DRILLING ACTIVITY IN THE MATALOKO GEOTHERMAL FIELD, NGADA – NTT, FLORES – INDONESIA.

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Key Word : Mataloko, Drilling history, Alteration, P-T logging and Flow-Test.

ABSTRACT

Drilling activity of MT-2 was completed with setting 4" perforated casing to a depth of 180 m (TD = 180.02 m) on 3 February 2001.

The first run of P-T logging tool to a depth of 104 m on 8 January 2001 showed down-hole temperature of 75.8°C. The second run recorded temperature of 78.1°C, then became 112°C and 130.4°C during the tool stayed for 2 hours and another 1½ hours at the bottom.

*A flow test with Lip Pressure Method was successfully done to MT-2 on 22-27 January 2001. Steam flow rates on 3" flow line varied between **10.87 – 10.98** ton/hour at **WHP of 7.9 Kscg**. At **WHP of 5.9 – 6.0 Kscg**, steam flow rate ranged from **14.48 – 14.71** ton/hour and a flow line temperature of **135 – 140°C**. Using 4" flow line, steam flow rate was about **14.29 – 16.34** ton/hour at **WHP of 3.1 – 3.9 Kscg** with a range temperature of 128 – 133°C. A maximum WHP of 14.0 Kscg was recorded while MT-2 shut-in on 17 - 18 January 2001.*

*Chemical analyisis (WESTJEC) during the flow test showed a very low of gas content in the **saturated steam** (NCG = 0.261 – 0.291 vol% or 0.612 – 0.692 Wt%, CO2 in NCG = 90.81 – 90.99 vol%, H2S in NCG = 6.33 – 6.59 vol% and residual gas in NCG = 2.61 – 2.68 vol%).*

Subsurface lithology of MT-1 consists of tuff breccia, pyroxene andesite, hornblende andesite with minor layers of tuff. All rocks have been altered into argillic type. Alteration intensity (SM/TM) varies between 30 – 90% and contain about 2 – 60% swelling clay. The lithology of MT-2 is nearly the same as the MT-1 well.

1. INTRODUCTION

The five-year (1998–2003) cooperative research between Indonesia-Japan proposed an exploration well (TD = 1000 m) to investigate a subsurface geothermal system in the Mataloko Geothermal Field. The first exploration well (MT-1) has shifted to MT-2 because MT-1 was plugged back with cement due to a suddent flowing and blowout of steam with gasses (H2S & CO) around the cellar while drilling 9 5/8" hole at a total depth of 207.26 m on 18 October 2000.

The exploration well of MT-2 (+ 952.86 m asl.) is situated at X = 286920.149 mE and Y = 9022732.12 mN **(Figure-1)**. MT-2 was stopped at a total depth of 180.02 m, because down-hole condition was unstable with caving materials made some difficulties to the drilling operation. Temperature measurement and flow test are aimed to determine important information about the thermal profile, flow rate and steam quality of MT-2.. In this report, we describe the drilling history, down hole temperature, result of the flow test and several disscussions for the next planning of MT-2 well.

2. DRILLING HISTORY OF MT-2

MT-2 well was spud on 30 December 2000 at 13.30 hours with drilling 12 ¼" hole and continued with setting 10" casing shoe in a depth of 17.6 m. Drilling 9 5/8" hole was penetrated to the depth of 104.56 m depth on 8 January 2001. Before setting 8" casing, P & T logging have been run to 104 m. During drilling 7 5/8" hole in between 160.0 - 162.35 m, mud circulation temperature was high (in/out = 53/60 °C). When pulling out BHA of hole to the surface on 17 January 2001, mud outburst occured to about 30 m high from the Rig's'floor. The well was ready for a flow test due to the similarity data with MT-1.

A flow test has been done for 6 days (22–27 January 2001). Then, the well was killed with pumping of mud, but subsurface lithology was unstable. Caving materials filled the hole untill to 136 m depth. On 30 January 2001, 6" casing shoe was set to 109.63 m and continued drilling 5 5/8" hole to a depth of 180.02 m on 1 February 2001. The hole was cleaned out several times, and made difficulties for drill pipe (DP) connection. Finally, 4" casing liner was run in hole to a depth of 180.0 m, and flowed the well to hole condition on 5 February 2001.

