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Earth-Science Conservation

An Absolute Need for Science and Education

By STEEN ANDERSEN, GEORGE P. BLACK, KEITH L. DUFF, LARS ERIKSTAD, GERARD P. GONGGRIJP, OSMO KONTTURI, HANS P. SCHÖNLAUB & WILLIAM A. WIMBLEDON

With 11 Figures

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1. Fundamental Thougths on Earth-Science Conservation

By GEORGE P. BLACK & GERARD P. GONGGRIJP*)

1.1. Introduction

The surface of our Earth has evolved through the prolonged operation of natural processes, some originating within the Earth, others occurring at its surface and still others being of extra-terrestrial origin. Together, over millions of years, the natural operation of these processes has produced an endless variety of geological landscapes, which differ from place to place and change with time.

Since the arrival of Man, however, nature has been manipulated. Initially, Man's impact was small but, as more and more natural resources came to be exploited, and as the scale of his attempts to control the natural operation of geological processes grew, this effect on the environment markedly increased. As a result, in many places on Earth, the local geology, geomorphology and pedology have been – and continue to be – greatly altered through human activities such as intensive agriculture, river regulation, coastal protection, mineral extraction and all types of construction. Such activities often lead to the partial or total destruction of entire geological sections, geomorphological features and soil profiles, and, although mineral extraction and road and railway construction often leads to the creation of exposures showing the internal structure and composition of landforms, this is only small compensation for the eventual destruction of the landform itself. For unless there is some intervention in the interests of Earth-science conservation, most such artificial exposures are likely to have only the shortest of lifespans. Furthermore, since many geological features are, in effect, "fossil" rather than still actively developing, a significant proportion of geological landscapes, once destroyed or damaged, can not be replaced or repaired.

At the end of the nineteenth century, the increasing impact of Man on the landscape led to the rise of nature conservation movements all over the world; in these movements, biologists took the leading role. Earth scientists, many of whom were involved in the exploitation of natural resources, were, in general, not fired with the same enthusiasm for conservation. Moreover, at that time, mineral exploitation was not extensive by present-day standards, was little regulated, and the "restoration" which today damages the scientific interest of so many disused workings was not commonly practised. Nevertheless, individual Earth scientists and members of nature conservation societies gradually became more and more involved in Earth science conservation until, in the second half of the present century, there was a general move towards the adoption of more active policies for Earth-science conservation during a general revival of interest in nature conservation as a whole. At this time, initiatives were taken in several countries to preserve important Earth-science sites for scientific and educational purposes and selection criteria were developed to identify where priority should be given to the needs of Earth-science conservation rather than to other potential land uses, when the future of exposures, sections and features was under consideration. At the same time, inventories of valuable sites were commenced and policies for Earth-science conservation were formulated at a national level. However, although geology pays no attention to frontiers, international contacts among Earth science conservationists remained few, except between some specialists.

1.2. International Co-operation

In 1987, inquiries made among Earth-science conservationists showed that there was a great need for, and a general desire for, an enhanced level of international contact. Based on the results of this inquiry, the first international workshop was organised in 1988 at Leersum in The Netherlands by the second author. At this meeting, the twelve participants from Austria, Denmark, Finland, Great Britain, Ireland, Norway and The Netherlands discussed the following subjects:

- Legislation; conservation policy; the classification, listing and selection of sites; site management and educational usage.
- The establishment of an international working group.
- The production of a newsletter.
- The implementation of international projects.

During the meeting, it became clear that, in the participating countries, Earth-science conservation had been treated more or less as a step-child in comparison to "biological" conservation, although there were legal provisions which make Earth-science conservation possible. There was confidence that this situation would be improved if an active working group were set up to operate on a national and international level.

This first meeting resulted in the establishment of the European Working Group on Earth-Science Conservation with the following aims:

- Exchange of information; by a newsletter and through meetings.
- Mutual support; as had happened in the past on the Bartonian type locality.
- Promotion of Earth-science conservation; on both national and international levels.
- Organisation of annual meetings; with general discussions, special items and an excursion.
- Production of a newsletter; twice a year.
- Implementation of common projects.

A common project identified at the first meeting was the preparation of an informative article on international Earth science-conservation to be illustrated by examples from the different countries. This to appear

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in Autumn 1990 in "Naturopa", a journal on nature conservation published by the European Information Centre for Nature Conservation of the Council of Europe. A wide variety of sites and areas of Earth-science significance from each of the participating countries will be discussed to draw attention to this special branch of nature conservation.

1.3. Second International Meeting on Earth-Science Conservation

The second international meeting on Earth-science conservation was organised by Dr. WALTHER KRIEG, Director of the Vorarlberger Naturschau in Dornbirn and was held at Schloss Hofen in Lochau, near Bregenz, from 6th to 10th May 1989. It was attended by Earth scientists from eight countries – Austria, Denmark, Finland, Great Britain, Ireland, The Netherlands, Norway and, for the first time, from Switzerland. On this occasion, the first day was devoted to the presentation of the papers which appear as the succeeding chapters, and was followed by a day spent in general discussions and the formulation of a strategy for the future. The two days of excursions showed a wide range of conservation problems, particularly those specific to mountainous regions.

During the discussions, it was reported that progress had been made with the preparation of site inventories in several countries. The inventories for Great Britain and The Netherlands had been completed and in the former country had even been partly revised. In Finland and in Switzerland the authorities are to undertake site selection in the near future and in Austria discussions on site selection at a national level will shortly be initiated. In Ireland, an inventory compiled in the '70's requires up-dating and incorporation in national nature conservation policy and this was to be discussed late in 1989. In Norway conservation policy gives priority to inventory preparation and to the protection of representative Quaternary landforms and of (threatened) fossil and mineral localites.

The need to prepare a European site list was considered as was the need to standardise the methodology and criteria of site selection. With the need to involve countries at present unrepresented on the working party in mind, consideration was given to the production of a manual on site selection, selection criteria and site grading (see below).

During the discussion on site management and educational usage, the problems caused by the concealment of landforms by reforestation were briefly discussed. For exmaple, in The Netherlands, reforestation plans which have been drawn up for an area of small landforms (creek ridge systems) threaten to change the landscape and render it impossible to see these fine-scale geomorphological features. Examples from other countries were mentioned and it appears that this is a problem of international occurrence.

Discussion on the benefits to be had from the adoption of sites by geological societies – generally agreed to be an effective means of conservation – led to a consideration of the degree to which each country's geologists were organised. This varies markedly from country to country, from a low level of organisation in Norway to a high level in Great Britain.

It was recognised that the usage of sites, even for quite legitimate purposes, could give rise to management problems and lead to difficulties with site owners, especially in the case of fossil and mineral localities and caves. In Britain much had been done to solve such problems through the adoption of a national "Code of Conduct" for geological fieldwork prepared by Dr. ERIC ROBINSON of the Geologists' Association. It was agreed that he should be asked to co-ordinate the drafting of a European code with the help of the representatives of the other countries.

