Polish Geological Institute Special Papers, 2: 5–8 (1999)

GEOSITES — an International Union of Geological Sciences initiative to conserve our geological heritage

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A b s t r a c t . GEOSITES aims to compile an international inventory of use in conservation, nationally and internationally, aiding national and wider efforts to protect sites and promote geoconservation. Past efforts to label sites as being of international interest or significance or as worthy of World Heritage status have always run up against the lack of a proper database of sites, let alone one selected and judged in a comparative manner. The consequence has been that there has been no meaningful attempt to list sites of "international significance" and judgements of sites for World Heritage status can only be undertaken using rather subjective methods, that do not consider the complexity of geology in space and time. Therefore, GEOSITES proposes to adopt the kinds of methodical approach already being used in some national schemes for selection. The intention is to extend the network of involved specialists in each country, to form regional and national groups of contributors, involving workers to cover all necessary topics (geological, geomorphological and landscape). We will identify the vital elements of the geology of each country — those salient and important features, large or small, which must be demonstrated; then Geosites will be selected — to exemplify the vital geo(morpho)logical elements of the country and region. We will use the Geosites standard recording format to start to document the preliminary site/terrain selections.

Key words: geoconservation, international programme, IUGS, geosites, inventory, site selection, ProGEO.

Willian A. P. Wimbledon (1999) — **GEOSITES — inicjatywa Międzynarodowej Unii Nauk Geologicznych na rzecz ochrony dziedzictwa geologicznego**. *Polish Geological Institute Special Papers*, 2: 5–8.

S t r e s z c z e n i e. Program GEOSITES ma na celu utworzenie międzynarodowego rejestru, na poziomie krajowym i międzynarodowym, który wspomagałby narodowe i szersze starania służące ochronie stanowisk i promocji geoochrony. Dawne starania, zmierzające do wyróżnienia stanowisk podlegających ogólnemu zainteresowaniu lub stanowisk o znaczeniu międzynarodowym bądź godnych statusu światowego dziedzictwa, zawsze napotykały na brak właściwej bazy danych obszarów/obiektów wybranych w sposób porównawczy. W konsekwencji nie podjęto ani istotnej próby spisania stanowisk o znaczeniu międzynarodowym, ani oceny stanowisk celem nadania im statusu światowego dziedzictwa. Można się tego podjąć przy zastosowaniu raczej subiektywnych metod, które nie biorą pod uwagę złożoności geologii w czasie i przestrzeni. W związku z tym, program GEOSITES proponuje przyjęcie różnego rodzaju działań metodologicznych stosowanych już w niektórych projektach krajowych dotyczących selekcji geostanowisk. W każdym kraju zamierza się rozszerzyć sieć zaangażowanych specjalistów tak, aby utworzyć regionalne i krajowe grupy współpracowników zajmujących się właściwymi tematami (geologicznymi, geomorfologicznymi i krajobrazowymi). Na pierwszym etapie należy określić podstawowe elementy geologii każdego kraju, te wyraźne i ważne cechy, które muszą być zademonstrowane jako indywidualne stanowiska lub obszary. Weźmiemy pod uwagę standardy, a udokumentowane ich stanowiska/obszary poddamy wstępnej selekcji celem wyboru przykładów geo(morfo)logicznych elementów istotnych dla kraju i regionu.

Słowa kluczowe: geoochrona, międzynarodowy program, IUGS, geostanowiska, rejestr, selekcja stanowisk, ProGEO.

Geoconservation is an activity of importance to all geologists: it is a vital support to the prosecution of geological research, education and training. Geoconservation is a fact of life and a necessity, but some geologists only take notice when a key site which they cherish is damaged or lost. Often nationally, and certainly internationally, geological conservation has been the Cinderella in nature conservation. However, geoconservation is a key element in conservation as a whole, and the physical and geological natural wonders of the globe deserve just as much recognition as other elements. Taking a holistic view, geology underpins all landscape and biotic nature, it frequently controls and determines both. Geo(morpho)logical sites and terrains of outstanding global significance certainly merit recognition on a par with other internationally significant sites, such as those protected for wildlife or their wilderness value. The geological story, time and its scale are a continuing source of wonderment to Earth scientists and, always, to a laypublic: the conservation of sites which encourage and foster such wonder and awe is a challenge we face as geologists. From that awe and an understanding of sites comes respect, and an appreciation of the need for conservation. The wonder and the importance of the geological record lies in and is demonstrated in sites and terrains. Without sites there can be no science.

