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# *Mercury Injection Capillary Pressure Analysis Of Selected Samples From Well : CASINO-3*

## *Australia*

Prepared for
**SANTOS LIMITED**

July 2004

File: PRP-04035

Rock Properties
Core Laboratories
Perth
Australia

CORE LABORATORIES
AUSTRALIA PTY LTD

4th August 2004

**SANTOS LIMITED**
Santos House
91 King William Street
ADELAIDE, SA 5000

**Attention : Andy Pietsch**

Subject : Mercury Injection Capillary Pressure
Well : Casino-3
File : PRP-04035

Dear Andy,

Presented herein is the final report comprising results of the mercury injection capillary pressure analyses conducted on selected samples taken from the Casino-3 well.

Thank you for the opportunity to have been of service to Santos Limited. If you have any questions regarding these results or if we can be of any further assistance please do not hesitate to contact us.

Yours sincerely,
**CORE LABORATORIES AUSTRALIA PTY LTD**

Ajit Singh
Supervisor - Rock Properties Group Perth

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# SECTION 1
# INTRODUCTION AND SUMMARY

## Introduction and Summary

This report contains the final results of the mercury injection capillary pressure analysis performed on selected samples from the Casino-3 well by Core Laboratories Australia Pty. Ltd. (CoreLab). This study was conducted on behalf of Santos Limited (Santos).

A total of thirteen samples (twelve core plug samples and one MSCT sample) were selected for this study. All selected samples had previously undergone routine core analyses measurements (reference our Final RCA Report, File : PRP-03086).

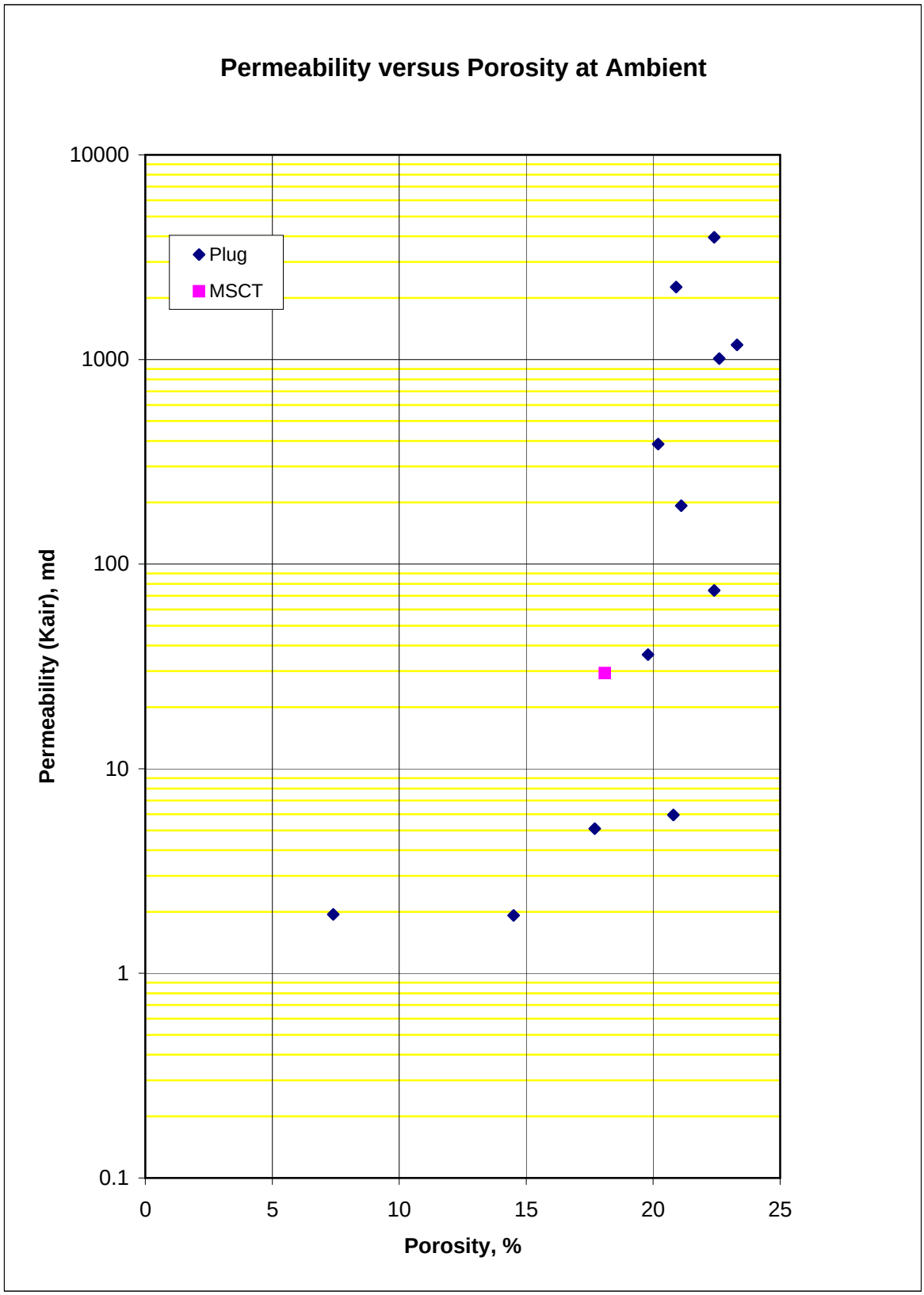
The complete list of samples which were selected for this study is presented on the following page. All the selected samples have previously undergone routine core analysis measurements at ambient (800 psi) using the CMS-300™ (automated core measurement system). The permeability (Kair) values range from 1.92 to 3950 md and porosities vary from 7.1 to 23.1 %. Grain density values range between 2.646 to 2.684 g/cc.

Results from the mercury injection capillary pressure (drainage) tests indicate mercury saturations ranging from 21.6 to 97.4 percent pore volume (% PV), representing an equivalent Swi range of 78.4 % PV to 2.6 % PV. Note that clay fabric can be altered by the sheer weight of mercury causing unrepresentative enlargements of pore throats, leading to increased mercury injection at a given capillary pressure, and therefore unrepresentatively low values of equivalent Sw.

# Sample selection and base data

| Plug / MSCT | ID | Depth (m) | At Ambient | | Grain Density (g/cc) |
|---|---|---|---|---|---|
| | | | Kair* (md) | Porosity** (%) | |
| Plug | 1 | 2004.37 | 3950 | 22.5 | 2.652 |
| Plug | 5 | 2005.46 | 2260 | 20.9 | 2.655 |
| Plug | 10 | 2006.94 | 386 | 20.3 | 2.659 |
| Plug | 17 | 2009.11 | 1180 | 23.1 | 2.649 |
| Plug | 20 | 2009.94 | 193 | 21.1 | 2.679 |
| Plug | 27 | 2012.13 | 1010 | 22.4 | 2.648 |
| Plug | 42 | 2016.68 | 1.94 | 7.1 | 2.684 |
| Plug | 46 | 2017.90 | 5.09 | 17.7 | 2.646 |
| Plug | 48 | 2018.48 | 36.1 | 19.8 | 2.667 |
| Plug | 52 | 2019.60 | 74.4 | 22.4 | 2.654 |
| Plug | 62 | 2022.60 | 1.92 | 14.5 | 2.682 |
| Plug | 73 | 2025.90 | 5.95 | 20.8 | 2.675 |
| MSCT | 8 | 2062.50 | 25.1 | 18.2 | 2.661 |

* Reported Kair values are those of the whole core plug (our file ref : PRP-03086).
** Reported porosity values were re-measured, on one half portion of the core plug, prior to mercury-injection analysis.


Permeability versus Porosity at Ambient
Plug
MSCT
Permeability (Kair), md
10000
1000
100
10
1
0.1
0
5
10
15
20
25
Porosity, %

# SECTION 2
# CAPILLARY PRESSURE

## Experimental Procedures

Twelve core plug samples and one MSCT sample were selected for mercury injection capillary pressure analysis. Half of each core plug and the entire MSCT sample was utilised during the mercury capillary pressure tests.

All samples were re-dried and sample grain volume re-determined. Samples were then each loaded into the mercury injection apparatus. Initially, the sample bulk volume was determined at ambient and the porosity value calculated.

