Introduction

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Article 1 of the World Heritage Convention (http://whc.unesco.org/en/conventiontext) defines as relevant cultural heritage monuments and groups of buildings "which are of outstanding universal value from the point of view of history, art or science". Article 2 recognizes natural features "of outstanding universal value from the aesthetic or scientific point of view", geological and physiographical formations "of outstanding universal value from the point of view of science or conservation", and natural sites "of outstanding universal value from the point of view of science, conservation or natural beauty". In view of these statements it is extraordinary that criteria for assessing science heritage are so underdeveloped: underdeveloped to the extent, in fact, that the thematic study on *The Heritage Sites of Astronomy and Archaeoastronomy in the Context of the World Heritage Convention* (Ruggles and Cotte 2010 [hereinafter "TS1"]) was the first in any field of science heritage.

Consequently, our efforts to identify and clarify some of the key issues that arise when assessing astronomical heritage have broader value in helping to clarify some of the fundamental issues that apply to science heritage more generally. UNESCO's Thematic Initiative on Astronomy and World Heritage (whc.unesco.org/en/astronomy) was created in 2003 with the aim "to establish a link between Science and Culture towards recognition of the monuments and sites connected with astronomical observations dispersed throughout all the geographical regions, not only scientific but also the testimonies of traditional community knowledge" (UNESCO 2012).

The Astronomy and World Heritage Initiative sets out to identify, safeguard and promote significant cultural properties connected with astronomy. The places in question do not just include sites (such as observatories) important in the development of modern scientific astronomy, but also much older constructions whose design or location relate to celestial objects and events, reflecting the ways in which ancient cultures attempted to make sense of the world—the cosmos—within which they dwelt (Ruggles 2009; 2012).

In 2008 a formal Memorandum of Understanding (MoU) was signed between UNESCO and the International Astronomical Union (IAU) agreeing a number of ways in which the two organizations would work together to advance the Astronomy and World Heritage Initiative. The IAU promptly set up a Working Group charged with fulfilling the IAU's commitments under the MoU. One of the first deliverables of the IAU WG, working in collaboration with ICOMOS International, was the global Thematic Study on astronomical heritage, mentioned above. This was published in June 2010 and presented at the 34th session of UNESCO's World Heritage Committee (34COM) in Brasilia. A downloadable electronic version is available at no charge from the Portal to the Heritage of Astronomy (www.astronomicalheritage.net).

The MoU between UNESCO and the IAU was renewed in 2013. In April 2015, following a major restructuring exercise, the IAU approved the creation of a new Commission on World Heritage and Astronomy, one of four Commissions within a new Division on Education, Outreach and Heritage, thus significantly raising the profile of world heritage among professional astronomers and placing the IAU's commitment to world heritage on a firmer, longer-term basis. In September 2015 UNESCO and the IAU entered into an Official Partnership agreement (consultative status).

According to the statement of Working Methods and Formal Processes for the Implementation of Activities within the Framework of the renewed MoU, agreed between UNESCO and the IAU, the IAU Commission will, among other things, continue to work on behalf of the IAU with ICOMOS International to define a common vision on astronomical heritage and develop robust general principles for assessing the value of different types and categories of scientific and technological sites relating to astronomy, whether or not they represent potential Outstanding Universal Value (OUV) under the terms of the World Heritage Convention. This will assist State Parties in the identification of properties of significance, and potentially of Outstanding Universal Value, in relation to astronomy.

The 2010 Thematic Study represented a first stage in this process. Its subject matter ranged from early prehistory to modern astrophysics and space heritage, including working observatory sites and dark-sky places. In view of the existence of a 2009 report on classical observatories produced by ICOMOS–Germany and the University of Hamburg (Wolfschmidt 2009), it was not considered necessary to give special emphasis to classical observatories from the renaissance to the mid-20th century, which were treated in equal measure to 14 other cultural heritage themes.

This Thematic Study continues the development of a common vision and robust general principles by presenting a selection of case studies in greater depth, structured as segments of draft dossiers, that raise and help explore key issues relating to astronomical heritage that had first been identified in the 2010 work. It originated from a request in October 2011 from the IAU to its (then) Working Group on Astronomy and World Heritage to develop in more detail some of the case studies included in the 2010 thematic study. WG members, working with other interested parties as appropriate, duly drafted a number of “extended case studies” highlighting the astronomical values of the properties concerned. These were presented and discussed at a Forum held in New Zealand in June 2012, and again at the IAU’s 28th General Assembly in Beijing, China in August 2012. Over the ensuing months and years, various of the case studies were finalized and released publicly on the Portal to the Heritage of Astronomy.

