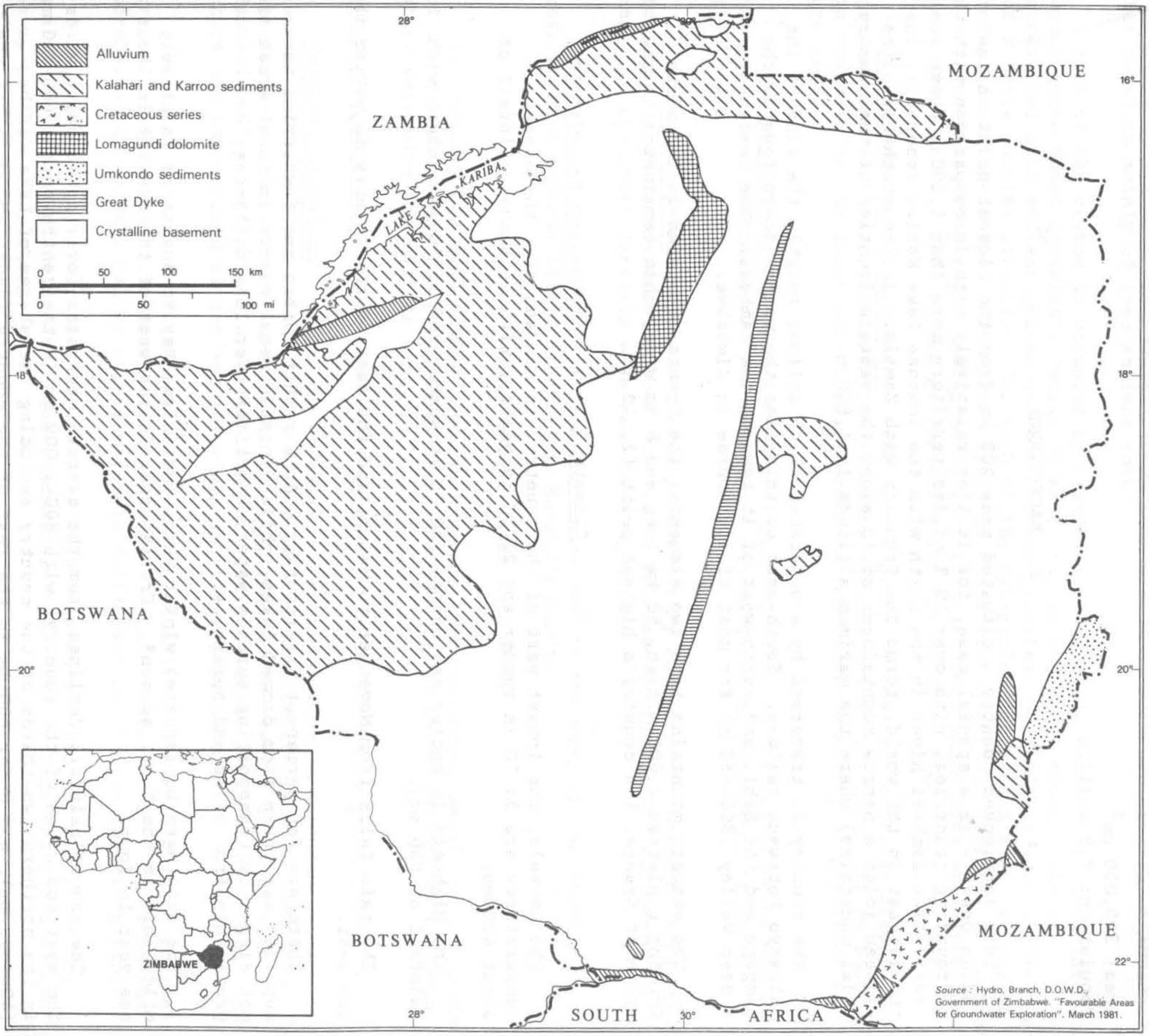
MAP 27. ZIMBABWE – FAVOURABLE AREAS FOR GROUND WATER EXPLORATION



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ZIMBABWE

Area: 390,000 km^2
Population: 7.8 million

I. BACKGROUND

This landlocked country - situated some 200 km from the closest point on the Indian Ocean - is a special case, for it lies relatively high in comparison with the surrounding countries, with over 20 % of its territory more than 1,200 m above sea level. The Zambezi River in the north with the immense Lake Kariba reservoir, one of the largest in the world, forms the frontier with Zambia. In the north-east, the plateau joins a narrow mountainous strip along the eastern frontier of the country (Udzi mountains) where the maximum altitude is 1,800 m.

