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Investigations of the geohydrology of the waters of the Negev Desert using U-234/U-238 disequilibrium

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SUMMARY

Title

Investigations of the Geohydrology of the waters of the Negev Desert using U-234/U-238 disequilibrium.

Research Institute

Tel Aviv University, Ramat Aviv, Israel

Department of Geophysics and Planetary Sciences

Chief Scientific Investigator

Joel Kronfeld

Period of Contract

June 1975 to June 1977

Scientific Background and Scope of Project.

One hundred and five uranium isotopic analyses were made on representative waters of the Negev Desert. This was done in order to better understand the uranium geochemistry of the region, to delineate specific water bodies within the desert region based upon their uranium "Signature", and to deduce flow patterns within the Beersheva Region Cenomanian-Turonian carbonate aquifer by examining the changes in both the uranium content and isotopic ratio and comparing them with changes in the water chemistry as the waters flow from the recharge region into the aquifer.

Experimental Method

The uranium analyses were carried by isotopic dilution techniques using alpha-particle spectrometry.

Results obtained and Conclusions

The results obtained are described in the 4 data tables and 6 figures located within the text of the report. It is found that the uranium content varies over a range from 0.008 to 36 μg/ℓ. Most of the waters are oxygenated, and therefore are uranium conservative. However, the uranium is very sensitative to reducing conditions. Where, when encountered it is effectively removed from solution. The waters can be seen to fit into distinct groupings based upon their uranium content and U-234 excess. The major groupings that can be differentiated are the Sinai crystalline province, the Arava Fill, the Hazeva formation, the Coastal Plain, and the Nubian Sandstone aquifers. It can not be established at present if the Nubian Sandstone Aquifer waters are derivatives of the Sinai crystalline waters. Further research on this is warranted.

By studying the changes in the uranium composition and isotopic ratio correlated to changes in the total water chemistry, a flow pattern can be derived for the Cenomanian-Turonian carbonate aquifer of the Beersheva Region.

Papers Published on Work Done under the Contract.

To be submitted to the Journal of Hydrology.

Introduction

Israel, lacking abundant rainfall, must exploit its water resources to the full. In the desert region proper, rain is scarce and irregular. Most important water resources exist as groundwaters or non-meteoric fossil brines. Direct recharge to the groundwater sources is slight (1) and probably takes place by flood flow through channel bottoms (2). Water unrelated to the present day local meteoroitic water cycle then assumes importance (3-5). Such water can originate in faraway mountainous fringe area or might be palewaters remaining from a prior period of greater pluviation. Issar et al (6) believe, for example, that huge quantities of fresh water are stored in the Nubian Sandstone aquifer that underlies the Negev and much of Sinai. A large part of the water in this aquifer is fossil, that entered the aquifer more than 13,000 years ago.

To maximize the use of the groundwaters it is of primary importance to delineate the geohydrologic parameters of the region such as; flow patterns, defining discrete water masses, relative ages, as well as the origin of the waters involved. The method that appears to offer great potential for service in such hydrologic investigations involves the natural fractionation between the parent U-238 isotope and its daughter U-234.

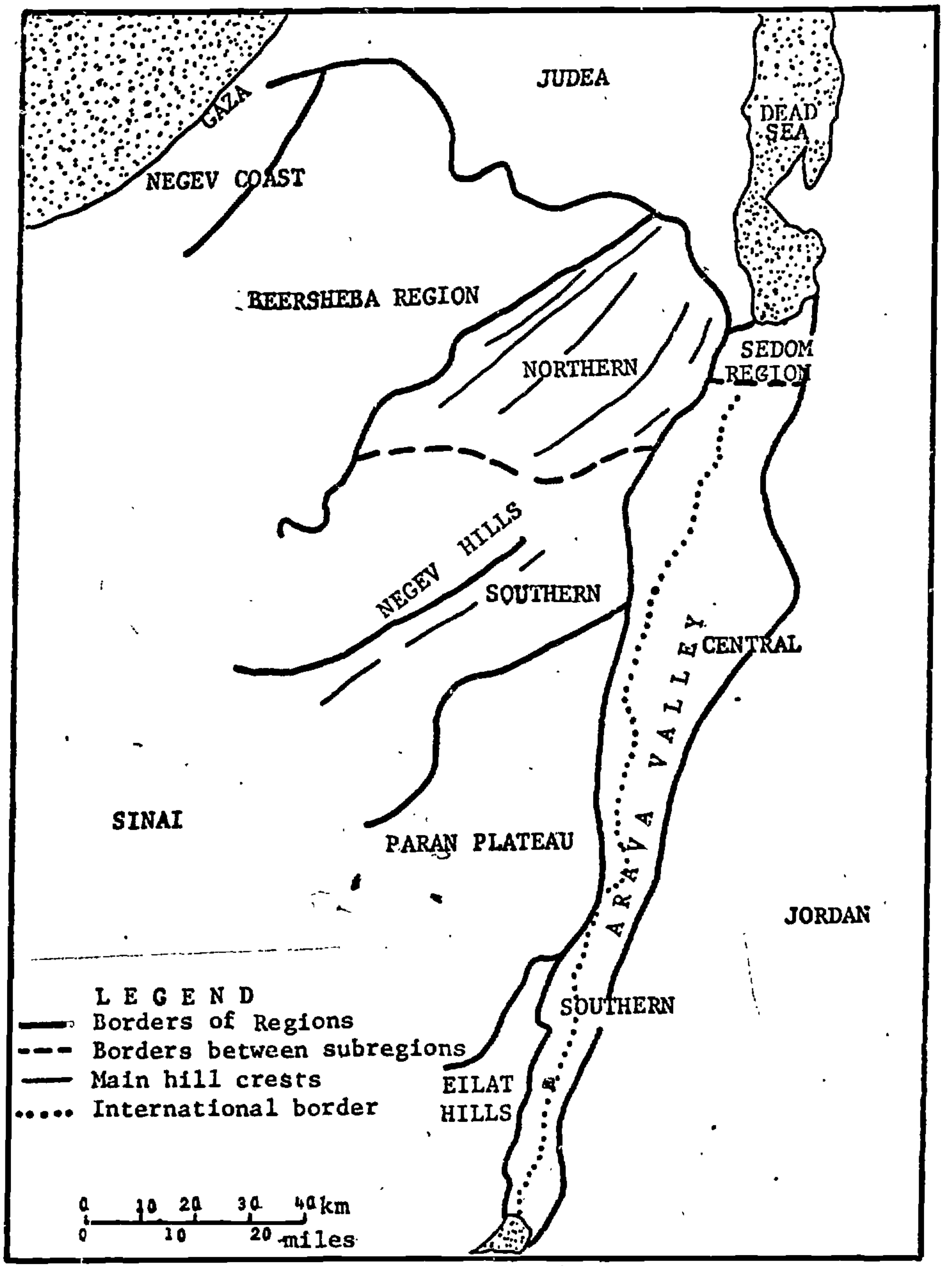
In closed geologic systems older than about a million years, U-234 is in equilibrium with its parent U-238 (i.e. the U-234/U-238 alpha activity ratio is 1.0). However, the activity ratio of these two isotopes varies significantly in aqueous environments. The alpha activity ratio used in conjunction with the uranium concentration provides a "fingerprint" of groundwater masses. By use of these parameters mixing volumes and flow patterns may be determined. That the variation in uranium isotope composition in groundwaters could be useful in deducing water sources was demonstrated by Osmond et al (7). Kaufman et al (8) differentiated water masses and related them to their hydrologic framework. Kronfeld and Adams (9) used the disequilibrium to establish flow patterns and flow rates. It is hoped that a better understanding of the geohydrology of the Negev Desert will be the outcome of the present research that is using uranium isotopic techniques.

