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GEOSITES - AN IUGS INITIATIVE: SCIENCE SUPPORTED BY CONSERVATION

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INTRODUCTION

Sadly, many geoscientists fail to see the fundamental supportive role of geosite conservation. Its role is to keep available the vital site resource that our community needs for future research, as well as for education and training. In essence, it is a simple principle, - no sites, no science. Geoconservation is essential to maintaining the best of our geoscience heritage. It lags far behind biological/habitat conservation. Administrators, often biologists, preoccupied with biological interests, tend to overlook the conservation of geological sites and monuments, and it has to be admitted that geologists are not good at ‘selling’ geo(morph)ology. It is thought, mistakenly, that biological sites are always more vulnerable to change or threat than geoscience sites, but biotic nature is at least capable of adjustment to change, whereas for abiotic nature this is often not the case: many geological and geomorphological monuments are frequently of finite extent, they cannot accommodate to development or retain their intrinsic value, and they are completely unrenewable. Neglect thus may threaten our best geoscience sites, and we all know of cases of key national or international sites in our home countries which have been lost or irreparably damaged. GEOSITES was started by IUGS in 1996. It is a project to involve the geological community in geoconservation: its aim to provide a factual basis (inventory and data set) to support any national or international initiative to protect the geological resource, our resource for research and education. It is intended to help to redress the imbalance in conservation. Its aims are not executive, but are designed to mesh with national and geocommunity initiatives.

BACKGROUND

A debate has gone on in the last ten years over the possibilities for the inclusion of geological sites in global conservation schemes and in the World Heritage List. In Europe the debate has been strongest. At ProGEO –and IUGS and UNESCO– organised workshops, the construction of interrelated global and national inventories has been discussed. Specifically, a whole string of regional Geosite workshops have occurred in the last three years, in Johannesburg, Copenhagen, Vilnius, Beijing, Stockholm, Krakow, Sofia, St Petersburg, Moscow and at the first two International Symposia, at Digne and Roma. All have addressed the issue of how best to represent the diversity and richness of our key geoscience sites. In addition, there have been numerous national meetings. In organising such efforts Academies of Science, National Committees, geological surveys and institutes, and national societies have played, and will play, a key role.

In 1995, the International Union of Geological Sciences decided, subsequently with the support of UNESCO, to promote a new project to compile a global inventory, and related database. The president of IUGS wrote in 1996 to all national committees and affiliated bodies to enlist their support for the project. For the geological community such a database could have many other uses besides conservation. IUGS has set up a specific, new Global Geosites Working Group to undertake the work, and to promote any international efforts which facilitate the conservation of geoscience sites and terrains.

IUGS's Global Geosites Working Group (GGWG) has the following published terms of reference :

1) To compile the Global Geosites list
2) To construct the Geosites database of key sites and terrains.
3) To use the Geosites inventory to further the cause of geoconservation and thus support geological science in all its forms.
4) To support regional and or national initiatives aiming to compile comparative inventories.
5) To participate in and support meetings and workshops that examine site selection criteria, selection methods or conservation of key sites.
6) To assess the scientific merits of sites in collaboration with specialists, research groups, associations, commissions, subcommissions etc.
7) To advise IUGS and UNESCO on the priorities for conservation in the global context, including World Heritage.

Geoconservation is an international responsibility. All geologists and related professionals, and all organisations, have a part to play in protecting this heritage. Geosites and geology are not confined by national borders; geology (and geologically controlled landscapes) crosses them. Also, the best sites - in the Morrison of the USA with its dinosaurs , for the Lower Palaeozoic of Bohemia, in the Pleistocene sequences of Calabria, in the Burgess Shale of British Columbia, or the Karoo vertebrates or Bushveld igneous, hominid sites of Iberia or etc etc - have regional and often even global significance, and sites in such areas have importance and relevance for all. Unlike biological conservation, geology has lacked a mechanism to recognise and justify the most important elements internationally - those of the greatest value to the science. Though geo(morpho)logists could be argued to have a far better and more objective, and therefore more balanced, understanding of the resource as it exists in space and time. Geology has been a coherent science for two hundred years, and from William Smith, Cuvier and Hutton onwards it has been a site-based endeavour.

The objective of GEOSITES is to select an international list of the most important sites for geological science. The Second International Symposium on Geological Conservation in Roma in 1996 saw the first discussion of the Geosites project. And the setting out of principles and guidelines (Wimbledon *et al*. 1998) to make such selections. This was the first such an attempt to move towards an effective and widely useable methodology, that could be applied in all countries, despite their varied approaches to geoconservation.

The principles and guidelines set out at the Roma Symposium try to unite a new science-based comparative method with objective national approaches, and apply them to selecting scientific sites worthy of international recognition and protection. The mechanism for constructing country frameworks for selection was tested at the Belogradchik, Bulgaria workshop in 1998. It is now for countries to recognise their frameworks and start to select sites and areas, following the guidelines and framework method.

Geosite Milestones:

1995 SE Europe regional workshop in Sofia discusses strategy

1996 IUGS President writes to all National Committee announcing Geosites project

1996 First workshop on Geosites at Second International Symposium on Conservation of the Geological Heritage. Roma, June. Criteria established for site selection.

1996 Geoconservation workshop at IGC in Beijing

1997 Geosites database workshop in Tallinn, Estonia.

1997 First African Geosite/World Heritage workshop GSSA Johannesburg, September

1998 Belogradchik ProGEO conference, Bulgaria: Geosite IUGS - UNESCO World Heritage workshop. A draft European Geosite list compiled and discussed.

