2008

INCO-CT-2005-015416- Project QuarryScapes

QuarryScapes
Publishable Activity Report
Period: 01.11.2005 - 31.10.2008

Instrument: INCO-STREP
Thematic Priority: Integrating and Strengthening the European Research Area
Date of preparation: 10.12.2008
Start date of project: 01.11.2005
Duration: 36 Months
Contract: 015416
Project coordinator name: Tom Heldal
Project coordinator organisation name: The Geological Survey of Norway (NGU)

Quarry Scapes

Conservation of Ancient Stone Quarry Landscapes in the Eastern Mediterranean

Executive Summary

In the project summary, Annex 1 to the contract, the QuarryScapes project is described as follows:

"The QuarryScapes project will enhance cultural heritage management of ancient quarry landscapes through the development of methodology and conservation models that can be effectively implemented in a range of cultural contexts. 'Quarryscapes' will develop scientific and practical methodologies for documentation, characterisation and conservation of ancient quarry landscapes, raise awareness of the significance and vulnerability of such sites and contribute to legal protection measures and sustainable management of ancient quarry landscapes. Through case studies in Egypt, Jordan and Turkey, the project will address development of theoretical and practical methods pertaining to the major steps in the process of conservation: from recognition, investigation and assessment of significance, to understanding the risks, developing sound conservation and monitoring concepts, and suggesting mechanisms for sustainable management. QuarryScapes will also organise open workshops and disseminate project results through the development of practical guidelines for conservation of ancient quarry landscapes."

The activities in QuarryScapes were distributed across ten work packages (WP's). WP1 to WP5 were research activities exploring different aspects of ancient stone quarry landscapes in eleven case study areas in Egypt, Jordan and Turkey. WP6 and WP7 were innovation activities, building a bridge between research and practical management of such sites. WP8 seeked to extract research outcomes from the case studies and compile research of general value to the international community. WP9 concerned dissemination activities and WP10 management.

The first year of QuarryScapes focused on getting all the planned activities up and running. The second year aimed at completing all the twelve case studies in the project, and the third year focused on analysing the empirical studies and collating specific research outcomes important to the strategic goals of the project, in terms of developing methods into the documentation, characterisation and conservation of ancient quarry landscapes..

The Strategic objectives of QuarryScapes were:

- Develop scientific and practical methodologies for documentation, characterisation and conservation of ancient quarry landscapes
- Raise the awareness of the significance and vulnerability of ancient stone quarry landscapes
- In the long term contribute to legal protection measures and sustainable management of ancient quarry landscapes

After three years, QuarryScapes has conducted 11 case studies of ancient quarry landscapes in the region; performed an in-depth analysis of risks and threats to such sites in Egypt; outlined a concept for conservation of a specific quarry landscape; made a national inventory of all known Egyptian quarry landscapes; developed methods for documentation and assessment of significance for quarry landscapes and delivered various dissemination products aimed at raising awareness of such sites across a range of audiences. The impact of the project can be seen inside the consortium as a mutual multidisciplinary learning process, and outside as a process of raising the awareness of specific sites at a local and national level. In addition, raising awareness of quarry landscapes

generally on an international scale and in the development state-of-the-art methods to visualise, document and characterise these sites.

Consortium members

1. Geological Survey of Norway (NGU), Norway
2. Katholike Universiteit Leuven (KUL), Belgium
3. University College London (UCL), United Kingdom
4. Middle East Technical University (METU), Turkey
5. Yarmouk University (YU), Jordan
6. Supreme Council of Antiquities (SCA), Egypt
7. North South Consultant Exchange (NSCE), Egypt
8. Università di Venezia - Istituto Universitario di Architettura di Venezia (IUAV), Italy.

