TECNOLÓGICO DE MONTERREY

# CHARACTERISTICS OF NANOPARTICLE ACCUMULATION IN LIGHT DUTY MOTOR VEHICLE FROM MEXICO

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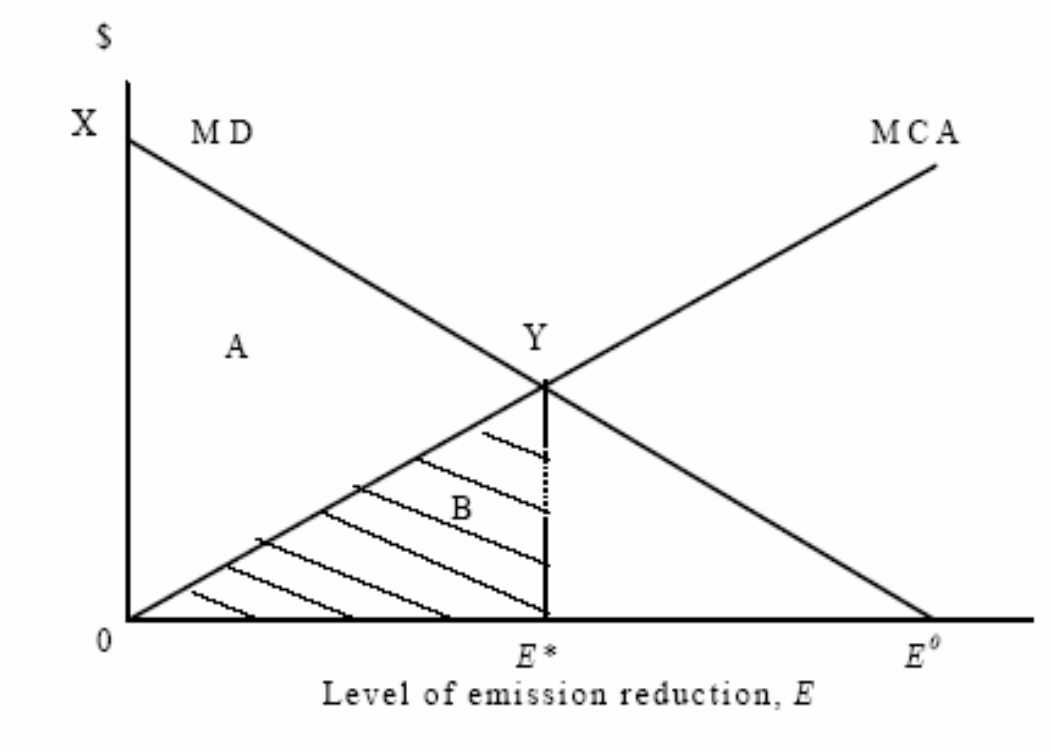
# INTERIOR AIR QUALITY, IAQ

- In Interior living or working Environment air contains about 900 contaminants, from various sources (EPA, 1989)

- IAQ Interior Air Quality problems are associated with:
  - improper ventilation 53%,
  - External Contamination 10%,
  - Microbial Contamination 5%,
  - Contamination by Construction materials 4%,
  - Unknown source 13% (OSHA, 1997)

Suspended particle in the Interior Environment is of great Health Concern (GRAMAGE, 1985)

# The goal is not to reduce environmental damages to zero, but to achieve an 'optimal emission level'




The optimal level of pollution is achieved when the marginal damage (MD) equals society's marginal cost of abating (MCA) that damage

B : total cost for society to abate this optimal level of pollution
A+B: total damage avoided

The additional cost of moving from one level to another is called the "marginal cost".

# INTRODUCTION

- Suspended Particles
- $PM_{10}$,$PM_{2.5}$ NPS???

  2µm ($PM_{2.5}$) Inhalation or ingestion of contaminated air with $PM_{2.5}$ can enter into blood circulation system (Popescu, 1995, Zarrkewski, 1998)

  $PM_{2.5}$ Reduced Visibility, Health Concern…..

