's original state

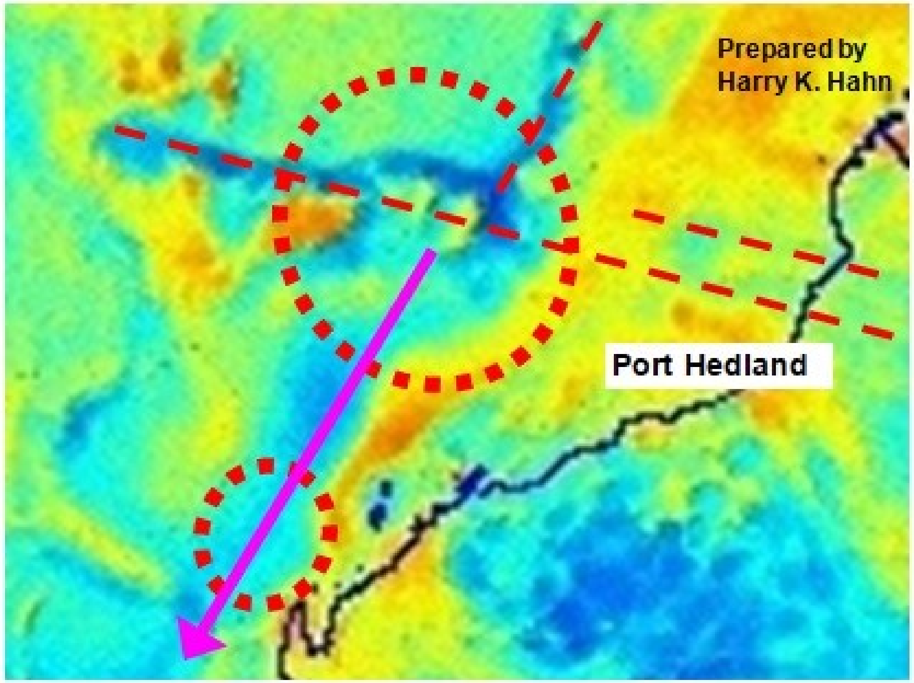


Here for comparison the original map

The main ejecta-rays of the Ø 400 x 350 km Port Hedland Crater (PHC) caused massive cracks in Earth's crust

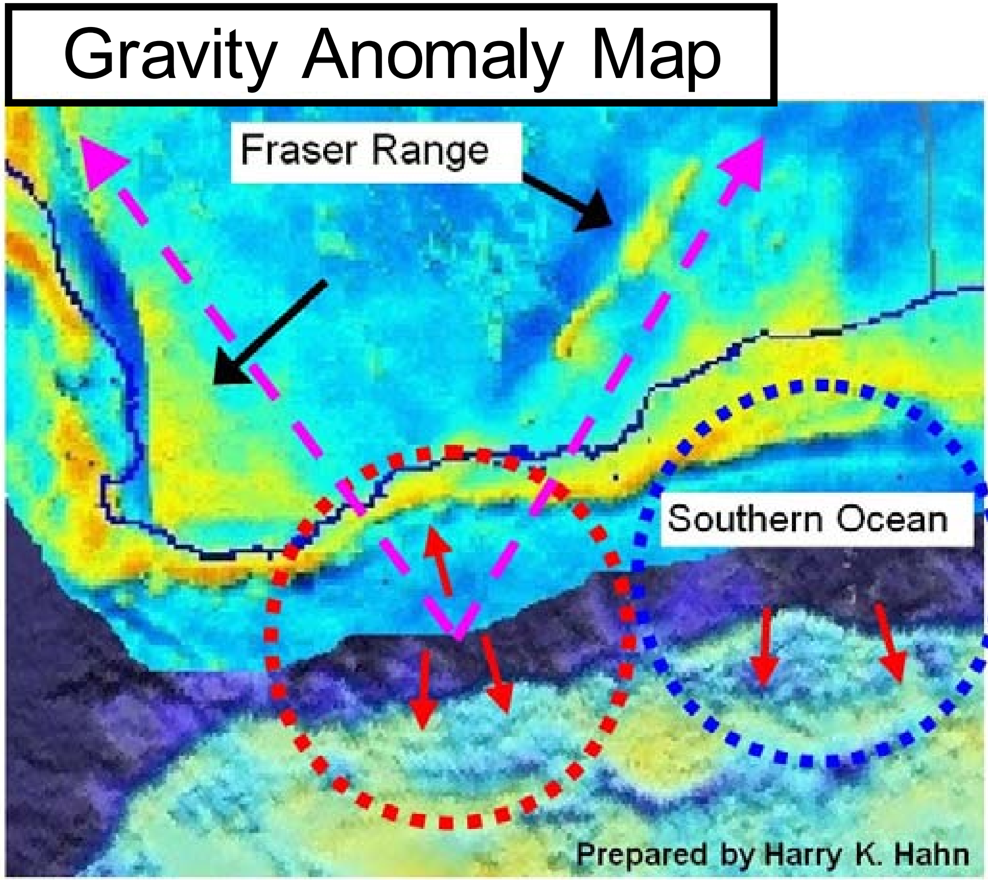
→ the cracks in Earth's crust are indicated by linear negative gravity anomalies (blue)

