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CONSERVATION SCIENCE AND RELATED SERVICES

In addition to CCI's research activities, approximately 40% of the conservation scientists' time is spent on client-related service activities. Some are ongoing services, such as the loan of environmental monitoring equipment, analytical services, or specialized treatment consultations. Other activities fit into a category called Major Service Activities. These include scientific services, performed at the request of client institutions, that are somewhat unique but are not considered to be research projects. The following is a summary of these activities and appropriate contact people.

ONGOING SERVICES:

Environmental Monitoring Equipment: CCI carries out the environmental monitoring equipment loan program. Under this program, Canadian museums and galleries can borrow an environmental monitoring kit (consisting of a light meter, an ultra-violet light meter, a hygrometer, and a psychrometer) for a period of three weeks, and can borrow a recording hygrothermograph for a period of three months. Details of the loan program are given in CCI Note 2/4, *CCI Environmental Monitering Kit.*
Contact: Charlie Costain

Environmental Control: CCI provides advice on methods of attaining environmental control (temperature, relative humidity, light) within buildings, display cases, and storage areas.
Contact: Charlie Costain

Analytical Services: Analysis of such materials as pigments, media, varnishes, wood, fibres, metals corrosion products, and other materials found in objects is undertaken, and non-destructive photographic and x-radiographic examinations are performed to assist conservators with specific treatment-related problems. Contact: John Taylor.

Commercial Product Analytical Reports: Approximately 375 commercial products used by conservators have been analyzed to answer specific conservation questions, and an index and report summaries are available on request. Contact: Elizabeth Moffatt.

Scientific Examination Service: In instances of clear or legal concern on the provenance or authenticity of an object, CCI's scientific examination services are available to assist public institutions and law enforcement agencies where there is a clear need for scientific study. Contact: John Taylor.

Specialized Treatment Consultations: From specialized research projects, CCI has developed expertise in a number of areas and can offer advice to clients in these areas in addition to the more conventional treatment advice available from our Conservation Services Division. The areas include rock art conservation, environmental control and monitoring options, pest control, display, storage and packing materials, waterlogged wood, paper, totem pole radiography, adhesives, display cases, and suction tables. Contact: K.J. Macleod.

MAJOR SERVICE ACTIVITIES IN 1987-88

Recording of Pictographs: Ian Wainwright and Carl Bigras together with Tom Sawyer of Heritage Recording Services, Environment Canada, completed the photographic and stereophotogrammetric recording of three pictograph sites on the Churchill River near Leaf Rapids, Manitoba, for the Historic Resources Branch, Manitoba Culture, Heritage and Recreation. The work was sponsored by Manitoba Hydro.

Contributions to the Analysis of Wall Painting Fragments and Related Materials from the Mogao Grottoes at Dunhuang, People's Republic of China: In a collaborative effort initiated by the Dunhuang Research Academy, Lanzhou, fragments of paint and support were characterized to assess the deterioration of the wall paintings in the Mogao grottoes. The analyses showed an absence of binding medium, cleavage within and between constituent layers in the fragments, and chemical conservation of some of the inorganic pigments. This led to a recommendation for a full monitoring and assessment of the environmental factors affecting the paintings.

Scientific Examination of Wood Samples from the Geodetic Hills Fossil Forest Site, Axel Heiberg Island: Microscopy and instrumental chemical analyses characterized the morphological and chemical makeup of the tree stumps composing the remains of an ancient forest recently discovered on Axel Heiberg Island in the Canadian High Arctic. This was done to aid the conservation research being conducted for the National Museum of Natural Sciences. Contrary to expectations, not one but two types of wood were discovered in the samples brought to CCI. Previously, *Metasequoia* sp. had been the only wood identified. Among the identifications of chemical constituents was amorphous silica. Based on the analyses, this was determined to have two possible sources. It may be biologically produced phytoliths or the product of early stages of silicification of the wood.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Study of the Vibration of Works of Art in Transit

CO-ORDINATOR: Paul Marcon

OBJECTIVES:

The purpose of this project is to assess the degree to which shock and vibration can be damaging to works of art. Emphasis is being placed on shock and vibrations that occur in transit, but the results will be applicable to similar influences from other sources. The research results will be directed toward producing a series of practical specifications and recommendations on package design.

The necessity for work to be carried out on this subject was stressed in the report of the CCI Research Groups (1987), which emphasized the importance of this topic to Canadian institutions.

ESTIMATED DURATION OF PROJECT:

This project was started in 1989. It is anticipated that it will run for three years, after which its direction will be re-evaluated.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. A presentation was delivered at the IIC-CG conference: "Practical Guidelines on the Use of Cushioning Materials for Protection Against Shock."
2. Information on packaging and transportation was presented to a group from the Quebec museum community at a seminar in Rouen-Noranda, Quebec.
3. A presentation on "The Packing and Transportation of Paintings" was given to a group of curators and conservators at the "Shared Responsibility" seminar held at the National Gallery of Canada. A written version of the paper has been submitted for publication in the post-prints of the seminar.
4. Ongoing correspondence, meetings, and advice concerning optimum packaging.

RESULTS TO DATE:

1. Vibration table and drop-testing equipment have been permanently installed.
   Shock and vibration analysis equipment has been received and is operating satisfactorily.
2. Research plans have been coordinated with co-workers in the National Gallery of Art in Washington, the Conservation Analytical Laboratory (CAL) of the Smithsonian Institution in Washington, and the Tate Gallery in London.
3. A review of the literature from the packing industry has identified the three basic elements of package design: a) object fragility, b) cushion performance, and c) shock or vibration environment. There is ample literature available on points b) and c), but no information is currently available on artifact fragility levels. Future research will be concentrated in this area.
4. Two weeks were spent at CAL acquiring familiarity with computer modelling and analysis techniques. Some paintings were modelled using ADINA and PATRAN programs.

1990 RESEARCH PLAN:

1. To design and perform experiments to assess the fragility of fabric-supported paintings and their reaction to shock and vibration.
2. To design and perform experiments to assess the fragility of panel paintings and their reaction to shock and vibration.
3. To test the performance of crates submitted by participating institutions using standard testing and reporting procedures.

4. To write the following sections for the handbook to be published for the 1991 conference on Art in Transit to be held at the Tate Gallery in London: Modes of Transportation, Shock and Vibration Isolation, and some material on Case Design.
5. To prepare a paper for presentation at the Art in Transit conference outlining the results of this research on a) fragility and b) performance of packing cases.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Study of Adhesives and Consolidants Used in Conservation

CO-ORDINATORS: Jane Down, Maureen MacDonald, Jean Tétreault

OBJECTIVES:

The purpose of this project is to study a variety of adhesive types within the chemical class of poly(vinyl acetates) (PVACs) and acrylics. This project has been designed in conjunction with a team of conservators in order to measure properties of the adhesives and consolidants that the conservators felt were important to them in selecting a product for a given application.

The project began with the chemical analysis of 43 acrylic and 90 PVAC adhesives. From these analyses, 21 different chemical classes of acrylics and 40 classes of PVACs were defined. Twenty-five different commercial acrylic adhesives and 27 different PVAC adhesives were selected for extensive testing. Samples would be prepared and naturally aged under both dark and light (190 µ/lm, 700-800 lux) conditions.

There are eight different properties that are to be tested on an annual basis. They are acidity or alkalinity, emission of harmful volatiles, flexibility or brittleness, cohesive strength, shrinkage, removability, softening point and/or glass transition temperature, and discolouration.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1983, but the actual testing did not begin until 1986/87. The samples will be monitored as they undergo natural dark and light aging over a 5-year period. The project is scheduled to run until 1991.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Down, Jane L. "Adhesive Testing at the Canadian Conservation Institute: Past and Future." *Adhesives and Consolidants*. Preprints of the Contributions to the IIC Paris Congress, 2-8 September 1984, London: IIC, 1984, pp. 18-21.
2. MacDonald, Maureen. "An Adhesive Testing Program Update." *IIC-CG Newsletter* 12/2 (December 1986): 16.
3. Down, Jane L. and R. Scott Williams. "Report on Adhesive Testing at the Canadian Conservation Institute." In *Symposium 88: Conservation of Historic and Artistic Works on Paper: Proceedings*, in press.

RESULTS TO DATE:

1. All of the products have been analyzed using FTIR, and have been grouped accordingly. The PVAC adhesives contained vinylacetate and vinylalcohol, ethylene, acrylic, or vinylpropionate as a copolymer. Other additives identified were polyacrylate, dextrin, phthalate, polyethylene glycol dibenzoate, cellulose nitrate, terpene phenolic resin, polyamide, china clay, polyvinylpyrrolidone, ketone resin N, or paraffin. Fourteen of the acrylic products were identified as various acrylate or methacrylate homopolymers, while the remaining 29 were copolymers. The majority of the latter were a copolymer of polymethylmethacrylate with either polyethylacrylate or polybutylacrylate. Very few additives were identified in the acrylic products. The results of the analyses have been grouped on charts that are being published in the *Symposium 88* proceedings.
2. Commercial information on the products have been entered into MCIN, the Materials Database of the Conservation Information Network.

3. pH measurements have been completed on samples that have aged from one to four years. The results to date have indicated the following: PVAC dry adhesive films are more acidic than the dry acrylic films; PVAC liquid emulsions are extremely acidic, while acrylic liquid emulsions are very alkaline; and aging under the lights tends to lower the adhesive pH in both PVACs and acrylics. The pH of 14 PVAC and 3 acrylic products will no longer be measured since their pH has consistently been below 5.0.
4. Measurements of potentially dangerous volatile compounds from the adhesives have been carried out for samples that have been aged for up to one year. The results to date indicate that the amount of acetic acid released from the PVACs is unlikely to be in a high enough concentration to be harmful to artifacts. No acid emissions have been detected from the acrylic adhesive samples. Some problems have been identified with the test procedure previously used, so some modifications will be necessary.
5. Mechanical measurements have been taken on samples that have aged for up to two years. Twelve of the 25 acrylic samples could not be run because it was not possible to make suitable films for testing. Although still being analyzed, the results indicate that 12 of the 27 PVACs initially have a low modulus of elasticity and high elongation at break (characteristics that are generally considered to be favourable for many conservation applications); aging increased the stiffness in 6 of these 12 PVACs. Further analysis must be carried out on the acrylic products before any trends can be identified.
6. Shrinkage measurements have been carried out on samples that have been aging for up to one year. Although a few samples (1 PVAC and 3 acrylics) have shown some shrinkage, it does not appear that this will be an important factor for conservators in selecting an adhesive.
7. Yellowing measurements have been taken for samples that have been aging for up to three years. In general, the PVACs are yellowing faster than the acrylics, and light aging results in faster yellowing of the PVAC adhesives. Further manipulation of the data is required.

1990 RESEARCH PLAN:

1. Continue with pH, volatile, mechanical tests, shrinkage, and yellowing measurements and calculations on aging samples as required by the project schedule.
2. Develop a technique for ranking removability of the products.
3. Do thermal analysis of the adhesives at zero-hour to determine glass transition temperature and softening point following the installation of new thermal analysis equipment.
4. Put all data on Lotus 1-2-3 spreadsheets to track the results, the age of the samples, and the date for the next measurement, and to perform calculations, draw graphs, and create result summaries and tables of results to identify correlations between composition and performance.
5. Write an article for the *CCI Newsletter* on the project.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Properties, Behaviour, and Function of Backing Boards

CO-ORDINATORS: Charlie Costain, Debra Daly Hartin, Paul Marcon, Stefan Michalski

OBJECTIVES:

To prepare a convenient "handbook" of backing boards and their properties. This will include both manufacturers' information and the results of laboratory tests. The buffering capacity of various backing boards with respect to both temperature and relative humidity will be measured. The effects of glass or acrylic on the buffering of a painting enclosure will also be evaluated. The results will be entered into the Materials Database on the Conservation Information Network (CIN).

This information should be of interest to both conservators and curators, as the actual effect of backing boards on paintings does not appear to have been measured. It should allow our clients to make more intelligent choices regarding whether or not to use backing boards, and what material to select.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1983, but has not been active for much of this time due to equipment failures and other demands on equipment and personnel. The project should be finished in 1990.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. "Overview of the Backing Boards Project at CCI." Internal Report.

RESULTS TO DATE:

1. Ten boards have been evaluated.
2. All of the backing boards have undergone testing with constant temperature and varying relative humidity.
3. The backing boards that performed best in the relative humidity cycles have also undergone temperature cycling.
4. The boards have been evaluated to determine their relative effectiveness in limiting relative humidity fluctuations.

1990 RESEARCH PLAN:

1. Write up a report summarizing all of the data accumulated on the various backing boards that were tested.
2. Prepare a draft of a "handbook" of backing boards and their properties for use by conservators.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Properties, Behaviour, and Effect of Biocides on Artifact, Display, and Storage Materials

CO-ORDINATOR: Tom Strang

OBJECTIVES:

There is a risk that the use of insecticides, fumigants, and other biocides may cause damage to artifacts and other materials. This project was set up to assess the compatibility of biocides with various materials. Some preliminary testing has been carried out using the biocides naphthalene, paradi-chlorobenzene, dichlorvos, thymol, chlordane and carbaryl; their compatibility with various types of paper, textiles, leather, feathers, furs, wood, plastics, and metals has been investigated and reported in the publications listed below.

