3. The Rashoop Granophyre Suite.

3.1. Field Relationships.

The Stavoren Granophyre, of the Rashoop Granophyre Suite, dated at 2084 ± 62 Ma (Walraven et al. 1981), is developed throughout the area and occupies different positions in relation to other rocks.

It occurs mainly as a sheet intrusive into Rooiberg Felsite Group (Fig.3.1), with a thickness of about 2300 metres on Probeeren 164JS. The intrusive relationship is obvious from an intrusion breccia in the riverbed of the Boekenhoutkloof River on the farm Mooiplaats 121JS, where angular blocks of felsite up to 40 centimetres in diameter are present in micro-granophyre (Fig.3.2). Intrusive relationships of granophyre into felsite were also observed on the farms Probeeren 164JS and Boekenhoutkloof 124JS.

The Stavoren Granophyre is also developed between Nebo Granite and Transvaal Sequence rocks, and it was also found intrusive into the upper shale member of the Timeball Hill Formation on the farm Loskop Suid 53JS. Intrusive relationships of Nebo Granite into granophyre are present in many localities, with a particularly good example in a riverbed (29°30'W, 25°15'S) on Rietkloof 166JS.

On Rietkloof 166JS the granophyre seems to be intruded by rocks of the Layered Sequence, because an inclusion of granophyre is present in rocks of the upper zone near the prominent magnetite plugs on this farm. This would imply that the granophyre predates the mafic sequence.

The Stavoren Granophyre is fairly homogeneous throughout the area. It displays a range in colour from brick-red to grey, where the red colour is due to oxidation of the iron in the feldspars. Grain size decreases towards the top of the granophyre sheet on the farms Boekenhoutkloof 124JS

Fig. 3.1.: The contact between Stavoren Granophyre on the left and Rooiberg Felsite on the right. Boekenhoutkloof 124JS.

Fig. 3.2.: Intrusion breccia of Stavoren Granophyre into Rooiberg Felsite in the Boekenhoutkloof riverbed on the farm Mooiplaats 121JS. Chemical analyses of these rocks, samples GR-155G and GR-155F respectively, are listed in Appendix 2.

and Tafelkop 120JS in the northern part of the area, where extensive outcrops of microgranophyre dipping at about 5°N are in contact with the felsite. Microgranophyres are not always present as a roof-facies of the granophyre in contact with the Rooiberg felsite. On Kwaggavoetpad 163JS the granophyre in contact with felsite is coarse-grained, but deeper in the sheet on Hartbeestlaagte 162JS microgranophyre is developed within the succession of coarse-grained granophyre. It is possible that granophyre intruded the microgranophyre at this horizon.

3.2. Petrography of the Stavoren Granophyre.

3.2.1. The granophyric intergrowth.

Granophyric intergrowth consists mainly of roughly equal amounts of quartz and perthite. These textures vary from specimen to specimen and are generally believed to have resulted from the simultaneous and sometimes rapid crystallization of quartz and feldspar.

Barker (1971) distinguished several types of intergrowth, viz. spherulitic, plumose, radiating fringe, vermicular, cuneiform and insular (Fig.3.3).

The plumose type, representing a mass of small spherulites, is fine-grained, while the spherulitic type is a coarse-grained version of the former. Radiating fringe types consist of homogeneous feldspar surrounded by granophyric intergrowth. Vermicular types resemble those found in myrmekitic textures, but the intergrowth is not restricted to grain boundaries. The cuneiform is similar to the type found in graphic granite, whereas the insular type consists of islands of quartz with feldspar in the centre of the island, set in a matrix of feldspar, suggesting a complex history of formation. Some intergrowths are more complex than those described above.