Area of Study

The Negev occupies approximately 12,000 sq km within the pre-1967 frontiers, then about 60% of the State. Most of the planned agricultural growth and the settlement of population is expected to occur in this area in the future. There are many favorable factors that would contribute to the success of this enterprise; however, the lack of available local water supplies is a major retarding factor in the development schemes.

The Negev can be divided into six geographical regions (Fig. 1). The most westerly section is the Negev Coast. The greater part of this region remained until 1967 outside of the borders of Israel, being included in the Sinai Peninsula and the Gaza Strip. Here the major water source is derived from a phreatic aquifer, consisting of Plio-Pleistocene to recent sands, that drains directly to the sea. The formation extends over a belt varying in width over the entire length of the coastal plain from the Judean Hills to the shore. The west the sandstone interdigitates with loams and clays which causes a subdivision of the single aquifer into a number of subaquifers. The coastal aquifer is recharged in the east, where it is phraetic, by rainfall and by flood

SUBREGIONS OF THE NEGEV - Figure 1



water flowing west from the hilly areas. In the west the subaquifers are semi-confined because of the interbedded clay and loam lenses.

After the Coastal Plain, the next most populous region is the Beersheva Region, which includes the city of Beersheva and about sixty farming villages. The area is the drainage basin of a single ephemeral stream, Nahal Besor. The Beersheva Region is a depression forming a triangle on the map, its base paralleling the Mediterranean shore on the west and its apex in the east wedged in between the Negev Hills and the Hills of Judea. Important wells are extracting water from the Genomanian-Turonian carbonate aquifer. This same aquifer offers an important water sources in the next geographic division eastward, the Central Negev Hills. This area is today the object of a great development effort. Foremost amoung the new centers is the town of Dimona, with approximately 20,000 inhabitants. Mitzpeh Ramon and Yoroham are nuclei towns to be based on mining and industry. Further to the east and south is the Paran Plateau and the Eilat Hills which are mostly uninhabited. The Arava Valley is the southern most section of the Great Rift in Israel, between the Dead Sea and the Red Sea. It bears typical graben features. The Arava Valley acts as a natural greenhouse, and agricultural development is promising. Here strong springs are developed by seepage in the fault zone. Here too water sources, though having smaller reserves, than the older carbonates and clastics, are found in young graben fill.

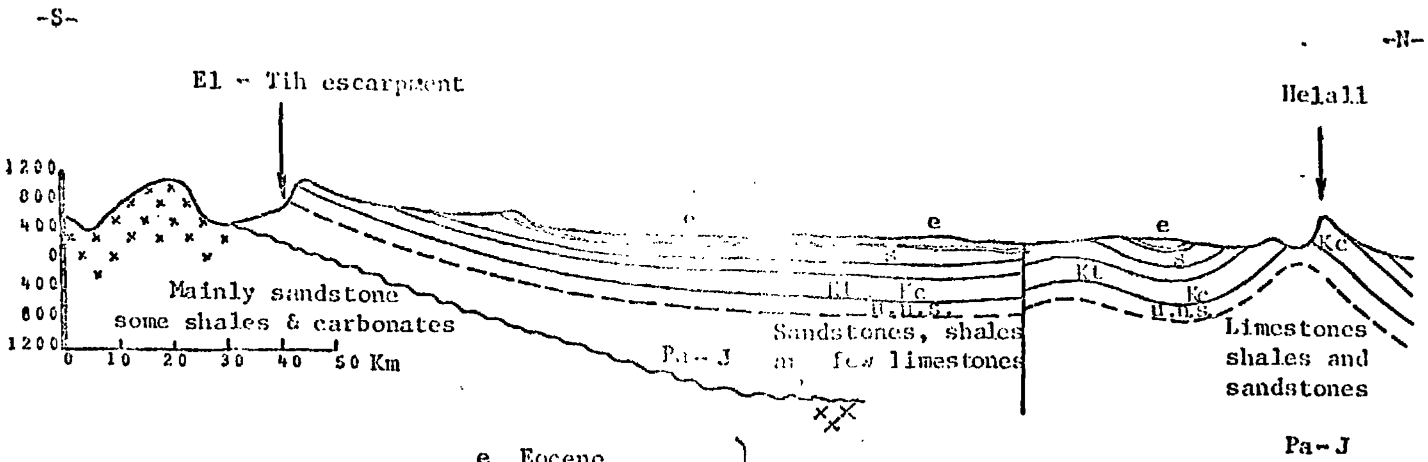
The alluvial formations transported into the morpho-tectonic depression of the graben furnish the main aquiferous beds. The sequence thickens towards the center of the Arava, where its cumulative thickness may exceed 1000 m. The sediments range in age from Miocene to Recent. In most general terms, the aquifer consists of lenses of coarse material which are interbedded and wedge-out and interfinger with finer-grained fractions towards the center.

