UNDERGROUND SCIENCE REPORT

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OUTLINE

1. Introduction
2. Bahcall Committee
   - Committee and Charge
   - Activities
   - Recommendations
     - Scientific Argument
     - Why one Principal Site ?
     - Site evaluation
3. The Aftermath

For more information see:

www.sns.ias.edu/~jnb

INTRODUCTION

- The two leading underground multi-experiment laboratories in the world:

  Kamioka in Japan

  Gran Sasso in Italy

  together with others (Baksan, Sudbury, Soudan, etc) have demonstrated their unique capability to probe exciting science, e.g

  - solar neutrinos
  - atmospheric neutrinos
  - long baseline accelerator oscillations
  - double-beta decay
  - dark matter searches
  - supernova neutrino detection ....

- Kamioka and Gran Sasso have been operating for ~ 15 years

- There does not exist a front-line US based underground laboratory facility

- Should one invest in a next generation underground laboratory facility in US ?

INTRODUCTION (ctd)

- To examine this issue, two NP community town meetings on neutrinos called for an ad hoc committee to examine these issues

- In response, the Institute for Nuclear Theory has convened a broad based committee to examine this issue.

- The funding agencies (NSF and DOE) have agreed to support this activity

Committee	email
John Bahcall (Chair)	jnb@ias.edu
Barry Barish	barish@ligo.caltech.edu
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Technical Subcommittee	
Frank Calaprice	frankc@Princeton.EDU
Peter J. Doe	pdoe@u.washington.edu
Marvin Marshak (Chair)	marshak@umn.edu
Kem Robinson	kerobinson@lbl.gov

COMMITEE ACTIVITIES

- 1st meeting – December 14, 2000
- January 9, 2001 – March 1 site visits
  (Soudan, WIPP, San Jacinto, Homestake, "green-field" sites in California/Nevada, + Gran Sasso + Kamioka)
- January 31 – request for "LOI"'s (33 received)
- March 3,4 – final meeting

E-mail and other communications during this period.

MODEL EXPERIMENTS

(to allow evaluation of different sites)

A – Ultra-low Background

B – Large Inventory of Flammables

C – Large Inventory of Cryogens

D – Ultra-K Water Detector

Committee Recommendations

The Committee unanimously recommends the establishment of a deep premier national underground scientific laboratory to enable US leadership and synergism in a broad array of scientific fields in the coming decades.

The committee endorses a single primary site as the most effective method of realizing the anticipated scientific program.

The Committee believes that there are two excellent sites for a premier deep underground science laboratory: Homestake and San Jacinto. The committee admires the commitment of the proponents of the proposals to outreach and communication of basic science to the American public. Based on the information we have received, and on the independent assessment by the committee, we judged that Homestake and San Jacinto are very similar in their technical suitability for underground experiments. Although the committee is not charged with making a formal site selection, time is of the essence, and the agencies need to be aware of the time-sensitive nature of the site selection. We strongly encourage interagency cooperation to help realize this exciting opportunity for science.

At the time of this meeting the committee favors the Homestake site for the following reasons:

- faster time scale to produce important scientific results,

- less initial capital outlay to produce world-class science,

- greater positive impact on the local population,

- lower inherent uncertainties.

SCIENCE JUSTIFICATION

1. Solar neutrinos

Would like to probe low energy part of spectrum.
To do this, need low level natural radioactivity, significant reduction of cosmic radiation flux.

2. Double beta decay

Addresses the issue of nature of ν's (Dirac/Majorana)
Could be sensitive to $m_\nu \approx 10$ meV
Needs greater depth, purer materials, active shielding + good ideas.

3. Dark matter searches (what is dark matter?)

Looking at 3-rd generation experiments
Will want to look (measure) for nuclear recoils
Will need suppression of neutrons (depth), ultra low radioactivity, large scale cryogenics
Nuclear/electron recoil discrimination very important

4. Nucleon Decay

No fundamental reason for ~~nucleons~~ protons to be stable
The interesting level might be "just around the corner" – 10^{34} yr lifetime?
Need large (~ 1/2 Mton) detector underground to reduce cosmic ray background.

SCIENCE JUSTIFICATION (ctd)

5. Atmospheric neutrinos

Provided first evidence for neutrino oscillations in the $10^{-3} < \Delta m^2 < 10^{-2}\ eV^2$ range.

Must be done underground to reduce cosmic rays.

