flow both above and below the cave entrance so that gradients may be noted.
3. The age, composition and, in particular, the structure of the flow must be determined.
4. Details of flow features must be noted so that the form of the cave, the age of various segments, and the history of the draining of the tube may be discovered.
5. The extent to which the morphology of the cave is related to the flow structure is of the utmost importance.

For our part, during our stay in Iceland this summer, we intend to make a detailed study of the lava tube caves of the Gullborganhraun and Snaefells peninsula, and to journey into the uninhabited interior of the island in order to examine and draw up a preliminary report on the vast Odadahraun flow of north-central Iceland.

LAVA CHANNELS AND ASSOCIATED CAVES IN VICTORIA, AUSTRALIA

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INTRODUCTION

Basaltic volcanoes of late Pliocene and Quaternary age are found over an extensive area of southeastern Australia (Fig. 13-1 , 13-2) as well as in several areas in the northeastern state of Queensland. Caves (Fig. 13-3) have been described from each area (Matthews, 1968). The caves of Victoria were described by Ollier and Brown in 1964. Until recently only minor new caves have been found (see Ollier and Joyce, 1968), but in the last few years caves have been found at Warrion Hill volcano (pers. comm., J. Taylor) and at Mt. Napier (pers. comm. L.K. Elmore), and further caves have been found at Mt. Eccles. The caves at Mt. Napier and Mt. Eccles are associated with the only lava channels known in Victoria. This paper discusses the channels and associated caves at Mt. Napier and Mt. Eccles, and describes their relationships. The features at Mt. Napier were discovered by Elmore and will be described elsewhere by him. Details of the lava channels and the newly-discovered caves at Mt. Eccles are given here for the first time.

THE MT. NAPIER AREA

The main area of lava flows around Mt. Napier (Figs 13-4 , 13-5) is about six miles across. An associated radiocarbon date suggests an early Holocene eruption. A lava channel and associated caves are found about 1 1/2 mile west of Mt. Napier, among the irregular flow ridges and depressions of the type known locally as "stony rises". A channel 2 to 3 m deep and 6 to 8 m wide leaves a lava depression at the foot of a small scoria cone with a crater, and runs for about 1/4 mile. Two caves open into the channel and a natural bridge across the channel is the remnant of a formerly more extensive cave. A number of other small cones and ridges are found up to two miles or more from the main volcano. Such a distribution is not known from any other local volcano. One spatter ridge contains a small cave about three or four meters long on its flank, possibly due to sagging.

The Byaduk Caves are about four miles southwest of the main volcano, where the lava began to flow down the Harman Valley for a further ten miles or more. Collapses in the flow surface (Fig. 13-7) give access to a number of caves here (Ollier and Brown, 1964). Mt. Napier itself (Fig. 13-4) is a multiple scoria and spatter cone which rests on a broad lava shield built up by the flows. On its northern flank are two small, irregular caves which were probably formed by later erosion beneath a small flow. On the western flank two small lava caves are associated with indistinct lava channels which lead out into the surrounding "stony rises". One cave here is in line with a channel which runs down the flank below a low point in the crater wall. It is within a small dome of lava built up of many thin layers (Fig. 13-9). Its cross-section has the form of a pointed arch, suggesting distortion of the upper walls and roof (Fig. 13-10). The floor and roof are parallel, and slope steeply down the flank of the volcano. Lava stalactites are inclined downflow. Near the upper entrance the cave's lining has fallen away to expose thin layers of lava which make up the upper part of the cave wall. In the other cave nearby, are found groups of needle-like stalactites with individual diameters of 1 m or less. Some bunched and helictitic forms are present (Fig. 13-11).

