# EXTENSION OF THE OFFERDAL AND SÄRV NAPPES AND SEVE SUPERGROUP INTO NORTHERN TRØNDELAG

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New evidence from the Tømmerås area requires redefinition of the extent of development of the Offerdal Nappe in Trøndelag. Särv and Seve units are recognized in the area. The Seve Supergroup and Särv Nappe have previously been shown to wedge out westwards, being largely restricted to Swedish territory. These units reappear as very large-scale lenses in Trøndelag. This evidence substantially increases estimates of nappe displacement. At the same time it emphasizes the importance of flattening (gravitational collapse) during the late-stage migration of the nappe pile eastwards onto the Baltoscandian platform.

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Westward thinning of the major allochthonous units of the Scandinavian Caledonides is well documented. The evidence has been summarized recently (Gee 1975a and b). Strömberg (1955, 1961) demonstrated that the Särv Nappe thins in the eastern limb of the Sylarna antiform. Zachrisson (1969) showed how the units of the Seve-Köli Nappe Complex generally thin out towards the west, the Seve largely being confined to Sweden (Zachrisson 1969, 1973). Rutland & Nicholson (1969) demonstrated that the westward wedging is characteristic for the metamorphic allochthon of the Sulitjelma profile (67° N).

However, despite this evidence of regional wedging (with units such as the Seve Supergroup, several kilometres thick in the east, being reduced to zero in the vicinity of the Norwegian border) it has been clear for many years that the thinning is far from regular. Thus, in his description of the Seve wedge, Zachrisson (1973) showed that the Seve Supergroup thins dramatically over the Mullfjäll antiform only to swell out again in the Helags synform before thinning to zero over the Sylarna antiform. And it is apparent from Törnebohm (1896) that the Seve units reappear again in a window west of the Norwegian border at Øyfjell.

This evidence of westerly wedging-out of major allochthonous units above a basement/cover décollement zone in Sweden was considered (Gee 1974) in relation to the evidence from the Tømmerås 'anticline' (Springer Peacey 1964) of a thick autochthonous cover. I concluded then that the Tømmerås antiform was a composite window composed of at least three nappe units related to the Offerdal and higher structural units and requiring translation distances (from west to east) of several hundred kilometres over the win-

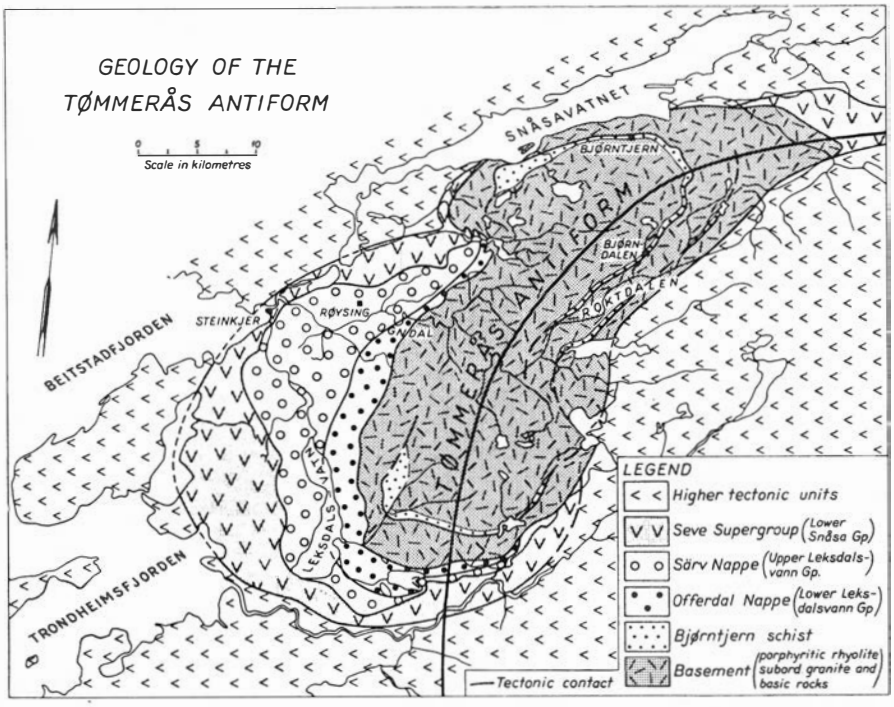


Fig. 1. Geological map of the Tømmerås area, based on Springer Peacey 1964.

dow. A recent reexamination of some aspects of the Tømmerås antiform has led to a further reassessment of this structure, and the results are summarized in Fig. 1.

