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Thermal spring at Kimberley

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Abstract

Water with a temperature of 24-25.3°C issues from a spring in an alluvial flat surrounding the Mersey River at Kimberley. The volume of flow increases downstream from the head of the spring to at least a small dam about 200 m away, where the estimated flow is in the range of 750-1500 *l*/minute. The temperature increases over this section of the stream. The dissolved solids content is fairly low for groundwater and it contains mainly bicarbonate and calcium ions. A gas which bubbles up from the base of the spring contains up to 6% CO_2. Any medicinal or therapeutic properties that the water may have are undetermined. It has a similar composition to some of the waters used for this purpose, but the concentration of dissolved solids is lower than for most, but not all, of these waters.

The Mersey-Forth Tourist Development Committee requested an investigation of the Kimberley warm springs [DQ575168], in particular the odour emitted, the volume of flow, temperature, composition of the water and their medicinal value.

Thermal springs have been reported from several localities in Tasmania, the best known being at Hastings in the south of the state, around one of which a swimming pool has been constructed. Springs from a number of localities in the Smithton district have been described as tepid (Nye *et al*, 1934). A tunnel in the area of the Victory Mine, Arthur River area, intersected a spring whose water was described by Waller (1902) as being about blood heat. The earliest known mention of the spring at Kimberley in geological literature is by Reid (1924), but its existence was probably known for some time previous to this.

GEOLOGY OF THE KIMBERLEY AREA

The geology of the area around and to the west of Kimberley was mapped by Jennings *et al.* (1959), while the area to the east was mapped by Gulline *et al.* (1973).

The spring issues at the southern end of a north-west trending strip of alluvium about 10 km long and up to 1.5 km wide which surrounds the Mersey River. The north-west elongation of this alluvium parallels the structural trend of the nearby older rocks and the flow direction of the Mersey River has obviously been controlled by these structures in this area. South of the spring, Permian sediments unconformably overlie Ordovician sandstone. Most of the eastern and western margins of the alluvial flat are bordered by rocks of Permian age, which have been intruded by Jurassic dolerite. Precambrian quartzite occurs on the northern margin of the area of alluvium.

The alluvium consists of sand, clayey sand and gravel. Near the head of the spring, an excavation with a backhoe to a depth of about 3 m encountered boulder beds with quartzite boulders up to 0.4 m across. Drilling to the north of Kimberly encountered up to 6.5 m of alluvium before entering the Permian rocks (Reid, 1924).

Reid suggests that limestone underlies the area at depth where the spring occurs. There is no surface evidence of this, although the chemical analysis of the water suggests that this may be so. The Permian sediments contain little limestone in the area so it is likely that if any limestone does occur, it may be Ordovician in age (Gordon Limestone or equivalent). It would have to be faulted to occur in this position. Drilling for oil shale in the river valley north of the spring (the nearest being 4.5 km away) struck quartzite and conglomerate basement under the Permian rocks, which does not support the presence of Gordon Limestone at depth. In all other areas of Tasmania where thermal springs are known to occur, they are associated with carbonate rocks, in particular dolomite, a rock similar to limestone but containing magnesium in addition to the calcium carbonate of limestone. Precambrian dolomite could underlie the spring area at depth, such an explanation involving a simpler structural history than if Gordon Limestone were to occur.

SOURCE OF HEAT

The water is warmer than surface waters and must come into contact with hotter material than the near-surface material. The usual and most likely explanation is that the water comes from a considerable depth, where the temperature is naturally higher. The temperature below the surface normally increases by about 1°C for each 30 m increase in depth (Todd, 1959) and the temperature of near surface ground water is usually 1-2° above the mean annual air temperature. The mean annual temperature from localities close to Kimberley with similar situations are 10.7° (Sheffield) and 11.2° (Doloraine). The minimum depth, using the above figures, from which the water would come if depth was the cause of heating would probably be about 350 m. The water would have to come from its heat source zone fairly quickly to minimise any temperature loss as it rose through the cooler upper zones. A fault zone, where the rock is brecciated and more permeable, would form a possible channel, for the water to rise quickly. Another possibility is that wide solution channels occuring in limestone or dolomite areas could allow quick flow of the water to the surface.

In other parts of the world, thermal waters occur in volcanic areas or near areas where igneous bodies have been intruded beneath the surface and have not cooled to the extent of fitting into the normal temperature gradient. The former cause does not apply to Tasmania and the latter is a very remote possibility.