THE MT. ECCLES AREA

Mt. Eccles volcano lies about 14 miles southwest of Mt. Napier and is probably about the same age. It is surrounded by an area of "stony rises" about six miles wide. Thence a valley flow ran west and south 19 miles to the coast, with a further nine miles now submerged. The main volcano

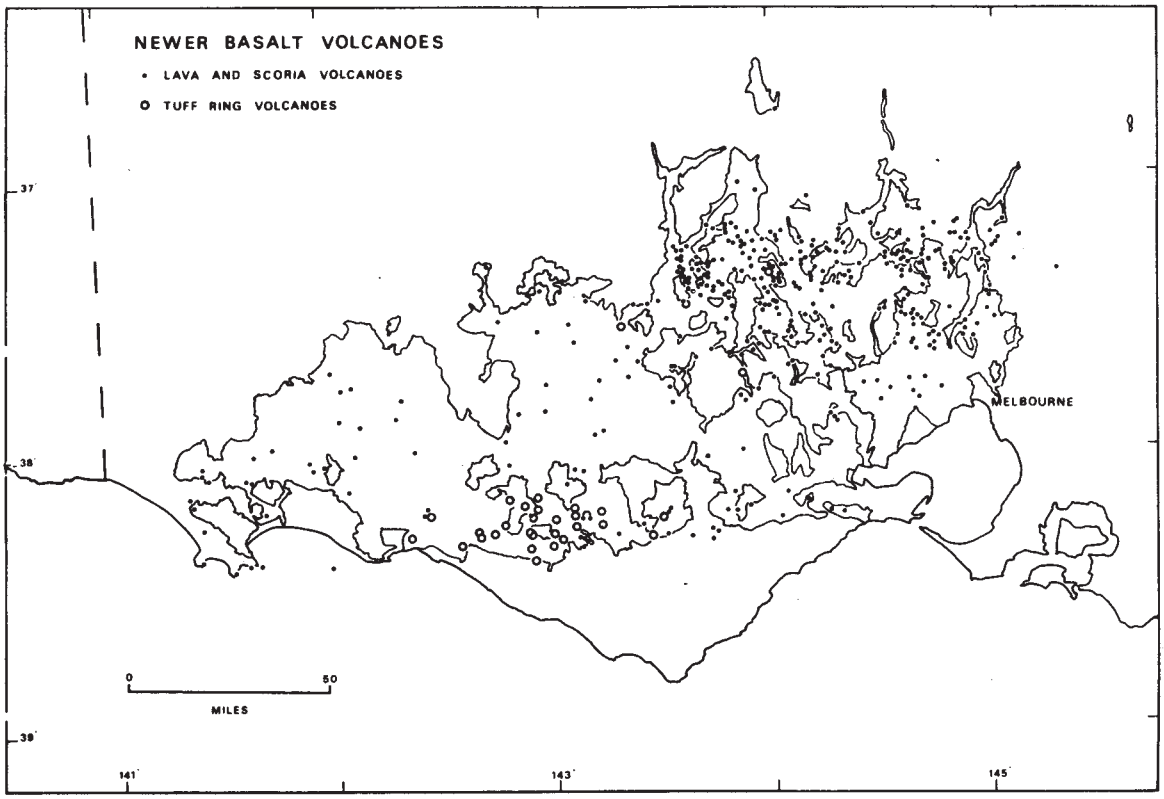


Figure 13-1: Distribution of holocene volcanoes in southeastern Australia.

Younger lava flows of Victoria, Australia:

N-Mt.Napier and its flows
E-Mt.Eccles and its flows
R-Mt.Rouse and its flows
P-Portland
PB-submarine extension of Mt.Eccles flows into Portland Bay
F-Port Fairy

For scale compare with Fig. 13-14.

