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Springs in the Table Mountain Group, With Special Reference to Fault Controlled Springs

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Abstract

One of the characteristics of the Table Mountain Group (TMG) is the numerous springs issuing from it. According to the mode of occurrence, three types of springs can be identified, namely shallow circulating springs, lithology controlled springs and fault controlled springs. The basic characteristics of the first two spring types are discussed briefly, while the characteristics of the fault controlled springs are dealt with in more detail. The multitude of springs emanating from the Table Mountain Group can be considered the region's most valuable natural asset and should be protected from indiscreet groundwater development.

Introduction

The TMG is a largely arenaceous rock group, extending from Cape Town northwards to beyond Clanwilliam and eastwards as far as Port Elizabeth. It is of Ordovician to Silurian age, and overlies the metamorphic rocks of the Namibian erathem, viz. the Malmesbury Group in the west, the Kaaimans and Kango Groups in the central region around George and Oudtshoorn and the Gamtoos Group, which outcrops mainly west of Port Elizabeth. The TMG is conformably overlain by the predominantly argillaceous rocks of the Bokkeveld Group. A product of the intensive folding which the rocks had undergone is the number of scenic fold mountain ranges which host numerous geological features such as folds, faults, fractures, fissures and intricate joint systems. Many of these features give rise to one of the distinct characteristics of the TMG, namely the abundance of springs issuing from it.

Springs according to mode of occurrence

Based on their mode of occurrence, the following spring types have been differentiated:

Shallow circulating springs

The shallow circulating springs seep from a network of joints, small, irregular fractures and from bedding planes within the TMG. These springs are draining generally small subterranean reservoirs, notably during and following rainy spells. They are generally low-yielding, many being seepages only. Their yields are highly seasonal, and most of them cease to exist with the onset of dry weather conditions. In view of their generally intermittent behaviour, it is debatable whether many of these springs can in fact be considered proper springs.

Lithology controlled springs

Lithology controlled springs (Fig. 1) issue due to the presence of impeding or impervious layers. Three types of lithology controlled springs can be identified, namely:

Springs issuing from contacts with interbeds

The Cedarberg Formation is the most important and well-known interbedded shale layer in the TMG and due to it's relative imperviousness it probably accounts for the bulk of the perennial springs in the TMG terrain. This shale unit is furthermore hydrogeologically important as it almost invariably divides the TMG into two separate groundwater systems. Saturation of the Peninsula Formation commonly results in the rise of springs on the Peninsula Formation/Cedarberg Formation contact at suitable topographical levels, from where it overflows onto the Nardouw Subgroup.

The following are a few well-known Cedarberg Formation related springs, to name but a few: the Hoeksberg Spring (south of McGregor), Vermaaks (currently dry) and Marnewicks Springs (in the Kammanassie Mountains), the Meiringspoort Spring (upstream from the waterfall), the Swartberg Spring (feeding the Dorps River at Prince Albert) and the Humansdorp Spring. Other unnamed interbedded

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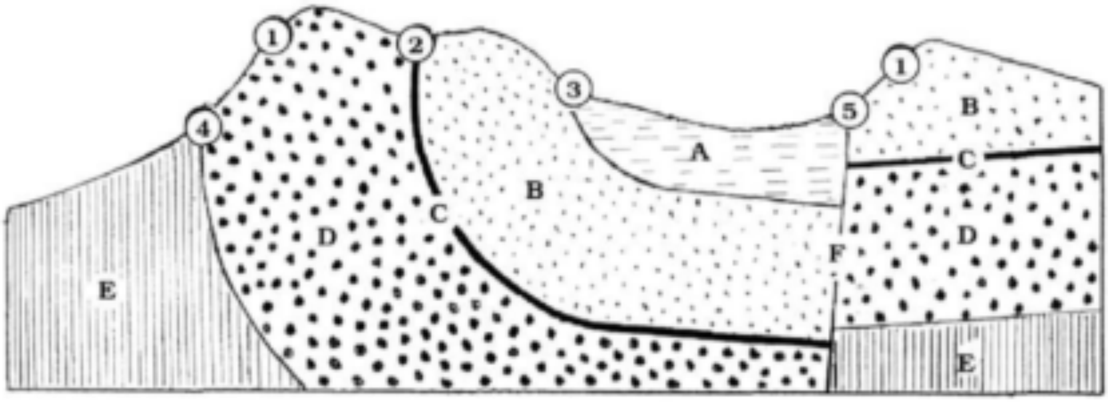

Figure 1

Schematic profile to illustrate spring occurrence in the Table Mountain Group (TMG)

A = Bokkeveld Group
B = Nardouw Subgroup
C = Cederberg Formation TMG
D = Peninsula Formation
E = Pre-Cape Namibian age rocks
F = Fault

1 = Shallow circulating spring
2 = Spring issuing from contact with interbed
3 = Spring on the TMG/Bokkeveld Group contact
4 = Spring issuing from an unconformity
5 = Fault controlled spring

shale layers may also account for spring occurrences, especially towards the east of Uniondale. The Kareedouw Spring, providing the town with water, is an example of a spring most probably issuing from an unnamed interbedded shale layer within the Peninsula Formation.