The water bearing lenses are thickest along the graben margins, opposite the outlets of the ephemeral streams draining into the Arava. The aquifer is spatially irregular and extremely heterogeneous in its composition and hydraulic properties. This non-uniformity reflects a response to the complex interaction between morphologic, climatic and tectonic factors. The sequence represent the super position of multiple generations of alluvial fans which retreated and expanded, in response climate changes and concurrent tectonic movements.

The desert climate, naturally, allows no perenial streams in the Negev. Dry wadis carry water a few times a year and then only for a few hours. Hope is attached to the exploitation of deep groundwater reserves which may be extant beneath the desert. For hydrological purposes the sedimentary sequences may be divided into three groups:

1) Lower Clastic Division - a sequence of rocks, mainly clastics, overlying the igneous basement of pre-Cambrian age. The Nubian Sandstone is the upper part of this division.
2) Middle Calcareous Division - a sequence of rocks, mainly carbonates of Cenomanian to Eocene age.
3) Upper Clastic Division - a sequence of rocks, mainly clastics of Neogene to Holocene age. Most important occurrences are found in the Arava as rift filling.

A representative, south-north, geologic cross section along the western edge of the Negev is presented in figure 2. The dominant recharge area of the Nubian Sandstone aquifer is located immediately to the north of the crystalline province of southern Sinai (6), or approximately at the position of the dashed line in figure 3. The recharge in the overlying



e	Eocene	Middle Calcarous Division
S	Senonian	
Kt	Turonian	
Kc	Cenomanian	
u.n.s.	Lower Cretaceous - Upper Jurassic Nubian Sandstone	Lower Clastic Division
Pa-J	Paleozoic - Jurassic	

xx Precambrian, crystalline rocks

Figure 3. Hydrogeological section A-A.

carbonate aquifer is belived to be from the Judean Hills (10), (11). Shiftan (12) maintains that the artesian water found in the limestone-dolomite in the aquifer Dead Sea region overlying the Nubian Sandstone comes from the Nubian Sandstone.

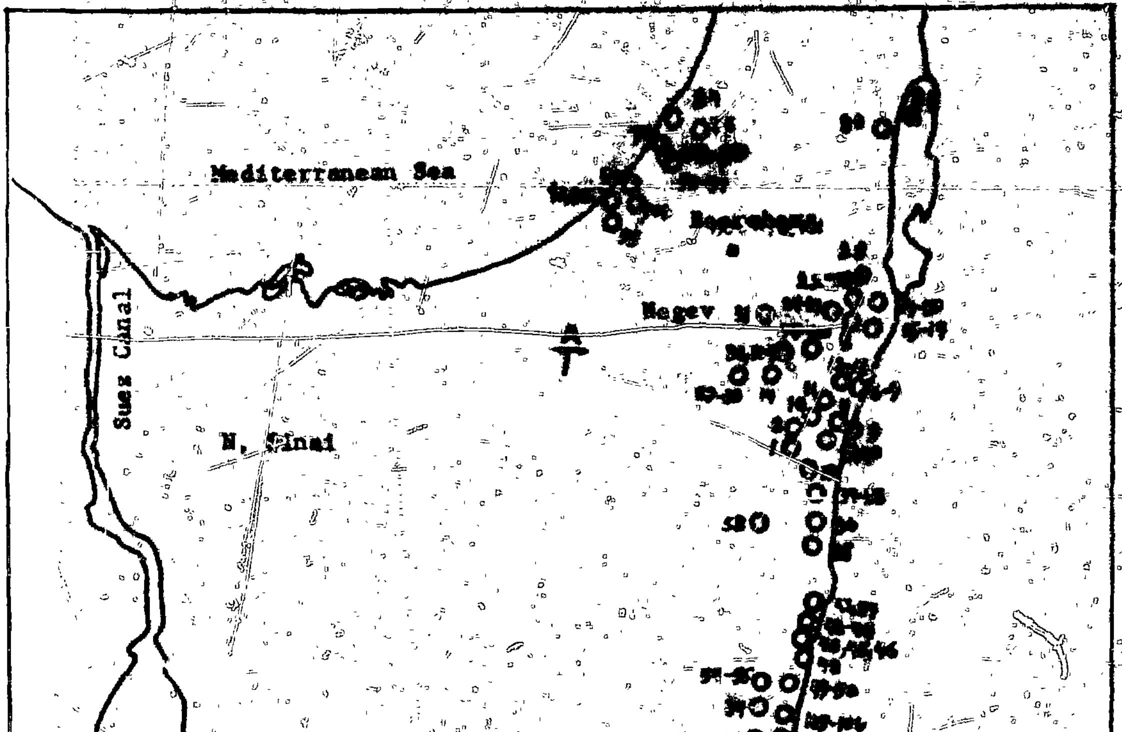
Sampling and Processing

Springs and wells in the Negev representative of various geological and hydrological formations were sampled. Samples representative of present day waters draining the crystalline rocks of Sinai were collected as well, to determine what could be expected from the Nubian Sandstone waters. Samples analyzed are located in figure 3, and figure 5.

20 liter samples were collected in polyethene jerry-cans. The samples were acidified in the field to a pH=1 and transported to the laboratory for further processing. There the samples along with appropriate blanks were spiked with a known quantity of U-232, and had a ferric carrier added. Uranium was coprecipitated with the iron carrier as ferric hydroxide.

A series of chemical steps followed involving solvent extraction and ion exchange which culminated in the electrodeposition of a very pure and thin source upon a stainless steel planchet. Isotopic analysis was then made using a solid state alpha-particle spectrometer.

SAMPLE LOCATION MAP - FIGURE 5



Results

The results of the uranium isotopic analyses are presented in Tables 1, 2 and 3. For simplification of presentation and explanation the data has been divided into three groupings. Table 1 presents the uranium analyses of the Negev with the exception of the Beersheva region. Table 2 presents analyses of water sources that can be considered representative of the water draining the crystalline province of southern Sinai, which is believed to be the major recharge area of the Nubian Sands. Table 3 presents the isotopic analyses of the Cenomanian - Turonian aquifer of the Beersheva Region. The chemical composition of these waters are presented in Table 4. The statistical errors reported in the uranium analyses are at the one sigma level of confidence.