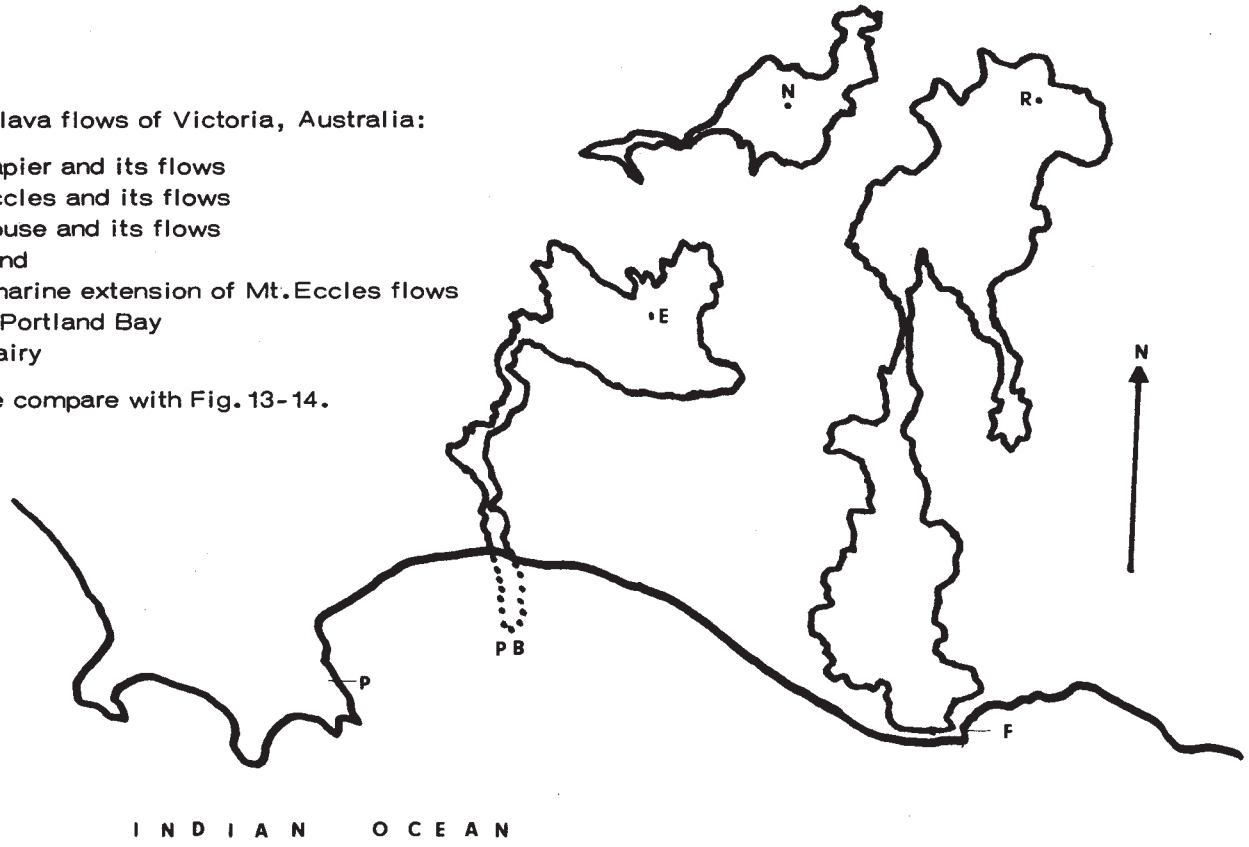


Figure 13-2: Lava flows of Mount Eccles, Mount Napier and Mount Rouse.

