From Powell to Pluto:
Planetary Exploration in Perspective

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NASA Ames Research Center

Charge:

"What are the most scientific compelling, most important questions to answer or address?"

- Easy – The Decadal Surveys have been getting it right for ***strategy***.
- What's hard is agreement on ***tactics***.
- Every sector of the community claims their favorite (planet/asteroid/satellite/dwarf planet/comet/instrument/mission …) is the absolute highest priority for addressing the Survey's questions.
- And don't forget to send plenty of R&A $$!

Outer Planet Strategy

- Need to go back and consider the nature of *Scientific* Exploration, not just lists of mission types
- This is not a new idea.
- Ten years ago …

Outer Planet Exploration and Science

Subset of T. V. Johnson presentation to AIAA Space Exploration Conference 1 Feb 2005

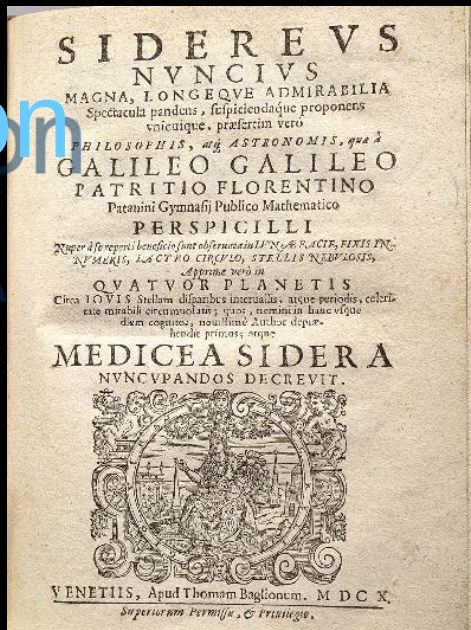
Presented to OPAG, 10 Feb 2005

Exploration and Science in the Outer Solar System

Torrence V. Johnson
Jet Propulsion Laboratory, Caltech

1st Space Exploration Conference, AIAA

1 February 2005
Walt Disney World, Florida

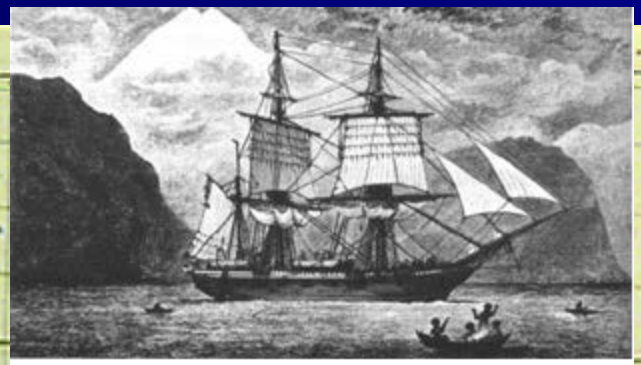

SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
unicuique, præsertim vero
PHILOSOPHIS, atq; ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS IN-
NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeri-
tate mirabili circumuolantes; quos, nemini in hanc vsque
diem cognitos, nouissimus Author depre-
hendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionem. M D C X.
Superiorum Permissu, & Priuilegio.

EXPLORATION

n 1: to travel for the purpose of discovery

SCIENCE

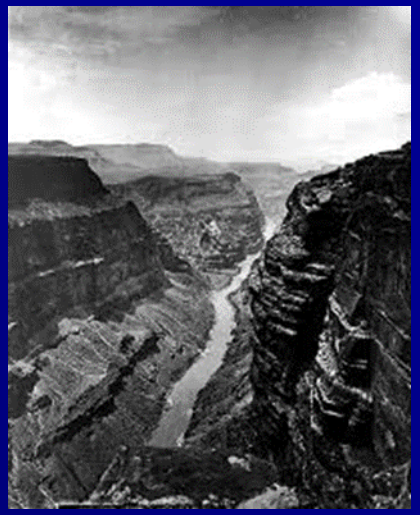
n 1: The observation, identification, description, experimental investigation, and theoretical explanation of phenomena



H.M.S Beagle in the Strait of Magellan

John Wesley Powell and the Grand Canyon

First camp of the second John Wesley Powell expedition, in the willows, Green River, Wyoming, 1871. There were no photographs taken on the 1869 expedition.



