3-2-5 Boundary and Initial Value Conditions

According to the previously mentioned facts, the model was assumed as a part of a symmetrical cylinder structure 6 km in diameter, with the Balatoc plug as its center and with no heat or flow transfer from the lateral wall.

Outside of the central area where the mining activities are seen, a recharge of 2.26 mm/day is given. From this amount and within the mining zone, 1.9 mm/day are seeping into the tunnel and remaining 1.9 mm/day are discharging into the neighboring river. As to mine drainage, underground water, including hot water coming from the bottom of the model, amounts to about 13.53 kg/s and 2.72 MW of mass and heat flow respectively. This volume is applicable only to the fan-shaped sector of 15^{o} angle of the cylindrical model, while these values serve as important checkpoints for the calibration of the simulator.

The boundary bottom plane is located at 1500 m.b.s.l., and as mentioned in sect.3.1.5, it is assumed supply 1.05 kg/s at $273^{o}C$ with a heat flow of 1.375MW in addition to an average 2 HFU of heat flow of the earth's crust. At the beginning of the simulation, a certain supply of recharge was given to a thin weathered zone on the surface, but later on to increase the speed of calculation, this zone was eliminated and recharge was given to the top block of the model.

Atmosphere temperature was fixed at $20^{o}C$, and to further simplify the model, the mining area was not considered as part of the model since its permeability must be very large.

On the other hand, this program solves transient initial value problems with appropiate boundary conditions, in our case, a rather stationary condition, an initial value must first be generated. Temperature and pressure distribution are first estimated from existing data on the surface and on the borehole AC-1D. Initial values for tem-perature distribution used in simulation are shown in Fig. III-3-6. If estimated values differ from true values, then simulation will consume a long time to reach that value. As to the initial values of pressures, used was natural water pressure according to elevation of the point.

A time step is required for simulation of the system in the transient state, time that is related to the size of the elements and to permeability etc. In the present simulation, and judging from the results of several trials, time steps increasing in geometric progression from 20 days to 1000 years, ended the calculations at the stationary state after more than 10,000 years. The variation of mass and heat flow in the Acupan Mine are given in Fig. III-3-7.

Table III—3—1 Primary physical value of rocks

		Weathered rocks	Basement rocks	Intrusive rocks
Density	kg/m³	2000.	2700.	2700.
Porosity		.3	.001	.002
Permeability	kx, m²	1. E-12	7. E-16	7. E-16
"	kz, m²	1. E-12	7. E-16	4. E-16
Thermal conductivity	W/m°C	2.1	2.7	2.7
Specific heat	J/kg°C	600.	910.	910.

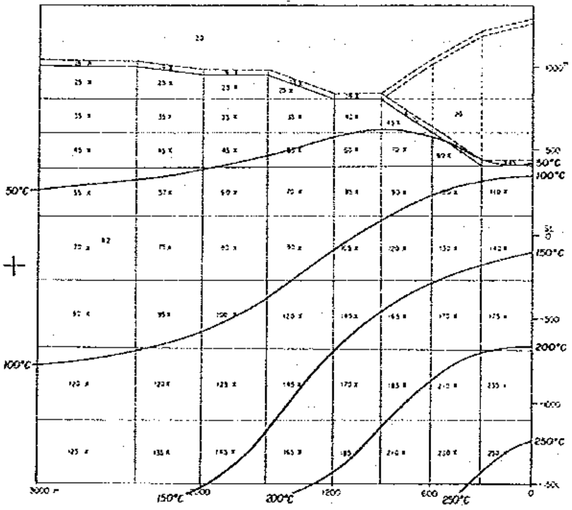


Fig. III—3—6 Estimated primary temperature distribution in °C

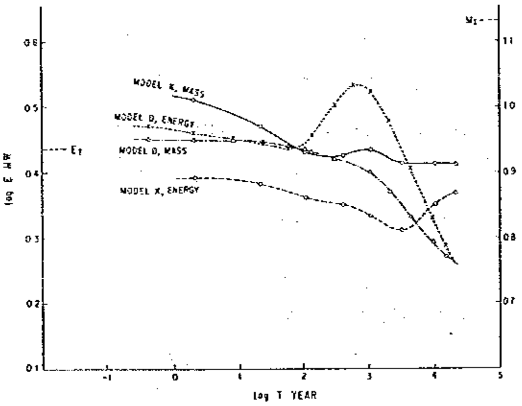


Fig. III—3—7 Variation of mass and heat flow into the Acupan mine in function of time

3-3 Discussion on Results of Simulation

3-3-1 Output

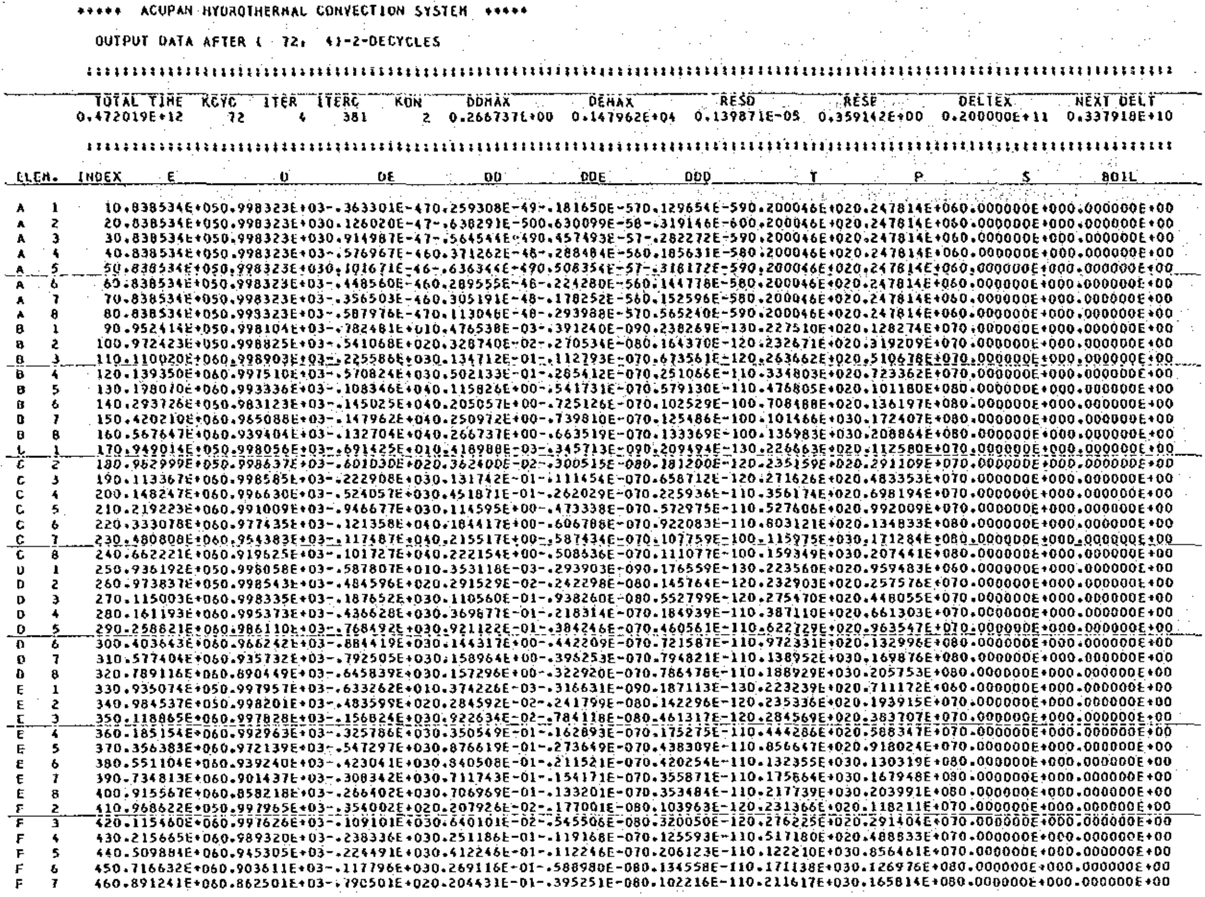
For every cycle of the simulation at the prescribed time step, there is a short printout of the steam condition, rate of the fluid flow across the interface of the elements, total energy change in the elements and so on.

Fig. III-3-8 gives the results of the fluid state in each element after changing the model six times with a time step of 72 and after a calculation time of 14,967 years. This Figure displays calculated temperature T, pressure P, and vapor saturation S based on internal energy E and the fluid density D. Fig. III-3-9 indicates the mass and heat flow of the fluid across the interface. The first three lines, A6G2, A7H3 and A8P4 of this table, indicate values of the underground heat and fluid flow into the Acupan Mine, which are important check values for evaluating the results of simulation. A satisfactory simulation can be obtained by checking various output data and correct-ing them properly after every running of the model.

In the running of simulation, nine corrections to the model were given, and even after that, the results were not completely satisfactory. However, through all of these calculated results, a deep geothermal structure in the Acupan area can be estimated. Besides the given list of output other data, there are still a lot of other data such as change of convergence of simultaneous equations and change in fluid mass. Some of these are listed in the Appendices.

3-3-2 Considerations of Results

After three trials in calculation by changing the model, produced was a model D that was somewhat close to the lumped parameter model indicated in Fig. III-3-10. Here, on this model, permeability of the upper blocks were enlarged ($1.2X10^{-14}$ m^2), while those of the lower blocks were rather small ($2.4X10^{-15}$ m^2).



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*****  ACUPAN HYDROTHERMAL CONVECTION SYSTEM  *****

  OUTPUT DATA AFTER (  72,  4)-2-DECYCLES

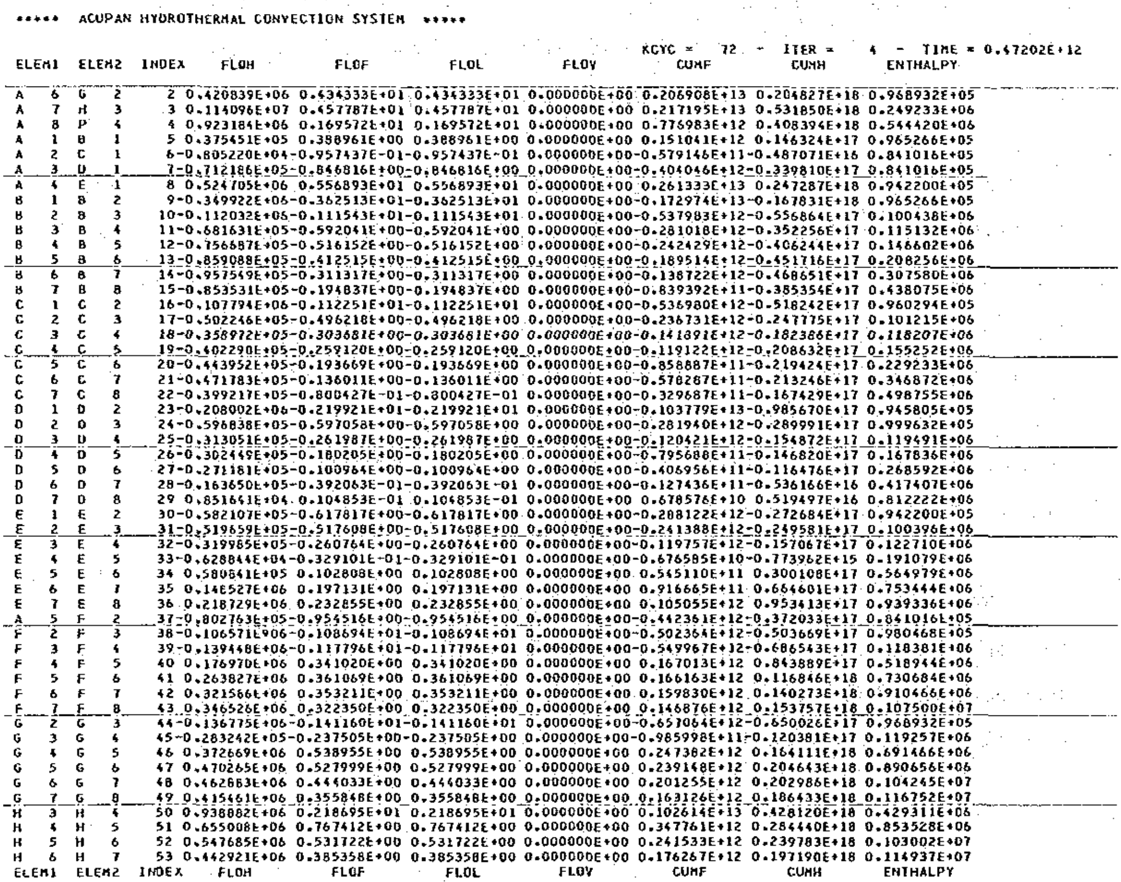
 :::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
       TOTAL TIME  KCYC   ITER  ITERC    KON     DDMAX        DEMAX        RESD         RESE        DELTEX      NEXT DELT
     0.472019E+12    72      4    381      2  0.266737E+00  0.147962E+04  0.139871E-05  0.359142E+00  0.200000E+11  0.337918E+10

 :::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

ELEM.  INDEX    E         U          DE         DD         DDE        DDD          T          P          S          BOIL

A   1     10.838534E+050.998323E+03-.363301E-470.259308E-49-.181650E-570.129654E-590.200046E+020.247814E+060.000000E+000.000000E+00
A   2     20.838534E+050.998323E+030.126020E-47-.638291E-500.630099E-58-.319146E-600.200046E+020.247814E+060.000000E+000.000000E+00
A   3     30.838534E+050.998323E+030.914987E-47-.564544E-490.457493E-57-.282272E-590.200046E+020.247814E+060.000000E+000.000000E+00
A   4     40.838534E+050.998323E+03-.576967E-460.371262E-48-.288484E-560.185631E-580.200046E+020.247814E+060.000000E+000.000000E+00
A   5     50.838534E+050.998323E+030.101671E-46-.636344E-490.508354E-57-.318172E-590.200046E+020.247814E+060.000000E+000.000000E+00
A   6     60.838534E+050.998323E+03-.448560E-460.289555E-48-.224280E-560.144778E-580.200046E+020.247814E+060.000000E+000.000000E+00
A   7     70.838534E+050.998323E+03-.356503E-460.305191E-48-.178252E-560.152596E-580.200046E+020.247814E+060.000000E+000.000000E+00
A   8     80.838534E+050.998323E+03-.587976E-470.113046E-48-.293988E-570.565240E-590.200046E+020.247814E+060.000000E+000.000000E+00
B   1     90.952414E+050.998104E+03-.782481E+010.476538E-03-.391240E-090.238269E-130.227510E+020.128274E+070.000000E+000.000000E+00
B   2    100.972423E+050.998825E+03-.541068E+020.328740E-02-.270534E-080.164370E-120.232671E+020.319209E+070.000000E+000.000000E+00
B   3    110.110020E+060.998903E+03-.225586E+030.134712E-01-.112793E-070.673561E-120.263662E+020.510678E+070.000000E+000.000000E+00
B   4    120.139350E+060.997510E+03-.570824E+030.502133E-01-.285412E-070.251066E-110.334803E+020.723362E+070.000000E+000.000000E+00
B   5    130.198070E+060.993336E+03-.108346E+040.115826E+00-.541731E-070.579130E-110.476805E+020.101180E+080.000000E+000.000000E+00
B   6    140.293726E+060.983123E+03-.145025E+040.205057E+00-.725126E-070.102529E-100.708488E+020.136197E+080.000000E+000.000000E+00
B   7    150.420210E+060.965088E+03-.147962E+040.250972E+00-.739810E-070.125486E-100.101466E+030.172407E+080.000000E+000.000000E+00
B   8    160.567647E+060.939404E+03-.132704E+040.266737E+00-.663519E-070.133369E-100.136983E+030.208864E+080.000000E+000.000000E+00
C   1    170.949014E+050.998056E+03-.691425E+010.418988E-03-.345713E-090.209494E-130.226663E+020.112580E+070.000000E+000.000000E+00
C   2    180.962999E+050.998637E+03-.601030E+020.362400E-02-.300515E-080.181200E-120.235159E+020.291109E+070.000000E+000.000000E+00
C   3    190.113367E+060.998585E+03-.222908E+030.131742E-01-.111454E-070.658712E-120.271626E+020.483353E+070.000000E+000.000000E+00
C   4    200.148247E+060.996630E+03-.524057E+030.451871E-01-.262029E-070.225936E-110.356174E+020.698194E+070.000000E+000.000000E+00
C   5    210.219223E+060.991009E+03-.946677E+030.114595E+00-.473338E-070.572975E-110.527606E+020.992009E+070.000000E+000.000000E+00
C   6    220.333078E+060.977435E+03-.121358E+040.184417E+00-.606788E-070.922083E-110.803121E+020.134833E+080.000000E+000.000000E+00
C   7    230.480808E+060.954383E+03-.117487E+040.215517E+00-.587434E-070.107759E-100.115975E+030.171284E+080.000000E+000.000000E+00
C   8    240.662221E+060.919625E+03-.101727E+040.222154E+00-.508636E-070.111077E-100.159349E+030.207441E+080.000000E+000.000000E+00
D   1    250.936192E+050.998058E+03-.587807E+010.353118E-03-.293903E-090.176559E-130.223560E+020.959483E+060.000000E+000.000000E+00
D   2    260.973837E+050.998543E+03-.484596E+020.291529E-02-.242298E-080.145764E-120.232903E+020.257576E+070.000000E+000.000000E+00
D   3    270.115003E+060.998335E+03-.187652E+030.110560E-01-.938260E-080.552799E-120.275470E+020.448055E+070.000000E+000.000000E+00
D   4    280.161193E+060.995373E+03-.436628E+030.369677E-01-.218314E-070.184939E-110.387110E+020.661303E+070.000000E+000.000000E+00
D   5    290.258821E+060.986110E+03-.768492E+030.921122E-01-.384246E-070.460561E-110.622729E+020.963547E+070.000000E+000.000000E+00
D   6    300.403643E+060.966242E+03-.884419E+030.144317E+00-.442209E-070.721587E-110.972331E+020.132996E+080.000000E+000.000000E+00
D   7    310.577404E+060.935732E+03-.792505E+030.158964E+00-.396253E-070.794821E-110.138952E+030.169876E+080.000000E+000.000000E+00
D   8    320.789116E+060.890449E+03-.645839E+030.157296E+00-.322920E-070.786478E-110.188929E+030.205753E+080.000000E+000.000000E+00
E   1    330.935074E+050.997957E+03-.633262E+010.374226E-03-.316631E-090.187113E-130.223239E+020.711172E+060.000000E+000.000000E+00
E   2    340.984537E+050.998201E+03-.483599E+020.284592E-02-.241799E-080.142296E-120.235336E+020.193915E+070.000000E+000.000000E+00
E   3    350.118865E+060.997828E+03-.156824E+030.922634E-02-.784118E-080.461317E-120.284569E+020.383707E+070.000000E+000.000000E+00
E   4    360.185154E+060.992963E+03-.325786E+030.350549E-01-.162893E-070.175275E-110.444286E+020.588347E+070.000000E+000.000000E+00
E   5    370.356383E+060.972139E+03-.547297E+030.876619E-01-.273649E-070.438309E-110.856647E+020.918024E+070.000000E+000.000000E+00
E   6    380.551104E+060.939240E+03-.423041E+030.840508E-01-.211521E-070.420254E-110.132355E+030.130319E+080.000000E+000.000000E+00
E   7    390.734813E+060.901437E+03-.308342E+030.711743E-01-.154171E-070.355871E-110.175864E+030.167948E+080.000000E+000.000000E+00
E   8    400.915567E+060.858218E+03-.266402E+030.706969E-01-.133201E-070.353484E-110.217739E+030.203991E+080.000000E+000.000000E+00
F   2    410.968622E+050.997965E+03-.354002E+020.207926E-02-.177001E-080.103963E-120.231366E+020.118211E+070.000000E+000.000000E+00
F   3    420.115460E+060.997626E+03-.109101E+030.640101E-02-.545506E-080.320050E-120.276225E+020.291404E+070.000000E+000.000000E+00
F   4    430.215665E+060.989320E+03-.238336E+030.251186E-01-.119168E-070.125593E-110.517180E+020.488833E+070.000000E+000.000000E+00
F   5    440.509884E+060.945305E+03-.224491E+030.412246E-01-.112246E-070.206123E-110.122210E+030.856461E+070.000000E+000.000000E+00
F   6    450.716632E+060.903611E+03-.117796E+030.269116E-01-.588980E-080.134558E-110.171138E+030.126976E+080.000000E+000.000000E+00
F   7    460.891241E+060.862501E+03-.790501E+020.204431E-01-.395251E-080.102216E-110.211617E+030.165814E+080.000000E+000.000000E+00
```

Fig. III–3–8 Example of calculated fluid state in each element



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*****  ACUPAN HYDROTHERMAL CONVECTION SYSTEM  *****

                                                             KCYC =   72  -  ITER =    4  -  TIME = 0.47202E+12
ELEM1  ELEM2  INDEX    FLOH         FLOF          FLOL          FLOV          CUMF          CUMH        ENTHALPY

A   6  G   2     2 0.420839E+06 0.434333E+01 0.434333E+01 0.000000E+00 0.206908E+13 0.204827E+18 0.968932E+05
A   7  H   3     3 0.114096E+07 0.457787E+01 0.457787E+01 0.000000E+00 0.217195E+13 0.531850E+18 0.249233E+06
A   8  P   4     4 0.923184E+06 0.169572E+01 0.169572E+01 0.000000E+00 0.776983E+12 0.408394E+18 0.544420E+06
A   1  B   1     5 0.375451E+05 0.388961E+00 0.388961E+00 0.000000E+00 0.151041E+12 0.146324E+17 0.965266E+05
A   2  C   1     6-0.805220E+04-0.957437E-01-0.957437E-01 0.000000E+00-0.579146E+11-0.487071E+16 0.841016E+05
A   3  D   1     7-0.712186E+05-0.846816E+00-0.846816E+00 0.000000E+00-0.404046E+12-0.339810E+17 0.841016E+05
A   4  E   1     8 0.524705E+06 0.556893E+01 0.556893E+01 0.000000E+00 0.261333E+13 0.247287E+18 0.942200E+05
B   1  B   2     9-0.349922E+06-0.362513E+01-0.362513E+01 0.000000E+00-0.172974E+13-0.167831E+18 0.965266E+05
B   2  B   3    10-0.112032E+06-0.111543E+01-0.111543E+01 0.000000E+00-0.537983E+12-0.556864E+17 0.100438E+06
B   3  B   4    11-0.681631E+05-0.592041E+00-0.592041E+00 0.000000E+00-0.281018E+12-0.352256E+17 0.115132E+06
B   4  B   5    12-0.756687E+05-0.516152E+00-0.516152E+00 0.000000E+00-0.242429E+12-0.406244E+17 0.146602E+06
B   5  B   6    13-0.859088E+05-0.412515E+00-0.412515E+00 0.000000E+00-0.189514E+12-0.451716E+17 0.208256E+06
B   6  B   7    14-0.957549E+05-0.311317E+00-0.311317E+00 0.000000E+00-0.138722E+12-0.468651E+17 0.307580E+06
B   7  B   8    15-0.853531E+05-0.194837E+00-0.194837E+00 0.000000E+00-0.839392E+11-0.385354E+17 0.438075E+06
C   1  C   2    16-0.107794E+06-0.112251E+01-0.112251E+01 0.000000E+00-0.536980E+12-0.518242E+17 0.960294E+05
C   2  C   3    17-0.502246E+05-0.496218E+00-0.496218E+00 0.000000E+00-0.236731E+12-0.247775E+17 0.101215E+06
C   3  C   4    18-0.358972E+05-0.303681E+00-0.303681E+00 0.000000E+00-0.141891E+12-0.182386E+17 0.118207E+06
C   4  C   5    19-0.402290E+05-0.259120E+00-0.259120E+00 0.000000E+00-0.119122E+12-0.208632E+17 0.155252E+06
C   5  C   6    20-0.443952E+05-0.193669E+00-0.193669E+00 0.000000E+00-0.858887E+11-0.219424E+17 0.229233E+06
C   6  C   7    21-0.471783E+05-0.136011E+00-0.136011E+00 0.000000E+00-0.578287E+11-0.213246E+17 0.346872E+06
C   7  C   8    22-0.399217E+05-0.800427E-01-0.800427E-01 0.000000E+00-0.329687E+11-0.167429E+17 0.498755E+06
D   1  D   2    23-0.208002E+06-0.219921E+01-0.219921E+01 0.000000E+00-0.103779E+13-0.985670E+17 0.945805E+05
D   2  D   3    24-0.596838E+05-0.597058E+00-0.597058E+00 0.000000E+00-0.281940E+12-0.289991E+17 0.999632E+05
D   3  D   4    25-0.313051E+05-0.261987E+00-0.261987E+00 0.000000E+00-0.120421E+12-0.154872E+17 0.119491E+06
D   4  D   5    26-0.302449E+05-0.180205E+00-0.180205E+00 0.000000E+00-0.795688E+11-0.146820E+17 0.167836E+06
D   5  D   6    27-0.271181E+05-0.100964E+00-0.100964E+00 0.000000E+00-0.406956E+11-0.116476E+17 0.268592E+06
D   6  D   7    28-0.163650E+05-0.392063E-01-0.392063E-01 0.000000E+00-0.127436E+11-0.536166E+16 0.417407E+06
D   7  D   8    29 0.851641E+04 0.104853E-01 0.104853E-01 0.000000E+00 0.678576E+10 0.519497E+16 0.812222E+06
E   1  E   2    30-0.582107E+05-0.617817E+00-0.617817E+00 0.000000E+00-0.288122E+12-0.272684E+17 0.942200E+05
E   2  E   3    31-0.519659E+05-0.517608E+00-0.517608E+00 0.000000E+00-0.241388E+12-0.249581E+17 0.100396E+06
E   3  E   4    32-0.319985E+05-0.260764E+00-0.260764E+00 0.000000E+00-0.119757E+12-0.157067E+17 0.122710E+06
E   4  E   5    33-0.628844E+04-0.329101E-01-0.329101E-01 0.000000E+00-0.676585E+10-0.773962E+15 0.191079E+06
E   5  E   6    34 0.580841E+05 0.102808E+00 0.102808E+00 0.000000E+00 0.545110E+11 0.300108E+17 0.564979E+06
E   6  E   7    35 0.146527E+06 0.197131E+00 0.197131E+00 0.000000E+00 0.916665E+11 0.664601E+17 0.753444E+06
E   7  E   8    36 0.218729E+06 0.232855E+00 0.232855E+00 0.000000E+00 0.105055E+12 0.953413E+17 0.939336E+06
A   5  F   2    37-0.802763E+05-0.954516E+00-0.954516E+00 0.000000E+00-0.442361E+12-0.372033E+17 0.841016E+05
F   2  F   3    38-0.106571E+06-0.108694E+01-0.108694E+01 0.000000E+00-0.502364E+12-0.503669E+17 0.980468E+05
F   3  F   4    39-0.139448E+06-0.117796E+01-0.117796E+01 0.000000E+00-0.549967E+12-0.686543E+17 0.118381E+06
F   4  F   5    40 0.176970E+06 0.341020E+00 0.341020E+00 0.000000E+00 0.167013E+12 0.843889E+17 0.518944E+06
F   5  F   6    41 0.263827E+06 0.361069E+00 0.361069E+00 0.000000E+00 0.166163E+12 0.116846E+18 0.730684E+06
F   6  F   7    42 0.321566E+06 0.353211E+00 0.353211E+00 0.000000E+00 0.159830E+12 0.140273E+18 0.910466E+06
F   7  F   8    43 0.346526E+06 0.322350E+00 0.322350E+00 0.000000E+00 0.146876E+12 0.153757E+18 0.107500E+07
G   2  G   3    44-0.136775E+06-0.141160E+01-0.141160E+01 0.000000E+00-0.657064E+12-0.650026E+17 0.968932E+05
G   3  G   4    45-0.283242E+05-0.237505E+00-0.237505E+00 0.000000E+00-0.985998E+11-0.120381E+17 0.119257E+06
G   4  G   5    46 0.372669E+06 0.538955E+00 0.538955E+00 0.000000E+00 0.247382E+12 0.164111E+18 0.691466E+06
G   5  G   6    47 0.470265E+06 0.527999E+00 0.527999E+00 0.000000E+00 0.239148E+12 0.204643E+18 0.890656E+06
G   6  G   7    48 0.462663E+06 0.444033E+00 0.444033E+00 0.000000E+00 0.201255E+12 0.202986E+18 0.104245E+07
G   7  G   8    49 0.415461E+06 0.355848E+00 0.355848E+00 0.000000E+00 0.163126E+12 0.186433E+18 0.116752E+07
H   3  H   4    50 0.938882E+06 0.218695E+01 0.218695E+01 0.000000E+00 0.102614E+13 0.428120E+18 0.429311E+06
H   4  H   5    51 0.655008E+06 0.767412E+00 0.767412E+00 0.000000E+00 0.347761E+12 0.284440E+18 0.853528E+06
H   5  H   6    52 0.547685E+06 0.531722E+00 0.531722E+00 0.000000E+00 0.241533E+12 0.239783E+18 0.103002E+07
H   6  H   7    53 0.442921E+06 0.385358E+00 0.385358E+00 0.000000E+00 0.176267E+12 0.197190E+18 0.114937E+07
ELEM1  ELEM2  INDEX    FLOH         FLOF          FLOL          FLOV          CUMF          CUMH        ENTHALPY
```

