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SOHAR COPPER PROJECT

N. OMAN

HYDROGEOLOGICAL SURVEY OF

WADI SUQ

Jan '85

SOHAR COPPER PROJECT, NORTHERN OMAN

HYDROGEOLOGICAL SURVEY OF WADI SUQ

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Summary

A survey of groundwater conditions along the Wadi Suq has been undertaken to assess hydraulic connection with the Wadi Jizzi. This was required due to the potential risk of contaminating important groundwater supplies in the W. Jizzi from the use of seawater in the operations of the Oman Mining Company.

In the upper reach of the W. Suq (above Sihlat, Km 14) and of the W. Jizzi (above W. Lasail) groundwater occurs in wadi deposits, weathered bedrock and in deeper fractures. In this area the W. Suq is at a higher elevation than the W. Jizzi and a potential hydraulic gradient must therefore exist. However, shallow groundwater along the W. Suq is contained within partially interconnected sub-basins, and is most unlikely to be in direct hydraulic connection with the W. Jizzi. The deeper groundwaters are also likely to be separated by a major NE trending fault between the two wadis. Consequently, it would not appear that any contamination from the OMC tailings dam will affect the upper reach of the W. Jizzi.

The two wadis are in direct hydraulic connection between Bani Kabir and the coast. However, this is no cause for concern since the surface and groundwater flow is from the W. Jizzi towards the W. Suq. Hence, groundwater supplies in the W. Jizzi fan are very unlikely to be affected should the lower reach of the W. Suq become contaminated.

SOHAR COPPER PROJECT,
NORTHERN OMAN

HYDROGEOLGOICAL SURVEY OF WADI SUQ

A. GENERAL

1. INTRODUCTION

The Council for the Conservation of the Environment and Pollution Prevention (CCEP) are concerned that seawater used for the copper plant operations in the Wadi Suq should not contaminate important groundwater supplies in the adjacent Wadi Jizzi.

A survey by the Water Resources Council has suggested that these two wadis are connected. In view of this possiblity, a visit was made to the copper smelting plant area at Sohar by a hydrogeologist from the Institute of Hydrology (UK) between 11 and 18 September 1984. The purpose of this visit being to survey the hydrogeological conditions along the W. Suq and from this survey assess whether hydraulic connection with the W. Jizzi is likely. The visit was undertaken on behalf of WLPU at the request of the Oman Mining Company (OMC).

Various preventative measures are already taken by OMC to reduce the risk of contamination from their tailings dam situated in the headwaters of the W. Suq. In addition, water levels and water samples are taken from monitoring wells downstream of the dam on a regular and frequent basis. The results of the monitoring programme indicate that the W. Suq is being contaminated by water from the tailings pond.

The W. Suq is not an important source of groundwater supply but for much of the length runs parallel and close to the W. Jizzi, a major source of groundwater on the Batinah.

The W. Suq can be subdivided at Sihlat (Km 14) into an upper and lower reach, each having different geological controls on interconnection with the W. Jizzi.

The W. Jizzi has also been subdivided at the confluence with the W. Lasail, with the upper reach extending upstream to about 2 km above the Lasail mine road where the water table elevation in the channel deposits is similar to the elevation of the tailings pond.

It is not known whether groundwater occurs in the area separating the W. Suq - W. Jizzi as no exploratory drilling appears to have been undertaken. Without such a programme of drilling a direct link between the two wadis along most of the W. Suq cannot be established. Consequently, we can only examine at this stage the potential for interconnection by establishing if an aquifer(s) is present that may link the two wadis and whether a gradient exists from the W. Suq towards the W. Jizzi.

2. AVAILABILITY OF INFORMATION

There is comparatively little regional hydrogeological information with the exception of a water resources survey of the W. Jizzi basin carried out by the Japan International Co-operation Agency (JICA) in 1982(1). This study largely excluded the W. Suq but has been used to examine interconnection in the Batinah region.

On a more local scale, the following previous studies have been carried out:

(a) Exploratory drilling and testing for water supplies around the plant and mine sites (Lasail, Aarja-Baida mines) and at the Magan township by Lavori in 1980(2). Simplified logs are available for ten boreholes together with simple yield-drawdown data where yields were sufficient for testing.

(b) In 1983 PAWR carried out a survey of efluent discharge at the plant and mine sites to assess potential effects on groundwater(3). A survey of wells was undertaken and water samples collected for major ion analysis, mainly to supplement the OMC and PAWR monitoring programmes.

(c) The area of the tailings pond has been investigated in detail for geotechnical information. This included a number of shallow boreholes and trial pits and four boreholes (MW1 to MW4) for routine monitoring purposes. Geological logs are available for most of these sites, together with six lugeon tests in bedrock and four sieve analyses of the wadi gravels.

(d) A survey was made by WLPU in October 1984 to identify the causes of seepage into the W. Suq dowstream of the trench[4].

We have been unable to examine the report concerning the preliminary survey by the WRC regarding interconnection between the two wadis.

3. GENERAL GEOLOGY

A geological map of the area (from Map 2 of the Oman Ophiolite Project is shown as Figure 1. A generalized succession is given in Table 1.

The area has a complex geology and structure and has been subject to prolonged weathering and erosion. Cemented, calcareous conglomerates of Quaternary age cover much of the area which comprises hills of moderate relief.

The succession has a regional eastward dip and is affected by major NE trending faults in particular, although other fracture patterns can also be distinguished. The W. Jizzi follows an NE trending graben along its upper reach.

The W. Suq traverses an extrusive sequence of pillow lavas of the Semail Ophiolite, limestones of the Hawasina Melange and a shallow water sedimentary sequence of Tertiary age before reaching the coastal plain. Outcrops are less frequent in the W. Jizzi but the succession is probably similar to that of the W. Suq but displaced by the bounding graben faults.

