RUBBERIZED FLANNEL IN CONTEMPORARY BEADED POWWOW REGALIA

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Abstract - Rubberized flannel is a commercially available fabric frequently used as a substrate for beadwork in modern powwow regalia and contemporary artwork. Comprised of two layers of flannel fabric laminated together with an elastomeric material, this product is commonly used in baby lap pads and waterproof bedding. Rubberized flannel has handling properties that are similar to semi-tanned hide, which is the traditional substrate for beaded regalia. It is less expensive than tanned hide and available at retail stores. Unlike leather, rubberized flannel can delaminate and fray once the fabric is structurally and chemically compromised. The elastomer component is likely to have poor longevity, as many elastomers are known to be sensitive to environmental pollutants and aging.

This project investigates the history and manufacture of rubberized flannel. The components of this fabric, as well its potential deterioration, were identified through several analytical techniques. NMAI Curator Emil Her Many Horses (Lakota) and other Native American beadwork artists were consulted on contemporary applications and the prevalence of rubberized flannel in contemporary beaded Powwow regalia. Following a survey of contemporary beadwork in the NMAI's collection, the authors evaluated the condition and conservation issues associated with beaded rubberized flannel.

Título - FRANELA PLASTIFICADA EN INDUMENTARIA INDÍGENA NORTEAMERICANA CONTEMPORÁNEA DECORADA CON CHAQUIRA

Resumen – La franela plastificada es un textil comercialmente disponible, frecuentemente utilizada como soporte para trabajo de chaquira en indumentaria indígena y objetos artísticos contemporáneos. Se compone de dos capas de tela de franela laminadas entre sí con un material elastómero y se utiliza comúnmente para fabricar mantas para cambiar pañales y ropa de cama impermeable. La franela plastificada tiene propiedades de manejo que son similares al cuero semi-curtido al tanino, que es el sustrato tradicional para indumentaria con chaquira; es menos costosa que la piel curtida y está disponible en las tiendas minoristas. A diferencia del cuero, la franela plastificada se puede exfoliar y deshilachar cuando se compromete su establidad estructural y química. El componente elastómero tiende a ser de baja longevidad, pues muchos elastómeros son conocidos por su susceptibilidad ante los contaminantes ambientales y el envejecimiento.

Este proyecto investiga la historia y la manufactura de la franela plastificada. Los componentes de la tela, así como su potencial deterioro, fueron identificados a partir de diversas técnicas analíticas. Se consultó al curador del *National Museum of the American Indian* (NMAI, Museo Nacional de Indígenas Norteamericanos), Emil Her Many Horses (de origen Lakota), así como a otros artistas indígenas norteamericanos que trabajan con chaquira, sobre las aplicaciones contemporáneas y la prevalencia de franela plastificada en la indumentaria con chaquira indígena

norteamericana. Haciendo un registro de la colección del NMAI de trabajo en chaquira, las autoras evaluaron el estado y los problemas de conservación asociados a la franela plastificada decorada con chaquira.

Titre - LA FLANELLE IMPERMÉABLE DANS LES TENUES DE CÉRÉMONIES PERLÉES POUR LES POW-WOW

Résumé – La flanelle imperméable est un tissu commercial fréquemment utilisé comme substrat pour la broderie perlée des tenues de cérémonie modernes de pow-wow et autres œuvres d'art contemporaines. Composé de deux couches de flanelle laminées avec un matériau élastomère, ce produit est généralement utilisé dans les piqués pour bébé et la literie résistante à l'eau. La flanelle imperméable a un corps similaire à la peau semi-tannée, le substrat traditionnel des tenues de cérémonies perlées. Ce tissu est moins cher que le cuir tanné et disponible dans les magasins de vente au détail. Contrairement au cuir, la flanelle imperméable peut se délaminer et s'effilocher une fois que le tissu est structurellement et chimiquement instable. La composante élastomère risque d'avoir une mauvaise longévité, puisque de nombreux élastomères sont connus pour être sensibles aux polluants environnementaux et au vieillissement.

Ce projet étudie l'histoire et la fabrication de la flanelle imperméable. Les matériaux composant ce tissu, ainsi que son éventuelle détérioration, ont été identifiés par plusieurs techniques d'analyse. Le conservateur Emil Her Many Horses (Lakota) du National Museum of the American Indian (NMAI) et d'autres artistes amérindiens qui travaillent la broderie perlée ont été consultés sur les applications contemporaines et la prévalence de la flanelle imperméable dans des tenues de cérémonies perlées pour pow-wow. L'étude des objets perlés contemporains dans la collection du NMAI a permis aux auteurs d'évaluer l'état et les problématiques de conservation liés aux objets contenant de la flanelle imperméable perlée.