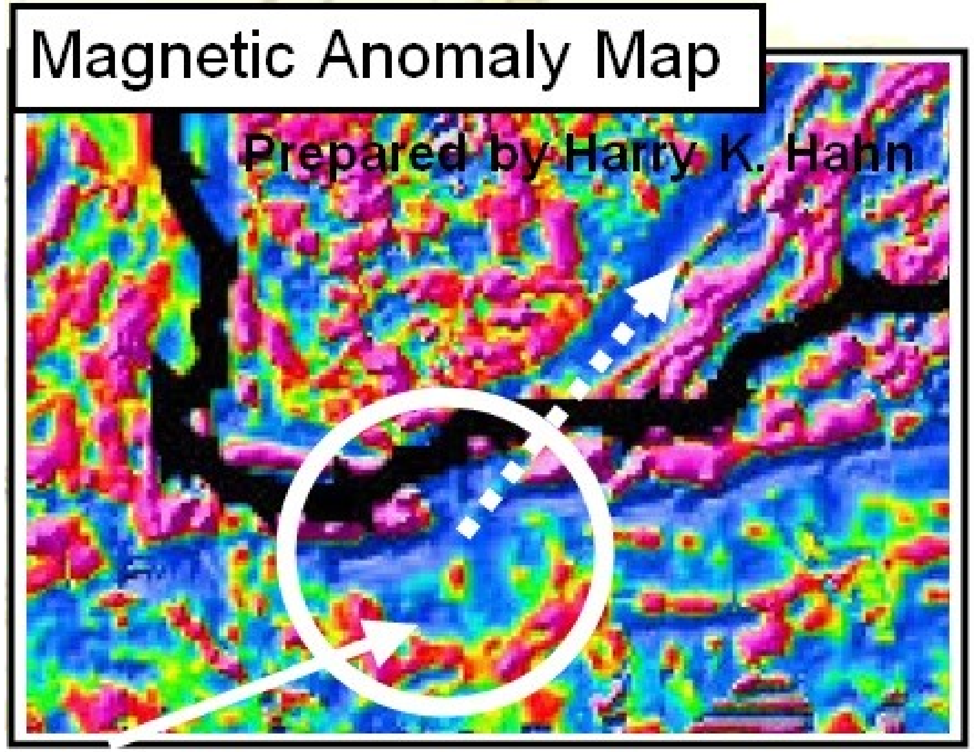




Gravity- & Magnetic Anomalies indicate a Ø 420 km Crater in South-West Australia

the circular (bow-shaped) structures indicate the crater. The linear features indicate strong ejecta-rays (-wings)

