

Jack-straw-textured olivines in some Norwegian metaperidotites

STIG BAKKE & ARE KORNELIUSSEN

Bakke, S. & Korneliussen, A.: Jack-straw-textured olivines in some Norwegian metaperidotites. *Norsk Geologisk Tidsskrift*, Vol. 66, pp. 271–276. Oslo 1986. ISSN 0029-196X.

Jack-straw-textured olivines, which are elongate olivines of metamorphic origin, occur in complexly metamorphosed ultramafites within the Norwegian Caledonides. The ultramafic bodies are lenses enclosed within high-grade mica-schists or gneisses. In general they consist of a dunitic core surrounded by massive olivine orthopyroxenite with a mantle of jack-straw-textured olivines in contact with the country rocks.

The jack-straw olivines are elongate, randomly orientated platy crystals from 3 cm to 1 m long. They lie in a matrix of orthopyroxene, carbonate and minor tremolite. Field relations between various rock-types, including jack-straw textured olivine + carbonate + talc +/- bronzite veins, are well exposed at the Nordvernes ultramafic body, North Helgeland.

S. Bakke & A. Korneliussen, NGU, Postboks 3006, N-7001 Trondheim, Norway.*

**Now at IKU, Postboks 1883, Jarlsletta, 7001, Trondheim, Norway. A. Korneliussen, NGU, Postboks 3006, N-7001 Trondheim, Norway*

Some Norwegian ultramafic bodies which experienced the Caledonian orogeny contain randomly orientated, platy, metamorphic olivines up to 1 m in length. Where this texture is well developed it superficially resembles olivine spinifex (Nesbitt 1971) that is frequently found in komatiites. In order to avoid confusion with spinifex texture this paper will adopt the proposal of Snoke and Calk (1978), and refer to the randomly-orientated metamorphic olivines as jack-straw texture.

In Norway platy olivines were first mentioned by Korneliussen (1976) with special reference to the Nordvernes ultramafic body (see below). In Scandinavia serpentine pseudomorphs after platy olivines are reported from the Lappvattnet-Mjøvattnet ultramafic bodies in the Precambrian of northern Sweden (Juve 1975). Juve interpreted them as spinifex while Nilsson (1985) has described them as jack-straw textures of metamorphic origin. Elongate olivines of metamorphic origin in talc-carbonate rocks formed during prograde metamorphism of serpentinites are well documented elsewhere in the world (Oliver et al. 1972, Evans & Trommsdorff 1974, Collerson et al. 1976, Snoke & Calk 1978).

This note will document the occurrence of jack-straw-textured ultramafic bodies in Norway, and describe the distribution of this texture in Nordvernes, an ultramafite at North Helgeland.

General macroscopic and petrographic features

Jack-straw-textured olivines have been observed in ultramafic bodies within Caledonian nappes of the Lesja, Helgeland and Troms areas (Fig. 1). The ultramafic rocks are Alpine metaperidotites of generally harzburgitic composition containing olivine + orthopyroxene (bronzite) + talc + carbonate + tremolite (smaragdite) +/- antigorite, with chromium-rich spinel as a common accessory mineral. Harzburgite is an igneous term. Because these rocks are of metamorphic origin, they will be referred to as olivine orthopyroxenite in this note. In Norwegian literature this rock type is often referred to as sagvandite (Pettersen 1883, Schreyer et al. 1972, Moore 1977).

The ultramafic bodies are generally tectonic lenses conformably enclosed within high-grade mica schists or paragneisses. The bodies show a zonal structure with a dunitic core surrounded by massive olivine orthopyroxenite with a mantle of jack-straw-textured olivine orthopyroxenite in contact with metasediments. Transitions between the three types of ultramafic rocks are gradual. The largest bodies observed have a large dunitic core, and the smallest ones, only a few metres across, consist only of jack-straw-textured olivine orthopyroxenite. Veins of jack-straw-textured olivine orthopyroxenite are observed with-

