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Historical conservation treatments in palaeontology: the geo-palaeontological collection of the Geology and Palaeontology Museum of the University of Turin managed by the Piedmont Council Museum of Natural Science of Turin

Dafne Cimino
Oscar Chiantore
Tommaso Poli

Department of Chemistry and NIS (Nanostructured Interfaces and Surfaces) Centre, University of Torino, Via Pietro Giuria, 7. I-10125, Torino.
E-mail: dafne.cimino@unito.it; oscar.chiantore@unito.it; tommaso.poli@unito.it

Daniele Ormezzano
Lorenzo Mariano Gallo

Piedmont Council Museum of Natural Sciences, Via Giovanni Giolitti, 36. I-10123, Torino.
E-mail: daniele.ormezzano@regione.piemonte.it; lorenzom.gallo@regione.piemonte.it

ABSTRACT

The change of environmental conditions following the discovery of fossils and mechanical stresses during the excavation phase can raise the already grave fragility of the findings. As a consequence, fractures, detachments and powdering phenomena can appear and a conservation treatment is required to restore the objects and preserve them from further degradation. Traditionally, scientists have been using products of natural origin (animal glues, resins or gums) as consolidants and adhesives, but in the course of the last century these materials have been often replaced by synthetic products. In this survey part of the geo-palaeontological collection of the Geology and Palaeontology Museum of the University of Turin managed by the Piedmont Council Museum of Natural Sciences in Turin has been evaluated by considering the efficacy of the consolidation treatments and the products employed over the years.

Key words:
palaeontological collections, fossils, conservation treatments, adhesives, consolidants.

RIASSUNTO

Trattamenti di conservazione storici in paleontologia: la collezione geo-paleontologica del Museo di Geologia e Paleontologia dell'Università di Torino gestita dal Museo Regionale di Scienze Naturali di Torino.

Il cambiamento delle condizioni ambientali a cui i fossili sono sottoposti dopo il loro ritrovamento e gli stress meccanici nel corso delle fasi di estrazione tendono ad aumentare la naturale fragilità dei reperti. Conseguentemente compaiono fratture, distacchi o spolvero della superficie che rendono pertanto necessari interventi di restauro atti a ripristinare l'oggetto e a prevenirne l'ulteriore deterioramento. In passato gli studiosi erano soliti impiegare consolidanti e adesivi di origine naturale quali colle animali, resine e gomme vegetali, ma durante l'ultimo secolo tali materiali sono stati affiancati da prodotti di sintesi.
Il seguente lavoro presenta lo stato di conservazione di alcuni reperti della collezione geo-paleontologica del Museo di Geologia e Paleontologia dell'Università di Torino gestito dal Museo Regionale di Scienze Naturali, valutando i trattamenti conservativi succedutisi negli anni e analizzando i materiali impiegati.

Parole chiave:
collezioni paleontologiche, fossili, trattamenti conservativi, adesivi, consolidanti.

INTRODUCTION

The palaeontological collection of the Geology and Palaeontology Museum of the University of Turin represents the historical nucleus of the collections of the Piedmont Council Museum of Natural Science and has been gathered in the last decades of the XVIII century. In 1833 Borson (Borson, 1833) gave information about the oldest material, still clearly recognizable in the collection: two bison skulls found in 1776 along the banks of the Po river, not far from Pavia. In the 1800s (Bellardi, 1871) new fossils arrived from all over the world generating a set of more than 100.000 objects and now one of the mission of the museum is implementing this already broad section. The collection was rich in invertebrate findings other than animal bones and skeletons, but also the palaeobotanical section was significant. Unfortunately during the bombings of the Second World War fossils were damaged and a large part of the collection was lost (Campanino & Pavia, 2003).

