2.6 Long-term monitoring

2.6.1 Aim

- To monitor the shallow hydrogeological environment (hydraulic head and groundwater chemistry) in the sedimentary rocks and the upper part of the granite during other borehole investigations and during shaft and gallery excavations and to understand any changes to the shallow environment in response to the other activities.

2.6.2 Work performed

Four sets of multipacker borehole completion systems (MP System^{TM}) with pressure transducers (Westbay Instrument Inc.) were installed in all boreholes; chemical probes were installed only in MSB-2 and 4. Continuous monitoring of hydraulic heads is done only in MSB-1 and 3; periodically hydrochemical data is obtained in MSB-2 and 4.

Packer location layout for each borehole was decided basically following plan for the hydraulic test sections, in representative rock facies of each sedimentary formation and the upper part of the granite. Five intervals were selected in MSB-1; these are the main part and the basal conglomerate of the Akeyo Formation and the Toki Lignite-bearing Formation and the fresh granite (Table 7). Seven intervals were selected in MSB-3; the main part and the basal conglomerate of the Akeyo Formation and the Toki Lignite-bearing Formation, the weathered and fresh granite and the NNW fault (Table 7). Ten and seven intervals were selected in MSB-2 and 4 respectively; above and below the redox boundaries, at natural gamma ray anomalies as well as in representative rock facies of each sedimentary formation and the upper part of the granite (Table 7).

2.6.3 Results

The results of the monitoring by the end of February 2003 immediately before MIZ-1 drilling started are summarised as follows

- Hydraulic head distributions at time of installation of the MP System^{TM} were almost the same as during the hydraulic tests.
- Hydraulic heads in the main part of the Akeyo Formation were 30 to 50 m higher than in the basal conglomerate of the Akeyo Formation, except for the intervals in MSB-2 (Figure 40).
- The hydraulic heads below the Akeyo Formation in MSB-1, 3 and 4 gradually decrease with depth, while that in MSB-2 gradually increases (Figure 40). Also, the hydraulic head distribution in MSB-2 is the same as that in DH-2 [7].
- Cross-hole pressure response was only observed in one instance; in the basal conglomerate of the Akeyo Formation in MSB-1 during pumping of the same horizon in MSB-4 (Figure 41).

Table 7 Summary of packer location layout for the MP System™

Borehole	Logging Number	Logging intervals				Target	Equipment (+ ; equipped, - ; absent)		
		Drilling Depth (mabh)		Vertical Depth (mbgl)					
		Top	Bottom	Top	Bottom		Pressure sensor	Measurement port	Pumping port
MSB-1	1	66.4	116.3	-	-	Main part, Akeyo Formation (Tuffaceous sandstone and mudstone)	+	+	+
	2	117.2	131.6	-	-	Basal conglomerate, Akeyo Formation	+	+	+
	3	132.5	176.3	-	-	Main part, Toki Lignite-bearing Formation (Arkosic sandstone and mudstone)	+	+	+
	4	177.2	195.1	-	-	Basal conglomerate, Toki Lignite-bearing Formation	+	+	+
	5	196.0	201.0	-	-	Fresh Toki Granite	+	+	+
MSB-2	1	18.8	22.7	-	-	Redox front	-	+	+
	2	23.6	38.9	-	-	Main part, Akeyo Formation (Tuffaceous sandstone)	-	+	+
	3	39.8	68.2	-	-	Main part, Akeyo Formation (Tuffaceous sandstone and mudstone)	-	+	+
	4	69.1	77.4	-	-	Basal conglomerate, Akeyo Formation	-	+	+
	5	78.3	120.2	-	-	Main part, Toki Lignite-bearing Formation (Arkosic sandstone and mudstone)	-	+	+
	6	121.1	130.4	-	-	Gamma anomaly	-	+	+
	7	131.3	153.7	-	-	Upper part of basal conglomerate, Toki Lignite-bearing Formation	-	+	+
	8	154.6	170.4	-	-	Lower part of basal conglomerate, Toki Lignite-bearing Formation	-	+	+
	9	171.3	175.2	-	-	Weathered zone, Toki Granite	-	+	+
	10	176.1	180.0	-	-	Fresh Toki Granite	-	+	+
MSB-3	1	15.4	71.2	14.5	67.3	Main part, Akeyo Formation (Tuffaceous sandstone and mudstone)	+	+	+
	2	72.1	85.9	68.1	81.2	Basal conglomerate, Akeyo Formation	+	+	+
	3	86.8	93.2	82.1	88.1	NNW fault	+	+	+
	4	94.1	140.0	89.0	132.4	Main part, Toki Lignite-bearing Formation (Arkosic sandstone and mudstone)	+	+	+
	5	140.9	176.7	133.2	167.3	Basal conglomerate, Toki Lignite-bearing Formation	+	+	+
	6	177.6	181.5	168.2	171.9	Weathered zone, Toki Granite	+	+	+
	7	182.4	199.0	172.7	188.5	Fresh granite Toki Granite	+	+	+
MSB-4	1	15.8	25.6	-	-	Main part, Akeyo Formation (Tuffaceous sandstone)	-	+	+
	2	26.5	33.9	-	-	Main part, Akeyo Formation (Alternation of mudstone/sandstone)	-	+	+
	3	34.8	62.1	-	-	Main part, Akeyo Formation (Tuffaceous sandstone)	-	+	+
	4	63.0	76.9	-	-	Basal conglomerate, Akeyo Formation	-	+	+
	5	77.8	81.7	-	-	Gamma anomaly	-	+	+
	6	82.6	93.9	-	-	Main part, Toki Lignite-bearing Formation (Arkosic sandstone and mudstone)	-	+	+
	7	94.8	99.0	-	-	Fresh Toki Granite	-	+	+