The radiating fringe type of granophyric intergrowth,

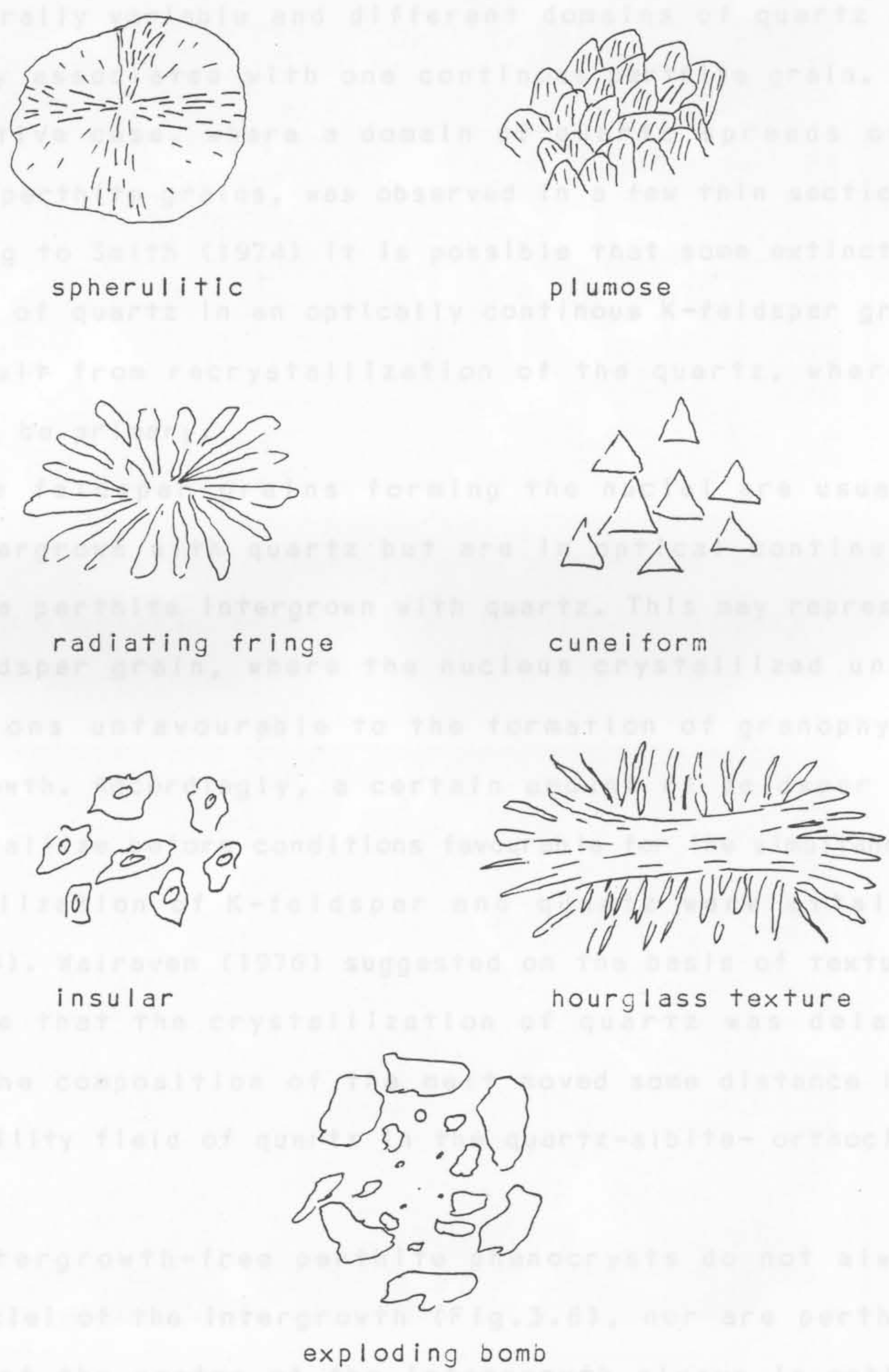

Fig. 3.3.: The different varieties of granophyric intergrowth after Barker (1971) and this study.

where the quartz coarsens as the rim of the intergrowth is approached, is the most common in the granophyres studied. K-feldspar or plagioclase may form the nucleus of this texture. Quartz as a nucleus to the intergrowth is extremely rare and was only observed in one sample (Fig.3.4). The intergrowths are generally variable and different domains of quartz are normally associated with one continous perthite grain. The alternative case, where a domain of quartz spreads over several perthite grains, was observed in a few thin sections. According to Smith (1974) it is possible that some extinction domains of quartz in an optically continous K-feldspar grain may result from recrystallization of the quartz, whereas some may be primary.

The feldspar grains forming the nuclei are usually not intergrown with quartz but are in optical continuity with the perthite intergrown with quartz. This may represent one feldspar grain, where the nucleus crystallized under conditions unfavourable to the formation of granophyric intergrowth. Accordingly, a certain amount of feldspar had to crystallize before conditions favourable for the simultaneous crystallization of K-feldspar and quartz were attained (Fig.3.5). Walraven (1976) suggested on the basis of textural evidence that the crystallization of quartz was delayed until the composition of the melt moved some distance into the stability field of quartz in the quartz-albite- orthoclase system.

