

THE JURASSIC AND CRETACEOUS OF ANDØYA IN NORTHERN NORWAY

By TOR ØRVIG

In addition to a number of erratic boulders (see below) the Mesozoic rocks of Northern Norway known so far consist of the Jurassic and Cretaceous deposits on the island Andøya in Vesterålen.

The existence of the Mesozoic field of Andøya was first detected by T. Dahll in 1867 when he investigated an outcrop of coal on the island, previously known to, and on a moderate scale also utilized by, the local farmers. According to the mapping subsequently carried out, particularly by Friis (1902) and J. H. L. Vogt (1905), this field lies in a down-faulted trough extending for some 8 km along the NE coast between Ramså and Skarstein, and inland for about 3 km at its broadest in the south, and 1 km near its northern end. It rests on granite, or, in some places, crystalline schists (chlorite schists) and is to a large extent covered superficially by moraine material and peat moss. The sequence of rocks of which it consists is known from exposures on the beach at Ramså and Skarstein and in some river beds, e. g. Gårdselva and Nordelva, but mainly from drill-borings carried out on various occasions with the purpose of ascertaining possibilities for coal-mining.

Our knowledge of the general geology and tectonic structure of the Mesozoic rocks of Andøya rests almost exclusively on the work by J. H. L. Vogt, published in 1905. Fossils have been collected on various occasions, and of these, the invertebrates have been dealt with especially by Sokolov (1912), and the plants by Heer (1877), Johanson (1920) and Bosc (1960). In the years before the second world war the Mesozoic deposits in question were commented upon by several writers discussing the correlation of the Jurassic and Cretaceous of Spitsbergen, East Greenland etc. (for a summary of this literature see Ørvig 1953). In recent years similar comments have been given by *inter alia* Arkell (1956) and Donovan (1957).

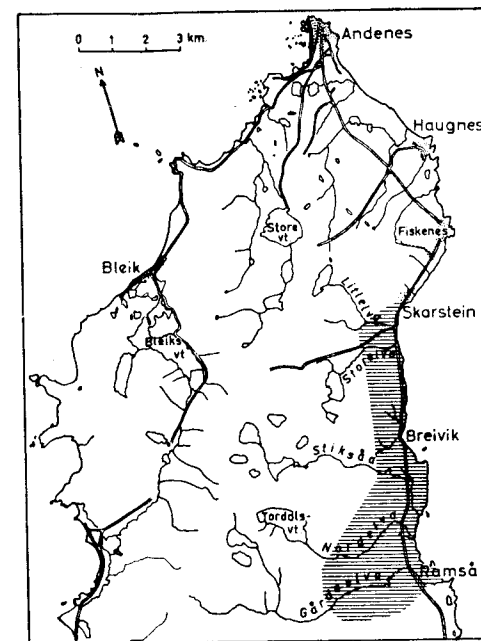


Fig. 107. Northern part of Andøya with the approximate extent of the Mesozoic field especially marked.

The Mesozoic deposits of Andøya may be subdivided, provisionally at least, into a lower part, the *Ramså Group* which consists of 3 formations (unnamed) and ranges, as it seems, from the Lower Upper Jurassic (Eooxfordian) into the lowermost Lower Cretaceous (Valanginian) and an upper part, the *Skarstein Formation*, which probably is of a Lower Cretaceous (Hauterivian) age. In tabular form, this classification is given on p. 346.

The Ramså Group is predominant over the whole southern part of the field. Its lower formation, exposed in its entirety at low tide on the beach of the Ramså farm, and in part in the lower course of the Gårdselva river, consists, basally, of deposits such as fire-clay, coal-seams of varying thickness and bituminous shale, the like of which are not encountered at all in any of the overlying beds and, in addition, of some layers of coarse-grained sandstone; higher up this formation is made up of a series of sandstone banks alternating with about equally thick layers of thin-bedded, shaly sandstone. Fossils include, from the basal beds various plants such as Equisetaleans, *Brachyphyllum* and

Rocks	Estimated thickness	Earlier classifications			Proposed classification	Age
		VOGT 1905	SOKOLOV 1912	ØRVIG 1953		
Argillaceous shales frequently containing iron-stone nodules; in places thin layers of sandstone	125 m	Upper division	(Not listed)	Skarstein Series (S)	Skarstein Formation	Haute-rivian?
—(no contact yet established.)						
Light-coloured sandstones, mostly fine-grained; marl	80 m	Upper part of middle division	Obere Schichten	Ramså Series (R)	Upper Formation	Valanginian
—(no contact yet established.)						
Dark, micaceous, fine-grained and thinbedded sandstones (the « <i>Aucella</i> layer»)	150 m	Middle part of middle division	Mittlere Schichten		Middle Formation	Portlandian (in part)
Dark to medium-greyish sandstones, thin-bedded and fairly soft, with local concretions and banks of harder consistency			Untere Schichten			Middle Eokimmeridgian
Light-coloured sandstones, interstratified with shaly sandstones	85 m	Lower part of middle division	(Not		Lower Formation	Oxfordian, possibly also Lower Eokimmeridgian
Coal-seams, bituminous shale, fire-clay, coarse-grained sandstones	60 m	Lower division	listed)			

Phoenicopsis, from the middle part of the formation scattered marine evertbrates including ammonites and belemnites, so far underscribed, and from the uppermost part, close underneath the boundary towards the next formation of the group, ammonites which may possibly belong to the early representatives of the *Pictonidae* (*sensu* Spath). A specimen of *Ammoeboceras alternans* (v. Buch), originally found loose in the Gårdselva river bed, and determined by Sokolov (1912), very probably came from this formation also.

