Submerged and tilted coastal features off Troms, northern Norway: a comment

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In *Norsk Geologisk Tidsskrift*, 1993, Vol. 73, pp. 198–208, Rokoengen & Dekko describe two submerged levels of wave-cut platforms and beach-like features on the continental shelf off Troms, informally named the Nordvestbanken and Malangsgrunnen Levels. The measured gradient of 2.3 and 2.0 m/km, respectively, and the youngest possible age assumed (13–11 ka BP) are not consistent with emerged radiocarbon-dated shorelines having gradients about 1.0 m/km from the same time period on the adjacent island of Andøya in northern Vesterålen. The mapped submerged shorelines on the shelf are situated 50–70 m below the emerged Andøya shorelines and are therefore older. Dated sea-level indicators (13–11 ka BP) on land in western Troms support this conclusion. Most likely, the assumed submerged levels off Troms are polycyclic having formed during the Cenozoic contemporaneously with the formation of the strandflat in the coastal zone.

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This is a comment on some views and assumptions regarding submerged wave-cut platforms and beach-like features on the continental shelf off Troms as expressed by Rokoengen & Dekko (1993). Based on shallow-seismic investigations and bathymetry, two submerged and tilted levels were mapped and informally named the Nordvestbanken and Malangsgrunnen Levels (in the following denoted NV and MA Levels, respectively). Their depth is 50–150 m and the youngest possible age is believed to be within the 13–11 ka BP range. The suggested age is based solely on one radiocarbon date, 13,310 ± 110 years BP (T-2326), obtained from shells in an overconsolidated glaciomarine deposit at the outer part of Nordvestbanken (Rokoengen et al. 1979), though an older age is not excluded. According to the authors, the sample possibly indicates the time the inland ice sheet last reached the shelf edge off Troms. The submerged beaches are coupled to the last deglaciation of the shelf area. As first introduced by Dekko & Rokoengen (1980), the authors still believe that Sveinsgrunnen, Malangsgrunnen, and parts of the Nordvestbanken formed dry land as late as 13–11 ka BP, and that there was sufficient time to form the assumed wave-cut platforms.

In the article, the authors discuss the assumed age of the submerged shorelines in relation to the system of emerged shorelines on the adjacent land areas. Based on their model of regional relative sea-level change (Fig 12; 206), they expect to find the NV and MA Levels (13–11 ka BP) below the Main Shoreline (Younger Dryas, 11–10 ka BP) (Andersen 1968) when extrapolated to coastal land areas. The levels, however, according to Rokoengen & Dekko (1993), have not yet been found mainly because several levels cross near the coast and are therefore difficult to distinguish. The authors also demonstrate that the extrapolated NV and MA Levels further inland happen to coincide with the marine limit (ML) of the Skarpnes event (12.5–12 ka BP according to Andersen, 1968). Assuming the same deformational history, they believe that at least one of the levels is contemporaneous with this event.

This comment has two aims: (1) to present available radiocarbon dates (13–11 ka BP) of raised shorelines from land areas in northern Vesterålen and western Troms; and (2) to discuss shoreline relation implications regarding the youngest possible age proposed (13–11 ka BP) of the submerged shorelines on the shelf off Troms in relation to data on land.

Rokoengen & Dekko (1993) underline that northern Andøya has been a key area in the discussion of the Late Weichselian glacial maximum (for references, see Møller et al. 1992), but the authors do not discuss the shoreline data presented in the literature during the last decades (Marthinussen 1962; Møller & Sollid 1972; Møller 1985, 1986, 1987, 1989; Fjalstad & Møller 1987; Vorren et al. 1988). Here, we focus on serious problems when correlating available shoreline data from Andøya with depth and assumed age of the submerged shorelines on the adjacent shelf area off Troms. We also present several new and unpublished radiocarbon dated sea-level indicators from Andøya (Fjalstad, in prep.; Fjalstad & Møller, in prep.) (Figs. 1 and 2).