Intergrowth-free perthite phenocrysts do not always form nuclei of the intergrowth (Fig.3.6), nor are perthite grains at the centre of the intergrowth always in optical continuity with the perthite of the granophyric intergrowth (Fig.3.6). This may indicate that the formation of granophyric intergrowth is dependent on the structural state of the perthite involved.

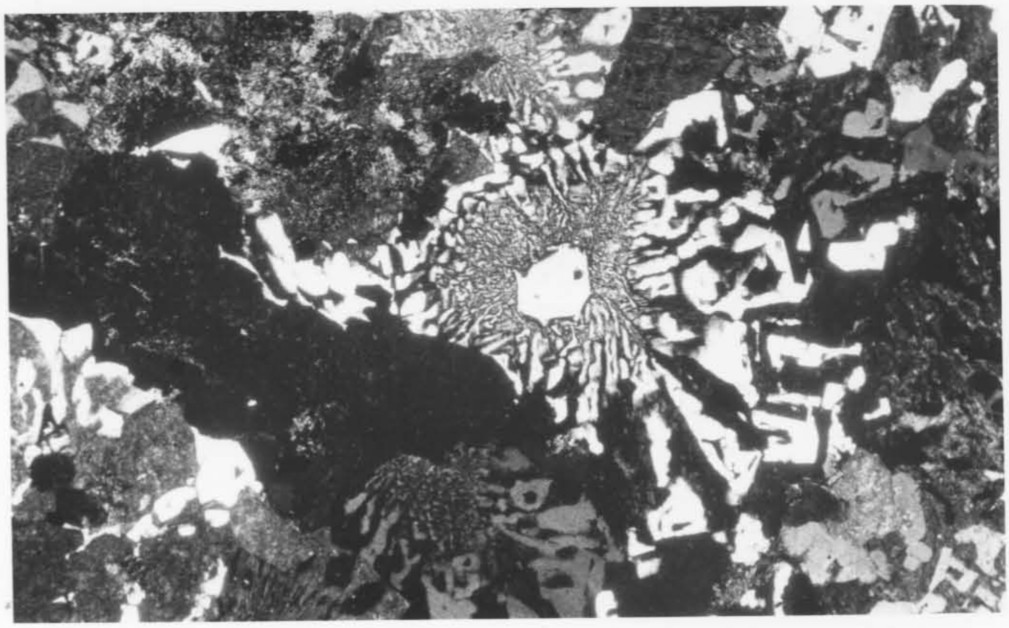

Fig. 3.4.: A quartz phenocryst forms the nucleus to a radiating fringe granophyric intergrowth. GR-268. X-Nicols. 25x. Hartbeestlaagte 162JS.

