The Geology of Istind, western Dronning Maud Land, and the Relationship between the Istind and Tindeklypa Formations

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Istind Peak was was visited in November 1973 and successfully scaled. Attention was given to the relationship between the Tindeklypa and Istind Formations and to the stratigraphy of the latter. The stratigraphy and lithology are discussed and it is concluded that the Istind Formation is merely an upward continuation of the Tindeklypa Formation and that no angular unconformity exists between these two formations. It was also established that the igneous rocks occurring in the sequence are intrusive sills and not lava flows.

Istind-piek is in November 1973 besoek en suksesvol bestyg. Aandag is gegee aan die verhouding tussen die Formasies Tindeklypa en Istind en die stratigrafie van laasgenoemde is ondersoek. Die stratigrafie en litologie word bespreek en daar word tot die gevolgtrekking gekom dat die Formasie Istind bloot 'n opwaartse voortsetting van die Formasie Tindeklypa is en dat daar geen klinodiskordansie tussen die twee formasies bestaan nie. Daar is ook vasgestel dat die stollingsgesteentes wat in die suksessie voorkom, intrusiewe plate en nie lawa-uitvloeiings is nie.

Introduction

Since 1962 Istind (02° 22′ W, 72° 06′ S) has been investigated by geologists of seven South African National Antarctic Expeditions. Two formations have been tentatively recognized.

The Tindeklypa Formation was named after Tindeklypa Nunatak, located near the confluence of the Viddalen and the Jutulstraumen *(Neethling*, 1967). In the type area this formation comprises a massive boulder bed deposit with occasional sedimentary interbeds having a regional dip of 5° to 50° ESE *(Neethling*, 1970). According to *Neethling* (1970) this formation is unconformably overlain by a sequence of sediments and intercalated lava flows which he termed the Istind Formation. The contact between these two formations has been exploited by a dolerite sill of unknown age. *Neethling* (1970, p. 24) tentatively divided the Tindeklypa Formation into four conformable members:

(i) A basal lava-pebble conglomerate.
(ii) A lower, reddish-brown boulder bed.
(iii) A bedded sandy graywacke.
(iv) An upper greyish boulder bed.

He notes that members (ii) and (iv) consist of pebbles, cobbles and boulders of earlier Ahlmannrygg Group *(Neethling*, 1970) sedimentary and igneous rocks.

Butt (1962) postulated a glacial origin for the Tindeklypa Formation, but *Watters* (1969) and later workers regarded it as a typical volcanoclastic deposit.

According to *Butt* (1962) and *Neethling* (1967) the Istind Formation comprises a 350 m thick sedimentary-volcanogenic sequence exposed in the upper part of Istind Peak. *Neethling* (1970) gives the dip as 5-7° SE and concludes that the relation of this formation to the underlying Tindeklypa Formation is one of angular unconformity (1970, p. 25). *Paterson* (1972) points out that all the steep dips (5-50°) in the Tindeklypa Formation were measured at Peak 1599 and not on the Istind main peak where contact between the two formations exists, and that an angular unconformity has therefore not been proved conclusively.

The igneous rock cropping out about 400 m below the summit has been described in a number of ways: *Butt* (1962) regarded the denser part as an igneous *intrusive* of gabbroic composition and the underlying amygdaloidal part as a "highly sheared amygdaloidal lava" of different age. According to *Bastin* (1966) this igneous rock is a flat-lying diabase sill which intruded parallel to the bedding with formation of gas bubbles (amygdales) in the contact zones. *Neethling* (1970) on the other hand describes it as a thick *basal lava flow* with a dense core. *Watters* (1969) apparently also regarded the intercalated igneous rocks at Istind as intercalated *flows*.

Because of the relatively inaccessible nature of the exposed face of Istind, all these investigations were done from a considerable distance and are therefore sketchy and speculative. In November 1973 the nunatak was successfully scaled and the geology was investigated with three objectives in mind, *viz* to test the validity of the proposed angular unconformity between the Tindeklypa and Istind Formations; to describe the lithology from the bottom to the top; and to clarify the relationship between the igneous rocks and the sediments.