Fig. III–3–9 Example of calculated mass and heat flow of the fluid across their interfaces

At the Balatoc plug, in the center of the area, there is vertical fracture with a vertical permeability twice as big as the horizontal fracture.

As previously mentioned, the model considered the recharge at 19°C in such a way as to provide a certain mass flow to the top blocks depending on their surface area. It was also mentioned that a heat flow of 2 HFU was given to the bottom of the model, and in addition, to heat flow of volcanic origin given under the plug.

Under these conditions, the expected values of water flow from the Acupan Mine tunnels are 13.53 Kg./s and 2.72 MW of mass and heat flow respectively. Fig. III-3-11 shows temperature distribution under stationary conditions. From here, it can be seen that a temperature gradient suddenly becoming steep near the Balatoc plug, the same gradient measured in the well AC-1D, reveals a value three times smaller than the calculated value. Fig. III-3-12 indicates a modeling distribu-tion of geothermal fluid, with a total mass flow of 5.86 kg/s and a heat flow of 1.95 MW, both of which are less than the expected values.

For the above reasons it, was therefore necessary to correct distribution of the rocks, their parameters, and boundary condition at depths, in that way preventing seepage of recharge into the underground, increasing of the heat flow up through the plug, and decreasing of the area of upflowing deep hot water. All these steps contribute to making easier the lateral flow of the recharge. Based on those concepts, further repetition of the simulations gave the results indicated in Fig. III-3-13.

No significant differences in permeabilities are given between intrusive rocks and basement rocks. Also, the primary geothermal fluid given to the bottom is caused to decrease radially from the center.

Fig. III-3-14 shows the temperature distribution based on initial values adopted by the previous calculation, after nearly 20,000 years. Here the thermal gradient of deep zones is lower than that of model D, tending to be close to the observed value in AC-1D. On the other hand, the presure distribution given in Fig. III-3-15 does not directly suggest the geothermal structure.

The distribution of geothermal heat and mass flow are indicated in Figs. III-3-16 and III-3-17 respectively, indicating that mass and heat flow in the Acupan Mine are 8.60 Kg/S and 2.30 MW respectively, and thus showing values closer to the observed values than in the case of model D. Should several more runnings of the simulation be conducted, results closer to the observed values could be obtained.

According to the results obtained from several simulations of the underground geothermal structure of the Acupan area, the following can be summarized:

1. Regardless of whether or not the basement rock is an intrusive rock, the permeability was small in the order of 10 $^{-15}$ to 10 $^{-16}$m^2 in spite of of the direction.

2. It is concluded that there is no eminent fracture upstream from the deep geothermal fluid. This is inferred from the fact that a strong sealing effect occurred when gold mineral bed formation was formed and volcanic activity was not so prominent to produce an active fault.

3. Upstream movement of the primary geothermal fluid may not be controlled by the Balatoc plug and the geological structure in the NE-SW direction.
It is considered that the flow rate of upstream movement of the geothermal fluid is nearly the same in this area, and within a radius of at least 3 kms it is assumed to be constant.

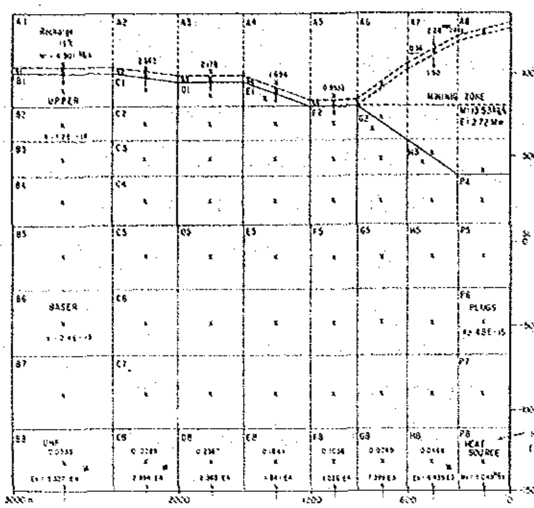


Fig. III–3–10 Simulation model D

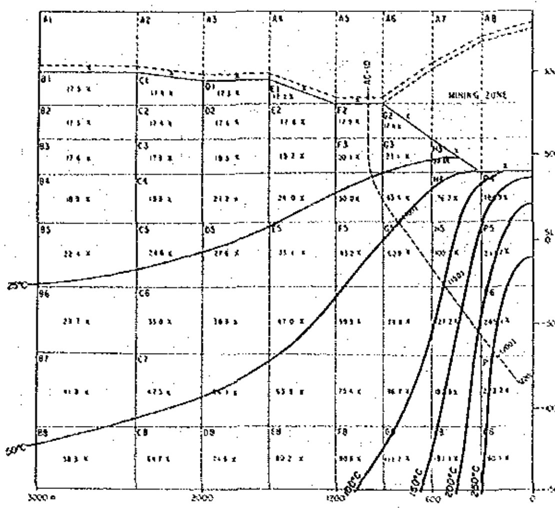


Fig. III–3–11 Temperature distribution for mode D in °C

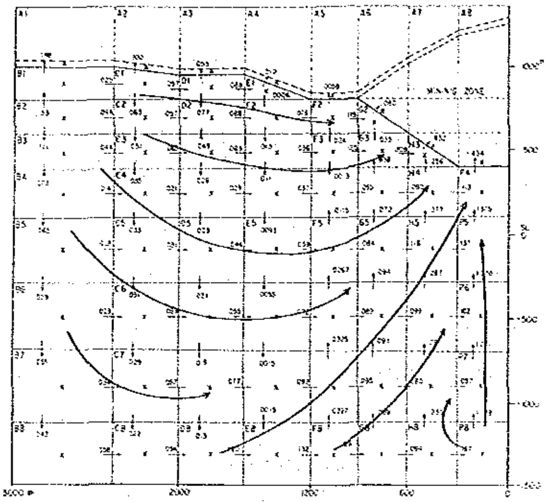


Fig. III–3–12 Heat flow distribution for model D in MW

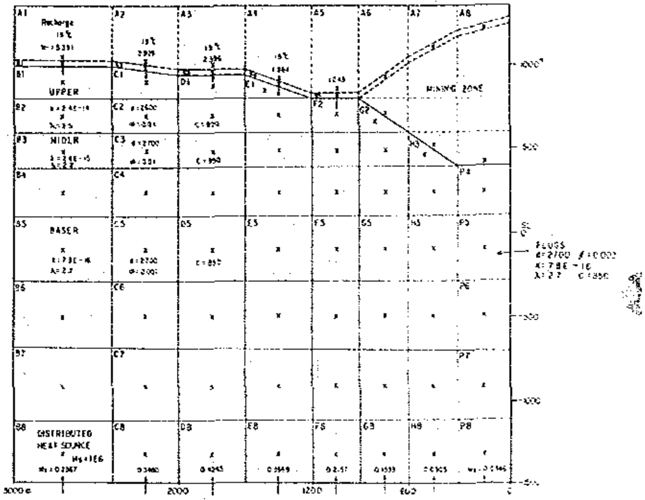


Fig. III–3–13 Simulation model K

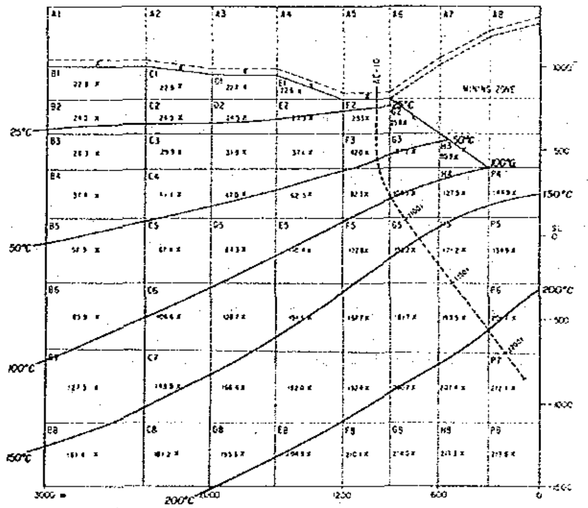


Fig. III–3–14 Temperature distribution (model K) in °C

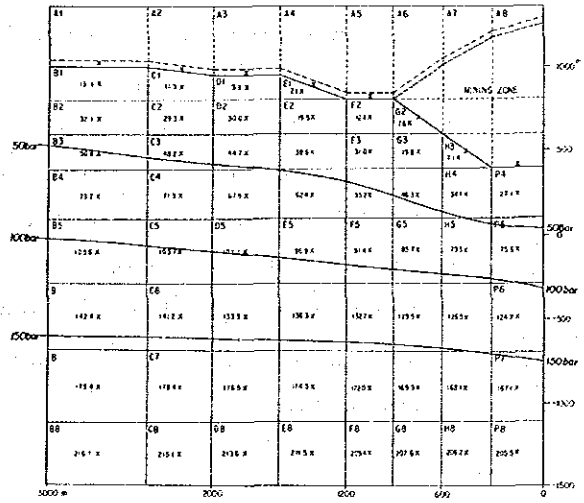


Fig. III–3–15 Pressure distribution (model K) in bar

4. Most of the geothermal heat flow of 33MW found in the Acupan Mine, caused by the hot spring and by drainage of the underground geothermal fluid, is deeply related to development of the Acupan Mine. Before development of the mine, manifestations must have been almost the same as hot springs around the Itogon area.

5. This stage, it is somewhat difficult to assure that there could have been developed high permeability fractures outside of the present simulated zone at depths lower than 1,500 m b.s.l.

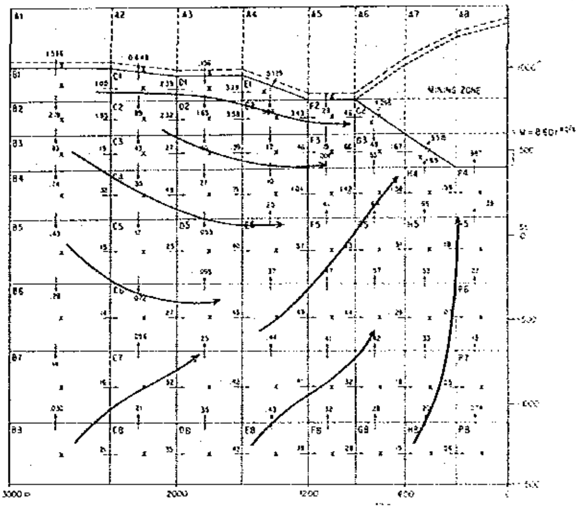


Fig. III–3–16 Heat flow distribution (model K) in MW

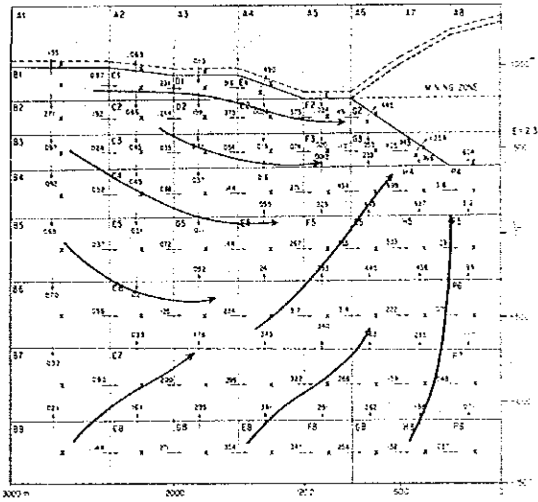


Fig. III–3–17 Mass flow destribution (model K) in kg/s

REFERENCES

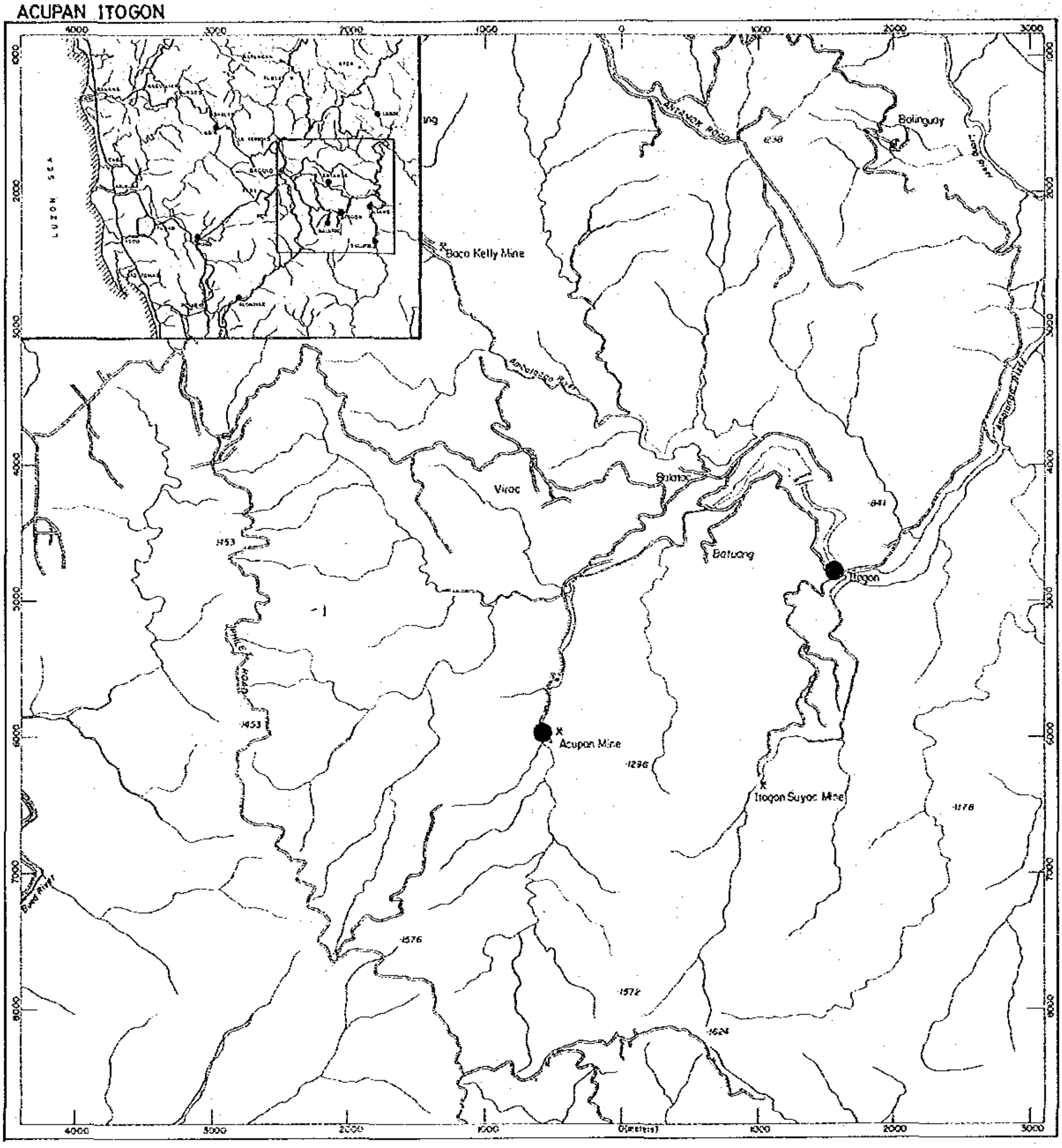
1. Pinder G.F., 1979, "State-of-the Art Review of Geothermal Reservoir Modelling"; LBL Report LBL-9093, Lawrence Berkeley Lab., Berkeley, U.S.A.

2. Pruess, K. et al, 1979, "SHAFT 78, A Two Phase Multidimensional Computer Program for Geothermal Reservoir Simulation", LBL Report LBL-8264, Lawrence Berkeley, Lab., Berkeley U.S.A.

