AN ARCHIVE ON THE MOON

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ABSTRACT

This paper is part of an effort to draw attention to the prospect of establishing a safe store of important information on the Moon. Such an archive could serve to hasten recovery after a global disaster on Earth, and also it could grow into an important resource for lunar settlers. In the process of deciding what to emplace on the Moon, humans would be examining the central values of society.

I. INTRODUCTION

Civilization is, in essence, an information structure. Since the rise of toolmaking, agriculture, medicine and government, humans have distanced themselves from all other earthly life forms, becoming ever more dependent on artifice.

At many times in the past, civilization's treasures and even some of its necessities have been wiped out by war, neglect, pestilence and natural disasters. But always recovery ensued as important information was retrieved, rediscovered or reinvented. Because the losses were local, the global information potential survived. Never in the multimillion-year history of hominids has there been a catastrophe of such magnitude as to demolish every creation of the human mind and hand.

Yet such disasters are conceivable. The most obvious example is an asteroid or comet impact like the one that is believed to have exterminated the dinosaurs. Other dire possibilities are an uncontrollable worldwide outbreak of disease or a thermonuclear weapons exchange followed by the universal collapse of agriculture and civil society. Unlikely as these events may be, no one can rule them impossible.

In this paper we describe and advocate one way to assure and hasten recovery after any such rare but devastating event; namely, to establish a safe store of vital information on the Moon.

In addition to its disaster-recovery role, a lunar archive would constitute an investment in the future of human lunar settlement. And, just in the process of deciding upon and emplacing its contents, humans all over the world would be re-examining the foundations of our global society. This might be the most important result of the project.

II. A LONG-TERM PERSPECTIVE

Human society has proved to be robust and resilient over time spans of thousands of years. Here and there, from time to time, parts of every living generation are driven back to bare subsistence, or beyond into famine and death, by natural or man-made disasters. But always civilization has continued in other parts of the world, becoming more and more interdependent and more and more in thrall to technology.

Based on this experience it is hard to focus on the extremely improbable event of a total collapse, and even harder to think through the vast variety of possible recovery scenarios.

The idea that no matter what happens we will muddle through somehow is very persuasive. But if we do dispassionately consider the odds, and if we do plan recovery, we may avert untold human misery in the future.

In this paper we intend to broaden discussion of the problem and to advocate further serious thinking about it by everyone concerned with the long-term future of humanity.

At the very least this is a stimulating mental exercise. Beyond that, considering a lunar archive (which would of course be accompanied by bombproof time capsules on Earth) gives us a chance to contemplate our most central and vital values and to articulate those that we may find to be universal.

This social, moral, philosophical, perhaps even religious dimension of the quest is not a surprise. Long anticipated in serious science fiction (Refs. 1 and 2 are classic examples, one profoundly pessimistic and the other hopeful) it can now come into the realm of our everyday concerns, driven there by recent scientific discoveries.

One of these discoveries confirms the dominant role of impacts in the evolution of planets and their satellites. Our Moon bears a clear record of ancient and continuing bombardment and similar cratering evidence is found throughout the solar system. On Earth the record has been largely erased by geologic activity and weathering, but enough traces remain to show that devastating impacts have occurred. Scientists have devised the 'Torino Scale' (Ref. 3) for describing the combination of likelihood and severity of an impact. As shown in Figure 1, civilization-destroying impacts are highly improbable. Lesser catastrophes, such as an ocean impact that would demolish coastal cities, are much more likely, and the probabilities grade onward to a certainty for the myriad harmless events that happen every day as small bodies burn up in our atmosphere. A modest effort is in progress to assess the population of near-Earth objects that may threaten humanity, and planetary defense is becoming a subject of serious inquiry.

A global catastrophe could happen tomorrow, in a thousand years, or never during the earthly reign of *homo sapiens* . Recovery planning thus demands a time perspective much longer than the time horizon of modern governments. Building a lunar archive should be a multi-generation project. Beginning with small, rugged implants just beneath the lunar surface, the archive could eventually grow into a great library serving not only the people of Earth but also a rising civilization on the Moon. In a far-distant future, lunar settlements may lead humanity in the generation of new ideas. Then their information store will become truly priceless.