## Bjørntjern Schists

The Tømmerås basement, dominated by porphyritic rhyolites with some granite and subordinate basic intrusive rocks, is separated into a lower and upper unit by a thin zone of metasediments. The latter (included in the Bjørntjern schists of Springer Peacey 1964) were correlated by Gee (1974) with units of the Jämtland Supergroup. The correlation is enhanced by the identification in Bjørndalen of a sequence within the Bjørntjern schists of (from base upwards) quartzite, black highly organic phyllite, limestone and quartz phyllites, comparable with units in northern Jämtland of the Gärdsjön, Fjällbränna, Kalkberget, and Norråker formations (Gee et al. 1974), respectively. None of these units exceeds a few metres in thickness in Bjørndalen. Comparison of this stratigraphy with that at a similar structural level within the Grong-Olden Culmination at Grasåmoen, taken in relation to the evidence that the latter units can be traced more or less continuously eastwards into the Jämtland Supergroup of western Jämtland, adds considerably to the security of this lithostratigraphic correlation.

The foliated allochthonous basement overlying the Bjørntjern schist locally also includes slices of Bjørndalen metasediment (only quartzite has so far been recorded in these occurrences), an association that is not known in the Offerdal Nappe elsewhere. The conclusion (Gee 1974) that this foliated basement unit along with the overlying Leksdalsvann Group metasediments should be included in the Offerdal Nappe cannot be upheld – a large part if not all of the allochthonous basement composes a lower tectonic unit below the Offerdal Nappe. The contact between the foliated basement porphyries and the overlying Leksdalsvann sediments is, at least locally, tectonic, showing a transitional zone of blastomylonites (Springer Peacey 1964: 44 "the boundary is sharp within five metres, but its details are blurred by secondary effects. The metamorphic grade seems to increase downwards in the unit, so that near the boundary the rocks are coarse, granular schists, often with augen of potash feldspar or quartz-plagioclase – Kf."). P.-G. Andreasson (pers. comm.) has shown that this contact is an important regional discontinuity and it is taken here as the base of the Offerdal Nappe.

## Leksdalsvann Group

The Leksdalsvann Group (Springer Peacey 1964) is a metasandstone/siltstone unit overlying the allochthouous basement referred to above. Gee (1974) compared these sediments with those of the Offerdal Group and included the entire unit within the Offerdal Nappe. Springer Peacey described the Group (1964: 38) to be divisible into two lithological units 'a) an upper unit of impure feldspathic sandstones and b) a lower unit of dark, sandy siltstones'. She commented that the two units passed gradationally into each other, and apparent 'primary sedimentary effect'. Springer Peacey commented elsewhere (p. 57) that whereas amphibolites are present both in the underlying Tømmerås basement ('numerous thin metadolorite sheets') and the overlying Snåsa Group they are 'very rarely present in the Leksdalsvann Group'.