1999 Geosites workshop at Third International Symposium Madrid, November

In 1998, the World Heritage Centre of UNESCO provided substantial financial support for the Geosites workshop at the European Symposium held in Belogradchik under the auspices of the ProGEO and the Bulgarian Academy of Sciences. In 1999, successful talks have been transacted between the International Union for the Conservation of Nature and IUGS, and a formal concordat achieved on mutual support has been reached between the two unions; with IUGS mustering its unique geoscience expertise and assisting the World Heritage functions of IUCN through means of the GEOSITES project.

HOW DO WE IDENTIFY THE BEST GEOLOGICAL SCIENCE SITES?

Geology, as represented in a scientific site-based resource, is vast: its scope in space and time is difficult to comprehend. Anyone considering the conservation of sites runs headlong into this complexity. To quickly find the key sites internationally is “like trying to find a needle in a haystack”. Even if one is simply trying to label sites as “of international importance”, consideration of priorities is unavoidable. Geosites, a systematic approach, is therefore an absolute necessity. This is because there is no superficial, quick, way to find the priorities. There has to be objectivity. There has to be a systematic consideration and understanding of the resource. It was recognised at the outset in 1996 that much more data and well-directed and focussed judgements were required before any significant progress could be made. This is the only possibility, if there is to be truly objective consideration of proposals of geological sites. It is impossible to look simultaneously at all categories of site in all geographical areas. Therefore the guidelines promulgated at the Roma meeting are essential (see Appendix 3).

There is no possibility to say, a priori, that a site is special or unique: that must be judged in an objectively identified context, not in isolation. We no longer attempt to spot isolated so-called special' localities: we start by looking objectively at a comparative framework. The criteria for this are discussed below (see section Guidelines and principles). Therefore, before any site can be selected, the setting (country or region, has to be examined. The important settings/frameworks need to be identified.

METHODOLOGY APPLIED

There in a voluminous geological literature, which has been developed over 200 years. There is a community of geologists, geographers, geomorphologists and other specialists with an interest in the science and in the conservation of sites of interest to science, and therefore society. That community of scientists should recognise that it has a vested interest in protecting key sites. It does.

The methodology defined at the Roma Symposium has since been applied and the process of translation into languages other than English begun (e.g. Svetovna geoloska dediscina: Geosites. 1998), and applications undertaken in the light of national circumstances (e.g. Ukraine: Ishchenko, Gerasimenko, & Wimbledon, in press). It should be remembered that the canvas is not blank: many countries already have refined site inventories (e.g. Lithuania, Poland, UK, Belarus, Sweden). The method employed in Geosites is to identify what is special and representative in the geology of each country. Looking at a country within its regional setting. Before selecting a single site, we look to identify those features (time, topic, geographical or geotectonic units) that are essentially and outstandingly characteristic of a country or a region. That might mean the extended Pleistocene loess stratigraphy of China or fossil soils and loess of Ukraine, the granite landscapes of Macedonia or Zimbabwe, or the Jurassic fossils of England or the late Cenozoic volcanicity of Italy.

The pilot work on criteria and also framework construction have been taken forward using the ProGEO European liaison network and its member-country national representatives. As examples, Ukraine has shown the effective use of national geological and geographical committees to start the process of framework definition, and Yugoslavia, for instance, has given a good lead in showing how to form small and effective specialist groups, under a national leadership. Colleagues in Poland are working in specialist subgroups to revise their lists based on an existing refined inventory. British colleagues have been early to publish on the approach and suggested UK frameworks (Cleal *et al.*, 1999). This publication and invitation of an open debate is the approach which is favoured for the project in each country. Regional groups have started to both identify their frameworks, within which to select, and to make choices of sites or areas (e.g. Johansson *et al.* 1998). Such identification processes will operate through two mechanisms : one by national groups and regional groupings of country participants, and secondly through specialist contributors providing a wider international perspective, on, for instance, fossils or minerals, or the history of science. The support of a number of such specialist bodies has already been sought and agreed, including the Commission on Stratigraphy and INHIGEO, for instance. Many specialists can support national efforts in other countries. One preliminary global framework, that for Palaeozoic fossil plants, has already been published for consultation (Cleal 1996). Such geosite inputs provide a focus for cross-border collaboration, and an actual mechanism to assist and push the process of site identification in the countries.

The relation of the June 1998 Belogradchik, Bulgaria workshop** on frameworks (Ishchenko *et al.*, 1998), and of the Geosites methodology in general, to World Heritage may be summarised as follows

IUGS GEOSITES	World Heritage
1) Create a network of informants in countries	
2) Definition of regional/time Frameworks**	
3) National provisional Geosite selections	
4) Regional comparisons and finalisation	
	5) Country selection of a WH indicative list of regional Geosite lists
6) Acceptance by GGWG	
	7) Proposal of WH sites by countries
8) GEOSITE added to IUGS database	

IUGS Geosites work (stages 1-4 and 6) makes possible the robust justification of Geosites regional and global inventories and, in a parallel and overlapping process, may eventually be used to form a factual basis for wider initiatives, including WH site selection in the countries (5 and 7). International judgements of many kinds may issue naturally as a consequence of Geosites site assessments, and geosite work is in itself a subset and natural corollary of national geoconservation activity. Geosites can feed data and justifications into World Heritage.

Geosites works through constituent regional working groups, and these are given legitimacy by country inputs: from national committees, agencies, geological surveys. The method employed in Geosites is to identify what is special and representative of each country within its regional setting. Before selecting a single site, we look to identify those features (time, topic, geographical, geotectonic etc.) that are essential characteristics of country or regional geology (see Appendix 1).

