Introduction to geology, mineralogy and sedimentology

2009

Rolf Kilian

Content

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9. Exogenic processs
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3. Literature

Literature:

Gill

Press, F. & Siever, R. (2003): Allgemeine Geologie. Spektrum Akadem. Verlag. Heidelberg. 3. Auflage, 723 S., ISBN: 3827403073.

Rollinson

Skinner, B.Y. and Porter S.C. (2004): The Dynamik of the Earth: An Introduction to physical geology. 5. Auflage, 648 Seiten. ISBN: 0-471-15228-5.

Tucker, M. (1996): Methods of Sedimentology. 366 S. Enke-Verlag.

Web sites related to mineraly, rocks and geology:

http://www.seilnacht.com/Minerale/index.htm (Minerals)

http://www.min.uni-bremen.de/kabinett/ (Minerals)

http://www.geolab.unc.edu/Petunia/IgMetAtlas/mainmenu.html (rocks)

http://www-seismo.hannover.bgr.de (Seismik weltweit)

http://pubs.usgs.gov/gip/dynamic/dynamic.html (plate tectonis)

http://www.wikipedia.de

4. Formation our solar system from a planetary cloud of dust (here Orion Nebula)

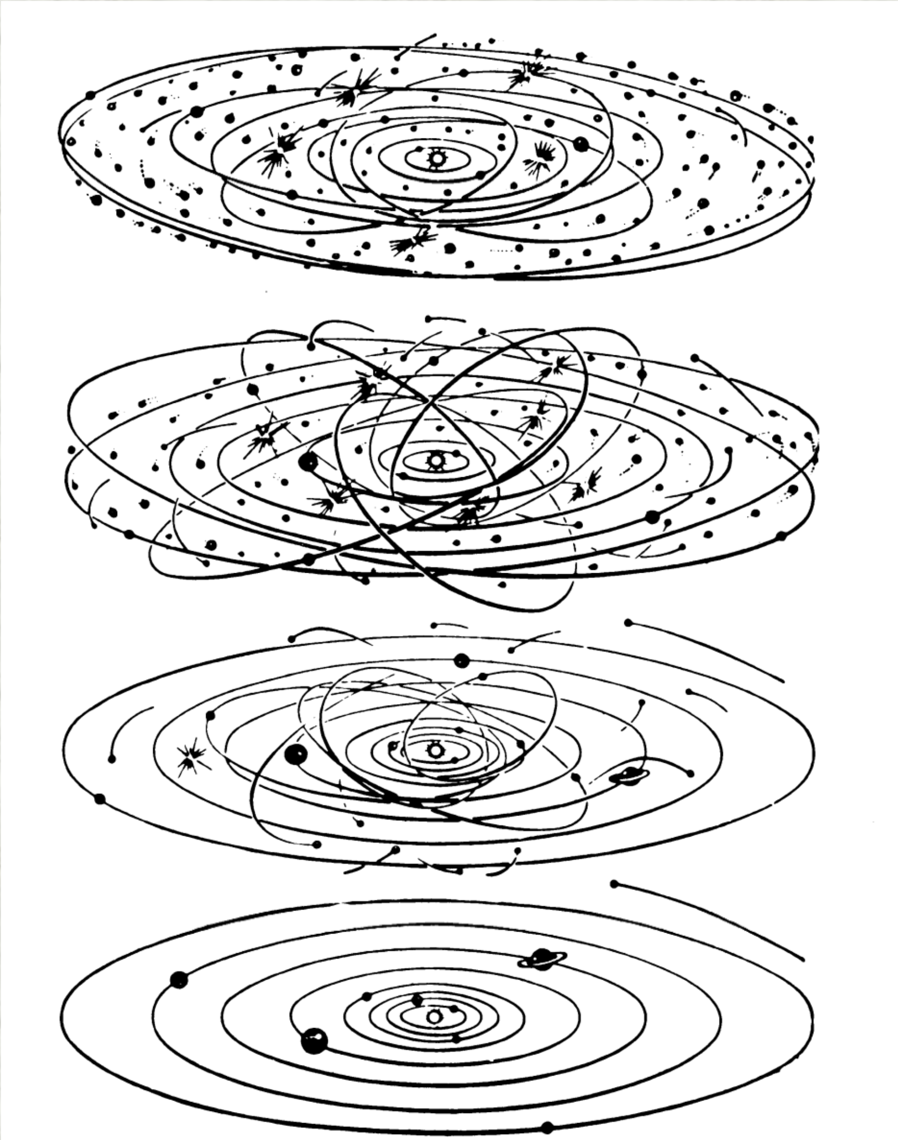
Early history of the inner Planets and the origin their Schalenbaus

- **The solar system was formed from by condesation of a dust nube** (first homogeneous later fractionated condensation ➔ 10 GA)

  ➔ 99% of the mass in the sun only 1% in satellites.

- ***Planetary simals*** and the later ***Protoplanets*** moved to Keplerbahnen orbits

  ➔100 Ma gravitative cleaning of the orbits around the sun



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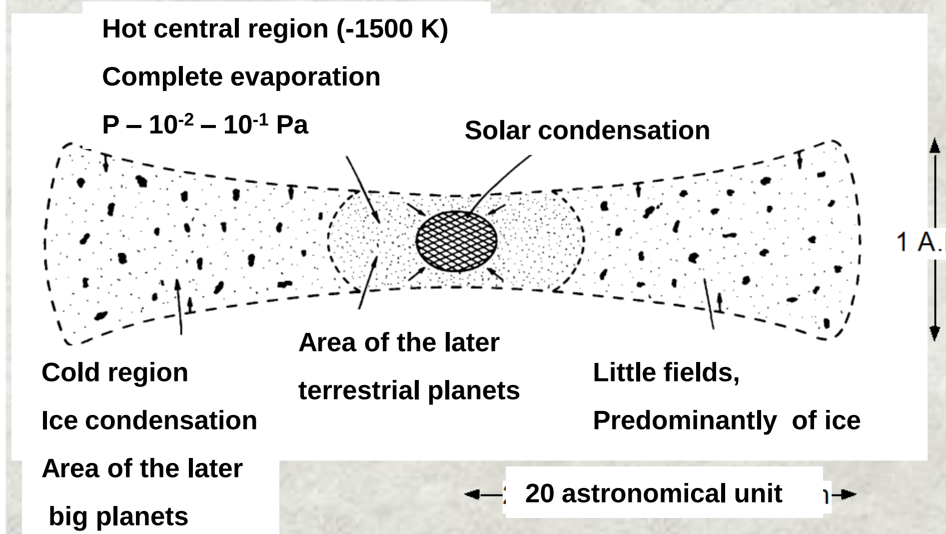
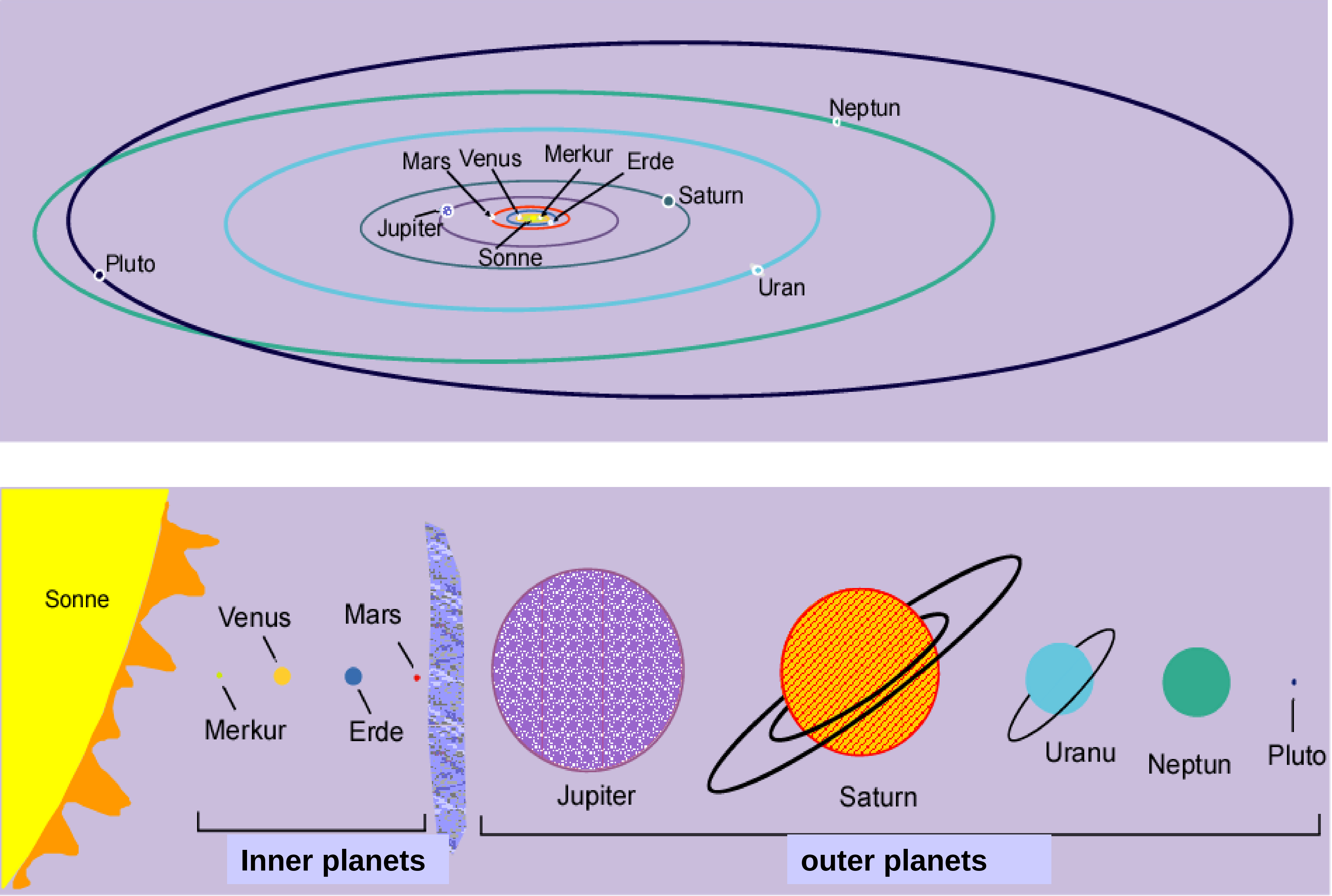