High level cemented calcareous conglomerate terraces up to 250 m OD extend from the W. Suq to the W. Bargah and are associated with the proto-W. Jizzi. They appear to increase in thickness towards the W. Jizzi

Table 1. **Geological Succession**

Age	Formation	Remarks
Quarternary	Alluvium	Unconsolidated to partly consolidated, poorly sorted. Occurs along wadi channels and forms coastal basin of Batinah
	Terrace conglomerates	Four levels identified. Very poorly sorted, consolidated with hard calcareous cement.
Tertiary	Mudstones and limestones	Form occasional low reflief hills and outcrops at the edge of the Batinah.
Mesozoic	Hawasina Melange	Monadnocks, mainly in upper part of lower wadi reach
	Semail Ophiolite Complex	Zonally arranged from east to west, mainly volcanic extrusives, widely distributed in upper reach of wadis
	Hawasina Group	Chart and siliceous limestones, mainly along upper reach of W. Jizzi.

and slope towards the coast on an eroded bedrock surface. The W. Suq may represent an advanced form of the gullying developed on the interfluvial area.

Recent wadi bed level terrace gravels rest directly on bedrock along the W. Suq. These are partly cemented and some 2-3 m higher than the modern active channel.

The important general features of the geology in relation to the hydrogeological conditions include the following:

- the active wadi channel deposits will have a much higher permeability than the wadi level terraces. Intergranular flow will take place preferentially in and along the modern channel deposits.

a weathered zone is present beneath the wadi channel sediments on an irregular unweathered bedrock surface where harder, less weathered zones form rock bars.

- groundwater within the bedrock at greater depth and in the high level conglomerates will be restricted to fractures, as faults and joints, producing a complex groundwater flow pattern and a very variable permeability.

4. STUDY APPROACH

The hydrogeological conditions suggested by the regional geology together with the more detailed information in the area of the tailings dam were used to identify the main features influencing the occurrence of groundwater. This was then extended using aerial photo-interpretation (1981, stereo pairs at scale 1:30 000) supported by ground traverses along the W. Suq and southwards across the divide at accessible points. A traverse was also made along the gas pipeline across the W. Jizzi fan. Topographic (1:50 000) and geological maps (1: 100 000) were available to assist with the interpretation and to construct sections.

During the survey of the W. Suq seepage areas were mapped and two pits dug downstream of MW3 for water level data and water samples in the channel deposits. Water levels were also measured in existing wells and pits and water samples collected from 13 locations for major ion analysis to examine similarities in water composition, water quality and the extent of contamination downstream of the tailings dam. Unfortunately, PAWR laboratory have only carried out a partial and heavy metal analysis on each sample which has resticted the use of hydrogeochemistry in evaluating interconnection and processes.

We are familiar with wadi systems in Oman from several previous studies, including the Water Resources Survey of Northern Oman[6)], and have therefore been able to draw upon this experience in our survey.

B. HYDROGEOLOGICAL SURVEY

The W. Suq and W. Jizzi run parallel to each other and about 1.5 Km apart from the tailings dam area for about 8 Km to Sihlat (Km 14). At this point they diverge around low hills until the northern flood channels of the W. Jizzi join the W. Suq 5 to 9 km inland from the coast in the area of Bani Jabir.

Logitudinal wadi profiles show that for the same distance from the coast the upper reach of the W. Suq has a higher elevation than the W. Jizzi. A potential gradient must therefore exist from the W. Suq towards the W. Jizzi. Consequently, we have examined whether there might exist a possible groundwater connection across the divide.

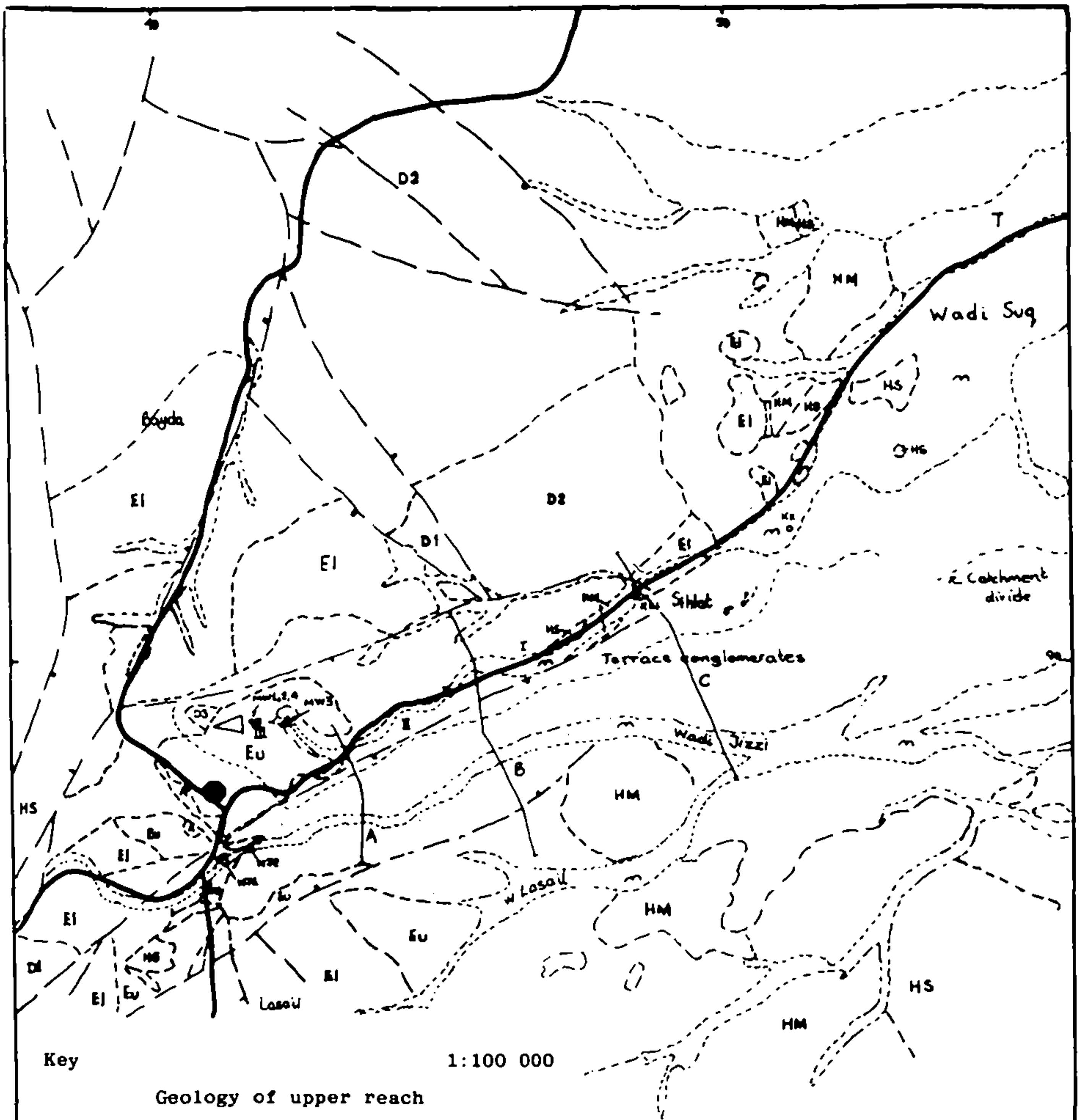
In contrast, the lower part of the W. Suq is slightly below or at the same elevation as the W. Jizzi. Since the alluvium of two wadis coalesce near the coast there must exist some hydraulic connection between them, but in this area it is the direction of groundwater flow which would determine the effects of any contamination.