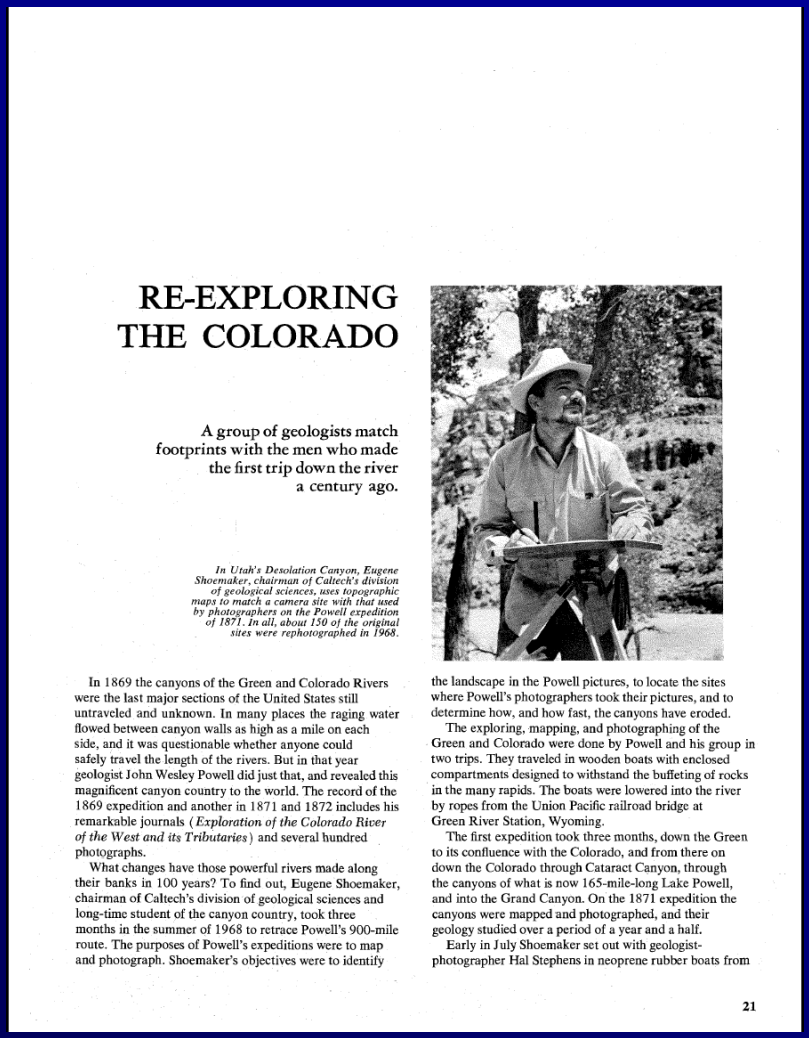
Source: Wikipedia

A Century Later … and still exploring

Jack Schmidt discussing photograph matching;

L to R: Tad Nichols, Gene Shoemaker, Kathryn Jones, Shirley Marston, Lois Jotter Cutter. At Badger Rapid.

Source: NAU Archives



RE-EXPLORING THE COLORADO

A group of geologists match footprints with the men who made the first trip down the river a century ago.

In Utah's Desolation Canyon, Eugene Shoemaker, chairman of Caltech's division of geological sciences, uses topographic maps to match a camera site with that used by photographers on the Powell expedition of 1871. In all, about 150 of the original sites were rephotographed in 1968.

In 1869 the canyons of the Green and Colorado Rivers were the last major sections of the United States still untraveled and unknown. In many places the raging water flowed between canyon walls as high as a mile on each side, and it was questionable whether anyone could safely travel the length of the rivers. But in that year geologist John Wesley Powell did just that, and revealed this magnificent canyon country to the world. The record of the 1869 expedition and another in 1871 and 1872 includes his remarkable journals (*Exploration of the Colorado River of the West and its Tributaries*) and several hundred photographs.