1. INTRODUCTION

Rubberized flannel is a commercially available fabric that is frequently used as a substrate for beadwork in modern powwow regalia and contemporary artwork. It is a waterproof fabric comprised of two layers of flannel that are laminated with an elastomeric "rubberizing" layer. "Rubberized flannel" is a generic term used by distributors and suppliers, which will be used throughout this paper. The same material is also called "lap pad" by powwow regalia makers (Tamayo 2013). This material is commonly found in baby lap pads and waterproof bedding and has been available in white, pastel colors, and children's prints. The fabric typically is advertised as waterproof cotton fabric with a non-allergenic rubber layer. While the waterproof component is described as rubber, more specific identification of the elastomer was not readily available from most of the distributors contacted during this paper.

The use of rubberized flannel in contemporary beaded powwow regalia came to the authors' attention while preparing objects for the exhibition *Circle of Dance*, which opened at the National Museum of the American Indian (NMAI) in New York, October 2012. *Circle of Dance* is a five year exhibition that presents Native dance as a vibrant, meaningful, and diverse form of cultural expression, through the presentation of ten social and ceremonial dances selected from the Americas (Ganteaume 2012). Each of the ten dances is represented by a single mannequin dressed in traditional regalia, posed in a representative dance position.

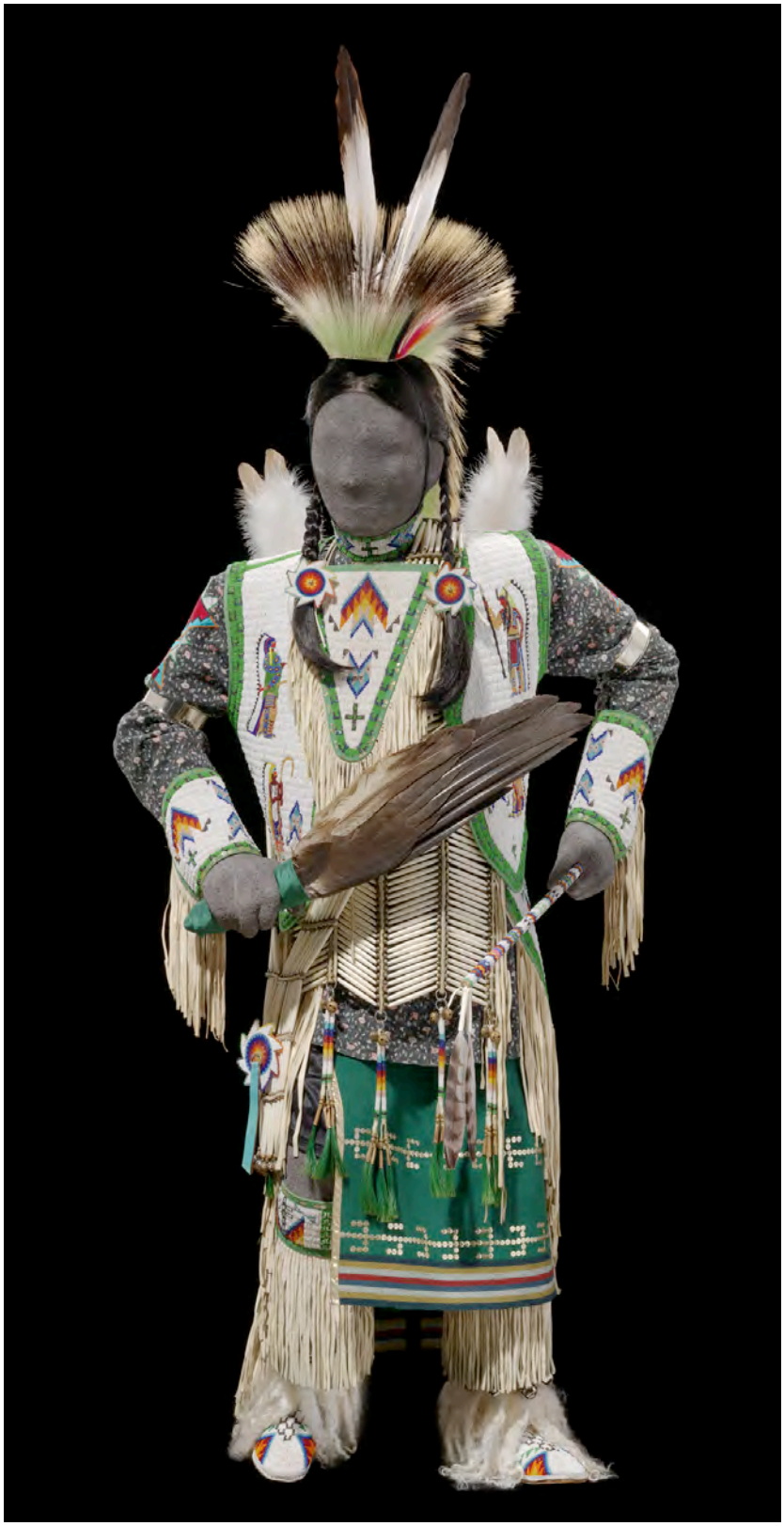

Fig. 1. Contemporary Men's Northern Traditional Powwow outfit made and worn by Robert Tiger Jr. (Hunkpapa Lakota). National Museum of the American Indian, Smithsonian Institution (26/7485). Photo by Ernest Amoroso.

