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HYDRAULIC TESTS IN HOLE UA-1 AND WATER INFLOW INTO AN UNDERGROUND CHAMBER, AMCHITKA ISLAND, ALASKA

By

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ABSTRACT

Hole UA-1 was center punched (a small-diameter exploratory hole drilled ahead of the large-diameter emplacement hole) from 1,524.0 to 1,981.2 meters (5,000 to 6,500 feet) and hydraulically tested to determine an ideal location for mining a chamber. Fifteen zones were tested; minor amounts of water bypassed the packers during five of the tests. The tested intervals ranged in length from 37.5 meters (123 feet) to 211.5 meters (694 feet). For purposes of comparison relative specific capacities were calculated from comparable 60.4-meter (198-foot) intervals of tested rock, and ranged from 0.1162 cubic meters per day per meter (0.0065 gallons per minute per foot) of drawdown to 0.0039 cubic meters per day per meter (0.0002 gallons per minute per foot) of drawdown.

The interval 1,745.0 to 1,836.4 meters (5,725 to 6,025 feet) appears to be the best location for mining a chamber so far as water inflow is concerned. This interval, 91.4 meters (300 feet), consists of about 27.4 meters (90 feet) of breccia and 64.0 meters (210 feet) of basalt.

The inflow to a spherical chamber 18.3 meters (60 feet) in diameter and placed in the center of the proposed 91.4-meter (300-foot) interval, was calculated to be about 175 cubic meters per day (32 gallons per minute) after the first day and would stabilize at about 57 cubic meters per day (10.5 gallons per minute) after about 200 days.

INTRODUCTION

Hole UA-1 is being constructed for the purpose of testing an underground nuclear device. The desired depth for the emplacement chamber is between 1,524.0 and 1,981.2 m (meters) (5,000 and 6,500 ft), which is within the zone of saturation in volcanic rocks. The chamber must be essentially dry; however, during excavation of the chamber, some influx of water can be tolerated.

Hole UAe-1 was drilled about 91.4 m (300 ft) southwest of hole UA-1. The hydraulic test data obtained from the first hole indicated that the interval from 1,524.0 to 1,981.2 m (5,000 to 6,500 ft) is hydrologically suitable for mining a chamber. The hydraulic conductivity of the breccia and basalt, which make up nearly 100 percent of the rock in this interval, is dependent for the most part upon fractures and joints. The hydraulic conductivity of the fracture and joints of the rocks penetrated varies widely from place to place, as indicated in the widespread values of transmissivity for the zones tested.

Because of the possible variations in hydraulic parameters within short distances and the low tolerance for water influx when mining chambers, hole UA-1 was hydraulically tested in the interval where the emplacement chamber is desired.

The hole was center punched (a small-diameter hole drilled ahead of the large-diameter hole) with 21.9-centimeter ($8\frac{5}{8}$-inch) diameter bit from 1,524.0 to 1,981.2 m (5,000 to 6,500 ft), using clear water as the drilling fluid. Inflatable packers were used to isolate specific zones for testing, but because an eroded borehole in some intervals resulted in a scarcity of suitable intervals for seating the packers, some of the tested zones overlap. Fifteen zones were tested, but minor amounts of water bypassed the packer during five of the tests. The zones were tested by first injecting water and then swabbing water through tubing and observing the rate of change in water level following each.

Water-level data from some tests suggest that the relative specific capacity of the zone was lower during the injection test than during the swabbing test. This apparent discrepancy probably resulted from fine drill cuttings being washed into formation openings during drilling. Normally, water is pumped or jetted from the hole prior to testing with packers, which removes much of the drill cuttings and drilling fluid from the formation. However, the UA-1 borehole wall was unstable and pumping from the hole probably would have caused caving of the walls.

The hydraulic properties of the rocks in the zones tested were determined from the injection tests. Therefore, in those cases where the formation was plugged at the time of the injection test, the computed hydraulic conductivity values are lower than true values. In some cases the ports in the packer tool became plugged. This is apparent when plotted data are examined. For this reason, some data considered to be unreliable are not included in the report.

This report presents an analysis of the hydraulic data obtained from the tests. Table 1 gives the results of the hydraulic testing. Lee (1969) has presented a detailed description of the geology of the hole.

METHOD OF ANALYSIS OF TEST DATA

The specific capacity (yield per unit of drawdown during pumping) of the entire open part of the hole, 1,524.0 m (5,000 ft) to 1,981.2 m (6,500 ft) was not obtained. The borehole wall had been eroded considerably, so that pumping might have collapsed the walls. However, the relative specific capacities of various zones were obtained by using straddle packers and performing injection and swabbing tests. Relative specific capacity is determined by the volume change of water in tubing for a 1-minute interval of time as related to the departure from the static conditions of the water level during this time interval.

A type-curve method for determining the transmissivity of an aquifer that is applicable to testing of selected intervals in deep wells was introduced by Cooper and others (1967). The method consists of applying an instantaneous charge of water to a well and using a set of type curves computed from an analytical solution to determine the aquifer properties. The type curves (fig. 1) are prepared from published tables by plotting H/H_o versus $\log \beta = \log Tt/r_c^2$ (a dimensionless time parameter) for values of $\alpha = r_s^2 S/r_c^2$, where

H_o = water level in tubing above initial head in aquifer at the start of injection, in meters (m)

H = water level in tubing above initial head in aquifer, in meters, at time, t, in days

T = transmissivity, in cubic meters per day per meter (m^3pd per m)

r_c = radius of injection tubing, in meters

r_s = radius of open hole, in meters

S = storage coefficient, dimensionless.

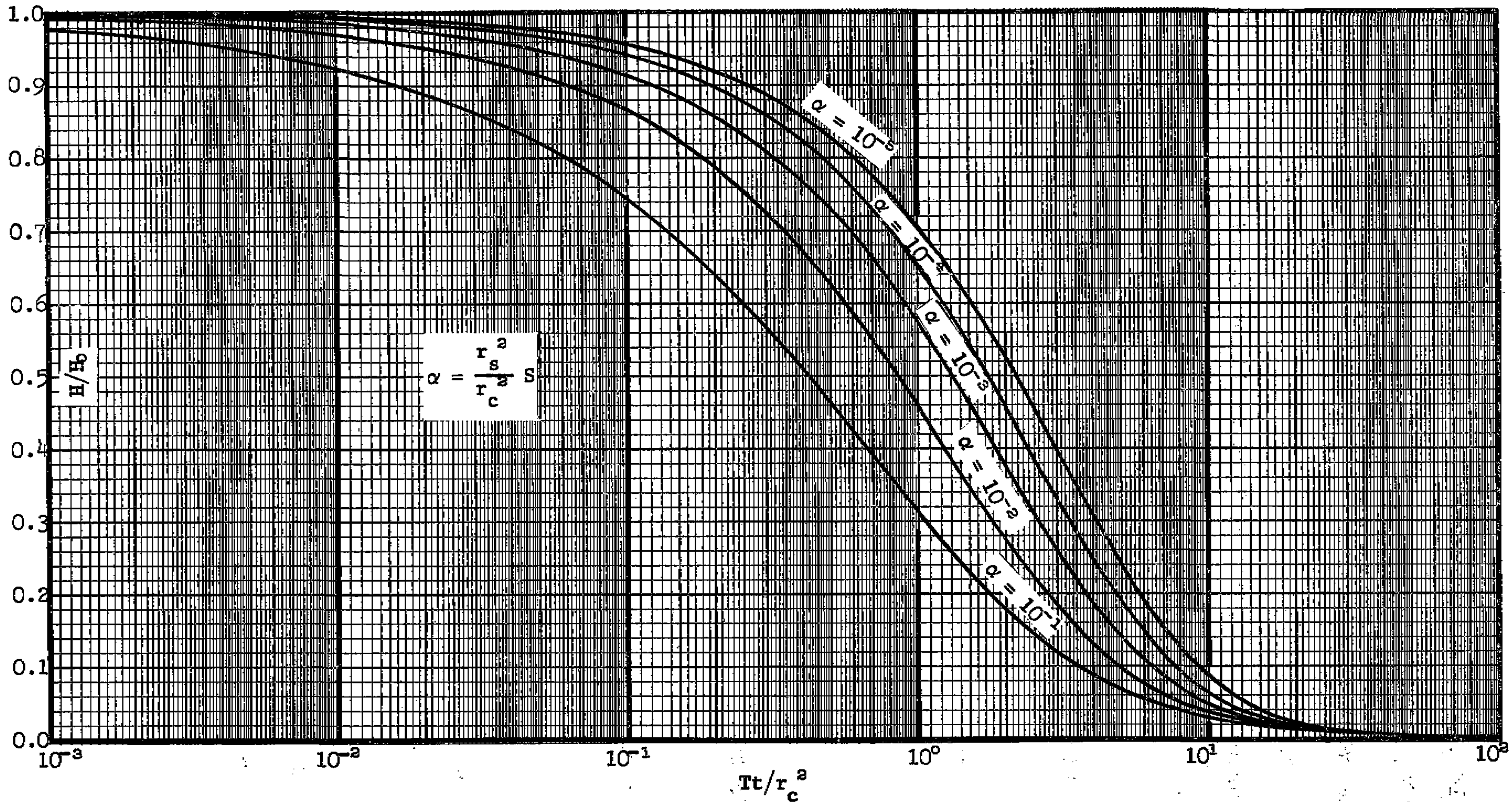


Figure 1.–Type curves for instantaneous charge in well of finite diameter.

The field curve is a plot, on the same scale as that of the type curves, of H/H_0 against log t. This is superimposed on the type curves to obtain the matching α, from which S is calculated, and a match point relating t to β, from which T can be computed.

Once a value of T is obtained, hydraulic conductivity, K, can be calculated by the equation

$$K = T/b$$

where K is cubic meters per day per square meter (m^3 pd per m^2) and b = thickness of the tested interval, in meters. Velocity of ground-water movement (v) can then be calculated by the equation

$$v = KI/\theta$$

where v is in meters per day (mpd)

I = ground-water (hydraulic) gradient, in meters per meter, and

θ = effective porosity, expressed as a decimal.

Hydraulic Characteristics

The analyses of data from injecting water into and swabbing water from individual zones in hole UA-1 are presented in table 1 and figures 3 through 36. The following parameters were constant for all intervals tested in hole UA-1:

Volume of tubing = 0.0030 m^3 per linear m

= 0.243 gallons per linear ft

r_c = 3.13 cm = 0.0313 m.

Variable parameters are shown on the figures. The effective rock porosity was estimated to be 1 percent of the bulk rock porosity.

HYDRAULIC GRADIENT

The hydraulic gradient is a characteristic of the ground-water circulation pattern which must be known in order to determine the velocity of ground-water flow. Water naturally seeks static conditions as it flows into streams and thence to the ocean. Some water penetrates the rocks to great depths. The water in the deep rocks is also in motion, seeking to relieve the hydraulic pressure by seeping through joints and fractures to areas of less pressure, in this case to the ocean.

From UA-1 the nearest point of ocean-land contact is the shore of the Bering Sea, about 1,400 m to the north. The maximum average hydraulic gradient is obtained by assuming that water in the deep rocks discharges into the ocean at this point. The gradient was determined for each of the tested zones by dividing its hydraulic potential, expressed as meters of water above sea level, by the horizontal flow path, 1,400 m. Because the range in hydraulic potentials of the tested zones is small, the computed gradients were nearly the same, about 0.019 m per m. The actual flow paths from the chamber depth would be perhaps twice as long as the horizontal projection; consequently, the more probable average gradient is about 0.01 m per m.

GROUND-WATER VELOCITIES

Ground-water velocities calculated for the various intervals tested are reported in table 1. The velocities are based on the assumptions that: a) the discharge point is at the water-land contact, and b) the entire straddled interval for each zone tested contributes water equally. Probably neither of these assumptions is entirely correct, and it is difficult to determine exact values for either the gradient or hydraulic conductivity. The discharge point may be in the vicinity of the 300- to 600-fathom contour and about 8 to 12 kilometers from hole UA-1. In this case the ground-water gradient would be less and the velocities of ground-water flow reported are probably too high. Also, most of the water contributed during the testing of an isolated zone probably flows through fractures. The length of the fractured interval varies with each isolated zone tested. The values of hydraulic conductivity reported are the minimum because they represent the entire zone tested in each test. The true value of hydraulic conductivity depends upon that part of the tested zone contributing water. If only half of a tested zone contributed water, then the conductivity would be about double the reported value and the velocity of flow would be greater.

Using assumptions a and b, values of ground-water velocities were calculated and reported in table 1. The values of ground-water velocities reported indicate that the time required for ground water to move from hole UA-1 to the ocean ranges from more than a hundred years for the permeable zones to more than a million years for the less permeable zones.

HYDRAULIC TESTING OF HOLE UA-1

Well History

Hole UA-1 is at coordinates 5,704,185.92 m N.; 646,321.59 m E., Universal Transverse Mercator Grid, Zone 60. Graphic coordinates are lat 51°28'18.68" N.; long 179°06'24.27" E. Ground elevation at the hole is 63.32 m (207.68 ft) above mean sea level.

The hole was drilled 228.6 cm (90 in.) in diameter to a depth of 1,524.0 m (5,000 ft). Casing, diameter 27.3 cm (10.75 in.), was installed to 1,524.0 m (5,000 ft) with the lower 30.5 m (100 ft) cemented. The hole was then drilled with 21.9-cm ($8\frac{5}{8}$-in.) bit from 1,524.0 to 1,981.2 m (5,000 to 6,500 ft). Water was used as the circulating medium during the drilling.

A generalized summary of hydrology, lithology, and construction are presented in figure 2.

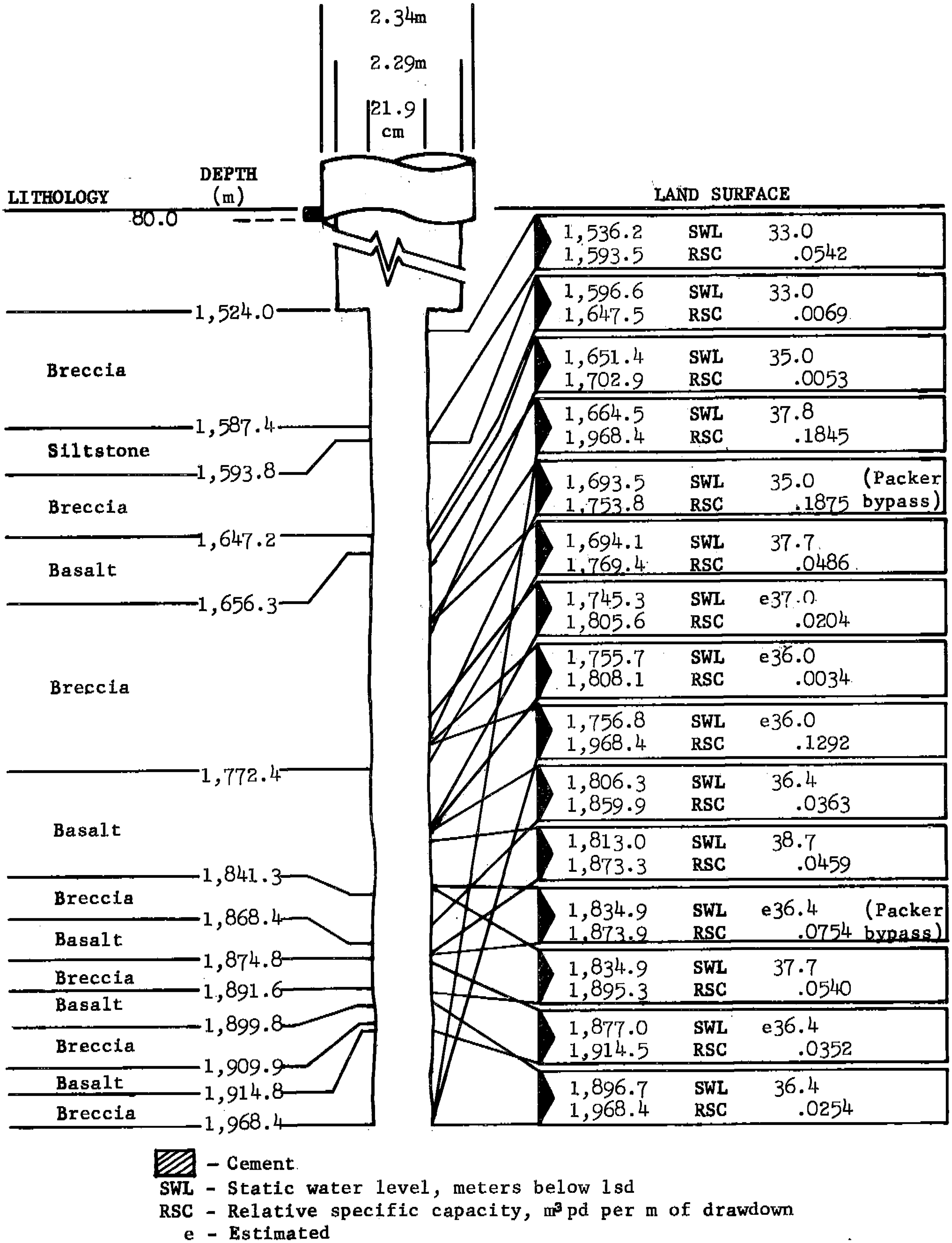


Figure 2.--Hydrology and lithology from 1,536.2 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska.

Hydraulic-Potential Distribution

The hydraulic potential was determined after the injection test and after the swabbing test of each zone. Because the rocks were very tight in most cases and the cost of rig time was very high, the measurement of water levels frequently had to be discontinued before static conditions were achieved. Therefore, the hydraulic potential was often estimated or assumed to be the same as that for the equivalent zone in hole UAe-1.

The hydraulic-potential changes are small in the 457.3 m (1,500 ft) of tested hole. The greatest potential is in the uppermost zone tested, from 1,536.2 to 1,593.5 m (5,040 to 5,228 ft). The potential was 33 m (108.3 ft) below land surface in this zone. The potential in most instances decreases as hole depth increases, but becomes approximately constant for all zones below 1,806.3 m (5,926 ft) at about 36.4 m (119.4 ft) below land surface.

Figures 3-36 show the analysis of data obtained from the hydraulic tests in hole UA-1.

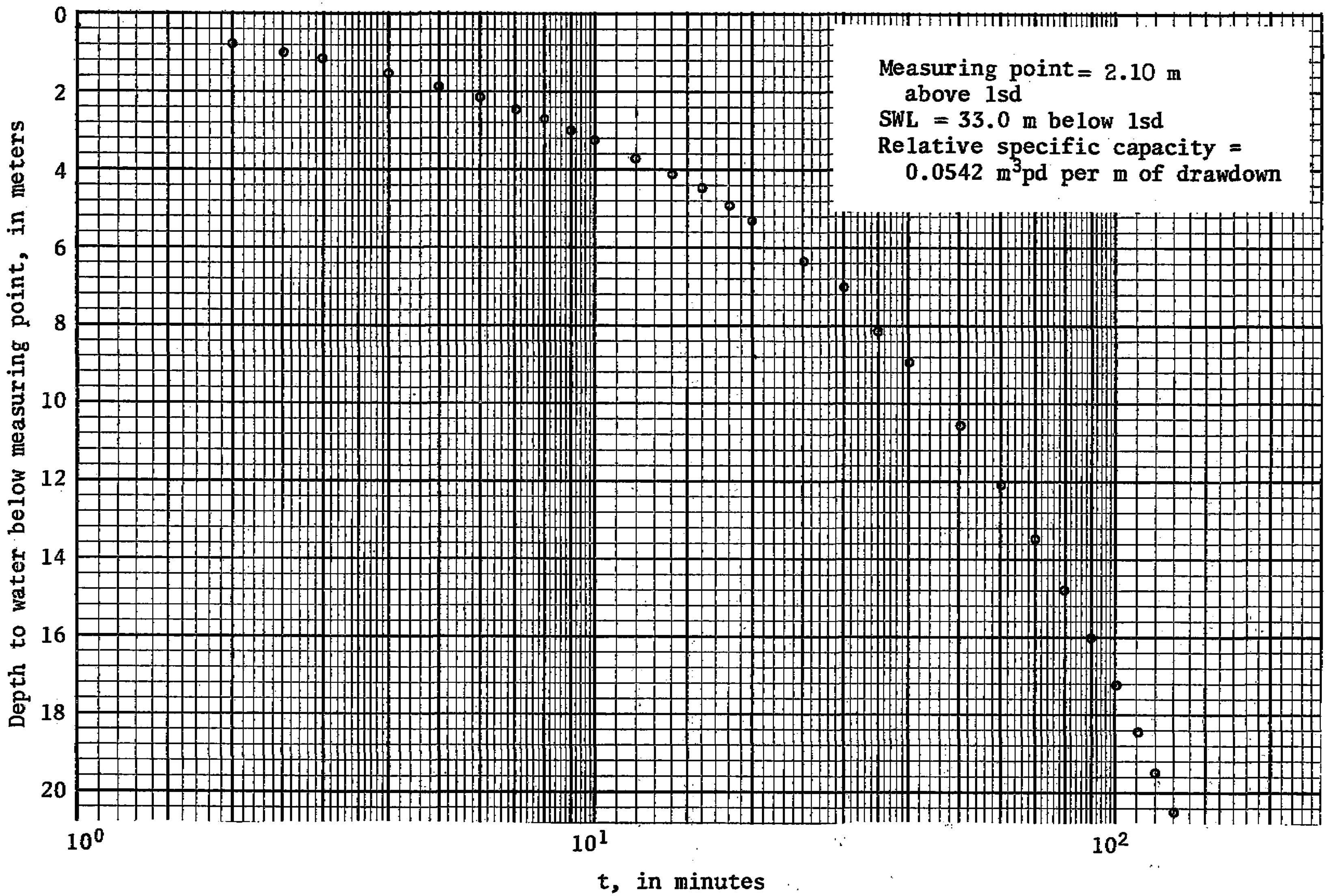


Figure 3.--Injection test of zone 1,536.2 to 1,593.5 m, hole UA-1, Amchitka Island, Alaska, June 13, 1968.

