MALAWI

MINISTRY OF NATURAL RESOURCES

RECORDS

OF THE

GEOLOGICAL SURVEY

OF

MALAWI

Vol. VI

1964

PRICE £1 5s

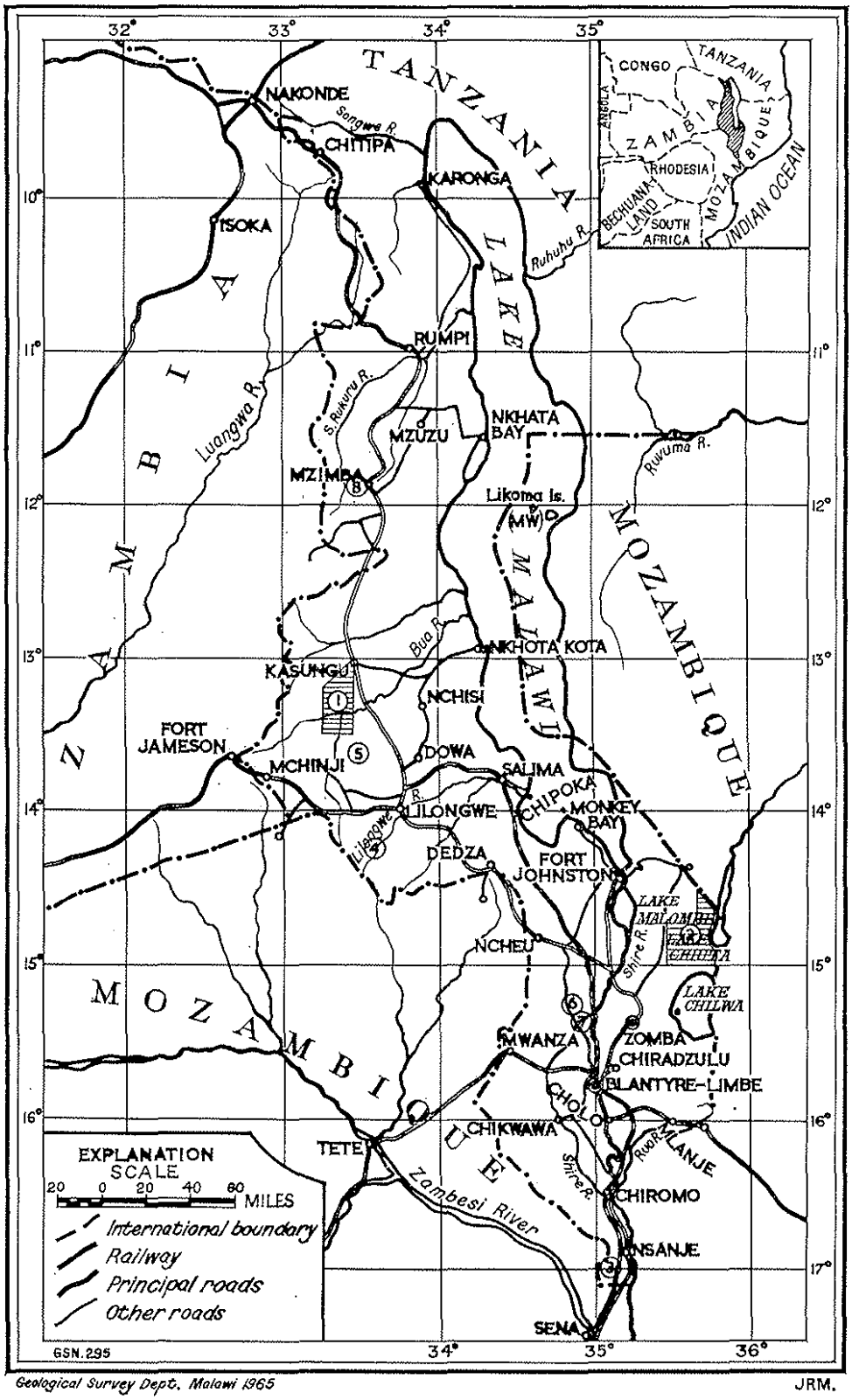
1966

PUBLISHED BY THE GOVERNMENT PRINTER, ZOMBA, MALAWI

PRINTED BY THE WHITEFRIARS PRESS LTD., LONDON & TONBRIDGE

FRONTISPIECE

LOCALITIES OF ARTICLES IN TEXT IN NUMERICAL ORDER



Geological Survey Dept. Malawi 1965

JRM.