Current research is concentrating on investigating the usefulness of a zero-span tensile testing technique to determine the effects of fumigants on several different types of paper. The effects of ethylene oxide and methyl bromide on paper are also being investigated using this technique.

This project was set up to answer the questions of conservators who were faced with the periodic use of biocides in a display or storage environment and wanted more information on how various products would affect their artifacts.

ESTIMATED DURATION OF PROJECT:

This project is scheduled to be completed in 1990.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. John Dawson. "Effects of Pesticides on Museum Materials." IIC-CG Peterborough Conference, 1984.
2. John Dawson. "Effects of Pesticides on Museum Materials: A Preliminary Report." In *Biodeterioration 6*. Proceedings of the Sixth International Biodeterioration Symposium. Slough, U.K.: C.A.B. International, 1986, pp. 350-354.
3. John Dawson. "The Effect of Insecticides on Museum Artifacts and Materials." In *ASC Pest Control in Museums*, in press.
4. Ongoing correspondence.

RESULTS TO DATE:

1. Problems of metal corrosion were encountered with dichlorvos; paradichlorobenzene causes softening of some plastics and resins; and thymol causes softening and discolouration of plexiglass.
2. No detectable alterations have been measured on paper (fold endurance, colour measurement) and textile (tensile strength, colour measurement) samples.

1990 RESEARCH PLAN:

1. Intern Makiko Sugiyama to assess the optimal conditions for using the technique of zero-span tensile strength measurement.
2. Tests to be carried out on treated and untreated paper samples to see if any differences can be detected.
3. Tests to be carried out on paper samples with known (previously measured) degrees of polymerization to determine the extent of correlation between DP and the zero-span measurements.

CCI RESEARCH PROJECT PREVIEW - 1989

PROJECT TITLE: Museum and Gallery Display Case Design
CO-ORDINATOR: Stefan Michalski

OBJECTIVES:

To publish a Technical Bulletin on display cases, including both theoretical and practical considerations. This will include sections on the functions of a display case, materials used in the construction of display cases, and several possible designs for different types of cases. It will also have a technical section that will deal with case leakage, measurement of case leakage, relative humidity control within a case, and surface humidity buffers.

This information will be of interest to curators, exhibition designers, and conservators who are involved in display in museums or galleries. A draft of the Technical Bulletin has been prepared and is available on request.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1984. It is anticipated that it will be completed in 1990.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Draft of Technical Bulletin prepared.
2. Ongoing correspondence.

RESULTS TO DATE:

1. Extensive work has been done on case leakage, quantifying the air exchange through cracks at different locations in a case. A case leakage meter was developed and has been used to measure the "tightness" of a display case in gallery situations. A private company has indicated an interest in producing the case leakage meter commercially. One collapsible, "portable" display case has been constructed and used in seminars to demonstrate lighting techniques and options in display cases; rough drawings were prepared for inclusion in the Technical Bulletin.
2. A second prototype case has been designed, built, and demonstrated. It is a shallow horizontal case with built-in light box.

1990 RESEARCH PLAN:

1. Complete work on theoretical and experimental air exchange measurements.
2. Construct prototypes of one other display case design and prepare drawings.
3. Complete work on Technical Bulletin on display cases.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Investigation into the Use of Freezing to Control Insect Pests
CO-ORDINATOR: Tom Strang

OBJECTIVES:

The use of low temperatures as a method of eliminating pests has been reported in the literature, and is being used with increasing frequency by galleries and museums. However, there is little hard data on the actual temperature and time required to ensure that insect pests are dead.

The purpose of this project is to determine the temperatures necessary to kill all stages of museum pest insect species, and to investigate the potential for damage to museum artifacts when exposed to low temperatures. The ultimate aim of the project is to prepare guidelines for the freezing of objects for pest control.

ESTIMATED DURATION OF PROJECT:

This is a new project that was initiated in 1989. It is scheduled to run for 3 years.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

John Dawson. "A Review of the Use of Freezing/Low Temperature in Insect Control." Draft internal report, 1987.

RESULTS TO DATE:

1. Initial runs using Differential Scanning Calorimetry (DSC) have produced encouraging results on the freezing point of insect eggs, larvae, pupae, and adults.
2. A data logger has been modified so that typical cooling curves for museum artifacts can be measured. These curves can then be programmed into the DSC to assess their effect on pests.

1990 RESEARCH PLAN:

1. Continue acquiring and testing museum pest insects in the DSC.
2. Measure cooling rates of museum materials for use in developing freezing guidelines.
3. Investigate the possibility of damage to museum artifacts.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Hygrothermomechanical Behaviour of Painting Materials
CO-ORDINATOR: Stefan Michalski

OBJECTIVES

The purpose of this project is to investigate the mechanical changes that occur in painting materials when they are subjected to fluctuating temperature and relative humidity. Although this project was initially intended to carry on the work of Mecklenburg and Kilpatrick using relatively fresh paint samples, the experimental emphasis has shifted over the past year for the following reasons: 1) a method has finally been developed to measure small, therefore old, samples; 2) a literature review has uncovered considerable data on fresh paint films; and 3) CAL is beginning a comprehensive study of fresh paint samples.

The new technique also allows two special hygrothermomechanical studies: 1) how do cleaning solvents affect the paint, both immediately by softening and later by leaching of plasticizing components, and 2) how do solvent vapours affect the paint?

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1983 and is a long-term project. Data will be accumulated in order to study changes in the paint film with age.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Michalski, Stefan and Debra Daly. "Humidity and Temperature Dependence of the Mechanical Properties of Painting and Lining Materials." AIC Baltimore Conference, 1983.
2. Hedley, Gerry. "Relative Humidity and the Stress/Strain Response of Canvas Paintings: Uniaxial Measurement of Naturally Aged Samples." *Studies in Conservation* 33/3 (Aug. 1988): 133-148. (Gerry carried out this work while on sabbatical at CCI.)
3. Michalski, Stefan. "Time's Effects on Paintings." *Shared Responsibility Conference.* Ottawa, Oct. 1988. Postprint in preparation. A substantial part of this paper was based on data obtained through this project and the related lining project.
4. Michalski, Stefan. "The Effects of Solvents on the Physical Properties of Oil Paints." Submitted Jan. 15, 1990, IIC 13th International Congress, *Cleaning, Retouching and Coatings*, Brussels, 1990.

RESULTS TO DATE:

1. Mechanical jigs have been designed and fabricated that will allow the measurement of strain in 10 samples over prolonged periods of time. Since the experimental technique has been modified to micromechanical testing, these large-scale jigs have been transferred to the lining project.
2. A novel micromechanical tester has been developed. It incorporates two machines that coincidentally had been replaced by modern units at CCI: a thermomechanical analyzer and a tensile tester. Samples on the order of 100 microns each side can be tested for modulus of elasticity, creep, and elastic recovery, all as a function of temperature, humidity, solvents, or vapours.

   Preliminary tests with eight-year-old burnt umber oil paint equilibrated to 50% RH show glass transition at -9°C; elasticity and creep both change a factor of ten for each 60°C increase. Interestingly, all creep at small strains eventually recovered when the load was removed, *i.e.*, it was elastic creep, not plastic. This would explain what conservators refer to as "memory" in paintings.
3. Data from 1923 to 1986 on the effect of RH on stiffness of oil paints has been fitted to a master curve, with each paint given a scaling coefficient relative to unpigmented films. It shows that

between 0% RH and 65% RH, stiffness drops by one half, whatever the pigment. Above 65% RH, stiffness drops increasingly fast, and depends strongly on the pigment. Zinc white shows the strongest effect, titanium white the least. All other pigments lie between.

1990 RESEARCH PLAN

1. Continue measurements with the micro-mechanical tester. Develop skills in the small sample preparation. Test the paint films from the old painting samples that Gerry Hedley studied.
2. Measure the softening, if any, due to various vapours, temperature, and RH for some paint samples from NGC. These belong to paintings that have been rolled for a long time. Eventually, the micro-mechanical tester could provide conservators with a comprehensive test of relaxation methods on a small sample before risking the whole object.
3. Write a review of the literature uncovered to date.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Characterization of the Behaviour and Function of Lining Supports and Adhesives

CO-ORDINATORS: Debra Daly, Stefan Michalski

OBJECTIVES:

The purpose of this project is to better understand the behaviour of linings so that optimum preventive conservation and laboratory treatment of paintings can be specified. The behaviour of model paintings lined using either traditional techniques or some more recently developed approaches will be studied. The ultimate goal of the project is to determine which lining method provides maximum protection and long-term stability to the paintings.

There are four stages involved in this project. In the first stage, a number of model paintings will be made and their mechnical properties studied. The second stage will involve measuring the bond strength between sized linen and various lining systems. The third stage will be the measurement of the mechanical properties of various lining supports, and the final stage will investigate the mechanical behaviour of the lined model paintings.

This is a joint project of the Environment and Deterioration Research division and the Fine Arts Conservation section at CCI. The results will provide useful information to fine arts conservators when making treatment decisions.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1983. It is scheduled to run for several more years.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Daly, Debra. "Methodology and Status of the CCI Lining Project." IIC-CG Peterborough Conference, 1985.
2. Daly, Debra and Stefan Michalski. "Recent Developments in Research in the Fine Arts Lab at CCI." IIC-CG Winnipeg Conference, 1986.
3. Michalski, Stefan, Debra Daly and Gerry Hedley. "Mechanical Properties of Paintings: Recent Data at CCI." AIC Vancouver Conference, 1986.
4. Daly, Debra and Stefan Michalski. "Methodology and Status of the Lining Project, CCI." *ICOM Committee for Conservation, 8th Triennial Meeting*, Sydney, Australia, 6-11 September 1987, pp. 145-152.

RESULTS TO DATE:

1. Construction of model paintings with various combinations of linen canvas, glue size, chalk, oil and acrylic grounds, and oil paint.
2. The following properties were measured to determine how the model paintings changed as a function of relative humidity: tension, fracture, stiffness; weight (moisture absorption), and free-hanging dimensional response. Stress relaxation is also being measured.
3. Peel tests were carried out by the Fine Arts section. The results have yet to be analyzed.

1990 RESEARCH PLAN:

Due to other commitments, little time will be spent on this project by Stefan Michalski in the coming year.

Note:

This project is closely related to the project on the hygrothermomechanical properties (HTMP) of painting materials. Most of Stefan's efforts will be going into the HTMP project in 1990, which means that he will not be able to commit much time to this project. Work on the lining project will resume in 1991.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Fluid-Preserved Natural History Collections: Methods for Documenting and Assessing Their Condition

CO-ORDINATOR: Tom Strang

OBJECTIVES:

To participate in the activities of the Society for the Preservation of Natural History Collections (SPNHC)Ssubcommittee on the Development of Standard Procedures for Assessing and Reporting the Condition of Fluid-Preserved Collections. Members of SPNHC have determined that in order to decide what actions need to be taken to improve the conditions of their collections, they first need to develop a set of standard procedures for designing, performing, and reporting surveys of current conditions in fluid-preserved collections.

The immediate task undertaken by CCI is to find ways to monitor the pH of non-aqueous preservation fluids.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1989 with the formation of the SPNHC working group under the direction of Rob Waller of the National Museum of Natural Sciences (NMNS).

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

A paper on "Standard Procedures for Assessing and Reporting the Condition of Fluid-Preserved Collections" has been submitted for publication in ICOM-CC 1990 Preprints; Tom Strang was one of the contributors to this paper.

RESULTS TO DATE:

1. A literature survey and investigation into the use of pH meters with combination electrodes and pH test strips to determine pH in buffered ethanol-water solutions.
2. Research has been carried out with Rob Waller of NMNS to compile data on the physical-chemical properties of the ethanol-water system for use by collection managers and researchers. Data was also collected on the isopropanol-water system.

1990 RESEARCH PLAN:

1. Test commercial pH indicator papers in buffered ethanol-water solutions. Compare pH paper results to similar tests with combination pH electrodes.
2. Search literature for information on use of electrodes and colourimetric pH determination in ethanol-water solutions. Develop a standard method for collection managers.
3. Submit results to SPNHC Conservation Committee - Assessment Subcommittee for publication as "Determining Standard Procedures for Assessing the Conditions of Fluid Preserved Collections." Preprints, ICOM Triennial Meeting, 1990.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: The Design and Use of Vacuum Suction Tables in Paintings, Paper, and Textile Conservation

CO-ORDINATOR: Stefan Michalski

OBJECTIVES:

The purpose of this project is to carry out research into suction table design, to present some simple designs for suction tables, and to lay out some guidelines for their construction and use in the different fields of conservation. It has been suggested that the final outcome of this project should be a brief "How To" manual that will cover basic design, construction, and use of suction tables.