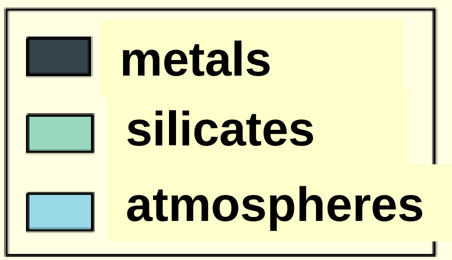
from unpublished Ms, Rainer Altherr

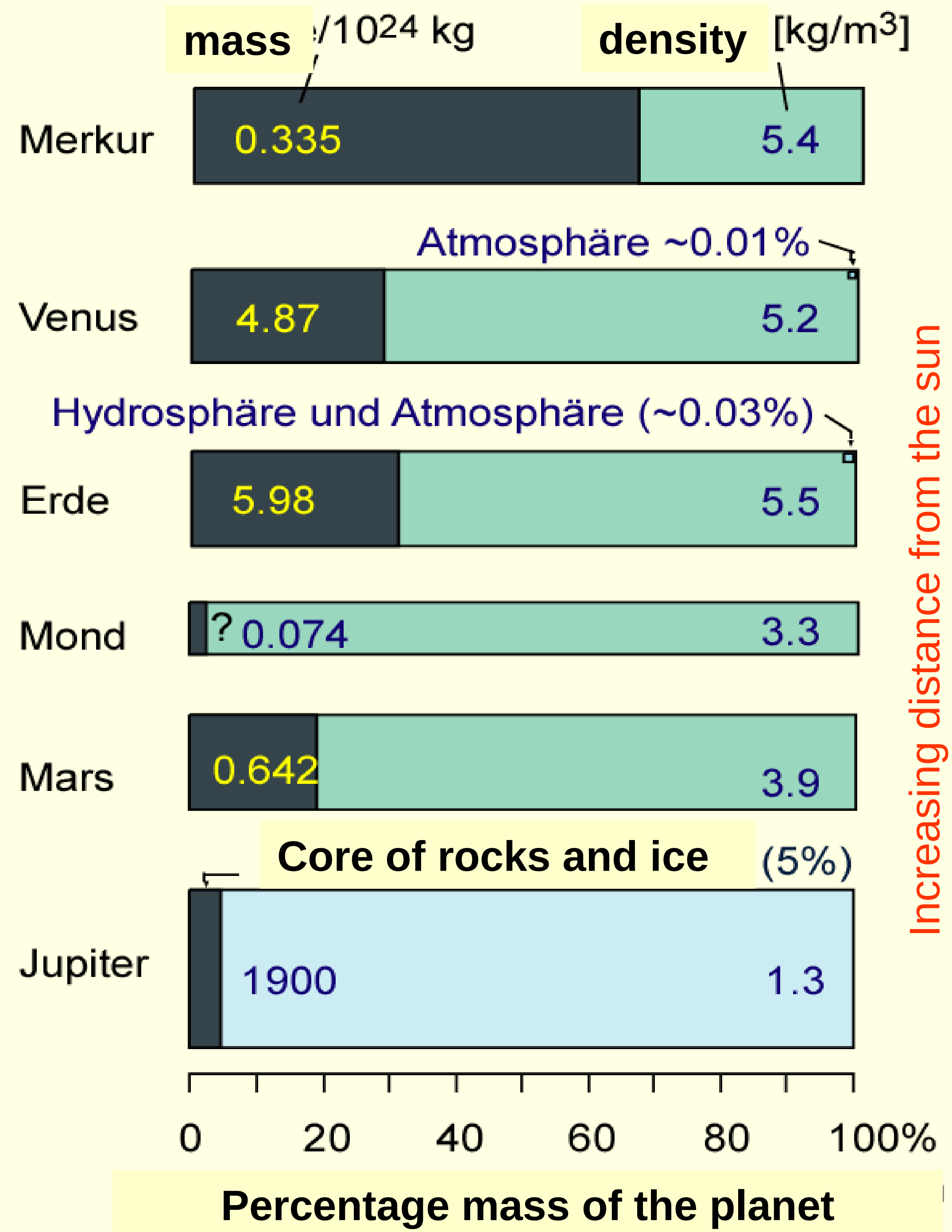


Distances from the sun, relative diameters of planets

Siever, Press
Understanding Earth
2. Edition, 1997
Figure1.3

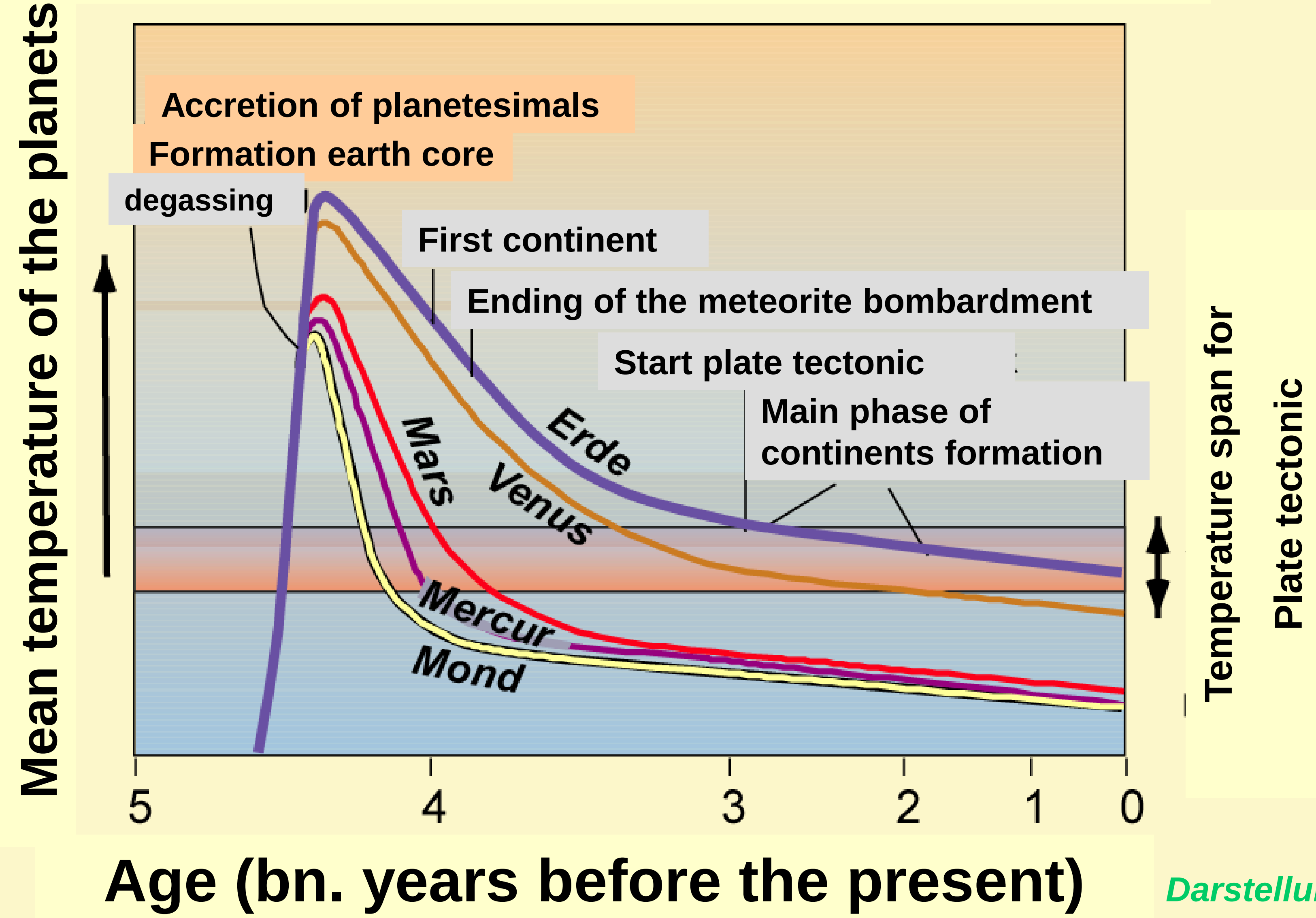
Composition of planets of our solar system





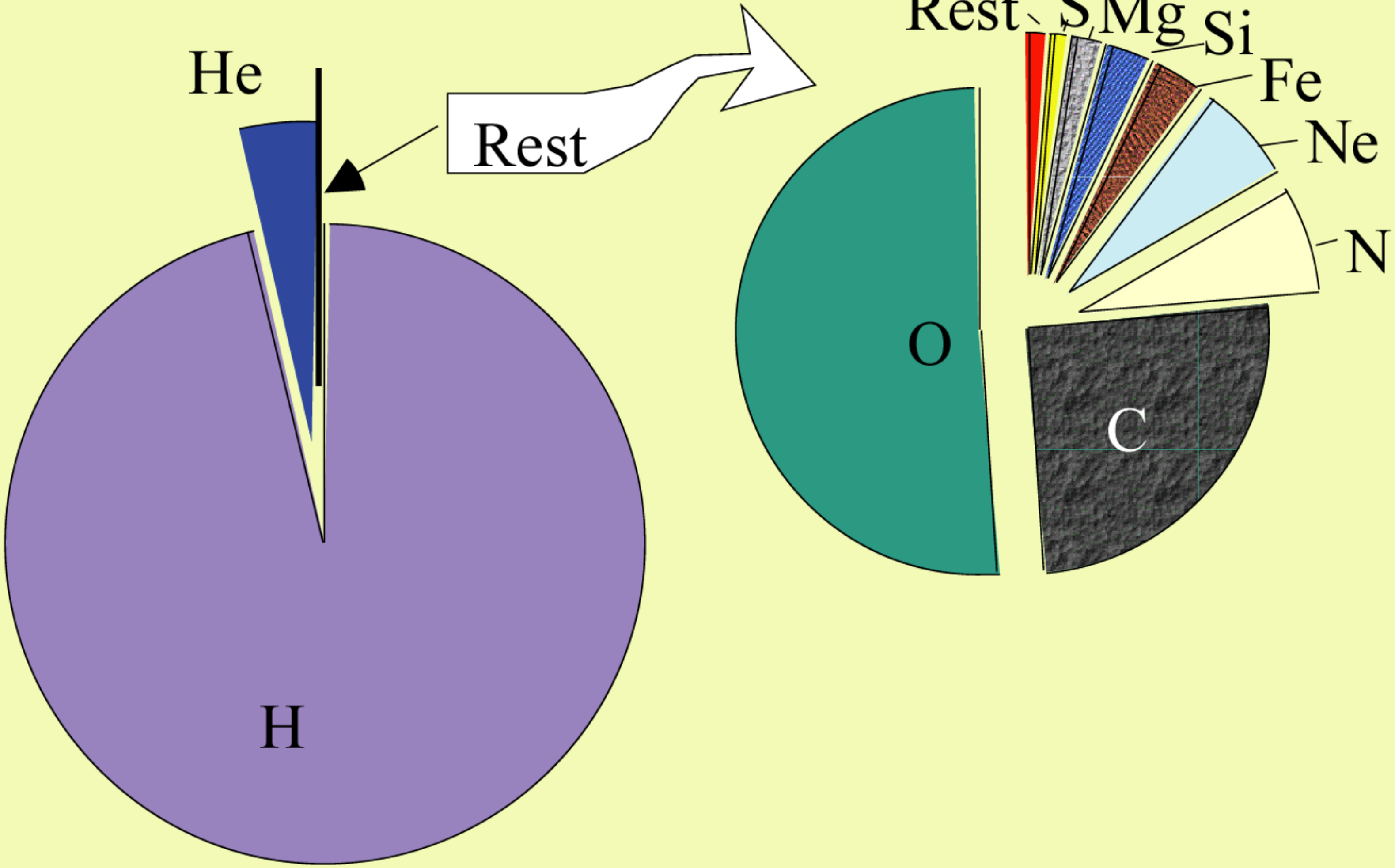
Gill (1994)

