Near-Surface Processes and Resources

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Here is a Laundry List-
With it, we can prioritize

Major Points in Introduction

- Near-surface is where we live; it is where we interact with the Earth; Societally most important(?)
- Societal relevance of shallow geophysics is increasing as pressures on the environment increase
- Near-surface can be a hostile environment for geophysics (extreme heterogeneity, high attenuation, plane-wave assumptions don't hold)
- Costs of shallow surveys are dropping, allowing for their application in more disciplines
- Need for geophysicists is exploding as near-surface and energy exploration efforts expand
- Need to get shallow geophysical methods into third world countries – need to reduce the costs further
- Seismic cannot be used alone – must use in conjunction with electromagnetic etc. methods
- Much of the near-surface geophysics is termed "applied"; in fact near-surface methods can be used in almost all major studies

Major Scientific Issues

1. Societal impact
2. Resources in the near surface
3. Near surface as a tool

▪International relations, educational programs, and interactions can focus on shallow seismology- a Federal focus?

▪Can't separate shallow seismological analysis from borehole geophysics, coring, sample analysis- with scaling the results can apply deeper.

▪Near surface is shallower than the whole crust- where fluid-flow effects are prominent.

- **Understanding the (fresh)water cycle**

- **Natural hazards prediction, assessment and remediation**

Characterizing heterogeneity and properties important in central US, linear and nonlinear. Poisson's ratio assumed 0.25, but varies hugely. Understanding is crucial for liquefaction.

Shallow velocity models for ground motion simulations. But do we understand near-surface material properties sufficiently?

Society's need for surveys and trained seismologists to guide development, assess hazard.

Concerns about dams after earthquakes- shallow geophysics as part of rapid earthquake response.

What is relation to SAFOD and their results? That is both a near-surface and near-fault study. Will be another bore into the Taiwan fault.

Secondary hazards from earthquakes- landslides, debris flows.

Industry interests in sea-floor density flows- communications as well as extractive industries- current funding opportunities.

Other groups are thinking of seismology as sub-field of acoustics- a community of acoustics experts concerned with shallow earth system, acoustic lidar?

- **Understanding and monitoring climate change**

Hydrate assessment using velocities has not been effective enough- stratigraphic variations lead to problems. Attenuation characterization, downhole experiments show promise. New techniques are being developed, in cooperation with industry. (Gas hydrates on land in Polar regions.)

- **Delineating energy and mineral resources**
- **Time-dependent Effects and Monitoring**
- **Defense/Security/Forensics**
- **Archeology**
- **Technological & Conceptual Frontiers**

Ultra-low-velocity surface materials- how to characterize? Fluid effects of great interest to industry. Need benchmark tests of scaling of measurements and property variations. Nonlinear variation of attenuation in such materials.

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- Group North:
- 1. Hazards: develop capability to model multi-hazard scenarios and validate them, foster broad studies. Develop better, more detailed data, community models, validation; then application to many hazard scenarios in many places. Testing and further application of current capabilities is crucial. Could this idea be applied to resources?
- 2. Fundamental soil physics questions- heterogeneity of properties and physical mechanisms. We don’t understand wave propagation at this level of detail or such high frequencies.

Simply describing heterogeneity is a current challenge- hard to measure at enough detail. New technology will enable such studies. Example: spatial incoherence of ground motions.

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- 3. Fresh-water reservoirs, ability to assess quality. Study of groundwater contaminants.

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- Group South:

- The near surface is the critical interface in ESS between oceans, atmosphere, deeper earth; and is the location of the anthrosphere and biosphere.

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- The 4d characterization of the near surface. Justified by societal needs- resources, hazards, climate. Heterogeneity, physics of nonlinear materials are issues. Near surface has the greatest theoretical, technical, observational challenges in seismology. Potentially the most cross-disciplinary, most interactions across lines. How to do 4d imaging: more cheaper instruments, wider deployments, new technology (non-contact); computational challenges of larger datasets; new physics to characterize materials in more detail. Includes hazard modeling?

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- Not just asking for more money; we are asking for more collaborations and more alliances.

- Need to collect more data faster, by an order of magnitude at least- a technological challenge. Automation of processing. The new instrument will show the physical quantity directly, like a thermometer.

- Understanding the Water Cycle
- Mapping and assessing large aquifers in 3D and 4D (monitoring)
- Characterizing aquifers (velocity=> porosity, permeability)
- Understanding fluid flow within aquifers
- Characterizing and monitoring contaminants within aquifers

Hazards prediction, assessment and remediation

- Imaging shallow faults for paleoseismic/slip analysis, fault zone characterization, time-variant properties (strain?)
- Characterizing geotechnical properties of shallow deposits, including liquefaction and ground failure potential
- Determining the velocity structure/geometry of sites for predicting ground motions
- Characterizing potential ground failure from landslides and karst
- Detecting man-made hazards such as abandoned mines, tunnels, buried landfills, unexploded ordinance (UXO)

Understanding and monitoring climate change

- Estimating paleoclimate from shallow deposits
- Characterizing and monitoring current climate change (permafrost thickness, changes in gas hydrate)
- Understanding the carbon cycle (mapping gas hydrates, accumulation of carbon in seafloor sediments, carbon sequestration)
- Aiding other climate studies such as coring

Delineating energy and mineral resources

- Mapping the volume of gas hydrates, and assessing their hydrate content
- Assessing geothermal resources, both obvious (Iceland) and less obvious (potential heat storage beneath buildings)
- Exploring and mapping energy and mineral deposits such as coal seams and ore bodies

Time-dependent Effects and Monitoring at Multiple Time Scales

- Non-linear soil response, expansive soils, groundwater recharge over wide areas
- 4D monitoring of fluid levels and flow; seasonal variations
- Changes in fault-zone properties over earthquake cycles
- Response of Earth to loading or unloading by

reservoirs, buildings, quarries, tides, storms

Defense/Security/forensics

- Forensics – locating blasts, explosions, impacts, industrial accidents
- Security monitoring for tunneling, trespassing, underground activity, troop movements
- Finding underground munitions, facilities, bunkers, tanks
- Search and rescue (avalanche, mudslide, trapped miners, cavers, building collapse)

Archeology

- 3D mapping of archeological sites
- Characterizing buried objects/chambers

Technological & Conceptual Innovation

- Development of passive imaging methods using ambient noise
- Characterizing properties of subsurface materials (interdisciplinary studies)
- Rapid, cheap 3D and 4D imaging over large areas
- 0-mass, 0-cost, inf-band recycled-paper sensor (millions of these!)
- Non-contact imaging (InSAR, LiDAR)
- Making technology affordable for geophysicists in developing countries (cell-phone seismograph?)