3. Pruess, K. et al, 1980, "SHAFT 79, User's Manual" LBL Report LBL-10861, Lawrence Berkeley, Lab., Berkeley U.S.A.

APPENDICES

ACUPAN ITOGON

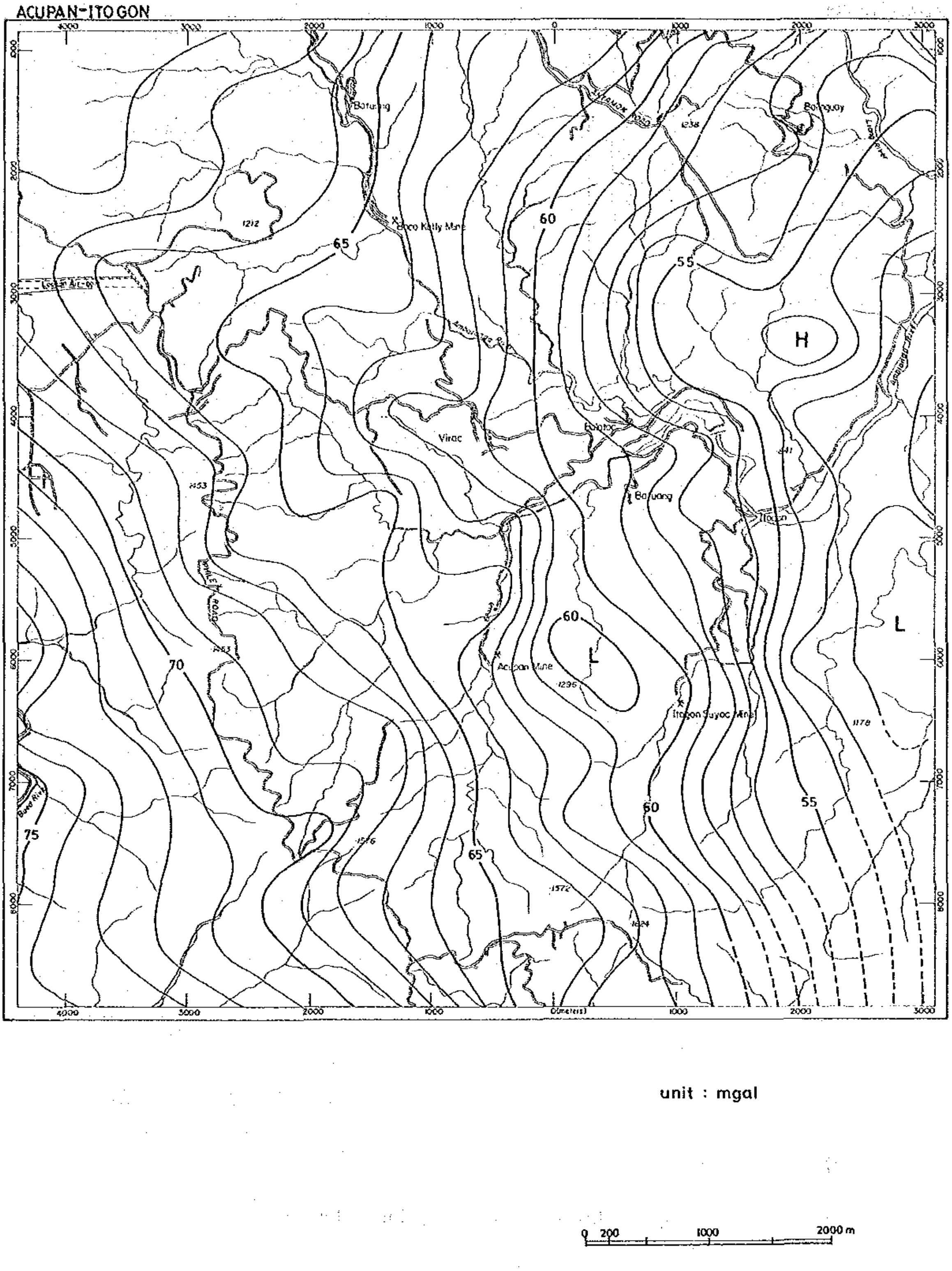


L E G E N D

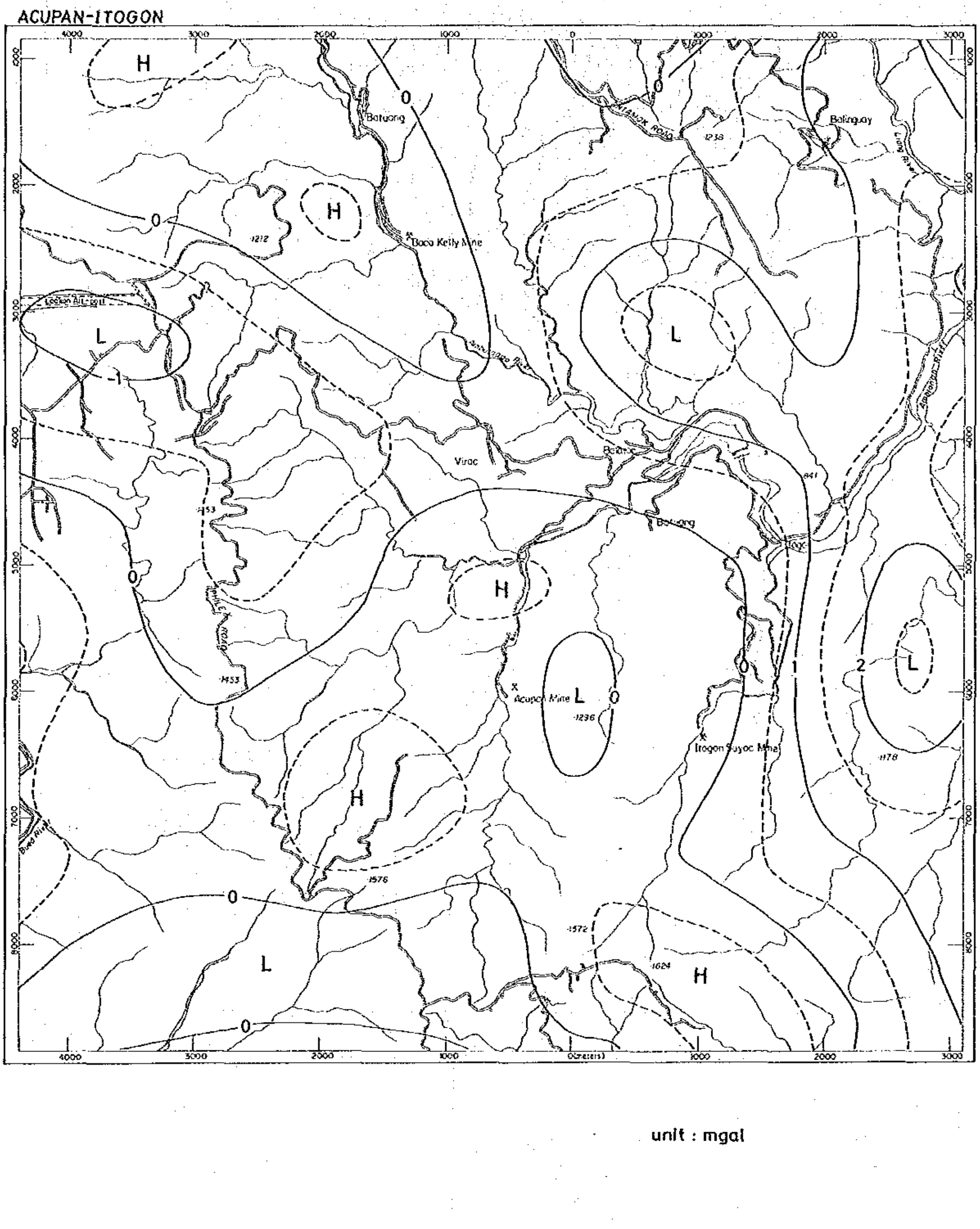
0 200 1000 2000 m

● sample location

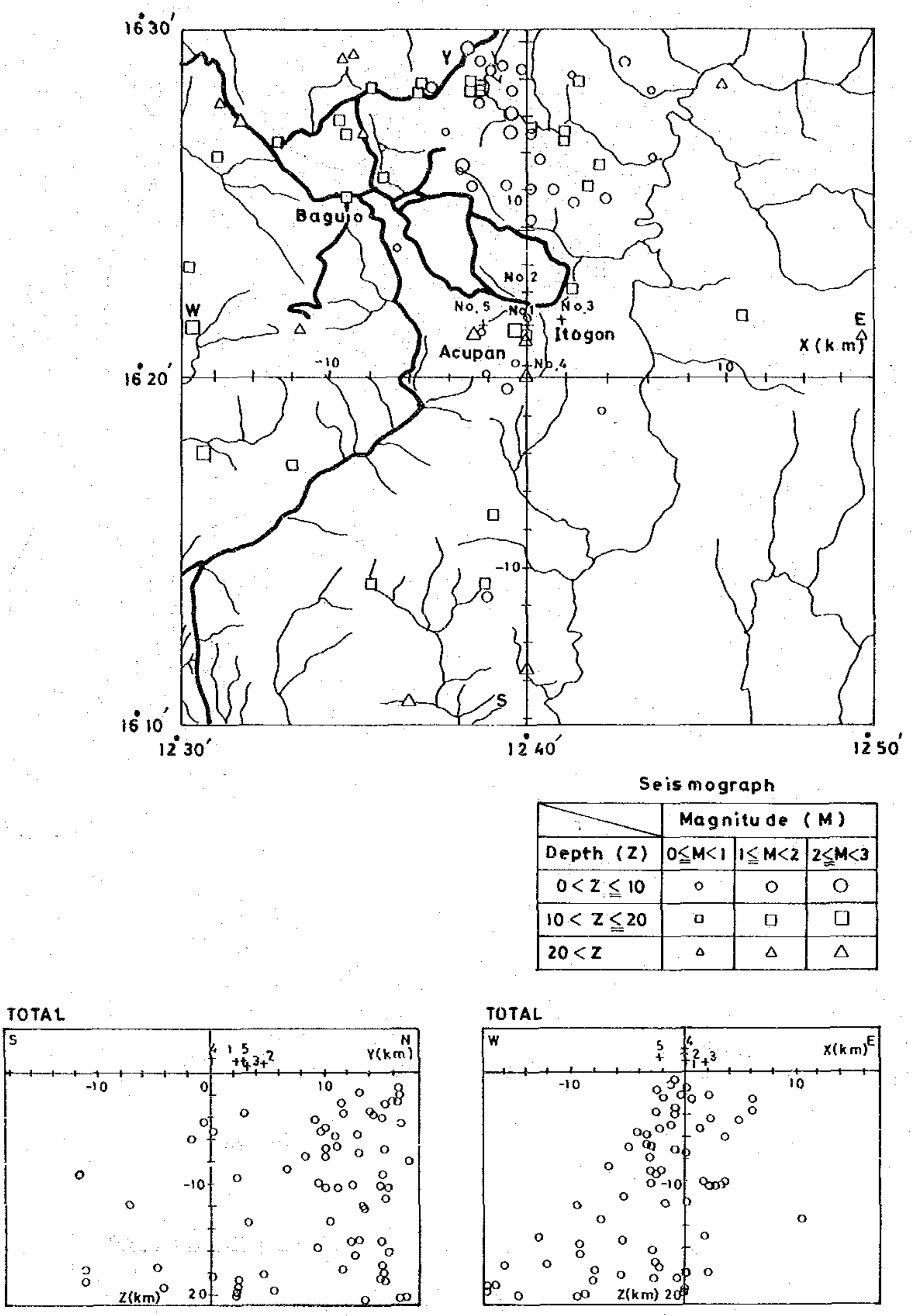
App. 1 Location map of spring water samples



App. 2 Bouger anomaly map ($\rho = 2.6$)



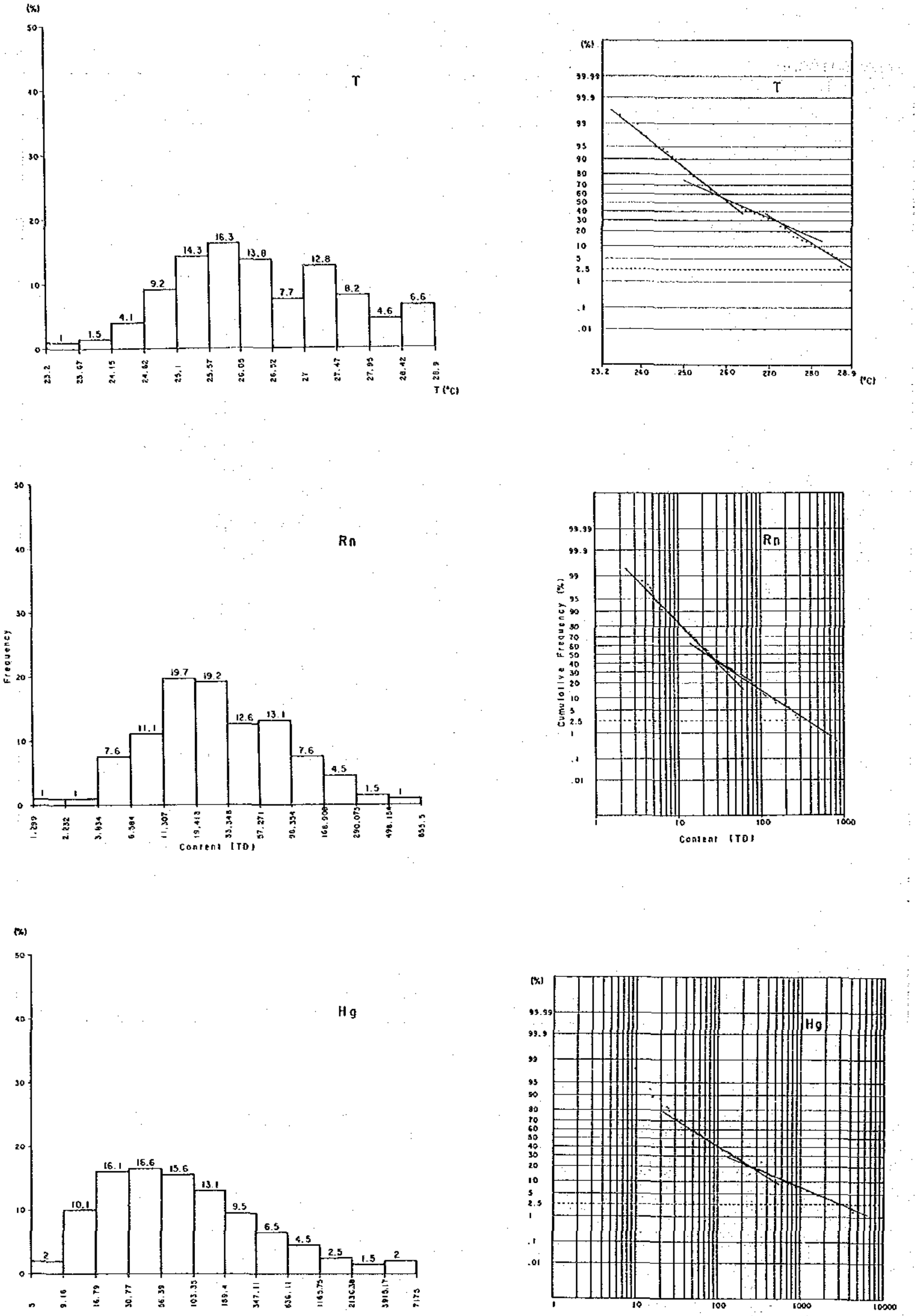
App. 3 Residual map (λ = 0.25 ~ 2.1)



Seismograph

	Magnitude (M)		
Depth (Z)	0≦M<1	1≦M<2	2≦M<3
0<Z≦10	○	○	○
10<Z≦20	□	□	□
20<Z	△	△	△

App. 4 Epicentrel and hypocentral distribution map of micro earthquakes



App. 5 Histograms and cumulative probability cahrts for T (°C), Rn (T/30 days, mm^2) and Hg (ppb) surveys

LEGEND

▩ 956 < Hg

▥ 478 ~ 955

▤ 239 ~ 477

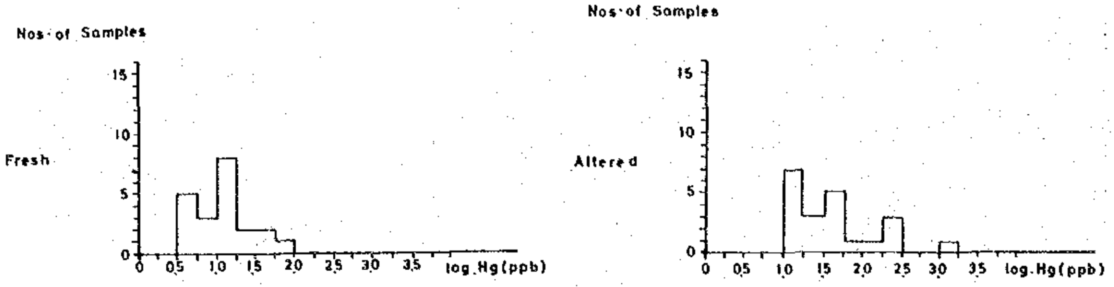
▤ 119 ~ 238

▒ 59 ~ 118

○ 58 > Hg

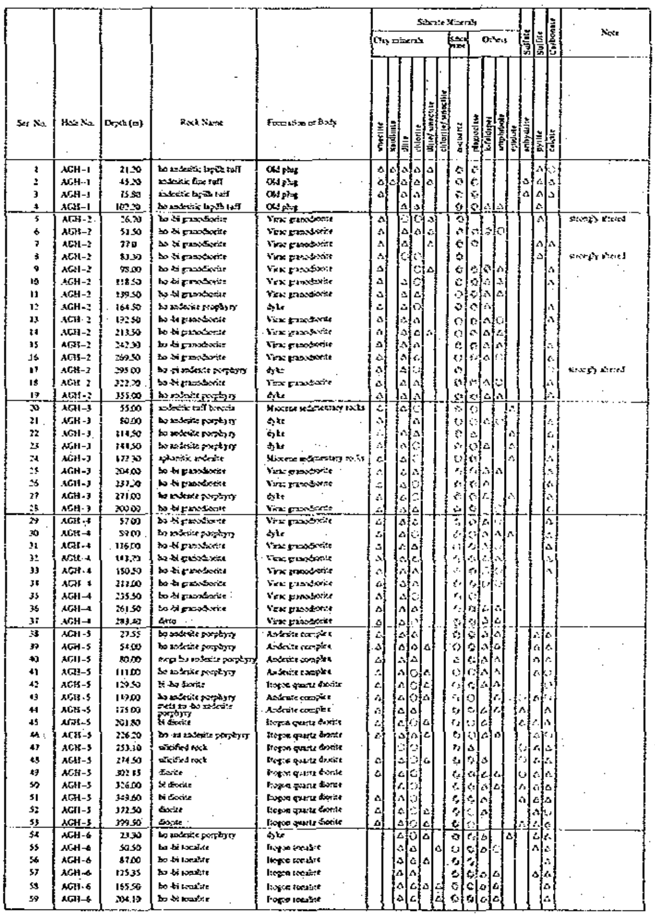
unit : ppb

App. 6 Soil Hg map



App. 7 Histograms of Hg contents in fresh and altered rocks

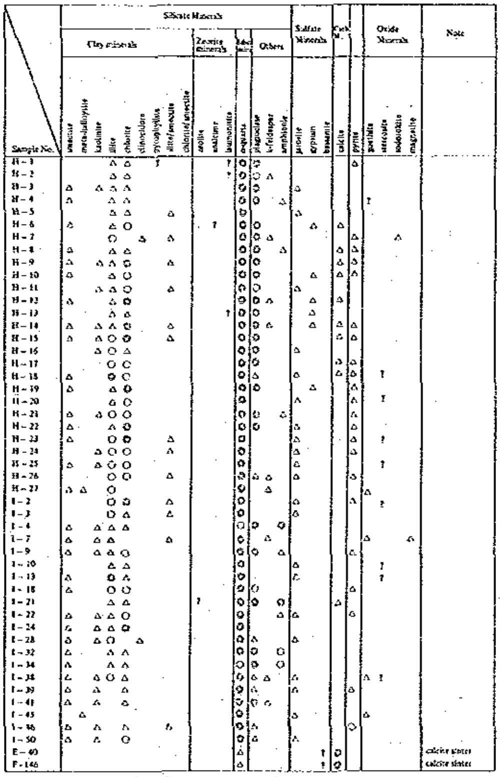
App. 8 List of minerals in core samples of gradient holes



Ser. No.	Hole No.	Depth (m)	Rock Name	Formation or Body	Note
1	AGH-1	21.20	ho andesitic lapilli tuff	Old plug	
2	AGH-1	45.20	andesitic fine tuff	Old plug	
3	AGH-1	75.80	andesitic lapilli tuff	Old plug	
4	AGH-1	107.20	ho andesitic lapilli tuff	Old plug	
5	AGH-2	26.70	ho-bi granodiorite	Virac granodiorite	strongly altered
6	AGH-2	51.50	ho-bi granodiorite	Virac granodiorite	
7	AGH-2	77.0	ho-bi granodiorite	Virac granodiorite	
8	AGH-2	83.30	ho-bi granodiorite	Virac granodiorite	strongly altered
9	AGH-2	98.00	ho-bi granodiorite	Virac granodiorite	
10	AGH-2	118.50	ho-bi granodiorite	Virac granodiorite	
11	AGH-2	139.50	ho-bi granodiorite	Virac granodiorite	
12	AGH-2	164.50	ho andesite porphyry	dyke	
13	AGH-2	192.50	ho-bi granodiorite	Virac granodiorite	
14	AGH-2	213.50	ho-bi granodiorite	Virac granodiorite	
15	AGH-2	242.30	ho-bi granodiorite	Virac granodiorite	
16	AGH-2	269.50	ho-bi granodiorite	Virac granodiorite	
17	AGH-2	295.00	ho-pl andesite porphyry	dyke	strongly altered
18	AGH-2	322.70	ho-bi granodiorite	Virac granodiorite	
19	AGH-2	355.00	ho andesite porphyry	dyke	
20	AGH-3	55.00	andesitic tuff breccia	Miocene sedimentary rocks	
21	AGH-3	80.00	ho andesite porphyry	dyke	
22	AGH-3	114.50	ho andesite porphyry	dyke	
23	AGH-3	141.50	ho andesite porphyry	dyke	
24	AGH-3	172.30	aphanitic andesite	Miocene sedimentary rocks	
25	AGH-3	204.00	ho-bi granodiorite	Virac granodiorite	
26	AGH-3	237.20	ho-bi granodiorite	Virac granodiorite	
27	AGH-3	271.00	ho andesite porphyry	dyke	
28	AGH-3	300.00	ho-bi granodiorite	Virac granodiorite	
29	AGH-4	57.00	ho-bi granodiorite	Virac granodiorite	
30	AGH-4	59.00	ho andesite porphyry	dyke	
31	AGH-4	116.00	ho-bi granodiorite	Virac granodiorite	
32	AGH-4	143.70	ho-bi granodiorite	Virac granodiorite	
33	AGH-4	150.50	ho-bi granodiorite	Virac granodiorite	
34	AGH-4	212.00	ho-bi granodiorite	Virac granodiorite	
35	AGH-4	235.50	ho-bi granodiorite	Virac granodiorite	
36	AGH-4	261.50	ho-bi granodiorite	Virac granodiorite	
37	AGH-4	293.40	ditto	Virac granodiorite	
38	AGH-5	27.55	ho andesite porphyry	Andesite complex	
39	AGH-5	54.00	ho andesite porphyry	Andesite complex	
40	AGH-5	80.00	meta ho andesite porphyry	Andesite complex	
41	AGH-5	111.00	ho andesite porphyry	Andesite complex	
42	AGH-5	129.50	bi-ho diorite	Itogon quartz diorite	
43	AGH-5	149.00	ho andesite porphyry	Andesite complex	
44	AGH-5	175.00	meta to ho andesite porphyry	Andesite complex	
45	AGH-5	201.80	bi diorite	Itogon quartz diorite	
46	AGH-5	226.20	ho-au andesite porphyry	Itogon quartz diorite	
47	AGH-5	253.10	silicified rock	Itogon quartz diorite	
48	AGH-5	274.50	silicified rock	Itogon quartz diorite	
49	AGH-5	302.85	diorite	Itogon quartz diorite	
50	AGH-5	326.00	bi diorite	Itogon quartz diorite	
51	AGH-5	349.60	bi diorite	Itogon quartz diorite	
52	AGH-5	372.50	diorite	Itogon quartz diorite	
53	AGH-5	399.50	diorite	Itogon quartz diorite	
54	AGH-6	23.30	ho andesite porphyry	dyke	
55	AGH-6	50.50	ho-bi tonalite	Itogon tonalite	
56	AGH-6	87.00	ho-bi tonalite	Itogon tonalite	
57	AGH-6	125.35	ho-bi tonalite	Itogon tonalite	
58	AGH-6	155.50	ho-bi tonalite	Itogon tonalite	
59	AGH-6	204.10	ho-bi tonalite	Itogon tonalite	