Reexamination of the Leksdalsvann Group has confirmed the lack of basic rocks in the metasediments of the lower unit. These isoclinally folded and refolded sandstones and siltstones appear to totally lack basic rocks. The unit compares well with the Offerdal Group metasediments of the type area in Jämtland both in lithology and secondary structures. In marked contrast, the upper Leksdalsvann unit, in general a coarse metasandstone frequently exhibiting crossbedding, convolute bedding etc., contains an important suite of metabasic rocks. These appear usually as foliated concordant biotite amphibolites but they have been shown locally (e.g. c. 1 km W of Røysing) to pass laterally into discordant porphyritic dolerites preserving chilled margins and primary textures. These intrusive rocks compare closely in handspecimen and in general petrography with the Ottfjället dolerites of the Särv Nappe. The presence of discordant sheets in the upper unit and their absence in the lower unit require that the schist separating the upper

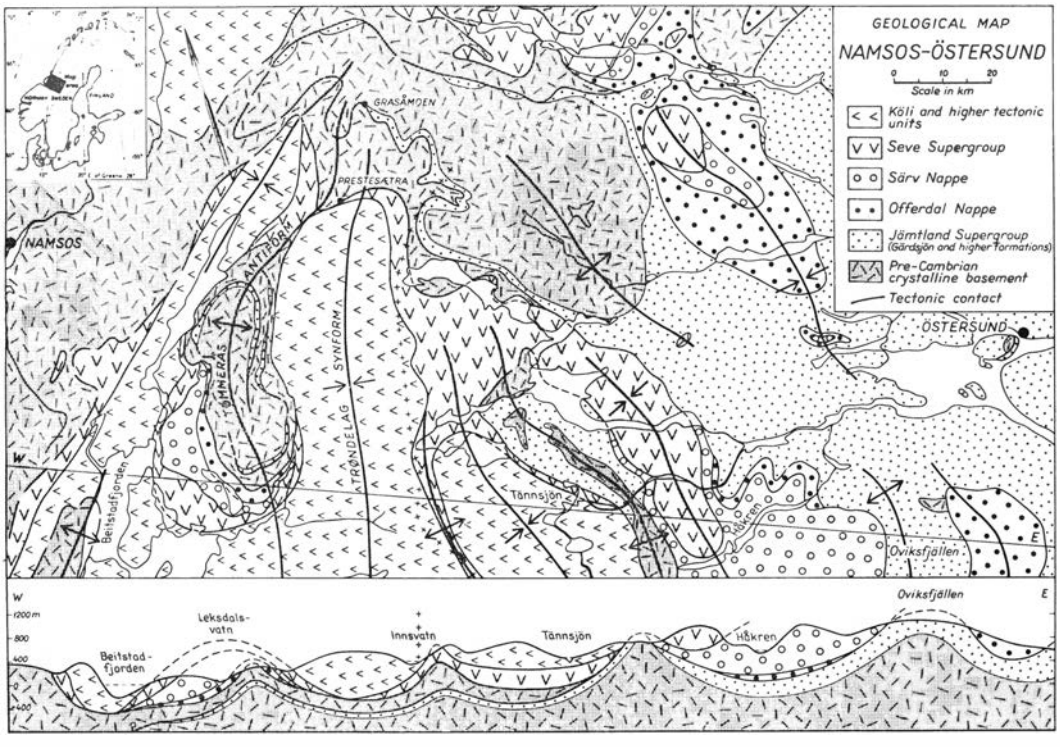


Fig. 2. Geology of the area from Namsos to Østersund. Based on Gee 1975b and partly on Springer Peacey 1964.

unit of the Leksdalsvann Group from the lower unit marks an important tectonic discontinuity. Whereas the lower unit represents a westerly extension of the Offerdal Nappe the upper unit is an essential part of the Särv Nappe.

## Snåsa Group

The basal unit of the Snåsa Group (well exposed in road cuttings on the E 6 a couple of kilometres south of Steinkjer) are composed of garnitiferous amphibolites, schists, and gneisses locally with peridotites. Retrogression to epidote amphibolites is ubiquitous. The internal structure is remarkably complex by comparison with that of the underlying Leksdalsvann Group or the overlying Snåsa Group units, a complexity that may partly be attributable to the greater variation in lithology. However, when taken in relation to the higher metamorphic grade, it seems more probable that this contrast in tectonite character is relatable to a tectonic history separate from that of the underlying and overlying units. It is concluded that this amphibolite-dominated lower unit of the Snåsa Group is allochthonous on the under-

lying Leksdalsvann Group (Särv Nappe). Törnebohm (1896) correlated this unit with the Seve.

