FIGURES
Fig 1 Hard Rock Geological Formations of India
(After Singh 1985)

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- Sandstone, Shales, Conglomerates
- Deccan Traps, Basalts
- Granitic Gneisses, Schists, Phyllites, Quartzites, etc.
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- Sunshine
- Precipitation
- Evaporation
- Wind velocity
- Saturation vapor pressure
- Relative humidity
- Temperature

Graphs showing variation over time.
FIG 8 CROSS SECTIONS ALONG LATITUDES

VERTICAL 1 CM 1000 M
HORIZONTAL 1 CM - 2000 M

SCALE
VERTICAL 1 CM 1000 M
HORIZONTAL 1 CM - 2000 M
FIG 12 CHANNEL GRADIENTS

SUB BASIN NO 1

ELEVATION ABOVE N.S.L IN METERS

SUB BASIN NO 2

SUB BASIN NO 3

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1 INEQUILIBRIUM YOUTHFUL STAGE
   WITH INTEGRAL VALUE 79.5

2 EQUILIBRIUM NATURE STAGE
   WITH INTEGRAL VALUE 43.0

3 MONADNOCK STAGE WITH
   INTEGRAL VALUE 17.6

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FIG 19 HISTOGRAMS OF SOIL SAMPLES SHOWING
GRAVEL, SAND AND SILT+CLAY

INDEX
- GRAVEL
- SAND
- SILT+CLAY

1-25 BLACK SOIL
26-30 PED SOIL

1 2 3 4 5 6 7 8
Figure 20 Triangular Classification of Soils of HHB (USDA 1960)

- Black Soil
- Ped Soil
- Silt
- Silt Loam
- Sandy Loam
- Loamy Sand
- Sandy Loam
- Loamy Sand
- Clay

(After U.S. Dept. of Agriculture Soil Classification USDA Washington 1960)
FIG 21 RELATION BETWEEN DEPTH AND YIELD OF BORE WELLS

INCHAL

MUTWAD

YIELD IN LPS

DEPTH IN MTRS

GONTMAP

CHACHADI

HAPUGOPA

HOSUR
FIG 21 CONTINUED

HIPY'OPA

MUPYUMBII

CHIP'OPA

MURGOD

YCN'GCRH

PUDEPAUP
FIG 21 CONTINUED

KAPIMANI

YIELD IN LPS

DEPTH IN MTRS

DUNDANYOP

YIELD IN LPS

DEPTH IN MTRS
FIG 22 HISTOGRAM TOP DEPTH WISE DISTRIBUTION OF BORE WELLS

**Basalts**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Number of Bore Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>1220</td>
</tr>
<tr>
<td>30-40</td>
<td>1463</td>
</tr>
<tr>
<td>50-60</td>
<td>1220</td>
</tr>
<tr>
<td>70-80</td>
<td>1950</td>
</tr>
<tr>
<td>90-100</td>
<td>732</td>
</tr>
<tr>
<td>110-120</td>
<td>488</td>
</tr>
</tbody>
</table>

**Phyllites**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Number of Bore Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>227</td>
</tr>
<tr>
<td>30-40</td>
<td>1136</td>
</tr>
<tr>
<td>50-60</td>
<td>1136</td>
</tr>
<tr>
<td>70-80</td>
<td>1918</td>
</tr>
<tr>
<td>90-100</td>
<td>2045</td>
</tr>
<tr>
<td>110-120</td>
<td>683</td>
</tr>
<tr>
<td>120</td>
<td>227</td>
</tr>
</tbody>
</table>

**Granitic Gneisses**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Number of Bore Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20</td>
<td>286</td>
</tr>
<tr>
<td>30-40</td>
<td>571</td>
</tr>
<tr>
<td>50-60</td>
<td>1143</td>
</tr>
<tr>
<td>70-80</td>
<td>1143</td>
</tr>
<tr>
<td>90-100</td>
<td>2000</td>
</tr>
<tr>
<td>100</td>
<td>2000</td>
</tr>
<tr>
<td>120</td>
<td>1429</td>
</tr>
<tr>
<td>140</td>
<td>571</td>
</tr>
<tr>
<td>160</td>
<td>857</td>
</tr>
</tbody>
</table>

