

From Powell to Pluto: Planetary Exploration in Perspective

T. V. Johnson

OPAG 19 Feb 2015

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

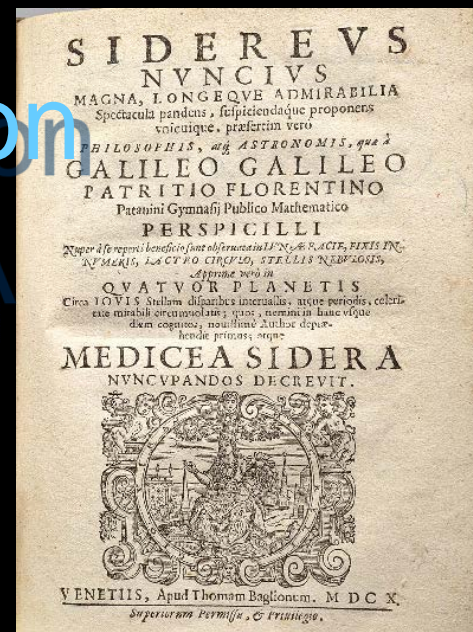


Exploration and Science in the Outer Solar System

Torrence V. Johnson
Jet Propulsion Laboratory, Caltech

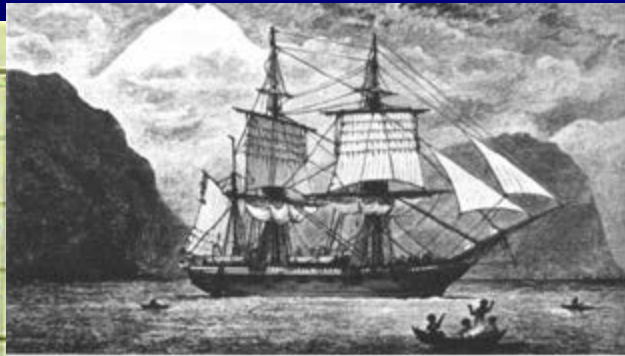
1st Space Exploration
Conference, AIAA

1 February 2005
Walt Disney World, Florida



EXPLORATION

n 1: to travel for the purpose of discovery



H.M.S. Beagle in the Strait of Magellan



SCIENCE

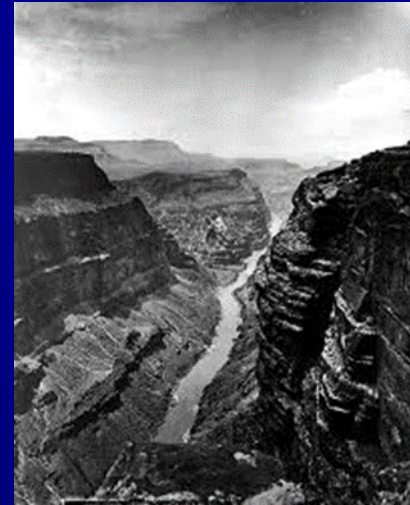
n 1: The observation, identification, description, experimental investigation, and theoretical explanation of phenomena



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.



