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.

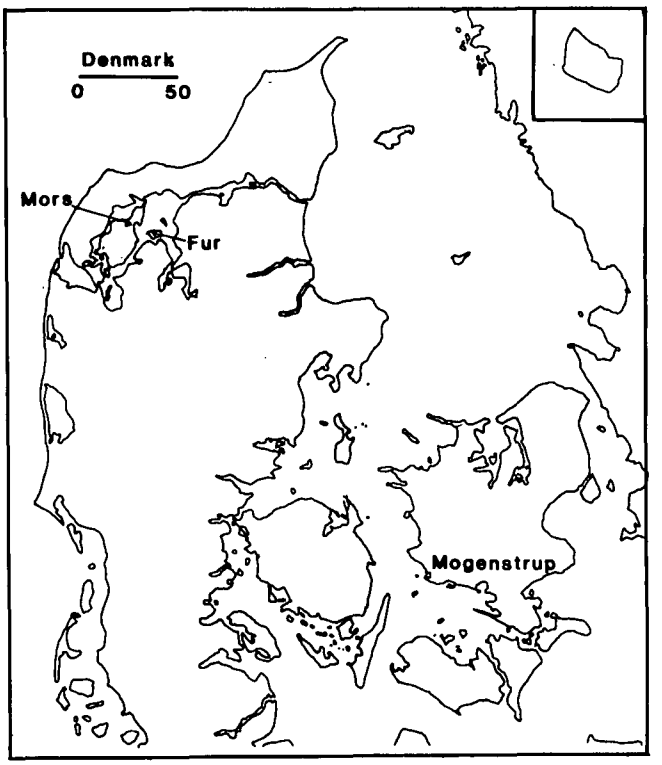

Fig. 2.
Locations mentioned in the text.

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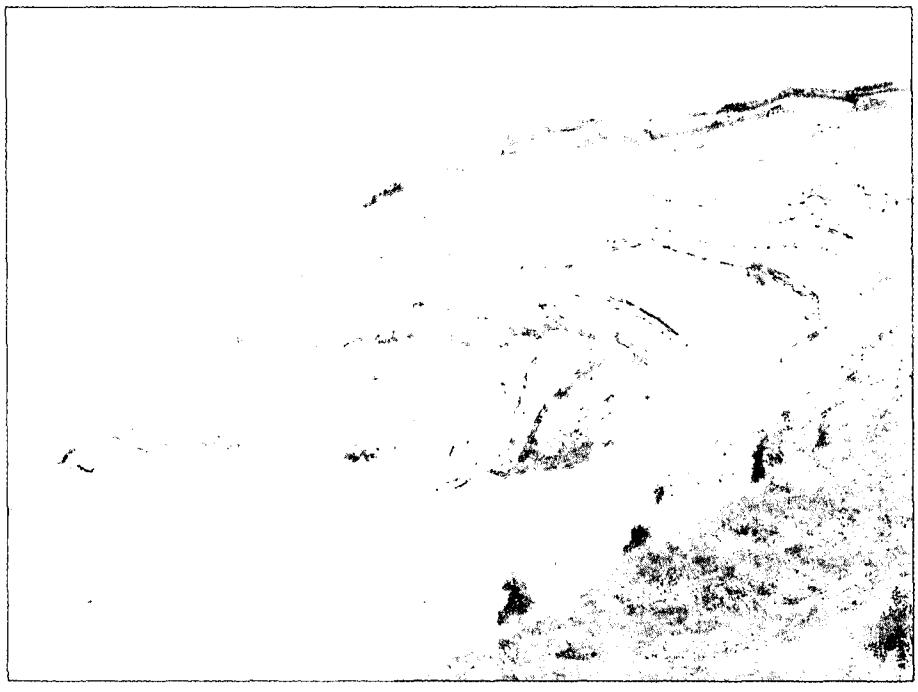

Fig. 3.
Folded mo-clay with ash layers.
Hanklit, Mors.
Photo S. SJØRRING.