CONTENTS

Progress Reports and Regional Notes

Economic Geology

Miscellaneous

LIST OF PLATES

MISCELLANEOUS

9

AN OUTLINE OF THE GEOLOGY AND GROUNDWATER CONDITIONS OF THE LOWER AND MIDDLE SHIRE VALLEY

by

F. HABGOOD

(PLATE VII)

CONTENTS

ABSTRACT

The area occupied by the Shire River drainage basin in Malawi south of Liwonde is considered. This is divided into four terrains on the basis of the dominant rock type: metamorphic and plutonic; sedimentary; volcanic; and unconsolidated. Groundwater conditions in each terrain are distinct and are briefly considered.

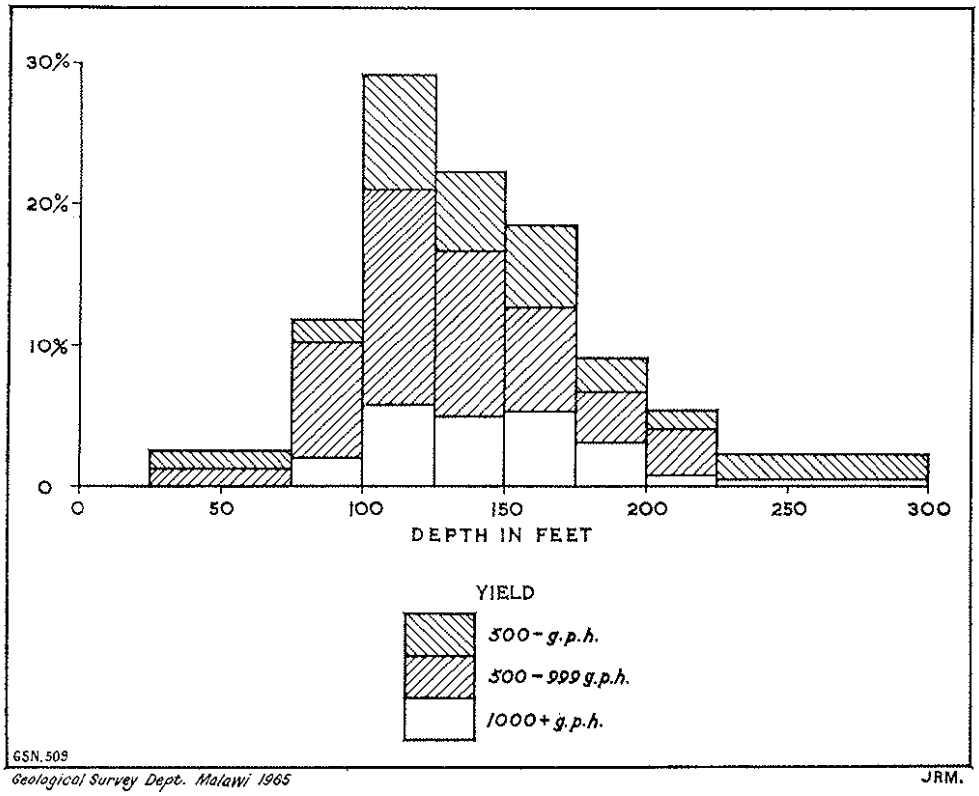
I. INTRODUCTION

IN an endeavour to plan the integrated development of the resources of the Shire River drainage area in Malawi south of Liwonde, an area of rather more than 7,100 square miles, the United Nations Organisation provided three experts to assess the problems concerned, advise on the feasibility of various projects and assist Government in their application for international aid funds. These experts visited Malawi in November 1964 and this account was prepared to provide them with background information.

The geological environment of the project area is known in some detail. Geological mapping on a scale of 1:50,000 is complete and published maps on a scale of 1:100,000 are available for most of the area. Direct appraisal of groundwater conditions is possible from approximately 320 drilled wells for which records are available.