Full regard was given to the need to promote Earth-science conservation among the general public through providing easily understood leaflets and displays at information centres and museums while, at the same time, attempting to interest national and international policy agencies such as EEC, IUCN and The Council of

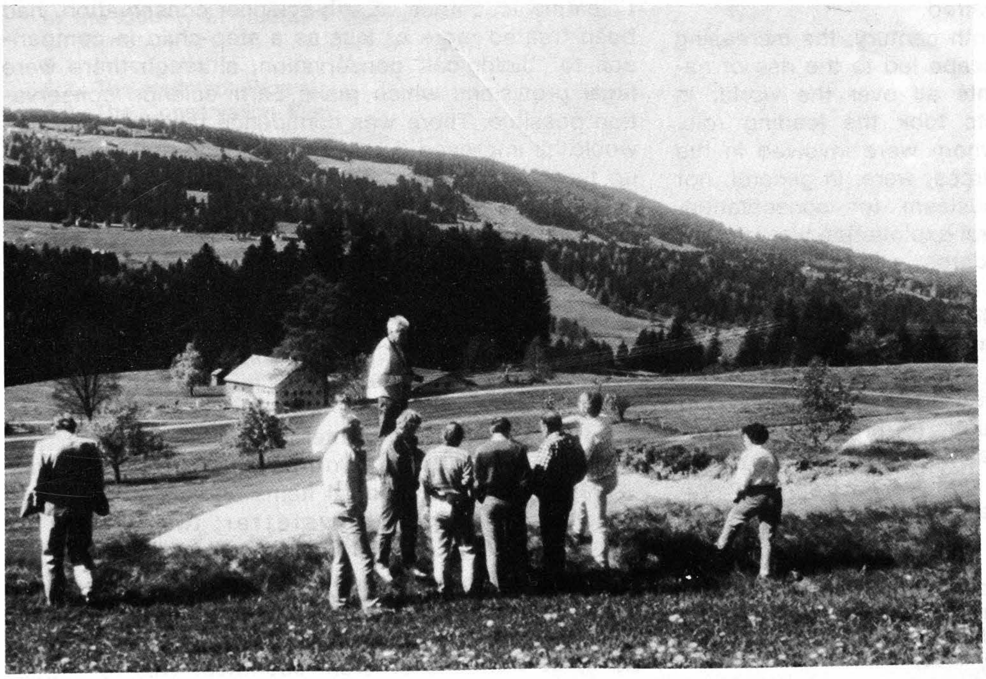

Fig. 1.
Members of the European Working Group on Earth-Science Conservation on excursion in Vorarlberg visiting a roche moutonnée.
Photo: G.P. GONGGRIJP.

Europe and scientific organisations such as IGU, IUGS, ISSS and INQUA.

A new opportunity has recently been given to nature conservation through the possible cessation of farming on marginal agricultural land. In places where this occurs, an enlargement of the areas protected in the interests should be possible and in The Netherlands and in Denmark, for instance, initiatives have already been taken to transfer farmland which is to be abandoned into biological nature reserves. It was felt that this opportunity was also relevant to Earth-science conservation and that geologists also should take part in the discussions and planning for any such changes in land-use.

The Working Group intends to publish a Newsletter twice a year to give news of the latest meeting and of the programme for its successor along with news from individual member countries and reviews of books, legislation and of any other relevant developments.

A sub-committee was formed to look into the preparation of a manual for Earth-science conservation, which was seen as being both a means of influencing authorities and of encouraging colleagues in other countries in addition to its long term aim of standardising methods. Such a manual should contain information on classification and inventory procedures, the selection, registration and management of sites, the role of conserved sites in education, the organisation of Earth-science conservation and other related topics. A draft is to be produced for discussion and ratification at the 1990 meeting and, when published, it is intended that ist should be presented to the Council of Europe and widely circulated to interested organisations.

To follow up the manual, a European site list, comparable with that produced by the Corine project for biological sites, should be produced, having been selected by use of criteria developed from those outlined below by Dr. WILLIAM WIMBLEDON. It is intended to take this matter further a the 1990 meeting to be held in Norway.

2. European Heritage Sites and Type Site Inventories

By WILLIAM A. WIMBLEDON*)

2.1. Introduction

All European countries have features of international interest to the Earth scientist. Landforms and rocks present evidence of past events and environments, and this evidence is not limited by national or regional boundaries. The Earth sciences are truly international in outlook, and the complex story of, for instance, volanic episodes, of ice-ages and of sealevel changes and many other widespread events can be traced across the continent.

At its meeting in the Netherlands in 1988, the European Working Group on Earth-science conservation discussed the need for the compilation of lists of "type sites". A type site is here defined as follows: any site in the modern or historical type area for a rock or chronostratigraphic unit, or the site/area where rock, geomorphological/landscape or pedological phenomena were first defined or recognised. The label is not here-confined to stratigraphic sites alone.

At its second meeting in Bregenz further consideration was given to this difficult task. The author proposed that the exercise was worth doing because, by the labelling such localities or areas we could

1) add support to local or national initiatives to protect sites,
2) submit finalised European lists to the EEC, Council of Europe, UNESCO etc. for use in their work in the wider protection of geological, geomorphological or landscape features,
3) gain added status for sites which are although already recognised locally deserve wider recognition, and
4) gain publicity for such labelled sites, which should heighten public and government awereness of all Earth-science sites, be they tiny fossil sites or enormous wilderness areas.

How to go about compiling lists of heritage/type sites.

2.2. Categories

Most European states have compiled or started to compile inventories of their earth-science localities. This does not, however, address the problem of priorities in an international setting. For instance it has been suggested that Britain has 100.000 "sites" of earth-science interest. Around 3100 of these are to receive protection under existing national legislation. Some hundreds of these might be considered as contender European type sites, but only a small percentage would be regarded as truly international heritage sites using present strongly anthropogenic criteria, even allowing for Britains unrivalled, rich and varied rock, fossil and landform record.

There are a number of possible ways in which sites may be categorised in attempts at putting together a European type site or type area list, all of which are used to a greater or lesser extent in prioritising site selection in local or national conservation schemes.

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Categories: 1) "Best" sites
2) Unique sites
3) Firsts
4) Patterns.

2.2.1. "Best" sites

That is the best example of a particular category, for instance where are the best Little Ice Age moraines and associated features, perhaps in Norway? Many countries have features from this period but where are the best suites of them? Depending on the number of categories one uses (e. g. representative parts of the geological column, key fossil groups, landform or landscape types) there is much scope for division and subdivision.

Just thinking of geomorphological and landscape examples – Where are the best natural soft coast landforms, Ireland? Where is the best example of a major tombolo – Chesil beach? Should such sites be considered singly or in a suite of coastal features? Where are the best unmodified last glacial erosional features? There are many Weichselian cirque assemblages. Where are the best push-moraines? And so on ...

Categories and their possible divisions are many. Some nations are richly endowed with unmodified landscapes but others have next to no intact landforms but many important hard rock localites. One nation might even possess all the sites in, for instance, a single landscape category.

2.2.2. Unique sites

Localities with international renown for the nature of their geology, be it rocks, minerals, fossils or landforms. Obvious examples that come to mind are:

- Holzmaden with its Lower Jurassic marine reptiles.
- Stonesfield or Swanage with their Jurassic mammal faunas.
- Monte Bolca's Tertiary fish.
- Fjords landscapes of Norway or the bogs of Ireland.
- Pleistocene beaches and international standard sections in Calabria.

2.2.3. Firsts

The localities where the first recognition of a depositional or erosional process took place, where a major time unit was first defined, or an orogenic or stratigraphic event or a vital step in organic evolution was identified – these are all of the highest historical interest. They have a high social history value also.