# IMPACTS THAT CAN RESULT FROM DIFFERENT DISCHARGES

| Source of environmental impacts | Human health | | | Material | Biological resources | | | | | | Global climate | Others | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mortality | Mobidity | Accident | | Crops | Forests | Fisherie | Aquatic | Terrestri | Ground water | | Visibility | Aesthetic | Other |
| **Air pollution** | | | | | | | | | | | | | | |
| Particulate matters | x | x | | x | | | | | | | | x | | |
| SO2 | x | x | | x | x | x | | x | | | | x | | |
| NOX | | x | | | x | x | | x | | | | x | | |
| Toxics, Lead, Mercury | x | x | | | x | x | x | x | x | x | | | | |
| CO | x | x | | | | | | | | | | | | |
| CO2/GHG | x | x | | | x | x | x | x | x | | x | | | |
| Radioactive | x | x | | | x | x | x | x | x | | | | | |
| Acids aerosols | x | x | | | | | | | | | | x | | |
| Acid deposition | | | | x | x | x | x | x | x | | | | | |
| Ozone (HC, VOC) | | x | | x | x | x | | | x | | | x | | |
| **Surface water disposal** | | | | | | | | | | | | | | |
| Chemicals | x | x | | | x | | x | x | x | | | | x | |
| Thermal | | | | | | | x | x | | | | | | x |
| Radioactive | x | x | | | | | x | x | | | | | | |
| Impoundment/Passage | | | | | | | x | x | x | | | | x | x |
| Consumption | | | | | | | | | | x | | | | x |
| **Solid waste disposal** | | | | | | | | | | | | | | |
| Transportation | | | x | | | | | | | | | | x | |
| Volume/Land use | | | | | | | | | x | | | | x | |
| Hazardous | x | x | | | | | x | x | | x | | | | |
| Toxics in ahs | x | x | | | | | x | x | | x | | | | |
| Radioactive (high and low) | x | x | | | | | x | x | x | x | | | | |

# NANOPARTICLES

## Impact Pathways Analysis – IPA

## Exposure Risk

- How are receptors exposed to Nanoparticles?
  (inhalation, ingestion, soil uptake, …)

- Who are the potential receptors of Nanoparticles?
  (adults, children, crops, forests, …)

- Is the receptor exposed to the Nanoparticle?

- What is the concentration of NPs, in the environment: air, water and soil?
  (pollutant fate or multi-media analysis)

