Spherulitic Jaspilite from Whangarei Heads

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Abstract

Spherulitic jaspilite occurring in small lenses at McLeod Bay, Whangarei Heads, is closely associated with fine-grained spilitic rocks. Individual spherulites within the jaspilite exhibit both concentric and radial form and show crowding of haematite and minute silica particles into concentric zones. The location of the jaspilite as xenoliths within spilite indicates that banded haematitic cherts caught up by the spilite have been partially dissolved and re-crystallized to their present spherulitic form.

Introduction

At the west end of the north side of McLeod Bay, Whangarei Heads, greywacke sandstones are associated with limestones, igneous rocks, and red spherulitic jasperoid cherts (Fig. 1). These rocks have been mapped by Allen (1951) as part of the basement (Trias-Jura ?) Waipapa Series. However, neither Allen nor Bartrum (1948) mentions the igneous rocks associated with the cherts, although a description of an altered tuff from near this locality is to be found in Allen's (1951) account. The jaspilites occur in the shore platform just below high water mark about half a mile east of the mouth of Parua Bay. The outcrop lies between two limburgite flows, a quarter-mile apart, which are described by Allen (1951).

Allen (1947) states, " The writer believes, then, that the radial structures in the spherulitic jaspilite were developed by slow crystallization along with haematite (or its precursor) in open cavities where colloform structures are of normal occurrence. The problem as to whether or not hydrothermal waters played a part in the silicification is a difficult one, for evidence is not readily forthcoming." This problem, as well as that posed by the occurrence of non-spherulitic jaspilites from other localities in the area, is overcome by the discovery by the writer of igneous rocks intimately associated with the jaspilites.

Field Occurrence

The jaspilites are found in spilite as xenolithic pockets and lenses, up to 5 inches deep, which give the appearance of having been folded into the enclosing black and green igneous rock. Individual spherulites within the jaspilite reach diameters of up to a quarter inch and range from dark reddish-brown to colourless. The sharp boundary of the haematite matrix of the jaspilite against the enclosing intrusives serves to accentuate the " rolled-up " appearance of the lenses.

Weathering has produced on the jaspilite a pisolitic surface which stands out in marked contrast to the angular pattern etched on the surrounding greywacke. Small patches of iron pyrites are scattered throughout the jaspilites, and both jaspilites and spilite are seamed by an irregular network of veins of crystalline quartz and calcite.

Petrography

Jaspilite

According to Pettijohn (1949) the term spherulite is applied to oolitic bodies " in which, however, only radial structure is visible." The structures described here are both radial and concentric and therefore fit the definition of oolites as well as spherulites. However, in many cases they have irregular outlines, indicating growth in a solid medium in the manner advocated for spherulite formation by Pettijohn (1949).

The extreme outer edge of each spherulite is bordered by an irregular band of grey silica which penetrates as far as the centre in long slender filaments. (Plate 13, Fig. 1). Immediately inside this grey selvedge a shell of orange silica with radially disposed cracks and minute inclusions extends towards the centre of the spherulite. The orange colouration gradually loses intensity inwards. Within this zone a concentric band of grey, tongue-like, radially-disposed silica commences and forms a corona around an almost clear shell of silica crossed only by occasional darker-grey threads. Inside this again, numbers of the minute grey inclusions form a mass which becomes less dense inwards. Ultimately, these inclusions can be seen as discrete particles at the intersection of a series of radiating cracks which occupy the central portion of the spherulite. These cracks contain quartz exhibiting shadow extinction, and they narrow and disappear outwards as the outermost almost colourless shell is approached.

Maltese cross extinction figures are obtained between crossed nicols (Plate 13, Fig. 2). It is of interest to note that these figures persist across some of the numerous quartz veins which transect the rock, and crystals in these veins extinguish as the arms of the crosses move over them during rotation of the stage. However, other veins show random extinction of individual crystals of quartz. On this basis quartz veins which cut across a spherulite may be divided into two categories. One type of vein contains crystals which show random optical orientation in relation to the spherulite, whilst the other type has crystals affected by the extinction pattern of the spherulite. The former obviously grew after reconstitution of the jaspilite, but the latter apparently were older structures and were affected, at least in part, by the changes which produced the concentric structures.