The recognition of the significance of a natural phenomenon e. g. the sites in Switzerland where CHARPENTIER and VENETZ identified glacial erosional and depositional landforms as being the result of a previous catastrophic ice age fall into this category. The detailed later elucidation of such glacial features of the chronology of such features in a key area e. g. the Würm (Weichselian) limit in the Danube tributaries by PENCK & BÜCKNER might be equally important.

The realisation that ancient volcanoes had produced the igneous terrains of Europe, and the elucidation of the workings of ancient volcanoes may be attributed to early geologists such as DESMAREST at localities in the Auvergne. Such sites, and those where HUTTON first recognised the significance of unconformities for what they prove about past upheaval of the Earth's crust, would rate highly in the history of science and in this category.

There are many many type areas for time or rock units (e. g. Allerød, Tiglian, Bajocian, Wenlock, Danian, Kimmeridgian, etc.) but not all such localities may have a wider international significance although many do.

2.2.4. Patterns

The commonest category of sites in most classification systems, the sites which demonstrate the salient or significant features, be they hard or soft rock or landform, which occur in or typify an area, large or small.

There are related suites of features (coastal landforms, ice front features, erratic trains and their source areas, volcanic episodes and stratigraphic units) which cross frontiers; these may be a need to be assessed in a wider context. There are many areas and sites in the historical stratotype or type example category which will always be of international importance (using stratigraphic examples – e. g. the Barrandian, Downtonian and Devonian type areas). Such type examples figured strongly in the early years of the science or of the branches of geology and they are still key localities. The standardisation of stratigraphy or any other field of study are the definition of a mere handful of global types, standards or stratotypes does not alter the significance or the daily usage or usefulness of historical sites or areas.

2.3. Conclusions

In collaboration with local, national and international bodies, and individuals, we the EWGE-SC should set up a steering group to refine a standard set of criteria for judging such sites in a European context, and then set to the task of compiling a type site list for Europe.

3. Managament and Educational Use of Earth Science Sites in Great Britain

By KEITH L. DUFF*)

3.1. Introduction

The relatively small size of Britain, with its high overall population density, means that there is a good deal of pressure on geological and geomorphological sites which are used for teaching or research. In many cases management of the site, either directly or by publishing guides which direct students to sites which can accomodate heavy use, is the best way of protecting the site so that it will remain usable in the future. This paper explains how site management is carried out, and shows how educational use is channelled towards appropriate sites.

3.2. Site Management

Management of geological sites in Britain is largely concerned with maintaining them in a state where they can be used for study. This usually consists of little more than ensuring that they are not destroyed or damaged through infilling with waste, through being built upon, or through being quarried away. Only in a relatively few cases does management consist of taking positive action to re-expose geological exposures, and this only usually happens when the site is owned or managed by a conservation organisation. Generally, site management is of an indirect nature, concerned with maintaining the status quo. This is mainly carried out through the operation of the physical planning legislation in Britain, and principally through obligations placed on the planning authorities as a result of specific localities being notified by the Nature Conservancy Council as Sites of Special Scientific Interest (SSSIs).

When geological SSSIs are threatened by development proposals it is often possible to negotiate and agree modifications of the schemes, so that a multipurpose land use which combines conservation and development is evolved. Many such agreements are negotiated with developers by Earth-scientists from the Nature Conservancy Council (NCC), with great success. For example, factories have been built in old quarries, but the rock faces have been left undisturbed, and building has been kept away from them, so that geologists can continue to study them. In other instances, important geological sections have been retained as parts of waste disposal schemes.

Direct management of Earth-science sites fall into two groups, those managed by the NCC and those managed by others. The NCC has indirect control over SSSIs, and can influence development proposals at them, even though it does not own them, and only has formal management agreements over a small percentage of others. However, few of our nationally important geological SSSIs have been destroyed, and the SSSI system continues to be an effective way of protecting Earth-science localities. In the case of National Nature Reserves (NNRs), the NCC has much greater direct control, either by owning, leasing or managing the land. Of the 234 NNRs, about 10 % contain nationally important Earth-science features, and these are much less at risk from damage than most other sites.

Other organisations who safeguard geological sites through management include local councils (who manage Local Nature Reserves), and the voluntary nature conservation trusts. The latter consist of a series of independent local groups made up of keen amateur and professional naturalists and Earth scientists, who own and lease land which is managed as nature reserve. Some of these are of geological interest, and British geologists are trying to increase the involvement of these local trusts in conserving Earth-science sites.

In addition, local geologists are working with the NCC and with national organisations such as the Geologists Association and the Geological Society to set up a system of "Regionally Important Geological Sites" (RIGS). These are notified informally to local councils, who are asked to do what they can to protect them as local assets.

At all of these sites positive management for geology is sometimes undertaken. This normally takes the form of excavations made by bulldozers or other machinery, to re-expose rock sections which may have been hidden by fallen rock, soil or vegetation. Many long-lost classic geological sites in Britain have been resurrected in this way.

3.3. Educational Use of Sites

In Britain, Earth-science sites are conserved so that they can be used for teaching or research, not so that people can be stopped from using them. There are very few sites in Britain which are so vulnerable that any form of access control has to be employed. However, there are undoubtedly a number of sites which could be damaged if they were used for teaching or collecting by too many people, and so the NCC has a policy of publishing geological guidebooks to specially chosen sites that can accomodate heavy user pressure without being damaged. This "diversionary" approach has been used in a number of areas, and depends upon making sure that the sites in the guide are easy to get to, show good clear features, and are well explained and described in the guidebooks. Our Mendips and Malvern guides fall into this category.

Other guidebooks direct geologists to smaller areas, or individual sites, which again are unlikely to be damaged by excessive use. To make sure that good fieldwork practice is encouraged, the guidebooks

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suggest exercises which may be undertaken at the sites, and these are intended to teach students to observe and think, rather than use their hammers to no useful purpose.

Other sites have been developed for local use, with notice boards and other facilities. Some of these have been developed by local councils, such as the Permian reef at South Elmshall in Yorkshire, where the local authority has worked closely with NCC and with the Geologists Association to produce a much-used teaching site.

Other initiatives include the publication by NCC of a manual for teachers of geology, which encourages the wise use of geological sites through the use of series of case studies which give examples of how sites can be used in novel ways.

In the longer term, it is important to raise the awareness of geology amongst landowners and the general public. The NCC is doing this through the production of a series of simple leaflets which explain what various elements of geology are all about. Other leaflets are being written specifically for planners, for the minerals industry and for policy-makers, to explain how and why geology is relevant to them. This form of general education is vital if geological conservation is to become better understood and more widely supported.

3.4. Conclusions

Management and educational use of geological sites are very closely linked, and we should become more innovative in our management of sites for teaching. In doing this it is most important that we build up more awareness of geology and its significance to the industrialised society in which we live, amongst the general public. Without this, geological conservation is always going to be a minority activity, poorly understood or supported by policy-makers, planners and landowners. It is important to all geologists that we succeed, and closer links between geological conservationists throughout Europe can serve as a powerful way of raising the profile of our work.

4. Geological Sites and Raw Material Exploitation

By STEEN ANDERSEN*)

4.1. Introduction

The exploitation of raw materials has a great influence on geological monuments as well as on the general geological environment. Such exploitation has a massive and largely negative impact on landforms but, on the other hand, one of the consequences of mineral working is to open up geological sections and make them available for study – an important fact of life in a country of low relief like Denmark.

