ISRAEL GEOLOGICAL SOCIETY

PROCEEDINGS
SYMPOSIUM ON THE DEAD SEA AND SDOM REGION

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CONTENTS

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Memorial meeting

G. S. Blake, 1876—1940

The Israel Geological Society has honoured the memory of the late George Stanfield Blake, B. Sc., A. R. S. M., F. G. S., M. I. M. M., Geological Adviser to the Mandatory Government of Palestine, by erecting a memorial plaque near the spot where he was so untimely killed 20 years ago. The plaque was unveiled during the annual general meeting of the Society held in Sdom, in the presence of H. M. Ambassador to the Government of Israel and other guests.

G. S. Blake was appointed Geological Adviser to the Palestine Government in 1922 and during the next 16 years, until his retirement in 1938, devoted himself to preparing a geological map of Palestine, besides advising on current problems of water supply and mineral prospecting. He travelled extensively all over the country to study its stratigraphy, building stones and mineral resources. The results of his investigations are summarized in comprehensive reports and detailed geological maps.

In 1940 he returned to Palestine to carry out a survey on behalf of the Palestine Mining Syndicate Ltd., and it was during this survey that he was murdered in the neighbourhood of Sdom.

Much of the geological work done since still rests on the sound foundations laid by Blake.

PUBLICATIONS CONCERNING PALESTINE BY G. S. BLAKE

1. *Geology and water resources of Palestine*, 1928, Govt. of Palestine, Printing and Stationery Office, Jerusalem, 51 pp. Map 1,000,000.
2. *The mineral resources of Palestine and Transjordan*, 1930, *Ibidem*, 41 pp.
3. *The stratigraphy of Palestine and its building stones*, 1935, *Ibidem*, 133 pp. Map 1: 1,000,000.
4. On the occurrence of marine Miocene in Palestine, 1935, *Geol. Mag.*, **72**, 140–142.
5. Old shore lines of Palestine, 1937, *Geol. Mag.*, **74**, 68–78.
6. *Geological map of Palestine* (*Northern part*), 1:100,000, 1937–39; handcoloured, unpublished.
7. *Geological map of Palestine*, (*Northern Sheet*). 1:250,000 1939, Govt. of Palestine, Jerusalem.
8. *A report on geology, soils and minerals and hydrogeological correlations of Transjordan*, *in* M. G. Ionides, 1940, *Report on the water resources of Transjordan and their development*, London.
9. *Geology and water resources of Palestine*, with M. J. Goldschmidt, 1947, Govt. of Palestine, Jerusalem, 413 pp.

The full text of a lecture by Prof. L. Picard on "*The life and work of G. S. Blake in Palestine*" delivered at the memorial meeting is to be published in Hebrew in the *Bulletin of the Israel Geological Society*, no. 5, 1960.

Contribution to the geology of the Mount Sdom area

ISRAEL ZAK, *The Geological Survey of Israel*

Mount Sdom is situated on the southwestern shore of the Dead Sea. It is elongated in N–S direction and rises abruptly to 250 m above the Dead Sea level. The morphology of Mount Sdom is characterized by sharp rugged features, steep walls and scarps, deep gorges, caves abutting in numerous vents and sinkholes.

The area has previously been investigated by many geologists, among them M. Blanckenhorn, B. K. N. Wyllie, G. S. Blake, L. Picard, A. Vorman and Y. Bentor.

The present investigation was carried out in connection with the prospection of potassium deposits. It was aided by chemical analyses, and the Cl/Br ratio was tested as a guide to stratigraphical and facies analysis.

Stratigraphy. The rocks of Mount Sdom are predominantly of lacustrine origin. They also comprise several horizons of fluviatile conglomerates. The deposits attain a thickness of several thousand metres and have accumulated during subsidence of the Arava Rift Valley and of the Dead Sea. The stratigraphic sequence — adapted and modified from Bentor and Vroman (1954 and in press) — is as follows:

5. Late Quaternary	—	Recent sediments Reg (hammada) Concretionary aragonitic beds and algal limestones Anhydrite
4. Lisan formation (L)	—	Marl, chalk, gravels, gypsum; partly varved; thickness over 60 m (on top of Mount Sdom only 25 m).
3. Anhydrite sequence (LH)	—	Anhydrite, clays, gypsum, dolomite, silt and sands; thickness 30 m.
2. Foothill formation (H)	—	Clays, silt, anhydrite; maximum thickness 700 m (not known on top of Mount Sdom).
1. Sdom formation (SS, with sub-units SS_1–SS_4)	—	Rock salt, silt, sand, clay, anhydrite, laminated shales with fish and plant remains; exposed thickness over 400 m; in Sdom I well, more than 1000 m.