## Comparison of relationships in the Tømmerås area with those to the northeast

Comparison of the structural succession in the Tømmerås antiform with that of the Jämtland Caledonides is striking and unlikely to be coincidental (Fig. 2). A nappe pile exists in the neighbourhood of Tømmerås that includes units directly comparable with the Seve Supergroup, the Särv and the Offerdal Nappes, and lower tectonic units composed of basement granites and rhyolites with sediments of the Sjoutälven and Tåsjön Groups of the Jämtland Supergroup. The Seve Supergroup can be traced from its type area (Åreskutan) in Sweden northwestwards along the southern margin of the Grong-Olden Culmination. F. Kautsky's recent remapping of the southern margin of the Culmination has confirmed (pers. comm.) previous observations that the Seve thins to zero in the vicinity of Prestesætra, but he has also shown that it thickens again further west (cf. Törnebohm 1896), being represented by the amphibolites, schists, and subordinate peridodites recorded by Foslie (1959) in the axial depression of the Tømmerås antiform between the basement of the Grong-Olden Culmination and Tømmerås. Kautsky has also shown that below the Seve unit there locally occur units of both Offerdal and Särv character. Offerdal Group sediments are the most prominent, appearing in a lens some five kilometres in strike length and up to fifty metres thick in the Prestesætra area. This development of the Offerdal unit is closely comparable with that in the type area where the metasediments (sandstones and siltstones) are characterized by a penetrative schistosity (related to isoclinal folding) and a resulting regular fissility that dictates their economic potential. As in Sweden it is extensively quarried for paving stones, etc. Occasionally, flattened cross-bedding is preserved but, in general, traces of such sedimentary structures are obliterated by the isoclinal folding and flattening; a regular parallel banding, a combination of primary compositional banding and penetrative secondary foliation, dominates.

## Concluding remarks

The recognition of Offerdal, Särv, and Seve units in northern Trøndelag has consequences for interpretation of the regional correlation of these units elsewhere in central Norway. It also bears on the interpretation of the general mechanism of nappe displacement in the Scandes.

With regard to correlation of the Seve units, Törnebohm's compilation (1896) of western Trøndelag is of particular interest. He showed that upper amphibolite facies complexes occurring south and southwest of Tømmerås (e.g. in the Levanger and Orkanger areas), dominated by schists, gneisses,

and amphibolites and separating the greenschist facies units of the Trondheim Supergroup from underlying augen gneisses, metasandstones and/or basement, were of Seve character. Locally (as at Driva near Oppdal) metasandstone units intruded by discordant sheets of metadolerite separate these Seve-like units from the underlying basement with its veneer of meta-arkose. Thus, correlation (Wolff 1967, Gee 1975) of these Seve-like units with the Gula Group of central Trøndelag is improbable and needs urgent reinvestigation. As Törnebohm (1896) showed, the Gula Group is restricted to central Trøndelag.

Recognition, in the vicinity of Steinkjer, of the Seve, Särv and Offerdal units, composing a mega-lens, have two important consequences. Firstly, it substantially increases estimates of displacement distances. It can be concluded that the Seve Complex has been displaced at least 150 km over the Särv Nappe, the Särv Nappe at least 200 km over the Offerdal Nappe, and the Offerdal Nappe at least 150 km over the underlying tectonic units. It should be emphasised that these are minimum displacement distances. The pinch-and-swell deformation of these tectonic units supports the theory that gravitational collapse and eastward extension were involved in the nappe displacement (Ramberg 1966). Nevertheless, there is no evidence that the stacking of the nappes was related to this regional flattening. It is concluded, as previously (Gee 1975a: 509), that within this segment of the Scandes exposed in Jämtland and Trøndelag gravitational collapse is superimposed on the nappe pile. The individual nappe units are derived from separate pre-tectonic environments (partly oceanic, partly continental margin) and have suffered important differences in history prior to emplacement. Emplacement of the nappes involved thickening of the tectonic pile; progressive thickening (with superposition of denser units, e.g. the greenschists and amphibolites of the Seve-Köli Nappe Complex) led to progressive collapse and extension of the nappes. Gravitational collapse must have accompanied the stacking of the nappes. The geometry of the mega-lenses indicates that it probably dominated the tectonic regime during the latter stages of nappe displacement.