The age of the lower formation of the Ramså Group, and in particular the basal layers containing coal-seams, cannot be established with full certainty on the basis of the fossils just referred to. On various evidence, particularly a comparison with the condition of the Jurassic in Hochstetter Foreland, East Greenland (Frebold 1932;

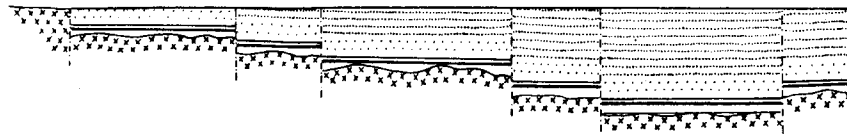


Fig. 108. W-E section of the southern part of the Mesozoic field of Andøya according to J. H. L. Vogt (1905). Above the basal granite first strata with coal-seams, then sandstones of the lower and middle formation of the Ramså Group.

Ørvig 1953), it is not inconceivable, however, that this formation corresponds, approximately at least, to the Oxfordian and that it may also, in its uppermost part, include strata of a lowermost Eokimmeridgian age. The question whether, basally, it also extends into the uppermost Middle Jurassic must be left unanswered for the present.

The middle formation of the Ramså Group, consisting of micaceous sandstones and exposed at various places in the Gårdselva river bed, has yielded a considerable amount of fossils and is better known, paleontologically, than the lower formation dealt with above. From the dark or medium-greyish sandstones in the basal part of this formation the collections include fossil wood, various invertebrates as e.g. *Rasenia* sp., *Gryphaea* cf. *dilatata*, *Pecten* (*Entolium*) *nummularis*, *Lima* sp., *Pholadomya* cf. *opiformis* Trautsch. and, in addition, vertebrae and other bones of Ichtyosaurians, not nearer determinable as to genus and species (Sokolov 1912; Ørvig 1953). Further upwards the formation consists of dark micaceous, fine-grained sandstones which are entirely unfossiliferous in all outcrops of the river bed, but which in drill-cores have been found to contain plants such as *Cladophlebis*, *Taeniopteris*? sp., *Feildenia* and *Sciadopitytes* (Johansson 1920), and invertebrates including ammonites probably referable to *Pavlovia* (*Epivirgatites*) *nikitini* (Mich.), belemnites, *Acanthoteutis* sp. and a series of *Aucella* species, e.g. *A. mosquensis* v. Buch, *A. lahuseni* Pavl. and *A. volgensis* Lahus. (Sokolov 1912).

The basal part of this middle formation is in all probability to be dated as middle Eokimmeridgian (presumably corresponding to the zone of *Rasenia cymodoce* of the British sequence), being suggestive, to a certain extent at any rate, of the *Amoebites* shale of Cape Leslie of Milne Land, East Greenland, with regard to its invertebrate fauna. As to the age of the middle and upper beds of the formation, on the other hand, various opinions have been expressed, but to judge from

the fossils determined by Sokolov (1912), there is reason to believe that one is here concerned with strata corresponding, in the main, to certain parts of the Portlandian in the Russian sequence. The existence, in the formation, of upper Kimmeridgian deposits has not been demonstrated so far; there is no telling at present either whether it also includes the very youngest part of the Upper Jurassic (see discussion by Spath 1947).

The light-coloured sandstones of the upper formation of the Ramså Group are encountered at some outcrops in the upper course of the Gårdselva river, W of the high-road Andenes—Risøyhamn; at one of these, even layers of light bluish-grey marl are exposed. The fauna of this formation clearly belongs to the Valanginian of the Lower Cretaceous, including *Bochianites* cf. *neocomensis* (D'Orb.), *Belemnites* cf. *subquadratus* Pavl. and, in addition, several *Aucella* species such as e. g. *A. keyserlingi*, *A. volgensis* Lahus. etc. (Sokolov 1912). No contact is exposed anywhere with the dark micaceous sandstones of the underlying formation.

The upper part of the Mesozoic deposits of Andøya, the Skarstein Formation, is more incompletely known, paleontologically as well as stratigraphically, than the underlying Ramså Group and a contact has not yet been established with the uppermost beds of the latter. The dark argillaceous shale, in places with ironstone nodules, of which this formation largely consists is met with in outcrops in the northern part of the field, particularly at the Skarstein beach and even in the Nord-elva river bed. According to previous investigations it is extremely poor in fossils, having yielded a *Pecten* sp. (Friis 1902) and, as noted by Spath (1947) presumably also a *Crioceratites* sp. Provided that this ammonite is correctly determined, and that it really is derived from the Skarstein Formation, one has reason to believe that this formation includes strata of Hauterivian age, the youngest ones of the field as a whole.

