SEISMIC PATRIMONY PRESERVATION TUTORIAL

What can we do with analog seismograms and related seismic documentation?

M.T. Merino, J. Batlló, T. Andrades

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With the collaboration of:

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PROLOGUE

Origin and purpose

The Fabra Observatory (*Observatori Fabra*) has been operating in Barcelona since 1904. It was created and is maintained by the *Royal Academy of Science and Arts of Barcelona* (*Reial Acadèmia de Ciències i Arts de Barcelona* – RACAB), a scientific association founded in 1764. Since its inception, the observatory has focused on astronomical, meteorological, and seismological research. Seismic observations in *Observatori Fabra* begun in 1906 and, since then, have continued. These include instrumental records as well as collected macroseismic data, primarily from the Eastern part of the Iberian Peninsula. The observatory's historical archive holds thousands of seismograms and complementary documentation in a wide range of supporting materials: handwritten and printed bulletins, station registers and notebooks, specialized and outreach scientific articles published in journals and newspapers, personal and scientific correspondence, and publications from other institutions worldwide. Almost all used instruments are preserved, some are exhibited in the observatory's small museum, while others are still in use today for various purposes.

Nowadays, *Observatori Fabra* continues as an active institution in its original fields of astronomy, meteorology and seismology. As an institution of small size, it adds its expertise to larger projects of interest for the scientific community and cares its valuable observation series. Following this line, in the last decades we have increasingly devoted more of our limited resources to preserving, using and sharing as much of our seismic heritage as possible. We participated in European projects TROMOS and EUROSEISMOS and obtained through many modest other projects partial inventories, restorations, studies and scans for preservation of the seismic heritage.

Besides, the observatory has outreach as another goal: it has a museum of old instruments, holds courses, conferences, scholar visits, and many other occasional activities. We are proud of maintaining our long tradition of being willing to share and collaborate in both scientific and outreach purposes with other investigators, institutions, individuals and groups in many and extremely diverse ways. An extensive summary of our seismic historical patrimony, along with a detailed inventory up to that date, were already presented in several international congresses and forums in order to contact and keep in touch with other institutions interested in these same fields.

In 2014, RACAB celebrated its 250th anniversary, coinciding with the 100th anniversary of Mainka seismographs series, recorded in smoked paper from 1914 to 1998. Besides, the RACAB main building in Barcelona center and the *Observatori Fabra* building had been recently officially declared buildings of cultural-historic national interest in Spain. Moreover, *Observatori Fabra* was also awarded with the *Historical Site* distinction by the *European Physical Society*. These milestones inspired and facilitated the continuation and development of projects aimed at recovering, preserving and disseminating the observatory's historical heritage. In these endeavors, we benefited from the invaluable advice, assistance and support of particulars and institutions, notably the *Institut Cartogràfic i Geològic de Catalunya* (ICGC) and the *Istituto Nazionale di Geofisica e Vulcanologia* (INGV). With their help, we have conducted record inventories, restorations, studies and document scanning and digitization. Comprehensive summaries of our seismological heritage, along with detailed inventories, have already been presented at international congresses and forums, fostering connections with other institutions engaged in similar fields.

Since the creation of the Catalan Seismic Network, *Observatori Fabra* has maintained a close and ongoing collaborative relationship with the institutions responsible for its management, which have been sequentially *Servei Geològic de Catalunya* (SGC), *Institut Cartogràfic de Catalunya* (ICC), *Institut Geològic de Catalunya* (IGC) and *Institut Cartogràfic i Geològic de Catalunya* (ICGC). With the support of the ICGC

and its predecessors, we have expanded our detailed inventory of seismograms and digitized most of the macroseismic documentation, bulletins, and related studies. The volume of classified and scanned documents continues to grow, and we are now working to make the majority of these records and the results of both completed and ongoing projects freely accessible to the scientific community and the general public.

Besides, we collaborated intensively with the SISMOS unit initiatives in INGV and, specifically, with its coordinator, Dr. Graziano Ferrari. In addition to TROMOS and EUROSEISMOS initiatives, and thanks to their help and support, many elements from our old instruments could be restored and many of our seismograms and accumulated complementary documentation for the study of the seismic records (station books, notebooks with corrections, etc) were scanned. In fact, the origin of this small tutorial now introduced relies in these works and the preparations for the exhibition "*Dal cielo alla terra: meteorologia e sismologia a Firenze dall'Ottocento a oggi*" ("From the Sky to the Earth: meteorology and seismology in Florence from the 19th Century to Nowadays") in the prestigious *Galleria* of *Palazzo Medici Riccardi,* where *Observatori Fabra*'s *Microsismografo Agamennone* instrument was exhibited. During the course of this work, Dr. Ferrari kindly arranged several visits through selected old observatories in Italy with Maria Teresa Merino (in charge of seismology section in *Observatori Fabra*) and Tana Andrades (specialist in conservation and restoration in the respective services for the old archives in the University of Barcelona - CRAI). As *Head of Functional Unit SISMOS* in INGV and *Coordinator of the Working Group "Methods and Data for the Study of Earthquakes Recorded on Pre-WWSSN Seismograms"*, Dr. Ferrari brings decades of experience across institutions, observatories, and archives. He wisely suggested the increasing need for some reference and basic knowledge compilation easily and freely available to all kinds of archive responsible and curators in order to avoid losing more seismic heritage and that the recent and ongoing *Observatori Fabr*a experiences could be regarded as useful examples for both, errors and suggestions, with the following main goals in mind: 1) set an example of doable activities and projects that a small independent observatory can undergo related to seismic heritage, even with severe limitations of resources and personnel; and 2) share with others these experiences, strategies and a few suggestions on what and why to do or NOT to do for each case.

The idea of creating a collaboratively written guide has circulated for several years and has always been seen as highly positive and useful. However, the personal and professional commitments of those involved—including the retirement of Dr. Ferrari—prevented its realization. After several years, Josep Batlló from ICGC revived the initiative, leading to the development of the tutorial presented here as a joint project supported by RACAB and ICGC, now freely offered to the international community.

The scope, purpose and elaboration of this tutorial has been progressively presented and discussed to a potentially interested audience through several public contributions in international forums and congresses in order to result in an enriched useful reference with as many contributions, doubts, and observations from our colleagues as possible. We decided to create a tutorial centered in paper-based legacy seismograms and its complementary documentation devoted to ease the smallest institutions to recognize their seismic patrimony and to face some minor actions or projects to improve its preservation and use, as a brief and useful compendium of best practices and problems to avoid about identification, inventory, conservation/preservation, restoration, use and exhibition of seismic patrimony. We think it can also be useful to bigger institutions as a guide to sharing initiatives towards using their limited available resources with accorded goals, standards and practices in order to maximize potential results.

A first public beta version of the complete tutorial was presented and made available online during ESC2024 and this first final version includes suggestions, corrections and improvements received since then. I sincerely hope this initiative helps observatories and institutes with seismic heritage with as much external influence and corrections as possible.

Jorge Núñez de Murga
Director of Observatori Fabra

INTRODUCTION

Goals, resources and constraints

Instrumental seismic recording began in the second half of the 19th Century and has since evolved into the sophisticated digital networks we use today. However, for over a century—until the late 20th century—seismic ground motion was recorded using analog instruments.

Analog seismograms and related documentation contain a wealth of original and scientifically valuable data. Preserving and utilizing these records requires dedicated effort. Recognizing this need, several initiatives were launched within IASPEI (*International Association of Seismology and Physics of the Earth's Interior*) and, at the European level, within the ESC (*European Seismological Commission*). In 1992, a Working Group on the "*History of Seismometry*" was established and has remained active to this day (see references [1], [2]). Seminal Italian projects such as TROMOS and SISMOS served as catalysts for further European developments (see reference [3]).

Many of these initiatives rely on voluntary contributions, which poses a significant challenge to their long-term sustainability. Nonetheless, there is growing recognition of the scientific importance of legacy seismograms and the urgent need to preserve and make use of them. This awareness has led to dedicated sessions at General Assemblies, where experiences and strategies are shared. These efforts aim to optimize limited resources through standardized, practical objectives that maximize the potential impact (see the final section of this manual: *Resources and References*).

Despite these advancements, many original records remain at risk—often stored in inadequate conditions within small (and sometimes larger) institutions that lack the resources or recognition necessary for proper preservation. In many cases, both human and material resources are scarce, making it extremely difficult to improve the current situation.

Legacy seismograms are not only scientific records—deliberately obtained data documenting seismic activity—but also unique historical artifacts (such as medieval manuscripts). As such, they require careful preservation to ensure their availability for future generations.

In many institutions, the custodians of these collections—referred to as curators in archival terminology—are scientists with backgrounds in physics, mathematics, or Earth sciences. While they are well-versed in the scientific content of the seismograms, they often lack knowledge about the physical characteristics of the materials and the specific preservation measures required. Conversely, when seismograms are housed in libraries or general archives, access can be limited because curators may not recognize them as scientific data, focusing instead solely on preservation. Although these challenges have begun to be addressed in recent years, much work remains to be done to bridge the gap between scientific and archival perspectives.

From the Working Group (WG), we firmly believe that guidance and collaboration on the preservation of legacy seismograms are essential. This freely distributed short handbook offers basic recommendations to help curators to respond appropriately to preservation needs.

We have aimed to make this guide as clear and accessible as possible, targeting readers with no prior expertise in the subject. It presents a concise overview of common issues, key considerations, practical suggestions, and foundational concepts. To maintain simplicity, examples from other initiatives are included in tables and figures, while more detailed and comprehensive references are provided in the final section.

This manual is intended to equip readers with the basic knowledge needed to explore more in-depth literature without becoming overwhelmed. As a starting point, we focus primarily on analog seismograms

recorded on paper—whether smoked, photographic, or ink-based—and their accompanying documentation, as these are the most common and accessible among historical records.

Legacy seismograms are not isolated artifacts—they are products of their time, shaped by the scientific, social, and technological contexts in which they were created. For this reason, it is equally important to preserve and document the broader environment surrounding their production, even though these aspects are not covered in detail in this manual to maintain its simplicity and focus. Key elements worth considering include:

- **Original Instrumentation and Related Materials:** This includes the seismic instruments used at the recording stations, along with any associated documentation and tools used for preparation, maintenance, and post-processing. Items such as calibration records, operation manuals, materials and tools for smoked or photographic paper processing, and information on the origin and composition of materials are all valuable for understanding and preserving the records.
- **Physical and Operational Contexts:** The locations where instruments were installed and operated, as well as the spaces used for maintenance, preparation, storage, and analysis of the seismograms and their accessory documentation, are crucial to document. Historical context and graphic information, including photographs, drawings, or architectural plans, can help resolve recurring questions about the conditions under which the data were recorded.
- **People and Practices:** Knowledge about the individuals involved in the operation of seismic stations, data processing, and archiving is essential. Much of the procedural knowledge was transmitted orally, and understanding the roles and routines of these individuals can be key to interpreting the records. Interviews, oral histories, and personal accounts should be recorded and preserved as integral parts of the documentation.

Looking ahead, we plan to expand this handbook with the support and collaboration of the seismological, archival, and conservation communities. Our vision is to develop a collaborative, dynamic, and evolving resource—similar in spirit to the *New Manual of Seismological Observatory Practice* (NMSOP, see reference [4])—where topics are continuously updated and expanded. This guide could serve as a complementary resource to the NMSOP, focusing specifically on the preservation and contextualization of legacy seismograms.

Figure 0. *Some seismograms from the first seismic station in Observatori Fabra (Barcelona, 1906-1913). Before (left) and after (right) considering and applying techniques and recommendations included in this manual. Source: Observatori Fabra*

CHAPTER 1

IDENTIFICATION OF SEISMIC PATRIMONY

How to get started: What do we have and what condition is it in?

Introduction

If we are responsible for a collection of analog seismograms or discover one, it is essential to first identify the materials and elements it includes and assess their condition. Before deciding on any actions, we must answer some fundamental questions (what?, how?, where?) as thoroughly as possible. Only then can we begin to address deeper questions (why?, when?, for what?, with what?).

In the following sections, we briefly review what is considered seismic heritage and outline the key questions that should be asked during the initial assessment.

IMPORTANT

- **Preliminary Assessment:** This chapter highlights several aspects to consider during the initial phase. It is valuable to note something for each highlighted point, even when answers are unavailable. This helps distinguish whether the lack of information is due to uncertainty, difficulty in accessing data at this stage, or complete absence of knowledge.
- **Minimize Risk:** This identification phase is purely informative. Care must be taken to avoid introducing disorder, damage or irreversible changes to the preserved materials, which could affect their conservation, cataloging or future studies. For this reason, we strongly recommend reading Chapters 2 and 3 before beginning this process.
- **Inclusive Inspection:** During the inspection, pay attention to all materials associated with the seismograms, including seismograms with no usable data, cut or broken fragments, photographs or copies of originals and any other related items. These materials should be preserved as well, as they may help clarify uncertainties or serve as useful references for tests and studies described in later sections.

Seismograms

Seismograms are the original **instrumental records**. As irreplaceable original data (in general unique pieces, often without any existing copies), their proper long-term conservation is a priority.

They can be significantly **different in their physical constitution**.