During examination of a contemporary Men's Northern Traditional powwow outfit (fig. 1), rubberized flannel was identified as the beading substrate. Artist Robert Tiger Jr. (Hunkpapa Lakota) made the outfit in the 1990s and danced it in many powwows. Rubberized flannel was first observed in the two most deteriorated outfit components, the choker and vest, where the layered fabric structure was exposed by damage. These two components would have been subjected to the most perspiration and physical agitation during dancing. Deterioration included embrittlement, cracking of the elastomer layer, and fabric abrasion (fig. 2). This degradation sparked interest in the composition of the elastomer; identification could help assess the material's potential instability, as well as appropriate conditions for storage and exhibition.

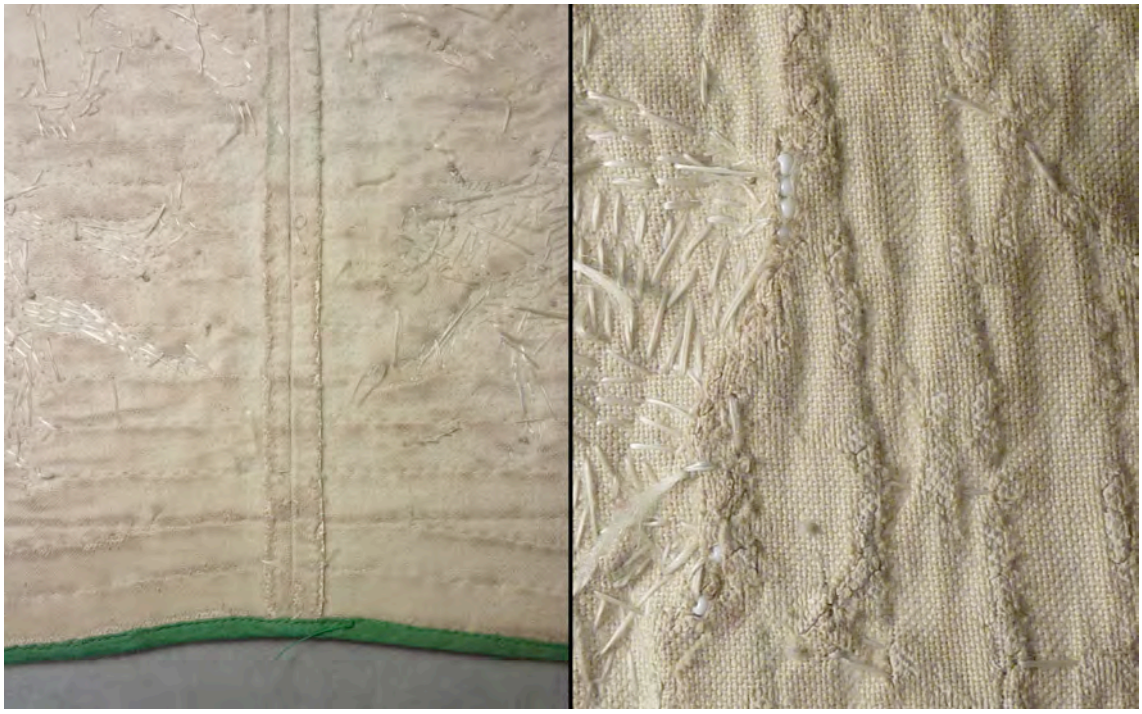

Fig. 2. Detail photographs of the inside of the vest illustrating the worn rubberized flannel substrate and subsequent structural damage. National Museum of the American Indian, Smithsonian Institution (26/7485).

The degree of deterioration on this relatively recent acquisition caused concern, prompting the investigation and re-examination of other heavily-beaded contemporary outfits in the NMAI's collection, such as those displayed in the NMAI's *Identity by Design* exhibition by artists Rebecca Hamilton Brady (Cheyenne/Sac and Fox/Pawnee/Oto), Jon Brady (Arikara), Keri Jhane Myers (Comanche), and Alice Jones Littleman (Kiowa) (fig. 3). Three beaded artworks by artist Marcus Amerman (Choctaw) also were examined. All of these pieces have rubberized flannel as a beading substrate.