Mercury was then injected into the core at increasing incremental pressures from 0 to 2,000 psia. Mercury saturation data were monitored at every stage through the test and, from these, the air-mercury capillary pressure curves and pore size distribution data were calculated. Results are presented within pages 2-2 to 2-17 of this report.

# Mercury Injection Capillary Pressure Analysis Results

| Sample no. | 1 | 5 | 10 | 17 | 20 |
|---|---|---|---|---|---|
| Depth (m) | 2004.37 | 2005.46 | 2006.94 | 2009.11 | 2009.94 |
| K air (md) | 3950 | 2260 | 386 | 1180 | 193 |
| Porosity (%) | 22.5 | 20.9 | 20.3 | 23.1 | 21.1 |

| Injection pressure (psia) | Pore throat radii (microns) | Mercury Saturation, Percent pore space * | | | | |
|---|---|---|---|---|---|---|
| **3** | **35.5** | 3.2 | 0.9 | 0.0 | 0.0 | 0.0 |
| **6** | **17.7** | 24.4 | 17.2 | 1.7 | 2.2 | 0.0 |
| **9** | **11.8** | 50.9 | 52.8 | 4.3 | 18.4 | 0.0 |
| **12** | **8.9** | 64.9 | 66.1 | 32.1 | 52.1 | 6.3 |
| **15** | **7.1** | 70.3 | 70.5 | 41.7 | 61.0 | 22.3 |
| **18** | **5.9** | 74.3 | 73.5 | 47.6 | 66.1 | 35.3 |
| **21** | **5.1** | 77.2 | 75.6 | 51.9 | 69.4 | 46.2 |
| **24** | **4.4** | 78.8 | 77.3 | 54.6 | 71.0 | 49.5 |
| **27** | **3.9** | 80.2 | 78.8 | 56.8 | 72.5 | 52.3 |
| **30** | **3.6** | 81.4 | 79.8 | 58.5 | 73.9 | 54.4 |
| **40** | **2.7** | 83.4 | 81.9 | 63.6 | 76.9 | 60.0 |
| **60** | **1.8** | 86.5 | 84.6 | 69.8 | 81.4 | 65.7 |
| **80** | **1.3** | 88.1 | 86.1 | 73.1 | 83.2 | 69.3 |
| **100** | **1.1** | 89.1 | 87.4 | 75.9 | 84.8 | 72.7 |
| **200** | **0.53** | 91.8 | 90.7 | 82.9 | 88.7 | 79.1 |
| **300** | **0.36** | 93.3 | 92.2 | 86.4 | 91.0 | 81.8 |
| **500** | **0.21** | 94.8 | 93.8 | 90.0 | 93.6 | 85.0 |
| **750** | **0.14** | 95.6 | 94.7 | 91.9 | 95.1 | 87.7 |
| **1000** | **0.11** | 96.2 | 95.3 | 92.6 | 95.6 | 89.3 |
| **1250** | **0.085** | 96.6 | 95.7 | 93.2 | 95.9 | 90.7 |
| **1500** | **0.071** | 97.0 | 95.9 | 93.5 | 96.2 | 91.7 |
| **1750** | **0.061** | 97.2 | 96.0 | 93.7 | 96.3 | 92.3 |
| **2000** | **0.053** | 97.4 | 96.1 | 93.8 | 96.4 | 92.7 |

***** Can also be considered to be the percent of pore space having pore throat entry sizes of that radii or greater.

# Mercury Injection Capillary Pressure Analysis Results

| Sample no. | 27 | 42 | 46 | 48 | 52 |
|---|---|---|---|---|---|
| Depth (m) | 2012.13 | 2016.68 | 2017.90 | 2018.48 | 2019.60 |
| K air (md) | 1010 | 1.94 | 5.09 | 36.1 | 74.4 |
| Porosity (%) | 22.4 | 7.1 | 17.7 | 19.8 | 22.4 |

| Injection pressure (psia) | Pore throat radii (microns) | Mercury Saturation, Percent pore space * | | | | |
|---|---|---|---|---|---|---|
| 3 | 35.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | 17.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 | 11.8 | 20.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| 12 | 8.9 | 50.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| 15 | 7.1 | 59.3 | 0.0 | 0.0 | 1.0 | 0.0 |
| 18 | 5.9 | 63.6 | 0.0 | 0.0 | 7.5 | 4.7 |
| 21 | 5.1 | 66.0 | 0.0 | 0.0 | 19.8 | 16.7 |
| 24 | 4.4 | 67.9 | 0.0 | 0.0 | 25.1 | 23.2 |
| 27 | 3.9 | 69.2 | 0.0 | 0.0 | 29.3 | 29.4 |
| 30 | 3.6 | 70.5 | 0.0 | 0.5 | 33.1 | 35.1 |
| 40 | 2.7 | 72.5 | 0.0 | 4.2 | 39.7 | 43.2 |
| 60 | 1.8 | 75.9 | 0.0 | 16.6 | 46.8 | 51.1 |
| 80 | 1.3 | 78.2 | 0.0 | 24.4 | 51.2 | 55.6 |
| 100 | 1.1 | 80.1 | 0.0 | 30.1 | 54.9 | 58.9 |
| 200 | 0.53 | 84.5 | 0.0 | 46.5 | 64.8 | 69.3 |
| 300 | 0.36 | 87.0 | 0.0 | 55.1 | 69.4 | 73.9 |
| 500 | 0.21 | 90.0 | 0.0 | 64.8 | 74.2 | 79.5 |
| 750 | 0.14 | 92.2 | 0.5 | 70.9 | 77.9 | 82.4 |
| 1000 | 0.11 | 93.6 | 8.3 | 74.2 | 79.7 | 84.0 |
| 1250 | 0.085 | 94.8 | 12.5 | 76.8 | 81.2 | 85.3 |
| 1500 | 0.071 | 95.3 | 16.4 | 78.7 | 82.4 | 86.4 |
| 1750 | 0.061 | 95.6 | 19.4 | 80.2 | 83.1 | 87.2 |
| 2000 | 0.053 | 95.9 | 21.6 | 81.4 | 83.8 | 87.8 |

* Can also be considered to be the percent of pore space having pore throat entry sizes of that radii or greater.