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IUGS, on behalf of the international geological community, has set up GEOSITES, an ambitious global scheme to promote geoconservation, focussing on the identification of globally significant sites and the compilation of an international inventory (Cowie, 1993; Wimbledon, 1996, 1997). Past attempts at selecting geological sites for World Heritage status have come up against the problem that there has been no international listing of key Earth–science sites, no inventory and no database. IUGS initiated GEOSITES (it is now also supported by UNESCO) in part to address this problem, and to realise geologists ambitions to have a representative selection of internationally significant sites and terrains included in world and regional listings, and site designations. Incidently, such activity will help to raise awareness nationally of the need to protect this heritage, simply by involving more geologists and colleagues in related disciplines.

The GEOSITES project, under the guidance of the IUGS Global Geosites Working Group (GGWG), aims to produce an evolving, comprehensive inventory (and database, to be held nationally and at IUGS Trondheim) of the most valuable sites for geology: sites included will be Geosites. Such a project has potential usefulness for education and research: it certainly has potential for promoting a greater knowledge of geology amongst a wider public, and for use in broader initiatives in geoconservation, including schemes to define international designations of site. It particularly invites and promotes cross-border links and collaboration.

Only geologists can compile a global geosite inventory and justify the significance of localities. This task will certainly take some years to achieve. It requires the promotion of meetings and workshops that examine site selection criteria, selection methods or conservation of key sites, and these tasks are already involving specialists, research groups, associations, etc. Ultimately, through Geosites it will be possible for IUGS to advise on the priorities for conservation in the global context. Without such a global inventory, and allied comparative assessments, designation of global sites would be much harder and open to the accusation that they were not based on an objective examination of the global picture: that has been the problem in the past.

GEOSITES methodology

The Earth is more than four and half thousand million years old. How do we demonstrate and judge what is valuable in that portion of history which survives in the rock record — evidence of plate growth, migration, collision and destruction, the evolution of life, of sedimentary basins, of mountain chains, rifts and volcanic provinces? To make any sense of the complex geology of any country or region, a concerted effort is needed to discern the patterns (regional and national), to define the context and fit sites (compared and graded) into that context.

Fortunately, the same classifications of rocks and landforms, of minerals and fossils, and divisions of geological time apply worldwide, so site categorisation is fairly easy. The identification and selection of potential sites for the international listing is the task. The scale of this undertaking immediately requires that a systematic method be employed, including integrated inputs from national and supranational groups of contributors.

If geological and landscape history had been the same in all parts of the world, and if the environments, minerals, rocks and fossils had been of uniform distribution, then the task would have been a simpler one. A lesser number of sites might have sufficed to demonstrate global patterns. However, this is far from being the case. We have therefore to select a limited, but representative, set of sites, to produce a balanced coverage between countries and regions. That group of sites has to represent many of the truly significant processes and events, time periods, features and topics. Geology and landscapes do not respect national borders: therefore coverage of sites and terrains has to conform to regional (supranational) patterns.

We need a coherent methodology for selection. Any *ad hoc* method would be unsatisfactory, for sites are then viewed in isolation, and the result would be a fairly random product, leaving too much to chance. It would be no simple or obvious matter to choose five or ten token sites to represent a geological period or minerals worldwide! Also, this method ignores the complexity of the rock record, and it could not give a fair coverage of localities between the countries; broader patterns cannot be thus assessed, and some countries would finish by having few or no sites in the list.

What is more, all countries do not have their geological sites inventoried (although GEOSITES may help with that problem), or some form of designation. Selecting a global list on the basis of pre-existing designations would therefore be difficult.

Time is of course the big factor which separates geology from other disciplines: in putting together a global listing, it is necessary to have representation not only of processes and features, but also to exemplify these through geological time. We avoid therefore the temptation of selecting just a few superlative localities ignoring the time matrix. It is not an easy task. GEOSITES is concerned with all of geo(morpho)logy, but to use a purely palaeontological facet of the record, the project has already come up against the puzzle posed by major extinction events in the Phanerozoic. Nineteen large-scale events that have been recorded (those with more than 50% species loss), each with varying degrees of clarity and precision. Some work is needed to decide which sites best represent an event, but first it has to be decided which events must be demonstrated. The same challenge exists at all levels: choosing which phases of glaciation must be demonstrated, and therefore which sites; choosing the mountain building or tectonic evidence that must be exemplified and so on.

