Chapter 20
Examination of Paint Delamination in *C'est grace à nous* by Asger Jorn

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20.1 Delamination or Cleavage Linked to Soft Paint

Previous published research pointed out repeatedly that there are some conservation issues related particularly to paintings dated after second world war. Already in 1994 Moffatt and Miller describe lead soaps in connection to cracking soft paint [13]. In 2001, it was suggested that lead soaps in the ground might be a factor for cracks in paintings by Borduas [15]. The connection between soap formation and delaminations have since been described by several authors [9, 12, 14, 17].

One of the earliest of several published findings of high concentrations of fatty acids in soft paint is from 1993 [16]. Later research has shown that the increased levels of polar fatty acids are the cause of the softness, and are the main constituent of the drip material [2, 6].

C'est grace à nous by Asger Jorn (1957) shows delaminations visually linked to the upper, soft paint layer. The simple build-up consists of a white ground with a pastose, partly soft, black paint layer on top which in local areas exhibits a strong efflorescence. SEM-EDX shows that the white ground has a high concentration of zinc, indicating the use of zinc white. The black pigment of the surface paint is bone black.

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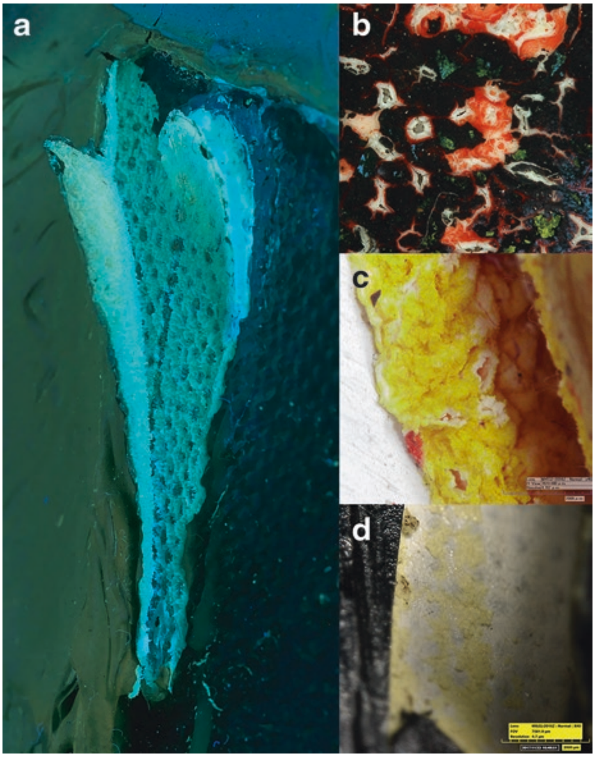

Fig. 20.1 (**a**) Delamination rupture in zinc containing ground under soft black paint in *C'est grace à nous* by Asger Jorn (1957) under UV light. (**b**) Delamination in an area of paint loss showing dome shaped deformations. *Composition* by Jean Paul Riopelle 1952. (**c**) Delamination in an area of soft yellow paint over a white paint layer. Libellules blesses by Karel Appel 1961. (**d**) Delamination in Pierre Soulages *Peinture* from 1954. (Photo **a**: The National Museum, Børre Høstland. Photos **b**–**d**: Jaap Boon)

The zinc white paint layer has split in two parts and is presently brittle and solid. The surfaces show a ductile looking split and break pattern that hints to a former mobility and fluidity inside the layer (Fig. 20.1a), although the white paint in the area was not soft or malleable when examined. Additionally, the peaks formed indicate that this change in condition must have happened over time as there are no clean breaks or ruptures visible in the SEM-BSE image in Fig. 20.2. Small, peak-like deformations of the ground layer exist in all the delaminating areas of the painting.

The research focusses on the differences in chemical composition between the ground still connected to the canvas (B), and the part of the ground connected to the soft black layer that curves away from the canvas (A) (Fig. 20.4). For sampling, an area that had not been treated with heat or solvents was chosen. Samples were analysed by SEM-EDX, ATR-FTIR and DTMS.