CHARACTERISTICS OF THE SPRING

Temperature

The temperature of the spring was measured on 26 January at about 3 p.m. At the head of the spring near the small bridge, the temperature was 24°C. About 25 m downstream it was 24.5°C and about 150 m further downstream at the small weir it was 25.3°C. The air temperature at that time was about 23.5°C and the temperature of the nearby Mersey River below the bridge was 21.8°C. Hughes (1960) recorded temperatures of up to 30°C for springs at Hastings, while recent measurements of springs near Smithton range from 17°C-20°C. From the five measurements taken at Smithton, it is apparent that there may be a direct relationship between flow rate and temperature. The spring intersected in the old Victory Mine working was described as about blood heat (36.9°C), but this temperature would most likely have been judged without the use of a thermometer.

Volume of Flow

It is not possible to give an estimate of the flow of water from the head of the spring without the installation of a weir. The volume of flow increases downstream and this is supported by the increase in temperature downstream. Within the reserve area, the volume is considerable and at the small dam about 200 m below the head of the spring, the flow could be of the order of 750-1500 *l*/min or greater.

Odour of the spring area

No particular odour could be noted coming from the spring, apart from that which is associated with the reeds and small marshy areas usually present around a spring. The slight smell is probably associated with rotting vegetation and the temperature of the spring would tend to enhance this. There is no strong smell of "rotten eggs" that is associated with the presence of hydrogen sulphide gas.

Gas is emitted at the base of the spring area near the bridge. Some of this gas was collected and was analysed by the Government Analyst. Three samples were collected, only one of which was not contaminated by air during the collecting process. Analysis indicated a carbon dioxide (CO_2) content of 1-6 %, the remaining constituents being the same as normal air, *i.e.* mainly oxygen and nitrogen. The CO_2 content of air is about 0.03%, so that the gas from the spring has been strongly enriched. The origin of the CO_2 is unknown, but it could be derived from the decomposition and solution processes of limestone. Alternatively, it may be derived from the solution by rainwater of the CO_2 contained in soil air and ground air in the unsaturated zone beneath. Soil air has a much higher CO_2 concentration than atmospheric air and its proportion of ground air in the unsaturated zone increases with depth (Atkinson, 1977). Rainwater percolating down would have a lower temperature than that at which the spring issues and would dissolve more CO_2 than could be held in solution at 25°C at atmospheric pressure. As the water reaches the level of its heat source, the CO_2 could be held in solution by the increased pressure despite the higher temperature. On arrival back at the surface, where the water experiences a pressure drop, a proportion of the dissolved CO_2 would come out of solution.

Gas emits from the springs in the Smithton district and again this is probably rich in CO_2 although no analyses have been performed.

Chemical composition of the water

Chemical analyses undertaken by the Department of Mines Laboratory, Launceston are given for two samples of the Kimberley water (Table 1). The samples were almost identical in composition and both were low in total dissolved solids (TDS). The water has less dissolved solids than two samples analysed from the Smithton district (Mowbray and Pulbeena) and slightly more than the analysis for Hastings water. The waters are all dominantly bicarbonate waters (as opposed to chloride waters) with calcium and magnesium predominating over sodium ions.

Notes on analysis. Table 1.

1. Head of spring, Kimberley.
2. 200 m downstream from sample 1, Kimberley.
3. Hastings.
4. Mowbray Swamp, Smithton area. Also contains 110 ppm organic and volatile matter (Nye *et al.*, 1934).
5. Pulbeena. Also contains 320 ppm organic and volatile matter (Nye *et al.*, 1934).

TABLE 1. ANALYSIS OF SPRING AND MINERAL WATERS

Item	1*	2*	3†	4*	5*	6x	7x	8x	9x	10*	11*	12*	13*
pH	7.5	7.5	7.2							7.2	6.8	7.0	7.2
Conductivity (µS/cm)	420	420									1060	760	760
	mg/l	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*	*mg/l*
CO_3	nil	nil	137	256	527						nil	nil	nil
HCO_3	240	240				3385.5				780#	910	500	500
Cl	27	27	29	55	40	254.4	16	16	7.5	110	53	60	60
SO_4	8	12	7	16	18	141.2	2	2	1171.2	41	7	<5	<5
SiO_2	18	18	9	12	9		10			29	11	16	15
Ca	63	63	47	111	182	96	51	51	484.872	64	170	110	110
Mg	13	13	26	37	103	10.3	41	41	68.068	27	93	34	34
Fe	<0.1	<0.1	(0.6	(8	(6		trace	trace	0.3	trace	<0.1	0.2	0.1
Al	<0.2	<0.2	(	(	(					nil	<0.2	<0.2	0.2
K	1.3	1.2	(16			75			3.2	16	1.8	2.9	3.2
Na	12	12	(	43	48	1330	40	40	10.3	248	27	33	33
Total dissolved solids	260	260	238	648	1252					870	830	520	510
Permanent hardness	21	21								270	67	5	5
Temporary hardness	190	190									740	410	410
Alkalinity	190	190								590	740	410	410
H_2S	n.d	n.d								Present			

