会议论文摘要

Abstracts

成像科学在考古和文物保护中的应用

Imaging Science for Archaeology and Art Conservation

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摘要：自从保护科学诞生以来，成像科学已经成为文物检测的重要组成部分。由于在天文学、遥感和医药中的需求，近 30 年来快速发展的成像科学已经成为一门崭新的学科，如生物医学成像学。在过去 30 年来，快速发展的成像科学已经成为一个新学科，如物医学成像。在近 15 年来，成像科学应用于保护和考古等方面的研究在非介入成像领域已经取得很大的进展。本文将介绍英国诺丁汉特伦特大学近年来将成像科学应用于考古和文物保护的成就。重点介绍非介入成像技术在壁画研究中的应用。将专门论述为高分辨率远距离检测壁画（不需要脚手架）而设计的多/高光谱成像系统 PRISMS。该仪器可以做准确的光谱分析、颜色成像、近红外和荧光成像。另外一个研究领域就是光学相干段层扫描技术(OCT)在考古和文物保护中的应用，该技术可以非介入和非接触对文物内部微结构成像。最后简单介绍非介入成像技术在其他方面应用前景和局限。

Abstract: Scientific imaging has been an integral part of ‘technical examination’ ever since the beginning of conservation science. Owing to the demands in astronomy, remote sensing and medicine, the rapid developments in imaging science in the last 30 years have firmly established new disciplines such as biomedical imaging. In the last 15 years, research in the application of imaging science to art conservation and archaeology has also flourished as a result of the achievements in other fields where non-invasive imaging is in high demand. An overview of current and recent projects conducted by the Imaging Science for Archaeology

and Art Conservation Group of Nottingham Trent University will be presented. Emphasis will be given to non-invasive imaging techniques applicable to the study of wall paintings. In particular, a multispectral/hyperspectral imaging device PRISMS (Portable Remote Imaging System for Multispectral Scanning) recently designed specifically for the high resolution recording and examination of wall paintings remotely from the ground level (without the need for scaffolding) will be discussed. Multispectral/hyperspectral imaging is flexible and can be used for accurate spectral reflectance measurements, colour, infrared and fluorescence imaging. Another area of active research in the group involved the development and application of Optical coherence tomography (OCT) to archaeology and heritage science which allows the non-invasive and non-contact imaging of subsurface microstructure of objects. Developments and limitations in other areas of non-invasive imaging will also be briefly discussed.

龟兹石窟研究中存在的问题

Questions in the Research of Kizil Mural Paingings

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摘要：以往对龟兹石窟的研究，多在佛教艺术层面上，在壁画题材、艺术风格、绘画技法、文化交流以及年代划分等方面，取得重要成果。但是，目前在龟兹石窟研究领域面临如下问题亟待解决：

一、对流失海外龟兹石窟壁画等文物资料的收集整理与复位。

对龟兹石窟的考察始于 19 世纪末、20 世纪初西方掀起的西域探险热潮，先后有俄国、日本、德国、英国和法国等探险队来龟兹石窟考察探险。伴随考察与探险，这些探险队或多或少地都从龟兹石窟劫掠过壁画等珍贵文物，其中德国探险队在龟兹石窟剥取的壁画最多，据初步统计，揭取壁画面积达 600 多平方米。

考察队运到德国的新疆文物总称为新疆藏品，由柏林民俗博物馆印度部保管。20 世纪 20 年代中期，博物馆为出版壁画图录，曾将少量壁画与塑像进行义卖，以募资金。第二次世界大战期间，柏林遭到盟军的轰炸，在匡尼类特街民俗博物馆保存的壁画损失

最多，约占 40%。被毁的都是展出的精品，其中有不少是龟兹石窟的壁画。1945 年，当苏联红军占领柏林时，拿走了部分沿丝绸之路收集的文物，这些文物现收藏在俄罗斯爱尔米塔什博物馆，一直没有向外公布。近年来，在展览中这批文物陆续公诸于众，但至今尚未完全公布。

流失海外的龟兹石窟壁画的大宗仍藏在德国，还有一部分散见于东京、汉城、圣彼得堡、伦敦、牛津、巴黎、纽约、波士顿、华盛顿、旧金山等地。

石窟是佛教艺术的综合体，洞窟建筑、壁画和塑像结合而成石窟艺术，它们中的任何部分都不是单体的艺术作品。每个洞窟中的一尊尊塑像、一幅幅壁画，将其精心组合布局，都有其特殊的宗教涵义和功能。不同派属、不同时代的石窟壁画有着不同的题材内容和组合。由于龟兹石窟壁画被外国探险队肆意切割与肢解，使它们脱离了母体——石窟，给整体研究工作造成了巨大困难。当年德国探险队在考察过程欠缺严格的考古记录，再加上不科学的命名，造成了壁画出处混乱，错记、漏记及重复命名洞窟的现象严重，甚至有一部分壁画所出洞窟长期不知所属。因此，收集、整理、核对并落实流失国外的龟兹石窟壁画等文物的出处与原位考证问题至关重要。

二、对龟兹石窟的思想基础、佛教派属和佛教历史问题的澄清

石窟建筑、雕塑、壁画的主要功能在于它是佛教思想的形象诠释，是佛教“表法”的手段。长期以来，对龟兹石窟与佛教历史、佛教义理关系等更重要方面的研究比较薄弱。龟兹石窟的佛教思想基础、佛教派属和佛教历史诸问题不解决，龟兹石窟的真谛和价值就难以解释清楚。

在以往国内外研究成果的基础上，以佛教理念和历史发展为立足点，用佛学的视角和观点，运用丰富的佛教文献资料，将龟兹石窟艺术形态放在佛教历史发展的框架内考察分析，从而对龟兹石窟的真实而深刻的内涵和历史地位、价值等问题，作多方面、多层次研究。

三、年代分期问题研究

年代分期问题是石窟研究的基础课题。如若缺乏客观准确的断代，则石窟其它方面的研究及洞窟材料的运用，势必受到较多限制，很难在广度和深度上有所拓展。目前，在龟兹石窟的研究中，年代学已经成为一个“瓶颈”问题。由于各石窟群中均未发现与洞窟开凿有直接关系的文字纪年材料，因此，对于龟兹各石窟群的年代问题，研究者主

要多从美术史角度出发，对整体石窟仅能划分出一个粗略的分期，而且，由于见仁见智，莫衷一是，目前尚未有一种分期理论被广泛地接受。这导致的直接后果是，石窟中的各种材料被学者们引用时，常常令使用者无所适从，只能各取所需。因此，龟兹石窟年代分期问题亟待解决。

四、洞窟题记的释读研究

龟兹石窟作为新疆最大的石窟群，不仅以其绚丽多彩的"龟兹风"和"汉风"壁画著称于世，而且还因有不少包涵重要历史信息的榜题、题记和题刻而引人瞩目。由于榜题、题记和题刻这类文字材料具有直观性，因此在我们研究石窟的过程中具有不可替代的重要作用。

龟兹石窟内榜题、题记和题刻有：龟兹文、回鹘文、汉文、梵文、突厥文、藏文和察合台文等，在这些文字资料中，龟兹文占得比例最大。

由于自然和人为因素，龟兹石窟遭到了严重的破坏。窟内的一些重要遗存，包括部分榜题、题记和题刻等资料连同壁画一起被外国探险队掠至国外，现在残存石窟内的这类材料，因年代久远，已逐渐漫患不清，甚至有一些已经彻底消失了。

龟兹石窟内保存的龟兹文榜题、题记和题刻尽管数量可观，但对其研究却远远滞后于对汉文的研究。造成这种局面有两方面的原因：一是由于解读难度较大，在世界范围内从事这方面研究的学者非常有限；二是由于有限的几位研究者没有获得足够的原始材料。

对于龟兹石窟的榜题、题记和题刻的整理和研究工作才刚刚起步，任重而道远。在此，我们热诚欢迎海内外有识之士能够积极参与到此项研究工作中来。

Abstract: This paper discusses the outstanding problems in the research of Kucha caves paintings. The main research questions are: 1) the archiving and collecting of information related to mural fragments in overseas collections; 2) the study of Buddhist history, philosophy and sects represented in the murals; 3) the dating of the caves; 4) the study of the inscriptions in various languages including Tocharian, Chinese, Uighur, Tibetan etc.