Scale:
- x axis 1 cm = 1 LPS
- y axis 1 cm = 10 %
FIG 23 HISTOGRAM TOP VARIATION OF YIELD OF BOREWELLS

**GPANITIC GNEISES**

- Basalts
  - Yield in LPS: 58.83%
  - Count: 5
  - Percentage: 23.53%

- Phyllites
  - Yield in LPS: 62.64%
  - Count: 9
  - Percentage: 9.08%

- Phyllites
  - Yield in LPS: 6.82%
  - Count: 6
  - Percentage: 2.27%

**Scale**
- X axis: 1 cm = 1 LPS
- Y axis: 1 cm = 10%

**Yield in LPS**
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

**Percentage of Borewells**
- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80

**Percentage of Yield in LPS**
- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80

**Borewells**
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
FIG 24 PELATION BETWEEN DEPTH / YIELD AND
TOTAL NUMBER OF BOREWELLS (BASALTS)
FIG. 25 Relation between depth/yield and total number of bore wells (Phyllitges)
FIG 26 RELATION BETWEEN DEPTH/YIELD AND TOTAL NUMBER OF BOPE WELLS (GRANITIC GNEISSLS)
# General Range of Electrical Resistivities of Common Rocks and Water (After Wapent 1987)

## Resistivity Range (Ω·m)

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Resistivity Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay soft shale</td>
<td>$10^{-1}$ to $10^{1}$</td>
</tr>
<tr>
<td>Shale hard</td>
<td>$10^{3}$ to $10^{5}$</td>
</tr>
<tr>
<td>Shale weathered sand</td>
<td>$10^{6}$ to $10^{7}$</td>
</tr>
<tr>
<td>Sandstone</td>
<td>$10^{8}$ to $10^{9}$</td>
</tr>
<tr>
<td>Limestone porous</td>
<td>$10^{10}$ to $10^{11}$</td>
</tr>
<tr>
<td>Limestone dense</td>
<td>$10^{12}$ to $10^{13}$</td>
</tr>
<tr>
<td>Basalt weathered</td>
<td>$10^{14}$ to $10^{15}$</td>
</tr>
<tr>
<td>Basalt vesicular</td>
<td>$10^{16}$ to $10^{17}$</td>
</tr>
<tr>
<td>Basalt massive</td>
<td>$10^{18}$ to $10^{19}$</td>
</tr>
<tr>
<td>Granite weathered</td>
<td>$10^{20}$ to $10^{21}$</td>
</tr>
<tr>
<td>Granite fractured</td>
<td>$10^{22}$ to $10^{23}$</td>
</tr>
<tr>
<td>Granite massive</td>
<td>$10^{24}$ to $10^{25}$</td>
</tr>
<tr>
<td>Water</td>
<td>$10^{26}$ to $10^{27}$</td>
</tr>
</tbody>
</table>
FIG 3. GEOCLLCTIPICAL CROSS SECTIONS OF VARIOUS LOCATIONS OF H H B
FIG 39: VARIATION DIAGRAMS OF CALCIUM

- Basalt
- Gneiss
- Phyllite

Station Codes

Co (PPM)
FIG 40 VARIATION DIAGRAMS OF MAGNESIUM

(basalts)

(granitic gneisses)

(phyllites)

Mg (ppm)

STATION CODE

101.04 (AVE)

82.40 (AVE)
FIGURE VARIATION DIAGRAMS OF BICARBONATE

**Basalt**
- Maximum: 265.2 PPM
- Minimum: 300 PPM

**Granitic Gneisses**
- Maximum: 242.67 PPM
- Minimum: 200 PPM

**Phyllite**
- Maximum: 335.5 PPM
- Minimum: 200 PPM

**Station Code**
FIG43 VARIATION DIAGRAMS OF SULPHATE

(basalt)

26.9 (AVE)

1 2 3 4 5 6 7 8 9 10

(granitic gneisses)

23.00 (AVE)

1 2 3 4 5 6

(phylites)

37.12 (AVE)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
FIG 44: VARIATION DIAGRAMS OF CHLORIDL

- Basalt: Avg = 92.8 ppm
- Granitic gneisses: Avg = 234 ppm
- Phyllites: Avg = 129.92 ppm

Station Code: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Figure: Variation diagrams of total hardness.

