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Philippine Geothermal Status

- Drilled a total of approximately 800 exploratory and production wells.
- Geothermal power contributed about 18% of the country's total electricity requirement.
- Total country geothermal resource potential is about 4,300 megawatts.
- There are six geothermal fields located in different parts of the country with a total installed capacity of 1,900 megawatts
- Saved the country about US$ 850 million in terms of foreign exchange with a displacement of about 17 million barrels of oil.

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Objectives of the Presentation

- To share drilling operations performance in the Philippines, Papua New Guinea, Mutnovsky in Russia, and Indonesia.
- To identify areas where ENGINE can contribute to the reduction in drilling cost in the geothermal drilling industry and to EGS, specifically.
- To share with the people in the geothermal drilling industry the techniques, new drilling tools, and equipment utilized that improved drilling performance.

.Drilling performance in the Philippines, Indonesia, Papua New Guinea and Mutnovsky

- All areas were assumed to have prepared for drilling the wells efficiently
- Rigs used in different areas have different rig capacity ratios
- Well profiles are somehow similar
- Different weather conditions
- Drillability of formation is somehow similar

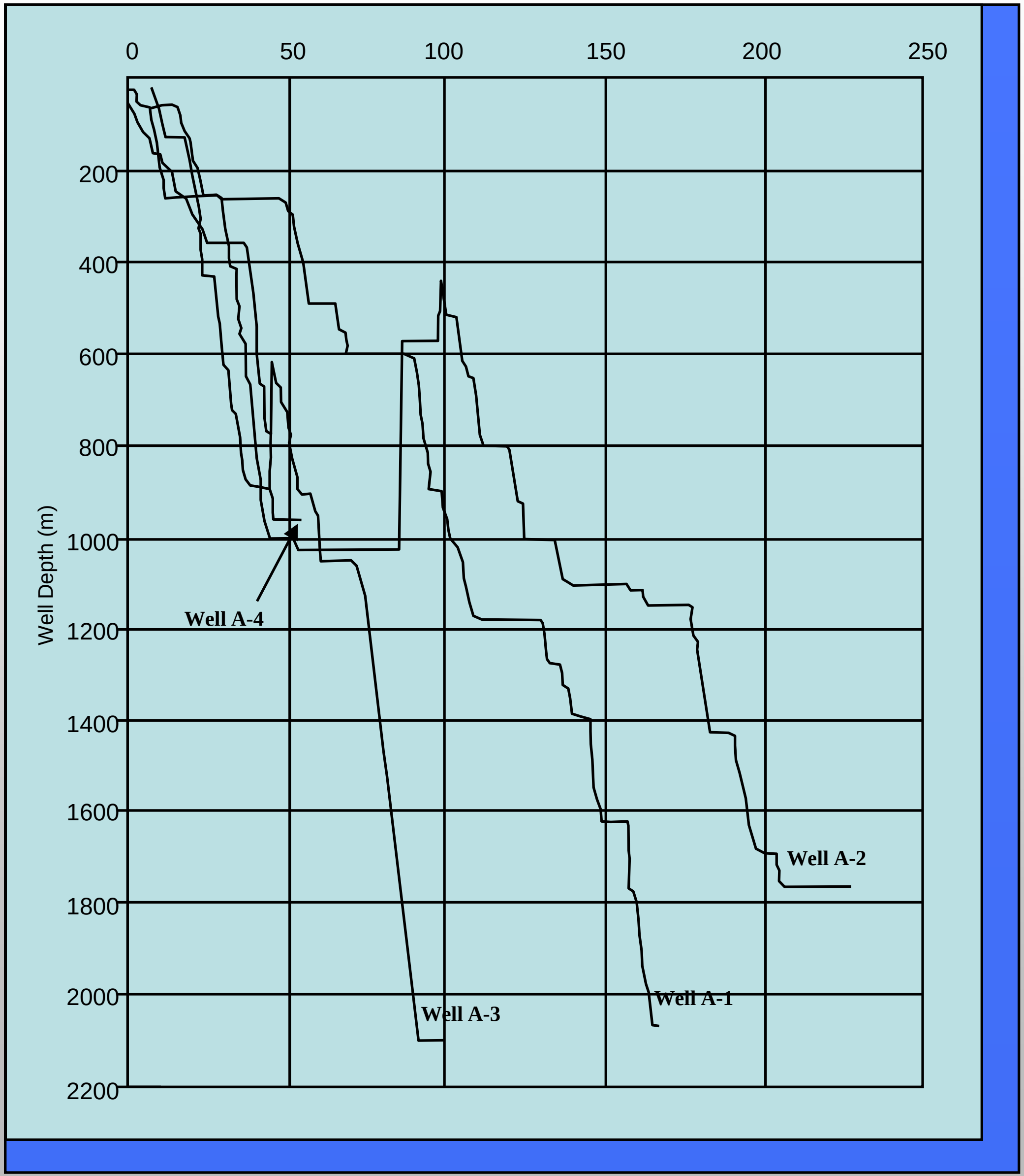
Rig Capacity Ratio based on Planned Depths (Reference: J. N. Southon & G. Gorbachev-2003 NZ Geo Workshop 2003)