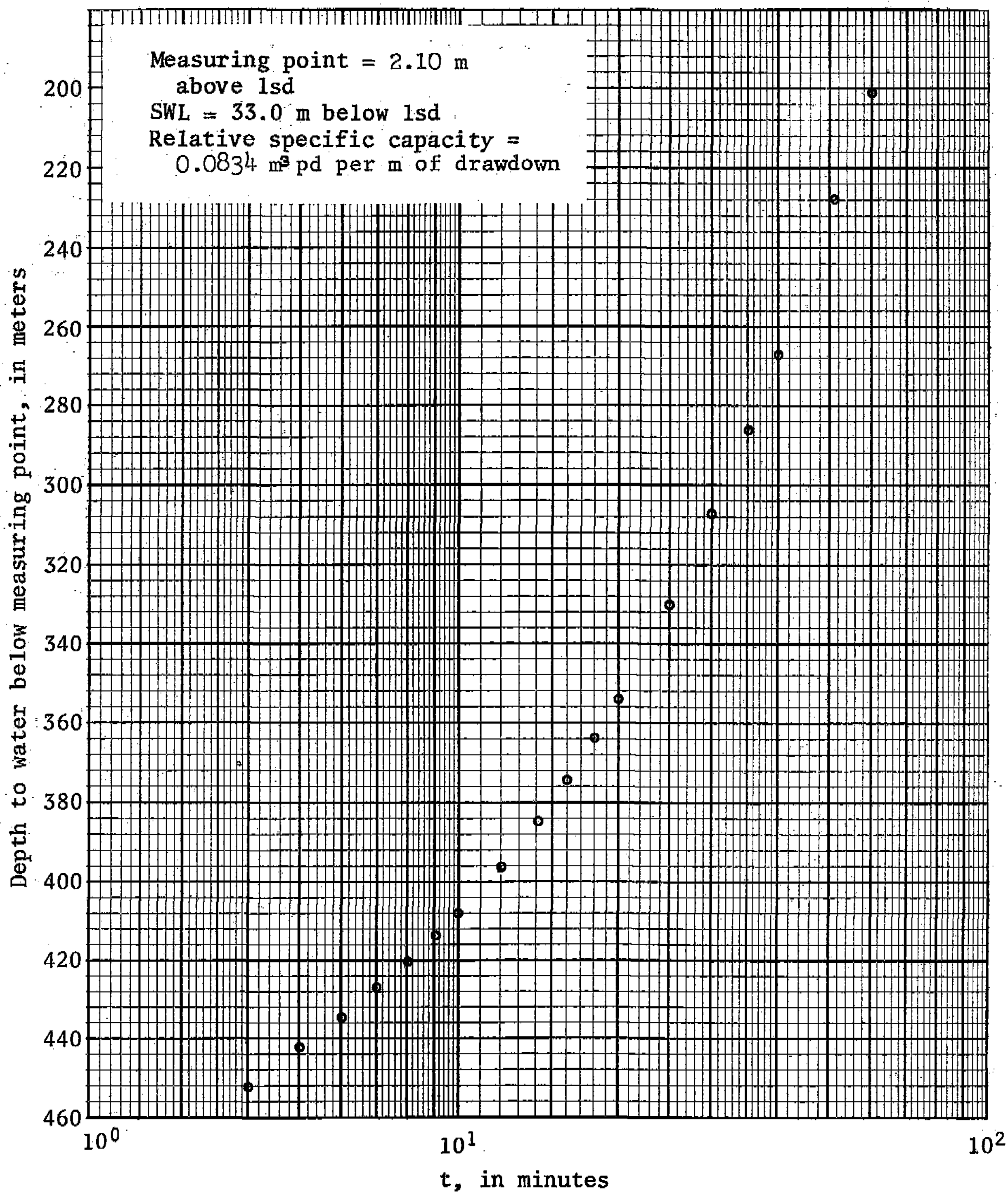


Figure 4.--Swabbing recovery test of zone 1,536.2 to 1,593.5 m, hole UA-1, Amchitka Island, Alaska, June 13, 1968.

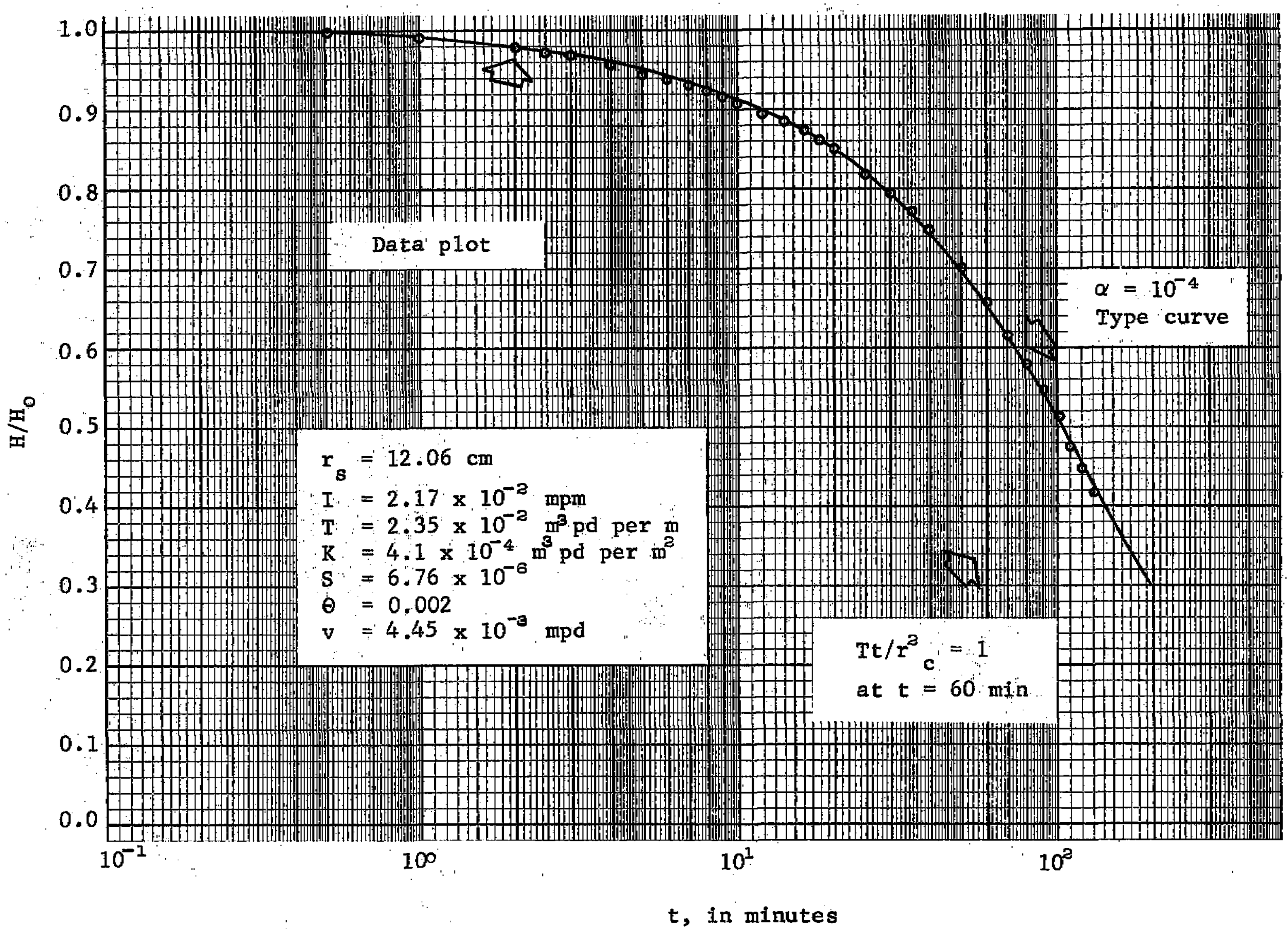


Figure 5.--Analysis of injection test of zone 1,536.2 to 1,593.5 m, hole UA-1, Amchitka Island, Alaska, June 13, 1968.

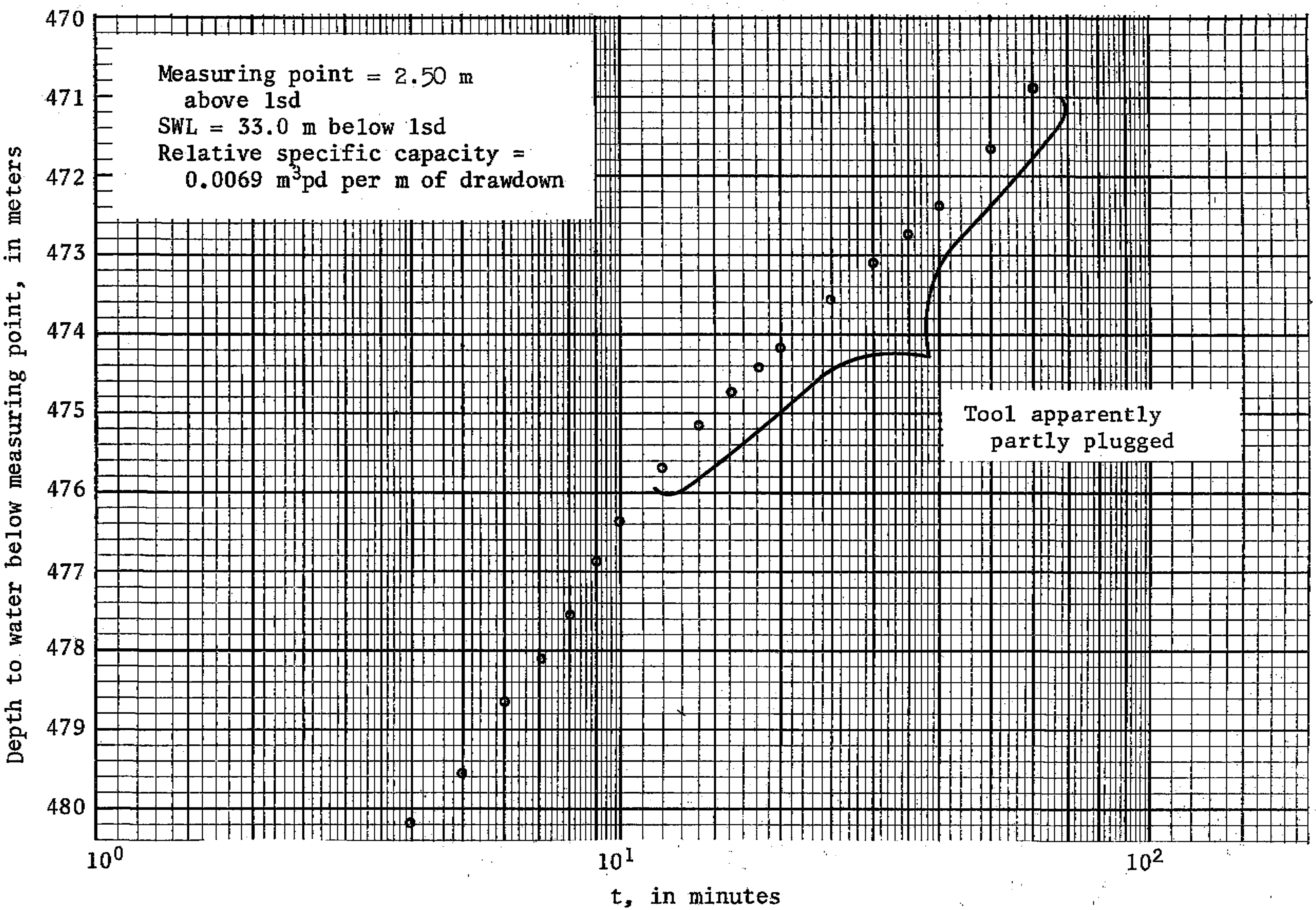


Figure 6.--Swabbing recovery test of zone 1,596.6 to 1,647.5 m, hole UA-1, Amchitka Island, Alaska, June 13, 1968.

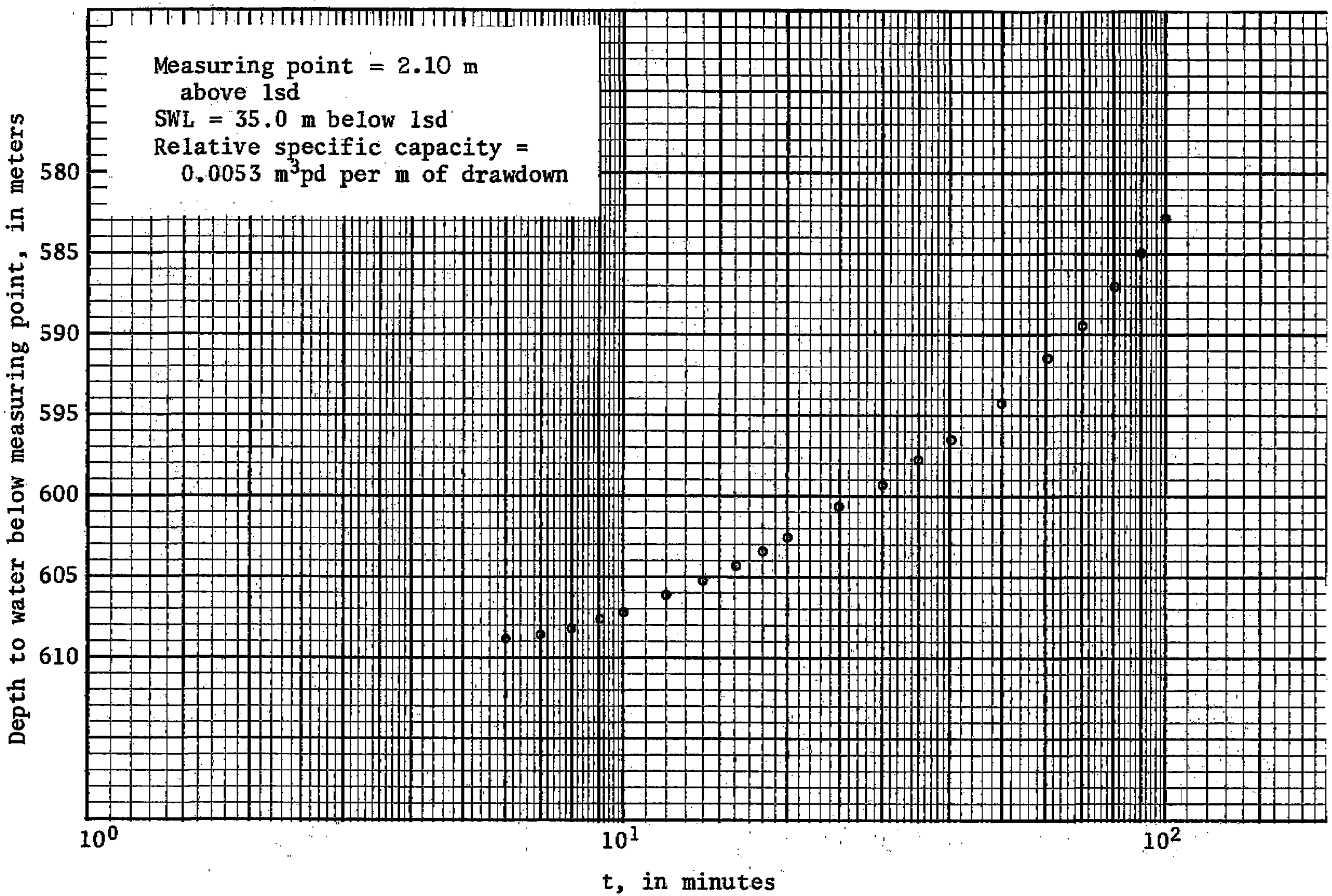


Figure 7.--Swabbing recovery test of zone 1,651.4 to 1,702.9 m, hole UA-1, Amchitka Island, Alaska, September 16, 1968.

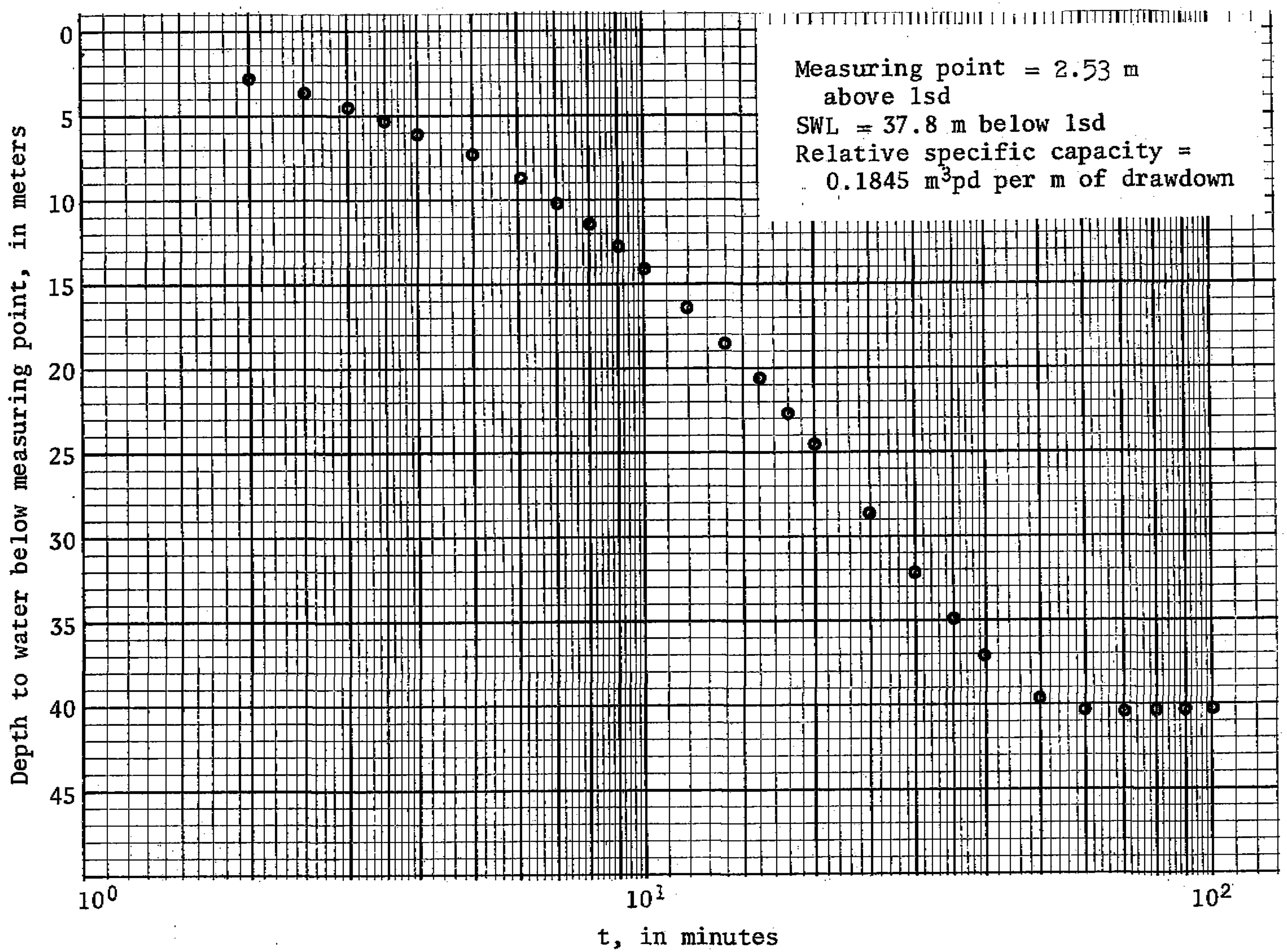


Figure 8.--Injection test of zone 1,664.5 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 21, 1968.