Selecting the „best" mineral or fossil sites, or one or two sites to demonstrate a system, say the Jurassic sounds simple. However, is it, if one considers the notion of geo- and palaeobiodiversity? The Jurassic, for instance, was over 75 million years long, with broadly distinctive, but changing, fauna and flora, reflecting in part climatic and topographic change, and fluctuating sea levels. Even such well known Jurassic sites as Tendaguru, Dorset, Solenhofen, the Volga river sections or Como Bluff (all superlative localities!) show only a fraction of what is special or typical in that period.

Avoiding the pitfalls of *ad hoc* and subjective approaches, we are looking to use methods which have scientific rigour, producing a balanced, representative and fair coverage between the countries.

A method based on systematic survey and comparative assessment

We have taken the first step and recognised the scale of the geological resource and the potential number of interests available, we have an indication of the potential for selection and the

numbers of sites involved, based on various natural classifications of geological themes and time.

We wish to identify and document, not token examples, but those features, sites and areas which give an in-depth understanding of the Earth's evolutionary story, that show broader patterns, and which allow comparisons and correlations. In our balanced compilation of a regional or global inventory, we look therefore to include site/terrains which show significant stages and events, the special and, especially, the representative. There is no possibility that GEOSITES can include all the vital stages of the inanimate or fossil record of every period, epoch or stage, or region. However, the ambition is to encompass many of them.

The superlative nature of the site will ultimately determine selection; selection being carried out in acomparative and thematic way. There is good sense in identifying the more obvious and characteristic elements that make up a region and then trying to select sites in the units that are recognised.

The objective is to compare sites interests and their merits in a defined framework — a topic, event, time or regional geotectonic element (Wimbledon *et al.*, 1995; Wimbledon *et al.*, in press; Zagorchev, 1996; Alexandrowicz, 1997). So, sites are not to be selected in isolation, but in a chosen context. The use of specified frames (e.g. basin, event, stratigraphic pile, metallogenic phase) is vital, otherwise the enormous diversity of geological history is too much to assess: we would 'drown' in the detail.

Contributers

GEOSITES in practice relies on contributions of site suggestions from country committees, national agencies, groups and individuals. The aim is to channel such suggestions of single localities through regional working groups, each endeavouring to place a locality within a meaningful time, rock or other setting. Such regional groups will be able to call on the advice of other specialists, including, for instance, IUGS subcommissions.

For the outcome to have a high professional standing, inputs must be invited from all with an interest in the sites. Although regional comparative assessment and validation is important, indeed the key to the process, ultimately all selections will be made by geo(morpho)logists within the countries workers must be left to propose those sites which they judge represent the geological record of their region. Considering complementary sites, and not just the most obviously superlative ones, GEOSITES can accommodate sites or terrains ranging from those of high sub-national value, through national and regional, to those of the highest international significance, and even local complementary locuses. GEOSITES will thus include undoubted World Heritage standard sites, but also many others vital to geological science.

GEOSITES' purpose and uses

What is the point of GEOSITES?

1. Firstly its aim is to compile the GEOSITE inventory: background information and relative assessments that are vital, and have always been lacking in geoconservation in the past. This missing data has made international assessment or prioritisation, including that for World Heritage, unworkable.

2. It aims to bring together workers in many countries to undertake the task, and therefore it offers many possibilities for cross-border co-operation, such as that already operative in the GEOSITE regional working groups.

3. It can also give impetus inside the countries to work towards the compilation of national inventories. For some it offers an opportunity to promote the methodical compilation of listings and documention.

4. The terms "local", "national" or "international importance" are used rather loosely and usually with limited objective justification in geoconservation. One has the greatest difficulty at present when trying to elucidate the true relative merits of geological and geomorphological sites or landscapes.

An international inventory using the GEOSITES methodology offers the prospects, for the first time, of introducing the essential ingrediant of relativity into judgements of sites. It should be able to grade relatively the key sites in a country or region. This ability has particular use for those protecting geological heritage in the countries.