III. TECHNICAL MATTERS

1. Why the Moon?

Safe storage of copies of important information, a familiar concept to computer users, has had a rather disheveled history here on Earth. At various times and places people have made efforts to capture and preserve civilization's treasures. Chinese dynastic records, the British Museum and the Smithsonian Institution are fine examples. But preservation is haphazard and history is full of examples of irretrievable loss. Libraries burn, art objects are plundered, governments succumb to tyranny and corruption, wars lead to devastation. In addition, every known storage medium has a limited lifetime.

Rapid obsolescence of magnetic tapes is already causing difficulty in maintaining existing data stores and extracting their information. Lunar time capsules, regardless of their particular storage medium, would need occasional maintenance.

With modern storage technology, refreshed and maintained over time, it would be possible to emplace huge archives containing faithful copies of all the central products of human knowledge and wisdom. Multiple copies of such information should be implanted within the Earth and marked to enhance the likelihood of recovery.

In Deep Time (Ref. 4) Gregory Benford treats the vexing problem of marking nuclear waste dumps for millennia. The archive problem is similar.

In addition to its invulnerability to terrestrial disasters, the Moon offers a near-perfect environment for long-term storage. A meter or more beneath the surface the temperature is constant and very low, a high vacuum prevails, seismic activity is negligible and radiation and meteoritic impacts are essentially totally shielded by the overlying regolith.

2. Robotic emplacement

Robotically implanting time capsules in the lunar surface presents no new technical problems. Both American and Soviet lunar programs have demonstrated all the needed techniques: delivery to the surface, digging and drilling, and depositing instruments and radio systems.

3. Retrieval

Information retrieval, on the other hand, presents a suite of interesting new engineering problems. Perhaps the most subtle of these relates to what needs to be emplaced on Earth.

It is easy enough to imagine multiple lunar time capsules, with "sleeping" (probably nuclear) energy sources, activated by radio command from Earth. Since radio waves penetrate the dry, porous regolith, each capsule's antenna can be part of the buried object. On Earth, however, system design is more complex and very scenario-dependent. To send a wake-up call and receive the stored information requires an efficient and robust two-way radio link. The multiple Earth stations need antennas that cannot be deeply buried, at least when they are operating, so some commanded opening to the surface is required.

ICBM silos, designed to survive and function during the nuclear blast overpressures of a counterforce exchange, could be good sites for lunar retrieval stations. Because they are dispersed on opposite sides of the planet even a large cratering event would be unlikely to destroy all of them.

The contents of the lunar archive should be at least partly duplicated on Earth so as to make retrieval more likely in the event of any but the most extreme disasters. Thus it is possible to visualize a dispersed set of information caches, emplaced in silos and marked to enhance the prospect that survivors of a catastrophe could find and exploit them.

However, much depends on what is assumed about the level of surviving technology and organization. Designing retrieval keys to be understood independently of languages and cultures, and used even in the most dire conditions, is an interesting problem yet to be investigated.

History provides many examples of messages that later generations were unable to decode. Hieroglyphics required the Rosetta Stone; Aztec writing was mostly unreadable until just a few years ago; and of course all languages that never made it to writing are lost forever.

Creating a retrieval system designed to survive, function on demand, and above all be discovered and used by unknown survivors in unpredictable circumstances is a problem worthy of serious attention with or without a lunar archive, as working on it could lead to new understanding of how humans generate and use information.

IV. WHAT TO SEND FIRST

If we assume a dispersed set of emergency information and supplies, stored in missile silos or equivalent underground sites on Earth, it becomes clear that the lunar archive has a very special function. In any but the most extreme catastrophe, survivors would perhaps possess enough technology and social organization to exploit the terrestrial archives and would have no need to send a wake-up call to the Moon.

However, in Earth Abides (Ref. 2) George R. Stewart imagines another scenario: As a worldwide pandemic rages on, technology gradually fails and the few bands of survivors eventually form small, primitive scavenging societies. Toward the end of his life an aged tribal leader rests near a great library, thinking wearily of a million books that now will rest unread into an unknown future.