# Mercury Injection Capillary Pressure Analysis Results

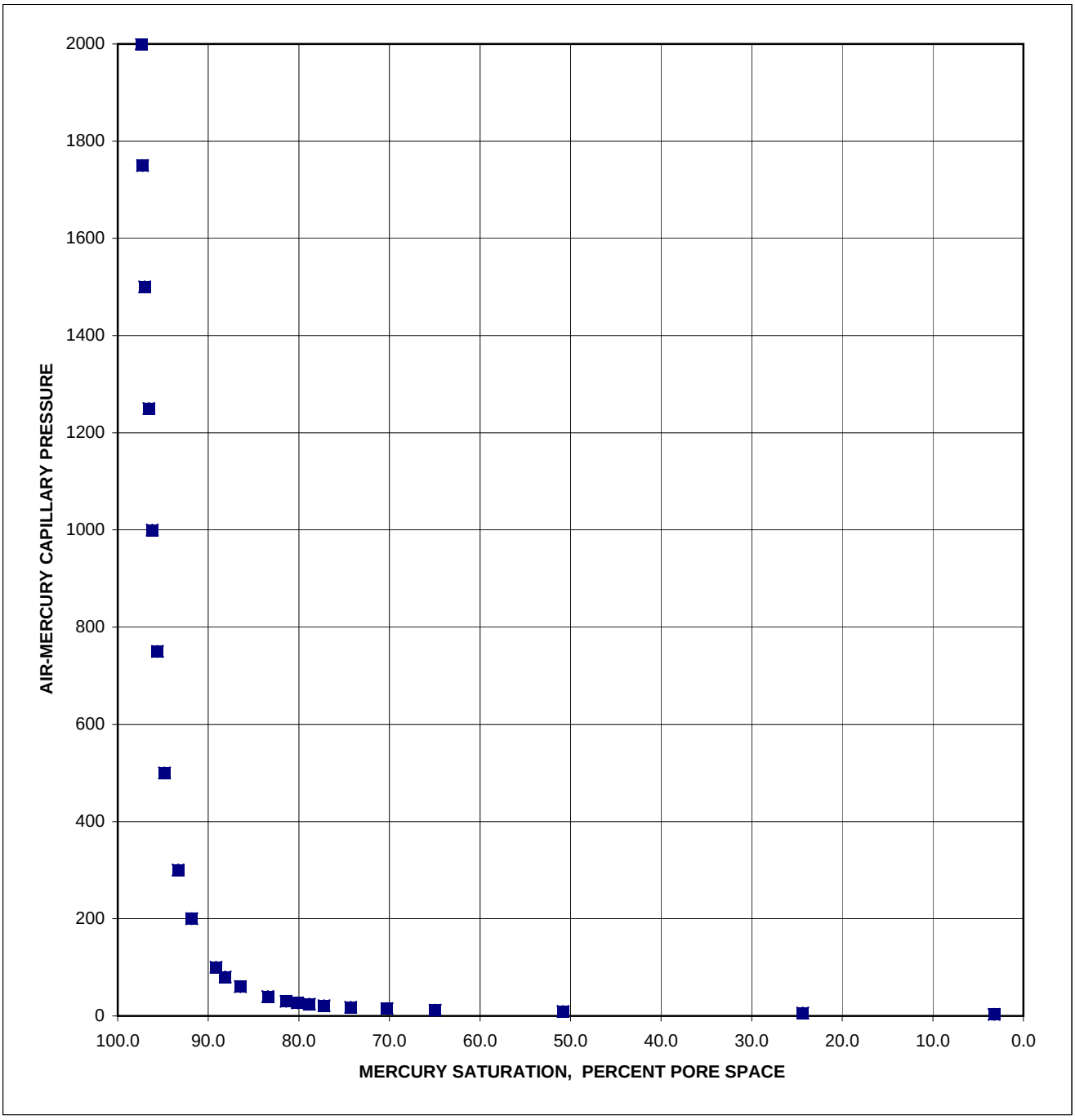
| Sample no. | 62 | 73 | MSCT 8 | | |
|---|---|---|---|---|---|
| Depth (m) | 2022.60 | 2025.90 | 2062.50 | | |
| K air (md) | 1.92 | 5.95 | 25.1 | | |
| Porosity (%) | 14.5 | 20.8 | 18.2 | | |

| Injection pressure (psia) | Pore throat radii (microns) | Mercury Saturation, Percent pore space * | | | | |
|---|---|---|---|---|---|---|
| 3 | 35.5 | 0.0 | 0.0 | 0.0 | | |
| 6 | 17.7 | 0.0 | 0.0 | 0.0 | | |
| 9 | 11.8 | 0.0 | 0.0 | 0.0 | | |
| 12 | 8.9 | 0.0 | 0.0 | 0.0 | | |
| 15 | 7.1 | 0.0 | 0.0 | 0.0 | | |
| 18 | 5.9 | 0.0 | 0.0 | 0.9 | | |
| 21 | 5.1 | 0.0 | 0.0 | 11.4 | | |
| 24 | 4.4 | 0.0 | 0.0 | 20.3 | | |
| 27 | 3.9 | 0.0 | 0.0 | 25.0 | | |
| 30 | 3.6 | 0.0 | 0.0 | 28.4 | | |
| 40 | 2.7 | 0.0 | 0.0 | 33.7 | | |
| 60 | 1.8 | 0.0 | 3.5 | 42.1 | | |
| 80 | 1.3 | 6.5 | 20.8 | 48.2 | | |
| 100 | 1.1 | 13.3 | 28.9 | 51.9 | | |
| 200 | 0.53 | 37.7 | 45.5 | 62.8 | | |
| 300 | 0.36 | 47.7 | 52.6 | 67.5 | | |
| 500 | 0.21 | 58.9 | 60.3 | 73.6 | | |
| 750 | 0.14 | 66.2 | 66.1 | 78.7 | | |
| 1000 | 0.11 | 70.4 | 69.4 | 81.6 | | |
| 1250 | 0.085 | 73.0 | 71.9 | 83.1 | | |
| 1500 | 0.071 | 75.4 | 73.9 | 84.3 | | |
| 1750 | 0.061 | 76.9 | 75.5 | 85.0 | | |
| 2000 | 0.053 | 78.1 | 76.7 | 85.4 | | |

* Can also be considered to be the percent of pore space having pore throat entry sizes of that radii or greater.

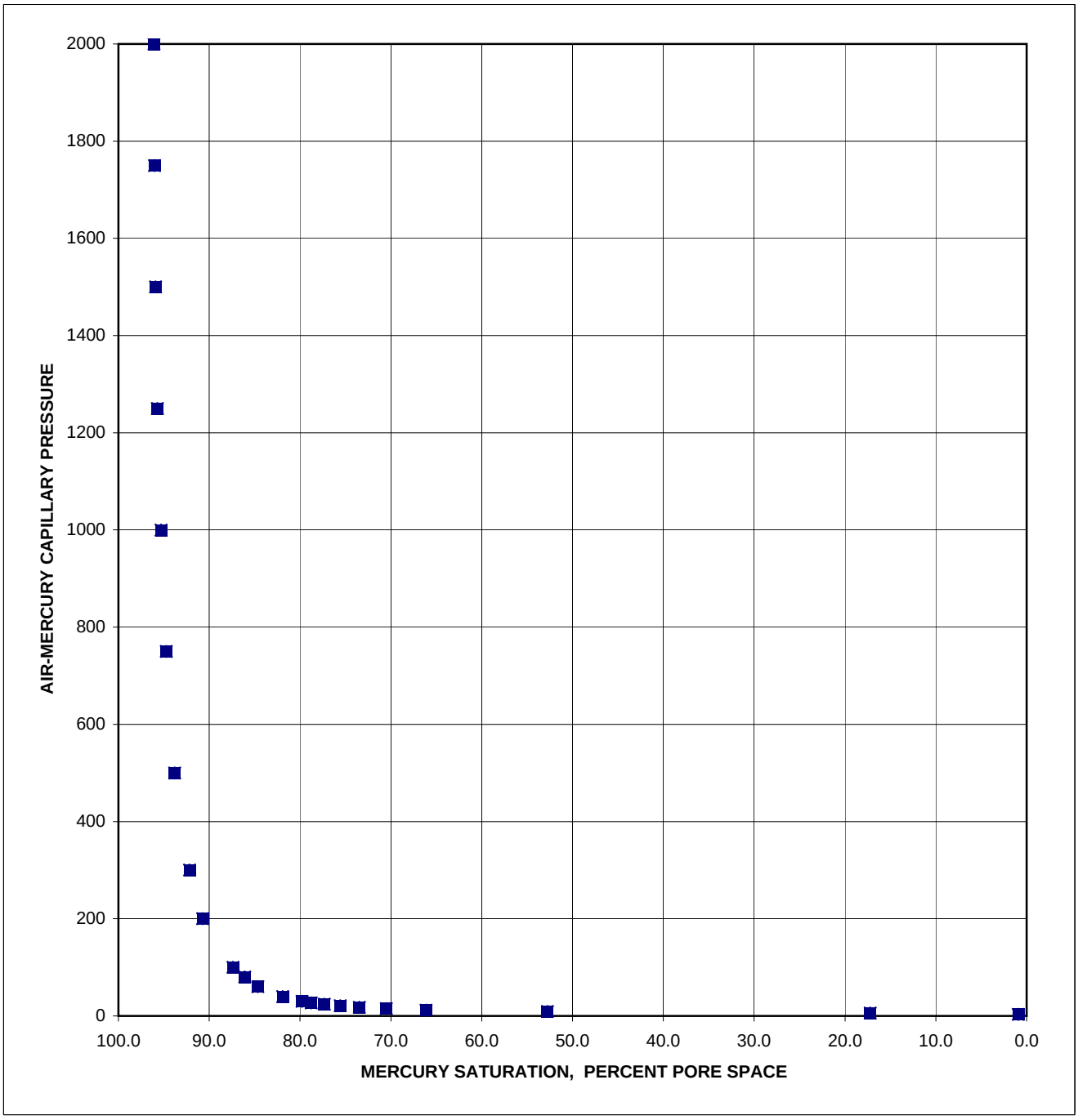
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 1 |
| **Depth (m)** | 2004.37 |
| **K air (md)** | 3950 |
| **Porosity (%)** | 22.5 |