What changes have those powerful rivers made along their banks in 100 years? To find out, Eugene Shoemaker, chairman of Caltech's division of geological sciences and long-time student of the canyon country, took three months in the summer of 1968 to retrace Powell's 900-mile route. The purposes of Powell's expeditions were to map and photograph. Shoemaker's objectives were to identify the landscape in the Powell pictures, to locate the sites where Powell's photographers took their pictures, and to determine how, and how fast, the canyons have eroded.

The exploring, mapping, and photographing of the Green and Colorado were done by Powell and his group in two trips. They traveled in wooden boats with enclosed compartments designed to withstand the buffeting of rocks in the many rapids. The boats were lowered into the river by ropes from the Union Pacific railroad bridge at Green River Station, Wyoming.

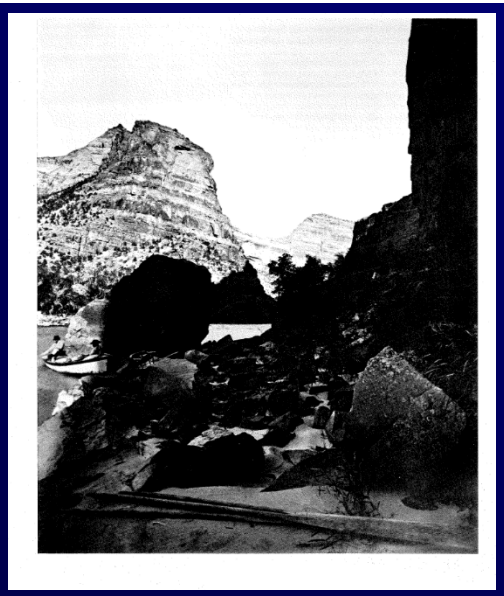
The first expedition took three months, down the Green to its confluence with the Colorado, and from there on down the Colorado through Cataract Canyon, through the canyons of what is now 165-mile-long Lake Powell, and into the Grand Canyon. On the 1871 expedition the canyons were mapped and photographed, and their geology studied over a period of a year and a half.

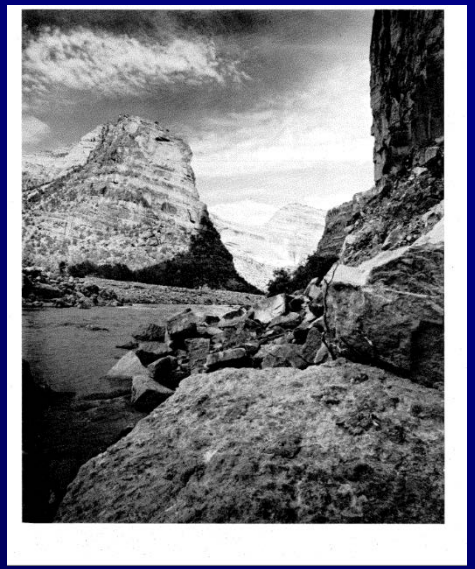
Early in July Shoemaker set out with geologist-photographer Hal Stephens in neoprene rubber boats from