Appended, as examples, are widely-separated country framework lists (Ukraine, Greece and UK). These were presented at the Bulgaria Geosite workshop. These examples show the level of interest of the framework elements, frameworks of wider geoscience significance, as well as how they are classified within Geosite categories. The approach will be to compare these framework with lists of adjoining countries in the regional working group, for NW Europe or the Balkans respectively, and to rationalise the country list and the lists of adjoining countries. Then the task of geosite selection starts. And sites will be fitted into their frameworks. As the first example of this, Appendix 4 shows this second step, a provisional comparison of a few Geosites (within frameworks) between Finland and Sweden. Thus we present three examples of the initial step (Appendix 1), the construction of generic frameworks, and also exemplars of step two - compared lists of actual geosites (Appendix 4).

The way forward now for Geosites is to spread an understanding of the methodology. The comparative evaluation of Geosites on a global scale is starting to take shape, but only starting. Preparatory work on criteria and frameworks has been done. For Europe we have a first draft list, to provoke a debate (Ishchenko *et al.*, 1998). Each country now needs to definitively establish its tectonic and stratigraphic/time frameworks through a process of refinement. This will show the essential elements that are regionally significant. Then, second, comes the job of selection of sites, as in the Finland/Sweden example.

PROGRESS SO FAR: FIRST COUNTRY STEPS

The GGWG in effect is constituted of, and operates through, regional working groups. These are made up of national representatives and specialists. In the initial stages of Geosites, lessons have been learned as pilots have been run, for instance, testing criteria in Europe, where geoconservation is more advanced. In Europe, several regional groups are in operation (North. SE, Central, Southern and Russia). Last June, at the Bulgaria ProGEO conference, the workshop met to consider a first draft list of frameworks, the essential building blocks, for European countries. There was discussion of this approach, and how this could meet the challenge of making a site coverage for Europe. Each country is now opening its list of frameworks to peer review and fuller internal discussion. In Italy the ProGEO Italian group has the responsibility of coordinating that work.

An important element of the Geosites method is that it depends not on suggestions of sites by individuals or a single agency within a country or external suggestions, but on selections agreed by all interested parties (and vetted ultimately by the IUGS national committee). This is an open consultation process. Groups, national and regional, are defining their framework elements, within which to make site selections. National lists for discussion have been and will be published. Some groups have studies on amplification of the basic criteria running, including through a number of national (Russia - Lapo, in press) and regional workshops (NW Europe - Johansson *et al.*, 1998; Central Europe - Alexandrowicz, 1999).

In selecting sites we have to find a way of overcoming and seeing through the complexity of the geological record. Many countries have some form of inventory, many do not. Few, if any, have comparative assessments of sites. In practical terms, the work of Geosites will be done in the countries and also through specialists groups.

For any country, depending on the nature of its geology and landscapes, we might identify special elements which must be demonstrated: they might, for instance, be ice limits, stratigraphic stage boundaries, the devel opment of a volcanic province or an orogenic arc, a set of meteorite impacts. The ice limits from Pleistocene glaciations in the Nordic countries were early identified as a special framework topic for investigation. One framework related to climate change and stratigraphy. In all countries there is now a need for a group to take the work forward. A National Committee, in Europe the National ProGEO group, or a group specifically convened to address the Geosite task. Each needs enough specialists from relevant disciplines so that the load is effectively spread and the best advice is obtained. This system is already operating in a number of countries (e.g. Alexandrowicz, 1999).

Stages to be followed in the Geosite process:

1) Form (or co-opt) a national group.
2) Invite general participation of geologists and other specialists in the country.
3) Identify country frameworks, and consult
4) Select first geosites in each framework.
5) Publish geosite lists and consult.
6) Revise lists and framework.
7) Compare in collaboration with neighbour-country colleagues.
8) Obtain a cross-border balance.
9) Publish and consult on regional geosite lists.
10) Finalise geosite list.
11) Document selected sites, and register them in the Geosites database.

The work done in preparation for and at the Belogradchik, Bulgaria conference, compiling a draft list for European country frameworks, was the first such work ever undertaken. It will be some time before valid comparisons and grading are possible on any scale. But the process has started. The pilot work has been done in Europe. After Europe, the priorities next are, in particular, Africa, and western and eastern Asia. Coming workshops in South Africa and Kazakhstan will be key steps to progressing Geosites.

PRINCIPLES AND GUIDELINES, ‘CRITERIA’, FOR GEOSITE SELECTION

The original Geosite “principles for assessment” and “guidelines for selection” were promulgated at the Roma Symposium (Wimbledon *et al.*, *in press*). They are repeated herein in Appendix 3. They are familiar to those concerned with site assessment in all its forms at national level. Allowing only for variations of terminology, they are familiar to many, they are not unusual, let lone unique, and have general utility, and are not affected by nor do they affect national or local practices.

Ishchenko and Gerasimenko (in press) usefully elaborated and discussed criteria for the selection of Geosites. These are summarised below.

The established Geosites method relies on use of a comparative and contextual matrix for site assessment. This provides a means to select the most valuable representative sites and areas, and these are intended to demonstrate chosen aspects of the geological heritage in their own spatial (time/space) or genetic (process/typological) patterns. But it is necessary to have criteria which allow one to evaluate sites of the same type, or to select sites which occur with others within a genetically homogenous area.

The Roma guidelines and principles stressed four important things, as a control on the selection mechanism for sites and terrains proposed as Geosites:

1) That the special, typical or unique features in space and/or time should be demonstrated in the proposal for a site.
2) The representativeness of a site in the geological column as a whole should be demonstrated.
3) A candidate should have an assessment within a named context (time/space), so that infomed judgements and comparisons with other candidates can be made.
4) Sites with complex records, a long history of research etc., are to be preferred as candidates (but new and unexploited sites were certainly not ruled out)

Geology as a science involves classification as a tool for understanding, but its main thrust is overridingly interpretive. Geoconservation is concerned similarly not with classification and comprehensive reperesentation of types, this would be sterile, butof natural themes, and a balanced understanding of the resource and its science. This understanding allows selection of the key sites, as evidence of the events and processes in geological time, and their three dimensional repesentation in that continuum.