On geological grounds, the area can be divided into four terrains, the hydrology of each being fairly distinct. These terrains are shown on Plate VII together with the position of some 240 drilled wells. The depth and yield of these wells is analysed in Figure 1 in the form of a histogram.

YIELD AND DEPTH OF WELLS, LOWER AND MIDDLE SHIRE VALLEY FIG.1



II. Metamorphic and Plutonic Rocks

The greater part of the project area (67.3 per cent.) is made up of crystalline granulites, gneisses and subordinate schists of the Mozambique belt ascribed to the Precambrian System. These are penetrated by dolerite dyke swarms of Karroo age and by late Jurassic to early Cretaceous plutons, volcanic vents and minor intrusions. For the present account, all these rock types can conveniently be considered together.

Metamorphic and plutonic rocks form the bed of the Shire River between Matope and a point some seven miles north of Chikwawa: they make up the Shire and Cholo Highlands, the Kirk Range and the Nsanje (Port Herald) Hills. The great majority of the Shire tributaries rise and flow for most of their length through this terrain.

Weathering is fairly general to depths of 20 feet or more and, locally, there is eluvial cover of over 50 feet. In the unweathered state these rocks are virtually impermeable but fracturing, consequent upon jointing, faulting and dyke intrusion, is common. These conditions, combined with the relatively heavy and well distributed rainfall in the highland areas, give rise to streams, the larger of which are perennial.

Pockets of deeper weathering and fracture zones can, at favourable locations, yield groundwater in amounts adequate to supply villages and small townships: yields of 500–800 g.p.h. are commonly obtained from depths of 100–150 feet and approximately 64 per cent. of all wells sunk in this terrain are within this depth range.

Although occasional wells give tested yields in excess of 1,000 g.p.h., such yields are rather exceptional and only 20 per cent. of all wells constructed through these rocks during the period 1950-1960 produced water in this quantity.

Except for the relatively small amounts of marble which are present, rocks of this terrain are relatively insoluble in groundwater and it would seem that circulation is good: all supplies obtained have been potable and of apparently low salt content. No geologist engaged on groundwater investigation has reported anomalous low resistivity values which could be ascribed to saline conditions in depth.

These metamorphic and plutonic rocks have been subjected to considerable petrological study and in general it can be said that foundation conditions are good and that large resources of rock suitable for use as aggregate and other building purposes exist. However, particularly in view of the frequent presence of shatter zones and joints, detailed geological examination of selected areas should precede any large-scale construction work: this is especially important in the case of barrages and tunnels.

III. Consolidated Sediments

Consolidated sedimentary rocks of Karroo and Cretaceous age occur along the western boundary of the lower Shire Valley. They consist of shales, some of which are carbonaceous; sandstones and grits, variously sorted and occasionally massive; marls which are locally gypsiferous; and impure limestone. Although their outcrop area is small (7.9 per cent. of the project area) these sediments may influence the quality of the groundwater over much of the western Shire Valley plain between Chikwawa and Chiromo.

These sedimentary rocks are of high permeability and, in addition, are extensively fractured by joints and faults, many of which contain siliceous/calcareous fault rocks: they are also fractured by dolerite sills and dykes. They also contain constituents which are highly soluble in meteoric water.

The sediments occupy an area of low rainfall and, except in small areas on shale country, give rise to pebbly soil of poor quality. Within the sandstone highlands, beds of different hardness give rise to numerous long, parallel ridges which are commonly whale-backed and separated by shallow sandy valleys. Where there are sandstone escarpments, gorges and canyons with precipitous sides are frequently produced, these being commonly fretted and pitted by stream and stormwater action. Often cross-joints produce detached blocks, pinnacles and towers of bare rock.

The river courses which traverse this terrain are generally dry and carry water briefly only after heavy rain. In shale country there are a very few perennial water holes around which the small population has settled: the water from these holes is noticeably brackish towards the end of the dry season.