Next generation detector might see dip structure and/or do better appearance experiments

6. Long baseline oscillation experiments

This may be the best method to study neutrino properties quantitatively.

Underground location reduces cosmic ray background, allows less restrictive trigger

Underground location probably essential ~~of~~ for μ-storage ring ν experiments (long spill time).

Also essential for emulsion experiments

7. Supernova neutrinos

Can learn about supernova mechanism

Would like to see NC interactions of $\nu_\mu, \nu_\tau, \bar{\nu}_\mu, \bar{\nu}$

Could determine mass of heaviest neutrino to ~30 eV

Different kinds of detectors are needed.

SCIENCE JUSTIFICATION (ctd)

8. Nuclear Astrophysics

Understanding solar fusion processes requires laboratory experimental data on various nuclear reactions in an energy regime not yet investigated.

Understanding nucleosynthesis in supernovae, X-ray bursts, etc. demands similar studies.

Experimental challenges arise due to very low cross sections, high backgrounds (cosmic rays) and short lifetimes.

High power, low energy accelerator in underground environment is required.

9. Geoscience

Traditional methods (surface coring, surface measurements) are limited in information they can provide.

The research in this science is critical for groundwater resource evaluation, energy resource extraction, environment remediation, nuclear waste isolation.

One needs underground studies, evaluation of processes over different spatial scales, long term monitoring.

10. Materials Development and Technology

The underground laboratory will allow further work in the area of low-background materials, counting techniques, and ultra pure chemical methods. These techniques are important in many research areas and allow great improvement in the sensitivity of trace analysis.

SCIENCE JUSTIFICATION (ctd)

11. Monitoring Nuclear Tests

Monitoring of radioactive noble gases is one of the techniques for detecting nuclear explosions.

Relies on measurement of ratio of ^{133}Xe ($\tau_{1/2} = 5.3$ d) to ^{135}Xe ($\tau_{1/2} = 9.2$ hrs) - to separate from nuclear reactor.

Measurement of radioactivity is complementary to seismic detection of nuclear detonations.

12. Microbiology

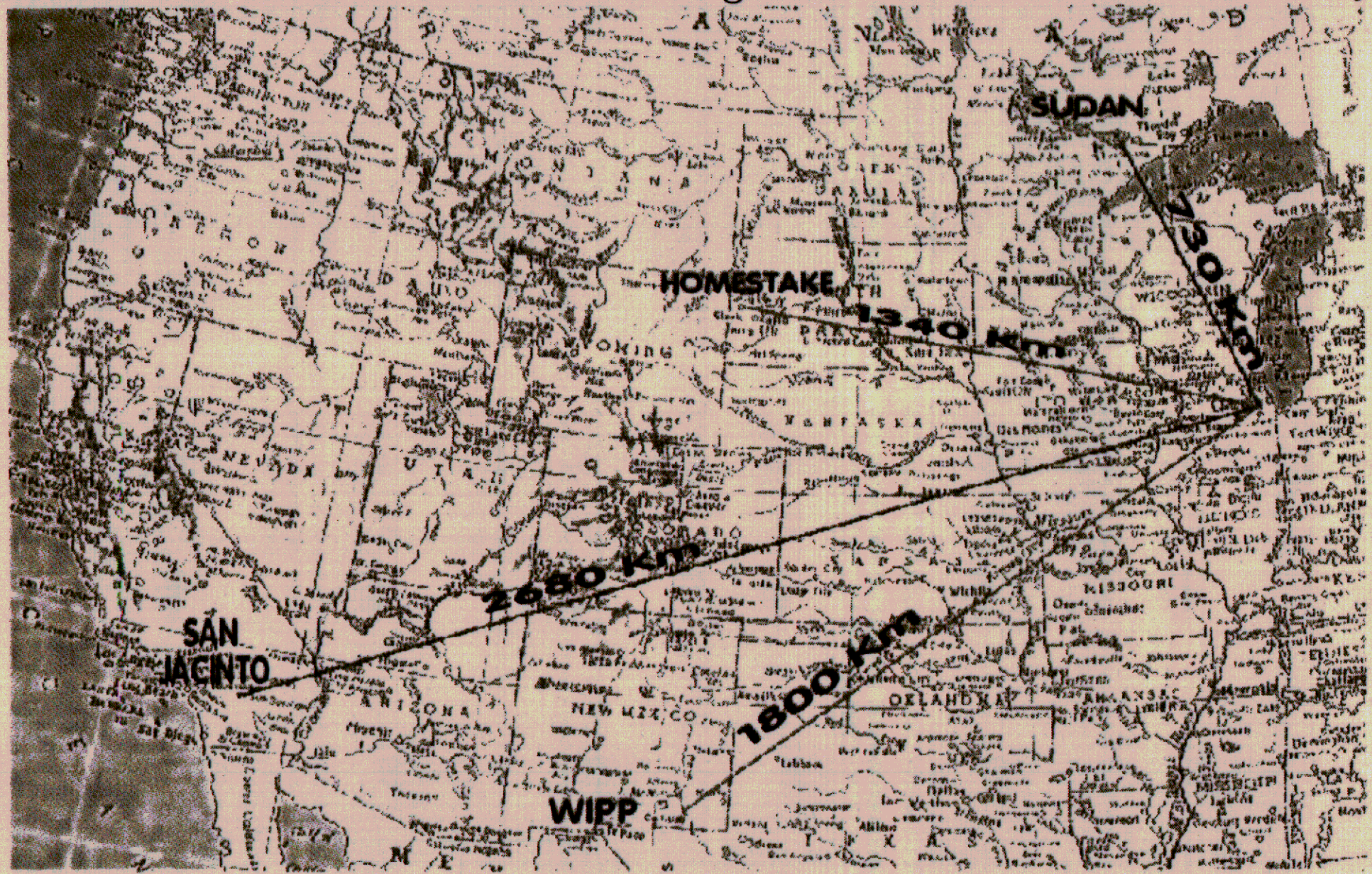
Microbial communities extend to 2.5 km below the earth's surface. They are difficult to study with coring samples.