List of deliverables

No	Deliverable title	Available
1	Report: *Landscape and provenance and conservation of stone sources from selected archaeological sites in Jordan, 175 pp, ISBN 978-82-7385-26-0* *Edited by: Nizar Abu-Jaber and Ziad Al Saad* *Authors: Nizar Abu-Jaber, Ziad Al Saad, Mohammed Al Qudah, Nihad Smadi and Abeer Al Zoubi*	Download at www.quarryscapes.no, or order hard copy from NGU
2	*Report: Inventory of Ancient quarry landscapes in Turkey: their characteristics, production and state of conservation. 29 pp, ISBN 978-82-7385-136-9* *Edited by: Emine Caner Saltik* *Authors: Emine N. Caner-Saltık, K. Göze Akoğlu, Evin Caner-Özler, Kemal Erdoğan, Alp Güney, Sinan Sülüner, Tamer Topal, Ayşe Tavukçuoğlu, V. Toprak, A.G. Turkmenoglu, M. C. Ustunkaya Taliye Yaşar*	Download at www.quarryscapes.no, or order hard copy from NGU
3	Report: *The Sagalassos quarry landscape: bringing quarries in context, 84 pp, ISBN 978-82-7385-122-2* *Edited by: Patrick Degryse* *Authors: Patrick Degryse, Tom Heldal, Elizabeth Bloxam, Per Storemyr, Marc Waelkens, E. Trogh, Hannelore Vanhaverbeke, Jeroen Poblome, Philippe Muchez*	Download at www.quarryscapes.no, or order hard copy from NGU
4	report: *Characterisation of complex quarry landscapes; an example from the West Bank quarries, Aswan, 275 pp, ISBN 978-82-7385-118-4* *Edited by: Elizabeth Bloxam, Tom Heldal, Per Storemyr* *Authors: Elizabeth Bloxam, Tom Heldal, Per Storemyr, Adel Kelany, Patrick Degryse, Reidulv Bøe, Axel Müller*	Download at www.quarryscapes.no, or order hard copy from NGU
5	Report: *The assessment of significance of ancient quarry landscapes – problems and possible solutions. The case of the Aswan West Bank, 26 pp, ISBN 978-82-7385-119-2* *Author: Elizabeth Bloxam*	Download at www.quarryscapes.no, or order hard copy from NGU

6	Report: *Risk Assessment and Monitoring of Ancient Egyptian Quarry Landscapes, 207 pp, ISBN 978-82-7385-125-3* *Editors: Per Storemyr, Elizabeth Bloxam, Tom Heldal* *Authors: Per Storemyr, Elizabeth Bloxam, Tom Heldal, Adel Kelany, James A. Harrell, Rawda Yousri, El Shaimaa Fathy*	Download at www.quarryscapes.no, or order hard copy from NGU
7	*Report: Site Management Concepts for Widan el Faras, Northern Fayoum, Egypt. 40 pp + appendices, ISBN 978-82-7385-135-4* *Prepared by NSCE with the close collaboration with Naguib Amin*	Download at www.quarryscapes.no, or order hard copy from NGU
8	Report/maps: *GIS Products for Management of Ancient Stone Quarry Landscapes: three Egyptian Site Maps, 20 pp and 7 maps, ISBN 978-82-7385-123-9* *Edited by: Naguib Amin, Rawda Yousri, Sara Kayser* *Authors: Elshimaa Fathy, Marwa Sadek, Rabab Abd-el-Kader, Rawda Yosuri, Sara Kayser*	Download at www.quarryscapes.no, or order hard copy from NGU
9	*Report/maps: Map of Ancient Egyptian Stone Quarries, 26 pp /6 maps, ISBN 978-82-7385-133-8* *Edited by: Naguib Amin, Azza Shawarby, Rawda Yousri, Sara Kayser* *Authors: Elshimaa Fathy, Marwa Sadek, Rawda Yousri, Sara Kayser*	Download at www.quarryscapes.no, or order hard copy from NGU
10	*Report: Identifying heritage values and character-defining elements of ancient quarry landscapes in the Eastern Mediterranean: an integrated analysis. 161 pp, ISBN 978-82-7385-134-6* *Authors: Elizabeth Bloxam and Tom Heldal* *With contributions from:* *Turkey: Emine N. Caner-Saltık, K. Göze Akoğlu, Evin Caner-Özler, Kemal Erdoğan,Alp Güney, Sinan Sülüner, Tamer Topal, Ayşe Tavukçuoğlu, V. Toprak, A.G.Turkmenoglu, M. C. Ustunkaya Taliye Yaşar* *Jordan: Nizar Abu-Jaber, Ziad Al Saad, Mohammed Al Qudah, Nihad Smadi and Abeer Al Zoubi* *Egypt: Naguib Amin, Adel Kelany, Rawda Yousri, Sara Kayser, Elshimaa Fathy, Marwa Sadek, Rabab Abd-el-Kader* *Belgium: Patrick Degryse, Marc Waelkens, E. Trogh, Hannelore Vanhaverbeke, Jeroen Poblome, Philippe Muchez* *Norway: Per Storemyr, Reidulv Bøe, Axel Müller* *Italy: Lorenzo Lazzarini*	Download at www.quarryscapes.no, or order hard copy from NGU
11	*Web: QuarryScapes guide to documentation and assessing significance of ancient stone quarry landscapes*	Download at www.quarryscapes.no, or order hard copy from NGU
12	*Web-publication: QuarryScapes workshop proceedings – abstracts and extended abstracts*	Download at www.quarryscapes.no, or order hard copy from NGU
13	*Web-publication: QuarryScapes Ancient quarry landscapes atlas*	Download at www.quarryscapes.no, or order hard copy from NGU
14	*QuarryScapes web*	www.quarryscapes.no
	Quarryscapes book, Geological Survey of Norway Special Publication	To be printed in 2009