Scientific Analysis of Kizil Paintings in the Berlin Collection

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摘要：来自克孜尔石窟的佛教壁画（断代为 5 世纪或 6 世纪）如今以残片形式保存在柏林的亚洲艺术博物馆。这些残片中的一部分来自于克孜尔石窟 16 窟，总面积 35 平方米，在 60 年代用聚合物粘结修复，所用的聚合物是 Calaton 胶（可溶尼龙）或者 Caparol 胶（聚醋酸乙烯酯）。这些措施及其副作用导致了壁画表面的灰化，并因此在近期引起了一个相关的研究计划。这个计划从 2009 年起由亚洲艺术博物馆和 Rathgen 研究实验室联合开展实施。

所应用的多光谱成像法由意大利佛罗伦萨的 Opificio delle Pietre Dure 所发展起来的，是一种便携式，无损的成像技术。可利用紫外光，可见光及及红外光进行操作，适用于颜料鉴定。

对壁画残片和标准样品进行多光谱成像分析，并结合 X 荧光光谱仪、扫描电镜能谱仪和傅里叶红外光谱就可以判定原始材料（例如青金石，赭石），并可以局部恢复以前使用过的材料。

Abstract: Buddhist mural paintings from Kizil (China) and dated from the 5th/6th century AD, are today stored in fragments at the Museum of Asian Art in Berlin. Part of these fragments, from cave 16 in Kizil, China, covering an extension of 35 m2, were consolidated with polymers in the 60s, either Calaton (soluble nylon) or Caparol-Binder (polyvinyl acetate). The greying of the surface of the painting, attributed to these treatments and their secondary effects, triggered a research project currently being implemented in collaboration of the Museum of Asian Art and the Rathgen Research Laboratory since 2009.

The multispectral imaging method applied was developed by the Opificio delle Pietre Dure in Florence, Italy. It is a portable, non-invasive imaging technique, operating from the UV/Visible to the near IR, suitable for pigment identification.

Multispectral imaging analysis from fragments of the painting and reference standards, in combination with XRF, ESEM/EDX and FT-IR allowed to characterize original materials (e.g.

lapis lazuli, red ochre) and to localize restoration materials which have been applied in the past.

成像科学与唐墓壁画保护研究

Imaging Science and the Conservation of Tang Tomb Paintings

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摘要：古代壁画是人类重要的文化遗产，西安是古代中国鼎盛时期——汉唐时期的国都，留有大量的壁画遗存。这些壁画是当时绘画艺术的最高表现形式，反映了当时社会生活、物质文化、艺术追求、科学技术等方方面面，具有极高的价值，弥足珍贵。

古代壁画保护研究，主要是对壁画本体的干预以及开展相关的科学分析，调查壁画的绘制工艺及材料，同时分析产生的各种病害。以往所要开展的分析研究，其主要手段包括的湿法化学分析、 仪器分析（XRF、XRD、SEM/EDX、RAMAN 光谱）等，这些手段大多数都要从文物上取样，并且测试分析只是局部、点上的结果，并不能给出全面的信息。而成像技术具有全面的遥感的作用，是一种非介入式、非接触性、非破坏性的可以实现原位实时分析和诊断，并且可以通过高清晰数字化获取，实现对文物从物理空间向数据空间的转换。光学成像技术包括了从紫外、可见到红外等多/高光谱成像技术，即获得壁画的空间数据，又可以获取光谱信息。

其他的成像技术还有 OCT 成像可以给出壁画的三维层位信息，激光全息摄影成像可以诊断壁画表面病害特征。

高清数字化扫描技术是不仅可以获得高解像度的数字图像，而且可以实现多种光源类型的多光谱成像，并可以实现对壁画表面起伏等三维信息的获取。可以实现对壁画绘制工艺，材料推定，病害诊断，以往修复干预的诊断，数字化研究与展示等。是一种最具潜力的文化遗产研究的新技术。

本文介绍了各种光学成像技术在古代壁画保护研究中的作用，同时重点说明高清数字化扫描技术的应用潜力。

关键词：光学成像，高清晰数字化扫描，古代壁画

Abstract: Ancient mural paintings form an important part of cultural heritage. Xian, the capital of the golden age of Chinese civilization - the Han and Tang period, has a large number of mural remains. Mural painting was one of the highest forms of art of the time, reflecting the material culture, artistic pursuits, science and technology and other aspects of the society.

Conservation research of historical wall paintings is mainly focused on the scientific examination of deterioration, intervention, material analysis and the study of technical art history. In the past, most of analysis involved wet chemistry and instrumental analysis using XRF, XRD, SEM / EDX, RAMAN spectroscopy etc. Most of these techniques involve taking samples from the objects and the analysis is restricted to small area point analysis and unable to give global information. Imaging technology, on the other hand, is often non-invasive, non-contact, non-destructive and can be achieved in situ with capabilities of real time analysis and diagnosis. Optical imaging technologies including ultraviolet, visible and infrared multispectral/hyperspectral imaging techniques can obtain both spatial and spectral information.

There are other imaging techniques such as OCT imaging can give information on the 3D layer structure of paintings, and laser holography imaging can diagnose surface damage of murals.

High definition digital scanning technology can provide not only high-resolution digital images but also multi-band imaging and surface texture information.

This paper describes the various optical imaging applications in wall painting’s conservation, while focusing on potential applications of high definition digital scanning technology.

Key words: optical imaging, high-resolution digital scanning, ancient frescoes

文化遗产的数字化生存

Preservation of Cultural Heritage through Digitization

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“成像科学与丝绸之路壁画保护研究”国际学术研讨会
Application of Imaging and Analytical Science to the Interdisciplinary Study of Wall Paintings along the Silk Road

Yinglan Zhang, Xi’an Conservation Centre

摘要：物质文化遗产之所以具有特定的价值，是其物理实体承载的信息所揭示的人类文化发展脉络，或与人类环境相关的自然界的演变沧桑。从这个角度来说，文化遗产的物理本体与其所蕴含的显性或隐性信息是居于同等重要的地位。我们还应当认识到，尽管我们可以采取多种技术手段延缓文化遗产本体的留存时间，但是文化遗产本体的消失是绝对的，其保存是相对的。如果一旦文化遗产本体因自然衰变等原因不复存在，那么我们通过各种技术所留存下来的文化遗产信息就尤显弥足珍贵。由此可见，随着现代科学技术的发展和在文化遗产保护领域应用的不断拓展，文化遗产的数字化生存将会成为文化遗产保护的一种重要方式，而且，在可预见的未来，将会成为文化遗产信息留存的主要方式。

