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Editorial

There are many different ways to approach and study rock art both in the field and in the lab (Bednarik, 2007; McDonald and Veth, 2012). for example, decorated sites can be mapped and analysed spatially using Geographic information Systems (GIS); the manufacture of rock paintings can be studied through chemical analyses using portable spectrometry (*e.g.* pXRF) or sampled for AMS radiocarbon dating. but the most frequent and fundamental task for rock art fieldworker consists of producing pictures such as photographs or drawings in order to visually document and analyse the art and its context.

Recording rock art is a complex process that does not simply aim at reproducing what is visible on the field. Recording is an operation that involves selecting and extracting the information considered as important from a rock face in order to transfer this information to both specialists and general public (Aujoulat, 1993; Domingo Sanz, 2014). Recording rock art, just as recording an excavated structure or a stratigraphy, is not reproducing the visible reality: it is interpreting the reality in order to make it more understandable archaeologically.

For a long time, the traditional way to record rock art was to use tracing on paper or plastic sheet directly applied to the rock surface (GRAPP, 1993). But from the 1990s, the emergence and development of computer imaging techniques have initiated a 'digital revolution' in rock art studies as in many other fields of the humanities. To sum up this very briefly, in 30 years we have gone from flat, two dimensional black and white drawings of rock motifs to interactive 3D models rendering both the contextual setting and the complex content of the art. How has this digital transition impacted our methods as well as our general approach and understanding of rock art?

This special issue of *Digital Applications in Archaeology and Cultural Heritage* is dedicated to digital imaging techniques for the study of rock art and results from a two-day workshop held in May 2014 at the McDonald Institute for Archaeological Research, University of Cambridge, UK. The aim of the workshop was to bring together international specialists working on different rock art contexts from different periods and areas (from Palaeolithic caves to Neolithic chambered tombs in Europe and to more recent rock art traditions in the USA and Africa) in order to share the recent technical developments in their own field and to discuss their advantages and limitations, as well as the future challenges for rock art digital techniques.

The 15 articles of the present issue reflect this geographical and chronological diversity and provide an overview of the different techniques currently used across regions and chronological contexts. Photo-processing techniques, frequently used to detect and record faint paint on rock surfaces, are presented by Miguel Angel Rogerio-Candelera, by Natalia Cortón Noya, Ángela López García and Fernando Carrera Ramírez, and by David Robinson and colleagues, while Jean-Loïc Le Quellec, Claudia Defrasne and Frédérique Duquesnoy give a critical assessment of the widely used DStretch photograph enhancement programme. Reflectance Transformation Imaging (RTI) and its application to prehistoric rock carving are the focus of the article by Marta Diaz-Guardamino, Leonardo García Sanjuán, David Wheatley and Víctor Rodríguez Zamora. Photogrammetry, which allows to build 3D models from photographs with an increasingly high resolution, is more and more used in the field of rock art studies. Many articles in this issue describe how they can serve various purposes (see Plisson and Zotkina, 2015; Dessi et al., 2015; Alexander et al., 2015; Cassen et al., 2015; Cortón Noya et al., 2015; Williams and Shee Twohig, 2015). Finally, 3D laser scanners have long been used to record rock art contexts such as caves or chambered tombs. Recent developments and original applications are described by Camille Bourdier and Oscar Fuentes, and by Kenneth Lymer. All these techniques and technologies have evolved quite rapidly in the past few years. The present special issue is aimed at giving an overview of state-of-the art developments through a collection of very recent, and often still on-going, research projects.