3. SUBSURFACE GEOLOGY AND P-T LOGGING

44 cuttings from MT-2 were megascopically analyzed in the field to determine mineral, textural relationship and alteration intensity. The lithology of MT-2 (0 –180.02 m) is nearly the same as MT-1 (0 – 207.26 m), consists of tuff breccia, pyroxene andesite, ash tuff and hornblende andesite **(Figure-2)**. All rocks have been altered into clay (*smectite* and *kaolinite*), pyrite with/without *carbonate*, *Fe-Oxide*, *secondary quartz*, *anhydrite*, *illite* and *zeolite*. Alteration intensity (SM/TM) varies between 30 – 90% and characterized by 2 – 60% swelling clay. Alteration of MT-2 is classified into argillic type (*clay cap*). Very fine fractures are only recoqnized from a static loss observation (42 liter/minute) in 162.35 m depth.

P-T logging was conducted in MT-2 at 02.20 WITA on 8 January 2001, using equipment of logging truck mounted made by Kaihatsu Kogyo Co, Ltd.–Japan. Tool logging was run twice from ground surface to 104.0 m depth **(Figure-2)**. For the first run, bottom hole temperature was 75.8°C. When the logging tool reached on bottom in the second run, down-hole temperature was 78.1°C, increased to 112°C and 130.4°C during heating-up 2 hours and 1½ ours, respectively. Bottom-hole pressure was 11 Ksc in a 104 m depth.

4. FLOW TEST

A flow test was carried out on a 162.35 m depth, because steam and gas accumulation caused WHP of 3.5 Kscg in MT-2 well during 24 hours shut-in on 17 – 18 January 2001. A maximum WHP when MT-2 shut-in was 14.0 Kscg. Steam was tried to flow on 18 January 2001, and success. Steam flow rates in 3" and 4" pipe lines were measured with *lip pressure method* **(Table-1)**. Gas and condensated samples were taken during the flow test and chemically analyzed on the field **(Table 2)**.

Steam flow rates on 3" flow pipe varied between ***10.87 – 10.98*** ton/hour at ***WHP of 7.9 Kscg*** with a flow line temperature of 126 – 128°C **(Table-1** and **Figure-3)**. At ***WHP of 5.9 – 6.0 Kscg***, steam flow rate ranged from ***14.48 – 14.71*** ton/hour, whereas steam temperature in the flow line varied between ***135 – 140°C***. Using 4" flow line, steam flow rate was about ***14.29 – 16.34*** ton/hour at ***WHP of 3.1 – 3.9 Kscg*** in a range temperature of 128 – 133°C. When WHP tried to set at 5.8 Kscg, a flow rate decreased to about 12.19 ton/hour and the steam was slightly wet.

Chemical analyisis (WESTJEC) during the flow test showed that the saturated steam contain *a very low of gas content* (NCG = 0.261–0.291 vol% or 0.612–0.692 Wt%, CO2 in NCG = 90.81–90.99 vol%, H2S in NCG = 6.33–6.59 vol% and residual gas in NCG = 2.61–2.68 vol%).

5. ESTIMATED DOWN-HOLE TEMPERATURE

As it mentioned above, a maximum WHP of 14.0 Kscg (14.63 bar abs.) was recorded while MT-2 shut in on 17 – 18 January 2001. After 4 hours flowing to hole condition (5 February 2001), a maximum WHP of 18 Kscg (18.55 bar abs.) shown by MT-2 on 13 February 2001 (5 days shut-in). Saturated temperatures for the WHP 14.0 Kscg and 18.0 Kscg are 197.12°C and 208.6 °C, respectively (STEAM TABLE, 1964). The data above strongly suggest that estimated down hole temperature of MT-2 ranged from about 197 – 208.6°C.

6. CONCLUSION AND SUGGESTION

From the earlier discussion, several conclusions and suggestions can be drawn i.e. :

1. Lithology of MT-2 well is characterized by argillic type of alteration. Alteration intensity (SM/TM) ranges from 30 – 90% with 2 – 60% swelling clay. Very fine fractures of the down hole of MT-2 are recoqnized from static loss of 42 liter/minute.

2. A maximum steam flow rate of MT-2 is 16.34 ton/hour at WHP of 3.7 Kscg in 4" flow line. At a higher WHP (5.9 Kscg and 7.9 Kscg), steam flow rates of MT-2 well are 14.56 ton/hour and 10.87 ton/hour, respectively. The steam are generated from down-hole in a range temperature of 197 – 208.6 °C.