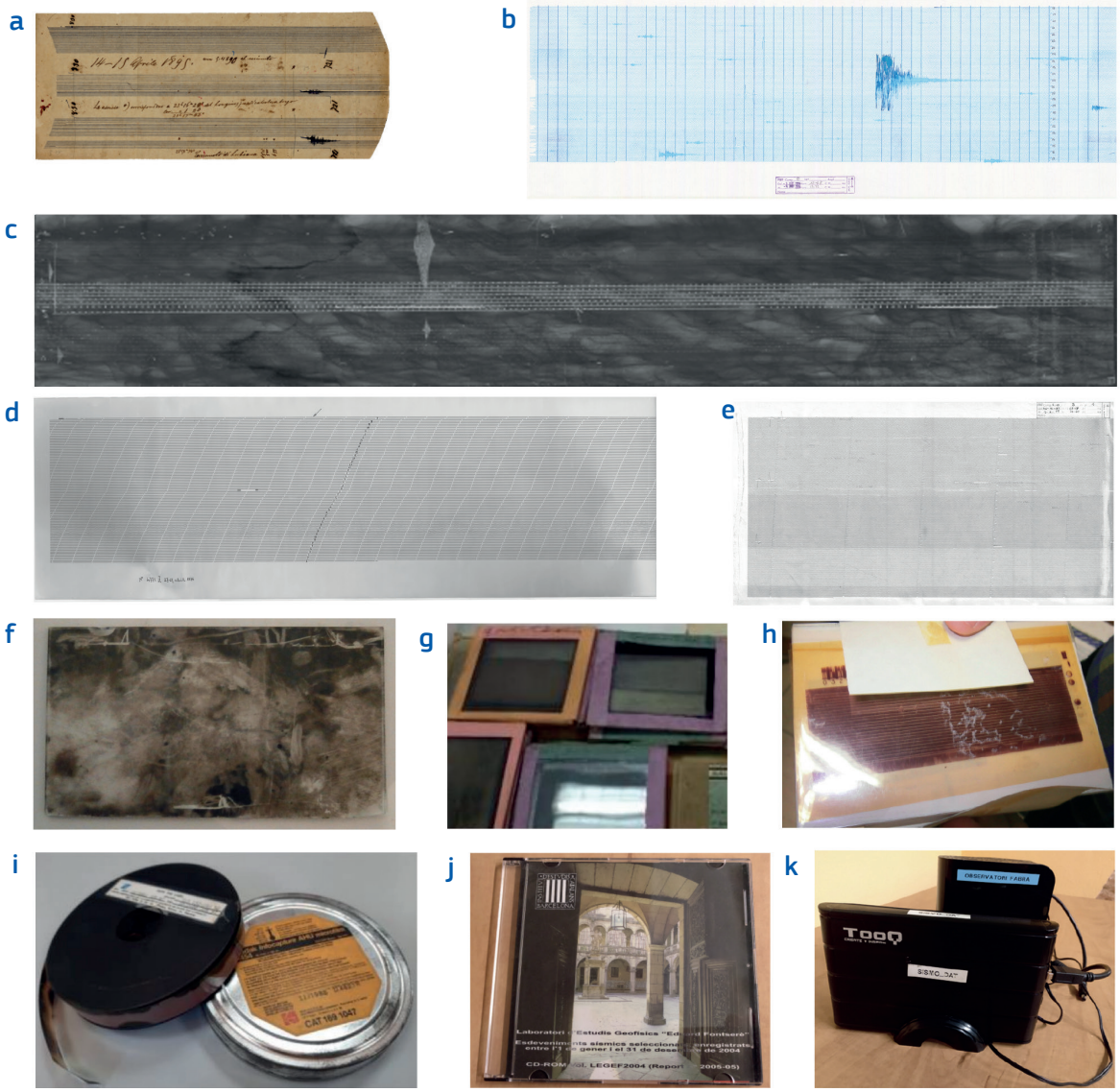


Figure 1. *Some examples of the diversity of supports and materials with analog seismograms recordings: (**a**) old paper with inscription in ink by a needle from beginnings of XX century of mechanical sensor; (**b**) paper with ink by a needle from last years of XX century of electromagnetic analog sensor; (**c**) smoked paper marked by a glass needle and fixed afterwards with rubber solution of mechanical sensor; (**d**) photographic paper with light inscription and afterwards development of analog electromagnetic sensor measurements; (**e**) thermal paper with inscription by thermal needle of analog electromagnetic sensor measurements; (**f**) smoked glass inscription by metallic needle and fixed afterwards of mechanical sensor; (**g**) glass photography afterwards developet of mechanical sensor; (**h**) celluloid photography fixed in negatives of analog electromagnetic sensor; (**i**) microfilm negatives of analog electromagnetic sensor ; (**j**) digitized in CDs as "permanent" support of analog electromagnetic sensor; (**k**) magnetic hard drive with digitized measurements from analog electromagnetic sensor.*
*Sources: INGV (**a**, **f**, **g**); Observatori Fabra (**b**, **c**, **d**, **j**, **k**); ICGC (**e**); Observatorio Geofísico de Toledo (**h**, **i**).*

It is crucial to identify and document as many of the following aspects as possible:

✓ **The type of media on which the registration was made.** The most common media types include:

- paper with ink inscription (Figures 1a, 1b),
- smoked paper (Figure 1c),
- photographic paper (Figure 1d),
- thermal paper (Figure 1e),
- smoked glass (Figure 1f),
- glass or celluloid photography (Figures 1g, 1i),
- microfilm (Figure 1i),
- information technology (tapes, diskettes, cassettes) (Figures 1j, 1k)

✓ **The method used to inscribe the data on the medium:**

- typographic ink inscription (Figures 1a, 1b),
- substrate alteration by friction and fixation (Figures 1c, 1f),
- photographic development (either positively or negatively) (Figures 1d, 1g, 1h),
- thermal needle inscription (Figure 1e),
- analogue electromagnetic recording (Figures 1d, 1i, 1j),
- digital recording (whether from original analog or digital data) (Figures 1j, 1k)

✓ **Annotations and other additional markings**

- **Location** with respect to the main recording:
  - above, next to, or behind the instrumental record (Figures 1a to 1e),
  - on stickers or other glued substrates (Figure 2a),
  - on additional papers, wrappers, filing systems or other substrates attached to the seismogram (Figures 1i, 1j, 2b, 2c),
  - on the creation and/or storage system (whether analog or digital) (Figures 1k, 2e, 2f),
  - embedded in a digital file via metadata, headers, order, or file properties determined by the chosen format (Figures 1j, 1k),
  - in separate digital or attached analog document (Figure 1k).
- **Materials** used for annotations or additional markings:
  - ink stamps or pads (Figures 1b, 2e, 2g),
  - handwritten notes (Figures 1a, 2a),
  - graphite pencil (Figure 2b),
  - colored pencils (Figure 2g),
  - ink pens (Figure 2f),
  - mechanical marks or friction (Figure 2d),
  - digital or automated annotations or markings (Figures 1j, 1k).
- **Type and meaning of content** (texts, drawings, symbols, etc.).
- **Whether or not there is a risk of losing the connection** between the annotation or mark and the correspondent record and/or content, especially if the original order or format is altered

FFigure 2. *Some examples of the diversity of annotations and other additional marks on analog seismograms recordings: (**a**) paper with inscription in ink glued to a smoked paper seismogram; (**b**) smoked paper rolled with a paper with some information surrounding it; (**c**) pieces of smoked paper stored into the observations book all together with the rest of the information gathered about the registered earthquake; (**d**) smoked paper with inscriptions made by mechanical friction and afterwards fixed with the rest of the register; (**e**) smoked papers kept in a pH-neutral box with inscriptions about the contents marked with a pad and also on a printed sticker; (**f**) smoked paper kept in cardboard boxes with manuscript inscriptions written using a marker pen; (**g**) photographic paper with ink marks (by pad and manuscript) and pen and pencil.*
*Sources: INGV (**a**, **c**, **d**); Observatori Fabra (**b**);Observatorio Geofísico de Toledo (**e**); Observatori de l'Ebre (**f**, **g**).*

✓ **Organization, conditions and materials in which it has been filed and preserved.**

- Stored individually or in grouped collections (Figure 3b vs Figures 3a and 3b).
- Wrap or protective layers directly in contact (Figures 3a, 3b).
- Possible additional wraps or protective layers not directly in contact (Figures 3b, 3c).
- Presence of adhesives or labels in other substrates stuck to the wraps, including evaluation of the risk of detachment (Figures 3a, 3c).
- Filing system or organizational method, if any.
- Ancillary documentation whether still present in the same space, relocated in another known place or missing (Figure 2c).
- Storage location and access conditions.
- Responsible entities or individuals (for storage, archiving, maintenance, conservation, research or consultation).
- Is this the original archive and organization? If not, can the previous structure be reconstructed? (Figure 0).
- Are there partial or complete copies in other formats?

Figure 3. *Some more examples of the diversity of ways and materials in which analog seismograms have been filed and preserved: (**a**) photographic paper seismograms in piled up cardboard folders tied with strings and lose papers with information about its contents; (**b**) smoked paper seismograms accumulated flattened in a proper ventilated fireproof wardrobe with a neutral paper between contiguous seismograms to avoid future conservation problems; (**c**) smoked paper seismograms rolled up on themselves, some wrapped in paper with additional information, stored into a cardboard box and with modern additional information in a code bar sticker.*
*Sources: Observatori Fabra (**a**); INGV (**b**, **c**).*

Additional and accessory documentation

Accessory documentation refers to all materials related to the original recorded data, the instruments used to acquired it, and any contemporary or subsequent elaborations connected to these data or instruments.

Such documentation is **often essential** for the accurate interpretation of the seismograms. Even when it appears redundant, it can prove invaluable for future studies, alternative processing methods, or even for identifying and correcting original errors or omissions.

During the identification phase **nothing should be considered redundant**. Whether original, copied or processed, all existing accessory documentation must be identified and documented. It is not surprising that in some cases apparently redundant copies or materials may later become essential due to unexpected issues or accidents.

Most common accessory documentation types are:

- **Station books**: logs and control records from data acquisition stations (Figure 4a).
- **Data books:** Records of detected phenomena, including internal and external data logs (Figure 4b).
- **Technical books:** documentation of incidents, repairs or maintenance (Figure 4c).
- **Calibrations:** original calibration data or results of calibrations (Figure 4d).
- **Photographs or graphic documentation** of instruments, locations, materials, people, etc. (Figures 4e to 4h).
- **Manufacturer catalogs** or other documents with additional information or technical specifications and details of instruments, materials and/or facilities (Figure 4h).
- **Published data:** publications or reports based on recorded data (Figures 4i, 4j).
- **Internal or external correspondence** (Figures 4k, 4l).
- **Manuals of technical procedures, archives or data analysis** (Figures 4m, 4n and 4o).
- **Backups or useful information about digital security access and protocols,** in case digitized copies exist.

For each item, the following aspects should be documented as thoroughly as possible during the identification phase:

- what it is: type of complementary documentation, whether it is one of those mentioned above or some other additional type;
- who made these registrations, for what purpose and in what context;
- primary source (created during the registration or immediately at the start or end of it), secondary (data recorded or copied shortly after by responsible personnel), or others (later compilations, processed data, protocols, unrelated but relevant information or not directly dependent on data acquisition);
- what period of time it covers: start, end, periodicity and frequency of entries, and if they are continued in a homogeneous way or any noticeable gaps or interruptions;
- if it consists of a single document or part of a multi-volume set;
- which instruments or data does it relate to: sensors, recorders, archives, processed data, etc.

And also, the same aspects detailed in the previous section, in an analogous way:

- Type of media on which the registration was made.
- Systems with which the registration has been made on the support.
- Additional notes, markings, or metadata.
- Filing method, materials used, and preservation conditions.

Figure 4. *Some examples of the diversity of complementary documentation that we can find among Observatori Fabra analogical patrimony: (**a**) station book, with logs of recordings and other instrumental incidences; (**b**) data book, with detailed information for each detected or reported earthquake; (**c**) notebook with comments about major repairs of the instruments; (**d**) book with calibration measurements performed and results obtained, with used formulae in the back cover; (**e**) photograph taken during Mainka pendulums installation in 1913; (**f**) photograph taken some years later, when they were fully operational; (**g**) photograph taken decades later, when there were also some other photographic and electronic instruments; (**h**) technical diagrams of Mainka pendulums; (**i**) bulletin from 1914 elaborated to be published and sent to other institutions; (**j**) manuscript for bulletin from 1939 never published due to difficult times during Spanish civil war and second world war; (**k**) folders with archive of international correspondence classified by origin; (**l**) postcard of acknowledgment of having received the original seismograms petitioned; (**m**) codes and protocols to understand the international telegrams with seismic data; (**n**) telegram received from Observatorio de Toledo; (**o**) "register" of phases from an earthquake analog register marked on a graph paper (upper image, from the front side) and a summary of its known parameters in the rear (lower image, from the rear side).*
*Sources: ICGC(**h**) and Observatori Fabra.*

Conservation state / Most common problems

During the initial assessment, it is crucial to document the general conservation state of all materials in as much detail as possible, and in particular to highlight if we detect any of the following problems on an occasional, frequent or global basis:

- Fungal growth or other non-animal infestations (Figures 5a to 5c).
- Adhesion problems (Figure 5c).
- Evidence of insects, rodents or other animal damage (Figure 5d).
- Dirt or stains, including suspected origin (Figure 5e).
- Physical damage: tears, missing sections or scratches (Figures 5a and 5c).
- Oxidation or material damage: by ink, by light, by the type of paper or material, by contact, etc. (Figure 5f).
- Deformations (Figure 5g).
- Lack of necessary software or hardware to totally or partially access digital content.

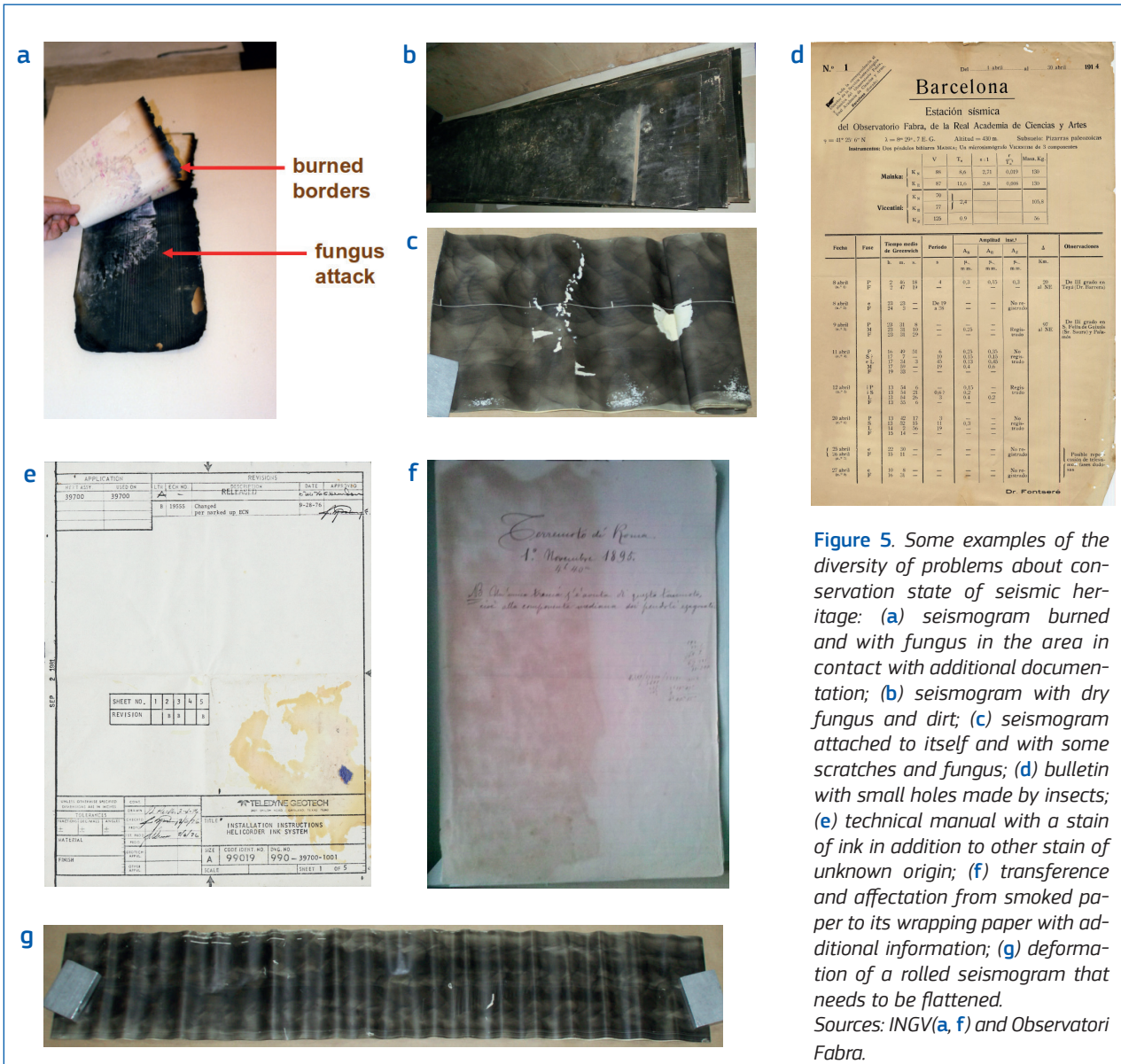


Figure 5. *Some examples of the diversity of problems about conservation state of seismic heritage: (a) seismogram burned and with fungus in the area in contact with additional documentation; (b) seismogram with dry fungus and dirt; (c) seismogram attached to itself and with some scratches and fungus; (d) bulletin with small holes made by insects; (e) technical manual with a stain of ink in addition to other stain of unknown origin; (f) transference and affectation from smoked paper to its wrapping paper with additional information; (g) deformation of a rolled seismogram that needs to be flattened.*
Sources: INGV(a, f) and Observatori Fabra.