# NANOPARTICLES Pathways Analysis – IPA

## Exposure route of Nanoparticles

**How does the NPs enter the receptor?**

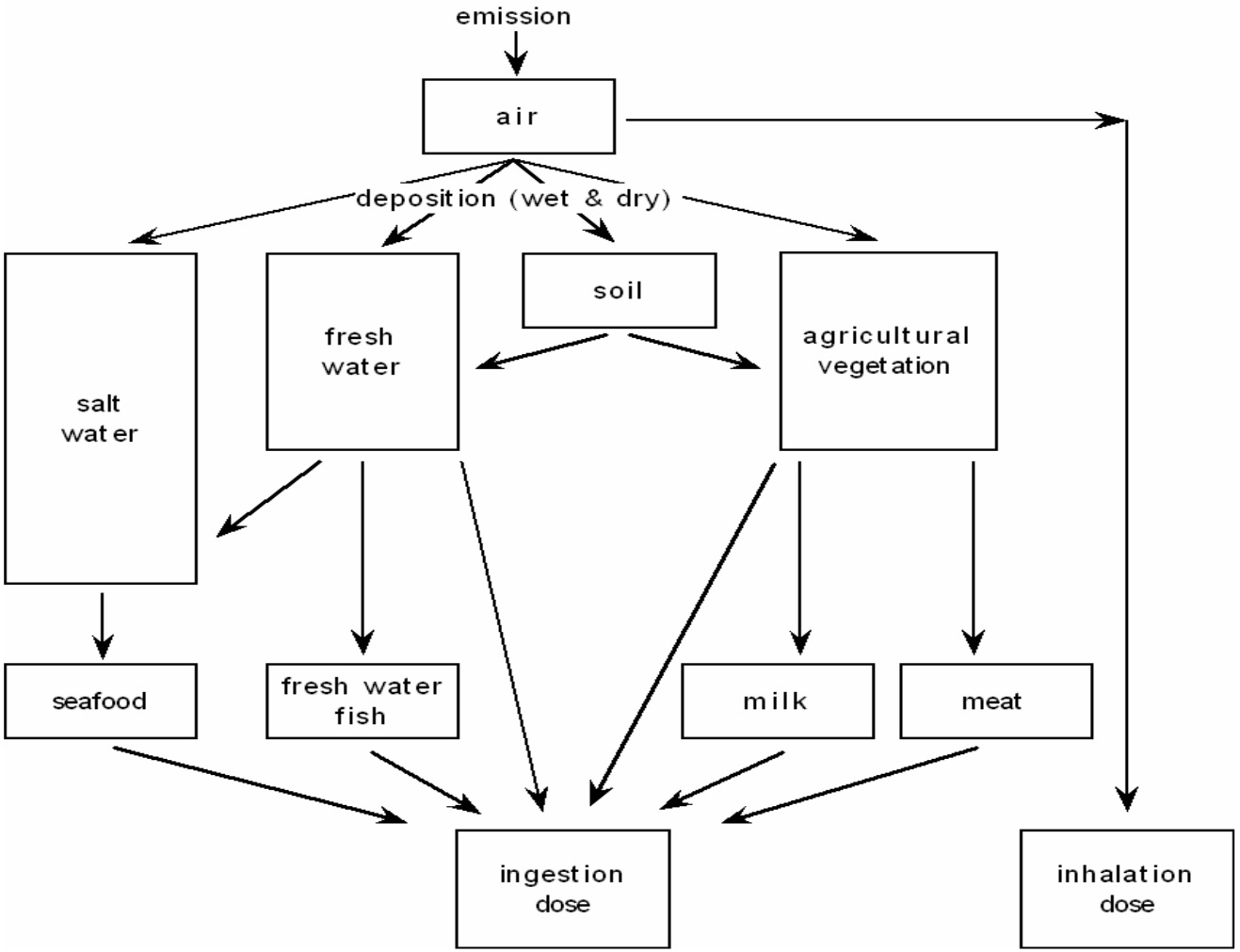
**What is the dose?**

**- for humans by breathing, drinking, eating and skin contact (dose = exposure × intake)**

**- for crops by foliar contact and soil uptake**

**- for materials by surface contact and wet deposition**

***NB, not all routes are equally toxic!***



# Which Pollutants, Which Impacts? ExternE 2000

## Major Health Exposure-Response Functions

| Receptor | Impact Category | Pollutant | fer |
|---|---|---|---|
| **ADULTS** | | | |
| | Restricted activity days | $PM_{10}$, Nitrates, Sulfates | 0.025<br>0.025<br>0.042 |
| | Chronic bronchitis | $PM_{10}$, Nitrates, Sulfates | 2.5E-5<br>2.5E-5<br>3.9E-5 |
| **ENTIRE POPULATION** | | | |
| | Acute mortality (YOLL) | $SO_2$ | 5.4E-6 |
| | Chronic mortality (YOLL) | $PM_{10}$, Nitrates, $PM_{2.5}$, Sulfates | 1.57E-4<br>1.57E-4<br>2.60E-4<br>2.60E-4 |

$f_{er}$, has units of [cases/(yr-person-µg/m$^3$)] for morbidity, and [YOLL/(yr-person-µg/m$^3$)] for mortality Source: ExternE 2000