TABLE 1

NEGEV WATER SOURCES
(Except Beersheva Region)

SAMPLE CODE	SOURCE NAME	$^{234}U/^{238}U$ Activity Ratio	U μg/ℓ	FORMATION
N-1	Nahal Shiuya Spring	1.48 ± 0.12	0.82 ± 0.06	Sen
2	Mayan Rachel Spring	0.84 ± 0.02	4.89 ± 0.19	Sen
3	Ein el Hufeira Spring	1.47 ± 0.05	5.83 ± 0.31	Hazeva
4	Ein Marzeva Spring	1.24 ± 0.02	7.07 ± 0.24	Hazeva
5	Kibbutz Ein Yahav	1.30 ± 0.02	8.51 ± 0.22	Hazeva
6	Marzeva-5	1.50 ± 0.05	7.50 ± 0.47	Hazeva
7	Hatzeva-3	1.55 ± 0.08	4.24 ± 0.31	Hazeva
8	Hatzeva-6	1.50 ± 0.05	5.35 ± 0.29	Hazeva
9	Hatzeva 424	1.36 ± 0.02	7.08 ± 0.23	Hazeva
10	Ein-Yahav-4	1.52 ± 0.10	0.059 ± 0.003	N.S. + Sen + C
11	Ein Shahaq - Spring	1.59 ± 0.22	0.057 ± 0.006	Neo
12	Hatzeva 8	1.52 ± 0.03	7.06 ± 0.22	Hazeva
13	Hatzeva 2	1.37 ± 0.03	7.33 ± 0.32	Hazeva
14	En Zin Spring	1.31 ± 0.01	36.0 ± 1.1	Sen
15	Neot Hakikar-1	1.39 ± 0.02	12.1 ± 0.5	Al + Lis.
16	Neot Hakikar 2	1.34 ± 0.02	17.1 ± 0.5	Al + Lis.
17	Neot Hakikar 3	1.40 ± 0.02	10.9 ± 0.4	Al + Lis.
18	Hakikar Spring	1.39 ± 0.04	8.6 ± 0.5	Al + Lis.
19	Zin 5	1.44 ± 0.22	1.24 ± 0.20	Lisan
20	Zin 3	1.27 ± 0.05	2.31 ± 0.11	Lisan

SAMPLE CODE	SOURCE NAME	$^{234}U/^{238}U$ Activity Ratio	U µg/ℓ	FORMATION
22 1975	Admon 2	2,87 ± 0,45	0.014 ± 0.001	N.S.
1977		3,55 ± 0,37	0.010 ± 0.001	
23	Admon 1	1,24 ± 0,36	0.061 ± 0.013	C
24	Tamar-3	2.18 ± 0.50	0.014 ± 0.003	N.S.
26	Tamar-6	1.47 ± 0.09	0.099 ± 0.005	C + N.S.
27	Tamar-5	1.29 ± 0.23	0.11 ± 0.02	C + N.S.
28	Amiaz-2	1.26 ± 0.04	1.55 ± 0.06	C
29	En Mor Spring	1.16 ± 0.08	4.10 ± 0.32	Eocene
30	En Avdat Spring	1,13 ± 0.07	1.60 ± 0.13	Eocene
31	Beer Yoroham	1,14 ± 0.03	5.23 ± 0.21	Al.
32	En Yorke'am Cistern	1,15 ± 0,10	1.91 ± 0.30	Turonian
33	Sabkah-10	1,79 ± 0.02	9.40 ± 0.24	Al.
34	Beer Ora	1,15 ± 0.04	5.68 ± 0.29	Al.
35	Beer Menuha	2,31 ± 0,06	1.42 ± 0.05	Sen.
36	Paran 14	1,68 ± 0,02	4.01 ± 0.09	Hazeva + Neo
37	Tzofar 4	1.56 ± 0,03	7.01 ± 0.26	Hazeva + Al.
38	Tzofar 3	1,50 ± 0,10	7,42 ± 0,99	Hazeva + Al.
39	En Yahav 5	1,93 ± 0,37	0,034 ± 0.005	Sen.
40	Marzava 4	1,39 ± 0.08	4,27 ± 0.36	Hazeva + Neo
41	Yaalon 3	4,52 ± 0,18	1.98 ± 0.11	N.S. + C.
42	Grofit 1	1,54 ± 0.02	11,08 ± 0.39	C
43	Yotvata 3	1,69 ± 0,03	10,27 ± 0,31	C

SAMPLE CODE	SOURCE NAME	$^{234}U/^{238}U$ Activity Ratio	U μg/ℓ	FORMATION
44	Grofit 2	1,56 ± 0.02	12.26 ± 0,34	C
45	Yotvata 10	1,61 ± 0,05	8.77 ± 0.56	C
46	Yotvata 11	1.62 ± 0,02	9,65 ± 0.25	C
48	Yotvata 2	1,63 ± 0,06	7.25 ± 0,74	C
49	Timna 3	1,56 ± 0,01	11,47 ± 0.22	Al.
50	Timna 7	2,61 ± 0,03	5,98 ± 0.13	Al.
54	Tima Mine "Green Pool"	2,30 ± 0,18	1,70 ± 0,16	Paleozoic
55	Tima Mine - Spring	1,65 ± 0,24	0,36 ± 0,06	Paleozoic
56	En Netafim Spring	0,99 ± 0,02	14.83 ± 0.75	N.S. + C
57	Yaalon 1	2,33 ± 0,14	0,92 ± 0,06	N.S. +
58	Paran 13	1,33 ± 0,02	7,16 ± 0,19	Hazeva
80	Mitzpeh Shalem	1,77 ± 0,08	0.79 ± 0,03	Al, + C
81	Dead Sea Surface	1.52 ± 0,10	2.42 ± 0.19	
84	Migdal	1.24 ± 0,02	3,10 ± 0,07	Coastal
85	Yoav	1,23 ± 0,05	3,29 ± 0,12	Coastal
87	N, Boqeq	1.15 ± 0,01	11.3 ± 0.3	Sen.
88	Yad Mordechai-3	1.25 ± 0.02	3.29 ± 0.07	Coastal
89	Yad Mordechai-10	1.17 ± 0,02	3.19 ± 0,07	Coastal
90	Niram 6	1,19 ± 0,02	5,68 ± 0,11	Coastal
91	Niram 13	1,25 ± 0,01	6,28 ± 0,09	Coastal
92	Kfar Darom	1.14 ± 0,02	4.57 ± 0.14	Coastal
94	Zikim-1	1,21 ± 0.02	2,79 ± 0,07	Coastal