The stratigraphic evidence from the late orogenic intramontane basins of western Trøndelag bears on the question of the driving mechanism of nappe displacement. The oldest late-orogenic sediments (on Hitra) contain a *Dictyocaris* fauna (Størmer 1935) thought to be of Downtonian (or possibly Ludlovian, Heintz in Gee & Wilson 1974) age. Clearly the nappe pile in western Trøndelag was established prior to the regional uplift of what is now sea-board Norway, and the vertical movements of a gravity regime must have dominated the tectonics during and for some millions of years prior to and after the deposition of the Hitra sediments. Nevertheless, in the southeast, translation of the nappes over the décollement surface was continuing, influencing Ludlovian sedimentation in the Mjøsa area and eventually deforming these sequences in post-Downtonian time.

New biostratigraphic evidence (R. B. Rickards, pers. comm.) that the upper

part of the Bångåsen formation of the Jämtland Supergroup is of uppermost Llandovery age (zone of *M. crenulatus),* and that the coral found by Thorslund (1948) as a clast in the overlying Ekeberg greywackes is of Ludlow age (zone of *M. nilssoni,* L. Karis, pers. comm.), emphasizes that deposition was continuing in the eastern parts of the orogen during stacking of the nappes in westernmost Trøndelag; further displacement of the nappe pile eastwards was accompanied by rapid uplift in western Norway.

Thus the stratigraphic record supports the geometrical evidence from the nappes themselves, both the large-scale geometry (pinch-and-swell deformation for the nappe pile) and the internal extensional phenomena (boudinage, pebble extension, mineral lineation, rodding etc.) that gravitational collapse has played a major role at least during the final stages of easterly displacement of the rock units.

This evidence influences estimates both of crustal shortening and rates of nappe displacement (cf. Gee 1975a and b). Assessment of the extent of flattening within the individual nappe units is essential for making these estimates and, with the major structure better established, priority should be given to these measurements. 'We have, as yet, no adequate assessment of the relationship between the crustal shortening required by the repetition within the nappe complex and the extension implicit in the evidence of boudinage, pebble elongation, et cetera' (Gee 1975a: 493) in such units as the Seve-Köli Nappe Complex. Nevertheless the composition of the nappe units and their individual tectonic and metamorphic histories provide indirect methods for estimation of crustal shortening. The fact that Sjoutälven Group sediments were the oldest units to be deposited on the Grong-Olden and Tømmerås basement as far west as Tømmerås and that these units are overthrust by similar basement requires that the depositional basin of the Offerdal sediments must have been located west of the Snåsa synform. The lack of a dyke *swarm* in the Grong-Olden basement culmination and in the sediments of the Offerdal Nappe requires accumulation of the Särv Group west of the Offerdal Group. The high grade character of the Seve Supergroup by comparison with the Särv Nappe requires derivation from substantially further west. This and other evidence has been summarized earlier (Gee 1975a and b) and will not be recapitulated here. Whereas this indirect evidence requires shortening in the order of at least 500 km, the actual measurable displacement distances are in the order of twice this amount. Pinch-and-swell deformation of the nappes requires that a large part of this difference is probably attributable to strain internal to the nappes and not to translation of the individual tectonic units.

*Acknowledgements.* – Springer Peacey's (1964) excellent reconnaissance of Tømmerås (supplemented only locally by my own observations) provides the basis for the tectonic interpretation presented in 1974 and here. That this interpretation differs radically from Peacey's in no way detracts from the major contribution she made in the early 1960s. The reinterpretation presented here is possible only with prior knowledge of nappe composition and geometry further east in Trøndelag and western Jämtland.

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