Ideally, geological investigation should follow closely on the exploitation of raw materials so that the benefits to geology are maximised or, at least, so that the injury caused by mineral working is minimised. In achieving this, the Raw Material Act provides Earth scientists with a useful tool.

The Danish Raw Material Act has four functions:

1) It ensures that the areas to be exploited are optimally located through the operation of the regional planning process.
2) The permissions given under the Act regulate the timing of the exploitation.
3) The plans for extraction and restoration describe in detail the pit as it will be during and after exploitation.
4) An economic guarantee is required and this secures that the restoration plan is followed.

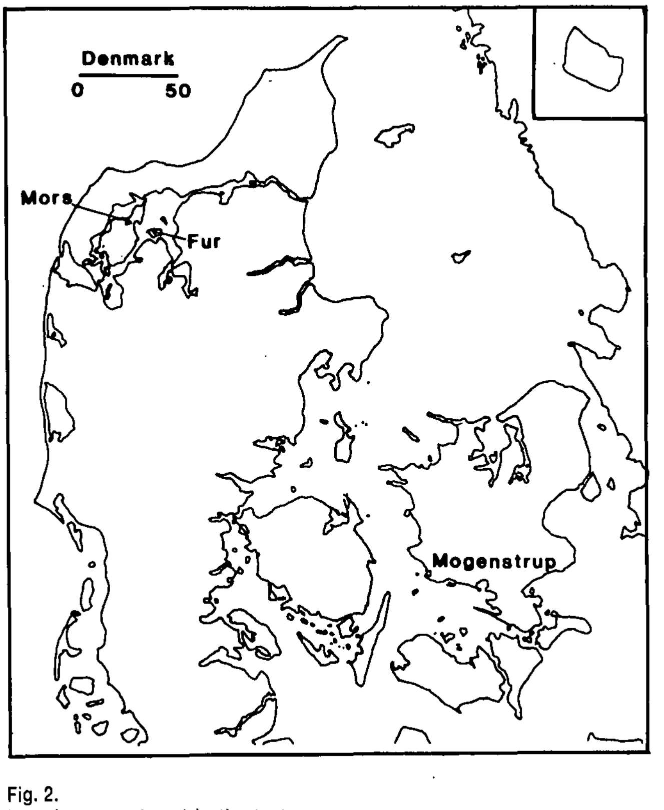

Fig. 2.
Locations mentioned in the text.

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Fig. 3.
Folded mo-clay with ash layers.
Hanklit, Mors.
Photo S. SJØRRING.

The geological benefits of the Raw Material Act arise mainly from the first provision, which determines the siting of the pit, and from the third, which ensures that both the extraction and restoration are planned in advance. These benefits are demonstrated in the two case histories which follow.

4.2. Mo-clay Exploitation on the Island of Fur and Mors

4.2.1. Geology

Mo-clay is a white, early Eocene, diatomite clay formed in shallow marine waters, within which are intercalated about two hundred contrasting layers of volcanic ash. Many of the ash layers serve as marker-horizons, and these can be as easily recognised by a layman as by a trained geologist.

The mo-clay occurs in elongated, ice-pushed ridges along the northern coast of the islands. There is a close relationship between morphology, fold structures and faulting, as innumerable sections demonstrate. The whole area is an extraordinary example of alpine folding on a pocket scale, a combination of features which makes the exposures of mo-clay of great value to Earth-science.

4.2.2. Exploitation

Exploitation of the mo-clay deposits has taken place since the beginning of the century, and a large number of small pits has been opened throughout the area of their occurrence. Most are placed along the crest-zones of the ridges because the anticlines of the fold structure bring the mo-clay close to the land surface. This location of the mo-clay workings poses a major problem for environmental protection as the pits catch the eye, even at a long distance.

The mo-clay provides a resource which is utilised for insulation bricks, absorption powder, etc., and reserves are large; the producers, however, face the problem that, under the provisions of the Raw Materials Act, the existing rights of exploitation expire in the year 2003.

4.2.3. Planning for Future Exploitation

There was thus an obvious need to devise a plan which will provide for both the protection of nature in

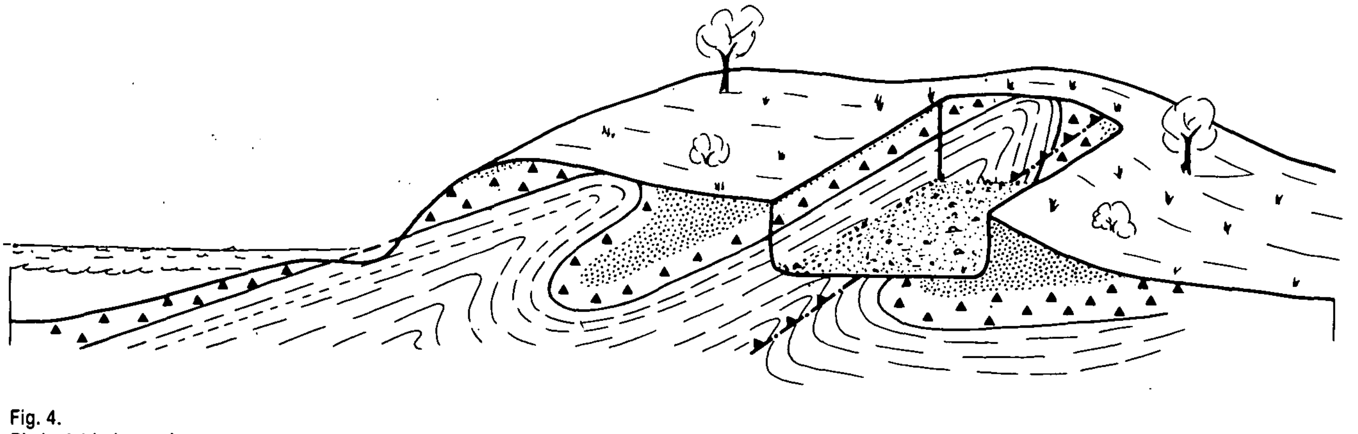

Fig. 4.
Pit in folded mo-clay.

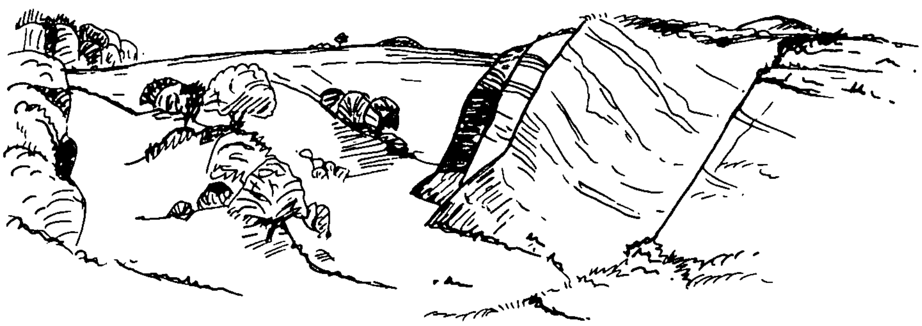

Fig. 5.
Restored mo-clay pit with open profiles.
Drawing after B. NIELSEN.

the general public interest and the long-term, legal rights of exploitation needed by industry, and this was done by a working group consisting of representatives from the mo-clay producers and from the local, regional and state authorities. The fundamental evaluation of the resources was made by the Geological Survey and an inventory was made of landscape values, geological interest, recreational usage etc.; an estimate of the required production of the different types of mo-clay was also prepared. Against this background, plans were then drafted to locate the areas of future exploitation and to prescribe the working and restoration routines for each extractive site.