Conditions of sedimentation may be summarized as follows. The basal part of the lower formation of the Ramså Group rests on an unevenly eroded granite surface, and as demonstrated by its coal-seams, bituminous shale and plant fossils, it was deposited in fresh water in a swamp landscape. On reaching the series of sandstones higher up in this formation, on the other hand, there was obviously an invasion by the sea, and from here to the top of the upper formation of the group a purely marine, littoral facies prevailed. Even the Skarstein Formation is probably of marine origin throughout, but the con-

ditions under which it was deposited are yet incompletely known in some respects.

The circumstance that, as shown by the invertebrate fossils, the whole marine part of the Ramså Group was deposited in shallow water, demonstrates a gradual submergence of the area in question during Upper Jurassic and Lower Cretaceous times. The fact, furthermore, that the Ramså Group is restricted to the southern part of the field, and that, to the north, the Skarstein Formation lies directly on granite, indicates a gradual transgression northwards during the same time-interval. The Mesozoic field of Andøya, needless to say, attained its present-day configuration as a result of a post-Neocomian land-elevation and a subsequent down-faulting.

It may be appropriate, in this connection, to say a few words on other occurrences of Mesozoic rocks on the Norwegian coast, for the most part erratic boulders of Jurassic or Cretaceous age.

A large boulder of Neocomian (possibly Hauterivian) conglomerate is known from near Hanøy in Vesterålen, containing a lamelli-branchiate fauna including species of *Avicula*, *Pinna*, *Gervillia*, *Perna*, *Lima*, *Pecten*, *Ostrea*, *Arca* and *Astarte* (Ravn & Vogt 1915); because of the petrographical nature of the conglomerate, this boulder may quite possibly have come from a down-faulted Mesozoic field somewhere in Vesterålen, similar to that of Andøya.

Small lumps of boghead-coal, generally assumed to be of Jurassic age and containing, some of them, plant fossils such as *Czekanowskia*-leaves and *Pinus*-needles, have not infrequently been found on the coast, thus both at Stavanger, in Møre, in the Lofoten—Vesterålen area and in Finnmark (Horn 1931; and others). In addition coal, in this case lignite, is also encountered in the parish of Verran, N of the Trondheim Fjord where it occurs together with boulders of brownish dolomitic rocks containing thin coal-seams and plant remains. Since this coal has too high specific gravity to be washed ashore by the sea, it may instead come from down-faulted Mesozoic rocks situated underneath large peat mosses further inland (Carstens 1929); no attempts has yet been made, however, of verifying the existence of such rocks there. Also in the Trondheim Fjord area, boulders of fine-grained, blue-greyish, calcareous sandstone have been found on the Fro Islands (Froan) containing well-preserved invertebrate fossils of a presumed Middle Jurassic age, e. g. *Pseudomonotis echinata* Sow., *P. braamburiensis*, *Tancredia* sp. *Trigonia* sp. and belemnites (Nordhagen 1921; fossils determined by Ravn in the same paper).

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ON SUPPOSED MARGINAL FAULTS AND THE OBLIQUE UPLIFT OF THE LAND MASS IN CENOZOIC TIME

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Even if in western Fennoscandia we have no rocks younger than the Lower Cretaceous, the faults which cut the Andøy deposits give some hints concerning the more recent history of the land mass.

As to the upper age limit of the faulting, we can, based on observations in the district itself, merely say that it must be older than the "strandflat" (see later), which no doubt was formed in Pleistocene time. From general reasons a Tertiary age suggests itself, since that period in the North Atlantic region was characterized by much crustal unrest.

A comparison with Spitsbergen, which has a similar general position near the northwestern border of the Eurasian continental block, gives some interesting evidence. The long narrow island of Prince Charles Foreland with mainly pre-Devonian rocks may be regarded as a northern parallel to Andøy. The said Spitsbergen island is separated from the main island (West Spitsbergen) by the Foreland Sound, which represents a down-faulted area with Older Tertiary sediments resting on pre-Devonian. Along the western margin of this narrow graben, a step-faulting has taken place, reminding of the Andøy structure. Other NNW—SSE striking faults of post-Eocene age are known from the extreme western part of West Spitsbergen further south. It is most probable that the faults of Andøy belong to the same system of dislocations.

Important conclusions concerning the more recent history of the Norwegian land mass can be drawn from a study of the submarine region off the coasts. The author has in a number of publications pointed to some very interesting topographical features characteristic of the inner part of the Continental Shelf (O. Høltedahl, 1933, 1940 a. o.). Additional data have been given by H. Høltedahl (1955).

In many areas there exists in the sea-bottom a marked trench running more or less parallel to the trend of the adjacent coastline (Pl. 14).