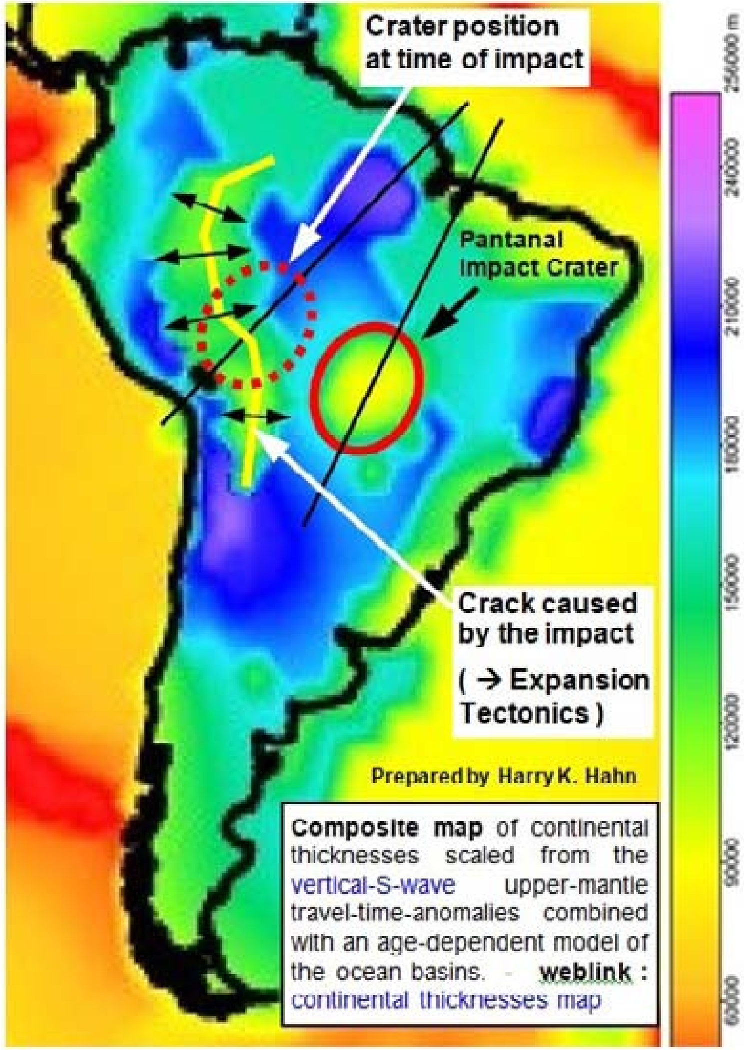


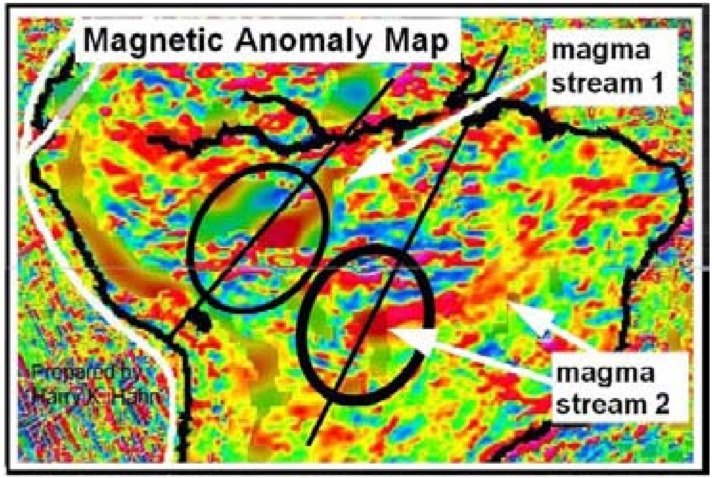


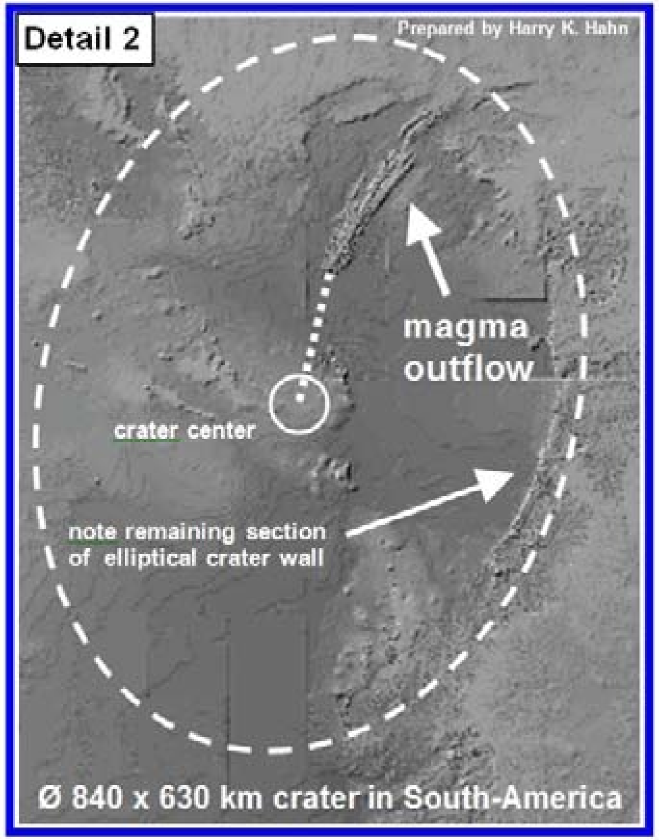
Note the semi-circular structure on the ocean floor !

