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Catalog of metadata on existing seismic soil properties and seismic soil response characteristics
-SOILRESP-

v.1.0

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Abstract

A lot of studies have been carried out in Switzerland regarding geophysical characteristics of Quaternary deposits. However these studies are dispersed in various research institutions and private companies and are rarely if not never accessible through internet.

This work proposes a partial compilation on existing geophysical data achieved in Switzerland through a database on metadata. The idea is to provide a metadata that can respond to the four W : who, where, when and what. The purpose was not to focus on obtained results as they may be sensitive or confidential. The study focuses on investigations carried out using seismic techniques (e.g refraction, reflection, ambient noise, etc).

Résumé

Il existe beaucoup d'études en Suisse qui portent sur les caractéristiques géophysiques des dépôts quaternaires. Mais ces études sont dispersées dans différentes institutions de recherche et compagnies privées et rarement, voire jamais, accessibles par internet.

Ce travail propose donc une compilation d'une partie des données existantes sous la forme d'une carte d'identité des mesures géophysiques ayant été effectuées en Suisse, sur les dépôts quaternaires. Cette carte d'identité avait pour objectif de répondre aux quatre W – who, where, when, what. Elle n'avait pas pour objectif de répertorier des résultats obtenus, ceux-ci étant parfois sensibles ou confidentiels. La recherche s'est concentrée sur les investigations effectuées par les méthodes sismiques (ex. réfraction, réflexion, bruit ambiant, etc).

1. Background

The Michoacan earthquake in Mexico, in 1985, focused the scientific attention on the main role played by local geology on the seismic response, especially when considering unconsolidated deposits overlaying rock.

Unconsolidated soil deposits, mainly Quaternary deposits, are usually represented as a homogenous layer on classical geological maps. However in regards with geological hazards, this unit shows diversity in its behavior, especially in relation with earthquakes. Local variation in seismic response can occur depending on the geological and physical characteristics of these deposits.

The seismic response on a specific site will depend primarily on the following parameters :

- type of deposits (rock, soil),
- state of deposits (consolidated, unconsolidated),
- age of deposits (e.g. Quaternary),
- geometry of deposits (hill, valley, plain),
- thickness of Quaternary deposits,
- geophysical and geotechnical properties (seismic velocities, density, CPT, SPT, undrained shear strength).

These parameters will have a major role on the length of the seismic movement, the resonance frequency and the level of amplification.

At the federal level, the former Federal office for water and geology published directives for seismic microzonation encouraging cantons to establish at least soil foundation maps based on the classes defined in the new Swiss building codes, SIA norm 261 (OFEG, 2004). Such maps give information on type of deposits and associated generic information on the main geophysical and geotechnical properties (e.g. shear-wave velocities, N-SPT, undrained shear strength, key parameters for the elastic response spectra) when available. Some of the cantons have already started producing these maps (OFEV, 2011) either at the canton scale (e.g. Geneva, Basel) or focusing first on sensitive areas (e.g. Valais).

Regarding rocks, some major researches have been or are carried out to utilize existing data to define physical properties across Switzerland (e.g. Marillier et al., 2007, Zappone et al., 2010), among which some are of interest for seismic site characterization, such as P-velocities or density.

Considering thickness of Quaternary deposits, it can be inferred from combination of seismic reflection, refraction profiles, gravimetric data and boreholes. A gravimetric study across Switzerland was achieved in 2001 at the scale of 1:100'000 (Olivier et al., 2001). 3D geological models are also currently developed at cantonal scale (e.g. Basel, Geneva).

Missing to this inventory is a catalog of existing studies on geophysical properties of Quaternary deposits. By physical properties, we means seismic velocities P and S and frequency of resonance. Those elements are of prime interest to characterize seismic soil response.