1. Experimenting with digital imaging techniques for the study of rock art (1980–2015): a brief historiographic overview

Digital techniques have been used in archaeology for many years and this special issue gives the occasion to look backwards and get an overview of this phase of technical transition from direct tracing to computer methods in rock art studies (see also Loendorf, 2001; Bednarik, 2007, chp. 5; Brady and Gunn, 2012; Mudge et al., 2012; Domingo Sanz, 2014). A rapid bibliographical research from my computer and various libraries has resulted in over 90 references (mostly journal articles and book chapters) published between the early 1980s and today and whose title deals specifically with the topic of computer methods applied to the recording of various rock art contexts from around the globe. This bibliography is certainly not exhaustive, I probably missed many articles from regionally-focused journals or volumes across the world, but it gives us an acceptable basis of information to look at historical trends in the experimental development of digital applications to rock art.

The table (Fig. 1) below presents the references in a chronological order and classified into three categories. The first column is for publications presenting advances in digital tracing and photographic enhancement techniques; the second table shows works dealing with 2.5D and 3D photographic techniques, such as

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Years	2D Photographic techniques Enhancement techniques CAD tracing	2.5D and 3D Photographic techniques PTM/RTI, photogrammetry, etc.	3D scanning Laser and light scanning
1980-1990	• Rip 1983; 1989 • Dickman 1984 • Aujoulat 1987	• Ogleby and Rivett 1985 • Aujoulat 1987	
1990-1994	• Swartz 1991 • Airvaux et al. 1992 • Mark & Newmann 1993		
1995-1999	• Henderson 1995 • García et al. 1996 • Montero et al. 1998 • Cacho & Galvez 1999	• Ogleby 1996 • Kirsch 1997 • Bertani et al. 1997	
2000-2004	• Cassen 2000 • McNiven et al. 2000 • David et al. 2001 • Mark and Billo 2002 • Cassen & Vaquero 2003 • Brady et al. 2004 • Clogg et al. 2000 • Read & Chippindale 2000 • Domingo & Lopez 2002	• Cooper 2000 • Simpson et al. 2004 • El-Hakim et al. 2004	• Kitzler 2000 • Robson Brown et al. 2001 • Ecklund & Fowles 2003 • Wasklewicz et al. 2004 • El-Hakim et al. 2004
2005-2010	• Brady 2006 • Brady 2007 • Fritz & Tosello 2007 • Maestrucci & Gianelli 2008 • Cassen & Robin 2010 • Gunn & al. 2010 • Mark & Billo 2006 • Fredlund & Sundstrom 2007	• Chandler et al. 2005 • Cassen et al. 2006 • Mudge et al. 2006 • Chandler et al. 2007 • Earl & al. 2010 • Ortiz Sanz et al. 2010 • Lerma et al. 2010	• Barnett et al. 2005 • Trinks et al. 2005 • Cassen et al. 2006 • Diaz-Andreu et al. 2006 • Barnett & al. 2007 • Angas & Serreta 2010 • Pinçon & Geneste 2010 • Lerma et al. 2010
2011-2014	• Hollman & Crause 2011 • Acevedo & Franco 2012 • Cerillo-Cuenca et al. 2013 • Martínez & al. 2013 • Caldwell & Botzojorns 2014 • Defrasne 2014 • Moya & al 2014 • Bea 2012 • Brady & Gunn 2012 • Förster 2013 • Le Quellec et al 2013 • Gunn et al. 2014	• Curci & Urcia 2011; 2012 • Gonzalez-Aguilera et al. 2011a • Plets et al. 2012 • Mudge et al. 2012 • Cerillo-Cuenca et al. 2013 • Duffy 2013 • Lopez-Romero 2014	• Gonzalez-Aguilera et al. 2011a & b
	• Domingo et al. 2013 • Lerma & Muir 2014 • Lerma et al. 2014 • Diaz-Guardamino & Wheatley 2013 • Cassen & al. 2014 • Miles et al. 2014		