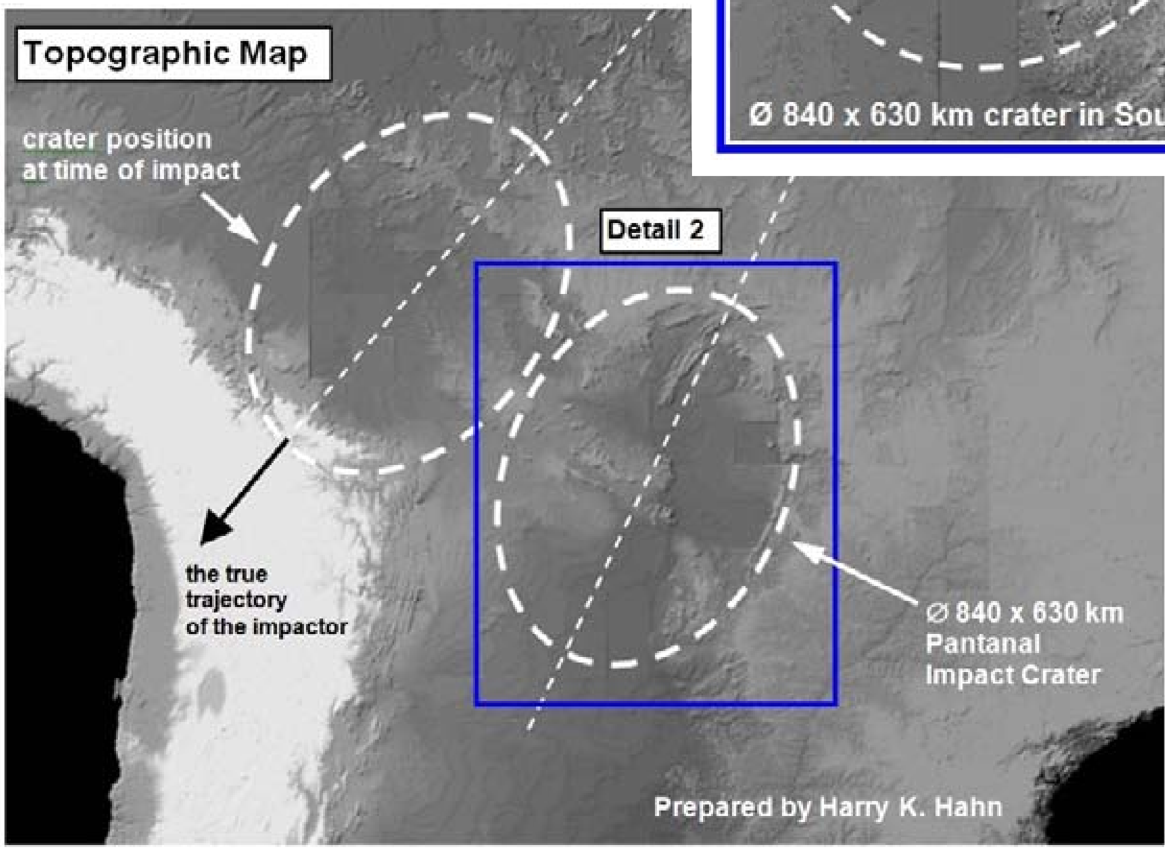
The image shows a gravity anomaly map of Australia and a topographic map of Antartica, arranged to each other so as they were ~200 Ma ago (at Pangea time).