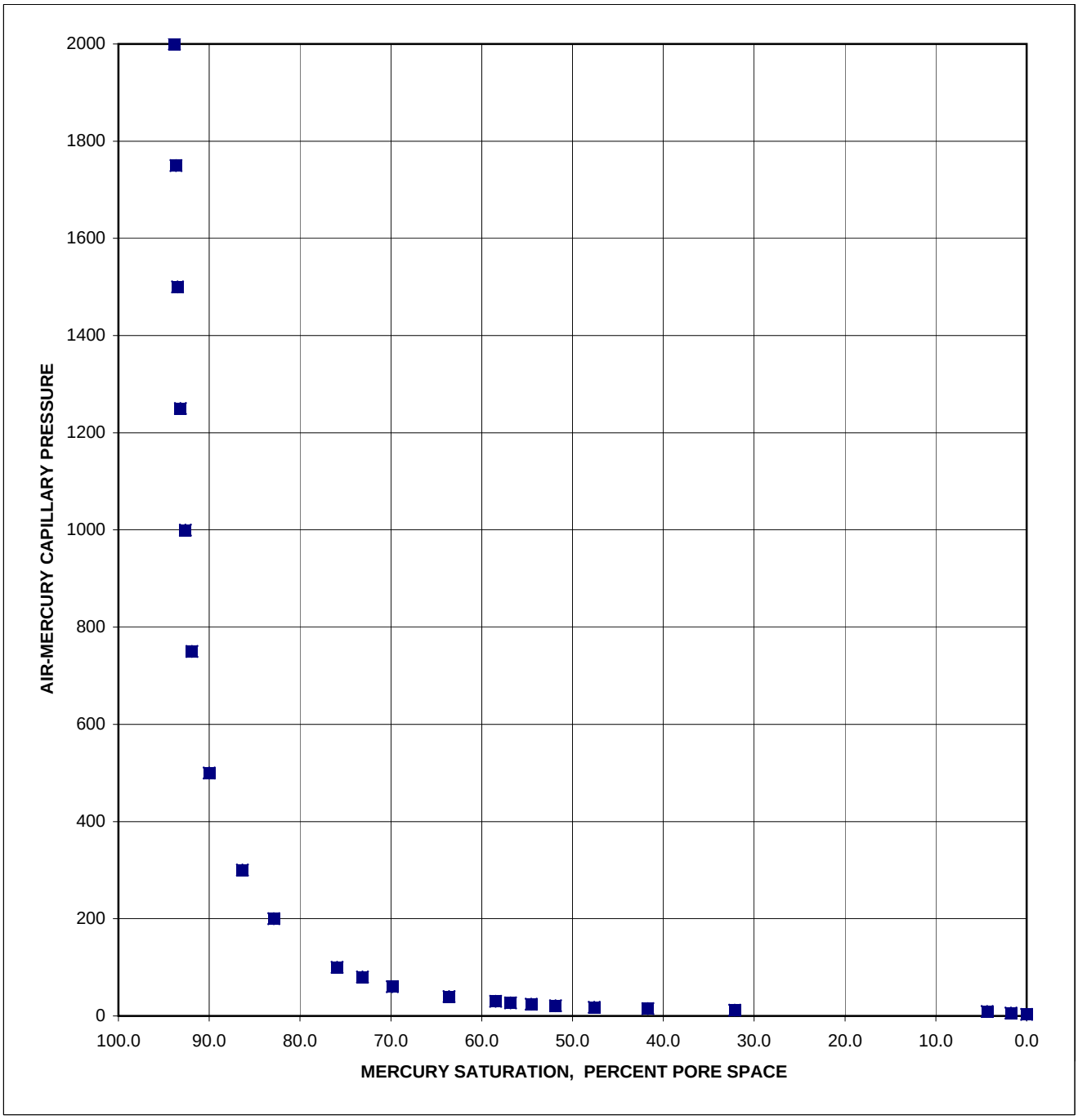
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 5 |
| **Depth (m)** | 2005.46 |
| **K air (md)** | 2260 |
| **Porosity (%)** | 20.9 |



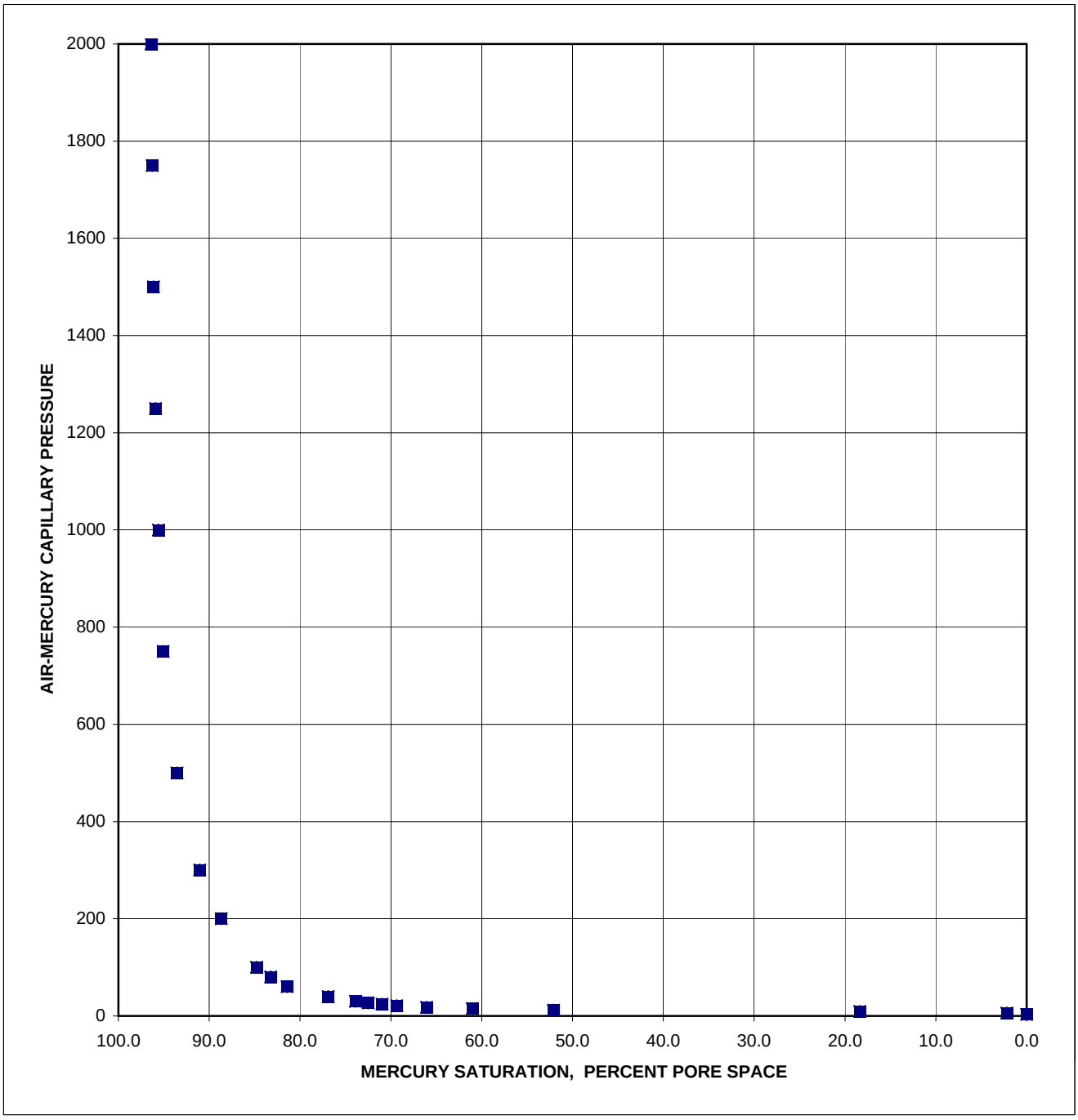
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 10 |
| **Depth (m)** | 2006.94 |
| **K air (md)** | 386 |
| **Porosity (%)** | 20.3 |



