

# International Conference on Comparative Planetology

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ESA/ESTEC

Noordwijk

Steve Saunders - Comments

# Dawn of Comparative Planetology

For 35 years now (47 now in 2009), beginning in 1962 with the dispatch of Mariner 2 to Venus, we have been exploring the solar system with spacecraft. These compact robotic agents of our curiosity have allowed us to examine our fellow travelers around the Sun in sufficient detail to finally see them for what they are: our sibling worlds. And as in any reunion with long lost relatives we find reassuring similarities and puzzling differences.

David Harry Grinspoon

# Themes

- Earth as “reference planet”?
- What do we need to make progress in comparative planetology?

New knowledge of Atmospheres - Surfaces – Interiors Identify biomarkers (micro and macro), field studies, instrument development, lab and theory studies (universal GCM, Expanded EOS), new missions

- Exoplanets for a glimpse into the past and future of Earth-like planets.

When we begin to be able to study a range of exoplanets we will be able to see planets in all stages of their evolution. We could be about to enter into a new age of comparative planetology.

# A few of the contributors

- Mariner 4
- Mariner 6 and 7
- Mariner 9
- Pioneer, Venera, VEGA
- Magellan
- Odyssey, Mars Reconnaissance Orbiter
- Venus Express

# Comparative Planetology has been a central theme almost from the beginning of our planetary exploration – and before.

In 1975 the Laboratory of Comparative Planetology was moved to Vernadsky Institute. Under the leadership of C. P. Florensky, the laboratory was involved in studies of lunar samples and meteorite materials, photogeologic analysis of images of surfaces of Mars and Venus taken by Mars 4,5 and Venera 9, 10, 13 and 14, ... These complex studies eventually resulted in writing the book **Etudes on Comparative Planetology** published in Russian in 1981 by Nauka Press, Moscow. This was book written by ... members of the Laboratory of Comparative Planetology, under ... leadership of C. P. Florensky.

**By Alexander T. Basilevsky**

Just one example - there were many more all over the world!

[Cyril Pavlovich Florensky](#)  
[\(1915 - 1982\)](#)

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

# Many Conferences

Just a sample:

- *Terrestrial planets: comparative planetology.*  
*Conference held at Pasadena, Calif., USA, 5 - 7 June, 1985.*
- **1<sup>st</sup>** Annual Conference on Comparative Planetology,  
Pasadena, CA, June, 1994
- And!!!!
  - ***The 50-th Vernadsky/Brown Microsymposium  
on Comparative Planetology***  
October 12-14, 2009, Moscow Russia

# A Great Meeting

Fred Taylor started us out with some challenging questions. (A sample:)

- How does the magnetic field affect atmospheric loss?
- What is the history of the atmospheric composition and pressure?
- Did the Earth have 90 bars of CO<sub>2</sub> like Venus? This asks whether Venus and Earth have similar carbon budgets.
- Did Mars have ancient oceans? How did Mars lose its atmosphere. (Boris says impacts won't work.)
- How much water was there on Venus and how much was lost? D/H for Venus suggests a lot has been lost.

Fred suggests that we need a general GCM that works for all three planets

A final point was that politicians need credible help from scientists to help them address problems like climate change and global warming.

# Earth as Reference Planet?

Earth is used as a reference planet because we know the most about Earth.

Unfortunately, Earth may be a spectacular exception to the usual evolution of planets of Earth's size and mass.

**Venus may be the “normal” planet for Earth-size bodies.**

Just one example - Paul Tackley pointed out that temperature dependant viscosity leads to formation of a stagnant lid. Mars and Venus behave as expected but Earth seems to be an oddball.

Again, raises the question of Earth's suitability as a reference planet.

# Earth as Reference Planet?

Pascale Ehrenfreund reported on Mars analog field studies. This is an appropriate application of Earth as **Reference Planet**. Earth analog studies provide limitations of exobiologic models and constraints on site selection.

Amils talk on extremophiles was for me a breakthrough in understanding the great interest in Rio Tinto. He has made a strong case that iron is critically important for all life forms because it can protect against radiation and oxidation, controls pH and is a good source of energy as an electron donor.

# Planetary Interiors

Christensen reviewed magnetic fields and dynamos. It seems that we have not come up with anything fundamentally new in 25 years. In areas where we have made improvement in our understanding – it is because of new data rather than new ways of thinking.

For progress on interior models what new mission data, theory, lab experiments do we need? Do we have a strategy? Why is this important?

For one, if we are going to be able to model exoplanets similar to Earth but perhaps 3x more massive, existing equations of state may not apply. **We need new work on extending EOS and rheology.**

# Geology, Surface Chemistry and Mineralogy

- Sasha Basilevski reviewed comparative geology of VEM. We need to understand the processes and how planets evolve and use this to understand exoplanets and Earth.
- Common to all planets seems to be early differentiation and heavy bombardment. (And as Grinspoon points out for rocky planets, probably steam atmospheres and magma oceans) At least up to Mars size, rocky planets seem to be able to sustain volcanism for a substantial time.
- Ellen Stofan raised several questions for Venus. **Seismology** will be critical for understanding more, both for Venus and Mars. Need **high resolution topography**. Need to know **composition of tessera**.