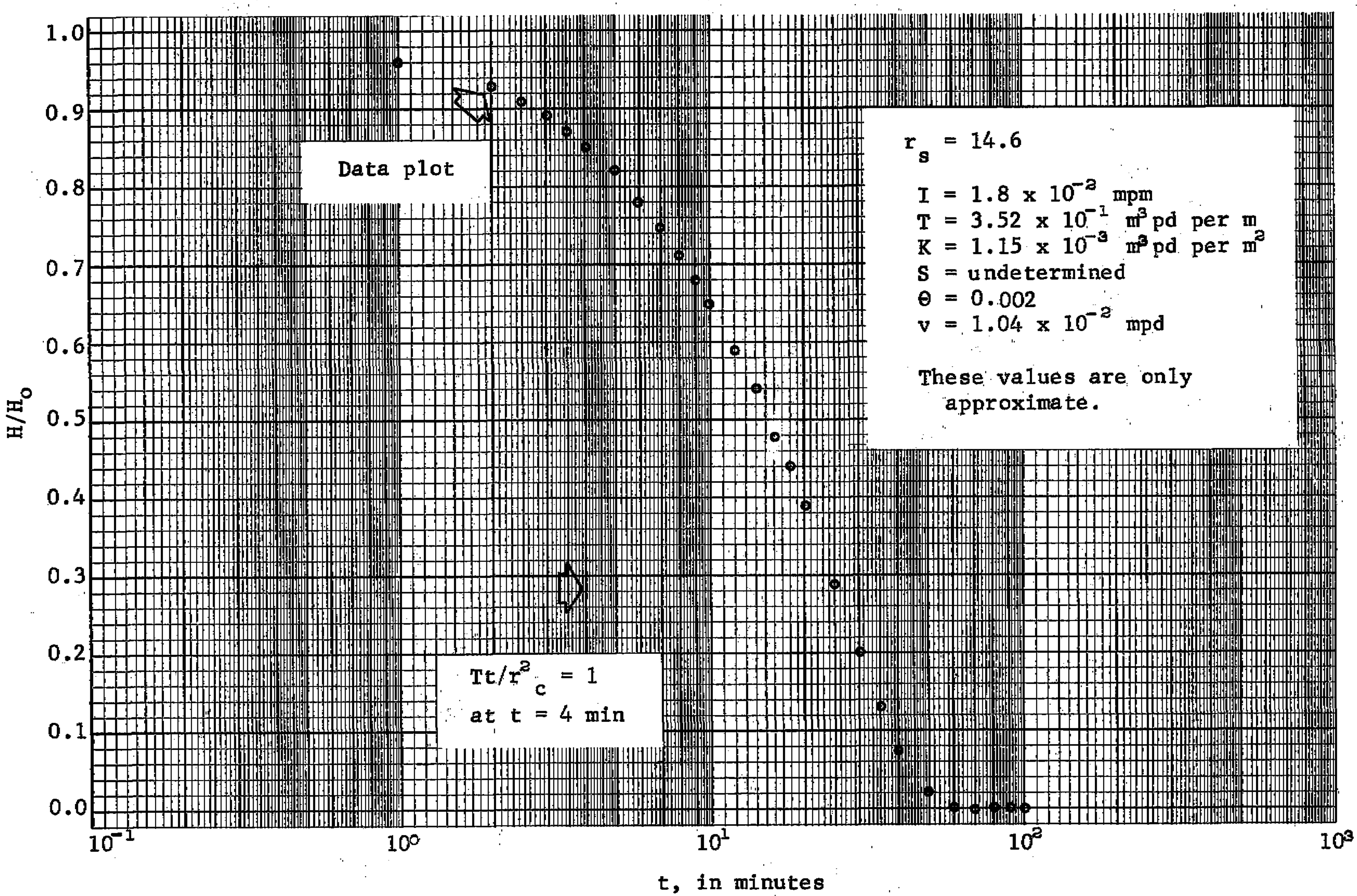


Figure 9.--Analysis of injection test of zone 1,664.5 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 21, 1968.

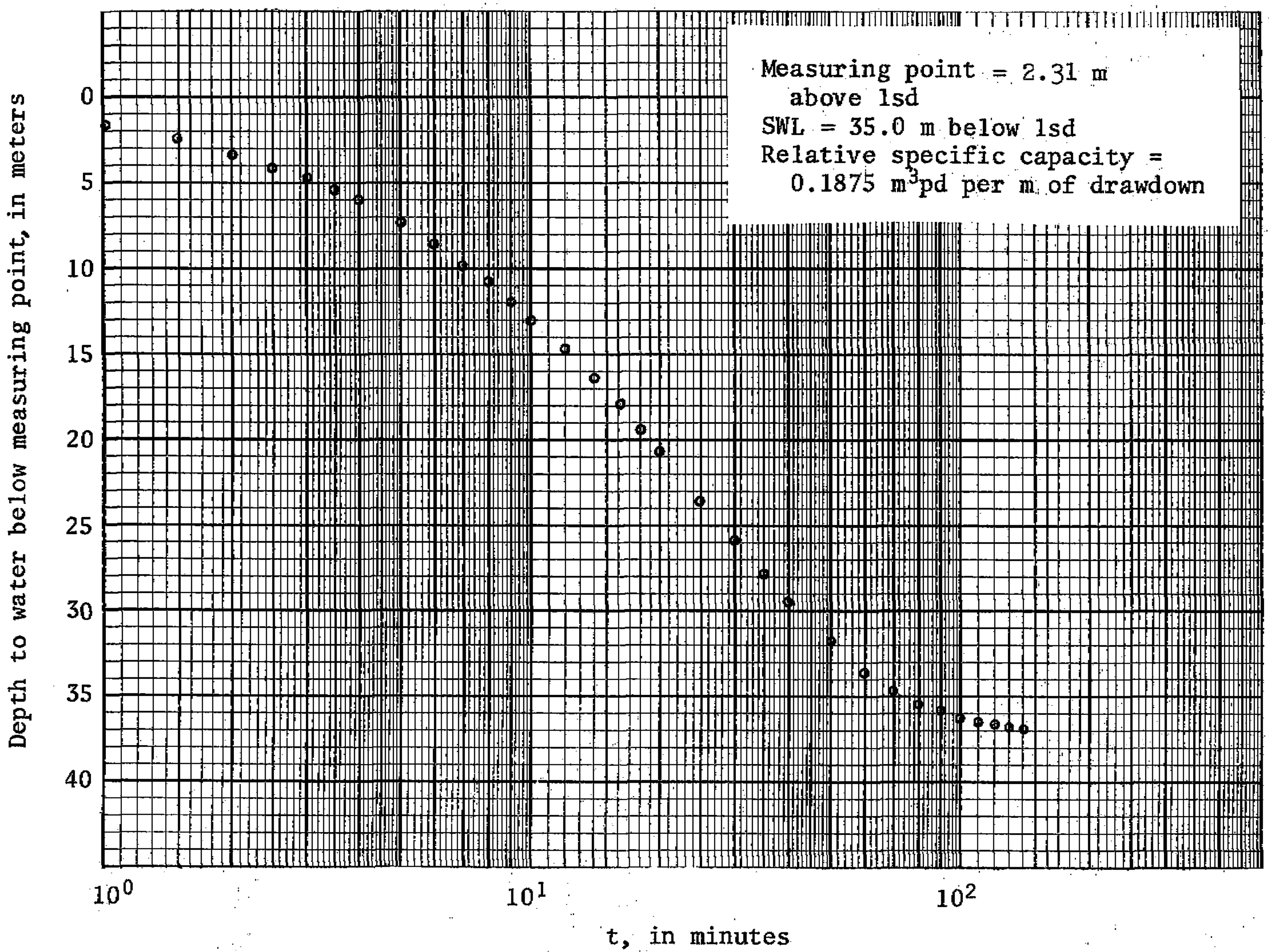


Figure 10.--Injection test of zone 1,693.5 to 1,753.8 m, hole UA-1, Amchitka Island, Alaska, October 23, 1968.

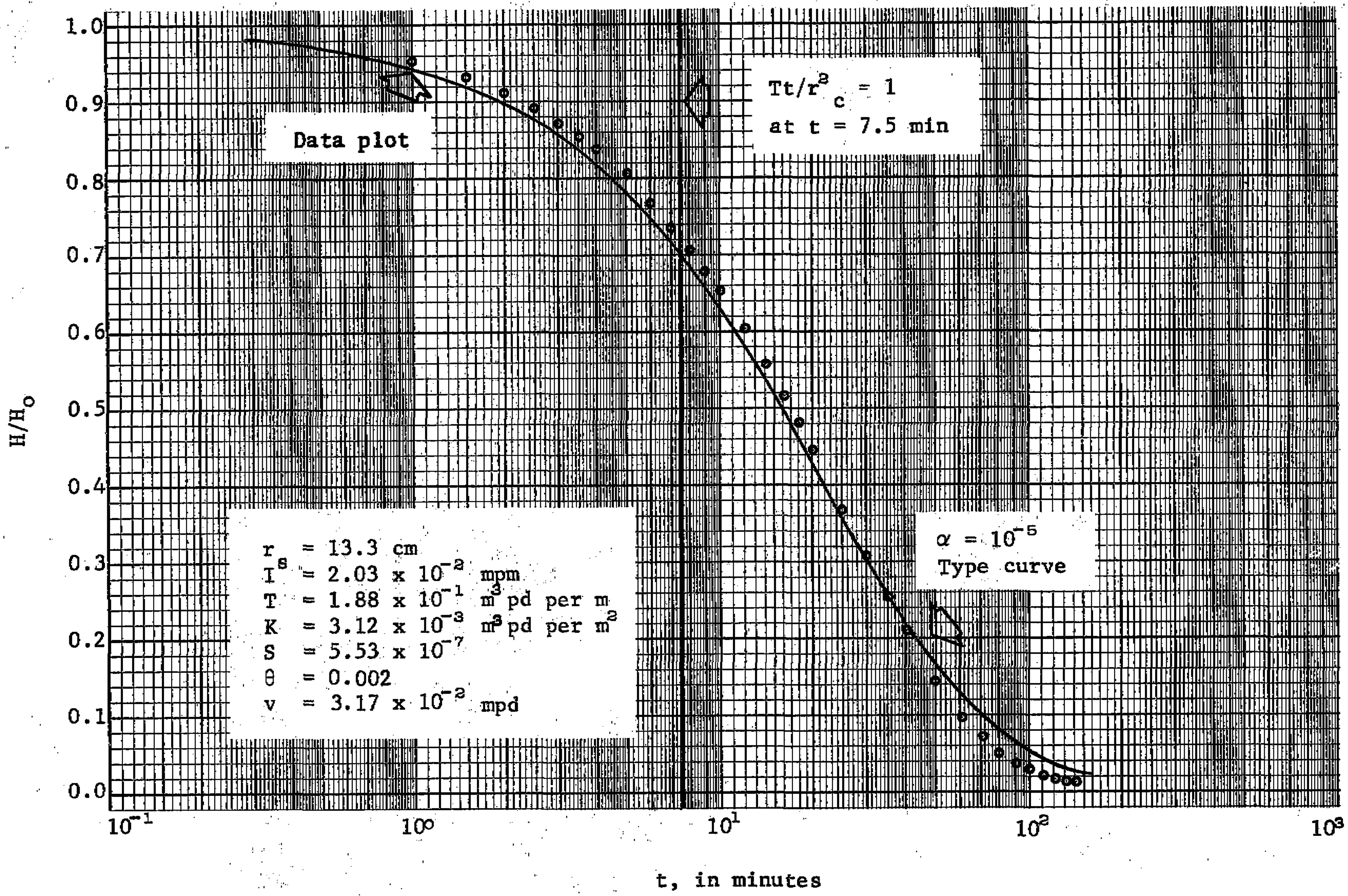


Figure 11.--Analysis of injection test of zone 1,693.5 to 1,753.8 m, hole UA-1, Amchitka Island, Alaska, October 23, 1968.

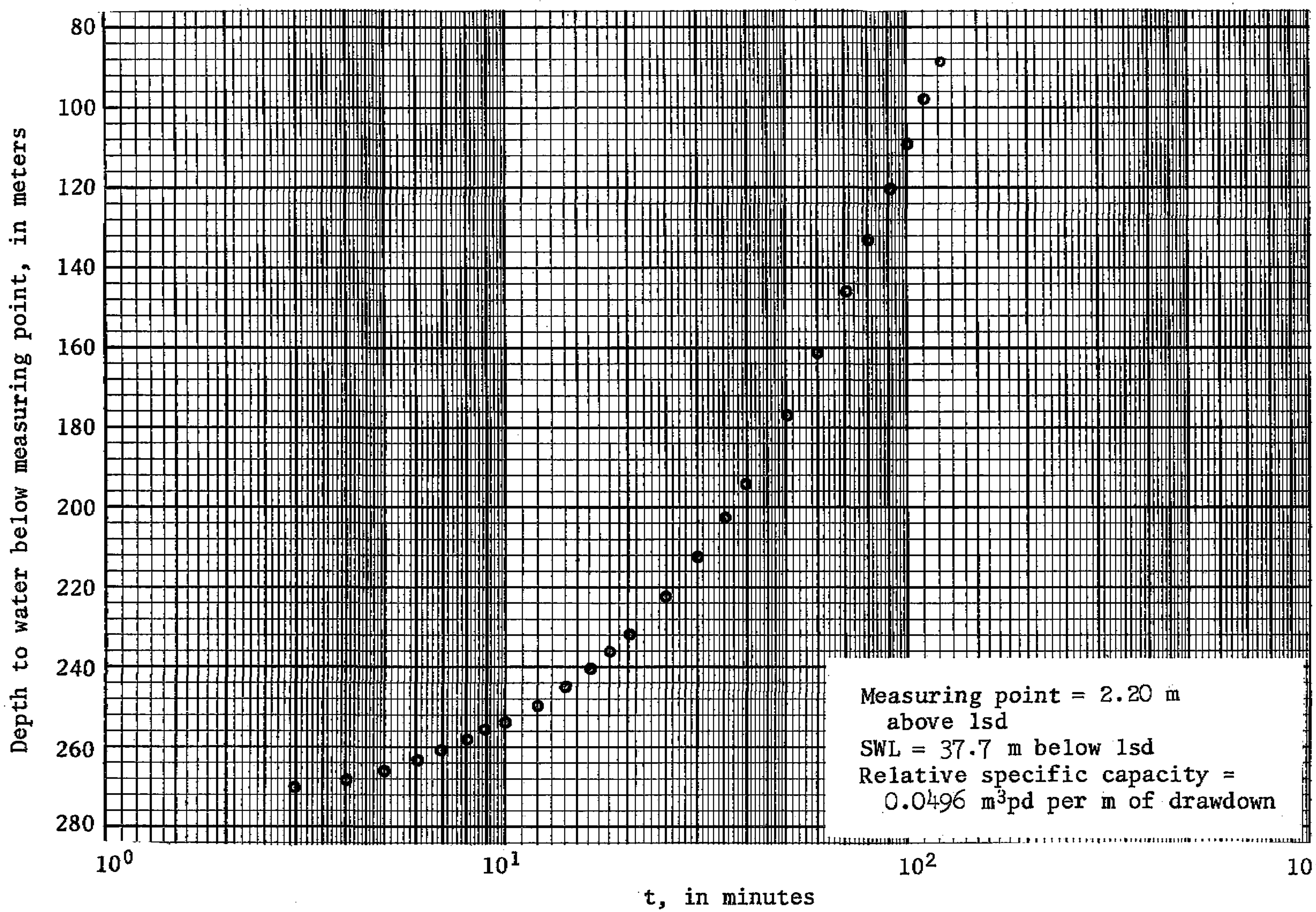


Figure 12.--Swabbing recovery test of zone 1,694.1 to 1,769.4 m, hole UA-1, Amchitka Island, Alaska, June 29, 1968.

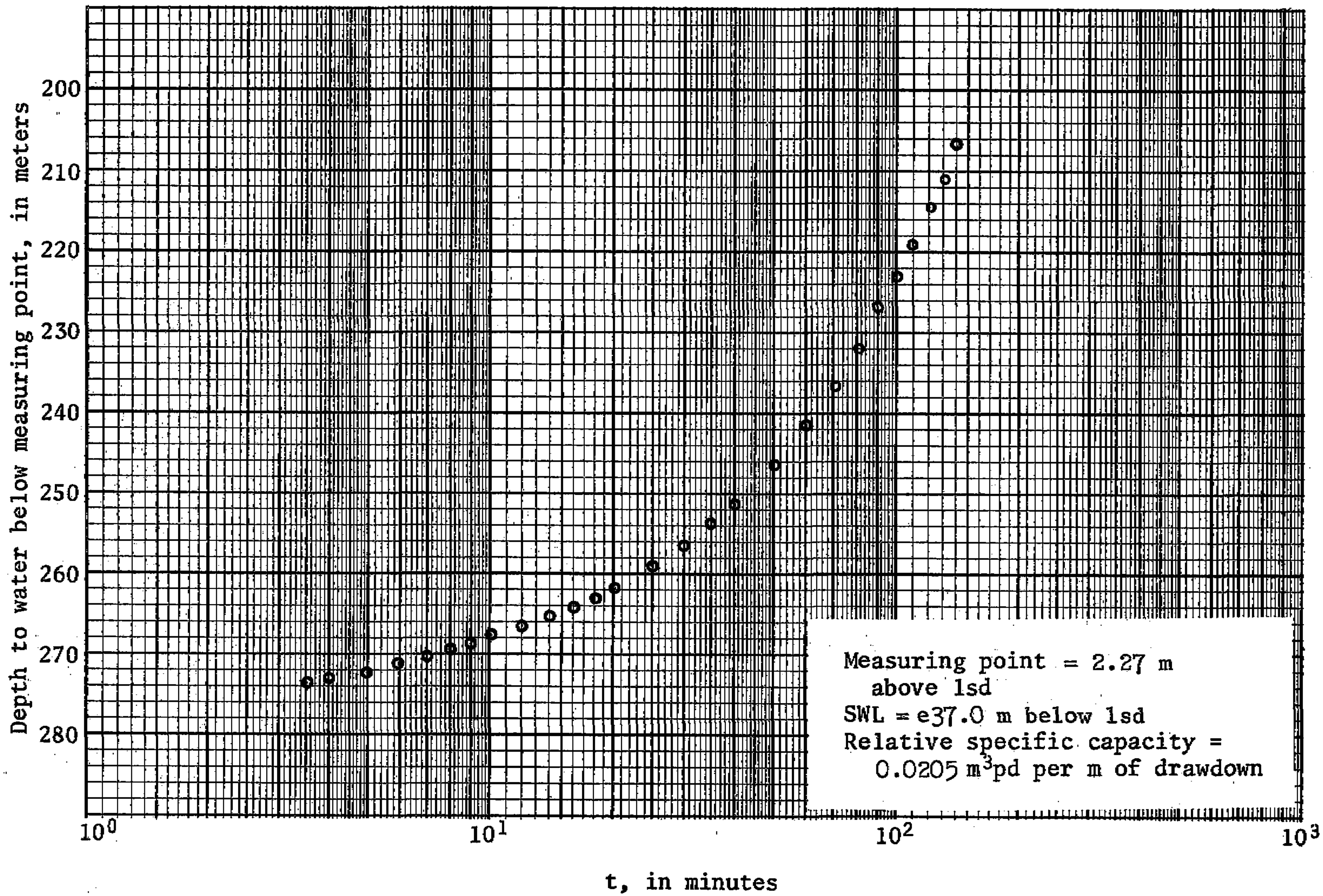


Figure 13.--Swabbing recovery test of zone 1,745.3 to 1,805.6 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