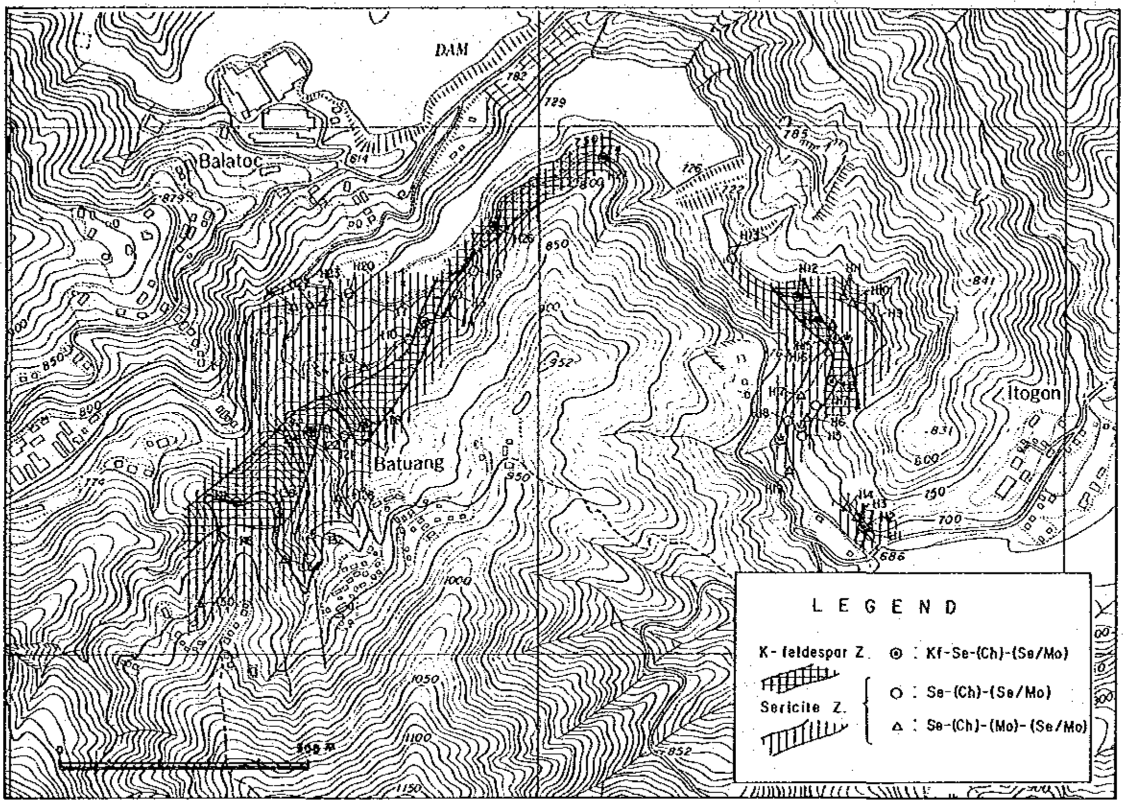
ho : hornblende, bi : biotite, pl : plagioclase, au : augite   : abundant,   : moderate,   : rare

App. 9 List of minerals in rock samples around Itogon plus

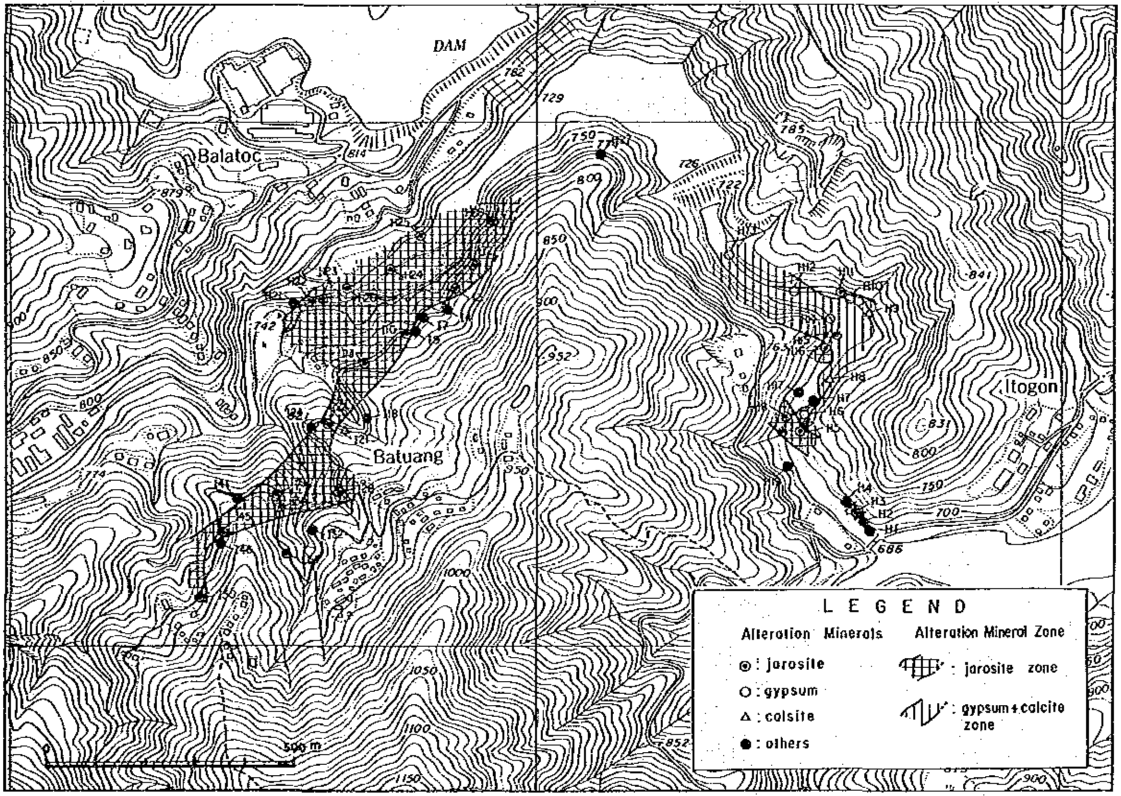


Sample No.	Note
H-1	
H-2	
H-3	
H-4	
H-5	
H-6	
H-7	
H-8	
H-9	
H-10	
H-11	
H-12	
H-13	
H-14	
H-15	
H-16	
H-17	
H-18	
H-19	
H-20	
H-21	
H-22	
H-23	
H-24	
H-25	
H-26	
H-27	
I-2	
I-3	
I-4	
I-7	
I-9	
I-10	
I-13	
I-18	
I-21	
I-22	
I-24	
I-28	
I-32	
I-34	
I-38	
I-39	
I-41	
I-45	
I-46	
I-50	
E-40	calcite stones
F-146	calcite stones

◎ : abundant, ○ : common, △ : rare, ? : inaccuracy



App. 10 Distribution of alteration minerals around Itogon plug (1)
(Neutral Hydrothermal Alteration Zone)



App. 10 Distribution of alteration minerals around Itogon plug (2)
(Jarosite Zone and Gypsum + Calcite Zone)

App. 11 Chemical analyses for core samples of gradient holes

Ser. No.	Hole No.	Depth	Rock Name	Formation or Body	SiO_2 %	Al_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	As ppm	B ppm	Ba ppm	Be ppm	Co ppm	Cu ppm	Hg ppb	Li ppm	Pb ppm	Rb ppm	Sb ppm	Sr ppm	Zn ppm
1	AGH-1	21.20	andesitic tuff breccia	Old plug	60.68	14.84	0.14	2.14	5.84	3.53	1.24	7	13	214	7	12	108	5	18	14	7	2	238	85
2	AGH-1	45.20	brecciated rock	Old plug	56.90	15.26	0.12	2.73	7.56	3.02	1.66	2	16	144	6	15	122	5	17	16	17	10	233	71
3	AGH-1	75.60	ho andesite porphyry	Old plug	56.94	17.09	0.14	2.71	7.20	4.16	1.09	0	5	292	6	14	80	5	14	11	6	0	350	83
4	AGH-1	102.20	ho andesite porphyry	Old plug	54.25	18.08	0.25	3.35	7.82	3.88	1.12	2	9	222	6	16	53	5	10	7	7	0	323	105
5	AGH-2	26.70	granodiorite	Virac granodiorite	67.01	11.98	0.18	2.63	0.44	0.47	4.62	25	11	367	9	21	155	9	13	14	39	5	12	179
6	AGH-2	51.50	granodiorite	Virac granodiorite	59.58	17.48	0.22	3.08	6.01	3.69	2.44	0	8	465	9	17	98	5	10	13	10	3	323	149
7	AGH-2	77.00	granodiorite	Virac granodiorite	60.83	15.30	0.13	2.76	4.93	3.72	1.54	2	8	182	11	20	100	5	6	16	9	0	264	104
8	AGH-2	83.30	granodiorite	Virac granodiorite	65.55	15.78	0.23	3.05	0.57	0.59	4.19	4	14	216	5	27	53	5	15	1	41	3	8	196
9	AGH-2	95.00	granodiorite	Virac granodiorite	57.90	16.04	0.31	3.10	5.78	3.33	2.29	0	10	442	10	22	192	5	6	18	9	0	323	172
10	AGH-2	118.50	granodiorite	Virac granodiorite	60.01	17.04	0.22	3.06	6.00	3.18	1.81	0	9	274	9	18	194	5	8	16	7	0	275	143
11	AGH-2	139.50	granodiorite	Virac granodiorite	57.29	17.56	0.19	2.59	6.41	4.15	1.87	1	10	399	10	13	38	5	6	11	7	0	378	100
12	AGH-2	155.50	ho-pl andesite porphyry	dyke	64.04	15.24	0.22	1.93	4.35	3.88	2.59	5	28	343	9	12	5	5	7	10	24	2	334	199
13	AGH-2	164.50	ho-pl andesite porphyry	dyke	56.98	16.55	0.20	1.94	5.75	3.76	2.59	8	9	321	8	10	40	5	8	11	19	0	263	133
14	AGH-2	192.50	granodiorite	Virac granodiorite	54.70	17.58	0.19	3.41	7.67	4.16	1.78	0	12	343	10	22	104	5	6	15	10	2	376	100
15	AGH-2	213.50	granodiorite	Virac granodiorite	54.76	17.29	0.17	3.21	6.59	4.35	4.28	0	13	336	9	13	15	5	6	8	12	0	349	83
16	AGH-2	242.30	granodiorite	Virac granodiorite	59.28	15.58	0.18	2.88	6.66	3.76	2.38	0	17	407	10	22	62	5	5	10	11	0	254	81
17	AGH-2	269.50	granodiorite	Virac granodiorite	55.85	15.30	0.17	3.09	7.54	4.23	2.75	0	12	366	9	15	114	5	6	12	16	0	352	86
18	AGH-2	295.00	ho andesite porphyry	dyke	58.05	15.94	0.20	2.55	4.21	0.74	3.86	17	14	224	7	24	91	11	9	13	21	3	39	106
19	AGH-2	322.70	granodiorite	Virac granodiorite	57.51	17.24	0.19	3.33	7.52	3.80	2.41	0	13	325	9	13	94	5	6	11	12	1	352	107
20	AGH-2	355.00	ho andesite porphyry	dyke	60.90	17.31	0.15	2.15	6.26	4.31	2.81	3	18	332	9	7	13	5	7	14	11	0	389	88
21	AGH-5	27.55	ho-pl andesite porphyry	Andesite complex	53.55	17.10	0.18	4.38	6.70	3.49	1.21	0	16	133	6	26	281	5	9	11	6	1	210	52
22	AGH-5	54.00	ho-pl andesite porphyry	Andesite complex	52.11	18.26	0.18	3.80	8.59	4.23	1.90	2	17	281	5	23	220	5	8	15	19	2	283	101
23	AGH-5	80.00	ho andesite porphyry	Andesite complex	53.70	17.91	0.16	4.06	8.91	3.25	1.21	0	17	176	6	24	116	5	4	6	8	0	356	92
24	AGH-5	111.00	ho andesite porphyry	Andesite complex	50.36	16.94	0.22	4.62	7.74	3.65	1.96	0	17	187	7	18	97	5	11	12	19	0	226	113
25	AGH-5	129.50	bi-ho diorite	Itogon quartz diorite	49.72	17.18	0.21	4.17	9.59	2.78	1.63	0	17	153	6	27	97	5	9	17	15	0	253	123
26	AGH-5	149.00	ho andesite porphyry	Andesite complex	53.53	15.62	0.18	4.05	7.25	3.53	1.78	3	19	174	7	21	256	5	13	17	10	0	256	129
27	AGH-5	175.00	ho andesite porphyry	Andesite complex	53.63	16.16	0.22	4.18	8.68	3.76	1.42	0	13	238	6	22	262	5	10	17	7	1	298	82
28	AGH-5	201.50	bi diorite	Itogon quartz diorite	57.78	15.39	0.07	3.34	5.08	2.86	1.69	0	18	129	6	18	21	5	14	15	10	1	300	54
29	AGH-5	226.20	ho-au andesite porphyry	dyke	53.45	15.90	0.19	3.55	8.47	1.92	2.20	0	24	360	10	21	170	5	12	12	13	0	311	98
30	AGH-5	253.10	brecciated diorite	Itogon quartz diorite	53.34	10.23	0.40	2.37	7.12	4.43	2.59	8	21	209	4	16	33	5	16	14	21	2	213	210
31	AGH-5	274.50	brecciated diorite	Itogon quartz diorite	56.58	14.65	0.11	3.25	6.69	3.69	1.90	0	25	138	3	8	138	5	11	13	16	3	311	108
32	AGH-5	302.15	brecciated diorite	Itogon quartz diorite	60.10	15.24	0.08	2.72	7.05	3.69	1.18	0	24	202	8	14	93	5	10	11	8	0	296	57
33	AGH-5	326.00	brecciated diorite	Itogon quartz diorite	56.25	16.60	0.07	3.37	7.80	4.35	1.24	0	20	164	7	25	45	5	6	9	7	0	294	48
34	AGH-5	349.60	brecciated diorite	Itogon quartz diorite	59.22	14.72	0.04	3.01	6.82	4.16	1.39	1	22	202	8	14	154	5	10	18	10	3	336	55
35	AGH-5	372.50	brecciated diorite	Itogon quartz diorite	52.25	15.26	0.40	3.80	8.03	2.31	2.50	0	25	256	8	28	58	38	11	15	13	0	223	214
36	AGH-5	399.50	brecciated diorite	Itogon quartz diorite	54.59	14.79	0.29	3.35	7.37	2.71	1.93	2	25	240	8	17	118	27	13	18	21	3	263	97

ho : hornblende, pl : plagioclase au : augite

App. 12 Factor components

Factor		1	2		3		4		5	
Contribution (%)		37.73		19.22		16.60		9.45		17.00
Elements and factor loadings	SiO_2	0.612	SiO_2	0.649	MnO	0.889	Cu	−0.492	Ba	0.755
	K_2O	0.708	MgO	−0.847	Hg	0.601	Pb	−0.728	Be	0.715
	As	0.775	CO	−0.746	Zn	0.748			Li	0.641
	Rb	0.777								
	CaO	−0.858								
	Na_2O	−0.765								
	Sr	−0.843								

App. 13 Analytical data sheet for spring water samples

No.	1		2		3		4		5		6		7		8		9		10		11	
Location	Itogon		Itogon		Dalupirip		Dalupirip		Dalupirip		Dalupirip		Dalupirip		Labeien		Klondykes		Klondykes		Klondykes	
Code	E1		E3		E4		E5		E6		E7		E8		E9		E10		E11		E12	
Sampling Date	3, June, '82		3, June, '82		3, June, '82		3, June, '82		3, June, '82		3, June, '82		3, June, '82		3, June, '82		4, June, '82		4, June, '82		4, June, '82	
T (°C)	50.5		27.0		44.0		41.0		43.0		22.0		21.0		23.5		39.0		45.0		24.0	
pH	7.43		7.64		7.10		7.08		6.78		7.60		7.50		7.93		7.43		7.78		7.48	
Conductivity (μ℧/cm)	2,348		1,701		1,361		1,429		1,361		201		315		199		2,025		2,348		451	
Discharge(ℓ/min)					7~8		4		7~8						7.5		1.5		3			
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	416	18.095	84.0	3.654	200	8.699	208	9.047	200	8.699	8.00	0.348	12.5	0.544	6.50	0.283	304	13.223	388	16.877	8.50	0.370
K^+	65.0	1.662	14.0	0.358	5.60	0.143	6.00	0.153	5.50	0.141	tr	–	1.50	0.038	tr	–	2.40	0.061	2.30	0.059	3.90	0.100
Ca^{2+}	98.0	4.590	309	15.419	87.0	4.341	94.0	4.691	96.0	4.790	28.0	1.397	38.0	1.896	29.0	1.447	116	5.788	132	6.587	76.0	3.792
Mg^{2+}	9.00	0.741	16.3	1.341	10.7	0.880	8.70	0.716	11.3	0.930	5.60	0.461	7.20	0.592	4.40	0.362	1.50	0.123	tr	–	7.07	0.582
Cl^-	145	4.090	104	2.933	45.4	1.281	47.2	1.331	43.8	1.235	4.17	0.118	19.2	0.542	4.08	0.115	486	13.708	597	16.839	7.09	0.200
SO_4^{2-}	586	12.201	758	15.782	588	12.243	639	13.305	586	12.201	5.50	0.115	67.8	1.412	8.25	0.172	296	6.163	340	7.079	123	2.561
HCO_3^-	660	10.817	47.0	0.770	6.10	0.100	8.54	0.140	7.32	0.120	87.8	1.439	62.2	1.019	97.6	1.600	30.5	0.500	40.2	0.659	70.2	1.151
CO_3^{2-}																						
H_2CO_3																						
Li	2.10		tr	–	tr	–	tr	–	tr	–							tr	–	tr	–		
As																						
B	9.63	0.891	tr	–	tr	–	tr	–	tr	–							2.38	0.220	3.95	0.365	tr	–
SiO_2	299	4.976	49.3	0.821	50.5	0.840	46.9	0.781	50.1	0.834	29.2	0.486	21.2	0.353	52.8	0.879	39.1	0.651	39.6	0.659	30.1	0.501
NH_4^+																						
T.S.M.(mg/ℓ)	2,287.6		1,381.6		993.3		1,058.3		1,000.0		168.3		229.6		202.6		1,277.9		1,543.0		325.9	
Alkalinity																						
Acidity																						
Remarks	hot spring		stream water		hot spring		hot spring		hot spring		stream water		stream water		cold spring		hot spring		hot spring		stream water	
Reference	B.E.D. (9/Aug/82)		do		do		do		do		do		do		do		do		do		do	

No.	12		13		14		15		16		17		18		19		20		21		22	
Location	Kennon Rd.		Kennon Rd.		Kennon Rd.		Acupan		Acupan		Acupan		Antamok		Antamok		Antamok		Batuang		Batuang	
Code	E13		E14		E15		E16		E17		E18		E19		E20		E21		E22		E23	
Sampling Date	4, June, '82		4, June, '82		4, June, '82		5, June, '82		5, June,'82		5, June, '82		7, June, '82		7, June, '82		7, June, '82		7, June, '82		7, June, '82	
T (°C)	21.0		23.0		19.0		62.0		85.0		80.0		19.0		20.0		18.0		18.5		19.0	
pH	7.62		7.76		7.28		7.99		7.95		6.88		7.07		6.20		6.78		6.62		6.73	
Conductivity (μ℧/cm)	134		314		515		4,931		4,514		4,839		835		1,805		1,656		121		131	
Discharge(ℓ/min)							5						10		10		10					
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	7.00	0.304	6.00	0.261	6.05	0.263	939	40.844	830	36.103	949	41.279	7.50	0.326	17.0	0.739	13.2	0.574	9.20	0.400	8.24	0.358
K^+	0.28	0.007	2.90	0.074	1.46	0.037	156	3.990	134	3.427	152	4.143	1.0	0.026	3.24	0.083	4.24	0.108	0.30	0.008	0.30	0.008
Ca^{2+}	16.8	0.838	55.9	2.789	84.8	4.232	130	6.487	45.6	2.275	54.4	2.715	151	7.535	425	21.208	310	15.469	7.20	0.359	6.40	0.319
Mg^{2+}	2.20	0.181	6.53	0.537	8.50	0.699	8.80	0.724	8.38	0.690	2.00	0.165	24.2	1.991	27.0	2.222	63.0	5.184	4.20	0.346	6.25	0.514
Cl^-	9.93	0.280	9.93	0.280	13.0	0.367	1,302	36.725	1,223	34.496	1,257	35.455	18.9	0.533	14.2	0.401	8.86	0.250	6.20	0.175	4.73	0.133
SO_4^{2-}	7.00	0.146	91.9	1.913	194	4.039	366	7.621	351	7.308	305	6.350	319	6.642	1,241	25.839	1,006	20.946	3.57	0.074	36.7	0.764
HCO_3^-	29.9	0.490	12.2	0.200	28.7	0.470	352	5.769	122	1.999	515	8.440	210	3.442	40.9	0.670	85.8	1.406	72.6	1.190	35.0	0.574
CO_3^{2-}																						
H_2CO_3																						
Li							4.60		4.50		5.10											
As																						
B							35.6	3.293	38.1	3.525	43.9	4.061										
SiO_2	23.4	0.389	44.6	0.742	19.1	0.318	133	2.280	206	3.429	182	3.029	27.7	0.461	37.4	0.622	44.6	0.742	37.0	0.616	40.3	0.671
NH_4^+																						
T.S.M.(mg/ℓ)	96.5		230.0		356.2		3,426.4		2,958.1		3,470.3		759.3		1,805.7		1,535.7		140.3		137.9	
Alkalinity																						
Acidity																						
Remarks	stream water		stream water		stream water		hot spring 3,350L		hot spring 3,300L		hot spring 3,150L		cold spring 400L		cold spring 400L		cold spring 400L		cold spring		cold spring	
Reference	B.E.D. (9/Aug/82)		do		do		do		do		do		do		do		do		do		do	

No.	23		24		25		26		27		28		29		30		31		32		33	
Location	Batuang		Batuang		Antemok		Antemok		Acupan		Acupan		Acupan		Acupan		Acupan		Acupan		Acupan	
Code	E24		E25		E26		Antamok		Benquet-1		Benquet-2		Benquet-3		Benquet-4		Benquet-5		Benquet-6		Benquet-7	
Sampling Date	7, June, '82		7, June, '82		9, June, '82				19, Aug., '77		18, Aug., '77		19, Aug., '77		19, Aug., '77		18, Aug., '77		19, Aug., '77		19, Aug., '77	
T (°C)	19.0		18.0		17.5		37.0		79.5		99		80		72.5		64.5		55		73	
pH	5.51		5.30		6.79		3.35		7.84		8.36		–		8.12		8.05		7.80		7.25	
Conductivity (μ℧/cm)	518		647		258		4,653															
Discharge(ℓ/min)	1		0.5		20				40				30		2~3				20		60	
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	12.6	0.548	14.8	0.644	5.10	0.222	360	15.659	866	37.669	1,245	54.154	1,077	46.846	990	43.062	856	37.234	37	1.609	41	1.783
K^+	0.61	0.016	0.73	0.019	0.60	0.015	22.3	0.570	117	2.992	178	4.553	158	4.041	138	3.530	122	3.120	3.9	0.100	4.7	0.120
Ca^{2+}	40.0	1.996	49.6	2.475	32.0	1.597	580	28.942	121	6.038	195	9.731	57	2.844	67	3.343	210	10.479	438	21.856	408	20.359
Mg^{2+}	28.8	2.370	39.0	3.209	7.75	0.638	94.0	7.735	5.4	0.444	0.3	0.025	2.0	0.165	2.2	0.181	8.3	0.683	11.2	0.922	8.5	0.699
Cl^-	7.09	0.200	2.95	0.083	2.36	0.067	613	17.290	1,202	33.904	1,550	43.720	1,405	39.630	1,248	35,202	1,260	35.540	7	0.197	12	0.338
SO_4^{2-}	230	4.789	247	5.143	52	1.083	2,199	45.786	392	8.162	332	6.913	540	11.243	495	10.306	410	8.537	1,440	29.983	1,420	29.566
HCO_3^-	16.5	0.270	22.4	0.367	83.9	1.375			157	2.573	278	4.556	–	–	198	3.245	316	5.507	87	1.426	85	1.393
CO_3^{2-}									2	0.067	10	0.333	–	–	4	0.133	5	0.167	1	0.033	0	0.000
H_2CO_3									6	0.097	3	0.048	–	–	4	0.064	8	0.129	3	0.048	10	0.161
Li							2.40		4.2		7.0		5.9		5.6		4.6		0.05		0.07	
As																						
B							10.60	0.981	47	4.348	68	6.290	55	5.088	57	5.273	47	4.348	<0.05	0.005	0.96	0.089
SiO_2	34.1	0.568	39.0	0.649	21.8	0.363	47.6	0.792	177	2.946	295	4.910	236	3.928	206	3.429	167	2.779	26	0.433	28	0.466
NH_4^+																						
T.S.M.(mg/ℓ)	369.7		415.5		205.5		3,926.5		3,092.4		4,154.3		3,530.0		3,409.2		3,429.3		2,054.2		2,018 2	
Alkalinity																						
Acidity																						
Remarks	cold spring		cold spring		stream water		hot spring 1,850L		hot spring 3,300L		hot spring 3,150L		hot spring 3,150L		hot spring 3,150L		hot spring 3,150L		hot spring 3,150L		hot spring 3,150L	
Reference	B.E.D. (9/Aug/82)		do		do		do		KKTA (Sep/77)		do		do		do		do		do		do	