GEOTHERMAL LOCATIONS	POWER RATIO (KW/M)	PULL RATIO (KG/M)
Darajat	0.466	189
Mak-Ban	0.229	116
Lihir	0.410	154
Mutnovsky	0.133	44
New Zealand	0.280	68
Iran	0.497	151

Overall Drilling Performance (Reference: J. N. Southon & G. Gorbachev-NZ Geo workshop 2003)

		AVERAGE	
FIELD	NO. OF WELLS	M/DAY	DEPTH (M)
Mutnovsky	3	13.6	1980
Mutnovsky BH	1	17.4	957
Mahanandong BH	14	36.3	2347
Mahanandong	16	37.3	2280
Darajat BH	11	44.3	2230
Mak-Ban BH (1993-2000)	8	50.0	2466
Darajat	1	53.5	2890
Lihir	8	65.1	1581
Mak-Ban BH (2002-2003)	6	77.1	3068

Mutnovsky Days versus Depth Plots (Reference: J. N. Southon & G. Gorbachev-NZ Geo Workshop 2003)



Mak-Ban Well F Drilling Rates (Reference: J. N. Southon & G. Gorbachev- NZ Geo Workshop 2003)

660 mm (26 inch) hole drilling rate (average including connections)	403.2 m/day
445 mm (17-1/2 inch) hole drilling rate (average including connections)	319.2 m/day
311 mm (12-1/4 inch) hole drilling rate (average including connections)	300.0 m/day
251 mm (9-7/8 inch) hole drilling rate (average including connections)	249.6 m/day
251 mm (9-7/8 inch) single bit run record meterage	851.3 m/day