A Ø 840 x 630 km elliptical (oblique) Impact Crater in the center of South-America (→Pantanal Area)



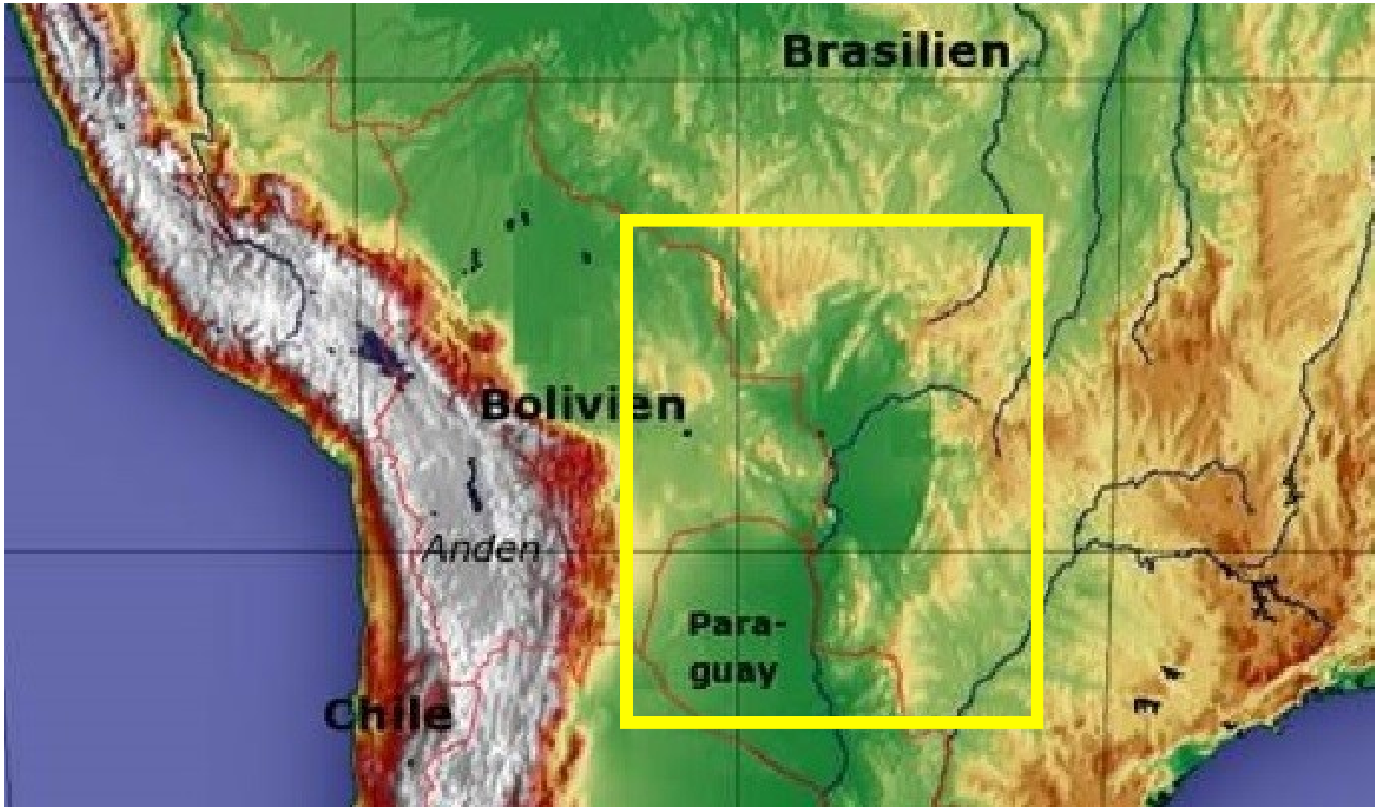


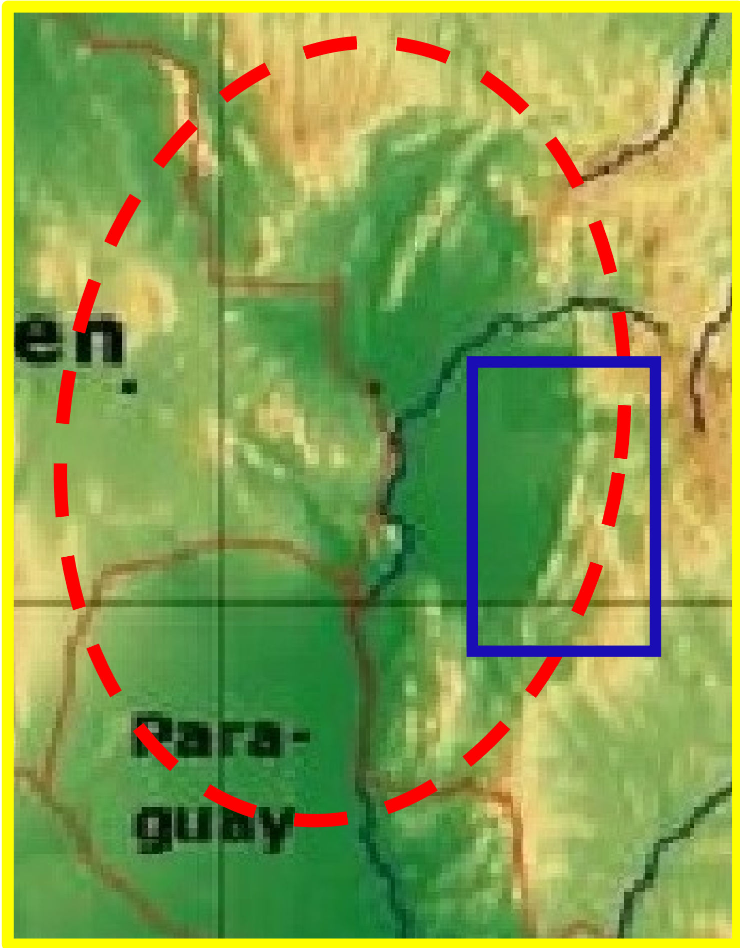




Topographic Map of the Ø 840 x 630 km Pantanal Crater

The detail marked in blue shows a still existing section of the crater-wall of the elliptical impact crater. This crater-wall section shows a triple wall-structure caused by the strong compression of this crust area during the impact event.