No.	34		35		36		37		38		39		40		41		42		43		44	
Location	Acupan		Acupan		Acupan		Acupan		Acupan		Acupan		Acupan		Acupan		Acupan		Acupan		Itogon	
Code	Benquet-8		Benquet-9		Benquet-10		Benquet-11		Benquet-12		Benquet-13		Benquet-14		Benquet-15		Benquet-16		Benquet-17		Benquet-18	
Sampling Date	19, Oug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		20, Aug., '77		19, Aug., '77	
T (°C)	57		65		52		97		63		51.5		–		45		24		43		94	
pH	7.25		8.23		7.89		–		7.57		7.04		7.61		7.75		–		–		7.47	
Conductivity (μ℧/cm)																						
Discharge(ℓ/min)	5		15		10		<1				8				50		200		20,000		5	
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	23	1.000	845	36.755	942	40.974	1,041	45.281	85	3.697	32	1.392	42	1.827	44	1.914	18	0.783	124	5.394	570	24.793
K^+	3.3	0.084	118	3.018	124	3.172	139	3.555	7.2	0.154	2 2	0.056	2.8	0.072	3.0	0.077	1.7	0.043	15	0.384	81	2.072
Ca^{2+}	425	21.208	50	2.495	98	4.890	119	5.938	312	15.569	505	25.200	592	29.541	550	27.445	274	13.673	445	22.206	86	4.291
Mg^{2+}	12.0	0.987	1.7	0.140	7.0	0.576	1.3	0.107	2.9	0.239	11.0	0.905	3.4	0.280	3.8	0.313	12.9	1.062	15.9	1.308	4.0	0.329
Cl^-	8	0.226	935	26.373	1,142	32.212	1,360	38.361	12	0.338	6	0.169	7	0.197	10	0.282	<5	0.141	151	4.259	397	11.198
SO_4^{2-}	1,400	29.150	740	15.408	622	12.951	488	10.161	1,000	20.821	1,520	31.648	1,500	31.232	1,475	30.711	770	16.032	1,185	24.673	655	13.638
HCO_3^-	173	2.835	188	3.081	266	4.360	–		72	1.150	259	4.245	195	3.196	192	3.147	–	–	–	–	473	7.752
CO_3^{2-}	0	0.000	5	0.167	3	0.100	–		1	0.033	0	0.000	2	0.067	2	0.057	–	–	–	–	2	0.067
H_2CO_3	21	0.339	3	0.048	8	0.129	–		4	0.064	58	0.935	10	0.161	6	0.097	–	–	–	–	38	0.613
Li	0.05		4.4		4.7		5.2		0.10		0.07		0.05		0.07		0.05		0.61		3.0	
As																						
B	<0.05	0.005	31	2.868	45	4.163	55	5.088	0.05	0.005	<0.05	0.005	0.32	0.030	<0.05	0.005	<0.05	0.005	7.8	0.722	24	2.220
SiO^2	26	0.433	140	2.330	153	2.546	177	2.946	46	0.766	36	0.599	34	0.566	32	0.533	30	0.499	32	0.533	137	2.280
NH_4^+																						
T.S.M.(mg/ℓ)	2,091.4		3,056.7		3,410.0		3,350.3		1,542.2		2,429.3		2,388.5		2,317.9		1,111.7		1,975.7		2,467.0	
Alkalinity																						
Acidity																						
Remarks	hot spring 3,150L		hot spring 2,900L		hot spring 2,900L		hot spring 2,900L		hot spring 2,900L		hot spring 2,900L		hot spring 2,900L		hot spring 2,950L		mine drainage 1,500L		mine drainage 2,000L		hot spring	
Reference	KRTA (Sep./77)		do		do		do		do		do		do		do		do		do		do	

No.	45		46		47		48		49		50		51		52		53		54		55	
Location	Itogon		Atin		Atin		Acupan		Acupan		Acupan		Acupan		Acupan		Itogon		Itogon		Batuang	
Code	Benquet-19		Benquet-20		Benquet-21		BED-1		BED-2		BED-3		BED-4		BED-5		BED-6		BED-7		BED-8	
Sampling Date	19, Aug., '77		21, Aug., '77		21, Aug., '77		25, Oct., '78		25, Oct., '78		25, Oct., '78		25, Oct., '78		25, Oct., '78		25, Oct., '78		25, Oct., '78		26, Oct., '78	
T(°C)	85		70		41		96		87		61		59		79		86		75		20	
pH	7.37		8.78		7.43		8.5		6.8		8.8		7.8		7.7		6.3		6.0		2.7	
Conductivity (μƱ/cm)							4,115		-		4,478		1,757		4,267		1,470		2,323		638	
Discharge(ℓ/min)					2.5		60		<6		30		very low		40		20		10		30	
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	m.eq/ℓ	
Na^+	355	15.441	523	22.749	122	5.307	783	34.058	-	-	775	33.710	187	8.134	750	32.623	183	7.960	376	16.355	8.67	0.377
K^+	56	1.432	11	0.281	1.7	0.043	125	3.197	-	-	88.2	2.256	18.5	0.473	88.2	2.256	36.1	0.923	62.2	1.591	0.57	0.015
Ca^{2+}	152	7.585	222	11.078	64	3.194	12.2	0.609	-	-	234	11.677	226	11.277	85.7	4.276	103	5.140	54.3	2.710	47.4	2.365
Mg^{2+}	16.0	1.317	N.D.	0.000	5.0	0.411	1.5	0.123	-	-	10	0.823	2.63	0.216	7.31	0.602	17.2	1.415	7.81	0.643	16.6	1.366
Cl^-	233	6.572	835	23.552	200	5.641	984	27.755	-	-	1,440	40.617	204	5.754	1,110	31.309	417	11.762	191	5.387	24.2	0.683
SO_4^{2-}	670	13.950	475	9.890	108	2.249	407	8.474	-	-	449	9.349	584	12.160	272	5.663	560	11.660	481	10.015	447	9.307
HCO_3^-	347	5.687	26	0.426	170	2.786	382	6.261	-	-	292	4.786	126	2.065	168	2.753	244	3.999	387	6.343	-	-
CO_3^{2-}	0	0.000	2	0.067	0	0.000																
H_2CO_3	34	0.548	0	0.000	21	0.339																
Li	1.8		0.2		0.1		3.36		-	-	4.11		0.48		4.55		1.28		2.50		-	-
As							2.25		-	-	2.50		-		4.0		0.4		1.0		-	-
B	9.5	0.879	9.5	0.879	3.3	0.305	38.9	3.599	-	-	40.9	3.784	5.26	0.487	41.8	3.867	3.57	0.330	13.7	1.267	-	-
SiO_2	103	1.714	32	0.533	32	0.533	267	4.444	-	-	210	3.495	118	1.964	244	4.061	172	2.863	195	3.245	81.3	1.353
NH_4^+							0.05		0.38		0.046		0.035		0.031		0.042		0.036		0.040	
T.S.M.(mg/ℓ)	1,975.5		2,135.5		727.0		3,000.6				3,539.1		1,471.4		2,767.0		1,735.9		1,768.0		625.7	
Alkalinity																						
Acidity																						
Remarks	hot spring		hot spring		hot spring		hot spring 2,900L		hot spring 3,150L		hot spring 3,150L		hot spring 3,150L		hot spring 3,300L		hot spring		hot spring		cold spring	
Reference	KRTA (Sep./77)		do		do		BED-ELC (Feb./79)		do		do		do		do		do		do		do	

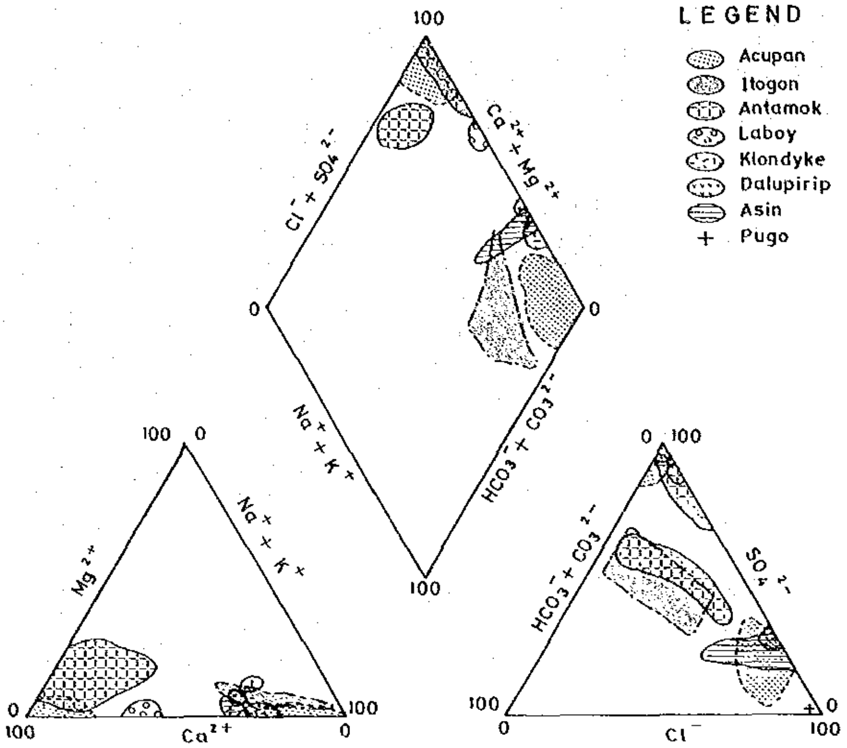
No.	56		57		58		59		60		61		62		63		64		65		66	
Location	Batuang		Batuang		Virac		Virac		Virac		Balinguay		Itogon		Itogon		Acupan		Acupan		Acupan	
Code	BED-9		BED-10		BED-11		BED-12		BED-13		BED-14		BED-15		BED-16		BED-17		76-B-3		76-B-4	
Sampling Date	26, Oct., '78		26, Oct., '78		26, Oct., '78		26, Oct., '75		26, Oct., '78		30, Oct., '78		1, Nov., '78		1, Nov., '78		31, Oct., '78					
T(°C)	20		19.5		20		20		20		20		20		20		20		63.7		46.1	
pH	3.9		4.2		7.3		8.2		8.0		8.0		7.4		7.4		7.2					
Conductivity (μƱ/cm)	532		247		275		224		183		279		104		134		870					
Discharge(ℓ/min)			6,000		600		6,000		6,000		300		400		400		500					
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	10.0	0.435	7.33	0.319	4.0	0.174	4.67	0.203	6.33	0.275	5.67	0.247	2.67	0.116	2.67	0.116	7.50	0.326	1,360	59.156	25	1.087
K^+	0.86	0.022	0.43	0.011	0.29	0.007	0.43	0.011	0.29	0.007	0.43	0.011	0.14	0.004	0.29	0.007	1.43	0.037	200	5.115	4.0	0.102
Ca^{2+}	12.7	0.634	13.0	0.649	42.6	2.126	30.4	1.517	20.0	0.998	47.8	2.385	19.6	0.978	23.5	1.173	220	10.978	30.5	1.522	489	24.401
Mg^{2+}	8.75	0.720	9.31	0.766	5.88	0.484	9.69	0.797	7.63	0.628	8.13	0.669	1.88	0.155	2.81	0.231	20	1.646	1.83	0.151	4.43	0.365
Cl^-	24.2	0.683	27.8	0.784	3.55	0.100	4.43	0.125	3.55	0.100	3.55	0.100	3.90	0.110	4.14	0.117	6.50	0.183	1,720	48.515	3	0.085
SO_4^{2-}	284	5.913	115	2.354	86.5	1.803	50.9	1.060	33.3	0.693	25.3	0.527	5.89	0.123	18.5	0.385	469	9.765	394	8.204	1,210	25.194
HCO_3^-	-	-	-	-	71.6	1.173	80.8	1.324	77.1	1.264	145	2.376	69.8	1.144	734	12.030	126	2.065	394	6.457	150	2.458
CO_3^{2-}																						
H_2CO_3																						
Li	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	6.75		<0.01	
As	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-				
B	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	5.88	0.544	<0.1	0.009
SiO_2	74	1.232	59	0.982	24.2	0.403	27.4	0.456	42.1	0.701	49.6	0.826	45.8	0.762	23.1	0.384	27.2	0.453	372	6.191	40.7	0.677
NH_4^+	0.049		0.050		0.015		0.140		0.015													
T.S.M.(mg/ℓ)	414.5		231.7		238.7		208.7		190.3		285.5		149.7		809.0		877.6		4,478.2		1,726.2	
Alkalinity																						
Acidity																						
Remarks	stream water		stream water		stream water		stream water		stream water		stream water		stream water		stream water		stream water		hot spring 3,150L		hot spring 2,600L	
Reference	BED-ELC (Feb./79)		do		do		do		do		do		do		do		do		Sawkins F.J. et. al., (1979)		do	

No.	67		68		69		70		71		72	
Location	Acupan		Itogon		Antamok		Antomok		Antomok		Acupan	
Code	76-B-5		76-B-11		76-B-12		76-B-14		76-B-15		76-B-26	
Sampling Date												
T (°C)	46.1		87.9		51.7		40.6		46.1		61.1	
pH												
Conductivity (μ℧/cm)												
Discharge(ℓ/min)												
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	30	1.305	620	26.968	1,620	70.465	167	7.264	120	5.220	920	40.017
K^+	4.3	0.110	8.6	0.220	107	2.737	6.1	0.156	4	0.102	110	2.813
Ca^{2+}	509	25.399	13.2	0.659	565	28.194	1,000	49.900	753	37.575	77	3.842
Mg^{2+}	4.25	0.350	8.3	0.683	92.0	7.570	20.5	1.687	19.1	1.572	14.1	1.160
Cl^-	4.4	0.124	516	14.554	1,890	53.310	828	23.355	302	8.518	1,270	35.822
SO_4^{2-}	1,370	28.525	480	9.994	1,660	34.563	1,360	28.317	1,240	25.818	87	1.811
HCO_3^-	162	2.655	522	8.555	886	14.521	590	9.670	758	13.079	470	7.703
CO_3^{2-}												
H_2CO_3												
Li	<0.01		2.80		1.05		0.40		0.5		4.0	
As												
B	0.12	0.011	2.35	0.217	4.83	0.447	0.64	0.059	0.52	0.046	3.95	0.370
SiO_2	42	0.699	191	3.179	143	2.380	82.3	1.370	69.5	1.157	254	4.227
NH_4^+												
T.S.M.(mg/ℓ)	2.126.1		2,361.5		6,967.8		4,054.5		3,306.1		3,206.1	
Alkalinity												
Acidity												
Remarks	hot spring 2,600L		hot spring		hot spring 1,850L		hot spring 1,850L		hot spring 1,550L		hot spring 3,150L	
Reference	Sawkins F.J. et al (1979)		do		do		do		do		do	

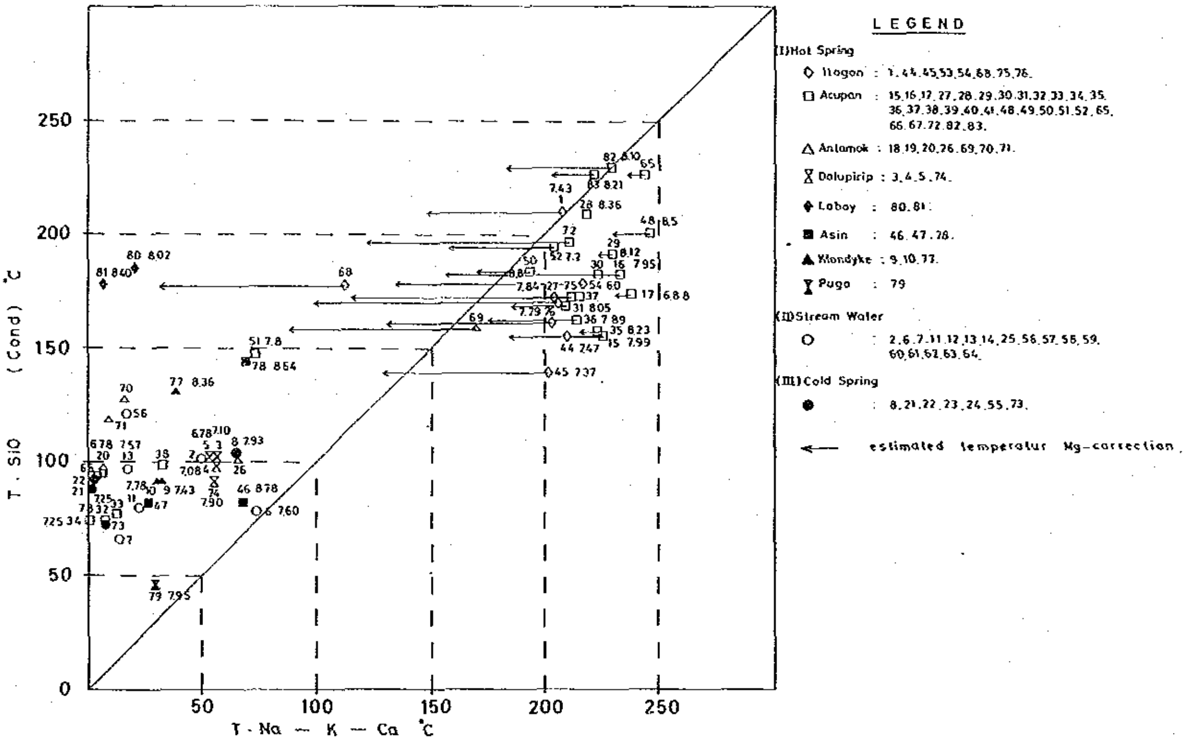
No.	73		74		75		76		77	
Location	Acupan		Dalupirip		Itogon		Itogon		Klondyke	
Code	76-B-27		DA		IT-1		IT-2		KL	
Sampling Date			24, Sep., '82		24, Sep., '82		29, Sep., '82		25, Sep., '82	
T (°C)	Cold		42.5		89.5		63.2		49.5	
pH			7.90		7.68		7.79		8.36	
Conductivity (μ℧/cm)										
Discharge(ℓ/min)			50							
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	8.3	0.361	71.0	3.088	267.0	11.614	332.0	14.441	397.0	17.268
K^+	2	0.051	2.8	0.072	43.8	1.120	53.5	1.368	2.8	0.072
Ca^{2+}	79	3.942	19.9	0.993	90.6	4.521	134.0	6.687	124.0	6.188
Mg^{2+}	12	0.987	2.8	0.230	12.6	1.037	14.2	1.168	0.2	0.016
Cl^-	3	0.085	7.0	0.197	55.0	1.551	64.0	1.805	555.0	15.655
SO_4^{2-}	168	3.498	125.0	2.603	600.0	12.493	600.0	12.493	355.0	7.392
HCO_3^-	110	1.803	98.0	1.606	294.0	4.818	600.0	9.833	17.0	0.279
CO_3^{2-}			0.0	0.000	0.0	0.000	0.0	0.000	0.6	0.020
H_2CO_3			0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
Li	<0.01		<0.1		1.4		2.0		<0.1	
As										
B	<0.1	0.009	0.3	0.028	4.5	0.416	5.9	0.546	4.9	0.453
SiO_2	24.8	0.413	39.0	0.649	178.0	2.963	151.0	2.513	88.3	1.470
NH_4^+										
T.S.M.(mg/ℓ)	407.2		345		1,436		1,686		1,548	
Alkalinity			1.60		4.80		9.80		0.20	
Acidity			0.10		0.20		0.30		0.00	
Remarks	cold spring 1,500L		hot spring		hot spring		hot spring		hot spring	
Reference	do		BED-JICA (1982)		do		do		do	

No.	78		79		80		81		82		83	
Location	Asin		Pugo		Laboy		Laboy		Acupan		Acupan	
Code	AS		PU		LA-1		LA-2		BA-1		BA-2	
Sampling Date	25, Sep., '82		26, Sep., '82		27, Sep., '82		27, Sep., '82		28, Sep., '82			
T (°C)	73.8		36.3		47.5		47.5		81.0		62.1	
pH	8.64		7.93		8.02		8.40		8.10		8.21	
Conductivity (μ℧/cm)												
Discharge(ℓ/min)	not sure		5		10		15		25		60~80	
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	525.0	22.836	570.0	24.793	162.0	7.047	145.0	6.307	892.0	38.799	942.0	40.974
K^+	12.0	0.307	3.0	0.077	2.8	0.072	1.6	0.041	129.0	3.299	145.0	3.709
Ca^{2+}	243.0	12.126	277.0	13.822	241.0	12.026	257.0	12.824	41.9	2.091	146.0	7.285
Mg^{2+}	0.1	0.008	0.1	0.008	0.8	0.066	0.1	0.008	5.0	0.411	5.4	0.444
Cl^-	763.0	21.521	1,200.0	33.848	6.0	0.169	6.0	0.169	1,280.0	36.104	1,270.0	35.822
SO_4^{2-}	217.0	4.518	2.0	0.042	930.0	19.364	910.0	18.947	385.0	8.016	420.0	8.745
HCO_3^-	10.0	0.164	24.0	0.393	27.0	0.443	13.0	0.213	19.0	0.311	541.0	8.867
CO_3^{2-}	9.6	0.320	0.0	0.000	0.0	0.000	0.6	0.020	0.0	0.000	0.0	0.000
H_2CO_3	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
Li	0.1		<0.1		<0.1		<0.1		5.2		5.5	
As												
B	9.1	0.842	5.1	0.472	0.1	0.009	0.1	0.009	39.5	3.654	42.9	3.969
SiO_2	113.0	1.881	12.0	0.200	215.0	3.578	194.0	3.229	388.0	6.458	374.0	6.225
NH_4^+												
T.S.M.(mg/ℓ)	2,427		2,598		1,563		1,465		3,396		3,748	
Alkalinity	0.50		0.40		0.50		0.20		3.20		8.90	
Acidity	0.00		0.10		0.10		0.00		0.30		0.10	
Remarks	hot spring		hot spring		hot spring		hot spring		hot spring 3,300L		hot spring 3,150L	
Reference	BED-JICA (1982)		do		do		do		do		do	

