

5. Kirkpatrick Lavas, Exposure Hill Formation and Ferrar Sills in the Prince Albert Mountains, Victoria Land, Antarctica

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INTRODUCTION

The Prince Albert Mountains are part of the Transantarctic Mountains (TAM) chain in Central Victoria Land. The Transantarctic Mountains are the uplifted western shoulder associated with the Cenozoic Ross Sea Rift system. The Prince Albert Mountains differ from the regions to the N and S by its lower elevations, subdued morphology as well as geophysical aspects (REDFIELD et al. this vol.). Tilting and uplift appears to be smaller than elsewhere in the TAM. These features make this area particularly suited, geologically and logistically, to study Jurassic igneous rocks (Kirkpatrick lavas, Exposure Hill Formation and Ferrar sills) which are well exposed in a complete section (Fig. 1). This section has been sampled for geochemical and isotopical analyses on bulk rocks and mineral separates. Here, the field aspects of the Jurassic igneous sequence are described.

Older literature introduced the terms „Ferrar Dolerites“ and „Kirkpatrick Basalts“ for intrusive, mostly coarse-grained sills and subaerial lavas, respectively. Petrographic and chemical analyses have shown that truly basaltic compositions rarely exist in these rocks. On the other hand, lava flows may reach ten to hundred meters in thickness resulting in coarse-grained „doleritic“ textures. For these reasons the terms „Ferrar Sills“ and „Kirkpatrick Lavas“ are more appropriate and will be used here.

FERRAR SILLS

The deepest exposed level at elevations around 1,000 m is represented by a 100 to 150 m thick Ferrar sill which intruded granitoid basement rocks N of Mt. Murray. A second sill above 1,280 m was found at Mt. Chetwynd near the coast to intrude sandstones of the Beacon Formation just above the erosional unconformity on the regional basement. This locates the Mesozoic Kukri Peneplain in the study area at approximately 1,250 m, 18 km inland from the Ross Sea coast. Over another 85 km inland, the only exposed rocks are Ferrar sills with minor and discontinuous interlayers of Beacon sandstones. Some peaks, such as Mt. Joyce, expose in a 1,000 m high cliff only three major sills with two thin seams of Beacon sediments intercalated which represent no more than a total of 50 m. Other nunataks expose sandwich-type interlayers of Beacon and Ferrar sills with individual units of 10-20 m (Trio Nunatak, SE). Beta Peak is a rare example where Beacon sandstones form cliffs up to 200 m. The elevation of the Kukri Peneplain near the coast and the deepest exposed sills inland at Mt. Joyce, respectively, suggest a regional minimum dip for the Ferrar/Beacon unit and thus the rift shoulder of about 1°. Visual inspection of continuous mesa morphologies formed by extensive sills as well as the morphological aspect of the Ferrar exposures indicates that the dip could not be much more than 1 to 2°.

Most sills in the eastern, more coastal parts of the study area (Mt. Joyce - Mt. Billings - Mt. Bowen - Mt. Howard area, Beta Peak, The Mitten) are well defined morphologically and have regular thickness and columnar cooling columns. Individual sills have flat-lying, continuous breaks in the vertical column structure. These are, however, clearly one continuously cooled intrusive body. Two interpretations are proposed for the two types of horizontal internal structure. Multiple intrusion of magma batches into a single sill form layered structures of 4-10 m in thickness with „blocky“ fracture pattern at the base and „feathery“ cleavage at the top of each intrusive sheet. In

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contrasts, horizontal breaks of columnar jointing in the order of 10-100 m may either result from the superposition of two individual sills or the intrusion of large scale magma batches close in time. True sill boundaries are rare and poorly defined where Beacon sandstones as interlayered markers are absent. However, it is possible to find single sills separating into two „individual“ sills with interlayered Beacon sediments (e.g. Mt. Joyce). This illustrates that the number and stratigraphy of Ferrar sills may change laterally. Mixing and superposition of individual magma batches may then be the general case rather than an exception. Compound cooling units of sills with internal petrographic and chemical layering are the result (GUNN 1966). Regular internal layering and cooling columns are interpreted to be the result of orderly intrusion and „inflation“ of sills at distance from the feeder fissures. Some outcrop areas, in particular in the southern Ricker Hills, are characterized by highly irregular cooling columns, irregular patches of sparsely vesicular lava and abundant rafts of Beacon sandstone some of which are highly brecciated and mixed with brecciated Ferrar rocks. The same area is also cut by faults and dikes. Such areas are interpreted to reflect sites proximal to Ferrar feeder zones. Dike swarms, however, have not been found.