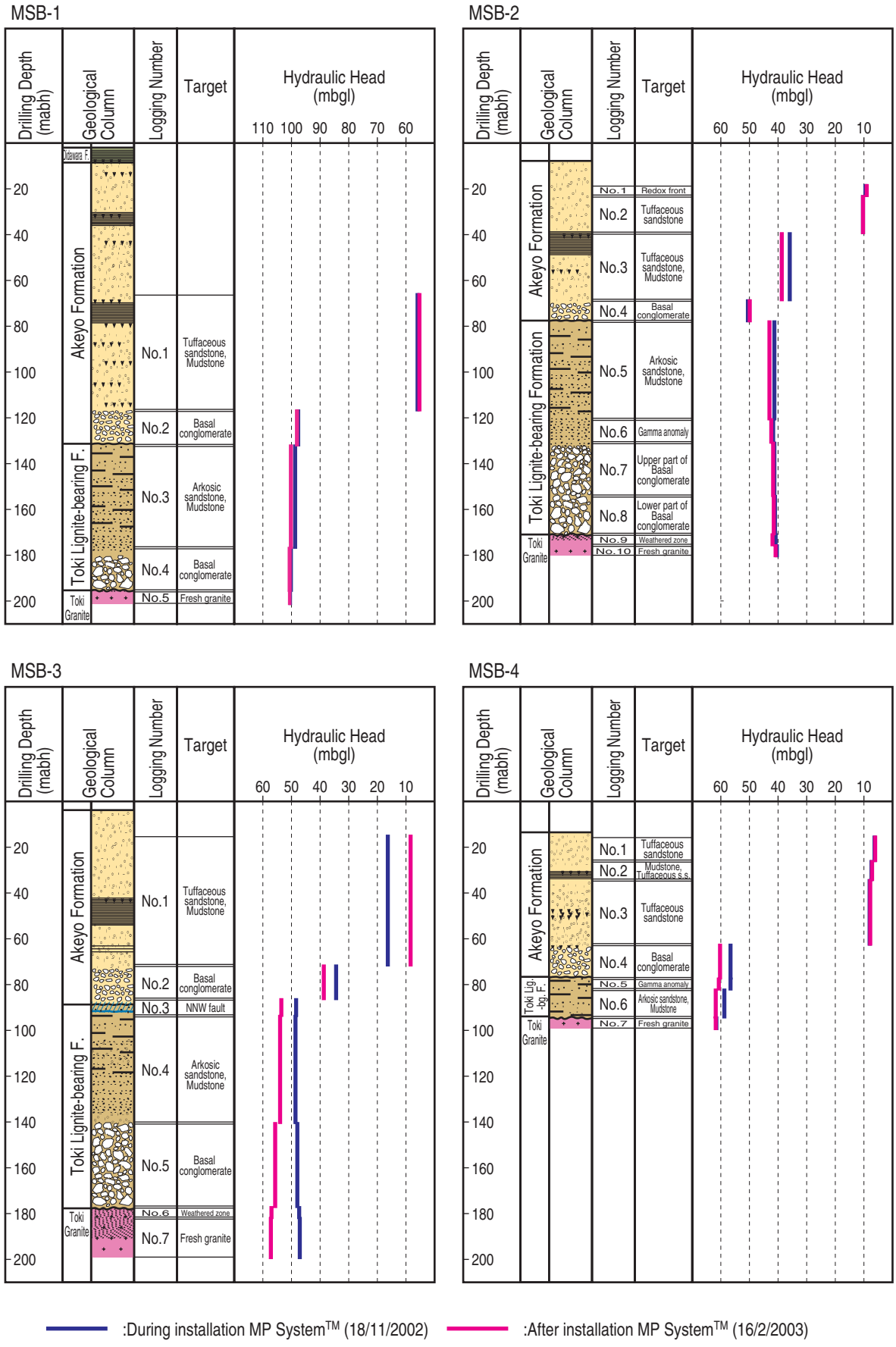

Figure 40 Measured hydraulic head in MSB boreholes

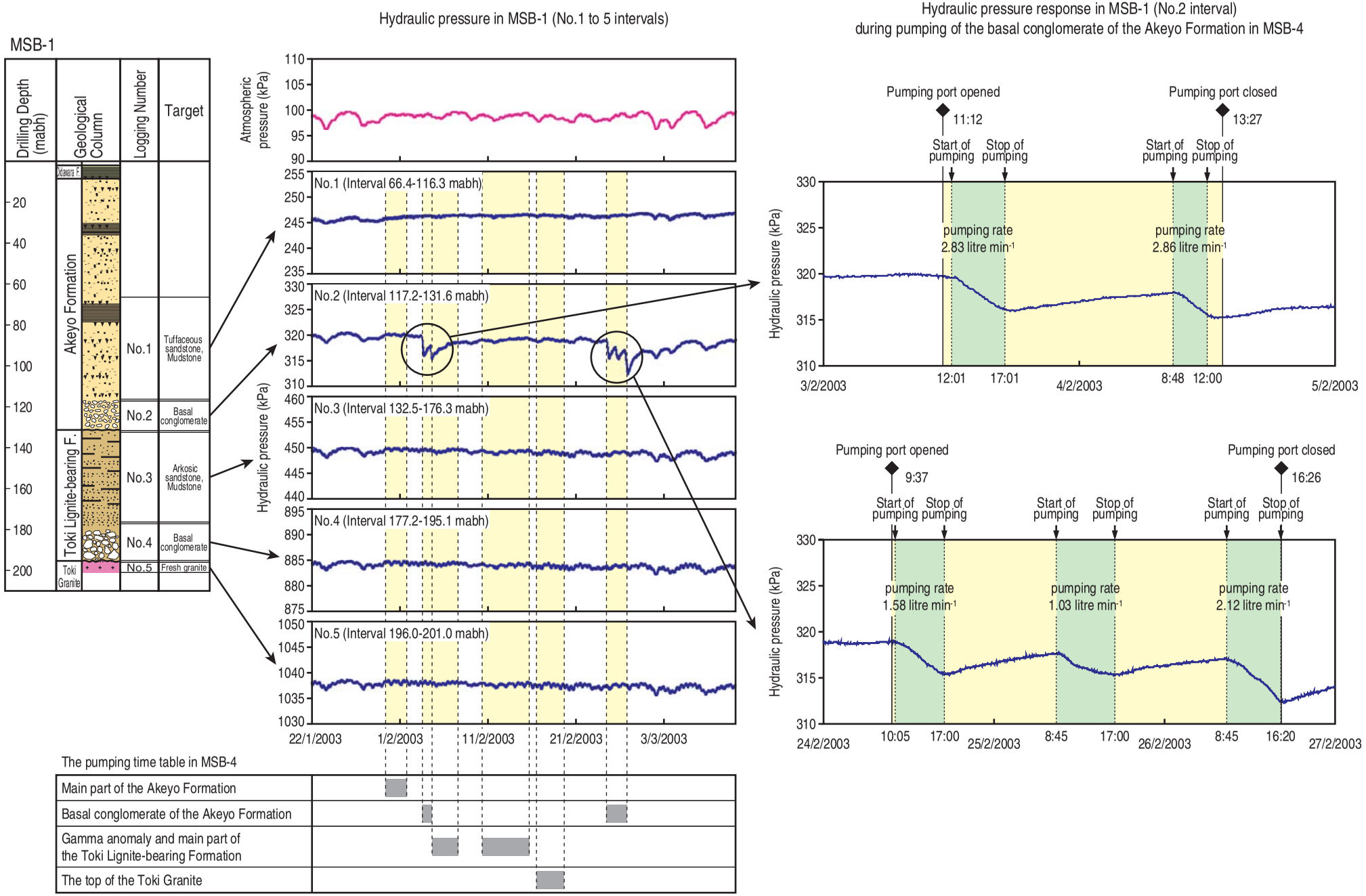

Figure 41 Hydraulic pressure response in MSB-1 during pumping in MSB-4

2.6.4 Evaluation

- Installation of four sets of the MP System™ was completed successfully in all boreholes and continuous monitoring of hydraulic head began. Drilling fluid was pumped out to determine initial geochemical composition and in situ redox parameters.

2.6.5 Lessons learned

- Borehole diameter should be kept as uniform as possible by control of drilling fluid supply, minimise flushing activities and perform periodic calliper logging during drilling of soft sedimentary rocks such as the Mizunami Group; settlement conditions of MP System™ can affect measurement quality.

2.7 Quality control and reporting

The JNC's QC system was employed to ensure that the purpose for which the work was carried out was successfully achieved. This consists of daily, quick look or prompt reports as well as check sheets on each borehole investigation, which were submitted by contractors as defined in the Working Programme for Shallow Borehole Investigations. Along with the internal review, external review by Nagra (National Cooperative for the Disposal of Radioactive Waste, Switzerland) experts was made in the relevant discipline.

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