本报告的主旨观点是，文化遗产的数字化生存，不仅仅居于文化遗产保护的从属地位，更应是文化遗产保护与数字化技术两者间全方位、多层次地有机结合。也就是说，从文化遗产的宏观和技术保护、管理和科学研究，到教育展示和相关信息的再挖掘等等诸多方面，都应当体现出“数字化无所不在”的原则。

在此基础上，本报告通过系统汇报秦兵马俑三维虚拟复原工作、秦兵马俑二号坑三维扫描和虚拟复原项目、陕西蓝田水陆庵彩绘泥塑三维扫描和虚拟复原项目、陕西淳化金川湾石窟三维扫描和三阶教刻经辅助判读研究等案例的具体实践经验，向国内外专家全方位地介绍陕西文物保护领域在文化遗产数字化技术应用方面的经验和收获，以共同推进文化遗产数字化工作的快速发展。

Abstract: Tangible cultural heritage has its specific value because it can reveal not only the cultural development but also its interaction with the natural environment. From this point of view，the physical object is as important as its information content. We should also be aware that the eventual deterioration and disappearance of historical objects is a reality and the preservation of it can only prolong its existence. Once the object vanishes by reason of natural decay，the information that we conserved by way of technical means will be extremely precious. Therefore with the development of technology and the extension of technological applications in the area of cultural heritage conservation, imaging and

digitization will become an important method of cultural preservation. It will become one of the main stream methods that preserve the information of cultural heritage in the foreseeable future.

The main view of this report is that preservation of cultural heritage through digitization is not only an addition to cultural heritage conservation but also should be the integral part of heritage preservation strategy. That is to say the principle of “digitization is ubiquitous” should be reflected from the preservation， administration and scientific research to educational dissemination of cultural heritage.

On this basis, this paper reports case studies of 3D scanning and virtual restoration of the Qin terracotta army, the No. 2 pit of the Qin terracotta warriors and horses, the Lantian Shuilu Temple, the Chunhua Jinchuanwan Grotto and identification of the engravings of the Sanjie scripture, in order to demonstrate the application of digital technologies in the area of cultural heritage preservation in Shaanxi and to promote the development of cultural heritage through digitization .

多光谱无损分析技术在敦煌壁画中的应用研究

Application of Multispectral imaging in the Conservation of Dunhuang Murals

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摘要：近 10 多年来，多光谱摄影技术在文物保护领域有了重要的研究进展。这种非介入或无损的调查方法在壁画保护方面得到了越来越广泛的应用，已被证明是文物保护学家和修复工作者的有力工具。它首先被用来进行绘画技法的科学调查和复原研究，也可用于研究古代档案模糊文字显示以及保护方法的评估。本文通过构建适合壁画检查的多光谱技术，并在敦煌壁画中进行实际应用，揭示出了壁画绘画方面更多的技法信息。

Abstract：In the past decade，multispectral imaging technique has made significant progress in the conservation of cultural heritage. This non-invasive or non-destructive investigation method is widely used in the conservation of mural paintings and is a proven tool in

conservation. It was firstly used for the scientific analysis of technical art history and for assisting restoration. It can also be used to reveal faded text and assess conservation method. Through establishing a suitable multispectral technique for the inspection of mural paintings and cases studies of practical applications on Dunhuang wall paintings, this paper shows how painting techniques and other technical art history information can be revealed.

数字成像技术在蓝田水陆庵的应用

3D scanning of Lantian Suilu Temple

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摘要：文物图像是最直观的文物资料，文物的数字图像将是这个时代为后人留下的宝贵的文物资料。水陆庵文物具有复杂的不可移动文物的所有特性，数字成像技术在蓝田水陆庵的成功应用，对文物的研究、交流及传播有一定的借鉴作用。数字成像技术在水陆庵主要应用了高清晰数字摄影、虚拟漫游、三维测量建模、摄影测量、三维扫描等几种技术，全面地展示了数字成像技术在文物领域的应用前景。

Abstract: Images of cultural artefacts give the most intuitive information about the relic. Digital images captured now will become one of the most precious information that we can leave for future generations. Shuilu Temple has all the features of complex immovable cultural relics. The successful application of digital imaging technology in the conservation of Lantian Shuilu Temple provides a reference for the research, communication and dissemination of cultural relics. The techniques applied in Shuilu Temple mainly consist of high resolution digital photography, virtual walkthrough, 3D modelling, photogrammetry and 3D scanning, which shows the potential of 3D imaging technology in the application to cultural heritage.

光学相干断层扫描在壁画上的应用

Optical Coherence Tomography for non-invasive subsurface imaging of wall paintings

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摘要：光学相干断层扫描是基于迈克尔逊相干仪的快速非接触性的成像技术，这种技术可以扫面内部结构。OCT 技术首次应用在上世纪九十年代对活体眼球的断层扫描。这种技术在生物医学成像领域是研究热点。从 2004 年，OCT 技术应用于架上绘画和考古遗物的无损检测。OCT 技术的无损分析特点使它能够检测文物的任何部位和不能采用有损分析的文物。

绘画样品的 OCT 断层扫描和样品实际断层的直接比较显示了 OCT 断层扫面技术的特点。除了可以无损检测壁画的地仗层和颜料层，由于它的动态范围、高分辨率和扫描深度的可选择性，OCT 技术还可以显示壁画的底稿。试验证明 OCT 技术的高灵敏度使它能够呈现不同颜料层的界面。OCT 技术已经用来动态监测不同颜料层的干湿变化，监测颜料层的老化情况，实时监测颜料层的激光清洗情况，实时追踪由于环境变化如湿度变化造成的画布变形。OCT 技术已经应用在检测玉器、古代玻璃器、羊皮纸、瓷器和彩陶。

以伦敦塔的 Byward 塔中 14 世纪英国壁画为例展示 OCT 成像技术的功能。不同于显微镜观察到的壁画样品断层，OCT 成像不能显示颜色，但是对相同样品的同一部位综合使用 OCT 成像和多光谱成像，就可以得到结构和颜色的信息，并且是无损分析。采用便携式远程多光谱扫描成像系统和 OCT 得到的综合信息用于帮助研究壁画制作的过程和技法，鉴定了伦敦塔中壁画的材料和结构。

Abstract: Optical Coherence Tomography (OCT) is a fast non-invasive 3D subsurface imaging technique based on the Michelson interferometer. OCT was first invented for the in vivo cross-section imaging of the eye in the 1990s. It is an active research area in biomedical imaging. Since 2004, OCT has been successfully applied to non-invasive examination of easel paintings and archaeological objects. The non-invasive nature of OCT makes it possible to examine any region on an object, which is virtually impossible with invasive techniques without destroying an intact object.

Direct comparisons between OCT cross-section images and real cross-sections of paint samples showed the effectiveness of OCT cross-section imaging. Apart from the non-invasive examination of the stratigraphy of paint and varnish layers, OCT has also been shown to be the most sensitive technique for revealing preparatory sketches or underdrawings beneath paint layers owing to its high dynamic range, depth selection capabilities and resolution. It was shown that the high sensitivity of OCT enables the interface between different varnish layers on a painting to be seen. OCT has been used for dynamic monitoring of the wetting and drying of different varnish, the examination of the difference between the roughness of the dried surface for the different types of varnish and the monitoring of the aging and solvent cleaning of varnish, monitoring real time laser ablation of varnish layers and real time tracking of canvas deformation due to environmental changes such as humidity. OCT has found application in the examination of jade, ancient glass, parchment, ceramics and faience.