* Analysis by Department of Mines Laboratory, Launceston.
† Analysis by Government Analyst.
x Commercial waters, stated analysis.
\# Calculated assuming unfullfilled cations in the analysis are all satisfied by HCO_3- ions. Because pH is 7.2, CO_3 is unlikely to occur.
n.d Not detected.

6. Vichy, France. Also contains 0.03 mg/*l* Zn, 0.04 Cu, 0.018 Pb, 0.24 As, 0.06N and 7.0 F.

7. Bisleri. Bicarbonate alkalinity 480, carbonate alkalinity nil.

8. Daylesford, Victoria. Bicarbonate alkalinity 480, carbonate alkalinity nil.

9. Contrex, France. Bicarbonate alkalinity 387.5.

10. Stinking springs, Cluan. H_2S present in large amounts which prevents the determination of CO_3^2 with any accuracy. Therefore permanent and temporary hardness are also affected.

11. Pulbeena, temperature 19.8^{o}C (recent analysis).

12. Mella, temperature 20^{o}C (recent analysis).

13. Mella, temperature 18.5^{o}C (recent analysis).

Hepburn Spa water (Victoria) contains Ca $(HCO_3)2$ 723 mg/*l*, Na_2SO_4 116, Mg $(HCO_3)2$ 1161, NaCl 116, N_2HCO_3 901, Fe slight trace. Contains no Cl or F.

MEDICINAL VALUE OF MINERAL SPRINGS

The particular health giving or curing properties of mineral and thermal waters is regarded with some scepticism in some quarters However there are groups of people in many parts of the world who have faith in the ability of particular waters to cure ills and "health clinics" have been set up around many mineral springs and thermal areas. Menadue (1972) gives a brief history of the use of mineral and thermal waters. Early records indicate that they were used for bathing by the people in the cities of Crete in 2100 BC. The Romans, during their period of power, developed baths at various places, including Bath, England but the facilities fell into disuse after their fall from power. The drinking of mineral waters became more popular than the use of the water in baths in the 15th and 16th centuries AD. In 16th and 17th centuries AD baths once again became popular. In the 5th century BC, Herodotus wrote of the prescribing of mineral waters, while about 400 BC the Greek physician Hippocrates wrote a book called "Airs, Waters and Places" which included descriptions of the therapeutic properties of river salt and seawater (Gol'dfail' and Oppengeim, 1973).

The fact that mineral springs and thermal areas still have widespread use is indicated by a study of the literature. Many spas of Western Europe have an extensive clientele and large tourist facilities surround them. Smaller scale facilities have been developed in the Daylesford-Hepburn area of Victoria. The mineral springs at Spa, a town in Belgium, provided the name used to describe a mineral spring.

Many eastern and western European countries as well as the United States of America have institutes and societies which investigate and promote the science of balneology. The use of mineral waters is not only confined to western societies. To quote from Korea today (a North Korean information magazine) President Kim Il Sung said: "We should use many mineral and hot springs in our country for various purpose. We must widely use them for the cure and prevention of diseases". It is claimed that North Korean mineral waters are used for the cure of chronic gastritis, hepatitis, gastric and duodenal ulcers and stomach nervous disorders. The water is supplied to hospitals, sanatoriums, holiday homes, coal and ore miners, smelters, fishermen and other working people. It can be seen then that the use of mineral waters has a wide acceptance.

Gol'dfail' and Oppengeim (1973) describe the effects of mineral waters. Applied externally they alter the permeability of the skin and studies have apparently indicated that the skin is permeable to CO_2 and other gases. Internally, the temperature and the mineral and gas content acts on the mucous membrane of various parts of the gastro-intestinal track. Scientists in the U.S.S.R. have found various organic substances in mineral waters and numerous and diverse microflora. Some of the complaints mentioned as being treated include arteriosclerosis, rheumatism, vascular diseases and diseases of the peripheral nervous system. A feature of many of the European mineral resorts is the invigorating climate in which they are situated. Many are above 600 m above sea level.