This work introduces a preliminary survey about the conservation state of the findings and in particular on the conservation treatments that have been done over the years. Generally, fossils require a conservation intervention when decohesion occurs among the layers, in the substrate or in the object structure, when there are fractures or when the material is known to be delicate and fragile (Shelton, 1994). The excavation phase from the palaeontological site and the arrangement of the fossils in a different environment are both stressful operations that can improve an already peculiar conservation state. Moreover, during the deposition of the organic material and the fossilization process as during the geological evolution of the rocks within the material is, a series of transformations (such as the load of new sediments) take place, jeopardizing the integrity of the objects.

Animal remains usually need a conservation treatment only when severely fractured, in order to recompose them with adhesives that have to create minimum thickness between the bonded parts. After this phase, a stage of integration follows, in order to fill in gaps and discontinuities over the bone or to reconstruct missing parts (Cencetti, 2006).

Among botanical findings, phyllites and woods do not need particular attention if lithified since the mineralization substitutes the organic component with a more resistant and stable inorganic one. Instead, fossils compressed or still rich in water can undergo faster degradation. The incomplete fossilization process, the consequent poor mechanical qualities of the organic material and the evaporation of the water itself are all causes of fragility of the object: the evaporation of water causes the shrinkage of the matrix and of the leaf, leading to fragmentation, delamination and exfoliation of the fossil, up to its complete loss (Collinson, 1995). The application of a consolidant which penetrates deep into the stone promotes an inner adhesion between the organic part and the substrate.

Natural and synthetic consolidants, adhesives and protectives have been widely applied in the field for the different conservation purposes. In the past, natural materials of vegetable and animal origin such as gums, resins and glues were used for their availability and their compatibility with the substrates to be treated (e.g. Arabic gum was preferred for samples rich in water). The choice of the product to be used most often was made not particularly considering the functionality of the compound but instead taking in particular account the final aesthetical appearance of the object. In this way the colour of the fossils was often modified or emphasised.

From the '50s of the last century, semisynthetic and synthetic polymers have been introduced (Mastrorilli, 1965; Anderson et al., 1994; Lepage & Basinger, 1993; Collinson, 1995; Leidi, 2004) and in particular acrylic resins and polyvinyl acetate "invaded" this field (Rutzky et al, 1994; Shelton & Chaney, 1994; Cencetti, 2006). Various application methods can be used: immersion, imbibitions, injection. The employment of these products followed the same purposes of the application of natural materials, believing in better performances than with the old products, in particular minor yellowing phenomena, better water repellence and durability. In 1977 Borselli, a specialist preparer of the collection of the Palaeontological Museum of the University of Florence, described in detail different consolidation methods, according to the typology of damage occurred: epoxy resins were recommended when findings were really fragile and full of inner fractures, while if the general state of the piece was good, immersion or brush application of polyvinyl acetate (10% w/w) in a proper solvent was considered to be sufficient. To paste fragments, pressure sensitive adhesives could be used unless big pieces need to be stuck together; in these cases it was suggested to use a particular mastic, also employed in archaeology, whose recipe is: 34% of zinc white, 34% of calcium sulphate hemihydrate, 15% of paraffin, 15% of beeswax and 2% of Greek pitch (Borselli, 1977).

It is important to highlight that in the course of time curators and qualified specialists have been responsible for the restoration of the objects. The procedures employed have been commonly handed out verbally, shared among colleagues and their bases are the curator's personal experiences; the most employed materials have been those available on the market and often not specifically formulated for this kind of issues (Matteini 1988, Shelton 1994). Also for this reason, there are few literature reports about

this subject and the memory of the curator becomes the only tool to reconstruct the vicissitudes of the pieces. Even today the curator is the responsible of the preservation in most of the collections, although there is now more sensibility about the modern restoration criteria that consider the aesthetical issue a secondary one in respect of the treatment reversibility and of the chemical modifications of the product and of the substrate (Brandi, 1979; Cencetti, 2006). Nowadays the awareness is present that, due to the chemical degradation or to the penetration of the compounds into the porosity, the removability is almost always not possible nor easy (Matteini, 1988).