The ‘criteria’ are as follows:

REPRESENTIVENESS is the first universal criterion proposed for the GEOSITES methodology. A geosite to be selected should represent the most complete and expressive manifestation of a geo(morpho)logical phenomenon of a certain category within a spatial-genetic pattern, and should allow the most comprehensive understanding of the nature and origins of the phenomenon. Categorisation is not key, but contextual relevance is. Sites are to be viewed in a context and not in isolation. The natural, but often subjective, and biased, tendency to select the ‘ best” site (see SPECIAL and UNIQUE below) must be subordinated to the need to be objective and systematic, and to reflect natural geodiversity. Otherwise, though some important sites will be selected, many others, vital to represent natural patterns, will be without recognition.

The criterion of being typical is more appropriate for assessment at a national or subnational level, in order to show the most common pattern of an area, for practical or scientific purposes. A typical site may not be very representative, and may not necessarily contribute a lot to the general understanding of related phenomena or a spatial-genetic pattern, considered in a wider regional or global setting.

The criteria of being SPECIAL or UNIQUE are closely connected. Actually the latter is an extreme manifestation of the former. Though it has to be said that no two sites are alike, and in that sense all may be said to be unique. (Specialness depends on the size of the area of search most of all, and even the most parochial of surveys will identify reputedly unique and special sites. It is necessary therefore to look at wider patterns and larger search areas.) The specialness (uniqueness) of a site can depend on different indicators: on quantitative parameters (thickness, depth, height, size, frequency –e.g. microfossils–, concentration –e.g.metals in ores–, rates of change –erosion, deposition–); or on qualitative parameters (an especially complete stratigraphic succession, unusual admixtures of mineral assemblages, or paragenesis, special combinations of fossils, soil processes, chemical signature for significant volcanic episodes); on spatial-temporal indicators (first, last, age range, appearances –e.g. first appearance of boreal floristic complex, a datable transgressive event, oldest crystalline rocks, youngest cryogenic features, last-dated Mousterian cultural elements–, or a disjunctive distribution for a species, opening of a plate suture). This criterion is important both on a national and a global level. A site, representative for a geological province, can be regarded as a special site in this category at a global level. One of the aims of a national contribution to the global inventory is to show different (special) patterns for a global category, demonstrated within the tectonic-geological provinces of a national territory. Sites, unique on a national level, may not be so at a global or regional level, whereas others are representative at a national level, but unique in a global context. The last are particularly valuable for a global inventory (and significant).

The criterion of SUITABILITY FOR CORRELATION is important, since sites selected on this basis demonstrate reliable evidence of temporal-spatial connections between the different ‘cells’ of a tectonic-geological framework, and they allow the justification of wider, global/regional, significance. The correlated objects themselves may not necessarily be very representative, but are typical in their setting. Reliability and usefulness of their correlation is the significant criterion of evaluation for such sites. The most valuable geosites are those that enable interregional correlation. So, chronostratigraphic stratotypes, or biozonal type localities, for instance, must always have wider significance than lithostratigraphic type localities or most type localities for species (fosil or mineral).

The criterion of COMPREHENSIVE MULTIDISCIPLINARY STUDY is essential as a tool for a well-reasoned justification of a site’s nature, origins and attributes, and of its place in a contextual-comparative framework, especially globally or regionally.

The criterion of AVAILABILITY AND POTENTIAL is a necessity because of the practical needs of the science, for further study to occur, and re-study, and so that the site may be used as a standard for some geo(morpho)logical phenomenon, as well as for educational and other cultural purposes.

These two last criteria are not leading ones, since they are preconditioned not by the intrinsic features of any site or monument, but by a human concern in them. Site evaluation employing these criteria is not constant, depending on the development of scientific and practical necessities.

Criteria of COMPLEXITY AND GEODIVERSITY may operate in the consideration of specific problems encountered when assessing complex geosites and geosite complexes. Due to the mutual impact of endogenic and exogenic (rock, and landform) geological processes, most sites are complex and polygenetic in their essence. This fact is further complicated by human socio-economic and aesthetic-cultural attitudes to some geological sites, and this add s to them other complexities and multi-faceted values. For instance a stratigraphic site, a single exposure, can be at the same time palaeontological, sedimentary, geochronological, palaeoenvironmental, petrographic, and historic-geoeconomic, and be the place to identify a time-stratigraphic unit. A geomorphological site, e.g. a river terrac,e may be at same time be a neotectonic feature, and if it is cut through have stratigraphic significance, and under the right circumstances could be a geoarchaeological (e.g. palaeolithic artefacts) or geological cultural-historic site (geoethnographic, aesthetical or for the history of science). To relate such a complex object to a certain site type for assessment in a regional setting needs firstly an evaluation of each of the site's substantive interests, viewed in the context of national comparative-contextual frameworks. So, the first step is to look at the contextual frameworks, rather than to look at all the interests of all the sites. The next step is to select those aspects in complex sites which are the salient ones, the most outstanding as against less important factors. This would show for which categories a site is most representative and this will trigger its nomination. The representativeness of a site in the specified category is a main criterion for further assessment. But under conditions of approximately equal grading, using this criterion, a more complex site should be preferred and be selected.