Temperature development of the planets since their formation



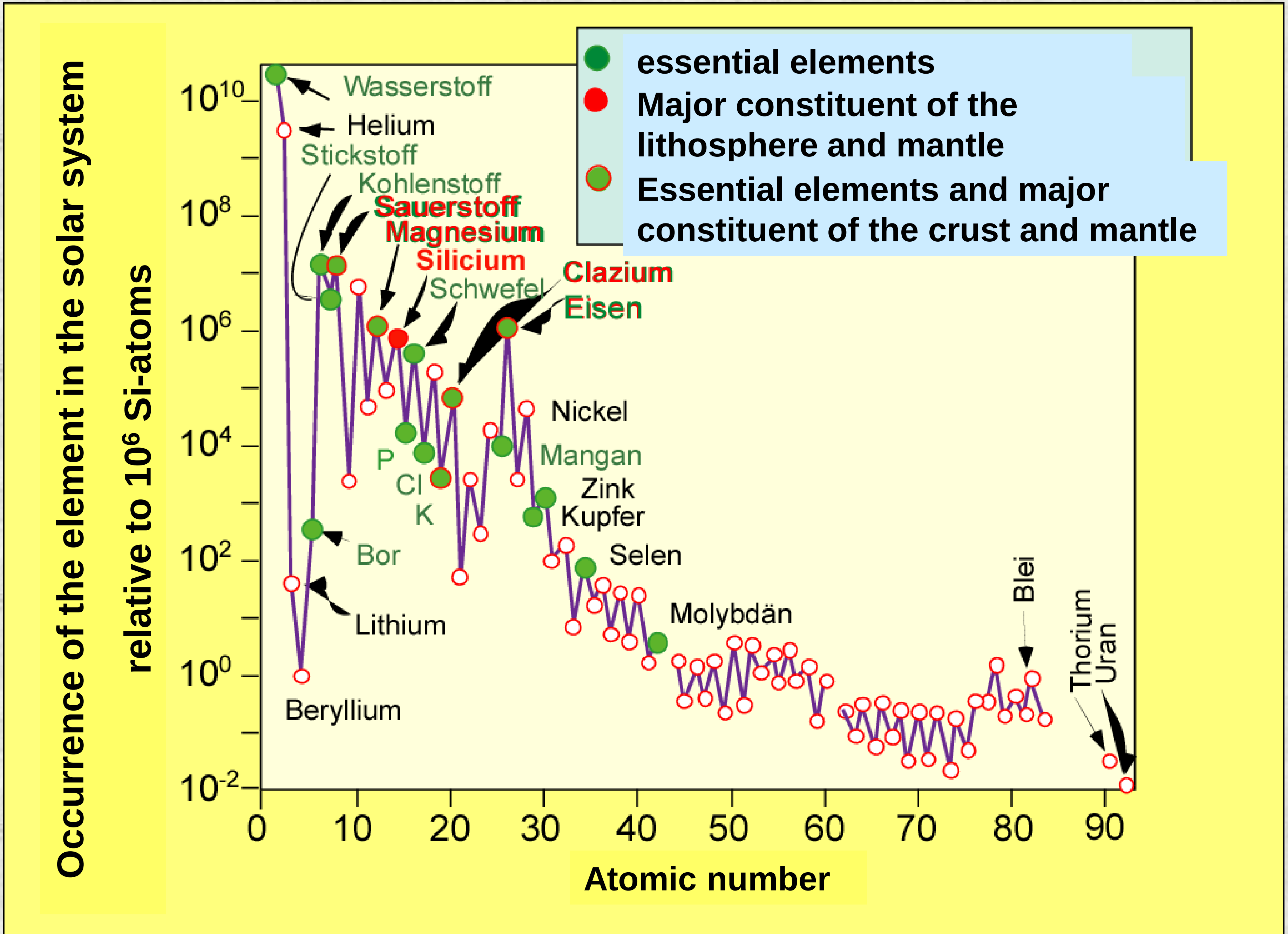
Darstellung v. G. Wörner

Chemical composition of the sun
(=98% of the mass of our solar system)