Many important questions in this field can be answered by studies using underground excavations. The location needs to be well characterized hydrogeologically and geochemically. Extreme conditions there are useful for field testing new technologies designed to search for life on other planets.

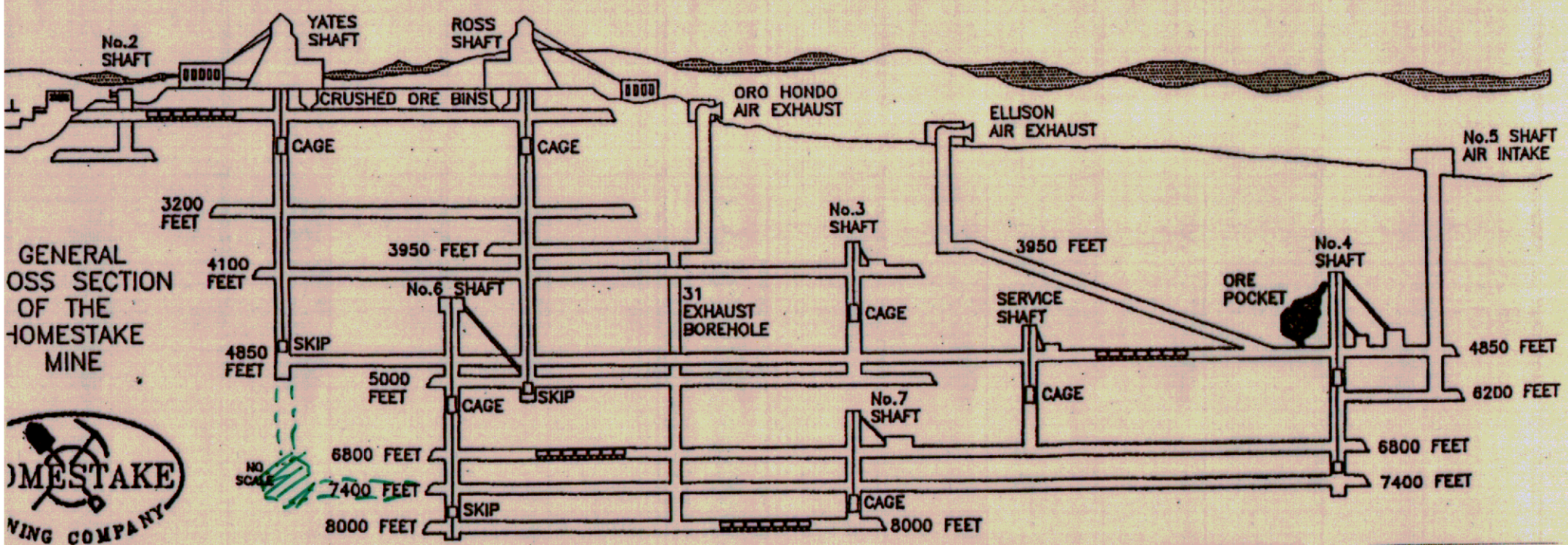
WHY ONE PRINCIPAL SITE?

