MINERALOGICAL MAGAZINE, SEPTEMBER 1974, VOL. 39, PP. 798–801

Serpentine minerals from the southern portion of the ultramafic belt of New Caledonia

K. A. RODGERS

Department of Geology, University of Auckland, Auckland, New Zealand

SUMMARY. Peridotitic rocks in the Massif du Sud, southern New Caledonia, have suffered about 30 % serpentinization. Optical studies combined with X-ray and chemical analyses indicate that chrysotile and lizardite are the dominant serpentine species present. Serpentinization probably occurred during emplacement of the Massifs in their present overthrust position.

FEW of the peridotite rocks of the alpine-type ultramafic belt of New Caledonia (Guillon, 1969; Rodgers, 1973, 1974*b*) fail to show evidence of serpentinization. On the average, some 30 % of both the dominant harzburgite substrate and of various dunite bodies consists of serpentine minerals. Where shear zones cut the peridotites, complete serpentinization has occurred.

Dunite-derived serpentines

Initial stages of serpentinization are represented in most rocks by the formation of a network of longitudinally divided, cross-fibre veins of γ-serpentine, which completely lace the rock. Subsequently, olivine fragments, surrounded by this mesh, may be replaced by isotropic fibrous mats of α-serpentine or irregular platelets of serpentine. Cross-fibre veins of both α- and γ-serpentine transect the network in a number of the rocks examined and prove to be most common in almost completely serpentinized rocks. These veins are two to five times the width of the initial, network veins and are occasionally divided longitudinally. The dividing line of the initial veins is usually picked out by a discontinuous and irregular layer of iron oxides. In completely serpentinized samples, this layer serves to delineate areas of initial serpentinization.

Solution studies (method of Nagy and Faust, 1956) and X-ray examination (method of Whittaker and Zussman, 1956) indicate that the initial γ-serpentine fibres, the α-serpentine fibrous mats, and the late-stage fibre veins all consist of chrysotile, possibly with a little intergrown lizardite. The irregularly shaped, massive platelets seated within the mesh of some of the more completely serpentinized specimens could be shown to consist almost entirely of lizardite.

No indicator could be found as to whether an individual dunite would yield as the end product of serpentinization either chrysotile alone or chrysotile plus lizardite. Attempts to construct facies maps of regions in the more serpentinized dunites proved unsuccessful but did show an irregular distribution although two points were noted: Lizardite is developed to a greater extent close to dunite–harzburgite and particularly dunite–gabbro contacts, especially where the olivine of the dunites contains a little more iron. Where lizardite plus chrysotile are formed, the deposits of iron oxides within the serpentinized rock are less than where chrysotile occurs alone.

Both these factors can be correlated with the data of Page (1968) who noted that lizardite tends to contain up to 4 % Fe_2O_3, whereas chrysotile contains less than 1 %. Since chrysotile appears to be the first serpentine mineral to have formed in New Caledonia, excess iron from the olivine lattice will become segregated between and within growing fibre zones giving the observed textural relationship. If only chrysotile

TABLE I. *Analyses and structural formulae of serpentines from dunites, southern New Caledonia*

	1	2	3		1′		2′		3′	
SiO_2	42·36	37·2	41·25	Si	1·952	1·963	1·726	1·879	1·989	2·014
Al_2O_3	0·21	2·8	0·48	Al	0·011		0·153		0·025	
Cr_2O_3	0·19	—	0·21							
Fe_2O_3	0·64	5·8	3·18	Fe^{3+}	0·022		0·202		0·112	
FeO	0·21	0·4	0·50	Fe^{2+}	0·008		0·016		0·019	
NiO	0·65	0·32	0·55	Ni	0·024	2·950	0·012	2·875	0·021	2·955
MgO	42·06	38·1	40·10	Mg	2·889		2·635		2·795	
H_2O^+	13·75	15·2	13·40	Cr	0·007		—		0·008	
Total	100·07	99·82	99·67							
				O^{2-}	4·774		4·296		4·820	
				OH^-	4·226		4·704		4·180	

1. Completely serpentinized dunite containing α- and γ-chysotile. Mine du Marais Kiki, RT2. Auckland University Geology Department no. 20004.
2. γ-chrysotile vein in dunite 20004. Contaminated with goethite. Analyst: T. H. Wilson.
3. Completely serpentinized dunite containing approximately 45 % α-chrysotile and 55 % lizardite. Pirogues headwaters, RT2. A.U.G.D. no. 20005.

1′, 2′, 3′. Atomic ratios to a basis of 9(O,OH).

continues to develop, the original segregations continue to grow, or new deposits of ferric oxide are formed throughout the mesh, giving a dirty appearance to the slides. If, however, lizardite is formed the iron can be assimilated in the lattice and a cleaner, inclusion-free section results.