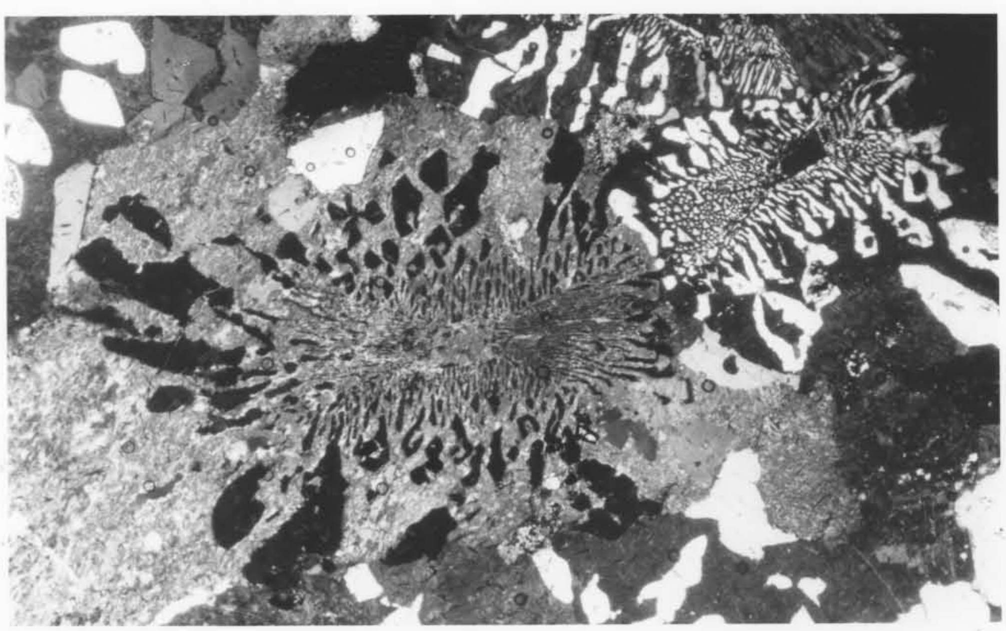

Fig.3.5.: Two hourglass textures, both containing a nucleus of K-feldspar, which is in optical continuity with the intergrown perthite. It is noteworthy that the perthite of the intergrowth extends beyond the domains of quartz. GR-54. X-Nicols. 25x. Weltevreden 165JS.

Sample GR-262 contains feldspar phenocrysts intergrown with quartz, with a rim free of intergrowth (Fig.3.7), separating it from more coarse-grained intergrown quartz and feldspar. A puzzling aspect of this texture is that the phenocryst is part of a larger feldspar grain with the same optical orientation.

The cuneiform texture, commonly found in graphic granite, is rarely developed (e.g. sample GR-242).

Insular types, with inclusions of feldspar in the quartz, are present in different forms (Fig.3.8) indicative of a complex growth history. The intergrowth shown in the photograph may also be called a cuneiform texture with inclusions of feldspar in quartz.

The micrograrophyres consist of spherulite-like and micrograrophyric intergrowth, in which it is difficult to distinguish between quartz and feldspar, even at very high magnifications. These spherulites, which display characteristic extinction crosses under crossed nicols, are set in a fine-grained groundmass of quartz and feldspar (Fig.3.9). The amount of groundmass between the spherulites varies and some rocks are composed almost entirely of spherulites. Orb textures of interlocking small spherulites are developed in some specimens (Fig.3.10).

The spherulite-like textures were formed by rapid crystallization during quenching of the granophyre magma when it intruded beneath the felsites. A gradual coarsening of the granophyric intergrowth in the spherulites and normal intergrown grains is observed as the distance from the contact with the felsites increases (compare Fig.3.9 and 3.11).

The hourglass texture represents part of a spherulite and homogeneous K-feldspar crystals may form the nucleus of the texture (Fig.3.5). Orientation of quartz and feldspar

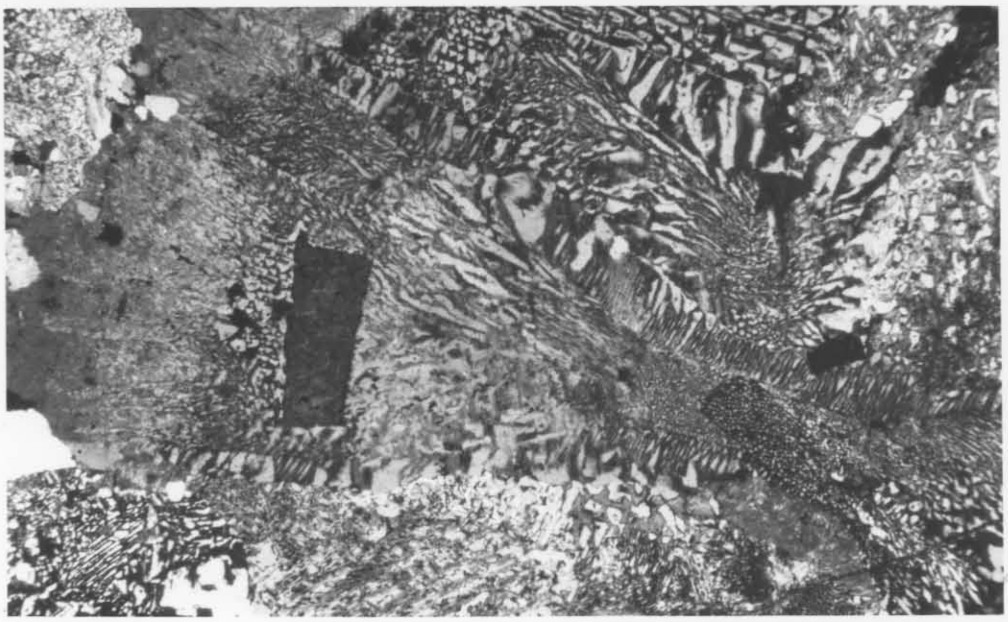

Fig. 3.6.: A complex intergrowth, where two phenocrysts of K-feldspar at the centre of the hourglass texture are intergrown with quartz, whereas another phenocryst (black) is not intergrown. GR-266. X-Nicols. 25x. Mooiplaats 121JS.