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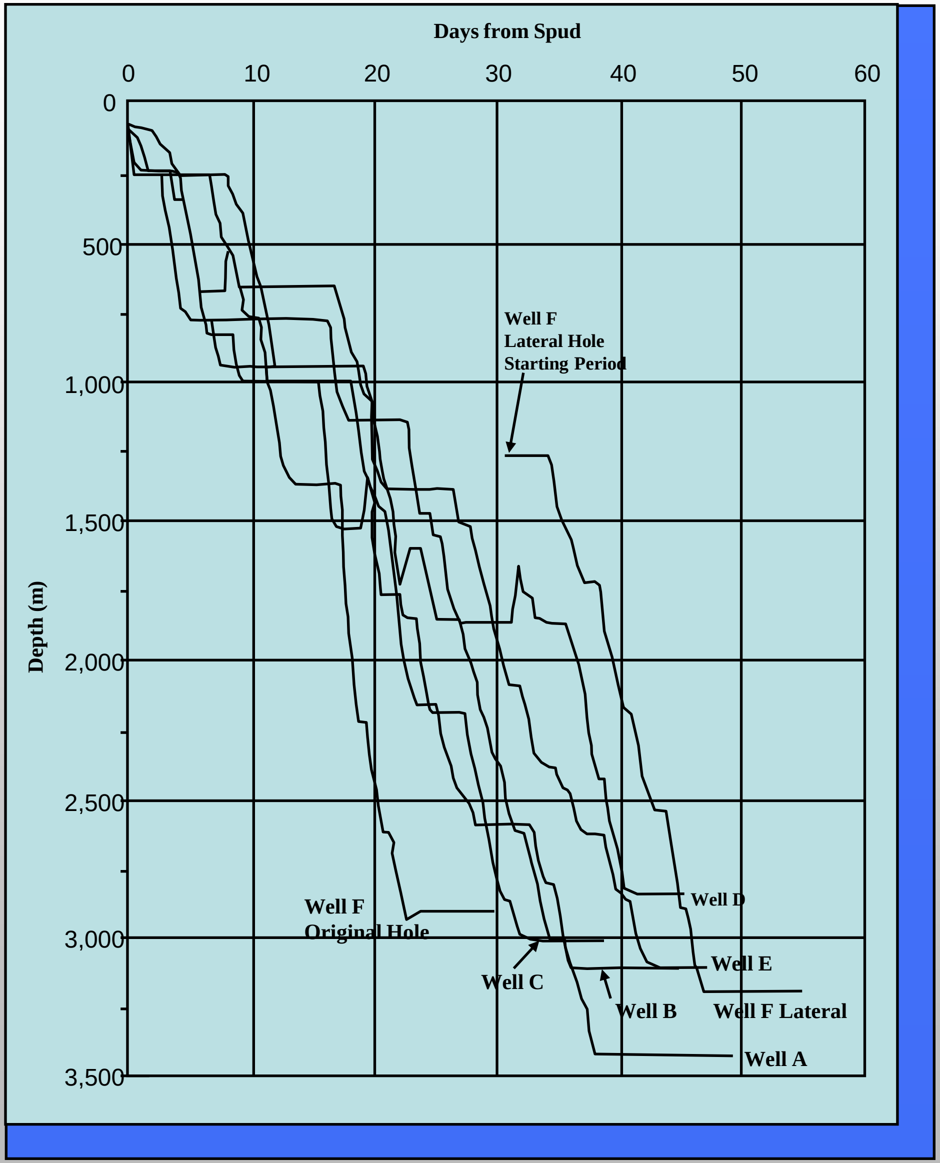
Mak-Ban Days versus Depth Plots (Reference: J. N. Southon & G. Gorbachev- NZ Geo workshop 2003)



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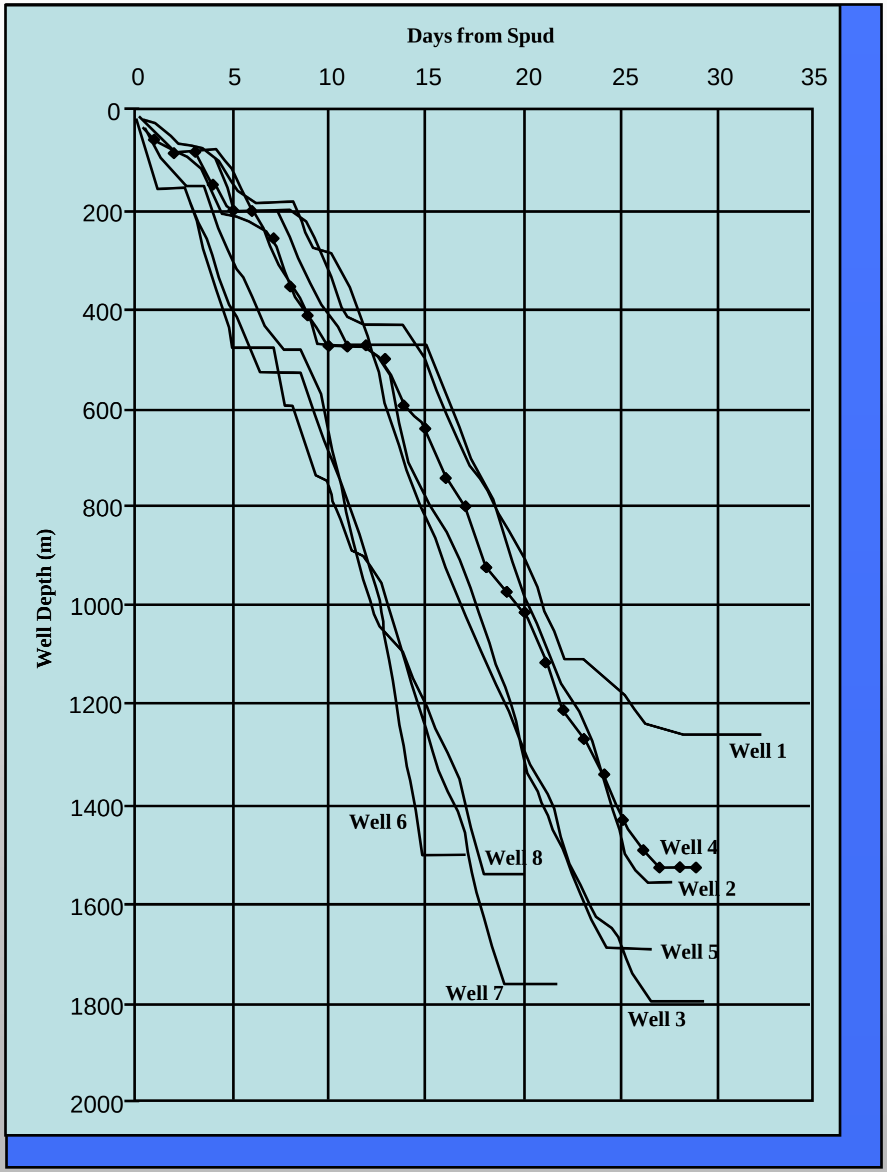
Lihir Days versus Depth Plots (Reference: J. N. Southon & G. Gorbachev- NZ Geo Workshop- 2003)