20.2 Results

After storage on a glass slide for several months, sample A, black paint without ground, showed some degree of phase separation of the black paint and a clear medium. DTMS analysis of the black paint sample after homogenization (Fig. 20.3a

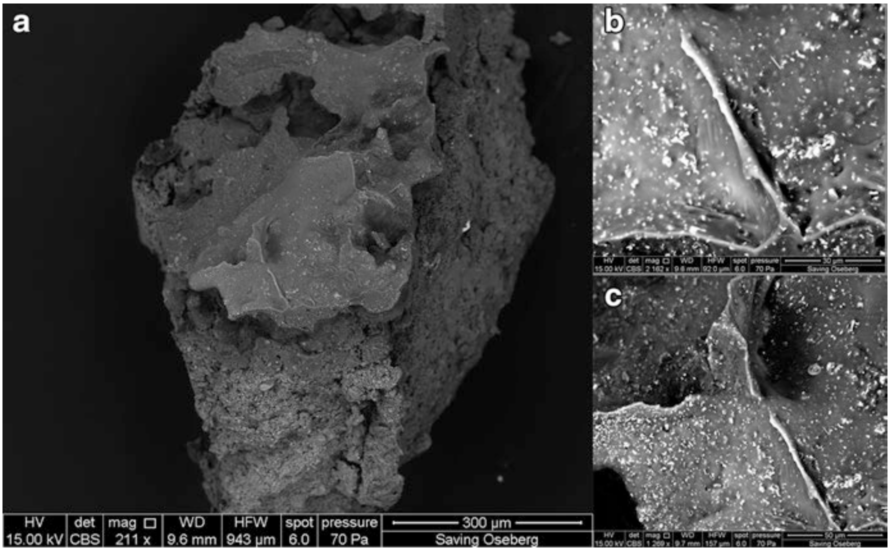

Fig. 20.2 (**a**) The sample upside down black down and white up. (**b**) The edge of the white layer. (**c**) Details of the sample in electron backscatter image from the point of delamination, showing formed ridges in the ground left on the underside of the black paint layer. (Photos: Calin Constantin Steindal)

and b) shows m/z of 62 indicative of phosphate (from the bone black), lead (m/z 207, 208, 209), zinc (m/z 66, 67, 68) at higher temperature. The spectra in the broad desorption profile of the total ion current profile, labelled X, are presented as a summed mass spectrum (Fig. 20.3b). Peaks indicative of fatty acids (palmitic (m/z 256) and stearic (m/z 284) acids), features indicative of azelaic acid (m/z 152) and various oxygenated (keto, hydroxyl and epoxy) stearic acids (m/z 155, 171, 280, 292) are observed. The intensity of features of azelaic acid and the oxygenated stearic acids are high relative to the features of palmitic and stearic fatty acid. The ratio of polar to apolar fatty paint constituents links to the degree of softening and the tendency to form exudates [6]. The desorption profile in DTMS points to a relatively large amount of fatty components. It can be expected that this excess of fatty acids does contribute to the cohesive failure of the paint layer structure.

The white ground was analyzed by SEM-EDX. The ground shows a high content of zinc relative to calcium, supporting that the paint is zinc white with some calcium carbonate filler. The black paint layer's main elemental peaks were phosphorous and calcium indicating the use of bone black pigment (unpublished results). When analyzing the delaminated part of the white ground adhering to the black paint layer, the main elements were zinc and calcium. The EDX identified L-line and both K-lines for zinc, and also K and L-lines for calcium. So, the results from the SEM-EDX strengthens the initial examination indicating that the delaminations occurs inside the white ground layer.