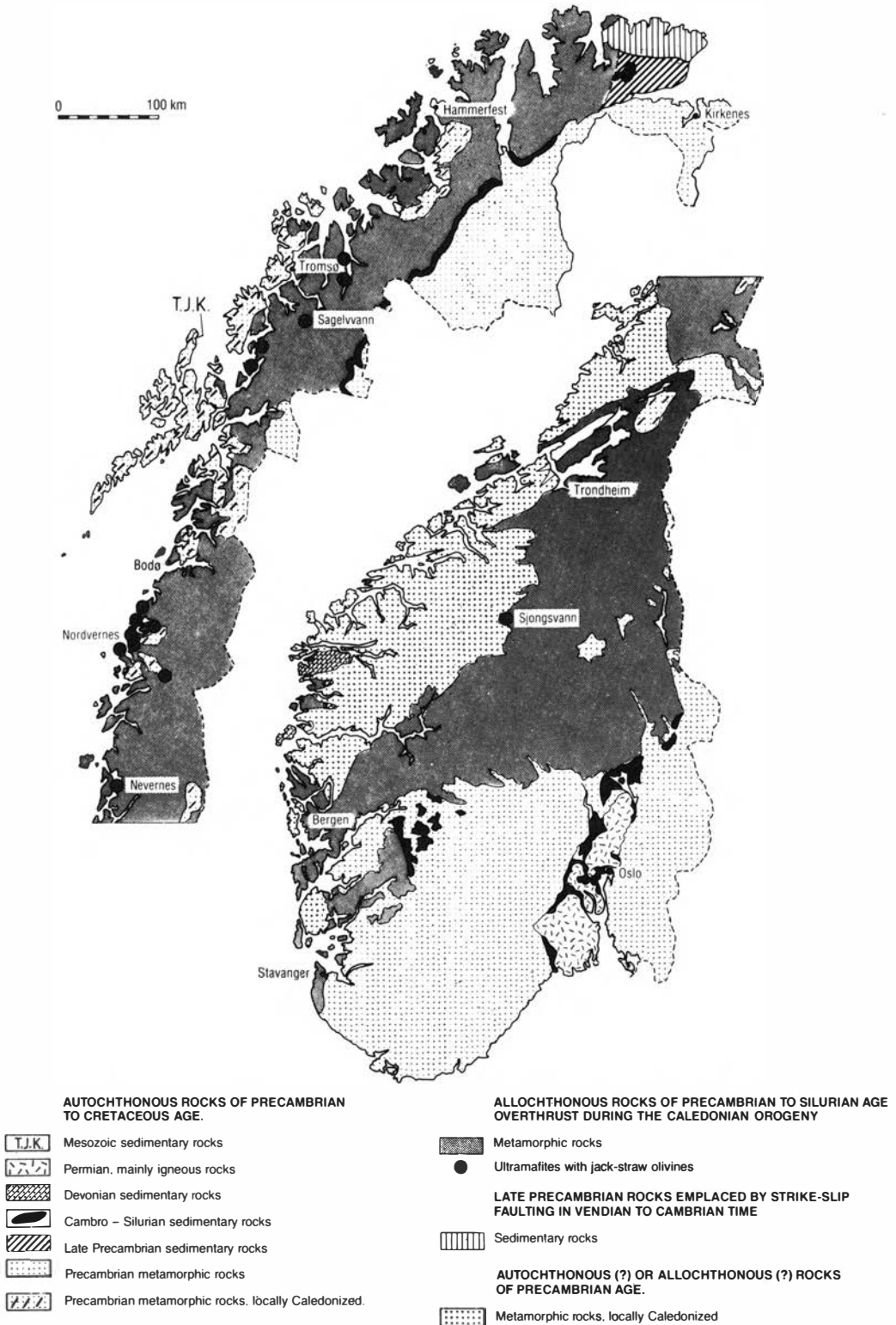


Fig. 1. Localities of jack-straw-textured olivines in Norway. Geological map after Sigmond (1985).

