
DELIVERABLE

D5.1 Deep Seismic Sounding Data

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Summary

This document is an interim report within a work package of the SERA project. The document lists a considerable number of previous Deep Seismic Sounding (DSS) projects, where data is available in some form. DSS projects are large scale, logistically complex, and there can be some problems in obtaining formal permission to use the very large seismic sources which may be necessary to be able to successfully record seismic signals penetrating to the relevant depths and distances. This implies that in some cases it would be very difficult to repeat the projects, or conduct a similar project along the same recording profile. This means that even older data can be potentially very valuable, and not all such data is available in modern, digital form (e.g. time series), and some metadata descriptions may be complicated or incomplete.

In the text below, we discuss what is meant by DSS data; some of the complications related to this type of data, metadata, different forms of data, and some common types of derived (processed data) which exist. We also present information on a considerable number of DSS projects related to the European area, and list some (but far from all) relevant publications. Note that the term “database” is used in SERA. For DSS data, much data is available in well-structured and maintained digital databases, some is available in digital form only as images of seismic sections, and some data exists only in analogue form e.g. as plotted seismic sections. We consider all such types of data to be relevant, and include them in the “database” concept, as discussed below.

This interim report has been produced by workers within the working group, primarily from the University of Uppsala and CSIC in Barcelona. Contributors include Monika Ivandic, Angeliki Adamaki, Ramon Carbonell, Roland Roberts, and others.

1 Seismic Data and DSS

The term “Deep seismic sounding” or DSS is commonly used to describe controlled source seismic data penetrating to greater depths (over a few kilometers) into the Earth. The term often refers to “long range refraction” profiles, where one or several seismic sources, such as explosions, are recorded by seismometers spread over the surface of the Earth, often along a profile. A distinction is often made between such data and other types of seismic data even when these provide information on similar depths. Such other types of data include e.g. teleseismic tomographic data, local earthquake tomographic data, and analyses of seismic ambient noise. Given appropriate deployment of sensors, data from cultural sources, such as quarry or mining explosions, can sometimes be used in a similar manner to where a seismic experiment generates its own source signal. Such signals are routinely and continuously registered by permanent (and sometimes temporary) seismic networks or arrays. Not least because such explosions are often repeated many times at essentially the same location (e.g. the same mine), shot timing may not be precisely known, and such explosions may be complex salvos consisting of several different explosions with time delays between them, such data may in some cases be regarded by seismic network operators as uninteresting, and not be stored in the form of an event file or analysed. In other cases, such data is extracted by researchers and collated into a data set which may be used for analysis in a similar manner as a traditional long range refraction profile (see below) where the source is generated as part of the experiment. It follows that a DSS data management system should have the format and capacity to allow inclusion of data sets from (some) sources such as quarry

blasts, but it is probably not sensible to have the ambition that all such data should be explicitly identified and included in the database system.

In DSS studies, seismic signals following different paths through the Earth propagate from source to receiver. There are “direct waves” which propagate directly as a P-wave or S-wave from source to receiver. As controlled sources are essentially always relatively close to the surface, in terms of a ray description of the wave propagation, these waves do not follow a straight ray-path, but follow a curved path “diving” into the Earth before returning to the surface. Much of the energy recorded consists of reflected, rather than direct, waves. The recorded data often shows clear reflected arrivals which can be observed at several neighbouring recording points at different distance from the source. Similarity from location to location in the waveform of the relevant wave packet or burst of energy (often consisting of one or a few cycles at the dominant frequency) allows the arrival to be “correlated” (using visual inspection or some algorithm) and thus identified as an incoming “phase”. In some, but not all cases, general knowledge about seismic wave propagation and the Earth structure in the relevant region allows the phase to be associated to a particular reflecting horizon, such as the Moho. Both P and S waves reflect from boundaries within the Earth, and in general undergo some phase conversion on reflection. Thus, an incoming P wave produces both a reflected P-wave and a reflected S-wave, as well as signals propagating through the boundary into the underlying medium with separate P-wave and S-wave parts. In addition, waves are multiply reflected, from the surface of the Earth (multiples) or within layering within the Earth (doglegs), before returning to the surface and being recorded. There are therefore a great number of ray-paths through the Earth which may correspond to observable signal amplitudes at the receiver. It is impossible to specifically identify many of these ray paths individually as “phases”, but for ray paths which correspond to larger amplitudes (e.g. often the direct arrivals or Moho reflections), the phase may be clearly visible and it may be possible to associate it with a specific ray path. When analyzing DSS data, one approach is to identify phases, “pick” arrival times of these (using visual inspection or some algorithm) and deducing which ray-path this phase corresponds to. The picked arrival times from different phases, and often different but overlapping shot-receiver geometries, can be modelled or inverted to reveal Earth structure in the sense of seismic velocity. An alternative approach is to invert waveform data, i.e. not first picking phase arrival times. Here, a numerical model describing Earth structure is automatically adjusted to, in some defined sense, optimize the fit between the recorded data and synthetic data generated using the numerical Earth model.