UPPER REACH OF W SUQ: Shallow Groundwater Occurrence

The W. Suq has an average width of about 100 m widening to about 400 m towards Sihlat with an active channel width of about 40 m. The wadi is about 230 m OD at the tailings dam and about 140 m OD at Km 14. Accacia trees are common indicating infrequent floods and shallow, permanent groundwater.

Throughout the length of the upper reach the wadi is cut into bedrock (predominantly extrusive volcanics) below the level of the high terrace cemented conglomerates. The gravels which cover the wadi slopes are derived from these conglomerates. The wadi channel deposits are not in contact with the conglomerates and interconnection cannot occur through these.

The bedrock surface beneath the conglomerates on the wadi sides has an irregular relief. As far as could be observed, this erosion surface is always higher than the level of the wadi. Consequently, there does not



Key 1:100 000

Geology of upper reach

Dam

Plant Site

Wells K14

Sub-basins III

Section lines A

Faults

Tertiary T

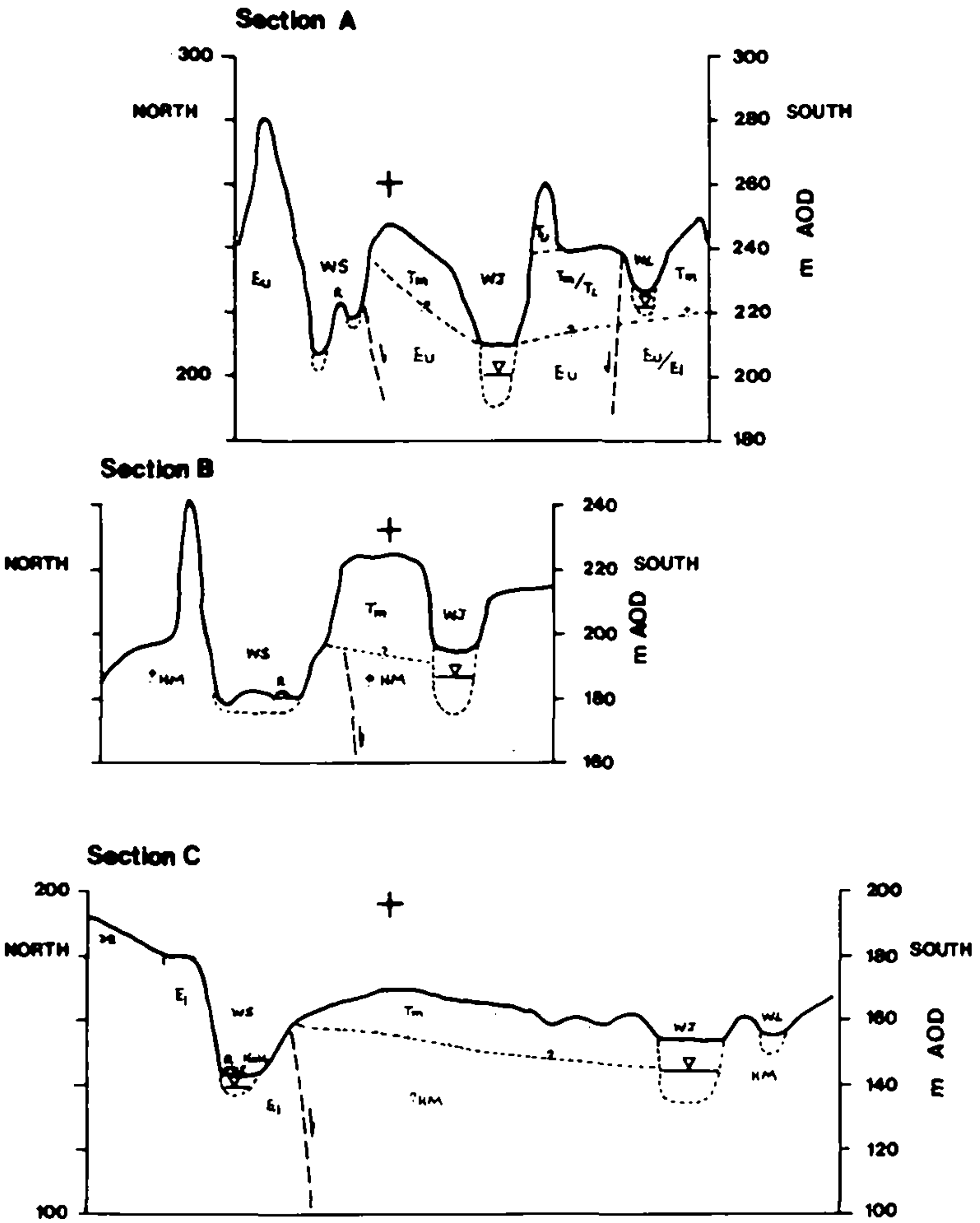
Hawasina Melange HM

Extrusives (Semail Ophiolites) Eu E1

Hawasina Group HS

Figure 1

Vertical sections : Upper W. Suq and W. Jizzi



HORIZONTAL SCALE 1:50,000

WS	W. Suq	+	Catchment divide	T_u	Upper, middle and lower terraces
WJ	W. Jizzi	R	Road	T_m	
WL	W. Lasail	▽	Water level	T_l	
			Fault	T_y	Tertiary sediments
		↓	Active wadi channel	HM	Hanasina Melange
		F	Falaj	E_u	Upper and lower extrusives
				E_l	
				HS	Hanasina series

Figure 2

appear to be any abandoned valleys in a southward direction that could connect the W. Suq to the W. Jizzi.

Whilst the depth of weathering is variable, relatively fresh bedrock forms the wadi sides to a general height of some 20 m above the wadi bed. Hence, even though the depth of weathering beneath the wadi bed may reach some 8 m, the thickness decreases towards the sides of the wadi. A continuous, saturated weathered zone does not therefore extend south from the W. Suq and any transfer of groundwater would have to take place in deeper zones within the bedrock. This is discussed further in the subsequent section.

Together the alluvial deposits and underlying weathered bedrock form a single hydraulic unit within the wadi channel which varies in both thickness and aquifer properties. Groundwater is present mainly within the weathered bedrock and the lower part of the alluvial deposits. The water table has a similar slope to the wadi channel of about 0.011. In the upper narrow parts of the wadi water levels are generally 1 to 2 m below ground level but where the wadi broadens out levels may be 5 m bgl and the saturated thickness reduced correspondingly.

Irregularities in the depth of weathering or erosion along the wadi channel have left rock bars which divide the wadi deposits of the upper reach into at least three partially connected groundwater basins (Figure 1):

From Km 14 to the roadbridge 4 Km upstream

II Roadbridge to MW3 (about 3 Km)

III Tailings dam area above MW3 (about 1 Km)

The rock bars restrict flow in a downstream direction and have given rise to seepages at low points along the channel at MW3 and for 3 Km downstream. The trial pits dug about 550 and 800 m downstream of MW3 encountered water in a thin zone on top of the weathered, broken bedrock at about 1.5 m depth.