Work Package 1: Jordan inventory and provenance

Work Package Leader: Prof. Nizar Abu-Jaber, Yarmouk University
Deliverable No: 1

WP1 comprised a study of three selected quarry landscapes in Jordan: Al Jafr (Neolithic to Bronze age chert quarries, probably a major supplier for stone tools in the region), Jerash (Greco-Roman limestone quarries used for building the ancient city of Jerasa) and Petra (Nabatean sandstone quarries used for building purposes in the ancient city of Petra). The study involved geological investigation of the raw materials (criteria for establishing provenance), identification and surveying of the quarries and interpretation of landscape and geology as important factors in the location of quarries. The chert quarry landscape of Al Jafr, Eastern Jordan, has been characterised and investigated, and methods for scientific characterisation of the raw material have been developed. This site may have been a major production site in the Neolithic and the early Bronze Age for the whole region. The methodology can provide a basis for proving the significance of the site. The quarry landscape around the ancient city of Jerash in northern Jordan has been located and characterised. A large amount of quarry sites have been discovered, carrying important information about the construction of the city and the exploitation of resources in the vicinity for that purpose. The quarry landscape thus adds value to the ancient city and can be significant for future research and promotion to a wider audience. The Petra quarry landscape has so far been largely "forgotten", but it has significant value when viewed not only as an integral part of the monumental city, but also in their own right in terms of research potential related to understanding a unique technology of quarrying (Nabatean). In general, the project has lifted three important quarry landscapes in Jordan from oblivion, has shown the importance of promoting quarry sites as important parts of our ancient cities and has provided methods for scientific characterization of the materials. Furthermore, the project has succeeded in raising the general awareness of such sites in Jordan.

Work Package 2: Turkey inventory

Work Package Leader: Prof. Emine Caner Saltik, METU

Turkey has a rich selection of ancient quarry landscapes, starting from Hittite, Roman, Byzantine and Selçuk periods onwards. WP2 aimed at identifying and characterizing four of these ancient quarries and quarry landscapes, their archaeological and geological properties and a general review of production-consumption patterns. In the old part of Ankara, the primary building material has been reddish coloured andesite. From the geological characterization, it seems clear that the building stones were taken at the site of construction, leaving Ankara as a unique, "dynamic" quarry landscape where quarrying, construction and re-use were deeply integrated. Marble was also used in Ankara, particularly in the Roman Period. From geological characteristics, the source of the marble was traced to an area outside the city (Ankara-Istiklalbağı(Sivrihisar)). Later, a well preserved quarry landscape of Roman age was found, being one of the major new discoveries in the project. In Cappadocia, one case study identified a tuff quarry from the Selçuk Period, used for the monument of Ağzıkarahan in Aksaray. Different scientific methods were used for distinguishing this quarry from more modern ones. Limestone quarries of the Hittites in Sapinuwa-Ortaköy, near Çorum, have been identified and characterised; these and other Hittite quarries are poorly investigated, and although the Hittite "technology" may have important contributions to the overall understanding of technology transfer in Antiquity. All the identified quarry sites needs better protection and efforts have thus been made to raise the awareness of them and contribute to conservation.