CHAPTER 2

INVENTORIES AND CATALOGS

What lists of items and related data do we need and how to get them.

Introduction

In order to face a specific project (determining how a seismograms archive is organized, improving its organization or its preservation for the future, setting it up from scratch, etc.), it is necessary to know what it involves, how many and in what condition are its contents. Inventories refer to a list or group of lists with this information, mainly based on counting units, while catalogs refer to those that prioritize information based on their type or contents. Their structure and exact content will depend in each case on the objectives and available resources of the specific project.

The following sections shortly review some key concepts and recommendations to maximize the potential results of these inventory and cataloging efforts in the specific case of analog seismograms and their accessory documentation.

IMPORTANT

- Unlike the previous identification phase, this stage is **not purely informative**. Now we seek to extract as much information relevant to the defined goals as possible from the available seismic patrimony. And this may involve acting on it, making some manipulation or changes (on the seismograms, on the boxes they are contained, etc.) potentially irreversible. Therefore, it is essential an important work of previous detailed planning of the objectives, together with a **careful planning of each task** and its possible effects before any action is taken.

Preliminary planning of tasks

The preparation of an inventory or catalog requires **detailed planning**. It is no longer the performance of an exploration and listings for informational purposes as in the previous identification phase described in Chapter 1. Now it is a project in itself that will require much more extensive and detailed, methodical and careful work that, depending on the volume and particularities of the seismic patrimony, may need significant resources. Therefore, it is important to make a good plan to maximize the obtained results. The preliminary planning of the tasks is the first part of this work, and if it is carried out in a sufficiently complete and detailed way, it will greatly facilitate the later stages and will avoid failing into inconsistencies and other problems that could create repetitions of tasks and undesirable corrections.

We recommend carrying out this planning explicitly documented with as much care and attention as possible, and taking into account the following important aspects to consider:

- Depending on the final objectives, different data are needed, but in order to avoid accidents or future conservation problems, it is better to minimize the number of interventions upon the patrimony materials (seismograms, documents, etc.). Therefore, it is recommended **to extract as much additional data as possible** when there is a doubt of whether that could be needed in the future or not.
- It is crucial to **collect information as complete as possible about how the physical situation of the patrimony is BEFORE changing anything**. We recommend to plan dedicate enough time to carry out and extensively document the preliminary identification phase (Chapter 1) and to collect and make photographs, diagrams, descriptions, explanations, etc. of the original organization of the seismic patrimony and any other elements or surroundings (boxes, labels on shelves, etc.), as well as from the space around them or related in some way.
- Depending on its state of preservation and available resources, this phase must be carried out before, after or in parallel with the preservation and/or restoration actions that could be considered necessary. Besides, the subsequent use and preservation that is intended for this patrimony has to be taken into account. That's why **we recommend reading this entire manual before starting the detailed approach and the inventory or cataloging tasks**.
- Basic resources (budget, time and staff) are usually scarce and very unstable. You might have insufficiently anticipated them or be left without an important part for many more or less unexpected reasons. Or, instead, a formidable opportunity might appear but with very little preparation time and possibilities to take advantage of it. **Managing foreseeable contingencies** is a very important point to take into account when planning and coordinating the work to be done. That's why it is very important that the proposed work is: (i) as scalable as possible; (ii) useful for parts even when incomplete; (iii) well documented; and (iv) easy to resume if unexpectedly interrupted.
- The preparation of the detailed **planning of the tasks should go from global to particular**. Initially consider a minimal useful classification very similar to the original. Then consider one by one the particular interests of the objectives that justify a different reorganization of the data and the positive and negative effects they may have on the overall work (plainly, consider "pros" and "cons"). And finally, consider how special cases could be dealt with, such as: a) if out-of-place seismograms will only be documented or if they will be rearranged; b) if it is desired to highlight any special data such as whether or not a seismogram contains any earthquakes from a certain catalog; c) whether or not seismograms with significant degradation will be set aside during the inventory tasks to be restored or to will be preserved differently from the rest; and so on. It is important that the selected approaches to the tasks are as detailed and contemplates as many cases as possible before the works start.
- Even if it seems redundant, it is usually easier, progressive and scalable to **inventory first the more external units completely** (such as boxes, shelves, folders, etc.) and to leave for a second stage, once that has been finished, the inventory or catalog of their internal contents (seismograms, books, letters, etc.).

- **Setting up a database** with several interrelated tables makes this planning stage more complex, but it is much more versatile and easier to adapt than the typical lists, especially for catalogs. In any case, for each list, additional unique codes should be proposed, different than the correlation codes between the tables of the same database.
- Have in mind that those results that are made public or displayed are always a by-product or a reduction of the accumulated data set. When creating each table or list, it must be **as comprehensive, complete and complex as possible**, even if there are fields not filled in many cases. It is important to clearly distinguish in those cases between: (i) non-existent; (ii) unknown; (iii) negative; o (iv) other specific "error/s code/s".
- **Reviewing how other institutions have approached these tasks** with more or less similar seismic patrimony can provide valuable insights, warnings and examples. We strongly recommend exploring the references included in the last section of this manual *Resources and References* and other works, even those still in progress.

Code (integer)	Value	Meaning
	void	Field not filled yet for that register (e.g. while this table is still in process to be filled in).
0	0	0 seismograms, filled after being reasonable sure that there is no seismogram with records for that earthquake from Station ID.
any number within: {1, 2, 3, ..., 127}	1, 2, 3,..., 127	The number of seismograms with records for that earthquake from Station ID (the type of each seismogram and its properties will be registered in other fields of the table "Identified Earthquakes from Station ID" and in other related tables with information about properties of those different seismograms.
-128	NO	It would not be logical to find a record of the earthquake from station ID in any seismogram, for example because the instruments at Station ID were installed after the date of this earthquake.
-1	Err1	There could be some, but the exact number of seismograms is unknown because a particular problem, such as for example that there could be some possible seismograms but some of them cannot be looked up yet because of being sent away for restoration.
-2	Err2	There could be some, but the exact number of seismograms is unknown because another particular problem, such as for example that there is complementary documentation about being identified in some possible seismograms which cannot be looked up yet because they are still to be found.
ny number within: {-3, -4, ..., --127}	Err#, on: #=-3, ..., -127	Other particular cases when there could exist some other but the exact number is unknown because another foreseeable particular problem that we are interested to be marked differently just in case in the future we could be interested in searching for those particular cases.

Table I. *Example of possible admissible values for the integer object "Number of analog seismograms with records from the earthquake" from the Table "Identified Earthquakes from Station ID" linked to the register related to a certain identifying code from the Table "Earthquakes" from a catalog that uses relational databases. This theoretical example shows how database architecture planning, even apparently complex, helps to discriminate specific situations and gather additional information potentially useful for many possible future uses.*

A1

B1

B2

C1

C2

C3

D1

D2

D3

Figure 6. *Some examples of different seismic archives to illustrate how the preliminary planning of the tasks for a specific inventory or catalog could be highly depend on, not only its objectives, but also the accessibility, preservation conditions and previous knowledge of the seismic patrimony: Massive storage facilities in California shown in* **A1**, *filled up with seismic patrimony, provoke difficult accessibility and high risk of degradation. Partially burned seismograms from Lisbon (shown in* **B1** *and closer in* **B2**) *are so damaged that require important restoration and advances techniques of safe manipulation. On the other hand, Observatori de l'Ebre archive shown in* **C1**, **C2** *and* **C3** *has managed to be maintained rather well preserved and easily accessible (even with digitized copies available online), with the scarce human and material resources typical of small institutions. And finally, Observatorio Geofísico de Toledo, as the central institution of the national seismic network in Spain, has been able to create a more professional and modern archive (shown in* **D1**, **D2** *and* **D3**) *to conserve their seismic patrimony to avoid further deterioration and loss, and to carry projects of detailed cataloguing and digitization of its more than one million of seismograms in different formats and supports in addition to their seismic complementary documentation.*
*Sources: L.Hawng (***A1**); *J.Batlló (***B1**, **B2**), *Observatori de l'Ebre (***C1**, **C2**, **C3**) *and Observatorio Geofísico de Toledo (***D1**, **D2**, **D3**).

Basic templates

Each inventory or catalog project should be guided by a template of data to be obtained, tailored to the speific set of patrimony being documented and the objectives of the project. If the project is organized in scalable phases, each phase may require its own distinct template.

For example, let us consider a theoretical case, with strong limitations in resources and time available, of a catalog of a small network of stations with seismic patrimony, whose primary goals are to locate and document their seismic patrimony and estimate the cost of a possible future project for transferring all those materials to a centralized archive with better preservation conditions. The preliminary planning of the tasks has divided them in subsequent phases:

- ✓ **Phase A**: each station in the network is documented and contacted to encourage them to perform their own identification of their seismic patrimony (as described in Chapter 1).
- ✓ **Phase B**: based on the initial identifications, additional questionnaires are developed to compile one or more common catalogs of the different types of patrimony present in those stations, with as much information as possible about their associated processes involved: recording, identification, publication and their particular state of preservation.
- ✓ **Phase C**: additional more specific measurements and quantitative assessments are planned for each type of patrimony to design its necessary preservation conditions and the volume, weight, risks, costs, etc. related to a possible relocation to a centralized archive.

In this theoretical case, each phase requires their own templates, and most probably the template fields in later phases may depend on the results of earlier ones. Templates may also vary depending on whether the produced catalogs are intended for publication, whether there is foreseeable continuation to these efforts, and other contextual factors. The outcomes may range from simple inventories or several loosely connected lists, up to a coordinated, scalable catalog that could be expanded and reused in the future with further purposes.

In any case, it is important to consider that this effort to obtain these data, in order to be most useful also to others, should be in accordance with the "**FAIR metadata**"principles, which refers to obtaining *Findable, Accessible, Interoperable, Reproducible data* (see references [5] and [6]) .

Similar projects previously initiated by other institutions and some initiatives to standardize this type of data for seismic patrimony can be found in the last section of this manual *Resources and References*.

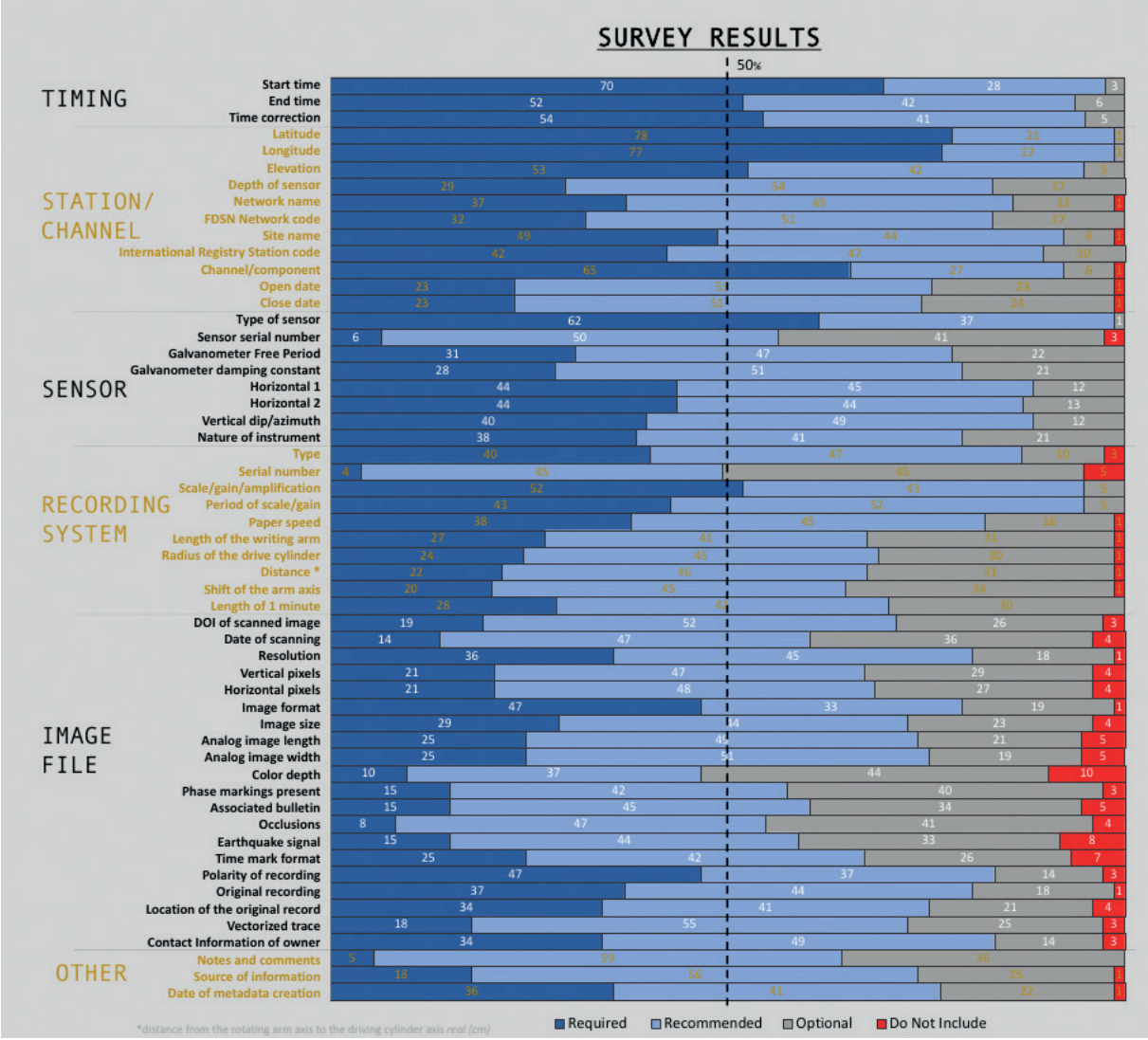


Figure 7. *List of the 55 metadata elements suggested for scanned images of analog seismograms in order to create a standard that will allow centers to coordinate in their publication and to ease the use of them under FAIR premises. A survey was sent to a number of centers all over the world asking to indicate for each of those elements if they thought they should be required, recommended, optional or directly do not include it. The graphic shows the survey results presented in reference [7]. Source: L.Hawng and T.Ahern.*

CHAPTER 3

CONSERVATION AND PRESERVATION

How to and not to do to best preservation with available resources.

