3.7 Gary Lofgren

Dr. Gary E. Lofgren is a senior planetary scientist and the Lunar Curator for NASA. He has been a research scientist and Principal Investigator in the NASA Cosmochemistry program since 1968. He has studied lunar and terrestrial basalts, and is currently studying the origin of chondrules in meteorites. Chondrules are the most primitive and the oldest material in our solar system that is available to study. Thus, these studies will shed light on the earliest history of our solar system. As Lunar Curator, his duties are twofold: 1) maintain the scientific integrity of the lunar samples; and 2) assist scientists that want to study lunar samples to obtain the materials most appropriate for their studies. He works with CAPTEM (Curation and Analysis Planning Team for Extraterrestrial Materials) a NASA advisory committee to meet both these objectives, and to ensure that the lunar samples are used for only high quality scientific studies. He oversees the preparation of lunar material for distribution to scientists for study, to museums for display, and for educational purposes. Most recently he is participating in the DRATS Analog program that is developing planetary surface operations including science operations.

Dr Lofgren's area of expertise is experimental petrology with emphasis on experimentation at high temperatures and pressures using controlled oxidation/reduction atmospheres. He conceived and built the Experimental Petrology Laboratory in the Solar System Exploration Division at JSC into a world recognized facility. He pioneered the modern science of the experimental study of the kinetically controlled crystallization (dynamic crystallization) of silicate rock melts. These studies have provided a standard for the interpretation of igneous rock textures (the relationship of minerals to one another) and other kinetically controlled phenomena and models for their formation. Particular emphasis is placed on understanding such textural features as crystal size and shape as a function of crystal growth conditions.

Dr. Lofgren received his Ph.D. (1969) and B.S. (1963) from Stanford University and his M.A. from Dartmouth College, all in geology. He began working for NASA in 1968. He served on the Lunar Sample Preliminary Examination Team. In addition to being involved in the initial examination of Apollo samples, he was involved with the geologic training of the Apollo astronauts. He was the geologic science training coordinator for the Apollo 15 crew and also worked with the Apollo 13, 16, and 17 crews. He convened a Geological Society of America, Penrose Conference on the "Application of Crystal Growth Theory and Experiments to Rock Forming Processes," in 1976. He was the leader of the Chemistry and Petrology Team of the NASA "Comparative Planetological Study of Basaltic Volcanism" Project (l976-l98l). Gary has advised on numerous graduate theses completed at several universities around the country. He has also advised more than 20 NRC Research Fellows during their studies at JSC.

A5 – Presentation of Gary Lofgren

Geologic Traverse Planning for Apollo Missions

[Slide 1] Geologic Traverse Planning for Apollo Missions, Gary Lofgren

[Slide 2] The science on Apollo missions was overseen by the Science Working Panel (SWP), but done by multiple PIs. There were two types of science, packages like the Apollo Lunar Surface Experiment Package (ALSEP) and traverse science. Traverses were designed on Earth for the astronauts to execute. These were under direction of the Lunar Surface PI, but the agreed traverse was a cooperation between the PI and SWP.

The landing sites were selected by a different designated committee, not the SWP, and were based on science and safety. As experience and confidence was gained, later mission were more "daring".

[Slide 3] Once the site was picked, the Lunar Surface PI worked with SWP and flight operations to script the traverses. Unlike field geology on the Earth, these traverses were highly scripted. The Lunar Surface PI was responsible for training the crew, CapCom, and backroom scientists to meet the science objectives of the landing site.

[Slide 4] The training of the crew became a critical aspect of success. Except for Apollo 17, we were dealing with a group of astronauts that were primarily pilots. They were very smart, but they did not have a geologic background. So it was necessary to develop a crew training program with the aspects listed here that allowed the team (crew, CapCom, scientists, etc.) to get the job done.

We started out carefully and as we gained experienced added more to the program. Later mobility allowed for more possibilities, but also meant more planning and training.