No.	84									
Location	Liang									
Code	103C									
Sampling Date	15, Apr., '85									
T (°C)	66.0									
pH	8.30									
Conductivity (μ℧/cm)										
Discharge(ℓ/min)	–									
Chemi. Ana.	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ	mg/ℓ	m.eq/ℓ
Na^+	260	11.3								
K^+	5.8	0.15								
Ca^{2+}	160	7.93								
Mg^{2+}	0.24	0.02								
Cl^-	277	7.81								
SO_4^{2-}	646	13.4								
HCO_3^-	Tr	0.09								
CO_3^{2-}	0.0	0.000								
H_2CO_3	0.0	0.000								
Li	0.21									
As										
B	10.6	0.981								
SiO_2	49.8	0.829								
NH_4^+										
T.S.M.(mg/ℓ)	–									
Alkalinity	–									
Acidity	–									
Remarks	hot spring									
Reference	BED (1985)									



App. 14 Key diagram for spring water samples



App. 15 Correlation between Tsio and $T_{Na-K-Ca}$

App. 16 List of O/H isotope analyses

Sample No.	Sample Location	Temperature (°C)	Disoharge (ℓ/min)	PH	δD (0/00)	δ^{18}O (0/00)	Remarks
1	AGH-1 Drill Hole	66.2	2	7.0	−58.9	−8.6	Nov., '83
2	Ambalanga River	73.8	3	7.0	−59.6	−9.3	〃
3	Acupan Mine 2900L	35.9	100	7.0	−66.7	−10.6	〃
4	Acupan Mine 2900L	43.5	50	7.0	−70.8	−10.8	〃
5	Acupan Mine 2900L	41.7	150 ~ 100	7.0	−70.2	−10.9	〃
6	Acupan Mine 2900L	65.0	5	7.5	−57.8	−8.1	〃
7	Acupan Mine 2900L	90.0	10	7.5	−56.5	−8.9	〃
8	Acupan Mine 2900L	65.0	2	7.0	−55.5	−8.7	〃
9	Acupan Mine 3150L	75.0	70	7.5	−55.2	−8.4	〃
10	Acupan Mine 3150L	80.0	60 ~ 50	7.5	−64.7	−10.1	〃
11	Acupan Mine 3150L	80.0	60 ~ 50	7.0	−68.0	−10.7	〃
12	Acupan Mine 3300L	57.1	25	7.0	−57.0	−7.8	〃
13	Acupan Mine 3300L	85.8	30 ~ 25	7.5	−59.6	−7.6	〃
14	Acupan Mine 2300L	32.8	100 ~ 50	7.0	−68.7	−10.3	〃
15	Acupan Mine Drainage Tunnel	73.1	5	7.5	−68.0	−9.5	Sep., '82
IT-1	Itogon Hot Spring	89.5	Total 10	7.7	−67.2	−9.8	〃
IT-2	Itogon Hot Spring	62.2		7.8	−67.6	−9.6	〃
BA-1	Acupan Mine 3300L	81.0	25	8.1	−62.3	−7.7	〃
BA-2	Acupan Mine 3150L	62.1	60 ~ 80	8.2	62.5	−7.6	〃
DA-ST	East of Dalupirip stream				−71.0	−10.1	〃
PRE	Precipitate at Baguio city				−66.9	−9.9	〃
Errors					± 2	± 0.1	〃

App. 17 Chemical analyses of water samples on Phase II survey

Sample No.	Sample Location		Temp. (°C)	pH	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Li (ppm)	B (ppm)	SiO_2 (ppm)	SO_4^{2-} (ppm)	HCO_3^- (ppm)	Cl^- (ppm)
1	AGH-1, drill hole		66.2	7.53	670	80.0	270	28.0	3.15	31.2	135	554	693	794
2	Ambalanga stream water		73.8	6.66	275	46.5	203	18.0	1.05	2.16	119	1,156	193	85.1
3	Acupan mine	2,900 L	35.9	7.18	15.0	3.5	640	15.0	ND	ND	29.8	1,179	153	7.09
4	〃	2,900 L	43.5	7.44	39.0	3.3	680	9.0	ND	ND	32.5	1,630	91.5	7.09
5	〃	2,900 L	41.4	7.45	37.5	3.6	650	10.0	ND	ND	32.2	1,584	110	7.09
6	〃	2,900 L	65.0	8.23	620	90.0	92.5	7.0	3.05	26.4	214	594	400	581
7	〃	2,900 L	70.0	8.09	370	56.0	155	7.0	1.75	13.4	128	881	125	411
8	〃	2,900 L	65.0	7.06	220	37.0	430	63.0	1.00	9.41	70.8	1,357	79.3	227
9	〃	3,150 L	75.0	8.60	890	120	150	14.0	4.40	43.1	302	385	384	1,191
10	〃	3,150 L	85.0	7.35	34.0	3.8	590	5.0	ND	ND	39.7	1,358	81.1	7.09
11	〃	3,150 L	80.0	7.87	39.0	6.0	600	14.0	ND	ND	47.2	1,205	67.1	10.6
12	〃	3,300 L	57.1	7.59	720	100	260	18.0	3.45	34.6	207	847	270	936
13	〃	3,300 L	85.8	8.23	870	115	47.5	6.0	3.50	44.8	280	356	144	1,163
14	〃	2,300 L	35.0	7.40	21.5	6.0	430	100	ND	ND	38.0	1,293	58.0	7.09
15	〃	2,300 L drainage	73.0	7.85	300	39.5	95.0	10.0	1.00	5.41	153	496	384	70.9

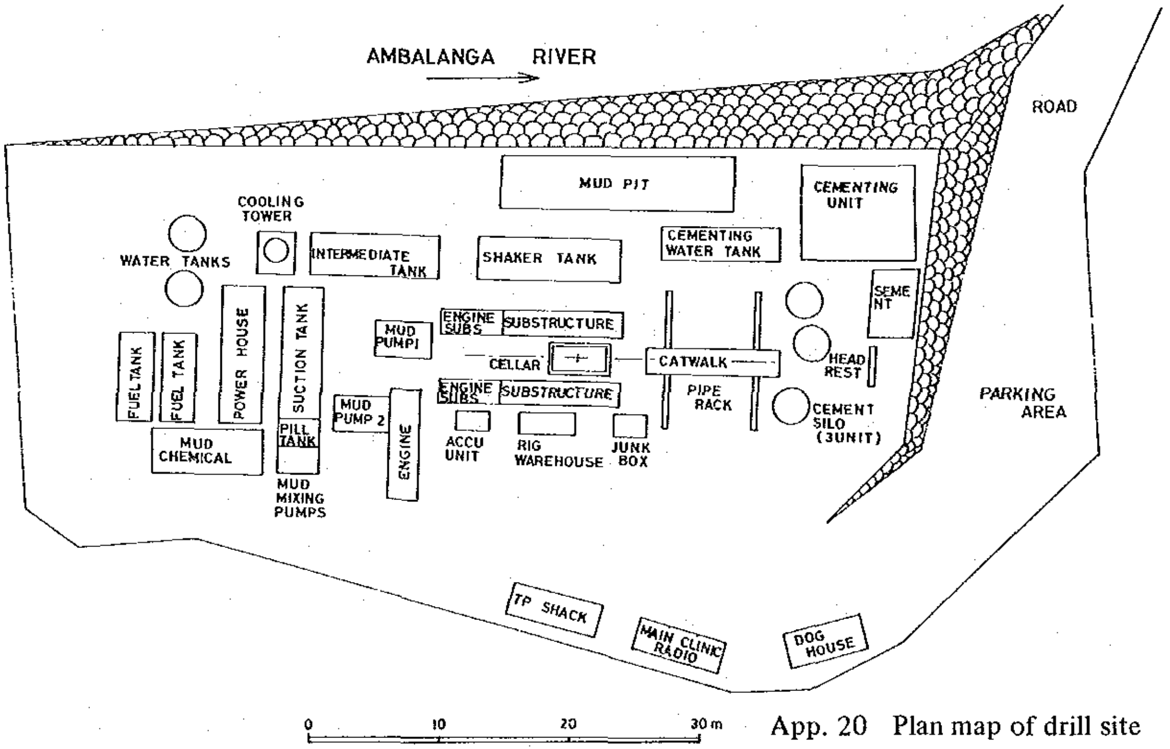
App. 18 List of main machineries

Article	Description	Maker	Quantity	Remarks
Drawworks	NATIONAL 610	NATIONAL	1 set	Hoist load capacity 10 line 180 ton
Engine	D 379	CATERPILLA	2 sets	Diesel engine 500HP/1200rpm
Rotary table	C 275	NATIONAL	1 set	Table opening 27 1/2"
Substructure	Two Section Box on Box	DERRIC SERVICES	1 set	Box:6'Wx9'Hx33'L Casing 180 ton
Derrick	Cantilever type	"	1 set	Height 40m Set back 110Ton
Mud pump No.1	7P-50 Triplex pump	NATIONAL	1 set	Volume 1,900ℓ/min (120kg/cm^3)
Engine	D 379	CATAPILLAR	(1) set	Use one of drawwork's engine
Mud pump No.2	8P-80 Triplex pump	NATIONAL	1 set	Volume 2,300ℓ/min (160kg/cm^3)
Engine	D 398	CATAPILLAR	1 set	Diesel engine 825HP
Mixing pump	5x6R Centrifugal pump	TRW	2 sets	
Engine	motor		2 sets	37KW/set
Mud agitator	34" Impeller	BRANDT	5 units	with 5.5KW motor
Shale shaker	Dual unit	BRANDT	1 unit	with 2.2KW motor (2 sets) Capacity 5,300ℓ/min
Desander	10" x double	SWACO	1 unit	Flow rate 3,780ℓ/min
Desilter	8T4	SWACO	1 unit	Flow rate 4,500ℓ/min
Mud tank (1)	Suction	PNOC	1 unit	Volume 43.5m^3
(2)	Intermediate tank	"	1 unit	Volume 43.5m^3
(3)	Setting tank	"	1 unit	Volume 37.2m^3
Cooling tower	with blower	"	1 unit	with 5.5KW motor
Generator	D 3406	CATAPILLAR	2 sets	Capacity 210KW/440V-60HZ (set)
BOP	21 1/4"-2000	SHAFFER	1 set	API class 2000 (140 kg/cm^2)
	13 5/8"-3000	"	1 set	API class 3000 (210 kg/cm^2)
	13 5/8"-3000	"	1 set	" "
Accumulator unit	T15110-3S	KOOMEY	1 set	with 11KW motor
Water tank		PNOC	2 sets	Volume 37.8m^3/set
Fuel tank		"	2 sets	Volume 22m^3/set
Cementing unit	HT-400	HALLIBURTON	1 unit	with diesel engine
Water tank for cementing		PNOC	1 set	Volume 57.2m^3
Mud house		"	1 house	include drilling mud tester
Toolpushers office		"	2 houses	include radio beacon equipment
Warehouse		"	1 set	
Welder		HOBART	1 set	with diesel engine capacity 300A
Crown block	42"x5W, 55"x1W	NATIONAL	1 set	1 1/8" with rope size 1 1/8"
Traveling block	40"x5W	"	1 set	Wire rope size 1 1/8" Capacity 250T/10 line
Water swivel	N-59	"	1 set	
Kelly drive	HDP roller	VARCO	1 set	Hexagonal kelly pin drive type
Kelly cock	6 5/8"	OMSCO	1 set	test pressure 700kg/cm^2
Drilling spool	20"-2000#	CAMERON	1 set	2"-2000 with side valve
	12"-3000#	"	1 set	3"-3000 with side valve

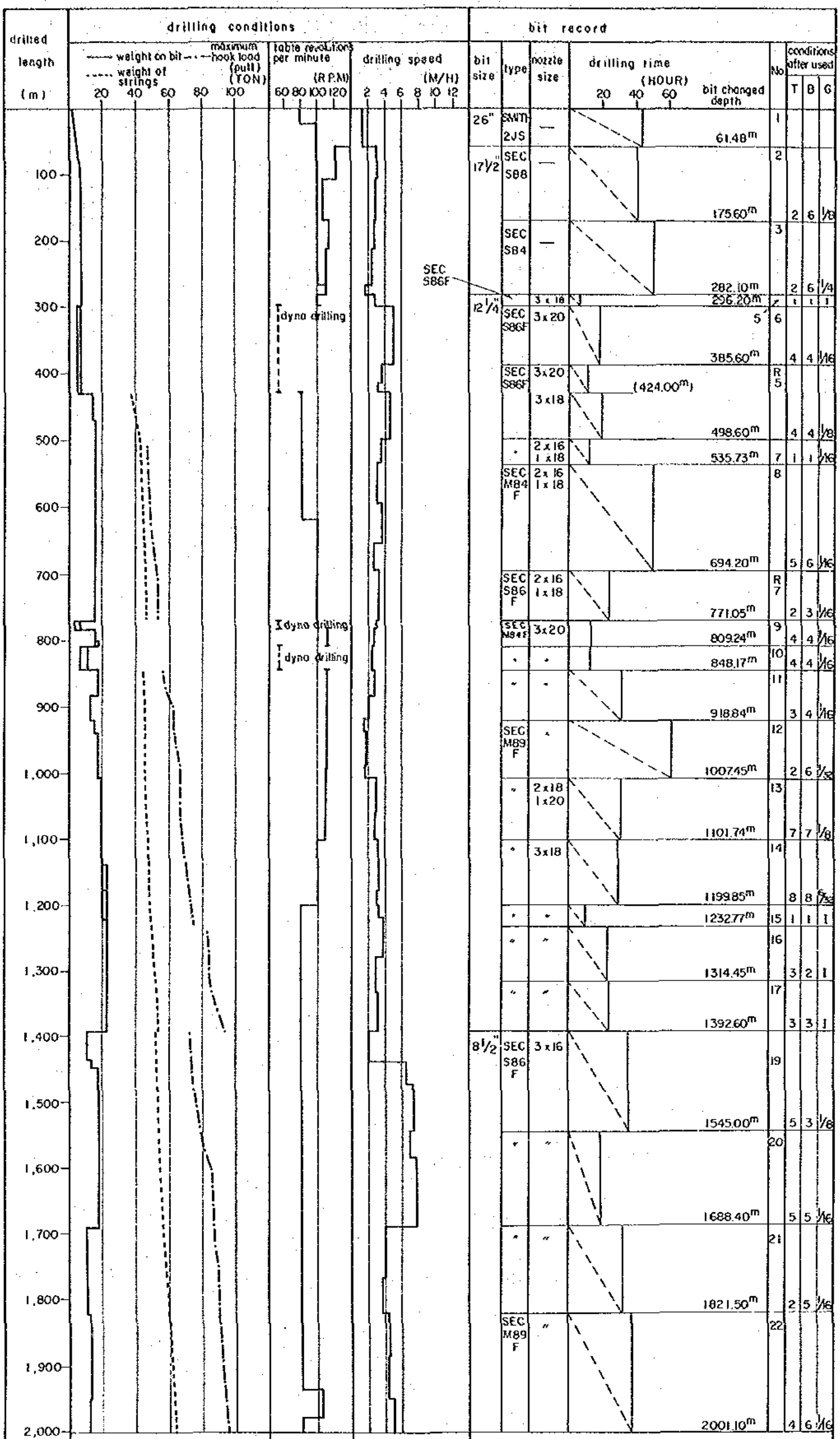
Article	Description	Maker	Quantity	Remarks
Expansion spool	12"-3000x10"-3000	CAMERON	1 set	
Master valve	E1AT-08 10" φ	WKM	1 set	ANSI 900, Gate valve
Side valve	2 1/16 M	"	2 sets	API 3000, Gate valve
Kelly	5 1/4' Hexagon	DRILCO	1	12m length
Core barrel	7 7/8"x4" double core barrel	DIABOART	2	
Drilling recorder	RGD 67D	MARTIN DECKER	1	6 pen type
Directional survey instrument	Sperry sun B		1	include thermal sealed complete and container.
	Totoco (0 ~ 8° type)	TOTCO	1	include container
Float valve	4R-G	BAKER	2	
Truck crane		GROVE	1	Capacity 550 ton hydraulic type
Tire loader	FL 220T	Furukawa Industry	1	
Desander pump	Centrifugal	BJ	1	with 37KW motor
Desilter pump	"	"	1	"
Pump for water supply	"	"	1	with 11KW motor
Oxygen cutting installation		VICTOR	2	
Dog house		PNOC	1	
Lighting equipment			1 set	110V

App. 19 Tools list for drilling

Article	Description	Quantity	Pin x Box	Remarks
Drill pipe	5" x 19.5 16/ft	266	4 1/2" IF	R–2, Grade E
"	5" x "	40	"	R–2, Grade G
"	3 1/2" x 13.3 16/ft	10	3 1/2" IF	R–2, Grade E
Tubing pipe	2 7/8"	60		R–2
Drill collar	(O.D.) 9 1/2" x (I.D.) 3"	1	7 5/8" REG	4.56m Short drill collar
"	9 1/2" x (I.D.) 3"	3	"	R–2
"	7 3/4" x (2 3/4"~3")	11	6 5/8" REG	"
"	"	4	API NC56	"
	6 1/2" x 2 1/4"	15	4 1/2" REG	"
Heavy weight drill pipe	5" x 50 16/ft	20	4 1/2" IF	"
Near bit stabilizer	26" Blade type	1	7 5/8" REG	
"	26" Roller reamer type	1	"	
"	17 1/2" "	1	"	
"	12 1/4" Blade type	1	6 5/8" REG	Replaceable sleeve type
"	12 1/4" Roller reamer type	1	"	6 point Reamer
"	" "	1	"	3 point Reamer
"	8 1/2" Blade type	3	4 1/2" REG	Integral blade type
"	" Roller reamer type	1	"	3 point Reamer
String stabilizer	17 1/2" Blade type	2	7 5/8" REG	I.D. 3"
"	12 1/4" "	5	6 5/8" REG	" 2 2/4"
"	8 1/2" "	4	4 1/2" REG	" 2 5/8" ~ 2 3/4"
Bit sub	26" T.B, 17 1/2" TB	1	7 5/8" REG	O.D. 9 1/2"
"	12 1/4" TB	1	6 5/8" REG	" 7 3/4"
"	8 1/2" TB	1	4 1/2" REG	" 6 1/2"
Shock sub	7 3/4"	2	6 5/8" REG	Hydraulic type
Hydraulic drilling jar	Down ward	2	4 1/2" IF	
"	Upper ward	2	"	
Non-magnetic drill collar	7 3/4" x 2 3/4" x 9.4 m	2	6 5/8" REG	
"	6 1/2" x 2 3/4" x 9.4 m	2	4 1/2" REG	
"	6 1/2" x 2 3/4" x 5.5 m	2	4 1/2" REG	
Dyna drill	7 3/4"	2	6 5/8" REG	include bent sub (orienting key setting
"	6 1/2"	2	4 1/3" REG	"



App. 20 Plan map of drill site

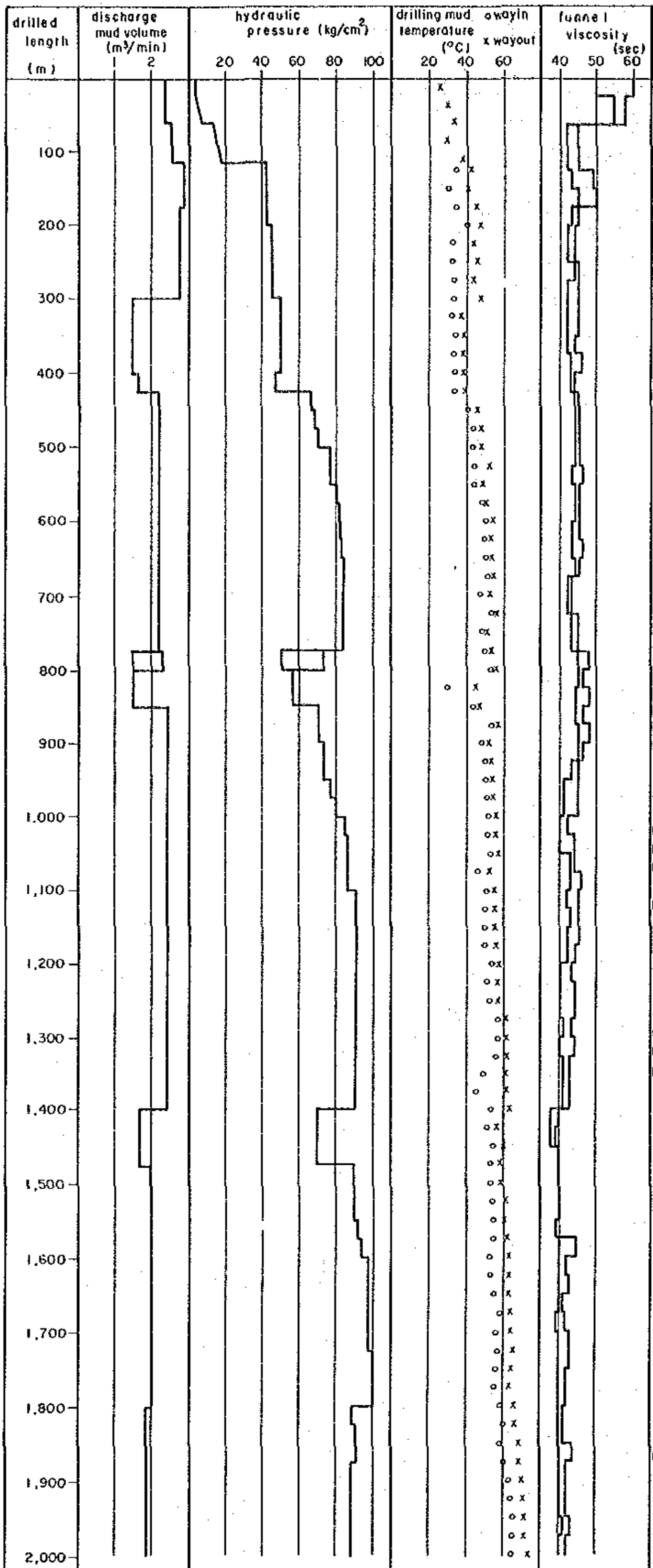


bit size	type	nozzle size	drilling time (HOUR)	bit changed depth	No	conditions after used T	B	G
26"	SWTH 2JS	—		61.48^{m}	1			
17 1/2"	SEC S88	—		175.60^{m}	2	2	6	1/8
	SEC S84	—		282.10^{m}	3	2	6	1/4
12 1/4"	SEC S86F	3 x 18		296.20^{m}	4	1	1	1
	SEC S86F	3x20	5	385.60^{m}	6	4	4	1/16
	SEC S86F	3x20 3x18		(424.00^{m}) 498.60^{m}	R 5	4	4	1/8
	〃	2 x 16 1 x 18		535.73^{m}	7	1	1	1/16
	SEC M84 F	2 x 16 1 x 18		694.20^{m}	8	5	6	1/16
	SEC S86 F	2 x 16 1 x 18		771.05^{m}	R 7	2	3	1/16
	SEC M84F	3x20		809.24^{m}	9	4	4	1/16
	〃	〃		848.17^{m}	10	4	4	1/16
	〃	〃		918.84^{m}	11	3	4	1/16
	SEC M89 F	〃		1007.45^{m}	12	2	6	1/32
	〃	2 x 18 1 x 20		1101.74^{m}	13	7	7	1/8
	〃	3 x 18		1199.85^{m}	14	8	8	6/32
	〃	〃		1232.77^{m}	15	1	1	1
	〃	〃		1314.45^{m}	16	3	2	1
	〃	〃		1392.60^{m}	17	3	3	1
8 1/2"	SEC S86 F	3 x 16		1545.00^{m}	19	5	3	1/8
	〃	〃		1688.40^{m}	20	5	5	1/16
	〃	〃		1821.50^{m}	21	2	5	1/16
	SEC M89 F	〃		2001.10^{m}	22	4	6	1/16