Introduction

Preventive conservation is a discipline that is based on preventing deterioration by managing the relationship between heritage materials and their environment. The first essential step is to evaluate the space and the initial state of materials (seismograms, station books, etc.). Then consider and plan in detail the urgent minimum changes to solve the most serious problems detected. The rest of the changes or improvements, not directly related to immediate threats, should be considered, studied and assessed later with more calm and planning according to the possibilities of each institution in a way that also fulfills the purpose and goals of its use and final visibility.

IMPORTANT

- **Do not assume that all changes are for better.** Studying how to maintain and/or preserve optimally does not necessarily imply making significant changes or expenses. Often, it only involves basically assessing, recognizing and properly documenting protocols that have long existed with very small or practically non-existent changes.
- **Context matters.** Possibilities and purposes for each archive and institution are very different. Not only in terms of its economic resources and planned activities, but also in similar previous experiences and interrelationships with other projects. Strategies must be tailored accordingly.
- **Planning prevents loss.** Many difficult or impossible to recover losses and degradation could have been avoided through proper exploration, evaluation and planning, even without great resources or costly interventions.

Evaluation of space, furniture, materials and related risks

The evaluation of the space and the present state (conditions) in which the heritage is located should include at least the following aspects:

✓ **General Space Features:**

- Existing basic services and facilities (electricity, water, gas) and active and passive risk mitigation systems (floods, fire, humidity control, etc.).
- Ventilation and cleaning services and protocols.
- Active and passive pest control (especially insects, rodents and birds).
- Security measures against theft or vandalism.
- Assessment of the most significant natural and artificial risks.
- Diagrams showing access points, ventilation, work areas, and circulation paths.

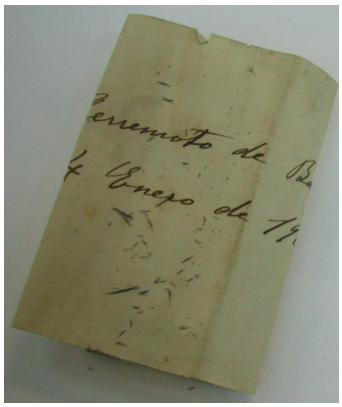
✓ **General storage furniture features:**

- Open or closed (specifying the type of closure and ventilation).
- Contact with ground (direct, isolated, or damped).
- Materials (wood, metal, plastic, etc.).
- Total capacity, useful available volume and currently occupied volume.
- External and internal dimensions.
- Weight per available support unit and current weight load.
- State of conservation of furniture and signs of possible pathologies.
- Diagrams showing location, access/openings and internal distribution.

✓ **General characteristics of the storage, protection and marking elements directly in contact with heritage:**

- Type: boxes, folders, wraps, separators, covers, strings, etc..
- Materials (wood, metal, plastics, etc.) recording their thickness and special properties (fireproof/fire-resistant, pH-neutral -phN-, opaque/translucent/transparent, pest-treated, etc.).
- Total volume, available useful volume and occupied volume.
- External and internal dimensions.
- Load capacity: maximum interior and exterior weight load per unit (theoretical and actual)
- State of conservation and possible pathologies (degradation, infestation, dirt, etc.).
- Suitability: is the material appropriate for the heritage it contacts? (phN, translucent/opaque, etc.).
- Usage: is it being used correctly? (overfilled, content that stands out for excess or excessive incorrect dimensions, incorrectly closed, excessive weight on top, incorrect position, stacked improperly, etc.).

a



b

c

d

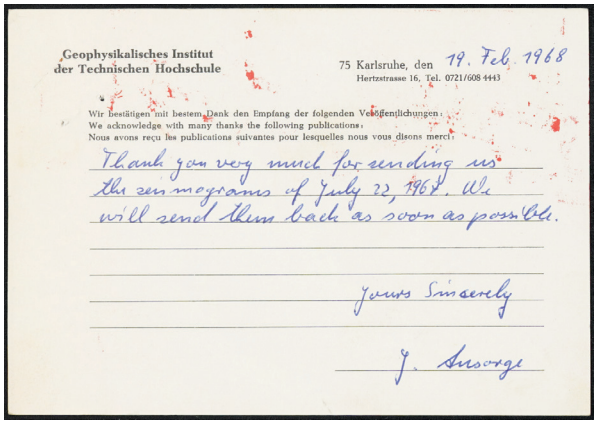
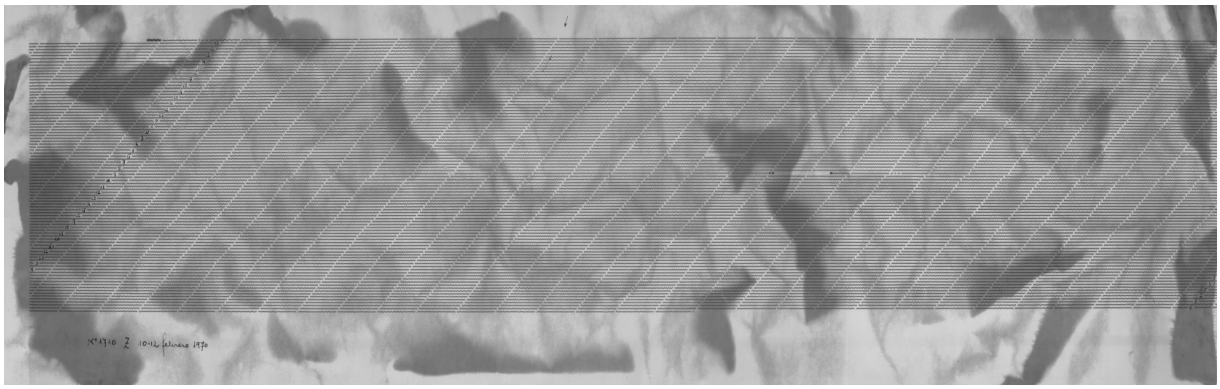
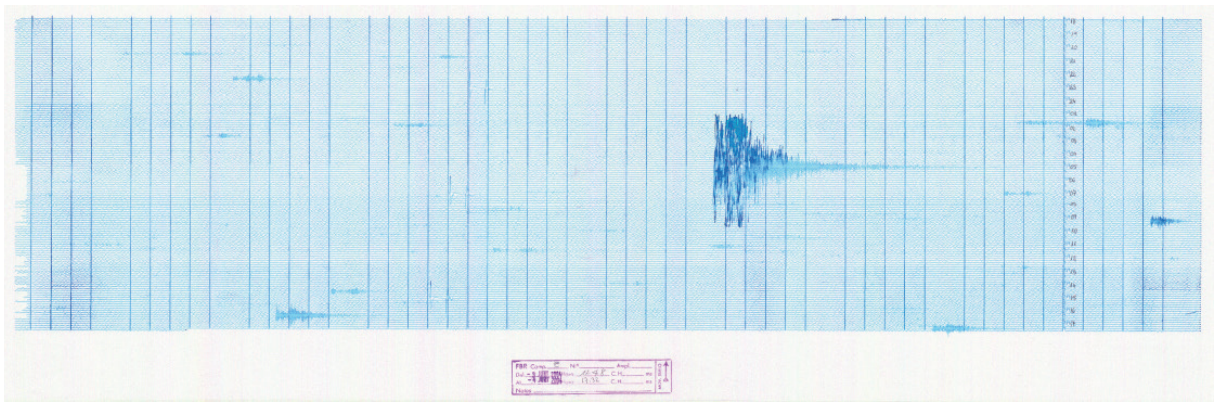


Figure 8. *Some more examples of the diversity of problems about conservation risks:*
a) *surface dirt;*
b) *mechanical degradation due to improper storage;*
c) *inadequate acidifying paper in direct contact;*
d) *ink spots;*
e) *degradation of chemical components;*
f) *ink atenuation because of excesive exposition to sunlight.*
Source: Observatori Fabra.

e



f



✓ **Variable Space Features:**

- The main variables to be measured are:
  - Climatic conditions: Temperature and humidity are the main variables.
  - Natural or artificial lighting, direct or indirect, indicating approximate frequency and intensity ranges.
- For each case, it is necessary to measure or at least estimate the maximum, minimum and cycles of typical oscillations (diary, monthly, seasonal and annual).
- Estimated measurements and values must be for contact surfaces and air (inner and outside furniture and other enclosed spaces).
- Also required for adjacent rooms and exterior areas with direct connection to foresee the possible impact of a failure of the mechanisms of artificial control of the elements, activity-related effects on poorly insulated annexes, etc.

✓ **Specific pathologies and problems detected in documents. For each issue, evaluate at least the % of the documents affected and the maximum degree of impact observed, possibly using an objective scale of severity level. Common issues include:**

- Cleanable surface dirt: dust, pollen, debris, etc.
- Stains (from use, contact, oxidation, etc.).
- Oxidation and acidification: due to paper composition, contact with another annex material (ink, acidified paper, etc.), excessive exposure to light, extreme climatic conditions, …
- Physical damage: mutilations, tears, losses, scratches, deformations or other mechanical damage.
- Adhesions, indicating if it is due to material degradation or external sources.
- Fungal growth, indicating all the possible additional information such as: color, relief, geometry, etc.
- Animal presence (insects, rodents, reptiles, etc.) indicating whether recent or old, in addition to any other additional information.
- Other damage, indicating as much additional information as possible (flooding, smoke exposure, burns, etc.)

✓ **Access and planned activities on heritage and its environment, indicating the minimum and maximum frequency for each type of manipulation. Especially those that may suppose:**

- Risk due to manipulation.
- Risk due to changes in usual environmental conditions.
- Risk of disorder or accidental loss.
- Risk due to theft or vandalism.
- Risk of incursions, infestations, exposure to dust, pollution or other foreseeable occasional hazards.

Actions and protocols to be planned and prepared

Prior to implementing any modifications, it is essential to explore, consider, plan and explicitly document the current state and the reasonably expected objectives for each of most common conservation and preservation actions:

1. Environmental control.
2. Infestation Control.
3. Routine cleaning of spaces, furniture and storage.
4. Cleaning of seismic heritage, if necessary.
5. Access control and security.
6. Management of planned activities, visits and usage.
7. Direct handling of seismic heritage.
8. Transport and/or temporary exhibition.
9. Regular monitoring of deterioration.
10. Specific actions and emergency response in incident management.

It is strongly recommended to document at least ***when***, ***who*** and ***how*** for each of those topics. Also to **establish a predefined review schedule to periodically reassess** them.

The resulting documentation of the initial state, the intended objectives and any revisions or updates should be kept along with the additional reports or documentation of any related incidents or anomalies that might arise. Not only to keep track of the progresses but also as useful data for example to detect recurring issues, support future planning and decision-making or optimizing resource allocation.

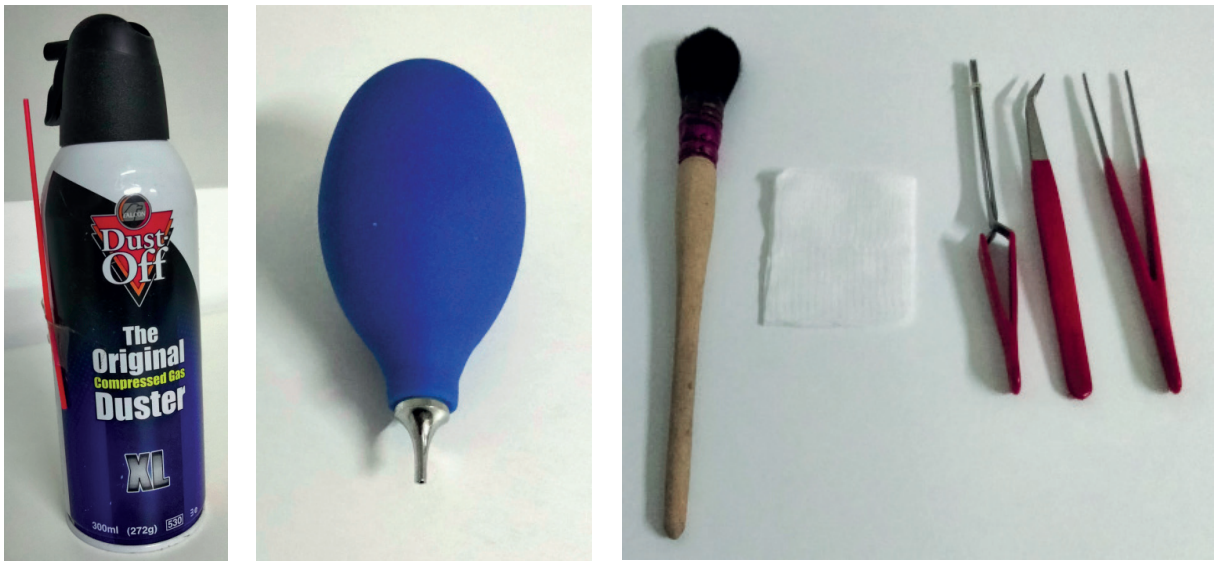


Figure 9. *It is prefereable to clean only the protective containers instead of the heritage itself. Only when it is really needed, simple and easy, mechanical cleaning could be applied to the heritage avoiding at all costs to damage or scratch surfaces or pieces using the softer option available. Using dry air (to avoid moisture when applied) gently applied from a reasonable distance (to avoid too much pressure or sudden change of temperature) could be used only if the material is not too fragile. Be aware that using any further instruments, liquids or other chemicals is not considered cleaning for preservation/conservation, but restoration instead (see next chapter).*
Source: Observatori Fabra

General guidelines

Three fundamental principles should guide all the phases related with conservation and preservation of seismic heritage:

I. **Respect Existing Stability.** An archive that has remained reasonably well preserved for a long time without great environmental or activity oscillations can be preserved without significant changes if it continues in the same micro-climate conditions, even if it does not meet all the ideal parameters. In any case, it is advisable to explicitly document the prior evaluation of the space, furniture, materials and associated risks, as well as the actions and related protocols already mentioned.

II. **Prevent Further Damage.** Good protection should minimize dirt, stains, mutilations, oxidations, deformations, etc. If such damage already exists, it may not require immediate intervention, but future handling and conservation practices must be adjusted to prevent worsening during possible manipulations or future actions and to allow gradual correction.

III. **Balance Preservation with Accessibility.** Proper preservation must be compatible with the availability and use of seismic heritage. Even with the advice within this section, it is important to achieve a balance between acceptable conservation and access that allows its usefulness and availability in order to be known and therefore recognized. Visibility and recognition of the heritage will also, in the long run, contribute to the interest of its preservation.