Since the end of the 80s, various investigations have been carried out in different parts of Switzerland related to seismic site response (e.g. Faeh, 1985, Schindler et al, 1995, Wagner et al., 2000; Frischknecht, 2000; Kind, 2002; Widmer et al., 2003; Roten et al. 2008; Hurter, 2008). These investigations brought some information either on soil geophysical properties (e.g. S-wave measurement) or seismic soil response characteristics (e.g. frequency of resonance).

All these studies and complementary works achieved by private offices are spread over Switzerland, but up to now, there is no general overview on what has already been measured.

This project focuses on areas located on plain and alpine valleys, generally inhabited, where Quaternary deposits are dominant and where their thickness can also be consequent.

2. Aims of this study

This aims at inventorying key geophysical data that have been acquired through the country on Quaternary deposits, generally in plains and valleys. By geophysical data, we mean seismic velocities, P and S, and frequency of resonance.

As the Swiss plateau is currently investigated through the SGPK project on the Swiss Molasse basin (Marillier et al., 2006) existing seismic profiles and boreholes are already integrated into a GIS database.

Consequently, this project deals with remaining data with the objective to answer the five W, i.e. what exists, which type of data, where they are existing, when they were acquiring, and who is the

owner of them. This is important in order to reduce redundancy of studies, to promote in some cases further surveys and also to define where new investigations could be carried out.

To achieve this goal, information were searched at universities, federal institutes of technology, geological offices, private companies, etc. and then a GIS database with associated metadata has been developed.

3. Data acquisition

Data contained in the present database are only those acquired in Switzerland. Data were either in analog (i.e. in reports, on paper maps) or digital formats.

3.1. Type of parameters

As the main objective of this investigation was to acquire and display only the metadata of geophysical investigations, i.e. which type of measurements was done, when, where and who own them, 13 parameters were considered (table 1). The OBJECTID has been defined by the author of this project to facilitate the homogeneity of the ID inside a specific file. In some cases, the owner of the data attributed two different labels of the data, which were kept. As a result, there are two owner identifications (NO_PRIVE, NO_PRIVEB). The attribute INSTRUMENT allows to indicate which type of material have been used for data acquisition. It can also be an indirect indicator on the development of the technique over the years. The attribute DATE is also a way to detect the evolution or the period where some techniques were used more than others. The attribute FORMAT may be an indicator to point out that some information should be copied and transferred in digital archives before they disappear.

Attributes	Description
OBJECTID	record identification defined for practical use
NO_PRIVE	Data owner identification
NO_PRIVEB	Data owner identification
MEASURE	type of measurement (e.g. h/v - single station, array measurement, seismic profiles, etc)
INSTRUMENT	type of instrument used (e.g. seismometer Lenhartz Marslite 3 components)
DATA	type of data obtained (e.g. spectral ratio, velocity profiles, etc)
SOFTWARE	software used for data acquisition or treatment (e.g. Spectratio)
DATE	date of acquisition
AUTHOR	owner of the data (e.g. UNIGE, ETHZ, private company)
FORMAT	Available data format (e.g. digital, analogical)
COORDX	Swiss coordinates (CH1903)
COORDY	Swiss coordinates (CH1903)
ACCESS	type of access (on request, not available, etc)

Table 1. Parameters used in the GIS metadata

3.2 Main sources

This paragraph presents institutions that contribute to the database building up. Other companies were contacted but they either didn't have data available on geophysical parameters regarding Quaternary deposits or were not willing to share them.

3.2.1 Research institutes

a) University of Lausanne - Institute of geophysics - Lausanne
The institute owns a lot of geophysical data in archives, which cover the period from 1975-2006. No digital database was available regarding seismic data acquisitions. All data were acquired during applied or research projects. The first task was then to compile all these data, looking for the defined parameters (table 1). All data were on paper maps or mentioned in reports, so in most cases, geographical coordinates were directly calculated on the available maps or retrieved from sketches. All the data concern p-wave velocity acquisition using either reflection or refraction techniques.

b) Swiss Federal Institute of Technology Zürich

Swiss seismological service
The data provided by the Swiss seismological service (SSS) concern ambient seismic noise measurements using either a single station or synchronized multiple stations (array approach). The treatment of raw data allow to obtain the fundamental resonance frequency at a given location (single station) and the dispersion curve of surface waves (synchronized multiple stations) which can be inversed to obtained shear-wave velocities. The metadata was provided and updated as the SSS is developing its own database in a general effort linked with the COGEAR project (Faeh and the COGEAR team, 2008).