In this talk we demonstrate the effectiveness of OCT imaging of wall paintings through a case study of a recent in situ OCT examination of a 14^{th} C English wall painting in the Byward tower of the Tower of London. Unlike cross-sections of paint samples viewed under a microscope, OCT cross-section images do not have colour information. However, a combination of OCT images of paint cross-sections and multispectral imaging of the same area can yield structural and spectral (hence colour) information non-invasively. The wall painting was also imaged with a hyperspectral/multispectral imaging system, PRISMS (Portable Remote Imaging System for Multispectral Scannking). The combined information is used to assist the understanding of the painting scheme and technique, the identification of the material and layer structures.

无损探测在新疆交河故城中的应用

Application of non-destructive sensing technology to the conservation of ancient ruins

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摘要：随着我国文物保护工程的发展，逐渐注重加固工程的适用性与科学性。尤其对加固后遗址体的性能与加固效果进行评价，由于理论与技术的缺乏，一直是极大的难题。作为丝绸之路的重镇，交河故城是世界规模最大的生土遗址之一。由于自然和人类活动的影响，交河故城载体发育有大量卸荷裂隙，严重威胁到遗址的稳定性。为此，国家投入巨资开展交河故城的抢险加固工程。除锚固外，裂隙加固的主要措施为注浆。裂隙注浆（充填注浆）的效果评价一直是我国遗址加固效果评价的难题。作为重要的研究项目之一，采用了多道瞬态面波技术、人工地震检测技术和电法探测技术对裂隙灌浆前后进行了无损检测。研究表明，无损检测适用于遗址加固后效果评价，对于遗址加固措施的评定、优化具有重要的意义。

Abstract: With the development of conservation of cultural heritage in China, more and more emphasis has been placed on the applicability and scientific evaluation of consolidation methods. In particular, owing to the lack of theoretical understanding and technical capability, the proper assessment of the effectiveness of the consolidation method and the properties of the ruins after consolidation has always been a major problem. As a historically important city on the Silk Road, the ancient city of Jiaohe is one of the biggest adobe cites in the world. There are many stress-release cracks caused by natural deterioration and human activities, threatening the structural stabilities. As a result, the government has given significant investments in a consolidation and conservation project. Injection of grouting in the cracks is one important method besides anchoring. Evaluation of the effectiveness of grouting injection has always been a difficult task. Multichannel transient surface wave, artificial seismic detection and electrical surveys are used before and after conservation to explore the effects of grouting non-destructively. The research shows that non-destructive evaluation of the consolidation efforts is a powerful tool.

陕西墓葬壁画保护研究新进展

New developments in the conservation research of Shaanxi tomb paintings

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摘要：根据墓葬壁画的制作工艺、特点及其保存状况，在发掘现场会采取不同的保护工艺和方法，或与地仗层一同揭取，或连同支撑体一起搬运，或与墓葬局部一起搬迁，或整体搬迁，以最大限度保护保存原始壁画内容。本文结合近几年所开展墓葬壁画保护的几个实例，介绍陕西墓葬壁画保护的最新发展。

关键词： 墓葬壁画，保护修复，整体搬迁

Abstract ： Different conservation methods for mural paintings from archaeological sites, including detachment of mural paintings with plaster layer, removal of wall paintings with plaster and support layers together, transferring partial tomb or transferring the entire tomb with the wall paintings, are chosen at the excavation sites according to the characteristics, method of construction and the state of conservation in order to maximize the protection of the original mural paintings. This paper presents the latest development of the conservation of tomb wall paintings using several case studies in the recent years in Shaanxi Province.

Key Words： Tomb Murals, Mural Conservation, Entire Transfer

POR-BAJIN –图瓦古代遗址

POR-BAJIN – THE MONUMENT OF TUVA’S ANCIENT HISTORY

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摘要：Por-Bajin 考古遗址（图瓦人的粘土房子）位于 Tere-Khol 湖的一座岛上（Tere-Khol 地区是图瓦共和国）。

这个城址的面积是 3.5 万平方米，几乎占据了整个岛屿。Por-Bajin 遗址有着复杂的

建筑结构：遗址的围墙是一个东西走向的标准的矩形（215x162m）。有两个毗邻的大型庭院，一个遗址建筑位于中轴线上，并且在这个矩形的围墙之中还有一系列沿着北墙、西墙和南墙而建的庭院，在东墙的正中有大门和被严重损坏塔楼，入口直通塔楼的坡道平行于围墙，保存下来的城址围墙最高处为 10m，内部建筑的墙最高处约为 1-1.5m。

Semen Remezov（西伯利亚的历史学家和人种学家）1971 年在他所写的< 西伯利亚图>中第一次提到这个遗址。对这个城址大规模的研究始于 2007 年，由 Por-Bajin 遗址文化基金提供资金支持。Por-Bajin 遗址的考古工作进行了 4 个月（6 月到 9 月）。来自莫斯科国立大学，俄罗斯科学院以及东方艺术馆科学家们参与这项工作。

在进行考古工作之前，对整个岛和遗址进行了激光扫描，最终制出一个该遗址的地形平面图（1:200）和一个三维模型。

建筑材料和制作工艺显示 Por-Bajin 城址的建造沿袭了中国的建筑传统。可能该城建造的计划结合了“理想城”的要素，即中轴线以及中心建筑占统治地位，以及“理想的佛教修道院”的要素，即居民住宅区则沿着靠近城址内围墙而建。

基本没有人类活动层暗示着该遗址的功能时间非常短暂。除此之外，没有发现取暖系统或是其他能让人们在冬天在这里生存下去的条件。但是，修复和一些重建的痕迹暗示出该城曾经存在过一段时间。

Por-Bajin 不仅仅是一个考古的遗迹，更是一个建筑上的不朽之作。它坐落于一个独特风景区的特殊环境里，因此对遗址的科研需要针对以下问题。

1．Por-Bajin 和 Tere-Khol 湖的历史。

传言说 Por-Bajin 城建于陆地上，而后湖才出现。这就提出了这个故事到底是一个神话，还是确有其事的问题。在后面的案例中，有必要调查湖是什么时候和为什么出现的。

2．Por-Bajin 城址的破坏过程

为了解答这些问题，一个由地球物理学家，地貌学家，水文学家和土壤专家组成的自然科学专家考察团展开了一项特殊的调查计划。在 2007 年的野外工作季中，展开了一个复杂的自然科学调查和后期数据分析。重要的结论涉及起源的历史，描绘了遗址的运作和遗弃，并且预言了它的未来。

1．Tere-Khol 湖早在宫殿建成之前就已经出现，不过要小一些。

2．在纵深明细地图上可以看到一个有趣的现象，Por-Bajin 岛是由一个更深的深渊带围绕着。

3．该城很可能竖立在一个大半岛的末端。

4．除了 Tere-Khol 湖水下各处都发现了永久冻土。

5．冰冻裂缝加速了对堤岸的侵蚀。

6.在挖掘过程中，地震的痕迹在遗址中被辨别出来。

因此，复杂破坏过程的主要原因已经被发现了，它们就是热岩溶过程导致的堤岸侵蚀，地震和随后的火灾。

Abstract: The archaeological site of Por-Bajin («Clay House» in Tuvinian) is situated on an island of Lake Tere-Khol (Tere-Khol kuzhuun (region), the Republic of Tuva).