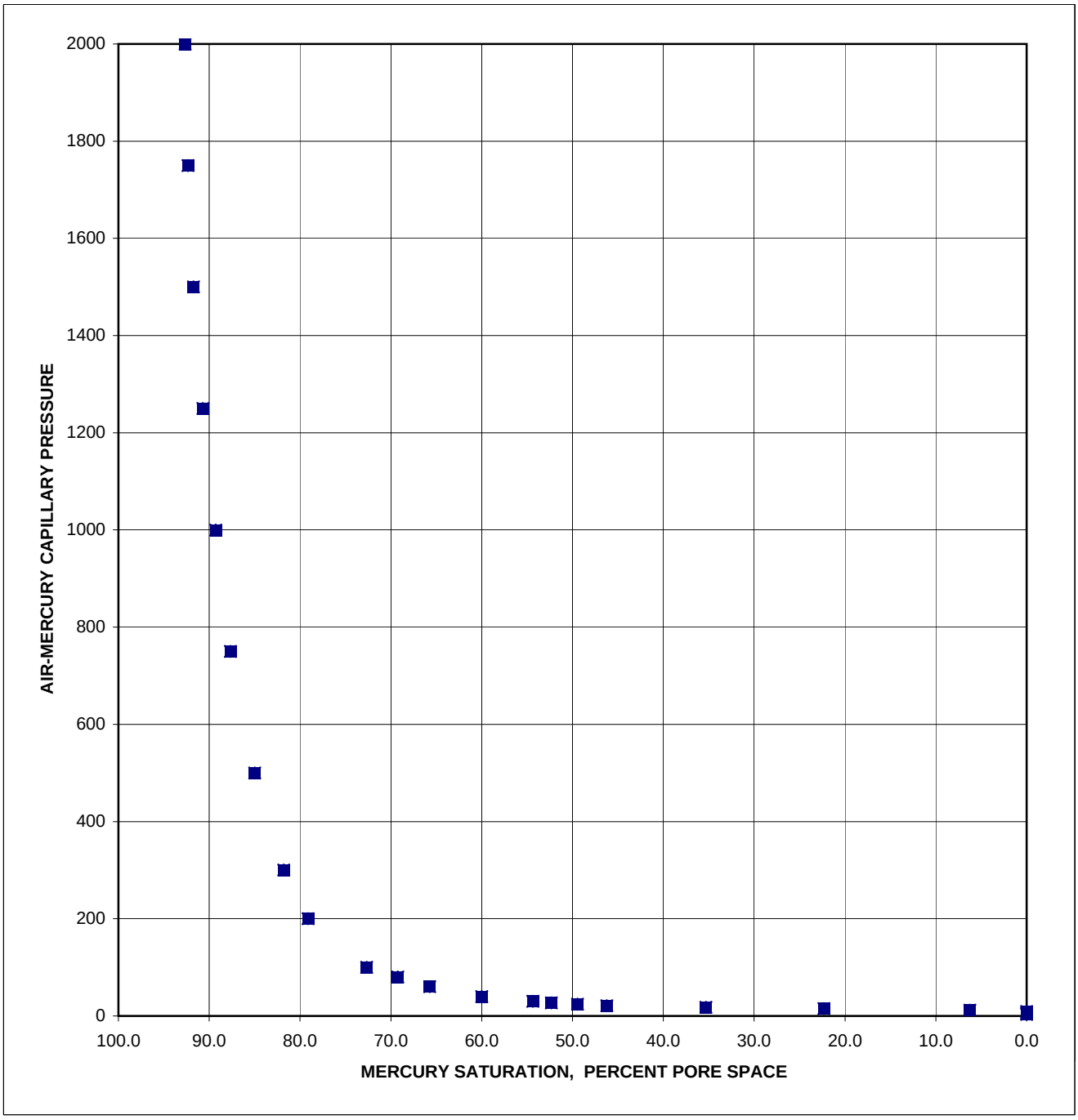
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 17 |
| **Depth (m)** | 2009.11 |
| **K air (md)** | 1180 |
| **Porosity (%)** | 23.1 |



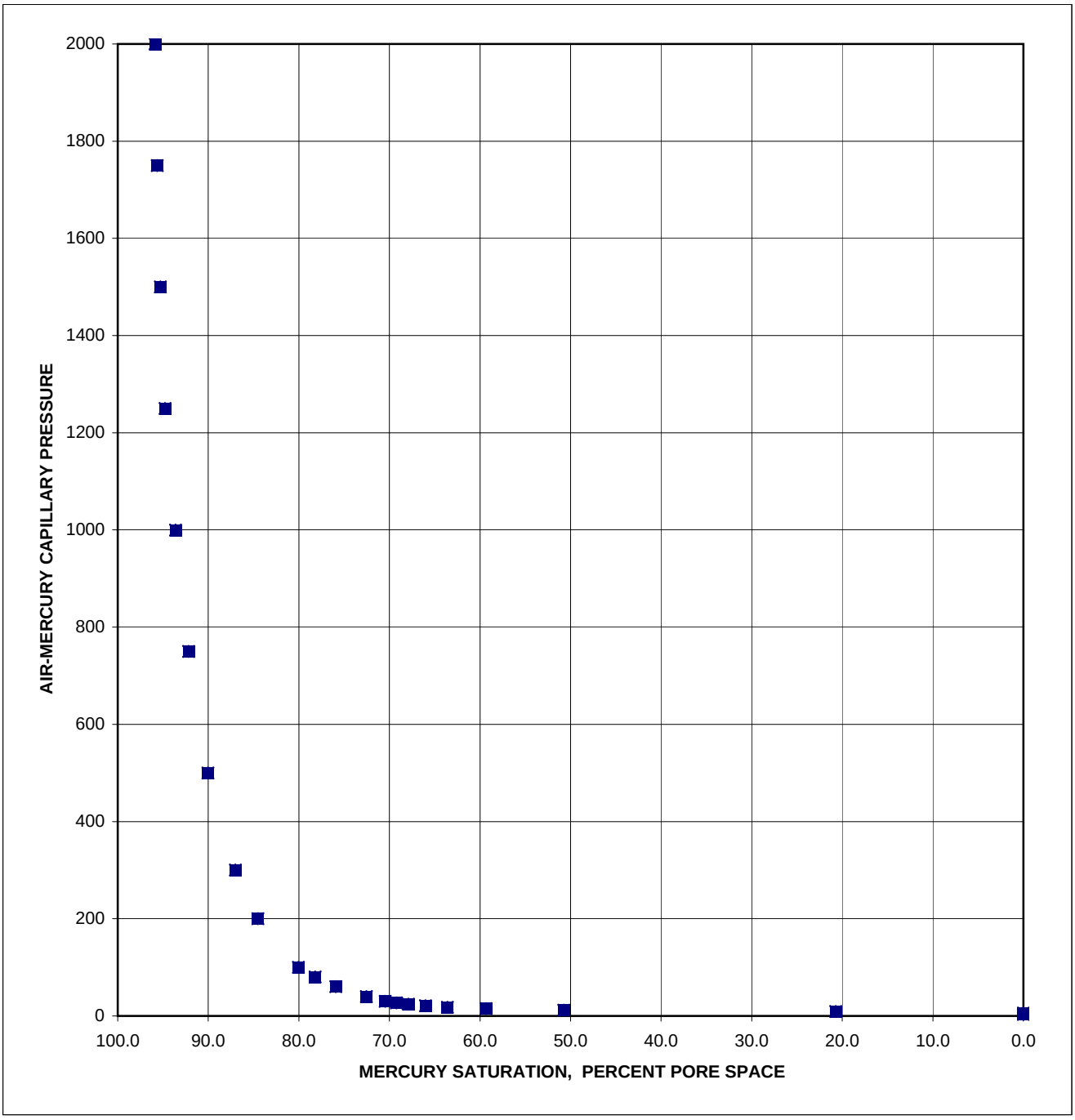
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 20 |
| **Depth (m)** | 2009.94 |
| **K air (md)** | 193 |
| **Porosity (%)** | 21.1 |