Figure 10. *With materials such as Remay®, Melinex® and pH-neutral cardboard or paper and a bit of handicraft the heritage can be more easily exhibited with a reasonable protection from light, humidity and other risks at low cost.*
Source: Observatori Fabra.

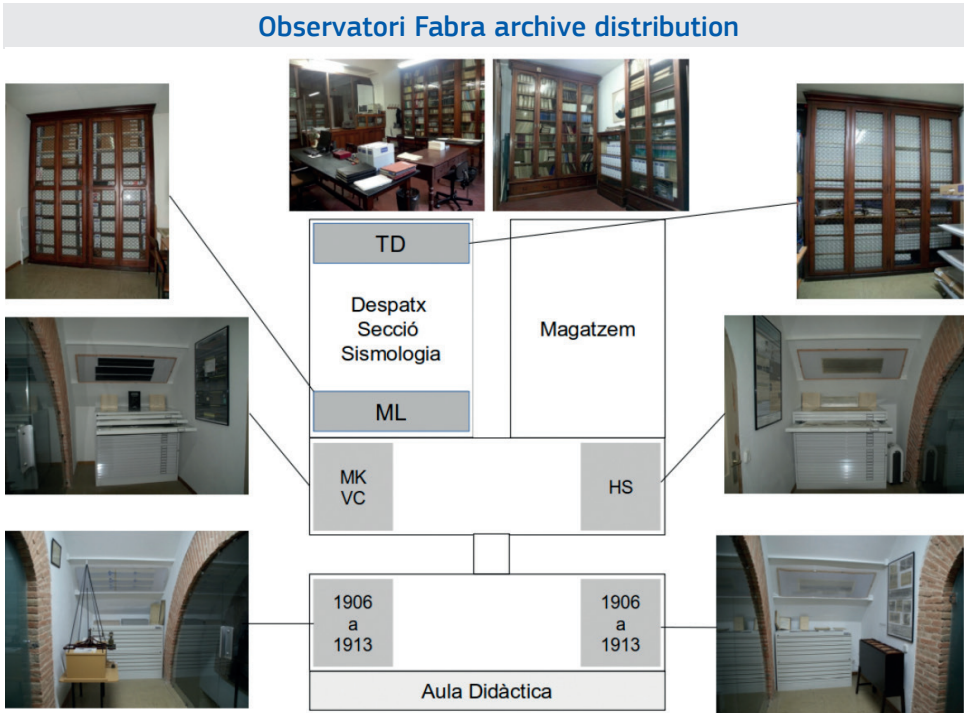


Figure 11. *Three examples of seismic heritage conservation approach. a) Observatori Fabra has introduced important changes and interventions in the last decades with limited resources in order to solve previous preservation problems detected and ease its use and exhibition; b) Observatori de l'Ebre archive is reasonably well preserved and available to use, so no urgent intervention is planned yet and nowadays their efforts focus in scanning; c) Observatorio Geofísico de Toledo, as the main and central archive of the national seismic network in Spain, has been able to create a more professional and modern archive.*
Sources: Observatori Fabra; Observatori de l'Ebre; Observatorio Geofísico de Toledo.

Specific suggestions to consider

- Wrapping materials are often the main cause of the degradation of the contained seismic heritage. It is essential to ensure using opaque neutral phN papers and cardboards that allow ventilation. In those cases where it is not possible to have the necessary resources to change the inadequate materials, you can choose to wrap them or use intermediate layers of neutral material (paper, cardboard or other suitable materials) to avoid direct contact until they can be replaced.

- It is worth noting the need to always avoid seismic heritage being in direct contact with:

  - ✗ rubbers or similar materials that degrade quickly and leave residues,
  - ✗ adhesives or plastic glue,
  - ✗ oxidizable metals (such as staples or clips),
  - ✗ coloured or acidifying inks, papers or cardboards that may transfer or cause chemical damage.

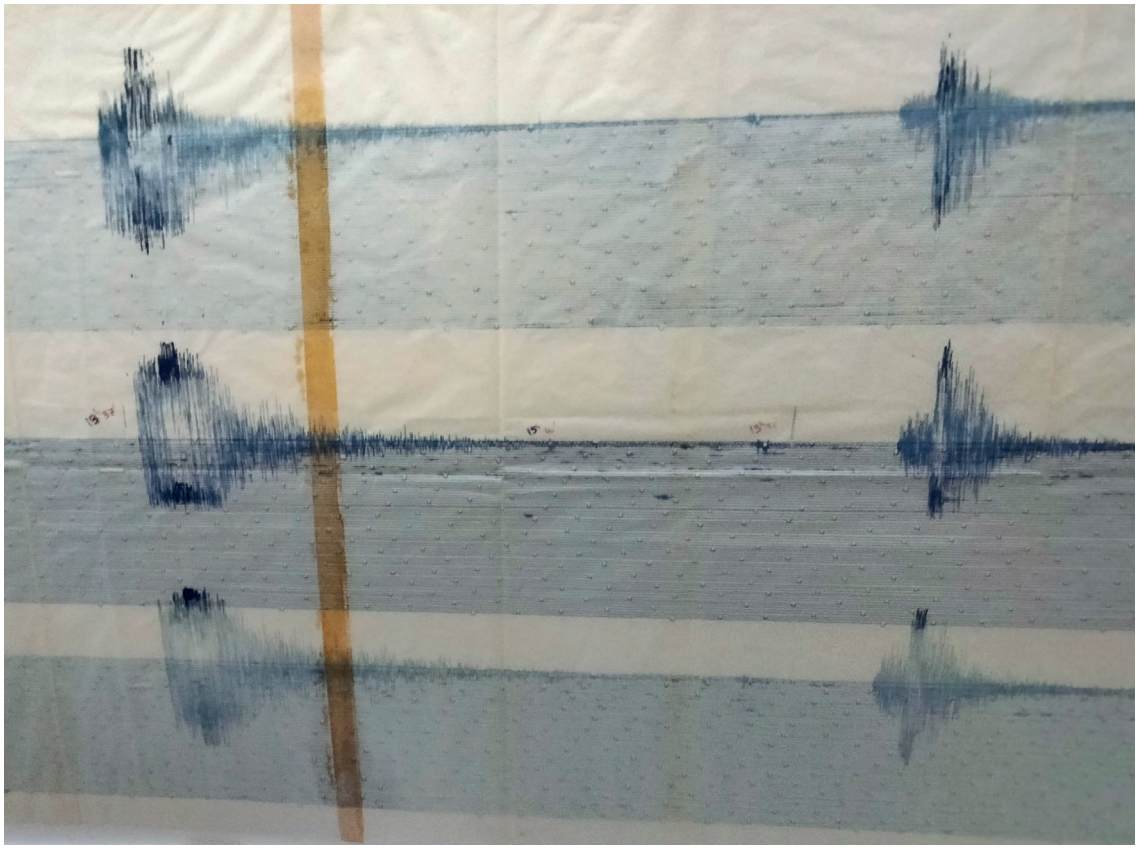


Figure 12. *Wrong materials in direct contact can cause serious preservation problems in the long-term. Source: Observatori Fabra.*

- Closed storage is generally preferable to reduce exposure to environmental pollutants and many other risks. However, it must be made of appropriate materials that guarantee proper ventilation and maintain stable environmental and access conditions.

Figure 13. *Folders with strings were very usual containers in the past. Unfortunately, they do not protect enough from insects, environmental pollution nor dust. Moreover, strings often cause accidental strips. PH-neutral cardboard boxes or adequate drawers are better options in all those aspects.*
Source: Observatori Fabra.

- A closed space with controlled use and access is recommended. Far from places or ordinary services facilities that pose unnecessary risks due to accidents (such as water, electricity, gas, drainage, attics, basements, etc.).

- For the design of the spaces, in addition to storage, it is necessary to take into account where and how the intended manipulation of the materials will occur. And whether the storage space is expected to be publicly displayed or accessed.

- Fireproof metal shelves, drawers and accessories painted with safe coatings are preferable to wood ones because they are safer and are easier to clean and maintain.

- Avoid stacking large amounts of volume or weight in order to minimize the risks of deformations or mechanical degradation of both materials and storage furniture.

Figure 14. *Adequate gloves, masks and tools to manipulate heritage should be kept available and easily visible in place to minimize manipulation deterioration and prevent allergies or other health risks. To select adequate sizes for each case is very important for a comfortable and proper use. Cotton gloves are the most soft, comfortable and reusable option. Latex, silicon or nitril ones can be also used as cheaper and versatile options, but only if they leave not traces (beware of added dusts/materials or deteriorated gloves).*
Source: Observatori Fabra.

Figure 15. *Protective surfaces should be used in every exposed material. Besides control and security against thieves, it helps to avoid accidents and improper handling and makes easier the control of unexpected activities or use. Locks are strongly advisable, even if not always closed or with common keys.*
Source: Observatori Fabra.

- About space lightning, in general, the less light the better (both in intensity and in exposure time). Direct natural light is especially harmful. It mainly affects, from most to least, to:
    1. Photographic substrates.
    2. Thermic paper.
    3. Inks.
    4. Paper (including smoked paper).
    5. Other materials.
- It is important to ensure regular and gentle ventilation that produces air renewal. And to avoid occasional condensation and nearby activities that may introduce contaminants that may affect the material (works, repairs, fumigation, painting, etc.).
- Ideal temperature for mixed archives is between 18ºC and 20ºC.
- Ideal humidity levels depend more strongly on the type of material. There are many nuances to consider in the specialized bibliography, but in *Table II* we indicate approximate ranges that are sufficiently valid for most cases within which significant degradation due to humidity should not occur.

➢ The further away from recommended optimal ranges for temperature and humidity and the more oscillations occur (especially fast ones), the more degradation will be caused on seismic patrimony.

Substrate material	Minimum humidity	Maximum humidity
Smoked paper	50	55
Paper with ink	50	55
Thermal paper	45	50
Photographic	45	50

Table II. *Optimal conservation recommendations of maximum and minimum humidity for several types of seismograms.*

Figure 16. *When economical resources are scarce, nowadays there are cheaper options that could help to control at least maximum and minimum temperature and humidity, which are the most critical variables to monitor.*
Source: Observatori Fabra.

➢ Infestations and fungi must be resolved as urgently as possible. It is very important to immediately isolate the affected elements from the rest to prevent their spread as far as possible.

Figure 17. Insect or rodent traps can be easily handcrafted, but there are also many cheap options available in the market to control pests as soon as possible. Every trap must be revised periodically to be useful. It is important to use traps that do not attract at all inside the heritage containers and to place the other with chemicals only outside to avoid attract new colonies.
Sources: Observatori Fabra and https://www.e-econex.net

Figure 18. *Cleaning with a known periodicity also helps to detect possible infestations or other problems and determine since when they could exist or not.*
Source: Observatori Fabra.

CHAPTER 4

RESTORATION

Realize when, what, and how it should/could or not be done.

Introduction

Restoration should only be considered after a throughout assessment and assuming the risks involved. In case of doubt, it is always preferable to improve conservation and postpone restoration until we are sure of its suitability. However, in this chapter we introduce outlines of basic principles for some small interventions that may be useful if necessary, mainly to have a minimum prior knowledge to facilitate communication with restoration professionals and help decide between available options in consideration.

IMPORTANT

- Restoration must aim to recover the potential unity of objects, whenever possible, without committing a historical or artistic falsification and without making the marks of the passage of time on the object disappear.
- Only after an adequate exploration, documentation and study could be assessed whether it is worth the risk of doing it and what steps it will consist of. The assessment is not only about the element to be restored but also the activities and their previous, subsequent and predictable environment. In case of doubt, it is better not to perform the restoration, except in cases of urgent and clearly justified need supported by unanimous expert consensus.
- It is always preferable to have the restoration done by qualified professionals with experience on elements that are very similar to those to be treated. But, if this is not possible due to urgency, in this chapter there are some small techniques and tips for minor interventions described, with the warning that if they are executed it must always be with extreme caution after having previously confirmed that the execution of the technique is mastered with numerous extensive controlled tests before risking doing so on real seismic heritage (seismograms and additional materials).

Preliminary planning before restoration

Before considering any restoration, all relevant details must be carefully studied and documented. In addition to the exploration and study described in Chapter 1, it is necessary to document in detail the following:

- **Justification for restoration**: arguments that justify the need and urgency of restoration (must be factors that cannot be achieved or improved by changes in conservation).
- **Understanding of deterioration**: any relevant knowledge about the type and cause of deterioration of the element to be treated..
- **Risk assessment**: evaluation of the the type and degree of risks, the reversibility of the treatment proposed, and potential impact on surrounding materials or elements.
- **Material compatibility**: ensure all elements involved are chemically and physically compatible.
- **Detailed documentation of the item**: all the details of the element to be treated, including photographs and general and particular comments of its previous aspect, condition, marks, annexed elements, problems or pathologies (whether they are sought to be solved or not).
- **Responsible parties**: identify the place, facilities, team or individuals responsible for the previous study and the later execution of the proposed restoration (they may differ and be more than one for each case).

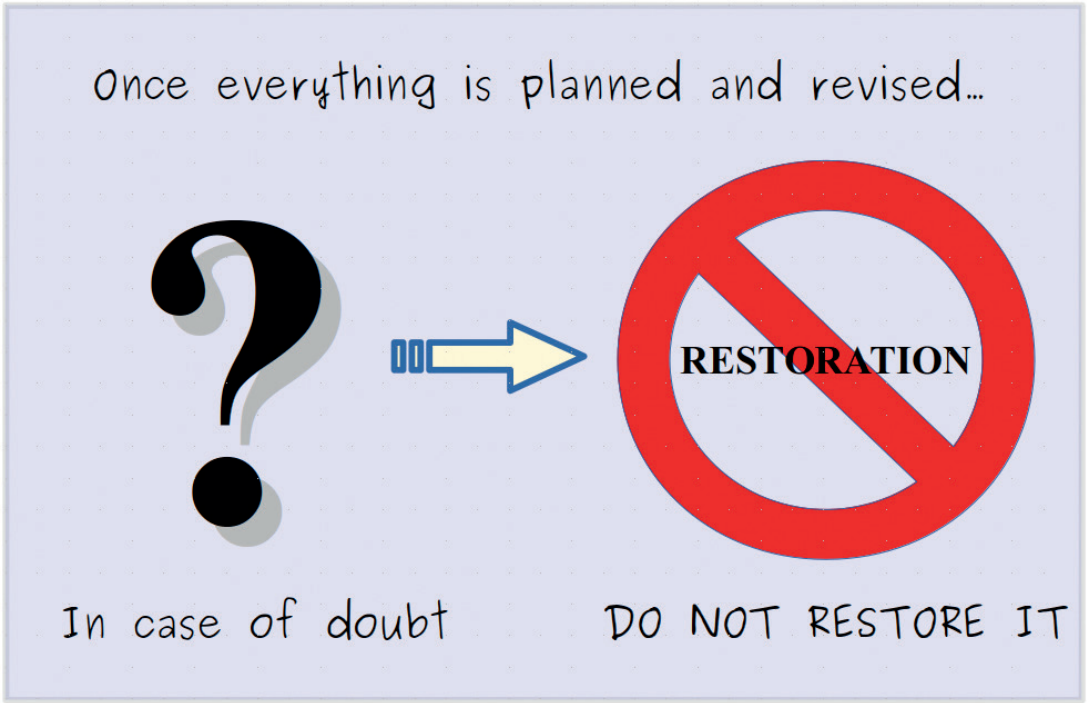


Figure 19. *Even though restoration is strongly discouraged to be performed by non-professionals, this manual includes this chapter to give the reader a bit of information and terminology to be able to explore and consider possible restoration projects.*

Control documentation

This includes the documentation that must be elaborated by the person in charge of the execution of the restoration ***BEFORE*** starting any action. The prior identification must contain a detailed description and the state of conservation of the seismic heritage at the time of the beginning of the study, as well as enough photographic documentation to show it graphically.

