SUBSEQUENT TOPOGRAPHY ALONG THE HIGHLAND BOUNDARY FAULT, ROSENEATH, SCOTLAND.

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INTRODUCTION.

"SCOTLAND furnishes remarkable evidence of the intimate relation between geological structure and the topographic features of the country" (Peach and Horne, 1930, p. 3). An example of such subsequent topography is well developed on the southern tip of Roseneath[1] Peninsula where it is traversed by the Highland Boundary Fault (Text-fig. 1; Pl. 1, Fig. 1). In its southwestward course across Scotland, from the east coast below Aberdeen to the Isle of Arran in the Firth of Clyde, the Highland Boundary Fault marks the border between the Highlands and the Midland Valley.

Roseneath Peninsula projects southward between Loch Long on the west and Gare Loch[1] on the east in west-central Dumbartonshire.[1] To the south is the Firth of Clyde.

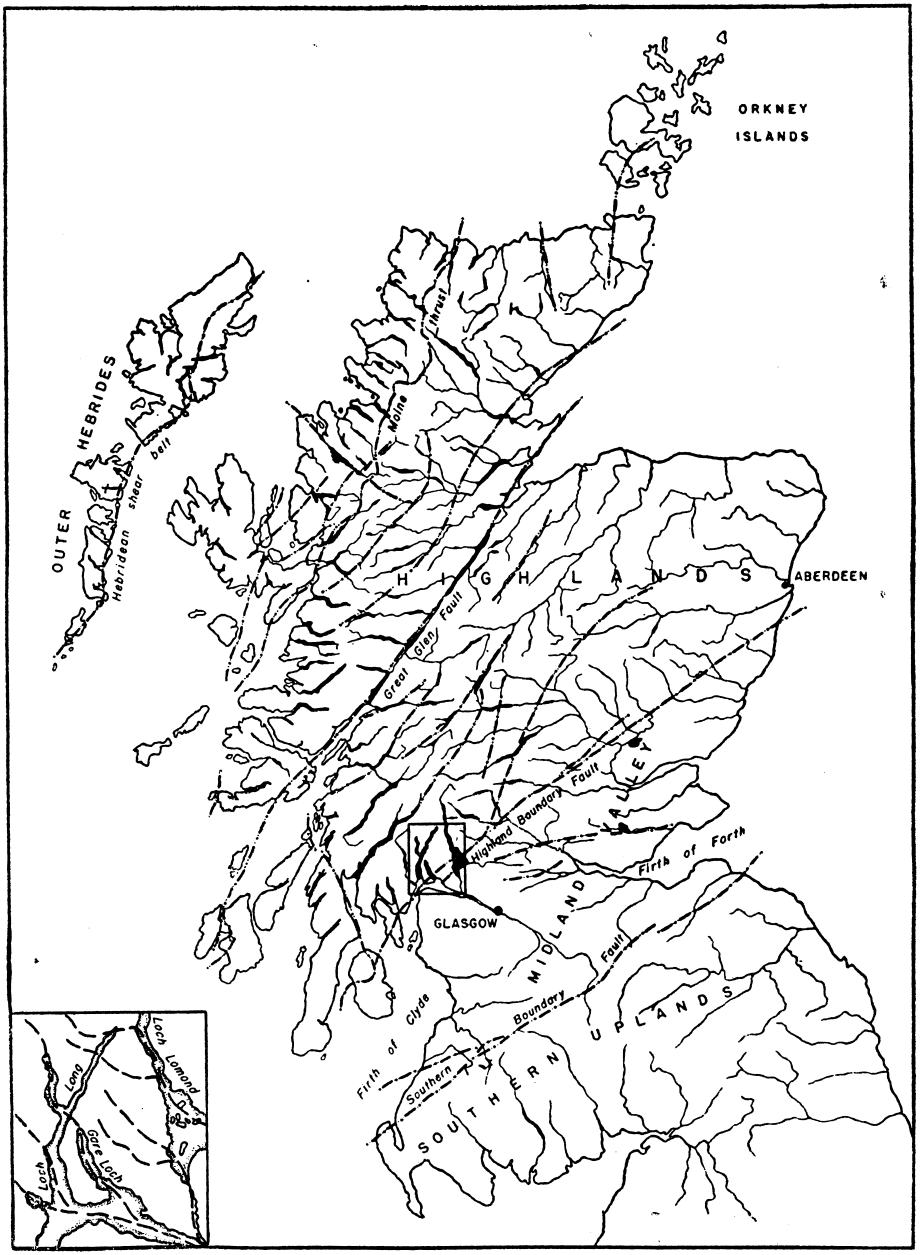
It is a pleasure to record my thanks to Paul MacClintock for his helpful criticism of the manuscript.