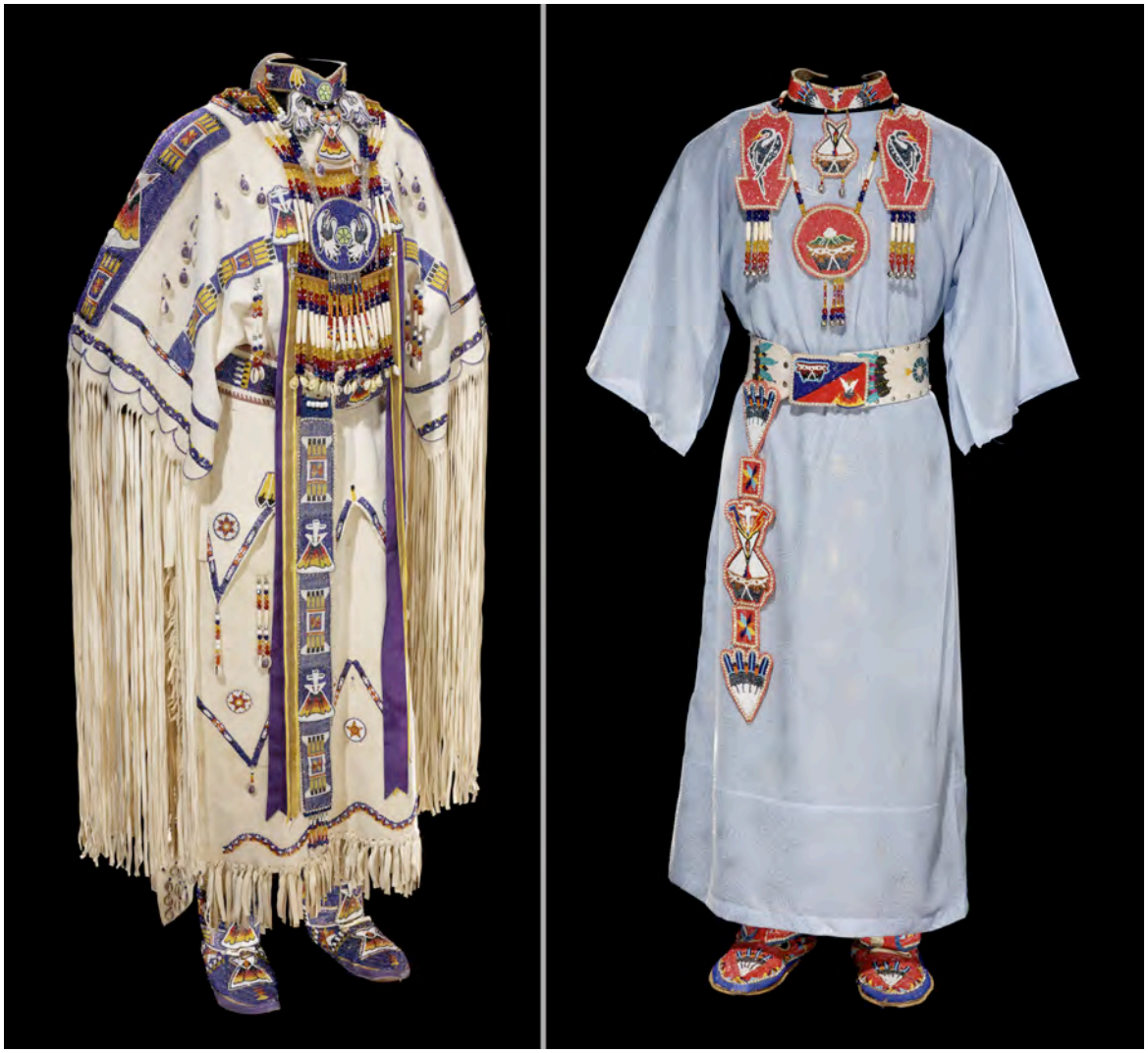

Fig. 3. Outfits displayed in the NMAI's *Identity by Design* exhibition. Made by artists Rebecca Hamilton Brady (Cheyenne/Sac and Fox/Pawnee/Oto) and Jon Brady (Arikara) (shown without crowns and earrings). National Museum of the American Indian, Smithsonian Institution (26/5186, 26/5187). Photos by Ernest Amoroso.

A review of previous NMAI conservation reports and museum catalogue records revealed that the rubberized flannel substrate has been loosely described as a backing or lining, or misidentified as cotton fabric or canvas. Identification of this substrate can be difficult as it is often completely covered with beadwork and backed with a different fabric, hide, or other material.

2. BACKGROUND

2.1 USE OF "RUBBERIZED" FABRIC AS A BEADED SUBSTRATE

In the course of this study, eight Native beadworkers were interviewed to learn about the use of rubberized flannel in powwow regalia and contemporary beadwork (Amerman 2013; Evans 2013; Fogarty 2013; Growing Thunder 2013; Growing Thunder 2013; Her Many Horses 2013; Holy Bear 2013; Tamayo 2013). Emil Her Many Horses (Oglala Lakota), a curator at NMAI, related the history of its use on the Lakota Rosebud Reservation in South Dakota. In the 1960s

and 70s, when the powwow was being revived, some people were working with sinew and semi-tanned hide, the traditional substrate for heavily beaded pieces, while others were beginning to incorporate new materials. Her Many Horses recalls a piece commissioned by his grandmother that was beaded with nylon monofilament on tanned hide. Alternative materials, such as cotton canvas, may have been introduced by neighboring communities. Alice Fish, an influential beadworker at Rosebud, was friends with Crow beadworker Gladys Jefferson. Crow beadworkers had a tradition of using cotton canvas, often recycled canvas tipis, as a beading substrate when the surface was entirely beaded (Her Many Horses 2013).