When examined under a binocular microscope the pyrite crystals present show a marked development of curved faces covered with fine parallel striae. Most of the crystals are small, with a maximum edge length of approximately 2 mm.

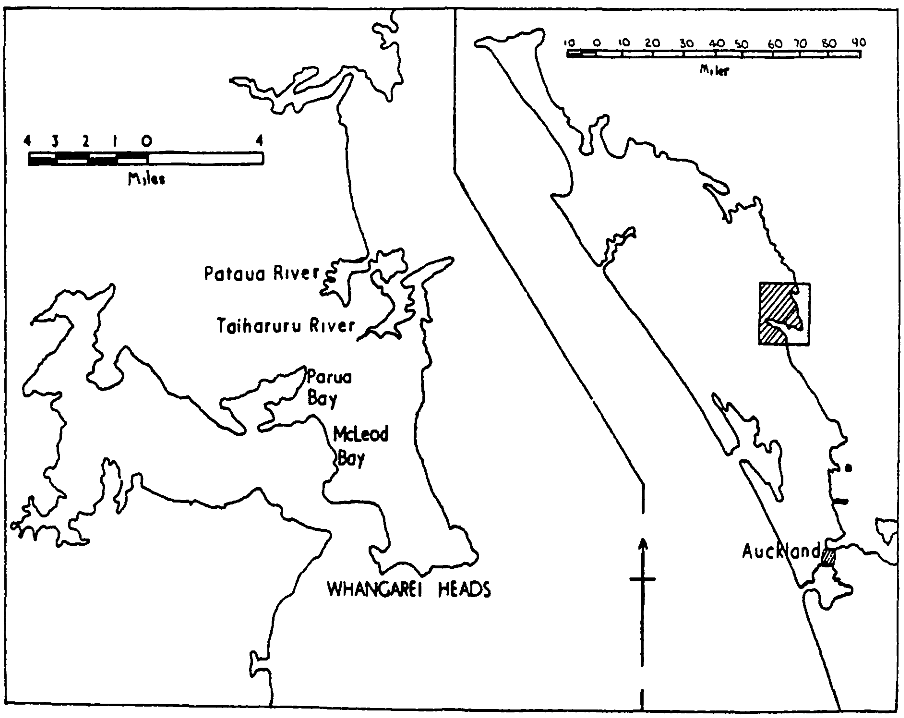

FIG. 1.—Locality Map: Whangarei Heads.