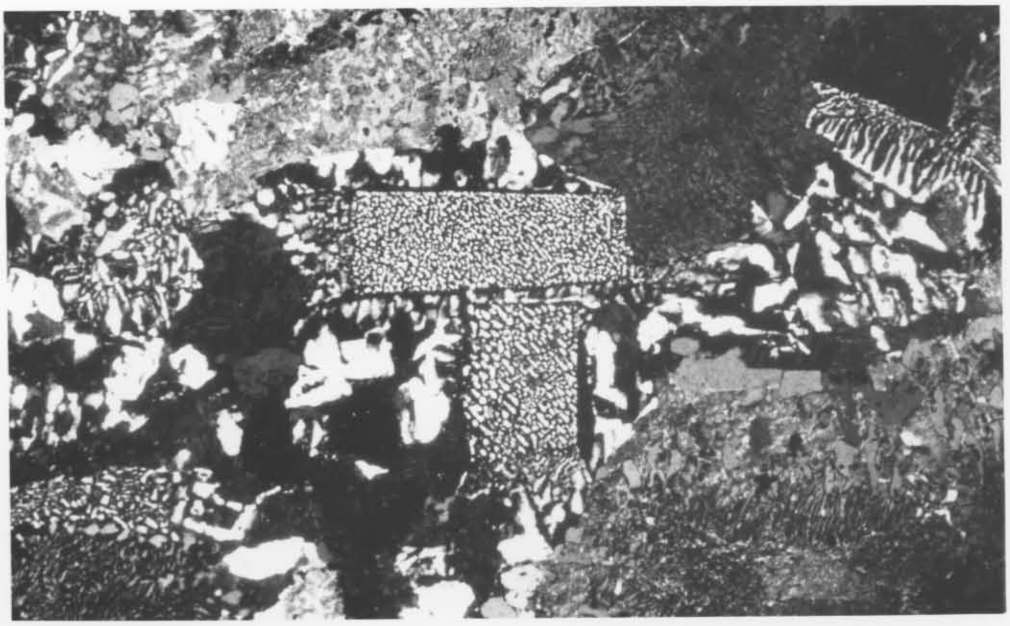

Fig. 3.7.: Two granophyrically intergrown phenocrysts, bordered by a thin rim which is not intergrown with quartz. GR-262. X-Nicols. 25x. Tafelkop 120JS.

Fig. 3.8.: The insular type of granophyric intergrowth with cuneiform outlines. GR-70. X-Nicols. 25x. Kwaggavoetpad 163JS.