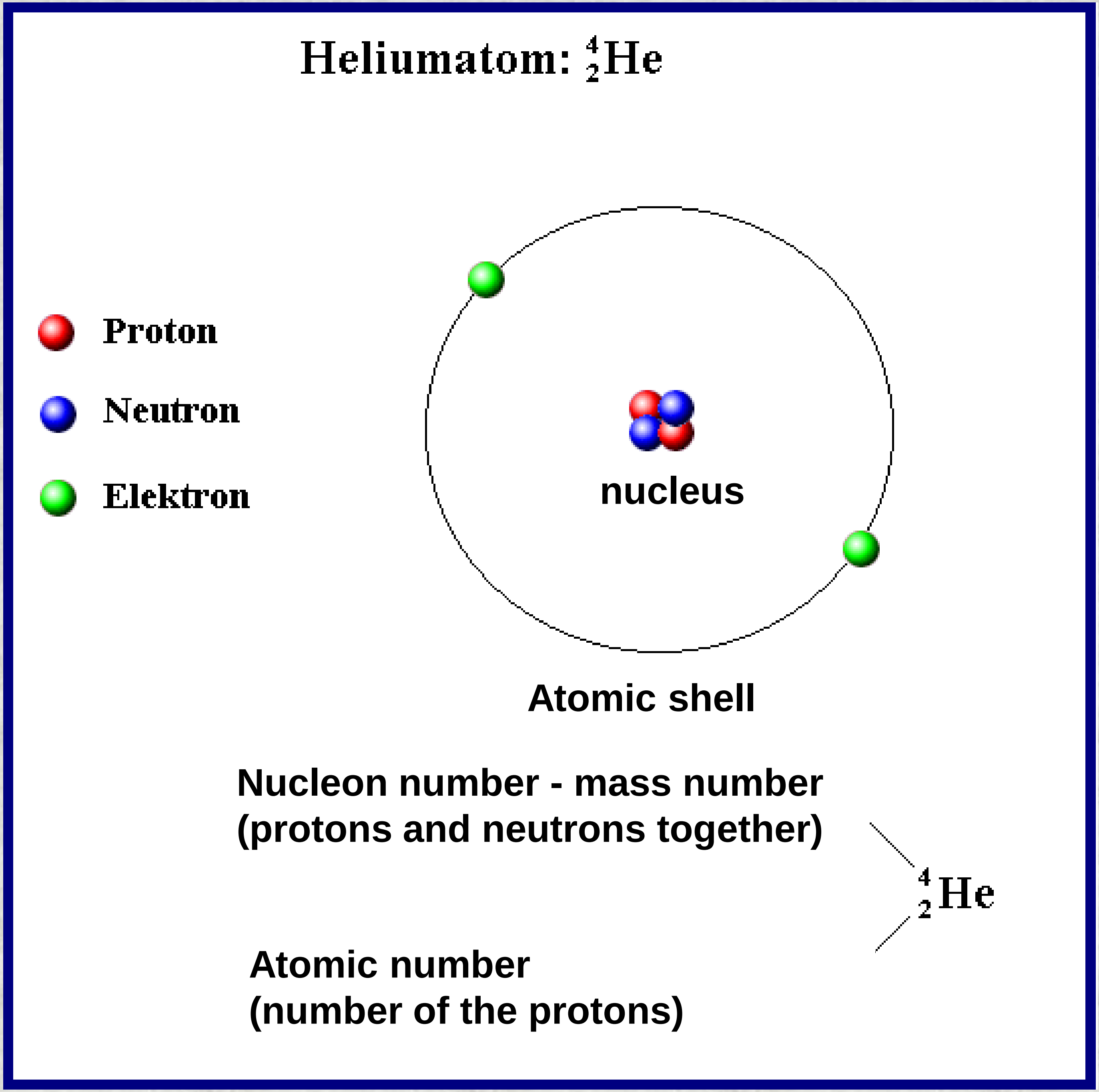


Gill 1998

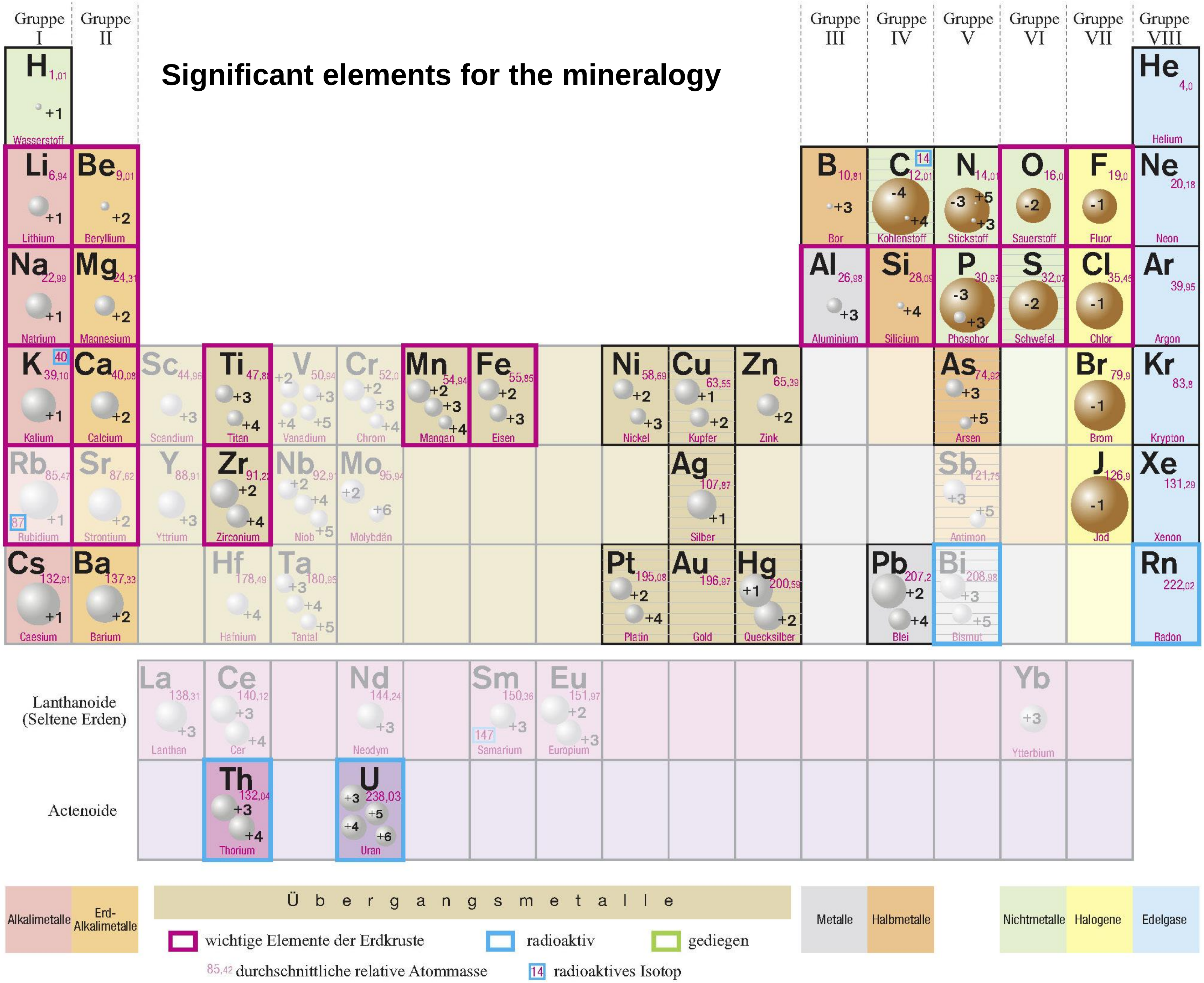
Element occurrence in the Solar system

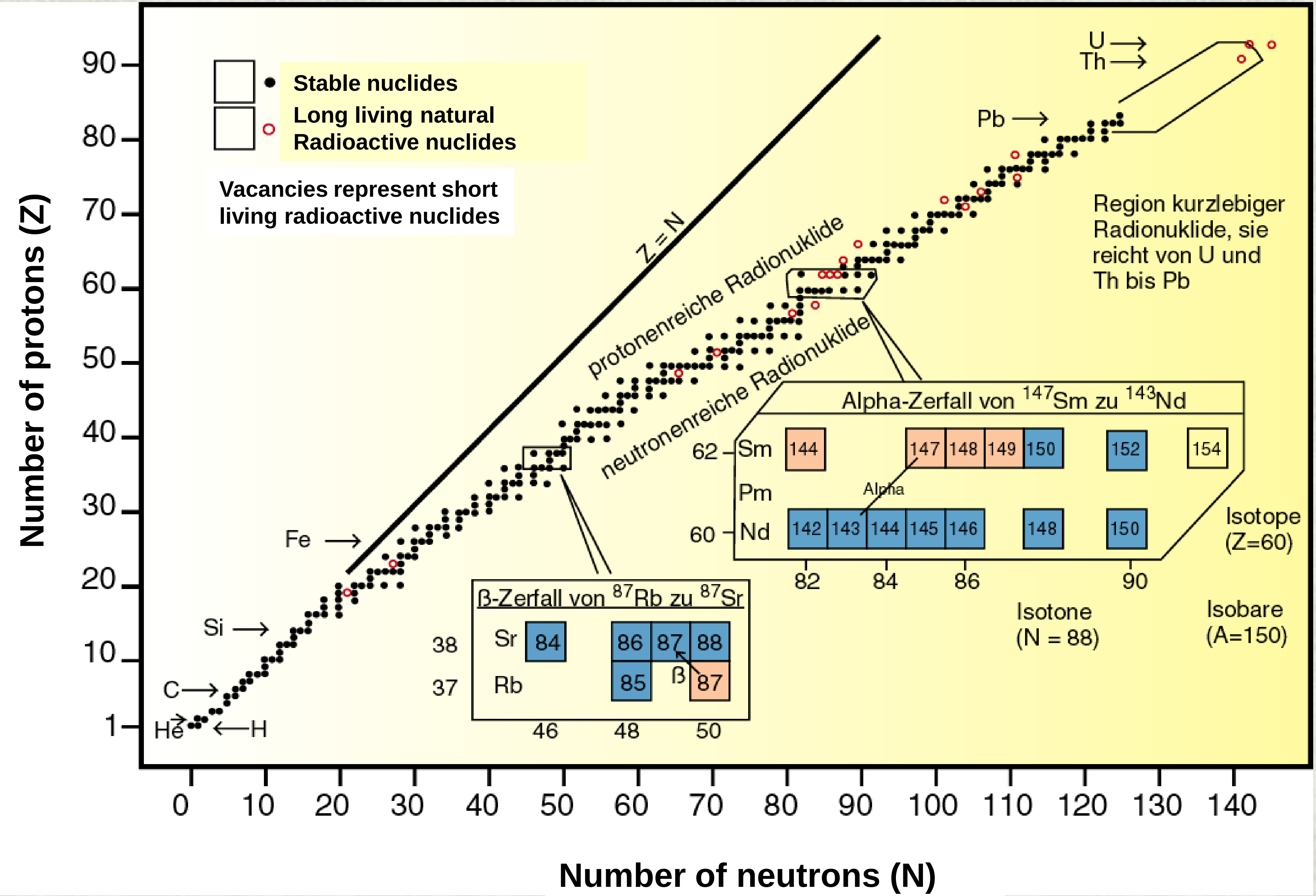


Atomic Structure:



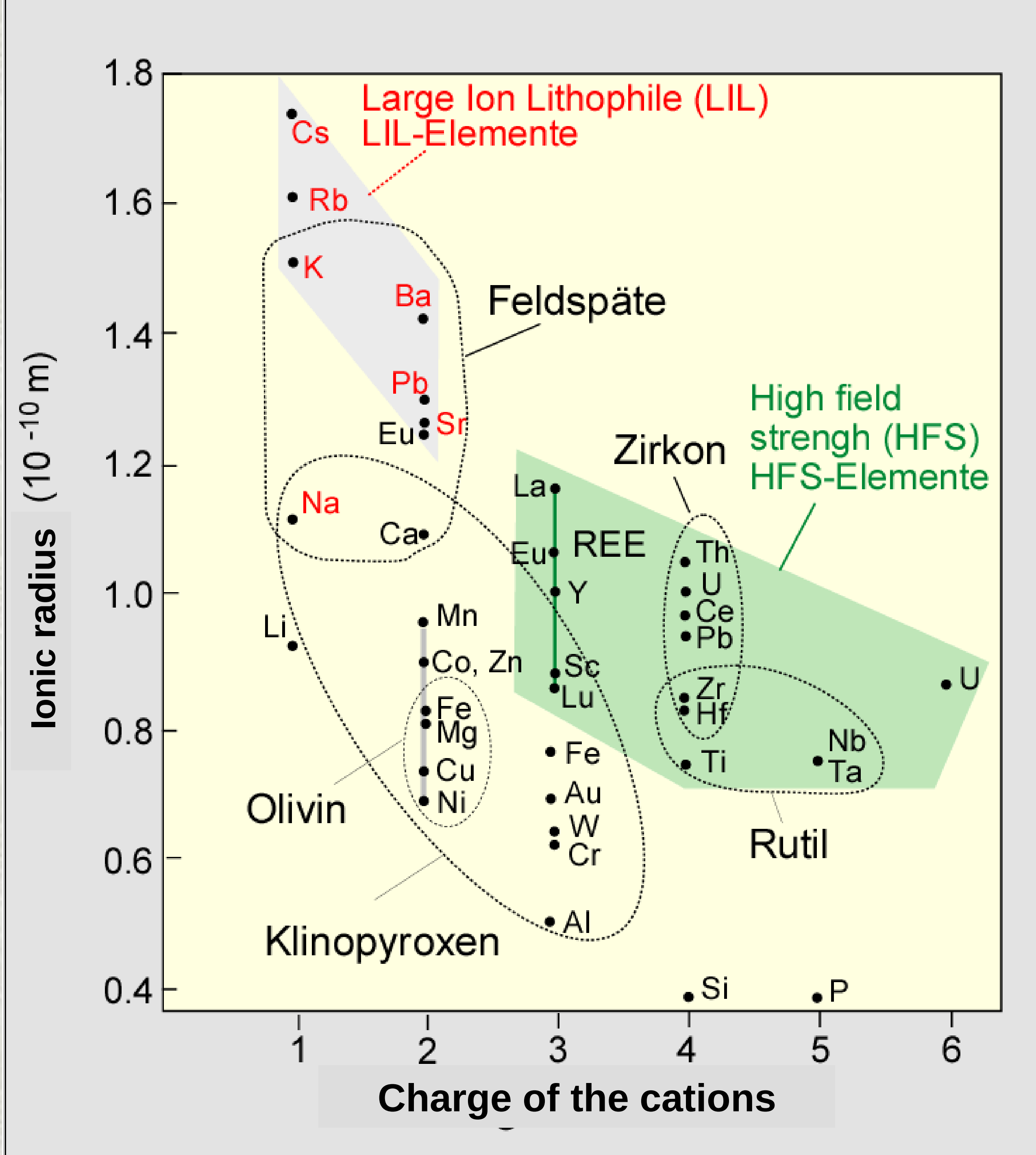
Significant elements for the mineralogy



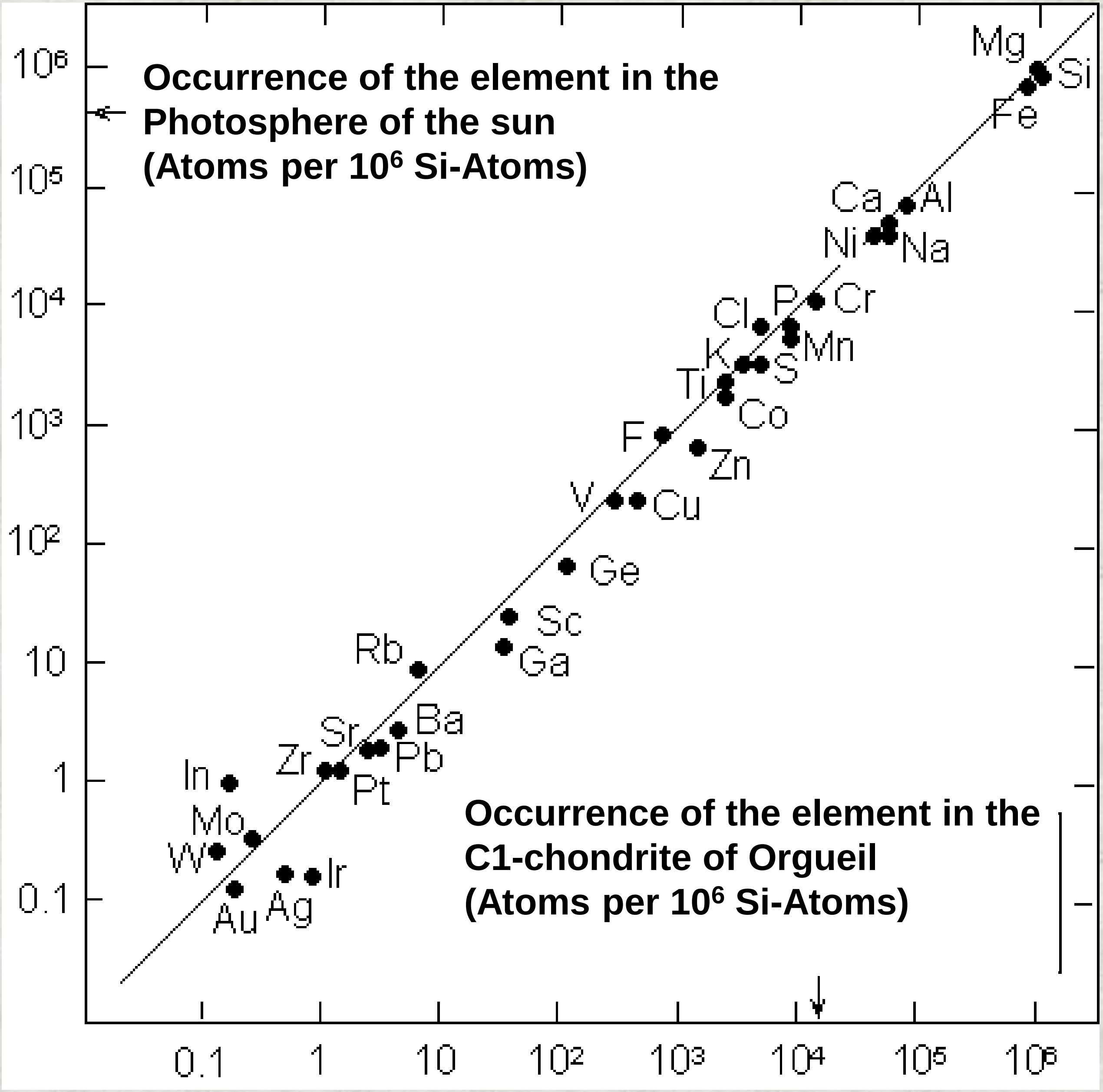


Rollinson 1993

The minerals olivine, zircon, feldspars, clino-pyroxene and rutile have different tolerance (pointed curve) relative to the ionic radius and the charge of the cations, by possible assembly of this cations in the crystal lattice of a mineral



Comparison of the element concentrations in the photosphere of the sun (Spectral lines of single elements) with that of the C1-chondrite of Orgueil.



6. Meteorites

Definition: Meteorite

natural object, which comes from the outer space and enters in the atmosphere or in the gravity field of the earth or other celestial bodies (in particular a planet or a moon). The meteorite can there to burn up or to reach the surface. (→ Crater formation, more than 200 are known)

The meteorites hail from the solar system and are well remains of asteroids (planetoids or minor planets).

Meteor,

the term meteor comes from the Grecian word *meteoron*, which mean "high in the air". The small particles of matter in the solar system that are directly observable only by their incandescence from frictional heating on entry into the atmosphere.

Meteorites

- *Undifferentiated meteorites* from millimeter size spherical silicate aggregate, the *chondres*, ➔ *Chondrite* ➔ *document the early composition of the solar system*
- *Differentiated meteorites* of planets, which are differentiated by dissolution in core, mantel and crust. In this group are the *Achondrite* (Stone-Meteorite), *Stone-Iron-Meteorites* and *Iron-Meteorite*.

➔ Document the evolution of the inner planets of the solar system.

Meteoriten Typen

Iron: to be composed basically of iron and nickel; similar to M Asteroid;

Stone-Iron: to be composed of iron and Stone-material; similar to S Asteroid;

Chondrite: by far the more abundant; the composition is similar to the mantel and crust from planets.