Structure. Mount Sdom is a raised tilted block of complex structure. Its lower part consists of rocks of the Sdom formation, the strata of which are strongly inclined 30°–50° to the west. Simple folds occur, which, however, do not disturb the continuity of the layers. The rock salt is well bedded and there is no evidence of dissolution and recrystallization. Younger deposits of the anhydrite sequence and the Lisan formation form the top of the block. These layers are horizontal or slightly inclined.

The structure of Mount Sdom is difficult to explain on the basis of its exposures only. The views offered by various investigators are diverging and even contradictory. The deep Sdom I well has shown that the roots of the mountain are much deeper than assumed hitherto.

Potassium in the area of Mount Sdom. The object of the present survey was to carry out a geochemical search for sources of potassium. The analyses of rocks and waters of the area provided the following data: (a) Abundance of potassium in salt rocks: The general background values are up to 0.8 % K^+. Anomalies of the order of 3–8 % K^+ were detected. (b) Abundance of potassium in springs and in brine seepages: The general background values in the springs originating in the area (excluding those deriving from the Judean Mountains whose salinity is much lower) are up to 1 gram/litre K^+. Anomalies of the order of 15–30 gram/litre K^+ are found in the brine seepages and wells originating in Mount Sdom itself.

Average values of K^+, Na^+ and total salinity are (in gram/litre):

	Springs	*Brine seepages and wells*
K^+	1	20
Na^+	20	20
Total salinity	100	400

REFERENCES

1. Bentor, Y. K., and Vroman, A., 1954, The geological map of the Negev on a 1:100,000 scale, *Sheet* **16**: *Sdom,* 1st ed., (in Hebrew), Tel-Aviv; 2nd ed. (in press, in Hebrew and English), *Geol. Survey of Israel Pub.*, Jerusalem.

The oil shale deposits at Ein Boqeq

Yaacov Nir, *The Geological Survey of Israel*

The Ein Boqeq oil shale deposits are situated on the western shore of the Dead Sea, about 25 km north of the Dead Sea Works at Sdom. Outcrops of this oil shale are known to occur over a distance of about 3 km on the northern and southern sides of Nahal Boqeq (Wadi Feshet ed-Darawish), between the main fault escarpment and the Dead Sea shore.

Most of the geologists who worked in this area mentioned these oil shale outcrops in their reports, especially G. S. Blake and A. Vroman. Detailed prospection was started in 1951 when the Research Branch of the Defence Ministry initiated a series of borings in this area. Some of the laboratory and field work was then done by E. Gilav, S. Heller and F. Steckel of the Weizmann Institute of Science. The present investigation started at the end of 1954 and lasted nearly one year. It was sponsored by the Israel Mining Industries, Ltd.

The main object of these investigations was to establish the presence of about 5 million tons of oil shale ore, with an oil percentage of not less than 6.5 %, which would be sufficient to build a small power plant using the crushed rock as fuel. Since the estimated reserves explored in the course of the investigations exceed 5 million tons, the programme was changed and the Israel Mining Industries laboratories are now investigating the feasibility of building a bigger power station than originally planned.

Regional Geology. The region is located on the western edge of the Dead Sea rift which abounds in drag faults. The enormous faulting displaced the shales at least 400 to 500 m from their original position. Additional faulting underneath the Dead Sea appears likely.

The oil shales are of Senonian (Campanian) to Danian age, as based on determinations of microfauna by Z. Reiss of the Geological Survey of Israel. The shales are covered unconformably over most of the area by the rocks of Lisan formation and Recent gravels and sometimes by the Hatseva formation.

Description of the deposit. As the deposit is situated on both sides of Nahal Boqeq, it has been divided into northern and southern fields. These fields were affected by the main rift faulting, and the throw of the northern field was much bigger than that of the southern one.

The fields are petrographically similar. The main rocks are limestone, dolomite, marly and clayey limestone, containing organic matter and varying in colour from light grey to brownish black.