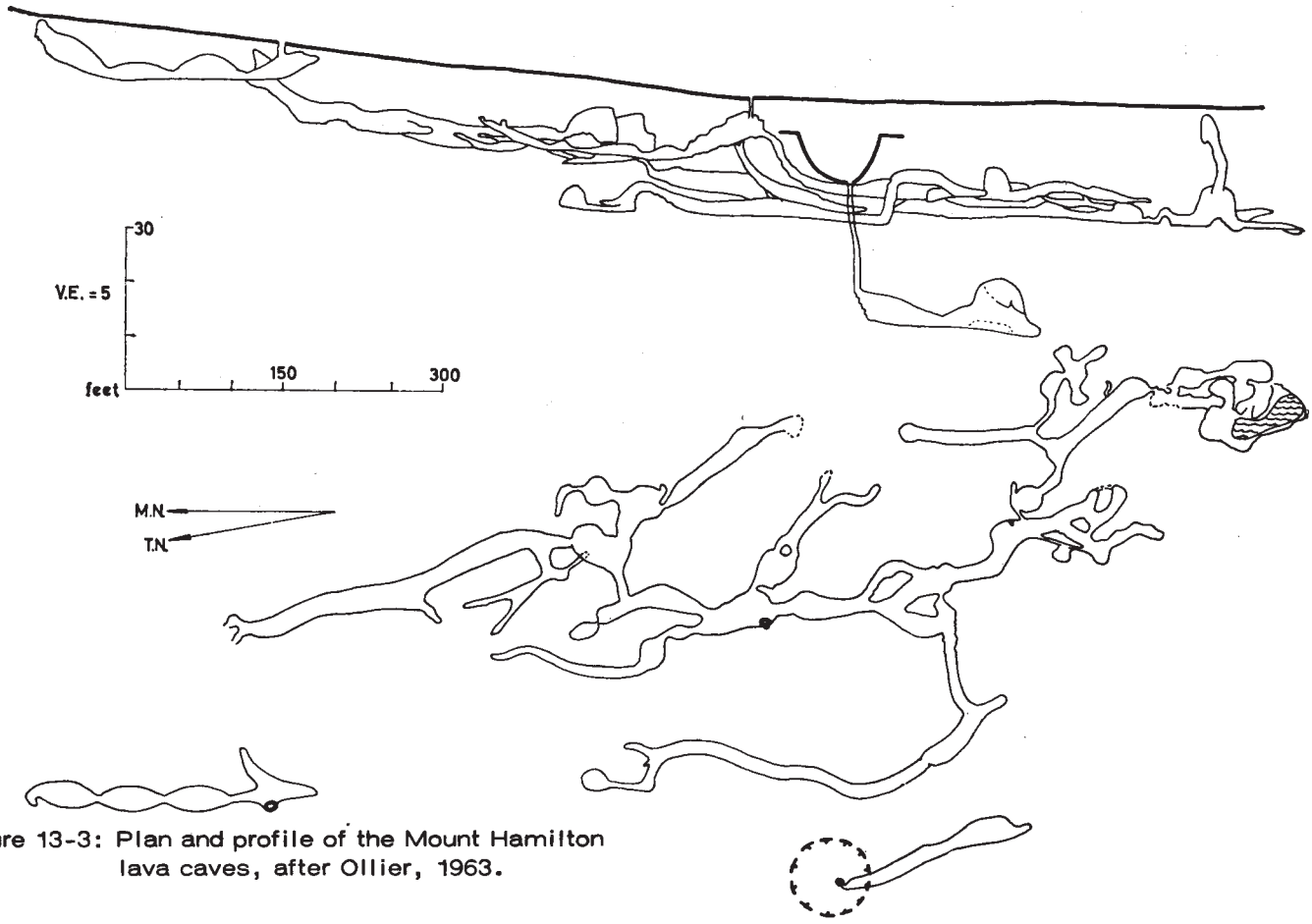


Figure 13-3: Plan and profile of the Mount Hamilton lava caves, after Ollier, 1963.

