CHAPTER 15

Formation of the Net-veined Complex

Introduction

There are considerable differences of opinion regarding the manner of formation and significance of net-veined complexes similar to that of the Austurhorn. A number of such complexes are listed in table 11. Besides that at the Austurhorn the writer has had the opportunity of visiting the following examples: at the Vesturhorn, at shore exposures south of Kliftatindur; at Ardnamurchan, where the quartz-dolerite of centre 2 outcrops at Sgurr nam Meann and also at outcrops of the similar quartz-dolerite of centre 3; at Slieve Gullion, layer 10, on the west side of the mountain above the "partition" (Bailey and McCallien, 1956, p 495); and at Carlingford, at the Castle Cooley Quarries (Bailey, 1959). In every case one of the characteristic features has been the occurrence within the enclosing acid rock of pillow-like basic inclusions possessing fine-grained margins and crenulate external contacts. The origin of such basic pillows is undoubtably significant regarding the formation of the net-veined complexes as a whole.

Various features of the pillows within the Austurhorn net-veined complex which need to be accounted for are summarised below:

1. The pillows are always more basic than the rock surrounding them.
2. They are extremely variable in size and shape.
3. They commonly occur in groups, in which case one pillow may often be seen to accommodate itself to the shape of another.
4. Pillows of porphyritic and non-porphyritic tholeiite, and also of olivine-basalt, often occur alongside each other.

Table

Net-veined Complexes

Age	Country	Location	References
Tertiary	Iceland	*Austurhorn (P)	Cargill, Hawkes and Ledeboer, 1928
"	"	*Vesturhorn (P)	Cargill, Hawkes and Ledeboer, 1928
"	"	?Lysuskard, Snaefellsnaes	Upton and Wright, 1961
Tertiary	Scotland	Skye: Marsco and Glamaig	Harker, 1904
"	"	Ardnamurchan: *Quartz-dolerite of Sgurr nam Meann, Centre 2(P)	Richey and Thomas, 1930 Wells 1854
"	"	*Quartz-dolerite of centre 3(P)	Richey and Thomas, 1930
		Arran: Glen Dubh area	Tyrrell, 1928
?Tertiary	"	St. Kilda (P)	Cockburn, 1935', Wager and Bailey, 1953'
Tertiary	Northern Ireland	*Slieve Gullion: dolerite layers (P)	Bailey and McCallien, 1956, Bailey, 1958, 1959, Elwell, 1958, 1962, Reynolds, 1951', 1954', Wager and Bailey, 1953'
Tertiary	Eire	*Carlingford (P)	Bailey, 1959
?Devonian	Channel Islands	Jersey (P)	Wells and Wooldridge, 1931'
"	"	Guernsey (P)	Elwell, Skelhorn and Drysdall, 1960', 1962'
?Devonian	U.S.A.	Mount Desert Island (P)	Chapman, 1955', 1962',
?Jurassic	Nigeria	Sara Fier (P)	Turner, 1961',

P = basic pillows present, * = examined by the author, ' = include figures or plates of pillows.

5. The pillows are texturally zoned, becoming progressively coarser-grained inwards away from the surrounding granophyre, and many pillows possess dense fine-grained margins which are of constant thickness within any one pillow.

6. The contacts of the pillows with the surrounding granophyre are characteristically highly irregular and cumulose in shape.

7. Acid veins of various types and thicknesses cut the pillows, and some of these veins are bounded by fine-grained basalt.

8. Sometimes the pillows have been completely broken up and pillow fragments, still recognisable as such, are scattered throughout the nearby granophyre.

9. The pillow-granophyre contacts are either sharp or diffuse.

10. The granophyre layers between individual pillows vary in width from less than 1cm. to more than 1 metre.

11. Under the microscope the fine-grained pillow margins show the following points:

    (a) Sheaf-like aggregates of plagioclase.

    (b) Occasional skeletal crystals of plagioclase.

    (c) Minute apatite needles showing a variety of parallel and skeletal growths.

    (d) Commonly skeletal iron ore.