3. Longterm of flow test with orifice method and P-T logging at a static and flowing conditions are being proposed to MT-2 well in recoqnition of a stable flow rate, feed zones and static formation temperature.

4. A proper of mud properties and mud cooling system should be prepared for drilling in geothermal system with a high content of swelling clay (clay cap) and a suddent outburst (blowout) of high temperature steam.

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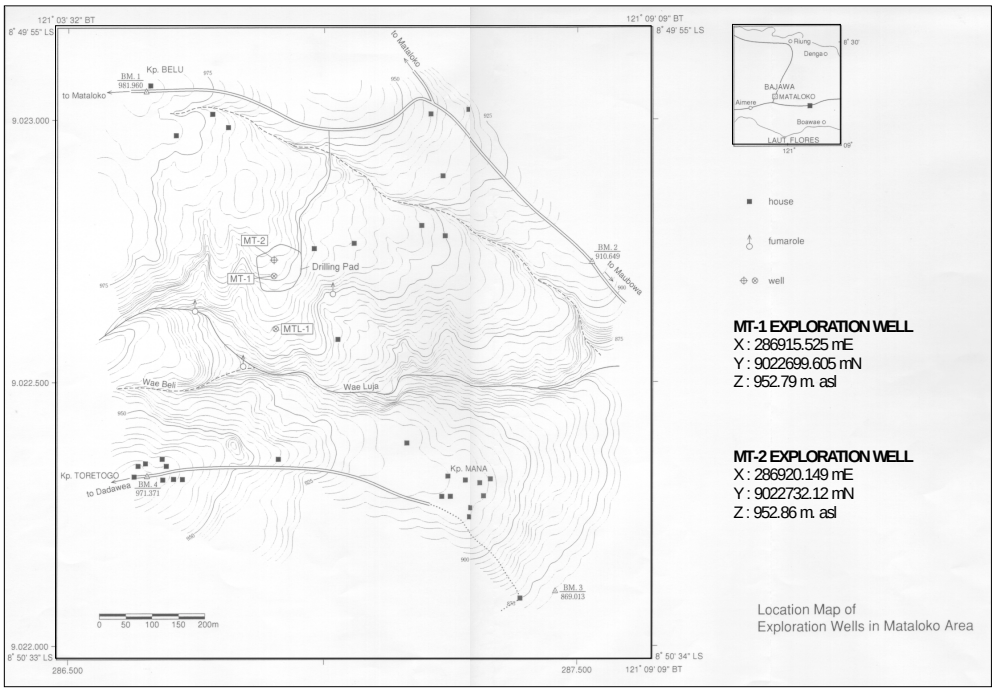