# EcoSense Model: Comparison between continents – Years of Life Lost (YOLL) resulting from the emisson of one kilo-tonne of pollutant

| | YOLL / kt_ $SO_2$ direct exposure | YOLL / kt_ $SO_2$ sulfate aerosols | YOLL / kt_ $NO_x$ nitrate aerosols | YOLL/kt _$PM_{10}$ direct exposure |
|---|---|---|---|---|
| **EU-15 average** | **1.7** | **27.0** | **28.5** | **56.7** |
| Germany | 2.2 | 31.6 | 27.9 | 68.6 |
| France | 2.3 | 40.0 | 51.4 | 62.9 |
| Sweden | 0.4 | 9.6 | 11.5 | 7.3 |
| Finland | 0.3 | 7.0 | 7.8 | 6.0 |
| **Asia average** | **2.5** | **55.2** | **56.9** | **130.8** |
| China | 4.6 | 104.7 | 145.2 | 131.7 |
| Japan | 2.5 | 36.1 | 39.7 | 84.6 |
| South Corea | 3.5 | 50.3 | 47.6 | 101.0 |
| **South America av.** | **0.34** | **4.9** | **6.8** | **16.3** |
| Brazil | 1.2 | 13.3 | 10.9 | 16.4 |
| State of Sao Paulo | 3.9 | 38.5 | 52.5 | 39.9 |
| Colombia | 0.33 | 3.6 | 6.0 | 5.5 |

Source: Krewitt at al. (2001);, Int. J. of Life CycleAssessment 6 (4), pp. 199-210

# OBJETIVES

Evaluation, Characterization (Physical and Chemical) of Nanoparticles in the Light Motor Vehicle Cabin

Dimension (Shape and Size), Chemical Composition

Rate of deposition, detect the source y Methods of control

# MEXICO METROPOLITAN VALLEY ZONE ZMVM

Area: 4681 $km^2$

Population: 16 millon

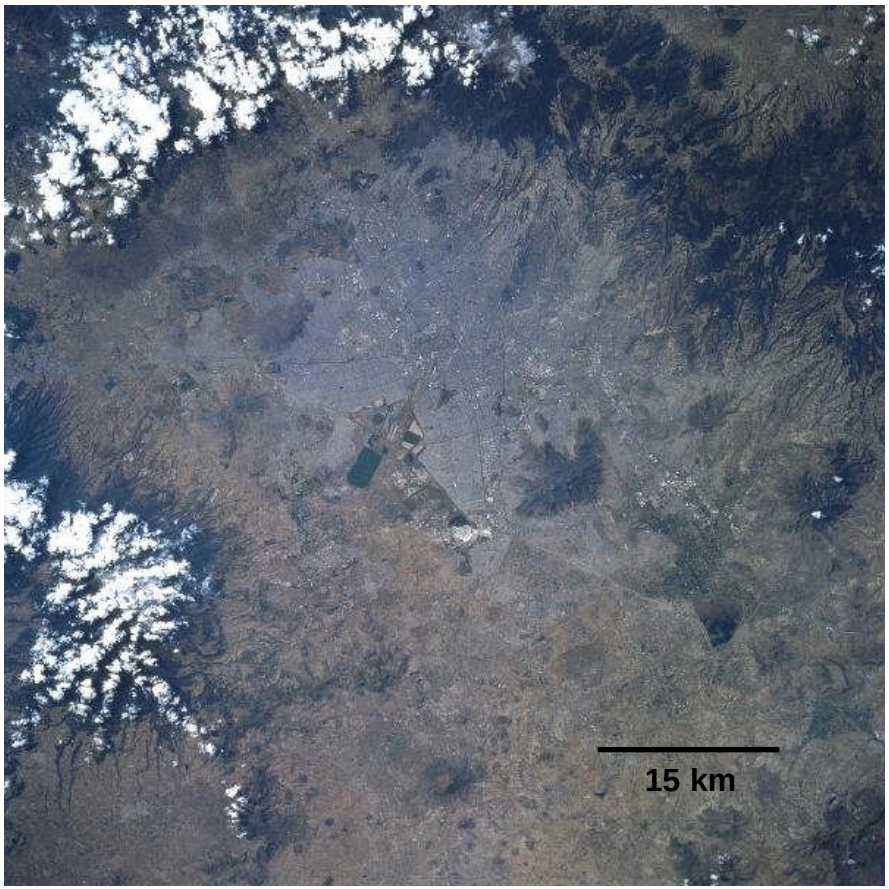
Popoulation Density: 3500 hab/ $km^2$

Industries, Commercial,

Service establishments: 44580

Number of Vehicles: 4.5 millon (INEGI-SEMARNAT, 2004)