A poor quality sodium-chloride-sulphate water containing about 600 mg/l chloride occurs at Km 14 well (Table 2 and Figure 2). A recent sample from this well shows a drop in sulphate content from 630 mg/l in February 1983 to 127 mg/l. This well is also monitored regularly by OMC. Poor quality water with 620 = 650 mg/l sulphate was also recorded at the trial pits downstream of MW3 (Table 3). These results indicate the occurrence of poor quality water along the upper reach of the W. Suq, which may be partly due to contamination from the tailings dam or from the seawater pipeline. However, wells K14 JD and K14 JU in the wadi entering the W. Suq at Km 14 from the north also have poor quality water with 250 to nearly 800 mg/l sulphate (Table 2) and of a similar composition to Km 14 well. This indicates that the natural groundwater is of a generally poor quality.

The presence of shallow, poor quality groundwater suggests restricted groundwater circulation in a downstream direction as well as poor connection between the wadi channel and any deeper permeable zones.

The survey along the upper part of the W. Suq strongly suggests that the shallow groundwater along wadi channel is not in connection with the W. Jizzi. However, contamination may spread through deeper zones and evidence for any deeper groundwater movement relies mainly on the information from around the plant and dam area.

2. TAILINGS DAM AREA: Evidence for Fissure Flow

Leakage occurs at the foot of the tailings dam, which rests on wadi deposits. This water is collected in a system of ditches, which connects to the interception trench, or by the lined trench itself. Water which bypasses the trench will be moving within the bedrock.

The high total dissolved solids (TDS) at monitoring well MW4 and the correlation with TDS changes in the trench or lagoon shows that water is bypassing the trench. Since this well is drilled directly into bedrock water must be moving through weathered and/or fractured zones. A fracture zone was reported at MW4 at 13.4 = 15.2 m bgl and the general depth of weathering extends to a depth of 7 to 8 m. The log of MW2, in the wadi channel itself, shows that deeper zones of weathering occur (at 12-14 and

Table 2. Water Analysis Results

Location	Source	pH	EC umhos	Na		ACO_3 mg/l	SO_4
W. Suq							
MW1 (N689062/E441749)	Monitoring well	7.56	4725	380	10.0	170.9	1380
MW2 (N689065/E441823)		6.55	5418	450	7.0	132.75	1150
MW4 (N688963/E441884)		6.72	24885	1810	26	78.92	1450
Seepage at MW3	Seepage	7.59	14164	888	7.5	155.22	1240
LHB pit 50 m upstream MW3	Pit	7.73	5670	870	4.5	206.44	780
MW3 (N689092/E442495	Monitoring well	7.91	2625	312	10.4	300	144
Middle pit 100 m downstream MW3	Pit	7.37	12075	970	13	96.69	1220
Pit 550 m downstream MW3 (N688522/E442881)	Pit	7.20	5040	575	3.5	182.4	650
Pit 800 m downstream MW3 (N688495/E443687)	Pit	7.43	3885	435	6.0	154.7	620
Pool 100 m downstream bridge on W. Suq	Pool	8.28	3360	600	8.5	179.26	620
K14	Well	7.51	3601	665	4.0	372.12	127.5
K11	Well	7.73	1512	264	2.4	227.35	150
W. Jizzi							
WJ2 (N686757/E441309)	Test well	8.21	724	56	3.2	221.08	41