Springs on the TMG/Bokkeveld Group contact

One would expect the TMG/Bokkeveld Group contact to be a likely locality for the emanation of lithology controlled springs. However, except for a few scattered springs emanating on that contact along the northern foothills of the Kammanassie Mountains (Water Research Commission, 2000) and possibly the springs at Dysselsdorp (dry since the late 1970s probably due to groundwater development in that area), no other springs issuing on the TMG/Bokkeveld contact have so far been reported.

Generally speaking, springs emerging on the TMG/Bokkeveld Group contact can be linked to faults in the TMG and can thus be termed fault controlled springs.

Springs issuing from unconformities

The discordant contact between the often fractured quartzitic-sandstone of the Peninsula Formation of the TMG and the underlying impervious argillaceous units of the Malmesbury, Kaaimans, Kango and Gamtoos Groups (Fig. 1), is an important locality for some of the lithology controlled springs. The series of springs emanating on the western side of the Kasteelberg west of Riebeek West, and the numerous springs issuing on the southern foothills of the Outeniqua Mountains north of George exist, due to the presence of impervious argillaceous rocks of the Malmesbury and Kaaimans Groups respectively. These springs are being fed by groundwater from the overlying fractured TMG rocks. Even the springs in the limestone units of the Kango Group north of Oudtshoorn reveal distinct TMG groundwater fingerprints (Barnard, 1993) from the nearby TMG of the Swartberg.

One of the distinguishing characteristics of the lithology controlled springs is their relatively wide-ranging yield fluctuations. The yield of the Marnewicks Spring (Cedarberg Formation related) for instance generally varies between 9 and 19 ℓ/s and that of the Rooi River Spring north of George (Kaaimans Group related) fluctuates between 0.4 and 4 ℓ/s. The groundwater quality of the lithology controlled springs is almost without exception excellent. ECs generally range between 10 and 35 mS/m, and no record of any chemical determinants exceeding recommended limits for human consumption have been received. The groundwater from these springs has a pronounced sodium-chloride nature.

Fault controlled springs

The eleven more important and well-known fault controlled springs occur from Citrusdal in the west to Uitenhage in the east. The alignment of these springs follows a remarkable incurvature (Fig. 2), which appears to mimic the shape of the Cape Fold Belt. The alignment of these springs may be meaningful in terms of the deeper Cape Fold Belt structure.

It is interesting to note that five (or 46%) of the major fault controlled springs are situated in the relatively limited syntaxis domain (Fig. 2), which is indicative of a greater frequency of deep fracturing in that domain compared to the rest of the occurrence area. It is also notable the area east of 23°E is