This survey is part of a wider project which aims at portraying the conservation state of the palaeontological collections of the natural science Museums of the Northern Italy, analysing the conservation treatments and trying to correlate the results with the history of the object, especially when no other information is available. In the end, it must be said that the introduction of synthetic polymers has not totally substituted the employment of natural and well known products, thus the presence of glues and resins is not limited to the treatments carried out before the 1950s. All the samples considered have been selected from the Museum warehouse and not from the exhibited findings. Where the treatment has been accompanied by documents, the sampling of the consolidant has not been considered necessary.

Data obtained from this research will be useful for further conservation treatments on the collection, making them more focused and accurate in the choice of solvents and products to be used.

MATERIALS AND METHODS

Objects arrived at the museum in different centuries (XIX, XX) have been selected in order to have a complete overview of the consolidation treatments applied over the years. Micro-sampling (few micrograms), when necessary, has been done by scalpel. In cases where detached scales of the conservative layer were present, a whole fragment could be taken and the homogeneity of the treatment verified.

Samples, 20 in total, have been analyzed by Fourier transform infrared spectroscopy (FT-IR) with a Bruker Vertex 70 spectrophotometer coupled with an Hyperion 3000 IR microscope and an ATR accessory (Harrick MVP Pro). A tiny amount of material (few micrograms) have been deposited and squeezed on a diamond anvil cell (High Pressure Diamond Optics, Inc.) and placed under the microscope, carrying out the analysis in transmittance mode. Bigger samples have been analyzed with the ATR accessory in attenuated total reflectance mode.

All samples spectra are the average of 64 spectra, acquired in the range from 4000 to 600 cm^{-1} with a resolution of 4 cm^{-1}. They have been reported in arbitrary absorbance units.

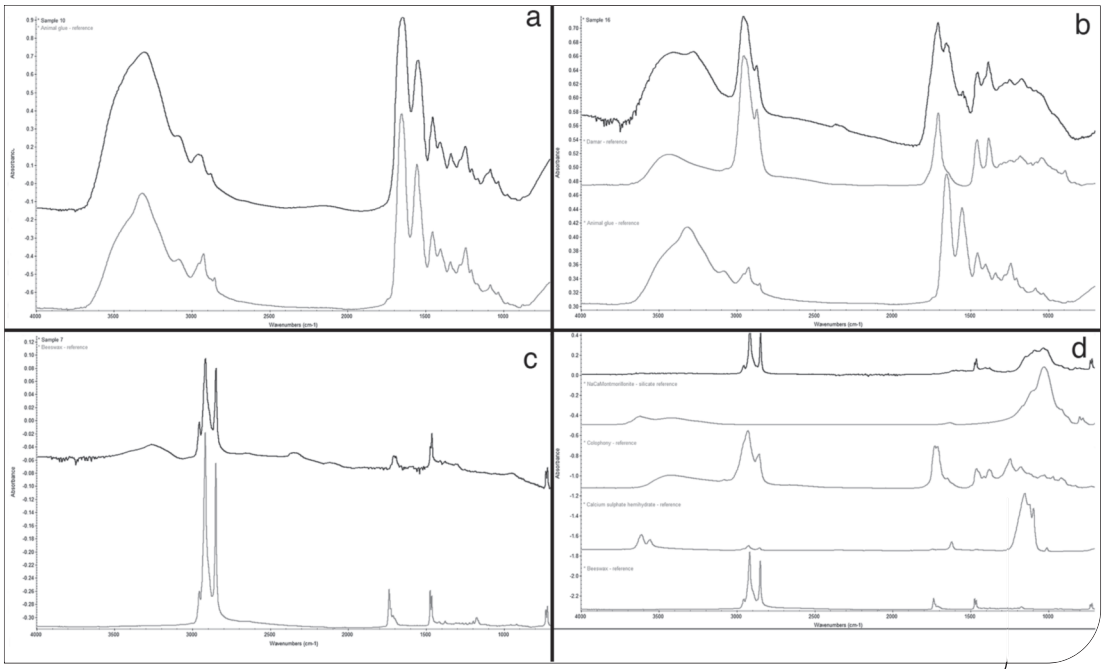

Fig. 1. a) FT-IR spectrum of a proteinaceus compound (above) along with its reference; b)FT-IR spectrum of the sample having a combination of protein and resin (upper spectrum) along with terpenic resin and animal glue reference spectra; c) Spectrum of a sample with wax (above) compared with beeswax spectrum; d) From top to bottom respectively: FT-IR spectrum of a stucco sample followed by silicate, colophony, calcium sulfate hemihydrate and beeswax reference spectra.