This subject was defined as being of importance in the report of the Research Review Teams (1987). It is of particular interest to textile and paper conservators, as there is very little information on the design or use of suction tables for these specialities.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1987. It is projected to be a 5-year project.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Michalski, Stefan. "Suction Tables: History and Behaviour." AIC Washington Conference, 1981.
2. Michalski, Stefan. "The Suction Table II: A Physical Model." *Preprints of Papers Presented at the AIC Twelth Annual Meeting*, Los Angeles, California, 15-20 May 1984, pp. 112-114.
3. Michalski, Stefan and Ela Keyserlingk. Seminar on suction tables given to the Textile Conservation Workshop, South Salem, New York, July 1987.
4. Michalski, Stefan. Seminar on suction tables, Glenbow Museum, September 1987.
5. Michalski, Stefan. Workshop and demonstrations for Book Conservation staff, National Archives of Canada, April 1988.
6. Michalski, Stefan. Lectures on suction tables in paper conservation, Conservation and Analytical Laboratory, Smithsonian Institution, Washington, DC., April 1988.
7. Michalski, Stefan. Demonstration of a new suction table designed for books. *Symposium 88*, Ottawa, Oct. 1988. Design drawings were available at the conference (over 100 were taken).

RESULTS TO DATE:

1. Simple suction tables have been constructed and are operating in the Textiles and Paper Conservation labs at CCI.
2. Developmental work is underway on a Fine Arts suction table.
3. A suction table specifically for books was designed in the Spring of 1988. National Archives of Canada borrowed it for several months, and built duplicates. Frank Mowery from the Folger Library saw it there and built a modified unit for himself. The original unit was then demonstrated at *Symposium 88*.
4. Textiles division at CCI decided that a medium-sized table tolerant of solvents was of a higher priority than the large, wet table planned earlier. After various meetings and discussions with the textile conservators, sketches of a design were finalized in November 1989.

1990 RESEARCH PLAN:

1. Supervise construction of the medium-sized textile suction table.
2. Consult on installation of large central vacuum pump and distribution piping at CCI.
3. Co-ordinate seminar on use of suction tables in paper conservation at CCI sometime in 1990. We would like to invite M. Weidner to co-lecture.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Treatment Methods for Waterlogged Wood-Metal Composites.
CO-ORDINATORS: Lyndsie Selwyn, Nancy Binnie

OBJECTIVES:

To identify and evaluate modifications of aqueous waterlogged wood treatments suitable for treatment of composites of waterlogged wood and metal. Treatment should allow stabilization of wood without seriously corroding the metal. Typical metals are iron (cast iron and mild steel), copper and its alloys (cast bronze, cast and rolled brass), and lead. The standard treatment incorporates a consolidant polyethylene glycol (PEG 400) into the cell walls prior to freeze-drying. Suitable modifications include (1) addition of commercial water-soluble metal corrosion inhibitors to PEG 400, or (2) replacing PEG 400 with a similar water-soluble resin that also contains functional groups that act as corrosion inhibitors.

To quantitatively test the recommended treatment methods by determining the corrosion rate of the metals using standard weight-loss techniques, with an emphasis on the ferrous metals. To extend these quantitative tests to include replacement of water with synthetic sea water to determine if these treatments are still effective and to what extent.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1984.

The general survey is finished. Weight-loss measurements on the ferrous metals are finished, and the work on the non-ferrous metals should be completed by the end of 1990. Two manuscripts, one on ferrous results and another on non-ferrous results, will be prepared and should be submitted by the end of 1991.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Cook, C., A. Dietrich, D.W. Grattan and N. Adair. "Experiments with Aqueous Treatments for Waterlogged Wood-Metal Objects." In *Waterlogged Wood: Study and Conservation.* Proceedings of the 2nd ICOM Waterlogged Wood Working Group Conference, Grenoble, 28-31 August 1984, pp. 147-159.
2. Dietrich, A. "Traitement des Composites-Bois-Métal Gorgés d'eau, 12 Nouvelles Solutions." *Rapport de l'ICC*, mars, 1984.
3. Cook, C. "Test of Resins for the Treatment of Composite Objects." *ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials Newsletter*, No. 14, Feb. 1986, pp. 3-6.
4. Gilberg, M., D.W. Grattan and D. Rennie. "Treatment of Iron-Wood Composite Materials." In *Proceedings of the Special Meeting of the ICOM Committee for Conservation, Metals-Water-Wood,* Fremantle, Western Australia, Sept. 1987 (in press).
5. Analytical Research Services reports ARS 2801, ARS 2806, ARS 2722, ARS 2714, and ARS 2311, and Environmental Deterioration Research report EDR 1681.

RESULTS TO DATE:

The treatments recommended in the initial survey of 61 solutions are either Pluracol 824 or a PEG 400/Hostacor KS 1 mixture for ferrous metals, Witcamine RAD-1100 for copper alloys, and Acrysol G110 for lead.

Weight-loss measurements of the corrosion rate of cast iron and mild steel, alone and paired with waterlogged oak, were made in water, 17% v/v PEG 400, 17% v/v PEG 400 plus 1% v/v Hostacor KS 1, 15% v/v Pluracol 824, sea water, 17% v/v PEG 400 in sea water, and 17% v/v PEG 400 plus 1% v/v Hostacor KS 1 in sea water. No major differences in the metal corrosion rate were observed with or without wood present. The lowest corrosion rate was observed in the PEG/Hostacor mixture.

Weight-loss measurements of the corrosion rate of cast brass, rolled brass, and cast bronze (all without wood) were made in distilled water, 17% v/v PEG 400, 17% v/v PEG 400 plus 25% v/v Witcamine RAD-1100, sea water, 17% v/v PEG 400 in sea water, and 17% v/v PEG 400 plus 25% v/v Witcamine RAD-1100 in sea water.

Weight-loss measurements of the corrosion rate of lead (without wood) were made in distilled water, 17% PEG 400, 17% v/v PEG 400 plus 20% v/v Acrysol G110, sea water, 17% v/v PEG 400 in sea water, and 17% v/v PEG 400 plus 20% v/v Acrysol G110 in sea water.

The pH of these solutions before and after the weight-loss measurements was measured.

1990 RESEARCH PLAN:

To complete corrosion rate measurements using the weight-loss technique and pH monitoring in the following systems: (1) cast brass, rolled brass, and cast bronze (no wood) in solutions of 25% v/v Witcamine RAD-1100, and 25% v/v Witcamine RAD-1100 in sea water, and (2) lead (no wood) in solutions of 20% v/v Acrysol G110, and 20% v/v Acrysol G110 in sea water.

To prepare a manuscript on the ferrous metal results, which will be submitted to the ICOM Working Group on Wet Organic Archaeological Materials in Bremerhaven, Germany, in August 1990, and to prepare a manuscript on the non-ferrous metals.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Ethylenediamine Treatment of Marine Iron Artifacts

CO-ORDINATORS: Lyndsie Selwyn, Nancy Binnie, Judy Logan

OBJECTIVES:

To collect, organise, and evaluate the existing results on the treatment of marine iron artifacts using ethylenediamine. Preliminary results identified the ethylenediamine treatment as a viable one in certain circumstances. It has subsequently been modified and is now being used at CCI in the Archaeology section. This continuing project aims to complete and publish the earlier work.

ESTIMATED DURATION OF PROJECT:

Evaluation of the already completed work should be finished within one year if time is available. Additional experimental work may need to be done, in which case the project will need to be extended.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Argo, J. "On Corrosion in Iron." *ICOM Committee for Conservation 6th Triennial Meeting*, Ottawa, 21-25 September 1981, No. 81/23/5.
2. Argo, J. "On the Nature of 'Ferrous' Corrosion Products on Marine Iron." *Studies in Conservation* 26 (1981): 42-44.
3. Argo, J. "A Qualitative Test for Iron Corrosion Products." *Studies in Conservation* 26 (1981): 140-142.
4. Argo, J. "The Treatment of Corrosion with Amines." *Conservation News* 17 (1982): 7-9.
5. Costain, C. and J. Logan. "Survey of Iron Artifacts from Red Bay, Labrador, to Assess the Effectiveness of Various Iron Treatments." ICOM Committee for Conservation, Metals Working Group, *Newsletter* 1 (1985): 8-9.
6. Logan, J.A. "An Approach to Handling Large Quantities of Archaeological Iron." *ICOM Committee for Conservation, 7th Triennial Meeting*, Copenhagen, 10-14 September 1984, 84-22-14.
7. McCawley, J.C. "Current Research into the Corrosion of Archaeological Iron." *ICOM Committee for Conservation, 7th Triennial Meeting*, Copenhagen, 10-14 September 1984, 84-22-25.
8. Costain, C. "Evaluation of Storage Solutions for Archaeological Iron." Draft submitted to *J. IIC-CG.*

RESULTS TO DATE:

James Argo identified the main corrosion products of wrought iron nails in or adjacent to a marine environment as

1. Ferric (Fe^{+3}) oxyhydroxides, with the polymorphs
   Goethite (alpha) FeOOH, yellow crystals
   Akaganeite (beta) FeOOH, red-brown crystals
   Lepidocrocite (gamma) FeOOH, orange crystals;
   (These corrosion products have colloidal properties. When excavated marine objects are allowed to dry prior to treatment, akaganeite is formed, and its presence promotes further corrosion.)
2. Magnetite, Fe_3O_4, black, magnetic;
3. Hematite, (alpha) Fe_2O_3, rust-red crystals.

He also found occurrences of ferrous chloride dihydrate $FeCl_2\ 2H_2O$, but no iron oxychlorides FeOCl.

Initial treatment involved suspension of partially mineralized iron objects over boiling aqueous 10-20% v/v ethylenediamine ($NH_2\ CH_2\ CH_2\ NH_2$) with daily solution changes. This treatment has been

modified, and now consists of immersion of mineralized iron objects in an aqueous 5% v/v ethylenediamine solution, with solution changes whenever the Cl^- concentration no longer increases. Chloride ion removal is assumed adequate when its level drops below 50 ppm.

1990 RESEARCH PLAN:

If time permits, to collect, organise, and summarize for publication the following aspects of the work completed on the ethylenediamine treatment of archaeological marine iron:

1. An explanation of the development of the treatment.
2. A description of how it works, including the chemistry of iron and its corrosion products, the role of chloride ions in promoting active corrosion in akaganeite, and the reactions occurring between ethylenediamine and the iron corrosion products.
3. The treatment as it has been carried out in the Archaeology lab, including techniques, problems, and success rate.
4. Recommendations for continued research.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Evaluation of Rust Converters for the Preservation of Rusted Iron Artifacts Displayed Outdoors.

CO-ORDINATORS: Lyndsie Selwyn, Bob Barclay, Carl Schlichting, J. Cliff McCawley

OBJECTIVES:

To identify suitable commercial products (usually called rust converters) that can be applied directly to a rusted surface after minimal surface preparation (washing, wire brushing) and that react to form a stable layer. Such rust converters contain an acid that reacts with the rust to form an insoluble, stable complex, and also contain a film-forming polymer that can accommodate paint if required.

To evaluate the effectiveness of these rust converters in protecting rusted iron and steel objects from further rusting. Evaluation includes accelerated corrosion tests (salt spray) and natural aging tests outdoors.

This project was initiated because of museum requests for advice on suitable products for direct application to large rusted iron and steel artifacts displayed or stored outdoors.

ESTIMATED DURATION OF PROJECT:

This project was started in the spring of 1987. Rust converters have been identified, and accelerated corrosion tests in the salt spray are finished. Long-term outdoor exposure (for five years) of test plates at CCI will be completed in October 1992, while identical long-term tests in Halifax and Edmonton will be completed around June 1993.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Rennie, D., M. Gilberg, R. Barclay, C. Schlichting and C. McCawley. "Which Rust Converter Would You Use on Your Artifact?" CCI poster presented at the IIC-CG conference in Toronto, Ontario, May 1988.
2. McCawley, C., D. Rennie, R. Barclay and M. Gilberg. "Evaluation of Rust Preventatives for the Protection of Rusted Steel Artifacts Exhibited Outdoors." *CCI Newletter*, No. 1 (Dec. 1987): 3.
3. Analytical Research Services reports by Elizabeth Moffat (ARS 2602, ARS 2648, ARS 2702, ARS 2796) and by Jane Sirois (ARS 2690).

RESULTS TO DATE:

Eight commercial products and tannic acid were originally identified for testing, and one more (Dominco 850) has been added to the list. The products being tested are *Conquest* Polymeric Rust Converter (National Chemsearch), *Dominco '850'* Rust Stabilizer (Dominco Coatings), *Extend* Rust Treatment (Loctite Canada), *Fertan* Rust Converter (Purolator Products), *Neutra Rust* (NYBCO), *Neutra Rust 661* Rust Converter (UNIC), *Noverox* Rustproofing Paint (Graf), *Oakite* Rustraint (Oakite Products), *Rust-Oleum 7830* Rust Converter (Rust-Oleum Canada), *Tannic Acid* - 5% w/w aqueous solution (Fisher Scientific).

Test pieces were made by applying the commercial products or the tannic acid solution to uniformly rusted mild steel plates. Two testing methods, indoor accelerated corroding with a salt spray for 30 days and outdoor natural aging for up to 5 years, are being used to evaluate these products. The first test has been completed and the outdoor aging is currently under way at three sites across Canada: an urban site in Ottawa, a marine site in Halifax (Maritime Museum of the Atlantic), and a rural site in Edmonton (Ukrainian Cultural Heritage Village). Photographic records have been collected after the salt spray

testing, and an evaluation procedure, including photographs, is taking place every 6 months during the outdoor exposure testing.