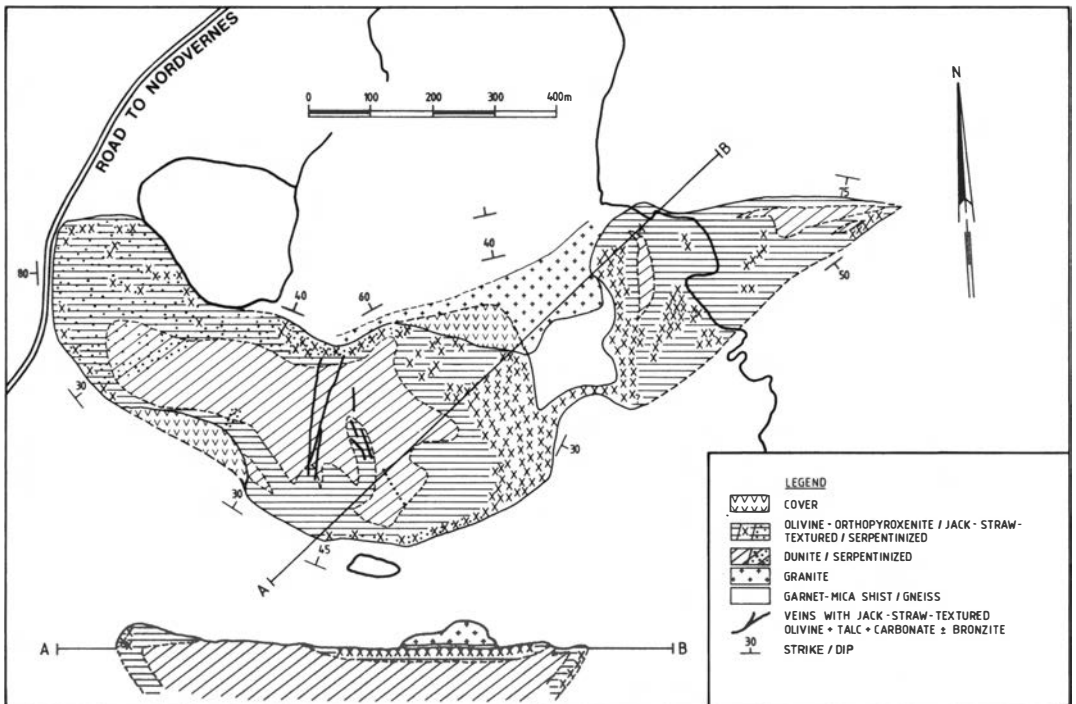


Fig. 2. Map and cross section of the Nordvernes ultramafic body, North Helgeland.

in the massive olivine orthopyroxenite zone of some ultramafic bodies (Fig. 2).

Near contacts between the ultramafic bodies and the country rock there are veins and lenses of a reaction product, which most commonly occurs in the country rocks 0 to 3 m from the contacts, but it has also been found within the bodies. They are garnet amphibolites +/-feldspar +/-tremolite +/-olivine +/-epidote +/-phlogopite +/-corundum.

In fresh rocks the jack-straw olivines form elongate, randomly orientated, platy crystals that vary in length from 5 cm to 1 m. They lie in a matrix of orthopyroxene (bronzite) and carbonate with some tremolite (smaragdite). The jack-straw-textured olivines contribute with 10 to 60 vol. % of the rock. The edges of the crystals often have an irregular, fingering appearance. Cross-section of an elongate olivine crystal is shown in Fig. 3b. Bronzite is the main mineral in the matrix and forms rosettes or sprays 2–20 cm across. Small grains of tremolite and dolomite +/- Cr-spinel are also present in the matrix. In thin section the jack-straw-textured olivines are homogenous with no sign of compositional zonation. Skeletal olivines have not been observed.

The jack-straw-textured olivine orthopyroxenites have suffered different grades of retrograde metamorphism. Metasomatic solutions from the country-rock containing CaO and CO₂ have led to the formation of dolomite and tremolite, which are present in all samples. In some bodies the jack-straw-textured olivines are completely pseudomorphed by serpentine in a matrix of talc/tremolite (pseudomorph after bronzite) with some dolomite.

The Nordvernes body

The relationship between various rock-types, including jack-straw-textured varieties, is well-exposed in the Nordvernes ultramafic body at North Helgeland (Fig. 2). The ultramafic body has a core of partly-serpentinized dunite surrounded by talc- and dolomite-bearing olivine orthopyroxenite with a rim of well-developed jack-straw-textured olivine orthopyroxenite along contacts with the country rock.

Jack-straw texture is developed both along the margin of the body and in cross-cutting veins. The distribution of the jack-straw texture in the