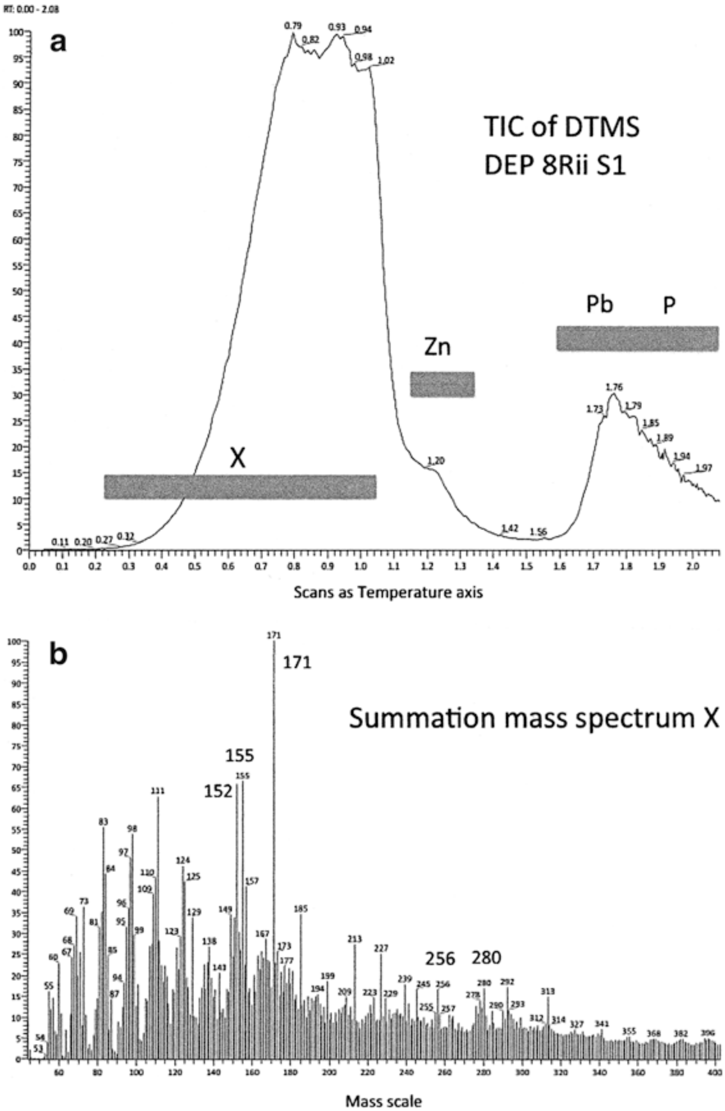

Fig. 20.3 DTMS data of soft black paint from *C'est grace à nous* by Asger Jorn (1957). (**a**) Total ion current profile. (**b**) Mass spectrum summed over band width X. Analysis: Jaap Boon and Karin Wyss SIK-ISEA, Zurich

The ATR-FTIR spectrum of the white ground attached to the black paint shows a strong, sharp band at 1528 cm^{-1}, with a shoulder at 1547 cm^{-1} and a weak band at 1592 cm^{-1}. The band positions are consistent with the presence of zinc fatty acid soaps (salts). Straight chain fatty acid soap shows a band near 1528 cm^{-1}, while diacids absorb near 1546 cm^{-1}. The band at 1590 cm^{-1} is exhibited by the more