1) The drag produced by direction drilling indicated in the following
(Maximum, hook load – weight of strings)

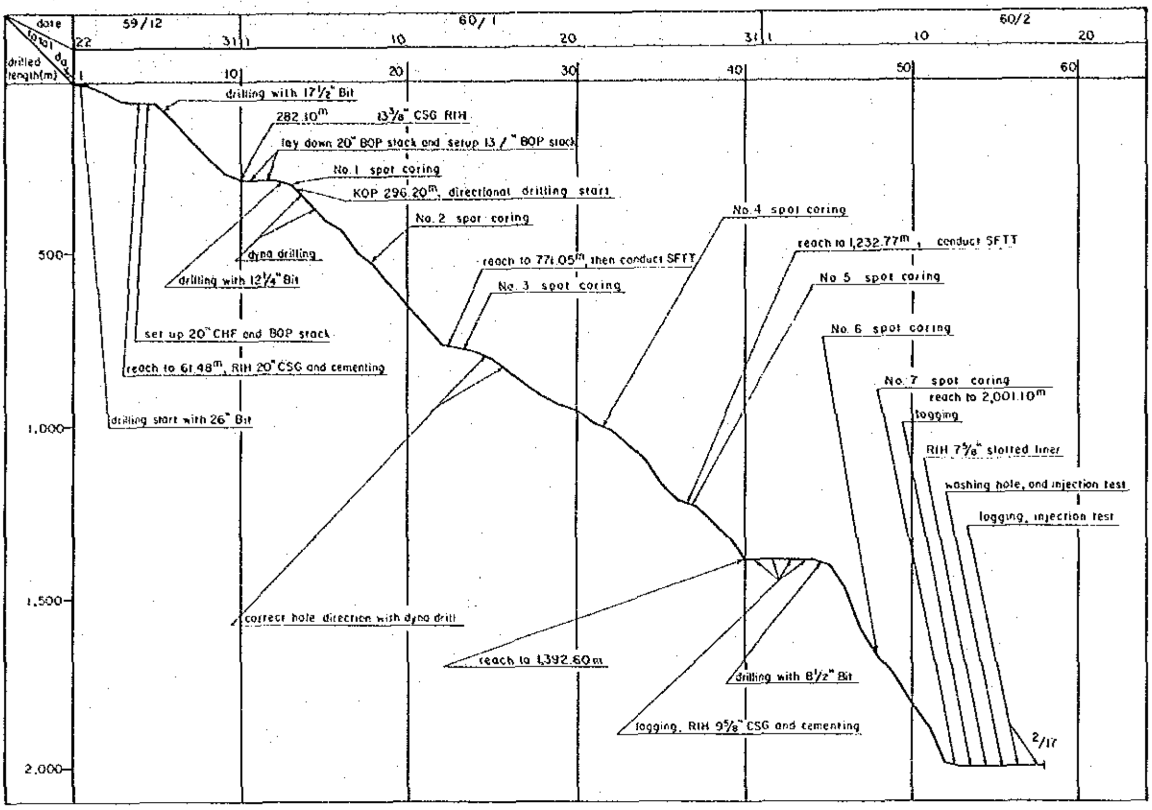
1) Not include drill outcement reaming and spot coring
2) Nozzle size indicate quantity x $16/32" \sim 20/32"$

App. 21 Record of drilling



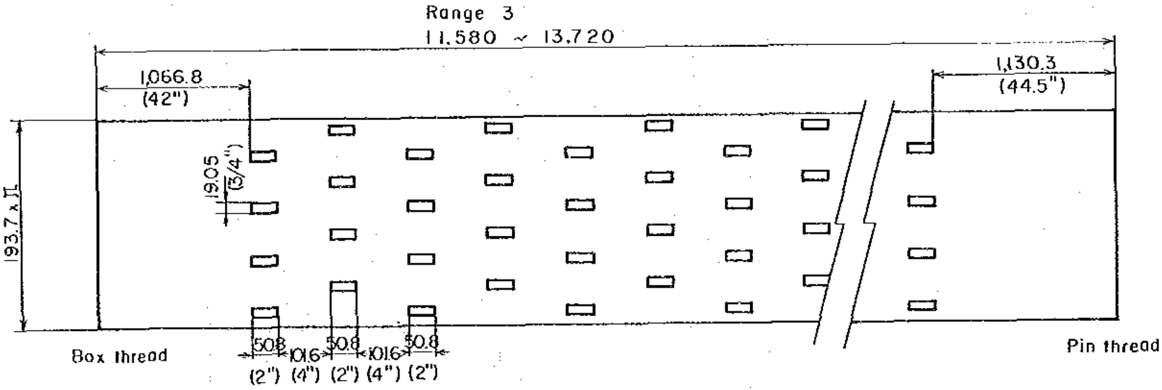
mud character					remarks
PV (CP)	YV (lb/100ft²)	WL (CC)	Mud wt.	sand contents (%)	
			1.04		bentonite mud water
			1.05		
10	5		1.04	0.25	lignosulfonate mud
10 11	5~6		〃	〃	
11 12	6~7		〃	〃	
10 11	6~7		〃	〃	
10 11	5~6		〃	〃	
〃	〃		〃	〃	
〃	〃		〃	〃	
〃	〃		1.05	〃	
12 13	7~9		〃	〃	
12 13	6~8		〃	0.20	dyno drilling
〃	〃		〃	0.25	
10 11	5~6		〃	〃	
14	8		〃	〃	
12 13	5~7		〃	〃	
13 14	6~7		1.06	0.20	
〃	〃	11.5	1.07	〃	
〃	〃	10	1.08	〃	
11 12	5~6	8.8	〃	0.25	
12 13	〃	10	〃	〃	
〃	〃	10	〃	〃	
〃	〃	9.6	〃	〃	
〃	〃	10	〃	〃	
13~16	5~7	9.4	1.09	〃	
15~16	7~8	9.2	1.10	0.30	
12	5	10.6	1.03	0.15	
〃	〃	10.5	1.05	0.25	
15	6~7	9.8	1.08	〃	cooling tower working
〃	〃	10.4	〃	〃	
14~15	5~6	8.4	〃	〃	dyno drilling
20	10	9.7	1.09	〃	cooling tower working
12~15	5~8	11.5	〃	〃	dyno drilling
15~17	〃	8.4	〃	〃	
14~16	6~8	8.5	〃	〃	cooling tower working
16~17	7~8	8.2	1.10		
17	8	7.8	〃	ND	
12~14	5~6	8.6	1.12	〃	
10~12	4~5	7.6	〃	〃	
11~12	5~7	8.2	1.10	〃	
14~15	6~8	〃	〃	〃	
10~11	4~6	8.8	〃	〃	cooling tower working
12	5	7.0	1.08	〃	
12~14	5~6	9.0	1.10	〃	
16	7	8.8	1.09	〃	
13	5	8.5	〃	〃	
14~15	5~6	8.6	〃	〃	
10~12	4~6	9.5	1.08	〃	cooling tower working
〃	〃	9.8	〃	〃	
〃	〃	9.0	〃	〃	
11~12	6~7	〃	〃	〃	
11~14	5~6	9.8	〃	〃	
12~13	〃	9.4	〃	〃	
10	5	8.8	〃	〃	
〃	〃	〃	〃	〃	
9	4	10	1.04	〃	colling tower continued working
〃	〃	〃	〃	〃	
10	5	9.6	1.05	〃	
〃	〃	〃	〃	〃	
9	4	9.4	〃	〃	
10	4	9 6	〃	〃	
9	4	9.8	〃	〃	
14	8	9.2	1.06	〃	
〃	6	〃	〃	〃	
10	4	9.6	〃	〃	
10	5	9.5	〃	〃	
〃	〃	9.4	〃	〃	
11	6	9.5	〃	〃	
15	8	8.4	〃	〃	
15	6	〃	〃	〃	
14	5	〃	〃	〃	
16	6	〃	〃	〃	
14	6	8.5	〃	〃	
12~16	5~8	7.5	〃	〃	
15	6	8.5	〃	〃	
14	6	8.2	1.07	〃	
12	5	8.0	〃	〃	
12	7	7.8	〃	〃	
12	6	8.0	〃	〃	

App. 22 Chart of drilling mud



Actual drilling proess

App. 23 Chart of drilling process



percentage of slotted area

slotted area 1.905 x 5.08 x 4 /steps= 38.71 cm^2/steps

average length of casing

65 steps x15.24 ^{cm}/steps)+106.68 ^{cm}+ (113.03 − 5) = 1,205.31 ^{cm}

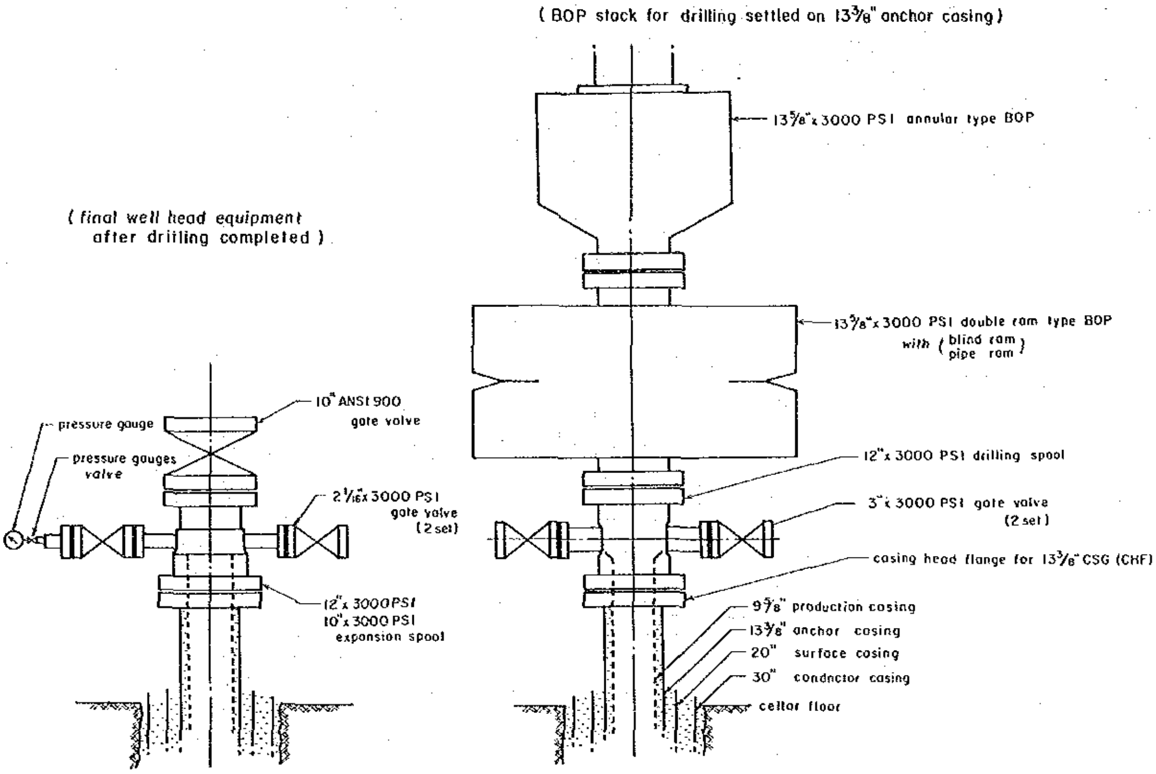
surface area of casing 19.37 x π x 1,205.31 = 73,309.12 cm^2

slotted area of casing 38.71 x 65 = 2,516.15 cm^2

percentage of slotted area 2,516.15 ÷ 73,309.12 − 0.0343

3.43%

App. 24 Design of slotted liner casing pipe



App. 25 Well head assemblies

App. 26 List of minerals in sludge samples of the test well (1)

Samples		Zeolite Minerals						Clay Minerals										Sulfate Minerals			Carbonate Minerals			Silica Minerals			Feld-spar		Others				Remarks
No. (m)	division	clinoptiolite	stilbite	mordenite	heulandite	laumontite	wairakite	smectite	saponite	vermiculite	chlorite/smectite	illite/smectite	chlorite	illite	halloysite	kaoline	pyrophyllite	alunite	anhydrite	gypsum	calcite	dolomite	siderite	α-cristobalite	tridymite	quartz	plagioclase	potassium feldspar	pyrite	magnetite	epidote	amphibole	
82.35 ~ 85.40	BULK							1					3	1		1					2					6	4	1	1		1	1	
	ORTD							⧺					⧻	⧺		+					+					-+-	-+-	+				+	
	EG							⧺					⧻	-+-		+											+					+	
	HCl							⧻						⧻		+											+					+	
146.40 ~ 149.45	BULK					1		1					3	1							2					8	5	1	1		1	1	
	ORTD					+		-+-					⧻	⧺							+					⧻	⧺	+	+			+	
	EG					+		-+-					⧺	⧺													+					+	
	HCl							-+-						⧺													+						
210.45 ~ 213.50	BULK							1					5	1					3		1					9	5	1	1		1	1	
	ORTD							+					⧻	⧻							+					-+-	⧺	+	+				
	EG							+					⧻	⧺													+						
	HCl							+						⧻													+						
274.50 ~ 277.55	BULK							1					5	3					3		1					11	4	1	1		1	1	
	ORTD							+					⧺	⧻					+		+					+	+		+				
	EG							+					⧺	⧻													+						
	HCl													⧻													+					+	
338.55 ~ 341.60	BULK							1					6	2					3		2					8	5	1	1		1		
	ORTD							+					⧺	⧺							+					-+-	-+-	+					
	EG							+					⧻	⧻													+						
	HCl							+						⧻													+						
402.60 ~ 405.65	BULK							1				1	2	1					1		1		1?			5	6	3	1			3	
	ORTD							+				+	⧺	+							+					+	⧺	+	+			-+-	
	EG							+				+	⧺	+													+					-+-	
	HCl							+				+		+													+					⧺	
466.65 ~ 469.70	BULK							1					1	1							1		1?			6	7	2	1			1	
	ORTD							+					⧺	⧺							+					-+-	⧺	+	+			-+-	
	EG							+					⧺	⧺													+					-+-	
	HCl							+						-+-													+					⧺	
530.70 ~ 533.75	BULK							1					1	1							1					6	6	2	1		1	1	
	ORTD							+					⧺	-+-							+					-+-	⧺	+	+			+	
	EG							+					⧺	-+-													+					+	
	HCl							+						-+-													+					+	
594.75 ~ 597.80	BULK							1					1	1							1					4	6	2	1		1	1	
	ORTD							+					⧺	+							+					-+-	-+-	+	+		+	+	
	EG							+					⧺	+													+					+	
	HCl							+						+													+					-+-	
658.80 ~ 661.85	BULK							1					1	1					1		2					6	5	3	1		1	1	
	ORTD							+					⧺	⧺							+					-+-	+	+				+	
	EG							+					⧺	-+-													+					+	
	HCl													-+-													+					+	
722.85 ~ 725.90	BULK							1					1	1					1		1					5	6	2	2		1	3	
	ORTD							+					⧺	+												-+-	⧺	+	+		+	⧺	
	EG							+					⧺	+													+					⧺	
	HCl							+						+													+					⧺	
786.90 ~ 789.95	BULK							1					1	1							1		1?			9	7	2	1			1	
	ORTD							⧻					-+-	+							+					⧺	⧺	+	+			-+-	
	EG							⧻					-+-	+													+					+	
	HCl							⧺						+													+					-+-	
850.95 ~ 854.00	BULK							1					1	1							1					11	7	2	1		1	1	
	ORTD							-+-				+	⧻	⧺							+					⧺	⧻	+	+			-+-	
	EG							-+-				+	⧺	-+-													+					-+-	
	HCl							+				+		-+-													+					-+-	
915.00 ~ 918.05	BULK							1					1	1					1		1					5	6	2	1		1	4	
	ORTD							+					⧺	+												-+-	⧺	+	+			⧺	
	EG							+					⧺	+													+					⧺	
	HCl							+						+													+					⧺	

LEGEND :

a) division of the samples
BULK : bulk sample
ORTD : oriented clay sample
EG : " EG treated
HCl : " HCl treated

b) quantity
⧻ abandant
⧺ common
-+- a little
\+ rare
? not clear

c) Quartz Index (QI)
QI = Im x 100 / Iq
Im : Peak intensity of the mineral in the sample (cps)
Iq : Peak intensity of the pure quartz (cps)

App. 26 Chemical analyses for sludge samples of the test well (2)

Samples		Zeorite Minerals							Clay Minerals												Sulfate Minerals				Carbonate Minerals				Silica Minerals			Feld-spar		Others							Remarks
No. (m)	division	clinoptilolite	stilbite	mordenite	heulandite	laumontite	wairakite		smectite	saponite	vermiculite	chlorite/smectite	illite/smectite	chlorite	illite		halloysite	kaoline	pyrophyllite		alunite	anhydrite	gypsum		calcite	dolomite	siderite		α-cristobalite	tridymite	quartz	plagioclase	potassium feldspar	pyrite	magnetite				epidote	amphibole	
979.05 ~ 982.10	BULK								1					1	2							2			1						5	6	2	1					1	3	
	ORTD								⧺					⧺	+																-+-	⧺	+	+						⧺	
	EG								⧺					⧺	+																	+								⧺	
	HCl								+						+																	+								⧻	
1043.10 ~ 1046.15	BULK								1					6	1			1							1						12	1	1	1					3	1	
	ORTD								+					⧻	-+-			+							+						-+-	+	+						+	+	
	EG								+					⧻	+			+																						+	
	HCl								+						⧺			+														+								+	
1107.15 ~ 1110.20	BULK								1					3	1							2			2						6	6	1	1					1	2	
	ORTD								-+-					⧻	⧺																-+-	-+-	+	+						⧺	
	EG								-+-					⧺	⧺																	+								-+-	
	HCl								-+-						⧺																	+								-+-	
1171.20 ~ 1174.25	BULK								1					2	1							1			1						4	6	2	1					1	5	
	ORTD								-+-					⧻	-+-										+						-+-	⧺	+	+					+	⧺	
	EG								-+-					⧺	+																	+								⧺	
	HCl								+						+																	+								⧺	
1235.25 ~ 1238.30	BULK								1					3	1			1				1			1						10	5	1	1					1	1	
	ORTD								-+-					⧻	-+-			-+-							+						⧺	⧺	+	+					+	+	
	EG								⧺					⧻	+			-+-														+								+	
	HCl								+						+			-+-														+								⧺	
1299.30 ~ 1302.35	BULK								1					2	1			1				1			1						5	7	2	1					1	2	
	ORTD								-+-					⧺	+			+							+						⧺	⧺	+	+						⧺	
	EG								⧺					⧺	+			+														+								-+-	
	HCl								+						+			+														+								⧺	
1363.35 ~ 1366.40	BULK								1					1	1										1		1				2	7	2	1						3	
	ORTD								+					⧺	+												+				+	⧺	+	+						⧺	
	EG								+					-+-	+																	+								⧺	
	HCl								+						+																	+								⧺	
1427.40 ~ 1430.45	BULK								1					1	1										1						1	6	2	1					1	2	
	ORTD								+					-+-	+																+	-+-	+	+						-+-	
	EG								+					+	+																	+								-+-	
	HCl								+						+																	+								⧺	
1491.45 ~ 1494.50	BULK								1					3	1							1			2						12	5	1	1					1		
	ORTD								+					⧻	⧺																-+-	+									
	EG								+					⧺	⧺																	+									
	HCl								+						⧺																	+									
1555.50 ~ 1558.55	BULK								1					3	1							1			1						12	3	1	1					1		
	ORTD								+					⧺	+																-+-	+	+	+							
	EG								+					⧻	+																	+									
	HCl								+						+																	+									
1619.55 ~ 1622.60	BULK								1					2	1			1				1			1						7	6	2	1					1		
	ORTD								+				+	⧻	⧺			+													-+-	+		+							
	EG								+				+	⧺	⧺			+																							
	HCl								+				+		⧻			+																							
1683.60 ~ 1686.65	BULK								1					2	1							1			1						8	6	1	1				1	1		
	ORTD								+					⧻	+																-+-	-+-	+						+		
	EG								+					⧻	+																	+							+		
	HCl								+						+																	+							+		
1747.65 ~ 1750.70	BULK								1					2	1							1			2						8	6	1	1				1			
	ORTD								+					⧻	+																⧺	-+-	+								
	EG								+					⧻	-+-																	+									
	HCl								+						-+-																	+									
1811.70 ~ 1814.75	BULK						1		1					2	1										1						11	6	2	1				1			
	ORTD								-+-					⧻	+										+						⧺	⧺	+					+			
	EG								-+-					⧻	+																	+									
	HCl								+						+																	+									

LEGEND : a) division of the samples
BULK : bulk sample
ORTD : oriented clay sample
EG : " EG treated
HCl : " HCl treated

b) quantity
⧻ abandant
⧺ common
-+- a little
+ rare
? not clear

c) Quartz Index (QI)
QI = Im x 100 / Iq
Im : Peak intensity of the mineral in the sample (cps)
Iq : Peak intensity of the pure quartz (cps)

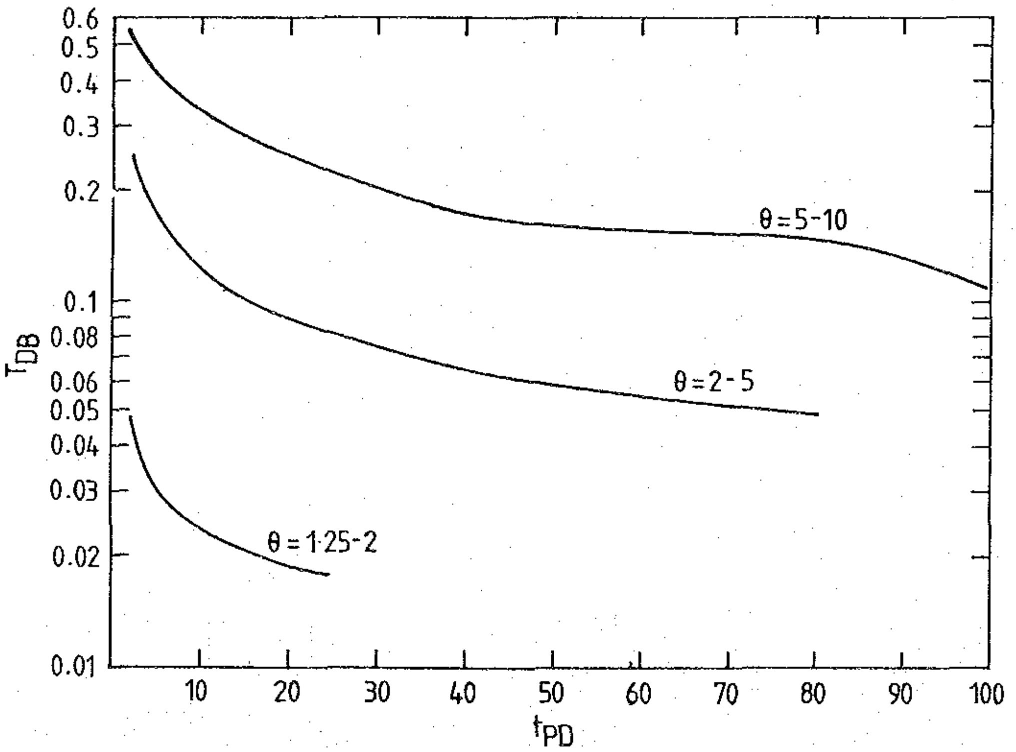
App. 26 List of minerals in sludge samples of the test well (3)

