Thesis presented to the University of Oxford

for the degree of

Doctor of Philosophy

GLACIAL, INTERGLACIAL, AND POSTGLACIAL SEDIMENTATION IN A LATE PRECAMBRIAN SHELF ENVIRONMENT, FINNMARK, NORTH NORWAY

Volume 1

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August, 1972

View of Reusch's Moraine at Bigganjargga, Varangerfjord. The striated pavement is developed on the upper surface of the Older Sandstone Series and is overlain by a basal tillite (Reusch's Moraine) in the Smalfjord Tillite Formation. While it is uncertain whether or not the tillite is a ground moraine, the striations are most likely subglacial in origin (see Chapter 4).

ABSTRACT

A belt of late Precambrian to Cambro-Ordovician sedimentary rocks trending WSW-ENE, 230 X 50 km, outcrops in the eastern part of Finnmark, North Norway. The belt rests in the south on Precambrian crystalline basement of the Fennoscandian shield, and is overthrust in the north by Caledonian metamorphic rocks. The autochthonous sedimentary rocks in this belt include three groups: the late Precambrian Tanafjord Group (Older Sandstone Series) at the base, overlain by the late Precambrian to lower Cambrian Vestertana Group, which passes up into Cambrian to Tremadocian rocks of the Digermul Group. Except for the lower part of the Older Sandstone Series, and the lower part of the Vestertana Group, the sediments are marine in origin.

The Vestertana Group is of considerable interest because it contains evidence for a late Precambrian glaciation as well as trace fossil evidence for the early development of metazoan life. This thesis presents the results of a detailed field study of the glacial and related rocks. The aim has been to resolve as accurately as possible the environments of deposition and the palaeogeography. Towards this end the techniques of facies and palaeocurrent analysis have been stressed, and supplemented by petrographic observations.

The lower part of the Vestertana Group contains two tillite formations, the Smalfjord Tillite (lower) and the Mortensnes Tillite (upper). These are separated by the interglacial Nyborg Formation, and are overlain by the postglacial Lillevatn Member of the Stappogiedde Formation. These four units were examined most carefully round Tanafjord and Varangerfjord.

The Smalfjord Tillite rests on a regional angular unconformity. Its typical development is in the Tanafjord and Laksefjord areas in the north and west respectively. The formation is generally 0-60 m thick and consists almost entirely of massive tillite and laminated siltstone with dropped in clasts. Sandstone is subordinate. Most of the tillite occurs in erosively based units up to about 15 m thick which grade up quickly into siltstone. Four such tillite to siltstone sequences are recognised in the Tanafjord area, three of which can be correlated to Laksefjord, 50 km away. Each sequence is interpreted as the product of a continental ice sheet (depositing ground moraine) retreating from a lake or sea (laminated siltstone). Ice advanced into the area from both the north and the south. At Varangerfjord the Smalfjord Tillite is locally at least 100 m thick and consists mostly of stratified conglomerate and sandstone. Tillite occurs at the base of the formation (including Reusch's Moraine) and evidence for both subglacial and supraglacial deposition is present. Two, possibly three glacial advances are recorded in this area. The predominant facies include marine sandstones deposited by turbidity currents and possibly mass flow, and conglomerates formed in submarine channels and braided streams analogous to glacial sandar.

The contact between the overlying Nyborg Formation and the Smalfjord Tillite is generally very sharp or slightly erosive. At the base of the Nyborg Formation dolomite, locally developed, is interpreted as a supratidal deposit formed during a rapid postglacial transgression. Above are purple siltstones deposited in quiet water, followed by a thick (up to 300-400 m) succession of turbidites which composes the bulk of the formation, and was deposited during strongly regressive conditions. The turbidites were

derived from a southern source area. The filling of the basin is shown by the overlying shallow marine facies. Tidal distributary, lagoon, barrier and nearshore environments are represented and their distribution indicates a change to transgressive conditions.

The Mortensnes Tillite up to 60 m thick rests unconformably on the Nyborg Formation over most of the area, and on older rocks in the Varangerfjord area. Like the Smalfjord Tillite it is composed mostly of massive tillite amd laminated siltstone. The first glacial retreat sequence which makes up the lower part of the formation includes probable ice shelf deposits. The retreat of the second ice sheet coincided with the termination of the glaciation and a major transgression. Ice sheets advanced from both the north and south. Correlation between Laksefjord and Tanafjord suggests the regional significance of the advances and retreats.

In the northern part of the area, during the rapid postglacial transgression a lag conglomerate was formed in shallow water by winnowing of the top of the tillite, upon which a mudstone formed as the water deepended. To the south, ice retreated from a relatively deep sea so that ground moraine deposition was followed by the deposition of mudstone in quiet water non-glacial conditions.