1990 RESEARCH PLAN:

To continue recording the evaluations of the plates at CCI every six months and to keep collecting these evaluations from the people in Edmonton and Halifax. If necessary, the 5-year long-term exposure will be terminated earlier if there is complete coating failure of all the plates at an earlier date.

To complete the following additional experiments.

(1) Reapplication: placing one test plate per coating outside CCI for 6 months, and then applying another coat to determine the ease of covering a previously coated surface.

(2) Removal: testing the ease of removal of old coatings once they have dried, possibly using paint stripper or NaOH.

(3) Pitting: recording the surface pitting under the coating/rust layer after failure using plates from both the salt spray test and the outdoor test. Surface treatment will probably involve rust removal with phosphoric acid and coating removal with paint removal.

To finish a manuscript for submission to the *IIC-CG Journal*. Results from the salt spray test and from one year of outdoor exposure will be summarized. Colour photographs will be included to allow readers to see results.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Protective Coatings on Outdoor Bronzes
CO-ORDINATOR: Lyndsie Selwyn

OBJECTIVES:

To evaluate protective coatings recommended for outdoor bronze statues under conditions encountered during the winter in Ottawa. Initially, the commercially available coating Incralac will be tested because it will be used in the treatment of the outdoor bronze statues on Parliament Hill. Eventually, other coatings will be considered.

To monitor coated bronze test pieces held on a test rack on Parliament Hill. The bronze test pieces will be treated and coated in an identical manner to that done on any given statue or statues in the vicinity of Parliament Hill by the conservator hired for the work.

This project was undertaken because of its universal nature and because of the work presently being done to treat many statues in the vicinity of Parliament Hill, Ottawa.

ESTIMATED DURATION OF PROJECT:

This project was initiated in December 1987. Accelerated freeze-thaw cycling (for 6 months) of several coatings on bronze pieces has been completed. Further testing of coatings will continue when the time is available to continue this aspect of the project. Monitoring of the test pieces on Parliament Hill is an ongoing project.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

Analytical Research Services report ARS 2675 by J. Sirois.

RESULTS TO DATE:

An ultra-low temperature freezer made by VWR Scientific, San Francisco, was purchased. This freezer has a range of -50°C to -15°C and is designed for continuous operation. A rack for this freezer was built to hold metal test pieces.

Three sets of coated bronze test pieces (coated on both sides) were cycled for six months inside this freezer. Cast bronze gun metal (88% Cu, 10% Sn, 2% Zn) with one rough side and one polished side was used to support these coatings.

These test pieces measured either 4" x 12" x 1/4" or 4" x 6" x 1/4". The three coatings tested were Incralac (an acrylic resin Acryloid B-44 in toluene with benzotriazole added), a water-based acrylate polyurethane lacquer called Bonacryl, and a solvent-based acrylic/urethane enamel called Mirathane. The freezer was allowed to cool to -40°C each night and was allowed to warm to room temperature during the day. No major failure of any of the tested coatings was found.

A literature search of the Chemical Abstracts and Metadex data bases has been completed on Incralac.

The first pair of statues, called Truth and Justice, created by Toronto artist Allward, were removed from in front of the Supreme Court building in December of 1988. Corrosion samples were collected before treatment started, and these samples are being stored at CCI until the Department of Public Works hires a chemist to analyze the corrosion products from about 52 statues (28 pieces surrounding Parliament Hill and 24 pieces associated with the National War Memorial). These two statues were treated and returned outside in July 1989. Four test pieces were also treated in an identical manner to the treatment used for Truth and Justice, and these test pieces were placed outside on July 27, 1989. They are being supported

on a Dexion steel rack at an angle of 45° and are facing south. These test pieces are made from commercial cast bronze (85% Cu, 5% Sn, and 5% Zn) and measure 4" x 6" x 1/4". As controls, two pieces of uncoated bronze were also placed outside with the test pieces.

1990 RESEARCH PLAN:

The test pieces on the Parliament Building roof will be monitored on a yearly basis, with both a visual inspection and a photographic record.

A search is needed of commercially available coatings for ones that are suitable for conservation application to outdoor sculptures. Such coatings must be rugged enough to withstand exposure to temperature extremes, significant amounts of ultraviolet light, acid deposition, vandalism, and environmental factors such as acid rain. These coatings must also be reversible. Some commercial coatings include Glasurit, a clear urethane acrylic auto finish, and Overcote, an acrylic resin. Overcote is being used on aluminum engines displayed indoors at the National Aviation Museum in Ottawa.

If time allows, testing of more coatings will continue. Waxes, coatings, and layered systems need to be considered. Different layers of coatings and waxes would be tested to determine whether an insoluble cross-linked urethane coating can be removed if a soluble primer coat is first applied. Wax mixtures, such as microcrystalline plus carnauba used by the US National Park Service, would also be tested and modified to suit a more severe Canadian climate. Testing facilities are now available to cool the pieces to -50°C if needed. Other facilities need to be set up to test aging under ultraviolet light and heating to temperatures typical of a metal exposed to the summer sun.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Corrosion Rates of Metals at Various Relative Humidities
CO-ORDINATOR: Lyndsie Selwyn

OBJECTIVES:

To be able to recommend relative humidity levels to museums for the safe storage and display of metals - either freshly treated and clean artifacts or fragile ones undergoing active corrosion. There is very little experimental data on which to base recommendations for the safe storage or display of museum artifacts, including metals. Generally, there would appear to be doubt and confusion on this subject. CCI recommends that a general museum collection be stored or exhibited at 21°C and at a relative humidity between 45% and 65%. An upper limit of 65% prevents mould formation while 45% keeps wooden objects at a desired equilibrium moisture content of 9-10%. Throughout CCI Notes and Technical Bulletins, it is generally recommended that metals should be maintained in a dry environment, although we are unsure of what the upper limit might be.

Initially, to determine the corrosion rates of clean metal surfaces in a range of relative humidities using a weight-loss measurement or reflectance measurements. Metals such as mild steel and cast iron, cast bronze, cast and rolled brass, copper, and lead would be considered.

To extend this work to include actively corroding metals, such as bronze disease on bronze or ferric oxyhydroxide FeOOH on marine iron that has been allowed to dry. Other systems that might be considered are corroded metals after treatment (copper and bronze coated with the corrosion inhibitor benzotriazole, iron after treatment in ethylenediamine).

ESTIMATED DURATION OF PROJECT:

This project cannot be started because of lack of personnel and time constraints. It is not an active project.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

There are no publications from CCI to date that deal specifically with the corrosion of metals in different relative humidities.

RESULTS TO DATE:

New project.

1990 RESEARCH PLAN:

If it were possible to assign a researcher to the project, the research plan would be as follows.

To define the goals of this project.

To complete a literature search to find any previous corrosion rate measurements on metals exposed to atmospheric conditions (closed environment at room temperature and fixed relative humidity) similar to those considered here. Information on typical corrosion rates are useful in estimating a reasonable exposure time.

To set up closed environments at room temperature and fixed relative humidity using closed containers such as desiccators. Fixed humidities will be generated either by glycerol/water solutions or conditioned silica gel, but not by saturated salt solutions. Another possibility would be to control the relative humidity continuously by combining two streams of air, one of low humidity and the other of high. The

environment within the chamber must be kept clean, possibly with a charcoal scavenger, to minimize nucleation by dust.

To test, possibly simultaneously, clean, corroding, and post-treatment metal coupons (1" x 2" x 1/8") in sets of four freshly polished and weighed coupons per metal under conditions of fixed relative humidity and temperature. The most appropriate method for determining the corrosion rate, whether it be weight-loss measurements, reflectance measurements, or some other procedure, needs to be decided and then set up.

To interpret the data and write a set of criteria for use by conservators and curators.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Silver Polishing Products

CO-ORDINATORS: Lyndsie Selwyn, Tom Stone, Bob Barclay, Judy Logan, Charlie Costain

OBJECTIVES:

To evaluate fourteen of the least aggressive commercial silver polishing products identified by Charlie Costain in earlier controlled experiments using practical testing by several 'polishers' at CCI.

Almost every gallery and museum holds silver plate in its collection. This, especially in urban areas, presents a significant cleaning and maintenance problem for museum personnel. There are a great many commercial silver polishes available, but no information on how a conservator should go about choosing between them. This project was undertaken because of the many requests of this nature received by CCI over several years.

ESTIMATED DURATION OF PROJECT:

The practical evaluation of silver polishing products was initiated in January 1988. Polishing of tarnished sterling silver flatware took place on March 8, 1989. Data collection is finished. A manuscript summarizing this work should be finished by the summer of 1990.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Selwyn, L. "Silver Cleaning Project. *CCI Newsletter* (Spring/Summer 1989): 6.
2. Analytical Research Services reports ARS 2696, 2697, 2698, and 2699.

RESULTS TO DATE:

The following fourteen silver cleaning products were purchased by the end of March 1988:

Polishes: Goddard Long Shine Silver Polish (Goddard & Sons), Goddard Long Shine Silver Foam (Goddard & Sons), Silvo Metal Polish for Silver (Reckitt & Colman), Twinkle Silver Polish (Bristol-Myers), and Hagerty Silver Foam (Hagerty & Sons).

Cloths: Birks Anti-Tarnish Silver Polishing Cloth (Birks), Hagerty Silver Gloves (Hagerty & Sons), and Shino Polishing Cloth (Pioneer).

Dips: Goddard Silver Dip (Goddard & Sons), Quik-Dip Silver Cleaner (Boyle-Midway), Solution Dip (D.P.R.), and CCI Dip (5% Thiourea 5% Formic Acid).

Wadding: Duraglit Silver Polish Wadding (Reckitt & Colman), and Duraglit Wadding Metal Polish (Reckitt & Colman).

Sixty-two pieces of sterling silver were borrowed from the New Brunswick Museum in Saint John, N.B. These arrived on April 20, 1988, and were given a CCI number (0,000,715). They were less tarnished than had been hoped so additional tarnishing was needed. The silver was left on open shelves until January 1989, when the silver was judged black enough for polishing. Pre- and post-polishing photomicrographs were recorded under magnification (about x5). The practical polishing 'bee' took place on March 1, 1989 using 56 pieces of flatware, 14 polishes, and 4 polishers (Denise Levesque, Lucie Forgues, Martha Perry, and Nancy Green) who rated the polishes according to a pre-defined set of questions.

Following polishing, an overall photograph recorded the set of 56 pieces. The silver was then left to retarnish for 6 months, and a second overall photograph of the same set of 56 pieces was taken. The 5 members of the project team have evaluated the slides of the magnified areas on each piece, comparing

'before' and 'after' shots and rating the slides according to scratching and etching. A literature search for silver polishes was submitted in April 1989 and has now been completed.

C. Leckie and G. Daggett, interns at CCI, repolished the flatware using Hagerty gloves for lightly tarnished pieces and Twinkle for the darker tarnished pieces, and then returned the accession numbers to the back of each object. The flatware has been returned to the New Brunswick Museum.

T. Stone and D. Kelly (CCI volunteer) rated the polishes according to the degree of scratching caused by each polish when used on a silver coupon that had first been polished to a mirror finish with diamond paste. Additional experimenting with other materials identified plexiglass as a possible material readily available to museum staff for their own 'scratch-testing' with locally available silver polishes.

1990 RESEARCH PLAN:

To collect the results from this practical test and from the earlier controlled study, and to prepare a presentation for the IIC-CG conference in Quebec City, May 1990. Following this presentation, a manuscript will be prepared for submission to the *J. IIC-CG* for publication.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Thermal Degradation of Polyethylene Glycol Solutions.
CO-ORDINATORS: Cliff McCawley, Malcolm Bilz

OBJECTIVES:

To study the thermal degradation of PEGs (M.W. 400, 1000, 3350) as used for stabilization of waterlogged wood and other organic materials. Experimental aging studies will determine if, and to what extent, PEGs break down into smaller molecules under prolonged periods of heating; the effect that various physical conditions and catalysts have on the process; and whether thermal degradation can be inhibited.

PEGs are widely used to stabilize waterlogged wooden objects and other organic materials. When the objects are very large (ships timbers, canoes, etc.), large quantities of PEG and special plant are needed. The process is, therefore, very costly. It becomes more so if the PEG must be changed at regular intervals because it has changed drastically due to thermal degradation.

ESTIMATED DURATION OF PROJECT:

Will finish during present fiscal year.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

"Thermal Degradation of Polyethylene Glycol Solutions." Internal report prepared by M. Bilz, to form the basis of a paper.

RESULTS TO DATE:

All aging experiments are completed.

All aged solutions were freeze dried and PEG concentrations determined. There was good agreement with concentrations from Size-Exclusion HPLC and refractive index. With increased aging temperature, there was increased colour of the final product ranging from white through yellow to red-brown. UV-visible spectra confirmed this, showing increased absorbance at 205 and 285 nm for samples aged at higher temperatures. Besides colour changes, there were also changes in the physical nature of the aged samples ranging from liquids through waxes to powders, showing change in the molecular weight of the more severely aged samples.