- Sharing common infrastructure
- Common safety support
- Synergistic interactions between scientists doing different experiments
- Establishment of common facilities (e.g for low level counting experiments)
- Critical mass for outreach programs
- Nurturing and exciting scientific environment
- Research center with scientific and technical staff which could support large scale experiments

FIG. 1. The distances of different underground sites from Fermi Laboratory

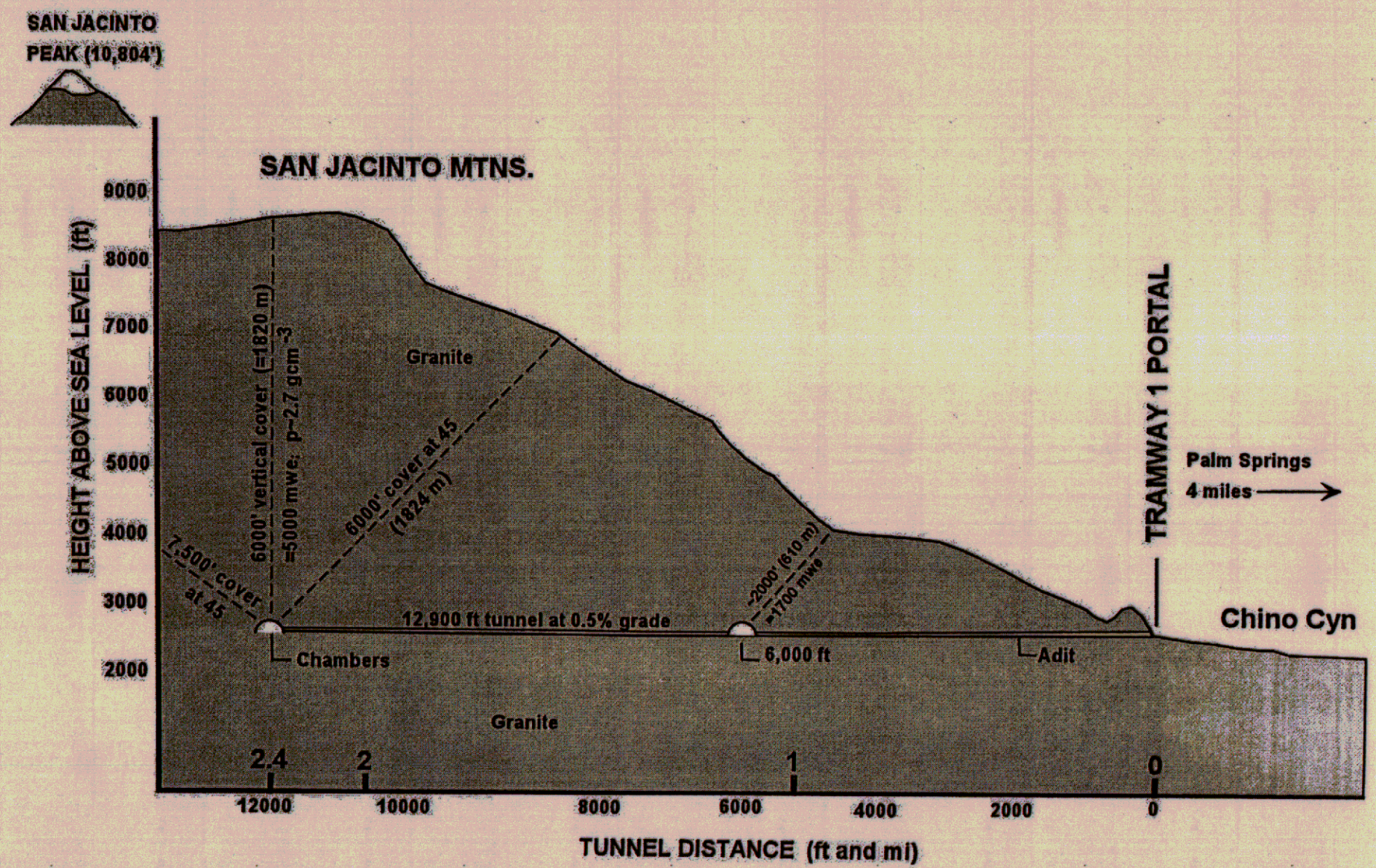


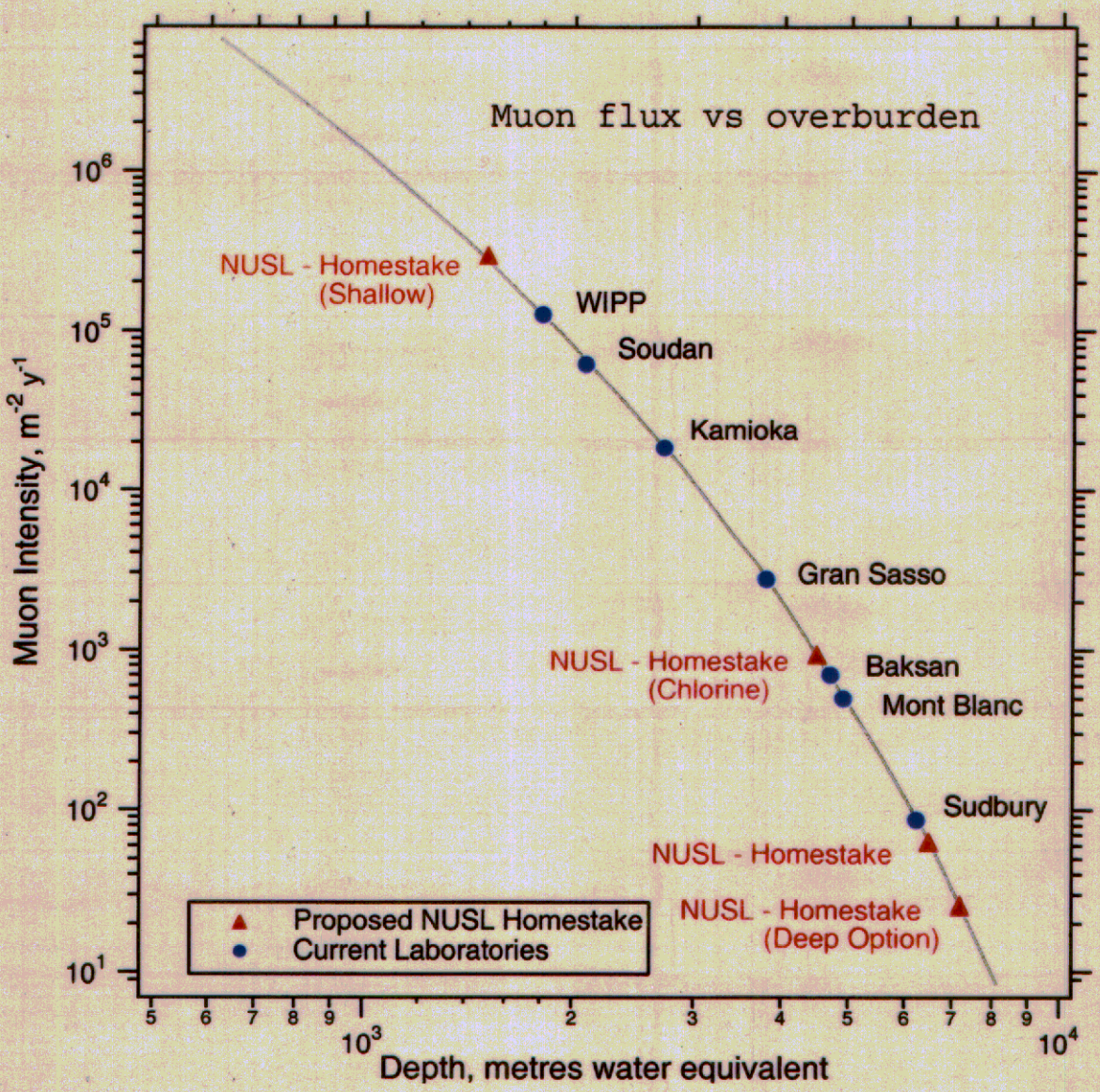
Existing Homestake mine



NATIONAL UNDERGOL. .ND SCIENCE LABORATORY

SAN JACINTO, TRAMWAY 1 SITE




Muon flux vs overburden
NUSL - Homestake (Shallow)
WIPP
Soudan
Kamioka
Gran Sasso
NUSL - Homestake (Chlorine)
Baksan
Mont Blanc
Sudbury
NUSL - Homestake
NUSL - Homestake (Deep Option)
Proposed NUSL Homestake
Current Laboratories
Muon Intensity, m-2 y-1
Depth, metres water equivalent

The San Jacinto site is also judged to have great potential for several reasons:

- horizontal access allows simple and cost effective access and operation,

- lower operating costs,

- the close proximity of strong scientific research universities.

