cces
Leading in Education, Research and Decision Support
Competence Center Environment and Sustainability
COGEAR: COupled seismogenic GEohazards in Alpine Regions

COGEAR

MODULE 3:

Analysis of existing recordings at Randa
Del. No.: 3b.1.1

Authors: Moore, J., Button, E., and Löw, S.

Engineering Geology, ETH Zürich

December 22, 2009

Task 3b.1.1

Analysis of existing recordings at Randa

Deliverable: 3b.1.1.1

Jeffrey Moore, Edward Button, and Simon Loew

Engineering Geology, ETH Zurich

Goal: Identify possible site effects in the fractured rock mass at the Randa rockslide.

Seismic site effects (attenuation or amplification) may be expected within a highly-fractured compliant rock mass. The goal of this task is to investigate site effects at the Randa rockslide using data collected during a previous micro-seismic monitoring experiment. The instrument network consisted of twelve 3-component geophone strings in three deep and nine shallow boreholes, and was in operation for more than two years. During this time a number of earthquakes occurred within the region, the largest of which was the M_w 3.2 event centred at Taesch, VS. Data from the micro-seismic monitoring network may be used to investigate the earthquake response at different depths and locations, thereby suggesting any possible amplification or attenuation of seismic energy within the variably-fractured rock mass.

However, two significant problems stand in the way of full interpretation of these data – (1) the fundamental frequency of the geophones is too high to be useful for interpreting earthquake waveforms, and (2) because the instrument gain was set very high, most earthquake waveforms will be clipped. Geophones near the ground surface had a fundamental frequency of 8 Hz, while those in the three deep boreholes had fundamental frequency of 28 Hz. Seismic energy below these frequencies will thus be strongly attenuated. Such geophones are therefore not particularly useful sensors for analyzing the ground motion resulting from an earthquake, where typical dominant frequencies lie within the range of 1 to 10 Hz. These instruments were designed to capture high-frequency energy emanating from small nearby sources, which explains the frequency and high gain settings.

This task has been superseded by new data gained through COGEAR measurements at Randa. Data are now available from the H/V array measurement campaign and the semi-permanent sensor deployment made in cooperation with SED partners. These data are more suitable for analyses at the seismic frequency range of interest. Analysis of ambient vibration measurements showed large spatial variations in seismic amplification at different frequencies. This amplification was seen to be maximum near the rockslide scarp, and exhibited an abrupt change at the boundary of the unstable rock mass. The directionality of amplification could further be seen to coincide with the direction of rockslide deformation. These results are fully summarized by Burjánek et al. (in press). Analysis of semi-permanent sensor data is now ongoing. Two seismometers were deployed at Randa from spring through fall, 2009 – one within the unstable rock mass and one on adjacent stable ground. The continuous recordings should be able to further indicate amplification within the unstable area, as well as any changes in the ground motion response with time. Plans for deployment of an SED valley-bottom ‘rock’ sensor are advanced, which could provide necessary base motion inputs to further analyze site response within the fractured rock mass at the Randa rockslide in conjunction with future measurement campaigns.

Recommendation: The option should be left open to work with the previously recorded micro-seismic data in the future, to be utilized as necessary.

Micro-Seismic Monitoring Network

Some relevant information and data pertaining to the micro-seismic monitoring network of Spillmann et al. is summarized below. Further information can be accommodated by contact with the Engineering Geology group (contact J. Moore).

- Time period of operation was 1 January, 2002 - 31 July, 2004.
- The sensor locations are shown in the attached figure, and all sensor specifications have been compiled and summarized in various data files.
- A list of candidate earthquake events that occurred during this time has been assembled. The list includes all events in the SED earthquake catalog M>2 within 50 km of Randa during the monitoring period.
- A data file containing the timing, location, and magnitude of all micro-seismic events cataloged by Spillmann et al. is available.
- Access to the full data set of waveforms can be organized through AUG partners.
- Data files are named by date string, so for example, the earthquake of February 4, 2003 at 20:49:40 is named 20030204204943.dat.
- The earthquake of February 4, 2003 (M_w 3.2) was the largest to occur in the immediate area during the micro-seismic monitoring period. Data from the complete monitoring network have been acquired through direct communication with T. Spillmann and are available to interested COGEAR partners.
- There were no microseismic events recorded during, immediately after, or within a few days following the 2003 Taesch earthquake.
- The lack of microseismic events associated with the 2003 Taesch earthquake does not conclusively disprove seismically-induced rock mass deformation, as some portion of the ongoing deformation at Randa is thought to be aseismic (Spillmann et al., 2007), while co-seismic events were likely unrecognizable amidst the clipped waveforms.