Analyses undertaken by PAWR Laboratory, Muscat

Samples collected 14 to 16 December 1984

Table 3. **Chemical Analyses (W. Suq)**

Reference	Date	EC mmhos	Ca	Mg	Na	HCO_3 mg/l	Cl	SO_4
Interception ditch	24.11.82	1750	113	37	195	186	417	152
JP well, S. side of tailings pond	8. 3.83	921	10		221	339	83	132
MW1	21. 2.83	1685	84	49	204	235	240	215
MW3	21. 2.83	1220	46	25	203	268	133	136
K14	21. 2.83	3910	84	85	640	459	619	630
K14JD	21. 2.83	5300	116	77	1030	408	1000	788
K14JU	21.2.83	2420	132	44	330	303	411	248

From PAWR, 1983

Sohar copper mine

: W. Suq - W. Jizzi study

Trilinear plot of chemical analyses

W Well in wadi near W. Lasail

LM, BM Mine seepage Lasail, Bayda mines

D Collector trench at tailings dam pre-use of seawater on large scale

(ref Table 2)

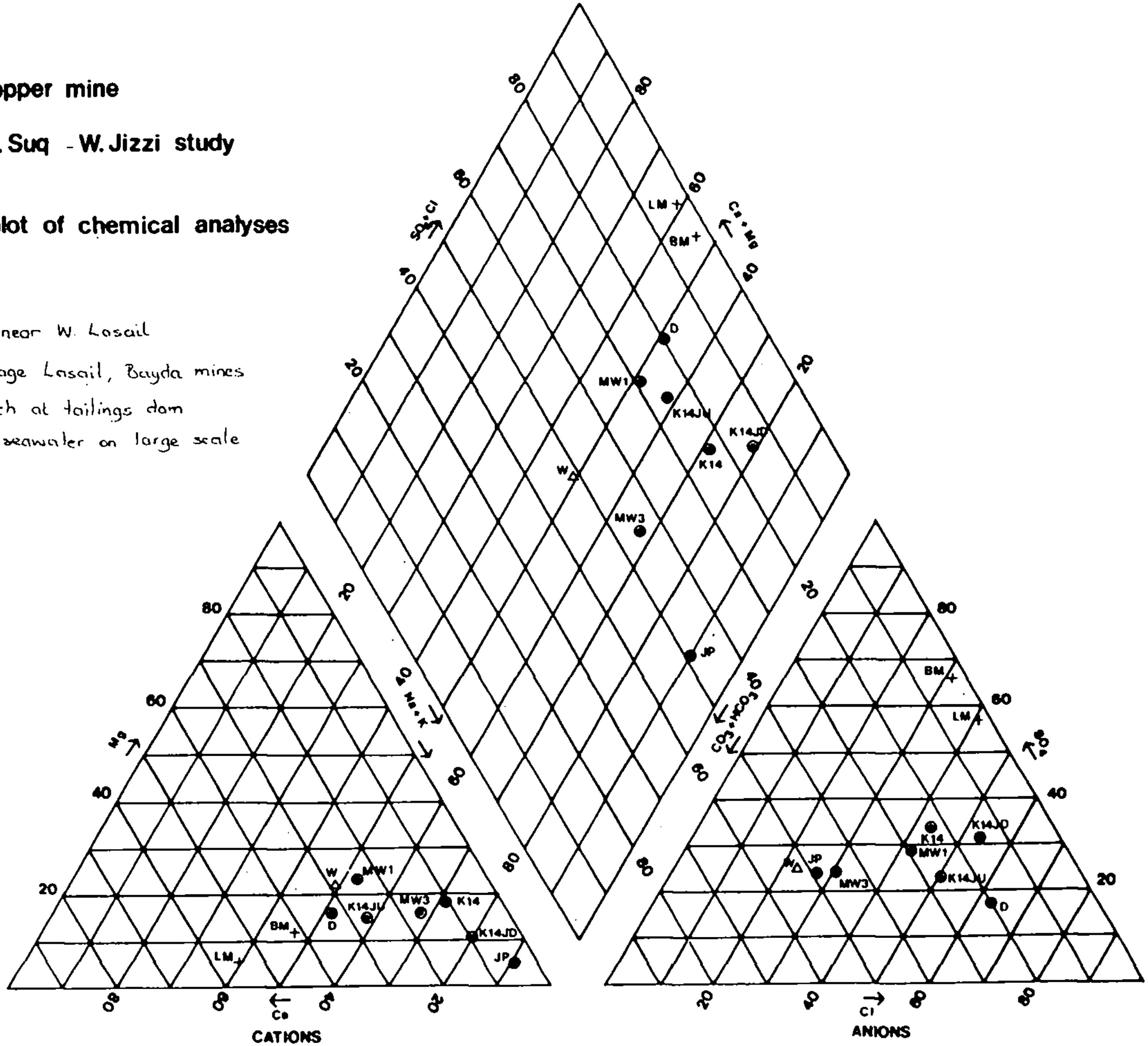


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Figure 3

17-21 m bgl), although the TDS at this site is similar to MW1 and much lower than MW4.