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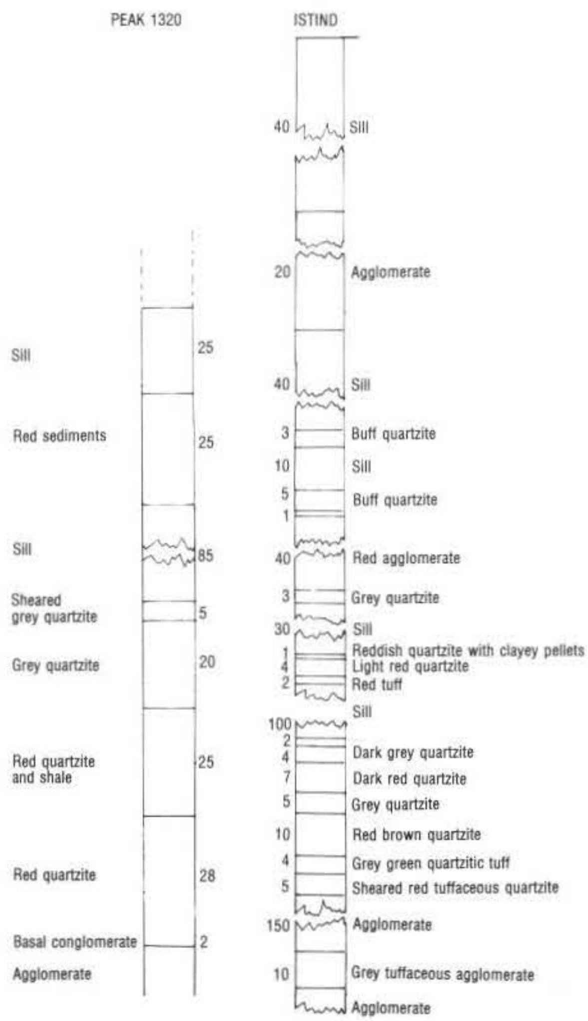

Fig. 1. Stratigraphic columns for Istind and Peak 1320.

Stratigraphy at Istind

A total thickness of approximately 750 m of rock is exposed at Istind Peak. The bottom 400 m consists mainly of agglomerate and tuffaceous agglomerate followed by sediments, more agglomerate and amygdaloidal igneous rocks up to the summit.

The agglomerates

The massive grey to reddish agglomerate at the foot of Istind is a text-book example of a true volcanoclastic deposit. The inclusions are angular with no definite orientation. There is no sorting and the inclusions range in size from barely visible to over 1 m across. Some form sharp contacts with the matrix whereas the contacts of others are diffuse. *Bredell & Paterson* (1972) made a careful study of the inclusions and found that about 90 per cent are of sedimentary origin and less than 10 per cent are mafic rocks resembling the Borg Intrusions. They found no recognizable inclusions of lava.

The agglomerates that occur higher up in the succession, e.g. the one 40 m from the summit, are less dense and not so coarse. Reworking by water is indicated by the fair roundness of some inclusions and the faint cross-bedding discernible in a tuffaceous layer 120 m below the summit.

The sediments

The first sediments appear 35 m below the lower amygdaloidal sill (Fig. 1). About 10 m of tuffaceous quartzites are followed by quartzites ranging in colour from dark red-brown to cream. Sedimentary structures are scarce and limited to a few current-ripples and weakly developed cross-bedding in the quartzite immediately below the first amygdaloidal sill horizon. The sill is followed by thin reddish tuff and quartzite similar to that below the basal sill. Six metres above this sill a 1 m thick quartzite with curious clayey pellets 1 cm in diameter occurs. Higher up a few thin layers of quartzite alternate with thick units of agglomerate and amygdaloidal sills.