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

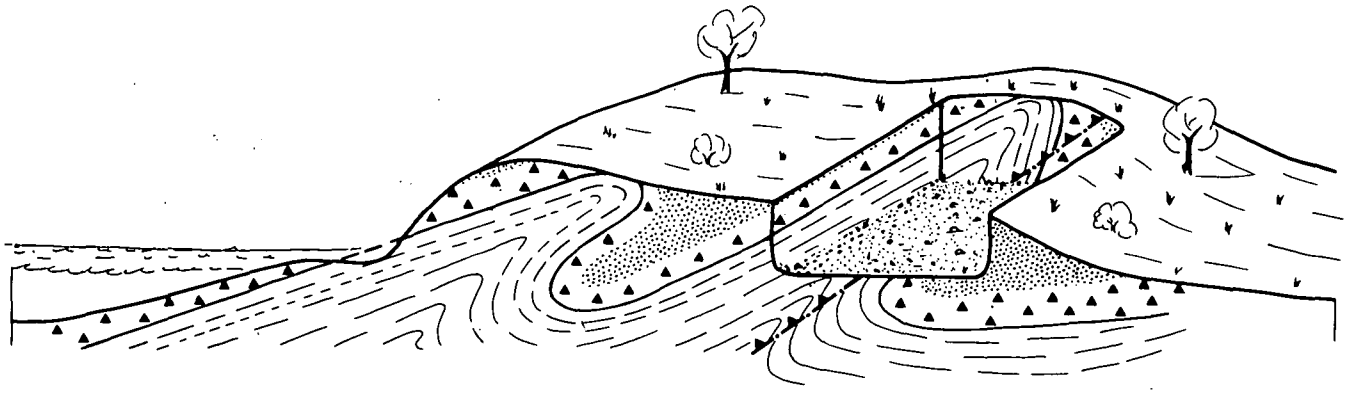

Fig. 4.
Pit in folded mo-clay.

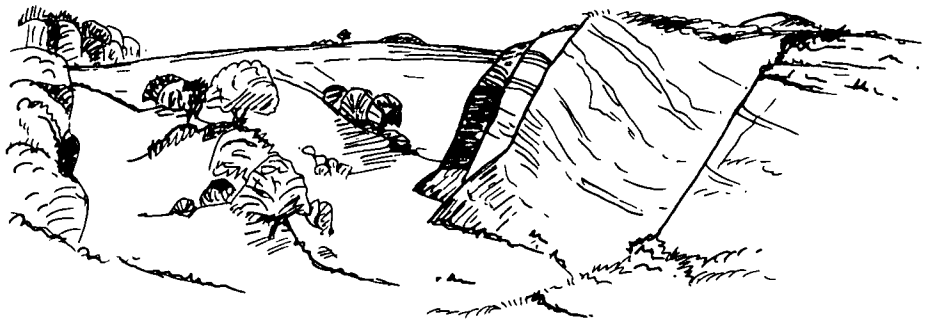

Fig. 5.
Restored mo-clay pit with open profiles.
Drawing after B. NIELSEN.

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 wholehearted 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

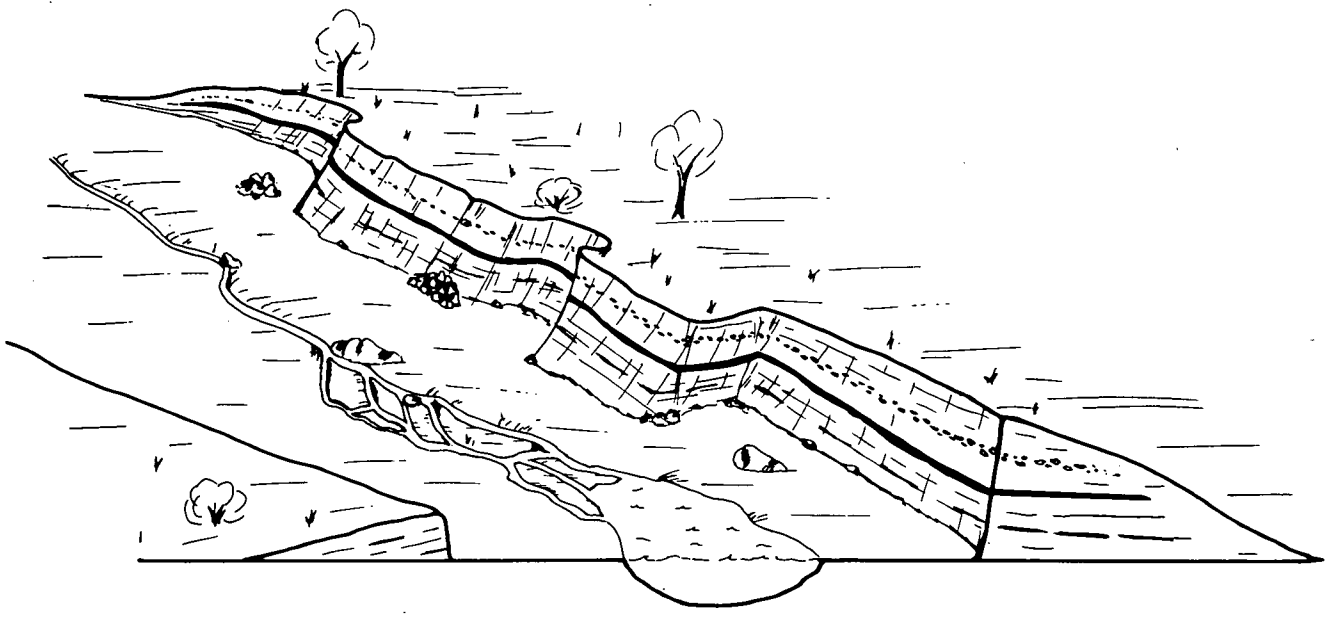

Fig. 6.
Restoration plan for the Mogenstrup Esker.

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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