Molecular weights determined from melting points of the waxes and solids showed good general agreement with molecular weights determined by intrinsinc viscosity, but were normally significantly higher than those determined by size-exclusion HPLC. Results obtained from HPLC using a variety of different techniques and columns have been inconsistent.

1990 RESEARCH PLAN:

1. Write paper; graphs and tables of data have yet to be prepared.

CCI RESEARCH REVIEW - 1989

PROJECT TITLE: Fossil Forest Axel Heiberg Island: Conservation Studies
CO-ORDINATORS: David Grattan, Malcolm Bilz, Margaret Morris.

OBJECTIVES:

As described in the 1987 review.

REPORTS, PUBLICATIONS TO DATE:

1. Grattan, D.W. "The Conservation of Specimens from the Geodetic Hills Fossil Forest Site." Accepted for publication in special publication of the Geological Survey of Canada.
2. Grattan, D.W. "The Use of Parylene (poly-para-xylylene) to Conserve Fragile Fossils, and Disintegrating Artifacts." This talk was given to the Chemical Institute of Canada (Local Chapter), April 1989, and was revised for an International Conference in October 1989 titled "Science: Teaching Canada's Future."
3. Grattan, D.W. "Minutes of the Parylene Review, Canadian Conservation Institute." Meeting held 1-2 March 1989.
4. Grattan, D.W. "Parylene at CCI." Poster presentation, IIC CG annual conference, St. John's, Newfoundland, 1989.
5. Grattan, D.W. "Parylene at the Canadian Conservation Institute." *Canadian Chemical News* 41/9 (October 1989): 25-26.

RESULTS TO DATE:;

The research plan as described in the 1987 review has been carried out.

It has been found that wet fossil wood behaves much like waterlogged wood, and shrinkage can be eliminated if the wood is impregnated with PEG 200 and then freeze-dried. Diffusion of PEG into the wood is very slow due to the highly compressed state.

Fragile and fragmenting cones have been successfully treated by the deposition of Parylene. No other conservation method was applicable because of the extreme delicacy of the specimens. As a result of these trial experiments, and because of their interest in the museum application, the Union Carbide Corporation has lent CCI a Parylene coater and will participate in an evaluation of the process (see Parylene project).

Leaf specimens have been treated with Parylene, and in some cases with both Parylene and PEG impregnation.

A large stump belonging to the National Museum of Natural Sciences has been rehydrated, PEG treated, and is in the last phases of preparation for display.

The collection of cones belonging to the National Museum of Natural Sciences has been treated, catalogued, and returned to the Museum packed in custom designed storage units.

Mapping of the fossil forest site has been completed and erosion studies commenced. The work with Parylene has become a separate research project, and other results are reported in that context.

1990 RESEARCH PLAN:

To monitor the erosion markers in the fossil forest as and when required.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: An Evaluation of the Effects of Sulphuryl Fluoride (Vikane) on Ligneous and Cellulosic Material

CO-ORDINATORS: Helen D. Burgess, Nancy E. Binnie

OBJECTIVES:

Twenty-five different fibre types (thirteen paper and twelve textile) have been selected for an investigation into the effects of fumigation by Vikane on ligneous and cellulosic material. The samples range in age, dating from 1622 to the present, and show a broad variation in fibre content and degree of degradation.

This project is a collaborative programme undertaken in conjunction with the Getty Conservation Institute and the Conservation Analytical Laboratory of the Smithsonian Institution. Sulphuryl fluoride was chosen because it showed potential in becoming an important fumigant for control of insect pests in museum collections.

ESTIMATED DURATION OF PROJECT:

This phase of the project was initiated in 1986/87 and is expected to be complete by the end of 1989/90.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Binnie, N.E. "Potential of Adverse Effects of Pest Control Agents on Materials of Artifacts." *First Quarterly Report*, November 1986.
2. Binnie, N.E. *Second Quarterly Report*, February, 1987.
3. Binnie, N.E. *Third Quarterly Report*, June, 1987.
4. Binnie, N.E. *Fourth Quarterly Report*, August, 1987.
5. Binnie, N.E. *Fifth Quarterly Report*, December, 1987.
6. Binnie, N.E. *Sixth Quarterly Report*, November, 1988.
7. Baker, Mary T., H.D. Burgess, N.E. Binnie, D.R. Chartier and M.R. Derrick. *Annotated Bibliography of Sulphuryl Fluoride*. August 1989 (available from Getty Conservation Institute).
8. Derrick, M.R., H.D. Burgess, M.T. Baker, and N.E. Binnie. "Sulfuryl Fluoride (Vikane): A Review of Its Use as a Fumigant." Accepted for publication in the *J. AIC* in 1990.
9. Burgess, H.D. and N.E. Binnie. "The Development of a Research Approach to the Scientific Study of Cellulosic and Ligneous Materials." Accepted for publication in *J. AIC* in 1990.
10. Burgess, H.D. and N.E. Binnie. "The Effect of Vikane on the Stability of Cellulosic and Ligneous Materials." Oral presentation to the General Session of the Annual General Meeting of the AIC, Richmond, VA, 1990 (given by H. Burgess).
11. Burgess, H.D. and N.E. Binnie. "The Effect of Vikane on the Stability of Cellulosic and Ligneous Materials: Measurement of Deterioration by Chemical and Physical Methods." Oral presentation to the Meeting of the Materials Research Society, San Francisco, CA, 1990 (given by N. Binnie).
12. CCI internal monthly reports.

Results to Date:

The lab experiments for this project will be completed during 1989/90. Degradation of the paper and textile fibres is being monitored by carrying out the following analyses before and after accelerated ageing: surface pH, cold extracted pH, iodometric total acid, carbonyl content, degree of polymerization, colour change, fluoride content, and tensile strength. The data collected showed that fumigation of the

paper samples with sulphuryl fluoride caused damage that led to a significant decrease in their permanence. Fumigation also resulted in fluoride residues in the paper substrates. The highest concentrations of residues were found in ligneous, gelatin-sized, and/or alkaline-buffered materials. Results suggest that a large portion of the detrimental effects of fumigation were due to acidic impurities (*e.g.*, hydrochloric acid, hydrofluoric acid) in the commercial fumigant. Fumigation of paper samples with a purified Vikane resulted in approximately 50% to 60% less damage.

Vikane fumigation caused similar types of damage to the textile samples, although the extent of the changes was significantly less. The relatively pure and undegraded nature of the textile fibres (in comparison to the paper materials) probably account for their better performance. A detailed interpretation of the data from the paper and textile samples will be completed during 1989/90, and the results will be written up and published in technical journals.

1990 Research Plan

1. Data will be interpreted and two oral presentations prepared for Spring 1990.
2. The work will be written up for publication in appropriate journal(s).

NOTES:

The cost of the researcher and of materials and supplies are being met by the Getty Conservation Institute.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: The Effects of Alkali on the Long-Term Stability of Cellulose

CO-ORDINATORS: Helen D. Burgess, Season Tse, Stephen Duffy

OBJECTIVES:

The purpose of this project is to investigate the physical and chemical effects of alkali on cellulosic materials such as paper and textiles. Acid hydrolysis is one of the most important mechanisms of cellulosic fibre deterioration. Therefore, alkaline salts of magnesium and calcium are frequently added to water as part of standard conservation processes. Low concentrations are commonly used in washing treatments; larger amounts are used in deacidification treatments aimed at leaving an alkaline reserve in the fibres. Consultations with paper and textile conservators across Canada showed that scientific evaluation of these treatments was of primary concern. The Conservation Committee of the Canadian Council of Archives has also expressed a great interest in this project.

The long-term goal of this project is to provide the preservation community with a series of recommendations on what material is most likely to be benefited by alkalization, as well as the most appropriate procedures to use. It is anticipated that our results will have broad applications to paper artifacts found within fine art, archival, and library institutions.

ESTIMATED DURATION OF PROJECT:

Initiated in 1987/88, the project will take a minimum of five years for completion.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Burgess, H. "Gel Permeation Chromatography: Use in Estimating the Effect of Water Washing on the Long-Term Stability of Cellulosic Fibers." In *Advances in Chemistry Series No. 212, Historic Textile and Paper Materials: Conservation and Characterization* (1986): 363-376.
2. Burgess, H. "Progress Report to the Conservation Committee of the Canadian Council of Archives." February 1988, May 1988, August 1988, November 1989.
3. Bertrand, F. "Six-Month Report to the Conservation Committee of the Canadian Council of Archives." August 1988.
4. Duffy, S. "Six-Month Report to the Conservation Committee of the Canadian Council of Archives." November 1989.
5. CCI internal monthly reports.
6. Discussion of this area is contained in two reports by the CCI Paper and Textile Research Group: *Discussion Paper: Major Research Projects* and *Research Project Recommendations: Report of External Consultations.*

RESULTS TO DATE:

The first experiments carried out (Phase I) have studied the effects of alkali on a wide variety of fibres, with an emphasis on naturally aged material. The thirteen papers chosen for this investigation include fibres from both rag and wood pulp sources; they represent a broad range of ages and degrees of degradation, and contain a variety of sizing and filling materials. The aim of this first set of experiments was to come up with some broad conclusions on which types of fibres are most likely to benefit from alkalization and which ones could be damaged.

The following treatment sequences have been carried out on each of the 13 fibre types:

1. untreated control;
2. paper washed in running deionized water for 90 minutes;
3. as for #2, followed by soaking in 20 ppm magnesium bicarbonate for one hour, solution changed every 15 minutes;
4. as for #3, except 200 ppm magnesium bicarbonate was used;
5. as for #3, except 20 ppm magnesium sulphate was used;
6. as for #3, except 200 ppm magnesium sulphate was used.

Loss of the contract scientist (France Bertrand) in October 1988 delayed the experiments for Phase I of the project. A replacement scientist (Stephen Duffy) was hired in May 1989. During 1989, Season Tse was assigned to the project in order to expedite the analysis of the unaged samples. The principal analytical technique being used in these experiments was the estimation of the viscometric average degree of polymerization. The data obtained by this procedure can be related to the average polymer length and, thus, provide a means by which a scientist can monitor degradative changes to the cellulosic fibre.

The results show that treating paper with magnesium bicarbonate or magnesium sulphate does not cause any immediate change in the degree of degradation of the fibres. Washing with pure water also does not cause any observable changes.

The effect of the various treatments on the permanence of the thirteen papers have been determined through DP analysis of all samples after accelerated ageing at 70°C and 50% RH. Preliminary results indicate that ligneous papers are being damaged by alkalization with magnesium bicarbonate (magnesium carbonate is deposited). In all cases, treatment of paper with the neutral magnesium sulphate salt is improving the permanence of the fibres. Washing with pure water does not consistently cause either improvement or damage to paper.

A follow-up to these initial results is being carried out in 1989/90. These Phase II experiments are aimed at verifying our initial findings as well as extending the study to include high levels of alkalization (*e.g.*, 2000 ppm magnesium). Results from the treatments at the higher reagent concentrations should magnify the observed effects and, therefore, clarify our conclusions regarding problems with ligneous material.

1990 RESEARCH PLAN:

1. Study the effect of the concentration of lignin on the alkaline sensitivity of wood pulp papers.
2. The CCA has expressed an interest in continuing with a collaborative research effort. Their priority over the next few years will be to investigate whether the observed problems with the aqueous deacidification of ligneous papers are also found to occur with non-aqueous mass deacidification processes. It is expected that these new experiments will be planned and initiated in early 1991.
3. The results from Phase I have not resolved many other important issues. One of the most important of these is whether rag papers can be damaged by alkalization under certain conditions, *e.g.*, treatment of highly oxidized materials. However, as stated above, rag papers are not a priority with the CCA, so it is unlikely that CCI will carry out research with the CCA in this area in the near future. On the other hand, these unresolved questions are extremely important to the preservation of paper collections in Canadian art galleries and museums (and to a lesser extent to archives and libraries). The problem of availability of resources makes it unclear whether CCI will be able to extend this research into this important area in the coming year. If the financial means can be made

available, CCI will specifically investigate the role of oxidative deterioration in causing alkaline sensitivity of rag papers.

NOTES:

The Canadian Council of Archives has funded the cost of a researcher for 18 months. This person will be carrying out a portion of the work described above.

The results of the experiments on paper fibres will lead to a detailed experimental plan for carrying out similar work on cellulosic textiles.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Development of Methods for the Characterization of Protein Materials (for Use in the Evaluation of Conservation Treatments).

CO-ORDINATORS: Helen D. Burgess, Season Tse

OBJECTIVES:

The main objective is to find analytical methods to characterize protein materials (expecially silk and wool) as an aid to evaluating the condition of artifacts before and after treatment. Progress in solving many of the problems associated with silk and wool has been hampered by the lack of characterization methods. Such methods are necessary for the assessment of cleaning methods, consolidants, storage, and display conditions.

The need to carry out research into some of the important problems with silk and wool has been expressed for many years by textile conservators at CCI and elsewhere. It is possible that progress made in this area may be of some benefit to the development of methods for the analysis of other proteinaceous materials, such as gelatin size in paper.