Chair of Engineering Geology
In the frame of the revision of the Swiss building codes, a compilation of geological and geotechnical data was achieved in order to propose standardized soil profiles mainly located in northern Switzerland (Löw and Pasotti, 2001). This information has been introduced into the dabatase, due to the fact that geophysical measurements, associated with these profiles, were carried out by the Swiss seismological service and Résonance Ingénieurs Conseils SA.

c) University of Geneva - Unit of geological risk
In the frame of research projects, ambient seismic noise measurements using the single station approach have been carried out in the Rhone valley (VS) and in Geneva. So the metadata concerns raw data (noise measurements) and the fundamental resonance frequency, when identifiable.

3.2.2. Private companies
Most of the contacted companies have shared the data with kindness and without financial counterpart. Some of them have being working with others companies, so authorizations of data sharing were sometimes needed.

a) Geo2x
This company works mainly with seismic refraction and reflection techniques. Most of the data already existed in a georeferenced database, as this company is using GPS for locating their measurements. Coordinates of the remaining data were retrieved from topographic maps.

b) GeoExpert AG
This company deals with high resolution hybrid seismic (Frei and Corboz, 2010), multichannel analysis of surface waves (MASW), seismic reflection and refraction techniques. They can therefore investigate P and S velocities. At the time of request, this company didn't seem to have a georeferenced database of their projects. In order for them to allocate time on georeferencing their data, they requested a financial support. Only a small financial mandate was attributed to obtain a sample of their data. Among the list of projects provided (more than 200), about 40 projects were selected that seemed to be related with investigations on Quaternary deposits. Location of data was provided in latitude/longitude based on the WGS84 ellipsoid, so it was necessary to project them into the CH1903 reference system, which may have introduced some location errors.

c) Geoform Ltd
The Geological consulting and studies Ltd (Geoform) company provided data from SEAG (Schweizerische Erdöl AG), Petrosvibri and ADNR Exploration GmbH.

As the seismic profile locations through the Swiss Molasse Basin were already introduced by UNIL (Marillier et al., 2006) into a GIS, the request focused on other data, such as uphole velocity acquisition and low frequency spectroscopy, and in other areas than the Molasse Basin, such as those achieved in Alpine valleys.

d) Résonance Ingénieurs-Conseils SA
One specialization of this company is H/V data acquisition and treatment with a single station approach. Data location was mostly achieved based on maps or sketches. Consequently, the accuracy of the position may not be as good as with a direct GPS acquisition. Some mandates were achieved in association with other institutions (e.g. SSS, Geo2X). In these latter cases, geographic coordinates given by these institutions were used.

Some data were acquired following the specific geological and geotechnical profiles determined by Löw and Pasotti, 2001 (see 2.2.1b), in the frame of the elaboration of the upgrade of the Swiss seismic building code. Consequently, in both GIS files, the attribute PRIVE_NO is identical.

3.3 Limitations

Data accessibility was limited by three main factors, time, finance and confidentiality. Some contacts were made to obtain data, but as they were not already organized in a digital database and the contacted person didn't have time to look after them, or was not willing to have an external person coming in, the data are not integrated in this database. In other cases, the data were accessible, but only through financed mandates. Finally in some cases, it was not possible to obtain the metadata at all, because of confidentiality and sensitivity of the data.

4. GIS framework

All data were pre-prepared as excel files. Consequently they were easily imported into GIS. The GIS software used was ArcGiS 9.3[1]. All data are expressed into the CH1903 reference system.