The ML on northern Andøya is about 40 m above sea level (a.s.l.) (Møller 1985), which is slightly lower and older than the ML on outer Hinnøya and Senja (Fig. 1A and B). TL and OSL dates of beach sediments at Kjølhågen, 38 m a.s.l., close to Nedre Æråsvatn, gave an age of 18 ± 2 ka BP (Table 1). This date corresponds well with radiocarbon dates of marine sediments from

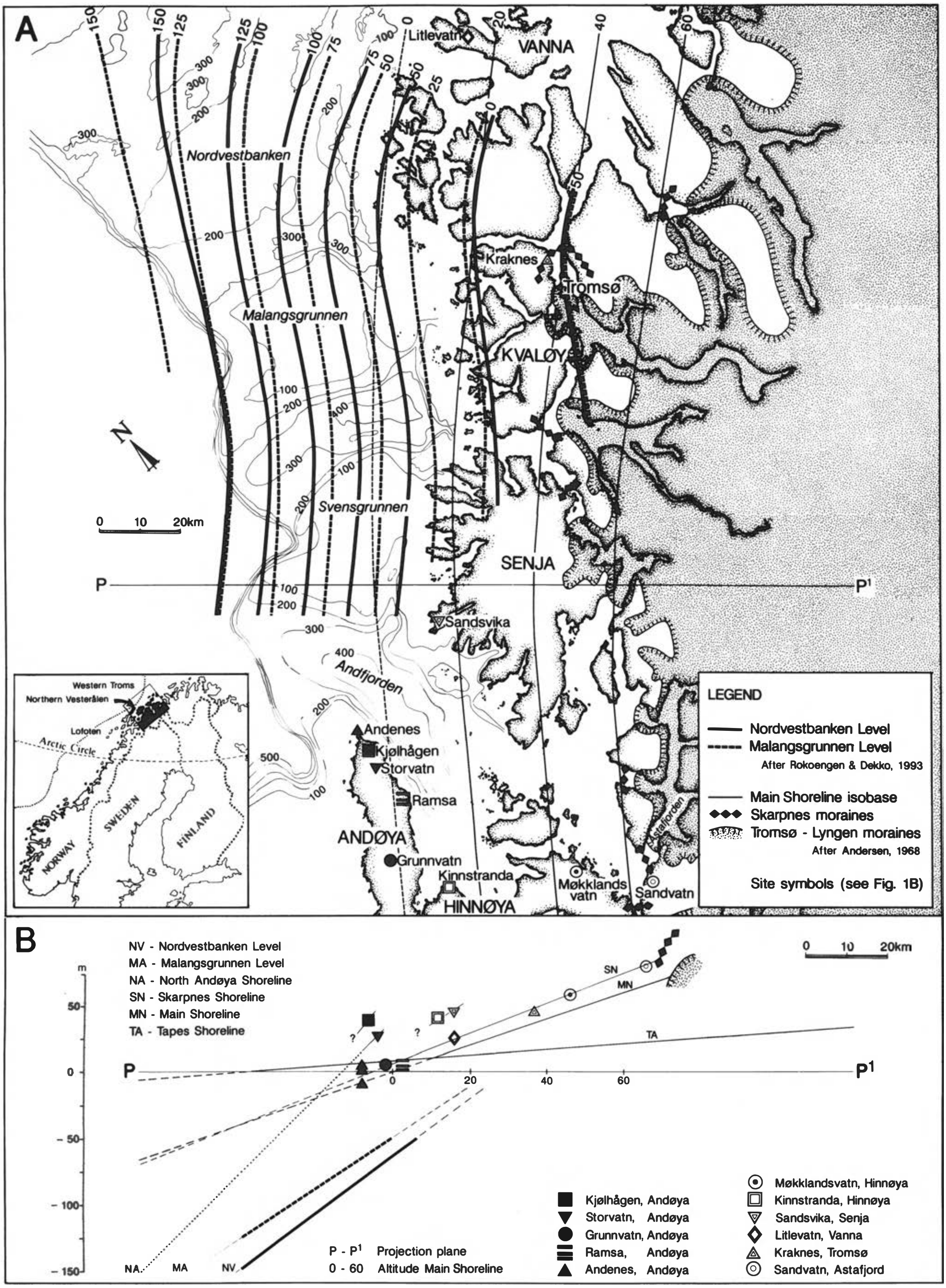

Fig. 1. A: Location map of northern Vesterålen, western Troms, and the adjacent continental shelf areas. B: Shoreline relation diagram for the area.