GEOSITES in action

In Europe, a number of national groups and individuals have already been running pilots for GEOSITES. ProGEO (the European Association for the Conservation of the Geological Heritage) is acting as an agent for IUGS in compiling a European inventory, and its regional working groups are assembling sub-European listings. Regional working groups operate in most parts of Europe (e.g. see Alexandrowicz, 1997). As an example of the approach, western and northern Europe, as a geological entity, is being considered under its natural subdivisions — the Fenno-Scandian Precambrian shield, the Caledonian orogen, the Variscide front, the Variscan massifs, the Alpine fold belts and so on. Within each tectono-geological framework element, stratigraphic, igneous or metallogenic successions or events can be considered and localised. Then sites are selected in such frameworks. Contextual elements may be of any kind. The aim will be to demonstrate the key features in, for instance, a tectonic setting such as the Variscan Front or a stratigraphic sequence within such a geotectonic framework element, such as a Tertiary section in the Danish Triangle or Permian volcanics in the Oslo Graben, or, totally different, ice-front features from the Weichselian Glaciation, or raised shorelines from interglacial or post-glacial times.

Regional inventories therefore will be made up of sites selected to show the character of chosen national and regional contexts: „shells" fitted one inside another, like nested Russian dolls.

Internationally, specialist groups will be asked to assist and work in parallel, to assist national efforts, contributing on particular topics, such as certain fossil or mineral groups or tectonic elements: for instance, a draft international list of sites recording the salient features of palaeobotanical history was presented at the IGC in Beijing, and discussions are going on over a similar vertebrate listing. The Stratigraphic Commission

are involved and INHIGEO has been asked to contribute sites of importance in the history of science.

Appended is the draft format for Geosite inventory recording which forms the basis for database construction and comparative assessment (Appendix 1).

The way forward: first steps nationally

GEOSITES offers prospects for strengthening efforts in both national and international conservation settings: lending support and helping to further national, internal initiatives and giving geologists regionally a focus for crossborder collaboration. It, for the first time, gives IUGS and the countries the possibility of having a database and an organic liaison network which it can use to advise on the scientific justification for global conservation priorities. It can help to put geoconservation on the map, and perhaps allow the proposal of candidates for the World Heritage List based on objective judgements. In the countries, GEOSITES has lead to advisory groups of specialists and GEOSITE committees being set up.

We have now to identify those features in each country which we regard as important in a wider context. For instance in my own country, most of the Permian and Triassic part of the geological column has very few sites of wider significance: we have no Miocene and little Pliocene compared to other countries, but there elements (for instance Variscan tectonic structures or Jurassic and Late Carboniferous stratigraphic sequences, Tertiary volcanism or Ordovician biotas, historical sites in the Cambrian and Silurian) which come to mind which will require Geosites to demonstrate them. Each country needs to examine its geo(morpho)logical strengths, nationally and regionally: it is these which will produce selectable sites.

The way forward therefore is:

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

2) to identify the vital elements of the geology of the country — those salient and important features, large or small, which must be demonstrated;

3) to select Geosites — areas to exemplify these vital elements (see Appendix item 9), or important parts of them;

4) to use the standard recording format (see Appendix) to start to document the preliminary site/terrain selections

These are the vital stages. It is important to state that regional selections come a little later in the process. Stages 1–5 in the country must be completed first, to give the factual basis for later comparison and comparative assessment.

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Appendix 1

Global GEOSITE Inventory and Database — format Oct '97

Primary identifying data:

1. Geosite accession number
2. *National site accession number
3. *Geosite name (plus synonyms)
4. *State, county, parish/town (or equivalent)
5. Geographical coordinates: national grid reference, or latitude and longitude
6. Character of site (e.g. crag/tor, quarry, sea cliff, mead-ow, river terrace, mine adit, reef, cirque, etc.).

Primary geological data:

7. Type of site (e.g. landform, stratigraphic profile, cave — see classification Rome Symposium paper: site may for instance be a cave, with a profile)
8. *primary geo(morpho)logical interest (qualifying for Geosite status)
9. *framework element or context represented (theme, region/province or age) (e.g. ice front, time unit, landscape unit, fossil/mineral group)
10. *chronostratigraphic age
11. *description of primary interest
12. *comparative assessment/justification (site justified as part of theme, province or age)
13. Related geosites.

Secondary supporting data:

14. Map boundary (1 : 50,000)
15. Elevation
16. Geosite area (hectares or sq. km)
17. Secondary interests (non-qualifying)
18. Non-geological interest(s) of site
19. Literature, key references
20. Sources of data, collections
21. Illustrations
22. *Proposer(s).

*Essential data required at first stage of geosite proposals: the rest can be filled in later, as documentation and comparison proceed.