Figure-1
The exploration well of MT-2

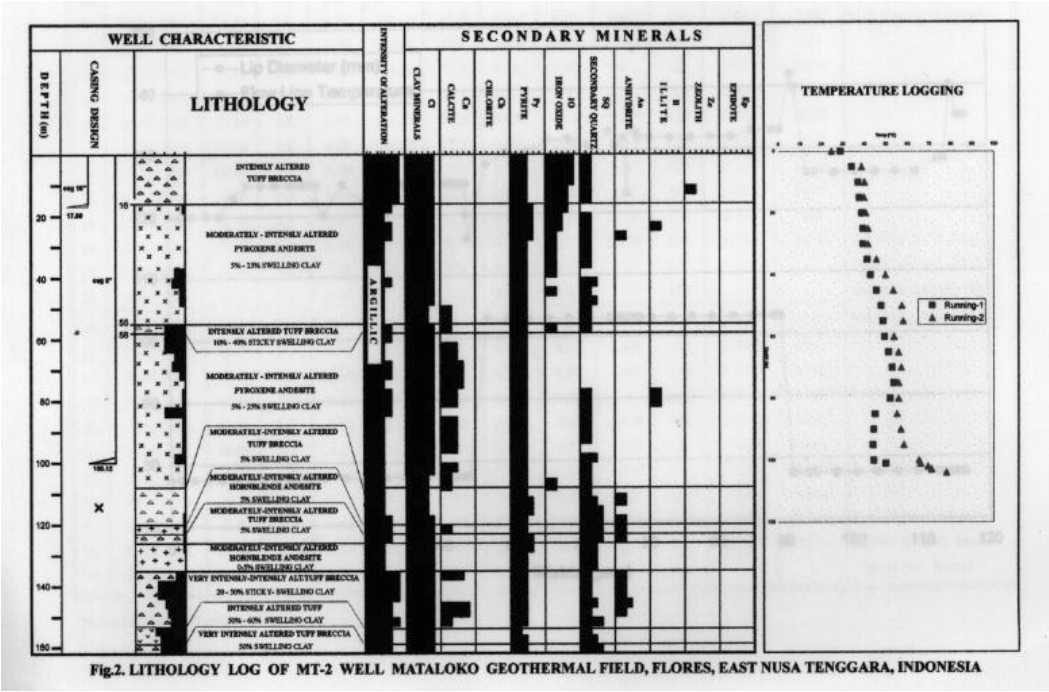

Fig.2. LITHOLOGY LOG OF MT-2 WELL MATALOKO GEOTHERMAL FIELD, FLORES, EAST NUSA TENGGARA, INDONESIA

FIG.3. MT-2 DISCHARGE DATA TREND DURING THE FLOW TEST ON 22 - 27 JANUARY 2001

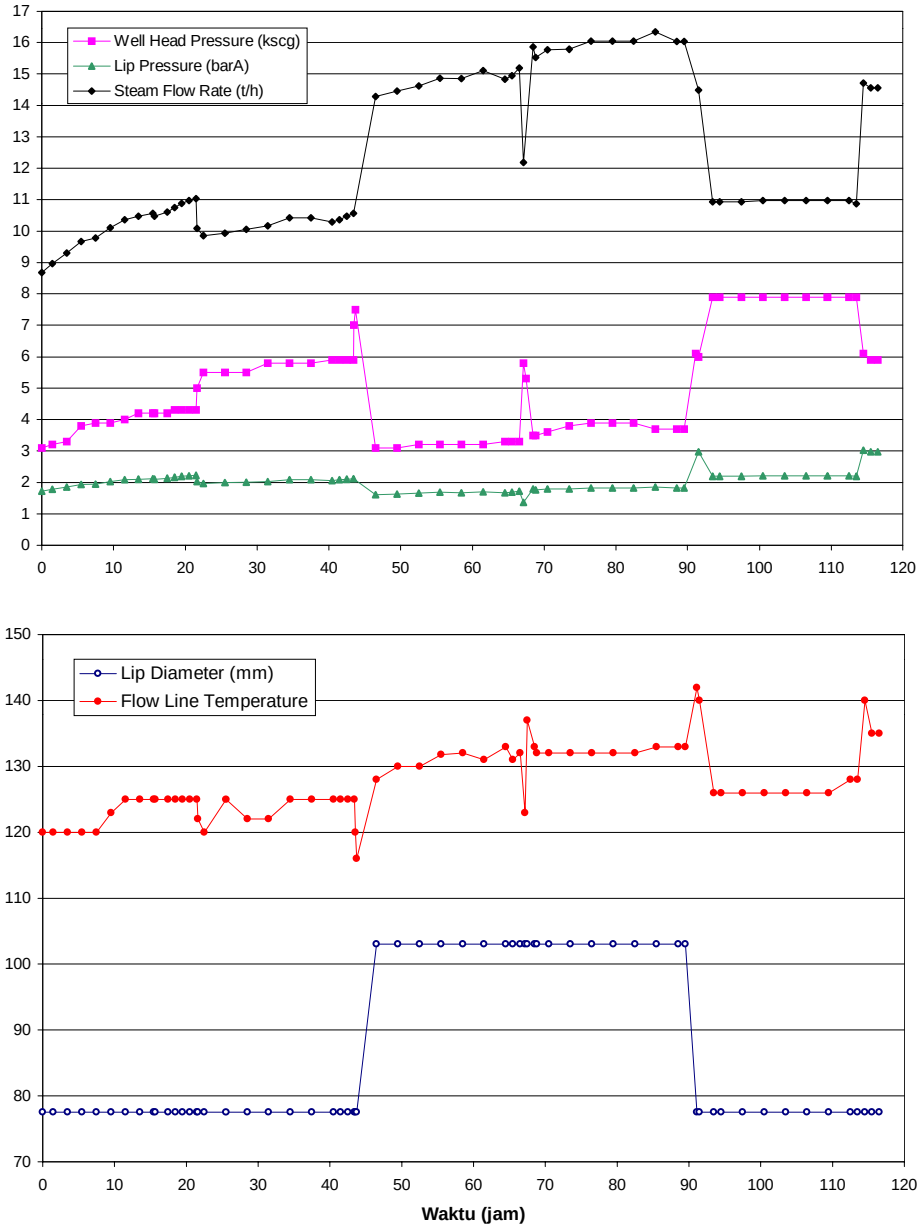

Table 1.
FLOW TEST DATA OF THE MT-2 WELL
THE MATALOKO GEOTHERMAL FIELD, NGADA - FLORES, NTT.

Production Engineer : Shimoike (WESTJEC), Sitorus, K. (VSI) MT-2 Exploration Well (+ 952.86 asl.)
Geochemist : Matsuda (WESTJEC), Terry Sriwana (VSI) 7 5/8" Hole : 162.35 m (TD)
Assistant Engineer : Sophian (VSI) 8" Casing Shoe : 100.12 m
Coordinate : (X = 286920.149 UTM; Y = 9022732.12 UTM)

No.	TIME		WHP		Saturated Temp. (°C)	ID Pipe	Pa	Pc		T° Steam	ENTHALPY (h)	FLOW RATE	EXPLANATION
	DATE	Hrs	Kscg	bar abs		mm	bar	bar	bar abs	°C	kJ/kg	ton/hr	
1.	22-01-2001	16.30	3.1	3.94	142.90	77.5	0.900	0.72	1.72	120	2706.3	8.67	Fully opened (100%)
2.	22-01-2001	18.00	3.2	4.04	143.67	77.5	0.900	0.78	1.78	120	2706.3	8.96	Check flow rate untill
3.	22-01-2001	20.00	3.3	4.14	144.87	77.5	0.900	0.85	1.85	120	2706.3	9.30	to a stable condition.
4.	22-01-2001	22.00	3.8	4.63	148.97	77.5	0.900	0.93	1.93	120	2706.3	9.68	
5.	23-01-2001	00.00	3.9	4.72	149.69	77.5	0.900	0.95	1.95	120	2706.3	9.78	
6.	23-01-2001	02.00	3.9	4.72	149.69	77.5	0.900	1.02	2.02	123	2710.6	10.10	