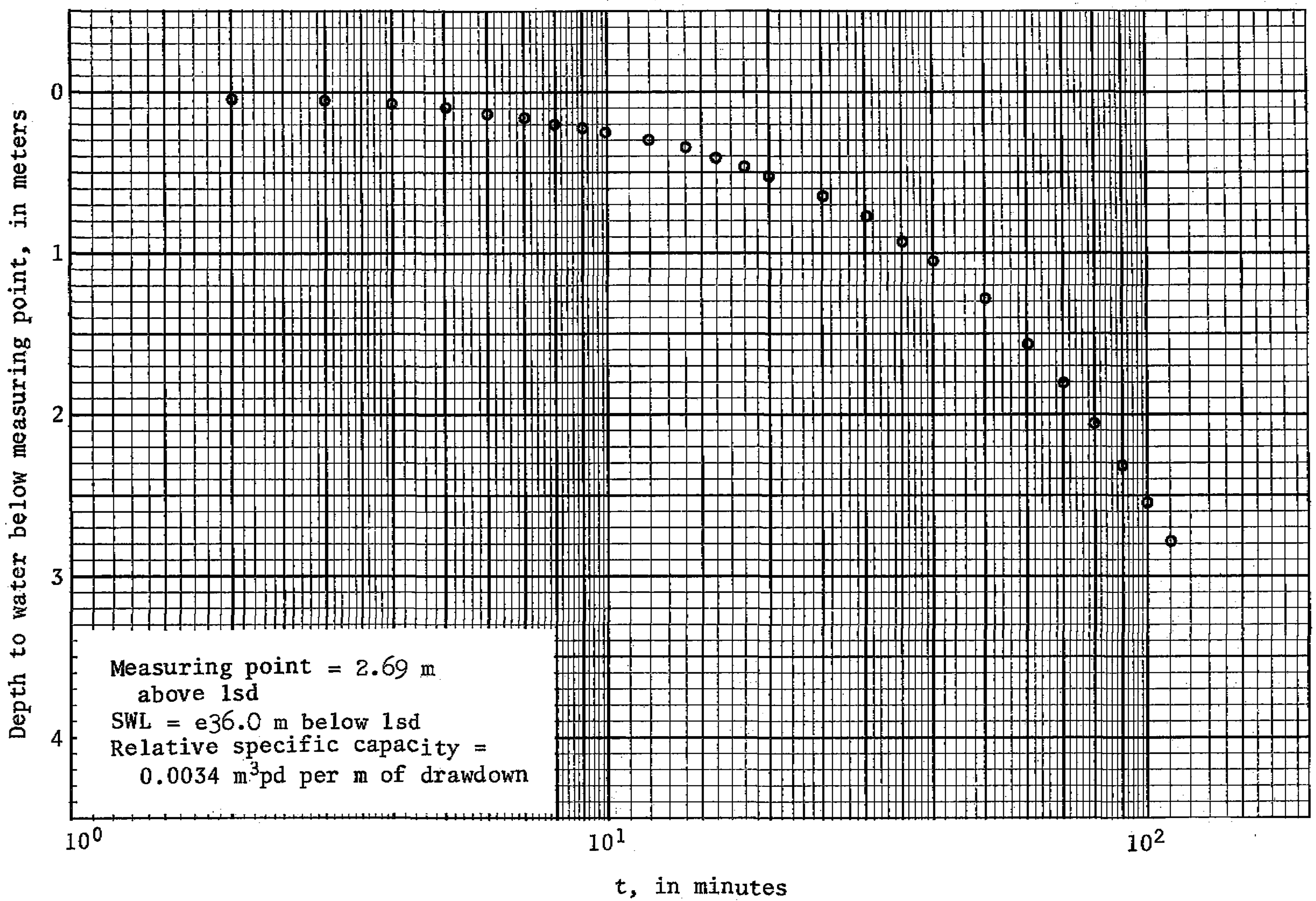
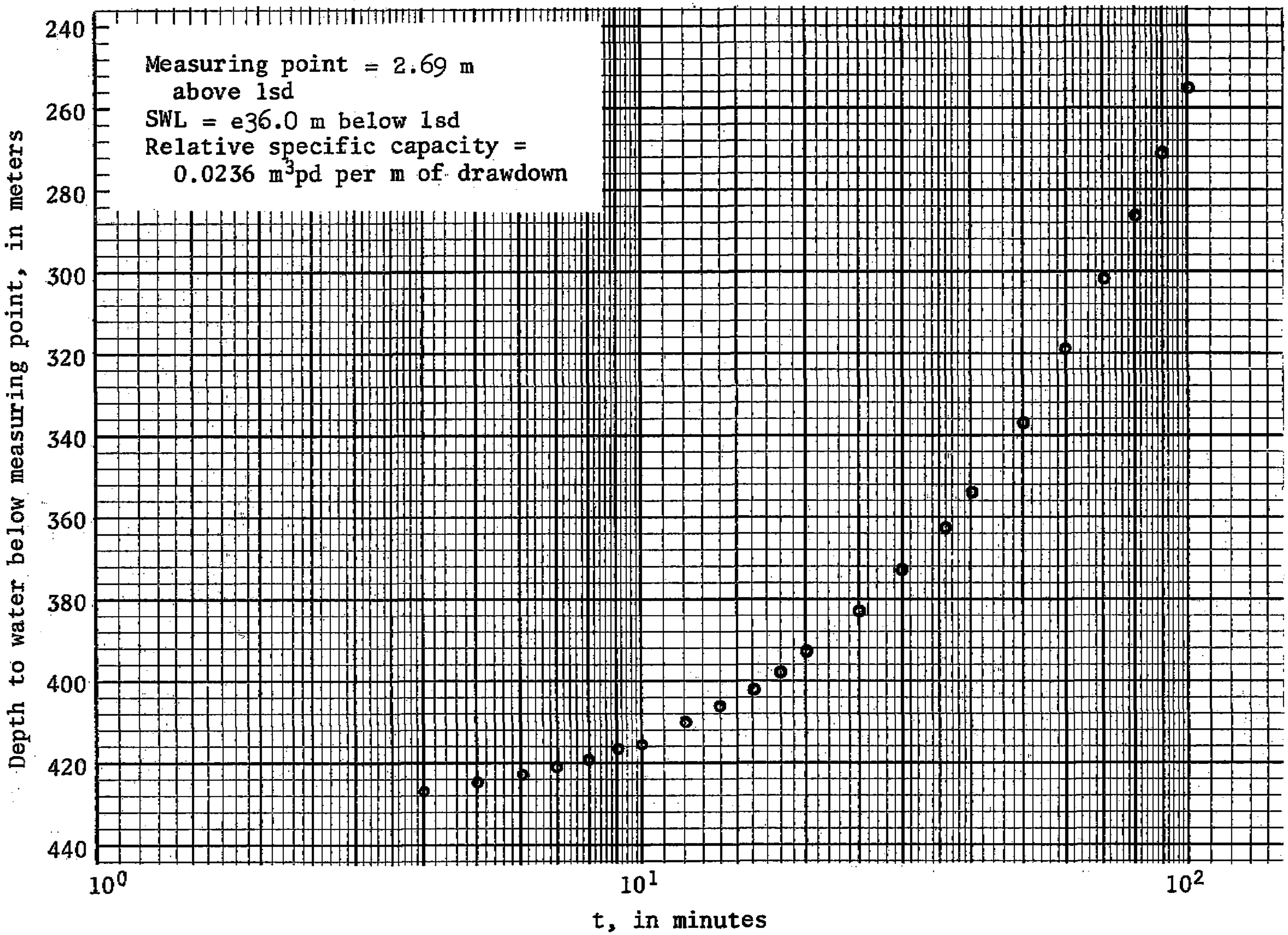


Figure 14.--Injection test of zone 1,755.7 to 1,808.1 m, hole UA-1, Amchitka Island, Alaska, September 20, 1968.



Figu 15. -Swabbing recovery test of zone 1,755.7 to 1,808.1 m, hole UA-1, Amchitka Island, Alaska, September 20, 1968.

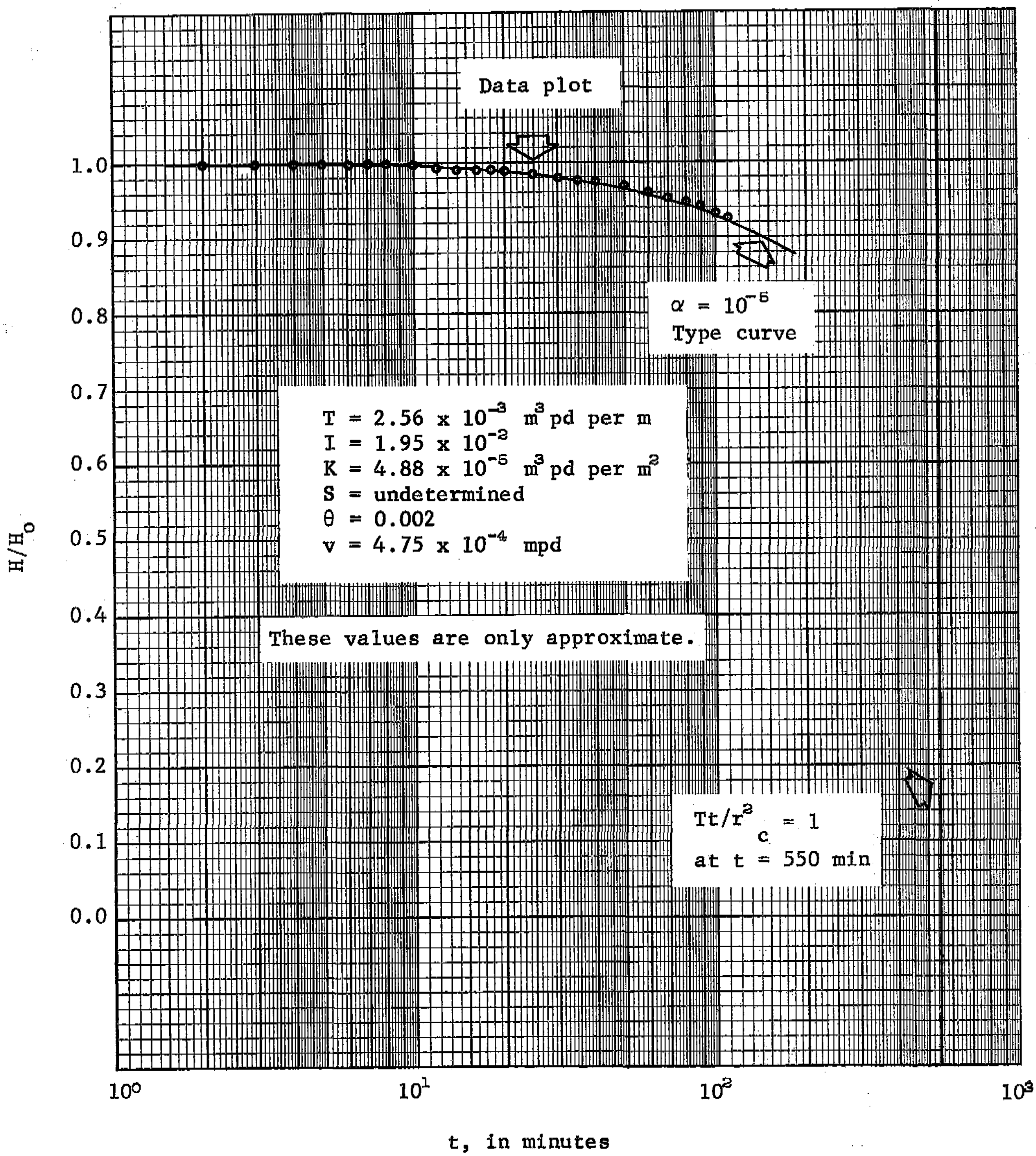


Figure 16.--Analysis of injection test of zone 1,755.7 to 1,808.1 m, hole UA-1, Amchitka Island, Alaska, September 20, 1968.

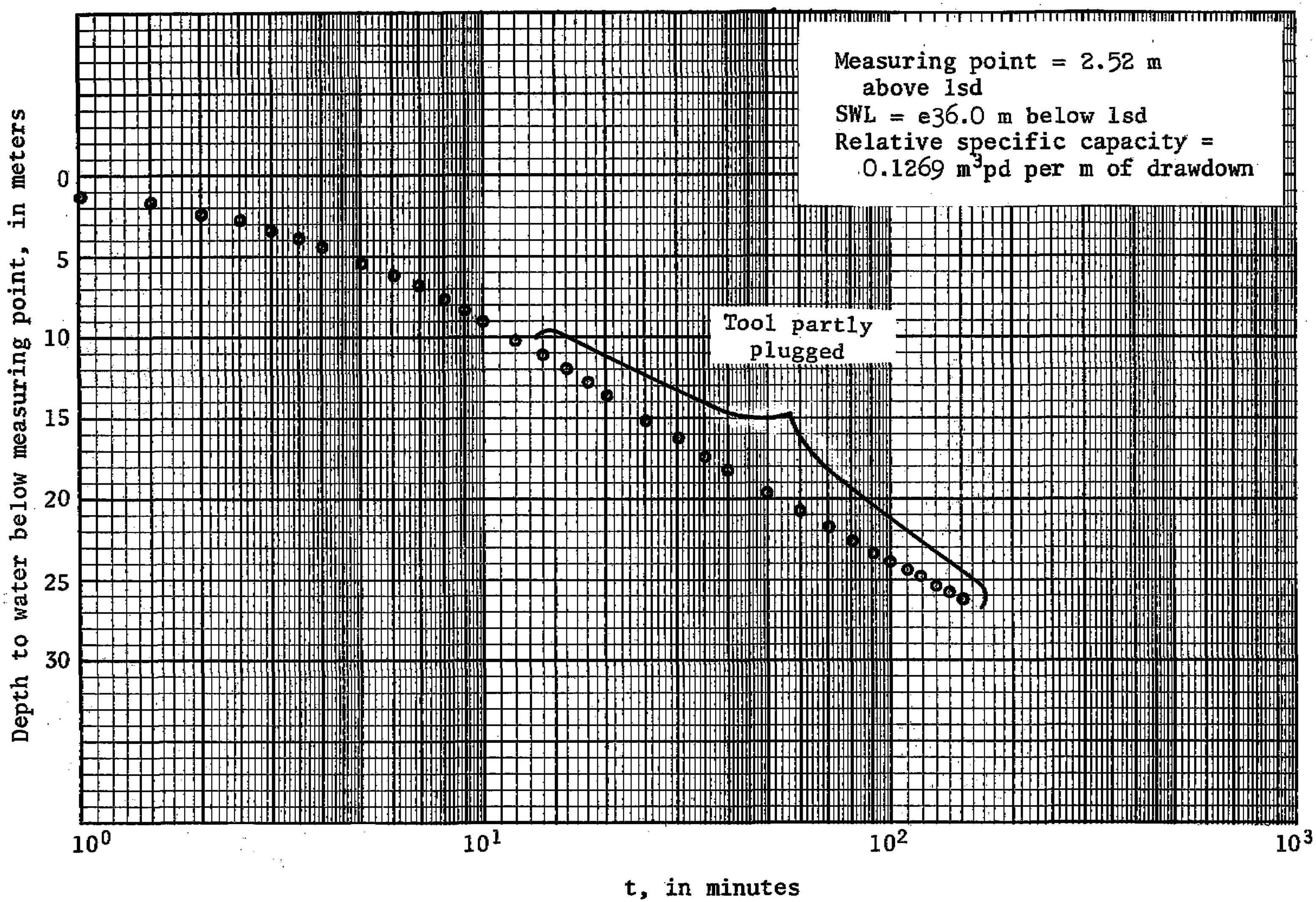


Figure 17.--Injection test of zone 1,756.8 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 23, 1968.

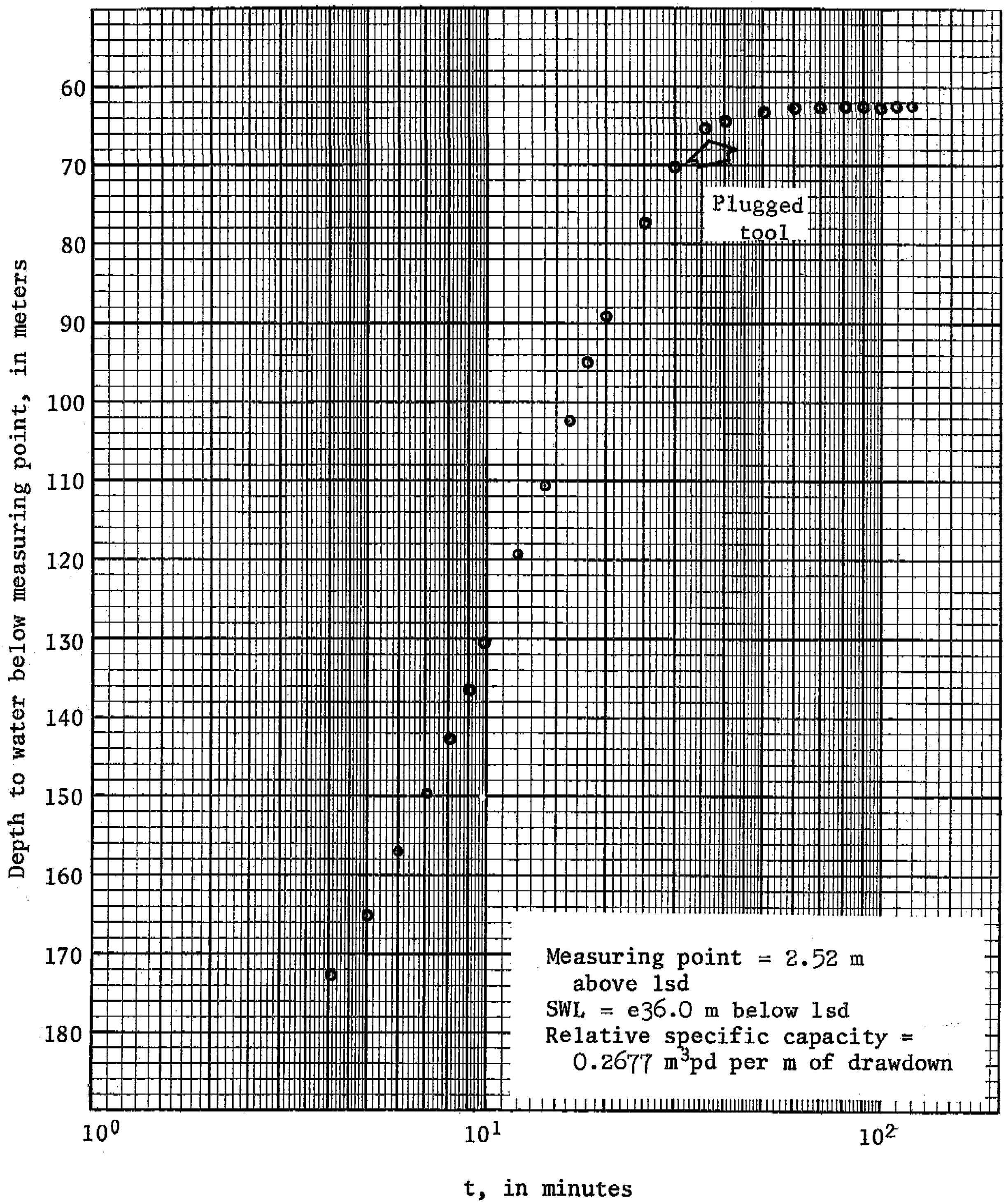


Figure 18.--Swabbing recovery test of zone 1,756.8 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 23, 1968.

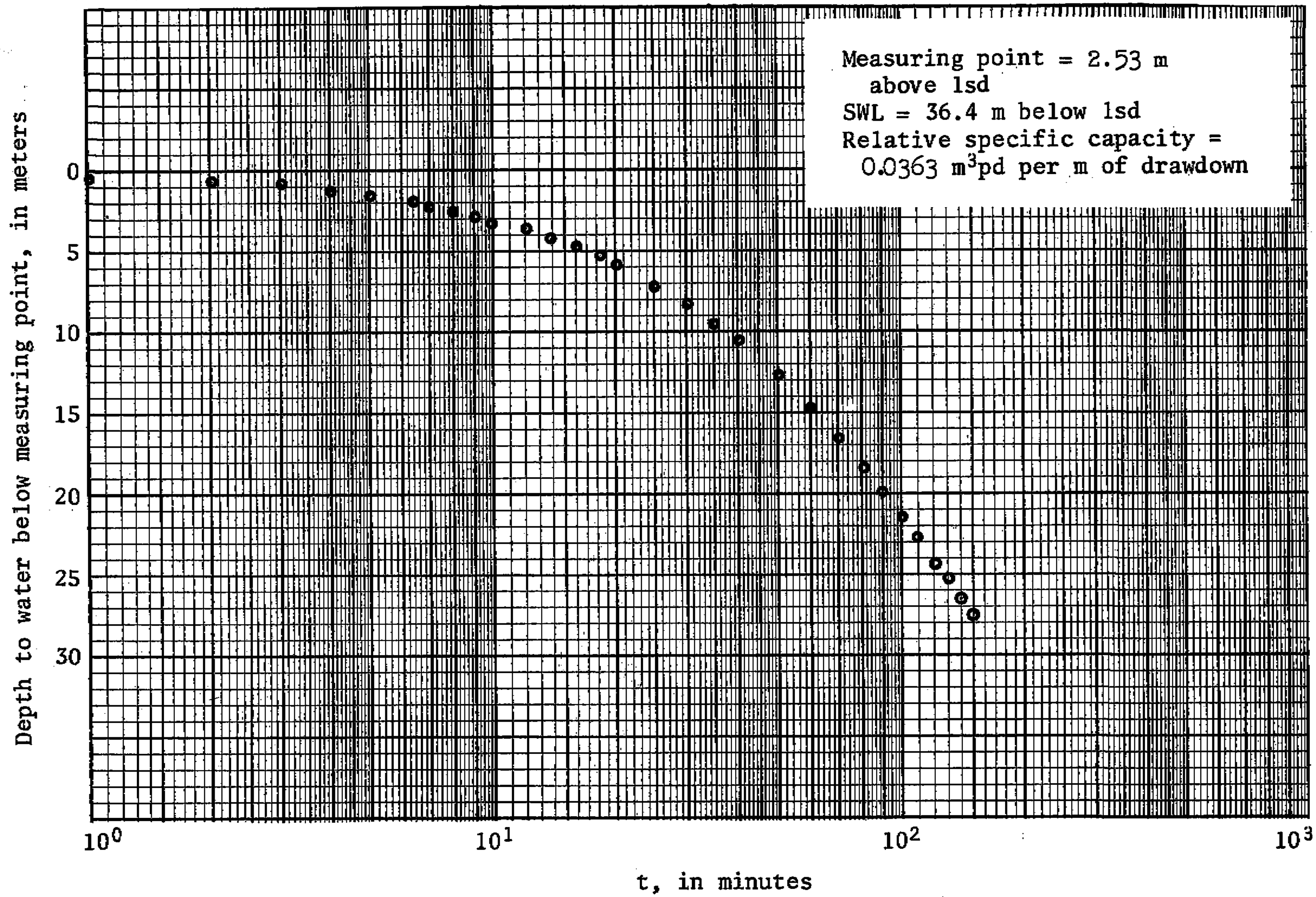


Figure 19.--Injection test of zone 1,806.3 to 1,859.9 m, hole UA-1, Amchitka Island, Alaska, September 27, 1968.

