Discussion

The inner shelf of North Cape, Norway and its implications for the Barents Shelf–Finnmark Caledonide boundary. A comment

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Recently it has been proposed that the WNW–ESE-trending Trollfjord–Komagelv Fault can be traced into the continental shelf of northern Norway northwest of Magerøya, where it turns into a more easterly trend. In the offshore elongation of the Trollfjord–Komagelv Fault, however, several sub-parallel (WNW–ESE) structures are identified in reflection seismic sections, and it is inferred that these features rather represent the Trollfjord–Komagelv trend in the area. These faults indicate Carboniferous extension, and partly late Jurassic–early Cretaceous reactivation.

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In a recent note in *Norsk Geologisk Tidsskrift* attention has been drawn to the offshore extension of the Trollfjord–Komagelv Fault and its implications for the structural development of the inner shelf of the Barents Sea (Townsend 1987). We agree that this fault is one of the important structural elements in the area, but we suggest an alternative offshore extension, a hypothesis which is more consistent with available reflection seismic data.

The Trollfjord–Komagelv Fault (Fig. 1) (Siedlecka & Siedlecki 1967, 1972) is regarded as one of the most important structural elements of north Norway. It has been seen as important in connection with Vendian to early Ordovician large-scale dextral strike-slip movements (Roberts 1972, 1985; Johnson et al. 1978; Kjøde et al. 1978; Lippard & Roberts 1987), and its regional implications may be demonstrated by a possible link to the Ribachiy Fault in the USSR (Siedlecka 1975). The fault was reactivated in Post-Caledonian times, again by ?dextral strike-slip which has been estimated at maximum 4–5 km, probably 1–2 km (Johnson et al. 1978; Kjøde et al. 1978). These movements were terminated ca. 340 Ma ago (Beckinsale et al. 1975), i.e. in Visean times (early Carboniferous).

Considering the regional significance of the Trollfjord–Komagelv Fault Zone, it seems reasonable to seek its offshore continuation along the westnorthwesterly trend that dominates its onshore branch in Finnmark. Such an extension was posulated by Ziegler (1981) and Ziegler et al. (1986), and a more detailed correlation was attempted by Gabrielsen (1984:653), who pointed out that WNW–ESE-striking faults north of Magerøya and in the eastern part of the Hammerfest Basin are candidates for the offshore continuation of the Trollfjord–Komagelv Fault. However, based upon the data available at that time, it was stated that in a regional context the WNW–ESE-trend seemed to have had only moderate influence on the Mesozoic and Cenozoic structuring of the Barents Sea area (Gabrielsen 1984:661).

Leaning on the lack of direct correlations to offshore faults, Townsend (1987) proposed that the offshore continuation of the Trollfjord–Komagelv Fault (or a splay thereof) turns westward off the coast of Finnmark, and links up with a ENE–WSE-trending escarpment recently described by Vorren et al. (1986) (see Fig. 1). To support this conclusion, Townsend (1987) argued that the offshore continuation of the Trollfjord–Komagelv Fault has not yet been convincingly detected, and that the Trollfjord–Komagelv