RESULTS AND DISCUSSION

Most of the samples present a proteinaceus component, which is considered to be animal glue (fig. 1a). Only in one case, a combination of protein and natural resin (terpenic) has been found and the different nature of the treatment was already perceived at the moment of the sampling because a patina stiffer and strongly stuck to the bone was noticed (fig. 1b).

Two samples revealed the presence of wax (fig. 1c) mixed in one case with colophony, calcium sulphate hemihydrate and silicates (fig. 1d).

Predictably, synthetic resins have been identified in samples treated in the last century, and in particular cellulose nitrate (CN), polyvinyl acetate (PVAc) and polyvinyl butyral (PVB) have been identified (fig. 2).

In general the collection is well preserved and does not require particular intervention. Although fossils are kept in a warehouse which has not the optimal environmental standard parameters for a museum storage, there are no evidences of serious degradation phenomena. Some of the findings consist of many pieces not yet recomposed, but this part of the collection is reserved to researchers for investigations and, accordingly, does not require particular aesthetical requisites.

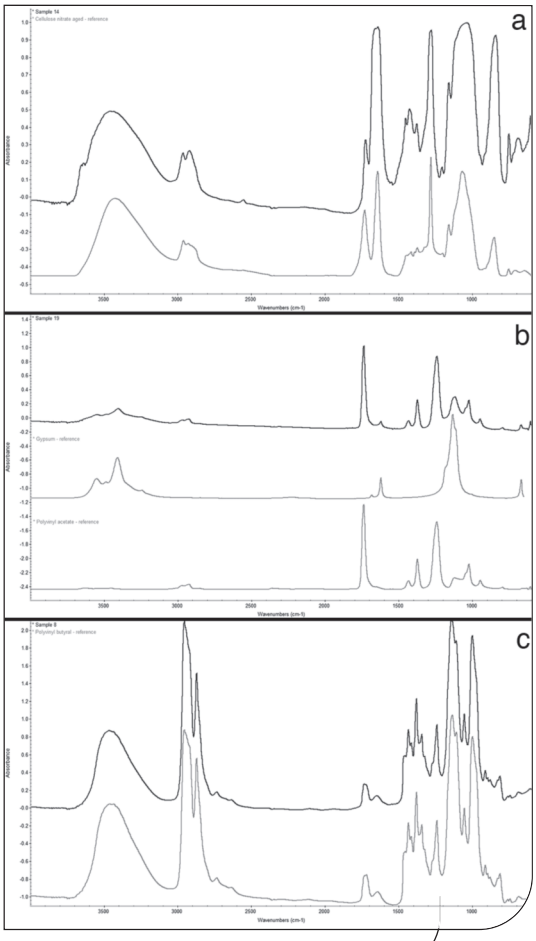

Fig. 2. a) FT-IR spectra of a sample (above) and of CN reference (below); b) FT-IR analysis of a fossil leaf consolidation treatment (upper spectrum) along with gypsum and PVAc reference spectra (middle and lower spectra respectively). The presence of gypsum is due to the stone powder remained on the polymeric film; c) FT-IR sample spectrum (above) compared with PVB spectrum.

Treatments made during the XIX century are often recognizable because of their yellowish and glossy aspect, sometimes with parts detached from the object probably because of a powdering phenomenon coming from a non optimal adhesion between product and substrate. The intervention, after different contraction and decontraction cycles, tends to originate micro-fractures in the bone structure and flakes from the surface.