Large controlled sources generate not only P- and S-waves, but also surface waves. These can also contribute information on Earth structure. The sensitivity of surface waves to velocity within the Earth is frequency dependent, with lower frequencies being sensitive to greater depths. Because of the frequency content of the signals generated, most surface wave data from DSS studies elucidates only relatively shallow structures.

There are established methods for presenting and describing DSS data. This includes a nomenclature for the description of ray paths.

Controlled source near-vertical incidence seismic reflection data is acquired for commercial and scientific reasons, and some of this data relates to considerable depths within the Earth. The total number of such projects, and the total volume of data from these is vast. In addition, much of the commercial data is confidential. Therefore, while much such data could be classified as “deep sounding”, in the SERA project we make a distinction between the “near-vertical incidence” data and DSS, and focus on the latter. We do not e.g. here have the ambition to list all relevant near-vertical incidence projects, even though there is near-vertical incidence data included in some of the projects which we list. In our context there is no clear and absolute distinction between “wide angle” and “near vertical” reflections, meaning that any distinction between DSS and near-vertical data sets must be pragmatic. While we do not, within SERA, hope to map all available data, our intention is that the metadata descriptions and discussions should be appropriate for the various types of controlled source seismic data relating to the deeper Earth.

1.1 Experimental configurations

A “classic” DSS experimental configuration consists of a long profile of recording stations (seismometers), extending over tens or hundreds of kilometres, or more. Station spacings vary from project to project, being steered by the length of the profile and the number of available sensors and their associated equipment for recording the signals. Separations of some kilometers are not unusual for longer profiles. At several points along the profile, shot points are defined, and large explosions are fired at these locations one or several times. Repeating shots at the same location allows for redeployment of recording stations, allowing more recording points along the profile for the given shot point(s). The explosions may be in boreholes, but for cost and logistical reasons are often in water (lakes or the sea). The explosions used may be very large – up to several tonnes of explosives. Even nuclear explosions have been used as DSS sources. It is also possible to use airgun sources. This has the advantage that many close-lying source locations can be used i.e. that there is a source “array” as well as a receiver array. Disadvantages include cost and that the sources can only be where there is accessible water of an appropriate depth for the boat. If boat-driven airguns are used as sources in a DSS study, it may be appropriate also to use a steamer containing sensors (hydrophones) to also record near-vertical incidence data. Also signals from other sources, such as vibrators, can effectively penetrate to considerable depths, if the vibrations are of sufficient amplitude and the Earth structure in the area is appropriate. The amplitude of signals which is practically feasible to generate from vibrators and airguns is limited, and large explosions may be necessary to produce observable signals at greater distances, corresponding to waves sampling the Earth at greater depths (deep into the mantle). In many areas, for e.g. environmental reasons it has become increasingly difficult to get permission to detonate such large explosions, precluding many conceivable new classic long range refraction studies. This means that much of the older data may be regarded as unique and not practically reproducible, so securing data from these projects may be important for the future, despite the major instrumental improvements which have been achieved over the last few decades.

1.2 Instrumentation

Due to the nature of the sources and attenuation of the seismic signals over the distances involved, only a limited range of frequencies are usually relevant for DSS studies. This may be e.g. 1Hz to 20Hz, but varies from project to project. In some cases, hydrophones or “ocean bottom” seismometers or hydrophones may be used. Usually, seismometers are deployed simply, by simple placement on a rock outcrop, if one can be found at the right location. If no outcrop is available, soft layers of top-soil may be removed before mounting the sensor. The details of deployment can be important for the quality of recording, and should therefore often be documented for each recording site. Similarly, it may be appropriate to document if there are any obvious significant noise sources close to the site, or e.g. if topography is severe (which may imply significant perturbation of waveforms).