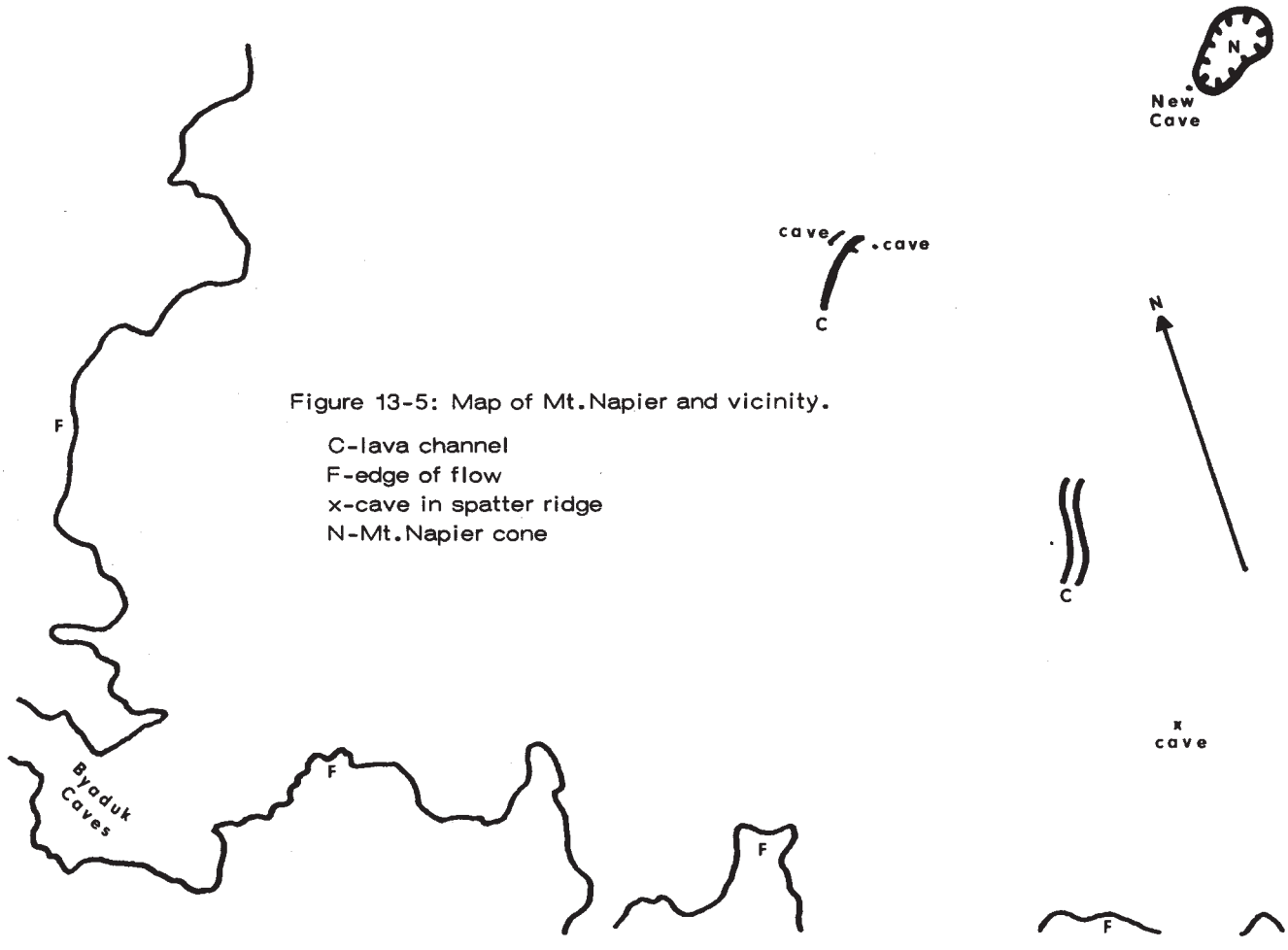


Figure 13-5: Map of Mt. Napier and vicinity.

C-lava channel
F-edge of flow
x-cave in spatter ridge
N-Mt. Napier cone

is a steep-walled elongate crater containing Lake Surprise (Figs. 13-12, 13-13). From the north end of the crater a lava channel runs out into the "rises" where it splits into two branches (Fig. 13 14). These features are jointly known as the Lake Surprise Lava Channels. The west branch extends over two miles from the crater, and the southwest branch, 2.4 miles. The average gradient is 25 feet/mile. Beyond these channels the gradient increases to about twice that figure.

Southward along the line of the main crater is a series of spatter cones. From one cone a narrow lava channel (Fig. 13-15) runs about one mile westward, with a roofed section known as Gothic Cave.

The known caves and other features of Mt. Eccles were described by Ollier in 1964. The area is not yet fully explored. Caves and side-channels known along the main channels are indicated on the accompanying map (Fig. 13-14). From the air, the channels closely resemble a type of lunar rille (Fig. 13-16). In some places the channel runs along a ridge-like area but elsewhere its walls are at the general level of the lava field around it. The western channel ends by the walls decreasing in height and the channel widening, but the southwestern channel appears to end in a depression, wider than the channel itself.

The known caves and side-channels are in the upper part of the main channel walls. The caves generally run away at right angles to the main channel for 50 to 60 m. Ollier (1964) used the name Tunnel Cave for the first such cave discovered, because of its perfect tunnel-shape.