Work Package 3: Sagalassos Quarry Landscape

Work Package Leader: Dr. Patrick Degryse, KUL
Deliverable No. 1

The Hellenistic-Roman city of Sagalassos is situated high in the Taurus Mountains in south-western Turkey. The local geology, comprising of limestone, sandstone and volcanic materials, has been quarried intensively for the construction of the monumental town. Moreover, marbles and other precious stones were imported from far away into the city, to serve their purpose as luxury products to boast the city's richness. A keyword for local quarrying is proximity, as in the immediate vicinity of important stone buildings, there are quarries, sometimes even integrated in the building itself. Hence, at Sagalassos, we are confronted with quarries in the town landscape. These stone extraction sites are an integral part of the cultural landscape due to the monumental purposes they served and are imperative to the story of the city of Sagalassos. In the research performed within WP3, the city and quarry landscape of Sagalassos were fully integrated. This not only led to the identification and description of all quarries in the vicinity of the ancient city, but also to the identification of particular sources of stone, which could be literally traced from quarry to building. Moreover, the broader significance of these research outcomes could easily be put into the context of the larger city landscape, as it makes the path of the stone from quarry to buildingvery visible. In addition, the significance of stone extraction vis à vis its incorporation into the Hellenistic-Roman town very tangible, even for the lay audience. As a final result, the WP3 research led to the initiation of a wider site management plan for the site of Sagalassos, which is now being developed.

Work Package 4: Aswan Quarry landscape

Work Package Leader: Dr. Elizabeth Bloxam, UCL
Deliverables No. 4, 5

The Aswan West Bank, Egypt, comprises a unique quarry landscape of great time depth. The main target for exploitation has been deposits of silicified sandstone ("quartzite") within the Cretaceous Nubian Group, but also non-silicified sandstone has been quarried, particularly for building stone. The quarries in silicified sandstone have been exploited for utilitarian and monumental stone products since the Palaeolithic into the Roman Period. The WP aimed at performing an in-depth investigation of this complex and large quarry landscape, using it for addressing detailed archaeological and geological surveys and the assessment of significance of such sites. The detailed survey of the area revealed many layers of quarrying activities and other archaeological features distributed over an area of more than 20 square kilometres. The earliest quarrying of silicified sandstone was in the Early to Middle Palaeolithic, when it was used for hand-axes, cleavers and other tools. From the Late Palaeolithic and at least into the Roman Period, the stone was used for hand querns (grinding stones), leaving huge areas transformed by quarrying. Yellow and purple varieties of the silicified sandstone were, furthermore, quarried for sculpture and obelisks in the New Kingdom, and for columns and other ornamental stone products in the Roman Period. The latter two activities have left a significant ancient road network made for transporting stone blocks. In addition to features directly related to quarrying, the area is also rich in rock art and other features related to human interaction with the landscape for millennia. The complexity of the case

study area made it ideal for developing methods for documentation and characterization of quarry landscapes, particularly in distinguishing different quarrying activities and time periods. The Aswan West Bank area was furthermore used as a case study for exploring methods for assessing significance of such complex quarry landscapes. Using world heritage criteria as applied on other production sites in the world, a model for establishing "outstanding universal value" on such quarries were developed and discussed.

Work Package 5: Risk and monitoring

Work Package Leader: Dr. Per Storemyr, NGU
Deliverable No. 6

WP5 aimed at investigating threats and hazards to ancient quarry landscapes, particularly man-made, based on three case studies in Egypt (Chephren's Quarry, the Aswan West Bank and Northern Faiyum). In these areas, extensive surveys including risk assessment and monitoring were undertaken. Also, the evolution of risk patterns through time were analysed, particularly for identifying the development of high risk areas in the near future. The major risks are related to ongoing and planned urban, industrial and agricultural development. Specific risks include widespread modern quarrying. The case studies also included development of methods such as integrated GIS analysis of satellite images, topographic maps, development plans and field surveys. Due to the fortunate turn of events that QuarryScapes could co-operate with the newly established SCA Department for Conservation of Ancient Quarries and Mines in Egypt and Prof. James Harrell of the University of Toledo (USA), who is a leading expert on ancient Egyptian quarries, it was possible to add additional goals to those initially proposed in WP5. Thus, supplementary to the case studies and developing tools applicable for risk assessment and monitoring of ancient quarry landscapes, WP5 has also used these tools for carrying out a nation-wide analysis of the status of ancient Egyptian quarry landscapes. This has enabled us to gain a much more comprehensive view of what can be done in order to safeguard these ancient quarries