A recent geological survey by WLPU suggests that water is moving at a relatively shallow depth along preferred zones in weathered volcanics from the southern part of the tailings lagoon; the interception trench does not extend along the southern 50 m of the tailings dam. Recent deposition of tailings in the this part of the tailings pond may have reduced the seepage loss.

A seepage zone has appeared east of MW4, where saline water of a similar TDS to MW4 emerges from the lava sequence. The discharge has remained constant at about 1 l/s (86 m^3/d). It would appear that the hills which restrict the wadi channel at MW3 provide a barrier to groundwater flow forcing water to the surface.

An area of low relief which extends south from MW4 was examined due to the possibility of southward migration of saline water through this area towards the W. Jizzi. A catchment divide occurs just north of the main road and the land slopes north-east towards the seepage above MW3. Thus the seepage zone occurs at the lowest point within this area which is also situated on a possible NE trending structure. Although the alternating lava-umber sequence dips SW in this area, the umber band themselves would probably also limit any southward movement of saline water.

Monitoring well MW3, although at the downstream edge of the saline seepage zone, has a different water composition to the nearby seepage and a TDS only slightly above natural levels. A slow but steady increase in TDS has occurred at MW3 since May 1984 but the water composition is associated with water moving in deeper weathered zones and indicates possible isolation of these from the channel sequence.

Exploratory wells PS1 and PS2 drilled by Lavori near the JP Camp and the overpass at the plant site were drilled to depths of 43.3 and 104.25 m respectively into the ophiolite sequence. At PS1 fissures were encountered containing groundwater at 26.5, 29.0 and 36.6 m. Water was struck at 26.5 m under confined conditions rising to 15.25 m bgl, with the main supply at 36.6 m. Site PS2 did not encounter any fissures and was dry.

WLPU report that the lava flows contain a maze of small voids which form preferential drainage paths and could produce higher permeabilities and that dykes which cut across the sequence, are heavily jointed at right angles to their contact could also be relatively permeable. Minor faults are common, although most appear to be infilled by calcite. At least three joint directions have been identified in the lava sequence, one set corresponding to columnar jointing at some localities.

High permeabilities can occur in lava sequences but are usually associated with sub-aerial extrusives. The pillow lavas were formed under submarine conditions and would tend to have a secondary permeability associated more with columnar jointing or fracturing. Transmissivities in the extrusive sequence are low; at PS1 the transmissivity from approximation methods is about 10 = 15 m^2d and lugeon tests in the area of the dam indicate permeabilities of only about 1 m/d.

The limited information on groundwater occurrence within bedrock, including seepage flow at the mines, indicates the role of fissuring within bedrock. Wells MW3 and PS1 suggest limited contact between the wadi deposits and shallow bedrock water bearing zones. The direction and even occurrence of groundwater flow in bedrock fissures is variable and largely unpredictable.

3. UPPER REACH OF WADI JIZZI

Above the Wadi Lasail confluence the Wadi Jizzi channel is some 250-300 m wide with at least 20 m thickness of coarse wadi sediments. Vegetation is absent along the channel.

There are three wells on the north flank of the wadi one kilometre upstream of the plant site. These provide potable water for the plant site and are the only groundwater abstraction in this upper reach. At this location and for about 1 km downstream the channel deposits rest on bedrock, the wadi bed being at about the level of the junction between bedrock and the overlying cemented conglomerates. Further downstream the wadi bed appears to be in contact with these conglomerates.

Test wells WJ1 and WJ2, drilled in 1980 at the plant site abstraction well location and 750 m downstream respectively in the centre of the wadi, encountered at least 20 m of wadi gravels with a 10 m saturated thickness. Their rest water levels are at about the same elevation as MW3 and the downstream gradient is about the same as the wadi bed. Pumping tests on these wells at 27.7 l/s (2400 m^3/d) produced no measurable drawdown and indicate very high permeabilities which are often associated with clean wadi gravels. The water chemistry at WJ2, based on the recent partial analysis, and would not appear to be influenced by water from the W. Suq.

Our survey of the W. Suq indicates that the wadi channels of the Suq and Jizzi are isolated from each other but that groundwater is also present in bedrock fissures. A major NE trending graben fault down-throwing to the south separates the Suq and Jizzi (see Figure 1). It is difficult to establish, due to the cover of calcareous conglomerates across the watershed, whether the SE trending fractures cross this major fault or which parts of the sequence are brought into juxtaposition. The fault extends to at least Km 14 and probably further northeast along the Suq. We consider that this major fault could act as a barrier to any southward flow of groundwater in deeper fissures that may originate in the W Suq, if only by intercepting such flow.