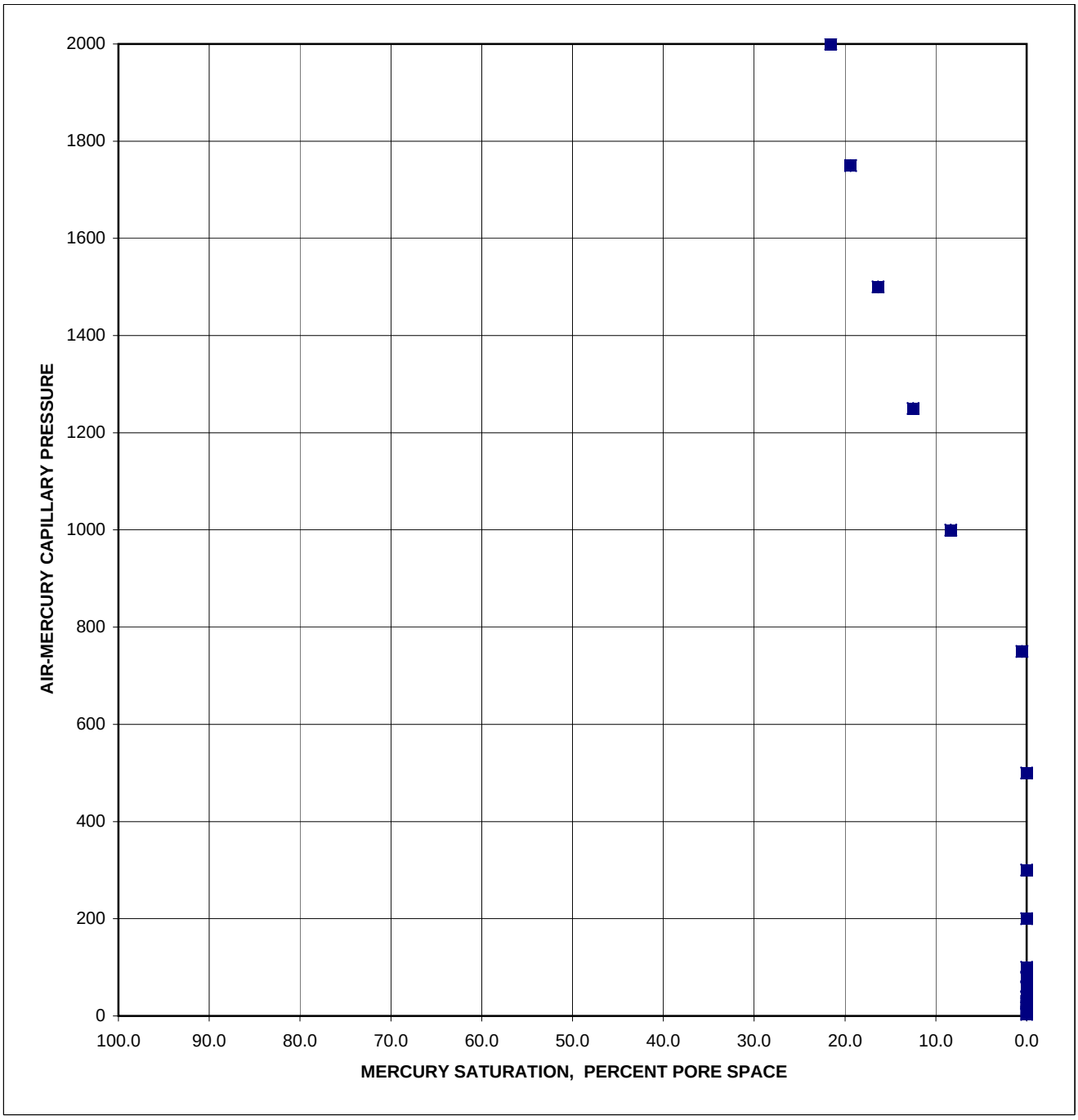
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 27 |
| **Depth (m)** | 2012.13 |
| **K air (md)** | 1010 |
| **Porosity (%)** | 22.4 |



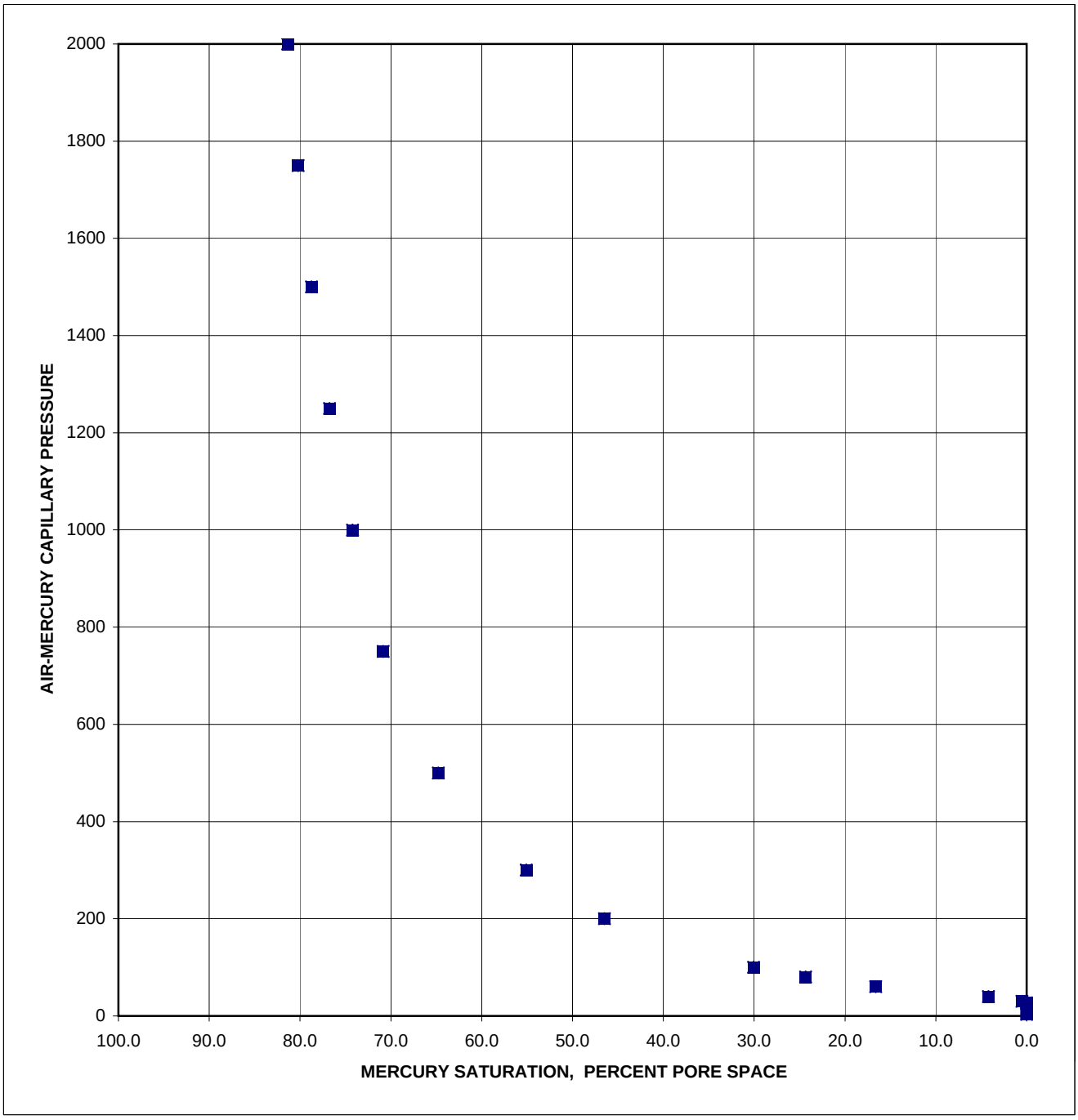
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 42 |
| **Depth (m)** | 2016.68 |
| **K air (md)** | 1.94 |
| **Porosity (%)** | 7.1 |