SAMPLE CODE NO.	SOURCE NAME	$^{234}U/^{238}U$ Activity Ratio	U µg/ℓ	FORMATION
95	Nahal Morag	1,17 ± 0,02	7,72 ± 0.26	Coastal
96	Nahal Katef	1,12 ± 0,07	4,82 ± 0.20	Coastal
97	Netzerim	1.18 ± 0,02	4,15 ± 0.11	Coastal
98	Maktesh Katan 1	4,05 ± 0,73	0,0065± 0,0011	N.S.
99	Maktesh Katan 2	1,44 ± 0,06	0.88 ± 0,05	N.S. + Jur.
100	Maktesh Katan 3	2.08 ± 0,40	0,0097± 0.0015	N.S.
101	Reim	1,16 ± 0,03	5,64 ± 0.21	Coastal
104	Yorke'am 1	1,95 ± 0,38	0,0081± 0,0013	N.S.
105	En Evrona 0-115M.	2,06 ± 0,29	0,019 ± 0,002	Al.
106	En Evrona 136-190M.	1,27 ± 0,12	0,058 ± 0,004	Al.

Abbreviations

Al = Alluvial Fill
N.S. = Cretaceous Nubian Sand
Sen = Senonian
C = Cenomanian
Lis = Lisan
Neo = Neogene
Jur = Jurassic Carbonate.

TABLE 2

CRYSTALLINE PROVINCE OF S. SINAI
(Major Recharge Region of Nubian Sands)

SAMPLE Code No.	SOURCE NAME	U^{234}/U^{238} Activity ratio	U µg/ℓ
137	Ein Portuga spring	1.90 ± 0.05	2.89 ± 0.20
138	Bir Ahdar well	2.09 ± 0.04	12.1 ± 0.07
139	Wadi Sakhab well	2.26 ± 0.05	21.4 ± 2.50
140	Bir Faranja well	3.03 ± 0.06	4.56 ± 0.28
141	wadi Sahl (new well)	3.16 ± 0.13	16.0 ± 0.8
142	wadi Sahl (old well)	2.69 ± 0.03	13.1 ± 0.2
143	wadi Nasseb well	2.35 ± 0.02	12.2 ± 0.51
144	Santa Katherina well	2.73 ± 0.11	9.3 ± 1.5
145	wadi Sheik Haron well	2.55 ± 0.07	13.1 ± 1.67
146	Jebul Nachlah well	2.23 ± 0.05	9.3 ± 0.8
147*	Bir Suwair well	1.62 ± 0.02	3.02 ± 0.21

*Sinai - coastal plain sample

TABLE 3

NEGEV WATER SOURCES
CENOMANIAN - TURONIAN AQUIFER SYSTEM
BEERSHEBA REGION

SAMPLE Code No.	SOURCE NAME	$^{234}U/^{238}U$ Activity ratio	U µg/ℓ
60	Ziklag-2	1.74 ± 0,04	2,98 ± 0.10
61	Ziklag-1	1,86 ± 0,02	3.44 ± 0,05
62	Ziklag-3	1,86 ± 0,04	3,29 ± 0.11
63	Mishmar Hanegev-2	1,13 ± 0,03	3.14 ± 0.09
64	Mishmar Hanegev-3	1,17 ± 0,05	1,54 ± 0,07
65 (1976)	Beersheva-2	1,03 ± 0,01	7,71 ± 0,13
(1977)		0.96 ± 0,04	8,23 ± 0,32
66	Beersheva-5	1,21 ± 0,04	4,79 ± 0,27
67	Beersheva-1	1,19 ± 0,02	6,30 ± 0,21
68	Beersheva-7	1,20 ± 0,03	5,49 ± 0,25
69	Beersheva-6	1,43 ± 0,04	3,65 ± 0,13
70	Hatzerim	1.10 ± 0,02	5,28 ± 0,16
71	Beersheva-9	1,59 ± 0,06	2,11 ± 0,09
72	Beersheva-8	1.40 ± 0,02	4,04 ± 0,11
73	Omer	1,45 ± 0,08	2,45 ± 0,17
74	Masabe Sade	1,27 ± 0,07	0,64 ± 0,03
75	Zeelim	1.31 ± 0.15	0,24 ± 0,02
76	Shoget	1,71 ± 0.05	1.52 ± 0.05
77	Beersheva-3	1,22 ± 0.09	5,33 ± 0.36
78	Nabatim	1.27 ± 0.04	0.36 ± 0.01

TABLE 4

WATER CHEMICAL ANALYSES
BEERSHEVA REGION

SOURCE NAME	pH	Na	K	Ca	Mg	Cl	HCO_3	SO_4
Ziklag-1	7.36	103	2.6	57	33	161	244	70
-2	7.30	77	2.3	61	33	131	258	52
-3	7.31	99	2.0	62	35	54	265	72
Mishmar HaNegev-2	7.19	162	4.2	75	40	266	254	113
-3	7.15	207	6.4	87	43	345	257	140
Beersheva-1	7.25	138	4.4	70	38	230	244	112
-2	7.5	150	3.2	74	43	262	244	123
-3	7.4	132	2.5	77	39	232	246	115
-5	7.5	134	2.5	68	40	227	242	104
-6	7.3	125	3.5	68	38	211	244	96
-7	7.22	132	1.8	75	36	213	242	112
-8		142	3.6	77	40	252	238	110
-9	7.35	64	2.3	56	32	111	241	47
Hatzerim	7.3	185	3.4	75	42	237	255	113
Omer	7.36	84	2.3	61	30	145	236	56
Masabe Sade	6.95	560	15	170	82	976	280	367
Shoqet		49	2.4	56	33	97	250	29
Nabatim	7.0					665		331
Zeelim	6.90	675	17	160	79	1129	317	333