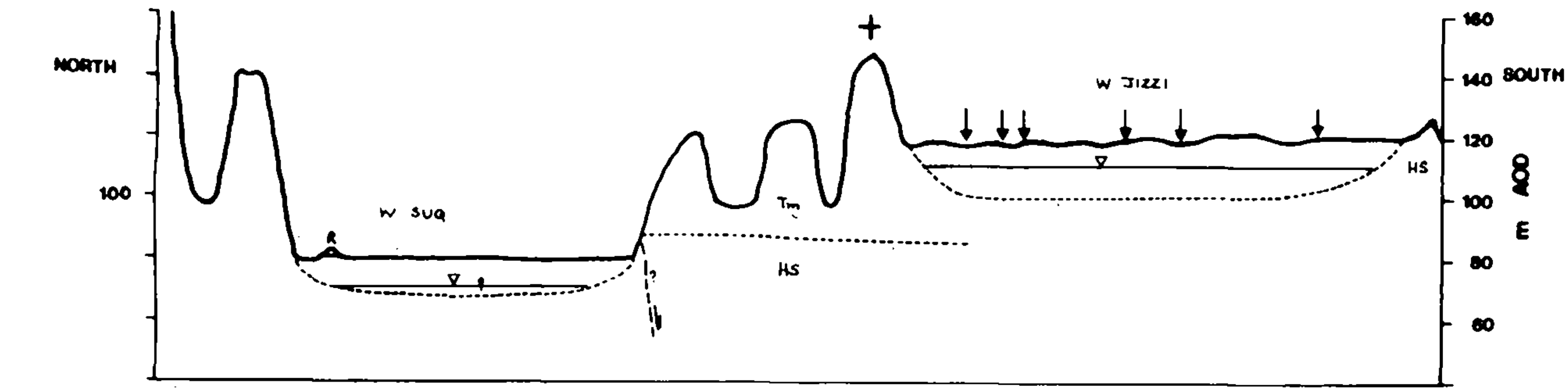
LOWER REACHES OF W. SUQ AND W. JIZZI

The W. Suq broadens out to about 1 km wide downstream of Km 14 at Sihlat before reaching the Batinah in the area of Magan and the coast at Majis. Over this reach the two wadis are some 4 km apart, separated by low hills of Hawasina and Tertiary rocks. The W. Jizzi forms a wide alluvial fan of a higher elevation than the W. Suq until near the coast. The northern flood distributaries of the W. Jizzi join the W. Suq over a reach of some 3 km between Magan and Bani Jabir. The coastal basin of the W. Jizzi is believed to close along the line of the W. Suq due to shallow bedrock.

To the south-east of Km 14 there is an area of date gardens and an abandoned falaj with a small seepage is present upsteam at about 150 m elevation, athough the origin could not be identified. At about Km 11 there is a well on the south side of the W. Suq with a water level 14.0 m bgl (about 100 m OD). An abandoned falaj, part of the Falaj al Qabail, extends along this reach of the W. Suq.