The country is traversed by a watershed which follows roughly the line of the Bulawayo Botswana railway. South-east of this line the waters drain towards the Limpopo and the Sabi, and north-west of it towards the Zambezi. The Zambezi flows in a deep valley (300-450 m) for most of its course in Zimbabwe.

The eastern mountains have two elements: the Nyanga mountains in the north forming a plateau 2,000 m high, 50 km long and 8 km wide; this terminates in the south at Nyanga, the country's highest point (2,592 m).

Climate

The Lowveld, the lowest part of the country, is hot and dry: the average temperatures are 34 °C in summer and 22 °C in winter, with an annual rainfall of about 400 mm.

The Highveld is cooler and wetter (20 °C in summer and 13 °C in winter, with rainfall of 800 mm).

The rain falls from November to March, and the east of the country is wetter than the west.

There are few permanent watercourses. As a result, urban and industrial water supplies are taken from dammed lakes, while domestic requirements in rural areas are met either by transporting surface water, sometimes over long distances, or preferably from wells and boreholes.

The (southern hemisphere) winter which lasts from May to August is relatively mild; this is the "cool season". Frosts occur in the west of the country in about one year in four.

The annual rainfall declines from the eastern mountains (over 1,000 mm) towards the west and south of the country, with 800-1,000 mm in the centre-north, 600-800 mm in the northern two-thirds of the country excluding the shores of Lake Kariba (400-600 mm), and under 600 mm in the rest of the country (under 400 mm along the southern frontiers with South Africa and Mozambique).

II. GEOLOGY

The geological map shows that a line running north-east to south-west separates an eastern zone (60 % of the country) consisting mainly of Precambrian granites and gneiss with a few inclusions of other rocks (schists, greenstone belts) from a western zone (40 % of the country) which includes some intrusive granitic formations but consists mainly of less ancient rocks.

Most of the craton is occupied by granitic rocks of the Precambrian basement eroded into domes ("dwalas", "whale backs", "castle kopjes"); these rocks are subdivided into ancient gneiss and more recent granites, but this is a simplification of a truly complex situation, for each of the categories contains a wide variety of rocks of different ages. The great dykes is not a true dyke. It consists in fact of four lopolithic complexes running north-east to south-west which have been preserved in a vast graben. This unique geological structure contains high-grade chromite.

Piriwi Demeras and Lomagundi. The Dewera group in the east contains arkoses and greywackes, with an orthoquartzite-carbonate association at the base. It is bounded in the west by the important Piriwiri group, which consists mainly of phyllites and greywackes.

Doleritic intrusions. These are found in particular in the schist belts and in the galleries of goldmines. The intrusions can be anterior and posterior to the great dyke.

The Karroo system. These are mainly schist-clay continental sediments deposited from the Upper Carboniferous/Lower Permian to Triassic periods. The sedimentation ended in the Lower Jurassic with vast lava effusions.

Cenozoic and Quaternary - An area of 45,000 km^2 in the west of the country is covered with unconsolidated sands - the Kalahari sands.

III. GROUND-WATER RESOURCES

The country has been divided into hydrogeological provinces, mainly on the basis of the lithology and the porosity of the rocks and of the geomorphological criteria which determine the aquifer type.

Non-crystalline rocks: These rocks are divided into the following provinces:

Kalahari alluviums. There are no extensive alluvial beds in Zimbabwe. The largest beds are found in the valley of the Sabi at its confluence with the Londi, on the Nuanetsi near its confluence with the Limpopo, and in several areas of the Zambezi valley. Alluviums are also found overlying Triassic rocks at Mzarabani, and there are thin crusts of ancient alluviums in other locations.

The sandy strata of the oldest alluviums are usually water-bearing although their transmissivity is poor. Nevertheless, this is a considerable resource: most of the boreholes in the Sabi valley supply water in sufficient quantities for irrigation.

The sand of the river beds is arkosic, with between a third and a half of the grains consisting of feldspath. The transmissivity is fairly high and the sand can be up to about 15 m thick.

In the north-west the Kalahari sands overlie Jurassic basalts, Triassic sandstones and crystalline rocks. Some projections of these sands extend beyond the great dyke. Some boreholes in the semi-consolidated Kalahari formations (at Intundhla) deliver up to 20 l/s, but it is difficult to drill boreholes in these fine sands. The sandy strata must in fact be cemented as the borehole passes through them, and the pumping chamber must be located in the overlying sandstones. If these sandstones are very compact, it is necessary to pump from the sandy strata, the sand being held in place by suitable strainers.

Jurassic lavas. These are mainly olivinic basalts, pyroxenic andesites and nephelinic basalts covering large areas in the south and north-west. These rocks are very poor aquifers.