As mentioned, terrains exist which are characterised by a high concentration of geosites of different types - individual locuses in the Global Geosite methodology (Wimbledon *et al.,* in press). A geosite complex might also demonstrate a unique interesting combination of different kinds of sites. As an expression of different patterns of geodiversity, such terrains are invaluable in their own right. They can be regarded as a special category - locuses of geodiversity. This category is quite different from the categories published in the original Geosite classification. For those we use methods of analysis of individual interests and data: for the locuses of geodiversity we use syntheses of records. At present the standard site/locus category used in the original Geosite classification is more important for geosite selection and protection, while the connected criterion of geodiversity can be used as a supplementary for the purposes of assessment. Each subject component of a site locus is judged individually, divorced from all background 'noise'. But its score may be heightened by the fact that it also plays a role in the demonstration of geodiversity.

ACTION

The way forward is:

1) to extend the network of involved specialists in each country, to form groups of contributors, involving workers to cover all necessary geological and geomorphological topics;

2) to identify frameworks, the vital elements of the geology of the country (or region) - those salient and important features, large and small, which must be demonstrated;
3) to select Geosites - sites and areas chosen to exemplify these frameworks, or important parts of them;
4) to use the standard recording format (see Appendix 2) to start to document the preliminary site/terrain selections.

Our international geosite heritage is essential for science and education, and it is the shared responsibility of all geoscientists. All with an interest are asked to participate in GEOSITES, a collaborative effort to document the best of that irreplaceable resource.

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APPENDIX 1:

United Kingdom

Stratigraphic	
Quaternary	Thames Pleistocene terrace stratigraphy gravels/interglacial
	Weichselian ice limits S. Wales
	Anglian (Oxygen Isotope 'Stage' 12) ice limit/tills Cromerian interglacial Norfolk
	Saalian (OIS 6-10) sequences River Thames
	Late Pleistocene interglacial/glacial cave/beach sediments (Saalian-Weichselian) S. Wales
	Late Pleistocene interglacial (OIS 7, 5e) raised beaches S. England, Cornwall, S. Wales
Phanerozoic	Cambrian type area north Wales, SW Wales
	Ordovician (Arenig, Llanvirn, Llandeilo and Caradoc) type area Wales
	L. Silurian (Llandovery) stratotypes S. Wales
	Silurian reef, shelf-basin transition, classic Ludlow-Wenlock sequences Welsh Borders
	Type Devonian (marine) carbonates and clastics Devon Old Red Sandstone stratal Wenlock-Ludlow sequences Welsh Borders
	Type Devonian (marine) carbonates and clastics Devon Old Red Sandstone stratigraphy/lacustrine and fluvial environments, Orcadian basin and S-W.Wales
	L. Carboniferous Limestone of Pennines and paralic sequences of S. Scotland
	U. Carboniferous Millstone Grit deltaic systems Yorkshire, Derbyshire and Lancashire
	Best U. Carboniferous coal-measures in Europe, S.Wales
	U. Carboniferous regional boundary stratotypes
	Basal Jurassic marginal marine facies and basal unconformity, Wales
	L. Jurassic, classic marine Hettangian-Toarcian, west Dorset
	Aalenian-Bajocian condensed marine sequences Dorset etc
	Oxfordian, Kimmeridgian and Portlandian of Dorset, stage stratotypes
	U. Carboniferous Coal Measures in coastal sections, undeformed by Variscan Orogeny, NE England
	U. Carboniferous red beds, marginal coals and tectonic controls of sedimentation W. England
	Late Permian Zechstein Sea deposits, evaporites etc NE England
	Triassic-Jurassic boundary beds Somerset-Vale of Glamorgan

	Permian-Triassic red bed sequence of Devon coast
	Jurassic-Cretaceous marine/non-marine transition beds Dorset-Wiltshire
	L. Cretaceous type Wealden, stratigraphy and fluviatile and lacustrine environments of Weald
	Sub-Albian regional unconformity Dorset-Devon
	U. Cretaceous Chalk SE England
	Early Tertiary Hampshire-Paris basin
	Basal Tertiary Kent
Proterozoic	Late Proterozoic red beds (Torridonian) NW Scotland
Archean	Archaean/Proterozoic Lewisian (Scourian and Laxfordian), NW Scotland
Palaeo environmental	Late Triassic desert wadi fills S. Wales
	Latest Jurassic most complex marginal marine/non-marine Wiltshire
Palaeontological	Late Silurian agnathans Lesmahagow
	Early vascular plants, and major land plant radiation, Late Silurian-Devonian, Old Red Sandstone S. Wales
	Old Red Sandstone agnathans/fish, Orcadian Cuvette, Welsh Borders
	Lower Devonian petrified 3D flora, 'insects'
	Lower Carboniferous plant petrefactions, fern and gymnosperm evolution, S. Scotland
	Upper Carboniferous Coal Measure, best Westphalian plants S. Wales
	L. Carboniferous fish, first reptiles S.Scotland/Midland Valley
	U. Carboniferous Coal Measure insects faunas, W. England/S. Wales Elgin Triassic mammal-like reptiles
	Oligocene insect faunas Hampshire basin
	Fissure faunas/floras late Triassic, first mammals worldwide
	Late Triassic insects W. England
	Early Jurassic marine reptiles, insects
	Middle Jurassic plants central-eastern England, best worldwide Middle Jurassic mammals faunas, S. England, richest worldwide
	L. Jurassic-Early Cretaceous mammals, reptiles, insects Isle of Purbeck
	Wealden plants, classic L. Cretaceous floras, and insects, Weald
	L. Cretaceous Wealden dinosaurs Isle of Wight