ESTIMATED DURATION OF PROJECT:

This project was initiated in 1987/88 and is expected to continue for 5 years.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Tse, Season. "A Literature Survey of the Use of Thermal Analysis for Characterization of Silk and Wool." Internal CCI report.
2. Discussion of the need for analytical development in this area is contained in two reports by the CCI Paper and Textile Research Group: *Discussion Paper: Major Research Projects* and *Research Project Recommendations: Report of External Consultations.*
3. CCI internal monthly reports.

RESULTS TO DATE:

Investigations of the thermal analytical techniques indicate that they are not very sensitive to small differences between fibre samples. Therefore, it is doubtful if these procedures will be used as a principal means of monitoring changes in silk and wool. However, they may be useful in looking at specific questions, or as an adjunct to other more sensitive techniques. The final conclusion on the usefulness of thermal techniques will be made after current work on new sample preparation techniques is completed.

In addition to thermal analytical techniques, we are investigating chemical methods of analysis that characterize proteins through reactions with specific functional groups, *e.g.*, the amino group. Preliminary work on the ninhydrin method has shown that it may not be specific enough to be of general use. A possible solution to the problem may be to chemically "block" functional groups that are interfering with the analysis. Experiments in this area have been planned.

Progress is being made in the development of electrophoresis as a means of determining the state of degradation of wool fibres. The following samples have been analysed and distinct differences noted:

1. modern wool challis from Test fabrics;
2. 19th-century degraded wool from a Paisley shawl;
3. wool from the Memorial excavation at Red Bay, Labrador, in relatively good condition;
4. as for #3, but sample in average condition;

5. as for #3, but sample in poor condition.

At this point, it would seem the most promising analytical methods are those based on molecular weight or polymer length differences.

1990 RESEARCH PLAN:

In the coming year, efforts will be made to carry out the following:

1. complete the development of electrophoresis as an analytical tool for wool fibres;
2. determine if electrophoresis is a promising technique for analysis of silk;
3. begin work on the use of gel chromatography to determine the molecular weight distribution of wool;
4. continue with work on chemical methods of analysis of terminal amino acids as a means of estimating average molecular weights of wool and silk;
5. begin work on the use of viscometry to determine polymer length of silk.

NOTE:

The ninhydrin work was carried out with the assistance of Dr. Nancy Kerr, University of Alberta, during her research sabbatical at CCI.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: The Use of Enzymes in Conservation
CO-ORDINATORS: Helen D. Burgess, Season Tse

OBJECTIVES:

The purpose of this project is to characterise, evaluate, and adapt commercially available enzymes for use in conservation.

Many different enzymes are available, varying greatly in cost, activity, and purity. The aim of this project is to fully understand these enzymes in terms of the optimal conditions for their safe use by conservators, and to identify impurities, such as other enzymes, that might be harmful to the artifact. The effect of these impurities on the long-term stability of cellulosics is also being studied. The end product of the research will be a kind of handbook for conservators using enzymes. Both protease and amylase enzymes are being studied.

ESTIMATED DURATION OF PROJECT:

The experimental work was initiated in 1984/85 and completed in 1988/89. The writing of the handbook is expected to be a large task, and will not be completed until sometime in 1990/91.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. McCawley, J.C. "Enzymes for Conservation." Notes from a talk given at a symposium on Book and Paper Conservation, CCI, 1979.
2. Burgess, H.D. and C. Charette. "Aspects of Image Safety in the Use of Enzymes in Conservation." *ICOM Committee for Conservation, 6th Triennial Meeting*, Ottawa, 21-25 September 1981, 13 pages, 81/14/10.
3. Grattan, D., J. St. Hilaire, H.D. Burgess and J.C. McCawley. Article in *International Conference of Library and Archives Materials and the Graphic Arts*. G. Petherbridge, editor. Cambridge (1980), pp. 6-13.
4. Grattan, D., J. St. Hilaire, H.D. Burgess and J.C. McCawley. "The Characterization of Enzymes for Use in Paper Conservation." In *Conservation of Library and Archives Materials and the Graphic Arts*. G. Petherbridge, editor. Butterworths (1987), pp. 15-24.
5. Tse, S. and H.D. Burgess. "Degradation of Paper by Commercial Amylase & Protease Enzymes.". *Symposium 88: Conservation of Historic and Artistic Works: Proceedings*. Ottawa, 3-7 October 1988, in press.
6. Burgess, H.D. and S. Tse. "Enzyme Treatments for Paper Conservators." Workshop held at Whaling Museum, New Bedford, MA, May 1989.
7. Several oral presentations, including ones at the Annual Meeting of AIC (1988) and the Art Conservation Programme at Queen's University, Kingston, 1988.

RESULTS TO DATE:

Twenty-nine proteases and amylases have been characterized for their activity as a function of pH, activity as a function of temperature, percent protein, purity as determined by electrophoresis, and activity levels of contaminating enzymes. The characterization studies can be used as a means of selecting the appropriate enzyme for specific working situations. The research on the purity of the commercial enzymes led to observations concerning the possibility of damage to paper fibres during enzyme treatments.

The initial experiments in the degradation studies investigated the effect of the 29 different enzymes on the viscometric average degree of polymerization of a 19th-century oriental paper. As this procedure is an indication of polymer length, it provides an excellent means of monitoring fibre degradation. Results showed that more than half of the enzymes were capable of causing significant damage to the paper. Accelerated ageing of the samples did not significantly alter the conclusions.

Follow-up experiments on five different naturally aged papers indicated that not all papers are as susceptible to damage by enzymes as was the oriental paper. The degradation studies have allowed us to draw the following three conclusions: 1) proteases are more likely to be degradative to paper than amylase enzymes; 2) the more impure the enzyme, the greater the chance of damage to the fibres during enzyme treatment; and 3) papers have a widely varying susceptibility to damage by enzymes.

The final phase of this project has been to translate the research data into a format that will be accessible to conservators. The most important means is the writing of a "handbook" that will summarize all the data available, and present suggestions that will help the conservator choose an appropriate enzyme and formulate a workable treatment plan. The first part of this handbook, *i.e.*, the summarization of data, has been completed in 1989/90.

The second way in which information will be transferred to conservators is to develop a workshop that integrates theoretical knowledge with practical "hands-on" experience. The ground work for this has been completed through the planning and execution of a short workshop in 1989/90.

1990 WORK PLAN

1. Complete the writing of the enzyme handbook.
2. Complete the development of a three-day workshop for conservators that will be aimed at teaching the necessary skills for the selection and use of enzymes in conservation. The first of these workshops should take place in either 1990/91 or 1991/92.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Deterioration and Preservation of Synthetic Materials
CO-ORDINATORS: David Grattan, Malcolm Bilz

OBJECTIVES:

As per 1987 report.

ESTIMATED DURATION OF THE PROJECT:

At least four years.

REPORTS, PUBLICATIONS TO DATE:

1. Grattan, D.W. "The Problem of Rubber Conservation." *20th-Century Materials: Testing and Textile Conservation.* The Harpers Ferry Regional Textile Group, 9th Symposium. Smithsonian Institution, National Museum of American History, 3-4 November 1988.
2. Grattan, D.W. "Ageless Oxygen Absorber: Initial Analysis of Oxygen Consumption." Unpublished internal report.
3. Grattan, D.W. "Ageless and Ageless Eye." *CCI Newletter*, June 1988, p. 7.

RESULTS TO DATE:

The original idea was to continue the study of the retro-addition of stabilizers to synthetic materials, however, a more hopeful method of preservation, the use of Ageless oxygen absorber, has been pursued.

If deteriorating objects can be placed in an oxygen-free environment, then those that decay via oxygen absorption (*i.e.*, most materials except for the modified natural polymers, cellulose nitrate, and perhaps cellulose acetate) will cease to decay. This has been well known for a long time, but the problem has been that there has been no simple, inexpensive, and readily available way of achieving these conditions.

Mitsubishi Gas Chemicals of Japan manufactures "Ageless oxygen absorber", which is composed of iron oxides and is marketed in small sachets that are inexpensive and that can be placed within a sealed container from which they remove all the oxygen. If used in a rigid container, this creates a partial vacuum that may cause leakage. Mitsubishi, however, suggests the use of heat-sealable oxygen-barrier plastic envelopes as a better option.

We have been in touch with Mitsubishi Gas Chemicals, and also with Dr. Mark Gilberg of the Australian Museum in Sydney, Australia, and we are in the process of conducting a joint evaluation. In addition to its application in the prevention of oxidation of synthetic organic materials, the product can also be used to prevent metal corrosion, to stop fungal and bacterial activity, and, it is claimed, to kill insects and insect eggs. Thus the project has now evolved into an evaluation of the Ageless product for application in museums, and Mitsubishi has participated by holding discussions with CCI and by providing materials.

Equally important as the Ageless oxygen absorber is the oxygen barrier plastic film. Du Pont Canada has been particularly helpful, and has provided four state-of-the-art types of barrier film for the evaluation. Condor Laminations Ltd. has also supplied a batch of barrier films for testing.

Heat-sealed bags containing Ageless capsules were prepared and the gaseous contents analyzed over a period of a few months. The primary objectives were to measure oxygen depletion and moisture content. First, we attempted to develop a reliable method of measuring oxygen and relative humidity within sealed bags. Since this was achieved, two series of experiments have been carried out. In the first, there was no attempt to control humidity, while in the second, conditioned silica gel was added to produce a

range of selected relative humidities within the sealed envelopes. At present, we have not been able to obtain low enough oxygen concentrations to make the technique useful, and have been trying to identify the source of the problem.

As mentioned above, the second aspect of this work is to determine the level of oxygen that must be obtained in order to decide whether the technique is useful. To accomplish this, a number of historic polymeric materials have been obtained. The Canadian War Museum has been particularly helpful in this regard. Samples of historic polymers have been placed in specially adapted Warburg manometers and their rate of oxygen absorption has been monitored.

RESEARCH PLAN:

1) To evaluate the performance of Ageless at various relative humidities.
2) To evaluate various types of heat-sealable containers for use with Ageless, bearing in mind performance and cost.
3) To find out whether oxygen levels are low enough to prevent oxidation of synthetic materials.
4) To estimate the useful lifetime of the recommended packaging system.
5) To show that the Ageless system is beneficial in conditions of operational use.
6) To co-ordinate research into the wider applications of Ageless.

NOTES:

There are numerous cross-impacts in other areas of conservation, as mentioned above. Ageless oxygen absorber has the potential to become as significant for conservation as silica gel.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Degradation of Polyox.

CO-ORDINATORS: David Grattan, Malcolm Bilz

OBJECTIVES:

High molecular weight polyethylene oxide (Polyox) is being increasingly adopted as a consolidant for textile artifacts, especially cotton and wool, from archaeological sites. It is thus important to characterize the aging properties to see if Polyox meets the requirements of a conservation material. In addition, it is also relevant to see whether stabilizers improve its performance.

A study of the aging properties of low molecular weight polyethylene oxide resins (PEGs or Carbowaxes) had been carried out, and it seemed logical to develop the study further by looking at the higher molecular weight members of the family.

The major questions that we hope to answer are

1) How quickly does the Polyox become insoluble?
2) Does it yellow?
3) Does it become acidic?
4) How do other relevant properties change with time (*i.e.*, strength, integrity, colour, hygroscopicity, dimensional stability)? and
5) Are these changes related to alterations in the intensities in the hydroxyl and carbonyl peaks in the infra red spectrum, *i.e.*, is the ir spectrum a useful monitor of degradation?

ESTIMATED DURATION OF THE PROJECT:

The work is planned to occupy two years.

RESULTS TO DATE:

Much developmental work was necessary to prepare satisfactory and even films of Polyox. It was only possible to make films from Polyox WSR 301. Once good film had been prepared, thermal aging was carried out at 36°C, 40°C, 45°C, and 50°C. Only a narrow temperature range could be used because of the low melting range of the polymer. The aging was followed by monitoring the development of the carbonyl peak in the infra red spectrum. It initially appeared as if Polyox was quite unstable because of rapid development of [C=O], however, the rate slowed and, finally, [C=O] stabilized. Interpretation of the aging data is not complete because the kinetics have not yet been analyzed. Use of the anti-oxidant Irganox 1010 did not significantly alter the aging performance. pH and solubility tests show that the polymer does not reduce in solubility with time nor does pH decrease. Yellowing is also negligible. Initial results show Polyox to be suitable for conservation work. No light exposure studies have yet been made. High molecular weight polyethylene oxide (Polyox) is being increasingly adopted as a consolidant for textile artifacts, especially cotton and wool, from archaeological sites. It is thus important to characterize the aging properties to see if Polyox meets the requirements of a conservation material. In addition, it is also relevant to see whether stabilizers improve the performance.

1990 RESEARCH PLAN:

Resins to be studied are Polyoxes WSRN 80 (MW200,000) and WSR-301 (MW 4,000,000).

EXPOSURE CONDITIONS:

1) Interpretation of the thermal aging data.
2) Natural dark aging at 0% and 50% RH.

3) Exposure to Xenon arc radiation at 100,000 lux.
4) Exposure to ambient window lighting (north-facing window) at 0% and 50% RH.