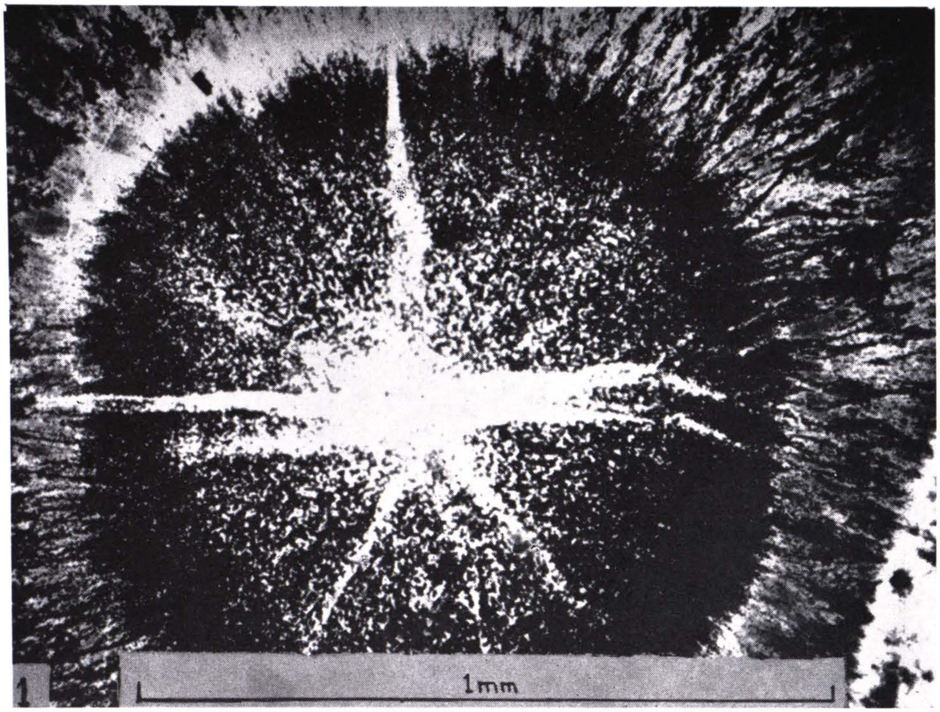

FIG. 1.—Jaspilite spherulite, showing innermost area of inclusions succeeded by a clear zone of silica. Part of the orange zone (dark) can be seen outside the clear silica. Plane light.

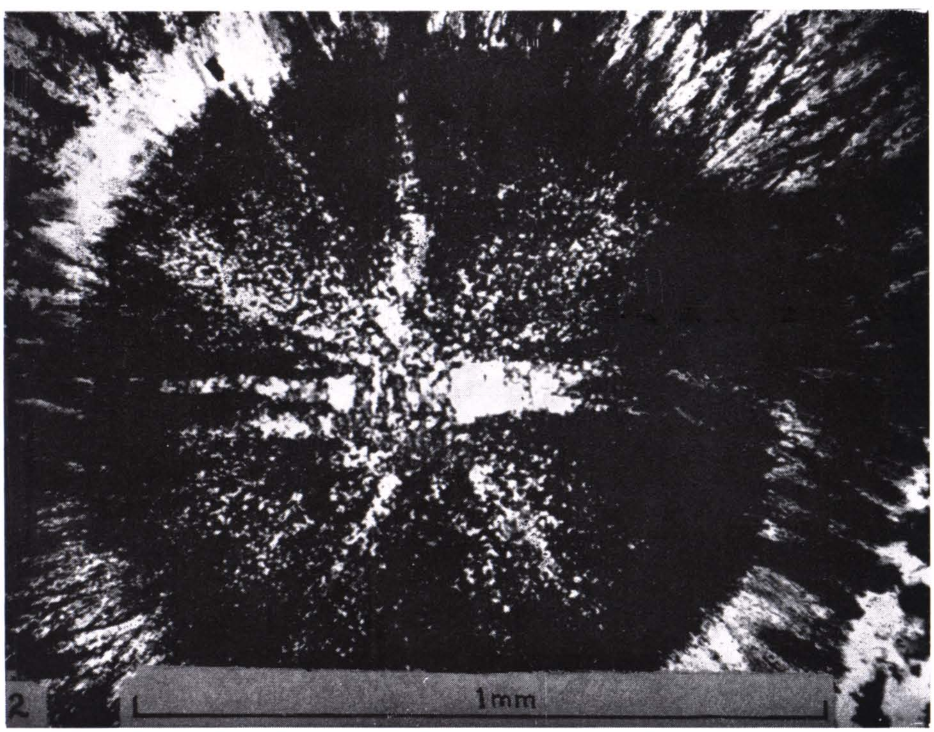

FIG. 2.—Jaspilite spherulite of Fig. 1 under crossed nicols.

Closer examination of the weathered surface revealed the presence of concretionary nodules of haematite approximately 1 mm in diameter. Because of the opacity of the mineral these nodules were not clearly distinct in thin section from the remainder of the haematitic chert.

Associated Igneous Rock

This is a dense fine-grained variolitic rock with radiating sheaves of plagioclase laths and crystallites set in a glassy chloritized groundmass. One or two larger phenocrysts of feldspar occur in the rock. Veins are common and some composed of calcite with occasional quartz crystals occur together with small irregular lenses of calcite. Narrow sinuous bands of alternating crystals of dark green chlorite and quartz are also frequent. One large quartz vein containing a few calcite crystals shows good development of crystal growth perpendicular to the vein walls. Movement subsequent to the formation of some veins has resulted in offsetting at points of intersection.

The extinction angles of the plagioclase crystals are small. Those measured (21 in all) were mainly of the order of 5°, but occasionally angles as great as 18° were recorded. The feldspar is therefore a sodic variety falling towards the albite end of the plagioclase series, indicating that the rock is spilitic in nature. In both field association and texture the rock is very similar to spilites determined from the basement greywackes at Tawharanui Peninsula and Kawau Island (Hopgood, 1956).