The Homestake pre-proposal at present is not complete. First the indemnification problem must be solved. Second, a representative, national group of underground scientists must be involved in the preparation of a formal proposal that describes a detailed science program and a complete cost estimate for the laboratory. Given the imminent closure of the Homestake mine, these two issues must be solved in a timely fashion, or the advantages which lead us to favor the Homestake site will be significantly reduced.

Like Homestake, San Jacinto could become the premier site in the world, but further work is needed. Concerns include cost, construction permitting, and site optimization. A more broadly representative group of proposers would be desirable, as well as a comparison of the San Jacinto site to nearby alternatives. We encourage the San Jacinto site advocates to continue working on the preparation of a proposal. If the issues with the Homestake mine are not resolved adequately in a timely fashion, the San Jacinto site is an excellent opportunity.

The Committee has received and considered a pre-proposal from advocates for the Carlsbad Underground National Laboratory. The Technical Assessment Sub-Committee visited the Carlsbad site and the existing Soudan Underground Laboratory. The Committee believes that both these sites have played important roles in the development of underground physics.

Charge to the Committee on an Underground National Laboratory (Draft 11/03/00)

The Committee on an Underground National Laboratory is asked to prepare a white paper that responds to the following issues:

The Scientific Justification for an Underground National Laboratory (50%)

- To evaluate the scientific justification for a national facility for deep underground science. The committee should consider the potential physics that will be produced by the next generation of solar neutrino, double beta decay, proton decay, dark matter, and related background-sensitive experiments. It should also consider the possible relevance of such a facility to other sciences and to industry.
- Experiments (25%)
  If the scientific justification for a national deep underground facility is judged to be sufficiently strong, the committee should consider the experiments such a facility might host and thus the attributes of the underground laboratory. Important issues include the depth; the number and dimensions of the experimental halls; access requirements (e.g., desirable lift dimensions in the case of vertical access); background radioactivity requirements that will influence ventilation, hall design, and other engineering aspects; and anticipated needs, such as cryogenic facilities, that could have major impacts on design. The committee's views on supporting facilities, both above and below ground, will also be very valuable. This includes power, data, and communications requirements; shops, computing facilities, and above-ground staging or laboratory space; and support facilities for visiting scientists (offices, library, living quarters, food services, administrative assistance). The committee should envision a facility-an above-ground campus, state-of-the-art deep laboratories, and support facilities, services, and personnel-that would remove many of the existing obstacles to underground experiments. The goal is to move the US to the forefront of underground science.
- Potential Sites (25%)
  To evaluate the suitability of suggested sites (Homestake, San Jacinto, etc.). This should include the potential quality of the envisioned laboratory; estimated construction costs; the convenience of the site (road and air access, nearby towns); practical obstacles to developing the site; the certainty of the geology (rock quality, hydrology, seismology, etc.); the plan for operating, administering, and maintaining the facility; and issues of ownership, liability, and remediation (in case the site is eventually abandoned). It would be most appropriate to invite proponents of various sites to address these issues in presentations to the committee.
- If an outstanding site (or sites) is identified, the committee should recommend procedures for formulating the strongest possible proposal. It would also be helpful if the committee could discuss possible administrative structures for the laboratory: how will the scientific community and host institution work together to guarantee that the best science is done? What structure-ownership, management, operations - will produce the strongest laboratory?

Back to Underground Laboratory

RECENT DEVELOPMENTS

- Interim proposal for $7.5 M submitted to NSF to allow preservation of mine and staff

- A 5-year proposal submitted to NSF for $281 M to develop Homestake Mine as a National Underground Science Laboratory.

  PI's: Wick Haxton, U of Washington
  Janet Conrad, Columbia
  Sherry Farwell, South Dakota School of Mines
  Marvin Marshak, U. of Minnesota
  John Wilkerson, U of Washington

- Proposal suggests that management be by Consortium for Underground Science (CUS) representing
  the National Science Foundation
  the State of South Dakota
  national and international science communities

- The question of legal indemnification is still unresolved. Requires legislative action

- Strong support for the project in the local communities and political leaders in South Dakota.