In all such cases the product applied has been found to have a proteinaceus origin, easily ascribed to the use of animal glue employed as consolidant, protective and adhesive. Among the procedures of the museum, in the past (1900s), the use of sturgeon glue has been handed down due to the cost of the product and it was limited to the most important fossils of the collection. This glue was preferred because of its transparency, which is maintained also with the ageing.

Part of the collection was damaged by the fires following the bombings during the Second World War and a carbonized phase over some of the fossils surfaces appeared as a consequence of the heat exposure of the restoration product. Nevertheless, the consolidation material can still be identified as animal glue by means of the spectroscopic analysis. Only in one case a combination of glue and terpenic resin has been detected, that could have been applied in different times or for obtaining a particular aesthetical result (fig. 3).

Silicate structures have been also identified in different spectra, and it is not to rule down the possibility that some inorganic filler was added to the glue as a colour modifier.

The presence of wax in one of the samples, along with colophony and calcium sulphate hemihydrate, suggests that the material employed was the mastic described by Borselli since these are three of its components; the complex mixture cannot be completely determined by infrared spectroscopy due to the limit in the identification of the oxides, but the literature of the same years of the intervention (1970s-'80s) confirm the hypothesis (Borselli, 1977).

Among the botanic findings polyvinyl acetate was the consolidant more commonly applied. PVAc aqueous dispersions have been used to repair fractures and to consolidate the fragile surface layers of leaves. Substrates like muddy stones do not maintain the adhesion once dry and the contraction movements of the consolidant, due to temperature and moisture variations, promote the detachment of the particles.