A Century of Erosion

1871

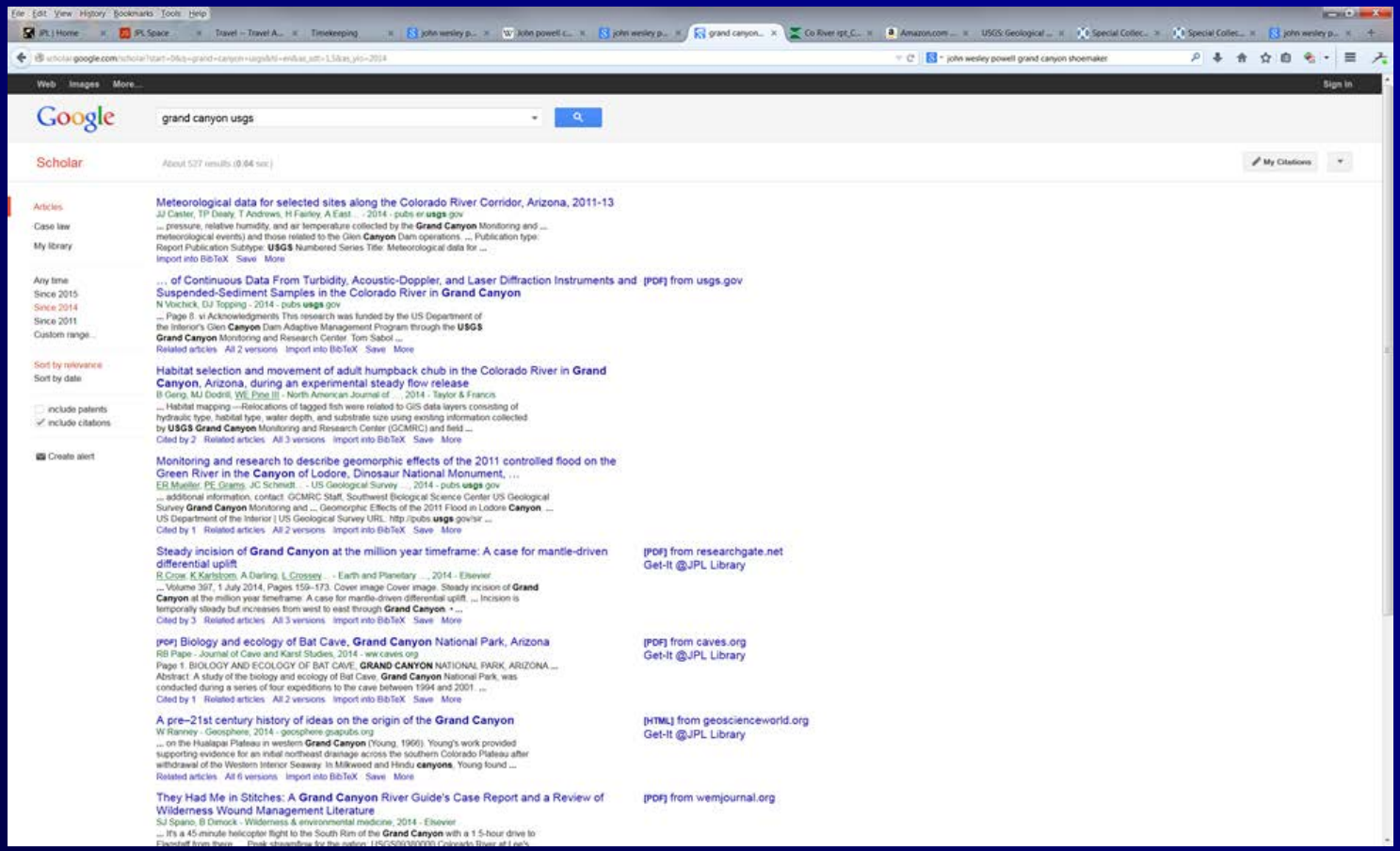
1968





Grand Canyon still fuels research

Google Scholar: Grand Canyon + USGS
> 500 entries in last year



Outer Planets

- Outer Planets offer a fertile (perhaps too fertile) area for ‘Powell expedition class’ scientific exploration
- But I’m prejudiced – Voyager was my generation’s ‘Powell’ trip through the Solar System
- Have to find ways of framing strategy that includes pure scientific exploration as well as follow-on in-depth studies

But what about Pluto?