TESTS:
1) solubility
2) pH
3) ir spectrum
4) colour change

STABILIZERS: The above tests are to be repeated with Polyox films containing stabilizers, if results from the light exposure studies merit.

TEXTILES: Some of the tests are to be repeated with Polyox coatings upon cotton, silk, and wool substrates.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: The Evaluation of Parylene Deposition as a Conservation Treatment.
CO-ORDINATORS: David Grattan, Margaret Morris, Malcolm Bilz.

OBJECTIVES:

With a coating device loaned by Union Carbide and the collaboration of a number of museums and other agencies, evaluate the use of Parylene in strengthening very delicate materials.

ESTIMATED DURATION OF THE PROJECT:

At least four years.

REPORTS, PUBLICATIONS TO DATE:

1. Grattan, D.W. and M. Bilz. "The Thermal Decomposition of Parylene and the Effect of Anti-Oxidant." To be submitted to *Studies in Conservation.*
2. Grattan, D.W. "Parylene at the Canadian Conservation Institute - An Initial Survey of Some Applications." To be submitted to the *ICOM Committee for Conservation - Preprints of the Conference to be held at Dresden in 1990.*
3. See also review of work on fossil forest for other relevant references.
4. In addition, there have been several television, magazine, and *Newsletter* reports of this technique.

RESULTS TO DATE:

1) Textile conservation.

In collaboration with Ms. Ela Keyserlingk (Canadian Conservation Institute). Satisfactory strengthening of delicate disintegrating silk textiles was achieved with Parylene C. It is possible that effective consolidation of certain fabrics may never be achieved without unacceptable flexibility changes.

2) Book, paper, and library conservation.

a) Books.

Books receive a nominal coating of 8u Parylene N, and are mounted in a clamp that holds them vertically and fully open. After coating, distortion may be present, but after a day or two, books return to shape. Dry books regained moisture at exactly the same rate whether coated or not. Books are very slightly thicker after coating. There is generally little alteration in appearance.

Initial observations are as follows:

Paper is strengthened noticeably, although sometimes coated paper breaks more easily on folding. Film thickness varies considerably throughout books. Films are thicker at the edges of pages and thinner towards the hinge. On pages with very smooth surfaces, such as colour plates, interference fringes are sometimes noticeable as a series of distorted rings, centred approximately at page centre. On end boards, adhesion is often poor. This effect is largely preventable with the adhesion promoter (Union Carbide A-174, an acrylic monomer containing a silane).

Use of a phenolic anti-oxidant, which has been shown to extend the service life of Parylene, gave an alarming result with certain books. Bright yellow colouration developed in regions of heavy degradation. Fortunately, Parylene is so stable, as discussed below, that an anti-oxidant is unnecessary.

Tests have been made on alternative ways of mounting books in the coating chamber. Those with very weak (*e.g.*, paper) or weakly attached end boards have been placed on their spines with the pages fanning out in a vertical arc. The results have been satisfactory.

b) Paper.

The study of paper strengthening is being coordinated by Paul Bégin (The National Archives/ Library of Canada). Materials studied include Ashless paper (Whatman filter paper), newsprint (groundwood), offset book (bleached), alkaline register paper, latex-saturated surface-coated and embrittled book paper.

In addition to standard procedures mentioned above, testing includes measurement of basis weight change, calliper, "zero-span" tensile strength, cross-section tearing strength, and bursting strength. Microscopic cross-sections could provide information as to how the Parylene is deposited on the fibres. Half of the acidic samples will be deacidified prior to coating. Improvements in strength for all of these papers have been recorded. The aging study of treated paper has not yet begun, but will include humid oven aging and light exposure studies.

c) Red-rotted leather end boards.

In collaboration with Mme M. Papineau (Archives nationales du Québec). The aim was to avoid rebinding approx. 10,000 19th-century ledgers that had badly red-rotting end boards. A binding with text block removed received 2 microns of Parylene C. This stopped the crumbling of the surface completely. A ledger with text block in place was then tested. The text block, in good condition, was wrapped in plastic film (Saran Wrap) to prevent it from being coated. Consolidation by 2 microns of Parylene was again satisfactory, and the text block remained Parylene-free. Experiments continue, but it is clear that the method can preserve the 19th-century bindings, which would otherwise be discarded.

3) Natural history specimens.

a) Arctic plant fossils.

i) Cones: The initial test, mentioned above, was carried out by Mr. B. Humphries (Nova Tran Corp.). The test cones were successfully coated with 12.8 microns of Parylene C. In subsequent work, it was found that the attachment of scales was poor for some cones, particularly the large spruce.

In another experiment, 3.6 microns of Parylene N was used initially to diffuse into and strengthen the cone as much as possible before a final coating with Parylene C to 13.7 microns. Attachment of scales was much improved.

Change in appearance of cones has not been possible to measure directly because of the cones' fragility (*i.e.*, before coating), surface irregularity, and size. Observations of the leaf mat sections (given below) show that colour is little altered by coating.

ii) Fossil leaf mat sections: Leaf mats vary considerably from highly compressed, semi-coalified deposits in which leaves are not easily distinguished to non-compressed, non-coalified layers with each leaf and cone preserved as a distinct entity. As with the cones, the leaf mats become excessively fragile on drying.

Several procedures were tested, and each type of mat required a different approach. Two examples follow:

Sample 11, non-coalified and composed of distinctly separable metasequoia leaves, was quite well consolidated after treatment with 8.7 microns of Parylene N.

Colour measurements after treatment indicated a slightly less reflective, i.e., darker, surface with a very slight trend towards blue. This confirms visual assessment of no obvious change.

Sample 4 was coalified with wood inclusions, and had poorly resolved leaves. It fragmented on drying under vacuum, and the wood inclusions warped badly. It was thus decided to treat another piece with polyethylene glycol to prevent the cracking and distortion caused by moisture loss in the coating process.

A section was soaked in 30% PEG 200 and freeze-dried. No warping took place, and it was then coated with 26 microns of Parylene N. Consolidation was completely satisfactory, and no delamination or separation of the Parylene film has since occurred.

b) Fragile mineralized plant and animal fossils.

In collaboration with Mr. G. Fitzgerald (National Museum of Natural Sciences). Evaluation was based mainly on the effectiveness of consolidation, visual changes, and the response to relative humidity change (ideally minimal). Samples were coated with both Parylene N and C.

(i) Fossil bone. Appearance was unaltered and Parylene inhibited dimensional response to relative humidity (RH) fluctuation. (This is not a suitable procedure for fossil bone, however, since most are too big and there are alternative procedures.)

(ii) Mammoth horn. Parylene did not stop the RH-related dimensional change.

(iii) Flaking cuticular material on an unstable inorganic (shale) matrix. After coating, the change in appearance was negligible, and the flaking was inhibited, but the Parylene did not prevent the shale from delaminating as RH changed.

It was concluded that, though a number of problems remain, Parylene probably had most application for mineralized fossils in shales.

c) Crustacea and other marine organisms.

In collaboration with Mr. L. Marhue (National Museum of Natural Sciences) and Ms. H. Coxon (Royal Ontario Museum).

Overall the results have been quite satisfactory, with minimal changes in appearance.

(i) Sponges have fine spicules that readily break off. Coating a sponge with 5.4 microns Parylene C consolidated these very well and solved the problem.

(ii) Crustaceans generally benefit from Parylene treatment. Consolidation of delicate setae is useful, and there are no obvious visual changes.

(iii) A red coral was losing sections, and breaking was well consolidated with 9.6 microns of Parylene C.

(iv) A crinoid was so fragile before coating that sections broke off with vibration in a car during transport, and it could not be handled. After coating with 16.1 microns of Parylene C, it was completely strengthened and could be handled easily.

(v) Fish skeletal material, previously coated with polyvinyl alcohol, was coated with 12.5 microns of Parylene C. Strengthening was noted, and suture lines in bone were still visible.

(vi) After coating with 2.4 microns Parylene C, the sea urchin became noticeably consolidated, and the spines became more rigid and did not break when handled. A slight sheen is noticeable, but the coating is hardly visible.

(vii) Shells were coated with 3.3 microns of Parylene C. No change in colour, gloss, or iridescence on a mussel shell was observed. An oyster shell closed up somewhat.

d) Insects.

Coordinated by Mr. T. Strang (Canadian Conservation Institute). A number of insects were coated with very good effect; they were much stronger and tended not to lose components. The Parylene is easily observable by SEM, and the conformal nature is very evident. The consolidation is very effective, but coatings have to be thin to avoid changing the appearance. Antennae are in the region of 1-5 microns in thickness, thus coatings must be below 2 microns. Irridescence on butterfly wings is lost.

e) Display specimen preparation.

This study of the use of Parylene in preparing Natural History specimens for use in displays and dioramas, etc., was done in collaboration with Mr. R. Seguin (National Museum of Natural Sciences). Generally, results of Parylene coating on a number of plant and animal specimens were satisfactory. Parylene adds strength to delicate specimens, and it is acceptable to sacrifice a little of the appearance. Parylene could be used in the preparation of a wide range of plant and animal specimens to allow display or to withstand frequent handling.

f) Archaeological and ethnographic objects.

This work was coordinated by Mr. R. Barclay (Canadian Conservation Institute). Samples were prepared by the Ethnography and Archaeology sections of the Canadian Conservation Institute.

(i) Disintegrating shredded cedar bark. 2 microns of Parylene C gave good consolidation of individual fibres, whereas 4 microns caused the bark strands to mat together.

(ii) Fur. The problem was that the vacuum caused irreversible contraction and hence distortion of the skin, so, at the moment, the process cannot be used to address such problems as hair slippage, etc.

(iii) Dry powdery pigments. Experiments were conducted to consolidate dry powdery pigments on various substrates. These included leather, parchment, bark, and cedar. On evacuation, and thus desiccation, the substrates tended to warp badly. The Parylene did stabilize the pigment, and at 4 and 8 microns it was not noticeable. If moisture loss could be minimized, the warping and damage would be lessened. Experiments will continue with higher deposition pressures, to minimize moisture loss, and thinner coatings.

(iv) Wet and fragile archaeological textiles. This was done in collaboration with Ms. J. Logan (Canadian Conservation Institute). Wool fibres from burials in Red Bay, Labrador, shed fibres continuously whether mounted or not. The value of this collection of textiles (including a hat and wool stockings) rests in its research potential.

For the Parylene experiments, very degraded wool samples were used. Coating with 4.4 microns Parylene C or 5.5 microns Parylene N gave very acceptable consolidation without alteration of appearance.

g) Burnt paper.

Our study of the strengthening of burnt paper is being carried out with Mr. D.C. Purdy (Royal Canadian Mounted Police), Mr. J. Garstang (Canadian Transportation Accident Investigation and Safety Board), and Mr. D. Tremain (Canadian Conservation Institute). Several kinds of paper, marked with different inks, have been charred in a furnace. After treatment with 4 and 8 microns of Parylene C, the burnt paper appeared unaltered, yet could be handled roughly without damage. Non-destructive analytical techniques, including examination by infra-red ultra-violet light, were found to be unaffected by the Parylene film.

A batch of water-soaked and burnt books from the Dryden air crash was freeze-dried and then subjected to treatment with 6-12 microns of Parylene N. The strengthened pages could be separated, yet did not stick together. Information retrieval has been almost complete.

The thermal oxidation of Parylene N and Parylene C has been studied. The results of previous investigations have been compared, confirmed, and expanded. It has been demonstrated that the useful lifetime of Parylene as a consolidant is probably 2182 years for "N" and 132,000 years for "C". Incorporation of the anti-oxidant 4,4' -methylene-bis-(2,6-di-ter-butylphenol) increases the stability substantially, but in view of the very high stability of the pure film its use in conservation is regarded as non-essential. The effect of light is under study.

1990 RESEARCH PLAN:

1) To complete the testing of fragile materials as requested by museums.
2) To complete the light stability study of Parylene.
3) To complete the study of Parylene-coated paper in collaboration with the National Archives/Library of Canada. Our particular role is to investigate the light stability.
4) To carefully monitor the fossil specimens treated with Parylene.

NOTES:

There are numerous cross-impacts in other areas of conservation, as mentioned above. Parylene has the potential to save many items for which there was previously absolutely no hope.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Analysis of Paints of Canadian Native Cultures

CO-ORDINATORS: Elizabeth Moffatt, Judi Miller

OBJECTIVES:

To obtain paint samples for analysis from well-documented Canadian Native artifacts in museum collections in order to establish a chronological database of pigments and binding media. Information on the pigments and their dates of use by the various Native groups is scarce and is frequently of questionable reliability. The database will assist curators and conservators in dating and authenticating objects, in selecting appropriate display conditions, and in devising treatments.

Conservators and curators at eight major Canadian federal and provincial museums and at a number of international institutions are participating in this project. List and correspondence available on request.