Another synthetic product which has been found is

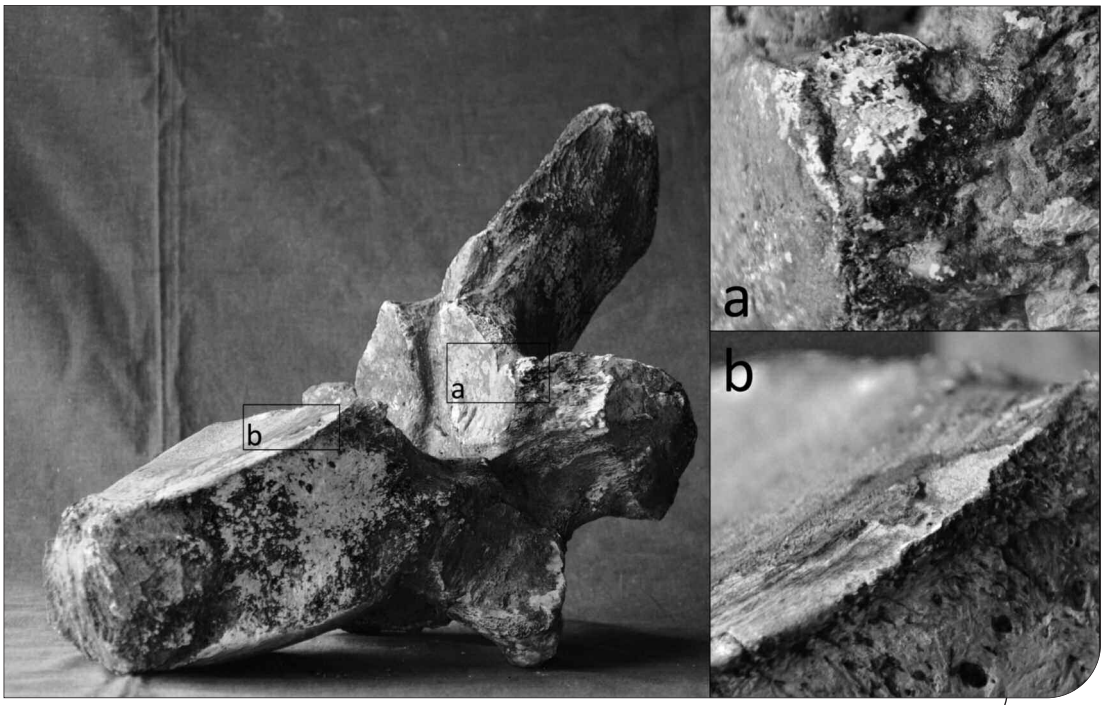

Fig. 3. Lumbar vertebra of *Megatherium americanum* (PU 15119/10). This fossil arrived with a Glyptodont skeleton in 1851 from Argentina, donation of Nicola Descalzi, an Italian explorer emigrant in South America (Sismonda, 1851). a) detail of the stiffer patina stuck on the bone surface, mixture of terpenic resin and glue; b) detail of the area treated with glue, flaking off from the surface.

cellulose nitrate. The sampling of this material has taken place in a limited area over the surface of the stone-support of the skeleton of a crocodile (*Crocodilus vicetinus*, figured and described by Sacco in 1895, hand-list PU 17329). It has been located because of a shiner aspect and it is the residue of a previous consolidation treatment, made with this synthetic resin. In fact, cellulose nitrate was one of the first polymers employed, but it was soon discarded because highly flammable. In the history of this piece, cellulose nitrate was first employed around 1950 and the application of a material bought as cellulose acetate followed in the 1970s. Later, also this film was removed and substituted with polyvinyl butyral. Considering the time of the second intervention and that on the fossil two cleaning operations have been carried out, the sample is most probably a residue of the second treatment and the hypothesis is that with the trade name of "acetate", nitrate and acetate both were sold. Cellulose acetate was replaced in the procedure of this Museum with polyvinyl butyral (Rhovinal B 10-20 by Rhône-Poulenc), borrowed from the archaeological field and described in literature as a very good and versatile product (Rixon, 1976; Horie, 2010). Effectively, PVB, diluted in ethanol in low concentration (<10% w/w), can penetrate deeper into the fossil structure or in its substrate, giving a better consolidation treatment and a preferred aesthetical aspect than PVAc, which forms a shiny film on the surface. Recently PVB has been substituted by acrylic resins like Paraloid formulations as suggested by the new guidelines of the Italian Cultural Heritage Superintendence and as already applied on other famous palaeontological collections (Ahumada, 2010), e.g. the palm fossil leaves belonging to the Geology and Palaeontology Museum of the University of Padua (Del Favero et al., 2012).

CONCLUSION

Fossils, due to their own fragility and to damages and degradation that occur once in the museum, have been always undergone consolidation treatments. According to the needs of the object, adhesives, consolidants and protectives have been used for repairing fractures, reinstating cohesion or preventing further degradation respectively. Although findings were often catalogued, there are no descriptions of the procedure followed to restore them and the treatment has always been based on the experience of curators and qualified specialists and on the availability of the chosen products. Before the beginning of the polymers production, natural products have been employed, either of vegetable or animal origin, but after the 1950s synthetic materials have been introduced in the conservation field.

This survey has investigated some of the fossils arrived in the collection of the Geology and Palaeontology Museum of the University of Turin in

different centuries. Since there is no information about the historical conservation treatments, the research has been focused on the current state of the objects and on the products that have been applied over the years, analyzing micro-samples by FT-IR spectroscopy. In general the collection is well preserved. Sampling has been carried out only on twenty samples after a careful visual observation and the identification of similar surface coats that can be ascribed to the same type of treatment. The analyses have showed the interventions on the oldest objects (XIX century) to be animal glue and, only in one case, a combination of glue and terpenic resin has been detected and interpreted as a second application or as a wanted different aesthetical result. Two samples of wax have been identified and the presence of this compound in one of the spectra helped revealing the use of a particular mastic described by Borselli in 1977 and largely employed in the archaeological field first.
During the last century, the procedures followed have been applied semisynthetic and synthetic products; in particular cellulose nitrate, polyvinyl acetate and polyvinyl butyral have been identified. These materials are not used anymore because of the new guidelines of the Italian Cultural Heritage Superintendence that indicate acrylic resins as the best products for this kind of objects.

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