This sort of thinking leads to these conclusions: (a) Lunar retrieval must be very robust and independent of the survivors' languages and capabilities, and (b) The first stored information must be basic, enabling the restart of social organization and technology from a very low state. Fundamentals of self-government, agriculture, toolmaking and medicine are obvious candidates; water and wind energy supply; perhaps some simple natural resource extraction – the list is endless, making the selection of what to send first a very interesting exercise in thinking about civilization's central priorities.

A recent book about medieval technology is instructive: In Cathedral, Forge and Waterwheel (Ref. 5) Frances and Joseph Gies trace the history of crumbling Roman skills and organizations and how they were replaced and elaborated in successor barbarian societies with knowledge rediscovered, imported via Islam from India and China, or recreated by invention. The main means of sustaining life survived, allowing continuous progress in textile-making, masonry and other arts, but European knowledge of how to make and use structural cement and concrete was lost and not rediscovered for centuries.

For the first aid to recovery, clearly the retrieved information should somehow deal with food. It is easy to imagine a brave restart of civilization ending when its first harvest fails. Somehow the surviving humans must get through a stage of scavenging, gathering, perhaps hunting, and then onward to some food production.

In Guns, Germs and Steel (Ref. 6) Jared Diamond traces the critical role of food production in determining the fates of different societies through history.

Returning to productive agriculture, through the use of retrieved knowledge both ancient and modern, would be the survivors' most urgent task. Like Mormons and other societies who traditionally store food to take them to the next harvest, the survivors would have to begin with some cache of previously-prepared staple edibles. But that is not enough: Not likely themselves to be farmers or even gardeners, they would have to learn quickly how to avoid failure.

Knowledge for clean water, equitable sharing of resources, religious and ethical creeds, ultimately literature, art and science – all would need to be transmitted through the imperfect channel of archive retrieval. Designing that channel would be a most difficult but rewarding task, as it would engage humans in an unprecedented examination of what is really important.

V. HOW TO MAKE IT REAL

Past efforts at communicating into the future have mostly failed in one way or another. As pointed out by Benford (Ref. 4), people have only a limited capacity to recognize the difficulties of language, culture and simple erosion of meaning due to time. For the highest-priority, life-critical knowledge to be placed on the Moon, a scheme involving multiple ways to convey information must be devised – a sort of super Rosetta Stone. Creating this, essentially the opposite of a code, has been the subject of some thinking by people who consider communication with extraterrestrial intelligences.

As in any other long-term and ultimately costly project, it will be wise to start at a small scale and learn in stages.

The first studies of the problem and its implied choices can be inexpensive enough to be done within public or private institutions under existing (e.g., educational) budgets.

However, because of the worldwide, intercultural nature of the problem, an international institution is required – perhaps UNESCO or a consortium of universities, library associations, encyclopedia producers or professional media societies.

In later stages the project could become a part of an international effort to prepare a real defense of Earth's people against either terrestrial or celestial catastrophes. Then in the longer term it could transcend defense and become a vehicle for the preservation and advance of culture.

The lunar archive would need tending, not only because storage media deteriorate but also to keep its contents current. A continuing program to do that could become one of humanity's outstanding cultural achievements.

VI. SHOULD WE DO IT?

Humans in every generation have sublime moments of glory and majesty, but given the universal persistence of human misery and misfortune it is fair to ask whether or not we should place for the ages, on both Moon and Earth, a full record of ourselves. Stimulating debate on that question is another way for this project to energize human progress.

VII. CONCLUSION

The main purpose of this paper has been to stimulate discussion of ways to forestall the worst effects of very unlikely but devastating global catastrophes. In the future, this discussion should reach beyond disaster recovery and encompass the broader question of how humans may take maximum advantage of their millennial transition to a multi-world society. With thriving lunar settlements and perhaps a permanent outpost on Mars, humanity will have new ways to protect the treasures and traditions of our past and to create new ones for our future.

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Figure 1. Expected interval between impacts versus size of impacting body and energy (Ref. 3)

Proceedings of The 4th International Conference on Exploration and Utilization of the Moon, July 10-14, 2000, ESTEC , Noordwijk, The Netherlands