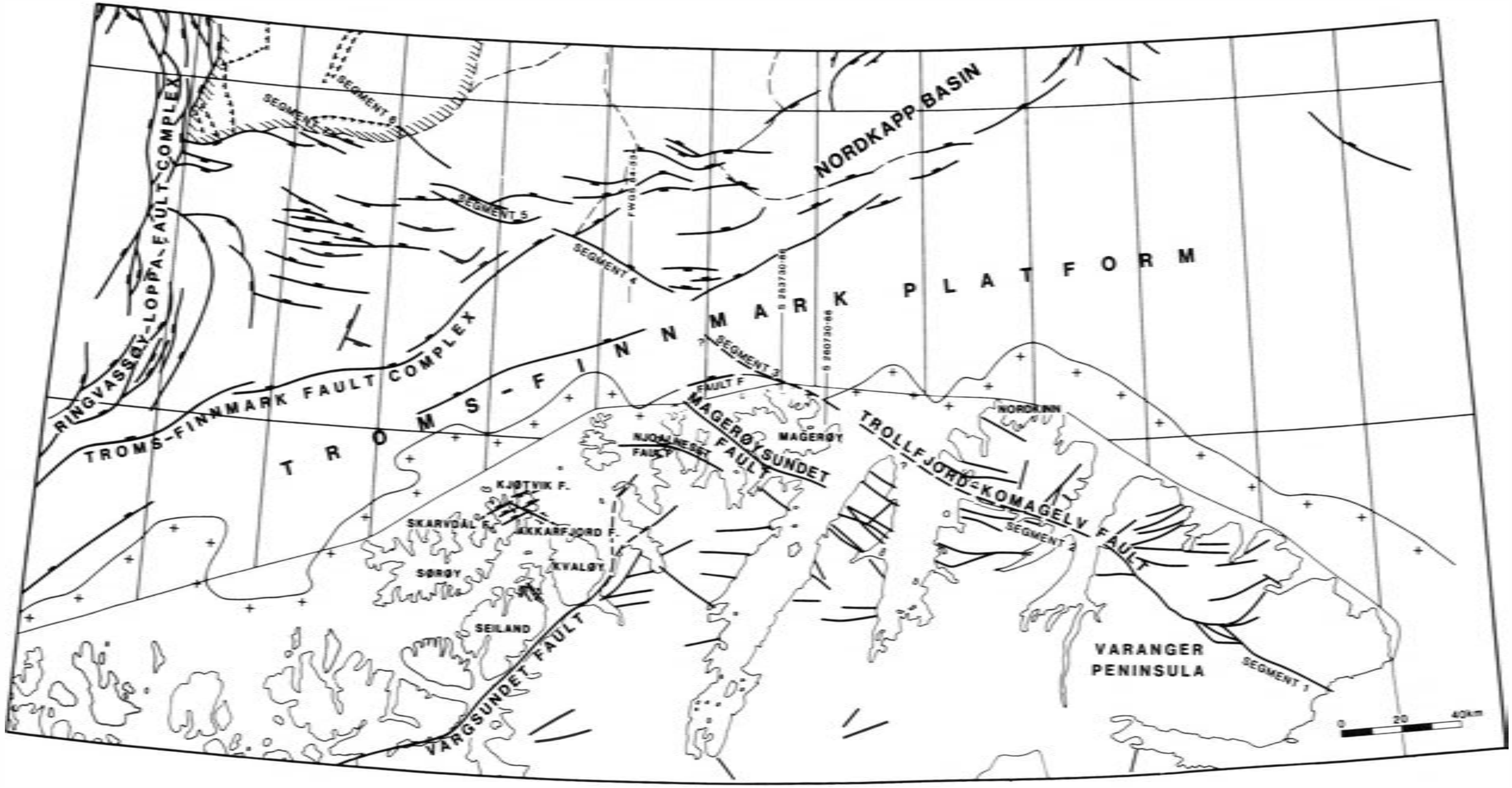

Fig. 1. Simplified structural map, southernmost Barents Sea and northern Finnmark. The offshore part of the map is based upon Gabrielsen et al. (in prep.) supplied with data from Gabrielsen (1984), Lippard & Roberts (1987), Roberts (1971), Sigmond et al. (1984), Zwaan & Roberts (1978), Worthing (1984). The fault discussed by Townsend (1987) (Fault F in Fig. 1) is plotted from location data in Vorren et al. (1986). The basement outcrop line (wiggled) northwest and northeast of Magerøya is the interpretation of the present authors. Segments 1 to 7 of the Trollfjord–Komagelv Fault discussed in the text, and locations of sections shown in Fig. 2 are indicated.