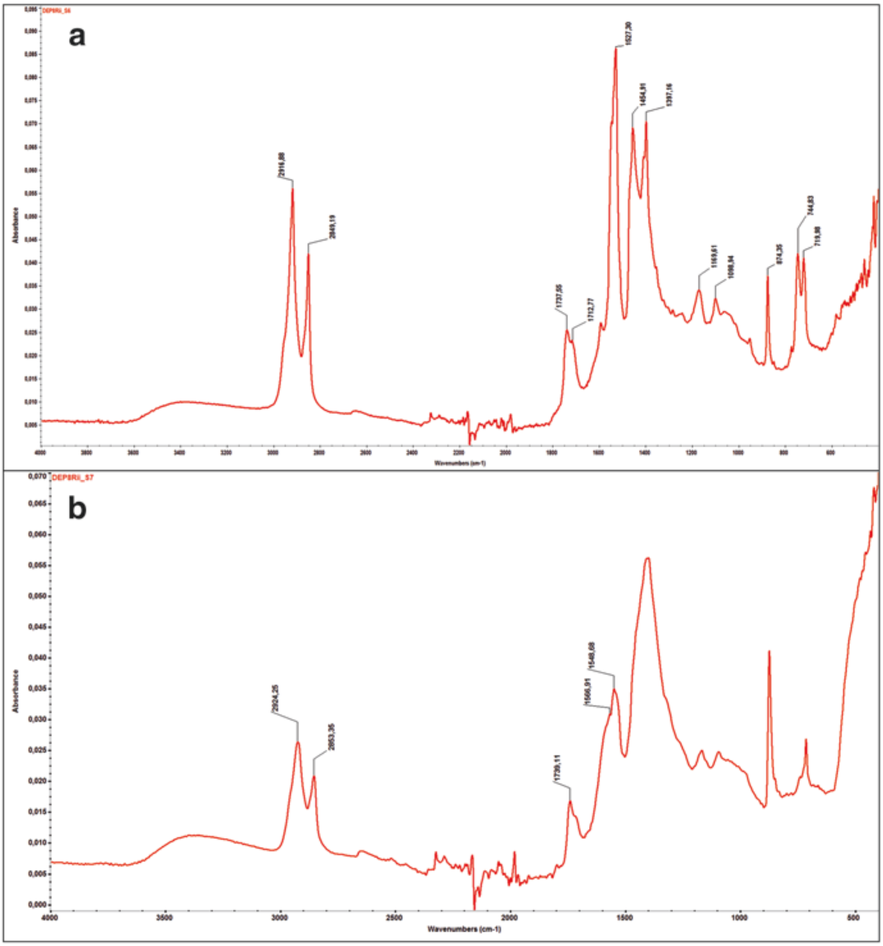

Fig. 20.4 (**a**) FTIR-ATR spectra from sample of white ground taken from the detached delaminated area of black paint. The peaks at 1527–1546 cm^{-1} indicate zinc fatty acid soaps. (**b**) FTIR-ATR spectra from sample of white ground still attached to the canvas. The peak profile at 1548–1590 cm^{-1} is indicative of the carboxylate absorption of zinc fatty acid soaps with a more amorphous structure. Spectra: Calin Constantin Steindal

complex zinc carboxylates observed in zinc white paint [10, 11, 14]. The spectrum also shows weak bands from ester and free fatty acid components at approximately 1730 and 1705 cm^{-1}.

The ATR-FTIR spectrum of the white layer still connected to the canvas Fig. 20.4b shows peaks at 873 and 713 cm^{-1} confirming the presence of calcium carbonate. The strong, broad band beginning at 500 cm^{-1} is consistent with zinc white vibrations. The bands of the zinc carboxylate region are shifted compared to those exhibited by the sample of white still attached to the black paint (Fig. 20.4a).

The spectrum shows a broad band between 1540 and 1590 cm^{-1}, suggesting more complex and amorphous zinc soap structures [8, 11].

The lower part of the ground exhibits a broad band belonging to zinc soaps, while near the interface the zinc soap bands are stronger and sharper. This suggests both a different structure of zinc soaps at the interface and an increased soap concentration. The fact that the zinc soaps at the interface are structurally different from those in the bulk of the ground indicates specific reactions in the contact zone. The additional zinc soaps in the delamination plane must have mechanically weakened the ground layer.

20.3 Discussion

The zinc soaps found in the white layer still connected to the black paint show that the interface between the soft layer and the ground is chemically active. It is inferred that, due to phase separation, the mobile components of the oil in the black paint not only move to the surface, but also diffuse into the underlying layers, thus reacting and creating a layer of zinc fatty acid soaps with problematic physical properties. It has been well documented that free carboxylic acid groups increase the reactivity for soap formation [1, 3, 14]. Zinc soaps have the tendency to increase in volume [14, 18]. High humidity promotes both soap formation and the increase in volume of the paint [14]. Zinc soaps are described as more mobile than lead soaps [18]. Mobile fractions in the structure most likely contribute to the formation of the peak-like ridges in the delaminated areas. Analysis of the spectra from the ground layer in contact with the bone black paint shows peaks from zinc carboxylates. The black paint in *C'est grace à nous* was found to have a high abundance of azelaic acid and oxygenated stearic acid moieties. This is consistent with previous studies of soft and dripping paints ([2], Unpublished, Bronken PhD thesis due 2021 [5]). The part of the zinc white ground layer attached to the delaminated black paint contains a high concentration of zinc fatty acid soaps. The combination of volume increase of zinc soaps with the malleable properties of the black paint is inferred to create delaminations.

Similar cases of interlayer cleavage between layers where one is zinc containing have been described in literature ([10, 12, 17] etc). Especially, the study presented in Maines et al. [12], where the description of cleavage in a Hans Hofmann painting bears a strong resemblance to this case study. The cadmium red paint in question was delaminating from areas in contact with zinc white. Moreover, GC-MS analysis of the red paint shows a distinct high peak for C9 diacid ([12], in Fig. 20.2 in this article) similar to the other case studies of soft paint. Hence, our interpretation is that the combination of zinc containing layers and their reaction with phase separating carboxylic acids from adjacent layers contribute to the severe delamination.