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

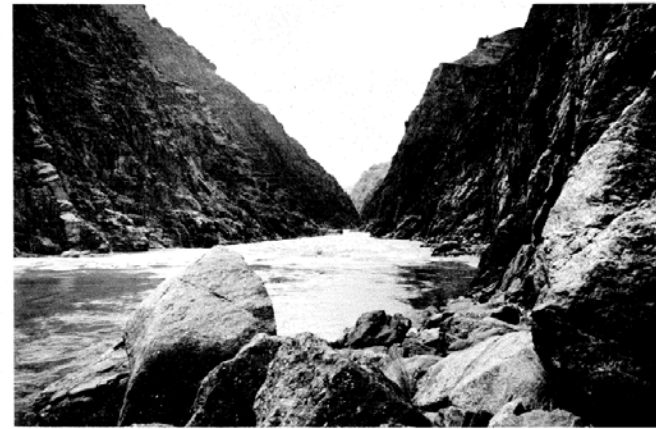
A Century of Erosion

1871

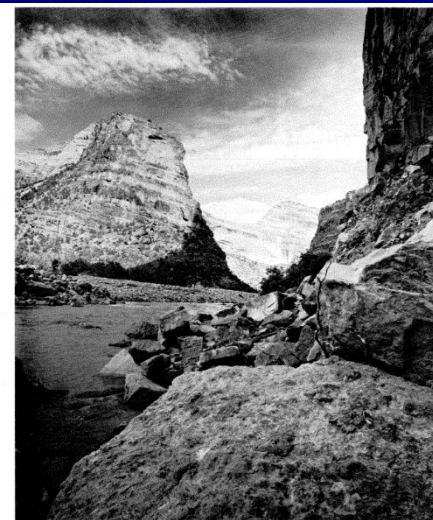


22

1968



23



Grand Canyon still fuels research

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

The screenshot shows a Google Scholar search results page for the query "grand canyon usgs". The search results are displayed in a list format, with each entry including a title, authors, year, and publication source. The results are sorted by relevance. The first result is "Meteorological data for selected sites along the Colorado River Corridor, Arizona, 2011-13" by JJ Caster, TP Deary, T Andrews, H Fairley, A East, published in 2014 in the USGS Numbered Series. The second result is "Habitat selection and movement of adult humpback chub in the Colorado River in Grand Canyon, Arizona, during an experimental steady flow release" by B Geng, MJ Dodrill, WE Poe III, published in 2014 in the North American Journal of Fish Management. The third result is "Monitoring and research to describe geomorphic effects of the 2011 controlled flood on the Green River in the Canyon of Lodore, Dinosaur National Monument, ..." by ER Mueller, PE Drans, JC Schmidt, published in 2014 in the US Geological Survey Grand Canyon Monitoring and Research Center (GCMRC) Staff. The fourth result is "Steady incision of Grand Canyon at the million year timeframe: A case for mantle-driven differential uplift" by R Coor, K Karlsbom, A Darling, L Crossley, published in 2014 in Earth and Planetary Science Letters. The fifth result is "Biology and ecology of Bat Cave, Grand Canyon National Park, Arizona" by W Ranney, published in 2014 in Geosphere. The sixth result is "A pre-21st century history of ideas on the origin of the Grand Canyon" by W Ranney, published in 2014 in Geosphere. The seventh result is "They Had Me in Stitches: A Grand Canyon River Guide's Case Report and a Review of Wilderness Wound Management Literature" by SJ Spans, published in 2014 in Wilderness & Environmental Medicine.

Search results for "grand canyon usgs":

- Meteorological data for selected sites along the Colorado River Corridor, Arizona, 2011-13**
JJ Caster, TP Deary, T Andrews, H Fairley, A East. - 2014 - pubs.er.usgs.gov
... pressure, relative humidity, and air temperature collected by the Grand Canyon Monitoring and ...
meteorological events) and those related to the Glen Canyon Dam operations. ... Publication type:
Report Publication Subtype: USGS Numbered Series Title: Meteorological data for ...
Import into BibTeX Save More
- ... of Continuous Data From Turbidity, Acoustic-Doppler, and Laser Diffraction Instruments and Suspended-Sediment Samples in the Colorado River in Grand Canyon**
N Vachek, DJ Topping. - 2014 - pubs.usgs.gov
... Page 8. vi Acknowledgments This research was funded by the US Department of the Interior's Glen Canyon Dam Adaptive Management Program through the USGS Grand Canyon Monitoring and Research Center. Tom Sabol ...
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- Habitat selection and movement of adult humpback chub in the Colorado River in Grand Canyon, Arizona, during an experimental steady flow release**
B Geng, MJ Dodrill, WE Poe III. - North American Journal of Fish Management. - 2014 - Taylor & Francis
... Habitat mapping—Relocations of tagged fish were related to GIS data layers consisting of hydraulic type, habitat type, water depth, and substrate size using existing information collected by USGS Grand Canyon Monitoring and Research Center (GCMRC) and field ...
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... additional information, contact GCMRC Staff, Southwest Biological Science Center US Geological Survey Grand Canyon Monitoring and ... Geomorphic Effects of the 2011 Flood in Lodore Canyon ...
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R Coor, K Karlsbom, A Darling, L Crossley. - Earth and Planetary Science Letters. - 2014 - Elsevier
... Volume 397, 1 July 2014, Pages 159–173, Cover image Cover image Steady incisions of Grand Canyon at the million year timeframe: A case for mantle-driven differential uplift. ... Incision is temporally steady but increases from west to east through Grand Canyon ...
Cited by 3 Related articles All 3 versions Import into BibTeX Save More
- Biology and ecology of Bat Cave, Grand Canyon National Park, Arizona**
W Ranney. - Journal of Cave and Karst Studies. - 2014 - www.caves.org
Page 1 BIOLOGY AND ECOLOGY OF BAT CAVE, GRAND CANYON NATIONAL PARK, ARIZONA ...
Abstract: A study of the biology and ecology of Bat Cave, Grand Canyon National Park, was conducted during a series of four expeditions to the cave between 1994 and 2001. ...
Cited by 1 Related articles All 2 versions Import into BibTeX Save More
- A pre-21st century history of ideas on the origin of the Grand Canyon**
W Ranney. - Geosphere. - 2014 - geosphere.gsapubs.org
... on the Hualapai Plateau in western Grand Canyon (Young, 1906). Young's work provided supporting evidence for an initial northwest drainage across the southern Colorado Plateau after withdrawal of the Western Interior Seaway in Milkweed and Hindu canyons. Young found ...
Related articles All 6 versions Import into BibTeX Save More
- They Had Me in Stitches: A Grand Canyon River Guide's Case Report and a Review of Wilderness Wound Management Literature**
SJ Spans, B Demock. - Wilderness & Environmental Medicine. - 2014 - Elsevier
... It's a 45-minute helicopter flight to the South Rim of the Grand Canyon with a 1.5-hour drive to Escalante from there. Desk-stuffing for the author: USGS/918/0001 Colorado River at Lodore