The fortress occupies practically the whole island and its area is 3.5 hectares. The monument has a complicated architecture: fortress walls form a regular rectangle (215x162 m) elongated along the east – west axis. Two large adjoining yards, a monumental building on the central axis and a chain of adjoining yards along the northern, western and southern walls are inside the rectangle. In the middle of the eastern wall there are gates with heavily damaged towers; on the inside of the entrance ramps go up to the towers parallel to the walls. The fortress walls have survived up to the maximum height of 10 meters. The maximum height of the inner buildings walls is 1 – 1.5 m.

For the first time the site was supposedly mentioned in 1701 by Semen Remezov, the first historian and ethnographer of Siberia, in his “Drafting Book of Siberia”. Large-scale research was initiated at the site in 2007 with the financial support from the “Por-Bajin Fortress” Cultural Fund. Archaeological work at the site was carried out during 4 months (June – September). Scientists from Moscow State University, the Russian Academy of Sciences and the State Museum of Oriental Art took part in the work.

Before the archaeological work, the whole island and the monument were laser scanned and as a result a topographical plan (1:200) and a 3D squaretail model of the object were produced.

Building materials and technologies show that Por-Bajin was erected within the Chinese

building tradition. Probably the planning of the monument combined features of the “ideal town” with its axial planning and domination of a central building and those of the “ideal Buddhist monastery” where residential zones were placed along the inner perimeter of the fortress walls.

The negligible occupation layer implies a very short-lived functioning of the site. Besides, no heating systems or other means making it possible to live there in winter conditions were found. Nevertheless, traces of repair and some rebuilding imply that the site had been maintained for a certain time span.

Por-Bajin is not only an archeological site and an architectural monument. It is situated in peculiar environment in a unique landscape zone, hence the need for scientific study of the site to address the following questions.

1. History of the monument and lake. Legend has it that the fortress was built on land and the lake emerged later. This raises the question whether the story is just a myth or has something to do with reality. In the latter case, it is necessary to investigate when and why the lake emerged.

2. Processes of the monument’s destruction.

To answer these questions, a special program of investigation was created and specialists in natural sciences were included into the expedition: geophysicists, geomorphologists, hydrologists and soil specialists. In the course of the 2007 fieldwork season, a complex of natural science investigations and analyses of the obtained data was carried out. As a result, important conclusions concerning the history of origin, functioning and desertion of the site were drawn and predictions about its future made.

1. Lake Tere-Khol existed long before the building of the palace complex but was smaller.
2. An interesting phenomenon can be seen on the detailed map of the depths around the Por-Bajin Island: the island is surrounded by a belt of greater depths.
3. The fortress was probably erected at the tip of a large peninsula.
4. Permafrost is found everywhere except under the water of the lake.
5. Bank erosion is stimulated by frost fissures.

6. In the course of the excavations, traces of earthquakes were identified at the site.

Thus, the main factors of the complex destruction process have been identified. These are thermokarstic processes and the resulting bank erosion, earthquakes and subsequent fires.

当前颜料鉴定的措施

Current approaches in pigment analysis

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摘要：绘画材料的鉴别，特别是颜料鉴定，始终是艺术品科学分析的关键部分。但是我们的研究现在处在什么阶段？我们可用的技术有哪些？我们在寻找些什么？这些分析鉴定结果能告诉我们什么？

现代的颜料分析已经逐渐发展为一门成熟的学科。颜料分析既使用象 X-射线光谱学、拉曼显微镜这样的常规工具，又使用基于同步回旋加速器的尖端技术，使得壁画材料得以精确表征。与此同时，大家自然会关心颜料分析会给文物带来什么影响，特别是可否在不进行物理取样的情况下说明问题。此外，我们可以从这些分析结果中学到什么？虽然可以很好的鉴定颜料，但这些古代颜料信息能告诉我们关于物质文明的哪些方面呢？

此陈述将会强调以下这三个领域的现行想法。首先，文物颜料分析所使用的基本工具有哪些？对于可以提供足够准确的分析的必要工具组合，能否对其给予定义，以便我们进行有意义的研究为人们所理解？此外，这个领域有哪些操作规范、合适的参考数据和行业标准？第二，无损分析发展到什么程度，它能否提供有价值的数据？对于在最小物理取样量的同时获得最大量的信息有多少余地？第三，颜料分析对广受争议的历史问题有何帮助？比如，如何用颜料数据研究古代材料产地，古代贸易模式和制作工艺的发展？

Abstract: Identification of the materials of painting, especially pigments, has been a key part of the scientific analysis of art since people first began such studies. But where are we now?

What techniques do we use? What are we looking for? What does it tell us?

Contemporary pigment analysis has evolved into a sophisticated subject. Utilising both routine instrumental tools like X-ray spectrometry and Raman microscopy, and cutting-edge techniques such as synchrotron-based methods, we can now characterise these materials with a refined precision. At the same time there is a natural concern about the impact our analysis can have on an object, especially what we can (and cannot) tell without physical sampling. Then, what are we learning from our analyses? While identification is all well and good, what does this information about pigments of the past actually tell us about material culture?

This presentation will highlight current thinking in these three areas. First, what should be the basic set of tools we now expect to use for pigment analysis on historic objects? Can we define for example what would constitute an essential toolkit that allows us to be sufficiently precise in our analyses so that we can perform meaningful research that will be understood by others? Moreover, what standards exist in the field such as methodological protocols and appropriate comparison reference data? Second, where has non-invasive analysis got to and can it provide us with worthwhile data? Is there also scope for example for hybrid approaches that maximises information while minimising physical sampling? Third, what are the broader historical questions being asked that pigment analysis can contribute to? How, for example, can we use data on pigments to look at past sources of materials, historical patterns of trade and the development of manufacturing technologies?

中国古代石窟壁画和彩绘颜料的特性

Characterization on the polychromic structures and pigments of ancient Chinese Grotto

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摘要：本文介绍了对中国广元石窟装饰结构和 15 种颜料样品地科学系统研究。包括通过光学显微镜对其截面进行观察和扫描电子显微镜和能量色散 X 射线分析（SEM-EDX）对其装饰结构为单层或多层的表征。通过傅丽叶变换红外光谱（FT-IR）、X 射线衍射

（XRD）、偏振显微镜（PLM）和拉曼光谱（RM）的综合分析，得出使用的颜料主要为绿色，红色，蓝色，白色和黑色矿物质。主要的绿色颜料为孔雀石(CuCO3·Cu(OH)2)，氯铜矿(CuCl2·3Cu(OH)2)和雄黄(As2S3)；红色颜料主要为铅丹(2PbO·PbO2)，土红(Fe2O3)和朱砂(HgS)；主要的蓝色颜料为青金石(3NaAlSiO2·Na2S)和有机材料；白色的颜色为铅矾 (PbSO4)；黑色则是长时间烧香留下的污迹。各技术在颜料分析上的优点及局限性使得需要将各种技术综合使用。

Abstract: This paper presents the systemically scientific examinations of polychromic structures and pigments of 15 polychromy samples from Guangyuan Grotto of China. The cross-sectional examination under an Optical microscope (OM) as well as scanning electron microscopy coupled with energy-dispersive X-ray analysis (SEM-EDX) analyses results has indicated the polychrome as the monolayer or multilayer. The combinational analyses results by Flourier transform infrared (FT-IR), X-ray diffraction (XRD), Polarization microscope (PLM) and Raman spectroscopy (RM) has proved that the pigments mainly used are green, red, blue, white and black minerals. Malachite (CuCO3·Cu(OH)2), atacamite (CuCl2·3Cu(OH)2) and realgar (As2S3) are the main green pigments. Miniumite (2PbO·PbO2), hematite (Fe2O3) and cinnabar (HgS) are contributed to the red colors. Lapislazuli (3NaAlSiO2·Na2S) and organic blue materials are the main blue pigments. The white color is attributed to anglesite (PbSO4) and the black surface of polychromy is due to smudging by folk burning joss sticks for a long time. The main advantages and limitations of each technique for pigment identification reveals the need for the use of complementary techniques.