These mudstones comprise the lower part of the Lillevatn Member. They accumulated under regressive conditions by the progradation of a prodelta slope, and are eroded into by the upper part of the member: a blanket of coarse fluvial (straight) channel and fine floodplain deposits about 20 m thick. Above, small-scale coarsening upward sequences interpreted as the deposits of small prograding distributary channels in an interdistributary bay, and relatively well sorted sandstones indicate increasing marine influence upwards. The grey sandy siltstones

at the top of the member grade up into the purple laminated marine mudstones at the base of the Innerelv Member. The Lillevatn Member represents a coarse regressive deltaic incursion into an overall transgressive trend. Palaeocurrent evidence suggests that flow was generally to the west.

The influx of continental ice from both the north and south and the fact that the greatest subsidence was in the centre of the study area suggest that land was situated both to the north and south. Palaeogeographic and palaeotectonic maps of the Russian Platform suggest the development of a trough in the Timan Mountains in the late-Precambrian-Early Cambrian. The trough was bounded to the northeast by a land area uplifted during the late Precambrian (Baikalian) orogeny. Geophysical evidence suggests that the structural trends continue onto the Barents Sea shelf adjacent to the East Finnmark coast.

The identification of Finnmark tillites as ground moraines indicates that accepted criteria for determining the origin of possible ancient tillites should be revised. Suggested revisions concern the following points:

1) Is the basal contact of the tillite really gradational? The incorporation of large amounts of the substrate may impart a gradational appearance to an erosively based ground moraine.

2) Is the lamination really lamination? The internal plastic flow of an ice sheet can mix together different types of material so that the resultant deposit has a banded appearance. Without careful examination, shear banding can be confused with lamination formed by aqueous currents.

3) The great lateral continuity and even thickness of tillites may be a result of deposition upon an area of low relief. This is typical of certain Pleistocene tills. It is not a criterion for a marine origin.

4) During a glaciation lowered sea-levels expose normally marine areas to subaerial and subglacial processes. The occurrence of tillite with marine sediments does not argue for a marine origin for the tillite.

The presence of two tillites in several widespread parts of the world in some cases followed by dolomite horizons, suggests that the cause of the glaciation was related to rapid worldwide climatic changes rather than to the successive movement of different continents into the polar regions.

ACKNOWLEDGEMENTS

I would like to offer my sincerest thanks to Dr. H.G. Reading for suggesting a challenging problem, and for supervision both in the field and in the Department. His comments and criticisms have done much to improve this research. During discussions in Oslo, Dr. S. Føyn gave to me some of his unique knowledge of Finnmark, both of its geology and how one might best come to understand its secrets. Dr. G.S. Boulton generously broadened my insight into glacial processes to a degree which I hope may reflect his personal experience and investigations of present day glacial environments.

My appreciation of the fascinating geology of the Varanger Peninsula is due to the stimulating field excursions led by Drs. A. Siedlecka and St. Siedlecki. Miss S.-L. Røe guided me to important exposures in the Varangerfjord area. Dr. A.M. Spencer gave helpful advice and encouragement on the tillite exposures of Finnmark. I am grateful to Dr. K. Bjørlykke for the opportunity to examine the Sparagmite district of southern Norway, and for discussions on the late Precambrian glaciation.

On the four expeditions to Finnmark, undergraduates gave generous and helpful assistance in the field work. In particular, M. Carpenter helped to unravel the complexities of the Smalfjord Tillite in its type area. P. Taylor helped especially with the Mortensnes Tillite, and R. Weinberg carried lots of rocks a long way. Assistance was also given by S. Holdship, H. Rollinson, C. Marmont, P. Baylis, M. Gibling, M. Potter and R. Suthren.

Discussions with fellow sedimentologists have been of great help towards crystallising my ideas. I wish to thank Dr. N.L. Banks, Dr. D.K. Hobday, Dr. M.G. Laird,

Mr. T. Elliott and Mr. H.D. Johnson. Dr. A. Hallam made helpful criticisms of a final draft of the thesis.

The invaluable assistance of the technicians in the Department of Geology and Mineralogy is recognized. R. McAvoy and S. Baker helped with the photography, and R. Holland prepared thin sections and polished surfaces of critical specimens.

The typing of the thesis was carried forth with the devotion and commitment of Mrs. P. Jackson (whose unlucky number is 57).

Most of the costs were borne by a New York State Higher Education Loan and, by my parents for whose faith in my search I am deeply grateful.

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