Sensors may be single component seismometers; if so, usually vertical component. Three component sensor may also be used. In some cases, small arrays of sensors may be used with the aim of enhancing signal to noise ratio for the DSS signals, but (in contrast to some near-vertical incidence studies) in general the advantages of multiple hard-wired sensors is limited. Instead, the processing of the data recorded by neighbouring stations can be used to achieve “velocity filtering” or some other type of array analysis. Early instrumentation recorded mechanically on e.g. paper or film. This was replaced by analogue recording on magnetic tape, and then digital recording. Some modern equipment allows

simple telemetric digital communication with sensors. Analogue recordings can be robust e.g. because of the low information density, so it can sometimes be possible to read data from aged and partly deteriorated fm tapes. However, such primitive forms of recording often do not contain reliability indicators, such as parity bits in digital recording. Different storage media may imply different types of potential data errors, e.g. timing drift during a recording.

As in most cases each recording instrument is stand-alone, and the relative time of arrival of signals at the stations is fundamental to analysis, accurate timing information for each recording is centrally important. Clocks may be used for this, but these (especially the older ones) have limited accuracy. Many modern instruments use timing information from GPS satellites. It is also possible to use timing signals transmitted by terrestrial radio antenna. The latter was common prior to the GPS-era, but has now largely been superseded.

Similarly, modern techniques can provide simple, high-precision, data on the location of a sensor. Earlier, precise locations were more difficult to assess, and were often simply estimated by reading off coordinates from a map. There may be significant errors in such location estimates. In addition, different coordinate systems may have been used (sometimes even within the same project). It is important to know in which system the coordinates are expressed.

Where three-component sensors are used, the horizontal alignment of the instrument must be defined and noted. Commonly, magnetic North is used for this. Alternatively, a simple compass reading may be used to align the sensor components with the orientation of the DSS profile. Errors in alignment are not uncommon, potentially causing difficulties with the analysis of three component data. Achieving vertical deployment is easier, but as many sensors are deployed individually and temporarily, it is likely that there are often small (but possibly significant) deviations from the vertical. With some types of instruments, it has been possible to confuse the connections for different sensors, implying that the three components may be incorrectly identified in the data.

The instruments used for DSS studies are usually rather robust field instruments. In many cases, these were not regularly calibrated, and users have simply assumed the calibrations (frequency response) quoted by the manufacturer. There may well be both smaller and larger miscalibrations in a given data set. In many cases, this is of limited significance, but for other types of analysis, it may be more important, for example if the sensor is not aligned physically with the profile, but rather a vector rotation of the data is used to produce the horizontal components perpendicular and parallel to the DSS profile.

Clearly, information on details of the instrumentation, timing accuracy, sensor location etc may be important for analysis of the data, including e.g. assessing if some types of analysis are feasible at all. It follows that the meta-data associated with each data set should contain all potentially relevant available information.

1.3 Data processing

Here, we summarize some of the commonly used steps in the analysis of DSS data. Not all methods are mentioned. Because in some cases only processed or derived data is available (as opposed to the waveform recordings from the individual stations) it can be important to understand which processing steps have been applied to produce the available data.

To enhance signal to noise ratio, data is usually filtered. This was sometimes done using analogue filtering, but for many years this has been done primarily digitally (albeit perhaps with an analogue Nyquist filter prior to digitization). The “optimal” frequency band for analysis may be different for

different wave types (P, S), for different phases, and for signals at different distances from the source. Therefore, analysis using several different filters on the same data set is not unusual.

Data can be presented as a “section” with the time series (“trace”) of each sensor plotted “vertically” and its “horizontal” position on the plot determined by the station’s distance from the shot. It is often convenient to use “reduced time” plots. The format of these is as described above, but the timing of each trace is shifted according to its distance from the source and a chosen reduction velocity. This means, for example, that if a phase has an apparent velocity between stations of 6km/s, then if a reduced time section using a reduction velocity of 6km/s is produced, then this phase will appear as a “horizontal” feature in the plot i.e. the phase will arrive at the same (reduced) time at each station. Plotting the same data with different reduction times may make the image look rather different, which may be of significance when e.g. picking arrival times (see below). Therefore the same data set may be investigated using plots with different reduction velocities.