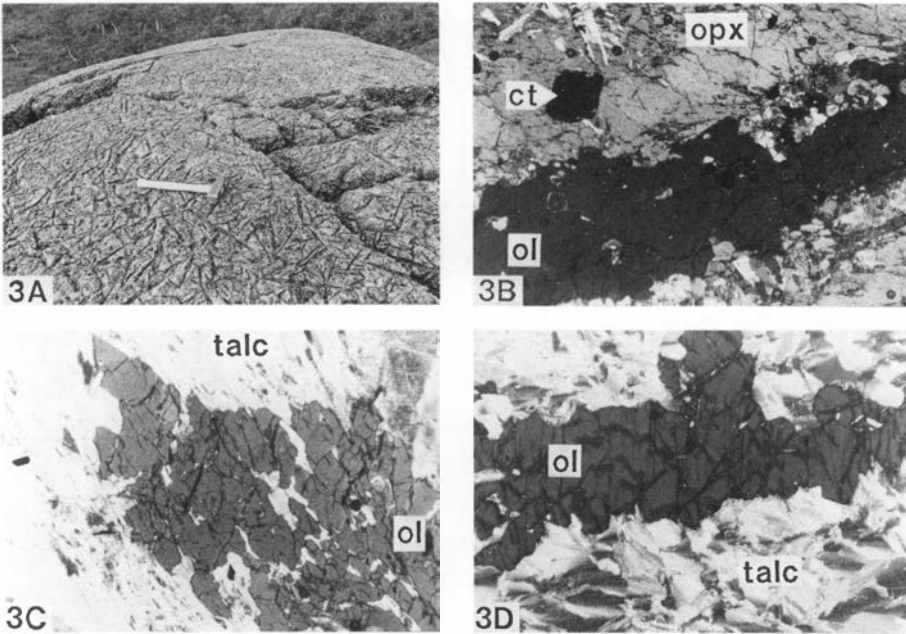


Fig. 3.
 a. Jack-straw-textured olivine in olivine orthopyroxenite, Nordvernes.
 b. Photomicrograph of jack-straw olivine in olivine orthopyroxenite, Nordvernes. Partly crossed nicols. Long side of picture is 9 mm.
 c. Photomicrograph of branching olivine in talc matrix from a talc+olivine+orthopyroxene vein, Nordvernes.
 d. Photomicrograph of jack-straw olivine in talc. Same locality as Fig. 3c.
 For Fig 3 a-d: ol-olivine, opx-orthopyroxene, ct-chromite.

olivine orthopyroxenite takes the form of a 2–4 m thick mantle around the body (somewhat exaggerated in the profile in Fig. 2), which is well exposed in its central part, where the contact is horizontal (Fig. 3a). The transition from jack-straw-textured olivine orthopyroxenite to massive olivine orthopyroxenites is gradational over 1/2 to 1m. In some localities of this transition zone and in the contact-metasomatic border-zones adjacent to the country-rock, up to 10 cm long and highly irregular, branching olivines are found.

Jack-straw olivines also occur in 0.5 to 2 m thick cross-cutting veins which contain olivine + carbonate + talc +/-bronzite (Fig. 3 c & d). Where the jack-straw olivines are less well developed, branching olivines are present (Fig. 3c). A gradual transition between the two types of olivine morphology is present.

Electronmicroprobe analyses (Table 1) of jack-straw olivines show that the olivine is MgO rich (Fo 90–92) and lacks compositional zoning. The NiO and CaO contents are 0.11 and 0.06% re-

Table 1. Microprobe analyses of jack-straw olivine and bronzite from Nordvernes.

	Olivine (*)	Bronzite (**)
SiO ₂	41.22	58.12
MgO	49.86	35.57
FeO	8.34	5.44
MnO	0.15	0.27
NiO	0.11	0.01
CaO	0.06	0.00
Total	99.74	99.41
	(FO 91.42)	(EN 92.10)

* Average of 17 point analyses

** Average of 2 point analyses

spectively. Compared to spinifex olivines the jack-straw olivines are lower in NiO and CaO, which is an indication of a metamorphic origin (Evans & Trommsdorff 1974).

In the Nordvernes body chromite-layers are observed to continue from the dunite core through the olivine orthopyroxenite and into the

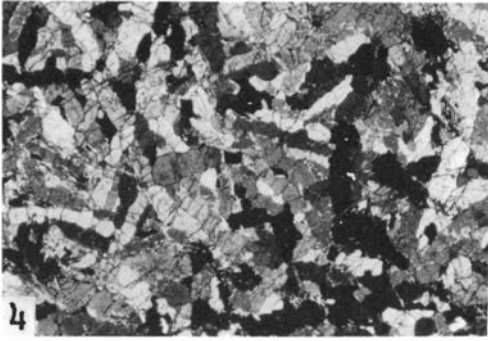


Fig. 4. Photomicrograph of jack-straw olivines in dunite from Nevernes, Velfjord. Long side of picture is 9 mm. Crossed nicols.

jack-straw-textured zone. This indicates that there has been negligible deformation during or after the formation of the jack-straw-textured zone.