Discussion

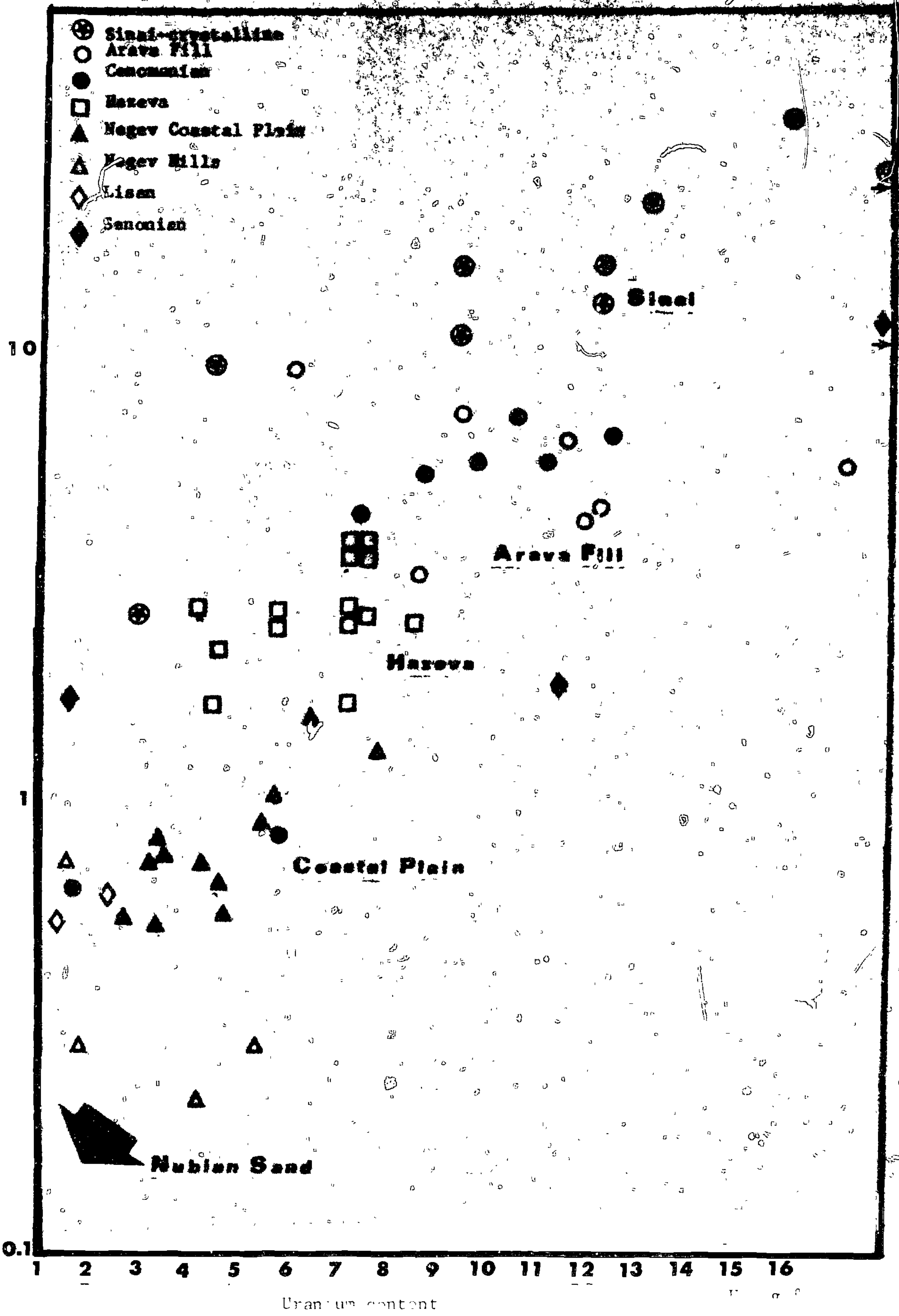
It can be seen from the data in tables 1, 2, 3, that both the Sinai and Negev are on the high side compared with representative groundwaters from many different regions of the world (13). The Sinai waters are characterized by a rather high disequilibrium ratio (2-3) and a high uranium content. The Negev waters are more variable and generally have a lower ratio and content. The Negev waters in turn have a generally higher uranium content than the waters to the north, in the Galilee, (14), the only other area for which such data is available in Israel.

The waters of the Negev are by and large oxygenated. Uranium that is taken into solution remains there as it flows through the aquifers. Exceptions to this are the waters from the deep Nubian Sandstone aquifer which is highly reducing. In addition, local reducing conditions that have been set up such as encountered by the En Evrona well (samples 105-106) drilled into a swamp-organic-rich sediment, as well as the swampy spring of Ein Shahag (no. 11), or in the sulfurated and reducing well of Ein Yahav 5 (no. 39), effectively remove uranium from solution. Therefore there exists a very large difference in the uranium concentration in the Negev waters due to changes in Eh conditions. The water of the Negev and Sinai can be identified upon the basis of their uranium content and uranium-234 excess. (The uranium-234 excess is defined as the uranium concentration multiplied by the activity ratio minus one). Figure 4 is a composite of Tables 1 and 2. Due to scale considerations the plot starts at uranium content of 1 μg/ℓ which includes all of the oxygenated samples. It can be seen that the different water sources have different groupings and that discrete water types can be identified by their uranium signatures. For example, the coastal aquifer is a rather coherent grouping. This is in good agreement with the published oxygen and hydrogen isotopic data for this aquifer (11). This grouping is similar to the four samples (No. 29-32) representing local surface waters from the Negev Hills, whose runoff is one of the sources of recharge of the coastal aquifer.

The Arava Fill waters are more variable in both content and ratio. There are several sources for waters entering the graben fill, which may originate from either Israeli or Jordanian sides. Locally two water types may exist within the fill column, one above the next, each representing a different source area. This can be illustrated by the waters from two horizons within the En Evrona well. The upper waters which are believed to be washing from the Timna mine region are distinctly different in isotopic ratio from the deeper waters which are believed to originate in Jordan (Amos Galay, personal communication). Though the scatter is larger these waters too appear to have distinct clustering. It is of interest to note that within this grouping lies six samples from the southern Arava (No. 42-48) whose wells are drilled into Cenomanian rocks. However these appear to be large blocks residing within the Graben fill and are not believed to be at present connected with the active Cenomanian aquifer. They appear to be pumping water representative of the fill within which they are encased. The in situ Cenomanian aquifer waters in the Arava region (No. 28, 34) are located in Figure 4 below and to the left of the Arava fill "Cenomanian", as would the Cenomanian-Turonian aquifer waters from the Beersheva region (table 3).