Such sections are one form of “data” which can be used for further analyses.

There are various methods aimed at enhancing features in the sections. This includes various types of velocity filtering, often based on simple delay and sum operations on segments of data. Different components of ground motion can be plotted separately, or the information can somehow be combined numerically. As in reflection seismics, we can also calculate and display “attributes” (e.g. instantaneous frequency) associated with the traces.

The traditional method of analysis of such data is to identify arrivals on the sections which are (according to visual assessment) correlated between neighbouring stations, and to pick the (first) arrival time for this phase at each individual station. From the timing of the arrival of this phase, its apparent surface velocity (slope on the section), its character (e.g. dominant frequency) and other information (e.g. existing insights into Earth structure in the area, similar phases seen for other shots) it is assessed if the phase is e.g. a direct wave, or e.g. a P to P or P to S Moho reflection etc. After analyzing several identifiable phases in this manner, a derived data set is generated, including the arrival times of particular phases at several stations, and from different shots. This derived data set can then be used for analysis to produce information on Earth structure via modelling or inversion.

1.4 Forms of data storage

Much waveform data is available in modern digital form, and should be directly accessible, technically. Some older data may be in digital form, but may be recorded on outdated media, including various now-defunct tape formats, going back to old-fashioned 7 track and 9 track computer tapes. Even where these tapes exist, it may no longer be possible to read them. It is, of course, unfortunate if such data has been lost. However, the work (and expense) necessary to long-term secure digital data was rather high e.g. three or four decades ago, and it was not unusual that it was not considered possible to maintain such data. Such tapes should be re-wound regularly at relatively short intervals (months) and copied to new tapes every few years. Analogue fm tapes also still exist in some places. In many cases, data has already been transferred to digital media, but not in all cases. It is possible that some such tapes are still readable, but the readability decreases as time progresses.

Some data sets only now exist in the form of sections, on paper or some other medium (e.g. microfilm). Digitizing such images is straightforward, if desired. In some cases, these images may exist only in the form of pictures in published articles in journals, with limited resolution.

Derived data, such as picked phases and derived Earth (velocity) models exist in many different forms.

1.5 Metadata

DSS data may be inhomogeneous in various different ways. Metadata definitions should preferably be such that all relevant data can be properly and completely described using a single suite of metadata definitions.

Several different forms of seismic data exist. Clearly, as far as possible, common data and metadata formats should be used. The formats for storage of DSS data as such should be common with other forms of similar data. There are, however, a considerable number of possible relevant additional types of information which are relevant for DSS data. It is also likely that the technical developments over decades and the consequent changes in relevant metadata mean that some metadata may be different in character for older contra more recent projects. Below, we list some of the characteristics which it may be important to document as part of the metadata for a particular data set. It is not intended that the list here should be complete. One reason for this is that it is plausible that there are some complications, and thus metadata definition issues, about we are unaware, especially for the older data. In addition, defined metadata structures should build upon and be fully consistent with metadata choices in general within the EPOS framework.

In contrast to e.g. seismological data, many DSS observation stations only exist very temporarily, registering very few events (shots). This implies that information on sites may be less reliable than in some other cases (e.g. data from seismological network stations), and that the risk of e.g. incorrect mounting of instruments (e.g. horizontal orientation) may be larger, with technical problems possibly being undetected.

In the continued work within the SERA project, we intend to identify and address as many such issues as possible. To achieve this, we will require support and input from a broad community. This will be achieved partly through the planned workshop meetings, partly through bilateral contacts with colleagues at relevant institutions. The first broader meeting is planned to be at the coming EGU meeting. The main intention there is to discuss a “position document” regarding DSS data, which we have circulated beforehand. This should provide us with comprehensive feedback from the community regarding how to proceed with the further steps within this project aimed at a more concrete “roadmap” document for the relevant types of data, and how DSS data best fits into the EPOS framework, conceptually and practically. We envisage that effective interaction with the community will be necessary in order to define optimally details regarding metadata and data structures, and related software. It may be relevant to have a workshop meeting in connection with the 2018 Seismix meeting, but this may be too soon after EGU, and it may be better to arrange a meeting separately.