Meteoriten Typen

Carbonaceous Chondrite: similar to C Asteroidean;

Achondrite: similar to basalt stone; origin → the Moon and Mars

Meteorite statistic	between 1740 and 1990 (total 4660piece); only 33% are KAT (1)			
Typ	observed [1] %	casual encountered [2] %	[1] weight	[2] weight
Stone	95.0	79.8	15200 kg	8300 kg
Stone-Iron	1.0	1.6	525 kg	8600 kg
Iron	4.0	18.6	27000 kg	435000 kg

Meteorites

Achondrite-Eukrit (Stone meteorite)
Camel Donga Museum (Australia)

Achondrite Camel Donga Museum (Australia)

Picture from http://www.carionmineraux.com/meteorite_chondrites.htm

Meteoriten

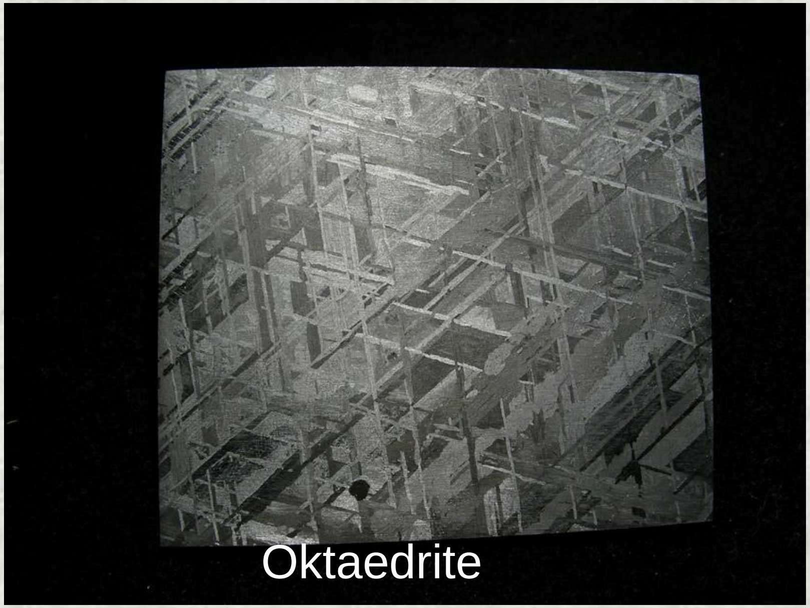
C1 Chondrite Allende

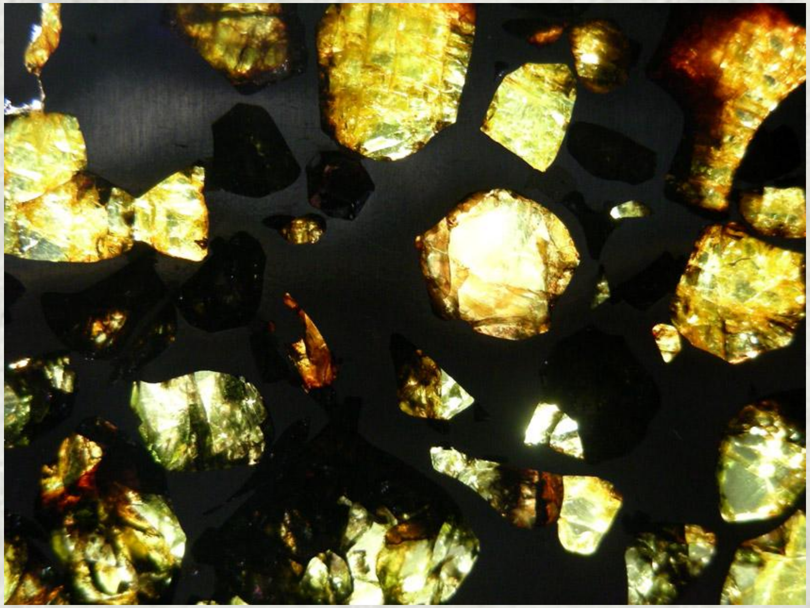
Achondrite Tatahouine (Stone meteorite)

Undifferentiated Meteorite

Pictures from http://www.carionmineraux.com/meteorite_chondrites.htm

Iron meteorite and Stone-Iron meteorite





Iron meteorite with Olivine (Esquel)

Pictures from http://www.carionmineraux.com/meteorite_chondrites.htm

Iron meteorite: Core destructed planets

Ca-Al-inclusions in carbonate Chondriten:
4567±0.6 Million Years alt

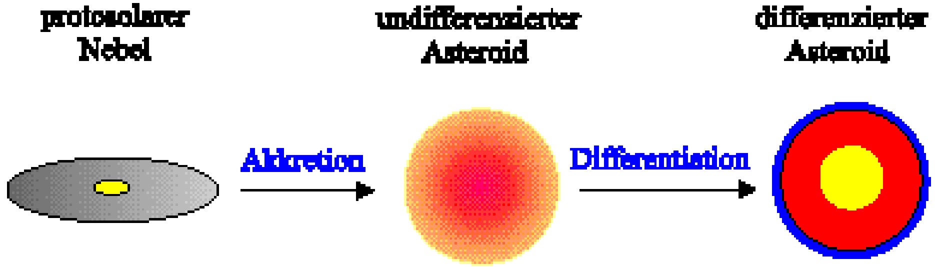


Abb. 1.7: Ursprung von undifferenzierten und differenzierten Meteoriten

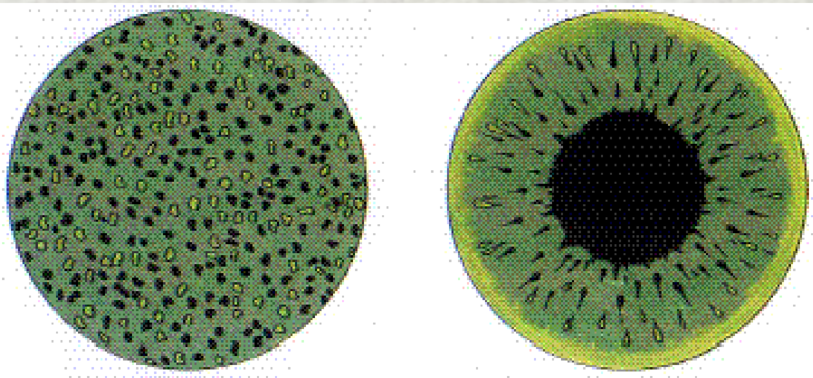
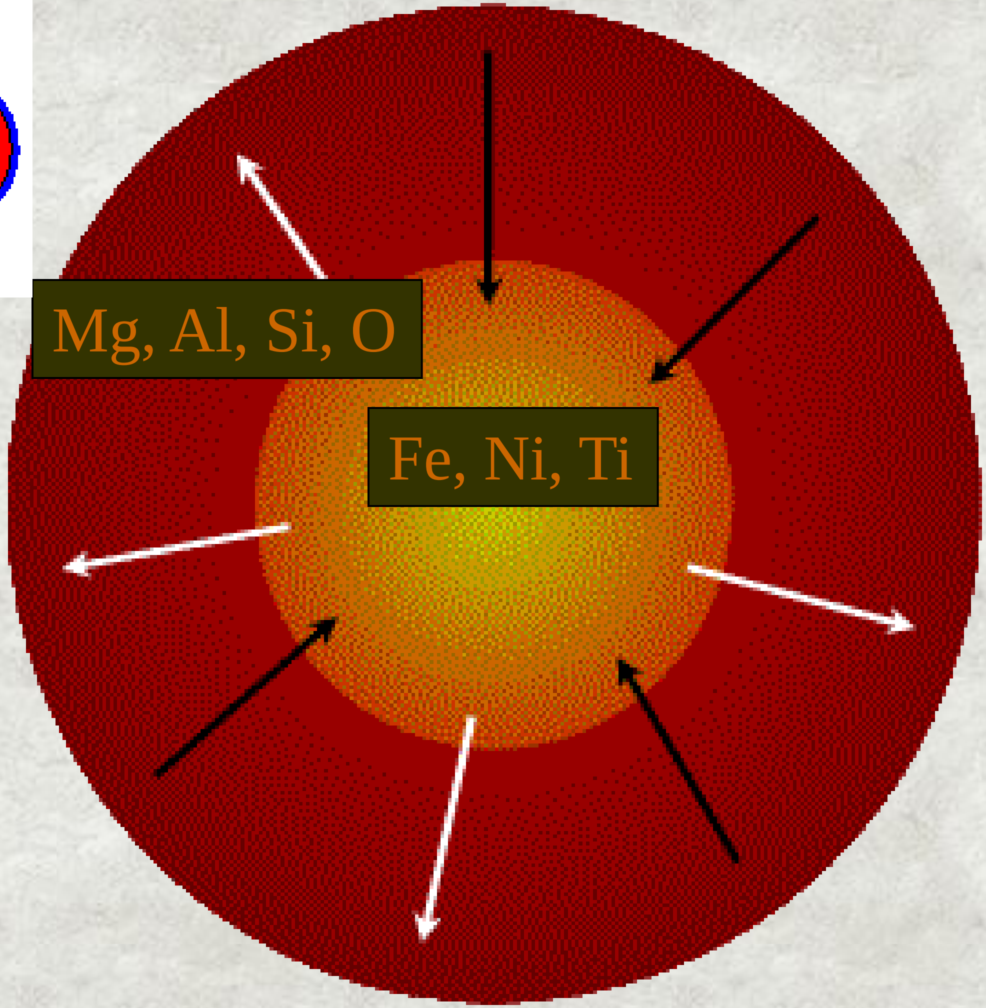


Abb. 1.16: Differentiation eines Asteroiden. Links: undifferenzierter Körper mit Metall u. Sulfid (schwarz) und niedrigschmelzenden, alkalireichen Silikaten (gelb), sowie hochschmelzenden Mg-Silikaten (grün). Rechts: Bildung von Kern und Kruste - die schweren metallischen und sulfidischen Komponenten sinken nach unten, die leichten, silikatischen Komponenten steigen auf und bilden die Kruste.



Differentiation some Asteroids:

and all Planets: heavy elements as Iron and Nickel sink in the Core (black arrows), light elements as Magnesium, Aluminum und Oxygen ascend and build the Mantel (white arrows).