In short, the mo-clay producers secured the rights of exploitation in selected areas for an estimated period of 50 years based on the rate of actual production. In return the producers committed themselves not to exploit the mo-clay in other areas where legal rights to do so already existed. Plans were prepared for the working and restoration of every locality. According to the agreement, the mo-clay producers will complete the restoration of new as well as old clay pits. This is substantially more than what is required by the Raw Materials Act and the new plan reflects the whole-hearted acceptance of the needs of nature conservation by the authorities.

With regard to the needs of geological conservation, three general principles were followed. Firstly, the morphology will be cleaned up by removing vegetation; secondly, all mo-clay pits will have to be retained but their appearance will be to some extent camouflaged by vegetation; and, thirdly, faces providing longitudinal profiles of mo-clay with ash layers will be left open, and cross-sections will be cut, for the benefit of science and education.

4.3. The Mogenstrup Esker

4.3.1. Geology

The Mogenstrup Esker in southern Sjaelland is one of the most impressive eskers in Denmark with a hight ranging from 25 to 50 meters and a total length of 10 km. The esker follows a major glacial drainage system across the Island of Sjaelland and consists of a number of isolated ridges of which only the easternmost has been described.

4.3.2. Exploitation

The esker, however, contains excellent gravel for use in concrete and in road construction. Therefore, by the time when the authorities obtained legal powers to intervene in its exploitation, more than half of its extent had already been dug away.

4.3.3. Planning for Future Exploitation

The future exploitation of the resources of the esker has been the subject of a working group representing

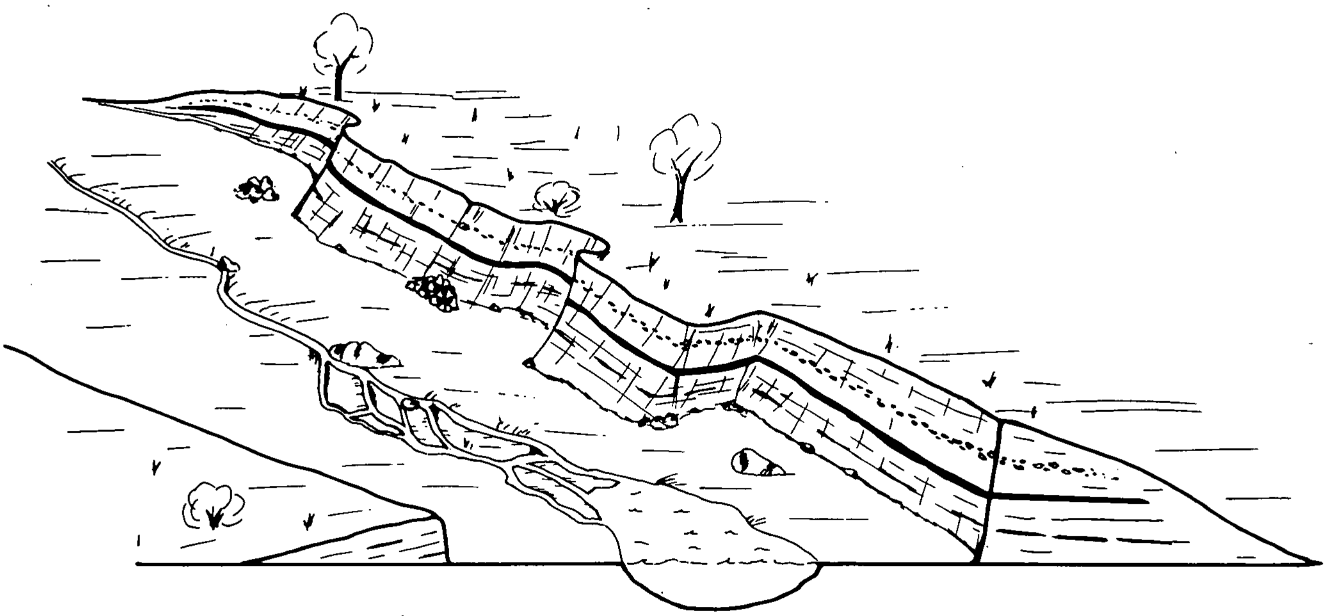

Fig. 6.
Restoration plan for the Mogenstrup Esker.

landowners, industry and authorities. An inventory has been made and has served as the basis for a planned completion of exploitation and restoration which incorporates the following principal provisions:

- The southern half of the esker has so far been left untouched by mineral working, because it is covered by trees. When viewed from the south, therefore, the esker still seems to be fairly intact.
- The long wall of the pit should be left as an open profile and small section should be cut at right angles to this so that the meltwater deposits which form the esker can be studied in three dimensions.
- A small part of the opposite (northern) flank of the esker is to be carefully protected to demonstrate the original width of the esker.
- The esker rests on an impermeable till and, on top of this till, a small pond will be constructed to feed a braided river which later will change into a meandering river.
- Samples of the various rock types represented in the boulders of the esker will be selected and preserved for demonstration.

The overall aim of this plan is to provide an educational facility which will illustrate the elements of a late glacial landscape. At present, however, the project has not progressed further than the drawing board.

5. The "Geo Trail" in Carinthia (Southern Austria), its Inception and its Acceptance

By HANS P. SCHÖNLAUB*)

5.1. Introduction

The "Geo-Trail" concept has been initiated to present some of the most impressive geological phenomena of the Carnic Alps in Southern Austria to the interested public and to support the local tourist industry in its search for alternative attractions for visitors.

5.2. The Gail Valley

For almost two centuries, the Gail Valley in Carinthia and the surrounding mountains have been well known to be one of the most interesting geological areas in the Alps. Here is the only place which has a continuous fossiliferous record of the Earth's history – without any gaps – ranging from the Middle Ordovician to the Triassic. During the last decade, numerous research studies have yielded not only a very detailed knowledge of the rocks and fossils, but also new geological maps, and revised tectonic framework and interpretations.

5.3. The Geo-Trail

This newly acquired, broadly-based knowledge led to the idea of extending the area's appeal beyond the purely scientific aspects of earth science by presenting some of the most spectacular features to those members of the public who might be interested. Early in 1985, the Geolgoical Survey proposed a presentation of this kind and this soon recieved approval from the officials from the communities involved and from representatives of the province of Carinthia. Financial support was promised and received from these communities, from the province, from the Austrian government, and from a few other sources; the final costs totalled more than 1,350,000 Austrian Schillings. The whole project was completed in the summer of 1988 and, since that time, the Geo-Trail has been generally welcomed and frequently visited.

The Geo-Trail covers and area of approximately 350 square kilometers. It consists of five geological trails which can be connected to form a super-trail with a length of more than 100 km at altitudes from 800 to 2300 m. Each trail consists of up to 13 stops, each marked by a plaque mounted on a wooden frame.