Other occurrences

At the southern part of the dunite at Nevernes in Velfjord there is a special variety of jack-straw olivine. Whereas the northern part of the dunite contains primary olivine crystals with deformation lamellae, the southern part of the dunite is recrystallized to a microscopic jack-straw texture (Fig. 4). The jack-straw-textured dunite has been affected by contact metamorphism associated with a nearby granitic intrusion. During metamorphism, wollastonite and brucite were formed in a marble which lies in contact with the ultramafic body (Bakke 1979, Øvereng, pers. comm. 1984).

At Sjongsvann in Lesja the Otta serpentinite

conglomerate (Bjørlykke 1905, Oftedahl 1969, Strand 1970) is situated within high-grade meta-sediments. The conglomerate is altered to a talc + carbonate + tremolite +/- bronzite rock and the conglomeratic structure is overprinted by coarse, randomly-orientated serpentine pseudomorphs after olivine in a jack-straw texture (Fig. 5 a & b).

In the Sagelvvann ultramafic body a vein contains jack-straw-textured olivine in a matrix of magnesite (Schreyer et al. 1972, Fig. 6). The present authors have observed jack-straw-textured olivines at the margin of the Sagelvvann ultramafic body.

Metamorphic conditions

Metamorphic origin of jack-straw textured olivines is demonstrated by the field relations of the Otta serpentinite conglomerate and the Nordvernes ultramafic body. In the former, olivine growth has overprinted the conglomeratic structure of the rock. At Nordvernes the distribution of the jack-straw textured olivines suggests that they formed during prograde metamorphism in areas of the body that had previously been serpentinitized: normally the shell + cross-cutting veins.

The stable mineral assemblage is olivine, bronzite, tremolite, at temperatures of 700°C to 800°C (Turner 1981, fig. 4-12). Talc is an alteration product from bronzite. Since anthophyllite is not associated with this retrogression, the pressure (H_2) must be above 8 kb (see Packtunc 1984, fig. 22).

In some occurrences, retrograde metamorphism has changed this stable mineral assemblage into serpentine pseudomorphs after jack-



Fig. 5. a & b: Serpentine pseudomorphs after jack-straw textured olivine which overlap a conglomerate structure, Sjongsvann.

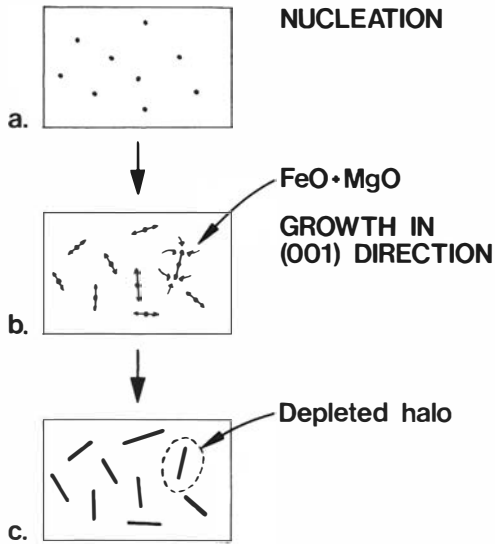


Fig. 6. Schematic growth of elongate olivines: Nucleation of olivine in a serpentine matrix (a) and preferential growth in the (001) direction of each olivine (b) produce a halo depleted in olivine components ($\text{FeO}+\text{MgO}$) around each crystal (c). Hence the larger crystal faces do not have an opportunity to grow.

straw-textured olivines in a matrix of talc/tremolite/dolomite-pseudomorphs after bronzite/tremolite partly or complete.

According to Sarah-Jane Barnes (pers. comm.), the shape of the olivine crystals may be understood by considering the Law of Bravais as extended by Donnay & Harker (1937, referred to in Dowty 1980, p. 438). These authors showed that the growth rate of a crystal face is inversely related to its size, i.e. crystals grow fastest in the direction of the smallest face. In olivines this would be the (001) face. A model for the formation of the jack-straw texture would be (Fig. 6): Nucleation of olivine in a serpentine matrix and preferential growth in the (001) direction of each olivine. This depletes the serpentine in olivine components ($\text{FeO}+\text{MgO}$) around each crystal and hence the larger crystal faces have less opportunity to grow.