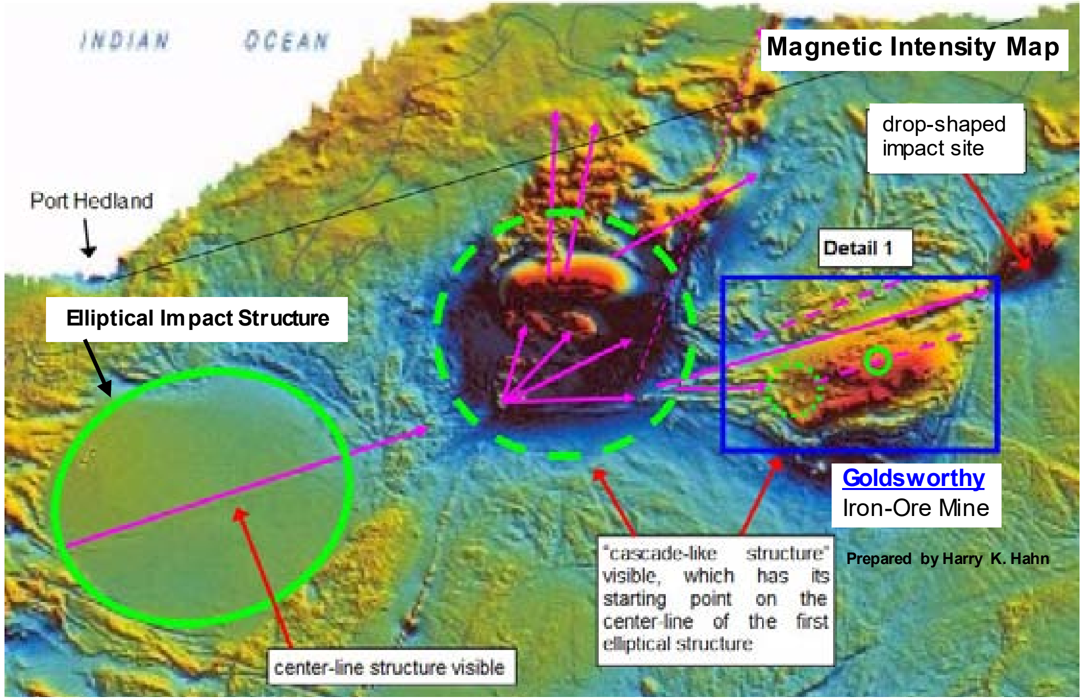


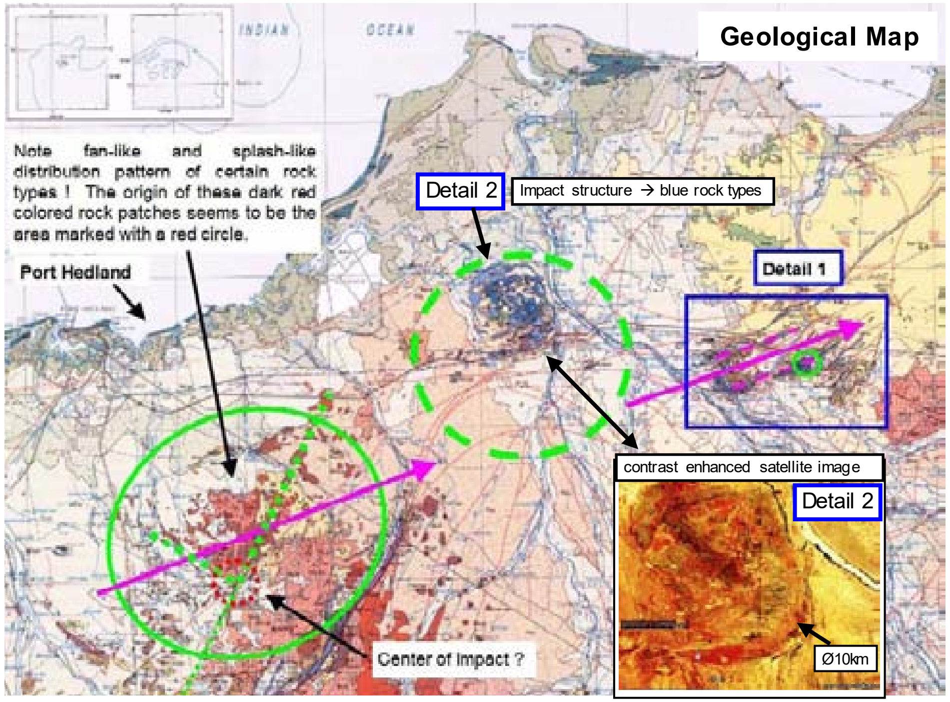


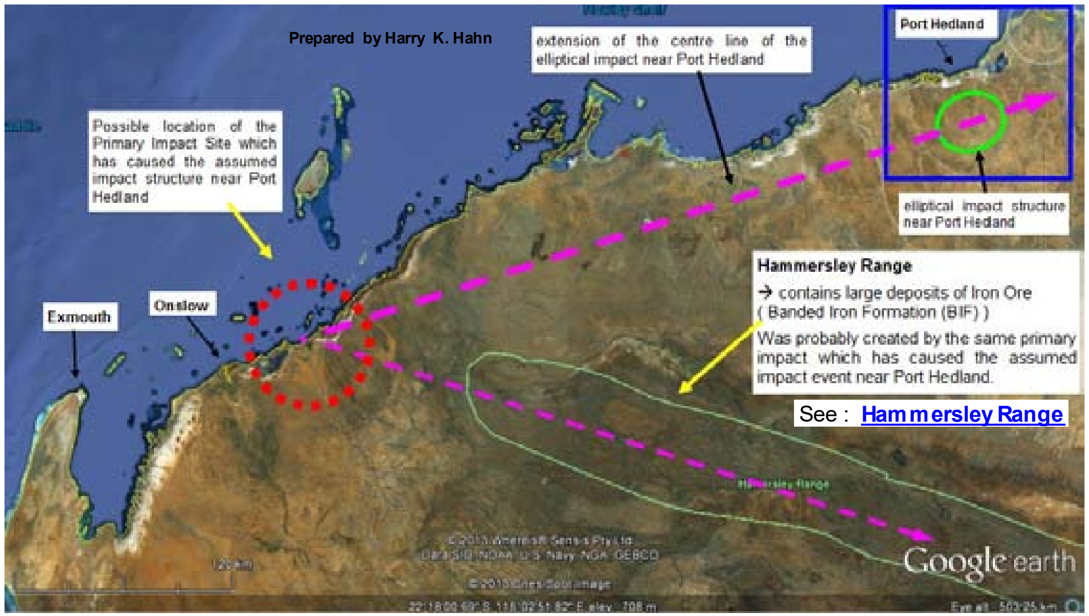
There is a triple wall-structure visible

Complex Impact Structure (> ∅30 km Crater) near Port Hedland in the Pilbara Region (in NW of West-Australia)

The satellite view, the magnetic intensity map and the geological map indicate a complex impact structure near Port Headland (in West-Australia), which probably was formed by secondary impactors ejected by a large asteroid impact crater further away. This impact structure must be > 200 Million years old.







Detail 1 : Satellite View with marked position of impactor sites & Iron Ore Mine