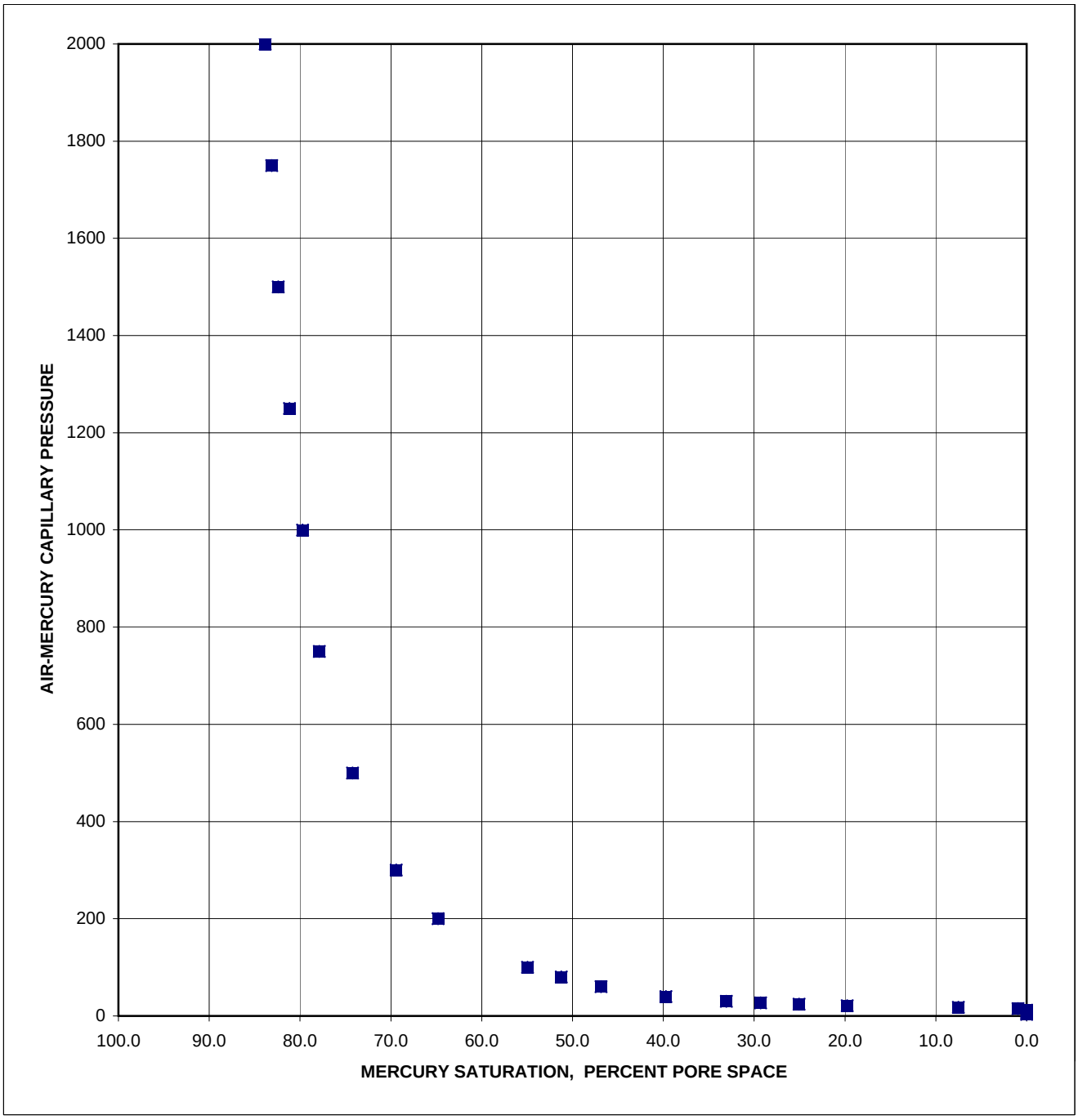
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 46 |
| **Depth (m)** | 2017.90 |
| **K air (md)** | 5.09 |
| **Porosity (%)** | 17.7 |



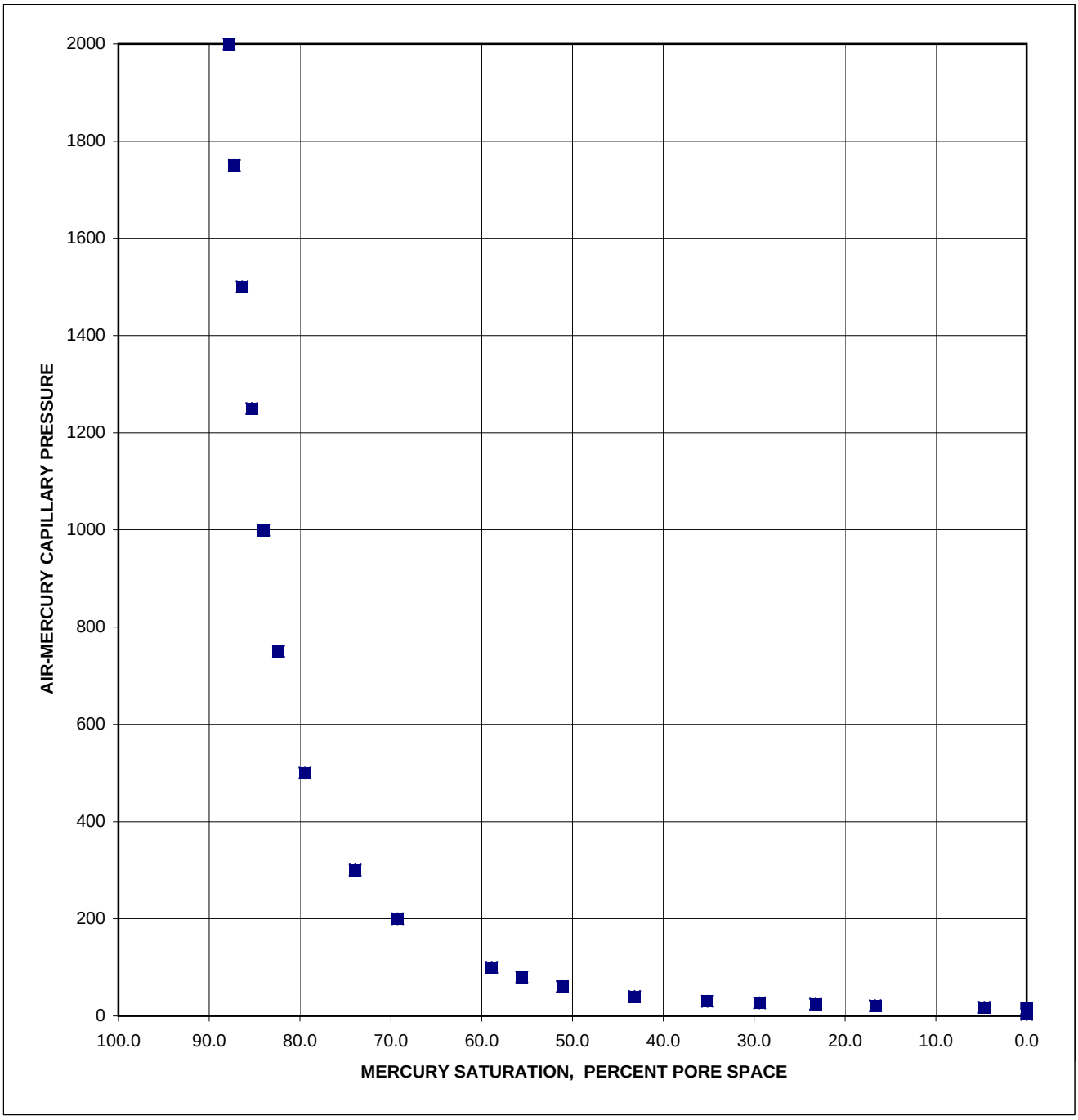
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 48 |
| **Depth (m)** | 2018.48 |
| **K air (md)** | 36.1 |
| **Porosity (%)** | 19.8 |