It should include at least the following fields:

- ✓ **Curator in charge**: contact details necessary for any past, present or future consultation.
- ✓ **Restorer in charge:** contact details necessary for any past, present or future consultation.
- ✓ **Registration code:** unique identification code or number for the item.
- ✓ **Identification:** description of the type of item (e.g., photo strip, manuscript).
- ✓ **Date of entry:** proposed start date of restoration, if any, could begin.
- ✓ **Origin:** location and context of its origin (e.g., station, instrument, time).
- ✓ **Dimensions:** geometry and descriptive sizes (e.g., rectangular with height 10cm, width 15cm and depth 0.1cm).
- ✓ **Support type:** material (e.g., satin paper, chemical paper, cardboard).
- ✓ **Registration technique:** ink, photographic, smoked, etc.
- ✓ **Annotations and marks:** type and description of each mark, indicating if they were made by pencil, pen, scratches, etc.
- ✓ **Observations:** additional comments or relevant details.

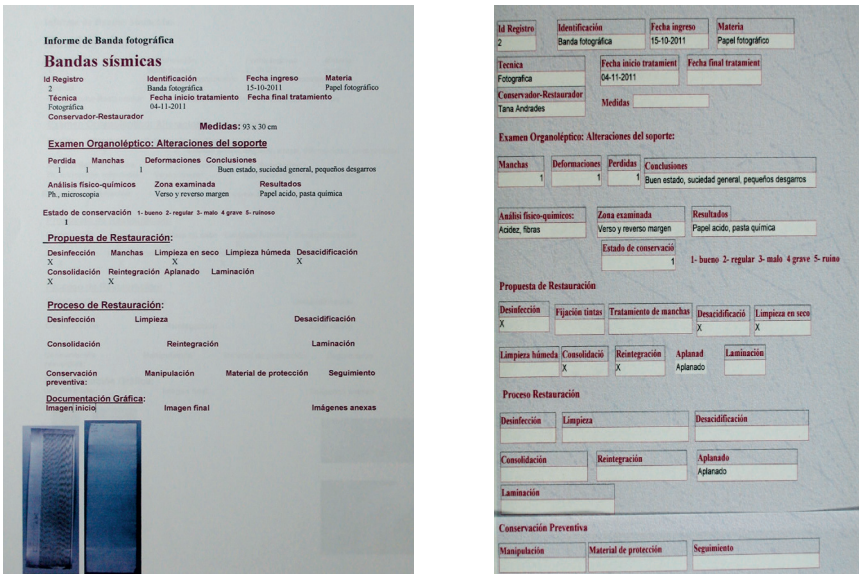


Figure 20. *Example of control documentation previous to a restoration of a seismogram from Observatori Fabra to consider whether to be performed or not at CRAI premises (see reference[8]).*
Source: T.Andrades

Detailed evaluation of composition and conservation status

Before any conservation action or restoration is taken, the previously diagnosed conservation status must be confirmed and quantified based on visual analysis and targeted chemical testing.

Visual analysis: it is important to estimate the likely origin of the observed pathologies, especially in case of:

- **Physical deterioration:** scratches, loss of support, tears, deterioration due to storage problems, etc.
- **Chemical deterioration:** acidity, oxidation, damage from contact with other elements, etc.
- **Biological deterioration:** fungal growth, insect infestation, attack or remains of other animals, etc.

With regard to possible chemical tests, it is important to point out that determining which one must be carried out depends on the treatment to be weighted, avoiding sample extraction whenever possible. If sampling is essential, use the smallest possible amount from a hidden and discreet area without useful registration. You must be fully aware that a negative result of the test is only indicative because it does not ensure that it will be also negative for the whole the element.

The most common chemical tests are:

- **Ink Solubility.** Before carrying out any treatment with water or any other solvent, it must be verified that it can be applied without risks.

- **Solubility of the adhered elements that must be separated.** Necessary to determine the suitable solvent or heat application to separate adhesives, self-adhesive ribbons, fat spots and other similar elements that could cause deformations and pathologies otherwise. These tests must be used locally.

- **pH measurement.** The element will be considered as excessively acidic when it has pH values below 6 and alkaline above 8.5. Ideally, the pH should be between 7 and 8. There are two basic systems for measuring the degree of acidity or alkalinity: colorimetric methods and electromechanical methods. In any case, manufacturer's instructions should be followed.

- **Fiber analysis.** It is important to determine the presence of lignin and/or paper fibers in order to know the composition of the substrate. The most common tests performed for its detection (see reference [9]) are the following:

  - **Lignin.** A drop of the fluoroglucinol reagent becomes purple-red for compositions of 5% or more, with the intensity of the colour being an indication of %.

  - **Paper fibers.** The main chemical fibers and plasters can be identified depending on the resulting colours with Herzberg reagents in general and Lofton-Merrit for lignified fibers. Herzberg's dye is very useful for determining mechanical, chemical and derived from natural cellulose fibers cloth plasters. Lofton-Merrit only dye the lignified plasters by changing the intensity with the % lignin present.

Ink Solubility	Adhered elements, spots	pH measurement
• Apply one drop on the ink or annexed element and immediately dry it with absorbent paper (secant paper or filter paper) which if it gets stained will show that is soluble. • Use a cotton swab or cotton bud with only a little of this solvent and observe if it gets stained by rolling it on the material without rubbing.	• Apply a minimum drop of solvent and monitor its behaviour and effect on both the element to be removed and the support of the element of interest by stretching slightly with tweezers, slowly separating with scalpel or using a spatula to estimate whether it is or not sufficiently softened. • Apply local heat to test suitable separation the adhesion.	• Colorimeter: based on chemical indicators that change colour according to pH, usually found either in strips that are impregnated with the sample or in the form of markers (those that can produce permanent dyes spots should be avoided). • Potentiometer: instrument with two electrodes to measure the electrical conductivity of a sample solution.

Table III. *Basic indications and tips for most common tests applications.*

Herzberg's dye results	
Fiber type	**Colour**
Lignified	Yellow
Chemical slightly delignified	Yellowish brown
Semi-chemical	Green to yellowish grey
Cloth (e.g. cotton, linen, hemp)	Wine red
Low lignified (e.g. wood, cereal straw)	Blueish grey to violetish blue
Artificial (rayon, viscose,etc.)	Colorless or light yellow

Table IV. *Most common results for Herzberg's dye test applications.*

Lofton-Merrit's dye results	
Fiber type	**Colour**
Mechanical and thermomechanical	Bright blue
Semi-chemical	Dark violet
Chemical raw to sulphate	Blue-green to light blue
Raw to sulphite	Purple violet
Chemically whitened and cloths	Colorless

Table V. *Most common results for Lofton-Merrit's dye test applications.*

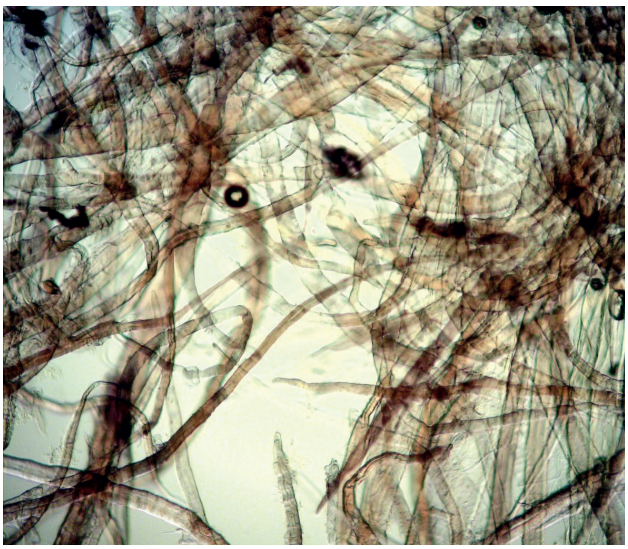
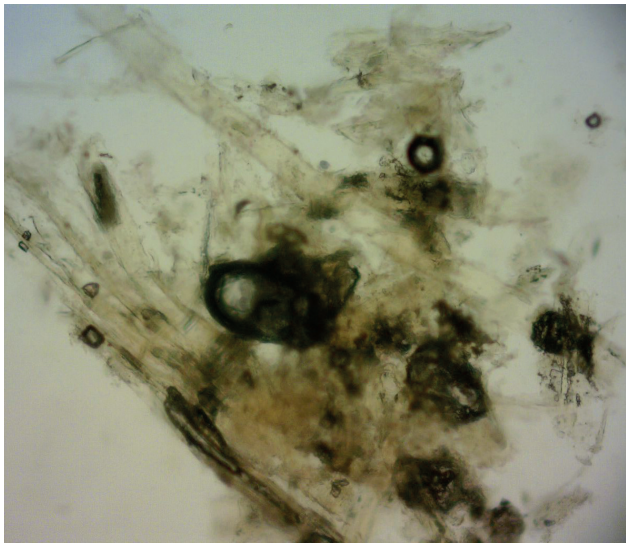


Figure 21 . *Cloth fiber (Herzberg's colorant). Source: T.Andrades.*

Figure 22. *Lignified fiber (Herzberg'scolorant). Source: T.Andrades.*



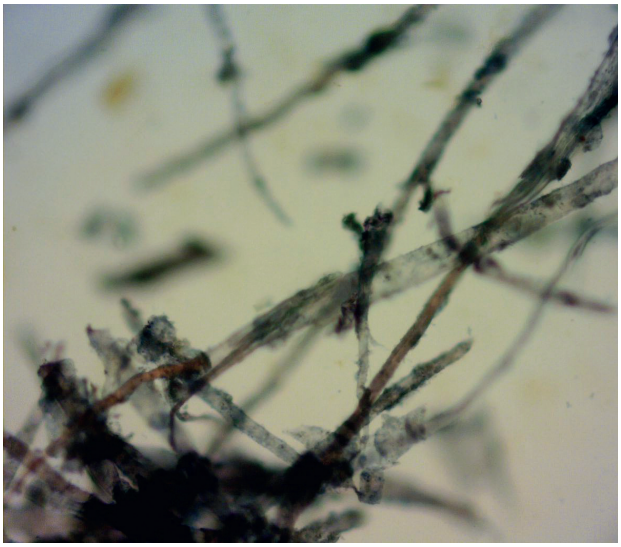


Figure 23. *Semi-chemical fiber (Lofton-Merrit's colorant). Source: T.Andrades.*

Simplified restoration procedures

Restoration is primarily manual, although some processes may be mechanized using specific tools to facilitate application to a large volume of items. It is very important that, as far as possible, the intervention should be carried out by qualified professionals with experience in similar materials. Only when it is not possible and an urgent restoration is necessary enough to justify it, other authorized personnel may proceed only after demonstrating proficiency through enough successful controlled testing.

✓ **Surface dirt removal.** It is an essential preliminar step before any other restoration process when dirt compromises the material physical or chemical stability or its designated function. It should always be taken into account and avoid affecting the non-original elements that have been intentionally added such as handwritten annotations, tampons marks, etc.
The most common mechanisms are:

- **Mechanical surface cleaning**, with thin hairbrushes more or less thick combined with aspiration tables or low-power domestic vacuum cleaners in the softest possible mode (those with adjustable power with different nozzles would be the most convenient).
- **Cleaning with instruments to eliminate adhesion** (from insect detritus, glue, mud, etc.). Scalpel tips, spatulas, eraser tips for ink or even harder rubbers are usually used. These processes involve much more danger of affecting support with losses or erosion, so you have to be sure of using the right instruments in each case and that you master the technique to be applied.
- **Wet cleaning**, if the support allows it, gently pass without rubbing the cotton swab or cotton bud slightly wet in water or other solvents. Before applying these techniques, the possible excess humidity should be eliminated with a dry paper so that no dirt penetrates into the substrate.

✓ **Removal of adhered elements and stains.**

- **Old rubber-based adhesive tapes can be mechanically removed with hot spatulas or heat application**, always without direct contact to prevent the adhesive from penetrating into the support. For each case, make sure of using the appropriate instrument or environment control to separate the adhesion minimizing other risks.
- **The slightly aged adhesive tapes can be removed with the application of solvents by impregnation such as xylene, toluene, etc.** The oldest ones usually come out using solvents with acetone, tetrahydrofuran, etc. For resistant cases, several solvent mixtures can be tested (see reference [10]).
- **When applying the chosen solvent or local heat**, it is essential to proceed slowly enough to carefully monitor, with the appropriate mechanical elements, the behaviour and effect on both the element to be removed and the support of the element of interest. This is necessary to estimate whether it is or not sufficiently softened to further act onto it (or not) to continue the separation process. The previous tests should help to determine adequate quantities to apply and speed of process.
- **Possible remnant spots should be tested and treated after the complete adhered element is retired.** Note that the separation process may alter the possible spot or create new ones.

- ✓ **Dive wash.** Aqueous washing that favors the elimination by dissolution and extraction of degradation products that cause the acidification and yellowing of the support. Oxidation and spots of microorganisms do not disappear, but some soluble or adhesive spots and additions of old repairs do. Before considering it, handwritten annotations, inks, and other elements must be taken into account. There may also be a loss of the glossy finishes or brilliance of the support in the case of satin papers. In order to carry out the process, the following materials are needed:
  - **Laminae that allow the circulation of water, of greater dimensions than the original document**, which allows easier and safer handling of the original during the different phases of washing. Different materials of non-woven synthetic fibers are currently used that are not adherent, do not deform, resist heat and many solvents. The most common are marketed under the following denominations: Remay® (polyester), Hollytex® (smooth polyester), Celex® (nylon) and Kiara® (polyester and polypropylene). In the last section of this manual *Resources and References* we include some examples of companies selling these materials.
  - **Flat washing container.** As far as possible, with a drainage pipe to avoid additional handling. Trays can also be used with due precautions.

- ✓ **Flotation wash.** More recommended than the previous one when the support shows fragility and it is not recommended too much handling. It is very similar, but uses low water levels and the element is put to be washed above the fabric so that by capillarity the degrading elements are dissolved without manipulating them.