Rubberized flannel rose in popularity in the 1970s and 1980s as an alternative to canvas, when the substrate would be entirely covered in beads (Her Many Horses 2013; Tamayo 2013). Rubberized flannel has several advantageous qualities. Unlike cotton canvas, the inner elastomer layer prevents fraying at the edges. This product can be bought at fabric stores or national department store chains such as Walmart, JC Penneys, and Target. It also is economical; a twin bed-sized piece of rubberized flannel costs $20-30, while a traditional brain-tanned hide costs $100 to $350 and can be difficult to obtain.

Fig. 4. Beaded portrait of NMAI's founding director Rick West (Southern Cheyenne), with a rubberized flannel substrate, by Marcus Amerman (Choctaw). National Museum of the American Indian, Smithsonian Institution (26/5559).

Steve Tamayo (Sicangu Lakota), Artist in Residence for the Omaha Public Schools, Cultural Activities Specialist for the Native American Advocacy Program, and former NMAI conservation intern, also offered some observations as a maker of powwow regalia. Many children are taught to bead using this fabric as a substrate. He noted that rubberized flannel is used widely for dress tops, aprons, purses, cuffs, side drops, head bands or crowns, braid ties, chokers, bibs, and leggings – all components of a powwow outfit. Many dancers wear a new outfit every year and a recent trend is for dancers to make several outfit changes in one powwow. Tamayo's daughters produce four to five powwow outfits each year (Tamayo 2013).

Rubberized flannel also is used as a substrate for fine art beadwork. NMAI has several pieces by artist Marcus Amerman (Choctaw) that feature beaded portraits on a rubberized fabric substrate, including one of NMAI's founding director Rick West (Southern Cheyenne) (fig. 4) in front of the Museum. Amerman confirmed that he uses this fabric for everything he beads. He tried beading on canvas, but prefers the rubberized fabric with the cotton flannel on both sides. He prepares the fabric for beading by washing it, dyeing it (to cover printed designs), and then coating it with a polyvinyl acetate emulsion before beading over an adhered paper template. When asked about its longevity, Amerman stated that his beadwork on rubberized fabric has worn better than his pieces beaded on leather or cotton canvas (Amerman 2013).

2.2 EARLY WATERPROOF FABRICS

Early waterproof fabrics, precursors to rubberized flannel, were developed in Europe and America, where production was industrialized in the 19th and 20th centuries. Natural rubber, *cis*-1,4-polyisoprene, derived from latex found in several plant species, was the first elastomer to be used for waterproofing fabrics. Inventor Charles Macintosh made an important contribution to the development of rubberized fabrics when, in 1822, he patented a process for waterproofing fabrics with a naphtha-softened natural rubber layer (Macintosh 1847). Large-scale production by the Macintosh & Co. firm probably began in 1832, when Thomas Hancock joined the company. In 1843 Hancock patented the process for vulcanizing rubber (Hancock 1857; Levitt 1986), wherein natural rubber is heated with sulfur to cross-link the polymer chains. The step greatly improved the working properties of rubber, by making it more durable and less heat-sensitive (Mills and White 2003). These technological developments led to a thriving waterproof fabric industry in England during the 19th century, where natural rubber was used as the waterproofing elastomer (Levitt 1986). Skals and Shashoua’s survey of waterproof garments from the Danish Defense Museum, Copenhagen showed that this industry continued into the 20th century. In their study, they identified garments with natural rubber elastomers sandwiched between two fabric layers that date circa 1910, 1945, and 1952. They also observed fabrics waterproofed with bitumen, rubber, drying oil, polyvinyl butyral, and polyvinyl chloride (Skals and Shashoua 2006).

In the early 20th century, industrial demand for natural rubber outstripped supplies and dramatically increased prices. New substitutes for rubber were developed from synthetic polymers, including polyvinyl chloride (PVC) and a butadiene-styrene copolymer, which is often called styrene-butadiene rubber (SBR). The synthetic rubber industry grew substantially during WWII. These advances in polymer science laid the foundation for the modern plastics industry (Morris 1986), which continues to influence waterproofing layers in fabrics.

2.3 MODERN RUBBERIZED FLANNEL

As part of this research, customer support representatives were contacted from eight rubberized flannel suppliers in the United States to learn more about the history and availability of this fabric. The representatives could not report on company records, but most remembered the product being sold for at least 50 years. They also did not recall a quality change in the product over time. Most representatives were unfamiliar with the type of "rubber" in the fabric (Customer Support Representatives 2013; Kay 2013; Ruck 2013). A representative of the Passaic Rubber Company, a rubber manufacturing company, indicated that the term rubber can be used for a variety of elastomers including neoprene, fluoroelastomers, styrene butadiene, nitrile rubber, natural latex rubber, silicone rubber, Hypalon, polyurethane rubbers, and ethylene propylene diene monomer rubber (EPDM). He also stated that a number of these elastomers could potentially be sandwiched between flannel (Mathey 2013). One representative from James Thompson & Co confirmed that their rubberized flannel product is in fact made with a PVC elastomer (Customer Support Representative 2013). Based on this information and preliminary analysis of a rubberized flannel sample, plasticized PVC was identified as a likely candidate for the elastomer in the beading substrate in NMAI's powwow regalia. For this reason, this paper focuses on the history of PVC and its deterioration.