[Slide 5] These are the field trip locations used to train the astronauts. Each location was picked to represent one of the aspects of the science to be done or the geology the astronauts would experience.

Field training was basically 3- to 6-day field trips once a month for 18 to 24 months. This resulted in over 1000 contact hours with the Apollo crews.

[Slide 6] We made the training realistic by having the astronauts trained wear volumetric representations of their suits. This version had their life support backpack, chest-mounted camera, and sampling tools. They also had communications similar to what they would have on the moon. Since the Hasselblad cameras did not have a view finder, it was important for the astronauts to learn how to get the object they wanted into the field of view by positioning their body.

[Slide 7] We worked to find field locations that could duplicate the view the astronauts would see on the moon. Here the Grand Canyon near Taos, NM, stands in for Hadley Rill; the view across the canyon is the same scale as what the Apollo 15 astronauts would see on the moon.

[Slide 8] Sampling techniques were practiced in detail using realistic tools, including using a simulated lunar vehicle from the US Geological Survey (USGS).

[Slide 9] One of the important things was the debriefings that came at the end. The crew would walk through entire traverse again with the scientists. They would discuss with the astronauts what they did well and what they could improve.

[Slide 10] The most important result was that the astronauts gained confidence in what they were doing. This included not only the science, but also the tools and the techniques for using them effectively. The sample gathering activity became second nature to them – automatic – which improved efficiency and accuracy. The training also gave them confidence in working with a highly scripted timeline; knowing that there were limits to certain activities and that sometimes they needed to move on.

Pre-flight orbital photography of the landing site was not that good; the crew had sufficient confidence to adapt once they saw what was really there.

Getting the mission commander on board with training was important and, in the end, they were one of the people pushing to make sure that training was included.

We learned that bringing the flight directors and other front room personnel out to the training about 4 months before the flight helped get everybody synced to what needed to be done. Training should include everyone in the support chain working together.

[Slide 11] The science support and backroom support was an important activity, but was not real-time. The communication needed to follow a route through several people (flight directory, CapCom, etc…) and was limited by quality and amount of video. I expect that this will change for our future exploration of the moon.

The backroom support was most used to help with replanning when problems occurred – advising on how to fix equipment and replanning of traverse sequences.

[Slide 12] A body is needed to settle disputes concerning science priorities. During Apollo, the SWP set the priorities and made the decisions as to what had priority when replanning was needed.

As the mission went on, the scientist would come up with more suggestions for sample collection; such as get sample from under other rocks or in shadows. Some of these suggestions started being made real-time. The SWP was responsible for deciding on the inclusion of these ideas.

We will need to decide what sort of overarching science committee model is appropriate for future lunar exploration. One close to the Apollo model is probable, but with better communications may allow more real-time interactions/support.

Geologic Traverse Planning for Apollo Missions

Gary Lofgren,

Planetary Scientist
Lunar Curator

Astromaterials Acquisition. & Curation
Astromaterials Research and Exploration Science
NASA Johnson Space Center

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How was Science Done on Apollo

science by several different committees
experiments by individuals

- Science PIs: Experiments were the work of individual science Pis, selected by committee
- Throughout Apollo there were many science PIs
- Landing sites chosen by a committee for that purpose
- Surface geology and traverse planning was a PI experiment, but approved by committee
- Crews were chosen by Flight Operations
- Astronaut training was done by surface PI

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Site Traverse Planning

Landing sites were restricted to near the equator

Each landing site had Specific Science Objectives

Field Geology PI had the task of meeting the Science objectives for a site

The FGPI planned the traverses based on photo geology

A high level science review board reviewed the traverse planning and defined specific experiments