7.	23-01-2001	04.00	4.0	4.82	150.47	77.5	0.900	1.08	2.08	125	2713.5	10.37	
8.	23-01-2001	06.00	4.2	5.02	152.00	77.5	0.900	1.10	2.10	125	2713.5	10.47	Unstable condition
9.	23-01-2001	08.00	4.2	5.02	152.00	77.5	0.900	1.12	2.12	125	2713.5	10.56	
10.	23-01-2001	09.10	4.2	5.00	151.85	77.5	0.880	1.12	2.10	125	2713.5	10.47	
11.	23-01-2001	10.00	4.2	5.02	152.00	77.5	0.900	1.13	2.13	125	2713.5	10.61	
12.	23-01-2001	11.00	4.3	5.12	152.74	77.5	0.900	1.16	2.16	125	2713.5	10.75	
13.	23-01-2001	12.00	4.3	5.12	152.74	77.5	0.899	1.19	2.189	125	2713.5	10.89	
14.	**23-01-2001**	**13.00**	**4.3**	**5.12**	**152.74**	**77.5**	**0.897**	**1.21**	**2.207**	**125**	**2713.5**	**10.98**	@13.38 - 13.59 hrs.
15.	23-01-2001	14.00	4.3	5.12	152.74	77.5	0.898	1.22	2.218	125	2713.5	11.03	(75 - 62.5% opened)
16.	23-01-2001	14.07	5.0	5.80	157.52	77.5	0.897	1.02	2.017	122	2709.2	10.09	@ 14.07 hrs, set WHP
17.	23-01-2001	15.00	5.5	6.29	160.69	77.5	0.897	0.97	1.967	120	2706.3	9.86	to 5.5 Kscg (25% opened)
18.	23-01-2001	18.00	5.5	6.29	160.69	77.5	0.899	0.99	1.989	125	2713.5	9.94	
19.	23-01-2001	21.00	5.5	6.29	160.69	77.5	0.901	1.01	2.011	122	2709.2	10.06	
20.	24-01-2001	00.00	5.8	6.59	161.32	77.5	0.901	1.03	2.031	122	2709.2	10.16	
21.	24-01-2001	03.00	5.8	6.59	161.32	77.5	0.901	1.09	2.091	125	2713.5	10.42	
22.	24-01-2001	06.00	5.8	6.59	161.32	77.5	0.901	1.10	2.091	125	2713.5	10.42	
23.	24-01-2001	09.00	5.9	6.69	163.14	77.5	0.900	1.07	2.06	125	2713.5	10.28	