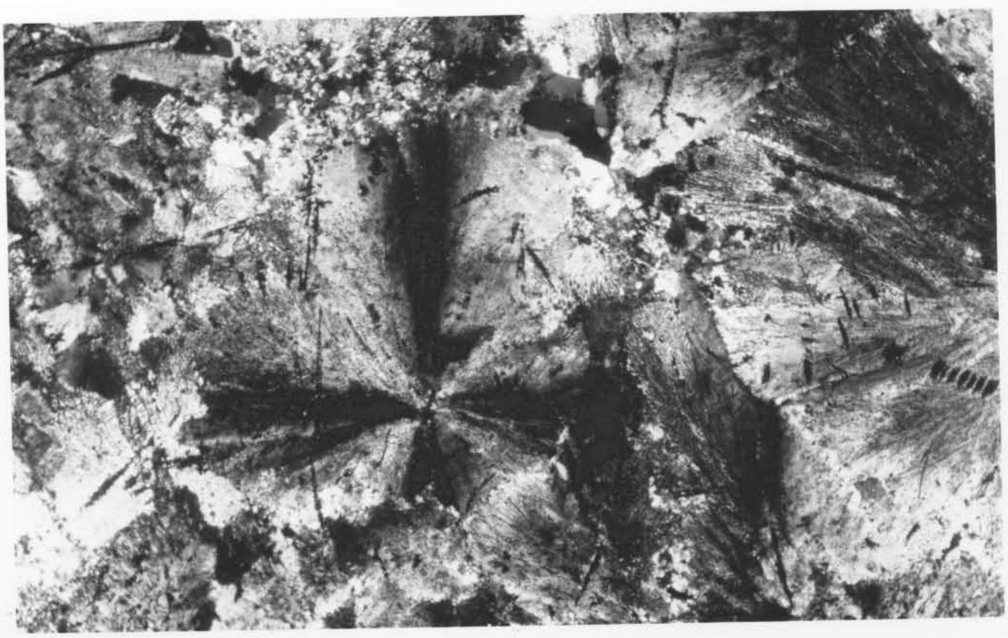

Fig. 3.9.: A spherulite with extinction cross in micrograninophyre of the Stavoren Granophyre. GR-133. X-Nicols. 25x. Tafelkop 120JS.

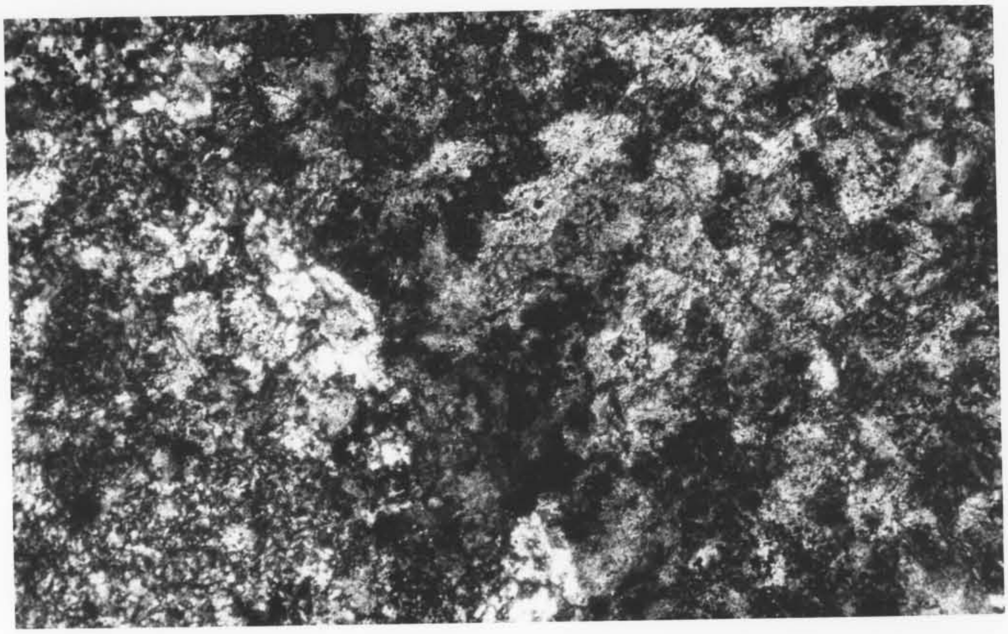

Fig. 3.10.: Orb texture in micrographophyre of the Stavoren Granophyre. GR-234. X-Nicols. 63x. Boekenhoutkloof 124JS.