- ✓ **Capillary wash.** Washing with secant papers, aqueous gels or on felt. Very similar to washing by flotation, but now the originals are placed on these materials long enough moistened for the degrading elements to be diluted by capillarity. It is a slower process but more suitable for very delicate materials that do not allow excessive upper humidification.

- ✓ **Drying.** The most recommended drying procedure is air drying on a flat, ventilated surface without currents, allowing uniform and progressive drying. Avoid pressed drying because can deform or modify materials, leaving marks of the fibers of the supports, reduce gloss, and a non-uniform drying that produces additional deformations and tensions.

- ✓ **Stabilization.** It is the deceleration of chemical reactions that cause deterioration due to environmental conditions. Humidity and temperature control is usually the most frequent and effective, ideally in slightly cooler conditions than standard recommendations. There are also other treatments to chemically stabilize certain specific reactions, such as paper aqueous washing to dissolve soluble acid components and acidic products formed by the absorption of contaminants.

- ✓ **Deacidification.** It is the neutralization of acidic particles by introducing alkaline compounds into the fibers, which act as a reserve for the neutralization of the acids that can be generated over time due to the aging of the paper. They can be:
  - **Aqueous treatments.** The most common is the dissolution of calcium hydroxide that creates an alkaline reserve when dried by the action of hydroxide with CO_2 from the air.
  - **Non-aqueous treatments.** Recommended for water-sensitive or non-stable materials due to their high degree of deterioration. They are applied by nebulization or with brushes. The components are often toxic, so they should be handled only by professionals using manufacturer-recommended safety protocols.

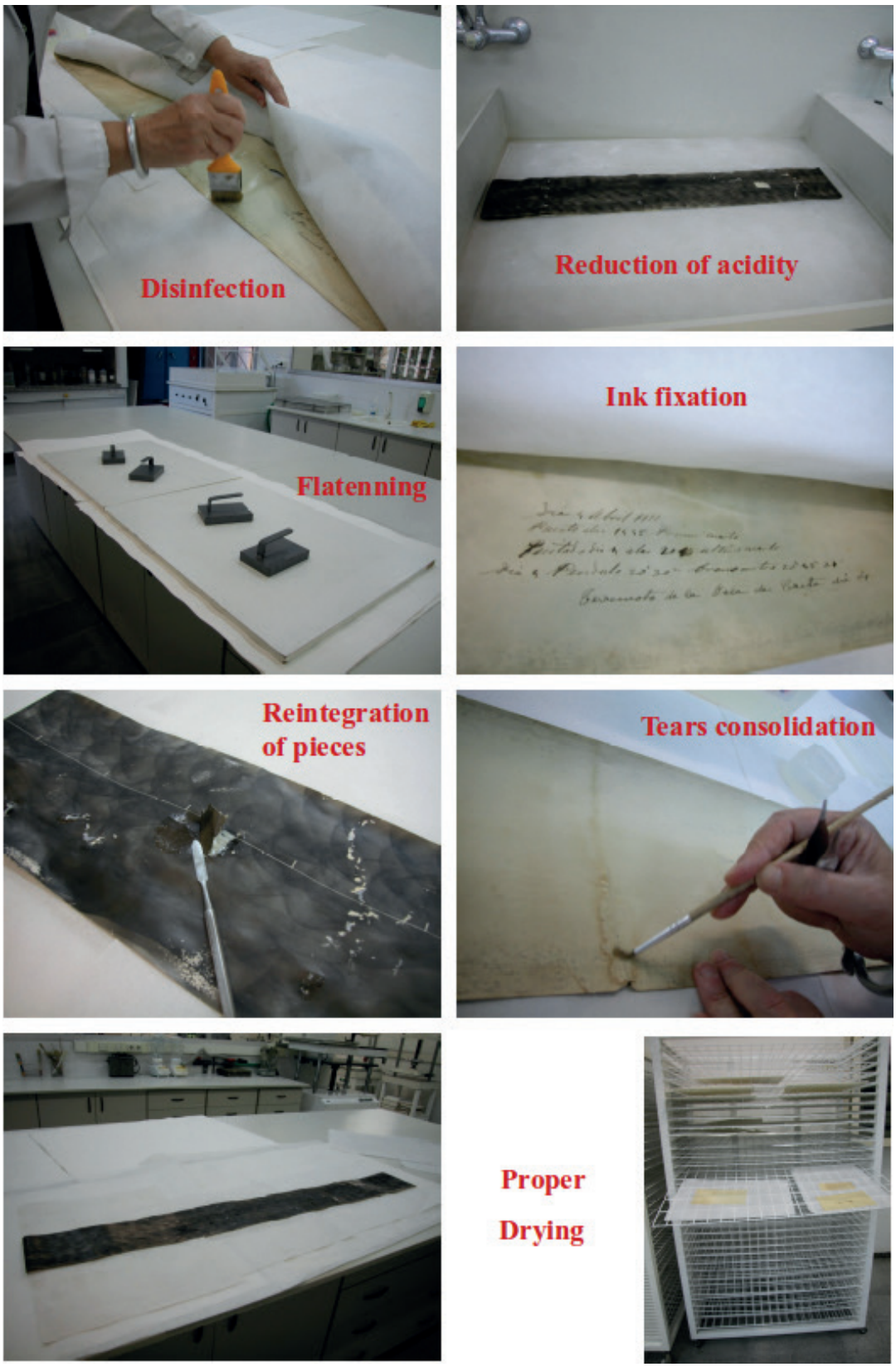


Figure 24. *Examples of restoration procedures. Each element always requires individual attention. Source: T.Andrades.*

✓ **Consolidation.** To reinforce the mechanical strength of the support, improving its handling through fiber reinforcement and cohesion. Usually using an adhesive that makes it more resistant and allows writing with ink without penetrating inside the fibers of the original substrate. Some of these adhesives due to their composition have been detrimental to long-term conservation as they may contain elements that harm and destabilize (such as starches) or that make them susceptible to biological attacks and oxidation. It should be noted that during washing processes these additional layers may disappear due to the dissolution of their components. The most common adhesives are:

- Midons or starches. They offer great stability and were widely used in most of the old papers treatments.
- Gelatins. Composed of the cooking of remains of parchments or remains of animal skins. They offer good results due to their penetrability while in some cases they provide alkalinity (parchment gelatin).
- Modified cellulose. Very stable, both dissolved in water and alcohol.

For its application we will always use a Remay®-type or similar synthetic support. Application methods are usually:

- **Brush application.** It must be applied from the center outward to the ends on both sides in order to avoid dilatations or the substrate blew when drying.
- **By immersion,** introducing it with the support to act for a certain time (usually 20 to 30 minutes) and then letting it dry in the air.
- **By nebulization.** Especially advisable when the substrate state does not allow any of the other options above.

✓ **Repair of breaks or tears.** Repairs with specialized self-adhesive materials are quick and eventual solutions that in many cases allow the conservation of pieces or fragments and prevent damage from increasing, but in the long run they can be harmful because adhesives become unstable.

- **In tab strips a neutral adhesive** (methylcellulose or starch) is applied to the fibers on both sides of the break joining and fitting them well. It is protected with a synthetic fabric such as Remay® on both sides and then dried by local pressure between drying materials or with a hot spatula. In case the fibers are scarce, the cutting is reinforced with a Japanese lame paper piece.
- **In clean-cut tears,** reinforcement is always required for repair, applying the adhesive and a piece of defibrated Japanese lame paper. For further consolidation, it is possible to assess the suitability of reinforce both sides of the original.

✓ **Reintegration of loss of support.** It is the application of additional new support to the sites where the loss occurred. The criteria for this intervention will be the same as for all restorations: minimum intervention, neutral elements, differentiation with the original and as much reversibility as possible of all the materials and adhesives used. It may be:

- **Manual reintegration.** It consists of the adhesion of a new substrate in the same way and size of the lost area, seeking the least possible invasion of the original so that the fibers that allow adhesion do not cover the original more than essential and by the area where it least affects its possible use or interest. The adhesion is done in a similar way to the repairs described above, but now the adhesive is applied only to the material to be added to the contact areas, carefully combing fibers so that to have a greater area and grip contact.

- **Mechanical reintegration.** The base is the defibration of Japanese paper fibers in water with adhesive. The manual technique, recommended for small losses or holes, is carried out in a suction table where the original is placed with a Remay® base and drops are deposited in all the fibers in water with the adhesive until obtaining the desired thickness that will form a new paper. It ends by applying an adhesive to the reintegrated set. For larger areas, paper reintegrating machines such as those invented by Esther Alkalay in the early 1960s (see reference [11]) are more effective. With a similar operation to the paper manufacturing process, the paper fibers in suspension in water are passed through the original so that for simple gravity they are deposited in the areas with losses forming new paper. These machines have evolved and improved until now they do the process very quickly and effectively even when the areas to be reintegrated are very large. To finish the mechanical reintegration, an adhesive is applied to the reintegrated area to achieve greater consistency and drying is done in the air or by press.
- **Lamination.** It is the adhesion of a reinforcement paper, usually a Japanese lame paper, with an adhesive similar to the previous ones. It is used only in very extreme cases when the support is very weak, so its manipulation is not possible to be performed by any of the above options, such as in cases of great fragility due to acidity, extreme weakness for microorganisms, etc. It is a very invasive modification of the original support and should preferably be done on the face with less writing or information since the Japanese lame paper modifies the visibility of the information.

CHAPTER 5

USE AND RAISE AWARENESS

How to best use it to avoid damage and risk of loss.

Introduction

What is not seen and used is easily devalued. It is essential to maximize the correct use of the heritage for its own long-term conservation. Recognition and appreciation frequently depends on its visibility and use. Without those, securing resources for proper conservation becomes significantly more difficult. The goals of responsible use, handling and exposition are to assess the true state of conservation, identify potential risks and guarantee their maintenance or improvement in a compatible way.

IMPORTANT

- **Visibility supports preservation**. A correct handling and display can enhance in the long term the conservation of the heritage by increasing their use and visibility and, consequently, their perceived value and the possibility of maintenance or improvement of its present conservation.
- **Environmental risks vs. controlled use**. Inadequate temperature, humidity or light radiation can be much more difficult to control than well-planned use and exhibition if a policy of restriction of use is developed depending on the type of user, objectives and associated risks.

Complete and updated documentation

It is important to maintain through documentation an explicit and well-documented follow-up of the usage and exposure of each heritage item. It is essential to be able to access opportunities to obtain future resources. Besides, it eases to assess whether their conservation and use are the right ones or whether it is necessary to make some specific intervention or update any protocol in this regard.

Some of the most dangerous moments are when sudden changes occur in staff, department or institution in charge of heritage. Good prior documentation of heritage and associated processes such as those described in the previous chapters facilitates training and transfer in general, ensuring continuity during transitions, and so greatly reducing the possible risks.

It is interesting to keep multiple digital copies and printed copies of all documentation, in all workspaces and computers of the responsibles for heritage and related works. It is also advisable to keep a copy of the digital ones on the servers of the department or institution of reference. And of the prints as annexed within the same physical archive where the analogue heritage is stored.

It is important to review and update or expand the documentation periodically and whenever significant changes occur.

It is also interesting to keep the documentation prepared for the projects that were postponed or dismissed for any reasons, from inventories or catalogs, conservation plans or restoration assessments. This archived information may prove valuable for future initiatives or reassessments.

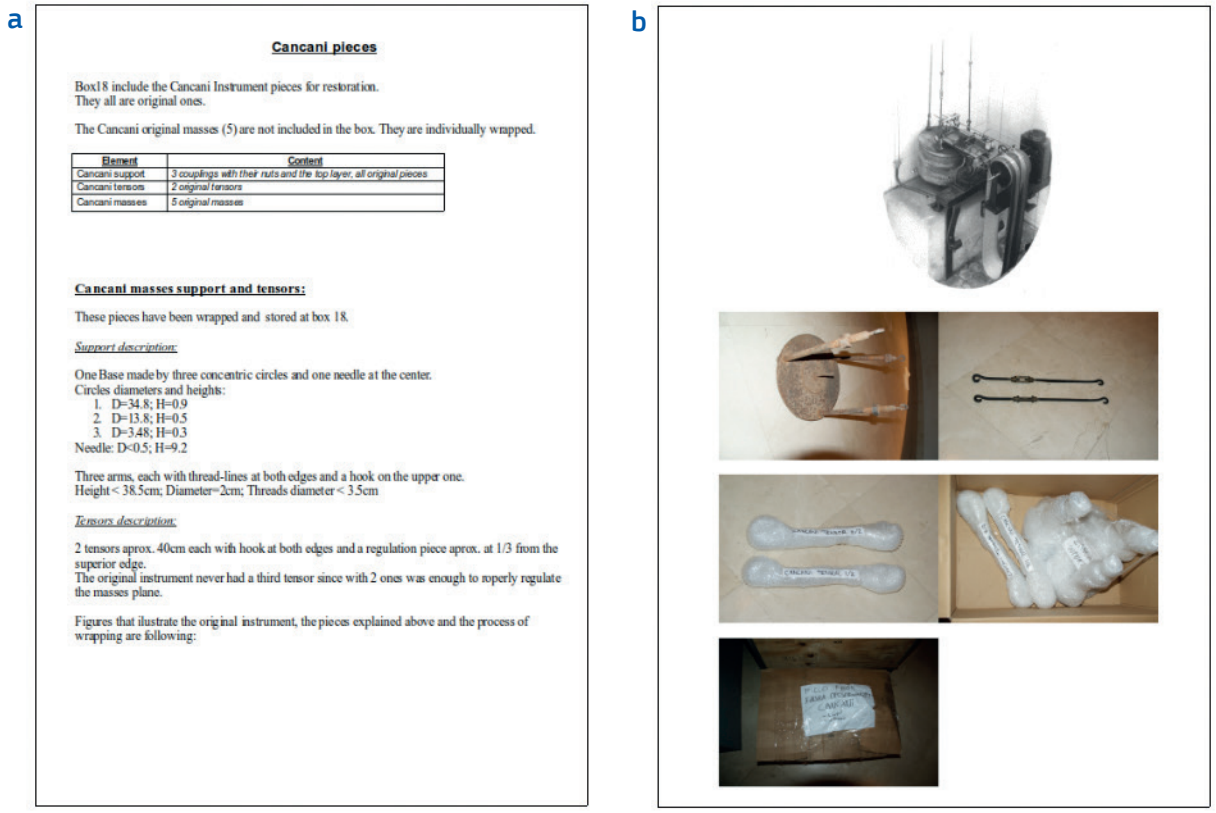


Figure 25. *Examples of useful documentation: a) inventory adapted for tracking a movement; and b) report with graphical testimonies of previous state and materials already prepared to travel. Source: Observatori Fabra.*

Visibility

We must give visibility to both the heritage itself and to each of the related works or those to which it contributes significantly.