24.	24-01-2001	10.00	5.9	6.69	163.14	77.5	0.900	1.09	2.08	125	2713.5	10.37	
25.	24-01-2001	11.00	5.9	6.69	163.14	77.5	0.900	1.10	2.10	125	2713.5	10.47	
26.	24-01-2001	11.55	5.9	6.68	163.08	77.5	0.899	1.12	2.119	125	2713.5	10.56	Set WHP to 7.0 Kscg.
27.	24-01-2001	12.00	7.0	7.76	169.16	77.5	0.899	0.76	-	120	-	-	Steam was wet, difficult
28.	24-01-2001	12.12	7.5	8.25	171.69	77.5	0.899	0.63	-	116	-	-	to decide enthalpy (h)
29.	24-01-2001	15.00	3.1	3.94	143.08	103	0.898	0.61	1.608	128	2717.7	14.29	**Set 4" pipe line.**
30.	24-01-2001	18.00	3.1	3.94	143.08	103	0.899	0.63	1.629	130	2720.5	14.45	
31.	24-01-2001	21.00	3.2	4.04	143.67	103	0.900	0.65	1.65	130	2720.5	14.63	
32.	25-01-2001	00.00	3.2	4.04	143.67	103	0.900	0.68	1.68	131.8	2723.0	14.87	
33.	25-01-2001	03.00	3.2	4.04	143.67	103	0.898	0.68	1.678	132	2723.3	14.85	
34.	25-01-2001	06.00	3.2	4.04	143.67	103	0.898	0.71	1.708	131	2721.9	15.11	
35.	25-01-2001	09.00	3.3	4.13	144.78	103	0.898	0.68	1.678	133	2724.6	14.84	
36.	25-01-2001	10.00	3.3	4.13	144.78	103	0.899	0.69	1.689	131	2721.9	14.95	
37.	25-01-2001	11.00	3.3	4.13	144.78	103	0.898	0.72	1.718	132	2723.3	15.19	Set WHP = 5.9 Kscg.
38.	25-01-2001	11.38	**5.8**	6.59	161.39	103	0.899	0.36	1.359	123	**2710.6**	**12.19**	(100% opened). Steam
39.	25-01-2001	12.00	5.3	6.10	154.05	103	0.898	1.4	-	137	-	-	slightly ***wet*** . **Install**