The depth of the channels varies, and lava mounds and ridges are found along the floors. The west channel is from 140 to 220 m wide and 4 1/2 to 6 m deep. The southwest channel is 80 to 100 m wide and 6 to 12 m deep. In places the walls are steep and even overhanging, and inward collapse is occurring. Nearer Lake Surprise the channel is only 40 to 70 m wide and 4 1/2 to 6 m deep. The walls of the channels may be of lava layers one to two m thick, but in places at least the upper part of the wall is in thin layers, 5 to 10 cm thick. These appear to be successive thin flows over the levee edge of the channel.

The area of "stony rises" through which the channels run is covered with scrub and eucalyptus trees. Immediately around the crater an ash deposit has left a small area of land suitable for farming.

The Gothic Cave Lava Channel runs out of a small cone south of Mt. Eccles (Fig. 13-15). Where it leaves the cone the channel has built levees of thin lava layers. Further downflow the channel is rather narrow (10 to 18 m) and steep-sided, and is floored by loose boulders 4 to 6 meters below the general ground level.

Gothic Cave was named for its shape in cross-section. It was described by Ollier (1964) who noted "contortions (which) indicate intense deformation after the formation of the layers but before complete solidification." In the entrance the layers appear as flaps which hang down. Within the cave the floor is seen to be well below the level of the floor of the channel outside. The ceiling height is about 7 1/2 m, and the cave is strikingly elongated vertically. Above the main cave is the remains of a small high-level cave (Fig. 13-18). Contorted layers can be seen in the figure. The layers appear to come horizontally from the walls and hang vertically into the cave. Ollier (1964) suggested that "a squashing in of the sides" gave the present shape, but the attitude of the layers suggests that the roof parted along a central axis, breaking originally continuous layers and allowing them to hang vertically. This parting did not extend to the surface which is continuous across the cave area, but the downward movement left behind a space which became the small upper cave (Fig. 13-18). The slumped layers originally were levee layers which formed the upper part of the cave and channel. Often more than one lining covers parts of the cave wall, indicating successive flows through the cave. In one location a lining is cracked into polygonal blocks. In another part of the cave the lining is marked with ridges and grooves which represent bands of differing vesicularity. Only behind this lining are found the true lava layers.

Apart from the section which now is Gothic Cave, the lava channel has been partly filled by collapse after flow ceased. Much of the channel thus was roofed originally.

CONCLUSIONS

1. Thin lava layers due to successive flows over the levees of lava channels can be important elements in the walls of lava channels and caves. Such thin layers will readily slump and contort and should be distinguished from the layered lava of generally greater thickness described by Ollier and Brown (1965) and apparently formed by differential movement within a flow.

2. In Victoria lava caves and channels are associated in two main ways. The lava channel may be the collapsed portion of a formerly more extensive cave, as is the Gothic Cave channel at Mt. Eccles, and the channels at Mt. Napier. Along the large Lake Surprise channels at Mt. Eccles overflow and break-through along the walls has given smaller channels and caves which

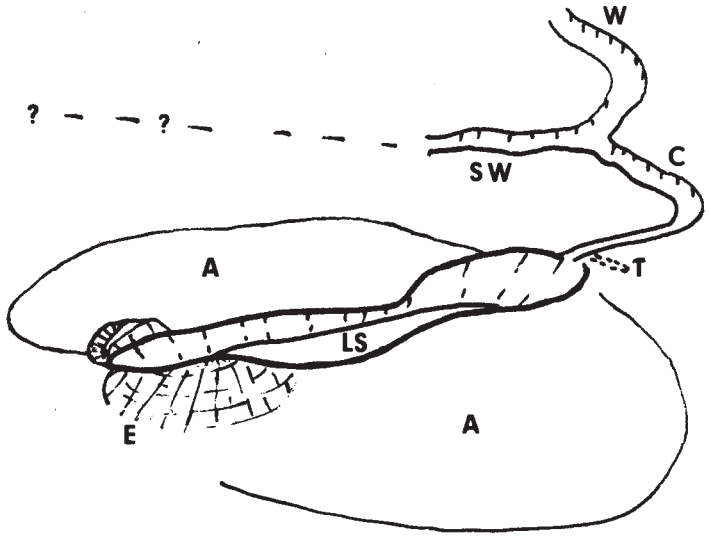


Figure 13-13: Diagram of aerial view of Mt.Eccles.