The Caledonian orogeny provided the metamorphic conditions for the prograde metamorphism of serpentinite and the corresponding growth of jack-straw-textured olivines.

Acknowledgements. – The manuscript profited from constructive criticism by Sarah-Jane Barnes, p.t. Trondheim, and Robert W. Nesbitt, Southampton. Brian A. Sturt and Gunnar Juve, both Trondheim, made valuable comments.

Manuscript received March 1986

References

- Bakke, S. 1979: *Ultrabasiske bergarter i Velfjord, Nordland*. Unpubl. NGU-report 1625/4.
- Bjørlykke, K. O. 1905: Det centrale Norges fjeldbygning. *Nor. geol. unders.* 39, 595 pp.
- Collerson, K. D., Jesseau, C. W. & Bridgwater, D. 1976: Contrasting types of bladed olivine in ultramafic rocks from the Archaean of Labrador. *Can. Journ. Earth Sci.* 13, 442–450.
- Donnay, J. O. H. & Harker, O. 1937: Généralisation de la loi de Bravais. *Acad. Sci. Paris C.R. t. 204*, 4, 274–276.
- Dowty, E. 1980: Crystal growth and nucleation theory and the numerical simulation of igneous crystallization. In Hargraves, R. B. (ed.), *Physics of Magmatic Processes*. Princeton University Press.
- Evans, B. W. & Trommsdorff, W. 1974: On elongate olivine of metamorphic origin. *Geology* 2, 3, 131–132.
- Juve, G. 1975: Om nye nikkelfunn i Nord-Sveriges grunnfjell og SGU's leting etter nye legeringsmetall. In Færden, J., Gammon, J. B. & Vrålstad, T. (eds.), *Nikkelprospektering i Norge. Malmgeologisk symposium, BVLI's Tekniske Virksomhet, Trondheim*, 26–36.
- Korneliussen, A. 1976: *Malmgeologisk undersøkelse med henblikk på økonomisk utnyttelse av kromittforekomstene på kartbladene Rødøy og Lurøy i Nordland*. Unpubl. thesis Geol. Inst. NTH, 172 pp.
- Moore, A. C. 1977: The petrography and possible regional significance of the Hjelmkona Ultramafic Body (Sagvandite), Nordmøre, Norway. *Nor. Geol. Tidsskr.* 57, 55–64.
- Nesbitt, R. W. 1971: Skeletal crystal forms in the ultramafic rocks of the Yilgarn Block, Western Australia: evidence for an Archaean ultramafic liquid. *Geol. Soc. Aust. Sp. Publ.* 3, 331–348.
- Nilsson, G. 1985: Nickel-copper deposits in Sweden. In Papunen, H. & Gorbunov, G. I. (eds.), *Nickel-Copper Deposits of the Baltic Shield and Scandinavian Caledonides*. Geol. Surv. Finl. Bull. 333, 313–362.
- Oliver, R. L., Nesbitt, R. W., Hansen, D. M. & Franzen, N. 1972: Metamorphic olivine in ultramafic rocks from Western Australia. *Contrib. Mineral. Petrol.* 36, 335–342.
- Oftedahl, C. 1969: Caledonian pyroclastic (?) serpentinite in Central Norway. *Geol. Soc. Am. Bull.* 80, 223–230.
- Paktunc, A. D. 1984: Metamorphism of the ultramafic rocks of the Thompson mine, Thompson Nickel belt, northern Manitoba. *Can. Mineral.* 22, 77–91.
- Petersen, K., 1883: Sagvandit, en ny bergart. *Tromsø Mus. Aarshefte*, 6, 72–86.
- Schreyer, W., Ohnmacht, W. & Mannchen, J. 1972: Carbonate-orthopyroxenites (sagvandites) from Troms, northern Norway. *Lithos* 5, 345–364.
- Sigmond, E. M. 1985: *Users Guide to Bedrock Map of Norway*. Nor. geol. unders.
- Snoke, A. W. & Calk, L. C. 1978: Jackstraw-textured talc-olivine rocks, Preston Peak area, Klamath Mountains, California. *Geol. Soc. Am. Bull.* 89, 223–230.
- Strand, T. 1970: On the mode of formation of the Otta Serpentinite, conglomerate. *Nor. Geol. Tidsskr.* 50, 393–395.
- Turner, F. J. 1981: *Metamorphic Petrology*. McGraw-Hill, New York, N.Y., 524 pp.