CHEMICAL COMPOSITION OF MINERAL WATERS

The chemical composition of mineral and thermal springs that are said to have therapeutic properties is variable. Some have very high amounts of dissolved salts and others have a very low salt content. Table 1 shows the chemical composition of some of the mineral waters commercially available in Tasmania. These are all bicarbonate waters and probably have free CO_2 present, except for Contrex which has a high concentration of sulphate and no doubt acts as a laxative if taken in large quantities. It is of interest to note that Vichy water contains 7.0 ppm of fluoride which is well above the limit suggested for public water supplies. Bisleri and Daylesford ("Deep Spring") waters have a relatively low salt content and appear to be the same water. The stated analyses show that the waters have the same chemical composition. To illustrate the range of salt content, a recent newspaper article described the comments of a panel of five people who tasted a range of waters available. Some were described as salty while one, a French water, (Evian) was described as having no taste at all and as being similar to distilled water. This water claims to help in the cure and organic regeneration of diseases associated with the urinary tracts, gout, arthritis and obesity. North Korean springs are said to contain 1.4-3.2 *g/l* (1400-3200 mg/*l*) of carbonic acid gas and 0.7-3.5 *g/l* (700-3500 mg/*l*) mineral matter.

TYPES OF THERMAL AND MINERAL SPRINGS

There are many types of mineral springs which are put to varying uses according to their mineral content, temperature and gas content. Dissolved gases present can include carbon dioxide, hydrogen sulphide, nitrogen, methane and oxygen. From their salt content, springs can be described as saline,alkaline, alkaline-saline, alkaline-earth, ferruginous and siliceous. Menadue (1972) in describing Austrian spas, lists some spring types:-

Bicarbonate rich water is used mainly for baths and as a cure for bodily ailments. Most of the bottled mineral waters on sale in Tasmania are bicarbonate rich as are the thermal springs of Tasmania.

Radioactive springs contain radon and spas containing this are said to have a general stimulating effect when used as a bath and aid in rheumatic and nervous complaints. When taken internally, it is said to cure gout. Springs in the Daylesford-Hepburn area contain some radon (Laing, 1977).

Sulphur Springs are used in baths and are said to have an anti-rheumatic effect on joints. This type was one the first to be known and used and has long been regarded highly for its curative powers. Stinking Spring, south of Cluan, has copious amounts of H_2S (table 1, analysis 10)

It may be slightly thermal with a temperature of about 16°C, but is a little cool to develop as a bath.

Chalybeate has a high iron content and is used as a general tonic and as a nutrient for blood corpuscle formation. There are some iron rich springs in the Smithton district as evidenced by the iron rich deposits surrounding them.

CONCLUSIONS

The spring at Kimberley has a temperature some 11-12°C higher than would be expected for near surface groundwater. This higher temperature is probably caused by the water rising quickly from deeper levels.

The water contains a fairly low concentration of dissolved solids, with the major constituents being bicarbonate and calcium ions. Bubbles of gas coming from the base of the spring are enriched in carbon dioxide with respect to air. The carbon dioxide may be derived from the decomposition of carbonate rocks at depth or it may be dissolved by rainwater seeping through the unsaturated zones above the water table. Soil air and ground air have a much higher concentration of carbon dioxide than the atmosphere.

The volume of flow of the spring has not been measured but appears to be at least in the range of 750-1500 *l*/min and may be greater at the point where a small dam has been installed downstream of the reserve area. Downstream from the head of the spring to this point, the flow rate increases, as is evidenced by the increase in temperature.

It cannot be stated whether or not the water has medicinal properties. Many of the mineral and thermal waters used for this purpose are fairly high in dissolved solids content but some have very low values. It is a bicarbonate water, as are many of the mineral waters available commercially in Australia. The presence of free carbon dioxide in fairly large quantities may have some value for its use as a bath.

The most obvious use for the water as a tourist attraction, whether it has medicinal value or not, is in a swimming pool, which could be used all the year round without any heating costs. Public swimming pools are generally heated to about 24-25°C which is about the temperature of this water.

There are a number of other uses to which the water could be put because of its temperature and stored heat. For example, it could be used in showers for a tourist facility. If a temperature higher than 25°C was desired, the heating of the spring water would require less power than if surface water was used, particularly in winter time. The water could be used to warm hot houses to grow agricultural products or exotic plants such as orchids. It may be possible to use the water for domestic heating or heating a tourist facility, if built.

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