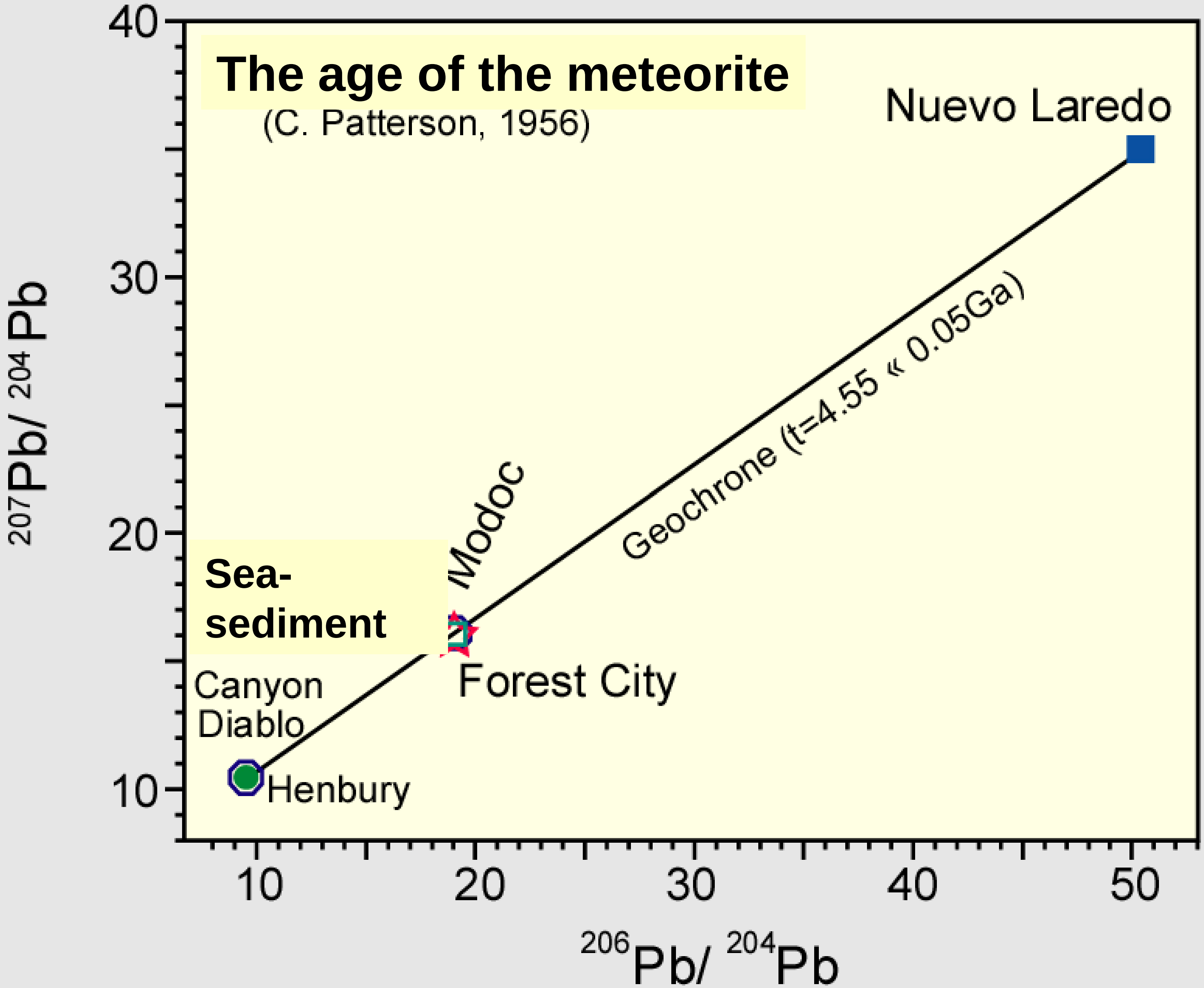
„Meteorites capture“

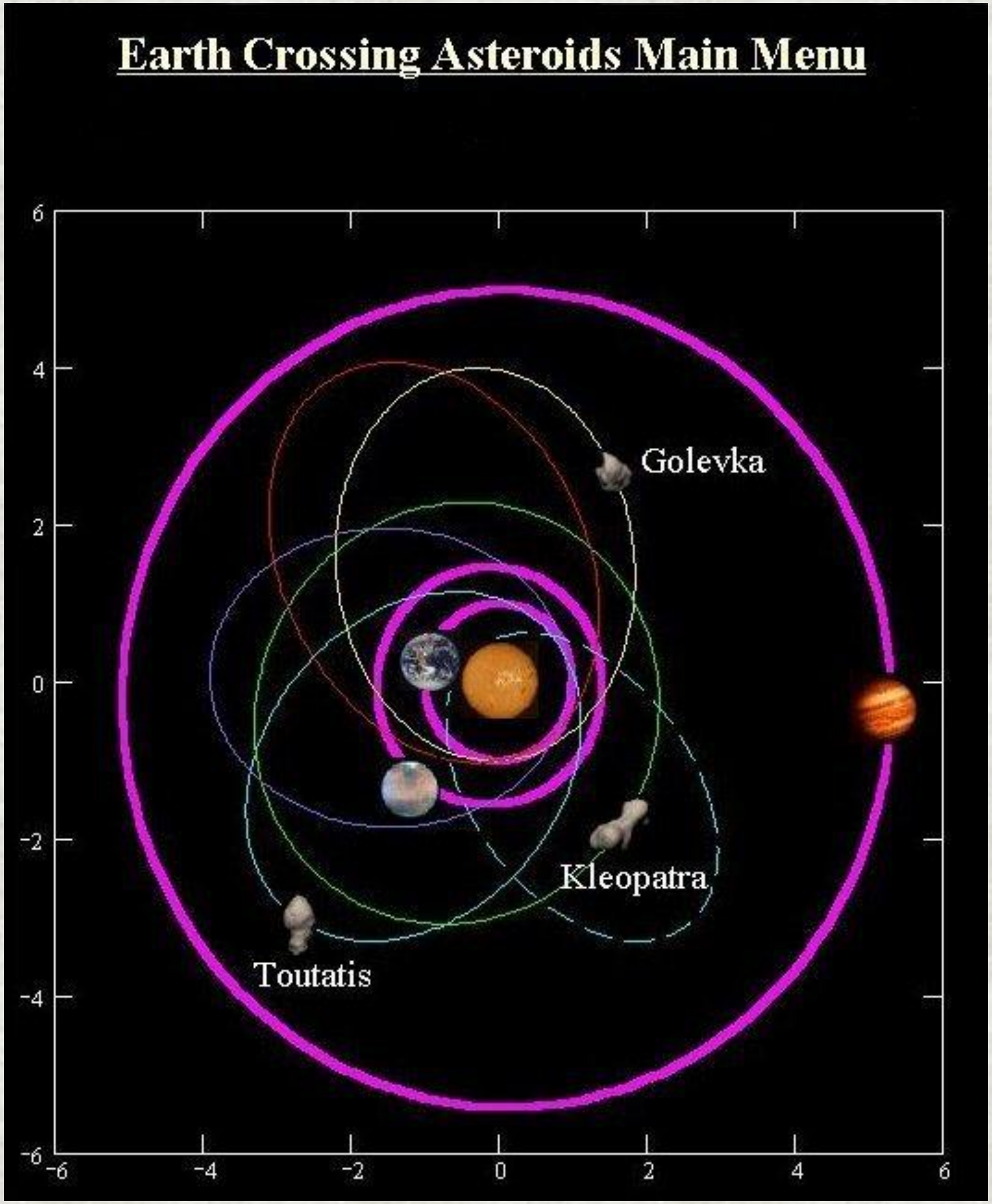
At the beginning of the earth’s history from 4.6 Ma impacted more of hundred millions years long over the Earth, Moon and other planets numerous meteorits dnd asteroids.

Due to tectonic movements and the posterior stark alteration and erosion haven not conserved vestiges for this meteorite's hail on the earth, whereas the Moon and Mercury show still many craters.

From 3.8 Milliard years declines the meteorite’s hail.

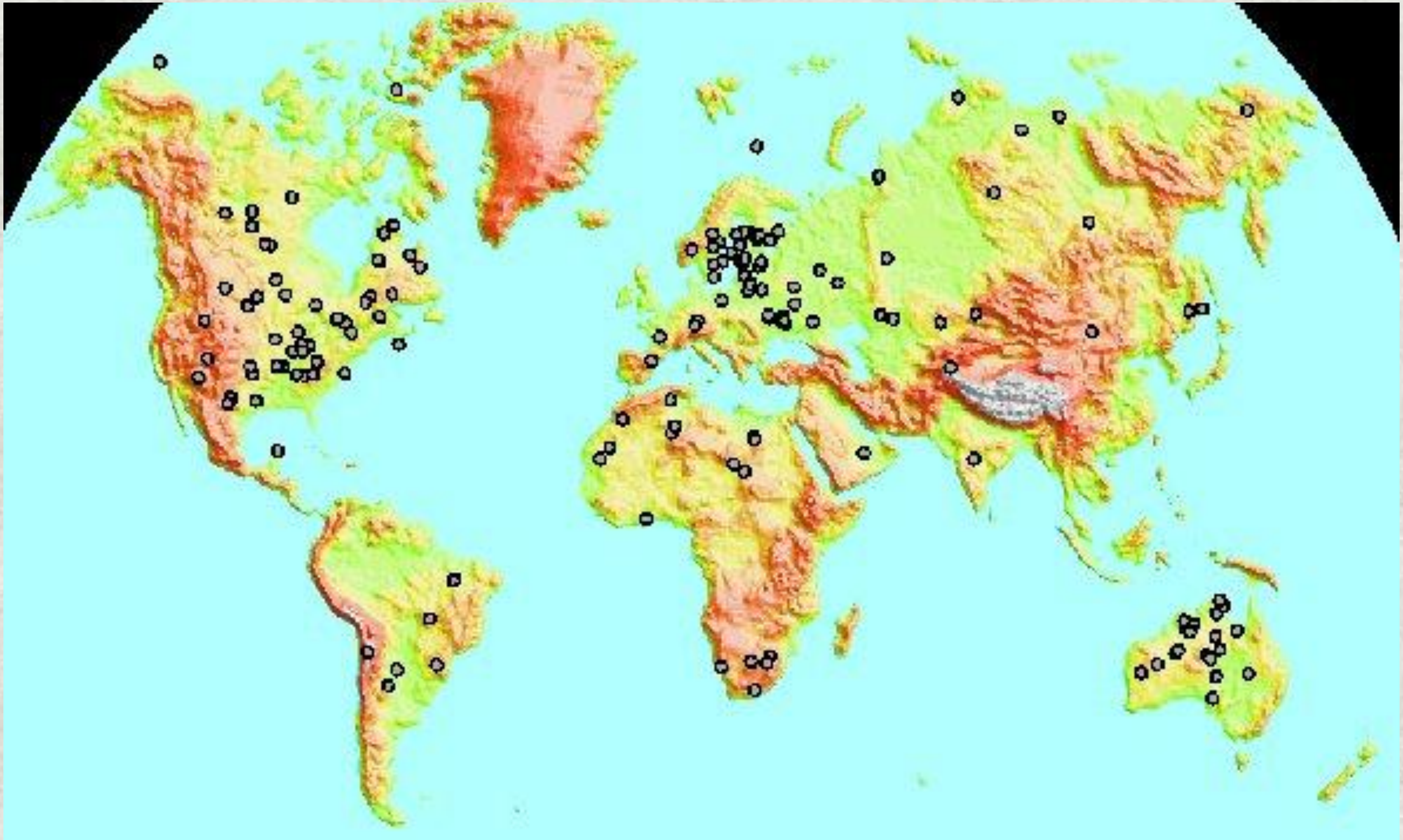
Something different for the age of the meteorite





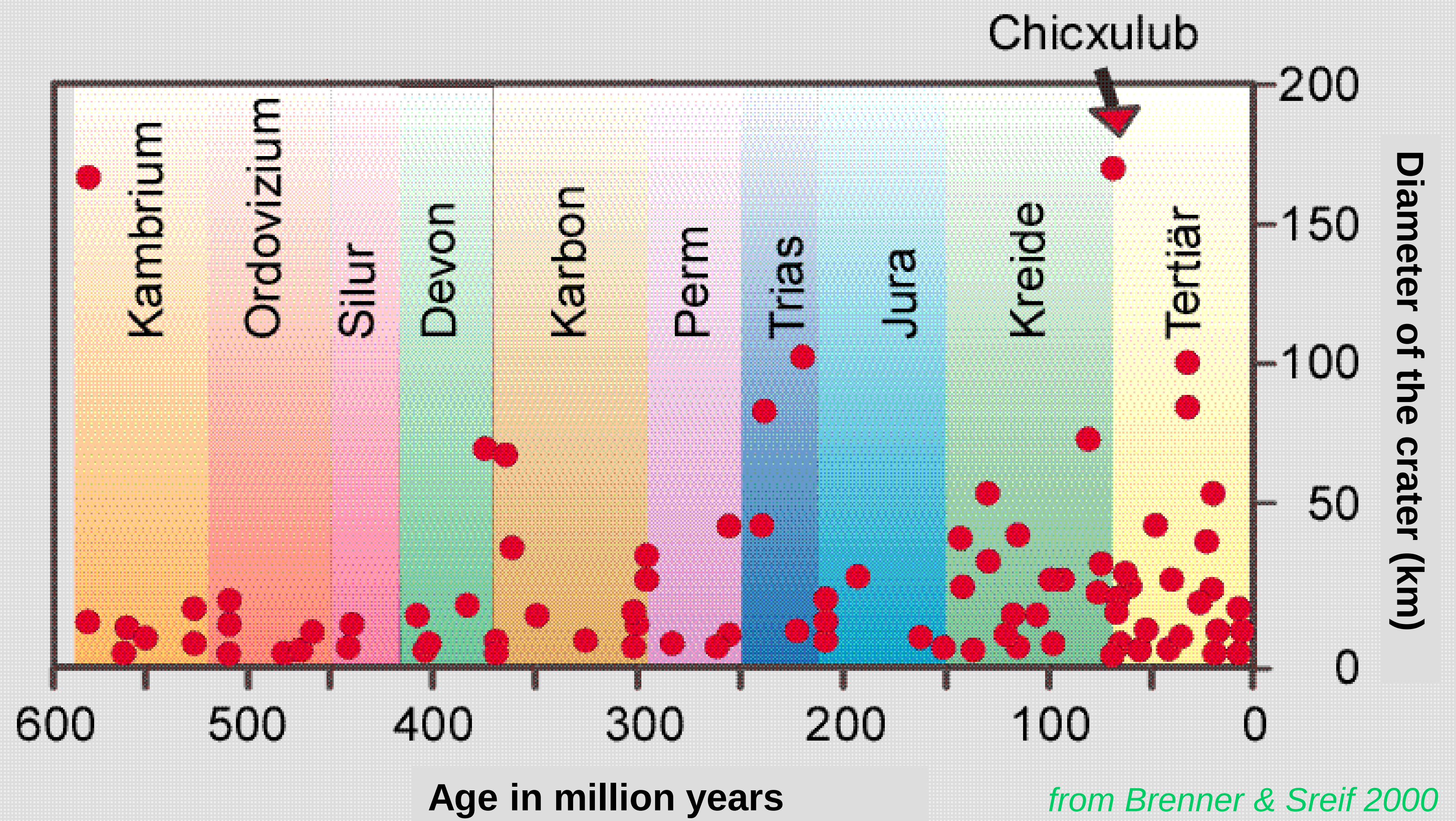
ersichtliche

Asteroidenbahnen welche die Erdbahn kreuzen



Distribution at present still existing structures, which can explained by impact of meteorites.