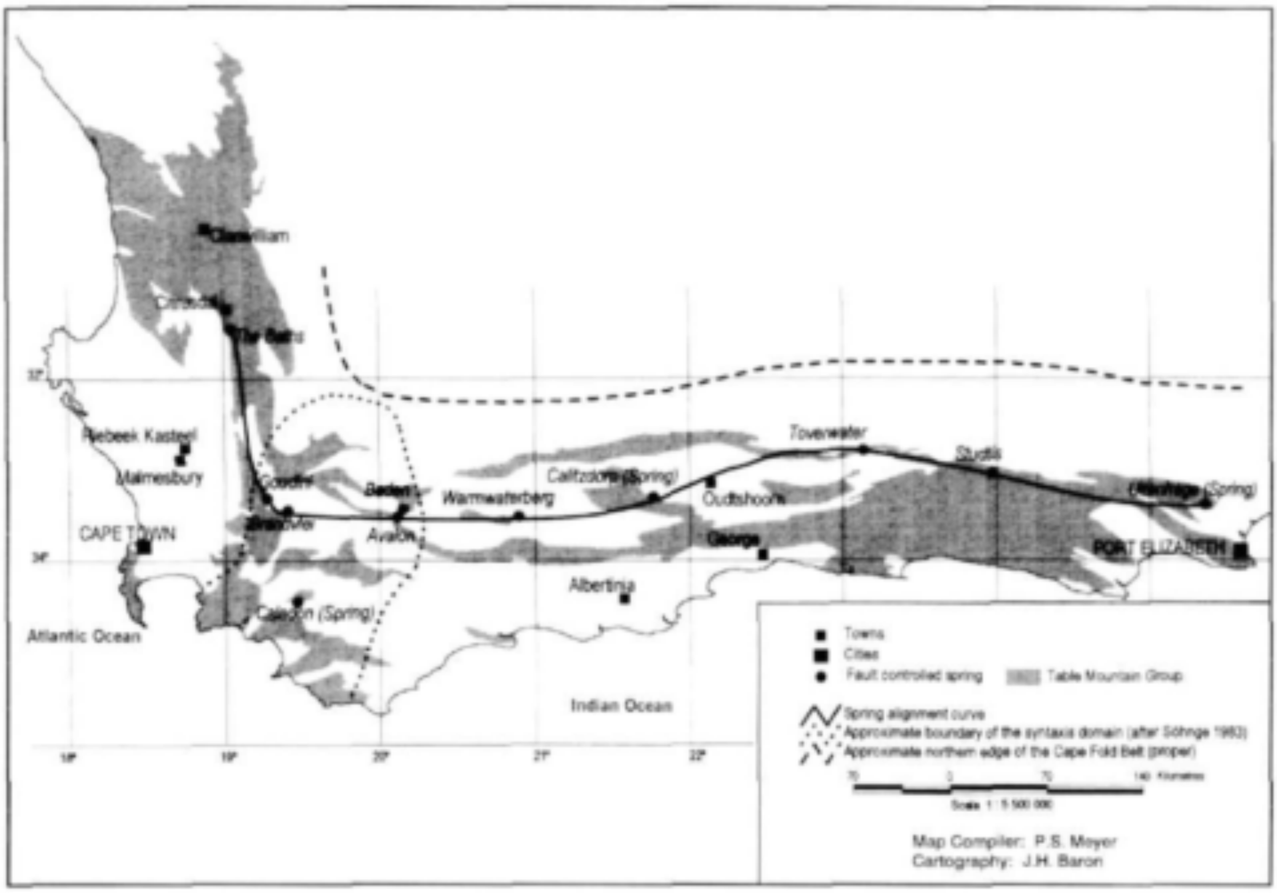

Figure 2

The positions of the most important and well-known fault controlled springs in the Table Mountain Group relative to the broader Cape Fold Belt realm

devoid of thermal and hyperthermal springs, indicating a region of less deep groundwater circulation. It would be interesting to determine whether this phenomenon could be linked to the prevalence of thrust faulting in the area east of 23°E (Booth and Shone, 1999; and Murray, 1996).

The major fault controlled springs have the following characteristics (Table 1):

- They all rise from conduits in competent, fractured and fissured quartzitic–sandstone of the TMG which are in all instances faulted against, or are in contact with incompetent Cedarberg Formation and Bokkeveld and Uitenhage Groups aquicludes.
- They are all at least hypothermal springs, with water temperatures in excess of 20°C. They are thus all relatively deep circulating springs.
- They are all strong yielding (yields range between 9 and 127 ℓ/s) and seasonal fluctuations are limited.
- The groundwater quality of all of them is excellent, and ECs do not exceed 35 mS/m.
- The dominant chemical determinants of the groundwater are sodium and chloride.
- Hydroxides of iron and/or manganese, ranging between 0.1 and 2.0 mg/ℓ, have been recorded in most of them.

Brief discussion and outlook

The Table Mountain sandstone terrain is generally mountainous, rough and often inaccessible. As a result, many springs in the TMG, particularly those issuing from interbed contacts, are largely situated where the influence of human activities is unlikely to be felt. Some springs, however, especially those bordering on or located within reach of areas with development potential, would be vulnerable in terms of groundwater abstraction and groundwater pollution. The reduction and even ceasing of spring-flow at a few localities subjected to groundwater development and subsequent large-scale abstraction, is proof of this danger.

The multitude of springs emanating from the TMG support numerous established communities and play an important role in the agricultural sector. These springs can thus rightly be regarded as one of the region's most valuable assets and warrant careful protection. To protect the springs from injudicious exploitation, any extensive groundwater de-