	Cretaceous insects in amber, Isle of Wight
	Paleogene best paratropical rainforests, floral collapse with cooling London/Hampshire basins
Igneous, metamorphic and sedimentary petrology, textures and structures,	Tertiary lavas/intrusions Inner Hebrides, opening N.Atlantic Permo-Carboniferous volcanic vents Edinburgh Lizard ophiolite, melange, mantle rocks, pillow lavas etc. from Hercynian Rheic ocean sea floor Devonian-Permian igneous SW England, post-orogenic granites Ordovician-Silurian volcanics, south side L. Palaeozoic Iapetus ocean
Mineralogical, economic	Metasomatic mineralisation post-granite, tin etc Cornwall Polymetallic ores in Triassic sandstones NW England
Structural	Variscan front structures S. Wales Variscan tear faults, major S. Wales disturbances
Geomorphological features, erosional and depositional processes, landforms and landscapes	Chesil beach major tombolo landform Erosional structure/lithology-controlled coast E. Dorset Rias west Wales, Devon/Cornwall Cuspate foreland Dungeness Granite tors Devon/Cornwall Giant's causeway
Astroblemes	
Continental or oceanic-scale geological features, relationships of tectonic plates and terrains	Subduction at S. edge of Iapetus Ocean, accretionary prism, S. Scotland
Submarine	
Historic, for development of geological science.	Huttons section, Salisbury Crags, Edinburgh Classical unconformities e.g. de la Beche's unconformity Jurassic on Carboniferous described 1822 Portrush fossiliferous Lias/ Tertiary intrusions, settled neptunist:plutonist debate

	Hutton 1795 angular unconformities S. Scotland S.S.Buckman condensed M. Jurassic S.England First described pre-Tertiary mammal sites S. England

Greece

Stratigraphic	
Quaternary	Neogene-Pleistocene tectonically controlled sequence: mixed marine, lacustrine and fluvial
Phanerozoic	Plattenkalk sequences of Crete First flysch of orogenic significance Pre-Alpine basement sequences Eocene-M. Miocene molasse (Rhodope, Mesohellenic and Axios troughs) Small molasse basins (West and Cyclades)
Proterozoic Archaean	
Palaeo-environmental	Messinian salt crisis, evaporites and petroleum ores Lignitiferous basins (Miocene, Pliocene, Pleistocene) and faunas
Palaeobiological	Late Miocene mammal faunas
Igneous, metamorphic and petrology, textures, events and processes	Volcanic arc S. Aegean Ophiolite complex, deep-w. sediments, Iro & Ero sequences sedimentary Volcanics of earlier arcs
Mineralogical, economic	Bauxite and aluminium ores Igneous associations with Au, Ag, Fe, Pb and Zn
Structural	
Geomorphological, features erosional and depositional processes and landforms and landscapes	Marine terraces, sea level change controls

Astroblemes	
Continental or oceanic-scale geological features, relationships of tectonic plates and terrains	Isopic zones reflecting geotectonic regime and palaeogeography
Submarine	
Historic, for development of geological science.	
Ukraine	
Stratigraphic	
Quaternary	Loess-palaeosol sequences, M&S Ukraine
	Glacial-loess sequences, N Ukraine
	Marine-loess sequences, Kerch region
	Dnieper (Saalian)glacial sequences, N Ukraine
	Oka (Elsterian) glacial sequences, W Ukraine
	Fossil peatbogs of Likhvin (Holsteinian) W Ukraine
	Fossil peatbogs of Mikulino (Eemian), Dnieper region
	Chernozem soil types (world standards)
Phanerozoic	Vendian-Devonian, Podillya
	Silurian - Devonian boundary beds, Podillya
	Devonian sequences, Donets Variscan massif
	Carboniferous sequences, Donets massif
	L. Permian sequences, Donets massif
	Triassic sequences, Donets & Carpathians
	U.Triassic flysch, Crimea
	L-M. Jurassic sequences, Donets & M. Dnieper
	U.Jurassic and L.Cretaceous, Crimea
	L. Cretaceous, Podillya
	U. Cretaceous, Volyn, Donets and Novgorod-Siversky
	U. Cretaceous flysch, Carpathians
	Paleogene sequences, Carpathians & Crimea
	Eocene sequences, Dnieper-Donets region
	Oligocene sequences, Carpathians & Dnieper-Donetsk

	Miocene, Precarpathians & Dnieper
	L. Miocene, Ternopil-Dniester
	Middle Miocene, Precarpathians
	Miocene-Pliocene, Konka region
	Marine Pliocene, Kerch region
	Pliocene marine-continental correlation, Odessa region
	Continental Pliocene, Crimea
Proterozoic	Granites, basics & ultrabasics, Ovruch, Korosten & Priazovye
	Lower Proterozoic granites of Kirovograd-Zhitomir complex
	Lower Proterozoic diorites and gabbro-norites of Osnitsa complex
Archaean	Granites, charnockites and gneisses, Ukraine crystalline shield
	Iron ores, Saksagan' massif
Palaeo-environmental	Upper Silurian reef system, Poldillya
	Carboniferous forest, Donetsk massif
	Permian reef system, Donetsk massif
	Permian and Triassic fossil soils, Donetsk massif
	Eocene brown coal, Kirovograd
	Miocene reefs, Podillya & Crimea
	Dnieper (Saalian) erratics
Palaeobiological	Vendian algae, Podillya
	Late Silurian plants, Podillya
	Devonian plants, Podillya
	Carboniferous and Lower Permian biotas, Donetsk massif
	Lower Jurassic biota, Donetsk massif
	Cretaceous biotas, Volyn'-Podillya, Donetsk and Novgorod-Siversky regions
	Paleogene plants, Kirovograd
	Paleocene fauna, Cherkassy region
	Eocene molluscs, Zadonets region
	Paleocene fauna, Dnieper-Donets region
	Eocene-Oligocene biota, Middle Dnieper
	Miocene plants, Zaporizhya, Ternopil & Kirovograd
	Miocene fish, Precarpathians
	Pliocene biota, Odessa catacombs
	Early Quaternary mammal sites, Prichernomorsk region