GEOLOGY OF ROSENEATH POINT.

Dalradian metamorphic rocks dipping steeply southeastward underlie the peninsula north of the Highland Boundary Fault (Text-fig. 2). South of it Upper Old Red Sandstone underlies Roseneath Point. The dip of these strata is gently northwestward except where locally reversed as a result of differential movement of small blocks.

Although most of the Dalradian rocks probably are of Pre-Cambrian age many of them received their metamorphism during the Ordovician period when they were thrown into great recumbent folds whose planar structures strike parallel to the Highland Boundary Fault (Bailey and Wier, 1939, pp. 386, 407). Late Silurian and early Devonian deformation along the fault was marked by steep reverse faulting, whereas the post-Carboniferous movement that fractured and tilted the Upper Old Red Sandstone was normal faulting.

[1] Also spelled Rosneath, Gareloch, and Dunbartonshire. See Fleming, 1947.



Base—Geological map of the British Islands, 1939.

Text-fig. 1. Map of Scotland (excl. Shetland Islands); showing the three physiographic provinces, the principal faults, and the drainage pattern which in the Highlands especially reflects the regional structure. Lochs are black.

Inset—reconstruction of headwaters of River Forth in early Cenozoic time (after Bailey, 1934). Roseneath Peninsula projects southward between Gare Loch and Loch Long.

Fig. 1. Roseneath Peninsula from upland north of Helensburgh, looking southwest across Gare Loch and through saddle on Highland Boundary Fault. Dotted line indicates approximate trace of fault across Gare Loch.

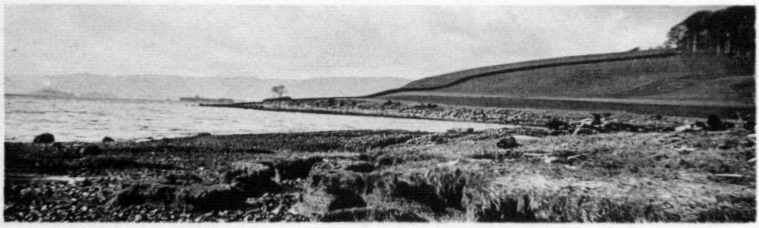


Fig. 2. Shoreline terraces on bank of Clyde, southern end of Roseneath Peninsula. Peat-covered, wave-cut platform of Upper Old Red Sandstone in foreground.

Fig. 3. Glaciated fault-line trough from Upper Old Red Sandstone cliff, looking southwest toward Kilcreggan. Black line indicates location of row of sinks. Ravine of Kilcreggan Burn is in woods southwest of barn.