Pc reading is corrected with + 0.1 bar.

Table 1 (Continued).
FLOW TEST DATA OF THE MT-2 WELL

Production Engineer : Sitorus, K. (VSI)
Geochemist : Takahashi (GSJ), Terry Sriwana (VSI)
Assistant Engineer : Sophian (VSI)

MT-2 Exploration Well (+ 952.86 asl.)
7 5/8" Hole : 162.35 m (TD)
8" Casing Shoe : 100.12 m
Coordinate : (X = 286920.149 UTM; Y = 9022732.12 UTM)

No.	TIME		WHP		Saturated Temp. (°C)	ID Pipe	Pa	Pc		T° Steam	ENTHALPY (h)	FLOW RATE	EXPLANATION
	DATE	Hrs	Kscg	bar abs		mm	bar	bar	bar abs	°C	kJ/kg	ton/hr	
40.	25-01-2001	13.00	3.5	4.33	146.50	103	0.898	0.78	1.80	133	2724.6	15.87	**GSJ equipments** at
41.	25-01-2001	13.20	3.5	4.33	146.50	103	0.898	0.79	1.758	132	2723.3	15.53	11.40 hrs. Sampling by
42.	25-01-2001	15.00	3.6	4.43	146.50	103	0.897	0.79	1.787	132	2723.3	15.77	GSJ & VSI at pressure
43.	25-01-2001	18.00	3.8	4.63	148.97	103	0.899	0.79	1.789	132	2723.3	15.79	0.07 Mpa (separator)
44.	25-01-2001	21.00	3.9	4.72	149.69	103	0.900	0.82	1.82	132	2723.3	16.05	
45.	26-01-2001	00.00	3.9	4.72	149.69	103	0.900	0.82	1.82	132	2723.3	16.05	
46.	26-01-2001	03.00	3.9	4.72	149.69	103	0.900	0.82	1.82	132	2723.3	16.05	
47.	26-01-2001	06.00	**3.7**	**4.53**	**148.16**	**103**	0.900	0.85	**1.85**	**133**	**2724.6**	**16.34**	
48.	26-01-2001	09.00	3.7	4.53	148.16	103	0.900	0.82	1.819	133	2724.6	16.04	
49.	26-01-2001	10.00	3.7	4.53	148.16	103	0.898	0.82	1.818	133	2724.6	16.03	
50.	26-01-2001	11.37	6.1	6.88	164.26	77.5	0.898	-	-	142	-	-	Change to 3" pipe line.
51.	26-01-2001	12.00	6.0	6.78	163.67	77.5	0.898	1.97	2.97	140	2733.9	14.48	Changed thermocouple
52.	26-01-2001	14.00	7.9	8.64	173.62	77.5	0.897	1.2	2.197	126	2714.9	10.93	Set WHP to 7.9 Kscg.
53.	26-01-2001	15.00	7.9	8.64	173.62	77.5	0.897	1.2	2.197	126	2714.9	10.93	
54.	26-01-2001	18.00	7.9	8.65	173.67	77.5	0.898	1.2	2.198	126	2714.9	10.93	
55.	26-01-2001	21.00	7.9	8.65	173.67	77.5	0.899	1.21	2.209	126	2714.9	10.98	
56.	27-01-2001	24.00	7.9	8.65	173.67	77.5	0.899	1.21	2.209	126	2714.9	10.98	
57.	27-01-2001	03.00	7.9	8.65	173.67	77.5	0.899	1.21	2.209	126	2714.9	10.98	
58.	27-01-2001	06.00	7.9	8.65	173.67	77.5	0.899	1.21	2.209	126	2714.9	10.98	
59.	27-01-2001	09.00	7.9	8.65	173.67	77.5	0.899	1.21	2.209	128	2717.7	10.97	
60.	**27-01-2001**	**10.00**	**7.9**	**8.65**	**173.67**	**77.5**	**0.898**	**1.19**	**2.188**	**128**	**2717.7**	**10.87**	
61.	27-01-2001	11.00	6.1	6.88	164.26	77.5	0.898	2.02	3.018	140	2733.9	14.71	Set WHP to 6 Kscg.
62.	**27-01-2001**	**12.00**	**5.9**	**6.68**	**164.26**	**77.5**	**0.898**	**1.98**	**2.978**	**135**	**2727.3**	**14.56**	
63.	**27-01-2001**	**13.00**	**5.9**	**6.68**	**164.26**	**77.5**	**0.897**	**1.98**	**2.978**	**135**	**2727.3**	**14.56**	MT-2 well shut-in.

Table 2.
Field Report on Gas Chemical Sampling of the Well MT-2 (reviced January 28th, 2001)

Sample Name **Sampling Date**		MT-2a 1/23/2001	MT-2b 1/24/2001	MT-2c 2001/1/25
Well Head Pressure (WHP)	kg/cm^2G	4.1 - 4.3	5.9	3.2
Mini Separator Pressure	kg/cm^2G	3.1 - 3.3	3.3	3.2
Atmospheric Temperature	°C	24.5 - 25.7	23.8 - 25.3	24.1 - 25.2
Atmospheric Pressure	hPa	901 - 903	903 - 904	902 - 903
NCG Content	vol%	0.261	0.291	0.258
NCG Content*	wt%	0.620	0.692	0.612
CO2 in NCG	vol%	90.81	90.99	90.83
H2S in NCG	vol%	6.59	6.33	6.50
Residual Gas in NCG	vol%	2.61	2.68	2.67
Note :		WHP opening = full open. Flow line lip = 3"	WHP opening = 25% Flow line lip = 3"	WHP opening = full open Flow line lip = 4"

* NCG (wtb %) is tentatively calculated assuming residual gas is of 100% N2