Altitude: 2240 m,




Satellite Image of ZMVM

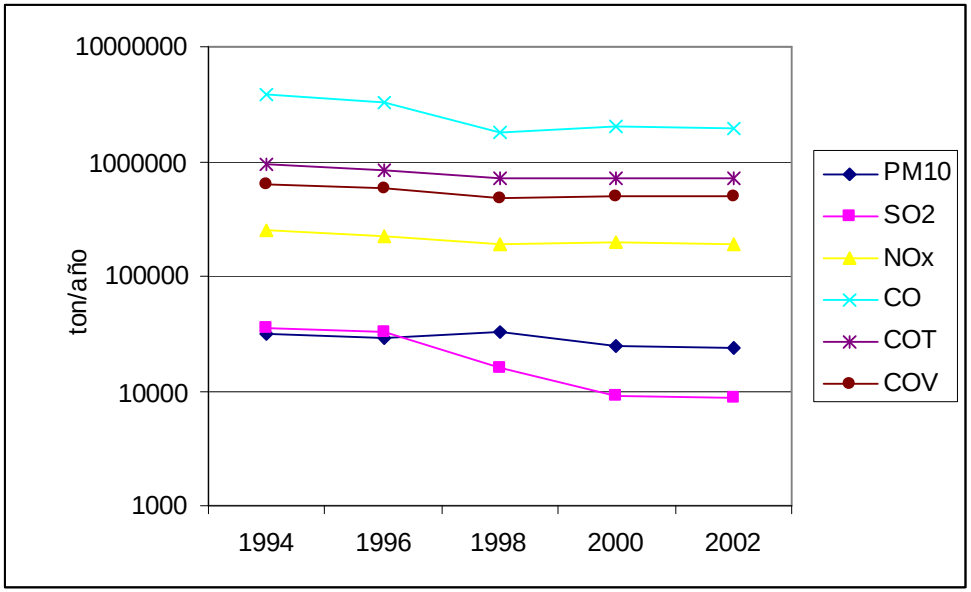
# ZMVM AIR QUALITY

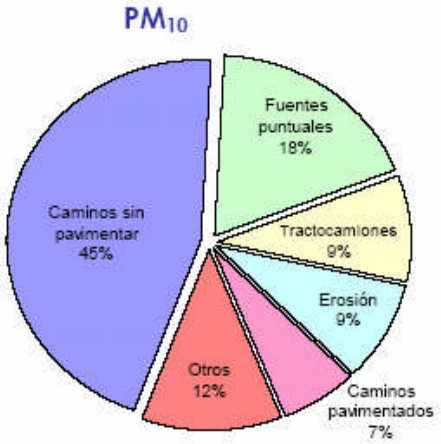
Air Quality
Contamination

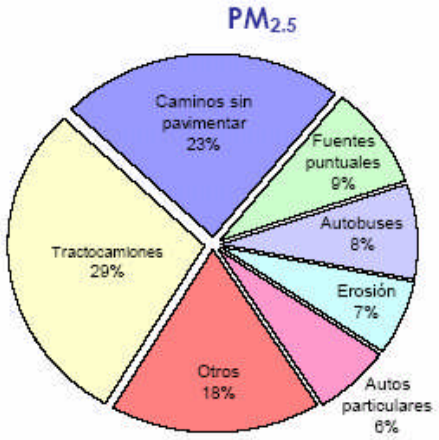
1994 -2002,
1994: 31,380 ton/año
2002: 23,382 ton/año