The presence of zinc soaps complicates any future treatments, but removal of the soap containing ridges in the areas of delamination seems not plausible for practical reasons (Fig. 20.1). If the painting material to be consolidated lacks stability, there will be extra demands for re-treatability.

20.4 Treatment, Tests and Choices

In the 1950s and 1960s, many of the artists used paint colours more directly, without extensive use of wet-in-wet, and often partly in thick layers. The structure is often found to be a mix of paint layers with varying physical properties: some solid and very stiff, others soft malleable and solvent/heat sensitive. This creates practical complications for consolidation of delaminations for paintings with soft and dripping paint.

Several of the paintings in the ongoing PhD project *Investigation of soft and dripping paint in selected paintings from 1946–1972* show delamination similar as the case study presented here and, in some cases, consolidation treatments were carried out (unpublished, Bronken PhD thesis due 2021 [5]). These treatments have given indications to issues of importance when choosing a treatment strategy for *C'est grace à nous* in the future. Considering the treatment reports from other institutions and through treatments of similar paintings, water soluble glues are so far showing to be ineffective [4]. An obstacle for consolidation is the heat and solvent sensitivity of the soft paint layers. Several earlier treatments have shown that Beva 371 works quite well when the area is easy to access with a brush. In practice, consolidants with low viscosity like Medium for consolidation help to ensure that the consolidating substance moves by capillary action as deep as possible into the delaminated area. Modifications of other consolidants may also achieve this. One drawback is that retreating consolidated areas often require solvents and heat. So no perfect treatment option seems to be apparent. Specific choices must be made for each individual case.

Heat will be needed for successful consolidation. In some treatments of other paintings, a hot air gun was used. Instead of a metal spatula, a malleable silicon tool was used for consolidation of the soft layers, minimizing the risk of flattening the structure when applying pressure in combination with heat.

Consolidation with a heat spatula on soft paint can be difficult as the surface is obstructed by the spatula and different paint layers, and different areas can have very different sensitivity to heat [7]. The silicon tool made it easy to work directly on the surface. Often consolidation treatments are done through a layer of melinex on top, but also this approach should be used with caution as it can stick to the surface and give gloss changes or surface deformations if left over time.

20.5 Conclusion

Analysis of an area of delamination from an Asger Jorn painting shows the result of reactivity of zinc ground, and the availability of fatty carboxylic acids in the superimposed black paint layer. Soft paints often have a high level of mobile free fatty acids, and can form fatty acid soaps with available metal ions. So, it is important to analyse the entire paint build-up as layers will chemically interact. The physical properties of zinc soaps could predict that future delaminations would be impossible to avoid. When planning to consolidate soft paint layers where soaps are present or suspected, conservators should inform the owners that the need for re-treatment of the paintings is probable. Furthermore, caution should be taken in transportation and during storage.

The possibility of removing original material is controversial and something conservators are trained to avoid. Removing the excess fatty acids when forming a pools or drips would be more advantageous for long-term preservation as the diacids and diacyl-glycerides have the potential to react with metal ions from surrounding paint layers. Many damages in paintings are related to soap formation, but this study supports the idea that mobile fatty acids are also a potential reason for future damages.

20.6 Analytical Techniques

20.6.1 Scanning Electron Microscopy Energy Dispersive X-Ray Spectroscopy (SEM-EDX)

A FEI Quanta 450 scanning microscope coupled to an X-Max^N Oxford analyser 50 mm^2 was used for SEM–EDX. Paint samples were placed directly on carbon tape.

20.6.2 Fourier-Transform Infrared Spectroscopy (FTIR)

FTIR spectroscopy measurements at the University of Oslo facilities were carried out in attenuated total reflectance (ATR) with an IS50 Thermo scientific Nicolet continuum FTIR microscope with a resolution of 4 cm^{-1}.

20.6.3 Direct Temperature Resolved Mass Spectrometry (DTMS)

DTMS was performed in a DSQ-II Thermo Quadrupole MS-instrument (EI-mode, 16EV, source T 250 °C, m/z 42-1050). The sample was homogenized and applied as methanol droplet on Rhenium filament (ramp 5 mA/s to 1000 mA). X-calibur software was used for data analysis.

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