2.3.1 Polyvinyl Chloride

The PVC polymer was initially synthesized around 1832, but not commercially produced until much later. B.F. Goodrich developed a technique to plasticize PVC in 1926; Germany began commercial production of plasticized PVC in 1938 with the United States following soon after. In the 1940s PVC largely replaced natural rubber for several reasons: ease of production, non-flammability, reduced corrosivity and better resistance to oil, water, and acids. After World War II, excess PVC was used for many consumer products: electrical insulation, packaging, shoes, waterproof clothing, flooring, and wallpaper (Shashoua 2008). Today, PVC is one of the world's most important commodity plastics (ASM 2003), despite problems with long-term stability, as well as environmental and health concerns linked to PVC plasticizers (Shashoua 2008).

Unplasticized PVC is a rigid polymer with high tensile strength (ASM 2003), as observed in plumbing and irrigation pipes. Plasticizers often are added in 15-50% concentration by weight (Shashoua 2008) to modify the material properties of the plastic, particularly to lower the softening temperature and make flexible materials such as medical tubing and plastic sheets. Phthalate esters are the most widely used plasticizers because they are chemically compatible with PVC and relatively inexpensive. Of the phthalates used, di (2-ethylhexyl) phthalate (DEHP), an isomer of the broader group of dioctyl phthalates, has been very common. However, beginning in the 1980s public concerns emerged about the role of DEHP and other phthalates in a host of health problems including asthma, allergies, hormone regulation, and cancer (Environmental Protection Agency 2007; Shashoua 2008; Kambia 2011; National Toxicology Program 2011; Freinkel 2012). Potential risks have led to a decreased use of heavily plasticized PVC products intended for babies and young children, like rubberized flannel.

2.3.2 Stability and Preservation Concerns with Polyvinyl Chloride

Williams states that PVC is one of the two most unstable plastics in museum collections (2008). Dehydrochlorination of PVC results in the formation of corrosive hydrochloric acid, shrinkage, and increased unsaturation along the carbon backbone leading to a material that is discolored and more rigid (ASM 2003; Shashoua 2008). The likelihood and rate of these reactions is increased under moderate heat and light. A range of stabilizers typically are added during manufacture to slow decomposition, but degradation still is observed in museum collections over decadal time scales (Mills and White 1992; ASM 2003; Shashoua 2008). Plasticizer migration out of the plastic is a competing deterioration mechanism characterized by formation of sticky or oily surface films and softening of other vulnerable materials in contact or nearby (Young and Young 2001; Shashoua 2003; Shashoua 2008).

There is limited literature about the longevity of rubberized fabrics. In the 2006 survey of waterproof garments at the Danish Defense Museum, Copenhagen, two garments from the 1950s were identified that had phthalate-plasticized PVC rubberizing layers applied to one side of the fabric. These fabrics were in significantly better condition than fabrics waterproofed with other materials (Skals and Shashoua 2006). Shashoua's 2003 study showed that retention of di(2-ethyl hexyl) phthalate (DEHP) plasticizers helps prevent dehydrochlorination of plasticized PVC in indoor environments, thus prolonging the life of this material in museum collections. Deterioration was accelerated by storage conditions that facilitated loss of the DEHP plasticizer, either through evaporation in open storage conditions or by transfer to adjacent materials, such as low density polyethylene plastic wrappings. Deterioration was slowed in storage conditions where the rate of DEHP evaporation was suppressed, such as in a non-adsorbent glass enclosure with no internal air movement or low temperature storage (Shashoua 2003). One concern is that these storage recommendations for PVC may enhance deterioration of other types of materials that are sensitive to acids or plasticizers, or be otherwise inappropriate for non-PVC rubberized flannels.