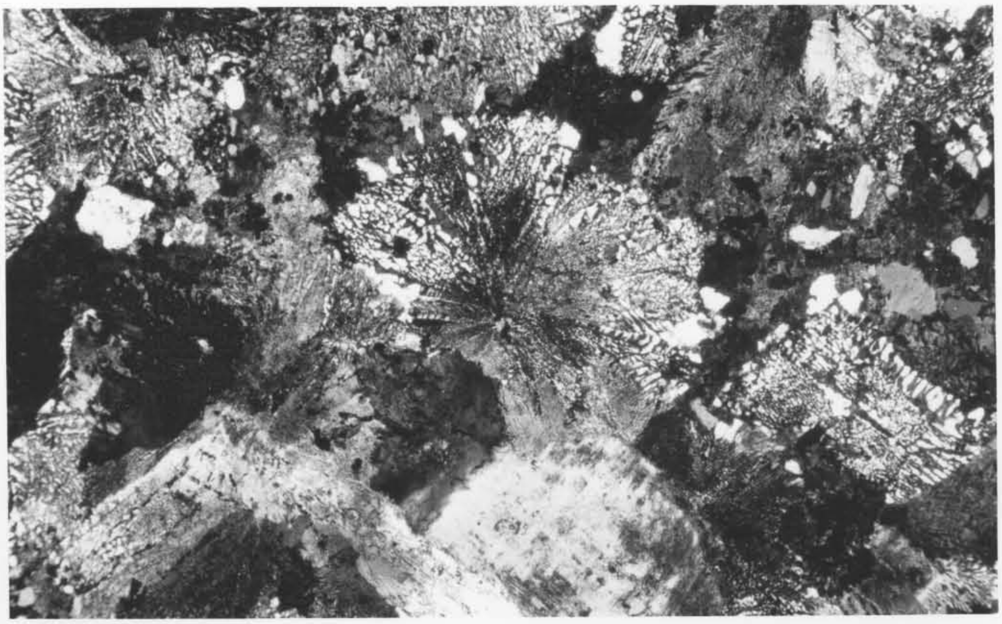

Fig. 3.11.: "Coarse-grained" spherulite in micrographophyre of the Stavoren Granophyre. GR-221. X-Nicols. 25x. Tafelkop 120JS.

within the intergrowth can vary.

The feldspars that form intergrowths with quartz in the micrographophyres are strongly zoned e.g. in sample GR-54. Here a plagioclase phenocryst is surrounded by a rim of K-feldspar, representing an intermediate zone, which in turn, is surrounded by perthite intergrown with quartz (Fig.3.12). This texture can be described as an anti-rapakivi texture. Similar features were also described by Barker (1970), where the feldspar changed in composition from a sodic plagioclase in the core to albite in the intermediate zone and K-feldspar in the outer zone. Abbot (1978) also described this feature in hornblende granophyres from the Red Beach Granite in extreme eastern Maine. According to him it appears that during the formation of anti-rapakivi texture the liquid portion of the magma remained in equilibrium with more than one feldspar only long enough for the plagioclase to become completely rimmed. After the formation of the anti-rapakivi phenocrysts the last liquids to crystallize were in equilibrium with two feldspars.

3.2.2. Minor and accessory constituents.

Clinopyroxene, hornblende, biotite and rarely fayalite may be present within the granophyre. The major mafic mineral is a clinopyroxene. It has a light-green color and a large extinction angle $Z^\wedge c$ of 45°. Microprobe analyses show that the MgO content is extremely low (Appendix 1) and that the clinopyroxene is a hedenbergite. Together with plagioclase, hedenbergite was the first mineral to crystallize from the melt. The crystallization was evidently rapid, as indicated by its occurrence as long thin crystals throughout the rock (Fig.3.13), and as thin needles in the spherulite-like textures and in the granitic groundmass of the micrographophyre. In most granophyres the clinopyroxene occurs as long stem-like

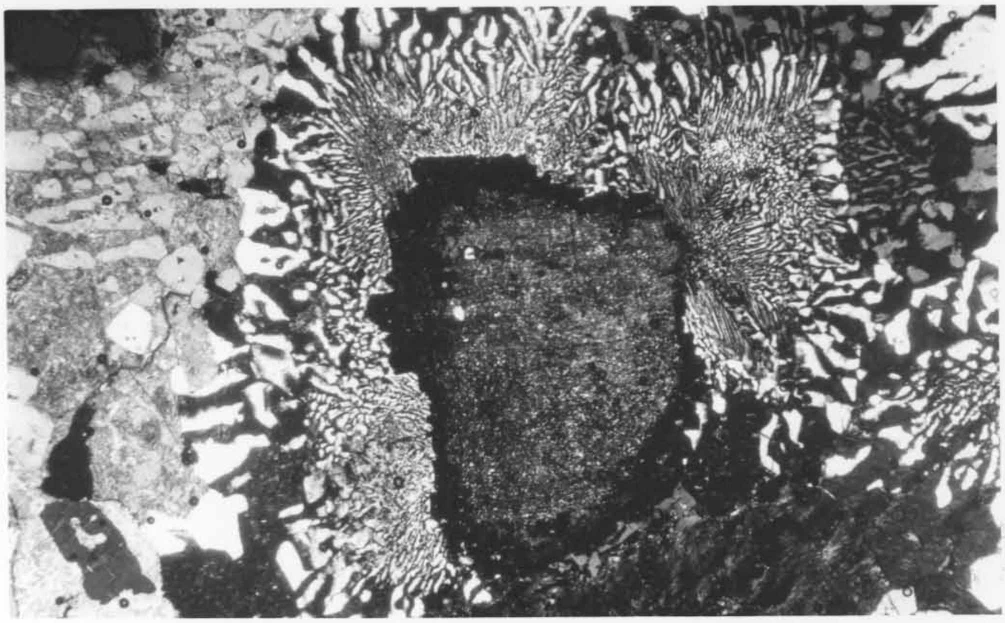

Fig. 3.12.: Strongly zoned phenocryst consisting of a plagioclase core rimmed by K-feldspar and an outer part of granophyrically intergrown perthite. GR-54. X-Nicols. 25x. Weltevreden 165JS.