The plaques consist of resistant aluminium plates to which a UV-resistant printed foil is glued and each gives information concerning the scenery, the geology, the age of the rocks and fossils and their origin, etc. in non-technical language. At scenic points, additional information is given and this is presented in even larger plaques which include keys to the whole panoramic view.

In addition to the information given in the field, small displays of fossils and rocks have been set up in huts and other special places such as local museums; a book, summarizing all field and additional data, can be obtained for a very moderate price; even stickers, a T-shirt and a badge are available on request.

5.4. Conclusions

The first year operation proved the whole programme to be very successful. Hotel owners and private landlords have started to organise tours for their visitors, while other guided tours are still being run by the tourist offices. Despite the Geo-Trail's popularity, there has been neither exploitation of fossil localities nor any wanton damage to the information plaques. The future of the Geo-Trail seems assured for its maintenance has been guaranteed by the local communities.

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6. A Plan for the Conservation of the Quaternary Geological Phenomena in the County of Hedmark (Norway)

By LARS ERIKSTAD*)

6.1. Introduction

In Norway, a national programme for the registration and protection of various natural features has resulted in the recognition of about 900 areas worthy of conservation during the past 15 years (ERIKSTAD & HARDENG, 1988). Within the field of Earth-sciences, Quaternary geology is given priority and a registation programme, based mainly on geomorphological criteria, will be completed this year. This will result in a conservation porgramme whose aim will be to protect localities and areas of national importance all over the country using the powers of the Nature Conservation Act (ERIKSTAD, 1984). The general management of sand and gravel extraction, however, is controlled by the Planning and Building Act, but this makes inadequate provision for conservation. As a means of improving this situation, a national registration programme for sand and gravel resources is being conducted by the Norwegian Geological Survey (NEEB, 1987).

6.2. The Hedmark Project

The Quaternary geology of Hedmark is dominated by the county's location on both sides of the culmination zone of the Scandinavian Ice Sheet. The ice divide lay to the south of the watershed and the county offers classical localities for ice-dammed lakes and ice-directed drainage patterns (SOLLID & REITE, 1983). In Hedmark is proved possibel to establish co-operation between the nature conservation authorities, the mapping authorities, and the road authorities in the county and the Hedmark Project thus included mapping on the scale of 1 : 250,000 together with the preparation of a popular description of the quaternary geology of Hedmark (SOLLID & KRISTIANSEN, 1983), mapping of the sand and gravel resources on the same scale (SOLLID & KRISTIANSEN, 1981), and the registration of sites of nature conservation value (SOLLID & KRISTIANSEN, 1982). This co-operation was extremely important as it minimised conflict between the road and nature conservation authorities when it came to putting forward concrete suggestions for protected areas. It was also important in establishing a realistic view of the economic implications of the suggested protected areas, especially as Hedmark is one of the most recent counties in Norway to register its sand and gravel resources (NEEB, 1987).

6.3. The Conservation Plan

Following the registration of 71 candidate areas, the Fylkesmannen i Hedmark (1984) selected 33 areas to be covered by the Conservation Plan. The selection was governed by a wish to make the coverage of the Conservation Plan representative in respect of those Quaternary landforms which are found in the county. Furthermore, it was intended that the areas selected for inclusion should contain continuous systems of landforms so that the Quaternary systems could be documented as thoroughly as possible within the protected area. Each of the different stages of the late glacial period in Hedmark would be represented, and each of the chosen landforms would be clear and instructive. Possible other conservation values, landscape values and educational values were then taken into account.

6.4. Sand and Gravel Resources

Sand and gravel resources in Hedmark are concentrated in the valley floors and along the paths of the ice-directed drainage patterns. In most parts of the county their quality is poor to medium but, in the south, the quality is good. Generally there is a surplus of sand and gravel in the county, but in the southern parts this is not the case. As most of the areas proposed for conservation are concentrated in the central and northern parts of the county, this should imply that the costs in establishing the protected areas will be fairly moderate.

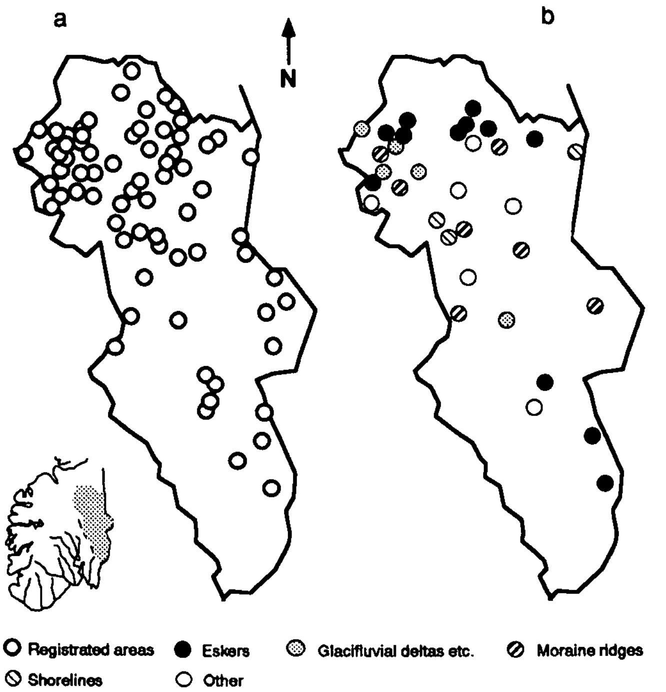

Fig. 7.
a) Registered localities of regional and national importance.
b) Areas suggested as protected areas in the conservation plan, indicating the dominating features.

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6.5. Conservation Rules

Compensation for the loss of income from sand and gravel extraction will, however, be only a part of the total costs incurred when these nature reserves and landscape protected areas have been established. Forestry is important in Hedmark and, although great emphasis has been laid on not proposing more restrictions for the conserved areas than necessary, it has proved difficult to draw up rules which give enough protection without having some effect on commercial forestry.

This at once raises the problem of whether or not it is sound conservation policy to draw up regulations specially tailored for the particular needs of each area to be conserved, rather than to adopt fundamentally standard rules which apply to all nature reserves whatever their interest. Current thinking in Norway has moved towards the former viewpoint and this implies, as in the case of the Hedmark Conservation Plan, that the regulations to be introduced will restrict all activities likely to damage landforms and geological structures, but will not in principle restrict activities affecting the rest of the ecosystem. When such a policy is adopted, it is important carefully to examine exactly what it is intended conservation should achieve within the protected areas so that purely economic reasons do not govern the establishment and the managment of each nature reserve.

6.6. Conservation Policy and Practice

Since 1984, the Conservation Plan has gone through an extensive political and administrative process, both locally and with national authorities and organizations. Although this has resulted in a plan approved in principle, ready for the establishment of reserves and landscape protected areas, progress has now been halted through changed economic considerations. The main problem arises from new legislation for compensation (made in 1985) which has now greatly increased the costs of establishing nature reserves. This, together with the overriding priority given to pollution control and the use of the new Planning and Building Act in nature management, has left the more classical forms of nature conservation somewhat behind.

This, hopefully, is only a delay and not an end to the work on the conservation of the key areas for Norwegian Quaternary geology. The government has recently stated that conservation of such areas and localities should continue through the operation of both the Nature Conservation Act and the Planning and Building Act. In addition to this, proposals for a new Sand and Gravel Extraction Act have been prepared and such an Act will be important and useful in the field of Earth-science conservation.