ESTIMATED DURATION OF PROJECT:

Initiated four years ago, this research was completed in 1989 as a major research project. However, as noted below, additional work will continue as appropriate samples become available on a limited basis to augment the data.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Annual Status Reports on the Native Materials Project of 8 March 1985, 11 March 1986, and 10 March 1987 circulated to all participating museums along with the preliminary results of the analysis of samples from the museum's collection.
2. Project summaries published in the *Ethnographic Conservation Newsletter of the Working Group on Ethnographic Materials* of the ICOM Committee for Conservation (June 1985), the *Newsletter of the Council for Museum Anthropology* (July 1985), the *IIC-CG Newsletter* (June 1986), the *Ottawa Archaeologist* (January 1987), and the *Proceedings of Symposium '86: The Care and Preservation of Ethnological Materials*, Ottawa, September 1986 (based on a presentation given by Judi Miller).
3. A paper entitled "Historic Paints of Canadian Native Cultures" was presented at the Annual Meeting of the IIC-CG in St. John's, Newfoundland, in May 1989.
4. Ongoing correspondence was continued to respond to client requests for information.

RESULTS TO DATE:

The Native Materials Reference Collection consists of 1350 paint samples obtained since the project was started. These samples represent artifacts from all areas of Canada with an emphasis on the Plains and Northwest Coast, with over 500 samples from each of these regions. The earliest documented dates range from the late-eighteenth century for Plains and Naskapi artifacts to 1879 for Northwest Coast objects. The most recent samples are mid-twentieth-century paints.

The analysis of all samples by Fourier transform infrared spectroscopy, x-ray energy spectrometry/scanning electron microscopy, as well as selected samples by x-ray diffraction and polarized light microscopy has been completed.

Of particular interest, the blue-green pigment found on about thirty Northwest Coast artifacts to date has been identified as green earth and not a copper-based pigment as frequently described in the ethnographic literature. This pigment is usually present without a binding medium. Another frequently identified pigment is Reckitt's blue or laundry bluing (a preparation containing ultramarine blue) often

referred to on catalogue cards as having been used by the Naskapi and Northwest Coast peoples. No pigments of vegetable or animal origin have yet been identified.

Although this project has been completed, it is important to note that, in order to augment the reference collection and data, work on the analysis of Native materials will continue in succeeding years as suitable samples become available. In particular, samples from well-documented early (pre-1880) samples are needed. As they become available, and if time permits, additional samples may be accepted for analysis.

1990 RESEARCH PLAN:

The completion of (a) reports for each participating museum, (b) an overall project report, and (c) a final publication are the goals for completing this project in 1990.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Development of Analytical Methods: Hydrothermal Stability of Collagen

CO-ORDINATOR: Gregory S. Young

OBJECTIVES:

To develop techniques, based on the hydrothermal stability of collagen, for (1) non-destructive measurements of deterioration of skin, hide, and leather artifacts, (2) assessments of the effects of traditional and experimental conservation treatments, and (3) monitoring of added deterioration in artifacts in storage or display.

ESTIMATED DURATION OF PROJECT:

This project was initiated as a result of a series of service requests, and proceeded intermittently. The project is expected to continue throughout 1990 and into 1991. Afterwards, evaluation of conservation materials and processes will continue in the form of service work.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. Young, G.S. "Shrinkage Temperature Interim Report." CCI Analytical Report, March 1985.
2. _____. "The Potential of Shrinkage Temperature Measurements for Use in Studies of Skin and Leather Conservation." Paper delivered at the International Institute for Conservation—Canadian Group 11th Annual Conference, Halifax, 17-19 May 1985.
3. _____. "Seal Skin Thongs: Characterization." CCI Analytical Report, A.R.S. 2455, July 1986.
4. _____. "Shrinkage Temperature of Collagen Fibers: Measurements of Hydrothermal Stability." Seminar delivered at the Workshop during *Symposium 86: The Care and Preservation of Ethnological Materials*, Ottawa, September 28-October 3, 1986.
5. _____. "The Potential of Shrinkage Temperature Measurements in Skin and Leather Conservation." *The Ethnographic Conservation Newletter of the Working Group on Ethnographic Materials*. The ICOM Committee for Conservation, No. 3 (March 1987): 16-17.
6. _____. "Analytical Methods for the Research of Collagen Hydrothermal Stability." CCI Analytical Report, November 30, 1987.
7. Maltby, S. "Padlemuit Inner Boot of Caribou: Shrinkage Temperature Measurements." CCI Analytical Report, A.R.S. no. 2644, Dec. 10, 1987.
8. Young, G.S. "Nubian Leathers: Deterioration Assessment; Phostoxin-Treated Leathers: Measurement For Change in Thermal Stability." CCI Analytical Report, A.R.S. no. 2668, March 31, 1987.
9. _____. "Buffalo Udder Indian Headdress: Deterioration Assessment." CCI Analytical Report, A.R.S. No. 2669.1, Feb 19, 1988.
10. _____. "Analytical Development for Skin and Leather Conservation." *CCI Newsletter*, June 1988, pp. 6-7.
11. Logan, J.A. and G.S. Young. "A Message in a Bottle: The Conservation of a Waterlogged Parchment Document." *Journal of the International Institute for Conservation—Canadian Group*. Vol. 12 (1987), pp. 28-36.
12. Logan, J.A. and G.S. Young. "Current Research in Wood and Leather Treatments at the Canadian Conservation Institute." In *Proceedings of the Joint Meeting of the Society for Historical Archaeology and Conference on Underwater Archaeology*, Savannah, Georgia, January 1987, pp. 54-56.

13. Young, G.S. "Microscopical Hydrothermal Stability Measurements of Skin and Semi-Tanned Leather." *Preprints of the 9th Triennial Meeting, Dresden, German Democratic Republic, August 1990*. Paris: International Council of Museums, Committee for Conservation, [in press].

RESULTS TO DATE:

A microscopical method of measuring the shrinkage temperature (Ts) of collagen fibers has been established, Ts being a simple measure of hydrothermal stability. Preliminary results for a sampling of archaeological and ethnographic artifacts have shown a broad range of Ts values. The most severely deteriorated artifacts have values of 21°C or lower (showing shrinkage at room temperature), and undeteriorated artifacts have values similar to those obtained from new skins and leathers, *i.e.*, 62°C to 68°C. Because the method requires very small quantities of sample material—it is essentially a non-destructive technique—tests are now conducted on a routine basis in the Ethnology and Archaeology conservation laboratories at CCI. A significant contribution of the method is in identifying severely degraded collagenous ethnological artifacts. Those that have Ts values at or near room temperature are extremely susceptible to drastic and irreversible damage in the presence of moisture, or even of high humidity.

Several thermodynamic properties of protein denaturation in solution and in solid phase have been identified from literature reviews, and will be used to characterize changes in collagen that are associated with lowering shrinkage temperatures.

1990 RESEARCH PLAN:

1. Thermal analysis of collagen denaturation will proceed to (a) correlate shrinkage temperatures, taken by microscopy, with thermodynamic functions derived through differential scanning calorimetry; and (b) determine how deterioration and treatments affect hydrothermal stability.
2. A paper that discusses shrinkage temperature measurements by microscopy has been submitted for publication (see no. 13 in REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE presented above). A second paper will report on thermal analytical research concerning the association of shrinkage temperatures and deterioration.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Development of Analytical Methods: Laser Scanner Development

CO-ORDINATORS: J. Taylor, I.N.M. Wainwright, R. Baribeau

OBJECTIVES:

To test the applications of a 3-D laser scanner system developed by the National Research Council of Canada for (1) the accurate high-speed measurement of three-dimensional museum objects for documentation and research application, (2) the fabrication of replicas or supports for objects using numerically controlled (NC) machining, and (3) determining the potential application of simultaneous colour and dimensional recording using "white" laser light.

The work on (1) and (2) has been performed on a contract basis with the National Research Council and Hymarc Engineering. The colour applications research work is being performed by a PhD student at Laval University and NRC on a two-year contract basis as part of the Department of Communications French-Language Centres of Excellence Program.

ESTIMATED DURATION OF PROJECT:

The work was initiated in 1985/86, and it will continue through until 1991.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. "Report on a Test Program to Investigate the Measurement of Museum Artifacts by a 3-D Laser Scanner." Hymarc Engineering Ltd., 66 Colonnade Road, Ottawa, Ontario, K2E 7K7, 8 May 1986 (available from CCI Library).
2. "Report on Head Measurements of a Human Model by a Laser Scanner." Hymarc Engineering Ltd., 66 Colonnade Road, Ottawa, Ontario, K2E 7K7, June 1987 (available from CCI Library).
3. Taylor, J.M., I.N.M. Wainwright, F.R. Livingstone, M. Rioux and P. Boulanger. "Applications of a Laser Scanner to the Recording and Replication of Museum Objects." *ICOM Committee for Conservation, 8th Triennial Meeting*, Sydney, Australia, 6-11 September 1987, pp 93-97.
4. Boulanger, P., M. Rioux, J.M. Taylor and F. Livingstone. "Automatic Replication and Recording of Museum Artifacts." *Reports, The 12th International Symposium on the Conservation and Restoration of Cultural Property - Analysis and Examination of an Art Object by Imaging Techniques*, Tokyo National Research Institute of Cultural Properties, Tokyo, Japan, 29 September - 1 October 1988, pp. 131-147.
5. Rioux, M. "Computer Acquisition and Display of 3-D Objects Using Synchronized Laser Scanner." *NRC Publication # 30,295*. Ottawa, Ontario: National Research Council of Canada, Division of Electrical Engineering, 1989.
6. Taylor, J.M., I.N.M. Wainwright, F.R. Livingstone, M. Rioux and P. Boulanger. "Applications of a Laser Scanner in Conservation: Recording and Replication." Poster Session 1, *Symposium 86: The Care and Preservation of Ethnographical Materials: Proceedings*, Canadian Conservation Institute, 1986, pp. 262-263.
7. Taylor, J.M. and I.N.M. Wainwright. "Applications of a 3-D Laser Scanner to the Recording and Replication of Works of Art." *Museums and Information: NewTechnological Horizons*, Conference organized by the Manitoba Museum of Man and Nature and the Canadian Heritage Information Network, Winnipeg, Manitoba, 3-4 May 1990.

8. Baribeau, R. and M. Rioux. *Influence of Speckle on Laser Range Finders*. Ottawa: Division of Electrical Engineering, National Research Council of Canada, 1990.
9. Baribeau, R. and M. Rioux. *Centroid Fluctuations of Speckled Targets*. Ottawa: Division of Electrical Engineering, National Research Council Canada, 1990.

RESULTS TO DATE:

To date, the laser scanner has been used in a test program to investigate the three-dimensional measurement capabilities on a wide range of museum objects including a small marble bust, waterlogged wood objects, ivory figurines, archaeological textiles, ceramics, Northwest Coast (NWC) wooden masks, natural history specimens, composites, a human model, and a section of a totem pole.

The Manufacturing Technology Centre of the National Research Council has performed Numeric Control (NC) machine replication experiments on a foam replica of a NWC stone mask using the data from the laser scanner. Recent advances in computer-assisted machining at NRC include a technique that permits the replication of surface texture. In a test of the method, a four-inch-square section was made of the inside of the mask. In addition, in 1989, a detailed 1:1 replica of a lead plaque discovered at Sainte-Marie Among the Hurons, which marked the burial place of the Jesuit martyr Jean de Brébeuf, was made. This replication tested the limits of resolution of the system, and showed that it was feasible to produce a very accurate replica of an object.

Testing by Hymarc Engineering Ltd. on the machining of mannequin heads for museum display applications revealed that replication of human models is problematic. Difficulties were encountered with the replication of different views of the subject as a result of small movements during the scanning process. Replication of inanimate objects is, on the other hand, completely successful.

In September 1989, Réjean Baribeau commenced work on his PhD thesis at Laval University on the development of the scanner for colour measurements.

1990 RESEARCH PLAN:

Research on this project will continue in 1990-91 on a contract with Réjean Baribeau for his PhD thesis at Laval University as part of the Department of Communications' French-Language Centres of Excellence Program. The research and development aspect of this project will be performed at the National Research Council and is entitled "Développement d'une caméra 3-D à l'aide d'un laser blanc: application à des objects d'intérêt muséologique." The objectives are attached.

CCI RESEARCH PROJECT REVIEW - 1989

PROJECT TITLE: Titanium Dioxide White

CO-ORDINATOR: Marilyn E. Laver

OBJECTIVES:

Production of a chapter for publication in Volume 3 of *Artists' Pigments: A Handbook of Their History and Characteristics,* to be published by the U.S. National Gallery of Art.

ESTIMATED DURATION OF PROJECT:

Five years. This project was initiated in 1984 and completed in 1989. Ongoing correspondence with the editors and minor revision work is anticipated at least through to the end of 1990.

REPORTS, PUBLICATIONS AND COMMUNICATIONS TO DATE:

1. An interim progress report was submitted to the National Gallery in Washington (May 1986).
2. A final draft manuscript was submitted to the National Gallery on 30 November 1989.
3. Correspondence in reply to requests for information from clients in ongoing.

RESULTS TO DATE:

The information in the chapter includes sections on history of development, use by artists, pigment properties, composition, sources and manufacture, identification, and notable occurrences on works of art.

1990 RESEARCH PLAN:

Except for minor revisions to the manuscript prior to publications, this project is complete.