The amygdaloidal igneous rocks

As far as bulk is concerned these are by far the most important rocks in the upper 40 m of Istind (Fig. 1).

The lower "lava", regarded by *Neethling* (1970, p. 25) as the basal part of the Istind Formation, is clearly intrusive into the sediments above and below it. Large xenoliths of grey quartzite (1 m × 2 m) occur 50-100 cm within the igneous rock along the lower contact. The upper contact with sediments is sharp with chilling in the igneous rock, giving rise to a dense aphanitic texture. The tuff adjacent to the sill has been baked with a thin (4-6 cm) development of hornfelsic texture.

The lower 2 m of the sill is highly amygdaloidal, changing abruptly to a dense rock without amygdales. Three metres higher up the amygdales appear again and become abundant and very large (up to 2 cm in diameter).

The igneous rocks occurring higher up show essentially the same relationship with the country rocks, i.e. concordantly intrusive. About 60 m below the summit a thick off-shoot cuts across a red agglomerate. Twenty metres higher the igneous rock again assumes an attitude parallel to the bedding of the beds.

The sequence at Peak 1320

At Peak 1320, about 6 km SSE from Istind, a sequence similar to parts of that at Istind was observed (Fig. 2). *Bredell & Paterson* (1972) summarize this sequence from bottom to top as follows:

(i) A 75-m thick layer of agglomerate, ranging from coarse grey at the bottom, through a finer greenish type to a reddish variety with small inclusions (up to 1 cm) near the top.

(ii) Thin basal conglomerate with well-rounded pebbles of red jasper and grey quartzite followed by about 28 m of intensely sheared red quartzite and quartzitic shale, showing occasional ripple marks and cross-bedding. The thin conglomerate may represent an agglomerate reworked by water.

(iii) Unsheared red quartzite and shale with frequent ripple marks and mud-cracks. Thickness about 25 m.

(iv) Dark brownish grey quartzite, 20 m thick, followed by 5 m of intensely sheared quartzites.

(v) A 35 m layer of lava with quartz amygdales.

(vi) Dark green lava with needle-like crystals; thickness 50 m.

(vii) Red sediments which were not visited and therefore of uncertain lithology. Judging from the colour they