	Middle Quaternary mammal sites, M. Dnieper Mammoth sites, Northern Ukraine Cave bear sites, Crimean mountains
Igneous, metamorphic and sedimentary petrology, textures, features, processes and events	Pliocene volcanoes, Transcarpathians Jurassic volcanoes, Crimea Riphean basalts, Rivne Jurassic marbles, Transcarpathians Devonian igneous rocks, Donets massif
Mineralogical, economic	Kaolinite, Ukraine crystalline shield Lead-zinc, Donets Variscan massif Hydrothermal minerals, Carpathians Palygorskite/bentonite, Ukraine crystalline shield Ozokerite, Carpathians Iron ores, Kryvy Rig Iron ores, Kerch Manganese ores, Nikopol Mercury sources, Donetsk region Titanic iron ore sources, Polessye Graphite sources, Ukrainian crystalline shield Sulphur sources, Carpathians Rock salts, Donetsk region Minerals of pegmatite veins, Ukrainian crystalline shield Mineral associations (amethyst, chalcedony, onyx, cornelian, jasper) of veins in igneous rocks, Crimea Weathering crusts of tuffs, Transcarpathians Veins of iceland spar, Eastern Crimea Polymetallic mineralization (galenite, sphalerite, smithsonite, cerussite), Precarpathians Ilmenite placer (Oligocene), Dnieper-Donets region
Structural	salt tectonics, Dnieper & Transcarpathians mud volcanoes, Indol-Kerch gothic folds, Carpathians Folds and faults of Proterozoic rocks, Dnieper region

	Vasilievsky fault (Precambrian) and North-Donetsk fault (Variscan), Donetsk massif Faults of Volcanic Carpathians and Crimea(Alpine)
Geomorphological features, erosional and depositional landforms	Karst lakes of Volyn Crimea carbonate-karst caves Donets salt karst Gypsum caves, Podillya Erosional landforms, Dnieper landslides, Carpathians & Crimea Crimea canyons Pinnacles of crystalline rocks, Ukrainian shield Pinnacles of Cretaceous rocks, Donets massif Pinnacles of Jurassic conglomerates, Crimea Caves in igneous rocks of Carpathians Glaciodislocation, Middle Dnieper Sand dunes of Lower Dnieper Danube delta system
Geoarchaeological and geological-historic sites	Acheulian - Mesolithic multilayered sites, Transcarpathians Paleolithic sites, Crimea Upper Paleolithic sites, Middle Dnieper Mousterian sites, Dniester region Final Paleolithic sites, Donetsk region Neolithic sites, Middle Dnieper region Bronze age sites, Donetsk region Scythian sites, Lower Dnieper region Heathen temples in Carpathian rocks Medieval cave towns in cuestas of Crimea The oldest mining of Donetsk coal basin The first oil mine of Precarpathians

APPENDIX 2

Format for recording Geosites for inclusion in IUGS GEOSITES Database

Primary identifying data

1. GEOSITE accession number
2. *National site accession number
3. *Geosite name (synonyms)
4. *State, county, parish/town (or equivalent)
5. *Geographical coordinate: national grid references, or latitude and longitude (international grid system preferred)
6. Character of site (e.g. crag/tor, quarry, sea cliff, river terrace, mine adit, reef, cirque, cave, drumlin, esker)

Primary geological data

7. Type of site (e.g. landform, stratigraphic profile - site may for instance be a cave, with a profile)
8. *Primary geo(morpho)logical interest (qualifying for GEOSITES status)
9. *Framework element or context represented (theme, region/province or age, e.g. ice front, time unit, fossil/mineral group)
10. *Chronostratigraphy
11. *Description of primary interest
12. *Comparative assessment/justification (site justified as part of theme, province or age)
13. Qualities in relation to other sites

Secondary supporting data

14. Map sheet (at least at scale of 1 : 50,000)
15. Elevation
16. Geosite area (hectares or km^2)
17. Protection status (assurances of integrity), accessibility
18. Literature, key references
19. Sources of data, collections
20. Illustrations
21. *Proposer(s)

* marks items that are the <u>essential data</u> required at the first stage of GEOSITES proposal. The rest can be filled in later.

APPENDIX 3
Principles for assessment of the scientific merits of proposed GEOSITES

A proposer of a GEOSITE should ask themselves the following questions with regard to the potential candidate site or area:

I) What is its significance for an understanding of geological evolution (inorganic and organic)?

ii) What is its significance for an understanding of geological/geomorphological mechanisms and processes?

iii) How complete are the phenomena present: are all relevant features covered, e.g. in a volcano, how complete is the magmatic series, how many effusive rocks and types, or periods of eruption, etc, are there?

iv) How well has the object been studied, how sizable is its literature, how well are key parameters measured (absolute'/radiometric age determinations, identification of minerals, fossils etc)?

v) What is the special, typical or unique feature of the site in time and/or in space? How are its rock/deposit/landform and its time/areal relationships significant?

vi) What is the quality of material which is the particular focus of interest at the site?

vii) For what part of the geological column or which geological phenomenon is this site representative?

viii) Categories (e.g. stratigraphic, mineralogical, volcanic etc) are not significant in terms of quotas. The types of site a country selects are to be determined by the nature of its geo(morpho)logical make-up, [its outstanding features and their contribution to geodiversity].

ix) In what selection network (time or thematic) does this locality fall, and make a vital part?