Karroo. This hydrogeological province is subdivided into:

- Upper Karroo (Triassic) with base conglomerate, fine-grained red marly sandstones, arkoses in pebble form and fine-grained eolian sandstones;
- Lower Karroo (Permian), including schists with carbonate strata and sandstones at Hwangi and in the Sabi valley. These sandstones are fine-grained with variable cementation. Their water-bearing potential is not known, but some test boreholes in the Sebungwe region have yielded artesian water. However, the oldest boreholes have given brackish or saline water.

Crystalline rocks

It is usually said in Zimbabwe that the crystalline rocks underlying the red soils yield more ground water than the grey soils. In fact, the rocks forming the Gold Belts are usually covered with red soils and contain more fractures and altered zones than the more recent intrusive granites covered by grey soil. They are therefore more productive.

There is no alteration in the zones of active erosion, between the peneplains and the plains and valleys of the Lowveld. Although the altered zone has been drilled in many places, it has hardly been possible to differentiate at the surface the transported alluviums from the parts altered in situ. In the case of altered granites and granitogneiss, the upper part of the alteration zone usually consists of white, pink or grey arkosic sands. In the case of alteration of green rocks, dolerites, epidiorites and other rocks, the alteration is instead argillaceous, coloured red to brown.

Most of the altered crystalline rocks are permeable and absorb and retain infiltrated rain water, part ot which is added to the stock of ground water. Most of the water extracted from boreholes in crystalline formations comes from a saturated zone at the base of the alteration.

The Umkondo province in the south-east of the country contains rocks of the Umkondo system resting in discontinuity on granites and gneiss. These rocks form the high plateaus around Chipinge and Mandidzudzure and the rock masses subsided by faulting west of the Sabi.

The Lomagundi province contains the Lomagundi rocks in a thick sedimentary series, which forms a clearly defined slope, with a lower group consisting mainly of sands with dolomites, quartzites, and slate, and an argillaceous upper group of quartzites and slates. North-east of the Hunyani mountains, boreholes drilled 45 to 60 metres into the fractured slates yield up to one litre per second for domestic uses. High yields have been obtained from dolomites which ought to contain large quantities of water according to the hydrological isotopic studies which have been made.

The province of intrusive granites occupies more than half of the country, including much of the agricultural area of the Highveld. These granites are the least favourable type of rock for the constitution of ground-water aquifers, for the porosity is confined to the fractured and altered parts of the contact zones of the gold beds. If there is no contact zone, the water is confined to the joints, which can take three directions, one horizontal and two vertical, perpendicular to each other. Alteration and erosion along the joints produces the "castle kopjes", common forms of relief in the country's landscape. The joints decline in size at depth as they become more compressed or filled with limestone concretions or other materials.

The granites of the Maroudera zone contain many doleritic dykes which have produced, on contact, altered zones easily identifiable by geophysical prospecting; most of the water is obtained from these dykes. At the surface, red soil and the presence of quartz and blocks of iron ore and dolerites indicate a fractured or decomposed zone warranting investigation.

The Gold Belts province. This province consists of bands of erosion residue of metamorphic rocks overlying the granites. These residues form three systems: Shamwian, Bulawayan and Sebakwian. The Bulawayan is the most important from the hydrogeological standpoint; it outcrops in most of the gold belts and contains basaltic lavas, tufas and conglomerates metamorphized into green rocks, with interstratified metasediments: metamorphized iron ore, arkose and greywacke, together with quartzites, phyllites and marbles. These are the green rocks which furnish the water in the existing wells. The average properties of the aquifers are set out in the following table.

Hydrogeological province	Specific yield (l/s/m)	Transmissivity (m^2/day)
Kalahari alluviums	Up to 50	10 - 1,000
Kalahari sands	0.1 - 1	5 - 50
Upper Karroo	0.3 - 3	30 - 65
Lower Karroo	0.01 - 0.3	1 - 10
Umkondo	0.1 - 0.2	1 - 20
Lomagundi	0.01 - 1.5	1 - 1,000
Intrusive granites	0.01 - 1	0.2 - 20
Gold Belts:		
Shamwian	0.1	10
Bulawayan	0.1 - 1	5 - 60

Water quality

Zimbabwe's ground water is generally of good quality. Most of the water in the granites and gneiss is of the calcium/magnesium bicarbonate type with poor conductivity. The water of the upper aquifers of the vast sedimentary basins is of a similar type, but the water of the deeper sedimentary aquifers has a higher mineral content, with sulphates and chlorides predominating. The water can have a very high mineral content in some places, with several grammes per litre; this is the case in the lower Sabi valley. Heavy concentrations of fluorides are found north-west of Bulawayo. There is in fact very little information available on the quality of Zimbabwe's ground water. The Canadian International Development Agency has indicated its interest in participating in a large-scale programme to study the quality of the country's water. The data on the fluctuation and recharge of the aquifers is insufficient. It is not certain that the geophysical prospecting and other research currently carried out for the rural water supply projects is always profitable.