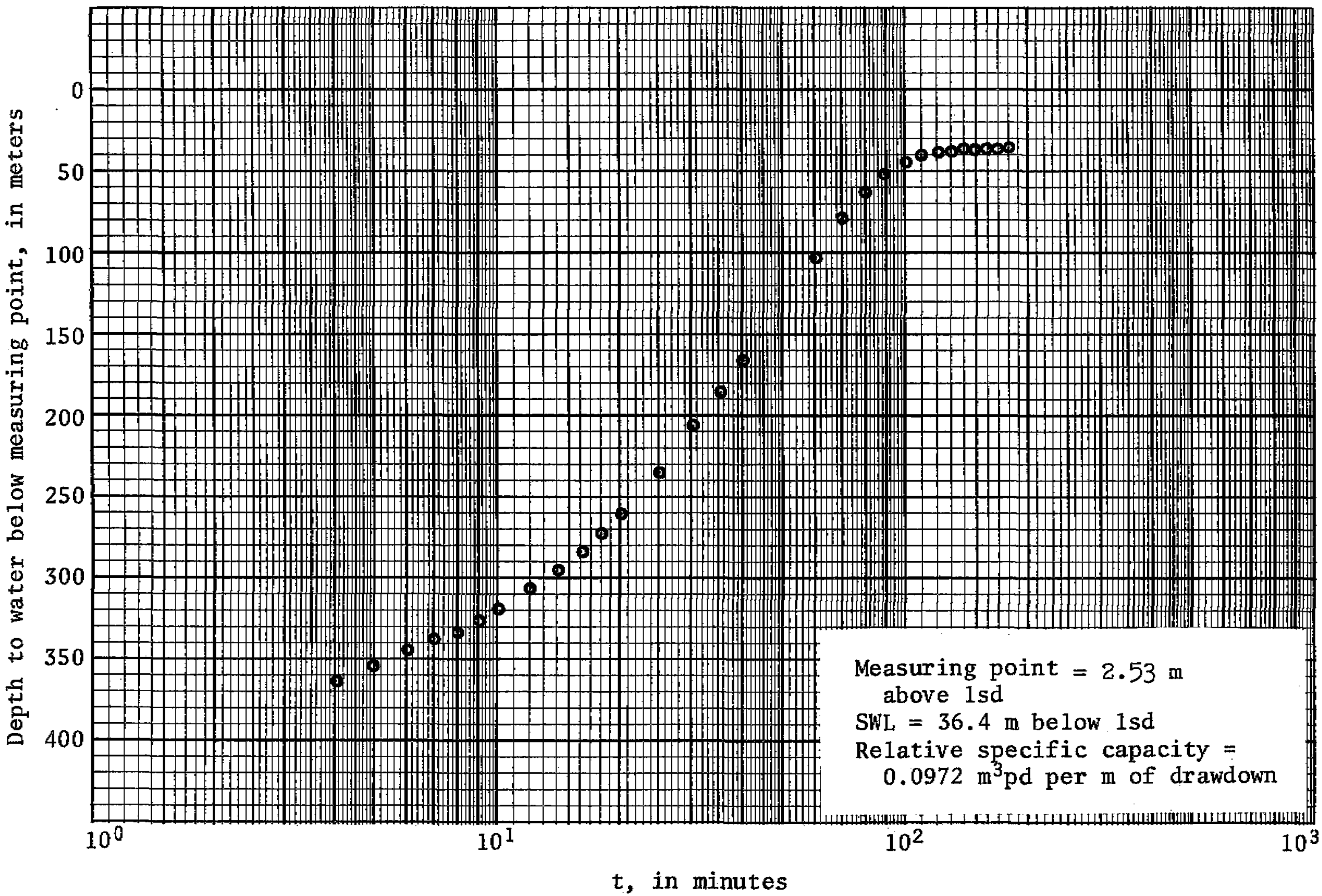


Figure 20.--Swabbing recovery test of zone 1,806.3 to 1,859.9 m, hole UA-1, Amchitka Island, Alaska, September 27, 1968.

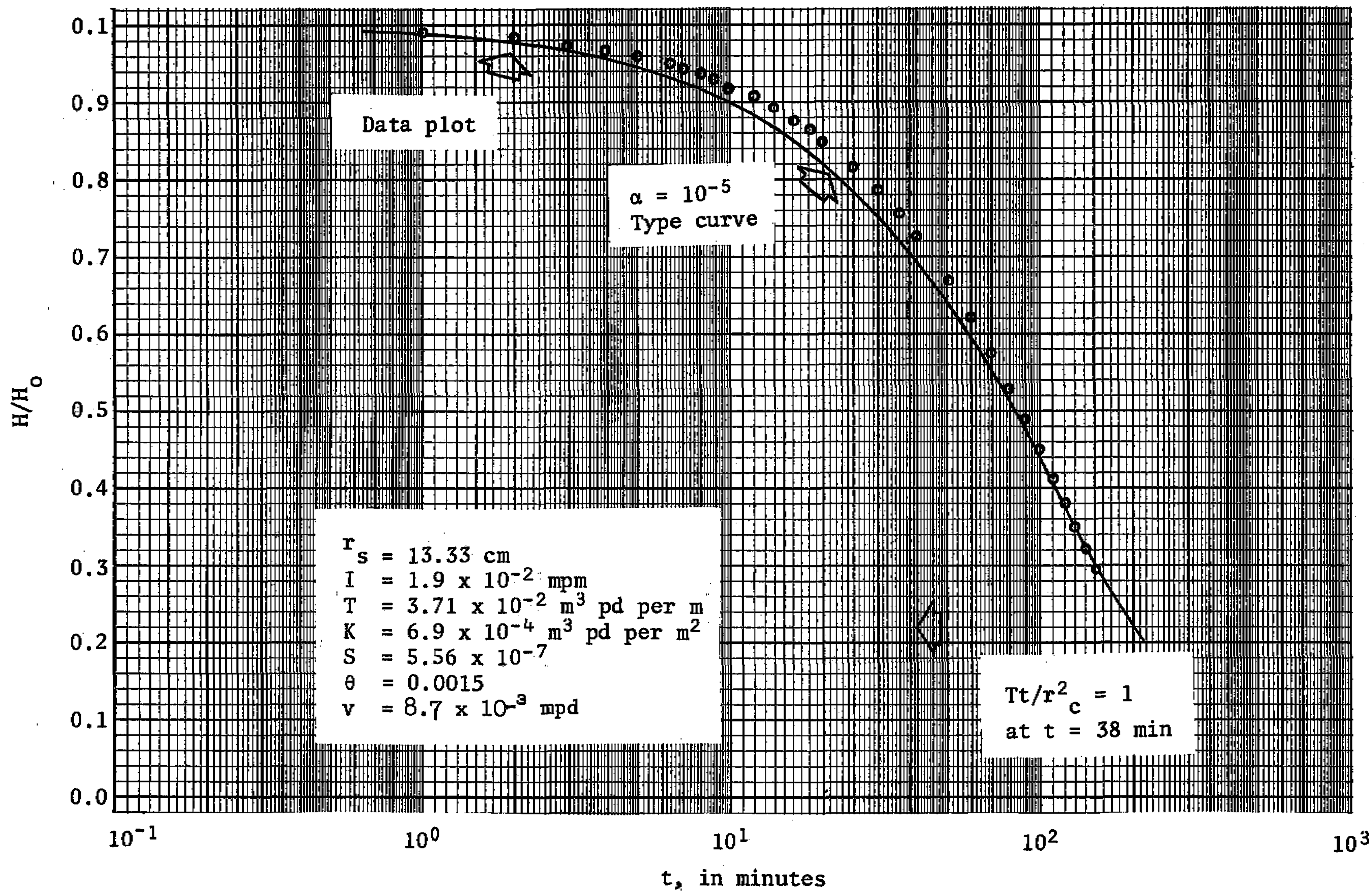


Figure 21.--Analysis of injection test of zone 1,806.3 to 1,859.9 m, hole UA-1, Amchitka Island, Alaska, September 27, 1968.

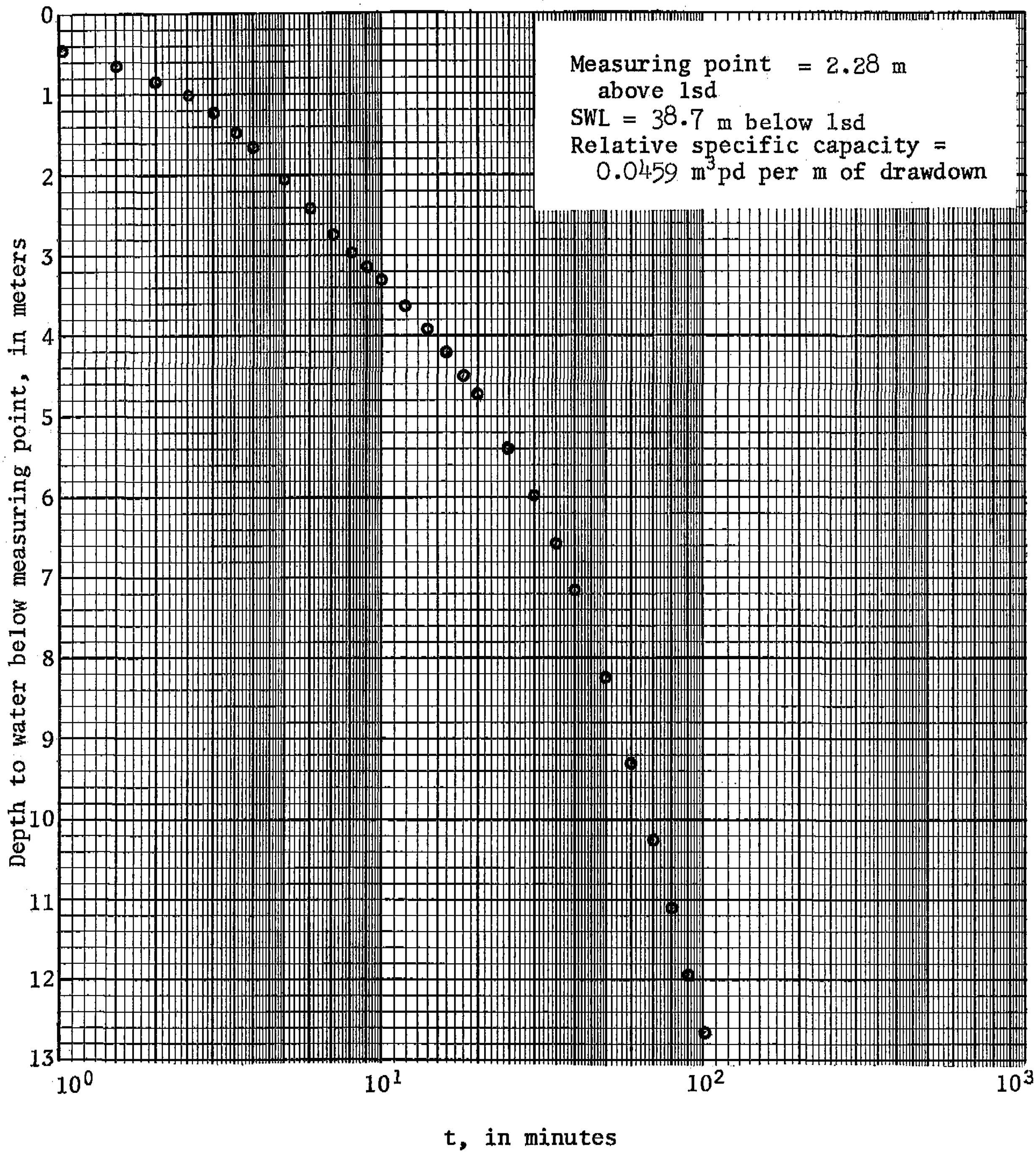


Figure 22.--Injection test of zone 1,813.0 to 1,873.3 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

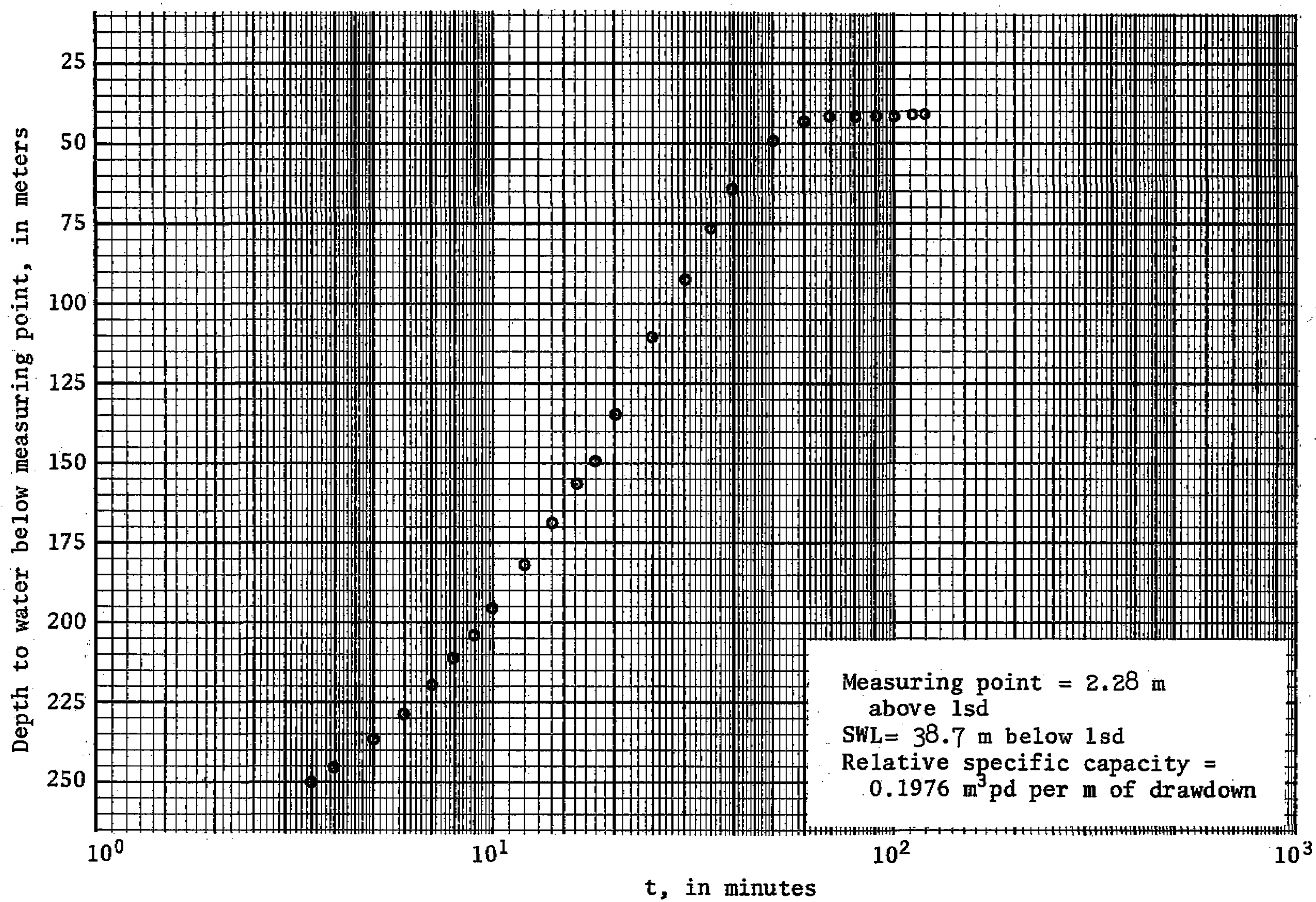


Figure 23.--Swabbing recovery test of zone 1,813.0 to 1,873.3 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

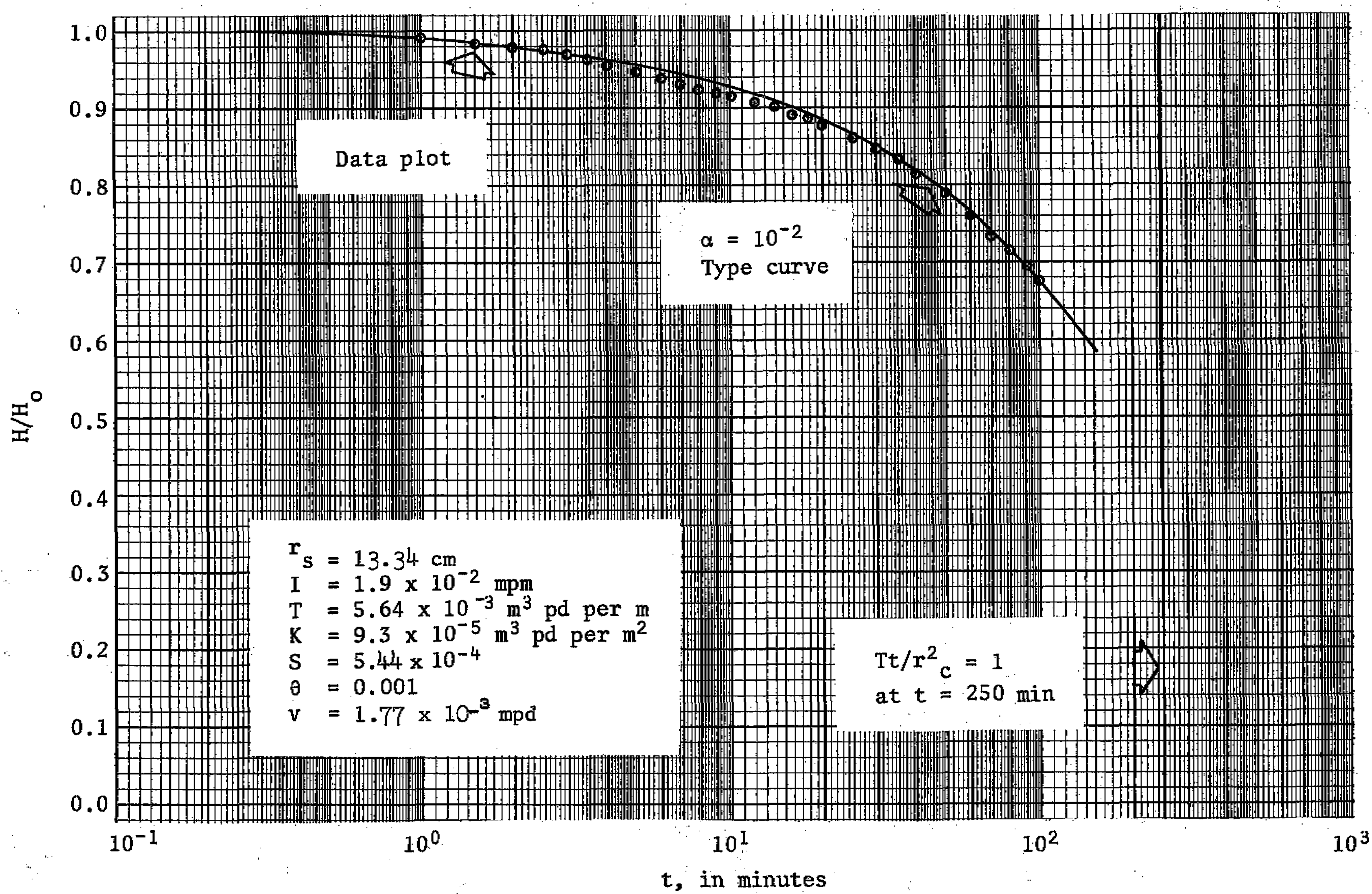


Figure 24.--Analysis of injection test of zone 1,813.0 to 1,873.3 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