E-Mt.Eccles
LS-Lake Surprise
A-Ash fall areas, cleared for agriculture
T-Position of Tunnel Cave
C-Lava channel up-flow from bifurcation
W-West branch of lava channel
SW-Southwest branch of lava channel, extending into forested areas and "stony rises" flows.

Figure 13-16: Aerial view of flow channels.

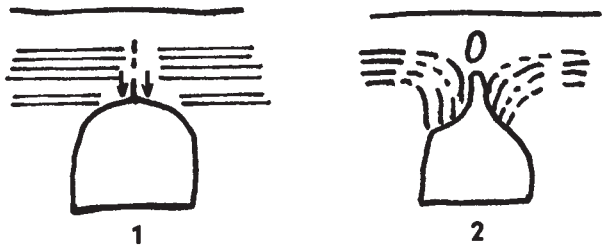
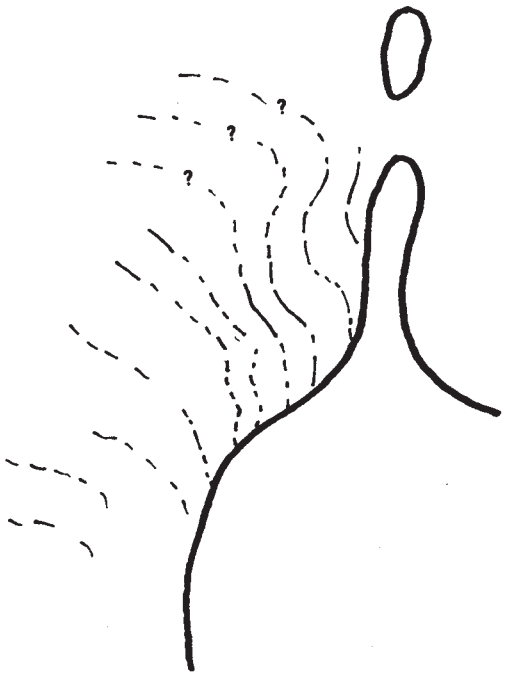


Figure 13-18: Cross-section of upper part of Gothic Cave, showing deformation and small upper cave.

Figure 13-12: Oblique aerial view of Mt.Eccles.