4.1. Metadata

For each layer a metadata has been associated based on the GM03 norm which is the Swiss metadata model for Geodata (Geocat.ch, 2009). As the database has been developed using ArcGis 9.3, an editor of the basic norm of GM03 (Geocat.ch, 2009), called GM03 core Editor (figure 1), can be added as an extension (Esri, 2009).

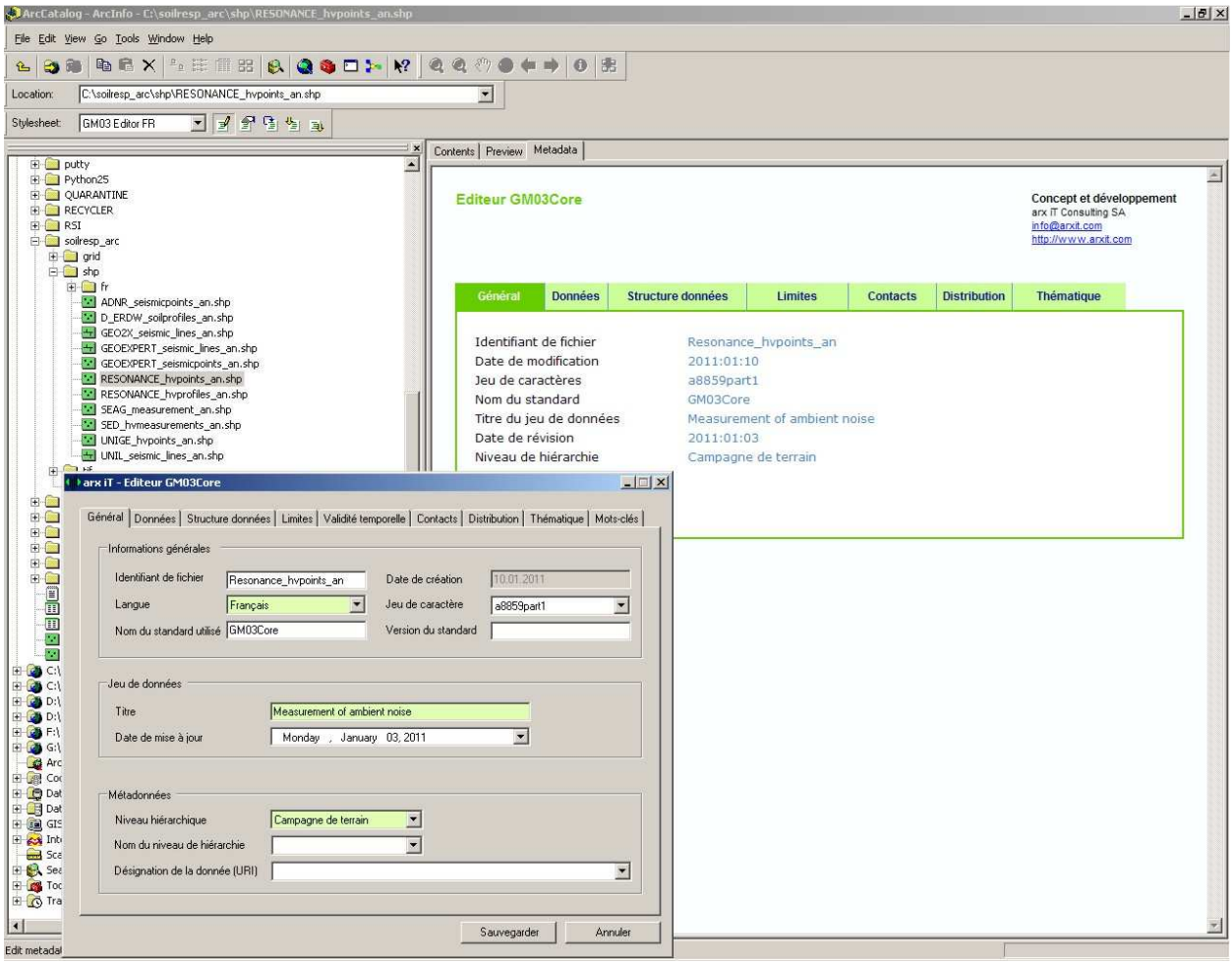

Figure 1. GMO3 Core editor

[1] ESRI – www.esri.com

4.2. Results

Figure 2 shows the distribution of data over Switzerland. Even though the database is far from complete, it can be seen that areas such as the Valais, Basel, the Swiss Molasse Basin are highly investigated, in opposite with Tessin and the Grisons. One explanation could be the low natural resource potential (e.g. oil, gas) and seismic hazard level of these two cantons that leads to a reduced interest in geophysical investigations.

The quantity, the owners and time frame of inventoried data are summarized in table 2. Accuracy of location and level of completeness of the data provided are also indicated based on a qualitative scheme.

As ambient noise measurement approach is known as a non-invasive technique that can be applied in urbanized contexts and quiet rapidly, it is not a surprise that a lot of data has been acquired over recent years.