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!**

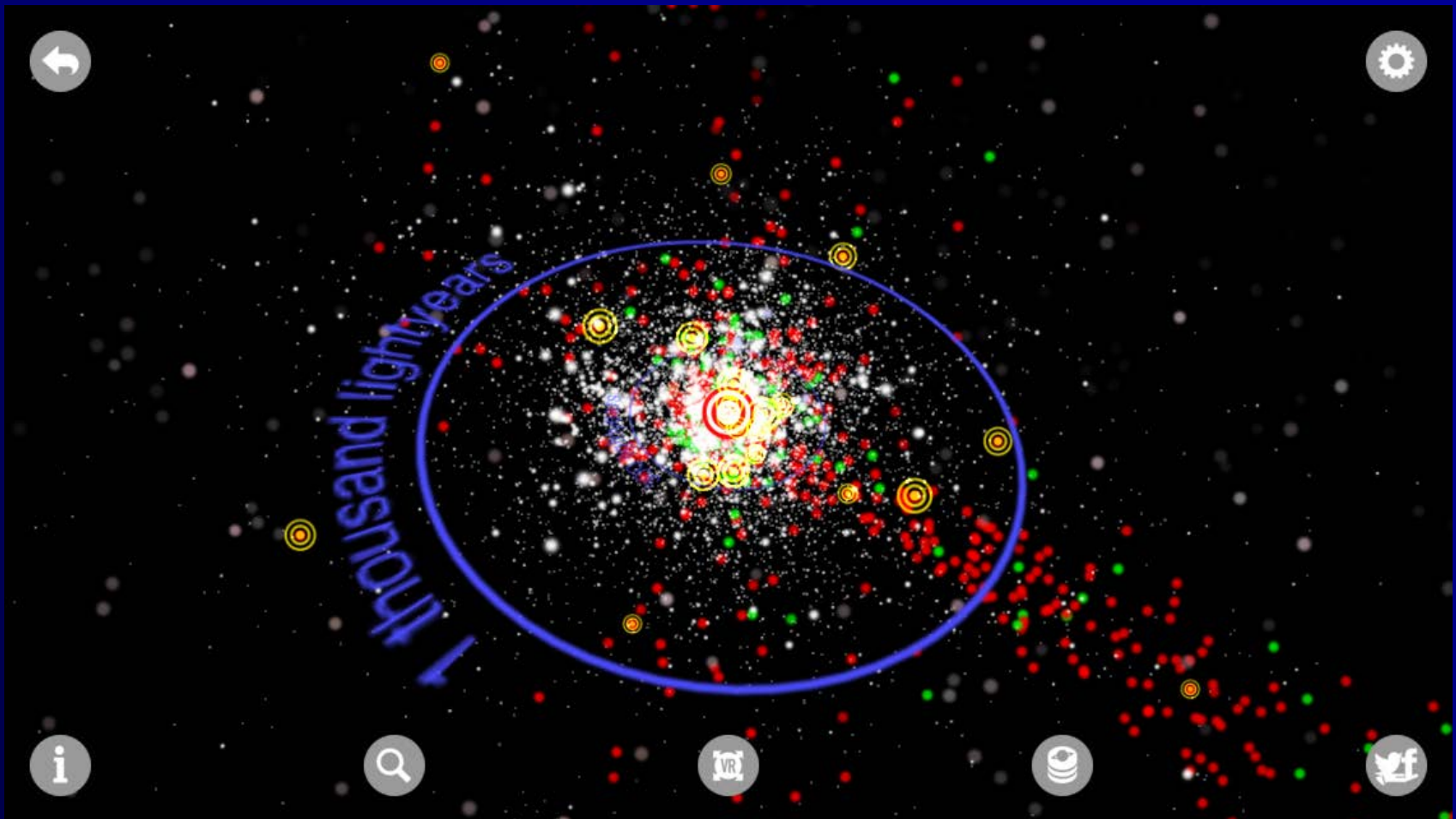
Future Strategic Issues

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 promote 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'