The aim of these “extended case studies” was always, and remains, to explore how significance in relation to astronomy might be used to demonstrate OUV. In particular, they seek to provide

- help and guidance relating to properties that might have a strong claim for inclusion on national tentative lists; and
- guidance for State Parties and stakeholders where it is considered that the property might have the capacity to demonstrate OUV.

Specific extended case studies might well facilitate the eventual preparation of a full nomination dossier should a State Party decide to prepare one, but it is fully recognized that this process must involve a wide range of stakeholders and must cover a range of legal and management issues as well as the scientific and heritage ones.

We also recall that the advice of ICOMOS’ panel is officially required for the value assessment of cultural heritage properties by the World Heritage Committee, including cultural landscapes and archaeological sites. This happens for every cultural property nominated for World Heritage recognition, as part of the process organized by the World Heritage Convention in order to ensure a collective and balanced evaluation. At each year’s World Heritage Committee session, ICOMOS is required to prepare an assessment by its experts and its final evaluation panel. The World Heritage Committee examines the assessments and recommendations by ICOMOS for cultural properties, IUCN for natural properties, and both for cultural landscapes, and then takes the final positive or negative listing decision.

Scope of the Case Studies

The case studies contained in the chapters that follow, together with the main issues that they highlight, are summarized in Table 1.1.

Table. 1.1. Case studies included in this volume and issues raised

Property	State(s)	Main themes and issues
Seven-stone antas	Portugal, Spain	Potential for serial nomination of a group of prehistoric monuments whose astronomical significance is only evident from the group as a whole
Stonehenge World Heritage Property	United Kingdom	Management issues given due recognition of astronomical values
Chankillo	Peru	Values of specific site in relation to astronomy as against broader values of archaeological landscape and related sites
Astronomical timing of irrigation in Oman	Oman	Cultural practices explicitly dependent upon dark night skies
Observatoire de Paris	France	Relative strength of individual v. serial nomination of classical observatory sites
Royal Observatory, Cape of Good Hope	South Africa	Importance of movable and intangible heritage in strengthening value of fixed heritage
Pic du Midi de Bigorre Observatory	France	High-mountain observatories
Leading optical observatories: AURA Observatory Canarian Observatories Mauna Kea Observatory, Hawai‘i	 Chile Spain USA	)) Modern optical observatory sites under) direct threat from light pollution)
Aoraki–Mackenzie International Dark Sky Reserve	New Zealand	Pristine dark-sky area with broad cultural connections
Eastern Alpine and Großmugl starlight areas	Austria	Relatively dark dark-sky areas with few or no direct cultural connections

The various case studies (Chapters 3–12) elaborate upon a range of issues raised in the 2010 Thematic Study. The major ones include:

- The relative strength of single-property as opposed to serial (typically transnational) nominations. This is explored both in the context of archaeoastronomical sites (seven-stone antas), classical observatories (Observatoire de Paris; Royal Observatory, Cape of Good Hope) and modern working observatories (Pic du Midi de Bigorre Observatory; Leading optical observatories).
- The importance of movable and intangible heritage in strengthening the value of fixed heritage (Royal Observatory, Cape of Good Hope and all other classical and modern working observatories).

- Recognizing and preserving the value of dark skies within cultural landscapes (Astronomical timing of irrigation in Oman), at cultural sites such as those used for modern scientific astronomy (Pic du Midi de Bigorre Observatory; Leading optical observatories) and natural sites (Aoraki–Mackenzie International Dark Sky Reserve; Eastern Alpine and Großmugl starlight areas).
- Recognizing, managing and protecting astronomical values at archaeological sites (Seven-stone antas; Stonehenge; Chankillo).

The "dark skies" issues are particularly complex as it is clear that dark sky places cannot, in themselves, be recognized as specific types or categories of World Heritage property, either cultural or natural. For this reason we include a specific discussion of the issues involved, and the potential for protecting dark skies associated with cultural or natural sites within the World Heritage Convention, in Chapter 2.

Given a strong interest in science and technology heritage related to space exploration, an attempt has also been made to develop a case study on Baikonur Cosmodrome in Kazakhstan. This attempt highlighted the inherent difficulties in obtaining relevant information, for example on protection and management, as well as the complexity of identifying criteria under which nomination might be proposed and in drafting a viable potential statement of OUV. The material developed so far is included in Chapter 13, but not in the "draft dossier" format. It is clear that the theme of science and technology heritage related to space exploration requires much more extensive attention, and it is possible that this could be the subject of a future thematic study in itself. The example of Baikonur is useful to consider in the present context, for example to explore relationships between science heritage and technology heritage.