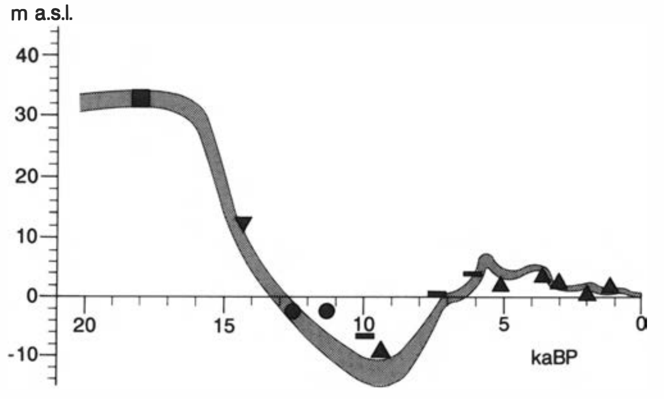

Fig. 2. Composite shoreline displacement curve for northern Andøya (Andenes). Altitudes of dated sea-level indicators have been adjusted to the tilt of the reconstructed shorelines in the region (Møller, 1985, 1989). Site symbols, see Fig. 1B.

the lake (Vorren et al. 1988). A distinct shoreline on northern Andøya, informally named North Andøya (NA) Shoreline, mapped by Møller (1985), represents the ML contemporaneous with the mid-Andøya event Kirkeraet (A3 according to Møller & Sollid 1972). Lake Storvatn, at 26 m a.s.l., is located at the same altitude as the NA Shoreline, which has a gradient of about 2.5 m/km (Fig. 1B). Organic gyttja just above the marine isolation contact is radiocarbon-dated to 14,020 ± 280 years BP (Table 1). This date represents a minimum age for the shoreline. Another important radiocarbon date with regard to the age for the submerged wave-cut platforms was obtained from shells in lake Grunnvatn on mid-Andøya. The ages of the mid and inner fractions were 12,650 ± 170 and 11,200 ± 170 years BP, respectively (Table 1). From Andenes harbour, a peat layer at about 10 m depth is radiocarbon-dated to 9580 ± 55 years BP. Based on these new radiocarbon dates (Fjalstad, in prep.; Fjalstad & Møller, in prep.) and previous dates (Møller 1986), a composite shore displacement curve is constructed for Andenes (Table 1, Fig. 2).

The height difference is 50–70 m between the emerged radiocarbon-dated shorelines on Andøya and the submerged levels of assumed similar age off Troms (Fig. 1B). Unless there has been a neotectonic subsidence of this magnitude of the entire shelf area after 13 ka BP, the emerged and submerged levels obviously are not of the same age. Such a neotectonic event remains to be identified.

As pointed out by Rokoengen & Dekko (1993), the NV and MA Levels have a gradient 2.3 and 2.0 m/km, respectively, which clearly indicate older ages compared to the distinct Main Shoreline (Younger Dryas, 11–10 ka BP) (Andersen 1968), which has a gradient of 1.0 m/km on the mainland. However, the authors seem to neglect this fact. According to Fig. 1A and B, the altitude of the marine limit distally to the Skarpnes moraines varies by ca. 20 m in mid-Troms. Therefore, the argument for a similar age for the Skarpnes Shoreline (12.5–12 ka BP), and at least one of the extrapolated NA and MA Levels based on the coincidence of one crossing point, is simply not reliable. In addition, the high marine limits on Andøya, Hinnøya, Senja, and Vanna (Fig. 1B) do not correspond with their model assuming a late deglaciation of the shelf areas.