激光诱导击穿光谱在壁画上的应用

Application of LIBS for mural painting characterisation

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摘要：在文化遗产的保护和修复中，需要进行大量的分析和处理。基于这些原因，光学

技术、无损或微损分析已在历史遗存领域应用多年。激光技术在此领域已有应用。在分析技术领域，LIBS（激光诱导击穿光谱）被用于在颜料，盐类，金属或其他材料的现场鉴定。这种激光技术有很多优点：便携性，元素的微量分析（轻元素分析）和地层分析能力，使这种技术的应用具有重要意义。归属于文化部的 LRMH（历史遗迹实验室）是第一家获得此技术的实验室，而且已在现场将该技术系统应用（巴黎圣母院大教堂，圣萨万教堂，阿维尼翁附近的维伦纽夫，瓦隆城堡等）。

我们将通过不同的例子，与其他分析方法进行比较，并介绍如何采用新技术改进一般的壁画分析方法。

Abstract: The field of Cultural Heritage has many analytical and treatment needs both in the field of conservation and in restoration. For these reasons optical techniques, non-destructive or microdestructive and particularly in the field of historical monuments are present for many years. The laser therefore found a ready-made place in this area. In the field of analytical technology, LIBS (Laser Induced Breakdown Spectroscopy) is used for in situ identification of pigments, salts, metals or other materials. This laser technique present a lot of advantages: portability, analysis of light elements, stratigraphic analysis capability that makes it an essential for this application. The LRMH was the first laboratory depending from a ministry of culture to get the technology and to apply it systematically in situ (Notre Dame Cathedral, Saint Savin sur Gartemps abbey, Villeneuve lez Avignon, Oiron castle…)

We will present different example, comparing other analytical method and how the introduction of new technology can modify the general analytical approach of mural painting.

巴米扬大佛彩塑的颜料与胶料的分析

The polychrome of the Giant Buddha statues of Bamiyan – investigation on pigments and binders

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摘要：著名的巴米扬大佛是丝绸之路沿线的中亚及东亚地区古老而又重要的艺术传统的

一部分。从中国最早的时期到之后的佛教文化，泥塑都代表着一种古老而又普遍的亚洲文化表现形式。自新石器时代开始，粘土或陶瓦制成的塑像就已作为陪葬品或宫殿庙宇的装饰物。塑像在宗教仪式中相比于周围的壁画更加重要，因此许多寺庙有很多的塑像。除去这些塑像的美学、艺术价值和名望外，对于他们的制作工艺我们知之甚少。已有一些分析颜料的例子，但是少有对其中胶料的研究，而且对胶料的鉴别还很不全面，很模糊，因此我们对于这些艺术品的整体彩绘技术还不够了解。我们不仅需要对这些面临危险的重要艺术品有正确的视觉方面理解，也要研究针对他们的保护技术。

本文主要就巴米扬大佛的色彩装饰进行讨论。巴米扬大佛在被塔利班摧毁前从未被全面检测过，现在只能从壁龛中抢救出一些粘土造型的碎片残骸。慕尼黑工业大学从这些残骸之中选取了一些很小的碎块以供研究之用。

碎块的各层研究由光学分析构成。据此，碎块可归为不同类型，也发现了有重层彩绘的存在。选定好的碎块按编号进行了颜料及胶料分析，采用偏光显微镜（PLM）、X 射线荧光光谱（XRF）、扫描电镜能谱（SEM-EDS）及 X 射线衍射（XRD）进行了形态分析和无机物含量分析。采用气相色谱-质谱（GC/MS）鉴定了油脂、天然蜡质、萜类树脂、蛋白质及多糖类材料，这些成分的鉴定都是采用同一微量彩绘样品进行，以避免受到无机物的干扰。微量样本的分析使得对样品成分的逐层分析成为了可能。

基于针对颜料、着色剂和胶料的几种联合分析技术得出的结论，所得到的样品组成和探讨得到的彩绘工艺，都将使得我们对于巴米扬大佛的彩绘工艺有首次的深入了解。

Abstract: The famous Buddha statues of Bamiyan are part of an ancient and important artistic tradition of Central and East Asia, along the Silk Road. Clay sculptures represent an ancient and widespread expression of Asian cultures, from the most ancient Chinese dynasties to later Buddhist cultures. Sculptures made of clay or terracotta served as burial figures and idols or decoration of sanctuaries and temples since the Neolithic Age. Many Buddhist temples had a rich furnishing with sculptures which in the ritual context were more important than the surrounding wall paintings. Despite the beauty, artistic value and fame of these objects, very little is known about their technical realisation. In few cases pigments have been characterised, but binders have been analysed very seldom, and their identification remains

partial or unclear. As a result the overall painting technique of these artefacts is still unclear, placing not only the correct understanding of the visual aspect of these important works of art at risk, but their very conservation.

In this work the characterisation of the polychromy of the Giant Buddha statues of Bamiyan is presented. The Buddha statues of Bamiyan have never been examined thoroughly before their destruction by the Taleban. Fragments of the clay modelling could be rescued from the cone of debris left inside the niches. Tiny fragments were brought at the Technical University of Munich for investigation.

The optical examination of all the fragments comprised the investigation of the layer sequences. From this, the fragments can be sorted into different groups, and several phases of repainting became visible. Pigments and binders have been analysed on a number of selected fragments. Polarised light microscopy (PLM), X-Ray Fluorescence (XRF), Scanning Electron Microscopy coupled with Energy Dispersive X–ray Spectroscopy (SEM-EDS and X-Ray Diffraction (XRD) were used for the morphological analysis and inorganic content determination. A Gas Chromatography-Mass Spectroscopy (GC/MS) analytical procedure was used for the characterization of glycerolipids, natural waxes, terpenoid resins, proteinaceous and polysaccharide materials in the same paint microsamples avoiding interferences from inorganic compounds. The analysis of micro sub-samples enables the determination of the sample composition layer-by-layer.

Results obtained by the combined use of several analytical techniques on the pigments, colorants and binders will be provided, the sample build-up presented and the painting techniques debated, giving a first insight into the painting technique of the Giant Buddha statues of Bamiyan.

成像科学应用于喜马拉雅壁画之潜力

Imaging: Diagnostic and Assessment Scope and Potential in Remote Wall Painting Sites of the Himalayan Region

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摘要：印度次大陆的喜马拉雅地区是世界上最大的壁画集中保存区之一。其壁画最早可以追溯到公元 10 世纪，并探索出了大乘佛教的一系列艺术、文化和宗教表现。

在缺少合适的诊断条件的地区，成像技术可以找出丝绸之路上 Ladakh 地区的遗址的位置和分布。

随着成像技术的发展，保护工作者应用数字成像和便携式电脑进行现状的记录和评估的可能性增加。这个报告希望强调的是，通过成像技术的现行研究可能解决一些挑战性问题。

Abstract: The Himalayan region of the Indian subcontinent is home to one of the largest concentrations of wall paintings in the world. The earliest examples date from the 10th C CE, and the wall paintings in the region explore a wide range of artistic, cultural and religious manifestations of the Mahayana Buddhism.