Small percentage of phosphate is present throughout the section. Oil comprises about one half of the total organic matter content of the rock. The oil content of the fields varies, but differences are largest in the thickness of the economic layer (over 6.5 % of oil). Its thickness averages 30 m in the southern as against 70 m in the nothern field.

The rocks throughout the sequence are very similar and could only be divided into three main members. A typical section is as follows:

Overburden: mainly Lisan marls and gravels, Recent gravels

— — — — — — — — — *Unconformity* — — — — — — — — — — — — — — — — — —

Top oil shale: Weathered non-economic oil shales (thickness 4–6 m)
Medium oil shale: Economic oil shales (thickness 30 m South, 70 m North)
Bottom oil shale: Flinty and bituminous phosphate (thickness 2–10 m)

Campanian flint

Origin. Sedimentation took place in small basins under reducing conditions, so that most of the organic matter putrafied without oxidation. Syngenetic pyrite crystals and aggregates are considered as attesting to this type of environment. The transition from oil shales to phosphate beds is gradual. It may therefore be assumed that the depositional environment of the oil shales was in certain respects similar to the environment of deposition of phosphate.

On the fluctuations of the level of the Dead Sea

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Based on the evidence obtained from photographs taken at various times of the present century, and on the presence of long parallel lines of recent bars covered by driftwood, conclusions were drawn on the position of higher water level in the past.

The most convenient index for measuring the fluctuations of the level in past centuries is a tiny island in the northwestern corner of the Sea called Rujm el-Bahr, which has been surveyed and mapped by several observers. From this evidence and descriptions of many travellers, it was possible to reconstruct the changes of the Dead Sea level of the 19th century almost year by year, as summarized in the following:

1. From the end of the 18th century till 1807: shrinkage of level;
2. 1807–1829: very low level (about – 402 m);
3. 1830–1835: *sudden rise* of level to – 399 m, Rujm el-Bahr became a peninsula;
4. 1836–1861: higher steady level, frequent changes of Rujm el-Bahr from peninsula to island (–399.50 to – 397.50 m);
5. 1862–1874: slow rise of level, Rujm el-Bahr mostly isle (–399.50 to – 396 m);
6. 1875–1891: high steady level, Rujm el-Bahr an isle (–397.50 to – 395.50 m);
7. 1892–1897: *sudden rise* of level, Rujm el-Bahr wholly under water (–395 to – 391 m);
8. 1898–1932: very high level, Rujm el-Bahr covered by 3.75 m – 4.25 m thick layer of water;
9. 1933–1937: *rapid drop* of level, Rujm el-Bahr showing from waves (–391.50 to – 395.25 m);
10. 1938–1956: lower level, fairly steady, Rujm el-Bahr mostly under water (–394 to – 395.50 m);
11. 1957– *rapid drop* of level, almost one half of Rujm el-Bahr uncovered (–395 to –397 m).

Since in 1867 a drift-wood line was obserwed at 30 feet above the level of the lake (– 399.5 m according to Rojm el-Bahr), it was concluded that the Dead Sea level decreased by at least 9 m from the 18th century to 1867. It rose 11 m during the 19th century (–402 to –391 m) and fell 6 m during the first 60 years of the 20th century. Both the rises and drops of the level were abrupt: during the years 1933–1937, almost 4 m, and since 1957 another 2 m.

Traces of the two main levels in the 20th century are observable in the small lagoons at the height of –394 m between the recent bars, as well as on the two planes of abraded caves on the steep eastern marly slope of the Mor delta: –394.90 m and –393.10 m respectively.

The recent drop of level of the Dead Sea uncovered numerous conglomeratic bars, severely broken and ruined by the waves, which indicates that the lower levels of the Dead Sea occurred also quite frequently in the past.

However, the maximum range of fluctuations of the Dead Sea level in historical times did not exceed 16 m (i. e. – 402 m to – 387 m), as the lower outer wall of the Roman Boqeq fort is built at the –387 m level. The –386.36 m level marks also the top of a long, uninterrupted line of relatively recent bars on the north side of the Hever delta, rising above the big dry salt-lagoon which crowns the drift-wood covered recent bars.