One relevant example of a possibly relevant existing metadata description can be found at e.g. <https://www.ngdc.noaa.gov/mgg/ecs/metadata/seismic/seismicmetadata.html>

Information on the specific project

Project ID

Subprojects (DSS projects often consist of subprojects e.g. in the form of different profiles)

Dates of project

General description (free-text) of project

Purpose of project (free-text)

Supplementary information, if relevant (free-text)

Type of data (in general)

Data format(s)

Data quality (free-text) For some of the older data, it may be appropriate to e.g. note that there is a risk of some confusion about which data is which (e.g. identification of profiles within a given project), or that some location information may be particularly questionable.

Project geographical information (location)

Institution responsible for project, with contact information

Other participating institutions, with contact information

Contact information to the institution or institutions providing data access

Information on the sponsor or sponsors of the project

Information on possible restrictions on data use (e.g. limitations in allowable use, embargo periods, if some data permanently confidential, etc)

Information on results from the project (e.g. published articles)

Information on who has been granted access to the particular data set (to avoid the risk of parallel analyses without communication. This information can presumably not be retrospective).

Information (not retrospective) on citations to this data set (journal publications etc)

Information on processing which has been performed on the data (possible partial overlap with some of the points below)

Positioning information of receivers and shots

Latitude and longitude, or x-y position in the coordinate system used.

Geographical altitude at the relevant point

Time(s) of the shot or station deployment

Depth (borehole or water depth)

Coordinate system used

Assessed uncertainty in the coordinates

Method used for location measurement (e.g. GPS or reading from a map)

Who (institution, individual) provided the location estimate

Possible comments on the location estimate

Information on the source

Type of source (explosion, airgun)

Deployment (e.g. explosion in water, and if so at what depth, airgun array description etc)

Size of source

Other relevant information, e.g. uncertainty in depth, uncertainties in size (e.g. if it is suspected that not all of the explosive detonated), observed indications of possible source directionality, possible secondary effects at the source (e.g. falling material after the explosion) etc.

Information on the sensor

Type of sensor (e.g. vertical component, 3 component)

Single or multiple sensors

If more than one channel, suitable identification of which is which in the data file(s)

If multiple sensors, how these are linked (e.g. separate channels recorded, or a summed trace)

Manufacturer

Manufacturers specific sensor type identification

Specific identification of the particular sensor, if it has one ("unique identifier").

If the sensor can be used in different modes (e.g. different analogue filters), information on which mode which is relevant, and when the sensor was switched to this mode.

Information on the manufacturer's calibration information (if this is not included in the metadata system)

If the individual instrument has been calibrated, and if so when, and where the calibration information can be obtained (if this is not included in the metadata system)

Information, if any, on e.g. previous problems with this particular sensor, or this type of sensor (e.g. problematic sensitivity to ambient temperature, sensitivity to inappropriate deployment e.g. tilt)

If the “sensor” includes an analogue to digital converter:

information on the type of a/d converter

identification of this specific a/d converter, if available

if a separate a/d converter is used, distance between sensor and a/d converter

Possible comments on the sensor e.g. if the sensor is recently repaired, which institute or individual did this, if the sensor or casing appears to be physically damaged in some way, etc.

Information on deployment of the sensor

What was the sensor mounted on (e.g. rock outcrop, shallow hole down to consolidate soil).

If the operator notes any possible local noise sources or strong local topography

For a 3-component sensor, how the sensor was oriented (e.g. N-S or aligned with the profile, and how this was achieved (e.g. compass).

Distance from the sensor to the recording equipment

Free comments

Information on recording equipment

Storage medium. Storage format.

Relevant technical information on this type of recording medium

Free comments

Timing methodology

Assessed accuracy of timing information

Information on filtering, if relevant

Free comments

Information on stored time series and related data

Data format

Information on how to read the data correctly

Information on possible complications, such as uncertain information.

Information on data sections

Component

Which data set (profile, shot etc) this refers to

Type of section (e.g. reduced time)

Reduction velocity

Frequency filter used – type, frequency band etc.

If any other processing (e.g. velocity filtering, attributes) has been applied, and if so relevant information on this.