$PM_{10}$ y $PM_{2.5}$
Particle Distribution:

29% $PM_{2.5}$
in ZMVM 2002, (SMA 2004)




# AIR QUALITY

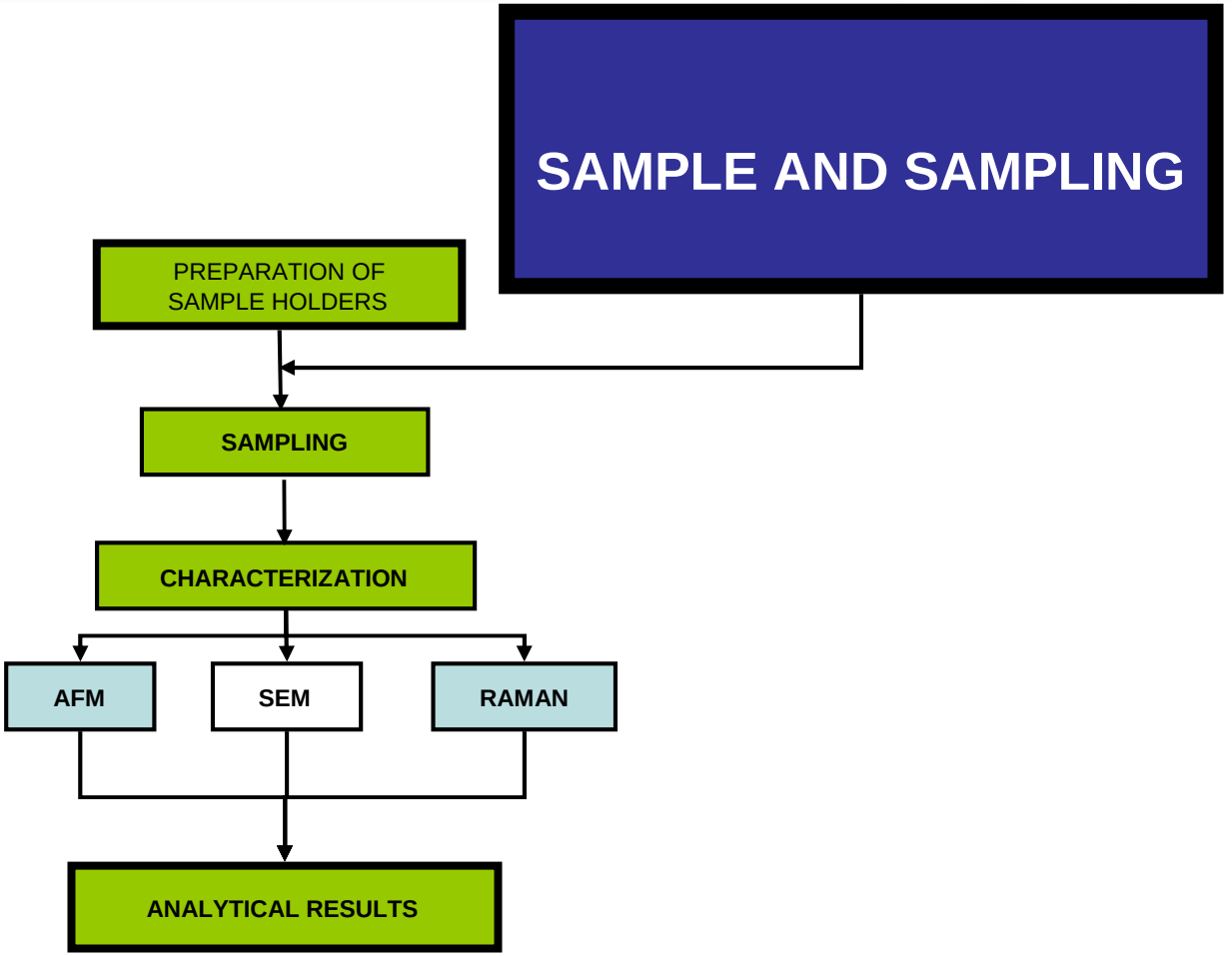
## Source of $PM_{2.5}$ Contamination in ZMVM