Samples		Zeorite Minerals							Clay Minerals												Sulfate Minerals				Carbonate Minerals				Silica Minerals			Feld-spar		Others							Remarks
No. (m)	division	clinoptiolite	stilbite	mordenite	heulandite	laumontite	wairakite		smectite	saponite	vermiculite	chlorite/smectite	illite/smectite	chlorite	illite		halloysite	kaoline	pyrophyllite		alunite	anhydrite	gypsum		calcite	dolomite	siderite		α-cristobalite	tridymite	quartz	plagioclase	potassium feldspar	pyrite	magnetite				epidote	amphibole	
1875.75 ~ 1878.80	BULK						1		1					3	1										1						11	6	1	1					1		
	ORTD								+					++	+																++	-+-	+								
	EG								+					+++	-+-																	+									
	HCl								+						+																	+									
1939.80 ~ 1942.85	BULK						1		1					1	1										1						8	7	1	1					1	1	
	ORTD						+		+					++	+																-+-	-+-	+	+						+	
	EG								+					++	+																	+								+	
	HCl								+						+																	+								+	
2003.85 ~ 2009.95	BULK						1							2	1										1						9	7	1	1					1		
	ORTD						+							+++	+																++	++	+						+		
	EG													+++	+																	+									
	HCl														+																	+									

LEGEND : a) division of the samples
BULK : bulk sample
ORTD : oriented clay sample
EG : " EG treated
HCl : " HCl treated

b) quantity
+++ abandant
++ common
-+- a little
+ rare
? not clear

c) Quartz Index (QI)
QI = Im x 100 / Iq
Im : Peak intensity of the mineral in the sample (cps)
Iq : Peak intensity of the pure quartz (cps)



App. 28 Correction term of Rous et al. (1979), for evaluating temperature recovery

App. 27 Chemical analyses for sludge samples of the test well

Ser. No.	Sample No.	Depth from	to	SiO_2 %	TiO_2 %	Al_2O_3 %	Fe_2O_3 %	MnO %	MgO %	CaO %	Na_2O %	K_2O %	S %	H_2O- %	IGL %	Total %	Ag ppm	As ppm	Au ppm	B ppm	Ba ppm	Be ppm	Co ppm	Cu ppm	Hg ppm	Li ppm	Pb ppm	Rb ppm	Sb ppm	Sr ppm	Zn ppm
1	1	529.2	532.3	53.27	0.51	16.68	7.65	0.17	4.18	7.28	3.68	1.86	0.60	0.10	3.95	99.23	0.5	0	0.05	4	139	3	8	85	97	7	13	36	0	210	59
2	2	578.0	581.1	55.71	0.66	15.92	6.25	0.24	3.12	5.40	3.19	2.74	2.01	0.15	6.00	99.23	0.9	5	0.10	3	239	4	6	77	97	9	26	71	0	162	312
3	3	626.8	629.9	50.95	0.59	14.82	7.68	0.51	4.03	6.36	1.58	4.61	2.06	0.06	8.58	99.71	0.0	0	0.12	3	273	4	11	272	124	12	284	116	1	135	736
4	4	675.6	678.7	55.13	0.86	16.80	6.92	0.16	3.64	7.67	4.10	1.82	0.43	0.10	2.85	99.95	0.0	1	0.03	3	147	4	8	50	108	6	0	32	0	244	54
5	5	724.4	727.5	54.61	0.67	16.87	6.50	0.19	2.99	7.85	3.64	2.10	0.68	0.14	4.13	99.55	0.0	2	0.01	2	154	4	8	84	85	6	14	28	0	218	53
6	6	773.2	776.3	58.82	0.59	15.03	4.88	0.16	1.93	6.26	3.76	3.56	0.86	0.24	5.95	100.94	0.5	0	0.02	1	196	4	26	56	87	6	49	52	0	217	781
7	7	822.0	825.1	63.60	0.36	15.88	3.87	0.12	1.46	5.14	4.20	2.87	0.28	0.17	2.43	99.93	0.3	0	0.04	1	218	4	4	75	105	3	11	36	1	234	152
8	8	870.8	873.9	52.78	0.71	15.75	7.77	0.27	4.76	8.73	3.24	1.89	0.39	0.07	4.13	100.03	0.6	1	0.00	2	98	3	10	86	67	7	7	30	1	232	68
9	9	919.6	922.7	52.88	0.70	16.02	7.41	0.23	4.89	8.59	3.71	1.62	0.28	0.10	3.56	99.61	0.5	2	0.00	2	127	3	10	72	86	8	15	33	0	249	118
10	10	968.4	971.5	53.47	0.74	16.28	7.46	0.21	5.57	8.80	3.24	1.73	0.51	0.10	2.77	100.27	0.5	2	0.00	3	104	3	11	67	104	6	8	33	0	235	84
11	11	1017.2	1020.2	52.98	0.61	13.04	7.72	0.39	4.20	9.73	1.87	1.33	0.60	0.14	7.66	99.53	0.9	3	0.03	3	75	3	10	49	87	12	14	33	1	156	115
12	12	1066.0	1069.0	53.96	0.75	16.01	7.77	0.26	5.24	8.41	3.29	1.51	0.40	0.09	3.09	100.29	0.6	0	0.00	6	129	3	11	72	111	7	10	22	1	255	86
13	13	1114.8	1117.8	52.51	0.75	16.99	7.34	0.18	4.26	8.56	3.97	1.71	0.77	0.05	3.00	99.27	0.3	0	0.00	8	116	3	10	43	80	5	7	27	0	237	63
14	14	1160.5	1163.6	53.05	0.80	16.35	7.43	0.24	4.63	8.18	3.61	1.84	0.72	0.02	3.64	99.77	0.5	0	0.00	3	98	3	10	88	90	7	10	22	0	225	107
15	15	1212.4	1215.4	55.81	0.66	15.91	6.80	0.15	3.40	7.15	3.47	1.93	1.14	0.08	4.33	99.61	0.5	0	0.11	3	154	4	9	165	81	6	8	26	0	230	61
16	16	1261.2	1264.2	54.40	0.60	16.46	6.81	0.26	3.13	7.41	3.34	2.91	1.02	0.11	4.51	99.83	0.4	0	0.00	6	158	4	8	80	82	8	13	40	0	239	129
17	17	1310.0	1313.0	53.27	0.68	15.91	7.55	0.26	3.74	7.60	3.01	2.54	0.64	0.16	5.25	99.81	0.5	3	0.02	4	172	3	9	107	84	12	10	44	1	224	212
18	18	1361.8	1364.9	54.17	0.85	16.57	8.37	0.17	3.87	8.10	3.50	2.03	0.93	0.10	2.84	100.47	0.0	0	0.00	5	132	3	11	72	90	6	8	35	0	259	124
19	19	1407.6	1410.6	55.23	0.79	15.85	7.23	0.23	2.90	7.50	3.12	2.17	1.06	0.12	4.57	99.59	0.4	0	0.01	4	113	4	7	90	134	10	26	51	2	220	144
20	20	1456.4	1459.4	55.32	0.67	14.95	6.65	0.33	3.80	7.31	2.17	1.84	2.15	0.11	6.15	99.19	0.4	7	0.01	5	92	4	8	77	90	19	30	43	0	231	243
21	21	1505.2	1508.2	52.74	0.87	15.46	7.37	0.31	3.81	7.75	2.80	2.03	1.65	0.11	6.19	99.33	0.6	12	0.01	3	157	4	10	139	94	15	33	35	1	257	292
22	22	1553.9	1557.0	55.26	0.53	16.22	5.70	0.16	2.81	6.08	3.59	1.54	1.53	0.11	7.32	99.21	0.5	8	0.00	2	200	4	8	68	84	13	10	23	1	257	66
23	23	1602.7	1605.8	57.46	0.57	15.23	6.93	0.16	2.85	4.96	1.70	2.45	2.73	0.39	7.23	99.54	0.4	0	0.01	3	143	3	9	99	35	13	130	60	1	148	886
24	24	1651.5	1654.6	59.58	0.55	15.96	6.12	0.16	2.88	6.29	3.55	1.54	1.19	0.15	4.13	100.76	0.5	2	0.00	2	164	3	8	67	90	13	11	26	0	209	63
25	25	1700.3	1703.4	59.64	0.47	15.40	5.92	0.15	2.40	5.81	3.15	1.68	0.52	0.19	4.56	99.18	0.3	1	0.00	3	227	4	7	52	63	13	19	37	1	237	86
26	26	1749.1	1752.2	59.06	0.49	15.29	5.58	0.14	2.52	6.00	3.41	1.75	0.71	0.17	5.04	99.28	0.2	3	0.00	6	180	4	7	48	64	11	13	37	0	216	58
27	27	1797.9	1801.0	61.81	0.46	15.56	5.15	0.16	2.56	5.41	3.68	1.78	0.59	0.15	3.25	99.82	0.1	0	0.00	2	249	4	7	49	74	12	10	33	0	244	71
28	28	1846.7	1849.8	60.76	0.48	15.20	4.94	0.08	2.43	5.53	3.15	3.07	1.72	0.13	4.07	99.71	0.3	0	0.00	3	117	4	7	45	90	10	7	28	1	219	49
29	29	1895.5	1898.6	62.44	0.46	15.37	4.88	0.11	2.45	5.75	3.26	2.05	0.87	0.14	2.88	99.65	0.2	2	0.00	2	205	4	5	52	64	10	7	33	0	249	54
30	30	1944.3	1947.4	61.36	0.47	15.44	5.71	0.15	2.44	5.79	3.50	2.66	0.62	0.18	2.78	100.30	0.2	3	0.00	3	246	3	6	48	75	9	6	33	1	246	63
31	31	1993.1	1996.2	60.38	0.47	15.22	6.25	0.15	2.55	5.76	3.40	1.89	0.66	0.21	3.01	99.08	0.3	0	0.01	4	236	3	8	42	80	13	11	35	0	251	65

App. 29 Records of the static formation temperature test

Test No. 1 (732.8 m)

Measured Drilled Depth : 732.8 m CHF
Vertical Depth : 701 mCHF , Elevation R.S.L. : +120 m

Date ; Drill Bit Passing : 11.30, Jan/12, 1985
Circulation Halt : 0 : 00, Jan/13, 1985
Temp. Log Starting : 3 : 30, Jan/13, 1985

Cooling Time, T_p : 12.5 hours

Temperature Measured	Time & Date	Recovery Time Δ t
62.2 °C	3 : 45, Jan/13	3.75 hours
63.6	4 : 15, "	4.25
64.3	4 : 45, "	4.75
65.0	5 : 15, "	5.25
65.9	5 : 45, "	5.75
66.4	6 : 15, "	6.25
67.0	6 : 45, "	6.75
67.4	7 : 15, "	7.25
67.9	7 : 45, "	7.75
68.4	8 : 15, "	8.25
68.8	8 : 45, "	8.75
69.3	9 : 15, "	9.25
69.8	9 : 45, "	9.75
70.0	10 : 00, "	10.00

Apparent Static Temperature T_{ws} : 79.1

Correlation Coefficient : 0.998
Slope of Horner Straight Line, m : 26.4°C/cycle
Roux Correction Term, t_{PD} : 5.0
Roux Correction Term, T_{DB} : 0.18

Initial Formation Temperature, T_i : 83.8°C

Table −1 (3) Static Formation Temperature Test

Test No. 3 (1200 m)

Measured Drilled Depth : 1200 m CHF
Vertical Depth : 1052 m CHF, Elevation R.S.L. : −231 m

Date : Drill Bit Passing : 06 : 30, Jan/26, 1985
Circulation Halt : 01 : 30, Jan/31, 1985
Temp. Log Starting : 06 : 33, Jan/31, 1985

Cooling Time, T_p : 115 hours

Temperature Measured	Time & Date	Recovery Time, Δt
82.0 °C	7 : 21, Jan/31	5.85 hours
91.6	13 : 07, "	11.62
96.5	20 : 14, "	18.73
100.1	0 : 44, Feb/1	23.21

Apparent Static Temperature, T_{ws} : 125.0 °C

Correlation Coefficient : 0.998
Slope of Horner Straight Line, m : 32.6 °C/cycle
Roux Correction Term, t_{PD} : 46
Roux Correction Term, T_{DB} : 0.18

Initial Formation Temperature, T_i : 130.9 °C

Static Formation Temperature Test

Test No. 3 (1400 m)

Measured Drilled Depth : 1400 m CHF
Vertical Depth : 1208 m CHF, Elevation R.S.L. : −387 m

Date ; Drill Bit Passing : 22 : 30, Jan/30, 1985
Circulation Halt : 01 : 30, Jan/31, 1985
Temp. Log Starting : 06 : 33, Jan/31, 1985

Cooling Time, T_p : 3.00 hours

Temperature Measured	Time & Date	Recovery Time, Δt
106.4 °C	07 : 30, Jan/31	6.00 hours
120.0	13 : 17, "	11.78
125.0	20 : 27, "	18.95
130.8	01 : 00, Feb/1	23.50

Apparent Static Temperature, T_{ws} : 138.6 °C

Correlation Coefficient : 0.989
Slope of Horner Straight Line, m : 184.4 °C/cycle
Roux Correction Term, t_{PD} : 1.2
Roux Correction Term, T_{DB} : 0.1

Initial Formation Temperature, T_i : 157.0 °C

Test No. 2 (1207 m)

Measured Drilled Depth : 1200 m CHF
Vertical Depth : 1052 m CHF, Elevation R.S.L. : −231 m

Date ; Drill Bit Passing : 16 : 00, Jan/26, 1985
Circulation Halt : 04 : 00, Jan/27, 1985
Temp. Log Starting : 09 : 42, Jan/27, 1985

Cooling Time, T_p : 12.00 hours

Temperature Measured	Time & Date	Recovery Time Δt
86.0 °C	10 : 50, Jan/27	6.83 hours
90.2	11 : 00, "	7.00
91.7	11 : 15, "	7.25
92.8	11 : 30, "	7.50
93.9	11 : 45, "	7.75
94.0	12 : 00, "	8.00
94.6	12 : 15, "	8.25
94.9	12 : 30, "	8.50
95.4	12 : 45, "	8.75
95.9	13 : 00, "	9.00
96.5	13 : 15, "	9.25
97.1	13 : 30, "	9.50
97.6	13 : 45, "	9.75
97.9	14 : 00, "	10.00
98.4	14 : 15, "	10.25
98.7	14 : 30, "	10.50
99.2	14 : 45, "	10.75
99.7	15 : 00, "	11.00
100.2	15 : 15, "	11.25
100.6	15 : 30, "	11.50
101.2	15 : 45, "	11.75
101.6	16 : 00, "	12.00

Apparent Static Temperature, T_{ws} : 127.7 °C

Correlation Coefficient : 0.971
Slope of Horner Straight Line, m : 86.5 °C/cycle
Roux Correction Term, t_{PD} : 4.8
Roux Correction Term, T_{DB} : 0.18

Initial Formation Temperature, T_i : 143.3 °C

Static Formation Temperature Test

Test No. 3 (1300 m)

Measured Drilled Depth : 1300 m CHF
Vertical Depth : 1131 m CHF, Elevation R.S.L. : −310 m

Date ; Drill Bit Passing : 04 : 00, Jan/29, 1985
Circulation : 01 : 30, Jan/31, 1985
Temp. Log Starting : 06 : 33, Jan/31, 1985

Cooling Time, T_p : 45.5 hours

Temperature Measured	Time & Date	Recovery Time, Δt
86.0 °C	7 : 25, Jan/31	5.92 hours
99.9	13 : 11, "	11.68
106.8	20 : 21, "	18.85
111.4	00 : 52, Feb/1	23.37

Apparent Static Temperature, T_{ws} : 135.8 °C

Correlation Coefficient : 0.998
Slope of Horner Straight Line, m : 52.9 °C/cycle
Roux Correction Term, t_{PD} : 18.2
Roux Correction Term, T_{DB} : 0.1

Initial Formation Temperature, T_i : 141.1 °C

App. 30 Records of temperature recovery test

unit : °C, AC-1D Well, 1985

No.		KT-1	KT-2	KT-3		KT-4	KT-5	
Date		16/Feb	17/Feb	19/Feb	22/Feb	22/Feb	28/Feb	28/Feb
Elapsed Time*		–	28hrs	73hrs		143hrs	279hrs	
Measured Depth (m CHF)	CHF	–	26	33	(R26)	31	34	
	100	–	38	33	(R38 N38)	36	35	
	200	–	44	45		48	37	
	300	–	46	50	(R48 N55)	53	50	(R53 N53)
	400	–	51	54		59	57	
	500	–	55	59	(R64 N68)	65	64	(R66 N67)
	600	–	60	65		72	70	
	700	–	66	71	(R78 N84)	81	78	(R84 N85)
	800	--	73	80		91	87	
	900	–	80	89		102	98	
	1000	–	89	99		112	110	
	1100	–	97	108		120	121	
	1200	–	104	116		129	129	(R134 N140)
	1300	--	112	124		140	139	
	1400	62	120	134		147	151	
	1500	70	129	143		156	158	
	1600	80	138	152		164	166	
	1700	94	146	160		170	174	
	1800	102	151	166		175	181	(R177 N193)
	1900	110	156	170		181	188	
	2000	118	164	176		193	193	
	MCD	162	193	199	(R 195 N >200)	197	204	
	RD	2019	2019	ND	ND	ND	2018	

* Elapsed Time : Time after halt of 2nd hydrofracturing (20:00, 16/Feb) at MCD

** R.D : Read value of depth meter as MCD

*** ( ) : Temperature from Maximum Thermometer, R : Reverse, N : Normal

Table 2 (2)

^{N} KT-6	KT-7	KT-8		^{N} KT-9	KT-10	KT-11	^{N} KT-12	
2/Mar	2/Mar	7/Mar	7/Mar	7/Mar	12/Mar	18/Mar	20/Mar	20/Mar
328 hrs	330 hrs	19 days		19 days	24 days	30 days	32 days	
–	34	–			39	37	–	
--	35	–			41	38	–	
–	36	37		51	47	46	–	
49.8	45	53		53	53	53	–	
61.9	50	59		61	59	60	59	
68.0	58	66		66	66	66	67	
74.1	65	–			72	74	73	
80.8	75	–			80	82	82	
89.9	84	–			92	92	92	
99.3	94	–			102	103	106	
109.6	107	114	(R119 R119 N122)	115	115	117	118	(R121 R126 N116)
123.6	118	–			126	128	129	
133.8	129	–			137	138	140	
143.5	137	–			144	149	150	
155.2	150	152	(R162 R160 N163)	160	159	160	159	(R169 R171 N164)
165.5	156	165		166	167	166	172	
173.1	166	172		175	173	174	179	(R183 R185 N180)
181.4	173	179	(R188 R190 N156)	184	180	181	189	
188.5	181	187		192	189	189	195	
195.4	187	193		202	195	195	201	
197.4	193	198		207	199	199	209	
205.2	204	208	(R214 R217 N212)	211	209	205	217	(R211 R214 N211)
2021	2020	2021		ND	2025	2022	2020	

**** Kuster Elements ; N : No. 27069, No Mark : No. 10504

App. 31 Records of injection test

Injectivity Test III (Hydrofracturing)
Date : 16/Feb., 1985
Method : Long time injection

Time	Well Head Pressure		Flowrate	
	(psig)	(Mpag)	(SPM)	(l/sec)
8:00	start			
8:30	1200	8.27	76	14.53
9:00	1250	8.62	70	13.38
10:00	1290	8.89	68	13.00
11:00	1300	8.96	68	13.00
12:00	1320	9.10	72	13,76
13:00	1340	9.24	77	14,72
14:00	1330	9.17	76	14.53
15:00	1330	9.17	75	14,34
16:00	1330	9.17	74	14.15
17:00	1320	9.10	73	13.95
18:00	1330	9.17	73	13.95
19:00	1320	9.10	73	13.95
20:00	1320	9.10	73	13.95

Injectivity Test II (Multitude Injection)
Date : 15/Feb., 1985
Method : Pressurizing well injection

Time	Well Head Pressure		Hole Press* (Mpag)	Flowrate	
	(psig)	(Mpag)		(SPM)	(l/sec)
06:00 to 06:30	500	3.45	15,43	14	2,68
06:30 to 07:00	700	4,83	17,10	27	5,31
07:00 to 07:30	950	6,55	18,67	41	7,84
07:30 to 08:00	1100	7,59	19,97	55	10,61

Hole Press. : Measured pressure at drilled depth of 1450 m.

App. 32 Records of pressure drop after inunction test

unit: Mpag, AC-1D Well, 1985

No.		KP-2	KP-3	KP-4	KP-6	KP-7
Date		17/Feb	19/Feb	23/Feb	2/Mar	7/Mar
Elapsed Time		28 hrs	73 hrs	167 hrs	330 hrs	19 days
Measured Depth (m, CHF)	CHF	0	0	0	0	0
	100	0.32	0	0	0	ND
	200	1.33	0.07	0	0	ND
	300	2.10	1.40?	0.8	0.55	0.8
	400	3.10	1.98	1.7	1.2	1.75
	500	3.97	2.88	2.5	2.5	2.75
	600	4.85	3.74	3.6	3.4	ND
	700	5.63	4.53	4.35	4.2	ND
	800	6.42	5.28	4.75	4.75	ND
	900	7.10	5.96	5.7	5.68	ND
	1000	7.78	6.64	6.4	6.38	6.60
	1100	8.44	7.41	7.1	7.05	ND
	1200	9.06	8,05	7.75	7.62	ND
	1300	9.80	8.70	8.4	8.3	ND
	1400	10.42	9.40	9.1	8.83	9.20
	1500	11.10	10.05	9.8	9.55	9.95
	1600	11.84	10.80	10.3	10.3	10.60
	1700	12.50	11.45	10.95	10.9	11.20
	1800	13.30	12.40?	11.85	11.77	11.95
	1900	13.95	12.81	12.50	12.48	12.60
	2000	14.68	13.45	13.20	13.0	13.10
	MCD	14.90	13.80	13.40	13.43	13.20
	RD	2019	ND	ND	2020	2021

* Elapsed Time : Time after halt of 2nd hydrofracturing (20:00, 16/Feb) at MCD
** R.D. : Read value of depth meter as MCD
*** ? : Doubtful value

Injectivity Test I (Hydrofacturing)
Date : 15/Feb, 1985
Method : Long time injection

Time	Well Head Pressure		Flowrate	
	(psig)	(MPag)	(SPM)	(l/sec)
15:30	start	–	–	
15:33	1000	6.90	70	13.38
15:35	1270	8.76	100	19.12
15:40	1320	9.10	97	18.54
15:45	1360	9.38	92	17.59
15:50	1390	9.58	95	18.16
16:00	1400	9.65	92	17.59
16:15	1410	9.72	88	16.82
16:30	1410	9.72	88	16.82
17:00	1410	9.72	88	16.82
18:00	1430	9.86	85	16.25
19:00	1450	10.00	80	15.29
20:00	1450	10.00	80	15.29
21:00	1450	10.00	80	15.29
21:30	1450	10.00	80	15.29

* (psi) : Well head pressure guege (power per inch)
** (SPM): Strokes per minute of pumping.
1 SPM = 3.03 gal/min = 19.12 ℓ/sec

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