Guidelines for selection

Justification of the outstanding value of a proposed geosite should be demonstrated: this means that its position nationally and regionally has to be made clear. Its validated place as an example of, or part of, for instance, a regional structure, a vital stratigraphic interval, tectonic episode or glacial phase depends on the essential part it plays in elucidating such a theme, structure, event or epoch.

I) Size of an individual site is of no significance. Larger areas may contain multiple core areas' each independently of special' interest: interest, significance and representativeness should be demonstrated for each of these.

ii) Integrity is important, and any site proposed should be conservable, and protected [effectively] from damage.

iii) Geological conservation principles should apply, i.e. conservation means protection for use, including, where appropriate, collecting, [not preservation].

iv) As far as possible, inappropriate collecting, by both professionals and amateurs, should be discouraged (except, particularly, in areas of appreciable material loss through natural processes.

v) Sites should not be worked out', with all good and representative material removed to remote museums, other collections or private establishments. If specimens are not readily visible, then there should be good potential for further collecting.

vi) Museums on sites, with collections, may be a satisfactory alternative.

vii) The provision of sites for education, recreation, training and research may be a desirable factor.

viii) The integrity and conservation of a proposed site should be subject to monitoring, where possible and appropriate .

ix) Geo(morpho)logical sites are best considered singly, each significant interest being assessed: but synergistically, it may be desirable to group like sites as clusters or within larger entities such as national parks. However, all sites must be judged individually and be capable of standing alone for the purposes of assessment and justification.

x) Equal concentration of sites by area is not feasible (relative to size of country or other area): this must be the case, to avoid the charge of subjectivity.

xi) In selecting sites for Geosites, it is more important to assess candidates comparatively within a context, to make informed comparisons with other possible candidates: this involves some further research.

xii) Size (the largest') and age (the first' or oldest') are only some of the relevant factors, they cannot automatically be equated with the best'.

xiii) Sites with a complex record, subject to multidisciplinary studies, or with a long history of research, or a substantial bibliography are likely to be better candidate sites. But this does not rule out new or unexploited sites.

xiv) Nomination of a Geosite should be in the form of a concise and focussed well-argued case. The Geosite documentation format should be used.

APPENDIX 4

Geological features	Finland	Sweden	Evaluation
Stratigraphy *Quaternary*	—	—	
Phanerozoic Fissure fillings of Cambrian sediments in crystalline basement	Archipelago at Turku	Province of Uppland	Turku
Lower Palaeozoic	Minor occurrences	Represented in Sweden	
Proterozoic Vendian	Muhos, S. Oulu, NW Finland	Torneträsk area, NW Sweden	Equal
Visingsö, S.Sweden			
Post-Jotnian olivine-rich dolerite	Vaasa, E. Central Finland	Ulvön and High Coast, E. Central Sweden	Equal
Jotnian sediments	Satakunta	Transtrand-Fulufjället, W.Central Sweden	Transtrand
Rapakivi intrusions	Åland archipelago	High Coast	Åland
Post-orogenic granites, c. 1.8 Ga	Seglinge, SW Finland	Dala Granites, C. Sweden	Equal
Syn-orogenic intrusions			Pending
Svecofennian volcanics and turbidites	Pellinge	W. Bergslagen area	Equal
Stromatolite-bearing carbonate rocks	Torneå, NW. Finland	Kiruna, N. Sweden S. Swedish ore province	Equal
Argillites	Tampere Slate, S.C., Finland	Grythyttan Slate, S. Sweden	Igual
Quartzites	Koli Formation S. Sweden	Leksand Formation	Igual
Archean	Kuhmo E. Finland 2800 3200 Ma		Kuhmo
Palaeo-environmental *Palaeobiological*	— —	— —	

Geological features	Finland	Sweden	Evaluation
Igneous, metamorphic and sedimentary petrology, textures, events and processes Phanerozoic intrusions of alkali rocks	Iivaara, 365 Ma	Alnön, C. Sweden c. 550 Ma	Equal
Mineralogical, economic	—	—	
Structural Zone of plastic deformation and thrusting			
Proterozoic polyphase	Kullaa, SW Finland	Karlskoga, E. Värmland	Pending
Nappe elements C. Scandes		Alsen, Jämtland	Alsen
Geomorphological features, erosional and depositional processes and landforms Marginal moraine	Salpauselkä I Lohja, S. Finland	Fjärås bräcka, SW. Sweden	Equal
DeGeer moraines	Archipelago at Vaasa	Åråsviken bay	Equal
Mire	Olavassuo aapa mire N. Lapland	Taavavuoma	Equal
Ice-marginal delta	Sääksjärvi, S Finland	Ödskölts moar, SW. Sw.	Equal
Rogen Moraine		Rogen Area W. Central Sweden	Pending
Esker complex	Sákylänharju	Uppsala	Equal
Kames		Valle härad, S, Sw.	Pending
Sandur	Pohjangangas-Hämeengangas	Röjan, C. Sweden	Pending
Drumlins	Pieksämäki	Hackvad, S, Sweden	Pending
Aeolian deposits, dunes	Lohtaja	Mora area, S. Sweden	Pending
Shell detritus terraces	Minor deposits	Uddevalla area, SW. Sw	Uddevalla
Pot-holes	Hirvas, N. Finland	Sveafallen	Hirvas

Geological features	Finland	Sweden	Evaluation
Raised beaches		High Coast, E. Central Sweden	Outstanding
Astroblemes	Lappajärvi, Late Cretaceous, 77 Ma	Siljan district, Late Palaeozoic	Equal
Continental or oceanic-scale geological features, relationships of tectonic plates and terrains	—	—	
Submarine	—	—	
Historic, for development of geological science	—	—	

(*Italics* denote original Geosite categories)