It has been proposed (6) that the Nubian Sandstone aquifer underlying the Negev is a potentially large and relatively untapped water source. Analysis of the stable isotopic composition of these waters from the samples taken in the Dead Sea region (6, 15) has shown that these are depleted in heavy isotopes

FIGURE 4 (22)



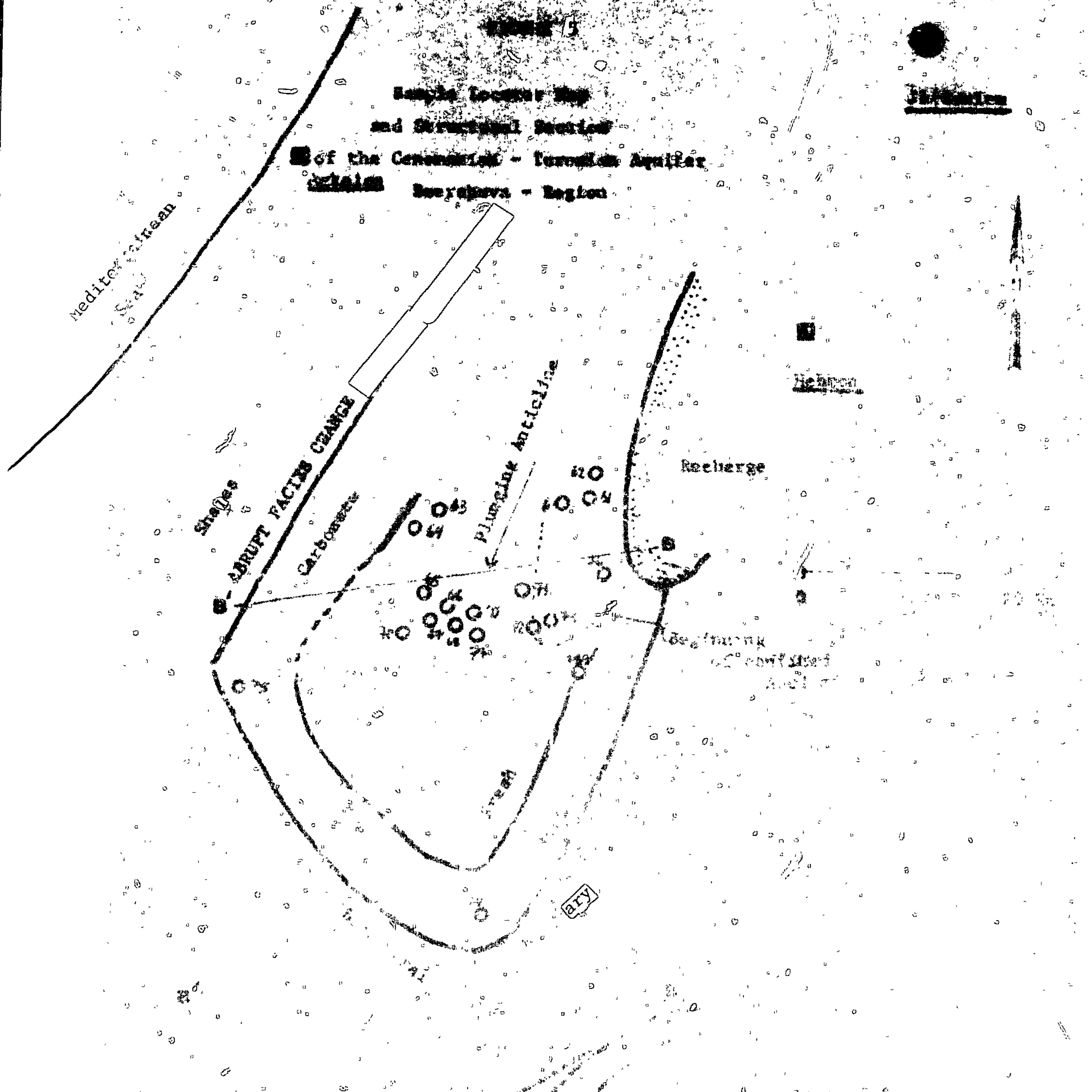
Sinai-crystalline
Arava Fill
Cenomanian
Hazeva
Negev Coastal Plain
Negev Hills
Lisan
Senonian
Sinai
Arava Fill
Hazeva
Coastal Plain
Nubian Sand
10
1
0.1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Uranium content

relative to other Negev waters carbon-14 (6) analyses in the Dead Sea Region yielded ages from 13000 to 30,000 years. One of the interesting hydrologic problems in the Negev at present is to define these waters, to see if they are a discrete and continuous aquifer extending, and to see if the source region can be detected. The current uranium isotopic work lack sufficient sampling points to answer all these questions. However it can be seen that the Nubian Sandstone waters do tend to differ from other overlying waters. They are characterized by a lower uranium content relatively nearby water sources and a relatively high degree of U-234 excess (ratios 2-4). It is possible that the uranium of the Nubian Sandstone did originate in the oxygenated Sinai environment and subsequently precipated upon entering the reducing conditions of the deep aquifer. The uranium ratios are not too disimilar to those of values characteristic of the crystalline Sinai waters (Table 2). It is also possible that these higher ratios merely reflect a selective input of U-234 by alpha-recoil processes within the aquifer after the uranium had precipitated. Only in the Northern Arava - Dead Sea Region do the samples (No. 22, 24, 98, 100, 104) exhibit sufficient simularity to say that the aquifer is distinct and continuous.

In the Beersheva Region a major water resource is found within the Cenomanian-Turonian aquifer that underlies the area. However not enough is known about the hydrology and geochemistry of the waters to enable the maximum effective exploitation of this resource. It is known that the recharge region is in the Judean Hills (Figure 5). The aquifer is within a basin whose outer limits to the west and south are anticlines. To the east the flow of water is restricted by an abrupt change in facies as the platform carbonates grude into a deep sea facies (Talme-Yaffe) shales and marls. Along the margins of the aquifer exists a very saline water whose origin and relationship to the sweeter water that exists from the recharge region to the center of the aquifer, is not established. A

Figure 5

Sample Location Map and Structural Section of the Cenomanian - Turonian Aquifer Beersheva - Region



potentiometric surface has not been established nor is the flow patterns of the water as it enters and flows through the aquifer, known.