Vertical section : Lower W. Suq and W. Jizzi

Section D



HORIZONTAL SCALE 1: 50,000

Section E

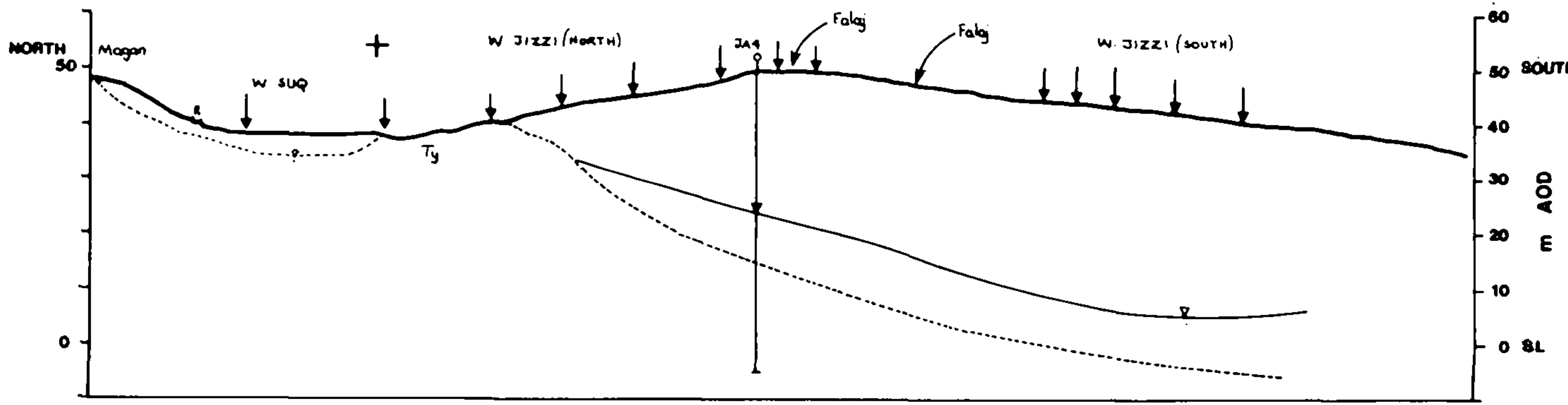


Figure 4

HYDROGEOLOGY OF LOWER WADI JIZZI

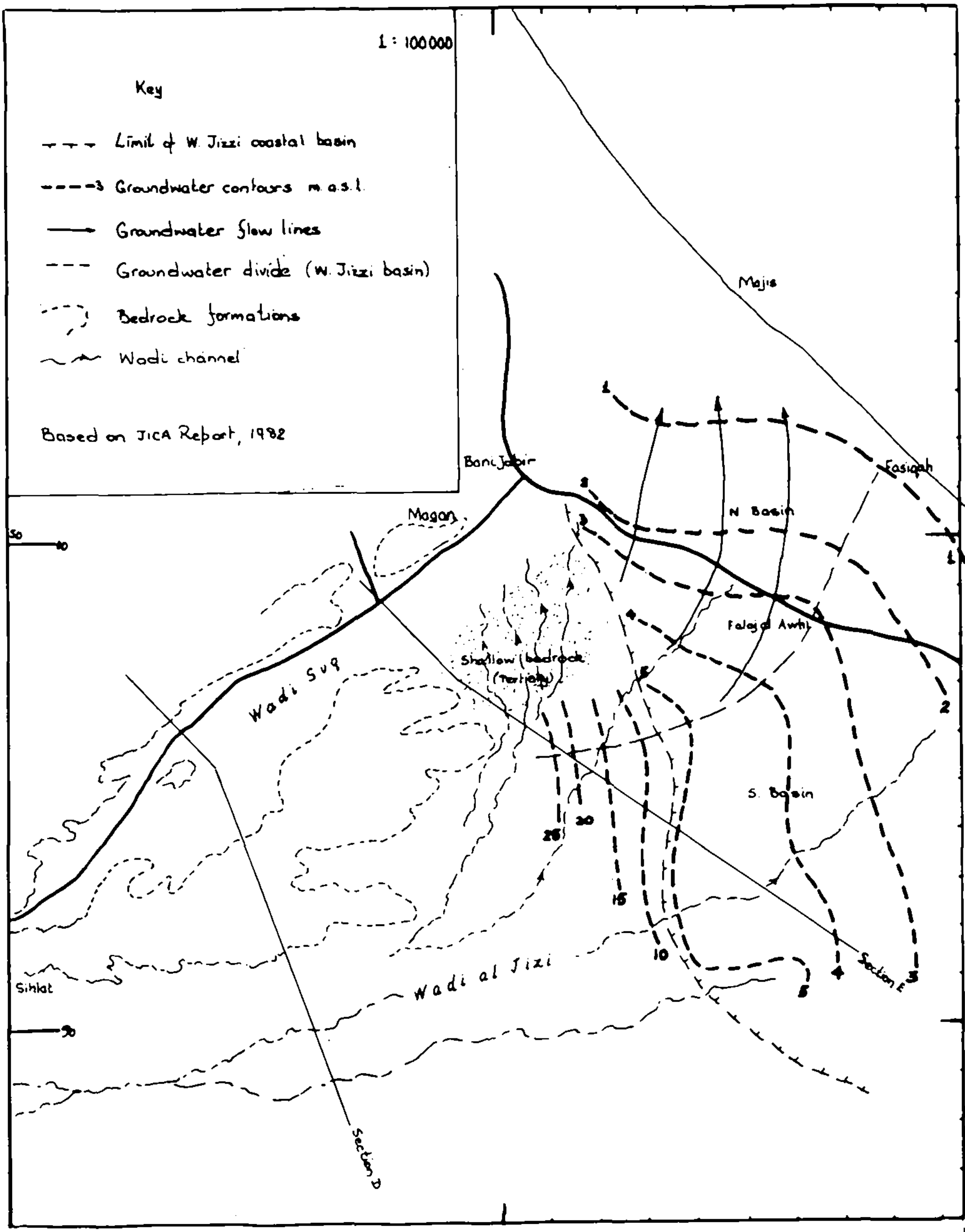


Figure 5

Figure 5 shows the lower part of the W. Suq and northern area of the W. Jizzi coastal alluvial basin (from JICA, 1982). Due to the relatively thin cover of alluvium on the Tertiary sediments around well TS6, the alluvial deposits of the W. Suq and W. Jizzi do not become hydraulically connected until the western edge of the coastal alluvial basin just south of Bani Kabir, some 5 km inland.

A groundwater mound extends from the upper part of the W. Jizzi alluvial fan along the line of the Falaj al Awhi to the coast at Fasiqah, separating the northern part of the W. Jizzi basin. The groundwater flow lines shown in Figure 5 demonstrate that recharge from the northern W. Jizzi distributaries is conveyed around the shallow bedrock area towards the W. Suq in response to the greater volume of recharge from the W. Jizzi. This pattern is sustained throughout the year, and would only be altered by large scale abstraction in the area north of Al Awhi, which in turn would be limited by the more serious risk of upconing and ingress of the coastal saline water interface in response to such abstraction.

Hence, although the lowest few kilometres of the W. Suq are in hydraulic connection, groundwater as well as surface water flow is from the W. Jizzi towards the W. Suq in this area and would thus effectively isolate any saline water contamination along the W. Suq.

CONCLUSIONS

Our hydrogeological survey of the Wadi Suq in conjunction with existing information indicate the following regarding hydraulic connection between the Wadi Suq and Wadi Jizzi:

* Shallow groundwater in the alluvial sediments and weathered bedrock are contained within several basins along the upper reach above Sihlat (Km 14). There would appear to be no shallow connection between the wadi channels deposits of the W. Suq and W. Jizzi in the upper reach.

* There is evidence to suggest the occurrence of deeper groundwater movement in fissures. Since there is a topographic gradient towards the W. Jizzi, a hydraulic connection in deeper zones cannot be entirely discounted. However, a major NE trending fault is likely to isolate the W. Suq from the W. Jizzi.

* Direct hydraulic connection occurs within the alluvial plain deposits in the lower reach of the W. Suq between Bani Kabir and the coast. However, the surface and hydraulic gradients are towards the W. Suq from the W. Jizzi. There is a far greater risk of contamination from upconing or inland movement of the coastal saline water interface

Under the terms of reference, this survey has only considered the extent of hydraulic connection between the W. Suq and W. Jizzi and we have concluded that the W. Suq is effectively isolated from the W. Jizzi. The immediate area downstream of the tailings dam in the W. Suq is being affected by contamination despite the preventative measures being taken by OMC but the volume of water involved is small, perhaps 30 000 m^3/year (based on the seepage flow at well MW3). The risk to groundwater supplies from the OMC operations should, however, also take into account dilution factors and other water quality considerations, such as:

- natural groundwater in the W. Suq is generally unsuitable for potable use.
- flood flows are estimated as 0.6 million m^3/year on the W. Suq, of which 0.4 million m^3 forms groundwater baseflow in the wadi deposits(5), and would dilute any contamination.

- water is contained within partially connected basins along the W. Suq and will not spread rapidly downstream.

- groundwater in the Bani Kabir area of the W. Suq may be influenced more by saline water upconing from the coastal saline water interface.

- groundwater inflow from the W. Jizzi towards the W. Suq downstream of Bani Kabir is estimated as 5 million m^3/year (from JICA information) which would further dilute any contamination.

- should saline water ever enter the upper reach of the W. Jizzi via fractures it will be diluted by floods and groundwater baseflow in the W. Jizzi sediments of 9 and about 4 million m^3/year respectively(4)

Consequently, it is exceedingly unlikely that the potability of groundwater supplies in the W. Jizzi will be noticeably affected by the OMC operations.

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