Work Package 6: Conservation concepts

Work Package Leader: Hagar Rakha, NSCE
Deliverable No. 8

The WP aimed at developing an integrated plan for the conservation and management of a specific quarry landscape (Widan el-Faras, Faiyum, Egypt), exploring the applicability of similar plans for quarry landscapes in general. The Widan el-Faras basalt quarries were predominantly exploited for the construction of the Pyramids during the Old Kingdom (3rd millennium BC), and this fact together with unique features such as the oldest paved road in the world makes this quarry landscape unique and significant. However, there are many competing interests present in the area, such as modern basalt quarrying (which partially destroyed ancient quarries), desert tourism, plans for mass tourism and an integrated natural world heritage site. The study included identification of stake holders, analysing their interests and co-ordinating efforts to approach them and disseminate relevant information. The main stakeholders were identified according to their interest in the conservation of the area and/or their economic involvement, particularly in relation to modern quarrying in the area. Organisations to which these stakeholders belong are largely the Egyptian

Environmental Affairs Agency (EEAA), the Supreme Council of Antiquities (SCA), relevant quarrying companies and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Based on analyses and review of written sources about the area in question, a management concept has been designed. The document highlighted the different steps to the design, approval and implementation of an integrated and participatory management plan. Recommendations for the management and conservation of threatened quarries have been made. Within this framework, the Egyptian Environmental Affairs Agency started implementing conservative management actions and site marketing orientations are also proposed. Their objective is to pave the way towards developing a marketing strategy, approach, tools and actions to promote the site, linked to the marketing of Faiyum as a whole, and as a World Heritage Site in particular. A socio-economic study conducted a detailed social and economic evaluation of the project area and the scope of undertaking economic activities adjacent to the ancient quarries. An assessment of the social and economic benefits and drawbacks of the existing quarrying activities on the national and local levels has been conducted, and a baseline of the current socio-economic environment of the Project Area (quarry landscape and the North and South Lake Qarun vicinity) was roughly drawn. In addition to the studies undertaken, the work package also included construction of a digital 3D model of the quarry landscape for visualisation of its different features and evolution of the landscape through time. Several field visits to monitor the condition of the quarry landscape and threats imposed by modern quarrying and tourism have been made.

Work Package 7: Quarry landscape GIS

Work Package Leader: Dr. Naguib Amin, EAIS
Deliverable No. 7, 9

The WP aimed at developing GIS tools for visualising important features of ancient quarry landscapes of benefit to practical cultural heritage management. The goals were twofold; first, to design and produce thematic site maps for the use in conservation and management plans, using three case study areas in Egypt; and second, to design and produce a national map/inventory of ancient Egyptian quarry landscapes for the purpose of general land-use management and awareness-raising. The thematic site maps were made from field survey data for the Aswan West Bank, Chephren's Quarry and the Widan el-Faras basalt quarry (WP4 and 5). They included polygon and line data of the archaeological features in the quarry landscapes, combined with other datasets; such as registered cultural heritage sites and modern infrastructure and development plans. The national inventory covered 184 quarry sites all over Egypt. This data was partly extracted from Quarryscapes activities and other written sources, but most of all they were provided by Prof. James A. Harrell (Univ. of Toledo, USA). Field visits were necessary in order to confirm location and status of several sites. In addition to geological and archaeological information, the national database includes information about the legal status of the quarry landscapes and risks (from WP5). In this process, information was also exchanged with local SCA offices (Taftish), revealing that only a minor amount (81) of the quarry sites were actually known by the cultural heritage authorities. Consequently, the complete list of quarries sites was translated into Arabic and distributed to the Taftish offices requesting that the status of these sites be reviewed, as a first step towards their registration and protection. Thus, the WP has provided not only a database and map,

but also started the process of implementation of the national inventory into practical heritage management.