- Basalt:
  - Average: 99.3 (AVG)
  - Values range:

- Granite gneisses:
  - Average: 146.17 (AVG)
  - Values range:

- Phyllite:
  - Average: 114.4 (AVG)
  - Values range:
FIG. 47: Piper's (1944) diagram showing chemical characters of groundwater. (Basalt, Phyllites, Granitic Gneisses)

- Basalt
- Phyllite
- Granitic Gneiss

(BASALTS, PHYLITIC, GRANITIC GNEISSES)

SAMPLES FROM
-
BASALTS
▲
PHYLITIC
□
GRANITIC GNEISSES

Ca, Mg

CO3, HCO3

Cl

Na

Mg

Ca

100 100

50

40
MECHANISM CONTROLLING THE GROUNDWATER CHEMISTRY (AFTER GIBBS 1970)

FIG 49: MECHANISM CONTROLLING THE GROUNDWATER CHEMISTRY

(AFTER GIBBS 1970)

TOTAL DISSOLVED SALTS (PPM)

PRECIPITATION DOMINANCE

ROCK DOMINANCE

SAMPLES FROM

BASALT

PHYLITIC

GRANITIC

GNEISSIC

TOTAL DISSOLVED SALTS (PPM)

Na

Na + Ca

Cl

Cl + HCO₃

0 1  2  3  4  5  6  7  8  9  10

0 1  2  3  4  5  6  7  8  9  10
FIG52 SALINITY LEVEL OF GROUNDWATER SAMPLES

0 0 - 0.75 NO PROBLEM
0.75 2.75 INCREASING PROBLEM
2.75 ABOVE SEVERE PROBLEM

(basalt)

(phyllite)

EC Micromhos

STATION CODE
FIG 53 VALUES OF ADJ SAR OF GROUNDWATER SAMPLES

(basalts)

(phyllites)

(granitic gneisses)

upper limit for toxicity and permeability

no problem for permeability

severe problem

increasing problem

no problem for toxicity

upper limit for toxicity and permeability

upper limit for permeability

lower limit for permeability

lower limit for toxicity

no problem for permeability

no problem for toxicity

STATION CODE
FIG 54 CHLORIDE CONCENTRATION OF GROUNDWATER Samples

(basalts)

(granitic gneisses)

(phylites)

CONCENTRATION (mg/l)

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

SEVERE PROBLEM

INCREASING PROBLEM

NO PROBLEM

0 1 2 3 4 5 6

SEVERE PROBLEM

INCREASING PROBLEM

NO PROBLEM

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

SEVERE PROBLEM

INCREASING PROBLEM

NO PROBLEM
Fig 55: Bicarbonate Concentrations of Groundwater Samples

- Basalt
  - Severe problem
  - Increasing problem
  - No problem

- Granitic gneisses
  - Severe problem
  - Increasing problem
  - No problem

- Phyllites
  - Severe problem
  - Increasing problem
  - No problem

Station code
FIG56 SULPHATE CONCENTRATIONS OF GROUNDWATER SAMPLES

(basalt)

(granite gneisses)

(phyllites)

unsuitable

doubtful

permissible

good

excellent

station code

concentrations (mg/l)

1 2 3 4 5 6 7 8 9 10

1 2 3 4 5 6

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
FIG 57 DISTRIBUTION OF LOG ACTIVITY OF MINERAL SPECIES

SAMPLE NUMBERS

1 MUTWAD
2 INCHAL
3 DUNDANYOP
4 MUPYUMBI
5 HIRCPA
6 HOSUP
7 MUPGOD

BASETS
PHYLITCS
GPRANTIC GNEISSLS

SAMPLE NUMBERS
FIG 59 PLOTS OF PCA COMPONENTS
FIG 60 LINEAMENTS AND YIELD OF BOREWELLS

- CHACHADI
- MUMWAD
- INCHAAL
- GODIPOR
- CHIVOR
- DUNDHIP
- SOGAL
- BAILHONGAL

BOROWELLS CLOSE TO THE LINEAMENTS (HIGH YIELD LPS)
BOROWELLS AWAY FROM THE LINEAMENTS (LOW YIELD LPS)
LINEAMENTS