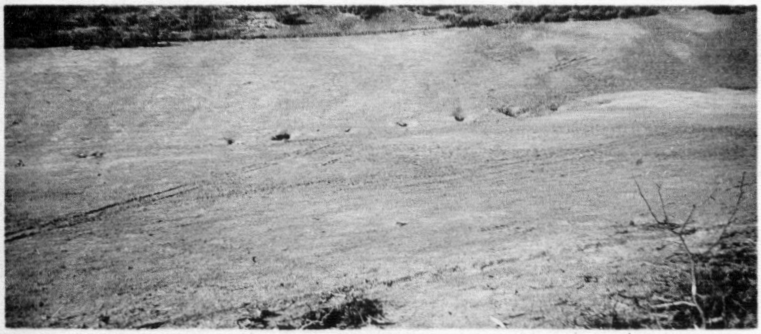
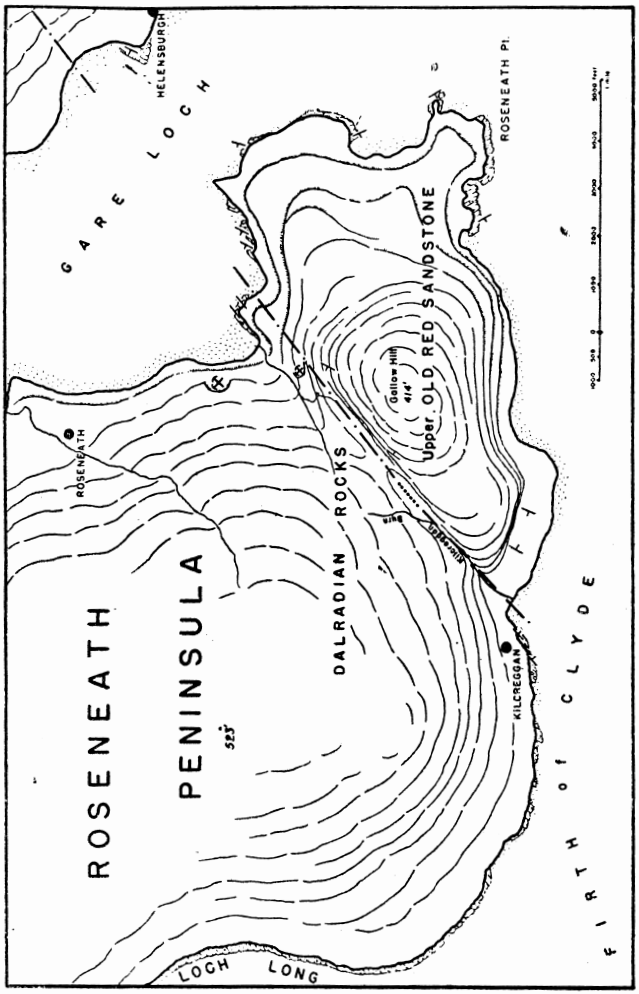


Fig. 4. Row of fault-line sinks, from cliff of Upper Old Red Sandstone south of Highland Boundary Fault, looking northwest. Dalradian metamorphic rocks outcrop on wooded slope beyond pasture. Length of row about 500 feet.

TOPOGRAPHY OF ROSENEATH POINT.

At its southern end Roseneath Peninsula rises 400-500 feet above sea level. The general topography consists of glacially smoothed slopes and deepened fiords now occupied by the long, narrow sea-lochs. Along the shoreline the smoothness is modified by a series of late glacial wave-cut terraces (Pl. 1, Fig. 2).



Base—Ordnance Survey Map, 1923 edition.

Text-fig. 2. Sketch map of southern end of Roseneath Peninsula, Dumbartonshire, Scotland. Top is north. Form lines indicate topography.

— . — . — . — — Highland Boundary Fault
. . . . . — fault-line sinks
— — — — — — minor fracture
" " " " " " — shoreline terraces

The highest was eroded when the land stood about 100 feet lower than it is today. During pauses in the succeeding regional uplift lower beaches and cliffs were cut which now stand at 50, 25, and 15 feet above sea level.

Two conspicuous topographic features reflect the location of the Highland Boundary Fault: (1) angular reëntrants on the south and northeast shores and (2) a broad erosional trough across the peninsula's backbone (Text-fig. 2). Within the trough two small postglacial streams run in opposite directions from a saddle (or pass) 250 feet below the crest-line (Pl. 1, Fig. 1).

KILCREGGAN BURN AND FAULT-LINE SINKS.

Kilcreggan Burn flows southward from the upland north of the saddle into the wide trough. Here its course turns southwestward in a straight ravine (Pl. 1, Fig. 3). Outcrops of Upper Old Red Sandstone on the southern valley wall and of Dalradian rocks on the northern bank reveal that the ravine is incised on the fault-line.