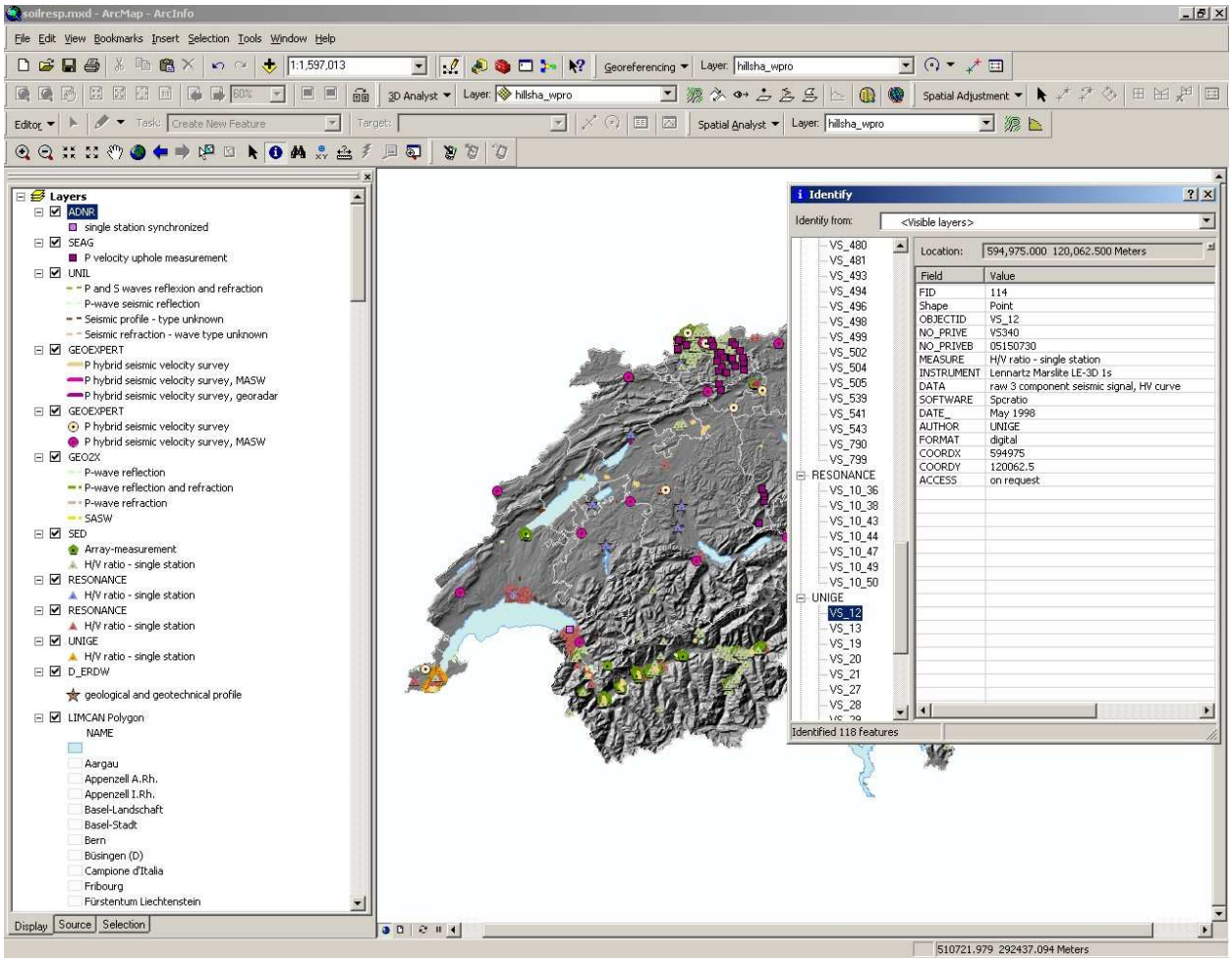

Figure 2. GIS layers and associated attributes

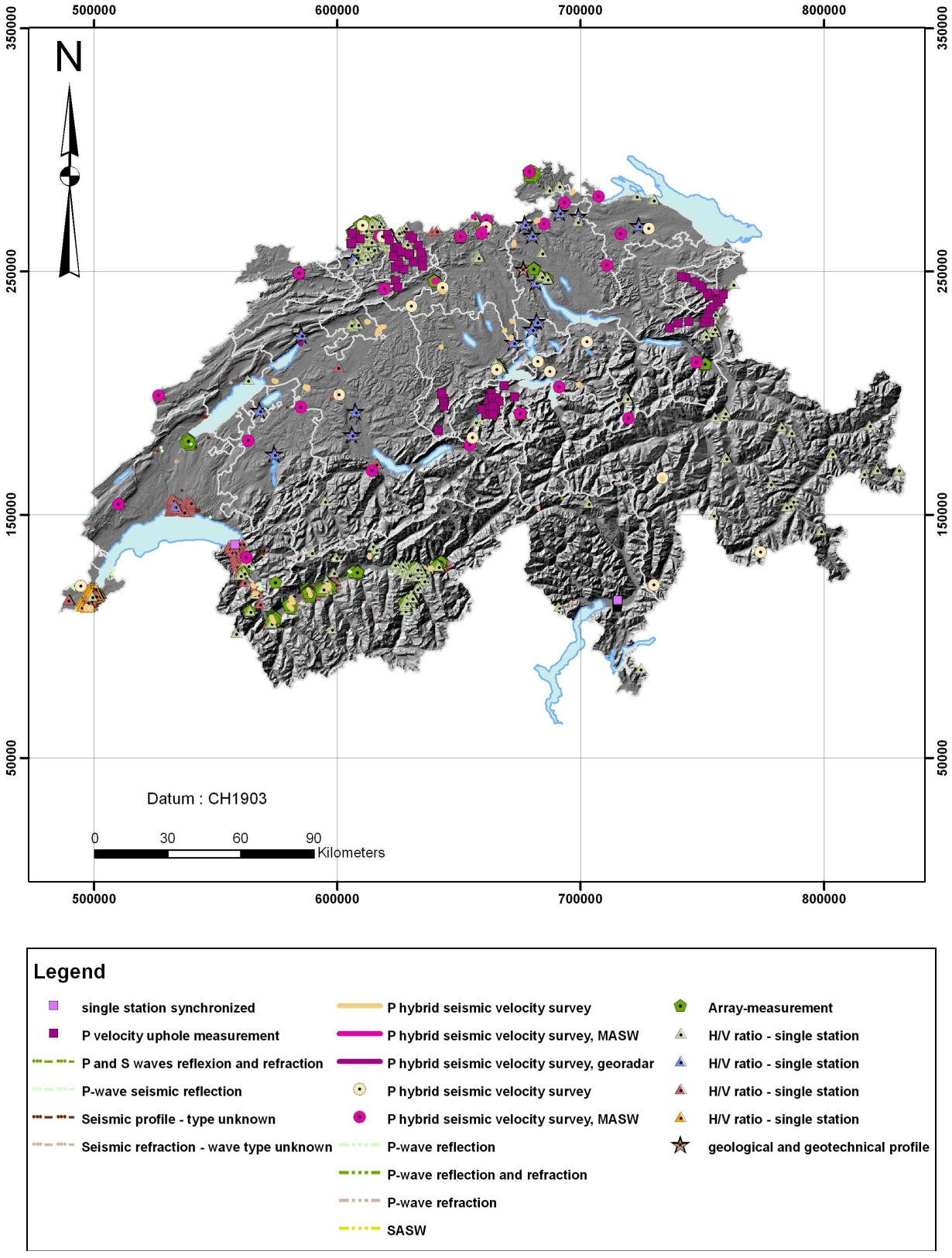

Figure 3. Location of geophysical measurements

Organization	Type of data	Quantity	Time frame	Accuracy of location	Level of completeness
UNIL (institute of Geophysics)	Reflection and refraction seismic profiles	126	1975-2007	Low to medium (on paper)	high
Swiss seismological service (ETHZ)	Ambient noise measurements	3626	1997-2009	Medium to high (GPS)	high
D-ERDW (ETHZ)	Geological and geotechnical profiles	23	2001	Medium (on paper)	high
Unit of Geological risk (UNIGE)	Ambient noise measurements	300	1998, 2006, 2010	Medium to high (GPS)	high
Geo2X	Reflection and refraction seismic profiles	129	1993-2008	Medium to high (maps and GPS)	medium
Résonance Ingénieurs-Conseils SA	Ambient noise measurements	395	1998-2009	Low to medium (on paper)	high
Geoform	P velocity uphole measurement and low-frequency spectroscopy (seismic noise)	116	1974-1985, 2006-2009	Medium (database)	medium
GeoExpert AG	P wave hybrid seismic survey, georadar, multichannel analysis of surface waves	100	1991-2008	Medium (reference system conversion)	Low (only a sample)

Table 2. Synthesis of data incorporated into the GIS database

5. Conclusions and perspectives