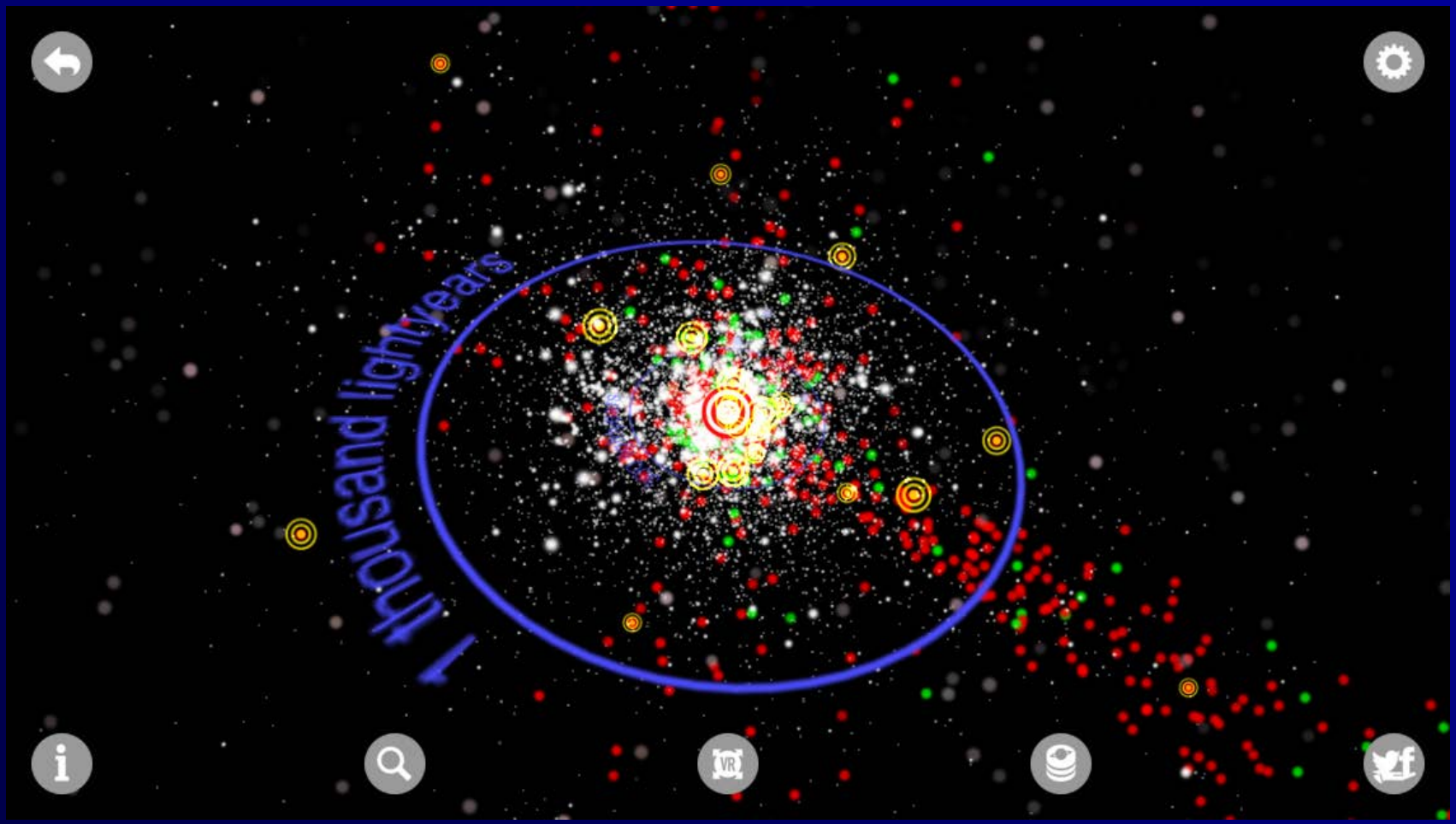
- A case study in the community sticking to a large scale strategic view of Solar System Exploration
- Pluto mission was debated at same time as new Galileo results made Europa a very exciting target.
- But when required to make a choice, Pluto was our choice. Reasons?
  - Completion of Grand Tour
  - Exploring reservoir of early SS materials
- Our advice to NASA was ‘get Pluto going’.
- New Horizons is almost there.
- AND WE MIGHT YET GET A EUROPA MISSION!

Future Strategic Issues
just some of my personal favorites

- Active satellites
  - It's been 40 + years since Peale et al. proposed that Io might be active due to tidal heating
  - It's a little embarrassing that we still don't have satisfying answers explaining the history and activity of Io, Europa, Enceladus, Titan, et al.
- Planetary 'rearrangements' during and after formation (Nice models vers XXX and counting)
- Which leads to my final item …

Exoplanets

Over 20 exoplanets with transit spectra!



Sources: Exoplanet app, Hanno Rein and personal communication, Rachel Akeson, IPAC, Caltech

Consider for strategy discussion

- Find more planets!
  - Work with astrophysics to promotes ways to find more planets for which we can get detailed physical and compositional data.
- Work link to exoplanets into the Outer Planet strategy
  - My opinion is that Michelle Dougherty's presentations linking JUICE, exoplanets and planetary formation helped sell mission to broader European science community.

Big Picture Advice: Keep ‘Exploration’