Above the –386.36 m line, the mountain side is cut by several terraces, strongly eroded by numerous parallel little streams. These terraces are at the elevations of –383 m, –380.5 m, –387.61 m, –375.96 m, –373.41 m, and –368.96 m. The altitudes of these terraces perfectly correlate with those measured by Huntington in 1909 on the North-East coast of the Dead Sea, and by Butzer in 1955 on the North-West coast.

This correlation as well as the 15 m range of fluctuations of the level of the lake in historical times, the big deltas of the main streams and the tiny ones along the steep slopes of the Judean Mountains on the western coast north of Engeddi, all seem to indicate the unimportance of tectonic forces as compared with climatological factors inducing the fluctuations of the level of the Dead Sea during historical times.

On the origin of the salts of the Dead Sea

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On the basis of estimates of total quantity of salts found in the Dead Sea and buried in the Rift Valley, divided by the estimated amount of airborne salts precipitated yearly over the present catchment area, it is calculated that only about 1 million years would be necessary under today's conditions to accumulate all the salts.

Radioactive water sources at Sdom

EMANUEL MAZOR, *Israel Atomic Energy Commission*

During recent years a survey of the radium content of the water sources of the country has been carried out. The results have shown that in the Rift Valley there exists a number of springs with unusual radium concentrations, the highest values being found in three cases near Sdom. The water brought up while drilling the Sdom I well contained 1000 $\mu\mu$g/l radium, and one of two small mineral springs on the eastern slope of Mount Sdom contained 705 $\mu\mu$g/l while normal water contains less than 2 $\mu\mu$g/l of radium and sources with 10 units are generally considered as unusual. Data from other parts of the world show that concentrations of the order found at Sdom are known only from sources connected with oil reservoirs or brines. Our observations thus lead us to suggest that at Sdom too, such a buried reservoir exists. This hypothesis is supported by the following evidence: (1) The water is rich in potassium compounds and other elements; (2) The water of Sdom I well contains an unusually high amount of gas which has been found to contain about 20% methane.

If the existence of such a buried "lake" rich in inorganic and carbonic compounds will be proven, it will lead to the following conclusions:

a) In the Rift Valley there may exist additional buried reservoirs. From this point of view a revised study of the Tiberias hot springs will have to be undertaken, as they have also an unusually high radium content (125 $\mu\mu$g/l) and are rich in other mineral compounds. Yet other reservoirs may exist that might be even richer in organic compounds and it might be worthwhile to prospect these regions for oil and gas.
b) Radium analysis of the Dead Sea may enable to locate additional mineral springs at the bottom of the lake and thus help to explain its unusual composition. Indeed, in one sample of the Dead Sea water an anomalous amount of radium (62 $\mu\mu$gl/)

has been found which may indicate that near the sampling site such a spring does exist.

c) The Sdom water discussed here is economically rich in potassium. The finding of additional springs of the same character in the Dead Sea may prove that the reservoir is big enough for large scale exploitation.

The geochemical development of the Dead Sea

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The Dead Sea, situated in the deepest part of the Jordan-Arava Rift Valley, presents many unusual geochemical features. Its water has an extremely high salinity, and its chemical composition is unique. The area is highly arid, with an average annual rainfall of about 50 mm. Although scien tific observations on the Dead Sea have been carried out intermittently since the Lynch expedition first studied the area in 1948–49, a study of its Pleistocene and Recent sediments was begun only a short time ago. A considerable amount of data has become known through research in connection with the potash and bromine production from the water of the Dead Sea; through hydrogeological work on the Jordan River and its tributaties; though a study of the Pleistocene sediments of the Lisan Lake, as a result of a hydrological survey.

An analysis of the geological history of the area indicates that the Dead Sea is not a relict body of sea water and that its salts are the result of accumulation from closed continental drainage under arid conditions. They originate from two main sources, about one-third from the Jordan River and about two-thirds from highly saline springs discharging into the Dead Sea. On these facts a method can be based for calculating the age of the Dead Sea, leading to a maximum figure of about 70,000 years, and a minimum of 15,000 years, the latter being more probbale. The calculated total and annual amount of chemical precipitation in the Dead Sea is in agreement with observations that the sediment must consist of about equal amounts of aragonite, gypsum and halite.

The vast bromine reserves of the Dead Sea are neither of volcanic nor of organic origin and their derivation from fossil residual brines, formed during the Tertiary, is deemed probable.