Relationship between Earths epochs and meteorite impacts



from Brenner & Sreif 2000

Large Meteorite impacts:

590 Million years ago: The **Acraman crater in South Australia** with 160 km diameter documents a large impact

367 Million years ago the **Alamo Impact Breccia** in Nevado USA, documents a strong impact.

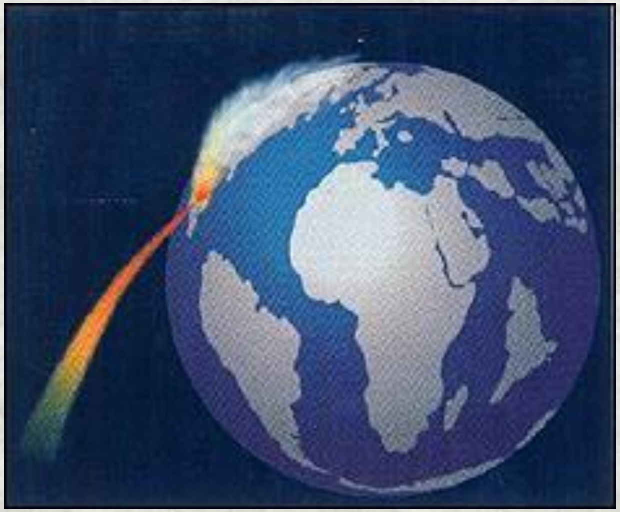
220 Million years ago the 80 km wide **Puchez-Katunki crater** in Russia, NW of Nishnij Nowgorod, was produced

Yukatan bzw. Chicxulub Meteorite

65 Million years ago a strong impact occurred at Peninsula Yucatán, in Chicxulub, in Mexico. It marks the extinction of many of the dinosaurian.

The cretaceous-Tertiary- transition is characterized by the occurrence of the metal Iridium (positive Iridium anomaly).

The disturbances on the environment by this meteorite impact is still strongly disputed.



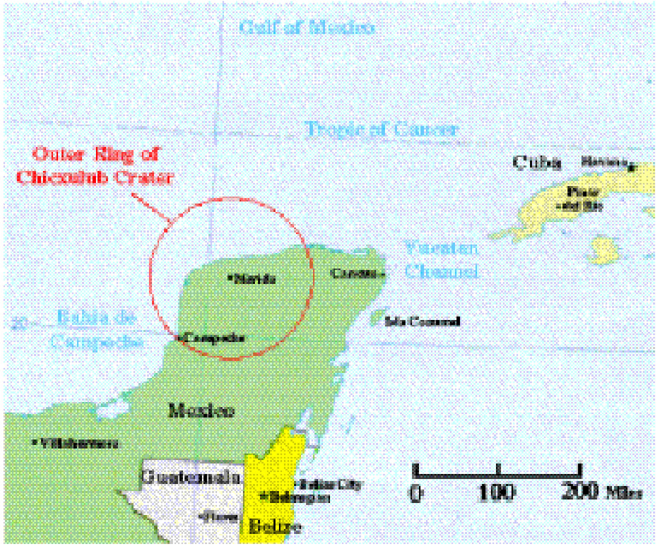
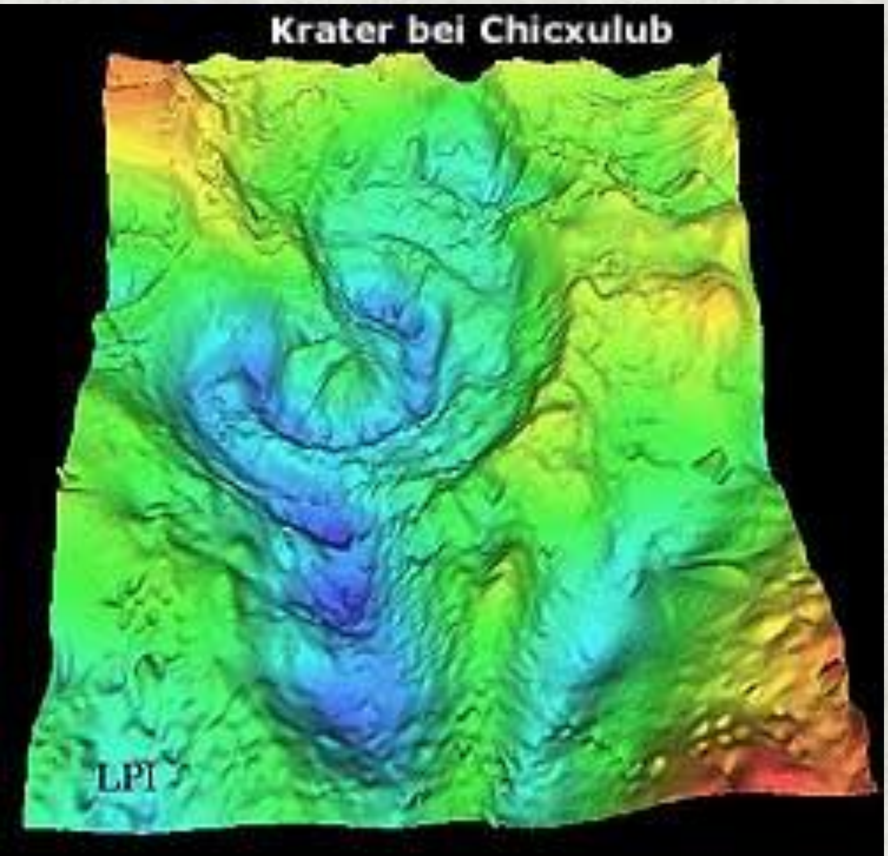


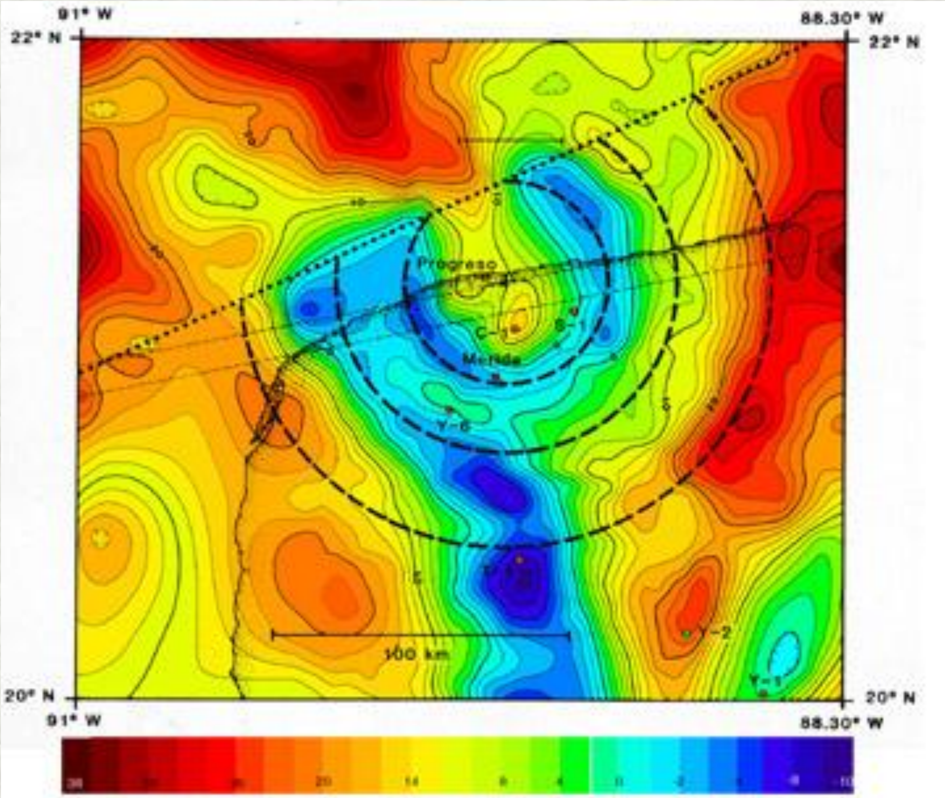
Abb. 1: Das Einschlagsgebiet auf der Halbinsel Yukatan (Mexiko)[1]

The impact structure seen as gravity anomaly

In view of the tremendous energies involved, it is no wonder then that we classify the Chicxulub impact in the Yucatan Peninsula as one of the biggest short-term natural events known in the geologic record (of nuclear-equivalent magnitude in excess of 100 trillion tons of TNT equivalent). It occurred 65 million years ago and led to a 200-300 km (>150 mi) wide (there's still some uncertainty regarding the location of the outer rim) and perhaps 16 km (10 mi) deep depression.

This huge structure has no evident surface expression, being covered by younger sedimentary rocks, but does appear subsurface as a strong gravity anomaly, as shown below. It was discovered almost incidentally through oil drilling, in which core samples, containing so-called volcanic rocks (now known to be shock-melted rock), showed distinct shock effects. The samples languished for years in the basement of the University of New Orleans' Geology Building, before someone re-examined them and discovered their origin.