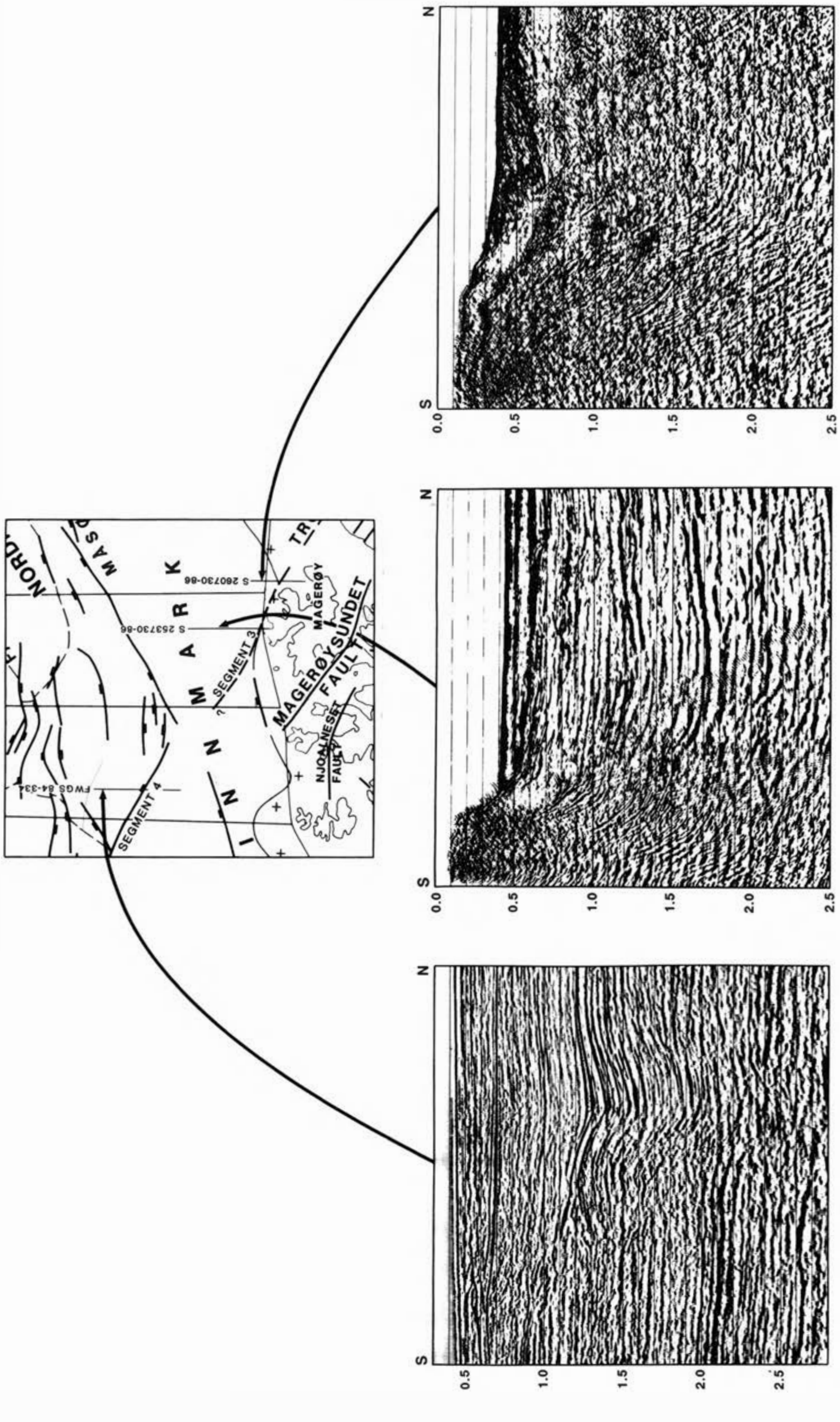

Fig. 2. Sections through segments 3 and 4 of the Trollfjord–Komagelv Fault trend. For location, see Fig. 1.

Fault changes its orientation to E–W on Nordkinnhalvøya. The latter is a new interpretation, not previously documented (see e.g. Sigmond et al. 1984).

Discussion

We feel that there are several arguments against a direct correlation of the Trollfjord–Komagelv Fault with the ENE–WSE-trending fault north of Magerøya as suggested by Townsend (1987).

1. Available seismic lines demonstrate that a fault with a WNW trend and a dip-slip component down to NNE is situated in the area where a direct link to the Trollfjord–Komagelv Fault has been missing (segment 3 in Figs. 1 and 2), (see also Lippard & Roberts 1987). This fault segment coincides with the transition from basement to younger sediments, and its hanging wall fault block is characterized by a wide roll-over.

2. Following the trend of the Trollfjord–Komagelv Fault towards the Hammerfest Basin, a major WNW–ESE-trending fault with a normal component is found (segment 4 in Fig. 1). Its hanging wall is severely deformed in a way that indicates inversion of the structure (Fig. 2). Subsidence was initiated by pre-Permian times, and the fault delineates a major basin of this age. Segment 4 has previously been considered a segment of the Troms–Finnmark Fault Complex (Gabrielsen 1984; Gabrielsen et al. 1984), but recent investigations suggest that it is not a natural part of this fault complex (Gabrielsen et al. in prep).

3. An important structural trend in the eastern part of the Hammerfest Basin parallels the Trollfjord–Komagelv trend (Berglund et al. 1986), and is defined by major fault systems of probable extensional origin modified by later strike-slip movements (segment 5 in Fig. 1). This system is slightly offset to the west relative to the normal fault segment described above. Strike-slip movements along this system are dated to late Jurassic–early Cretaceous, but isopach mapping indicates that the structure has an even older history.

4. Further northwest, at the transition between the Hammerfest Basin and the Loppa High (Gabrielsen et al. in prep.), another distinct subparallel fault zone with similar trend is located (segments 6 and 7 in Fig. 1). Reflection seismic data indicate that these elements were activated already by Carboniferous times. We feel that the trend defined by segments 3 to 7 constitute a lineament that is the most likely candidate to be the offshore extension of the Trollfjord–Komagelv Fault.