FGPI Trained the Crew, Capcom, and BR scientists to meet science objectives

3

Crew Training Critical

Problem solving: The geologic thought process in field

Common language: Do you have the words that work

Observation skills: Can you describe what you see

Train the Crew, Capcom, Scientists together

Realistic simulated traverses, science back room, debrief

Practice routine procedures:
- Navigation, follow the map, photo panoramas
- Collecting, documenting rock and soil samples
- Description from small to large scale features
- Repetition, repetition, repetition

Classes in moon rock type recognition
Detailed discussion of mission objectives

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Geologic Field Training Sites

Volcanic Craters and Flows
- Coso Hills, CA
- Hawaii
- Rio Grande Gorge Taos, NM
- Buell Park, AZ
- Kilbourne Hole,
- Ubehebe Crater, Death Valley, CA
- Flagstaff, AZ (3 times)

General, Surface Features
- Orocopia Mtns., CA
- Mojave Desert, CA

Plutonic (Crustal) Rocks
- No. Minnesota
- San Gabriel Mtns., CA
- San Juan Mtns., CO

Craters, impact & explosion
- Meteor Crater, AZ
- Medicine Hat, Canada
- Nevada Test Site

Each trip 3-6 days including travel time

Over 30 people participated in A-15 training

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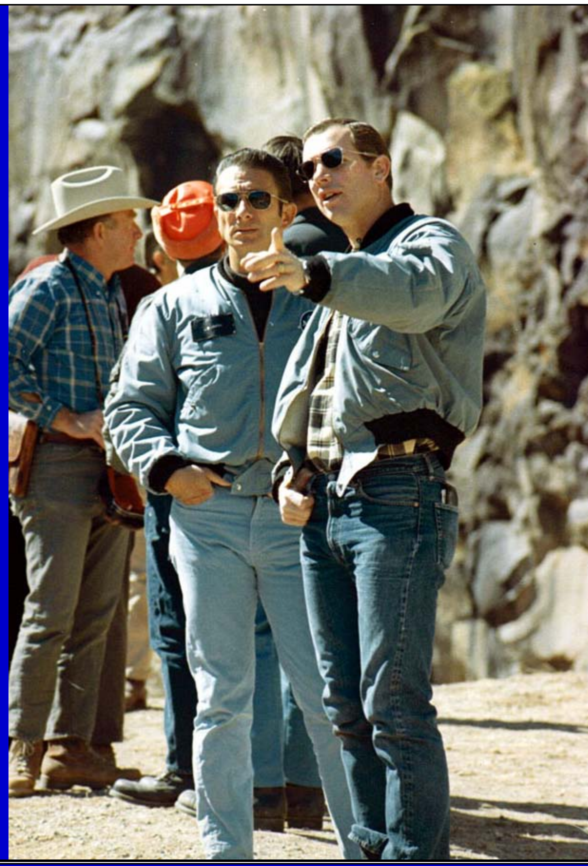

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How Well Did It Work

Confidence in their understanding the mission science objectives and knowledge of how to succeed

Built rapport with scientists and a common language

Astronauts became a stakeholders in achieving objectives

Confidence in the tools and how to use them effectively.

Learned to work with highly subscribed timeline requiring high efficiency and focus on objectives

In short, became field geologists

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Science Support/Backroom

The concept and the practice evolved, matured?

Formal Science BR 10 or so people that followed activities and were ready to advise

What BRs: Separate with own channels of communication
- Field Geology PI
- Surface ALSEP PIs
- Orbital PIs

Communicated thru formal channels, e.g. Lovell to Flight director to CapCom for Field Geology PI

Limited information, voice and TV where available

Limited input, usually in response to questions or necessary changes to traverses due to problems.

11

Overarching Science Committee

The committee evolved, matured?

Needed a body to settle disputes between the science priorities of different science objectives

Surface Working Panel (SWP) Set Priorities
- Reviewed FGPI traverse planning
- Decided what experiments would be deployed
- Special sample collection
- Interfaced with engineers somewhat, again evolved
- Defined sample collection procedures and needs

Had a representatives in the Science BRs, real time priorities

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