Visibility should be promoted across multiple audiences:

- **Internal Staff.** To improve institutional knowledge, priority in resource allocation, and continuity in responsibilities when possible substitutions or changes occur.
- **Related Institutions.** To foster and facilitate synergies, shared initiatives, and future joint actions.
- **Professional Community.** Especially those related or working with similar heritage or its potential applications.
- **General Public**. Through adapted formats that consider varying levels of interest and prior knowledge.

Single documents or one side flat pieces can be more suitably exposed using transparent Remay® covers with Melinex® bases that allow ventilation avoiding fungal growth and dirt accumulation.

It is advisable to periodically change the pieces chosen for the exhibition and update their state of conservation and the incidents detected in each change.

Contributions to conferences, publications or partial translations of reports help to share knowledge and information in a language intended to be disseminated outside the immediate working group.

Digital images and other digitization of heritage enhances visibility and dissemination for multiple uses and actions while reducing the need for direct handling.

In order to achieve a better follow-up of the works where they are used, a differentiated policy of sharing digital products can be valued according to their dpi density, detail, resolution, etc.

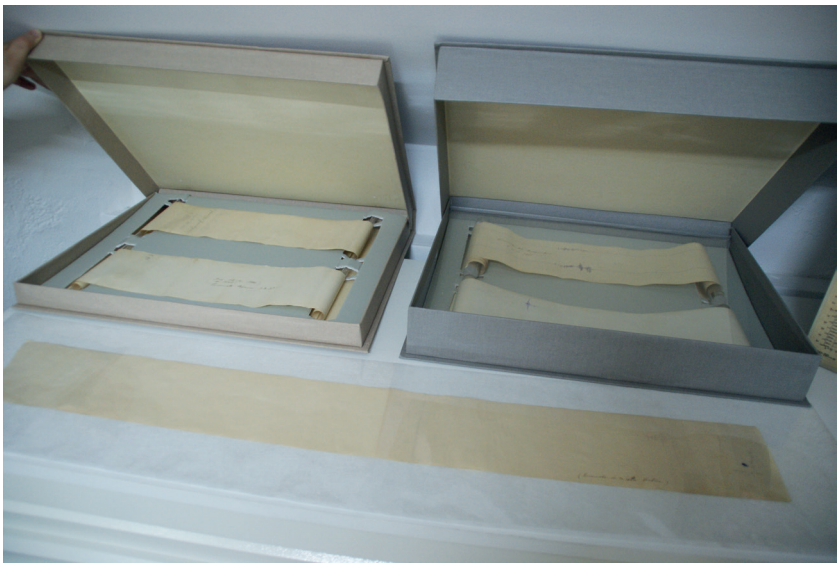


Figure 26.
Special cases of seismograms deserve special pH- neutral containers to provide adequate conservation with easy visualization. Source: Observatori Fabra.

Preferred Uses

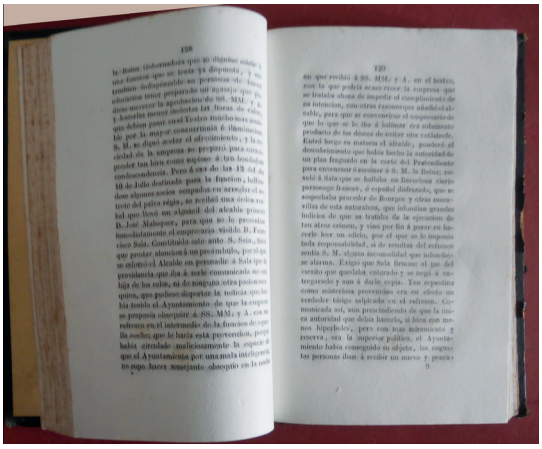
Analogue seismic heritage offers a wide range of potential uses. Promoting its responsible use is essential not only for scientific and historical value but also for its long-term preservation. Visibility and utility are key to securing resources and avoiding neglect or loss.

The final section of this manual includes references to diverse examples of use cases. Below are some of the most common and recommended applications:

- ✓ Public dissemination through direct exhibition (temporary or permanent displays of originals).
- ✓ Elaboration of reproductions (low resolution scanning, partial copies, etc.).
- ✓ High resolution scanning to obtain digital copies for archival and research purposes.
- ✓ Digitization of seismograms or OCR of additional documentation for analysis.
- ✓ Data compilation for external catalogs (regional networks, ISC, etc.).
- ✓ Historical studies of specific phenomena or events (historic earthquakes, artificial explosions, etc.).
- ✓ Microseismicity analysis.
- ✓ Anthropogenic seismicity studies.
- ✓ Research on seismic stations or instrumentation.

Every use, whether for research, exhibition, or digitization, involves handling and therefore risk. Proper planning and risk assessment are essential.

a



b

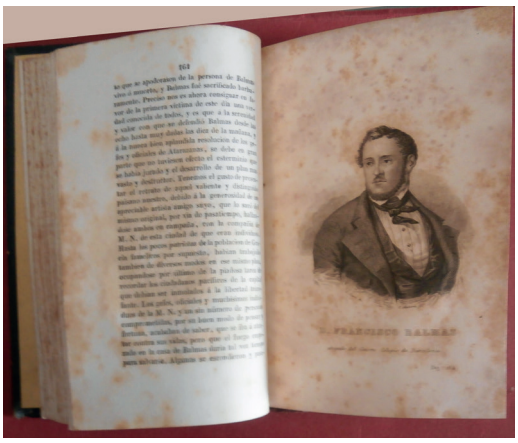


Figure 27. *Books opened for exhibition accelerate its degradation in the exposed page unless adequate protection measures are considered:*
a) *ordinary page;*
b) *exposed page (far more degraded).*
Source: T.Andrades.

Always keep in mind the following aspects:

- Heritage originals are fragile and must be handled with care. When use occurs plan ahead stronger preservation measures keeping in mind that they are irreplaceable. Make sure to prepare and apply clear policies about who, how, when and for what is or is not allowed to access them.

- Keep always in mind that wilful destruction is a quick and real risk. Most institutions undergo great pressures to justify the costs devoted to maintain patrimony within its limited resources. Therefore, avoiding any use often is not an advisable or even a viable recommendation. The most long-term solution to avoid wilful destruction is a correct preservation with well prepared and documented plans and policies for its use and visibility.

- Never destroy or endanger original data nor documentation since they are irreplaceable. Keeping originals is a basic and strict rule that should never be seen as hoarding. Even when already "fully" processed, scanned or copied somehow, original records should be preserved and given use and visibility to avoid the risk of loses.

  - Analog records provide invaluable information to be explored and exploited with present and future knowledge. But they need to be preserved and easy to convert to other formats once and again, who knows how many times because one's generation noise can be other's generation signal.

  - Every intervention or processed data has a non-negligible % of errors or loses, or will have in the future. Even the most verified process might have, or most probably will have, some.

  - Formats evolve very quickly and soon might be difficult to ensure their recovery because of changes of technologies (p.ex.: floppy disks, zip or magnetic bands), standards (e.g.: original registered formats vs. mseed, etc.) or expected durability (e. g.: microfilms, CDs, DVDs). In addition to be safer, often it is also even more easy and even cheaper in the long term to preserve original analogue records than their digitized or processed copies.

- Patrimony disorder or separation is a great danger in almost every intervention. It should be avoided as far as possible unless there are very justified reasons for a partial change during short time, well documented and with a previous detailed planned verification when the intervention finishes.

- Minimize transportation. Those are crucial moments when damages (both accidental and due to improper handling) occur. Disorder and damages are very difficult to avoid, leading easily to even partial losses. Local interventions, whenever possible, should be preferred to minimize them.

- Scanning is a very costly and dangerous process. Unfortunately, not all current scanning projects will allow the data from these now scanned images to be properly digitized/vectorized correctly in the future. It is important to explore not only costs vs. present objectives, but also possible limitations for each possible different approach for the scanning options, current standards and other previous initiatives with their own results and limitations.

Figura 28. *Extra layers of protection must be used for transport and exhibition. Be aware of risks of unexpected humidity, temperature and position changes and prepare accordingly. Prepare an extended inventory of each piece of heritage with photographs from their original situation, prepared to be sent, exhibited, and once back to its permanent storage. Documentation of any change (or that fully revision has been made but no change has been detected) should be kept along with the rest of the documentation of the heritage.*
Source: Observatori Fabra.

- Standards greatly facilitate the interoperatibility and enables cross-disciplinary uses of data. Every intervention should aim to involve and produce as much FAIR metadata as possible to ease and therefore increase its present and future use. This increases both the present utility and future potential of the heritage and its associated data.

➢ Try to expand areas of interest of your seismic analogue patrimony.

- ✓ Scientific use and visibility of seismic analogue patrimony do not necessarily reduce to earthquakes and their related hazards. Seismic analog records and documentation can be very useful to many other geophysical studies of earth crust, deep internal structure, terrain local structure and fault mapping, volcanic activity monitoring, landslides detection, etc. Moreover, they are also very important for other more diverse fields such as monitoring of explosions and other artificial structures, study of glacial movement and other meteorological and oceanic phenomena, etc.
- ✓ Historical importance in broader terms should not be avoided nor infra-valuated. War bombings and many other historical local effects recorded forever in seismic analog records deserve also attention and recognition. Besides, analogue records may add significant information about the historical importance of the different technologies to obtain those records, the people in charge of them, their processes and their results, etc.

➢ Keep in mind and respect your institution and other institutions policies for credit recognition.

- Try to keep in touch and explore other's initiatives, both successful and problematic. Sometimes we learn more from unexpected problems than from expected results. Do not hesitate to recognize and acknowledge those learned lessons.
- Cite always appropriately data origins and try to recognize other's efforts to maintain it and make it accessible.
- Advocate for FAIR use of your patrimony, but accept and navigate within your institutions present policies. Drastic changes sometimes lead to unexpected risks or critical decisions. Long term changes often need time to occur peacefully.
- Try to join external collaborations and standard practices as far as possible. Joint efforts, shared standards and dissemination of knowledge can be one of the most helpful resources.

Figure 29. *Melinex® and Remay® are used in Observatori Fabra to be able to see the seismogram on top when drawer opens so visits can see selected originals keeping reasonable protection.*
Source: Observatori Fabra.

RESOURCES AND REFERENCES

Where to search for more? Who might ask to?

This is just a brief and limited manual made as a simple guide to start with only basic knowledge on the topic so that the interested reader can access other much more extensive literature that deals with the different topics in greater depth without getting lost. References and resources in this section include more detailed and comprehensive information. Additional online resources contain diverse URL with listings and compendiums more extensive and updated that this short manual.

Legacy seismograms and stations:

There are three main websites where to find information on legacy seismograms and stations in Europe:

- SISMOSLAB (INGV):
  https://sismoslab.ingv.it
- ESC Working Group 02-13
  "Preservation, valorisation and analysis of seismological legacy data":
  https://www.legacy-seismograms.eu
- Legacy Seismic Data Project (LSD):
  https://legacy-seismic-data.github.io

Complementary information can be found in the bulletins stored in the *International Seismological Centre (ISC)* section *Printed Station Bulletins*:

https://isc.ac.uk/printedStnBulletins

Also at the *Seismo Archives* at:
https://ds.iris.edu/seismo-archives

Also at the *Euroseismos* website at:
https://storing.ingv.it/es_web/index.htm

And at the *SISMOS SeismogramRequest 2.0* website at:
http://seismogramrequest.rm.ingv.it

Preservation and conservation:

A website with a large amount of information on preservation and conservation is the:

Northeast Document Conservation Center
https://www.nedcc.org

Specifically for paper conservation:
https://www.nedcc.org/paper-conservation-at-nedcc/resources

With helpful pages such as:
https://www.nedcc.org/free-resources/preservation-leaflets/overview
https://www.nedcc.org/free-resources/overview

Another website plenty of information is:

Weissman Preservation Center from Harvard University:
https://preservation.library.harvard.edu/weissman-preservation-center

And, specifically:
https://preservation.library.harvard.edu/guidelines

In case of further curiosity on more advanced topics, there are online resources by and for conservators and related fields operated by the Foudation for Advacement in Conservation available through:

***CoOL Conservation OnLine website*:**
https://cool.culturalheritage.org

The authors of this manual have obtained most materials and services for the projects performed in Observatori Fabra (Barcelona) from the following companies:

https://www.arteymemoria.com/eng/home.html
https://www.tecnihispania.com

But additional providers lists can be found online such as in:
https://cool.culturalheritage.org/bytopic/suppliers

The ***Society of American Archivist*** (https://www2.archivists.org/aboutsaa) publishes a journal with interesting contents:

https://www2.archivists.org/american-archivist

Other Journals on the tòpic are:

Journal of the American Institute for Conservation
https://www.tandfonline.com/journals/yjac20

Heritage
https://www.mdpi.com/journal/heritage

Heritage Science
https://heritagesciencejournal.springeropen.com

FAIR Principles:

Important references on **FAIR Principles** are:

L. J. Hwang, T. Ahern, C. J. Ebinger, W. L. Ellsworth, G. G. Euler, E. A. Okal, P. G. Okubo, W. R. Walter (2020). Rescuing Legacy Seismic Data FAIR'ly. *Seismol. Res*. Lett., 91 (3), pp. 1339–1340. https://doi.org/10.1785/0220200027

Wilkinson, M., Dumontier, M., Aalbersberg, I.J., Appleton, G., Axton, M., Baak, A. et al. (2016). The FAIR guiding principles for scientific data management and stewardship. *Scientific Data*, 3, 160018. https://doi.org/10.1038/sdata.2016.18

P. G. Richards, M. Hellweg (2020). Challenges and Opportunities in Turning Large U.S. Archives of Analog Seismograms into a Modern Usable Resource. *Seismological Research Letters*; 91 (3), pp. 1531–1541. https://doi.org/10.1785/0220200053

Other projects for preservation of seismograms:

Information about Institutions developing projects for preservation of seismograms in different countries can be found on several articles following:

Italy

Michelini, A., B. De Simoni, A. Amato, and E. Boschi (2005). Collecting, digitizing, and distributing historical seismological data, *Eos Trans. AGU*, 86 (28), pp. 261–266,
https://doi.org/10.1029/2005EO280002

Ferrari, G. (a cura di) (2014). Dal cielo alla terra. Meteorologia e sismologia in Italia dall'Ottocento a oggi, *Bononia University Press*, Bologna, pp. 298–301,
https://doi.org/10.1029/2005EO280002

https://storing.ingv.it/tromos/home.htm

https://storing.ingv.it/es_web/index.htm

https://sismoslab.ingv.it/index.php

Japan

Satake K., H. Tsuruoka, S. Murotani, K. Tsumura (2020). Analog Seismogram Archives at the Earthquake Research Institute, the University of Tokyo. *Seismol. Res. Lett.*, 91 (3), pp. 1384–1393
https://doi.org/10.1785/0220190281

Furumura M., K. Iwasa, Y. Suzuki, T. Demachi, T. Ishibe, R. S. Matsu'ura (2020). Data Retrieval System of JMA Analog Seismograms in the Headquarters for Earthquake Research Promotion of the Japanese Government. *Seismol. Res. Lett.*, 91 (3), pp. 1403–1412.
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