By a Royal Decree of 22nd December 1989, 22 nature reserves and one landscape protected area were established as a result of the Hedmark Plan. Most of the areas excluded from the Plan were mountain areas with a low level of land-use conflict and their conservation interests are to be guarded by means of the Planning and Building Act.

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7. Glacial and Glaciofluvial Landscape Types of Finland and Practical Problems of their Utilisation

By OSMO KONTTURI*)

7.1. The Genesis of Glaciofluvial Landscapes

The glaciofluvial landscapes in Finland originated and developed as the result of a combination of geological (IGNATIUS, etc., 1980), biological and socio-economic processes over the last 12,000 years. Glaciofluvial deposits, i. e. gravel and sand areas, are very suitable for many purposes. They consist of material important for its use as aggregate and form rich stores of ground water supplies. Glaciofluvial areas are also good buidling bases for roads and railways – many towns and other centres are situated on them. On the other hand, glaciofluvial landscapes are unique natural formations even on a worldwide scale and thus are important for nature conservation. Because of their variable terrain, pleasant forests and lakes, they are very suitable for recreation. Thus glaciofluvial areas

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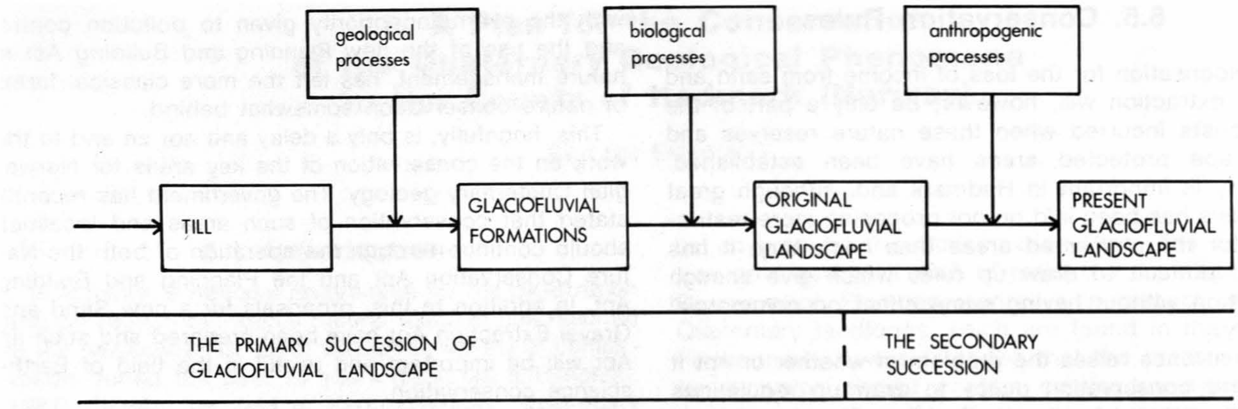

Fig. 8.
Scheme showing the development of a glaciofluvial landscape and its primary and secondary succession.

often are the focus of land use conflicts, and they give rise to difficult environment planning problems in Finland.

7.2. Sand and Gravel Resources

Until recently there has been lack of valid data concerning gravel resources, the extent of gravel areas, and the state of glaciofluvial landscapes in Finland (KONTTURI, 1984a; KONTTURI & LYYIKÄINEN, 1983). The main purpose of this paper is to try to reduce this lack of information by collecting data from various sources and unifying them. Only then will it be possible to estimate the future land use of glaciofluvial areas and the factors controlling it.

The results of the National Inventory of Gravel and Sand Resources published in 1979 (NIEMELÄ) estimate the total area of gravel and sand resources in Finland to be about 750,000 hectares or 2.2 % of the total land area. The total volume of gravel resources situated above the groundwater level was estimated at 47.5 billion m³, of which only 1.1 billion m³ (2.2 %) are suitable for crushing and usable for the most exacting construction purposes.

Gravel resources in Finland are rather unequally distributed. Although the gross resources are quite rich, there are large areas with little or no gravel. On the other hand, about 50 % of the gravel is concentrated in the zone of the Salpausselkä ice-margin formations, which account for only 10 % of the total area of the country.

7.3. Aggregates Consumption

Although no exact figures are available, the present annual consumption of gravel in Finland is minimal compared to the gross gravel resources. Several estimates have been presented suggesting figures of about 50 million m³ per year in the mid-1970's, whereas the sum total obtained from the results of 20

Fig. 9.
Large gravel pit in the middle of Finland. These pits are often situated along national highways without any sheltering.
Photo A. LYYTIKÄINEN.