One of the very few drilled wells sunk in this terrain was in carbonaceous shales where water was required for diamond drilling. This well yielded 800 g.p.h. from a depth of 95 feet and the water was highly mineralized and impotable, smelling strongly of sulphur. Pyrite is a common constituent of these carbonaceous horizons and is a probable source of sulphate in the groundwater of the area. The other wells drilled in these sediments have been in sandstones and grits yielding over 500 g.p.h. from depths of more than 150 feet. These rocks contain large quantities of calcium and magnesium carbonate as cement which would be expected to render hard any water which they contain. The grits are also rich in feldspar and consequently sodium bicarbonates could be expected to form in the groundwater by base exchange with calcium. The impure limestones and marls certainly contribute calcium bicarbonate to the water and, at one horizon, tested by rotary drilling, the marls

were proved to be gypsiferous. These could yield calcium sulphate to the groundwater but it should be noted that the beds would not be an economic source of gypsum.

IV. Plateau Lavas

Plateau lavas, principally basalt, of late Karroo age, occur near the area of Karroo sediments. They occupy approximately 1.7 per cent. of the project area. These rocks are generally dense and material from the centre of the flows appears impermeable. However, the contacts between flows contain interstitial spaces; the tops of flows are generally vesicular and such contacts probably have high permeability. In addition, the lava flows are considerably cracked and broken by jointing and faulting and, in mass, the permeability of the flows is undoubtedly high.

Water courses follow joints in the lavas and carry water for short periods following heavy rains: the larger may have silted up crevices in their channels to some extent. In general, the water table must be well below the surface and there are no permanent supplies of surface water. Soils are generally poor and thin and there is no permanent settlement except on the margins of the lavas where the eluvial cover is thicker.

Six drilled wells have been constructed through the lavas near their junction with colluvium. They each gave yields of about 1,000 g.p.h. from depths of up to 180 feet. This water is of apparently good quality: some of the vesicles contain calcite which is also present in certain of the joints cutting the lavas. However, as percolation is probably rapid, groundwater from this terrain would not be expected to be highly mineralized.

V. Unconsolidated Sediments

Unconsolidated sediments make up much of the Shire River plain. They occupy 23.1 per cent. of the project area and underlie those portions of the Shire Valley for which reclamation and irrigation work has been proposed. They consist of river alluvium, colluvium and drifts, a decided correlation having been established between the pedisediment deposits responsible for much of the infilling of the valley and the solid geology of the uplands.

The surface soils were examined in some detail during the course of Shire Valley Project surveys. Although a comparatively large number of drilled wells have been constructed in these unconsolidated deposits, these have been drilled by percussion methods which yield samples unsuitable for determining the sub-surface conditions so that data concerning the subsoil are incomplete and unsatisfactory in many respects. These drilled wells have however indicated that the thickness of the unconsolidated material is generally great: it has never been penetrated completely by a drill.

The depth of the zone of saturation in these deposits would be expected to vary with the time of year and with the height of the surface above river level. The Shire tributaries are generally influent and over much of this terrain for most of the year near-surface water supplies are available only from shallow holes dug in the water courses. Except near the marsh areas, where, locally, poor circulation has resulted in salination of the soils, and near tributary water courses, the zone of saturation is rarely less than 10 feet from the surface and on higher ground the saturated zone must normally lie much deeper than this.

Where the zone of saturation is in clay soils of low permeability, concentration of salts could be expected. West of the Shire between Chikwawa and Chiromo high salt concentrations appear to result from evaporation of water from the unconsolidated deposits which originated in the Karroo and Cretaceous sedimentary area. This salt has been indicated by resistivity surveys and struck in drilled wells in the

area between the Karroo outcrops and the Shire River. Although high salt concentrations are occasionally indicated in drift derived from and fed with water from metamorphic terrain, such saline areas are of generally restricted extent and the result of poor permeability which is localized both vertically and laterally.

Groundwater which is drawn from the unconsolidated deposits for rural use is generally from depths greater than about 70 feet: 47 per cent. of drilled wells in these deposits are 100–150 feet deep, 35 per cent. are 150–200 feet deep and 14 per cent. have depths of over 200 feet. It is normal practice to drill until an aquifer of relatively high permeability containing water of acceptable potability is reached, casing off any supply of saline water which may first be encountered. In the majority of cases, this supply proves to be sub-artesian. It is noteworthy that potable supplies have been obtained from depth in areas where the surface soils are saline. Yields of 1,000 g.p.h. are not exceptional but it seems likely that the salt content of this water would, in many areas, be too high for spray irrigation.