Work Package 8: Integrated scientific analysis

Work Package Leader: Dr. Per Storemyr, NGU
Deliverable No. 10

An important aim of WP8 was to perform a critical evaluation of the empirical data in the project in order to establish a scientific foundation for practical conservation and management of quarry landscapes, which can be used in a range of cultural and historical contexts. Furthermore, to develop general approaches and methods that can produce a documentation and characterization guide for ancient quarry landscapes. In the report 'Identifying heritage values and character-defining elements of ancient quarry landscapes in the Eastern Mediterranean: an integrated analysis' the empirical data from the different case studies across the QuarryScapes region were analysed, and a methodology to articulate historical and informational values in a statement of significance to decision-makers is designed. This work was undertaken by producing a methodology for 1) identification and documentation of features related to quarrying; 2) micro-level interpretation of such features and their relationship, 3) "constructing" quarry landscapes from connected activities and complexes, and 4) assessing values from macro-level concepts that view ancient quarry landscapes within their broader historical context. This macro-level stage of interpretation took a holistic view of an ancient quarry landscape in terms of its connection with other places or events of historical significance. 'Socially constructed landscapes', 'associative historical landscapes', 'contact landscapes' and 'dynamic landscapes' were four macro-level concepts specially designed to articulate significance in a meaningful way to decision-makers of these difficult archaeological sites. In addition, ways to 'best project' where these historical and informational values may be attached to material remains within a quarry landscape were developed as a key planning tool when landscapes are under pressure from modern development. The information that decision-makers, managers and stakeholders would take away from a 'statement of significance' in relation to an ancient quarry landscape in terms of scale, importance, uniqueness and representativeness, would then be integrated into other frameworks of value assessment in their domain.

Work Package 9: Workshops and Dissemination

Work Package Leader: Tom Heldal, NGU
Deliverables: 11, 12, 13, 14

The dissemination activities in QuarryScapes has focused on four channels: web site, annual workshops, scientific publication and other dissemination activities for a broader audience. Also, practical training of heritage inspectors has been an important issue during field work in Egypt. A strong driving force in the dissemination activities has been to make the products easily available, preferably as free downloads on the web.

The web site (www.quarryscapes.no) is the focal point of dissemination, where general information about the project and lists of publications are given. Furthermore, all the deliverables can be

downloaded, viewed and ordered in hard copy from the web site. Deliverable 1 to 9 can be obtained as case study reports, providing documentation of the research and innovation activities that have been carried out in the project. Deliverable 10 extracts a general methodology for identifying and characterising quarry landscapes as developed from the case studies. Deliverable 11 is a web-guide to documentation and interpretation of quarry landscapes, deliverable 12 a collection of abstracts and extended abstracts from the workshops, and deliverable 13 an atlas of selected quarry landscapes, displaying in a more tabloid way the variability of such sites. The web site has attracted much attention as clearly indicated by the large amount of downloads of deliverables (in total approximately 9000) and the doubling of returning visitors each year. This has clearly inspired us to maintain and develop the web site after the project ends.

Annual workshops were held in Antalya, Turkey (2006), Petra, Jordan (2007) and Aswan, Egypt (2008). In addition to pure administrative issues, each workshop had an open symposium where results from the project were presented as well as contributions from invited speakers, and field trips to case study areas in the project.

Scientific publication includes journal and proceedings. By the end of the project, 6 papers were published and two were still "in press" (see list at www.quarryscapes.no). The number of journal publications will increase after the project. Furthermore, a book volume of "Geological Survey of Norway Special Publications" to be printed in 2009 will be dedicated to QuarryScapes papers.

Other dissemination products so far include 3 leaflets/brochures, 20 newspaper articles/webnews/public lectures, four articles in professional journals, 17 presentations at scientific conferences, one presentation at a stone industry conference, three training courses, one radio programme and two television programmes.

The plans for further dissemination from the project include:

- Transferring the web site to a general site on ancient stone quarry landscapes, to be further developed and maintained by the Geological Survey of Norway. "QuarryScapes" has become a "brand" that should be further developed
- Make the Atlas of ancient stone quarry landscapes into a dynamic product that will evolve after the project to become an international display of such sites, both as a "showcase" for the lay audience and for providing inducements for future promotion of ancient quarry landscapes as world heritage sites
- Compile and print "*Lost Landscapes: Geological Survey of Norway Special Publications 12*" (preliminary title), dedicated fully to QuarryScapes. The book will be in full colour, peer-reviewed, reasonably priced, and after a short period freely downloadable on the web to ensure maximum distribution. The book will be financed by the Geological Survey of Norway.
- Continue scientific publication of results in journals and proceedings
- Continue publication of professional and popular science articles