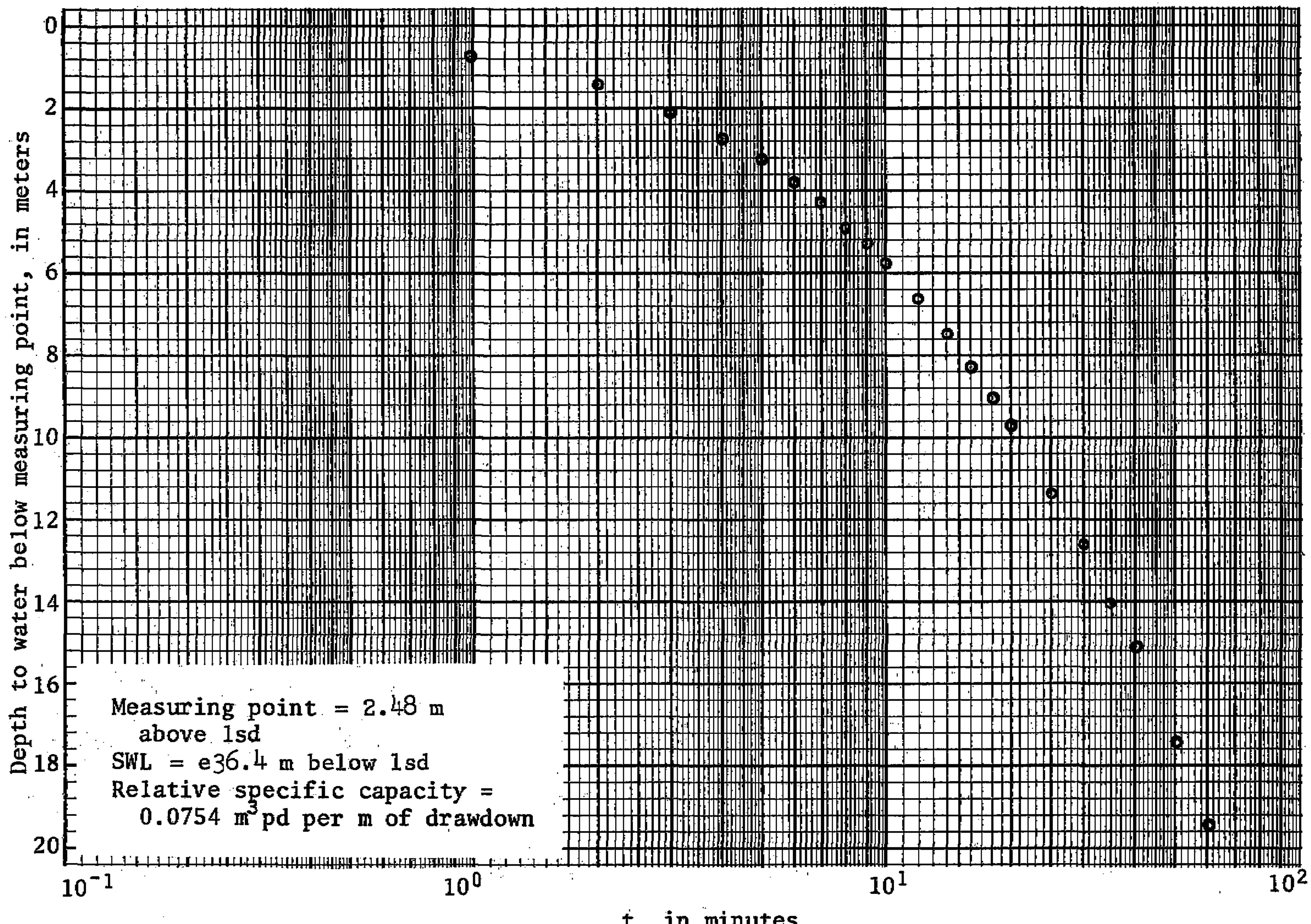


Figure 25.--Injection test of zone 1,834.9 to 1,873.9 m, hole UA-1, Amchitka Island, Alaska, October 9, 1968.

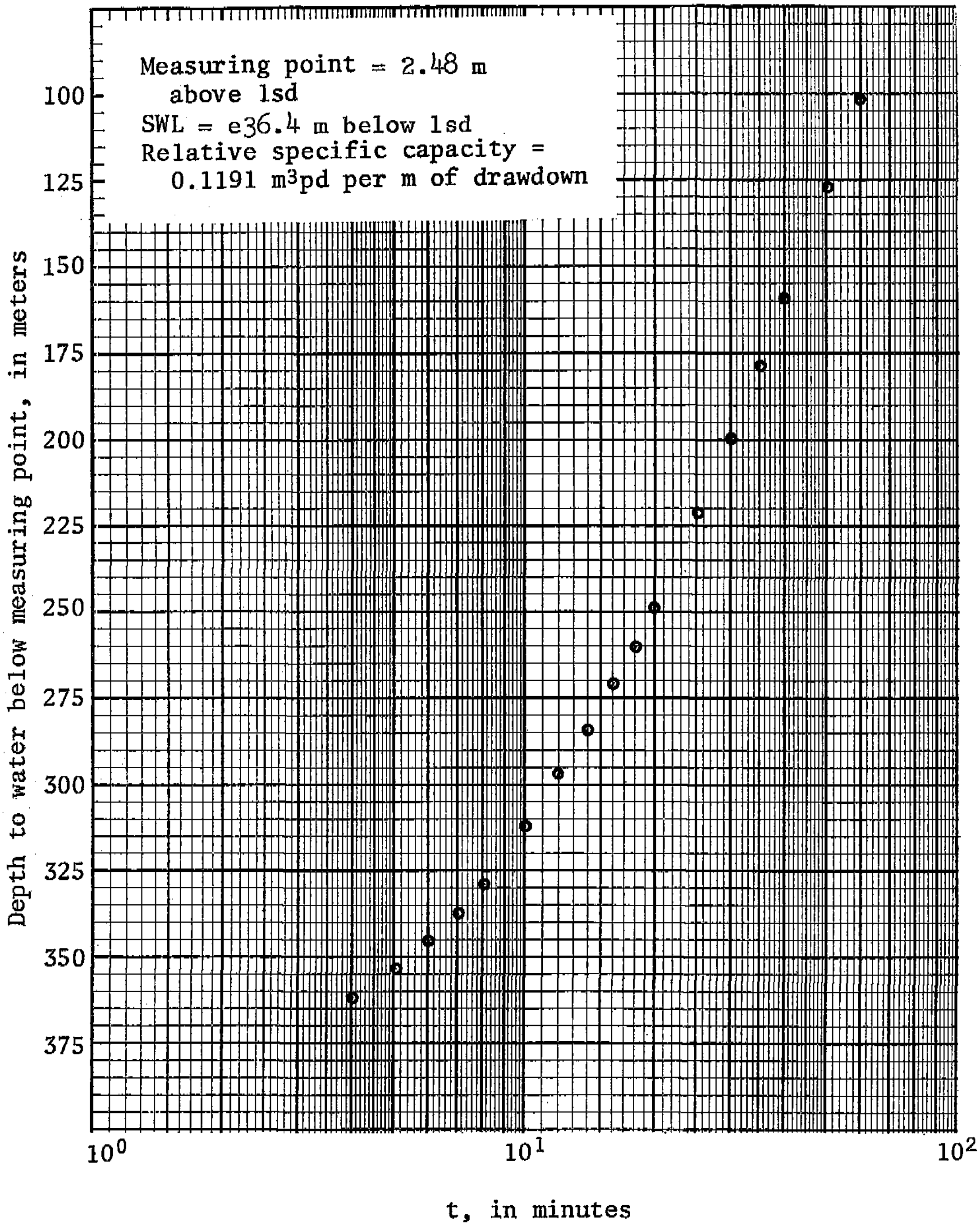


Figure 26.--Swabbing recovery test of zone 1,834.9 to 1,873.9 m, hole UA-1, Amchitka Island, Alaska, October 9, 1968.

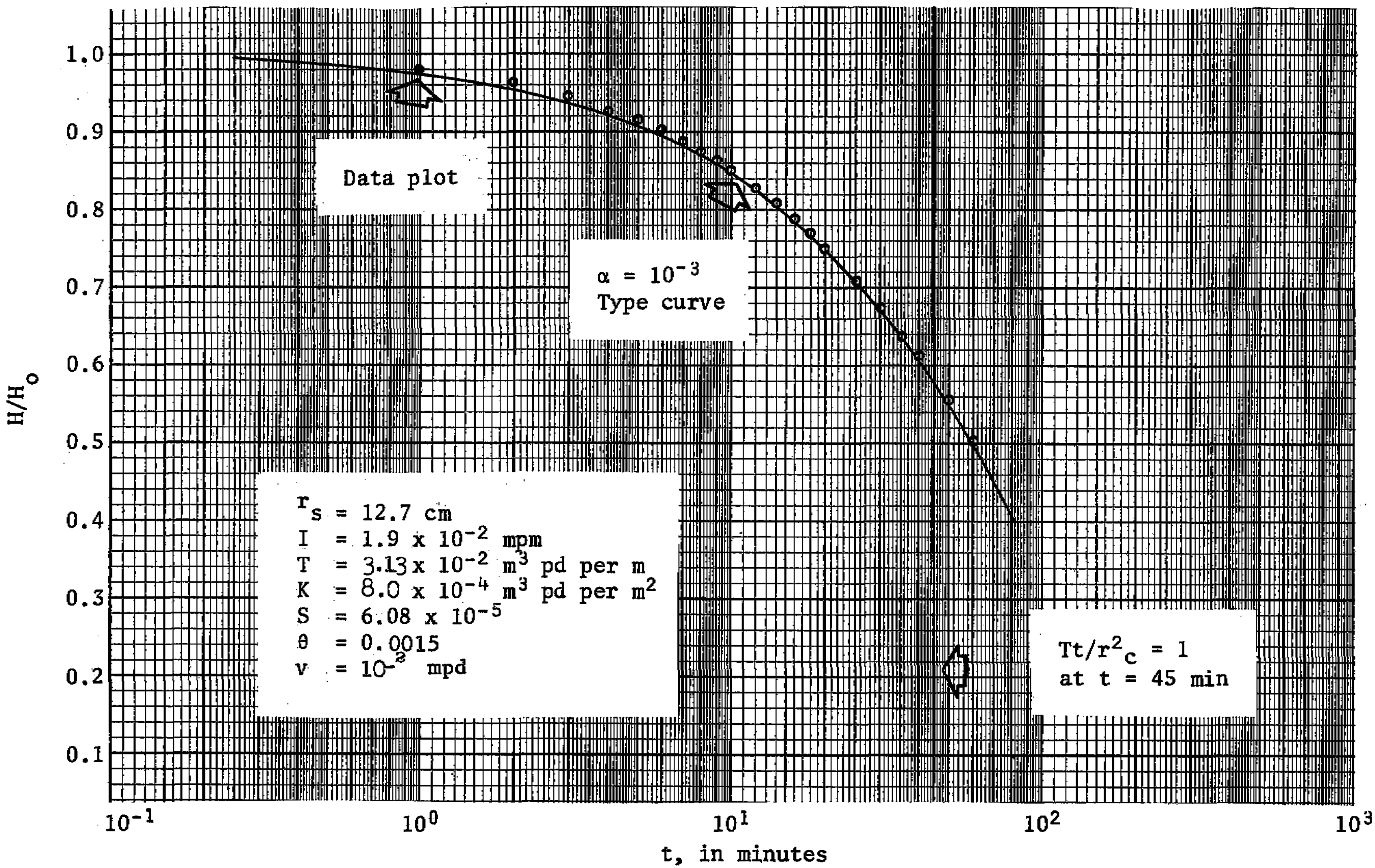


Figure 27.--Analysis of injection test of zone 1,834.9 to 1,873.9 m, hole UA-1, Amchitka Island, Alaska, October 9, 1968.

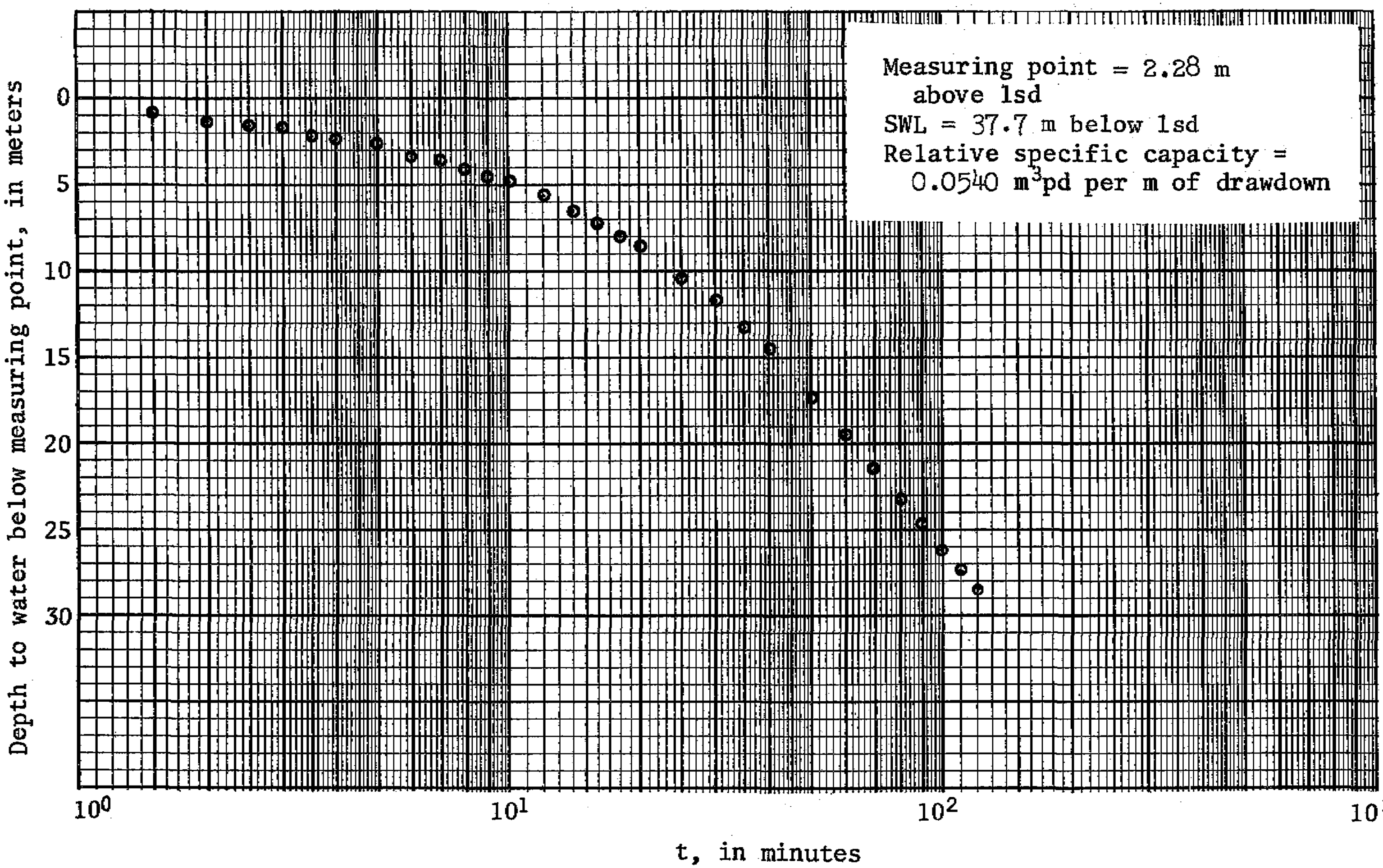


Figure 28.--Injection test of zone 1,834.9 to 1,895.3 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

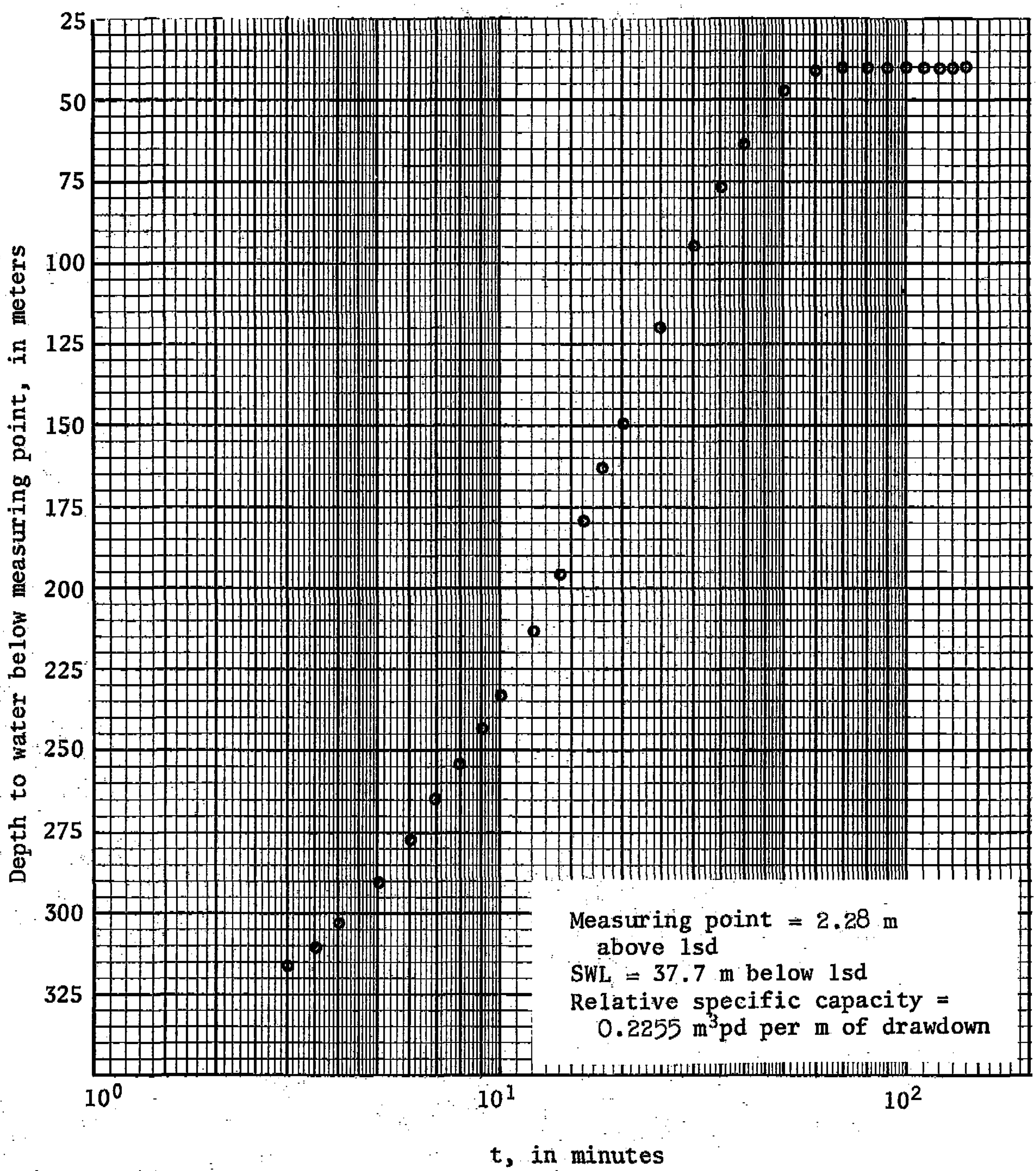


Figure 29.--Swabbing recovery test of zone 1,834.9 to 1,895.3 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

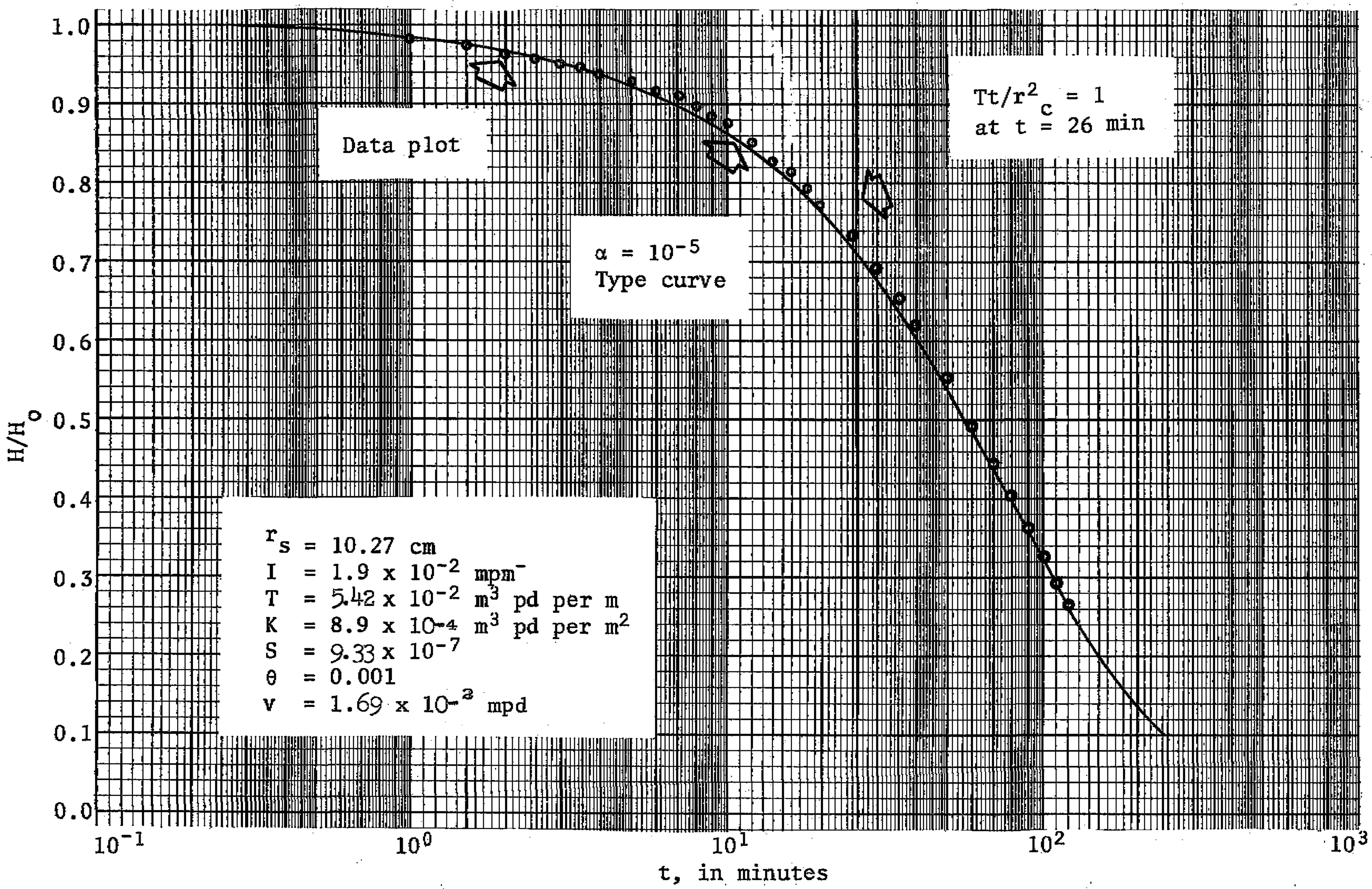


Figure 30.--Analysis of injection test of zone 1,834.9 to 1,895.3 m, hole UA-1, Amchitka Island, Alaska, October 22, 1968.