Three analyses of serpentines are given in Table I and are typical of those expected from the mineral association (cf. Faust and Fahey, 1962; Page, 1968).

Harzburgite-derived serpentines

The serpentine mesh of the harzburgites is essentially similar in both mineralogy and texture to that of the dunites, differing only in the presence of enstatite and its alteration products, neither of which seem as susceptible to serpentinization as olivine. The γ-serpentine mesh laces all sections but stops short at enstatite–olivine grain boundaries. Sometimes this mesh is concentrated in parallel, multistranded, rope-like veins. On rare occasions a change from γ- to α-serpentine occurs at olivine–olivine boundaries.

Later-stage, cross-fibre veins, of slightly greater width than those of the network, may penetrate and pass through enstatite crystals. These consist of both α- and γ-serpentine, either alone or as a mixture. Where they occur within an enstatite they were always α. They may be cross-fibre or longitudinal fibre or a mixture or contain a mottled platelet-like core.

Longitudinal divisions of both network and the later stage veins are not as clearly delineated by secondary iron oxides as in the dunites, and often the median portion of fibres is marked by a narrow discontinuous zone of differing extinction or mottled appearance.

Serpentinization of enstatite is a complex and variable process. It probably commenced after formation of the original mesh and was associated with formation of the secondary veins. Subsequent alteration was by replacement with near isotropic, amorphous, platey serpentine forming along fractures and then proceeding on a wide front, down the length of the silicate chains to yield bastite. Where a corona of talc enclosed the orthopyroxene, alteration tended to be delayed. Again a platey serpentine was generated but this may have been associated with or superseded by a fibrous mineral of higher birefringence. The talc does not appear to have been affected by serpentinization.

Efforts to determine the mineralogy of the differing serpentine products were complicated by the variety of habits and associations present. X-ray studies of veins and replacement products removed from thin section, coupled with solution methods, showed that the initial γ-serpentine, cross-fibre network, the majority of the later stage veins, and the ropy fibrous veins consist predominantly of chrysotile. Replacement products of enstatite appear to be predominantly lizardite. α-veins across orthopyroxenes are a mixture of both chrysotile and lizardite. Further efforts to correlate habit and polymorph type were inconclusive.

Discussion

No evidence has been found in the course of the present investigations to support the theories of Avias (1955), who contended that olivine was formed after, and from, serpentine by metasomatic processes that affected the whole of the New Caledonian ultramafic belt. Often, in fact, serpentine is found forming pseudomorphs after olivine as in the orbicular chromitite ores of Mine Anna Madeleine (Rodgers, 1973). The textural types and serpentine mineral species found in the New Caledonian rocks are comparable to those reported from other alpine-type ultramafic masses (e.g. Francis, 1956; O'Brien and Rodgers, 1974). However, the complexities of textural patterns, such as O'Brien and Rodgers have described from New Zealand ultramafics, are common in New Caledonia only in the less common, totally serpentinized rocks, such as occur in shear planes and particularly above the basal thrust plane of the great southern massif (Rodgers, 1974*a*).

The lack of evidence of widespread dislocation and deformation of the various serpentine textures points to the processes of serpentinization, responsible for forming the networks and later stage veins, as having operated subsequent to or contemporaneous with the main emplacement episode of the massifs on the sialic crustal segment of the island (Rodgers, 1974*b*), which in turn postdates a recrystallization episode that affected these ultramafics.

REFERENCES

Avias (J.), 1955. *Sciences de la Terre*, no. hors serie, 213–35.
Faust (G. T.) and Fahey (J. J.), 1962. *U.S. Geol. Surv. Prof. Paper*, **384A**.
Francis (G. H.), 1956. *Amer. Journ. Sci.* **254**, 201–26.
Guillon (J. H.), 1969. *Cahiers O.R.S.T.O.M., série Géol.* **1**, 7.
Nagy (B.) and Faust (G. T.), 1956. *Amer. Min.* **41**, 817–38.
O'Brien (J. P.) and Rodgers (K. A.), 1974. *Journ. Roy. Soc. N.Z.* **4**.
Page (N. J.), 1968. *Amer. Min.* **53**, 201–15.
Rodgers (K. A.), 1973. *Min. Mag.* **39**, 326–39.
—— 1974*a*. A comparison of the ultramafic belts of Papua and New Caledonia (in preparation).
—— 1974*b*. Ultramafic and related rocks from southern New Caledonia *Journ. Geol.* (in press).
Whittaker (E. J. W.) and Zussman (J.), 1956. *Min. Mag.* **31**, 107–26.

[*Manuscript received 13 January 1974.*]