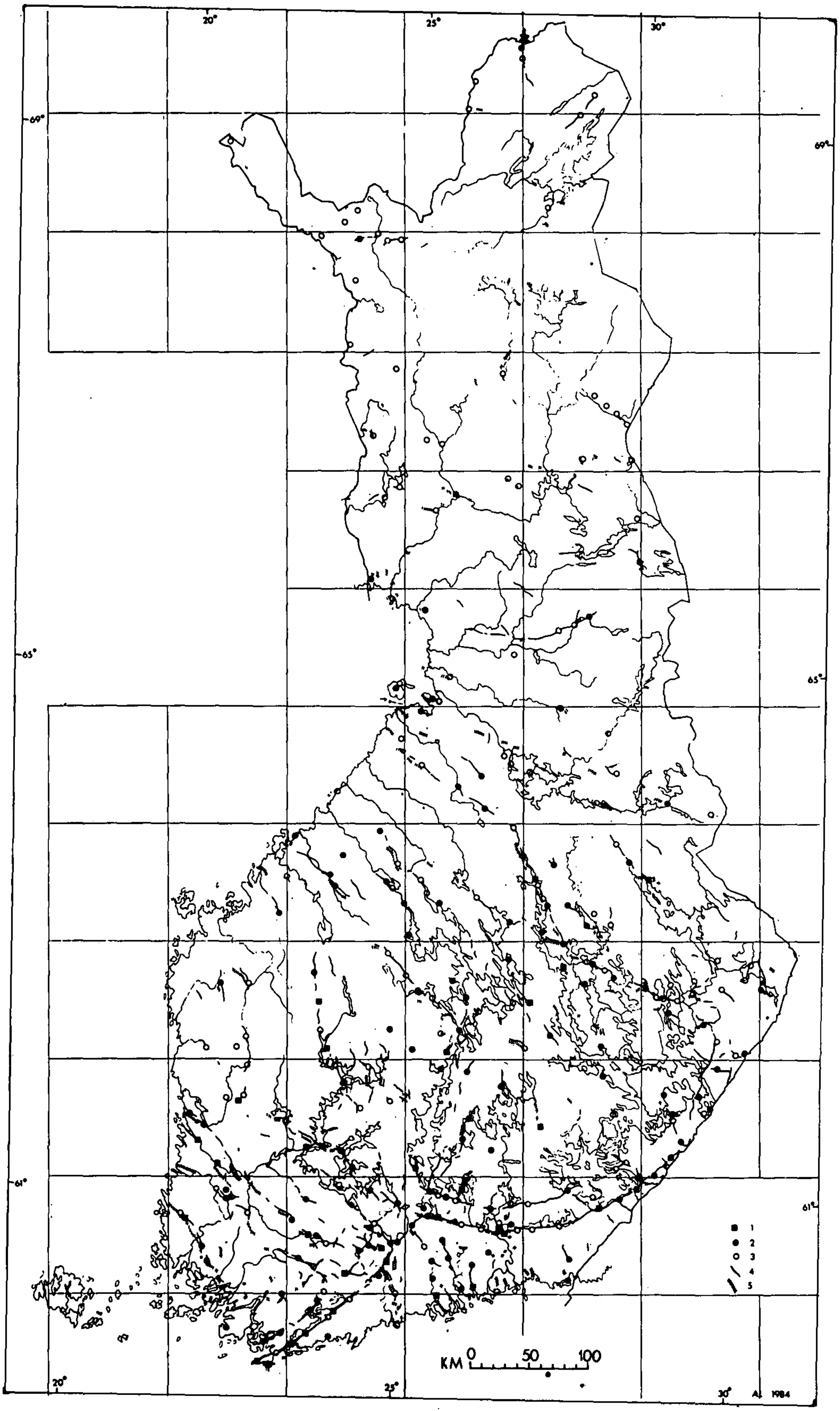

Fig. 10.
Locations of the most seriously altered and deformed esker landscapes.
This may be due to
1) towns,
2) other large built-up areas,
3) small built-up areas,
4) roads or railways,
5) gravel pits.

provincial investigations by the Regional Planning Associations places the total gravel consumption at the same time at only about 37 million m^3 per year. The total consumption in historical times has been only about 4–5 % of the total gross resources.

Like the distribution of gravel resources, gravel consumption varies markedly in Finland. About 50 % of the total consumption is concentrated in the four southernmost Finnish provinces, which make up only 20 % of the total land area, although they contain about 60 % of the total population. Correspondingly, about 50 % of the total consumption takes place in urban areas. The most important sectors involved in gravel use during the mid-1970's were public roads and railways (55 % of the total) and house-building and concrete production (over 20 %) (KONTTURI, 1983).

7.4. Land Use Problems

Although total gravel consumption is minor compared to the gross resources, gravel extraction has caused extensive environmental damage, e. g. destroying beautiful esker landscapes, creating groundwater hazards and detracting from the recreational use of esker areas. The large esker areas of southern and central Finland have been particularly badly damaged or destroyed, e. g. many esker chains have been exploited for many kilometres at a time. Furthermore, natural esker landscapes have largely disappeared from all areas within 40–60 km of major population centres in southern and central Finland.

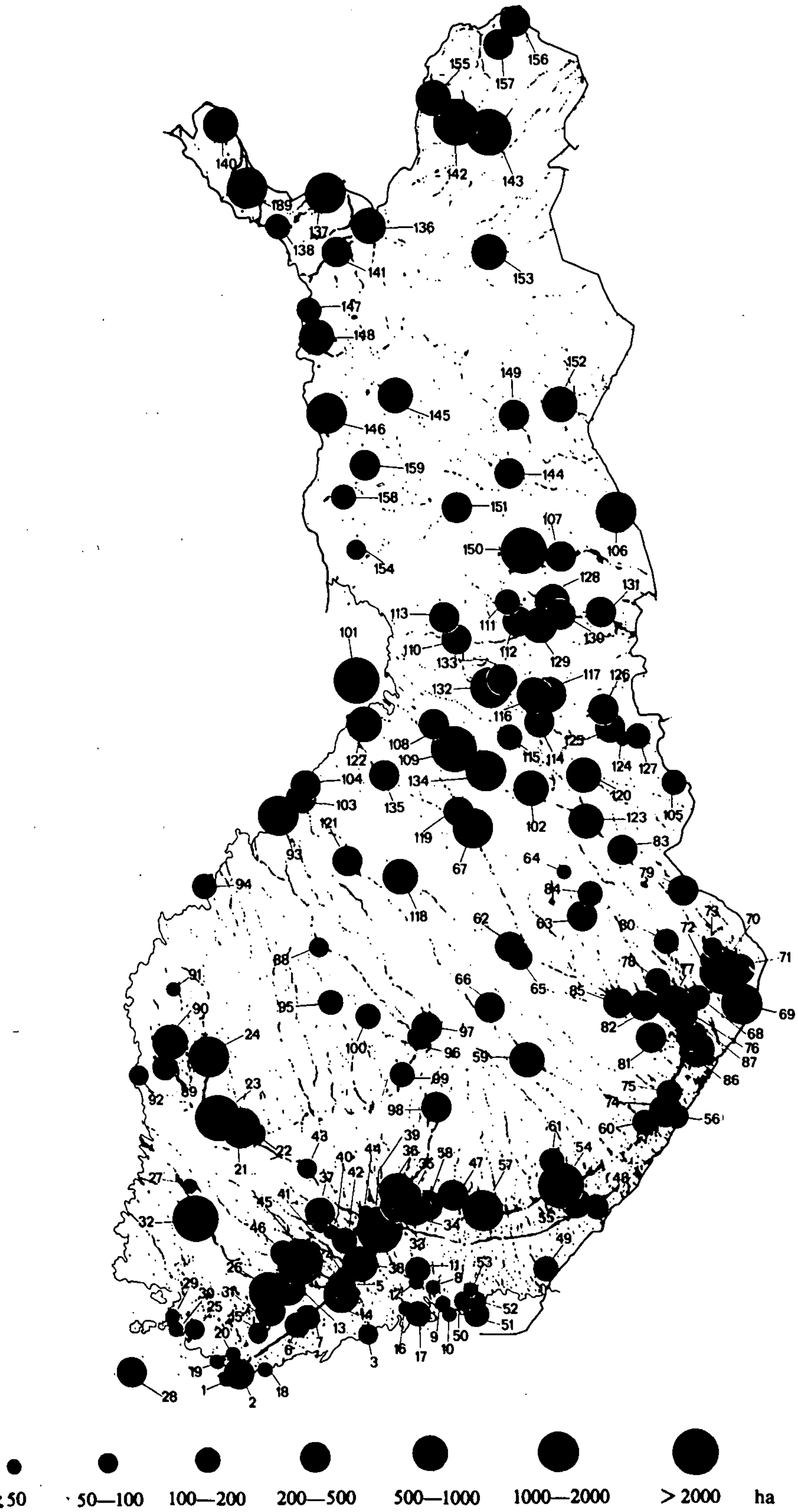

Fig. 11.
Location of sites included in the National Esker Conservation Programme and selected glaciofluvial areas.

7.5. Conservation of Glaciofluvial Landscapes

A nation-wide inventory carried out in 1972–1981 showed that there are still about 220,000 hectares of natural or near-natural glaciofluvial landscapes in Finland which is 0.7 % of the total land area, and 30 % of the total esker area. Today only 15,000 of hectares glaciofluvial landscape have been protected by nature conservation acts or by resolutions of authorities and thus belong to national parks and nature reserves. However, in 1984 the Ministry of the Environment prepared a special conservation program, which included 96.000 hectares of glaciofluvial landscape (HAAPANEN, 1982).

7.6. Controlling of the Land Use of Glaciofluvial Areas

In practice, gravel extraction in Finland has altered very markedly from 1st January 1982 onwards, with the enforcement of a new law restricting the previously almost free extraction of sand and gravel. Nowadays it is necessary to have permission from the local council and to present a plan outlining the area, the amounts. of gravel concerned, and the proposed measures for restoring the landscape after exploitation.

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