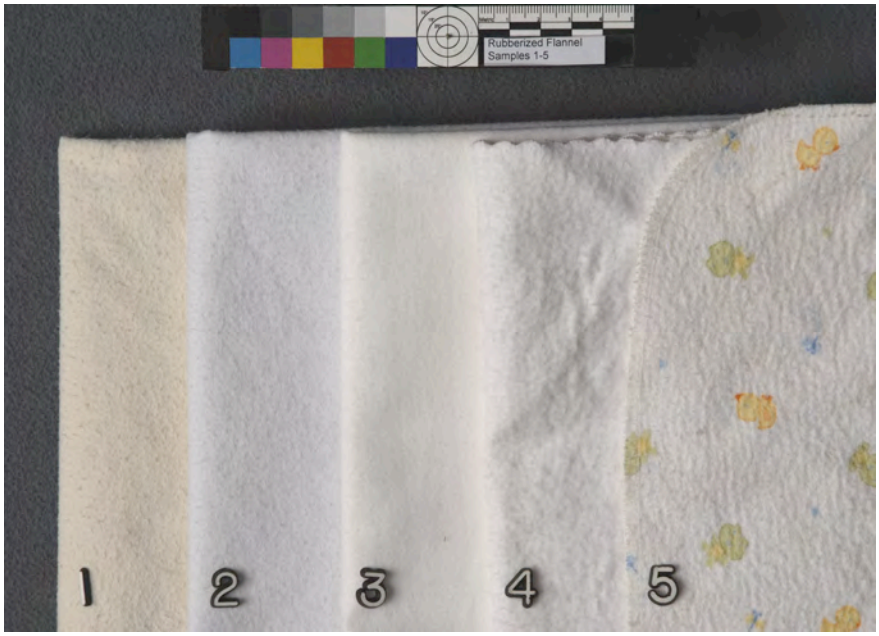

Fig. 5. Rubberized flannel reference samples 1-5. National Museum of the American Indian, Smithsonian Institution.

3. ANALYSIS OF RUBBERIZED FABRICS

NMAI maintains a strict destructive sampling policy, requiring approval by the Museum's board. Before requesting permission to test objects in the collection, the authors gathered samples of rubberized flannel from one distributor and the households of authors Heald and Giaccai. These samples range in age from new to approximately 50 years old (table 1, fig. 5). These dates are based on the years the fabrics were acquired, but not their dates of manufacture, which could be older.

Results at the time of submission can be seen in Table 1. The fibers were identified by polarized light microscopy (PLM). Attenuated total reflectance- Fourier transform infrared spectroscopy (ATR-FTIR), pyrolysis gas chromatography mass spectrometry (Py-GC-MS), and Raman spectroscopy are used for identification of the polymer, additives, and if applicable, fibers.

Table 1. Rubberized Flannel Reference Samples

Sample Number	Date of Acquisition	Description	Fiber	Polymer	Additives
1	~1963 (~50 years old)	yellowed, slightly stiff, brittle polymer	cotton	polystyrene butadiene copolymer	DEHP*, calcium carbonate, titanium dioxide
2	1999-2002 (11-14 years old)	white and flexible	cotton/ polyester blend	polyvinyl chloride	Mainly DEPH, at least 15 other phthalates also present
3**	2013 (>1 year old)	white, flexible, obtained from the Carnegie Textile Co.	cotton	polyurethane	1,2-cyclohexane dicarboxylic acid diisononyl ester (DINCH) and related compounds
4	2010 (3 years old)	white and flexible, but delaminating, purchased in a fabric store	cotton	methyl methacrylate & styrene polymers	kaolin
5	2010 (3 years old)	white with duck and frog print, flexible, Carter's brand	cotton/ polyester blend?	polyurethane	DINCH and related compounds

* DEHP could result from impurities absorbed during storage and aging.
** All samples except #3 have been naturally aged and periodically laundered.

Analysis of the five rubberized fabric samples in this study revealed a variety of waterproofing layers. Of the five samples, three and five are both polyurethane with identical additives. From this we can extrapolate that they are from the same manufacturer. The other three samples contain different elastomer layers: polystyrene butadiene, polyvinyl chloride (PVC), and methyl methacrylate and styrene polymers. Samples one and two both contain significant amounts of phthalate plasticizers. In the case of the PVC in sample two, DEHP was detected by Py-GC-MS

as the primary plasticizer in addition to at least 15 other phthalates. Further characterization of the polymers is underway.

4. DISCUSSION

The compositional variations noted in the analysis of the five rubberized fabric samples indicate an industrial production that is ever-changing as new materials are introduced and others are discontinued. The evolution of this fabric is reflected in the historical research and analytical results of this study. The elastomer in the oldest fabric in the sample set (sample 1) is styrene-butadiene, a synthetic rubber. Samples one and two are separated from each other by approximately thirty-five years. The analytical results suggest that within this time period the prevalence of certain elastomers, like PVC, may be consistent with changes in the plastics industry.

The distributors who were contacted in this study were unable to comment on manufacturing developments in rubberized flannel production, such as shifts in the use of synthetic rubber elastomers to PVC elastomers to non-PVC elastomers. Analyzing a broader range of samples, with fabrics from the 1970s, 1980s, and early 1990s could help reveal trends in the elastomer composition of rubberized flannel throughout this period, when many of NMAI's beaded regalia was created.

Deterioration observed such as embrittlement and cracking of the elastomer layer in the NMAI's powwow outfits is more obvious where the fabrics were in direct contact with the wearer's skin and/or perspiration. Exposure to oil, perspiration, and energetic physical wear during dancing may contribute chemically and/or physically to the fabric's deterioration. Regalia components that have not been in direct contact with skin or perspiration have fared much better. Amerman's pieces which have not been worn appear to be in excellent condition.

The early stages of plasticized PVC degradation, characterized by an oily surface film, may not be readily observable on rubberized flannel in powwow regalia. The elastomer layer is sandwiched between two fabric layers and obscured with dense beading on one side and often a lining or backing on the other (fig. 6). It is possible that these layers slow degradation by blocking light exposure and retarding the loss of plasticizer. Plasticizer could potentially migrate into and be absorbed by the adjacent flannel. It is unclear what impact migrating plasticizer could have on other components of the beaded design, such as plastic beads and trim.