The goal of this work was to develop a metadata on geophysical investigations achieved on Quaternary deposits. Once this project launched and discussing with people, it appeared that there were more data than it was expected. As a consequence, the current metadata is only the tip of the iceberg of what has been really investigated through Switzerland, and for two main reasons, lack of human and financial resources.

Moreover when finalizing this report, new data are already acquired or will be acquired in Switzerland, especially in the field of seismic ambient noise and/or seismic velocities, either

profiles (e.g. Poggi et al., 2011) or in boreholes (e.g. Geneva, Yverdon). This demonstrates the dynamism in this domain.

Nevertheless the existence of such a database facilitates the overview of an area regarding geophysical investigations and permits to identify who to contact in order to have more information about the data. This database could be made public, with the agreement of the institutions involved, for example through the web-viewer of Swisstopo (Swisstopo, 2011).

To be more attractive, this database could be combined with existing works, such as the compilation of seismic profiles (Marillier et al. 2006, 2007) or the database on electric well logs (Chapellier and Dumont, 2003). It can also be complemented by geotechnical data from boreholes (e.g. SPT). In some cantons (GE, VD), public borehole logs are already accessible through internet (appendix I).

In case of interest in pursuing the development of this database, some suggestions can be made to improve the content :

- updating the database with missing and new data;
- integrating description of raw data, pictures of seismic profiles, of ambient noise measurement, etc;
- adding some characteristics on measurement, such as length of records, sampling rate;
- adding results, such as resonance frequency, level of amplification for ambient noise measurements, seismic wave velocity ranges, profiles, etc;

and the maintenance and upgrading :

- selecting an institution that should lead the update and development of this database that can be useful for multiple applications (e.g. seismic risk, landslide risk, water resources, geology etc);
- defining a frame for sharing data among institutions. As an example, the SITG Geneva (2010) is based on a charter where the role of each institution participating to the database is defined as well as their preferential access to the entire dataset. In that case, each institution is responsible of their data, but they follow some rules on the type of attributes needed to nourish the database.