Gravity Anomaly Map of the Chicxulub Crater

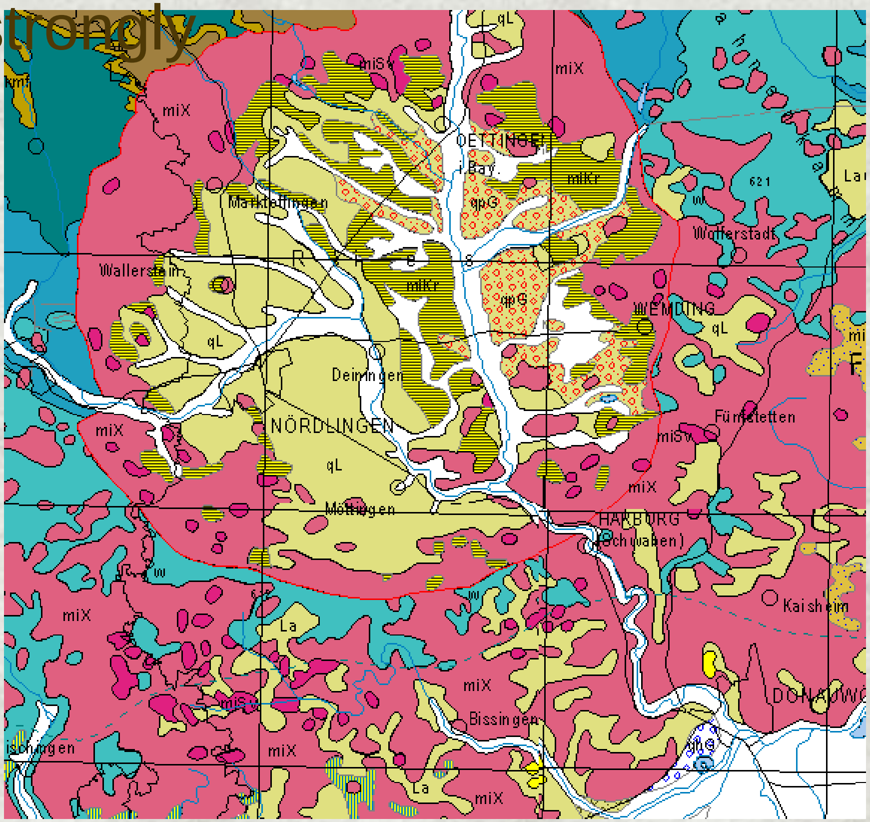
Demise of the dinosaurs

The Chicxulub Crater is believed to be the result of the collision with an asteroid measuring some 10 to 20 km across. The environmental effects that accompanied its formation were thought to have been responsible for the mass extinction at the end of the Cretaceous period, about 65 million years ago, in which the last of the dinosaurs, along with many other species, disappeared (see Cretaceous-Tertiary Boundary). However, this theory was called into question in February 2004, when An international group of scientists led by Professor Gerta Keller, of Princeton University, published results, based on a core sample, that the Chicxulub crater predates the extinction of the dinosaurs by about 300,000 years. The authors say this impact did not wipe out the creatures, rather two or more collisions could have been responsible. Keller and her colleagues analyzed rock from their core using five separate indicators of age, including fossil planktonic organisms and patterns of reversals in the Earth's magnetic field. The results suggest the crater was punched into the Earth around a third of a million years before the dinosaurs disappeared from the face of the planet. Keller and her team contend their findings prove the Chicxulub impact did not by itself trigger the extinction of the great beasts. Instead, they believe a cooling of the global climate shortly followed by a period of greenhouse warming placed enormous stress on the dinosaurs. This warming could have been triggered by carbon dioxide released by a massive eruption of lava seen today in the Deccan traps of India. The Chicxulub impact occurred during this warming period and, although the environmental effects were severe, it did not cause the extinction of the dinosaurs. The team believes a second impact, 300,000 years after the Chicxulub collision, finished off the creatures. The structure of the sea bed beneath the Indian Ocean suggests this second impact could have been there, Keller has indicated.

Further details see: http://en.wikipedia.org/wiki/Chicxulub_crater

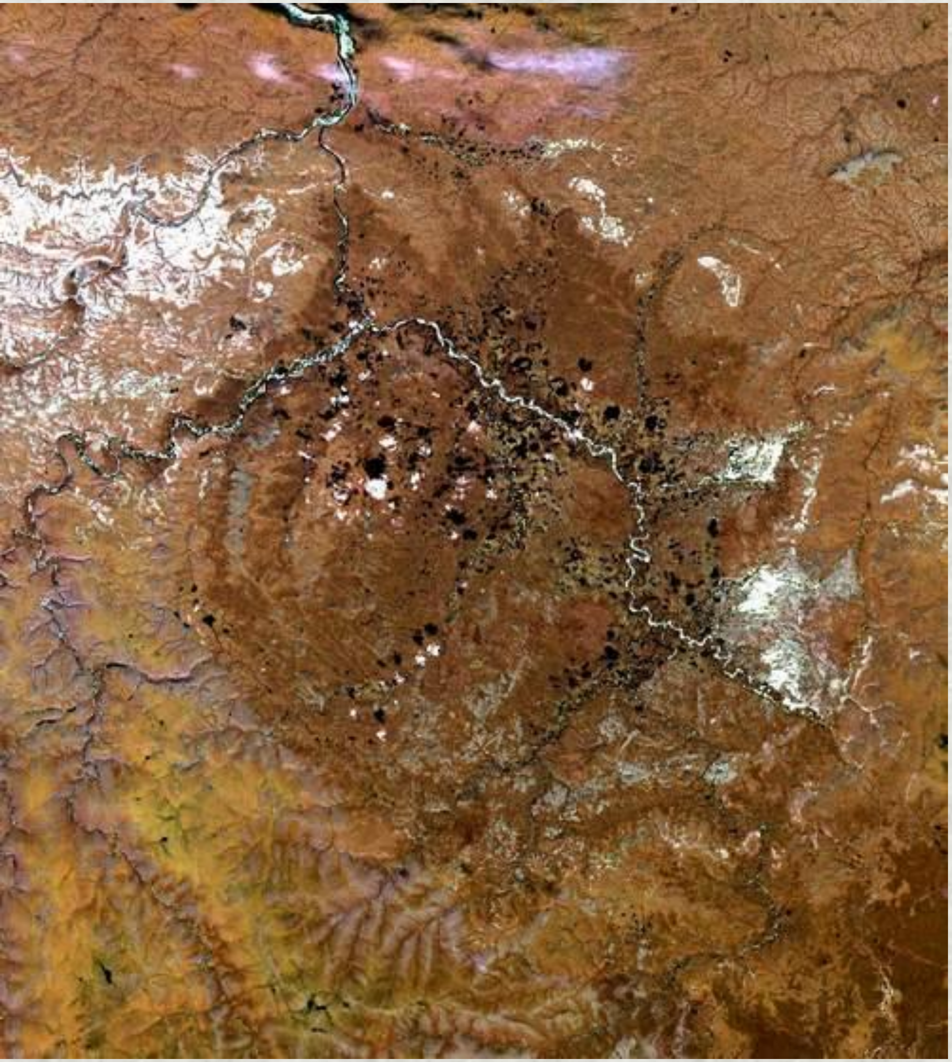
Impact example of the Nördlinger Ries
in Germany

- 15 Million years ago
- 25 km diameter of the crater (see geology map below
- The discovery of the high pressure quartz modification coesite and Stishovite confirmed that their was an impact. This was disputed strongly previously, like in many other cases where the old impact structure was not so evident.



Geophysical anomalies Anomalien

Gravity anomaly



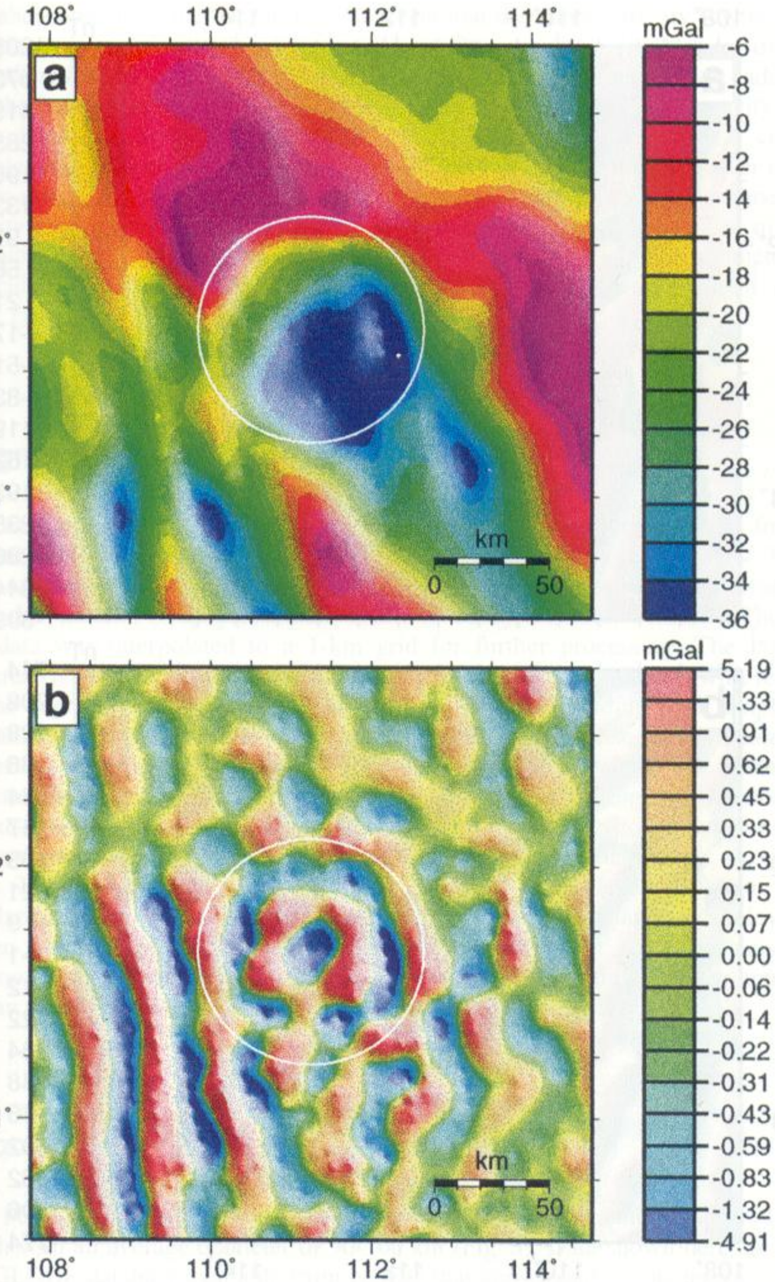


Fig. 3. (a) Gravity field over the Popigai region (data courtesy of GETECH Ltd.). White circle represents estimated crater rim at 100 km diameter. (b) Gravity field data, high-pass filtered to retain wavelength components <50 km (data courtesy of GETECH Ltd.).

Popigai crater, Sibiria.

The Tunguska meteorite impact

- Almost a century ago, on June 17 (30), 1908, a massive explosion occurred near the Podkamennaya Tunguska River, in what is now Russia's Krasnoyarsk Territory, Central Siberia. The residents of the Vanavara trading post, 65 kilometers (40 miles) south of the blast site, later claimed that the ground trembled violently when attacked by a huge ball of fire, followed by a terrible storm that destroyed everything in its wake.
- The explosion was most likely caused by the airburst of a large meteoroid or comet fragment at an altitude of 5-10 kilometers (3-6 miles) from the Earth's surface
- Studies have yielded varying estimates for the object's size, with most experts agreeing that it measured several dozen meters in diameter. Estimates of the energy of the blast range from 5 megatons to as high as 30 megatons of TNT, with 10-15 megatons being the most likely yield. The blast, about 1,000 times more powerful than the Hiroshima bomb, felled an estimated 80 million trees over 2,150 square kilometers (830 square miles). The earthquake caused by the blast measured 5.0 on the Richter scale. The region has never completely recovered.
- The Tunguska blast was the largest meteoroid impact in the Earth's recent history, and demonstrated the awesome destructive power of near-space objects. An explosion of the scale of the one in Tunguska could destroy large metropolitan areas. It is this possibility that has helped to spark discussion of asteroid deflection strategies.
- Due to the rotation of Earth, if the collision had occurred 4 hours 47 minutes later, it would have completely destroyed the Imperial Russian capital, St. Petersburg. A little later still, and the Tunguska meteorite would have wreaked chaos and destruction in densely populated Europe.



Wolfe Creek, Australia
19°18'S, 127°46'E; 0.9 km
Diameter of the crater;
age 300 000 years

Wolfe Creek is a well preserved crater in the northwestern dessert of Australia, which is partly overlain by blown sand. The rim is about 25 m above the surrounding plain Rand and the crater floor is depend around 50m. Oxidized remnants of an iron meteorite and glass from an impact fusion have been found.

Photo from*Courtesy of V. L. Sharpton, LPI*

Barringer meteorite crater in Arizona

diameter 1.2 km; Age: 49,000 years

Despite the classical impact morphology, the origin was disputed for a long time until meteorite fragments (Canyon Diablo meteorite) and breccia as well as minerals and rocks affected by a shock metamorphism have been found. *(Courtesy of USGS/D. Roddy and LPI)*