The danger of soil salination in areas proposed for irrigation would appear to be very real and a programme of investigation designed to provide data concerning the chemical and physical characterization of the sub-soil, the movement and salt content of water in the zone of saturation, and the relation between the two was proposed to the U.N. experts.

Acknowledgments

The position of the wells shown in Plate VII was obtained from a map provided by Mr. J. A. Davies of the Ministry of Works, who also produced histograms from which Figure 1 was prepared. Thanks are also due to Mr. E. Wilson Latham for his suggestions and comments.

VI. Selected Bibliography

Bloomfield, K. 1958. The geology of the Port Herald area. *Bull. geol. Surv. Nyasaland,* **9.**

——. 1965. The geology of the Zomba area. *Bull. geol. Surv. Malawi,* **16.**

——. and M. S. Garson. 1965. The geology of the Kirk Range-Lisungwe Valley area. *Bull. geol. Surv. Malawi,* **17.**

Cooper, W. G. G. 1965. Electrical aids in water finding (2nd edn.) *Bull. geol. Surv. Malawi,* **7.**

——. and K. Bloomfield. 1961. The geology of the Tambani-Salambidwe area. *Bull. geol. Surv. Nyasaland,* **13.**

Dixey, F. 1925. The physiography of the Shire Valley and its relation to soils, water supply and transport routes. *Rep. geol. Surv. Nyasaland.*

——. 1926. The Nyasaland section of the Great Rift Valley. *Geog. J.,* **68,** pp. 117–140.

——. 1938. The Nyasa-Shire Rift, *Geog. J.,* **91,** pp. 51–6.

——. 1941. Geomorphic development of the Shire Valley, Nyasaland. *J. Geomorph.,* **4,** pp. 97–116.

——. 1950. *A practical handbook of water supply* (*2nd edn.*). Thos. Murby and Co., London, pp. 573.

——. 1956. The East African Rift system. *Bull. Suppl. Colon. Geol. Miner. Resour.,* **1.**

Evans, R. K. 1965. The geology of the Shire Highlands. *Bull. geol. Surv. Malawi,* **18.**

Garson, M. S. and R. D. Walshaw. 1966. The geology of the Mlanje area. *Bull. geol. Surv. Malawi* (in preparation).

Griffin, A. E. 1946. *A report on flood control and reclamation on the Lower Shire River and other specified areas in Nyasaland.* Crown Agents for the Colonies, London.

Habgood, F. 1963. The geology of the country west of the Shire River between Chikwawa and Chiromo. *Bull. geol. Surv. Nyasaland,* **14.**

HABGOOD, F. 1966. The geology of the Cholo area. *Bull. geol. Surv. Malawi* (in preparation).

HALCROW, Sir WM. and PARTNERS. 1954. *The Shire Valley Project. A report on the control and development of Lake Nyasa and the Shire River,* **1** and **2** Nyasaland Govt.

HOLT, D. N. 1955. The location of underground water supplies in Nyasaland. *Colon. Geol. Miner. Resour.,* **5,** pp. 438–440.

——. 1959. A note on the underground water resources of the Protectorate. *Nyasaland J.,* **12,** pp. 60–82.

KANTHACK, F. E. 1942. The hydrology of the Nyasa Rift Valley. *S. Afr. geog. J.,* **24,** pp. 3–34.

KIRKPATRICK, I. M. 1966. The geology of the Lake Malombe area. *Bull. geol. Surv. Malawi* (in preparation).

MOREL, S. W. 1958. The geology of the middle Shire area. *Bull. geol. Surv. Nyasaland,* **10.**

MUIR, A. and I. STEPHENS. 1957. The superficial deposits of the Lower Shire Valley, Nyasaland. *Colon. Geol. Miner. Resour.,* **6,** pp. 391–406.

RICHARDS, E. V. 1954. The Shire Valley Project. *Nyasaland J.,* **7,** pp. 7–18.

WALSHAW, R. D. 1965. The geology of the Ncheu-Balaka area. *Bull. geol. Surv. Malawi,* **19.**

Annual Reports of the Geological Survey for the years 1950–56.

Annual Water Supply Progress reports of the Geological Survey, nos. 1–10 (1931–1941).

Annual Reports of the Water Development Department for the years 1957–1964.