The tritium content of the water has been studied in some cases with a view to determining the infiltration rate. Radio-isotopes have also been used in detailed studies, in particular in the Sabi valley, which contains the country's largest alluvial mass, in the Forest Sandstone aquifer north-west of Bulawayo and in the Gokwe basalt. The hydrogeological studies are continuing, with the participation of specialized research organizations.

Prospecting methods

Electrical prospecting (resistivity method) is used in 90 % of the geophysical research; seismic refraction is used at shallow depths, together with magnetometry. Geophysical prospecting has been used in a large number of projects financed mostly by foreign aid. The effectiveness and economic return of these projects remain to be determined. The Swedish Government recently offered 15 sets of modern electrical prospecting equipment.

IV. EXPLOITATION OF THE GROUND WATER

The Ministry of Energy and Water Development is responsible for the overall development of water resources, both surface and ground water.

A ground-water service was recently created for the purpose of coordinating and centralizing all aspects of the exploitation of ground water, including prospecting, drilling, test pumping and construction of installations.

The Central Service has a manager and several geophysicists based at Harare. The Ministry has five regional offices with staff specializing in the ground water of each region.

Water-drilling operations are carried out both by the government services and by private companies. The Ministry has 33 drilling rigs, mostly cable but including two down-the-hole hammer rigs operating on compressed air and one inverse-circulation rotary rig. The projects financed by external aid have cable and compressed-air rigs which should normally be transferred to the Government on conclusion of the project. There are 12 private drilling firms in Zimbabwe with a total of 68 rigs (cable and compressed-air). Most of the drillers are nationals of Zimbabwe; they have been trained "on the job" and have received hardly any theoretical instruction.

Ground water is used principally in rural areas to meet the needs of the people and their livestock. The towns take their supplies mainly from surface water, backed up by ground water in some cases.

With a few exceptions, such as the dolomitic aquifer north and south of Chinhoye, there have so far been hardly any cases of pollution of aquifers or adverse effects resulting from their overexploitation. Intensive pumping has caused some deterioration of the water quality in the south-west of Zimbabwe. Experiments with artificial recharge from flood waters are planned for this area.

The periods of drought which the country suffered recently for three years have invested ground water with increased importance. An emergency drilling programme has been carried out.

The Government believes that ground water is one of the country's most important natural resources and that the development of the rural areas depends largely on the possibility of extracting ground water. This entails an additional effort to study this resource and protect it against pollution and overexploitation.

V. REFERENCES

Banda, Hindson and Wurzel, Nyamandhlovu exploratory drilling project. Hydr. Branch, M.W.D., Salisbury, 1977.

Dessnis and Hindson, Ground-Water in the Sabi Valley, Southern Rhodesia. U.S.G.S. Administrative report, 1960.

__________, Ground-Water provinces of Southern Rhodesia. U.S. Geol. Survey, water-supply paper No. 1757-D, 1964.

Harrison, M.L., The Karroo succession at Tjolotjo, Nyamandhlovu district. Ann. Rhod. Geol. Surv., Vol. III, 1978.

Hindson and Wurzel, Groundwater in the Sabi Valley alluvial plain. Rhod. J. Agric. Res. 1 (2), 1965.

Hydrotechnica, Accelerated drought relief project, Victoria Province. Project implementation, Vol. I, 1984.

__________, Acelerated drought relief project, Victoria Province. Scientific text, 1984.

Japanese International Co-operation Agency, Rural water supply programme in communal lands in parts of Masvingo and Midlands Provinces, vol. I and II, 1983.

Lister, L.A., The erosion surfaces of Rhodesia. Unp. Ph.D. Thesis, University of Rhodesia, 1976.

Martinelli, E., Geophysical exploration for potable water supplies in the Kalahari Gemsbok National Park. Water S.A. Vol. 1, No. 2, 1975.

__________, National master plan for rural water supply and sanitation-hydrogeology. Interconsult. Norwegian Agency for International Development, 1985.

Stagman, J.G., An outline of the geology of Rhodesia. Bull. Rhod. Geol. Survey, No. 80, 1978.

Wurzel, P., Ground-water in Zimbabwe - Development aims for 1980's. Ground-water 81, Kuala Lumpur, Malaysia, 1981.

__________, A comparison of classical and radioisotope methods - what is the additional safe yield in the Sabi Alluvial Plain in Zimbabwe? Int. Conference Ground-water and Man. Australian Water Resources Council, Sydney, 1983.