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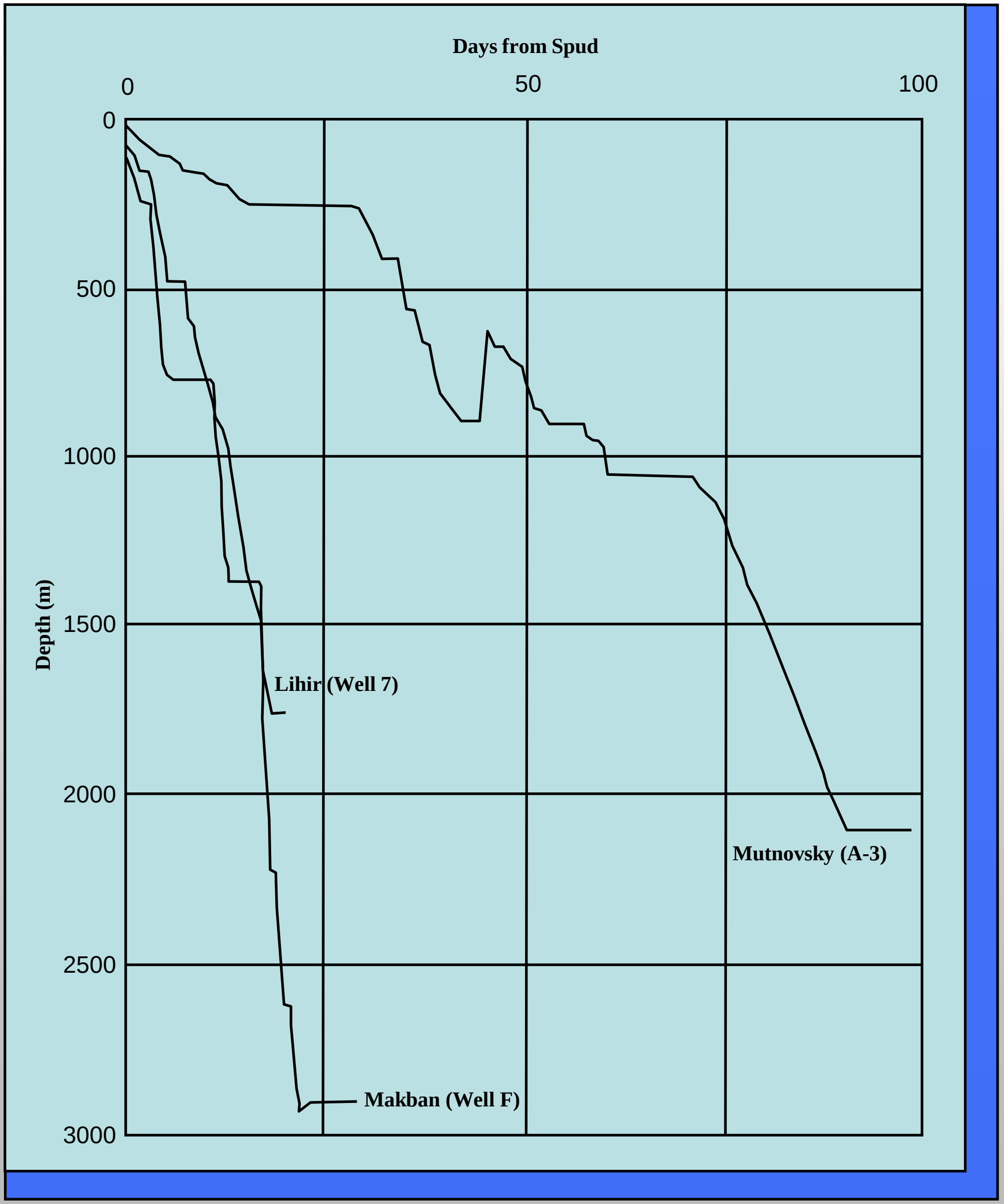
Days versus Depth Plots