It is only when a specific frame and an official mandate will be defined that the database could be developed and kept updated with a minimum effort and a maximum of efficiency.

6. Acknowledgements

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- Donat Faeh, Clotaire Michel, SSS-ETHZ,

- Corinne Lacave, Martin Koller, Résonance-Ingénieurs Conseils SA,
- Werner Leu, Geoform Ltd,
- Jacques Jenny, David Dupuy, Geo2x.

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Appendix I

Free accessibility of borehole data through cantonal geoportals. Situation on January 2011.

Canton	Website	comments
Argovie	http://www.ag.ch/umwelt/de/pub/themen/boden_rohstoffe/geologie_und_bohrungen/bohrinfo/bohrinfo_datenbank.php	On-line Borehole database but only with indication on location and depth – no map
Bâle-Campagne	http://www.geo.bl.ch/parzis/g.navigator/html2/main.html?RESTRICTED=FALSE	Short description of boreholes – no on-line link
Bâle-Ville	http://www.stadtplan.bs.ch/geoviewer/index.php?theme=190	Short description of boreholes – complementary information on-going (description, profile, pictures)
Berne	http://www.geoportal.sites.be.ch/site/geo	No data available online on boreholes
Fribourg	http://www.geo.fr.ch/	No data available online on boreholes
Genève	http://etat.geneve.ch/geoportail/infogesdec/	Boreholes location with on-line log for public ones
Glaris	http://gis.gl.ch/geoshop/client.html?user=oeffktgl&password=n	No data available online on boreholes
Grisons	http://mapserver1.gr.ch/gsv/index.html	No data available online on boreholes
Jura	http://sitn.ne.ch/jura.php	No data available online on boreholes
Lucerne	http://www.geo.lu.ch/map/boden/	No data available online on boreholes
Neuchâtel	http://sitn.ne.ch/	No data available online on boreholes
Niedwald	http://www.lis-nw.ch/moz/index.html	No data available online on boreholes
Obwald	http://www.gis-ow.ch/moz/index.html	No data available online on boreholes
Saint-Gall, Appenzell AR, Appenzell AI	http://www.geoportal.ch/	No data available online on boreholes
Schaffouse	http://www.gis.sh.ch/GIS_SH/BM3.asp	No data available online on boreholes
Soleure	http://www.so.ch/departemente/bau-und-justiz/sogis/interaktive-karten.html	No data available online on boreholes
Schwyz	http://webmap.sz.ch/bm31_webmap/BM3.asp	No data available online on boreholes
Tessin	http://mapserver3.internetgalerie.ch/ti-geo/ti-geo.php	No data available online on boreholes
Thurgovie	http://www.thurgis.tg.ch/	No data available online on boreholes
Uri	http://www.lisag.ch/de/daten-plaene/daten-kanton-uri-m462/	No data available online on boreholes

Valais	No geoportal available at the cantonal level	No data available online on boreholes
Vaud	http://www.geoplanet.vd.ch/index.php#	Boreholes location with on-line description for those being public, including a classification based on norm SIA 261
Zug	http://www.zugmap.ch/zugmap/BM3.asp	No data available online on boreholes
Zürich	http://www.gis.zh.ch/gb4/bluevari/gb.asp	No data available online on boreholes

Appendix II

Contents of the DVD

Elements	Description
Files	
Readme.txt	Short note
Soilresp.mxd	ArcGIS project allowing the launch of the soil response project content
Folders	
grid	Shaded relief and canton limits
shp	Data from each institution having shared their data, with an associated metadata (*.xml format)
tif	Topographic maps at 1:25'000 from Swisstopo