# Conditions for Life (Biosignatures?)

- Macro - suggestive perhaps – granite, plate tectonics, atmospheres far from chemical equilibrium
- Micro - more conclusive – carbon molecules, biominerals, element combinations, microbe influences, cells, colonies and mats.

# Atmospheric Chemistry and Clouds

- Montnessin provided a tutorial on clouds. The biggest uncertainty in climate models is the cloud albedo effect. Many other talks confirm this assertion.
- Biggest open issues:
  - Venus – Lower atmosphere composition and surface equilibrium, Role of lightning, Sulfur cycle. Observation of wind and cloud motions down to the surface (Sanjay) **Need *in situ* observations in the lower atmosphere = balloons**
  - Mars – Methane chemistry and sources and sinks. Water and methane reactions should be studied in the laboratory. **Need to map and monitor methane with an instrument designed to measure methane.**

# Climate Dynamics of Planetary Atmospheres

- For GCMs most all the parameters and physics seem to have been identified and there seems to be agreement that we should be able to develop a universal GCM.
- Titov – Do we have the Big Picture of terrestrial atmospheres dynamics now? The answer is a qualified yes.
- Forget – But, if there were no Titan in the Solar System we could not imagine a Titan with a GCM
- Read – Our GCM models can tell us about today but we have no observations or data to tell us about other cases.

# Aeronomy and Solar Wind Interaction

There is an active and expert community making great progress in analyzing aeronomy data.

Understanding escape history (**especially O**) is clearly critical to understanding evolution of atmospheres and climate and history of water.

However, there does not yet seem to be a lot of integration among the various experiments - This underscores the difficulty of this discipline.

# Evolution

## (of Venus, Earth and Mars)

- David Grinspoon argues that there is a strong case for similar early environments in the larger rocky planets. An interesting idea is that we might develop an H-R diagram for planets - but far more complex than the stellar H-R. Ivanov comments that the Moon-forming impact played a major role in Earth's development.
- Bibring has stressed the importance of the earliest period on Earth and Mars when water was still on Mars. Mars may have been habitable very early. It will be important to look in the oldest terranes on Mars.
- Sharkov describes evidence for very early granitic crust. We don't require oceans and plate tectonics for all granites.
- Questions remain: Lichtenegger addressed possible ways to preserve Earth's nitrogen atmosphere. Bertaux revisited the issue of H escape and summarized current knowledge.

# Future Missions

- NASA -
  - Mars Missions: 2011 - Mars Science Laboratory; 2013 - Scout Aeronomy Mission - MAVEN; 2016 - Mars Science Orbiter - then not so clear. Sample Return 2022-2024
  - Venus Flagship Mission - ~2021 - Orbiter, 2 balloons, 2 landers (5 hr life)
- Japan -
  - Developed 20 year science strategy
  - 2010 - Planet-C - Venus Climate Orbiter
  - 2016-18 - Mars Exploration with Lander-Orbiter Synergy
- Russian Plans for Mars and Venus (IKI Vision)
  - Oct. 2009 - Phobos Sample Return; 2016 - MARS-NET; 2022 - EXPEDITION-M (MSR)
  - 2016 - VENERA-D, orbiter, balloon, lander (land on tessera)
- ESA Exploration Program
  - 2016 - ExoMars - Joint ESA/NASA mission

# Future Comparative Planetology Exoplanets

- With nearly 350 exoplanets now found, and more each year at an expanding rate, and the next generation of space based observatories we are about to enter into a new phase of Comparative Planetology.
- Observing planets in other stellar systems will allow us to study planets in all stages of evolution (we are stuck here at 4.6Gy)

# Exoplanets

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# Exoplanets

- Exoplanets –
  - Earth-like planets in early stage - 1<sup>st</sup> Gy (what might be biopotential signatures?)
  - Earth-like planets in waning stages after ~6By – Are there biosignatures?
- Lundin described the loss of water through solar forcing where for Earth there is not much effect, but major loss from Venus and Mars mostly through O<sup>+</sup> and H<sup>+</sup> loss.
  - Can we evaluate this for exoplanets at various stages of evolution.
- If we see a Venus or Mars or Earth in the first Gy of their evolution, before they lost most of their water, how would we evaluate biopotential?

# What do we need from our agencies?

Atmospheres, Crustal and Surface geology and Interior Dynamics are complexly related.

For example, Rosenblatt pointed out that the atmosphere and interior affect rotation and the magnetic field history affects atmospheric loss.

- We now need to develop interdisciplinary research programs that involve all these fields.
- We need to provide liason with the astrophysics community to help guide observations of exoplanets
- International cooperation is the only way we will be able to make significant progress (agency down to grass roots levels)

# Exoplanets

**The** books that I would most like to read are the ones that can't yet be written: One I do expect to see in my lifetime is a book on **comparative planetology** that incorporates knowledge of dozens of solar systems, putting our own in proper perspective. You could try to write this now, but it would have to be completely revised in a few years. We are uncovering the demographics of planets in our galaxy at an astonishing rate, and it won't be long before this includes worlds in Earth's size range.

**DAVID GRINSPOON (Discover, October, 2005)**