The complete thickness of Ferrar sills is estimated to be in the order of 800-1,000 m. Sampling of Ferrar sills for geochemical and isotopic studies concentrated on sections where several individual sills could be distinguished (Mt. Murray, Mt. Joyce, Trio Nunatak, Ricker Hills). Thumb Point sill has been resampled for mineral separation because GUNN (1966) described the rare occurrence of olivine-phyric Ferrar basalts from this locality. Material from a large number of isolated sills and scattered nunataks complete the present collection of Ferrar sills.

EXPOSURE HILL FORMATION

Rocks of the Exposure Hill Formation have been described by ELLIOTT et al. (1988) from the Mesa Range in North Victoria Land and their occurrence has also been reported from the Convoy Range further south. In the Prince Albert Mountains, these rocks are exposed in small isolated nunataks in the area between Brimstone Peak, Ricker Hills and Sheppard Rocks. The Exposure Hill Formation was defined (ELLIOTT et al. 1986) as a post-Beacon sequence of subaerial to subaqueous primary and reworked pyroclastic rocks at the base of the Kirkpatrick lavas. In the study area, these rocks comprise volcanoclastic breccias, lahars, hyaloclastites interlayered by pumice-bearing tuffites as well as sand- and siltstones. One possible ignimbrite, reworked at its surface, has also been found. A remarkable feature of these rocks is their dominantly siliceous composition which suggests a precursor volcanism to Kirkpatrick and Ferrar magmatism of distinctly evolved character. Base and top of this unit can be mapped out between individual exposure areas. However, direct stratigraphic contacts are rarely observed. The thickness of this unit is difficult to assess but may be variable and in the order of a few tens to a hundred meters.

KIRKPATRICK LAVAS

Those nunataks most distal from the coast line (from N to S: Sheppard Rocks, Thomas Rocks, Tent Rocks, Brimstone Peak, Outpost Nunatak, Griffin Nunatak and Ambalda Peak) are almost entirely built up from a succession of subaerial Kirkpatrick lava flows. In some outcrops there are basaltic (s.l.) hyaloclastites with immersed pillows directly underlying the Kirkpatrick lava pile. However, regional correlation of individual lava flows (see below) allows to correlate flows from one nunatak with these hyaloclastite breccias in another. Clearly, this indicates a pre-Kirkpatrick morphology with extensive lakes. Internal structures of the hyaloclastite suggest an origin as a flow-foot breccia typical for thick lava flows invading a large water body laterally. Flow directions are inconsistent and change from N to S indicative of irregularly advancing flows. The distinction of these pyroclastics from those of the Exposure Hill formation is given by (i) the lateral equivalence of Kirkpatrick flows and flow-foot breccias, (ii) their less evolved chemical character and (iii) different style of alteration and generally better degree of preservation.

A complete 700 m section of lavas was studied at Brimstone Peak. Flows are highly variable in thickness (1-1,000 m) and range in texture from coarse-grained to glassy, highly vesicular and altered to dense, glassy and fresh. Flows typically have a brecciated base, dense central position and a vesicular flow top, sometimes scoriaceous. Pillows occur at the base of some flows where they are underlain by 1-2 m thick tuffite sediments.