    (e) Plagioclase phenocrysts of typical igneous aspect are quite common.

    (f) Hornblende is always present in the groundmass and often occurs in place of pyroxene.

    (g) Large crystals of poikilitic biotite and, less commonly, hornblende, are common and similar crystals, particularly those of hornblende, often occur in the adjacent granophyre. Sometimes a single large crystal of either biotite or hornblende grows across the granophyre - pillow contact.

Features 1, 2, 3, 5, 6, 7, 9 and 10 are found in all net-veined complexes where pillows are found; in addition features 11(a), 11(b) and 11(f) are recorded by Chapman (1962) from Mount Desert Island, Maine.

Theories of Pillow Formation

Three main theories have been put forward to account for pillows in net-veined complexes. These are the fluidisation theory, proposed by Reynolds (1954); the replacement theory, the chief advocate of which is Chapman (1955, 1962); and the commingling theory of Wager and Bailey (1953).

The term "fluidisation", which is normally used to describe the process by which solid particles are supported and transported by gas, has been extended by Reynolds to include liquid particles as well. As such, fluidisation is a well known volcanic process (Reynolds, 1954). In the acid net-veining of layered doleritic rocks at Slieve Gullion Reynolds considers that an intense flow of gas containing tuff-size liquid particles was injected along fractures within the dolerite. The gas eroded and melted the adjacent dolerite, the latter developing the characteristic highly irregular margins. The narrow fine-grained edges of dolerite adjoining the granophyre veins are hence considered by Reynolds to be due to melting. "Proof" of this is found (Reynolds, 1954, p.596) "where granophyre veins transgess dolerite characterised by phenocrysts of bytownite, An84. The finer-grained dolerite edges then contain relics of bytownite dissected by stringers of pale glass such as result from partial melting. The refractive index of the glass is consistent with its having a composition, An 53, corresponding to that of the liquid which would form first if the bytownite were fused (Reynolds, 1952b)". Reynolds also infers, because of the presence of swallow-tail plagioclases in many of the fine-grained edges, "that the melted material mainly solidified as glass which has since devitrified".

Chapman has described certain "composite" dykes from Mount Desert Island, Maine, U.S.A., where pillows of dolerite are enclosed in a matrix of granite and granophyre. He suggests that originally the dykes were formed of dolerite which later became partly replaced metasomatically by granitic material introduced along numerous fractures in the dyke, so forming the pillow-like masses of dolerite. The fine-grained margins of the dolerite pillows are considered by Chapman to have been formed by recrystallisation during metasomatic replacement.

Wager and Bailey, in their "commingling theory" (so called by Chapman, 1962), suggested that basic magma, on coming into contact with cooler acid magma, will become marginally chilled and develop a solid or semi-solid skin. With physical mixing of the two magmas pillows of basic magma may form within the acid, and the pillows so formed are thought to be able to assume all the shapes seen in the field. On this theory the fine-grained margins of the pillows are considered to be true chilled margins. Elwell (1958, 1962), at Slieve Gullion, and Elwell, Skelhorn and Drysdall (1960, 1962), in Guernsey, also favour the chilling hypothesis for similar fine-grained margins of basic rock against granophyre, though in Guernsey they believe that the chilling may have been caused by gaseous fluids rather than by normal acid magma.

Each of the theories has been the subject of some critisism. Bailey and McCallien (1956), have critisised the fluidisation theory for the formation of pillows at Slieve Gullion, and Chapman (1962) rejects this theory, and also the commingling theory, for the pillows in the Mount Desert Island dykes, while there are strong arguments against the theory of metasomatic replacement.

3. Objections to the fluidisation theory

(a) Bailey and McCallien (1956), Elwell (1958), Elwell, Skelhorn and Drysdall (1962) and also the writer find it difficult, if not impossible, to believe that the crystallisation of a fused margin, as envisaged by Reynolds (1954), will become progressively finer-grained towards the source of heat. Chapman (1962, p.560) even considers that if fusion had taken place the marginal basic rock would have become