Uranium isotopes were studied in the pumping wells of the region. It is felt that changes in the uranium content and isotopic ratio is related to the flow of the water within the aquifer. Three wells representing the saline waters were sampled (74, 75, 78), fourteen freshwater (60-62, 65-73, 76-77) and two wells from the Mishmar Hanegev wells, intermediate in salinity, were analysed. The uranium analyses are presented in Table 3. Table 4 presents analyses of the water chemistry.

The Saline waters are represented by a low uranium content and intermediate isotopic ratio. The uranium content in the fourteen sweet water wells exhibits an increase in uranium from the recharge region to the inner parts of the aquifer, accompanied by a corresponding decrease in isotopic ratio. The correlation coefficient between the ratio and the uranium content is - 81 for the 14 sweet water samples. The correlation decreases to - .58 when including the Mishmar Hanegev wells and - .34 when including the saline waters as well. Correlation between the calcium content and the uranium content yields a high degree of correlating 0.79 for the 14 sweet water samples, which decreases to a coefficient of correlation 0.36 when including the Mishmar Hanegev wells.

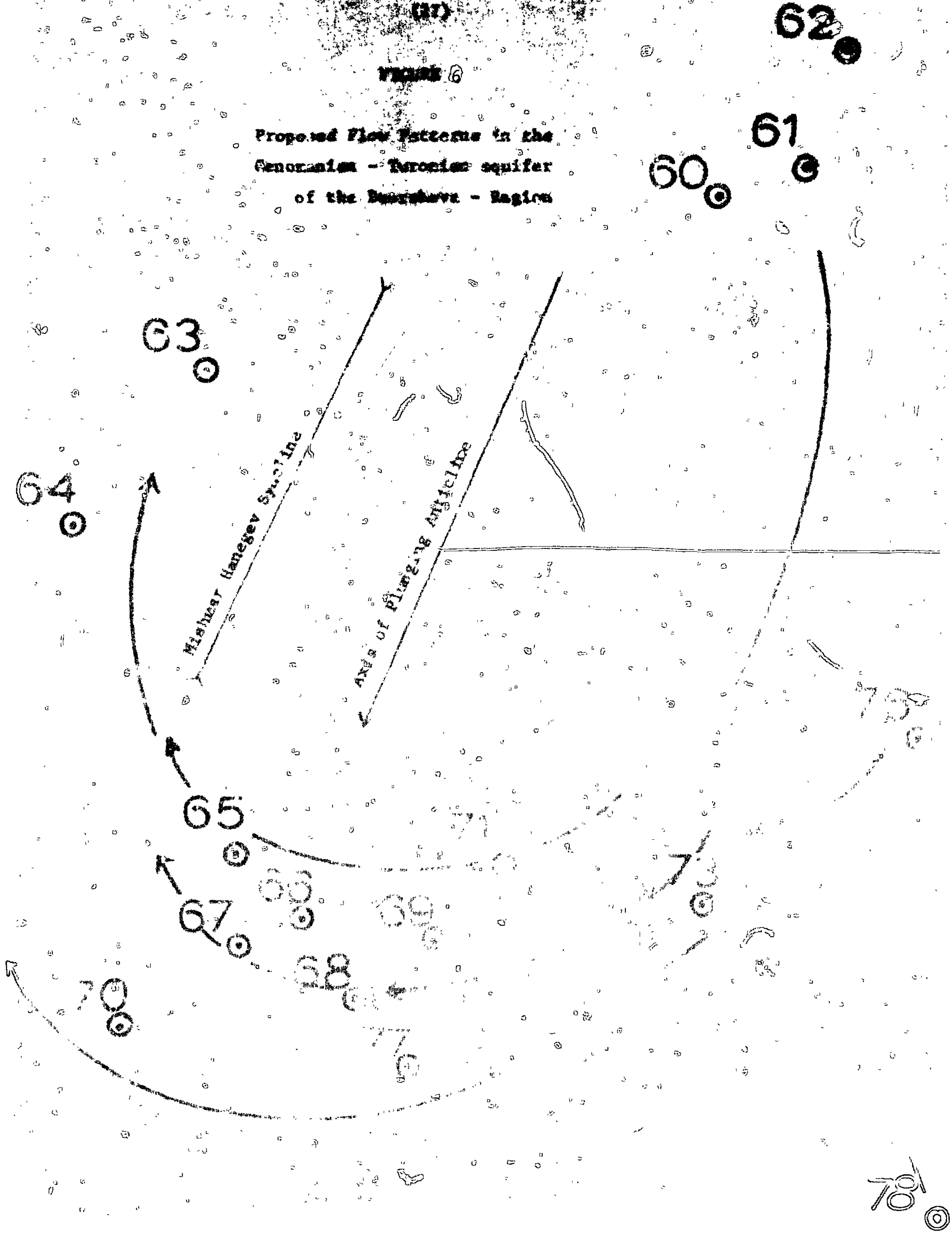
Likewise a high degree of correlation is found between the uranium content and the SO_4 content for the fourteen sweet water samples, 0.91. This decreases to 0.57 when including the Mishmar Hanegev wells. These correlations can help to explain the flow patterns within the aquifers.

Water flowing from the recharge region in the Ziklag field is not believed to be able to directly flow westwards due to a steeply plunging anticline that lies between the Ziklag field and the Mishmar Hanegev field. The anticline flattens out to the south. It is felt that the waters flow southwards towards the Omer well. At this point it is believed that these waters mingle with more salty waters flowing north east towards the Omer well from the Nabatim well (Yitzhak Kidron, personal communication).

The result of the mingling of the waters leads an intermediate value of the uranium content and ratio from the two end members. From that point onwards the waters flow eastwards. As they flow their uranium calcium and SO_4 content increases and the ratio decreases. This is interpreted as a isotopically selective leaching of the uranium from the overlying Senonian strata (Fig. 5). The Senonian phosphites are rich in organic material, sulphate, and uranium (100-200 ppm). This non-fractionated leaching raises the uranium content and lowers the isotopic ratio. Finally, the waters flow northwards, where they once more mingle with the saline waters of low uranium content to yield intermediate waters of the Mishmar Hanegev type. The proposed flow patterns are represented in Fig. 6.

FIGURE 6

Proposed Flow Patterns in the Cenomanian - Turonian aquifer of the Beersheva - Region



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