For the critical time period (13–11 ka BP), Corner & Haugane (1993) dated shelly bottom sediments and organic gyttja from the marine isolation contact to 12,140 ± 300 (T-5161) and 11,480 ± 290 years BP (T-5159B), respectively, in lake Litlevatn at 25 m a.s.l. (ca. 10 m above the Main Shoreline) on Vanna, northern Troms. Vorren & Elvsborg (1979) dated paired shells from the Skarpnes moraines at Kraknes north of Tromsø to 12,280 ± 140 years BP (T-2379). The ML at the locality is about 45 m a.s.l. (Andersen 1968). Marthinussen (1962) dated shells in lake Sandvatn at 70–74 m a.s.l. in outer Astafjord to 12,300 ± 250 (T-269) and 11,700 ± 250 years BP (T-316). The contemporaneous sea level (ML) is about 80 m a.s.l. (Andersen 1968). A dating on shells at Møkklandsvatn, Hinnøya, gave an age of 12,280 ± 90 years BP (T-3207, Møller, unpubl.). The ML is 59 m a.s.l. according to Møller & Sollid (1972). These dated sea-level indicators (13–11 ka BP), comtemporaneous with the Skarpnes moraines, support the data from Andøya (Fig. 1A and B), and are contradictory to the views of Rokoengen & Dekko (1993), who

Table 1. Altitudes and radiocarbon-dated sea level indicators on northern Andøya.

Locality name	Altitude/depth in meter	Sample material	^{14}C age BP	Laboratory reference	References
Kjølhågen	38	sand	18,000 ± 2000	R-930803	F & M
Storvatn	26	gyttja	14,020 ± 280	T-6612A	F & M
Grunnvatn	5	shell	12,650 ± 170	Ua-48	F & M
Grunnvatn	5	shell	11,200 ± 170	Ua-49	F & M
Ramsa	2.5	peat	9,890 ± 130	T-5280	M
Andenes	− 10	peat	9,580 ± 55	T-10191	F
Ramsa	3	peat	7,400 ± 60	T-5282	M
Ramsa	8.5	peat	6,090 ± 100	T-5287A	M
Andenes	3.4	shell	5,075 ± 105	T-9424	F
Andenes	4.3	shell	3,535 ± 90	T-9430	F
Andenes	2.7	peat	3,130 ± 65	B-51778	F
Andenes	3	peat	1,190 ± 60	B-51769	F

F & M = Fjalstad & Møller (in prep.).
M = Møller (1986).
F = Fjalstad (in prep.).

suggest that the NV and MA Levels should occur below the Main Shoreline in the coastal land areas, and that dry land existed on the continental shelf in postglacial time.

In the coastal cave *Helvete* (blocked by a ca. 30 m thick moraine according to Møller, 1985) on the island of Trenyken in southern Lofoten, shell fragments at 19 m a.s.l. were radiocarbon-dated to 33,560 ± 1150 BP (Ua-2016) (Møller et al. 1992). This date represents a maximum age when the strandflat was overriden by the continental ice sheet. The date also indicates that the sea inundated the strandflat in late Middle Weichselian at the level of present sea level. Stratigraphic investigations and radiocarbon dates from the shelf off southern Troms (Vorren et al. 1983) indicate that the ice sheet probably advanced across the outer shelf areas after ca. 36 ka BP. Radiocarbon dates and stratigraphic studies at Nordvestbanken by Vorren et al. (1978) show that the continental ice sheet probably did not extend beyond the inner shelf area during the Middle Weichselian. The lowstand of the sea level was identified at minimum ca. −120 m at the outer shelf areas. If the extrapolation of the North Andøya Shoreline (Fig. 1B) is correct, this lowstand occurred prior to the maximum of glacio-isostatic depression at 20–16 ka BP (Fig. 2). Vorren & Kristoffersen (1986) claim that the chronology of Rokoengen et al. (1979), reintroduced by Rokoengen & Dekko (1993), is too young. This is in agreement with the shoreline simulation model for northern Norway (Møller 1989), which indicates that relative sea level has not been at 50–150 m depth off the coast of Troms during postglacial time if one assumes a linear isostatic rebound for the entire shelf and land areas. However, even if such a lowstand existed due to a forebulge effect, we doubt that there has been sufficient time to form 0.5–2 km broad wave-cut platforms on the shelf, several of them located in a low wave-energy environment.

In conclusion, shoreline data from Andøya, Vanna, Tromsø, Astafjord, and Hinnøya clearly show that the assumed submerged wave-cut platforms and beach-like features mapped at 50–150 m in depth on the continental shelf off Troms are not of postglacial age. The Nordvestbanken and Malangsgrunnen Levels are, most likely, polycyclic features formed during Cenozoic time contemporaneously with the formation of the strandflat in the coastal zone.

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