For reference we include below an abbreviated list of the World Heritage Committee's criteria for the assessment of OUV (Table 1.2; for the complete criteria see the *Operational Guidelines*).

Table. 1.2. Criteria for the assessment of OUV (abbreviated)

(i)	Masterpiece of human creative genius
(ii)	Exhibit an important interchange of human values on developments in architecture, technology, monumental arts, landscape design
(iii)	Unique/exceptional testimony to a cultural tradition, either living or disappeared
(iv)	Outstanding example of architecture, technology or landscape that illustrates significant stage(s) in human history
(v)	Settlement or land use that represents human interaction with the environment, especially where vulnerable owing to irreversible change
(vi)*	Something directly or tangibly associated with events, living traditions, ideas, beliefs etc. of OUV
(vii)	Superlative natural phenomenon/a or area of exceptional natural beauty and aesthetic importance
(viii)	Outstanding examples representing major stages of earth's history
(ix)	Outstanding examples representing significant ongoing ecological and biological processes
(x)	Significant natural habitats for in-situ conservation of biological diversity

* "The Committee considers that this criterion should preferably be used in conjunction with other criteria"

Structure of the Case Studies

The Case Studies in this volume are structured according to categories identified in UNESCO's *Operational Guidelines*, Annex 5. The reason for this is to draw out the astronomical heritage issues that might arise if such a site were nominated for inscription on the World Heritage List. Since our case studies focus particularly on these astronomical heritage issues, many of the categories will be only partially relevant, and sometimes completely irrelevant, in any individual case study. Obviously there is a need to refer as clearly and as fully as possible to broader issues that are not directly astronomical, but we do not need to elaborate them as if we were actually writing the dossier. It is also vital to try to identify the most appropriate category or categories under which to raise and elaborate upon specific types of issue, for example those relating to dark sky preservation.

One major difference between the structure of our case studies and that of actual dossiers as specified in the *Operational Guidelines* occurs in the "Justification for Inscription" section. We place the *Comparative Analysis* (3.c) and *Statement of integrity and/or authenticity* (3.d) before, not after, the *Potential criteria under which inscription might be proposed* (3.a) and the *Suggested statement of OUV* (3.b). This is because the comparative analysis and the consideration of integrity and authenticity must precede, and support, the consideration of the criteria under which OUV might be demonstrated and the development of the proposed statement of OUV.

In Table 1.3 below, we list the categories together with a preliminary indication of how relevant they are likely to be.

Table. 1.3. Structure for case studies in this volume, with an indication of the likely relevance of each category

Operational Guidelines Annex 5 [UNESCO]	***Section no.***	***Included?***
Identification of the property:		
Country/State Party	1.a	Always
State/Province/Region	1.b	Always
Name	1.c	Always
Geographical co-ordinates to the nearest second and/or UTM to the nearest 10m	1.d	Always
Maps and plans, showing the boundaries of the property and buffer zone	1.e	As relevant
Area of property and buffer zone	1.f	As relevant
Description:		
Description of the property	2.a	As relevant
History and development	2.b	As relevant
Justification for inscription:		
Criteria under which inscription is proposed	3.a	Always
Proposed statement of OUV	3.b	Astronomical part always; rest optional
Comparative analysis	3.c	As relevant
Integrity and/or authenticity	3.d	As relevant
Present state of conservation	4.a	As relevant

Factors affecting the property:		
Development pressures	4.b.i	As relevant
Environmental pressures	4.b.ii	As relevant
Natural disasters and risk preparedness	4.b.iii	As relevant
Visitor/tourism pressures	4.b.iv	As relevant
No. of inhabitants	4.b.v	If relevant
Protection and management:		
Ownership	5.a	If relevant
Protective designation	5.b	If relevant
Means of implementing protective measures	5.c	If relevant
Existing plans	5.d	As relevant
Property management plan	5.e	As relevant
Sources and levels of finance	5.f	Only if relevant
Sources of expertise and training	5.g	Only if relevant
Visitor facilities and statistics	5.h	As relevant
Presentation and promotion policies	5.i	As relevant
Staff levels	5.j	Only if relevant
Monitoring:		
Key indicators for measuring state of conservation	6.a	As relevant
Administrative arrangements	6.b	Only if relevant
Results of previous reporting exercises	6.c	Only if relevant
Documentation:		
Photos and other AV materials	7.a	As relevant
Texts relating to protective designation	7.b	Only if relevant
Most recent records or inventory	7.c	Only if relevant
Agencies holding inventory records	7.d	Only if relevant
Bibliography	7.e	As relevant

Bibliography

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