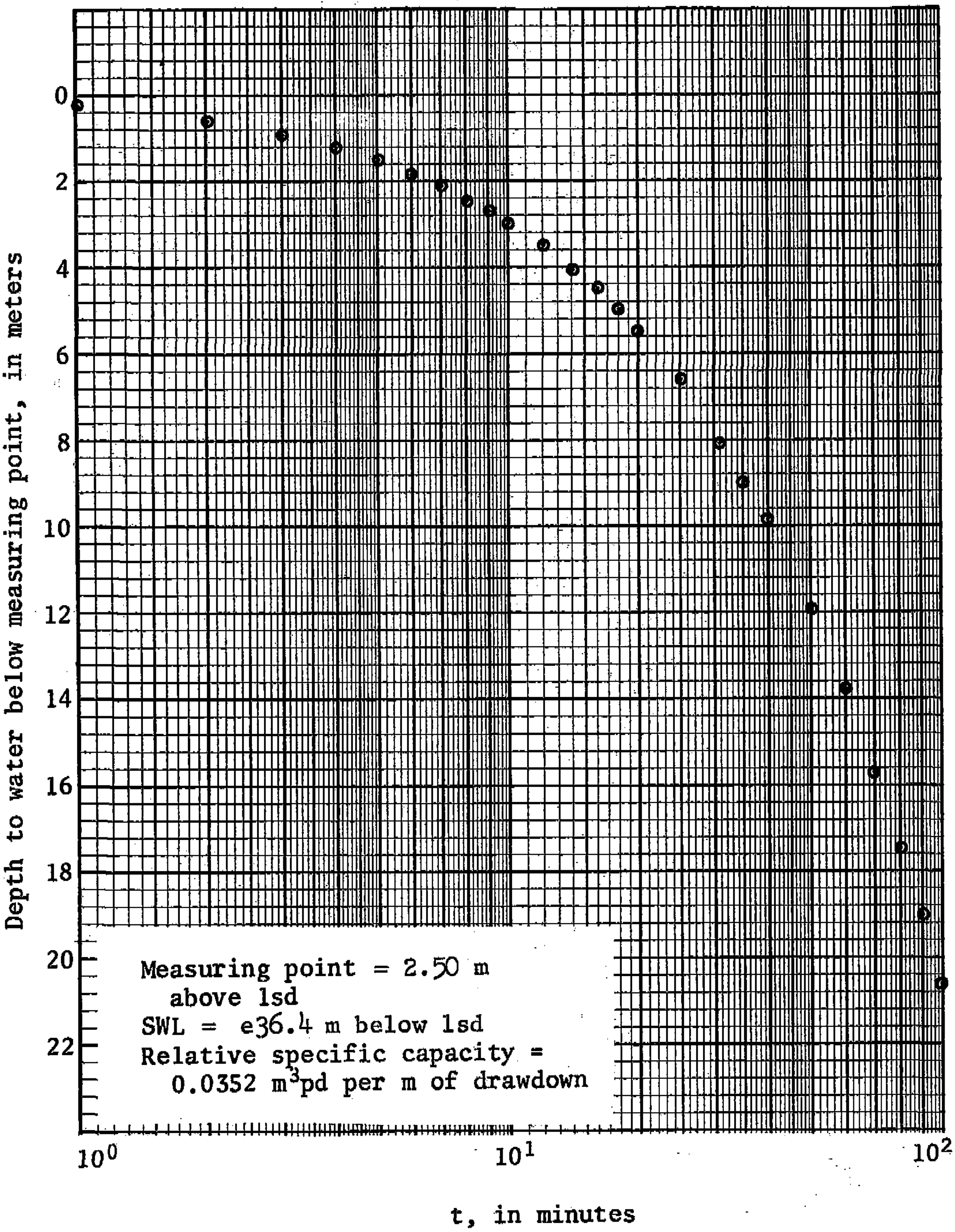


Figure 31.--Injection test of zone 1,877.0 to 1,914.5 m, hole UA-1, Amchitka Island, Alaska, October 8, 1968.

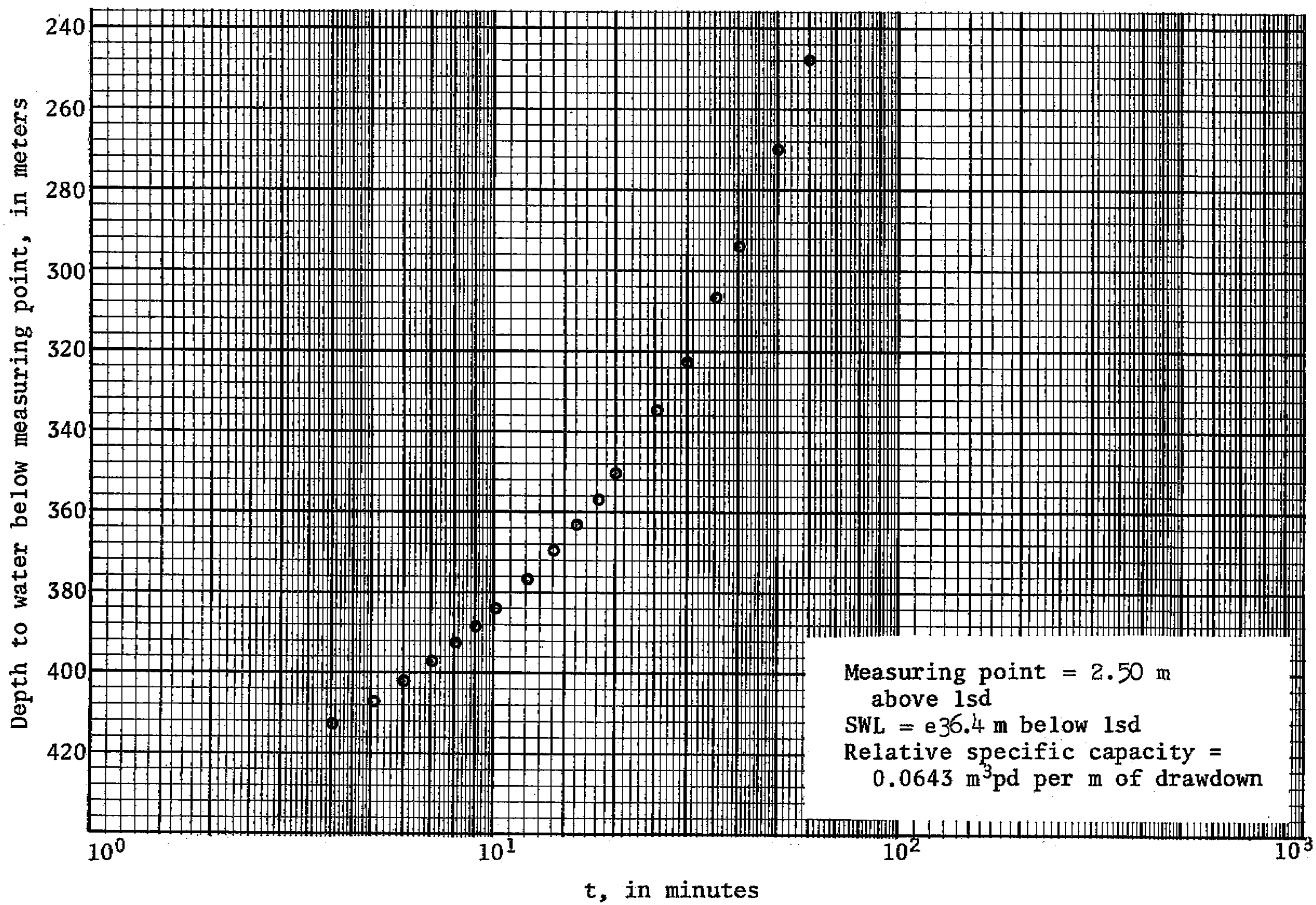


Figure 32.--Swabbing recovery test of zone 1,877.0 to 1,914.5 m, hole UA-1, Amchitka Island, Alaska, October 8, 1968.

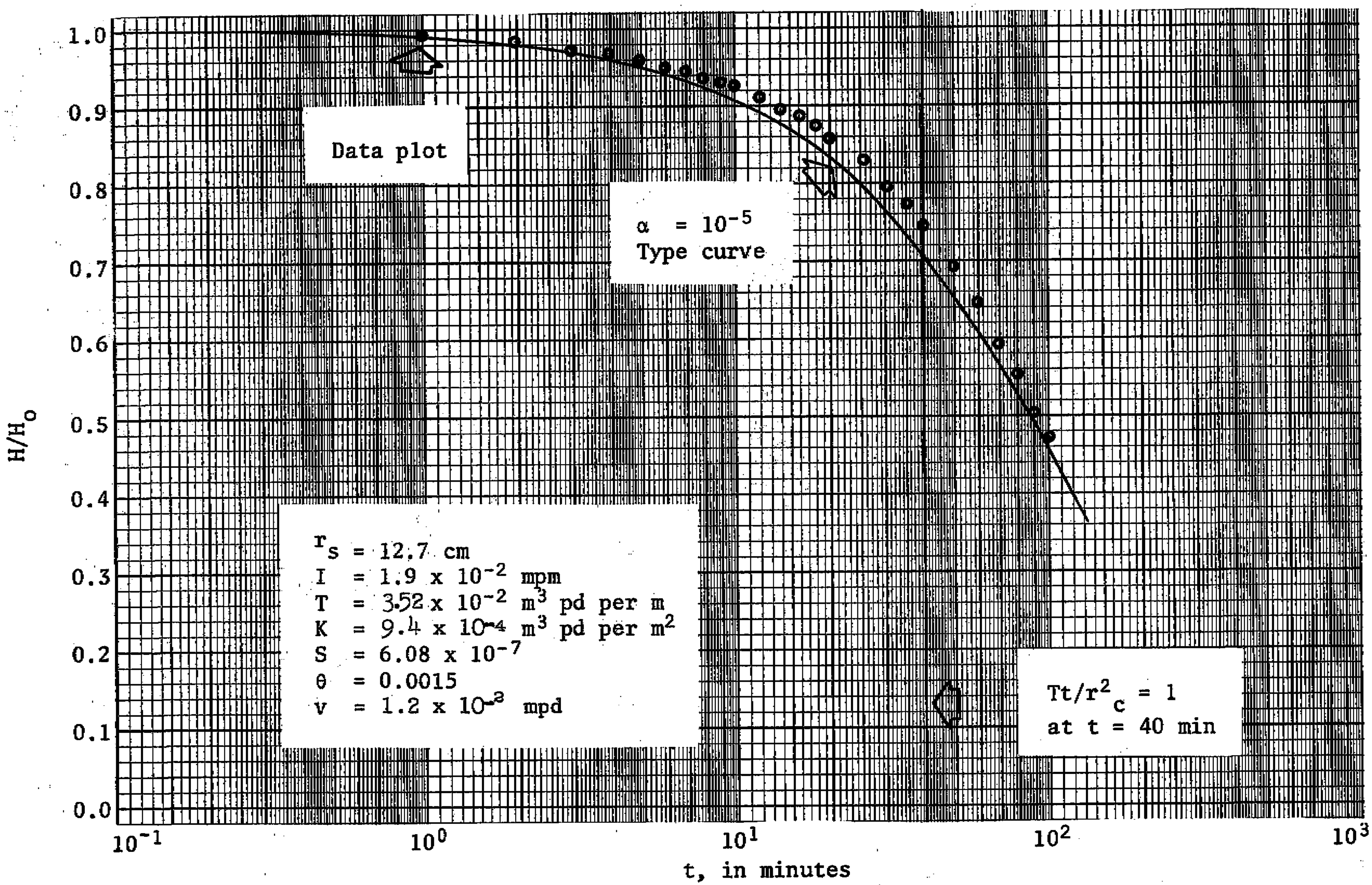


Figure 33.--Analysis of injection test of zone 1,877.0 to 1,914.5 m, hole UA-1, Amchitka Island, Alaska, October 8, 1968.

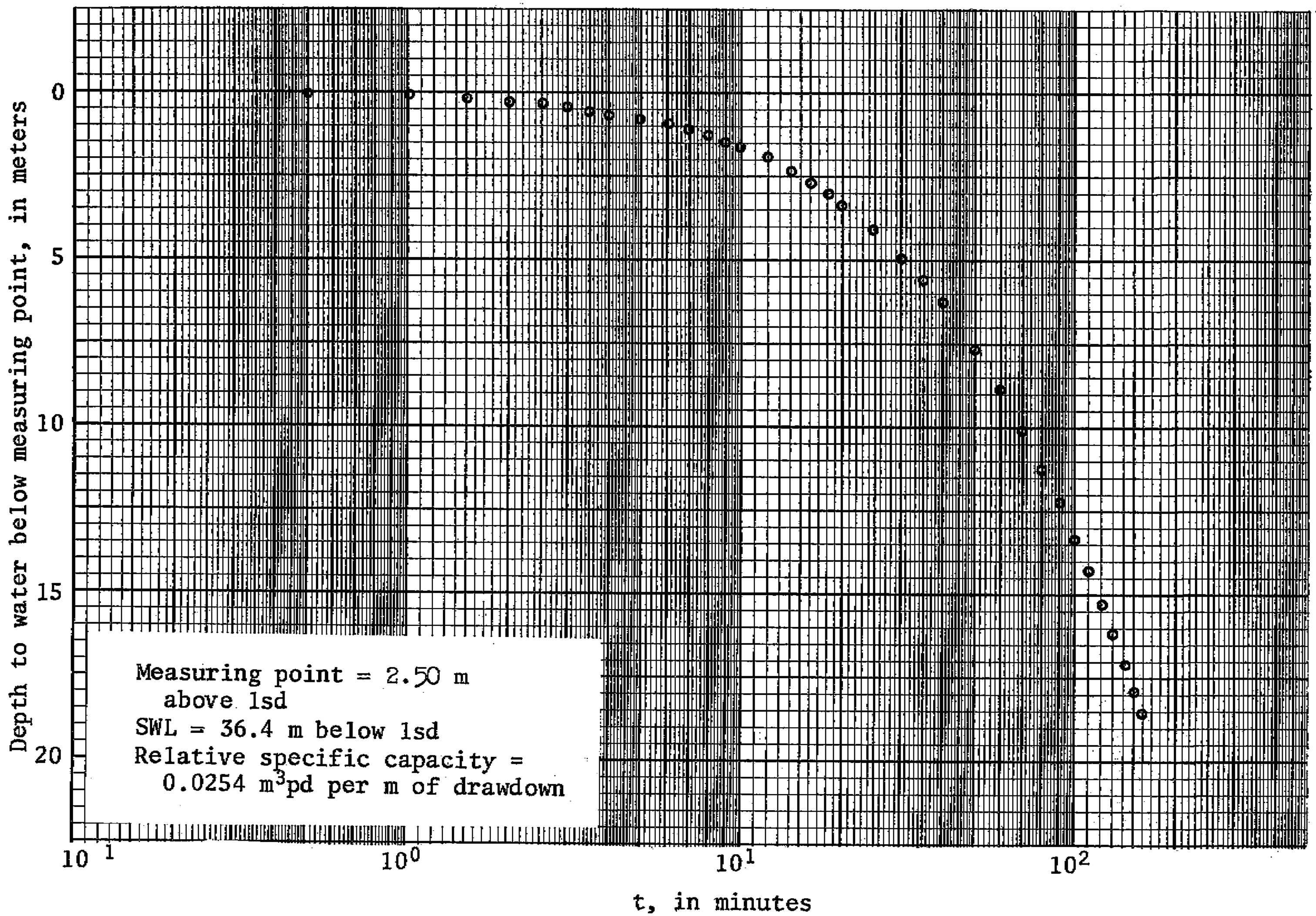


Figure 34.--Injection test of zone 1,896.7 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 21, 1968.

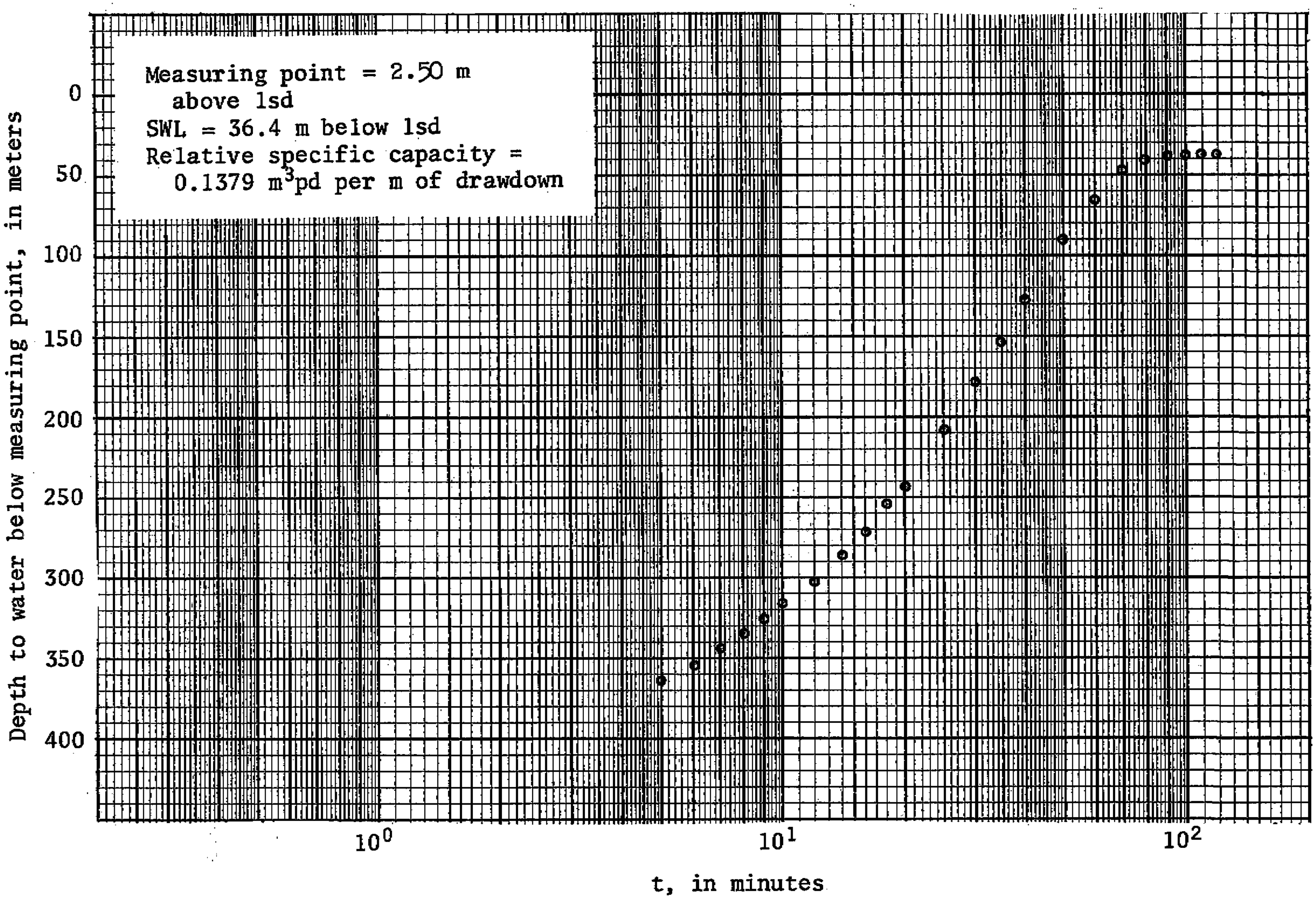


Figure 35.--Swabbing recovery test of zone 1,896.7 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 21, 1968.