In absence of proper diagnostic facilities available to conservators, working in the region, such as access to laboratory analysis, this oral presentation tries to locate the scope of imaging with specific reference to sites in Ladakh an outpost of the silk route, and other locations in the region.

The possibilities that digital imaging and portable computers have opened up for the conservator in terms of documentation and condition assessment can further be enhanced with imaging techniques. With this presentation the author also hopes to highlight some of the challenges that potentially can be addressed by the ongoing research in imaging science.

库木吐喇石窟壁画保护现状及其治理措施

————以库木吐喇 58 窟壁画保护修复为例

Conservation Strategy and the Current Status of the Kumtula Murals – A Case Study of Cave 58

叶梅，新疆龟兹研究院

Mei Ye, Xinjiang Kizil Research Institute

摘要：新疆境内的库木吐喇石窟为丝绸之路文化遗产重要的组成部分之一，保存着众多的洞窟和丰富的壁画内容，具有着极高的历史、艺术价值。

历经千年，库木吐喇石窟遭受到了自然的和人为的破坏，出现了多种病害，严重危胁着石窟的安全，我们必须对其进行有效的保护修复，才能使石窟壁画更长久地保留下来。根据库木吐喇石窟壁画制作材料和制作工艺的特点，在做好前期分析研究的基础上，针对不同的壁画病害选用不同的修复材料、采取不同的修复工艺及保护措施，使所修复的壁画得到了有效的保护。

Abstract： Situated in the Xinjiang Uygur Autonomous Region, Kumtura caves with numerous well-preserved caves and rich mural paintings constitute an important component of the Silk Road heritage which is extremely valuable in both history and art.

Over the past thousand years, Kumtura caves have experience natural erosions and damages as a result of human activities. The deteriorations pose severe threats to the conservation and preservation of the caves. Urgent conservation and restoration campaigns must be carry out for the sake of its long term existence. In accordance with the characteristics of the production methods and materials, and on the basis of conservation assessment and survey, we select different conservation strategy according to the types of problems using different materials and techniques to ensure effective protection.

阿夫拉西阿卜七世纪壁画的研究历史

Afrasiab wall paintings (7thC AD): a short history of research

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Afrasiab Irina Arzhantseva, Institute of Ethnology and Anthropology of Russian Academy of Sciences

摘要：著名的阿夫拉西阿卜(撒马尔罕的遗址-中世纪早期粟特中心) 壁画在业内众所周知。

1913 年，历史学家和区域学家 N. Viatkin 在这一遗址第一次发现了壁画，但阿夫拉西阿卜壁画的主体是在 1965 至 1967 年发现的。V.A. Shishkin 领导的考古探险队在 1965-1967 年对这些壁画进行了调查。乌兹别克科学院考古中心的化学技术实验室对北墙和东墙的壁画进行了揭取，使其在实验室条件下更长久的保存。从 1989 年开始，法国考古代表团和乌兹别克科学院考古中心合作进行了大范围的田野调查。为保护壁画免受破坏，阿夫拉西阿卜壁画保护机构（1997 年在法国创建）对展厅进行温湿度控制。

壁画完全覆盖于一种宫殿式的建筑物墙面。画面的主题有：狩猎、过河、庄严的队伍、最主要的画面是各国使节来到粟特统治者 Varkhuman 的朝廷。这些壁画的主要特色之一在于粟特文题词，内容包含有 665 年 Chaganian（撒马尔罕的统治者）的觐见，这点已被中国的一些资料所证实。

阿夫拉西阿卜壁画像亚洲中部中世纪早期的壁画一样，属于所谓的“民族现实主义”风格。着重强调每个人的民族特点，壁画里所呈现的物件和服饰都最大程度的真实化，即使是最细小的细节也被刻画出来。最吸引考古学家的是考证壁画中的真实物件并和已知的考古类别相比较。

Abstract: The far-famed early medieval wall-paintings of Afrasiab (the ancient site of Samarkand - the centre of the early mediaeval state of Sogdiana) are well known to specialists, but not outside this circle.

The first wall painting at the site was discovered by the historian and regional expert N. Viatkin in 1913, but the main body of paintings was found only in 1965-67. The paintings

were investigated by the archaeological expedition headed by V.A. Shishkin in 1965-1967. In 1978 a the Chemical-technological Laboratory of the Institute of Archaeology of the Uzbek Academy of Sciences was setting the stage for the removal of the coat of paint from the northern and eastern walls for further restoration in laboratory conditions. Since 1989 large-scale fieldwork has been carried out by the Mission archéologique française in collaboration with the Institute of Archaeology of the Uzbek Academy of Sciences. «L' Association pour la Sauvegarde de la Peinture d'Afrasiab (was created in France in 1997) has taken steps to ensure the required temperature and humidity conditions in the exposition hall to prevent the paintings from damage.

The paintings covered the walls of a building meant for habitation, a kind of palace. The themes are: hunting, crossing a river, a solemn procession and, lastly, the fundamental scene, the arrival of emissaries of various countries at the court of Varkhuman, the ruler of Sogdia. One of the chief features of these paintings is a Sogdian inscription, containing the address of the Chaganian ambassador to Varkhuman, the ruler of Samarkand, in 655, which is confirmed by Chinese sources.

The Afrasiab paintings, like all early mediaeval paintings in Central Asia, follow the so-called "ethnic realism" style, i.e. taking special care to emphasize ethnic peculiarities in persons, so that all objects and costumes in the paintings are rendered with the maximum realism and the most minor details are painted. Examining the real objects in the paintings and comparing them with known archaeological categories is what attracts archaeologists most of all.

红外热像技术在文物保护中的应用

Application of thermal infrared imaging to conservation

齐扬 西安文保中心

Yang Qi, Xi’an Conservation Centre

摘要：红外技术是近年发展起来的一种新的无损检测方法，由于红外热成像技术具有非

接触、远距离、实时、快速、全场测量等优点，因此已广泛地应用于预防性维护、故障检修、质量控制、科学研究等领域。本文通过具体实例说明了红外热成像技术在文物调查、文物病害产生的原因分析及评价方面的应用。

Abstract: Infrared technology is a new non-destructive detection technology that has recently been applied to conservation. Thermal Infrared imaging has many advantage such as non-invasive，long-distance (remote), rapid, dynamic，global examination and so on，It has already been widely applied in the fields of preventative diagnostic，fault detection，quality control，other scientific research areas. This paper demonstrates the application of thermal Infrared imaging in the examination of cultural relics for diagnosing damage and condition assessment, through a number of case studies.