Fig. 3.13.: Laths of clinopyroxene in granophyre. The large extinction angle of 45° can be seen from the position of one clinopyroxene lath. GR-43. X-Nicols. 25x. Tussenin 21JS.

crystals. It is readily altered to hornblende and different stages of this transformation have been observed.

Some granophyres contain hornblende as a major mafic mineral. This hornblende is pleochroic with X = light brown-green, Y = dark olive-green and Z = very dark olive-green, has an extinction angle $Z^{\wedge}c$ of $\pm$ 10° and is probably a ferro-hastingsite. It did not originate through the transformation from clinopyroxene but occupies interstitial spaces between the intergrowth rosettes and therefore represents a primary late-crystallized phase.

Fayalite was only observed in a few samples. It is usually altered to iddingsite which is reddish-brown in thin section and which has a higher birefringence than olivine. An olivine grain in one of the granophyres is altered to an isotropic mineral, probably chlorophaeite (Deer, Howie and Zussman Vol 1, 1962). Fayalite, which crystallized early, is always associated with clinopyroxene (Fig.3.14).

Biotite is a subordinate mineral and occurs interstitially or associated with magnetite.

Sphene is an important accessory constituent, especially in the microgranophyres. The colour is brownish-yellow with slight pleochroism, indicative of an iron(III)-rich variety (Tröger, 1969).

Fluorite, which occurs as small interstitial patches, is present in every thin section investigated. It also occurs as patches in interstitial hornblende. The fluorite is apparantly a primary magmatic mineral.

The few zircons of the granophyres are generally very small and carry inclusions of foreign material. Secondary overgrowth is developed in some grains and radioactive halos are present.

Other accessory minerals are allanite, apatite, calcite, magnetite and ilmenite.

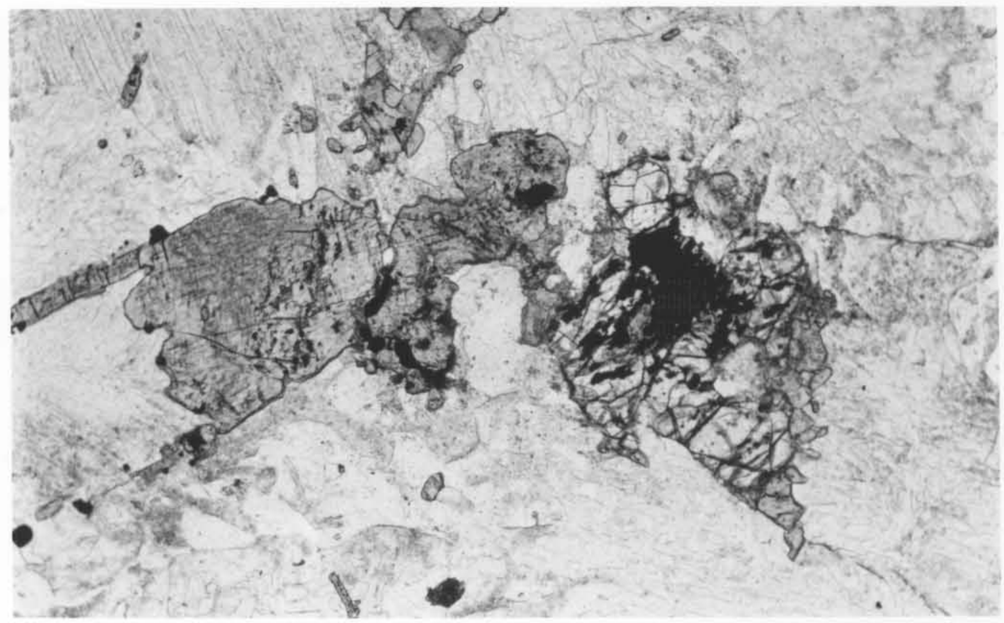

Fig. 3.14.: Clinopyroxene and olivine in Stavoren Granophyre. GR-43. 63x. Tussenin 21JS.