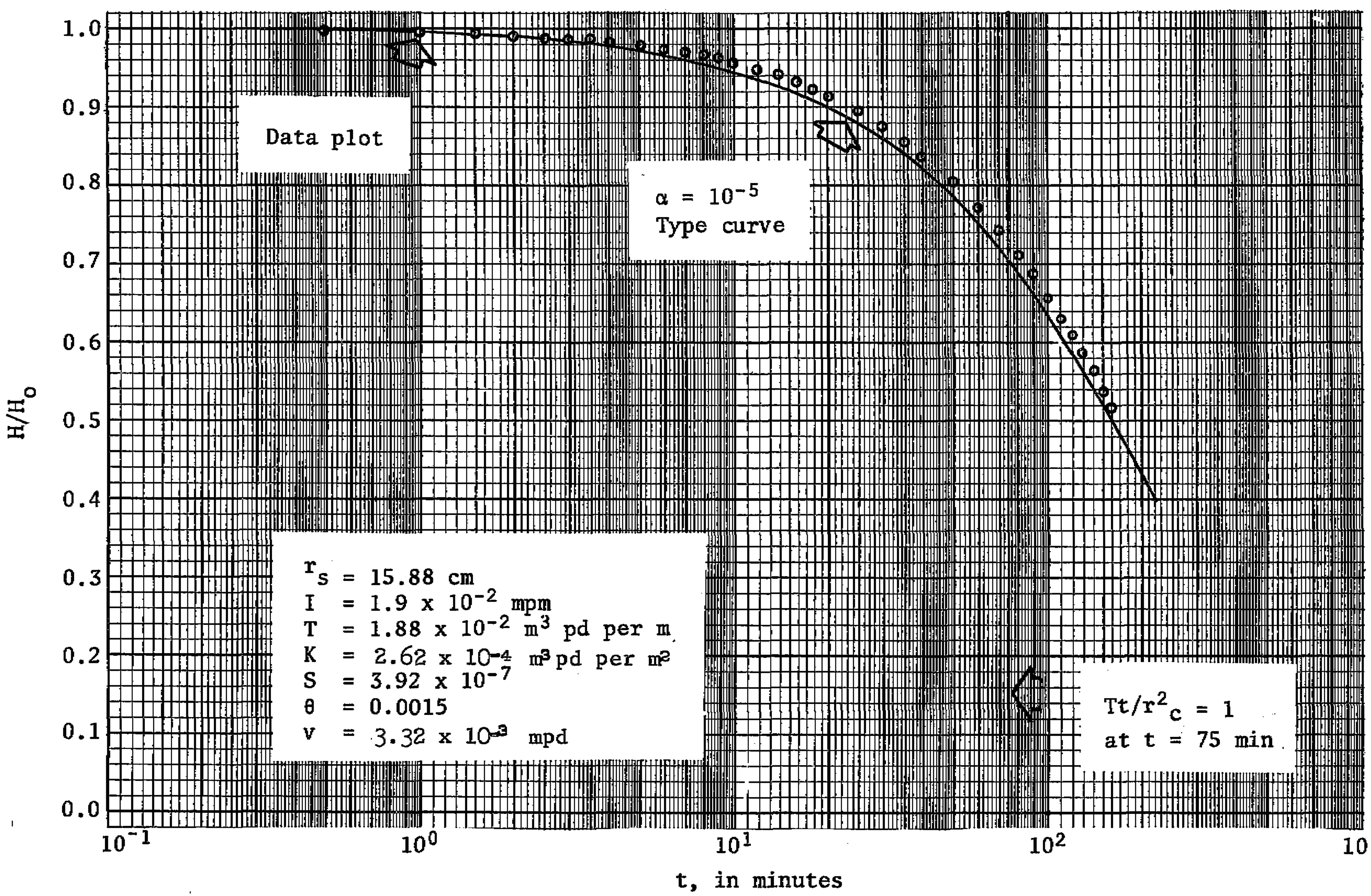


Figure 36.--Analysis of injection test of zone 1,896.7 to 1,968.4 m, hole UA-1, Amchitka Island, Alaska, October 21, 1968.

PROPOSED CHAMBER LOCATION

The possibility of large water yields from rocks thousands of meters beneath the water table presents a safety problem in the mining of chambers. Also, in the detonation of nuclear devices, contaminants must be contained in the host rocks to prevent contamination of surface water.

The analysis of data from hydraulic testing of hole UA-1 in the interval 1,536.2 to 1,968.4 m (5,040 to 6,458 ft) is presented in table 1. The rock between 1,745.0 and 1,836.4 m (5,725 to 6,025 ft) below land surface was selected as a desirable interval in terms of low hydraulic conductivity. The rock in the interval consists of about 27.4 m (90 ft) of breccia in the upper part and about 64.0 m (210 ft) of basalt in the lower part.

The chamber to be mined will be a sphere 18.3 m (60 ft) in diameter. Calculations of water inflow to the proposed chamber were made for several locations within the boundaries set forth above. The chamber probably will be in the interval 1,781.6 to 1,799.9 m (5,845 to 5,905 ft). At this location the chamber would be entirely within basalt.

INFLOW TO AN UNDERGROUND CHAMBER

In the calculation of water inflow to the chamber, the time-dependent discharge to a large-diameter well at constant drawdown must be determined. Hantush (1959) derived equations that can be used for computing inflow to underground chambers using hydraulic-test data from deep wells and Walton (1962) prepared a set of type curves that are at a convenient scale for aquifer analysis. The method can be used if certain physical assumptions are made concerning the construction procedure and the hydraulic characteristics of the rocks. These assumptions are: 1) that partial penetration in the center of a rock unit can be treated as a leaky-aquifer problem with vertical leakage from above and below; 2) that excavation is sufficiently rapid to simulate instant drawdown; and 3) that construction includes a sealed sump that stores all inflow to the chamber or the inflow is removed by pumping, thus maintaining constant drawdown at the chamber.

The formula that describes leaky artesian constant-drawdown variable discharge conditions as presented by Walton (1962) is:

$$s_w = 229Q/[G(\lambda, r_w/B)T]$$

$$\lambda = 9.29\times10^{-5}Tt/r_w^2S$$

$$r_w/B = r_w/\sqrt{T/(P'/m')}$$

where:

$$G(\lambda, r_w/B) = (r_w/B)[K_1(r_w/B)/K_o(r_w/B)] + (4/\pi^2)\exp[-\lambda(r_w/B)^2] \int_0^\infty \frac{u\exp(-\lambda u^2)}{J_o^2(u)+Y_o^2(u)} \cdot \frac{du}{u^2+(r_w/B)^2}$$

$u = r_w\sqrt{1/\exp(i\pi)B^2}$
T = coefficient of transmissivity, in gpd/ft
S = coefficient of storage, fraction
Q = discharge, in gpm
r_w = nominal radius of pumped well, in ft
s_w = drawdown in pumped well, in ft
t = time after discharge started, in min
P' = coefficient of vertical hydraulic conductivity of confining bed, in gpd/sq ft
m' = thickness of confining bed through which leakage occurs, in ft
$K_1(r_w/B)$ = first-order modified Bessel function of the second kind
$K_o(r_w/B)$ = zero-order modified Bessel function of the second kind
$J_o(u)$ = zero-order Bessel function of the first kind
$Y_o(u)$ = zero-order Bessel function of the second kind

The proposed chamber is to be a sphere 18.3 m (60 ft) in diameter, the center of which is 1,790.7 m (5,875 ft) below land surface. Calculations of the inflow were determined by assuming the horizontal and vertical permeability are equivalent. This assumption conflicts with the limitations stated by Cooper and others (1967), "The vertical permeabilities of most stratified aquifers are only small fractions of the horizontal permeabilities. . .". However, by assigning horizontal permeability values to the vertical permeability, the computed inflow should be greater than actual inflow. This is preferred over indicated inflow being less than actual inflow. Also, as stated earlier the permeability of the rocks in hole UA-1 are mostly in fractures and all fractures are not horizontal. Possibly the vertical permeability is more than a small fraction of the horizontal permeability expected in stratified rocks.

Calculation of the inflow was determined by assuming that the chamber will appear instantaneously at the beginning of construction. Obviously, this cannot be accomplished; therefore, the calculated inflow of water is larger than the actual inflow will be during construction. Figure 37 shows the theoretical inflow to an instantaneously constructed chamber. The actual inflow resulting from time lag in construction will be less than indicated at early times and somewhat greater at later times. The theoretical inflow is about 175 m^3pd (32 gpm) after 1 day, 85 m^3pd (15.5 gpm) after 10 days, and 60 m^3pd (11 gpm) after 100 days. After about 200 days

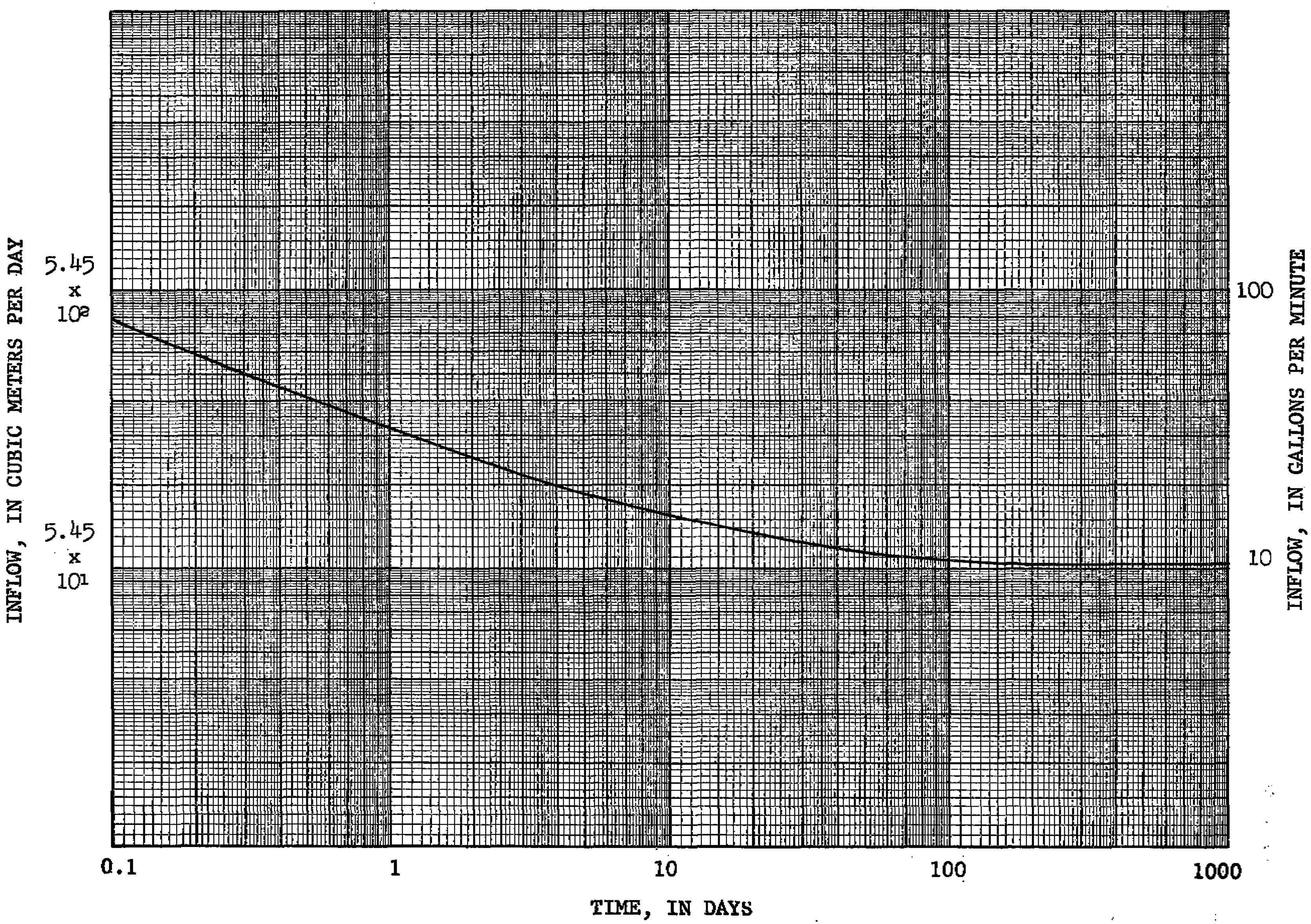


Figure 37.--Theoretical water inflow to a spherical chamber 18.3 meters (60 feet) in diameter and 1,790.7 meters (5,875 feet) below land surface, as a function of time, hole UA-1.

the inflow will stabilize at about 57 m^3pd (10.5 gpm). If 8 days were required to mine the chamber to full dimensions, the 1-day inflow would be less than 175 m^3pd, but the 10-day value would be greater than 85, perhaps on the order of 100 to 125 m^3pd. The 100-day inflow would not differ significantly from the theoretical value, as can be seen from the similarity of inflows at 90 and 100 days on figure 37.

Table 1.--Summary of hydraulic testing in hole UA-1, Amchitka Island, Alaska

Interval tested (depth below lsd)		Method of testing	Static water level (depth below lsd)		Relative specific capacity		Packer bypass	Storage coefficient[1]	Transmissivity[1]		Hydraulic conductivity[1]		Velocity[1]		Rock type
m	ft		m	ft	m^3 pd per m of dd	gpm per ft of dd			m^3 pd per m	gpd per ft	m^3 pd per m^2	gpd per ft^2	mpd	ft pd	
1,536.2 - 1,593.5	5,040 - 5,228	Injection	a/33.0	a/108.3	0.0542	0.0030	No	6.76×10^{-6}	2.35×10^{-2}	1.89	4.1×10^{-4}	1.0×10^{-2}	4.45×10^{-3}	1.46×10^{-2}	Breccia Siltstone
		Swabbing			.0834	.0047	Yes	--	--	--	--	--	--	--	
1,596.6 - 1,647.5	5,238 - 5,405	--	a/33.0	a/108.3	--	--	--	--	--	--	--	--	--	--	Breccia
		Swabbing			.0069	.0004	No								
1,651.4 - 1,702.9	5,418 - 5,587	--	a/35.0	a/114.8	--	--	--	--	--	--	--	--	--	--	Basalt Breccia
		Swabbing			.0053	.0003	No								
1,664.5 - 1,968.4	5,461 - 6,458	Injection	37.8	124.0	.1845	.0103	No	--	3.52×10^{-1}	2.84×10^{1}	1.15×10^{-3}	2.82×10^{-2}	1.04×10^{-2}	3.42×10^{-2}	Breccia Basalt
		--			--	--	--		--	--	--	--	--	--	
1,693.5 - 1,753.8	5,556 - 5,754	Injection	35.0	114.8	.1875	.0105	Yes	5.53×10^{-7}	1.88×10^{-1}	1.51×10^{1}	3.12×10^{-3}	7.64×10^{-2}	3.17×10^{-2}	1.04×10^{-1}	Breccia
		--			--	--	--	--	--	--	--	--	--	--	
1,694.1 - 1,769.4	5,558 - 5,805	--	a/37.7	a/123.7	--	--	--	--	--	--	--	--	--	--	Breccia
		Swabbing			.0496	.0028	No								
1,745.3 - 1,805.6	5,726 - 5,924	--	e37.0	e121.4	--	--	--	--	--	--	--	--	--	--	Breccia Basalt
		Swabbing			.0205	.0011	No								
1,755.7 - 1,808.1	5,760 - 5,932	Injection	e36.0	e118.1	.0034	.0002	No	--	1.76×10^{-3}	1.42×10^{-1}	3.36×10^{-5}	8.23×10^{-4}	4.75×10^{-4}	1.56×10^{-3}	Breccia Basalt
		Swabbing			.0236	.0013	No		--	--	--	--	--	--	
1,756.8 - 1,968.4	5,764 - 6,458	Injection	e36.0	e118.1	.1269	.0071	No	--	--	--	--	--	--	--	Breccia Basalt
		Swabbing			.2677	.0150	No								
1,806.3 - 1,859.9	5,926 - 6,102	Injection	36.4	119.4	.0363	.0020	No	5.56×10^{-7}	3.71×10^{-2}	2.99	6.9×10^{-4}	1.69×10^{-2}	8.7×10^{-3}	2.85×10^{-2}	Basalt Breccia
		Swabbing			.0972	.0054	No	--	--	--	--	--	--	--	

Table 1.--Summary of hydraulic testing in hole UA-1, Amchitka Island, Alaska--Continued

Interval tested (depth below lsd)		Method of testing	Static water level (depth below lsd)		Relative specific capacity		Packer bypass	Storage coefficient1/	Transmissivity1/		Hydraulic conductivity1/		Velocity1/		Rock type
m	ft		m	ft	m^3 pd per m of dd	gpm per ft of dd			m^3 pd per m	gpd per ft	m^3 pd per m^2	gpd per ft^2	mpd	ft pd	
1,813.0 - 1,873.3	5,948 - 6,146	Injection	38.7	127.0	0.0459	0.0026	No	5.44×10^{-4}	5.64×10^{-3}	4.54×10^{-1}	9.3×10^{-5}	2.28×10^{-3}	1.77×10^{-3}	5.81×10^{-3}	Basalt Breccia
		Swabbing			.1976	.0111	Yes	--	--	--	--	--	--	--	
1,834.9 - 1,873.9	6,020 - 6,148	Injection	e36.4	e119.4	.0754	.0042	Yes	6.08×10^{-5}	3.13×10^{-2}	2.52	8.0×10^{-4}	1.96×10^{-2}	1.0×10^{-2}	3.28×10^{-2}	Breccia Basalt
		Swabbing			.1191	.0067	Yes	--	--	--	--	--	--	--	
1,834.9 - 1,895.3	6,020 - 6,218	Injection	37.7	123.7	.0540	.0030	No	9.33×10^{-7}	5.42×10^{-2}	4.37	8.9×10^{-4}	2.18×10^{-2}	1.69×10^{-2}	5.54×10^{-2}	Breccia Basalt
		Swabbing			.2255	.0126	Yes	--	--	--	--	--	--	--	
1,877.0 - 1,914.5	6,158 - 6,281	Injection	e36.4	e119.4	.0352	.0020	No	6.08×10^{-7}	3.52×10^{-2}	2.84	9.4×10^{-4}	2.30×10^{-2}	1.2×10^{-2}	3.94×10^{-2}	Breccia Basalt
		Swabbing			.0643	.0036	No	--	--	--	--	--	--	--	
1,896.7 - 1,968.4	6,223 - 6,458	Injection	36.4	119.4	.0254	.0014	No	3.92×10^{-7}	1.88×10^{-2}	1.51	2.62×10^{-4}	6.42×10^{-3}	3.32×10^{-3}	1.09×10^{-2}	Breccia Basalt
		Swabbing			.1379	.0077	No	--	--	--	--	--	--	--	

1/ Computed from injection tests only.

2/ Static water level assumed to be the same as equivalent zone in UAe-1.

EXPLANATION:

lsd = land-surface datum
m = meters
ft = feet
m^3 pd = cubic meters per day
dd = drawdown
gpm = gallons per minute
gpd = gallons per day
m^2 = square meters
ft^2 = square feet
mpd = meters per day
ft pd = feet per day
e = estimated

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