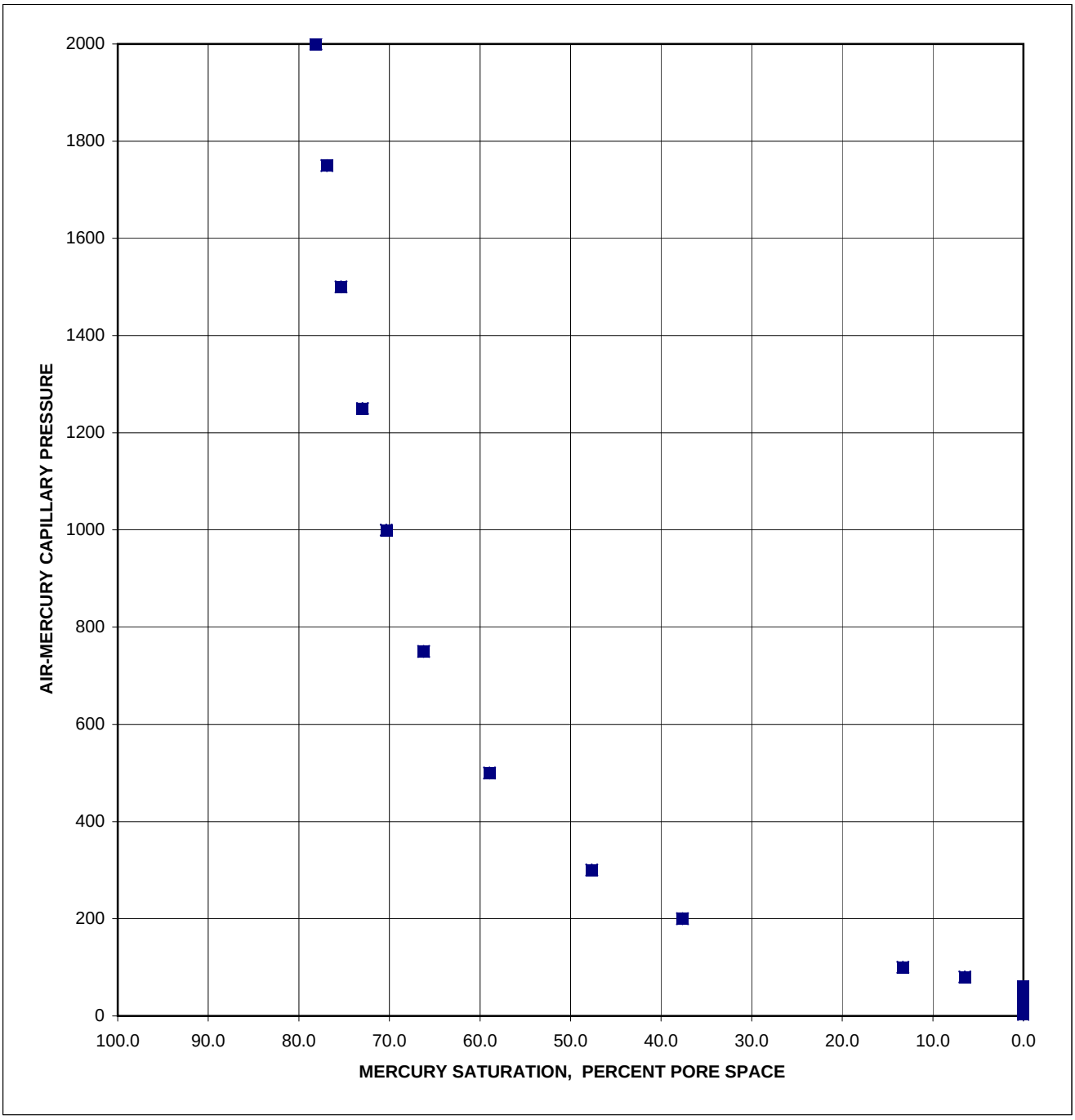
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 52 |
| **Depth (m)** | 2019.60 |
| **K air (md)** | 74.4 |
| **Porosity (%)** | 22.4 |



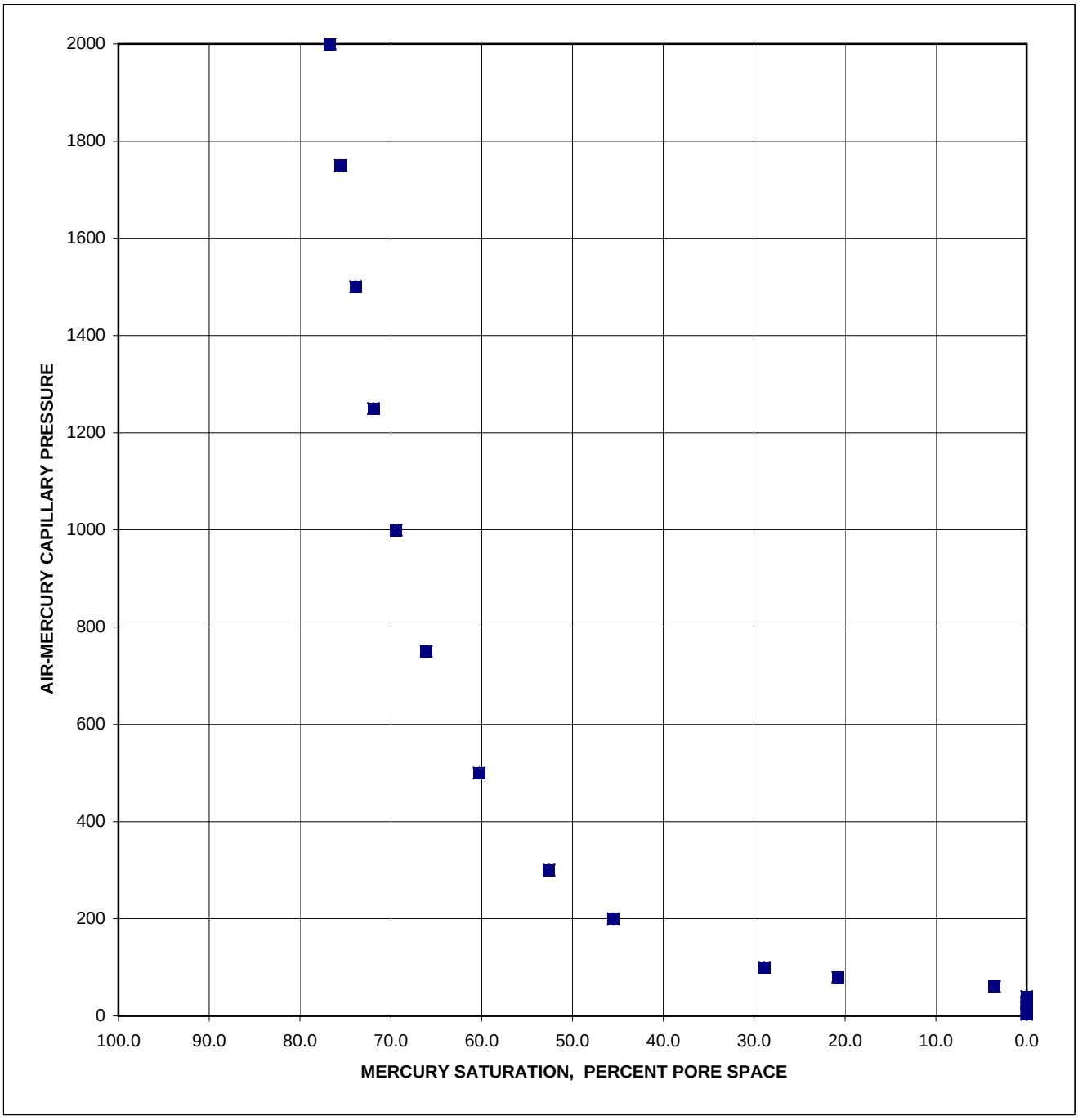
# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 62 |
| **Depth (m)** | 2022.60 |
| **K air (md)** | 1.92 |
| **Porosity (%)** | 14.5 |



# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | 73 |
| **Depth (m)** | 2025.90 |
| **K air (md)** | 5.95 |
| **Porosity (%)** | 20.8 |



# Mercury Injection Capillary Pressure Analysis Results

| | |
|---|---|
| **Sample no.** | MSCT 8 |
| **Depth (m)** | 2062.50 |
| **K air (md)** | 25.1 |
| **Porosity (%)** | 18.2 |