Fig. 1. List of publications focussing on digital imaging techniques for the recording and analysis of rock art, presented in chronological order (1983–2014) and with reference to the main technique(s) they discuss. The list is not exhaustive and is just aimed at showing general trends in the use of digital techniques between the 1980s and today (Acevedo and Franco, 2012; Airvaux et al., 1992; Angás Pajas and Serreta, 2010; Barnett et al., 2007; Bea, 2012; Bertani et al., 1997; Brady, 2006, 2007; Brady et al., 2004; Cacho Toca and Gálvez Lavín, 1999; Caldwell and Botzojorns, 2014; Cassen, 2000; Cassen and Robin, 2010; Cassen and Vaquero Lastres, 2003; Cassen et al., 2006; Cerillo-Cuenca et al., 2013; Chandler et al., 2005, 2007; Clogg et al., 2000; Cooper, 2000; Curci and Urcia, 2011, 2012; David et al., 2001; Díaz-Guardamino and Wheatley, 2013; Dickman, 1984; Domingo Sanz and López, 2002; Duffy, 2013; Earl et al., 2010; Ecklund and Fowles, 2003; El-Hakim et al., 2004; Förster, 2013; Fredlund and Sundstrom, 2007; Fritz and Tosello, 2007; García et al., 1996; Gonzalez-Aguilera et al., 2011a, 2011b; Gunn et al., 2014; Henderson, 1995; Kirsch, 1997; Kitzler, 2000; Lerma and Muir, 2014; Lerma et al., 2010, 2014; Maestrucci and Giannelli, 2008; Mark and Billo, 2002, 2006; Mark and Newmann, 1993; Martínez Collado et al., 2013; McNiven et al., 2000; Miles et al., 2014; Montero Ruiz et al., 1998; Moya et al., 2014; Mudge et al., 2006; Ogleby and Rivett, 1985; Ortiz Sanz et al., 2010; Pinçon and Geneste, 2010; Rip, 1989; Robson Brown et al., 2001; Simpson et al., 2004; Swartz, 1991; Trinks et al., 2005; Wasklewicz et al., 2004).

Polynomial Texture Mapping (PTM) and Structure From Motion (SfM or photogrammetry), and a third column presents articles discussing applications of 3D scanning to rock art sites.

This rudimentary bibliographical overview gives us three main information. The first one is that digital applications to rock art were first experimented in the early 1980s, which is much earlier than I expected. For example, Rip (1983) in South Africa and Aujoulat (1987) in France were probably the first archaeologists to use a computer for the colour enhancement of photographs of rock paintings (see also Brady and Gunn, 2012). These experimentations gave good results although the processes themselves were fairly limited technically: computers were off course not as powerful as today then; moreover the photographs themselves were analogue images (not digital ones) that had to be scanned before being processed, which influenced both the operating time and results quality of the technique. Similarly, in the 1990s, first attempts by Ogleby (1996) and Russell Kirsh (1997) to build digital 3D photogrammetric models of rock paintings and petroglyphs on a computer were limited because based on analogue photographs and low-powered computers (see also early, computer-free, photogrammetric recording of rock art panels: Clouten, 1974; Rivett, 1977, 1978, 1980, 1983; Turpin et al., 1979). However, it is interesting to note that various techniques we are routinely using today, such as colorimetric enhancement of photographs or 3D photogrammetry, were already experimented before digital photography was in use and with relatively limited computer power. In other words, the idea of the application was there before the techniques became really available.

The second information that we learn from this global bibliographical overview is that the year 2000 marks a major turning point in the methods used to record rock art. The year 2000 is the real starting date of digital applications in rock art studies and this is reflected by a 'boom' in the number of publications addressing that specific topic. The sudden expansion of digital techniques and their wide use and application in the field of rock art studies from that particular moment is due to the simultaneous availability of three important technologies: digital cameras, which were created and commercialised before the 2000s but began to be really efficient and affordable at the end of the 1990s; powerful computers, which then became able to run sophisticated image processing software such as Adobe Photoshop; and 3D laser scanners, which also became more technically and financially available to the archaeology and heritage sectors at the very end of the 1990s.

Finally, the third information highlighted in table is that most recent works do not use one single technique but a combination of several 2D and 3D techniques to study rock art sites. I will further discuss this particular trend below.