The Best from Mak-Ban, Lihir, Mutnovsky (Reference: J. N. Southon & G. Gorbachev- Geo workshop 2003)



Problems encountered and solutions applied on sample wells

- Circulation losses while drilling
  - . Conducted cement plugs
  - . On few occasions mud was used to drill blind all the way down to target depth
  - . Dumping of lost circulation materials down the hole on wells with massive losses
  - . Completed the wells prematurely if lost circulation is not regained despite efforts

Problems encountered and solutions applied on sample wells (continued)

- Circulation losses while cementing

  . Continued cementing until desired volume has been pumped and displaced and determine the top of cement. Decide on whether to perforate casings and pump cement

  . Top job if warranted, making sure that annulus is water free to ensure that water is not trapped between cement

Problems encountered and solutions applied on sample wells (continued)

- Equipment failure
  - Thorough review of maintenance program
  - For third party equipment contractors are advised to ensure equipment are in good condition
  - Proper coordination on all concerned groups
  - Continues education on personnel concerned
  - Rejected equipment provided by third party contractors and replaced with reliable units

Problems encountered and solutions applied on sample wells (continued)

- Logistics problem
  - Proper coordination with concerned parties
  - Continues training of concerned personnel
  - Hired experience personnel

Problems encountered and solutions applied on sample wells (continued)

- Inappropriate tools, equipment and materials
  - Immediate replacement was done
  - Warned contractors
  - Reviewed capabilities of contractors and terminated those that were found to have below par performance

Problems encountered and solutions applied on sample wells (continued)

- Other formation problems
  - Close coordination with geologists and other concerned parties
  - Applied appropriate solutions on particular formation problems

Problems encountered and solutions applied on sample wells (continued)

- Improper drilling practices
  - Continues education of drilling personnel
  - Involved only experienced personnel

Problems encountered and solutions applied on sample wells (continued)

- Low penetration rate
  - Closely coordinated with bit manufacturers and utilized only proven type of bits on particular formation
  - Used down hole motors on some of the wells
  - Used top drive on some of the wells
  - Applied air drilling on some of the wells

Problems encountered and solutions applied on sample wells (continued)

- Accidents
  - Assigned dedicated safety officer to supervise rig personnel
  - Provided appropriate safety equipment
  - Continues safety training

Attaining Economical and Successful Geothermal wells

- In all of the studies conducted in the US and worldwide, the objective of the drilling is to reach a target depth at the lowest cost, highest degree of safety, and minimal damage to the formation.

Attaining Economical and Successful Geothermal wells

- Achieving this requires:
  - Proven technical capabilities of the operating crew
  - Proper choice of a drilling outfit and drilling equipment with the highest degree of success in the field of business
  - Utilization of proven new drilling techniques and equipment
  - Proper well design
  - Application of proven techniques in dealing with problematic situations.

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Drilling performance on selected problematic wells

Year	Depth (meters)	% of depth	% of time
Year 1	2500	100%	91%
Year 2	1980	86%	152%
Year 3	2585	91%	133%
Year 4	2340	86%	133%
Year 5	2500	91%	125%

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RECOMMENDATION

- Chose or utilize equipment that can improve drilling but carefully considering/evaluating costs
- Regular review and evaluation of practices
- Operator should have an experienced drilling/project personnel to oversee the day to day drilling operation
- Allocate budget for research and development
- Hire only experienced drilling contractor with experienced and properly trained drilling personnel
- Provide incentives to operating personnel
- Conduct regular review of performance
- Never compromise safety
- Properly coordinate with regulating bodies
- Always involve third party contractors on meetings, studies and research
- Regularly update training of operating personnel
- Well planning should involve parties who will implement the project