5. CONCLUSION

The preliminary analytical results of these rubberized flannel samples suggest that the elastomeric layers in the NMAI's powwow regalia may be one of any number of polymers. It would be advantageous to analyze reference samples from the 1970s, 1980s, and early 1990s, as these would be contemporary with the rubberized flannel found in the NMAI's collection. Future work also will include an extended study of the elastomers in rubberized flannel, such as polystyrene butadiene copolymer, polyurethane-based elastomers, and methyl methacrylate and styrene polymers. Identifying the elastomeric composition in the NMAI's powwow regalia with a nondestructive analytical technique, such as Raman spectroscopy, is expected to help conservators to understand the observed deterioration and collections managers to develop a

storage plan for preserving the regalia. Portable spectrometers may facilitate direct analysis of artifacts in situ. Preservation of the beading substrate is important for preserving the design and artistry of the beadwork, which is often the reason why certain pieces of regalia are acquired by the museum.

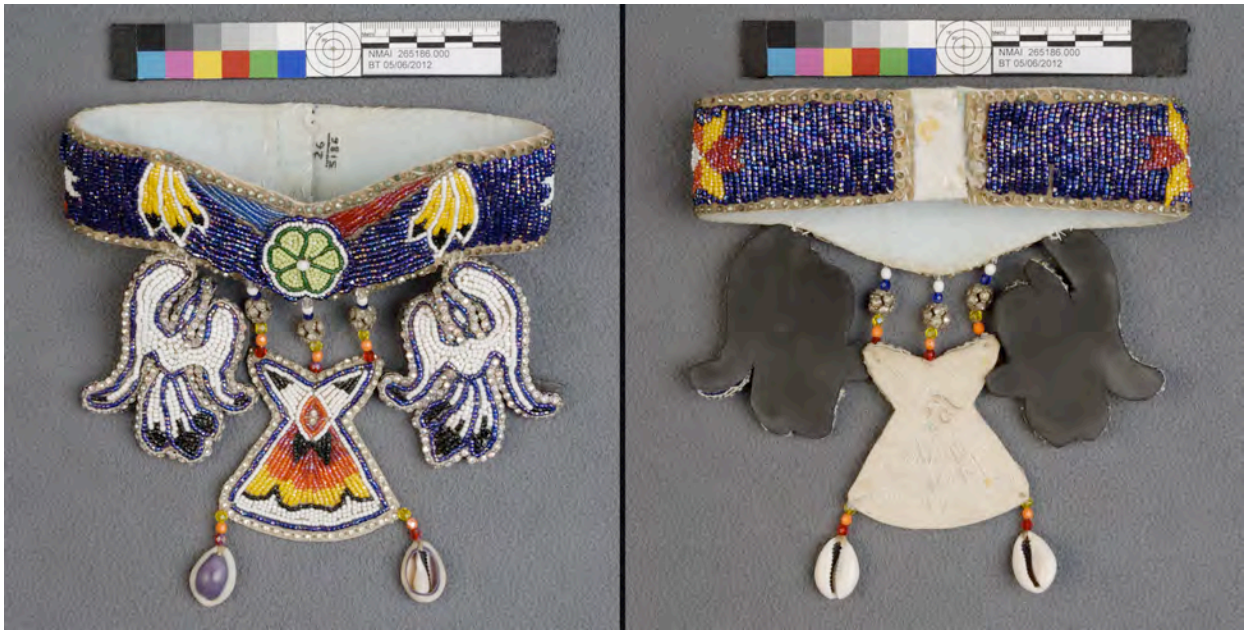

Fig. 6. Front and reverse of the choker illustrating various types of rubberized flannel on a single outfit component. National Museum of the American Indian, Smithsonian Institution (26/5186).

Based on interviews with eight Native American beadworkers, rubberized flannel has become a preferred beading substrate that is likely entering museum collections and being misidentified in contemporary Powwow regalia and beaded artwork. When these works are acquired by the museum, accurate identification of the materials used in the outfit's construction can be helpful for overall preservation. Likewise, it is important to be aware of current trends in powwow regalia construction and beadwork which are evolving art forms.

ACKNOWLEDGEMENTS

This research was made possible by the support of Andrew W. Mellon Foundation. The authors gratefully acknowledge Emil Her Many Horses (Oglala Lakota), Steve Tamayo (Sicangu Lakota), Jessa Rae Growing Thunder (Assiniboine/Sioux), Juanita Growing Thunder Fogarty (Assiniboine/Sioux), Joyce Growing Thunder (Assiniboine/Sioux), Rhonda Holy Bear (Cheyenne River Lakota), Marcus Amerman (Choctaw), and Tom Evans (Skidi Pawnee) for their comments on beadwork practice. In addition, we thank Carren Kay, Jayden Mathey, Cindy Ruck, and the other customer support representatives who provided information about rubberized fabrics, as well as Marian Kaminitz, Head of Conservation at NMAI, for her support in this research project.

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