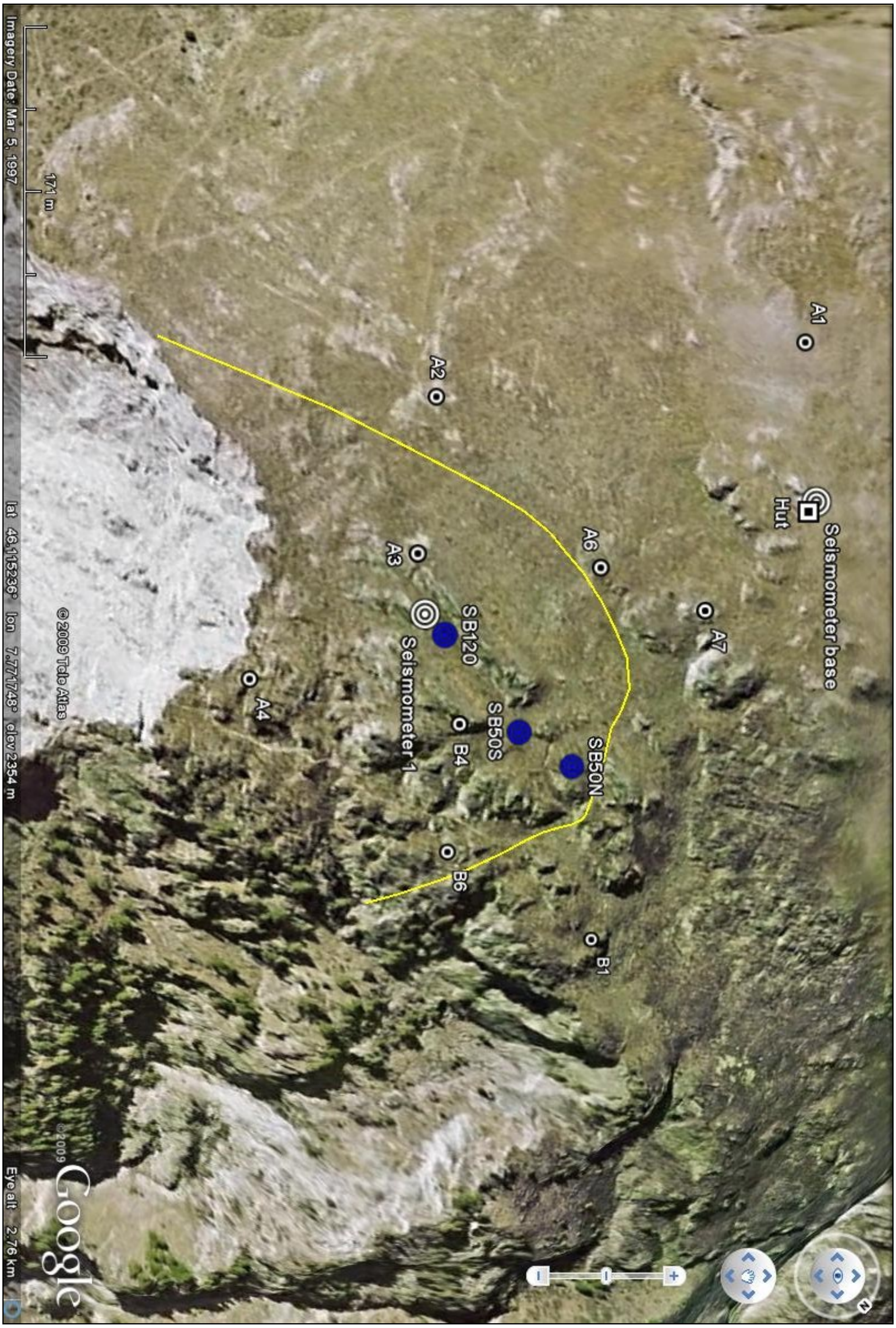
References

Spillmann, T., Maurer, H., Green, A.G., Heincke, B., Willenberg, H., and Husen, S. (2007b). Microseismic investigation of an unstable mountain slope in the Swiss Alps. Journal of Geophysical Research 112(B7).

Spillmann, T. (2007). Borehole radar experiments and microseismic monitoring on the unstable Randa rockslide (Switzerland). D.Sc. Thesis, Institute of Geophysics, ETH Zurich, Switzerland.

Burjánek, J., Stamm, G., Poggi, V., Moore, J.R., and Faeh, D. (in press). Quantifying slope instability using ambient vibrations. Geophysical Journal International.

Swiss Seismological Service (2002): ECOS - Earthquake Catalog of Switzerland. ECOS Report to PEGASOS, Version 31. 3. 2002. SED: Zürich.



Layout of the micro-seismic array of Spillmann et al. (A# and B#, three boreholes), and the location of the two semi-permanent seismometers installed by SED in 2009. The approximate boundary of the unstable rock mass is shown.