近红外高光谱成像和核磁共振用于非侵入性原位水分检测

Non-invasive in situ moisture detection with near infrared hyperspectral imaging and NMR

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摘要： 石窟开凿崖体由泥质砂岩和砾岩组成，岩性容易受渗透水的影响。洞窟湿气是由地下水的毛细运动或者可溶盐的渗透析出引起的，湿度的升高和岩石中可溶盐的溶解。大部分原位含湿量监控的普遍技术都基于电阻性能并且只允许成比例的测量。这些监测方法不仅会受到水分的影响，同样也会受到不同种类离子的浓度和其它杂质的影响。

PRISMS（多光谱成像便携式遥控成像系统）针对不可及的高度的原位远程高光谱成像而设计的。这是一种能同时记录数百万个点每像素的光谱反射比，非侵入性技术。该系统配备有一个 AOTF(声光可调谐滤波去)系统，可提供光谱带间的快速切换和滤波器中心波长和带宽的灵活性。在这项研究中 1000-1600nm 的范围由 61 个 10nm 带宽的过滤器通道占据。近红外区水吸收谱带的反射比可用来监控多孔介质的的表面和次表面相对含水量。可以根据吸收谱线的等效宽度决定相对含水量。这种方法可以有效测定石灰岩和砂砾岩样品的表面和内部含水量，并且已经在一个彩绘窟壁的实体模型上得到验证。

由于使用近红外光谱测量湿度的方法需要将样品移至实验室进行重量分析法校准，在文化角度上文物材料的重要性这就使得该方法的应用受到限制。

对于表面湿度进行定量的方法需要校准。核磁共振技术作为标准重量分析法的替代，可对水分含量进行非侵入性测量。核磁共振成像（MRI）是一种非侵入性的成像技术，它通过对流体氢的空间核磁共振信号进行分辨检测，用于研究多孔介质中水的存在。

我们的方法使用一台便携式核磁共振成像设备，即核磁共振可移动通用表面探测仪（核磁共振鼠标），可以实现对置于仪器外的样品进行扫描（inside-out NMR）。核磁共振探测深度可达 10 毫米，同时测量饱和样品的孔隙度和孔径分布。虽然核磁共振是一种绝对式测量技术，但是由于其速度很慢，不适用于大面积监测。

近红外光谱成像是一种较快的成像技术，可以利用其测量相对湿度，再通过核磁共振测量某些特定点以进行校准。这种方法在原地对水分含量进行定量测量，不需要移动样品，同时不会对脆弱的石质文物表面或其他多孔材料带来任何破坏。这提供了一种有效且非侵入性的技术，出于保护文物的目的，可应用于历史文化遗存的多孔介质表层和次表层湿度动态变化的原址监测。例如：洞穴的墙壁，建筑物和壁画等。核磁共振可用于这些材料深度剖面 10 毫米范围内的含水量测量。

Abstract: Cliffs into which grottoes are excavated consist of argillaceous sandstone and conglomerate; lithologies that are susceptible to water penetration. Dampness in caves can be brought about by the capillary movement of ground water or the infiltration of precipitation, raising the humidity and dissolving soluble salts in the rock. Most common techniques for monitoring moisture content in-situ are based on electrical properties and allow only relative measurement. Such methods are not only influenced by the presence of water but on the concentration of ion species and other impurities.

PRISMS (Portable Remote imaging system for Mulitspectral Imaging) is a system designed for in situ remote hyperspectral imaging at inaccessible heights from ground level. It is a non-invasive technique capable of recording the spectral reflectance per pixel of millions of points simultaneously. The system is fitted with an AOTF (acousto-optical tunable filter) system that provides fast switching between the spectral bands and flexibility in terms of the central wavelength and bandwidth of the filters. In this study 61 filter channels of 10nm

bandwidth are used across the range of 1000-1600nm. The reflectance at water absorption bands in the near infrared (NIR) can be used to monitor the relative water content in the surface and subsurface of porous media. The relative moisture content can be determined from the equivalent width of the absorption line. The method has been found to be effective at determining water content in the surface and subsurface in limestone and sandstone samples and has been tested on a mock up of a painted grotto wall.

The use of near infrared spectrometry for moisture measurement has been limited for culturally important materials by the need to remove samples for laboratory calibrations using gravimetric methods.

To quantify the surface moisture content the method requires calibration. Nuclear Magnetic Resonance provides a means to non-invasively measure water content as a new alternative to standard gravimetric methods. Magnetic Resonance Imaging (MRI) is a non-invasive imaging technique which relies on the detection of the spatially resolved NMR signal from a hydrogen containing fluid and can be used to investigate the presence of water in porous media. Our method uses a portable MRI device, the Mobile Universal Surface Explorer (NMR-MOUSE®) which allows scanning of samples placed outside the instrument (inside-out NMR). The NMR can provide depth profiles up to 10mm into the surface and measure the porosity and pore size distribution in saturated samples.

While NMR is an absolute measurement technique, it is very slow making it impractical to be used for monitoring a large surface. NIR hyperspectral imaging is a much faster imaging technique giving relative moisture measurements which can be calibrated by NMR measurements at specific points on the surface.

This methodology allows for quantitative monitoring of moisture content in-situ without the need to remove samples or in any way damage the vulnerable surfaces of stone artifacts or other porous material. This may provide a useful and non-invasive technique with applications for in-situ monitoring of dynamic changes in moisture content of historical and cultural artefacts at the surface and subsurface of porous media e.g. cave walls, buildings, and murals, for conservation purposes. The NMR may be applied to produce depth resolved profiles of

water content up to a 10mm depth within these materials.

科学断代技术与壁画研究

Scientific Techniques for Dating Mural Paintings,

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摘要：许多科学的方法应用到考古文物和艺术品材料的年代测定上。可靠的测定年代需要严格的体系来评价已知确切年代的事物（如植物的生长轮）和考古文物或历史艺术品（如壁画）的关系。

放射性碳测年在考古遗址的应用最早可追溯至 1971 年，由 H T Waterbolk 首先提出。近年来，Matthew Spriggs 提出了更加详细精密计时的方案。

其他测年技术发展则较为缓慢，但是我建议可以通过采用适当的标准来发展精确计时这种测年方法（Millard 2008）。本文讨论了适合丝绸之路壁画的测年方法，包括放射性碳，光释光，并提出建议如何发展专门的遗迹评价标准。

Abstract：A wide range of scientific dating methods have been applied to archaeological and art historical materials. Reliable dates require a critical evaluation of the relationship of the event being dated (such as the growth of a plant) to the event of archaeological or art historical interest (such as the painting of a wall).

Pioneering work on such evaluation for radiocarbon dates from archaeological sites was in 1971 by H T Waterbolk and more recently elaborated into a scheme of ‘chronometric hygiene’ by Matthew Spriggs.

Evaluation of dates from other techniques is less well developed, but I have suggested how the ideas of chronometric hygiene can be expanded to cover them by using appropriate criteria (Millard 2008). This paper will consider the dating methods applicable to Silk Road mural paintings, including radiocarbon and optically stimulated luminescence, and will suggest how evaluation criteria specific to these monuments can be developed.

汉唐壁画墓天象图的研究

Astronomical charts in Han and Tang Dynasty tomb paintings

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摘要：目前发现的很多汉唐墓葬中都保存有天象壁画图，这一现象体现了独特的法天象地的东方文化特色，是中国古代天文学在古代墓葬中的折射，也是中国古代宇宙观念在地下天国的体现。自汉至唐天象图的结构与变化，反映了古代人类的宇宙观及某些宗教思想。本文通过对一些有代表性的汉唐壁画墓天象图进行梳理和研究，分析壁画中绘制的天象元素，找到其时代的特点和文化的象征，并结合历史及相关的科技资料对其进行探讨。

Abstract： Astronomical maps are found in many Han and Tang dynasty tombs which shows unique oriental cultural characteristics. These maps reflect ancient Chinese astronomical ideas and cosmology in the underground kingdom. The evolution of astronomical charts found in tombs of the Han to Tang period reflects the cosmological and religious ideas of the period. This paper examines some typical astronomical maps in Han and Tang dynasty tomb paintings, conducts a survey and analyses elements of astronomical phenomena painted, finds the characteristics and cultural symbols of the times through a combination of relevant historical and scientific information.