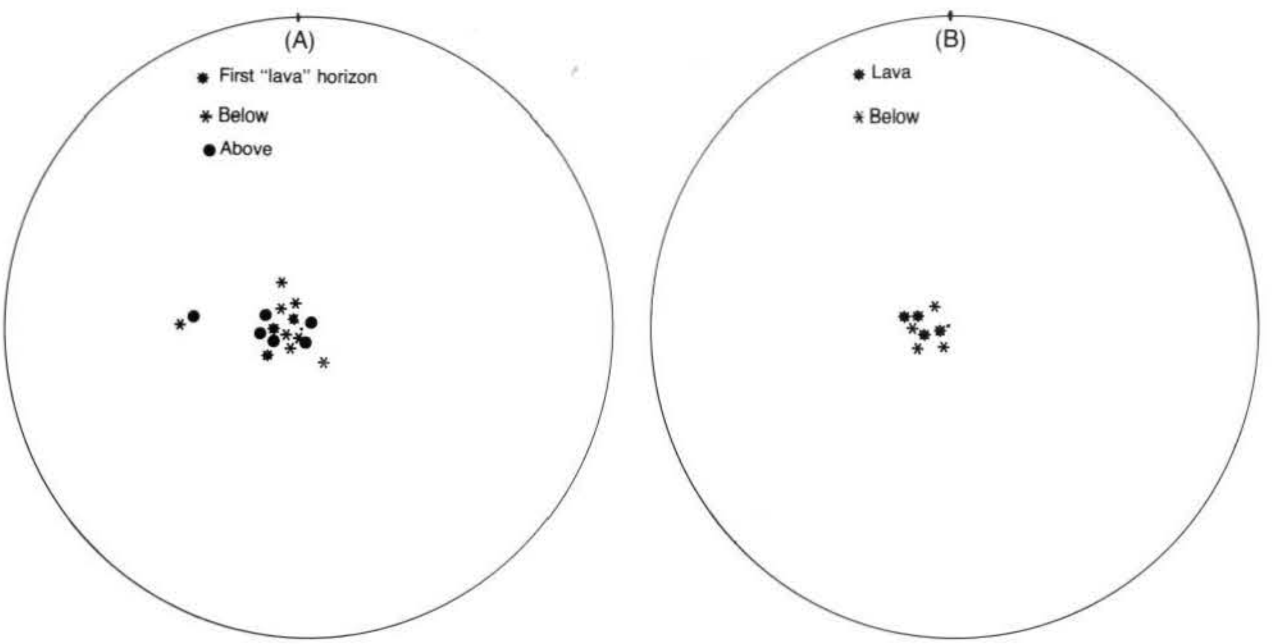

Fig. 2. Lower hemisphere plots of poles to bedding planes. A – Istind; B – Peak 1320.

could be the equivalent of either the red agglomerate or the reddish tuffaceous quartzite as observed at Istind. Thickness 25 m.

(viii) Lava, 25 m thick.

These "lavas" at Peak 1320 are without doubt the same rocks as the amygdaloidal igneous rocks occurring as sills in the sequence at Istind.

Attitude of the beds

In order to test the validity of the proposed angular unconformity between the Tindeklypa and Istind Formations *(Neethling*, 1970) the attitudes of beds were determined at different levels below and above the proposed contact, i.e. the basal "lava" horizon at Istind Peak. The only accurate way to do this was by the technique described by *Phillips* (1967) using two or more apparent dips. In the more tuffaceous zones occurring at different stratigraphic levels in the agglomerate the traces of bedding-planes were clearly discernible and the determination of the attitude of the agglomerate consequently did not prove to be as problematical as was expected. In the amygdaloidal sills, flow layers, usually emphasized by the occurrence of vesicles along them, facilitated the necessary measurements.

From Fig. 2 it is clear that there is no angular unconformity between the sequence below the basal "lava" and that above it. The average dip is 3° ESE (3°/100°). The beds at Peak 1320 show the same attitude.

Conclusions

The Istind Formation is merely an upward continuation of the Tindeklypa Formation. The sequence at Istind Peak is mainly volcanogenic and true volcanoclastic deposits (i.e. agglomerates and tuffs) occur from the bottom almost to the very summit. In the higher part true fluvial sediments become more frequent indicating periods of volcanic quiescence. These sediments were deposited in a high-energy shallow-water environment as is shown by the cross-bedding, ripple marks and mud-cracks.

No angular unconformity exists at Istind; the entire sequence dips 2-5° ESE.

The "lavas" intruded as sills and are not extrusive flows. These intrusions usually follow the bedding of the older sediments, but occasionally cut across it.

The age of these igneous rocks has not been determined reliably and their relative position in the general stratigraphy of western Queen Maud Land remains obscure. A $^{40}Ar/^{39}Ar$ analysis showed an apparent age of 603 m.y. (L.G. Wolmarans, personal communication, 1974) but this is caused by a later period of intense hydrothermal activity. In hand specimen these rocks are very similar to lavas from a number of outcrops, e.g. at Peak 1599 and the Straumsnutane, but any correlation on purely lithological grounds serves no real purpose and only adds unnecessarily to the already wide array of speculations.

The sequence at Peak 1320 is undoubtedly a lateral extension of the same rocks as at Istind. The thicknesses of the individual units differ, but the fit, as can be seen from the two stratigraphic columns (Fig. 1), is nevertheless remarkable. The sequence at Peak 1320 is at a lower elevation as a result of down-faulting *(Paterson*, 1972, p. 24).

In the light of all this it is clear that the term Istind Formation should be abandoned.

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