Figure 13-4: Vertical air photo of Mt.Napier



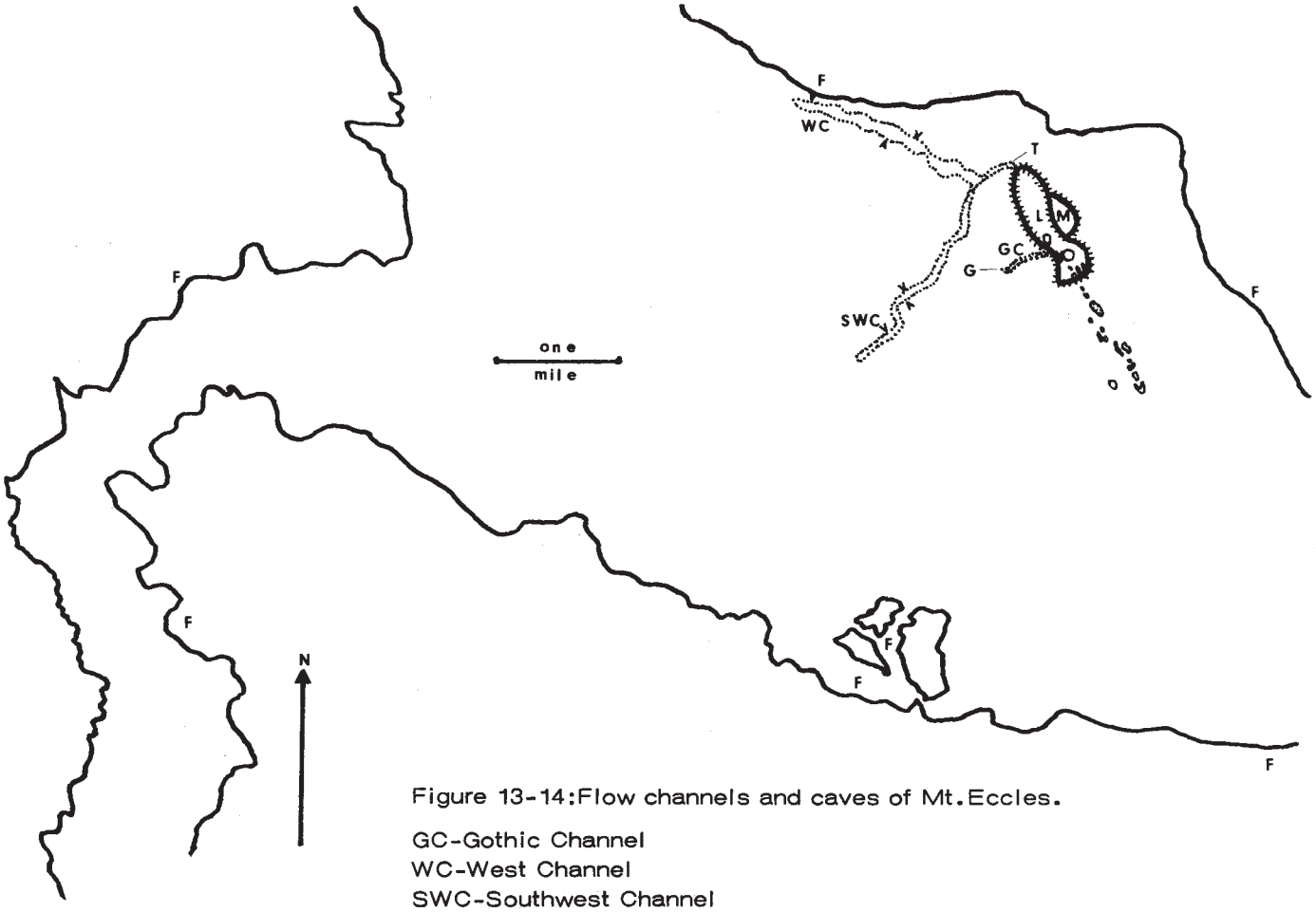


Figure 13-14:Flow channels and caves of Mt.Eccles.

GC-Gothic Channel
WC-West Channel
SWC-Southwest Channel
v-side channel or minor cave
T-Tunnel Cave
G-Gothic Cave
F-margin of flow
LM-Lake Surprise-Mt.Eccles complex.

Figure 13-15: Segmental collapse and flow channel near Gothic Cave.

Figure 13-7: Sequential collapses in the Mt. Napier area.

Figure 13-9: Entrance of cave in small lava dome.

Figure 13-10: Interior view of same cave.

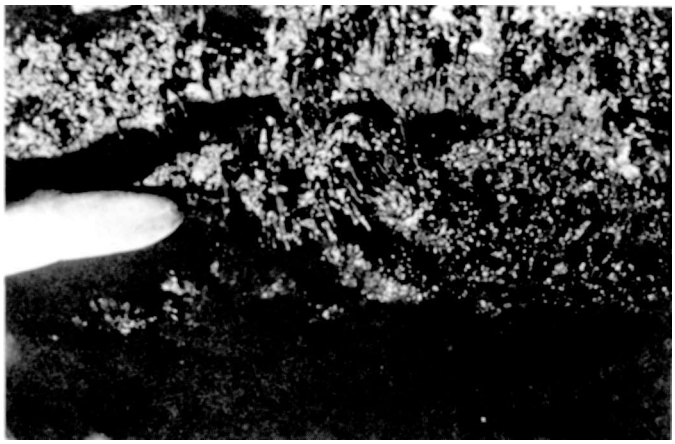


Figure 13-11: Needle-like speleothems in same cave.

lead away from the main channels. This second type of association suggests that lunar rilles may have small caves developed at reular intervals along their upper walls.

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