Unusual dolomite from Portsoy, Banff.

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A THIN belt of serpentine up to 400 yards wide and about 6 miles long runs SSW. from Portsoy, Banff, and parallel to the general structure lines at that locality. Near Damhead, 1½ miles SSW. of Portsoy, an old quarry has recently been reopened in this belt and worked to a depth of 98 feet for the exploitation of talc. The general association in this quarry, stated in order of quantitative importance, is serpentine, talc, dolomite, the last being present in very minor amount but of an unusual character meriting description. In the following account the particular task of one of us (E. M. P.) has been the preparation of chemical analyses, the other author being responsible for descriptions and discussion.

A foliated olivine-serpentine with massive green, dark and lighter coloured varieties composes by far most of the rock in Damhead quarry. Certain types that may be 'shaved' with a penknife are used as low-grade talc in the roofing-felt industry, others are employed in tile manufacture. Occasional thin chrysotile veins have been observed. The serpentine is highly sheared, good curved slicken sided surfaces being commonly developed. The stronger dislocations are approximately vertical and strike parallel to the outcrop of the serpentine. Talc is developed as impersistent lenticular bodies in vertical crush zones in serpentine. Thick sheaths coating serpentine lenses are common, and pieces of talc up to 6 inches across may be obtained. In general the talc 'veins' broaden downwards. Talc also coats minor shear planes in serpentine. Both white and pale green varieties occur. Disseminated magnetite is present, and is removed before using the talc for refractory purposes in industry.

Dolomite is found from time to time whilst breaking up serpentine blocks in the heart of which it forms masses up to one foot across with irregular margins and no apparent 'feeders'. These occur throughout the quarry but are exclusively within serpentine, especially where the latter has been sheared into lenses. They are white in colour, opaque, resemble calcite in general appearance, and present large perfectly plane cleavage surfaces uninterrupted across their whole mass and often $\frac{3}{4}$ square foot in area, i.e. each body is a large individual crystal. The mineral has a sub-vitreous lustre, *rr'* $(10\bar{1}1):(\bar{1}101) = 73°\ 45'$ and may show secondary twin lamellae. Curved *r* faces are very rarely found. It does not react with cold dilute HCl, and it scratches calcite easily. Specific gravity 2·86. Powdered and treated with Lemberg's solution it is but faintly stained after 20 minutes.

Two samples selected to be as free as possible from included fragments of serpentine were taken for chemical analysis from a large quantity of material. They were treated with boiling 5 % HCl and gave the following results:

	I.	II.
CaO	30·59	30·53
MgO	21·33	21·10
CO_2	47·21	47·01
Insol. in HCl ...	0·37	0·84
	99·50	99·48

The hydrochloric acid soluble portion was tested for iron by the highly sensitive colorimetric tests using thioglycollic acid and potassium thiocyanate. Only traces were detected, indicating practically no $FeCO_3$. Lead was absent. Spectrographic analyses of the hydrochloric acid soluble portion of each sample were made at the Ministry of Agriculture Research Laboratories, Belfast, by permission of Professor Baskett. The Lundegårdh air-acetylene flame method was used, with the following results:

	I.	II.
BaO	1·15	1·68 %
SrO	0·017	0·018

The high summation when the content of equivalent $BaCO_3$ is added to the results of the chemical analysis is believed due to co-precipitation of part of the barium with the calcium, due to the great excess of the latter. An accuracy of ±25 % for the barium content is likely and a somewhat higher degree of accuracy in the case of strontium. Of geochemical interest is the high content of soluble barium. The carbonates of calcium and magnesium and the double carbonate dolomite are trigonal, whereas barium and strontium carbonates are orthorhombic. Also of interest is the remarkable purity of the dolomite, especially compared with other Scottish dolomites in similar as well as other parageneses.

The association serpentine–talc–dolomite is well known and usually referred to metasomatic processes operated by low-temperature solutions. Hess,[1] for example, defines steatitization as 'that process of hydrothermal alteration of an ultrabasic which in its final stages results in the formation of a talcose rock'. Depending on the composition of the active solutions, dolomite may or may not be a by-product of such reactions; though all three minerals may form stable phases under metamorphic conditions corresponding to the green-schist facies. At Damhead, although, from general considerations stated below, the dolomite and talc appear related, if the former had formed as such a by-product it must since have been completely differentiated from its parent, as it occurs only in serpentine. So complete a separation seems unlikely. Again, talc at lower metamorphic temperatures is unstable in the presence of CaO- and CO_2-bearing solutions, being dolomitized. This reaction also cannot satisfactorily explain the Damhead occurrence, since traces, at least, of some half-way stage would be expected had such replacement been effected, but as remarked, the amount of the talc associated with the dolomite is quite negligible. The dolomite is considered to be the result of direct replacement of serpentine by CaO- and CO_2-bearing solutions of unknown origin. If growth had taken place within a cavity, then each early crystal deposited on to walls must have been identically orientated to explain the crystal continuity within each body. Such is not reasonable and is contrary to experience of known cavity fillings. The intricate relations between dolomite and serpentine further indicate replacement, and possibly the lack of free faces during such growth may account for the lack of characteristic curved *r* surfaces. It follows, then, that each dolomite body is a single crystal and may be regarded as a large porphyroblast.

It is here of interest that Eskola[2] has attempted to generalize, assigning most ankerite-poor dolomites to a metasomatic origin and ankeritic varieties characteristically to ore veins. The mineral, as noted, is strikingly pure, the more so considering its environment. An analysis of typical associated green serpentine, kindly lent by Rowebb Ltd., showed Fe_2O_3 7·58 % and FeO 0·71 %. It would seem that this purity may be largely ascribed to dominance of Fe''' in the serpentine which

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[1] H. H. Hess, The problem of serpentinization and the origin of certain chrysotile asbestos, talc and soapstone deposits. Econ. Geol., 1933, vol. 28, pp. 634–657.

[2] P. Eskola, Kristalle und Gesteine. Wien, 1946. [M.A. 10–191.]

on account of its ionic radius was unable to enter the dolomite lattice and therefore cast out, some forming occasional included magnetite grains. In addition to this role of iron, however, serpentine included in and bordering the dolomite is usually paler in colour and therefore, from reference to chemically investigated serpentines, presumably poorer in iron than the surrounding rock, suggestive of leaching by the dolomitizing solutions.

That the Damhead association is of common occurrence suggests in itself that each member may be referred to stages in the same geological process (retrogressive metamorphism). That this latter depended mainly upon metamorphic stress is indicated by the highly crushed nature of the rock at the quarry and by the fact that there is no field association of igneous rock to which the diaphthoresis may be suitably ascribed. Active solutions mobilized by stresses gave rise to the transportation and recrystallization of dolomite at localized centres of lower pressure where the solubility of the carbonates would decline.[1]

This replacement took place at the same time as, or slightly before, steatitization, to account for the absence of similar dolomite masses in the talc lenses, and was most probably not isovolumetric. In conclusion, reference may be made to exposures, particularly near Balmaha, east side of Loch Lomond, in the serpentine belt of the Highland border, where dolomitization of serpentine is associated with faulting.[2]

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[1] R. E. Gibson, The nature of solutions and their behaviour under high pressures. Scientific Monthly, New York, 1938, vol. 46, pp. 103–119.

[2] J. G. C. Anderson, The geology of the Highland border: Stonehaven to Arran. Trans. Roy. Soc. Edinburgh, 1947, vol. 61, pp. 479–515.