CONCLUSIONS

The spherulitic jaspilites from McLeod Bay appear to have been formed by hydrothermal reconstitution of bands of sedimentary haematitic chert. These cherts are common in the greywackes of North Auckland, and they occur elsewhere in the Whangarei district on the north shore of Parua Bay and on the ridge between Pataua and Taiharuru Estuaries (Fig. 1). It is significant that the spherulitic sequence has been invaded by a magma of spilitic type subsequent to partial lithification of the sediments. An advanced state of lithification in the cherts, prior to spherulite formation, is suggested by the presence in the rocks of quartz veins cutting across the spherulites. The fact that these have been optically affected by the growth of the spherulites, so that the radial extinction of the latter has been superimposed on the quartz crystals of the veins, points to the fact that they were altered under the same conditions as the remainder of the rock. If the silica of the cherts was still gelatinous at the time of intrusion, then the effect on the veins can be explained by the great difference in solubility which exists between amorphous and crystalline silica. According to Krauskopf (1956, p. 5), the solubility of quartz in aqueous solution at ordinary temperatures is no higher than 6 p.p.m. as compared with a solubility of 100 p.p.m. for amorphous silica under the same conditions. Kennedy (1950) figures solubility curves for both amorphous silica and quartz over a temperature range of 20° C. to 340° C., and these show that over the whole range, amorphous silica has a constantly higher degree of solubility than does the crystalline form.

It seems likely then, that prior to invasion by spilitic magma, the silica of the cherts existed as a gel which had already dehydrated sufficiently for shrinkage cracks to form. In these irregular fractures veins were formed by the growth of quartz crystals, perpendicular to the walls, separated by interstitial gelatinous silica.

Hydrothermal solutions arising from the intrusive body "dissolved" the amorphous silica of the xenoliths, including that in the veins, but had insufficient solvent action to cause significant change in the crystalline silica of the vein material. Recrystallization of the dissolved silica was in the form of spherulites whose structures were more or less continuous through the veins affected by the radial extinction pattern. During later slow cooling of the mass the concentric and radial structures of the spherulites would have ample time to form. Around any one centre of crystallization, the first shell to form would deplete the solution or gel in its immediate vicinity, so that a metastable state of slow growth then followed (Buckley, 1951). Outside this core another concentric layer of labile material would form, leading to the development of a further shell of rapidly formed crystallites. These stages are clearly shown by the arrangement of the various components of each individual spherulite described earlier. Accompanying this build-up of concentric shells there was a segregation of minute inclusions which might be remnants of radiolaria that had survived " digestion " by solutions from the dyke rock. A notable feature is concentration of haematite towards the outside of each completed structure and its concentration in the matrix surrounding the spherulites. The radial tongue-like growths of grey silica probably resulted from outgrowth of dendritic structures which arose at the centre of crystallization and continued to extend outwards, with modifications, across the various shells.

Spherulitic jaspilites from localities in California seen in hand specimen and thin section are similar to those described. As far as the writer could ascertain, the field relations are the same as those at Whangarei Heads, the cherts occurring as xenoliths in spilites or pillow basalts.

This hypothesis does not necessarily differ from that proposed by other writers (e.g., Park, 1946), who advocate the emplacement of normal banded cherts contemporaneously with submarine volcanic flows, since the jaspilites described here merely constitute an example of such cherts affected by later igneous intrusion.

Microstructures in haematitic jaspers from Langban, Sweden, which bear a strong resemblance to the spherulites described above, have been interpreted by Brotzen (1955) as being of primary origin. Brotzen attributes the formation of the spherulites to aggregations of flocculated silica particles around nuclei of iron oxide. This rock is also cut by veinlets, but since all the specimens were examined by reflected light, it is likely that the optical relationship of the vein quartz to the silica of the spherulites was not observed. The veins are therefore considered by Brotzen to have been formed subsequently to the spherulites. It is possible, however, that these spherulites also, together with their associated veins, were formed in a manner analogous with that described above.

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