Which data not included, and why (e.g. corrupt data from one station)

The form in which this section exists (e.g. on paper, as an image from a journal, etc)

Free comments

Information on picked derived data

Which data set this refers to
 Phase identification
 Station identification or position
 Time of the pick
 Quality assessment of the pick, if available
 Who (institutionen, individual) picked this data
 Free comments

Earth (velocity) models

The issues here are very largely common with such models derived from other forms of data, so we do not attempt to list these here. There are some aspects which are especially or only relevant for DSS data e.g. in assessing Earth models from such data, it is often very important to examine ray-path coverage, which may affect interpretation. Therefore, it is common that for each Earth model there is an associated image showing the ray coverage.

1.6 Existing data repositories

Considerable amounts of data are already secured in various data repositories around Europe, including e.g. GFZ, Helsinki University, CSIC in Barcelona, and many others. Much data is still stored at a large number of institutions in different countries, sometimes in a well-organized and accessible form, sometimes not. Aims for SERA include identifying as much such data as possible, and together with the relevant institutions finding a suitable way of making this data secure and accessible for the future. In some cases (e.g. images of sections) it is possible that it will be considered best to store some of the data centrally within the EPOS database system. Much data will likely be best stored in a more distributed manner, with metadata information within the EPOS system. Data access could in principle be achieved by having a centralized European “thematic service”, perhaps maintained by one of the existing institutions which already have well-functioning database systems. However, given the special character of the relevant data (some of which is rather old, and there may be various complications and a lack of some information regarding the data) it seems likely that it will be better to aim for a more distributed system, possibly including direct access to data from many data-owning institutions, possibly via a more limited number of institutions who consider it appropriate to offer a service to other institutions e.g. within their own geographical region. As many of the relevant DSS projects were collaborations between several different institutions around Europe, it is possible that some coordination of data access between these institutions may be necessary regarding individual projects. In contrast to e.g. near-incidence reflection data, much DSS data is academic rather than commercial, and complications related to data ownership appear likely to be relatively few compared to some other forms of data relevant for EPOS. With some exceptions (e.g. some major projects including many airgun shots and combined wide-angle/near-vertical incidence data collection) because of the nature of DSS data the volumes of data involved are rather small, implying that technical issues related to data storage and distribution should not be particularly problematical.

In the coming work within SERA, an important step will be to follow through a dialogue with institutions with existing database systems. It seems plausible that one or more of these can provide the technical basis for the design of a homogeneous European system suitable for EPOS. One central issue here is, of course, metadata definitions.

Some of the older data may only now exist in the form of sections published in journals. Technically, making such data available via EPOS should be straightforward. However, some complications may arise regarding copyright.

Some of the existing databases offer not only access to data but also to some processing tools. Pan-European coordination of such tools is a natural development in the EPOS context, and this will be further investigated, not least by dialogue with the relevant community, during the continued work within this work package.

1.7 Information on past DSS Projects and Profiles, Databases and relevant literature (attached Tables)

Prodehl and Mooney (2012, “Exploring the Earth's Crust – History and Results of Controlled-Source Seismology”) have presented and described major seismic projects (on land as well as oceanic) which took place worldwide, from 1850 to 2005. More than 300 projects from those mentioned in this book were located around Europe, since 1940, and are listed chronologically in **Table 1** (see supplementary Excel files), where the year (column 1), location (column 2) and a reference article (column 3) are mentioned for each project. In cases where the profile was part of a bigger project, brief information is also listed (column 4).

About 50 major and relatively recent projects located in Europe are listed alphabetically in **Table 2** (see supplementary Excel files), where the acronym (column 1), the full name (column 2) and the year of the project (column 3) are mentioned. For most of these projects a list of relevant links is provided (column 4), to provide information given from institutes where each project might be affiliated to, and occasionally a relevant publication. Accordingly, **Table 3** (see supplementary Excel files) includes similar information on profiles that have been part of bigger projects and can be found in the literature.

Some of the main groups and programs that have been involved in DSS projects are listed in **Table 4** (see supplementary Excel files). Acronyms (column 1), full names (column 2), affiliated Institutes and names of contacts (column 3) as well as links (column 4) are also included. More information about the existing data can possibly be found through these contacts, for the following steps of this work.

After visiting part of the relevant literature and several institutes and associations involved in DSS projects, information on data centres that apparently have archived data has been collected and listed in **Table 5** (see supplementary Excel files). The type of data is not always clearly mentioned, but the links provided in the table (column 2) also include contacts for further communication.

A list of references relevant to the information found in the tables and described above, can be found together with this documentation.

2 References

References, listed geographically, to major projects and other material.

France

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