Table 1
Salient information on the major fault controlled springs

Name of spring	Co-ordinate		Temp. (°C)	Yield (ℓ/s)	Cond. (mS/m)	Probable depth of circulation (m)*	Classification of thermal water #	Remarks
	South	East						
The Baths (Citrusdal area)	32° 44' 22"	19° 02' 06"	43	29	8	2000	Hyperthermal	Geological setting: situated on an E-striking fault in Peninsula Formation (TMG) sandstone, on the western limb of a deep syncline on the contact with the Cedarberg Shale Formation. Dominant chemical determinants: sodium and chloride. Utilisation: recreation.
Goudini	33° 24' 00"	19° 15' 53"	40	11	7	1700	Thermal	Geological setting: situated on a NNW-striking fault in Peninsula Formation (TMG) sandstone near the contact with Bokkeveld Group shale. Dominant chemical determinants: sodium, sulphate and chloride. Utilisation: recreation.
Brandvlei	33° 43' 46"	19° 24' 58"	64	127	8	3600	Hyperthermal	Geological setting: situated on a NE-striking fault in Nardouw Subgroup (TMG) sandstone on or close to the contact with Bokkeveld Group shale. Dominant chemical determinants: sodium and chloride. Utilisation: under-utilised, partly used for domestic supply.
Caledon	34° 13' 20"	19° 26' 18"	37	9	20	1600	Thermal	Geological setting: situated on an E-striking fault. Peninsula Formation (TMG) sandstone faulted against Bokkeveld Group shale. Dominant chemical determinants: sodium and chloride. Utilisation: recreation.
Avalon (Montagu)	33° 45' 57"	20° 07' 02"	43	38	11	2000	Hyperthermal	Geological setting: situated on an E-striking fault. Nardouw Subgroup (TMG) sandstone faulted against Bokkeveld Group shale . Dominant chemical determinants: sodium and chloride. Utilisation: recreation.
Baden	33° 42' 20"	20° 07' 33"	38	37	10	1500	Thermal	Geological setting: situated on an ill-defined E-striking fault in Nardouw Subgroup (TMG) sandstone on the contact with Bokkeveld Group shale. Dominant chemical determinants: sodium and chloride. Utilisation: recreation.
Warmwater-berg	33° 45' 57"	20° 54' 08"	45	9	26	2100	Hyperthermal	Geological setting: situated on a NE-striking fault. Nardouw Subgroup (TMG) sandstone faulted against Bokkeveld Group shale. Dominant chemical determinants: sodium and chloride. Utilisation: recreation.

Table 1 (continued)

Name of spring	Co-ordinate		Temp. (°C)	Yield (ℓ/s)	Cond. (mS/m)	Probable depth of circulation (m)*	Classification of thermal water #	Remarks
	South	East						
Calitzdorp	33° 39' 38"	21° 46' 24"	50	8	31	2500	Hyperthermal	Geological setting: situated on a NE-striking fault. Nardouw Subgroup (TMG) sandstone faulted against Bokkeveld Group shale. Likely dominant chemical determinants: sodium and chloride. Utilisation: recreation.
Toverwater	33° 24' 00"	23° 09' 10"	44	11	15	2000	Hypothermal	Geological setting: situated on the E-striking Cango fault. Peninsula Formation (TMG) sandstone faulted against Enon Formation (Uitenhage Group) conglomerate. Dominant chemical determinants: sodium and chloride. Utilisation: irrigation.
Studtis	33° 32' 48"	23° 57' 50"	24	31	18	480	Hypothermal	Geological setting: situated on a NE-striking fault. Nardouw Subgroup (TMG) sandstone faulted against Bokkeveld Group shale. Likely dominant chemical determinants: sodium and chloride. Utilisation: irrigation.
Uitenhage	33° 42' 05"	25° 26' 18"	23	45	34	400	Hypothermal	Geological setting: situated on an ESE-striking fault (Maclear 1996) in Peninsula Formation (TMG) sandstone, on or close to the contact with Kirkwood Formation (Uitenhage Group). Yield fluctuates in accordance with abstraction from aquifer (Maclear 1996). Dominant chemical determinants: sodium and chloride. Utilisation: municipal use.

* Average geothermal gradient of 1°C/80 m was derived from relatively deep geophysical borehole logging data of six scattered boreholes in the TMG, assuming the downward rate of increase continued uniformly. Ambient water temp. 18°C.

\# Italian classification (Kent 1969):
Water temp. below 20°C = cold
Water temp. between 20°C and 30°C = hypothermal
Water temp. between 30°C and 40°C = thermal
Water temp. above 40°C = hyperthermal

Note: For information on isotopes, see in this issue: "*Thermal Springs of the Table Mountain Group*" by C. Harris and R.E. Diamond.

velopment in the TMG should be preceded by a study to assess the impact of this development on the springs, taking into account, amongst others, the mode of occurrence of springs in the proposed development area.

To fully understand the hydrogeological complexities of the TMG, a knowledge of the distribution and mode of occurrence of springs in the TMG is necessary. Relatively little is, however, known about springs in the TMG and a comprehensive study, including aspects such as spring distribution, mode of occurrence, yield sustainability and vulnerability to exploitation is highly recommended.

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