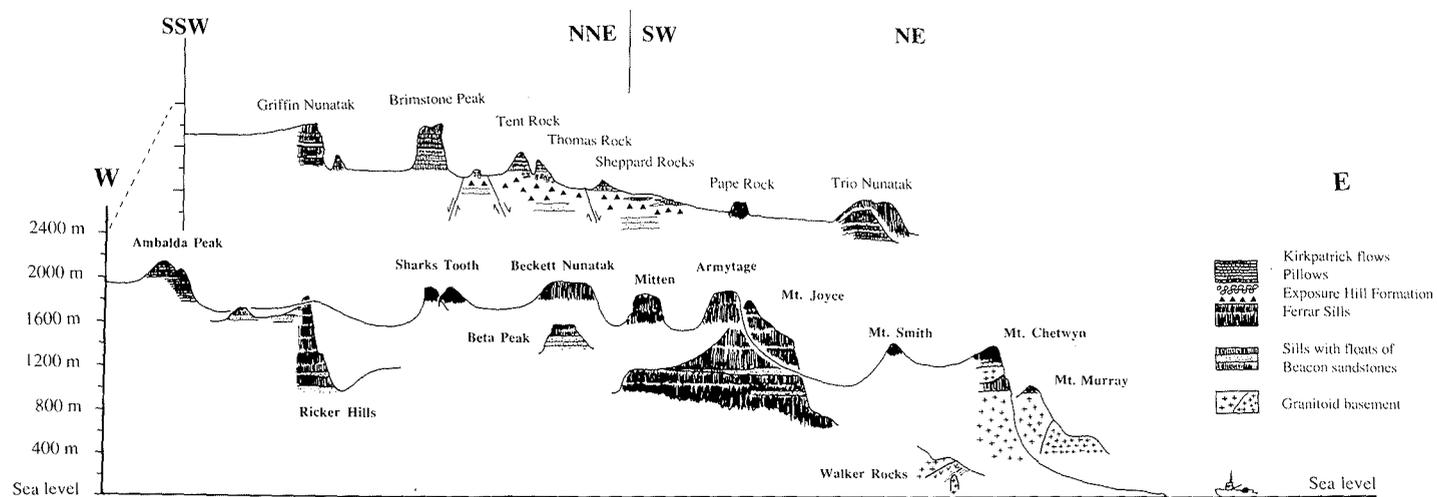


Fig. 1: Schematic sections from the granitoid basement at the Victoria Land coast to the easternmost nunataks of Kirkpatrick lavas. Note that a regional dip toward the E of 1° has been assumed. The cumulative thickness of the Ferrar/Kirkpatrick section sampled here is in the order of 1,600 m.

Abb. 1: Schematisches Profil vom granitischen Grundgebirge an der Victoria Land-Küste bis zu den Laven des Kirkpatrick-Basalt der westlichsten Nunatakker, unter Annahme eines regionalen Einfallens des Deckgebirges von 1° nach Westen. Die Gesamtmächtigkeit des beprobten Ferrar/Kirkpatrick-Profiles liegt hier bei etwa 1,600 m.

However, neither sediments nor pillows are laterally consistent which indicates discontinuous patches of water on the pre-flow land surfaces. Tree fossils were found rooting in one flow top breccia. Some thicker flows (>50 m) show a lateral extensive horizontal fracture pattern identical to those observed in Ferrar sills. Multiple pulses within individual flows are therefore also suggested here.

The degree of alteration varies from absent (in the chilled dacitic portions) to extreme in the highly vesicular top parts of some flows. Large amygdales either within the lavas or, even larger, in the brecciated basal and top portions are filled with various zeolites (stilbite, mordenite, scolecite?), calcite and quartz. Additional alteration minerals have been observed but not been identified in the field.

The differences in thickness and appearance of flows is a function of their composition (dacitic rocks tend to be more glassy), magma discharge and flow rate and cooling. Some flows have developed distinctive characters (such as double flow units each with a black glassy base in one flow) which allows regional correlation between nunataks of up to 30 km distance.

Sampling comprises the entire lava sequence as well as abundant secondary minerals. Lava samples will be combined with the sill samples for a geochemical and isotopic investigation on the origin of Ferrar/Kirkpatrick magmas. In addition, it is planned to date the secondary minerals by either K-Ar or Rb-Sr, or both. The latter addresses the problem of dating Ferrar magmatism and possible disturbance of K-Ar dates by an as yet ill-defined secondary thermal event. The petrological/geochemical study on Ferrar magmatism hopes to contribute to the as yet unresolved question of crustal contamination versus enriched mantle source as possible explanations for the unusual geochemical and isotopic characteristics of these magmas.

References

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