5. Townsend (1987:153) states that 'on Nordkynnhalvøya, the Trollfjord–Komagelv Fault changes its orientation to almost E–W'. Lippard & Roberts (1987) have shown that E–W-trending faults are common on Nordkinnhalvøya, but that these preferentially curve into a NE–SW-trend. (On the other hand, some of the major ENE–WSW-trending structures that can be followed offshore north of the peninsula of Porsanger show slight westerly bends.) Furthermore, it should be remembered that local E–W-trending segments have been described from the Trollfjord–Komagelv Fault elsewhere (Johnson et al. 1978). Johnson et al. (1978) demonstrated that the E–W segments represent abandoned early splays of the main fault rather than curved segments of the fault trace itself. Accordingly, it is questionable as to whether the E–W-trending fault referred to by Townsend (1987) can be correlated to the Trollfjord–Komagelv Fault itself.

6. The existence of NE- to ENE-trending faults in the inner shelf of the southwestern Barents Sea is well known (e.g. Figs. 1 and 2 in Gabrielsen 1984), and were, in fact, indicated already by Holtedahl (1956). The most prominent of these structures is the Troms–Finnmark Fault Complex (Moe 1974; Gabrielsen 1984). This structure was active in Carboniferous times (Gabrielsen et al. 1984), and is part of a complex of profound parallel structures that has been of great significance for the structural development of the area. It has also been realized that the Troms–Finnmark Fault Complex is accompanied by significant faults on its landward side (i.e. in the Troms–Finnmark Platform, e.g. Gabrielsen 1984, Figs. 2 and 3), and that the innermost of these, as identified in commercial reflection seismic data (Fig. 3), coincides with the transition between late Palaeozoic and younger sediments and the Caledonian crystalline rocks. Also onshore NE–SW-faults are important structures, and several major faults with this trend have been reported, e.g. the Skarvdalen and Kjøtvika Faults (Roberts 1971) and the Vargsundet Fault (Worthing 1984). These are regarded as Caledonian structures characterized by multiple deformation and late Caledonian or younger reactivation (Roberts 1971, 1985).

It is therefore more reasonable to look on the E–W-trending in connection with the Troms–Finnmark Fault Complex and the subparallel onshore structures rather than as connecting with the Trollfjord–Komagelv Fault as preferred by Townsend (1987).

Implications of timing

The timing of the fault activity has obvious implications as regards the correlation of the potential elements of the Trollfjord–Komagelv trend (Fig. 4).

1. A basement structural grain comprising NE–SW-, ENE–WSW- and WNW–ESE-trending faults was established by late Caledonian times.
2. There was a relatively mild phase of reactivation of the Trollfjord–Komagelv Fault Zone after emplacement of the upper Caledonian nappes, but before intrusion of the latest set of dykes, i.e. ca. 340 Ma (Beckinsale et al. 1975). This eposide was characterized by ?dextral strike-slip (Johnson et al. 1978; Kjøde et al. 1978).
3. Segment 2 (Fig. 1) was active as a normal fault in Carboniferous times, at the same time as normal faulting took place along segment 3.
4. Inversion, probably as a result of strike-slip faulting along segment 5 is known in late Jurassic–early Cretaceous times. In the reflection seismic data, however, there can be seen an offset of the (?)Permian level, and it is likely that there was an earlier period of activity even for this segment. Slight early Cretaceous inversion can also be traced in segment 4.

This chain of evidence indicates that the Trollfjord–Komagelv trend is an old (Vendian–early Ordovician) zone of weakness which was reactivated in Devonian to early Carboniferous times as a ?dextral strike-slip fault (Johnson et al. 1978; Roberts 1985). In the late Carboniferous period subsidence took place at least along the offshore part of the structure, and the zone is inferred to have been reactivated again in late Jurassic–early Cretaceous times with moderate strike-slip movement. The two latter phases of activity are not known from the Trollfjord–Komagelv Fault Zone on land. However, Landsat lineament analysis (Gabrielsen & Ramberg 1979; Gabrielsen 1984) shows that the Trollfjord–Komagelv fault zone to be a complex structure. Minor movements along one or more of its splays would be difficult to detect and cannot be ruled out.

Conclusions

We agree with Townsend (1987) that the fault close to the coast of Finnmark, indicated in the data of Vorren et al. (1986), is an important structure in the area. Moreover, this structure defines the transition between the crystalline rocks on land and the late Palaeozoic and younger sediments in the shelf area as proposed by Holtedahl (1956). However, we suggest that these faults are genetically related to the Troms–Finnmark Fault Complex, and probably not to the Trollfjord–Komagelv Fault.

The present state of the art in structural mapping in the eastern part of the Hammerfest Basin indicates that fault systems of regional importance are located at the offshore elongation of the Trollfjord–Komagelv Fault Zone.

Offshore activity along the trend can be dated back to Carboniferous times and there are clear indications of late Jurassic–early Cretaceous inversion. At present, the Mesozoic episode of activity has not been identified for the Trollfjord–Komagelv Fault itself, but we feel that this does not exclude the correlation between this fault zone and the WNW–ESE-trending offshore structures described above.

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