Abstract of the Craquelure project

Looking at paintings, we admire colours, shapes formed, the brushwork … but we see also crack patterns – the craquelures which give historical "patina" to painted surfaces and enrich viewer's aesthetical perception. Variations in the craquelure pattern geometry have been recognized – distances between cracks, shapes and sizes of "islands" created by cracks, or crack orientation in relation to wooden or canvas substrates. Since these geometries depend on the substrate of the pictorial layer, ground layer thickness and the binder used in its manufacturing, or pigment/filler grain size in the layers, the crack typologies may be correlated with different – geographically and chronologically - artistic traditions. However, the mechanisms along which the stress fields in paintings are generated and dissipated in the crack development are understood in the heritage science only in very general terms. More importantly, there is no quantitative understanding of the ways in which craquelures influence vulnerability of paintings to further damage induced by changes in temperature and relative humidity (RH) in their environments. Therefore, the strategic aim of the project is to develop a global three-dimensional physical model of original cracked pictorial layers and through this decisively contribute to the development of evidence-based environmental specifications in museums. The implementation of this cross-sectoral project blending problems of humanities with methods and instruments used by natural and engineering sciences is possible owing to collaborative effort of partners from Poland and Norway, supported by research groups or museums from France, UK and USA to advance knowledge in the area at the interface between natural sciences, history of art and conservation.

In the first phase of the project, a database of properties for historical artistic materials applied in paintings and for modern materials used to consolidate the pictorial layers will be developed. Determining fracture toughness and energy release rate during fracturing of materials, key parameters for the analysis of crack formation, will be a particularly innovative aspect. In the next stage of the project, a global 3D model of pictorial layer with craquelure patterns will be developed for paintings on wood and canvas using finite element analysis. The model will cover representative crack patterns and will consider the effects of crack periodicity, crack thickness and material properties of historical materials and consolidants. The developed model will be integrated with a hygrothermal model of wooden substrates as well as glue-sized canvases on stretchers. In this way, Representative Virtual Objects (RVOs) will be created, allowing their 'real-time' moisture dimensional change and the resulting dynamic strain and stress fields in response to RH variations in the environment to be quantitatively analysed. In the next phase of the project, Real Representative Objects (RROs) will be selected from the database of more than 1000 paintings with diverse craquelure patterns developed by the Hamilton Kerr Institute's, Cambridge University as well as from the database of X-ray radiograms and macro-photographs of British canvas paintings made available by the Center of British Art, Yale University. Real craquelure patterns documented for each ROR will be embedded into the model of paintings elaborated earlier. To validate and optimize the models developed, specimens mimicking the selected RROs will be produced. They will be subjected to controlled RH variations in an environmental chamber while damage formation and development will be traced using Digital Speckle Pattern Interferometry (pictorial layer delamination) and Acoustic Emission monitoring (fracturing). Finally, safe ranges of RH changes for paintings with craquelures will be determined by modelling the response of RVOs and RROs to virtual RH variations of systematically changed amplitude and duration, by comparing the energy release rate calculated in the model with fracture toughness determined experimentally.

The proposed project, innovative on the global scale, is of great importance to the society, and its ambition is to significantly support the sustainable care and conservation practice for paintings. Therefore, the dissemination of project's outcome and reaching users and stakeholders in the conservation and museum sector globally are important additional tasks. Especially, two approaches are envisaged to ensure effective acceptance of the proposed solutions by the museum and conservation community: support to the development of standards and guidelines in protection of cultural heritage, and development of HERIe, a web-based tool for assessing risk of physical damage to heritage objects vulnerable to changes in the environmental parameters. It is a unique tool of that kind globally, continually refined by the Applicant, freely available to anybody engaged in the protection of cultural heritage, and requiring no specialized background in natural sciences (herie.mnk.pl).