Northeast of the ravine, and alined with it, there are a dozen shallow sinks from a foot to four or five feet in diameter, irregularly spaced in a row 500 feet long (Pl. 1, Fig. 4). Each pit passes through the sod into the dark soil beneath. At the margins of the holes the turf has been undercut and slumps inward, suggesting that it covered the entire area before the development of the sinks which are now being enlarged by undermining of the peripheral sod. Shallow, grass-covered depressions between some of the holes apparently are incipient sinks not yet cut through the turf.

To call these features sinks is not to imply that they are the result of rock solution for no limestone or marble is known in the local stratigraphic sequence. Their location suggests, instead, that they have been developed by ground water moving downward in the Highland Boundary Fault zone. According to this interpretation movement along the fault opened subterranean passages through which ground water has transported fine sediment removed to make the sinks.

HISTORY OF THE DRAINAGE AND THE SINKS.

In mid-Cenozoic time Gare Loch, the lower part of Loch Long, and the Clyde below Glasgow were southeastward-flowing headwaters of the ancient River Forth draining

through the Midland region (Text-fig. 1, inset). As a result of preglacial regional uplift this consequent system was disrupted by subsequent streams developed along shatter belts (Bailey, 1934; Bremner, 1943). Probably at this time opposite-flowing streams eroded the fault-line trough across Roseneath Peninsula.

Although the Roseneath pass is undoubtedly of preglacial origin, its broad floor and steep sides (Pl. 1, Fig. 3) indicate glacial erosion of older stream valleys. After the peninsula was covered by the Scottish ice sheet, whose general movement in this region was southward (Geikie, 1901, Pl. IV), basal currents may have flowed southwestward through the trough, rounding off the stream divide to form the present low saddle. On the other hand, because Gare Loch is shorter and shallower than Loch Long and has a broader catchment area (see Anderson, 1896) its basin may have filled more rapidly than that of Loch Long during the advance of the ice, and as a result an ice tongue may have overflowed southwestward through the fault-line gap, thus remodeling the cross profile. Then as the ice continued to advance Roseneath Peninsula was completely submerged beneath the Scottish ice sheet.

Following the deglaciation of the area two small streams reoccupied the fault-line trough. Except for the incision of Kilcreggan ravine their principal activity has been the removal of a small amount of drift. Moreover, the saddle is essentially as it was after modification by the ice because the streams now head in the upland north of the divide.

The present fault-line sinks undoubtedly are of recent origin for they are cut through the postglacial grass cover and incipient ones have not yet penetrated the turf. Any sinks developed before glaciation would have been obliterated by the passage of ice through the trough.

Recent movement along the Highland Boundary Fault which is believed to have initiated the downward drainage, may have been registered in an earthquake centered on the zone of weakness. There are 421 recorded earthquakes (1788-1921) of the Cromie center 40 miles northeast of Roseneath Peninsula, and four Dunoon earthquakes (1756, 1871, 1904 and 1908) centered only a few miles to the southwest. The Dunoon earthquake of 1871 was a strong shock felt in Kilcreggan and in Roseneath and the waters of Gare Loch were disturbed as if boiling (see Davison, 1924, pp. 62-120). Some such earth-

quake may have resulted from the movement which opened fractures and thus led to the development of the sinks.

REFERENCES.

Anderson, James: 1896. Evidences of the most recent glaciers in the Firth of Clyde district, Trans. Geol. Soc. Glasgow, **10**, 198-209.

Bailey, E. B.: 1934. The interpretation of Scottish scenery, Scottish Geog. Mag., **50**, 308-330.

Bailey, E. B., and Weir, J.: 1939. Introduction to Geology, MacMillan and Company, London, 498 pp.

Bremner, Alex.: 1943. The origin of the Scottish river system, Scottish Geog. Mag. **58**, 15-20, 54-59, 99-103.

Davison, Charles: 1924. A history of British earthquakes, Cambridge Univ. Press, London, 416 pp.

Fleming, J. A.: 1947. The Gareloch—ancient and modern, Scottish Geog. Mag., **63**, 20-25.

Geikie, Archibald: 1901. The scenery of Scotland, MacMillan and Company, London, 540 pp.

Peach, B. N., and Horne, John: 1930. Chapters on the geology of Scotland, Oxford Univ. Press, London, 232 pp.

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