- >60% from Vehicles
- >40% Food Preparation
- (RESIDENTIAL AND COMERCIAL CENTRES)

## Nanoparticles in ZMVM

– There is no Regulatory Standards for Nanoparticle emissions (NPE) /contamination in the Air

# METHODOLOGY



# METHODOLOGY

- **SAMPLES AND SAMPLING**

- Non Smoking Drivers
- Time of Sampling 5d
- 7 Automobiles from different manufacturers (Ford, GM, Nissan,Honda,VW, Renault,BMW)
- Vehicle Model,
- The most Common Vehicle
- Transit Zone,
- Route
- Total transited KM (125-550KM/5d)

# STAINLESS STEEL SAMPLE HOLDER

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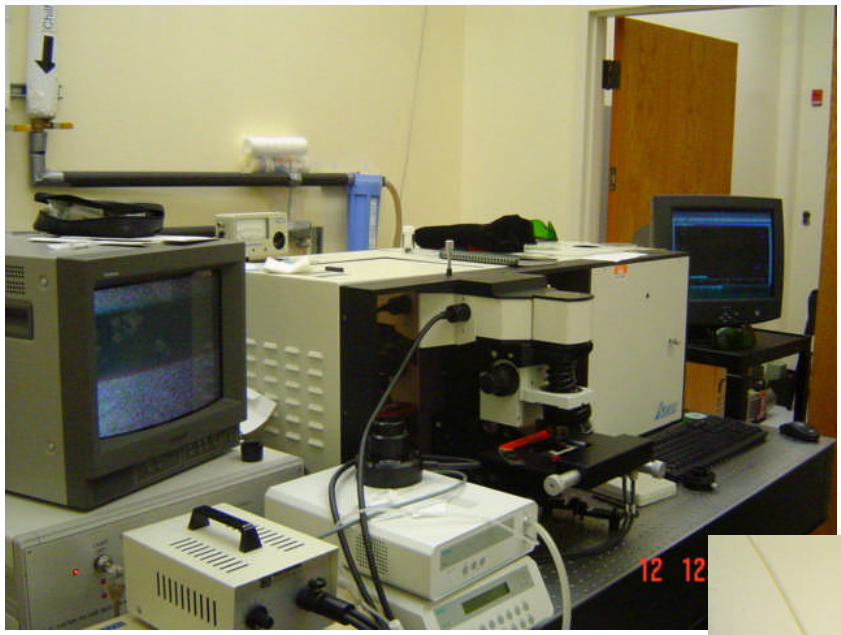
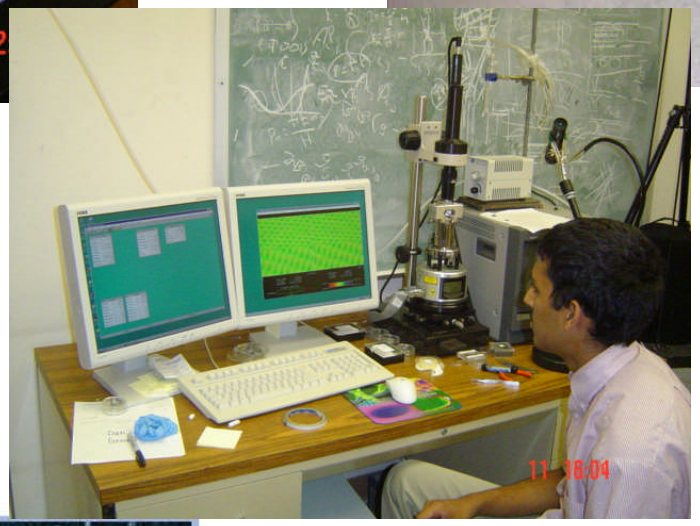
# SAMPLING AREA IN THE VEHICLE

# AFM-SEM-RAMAN





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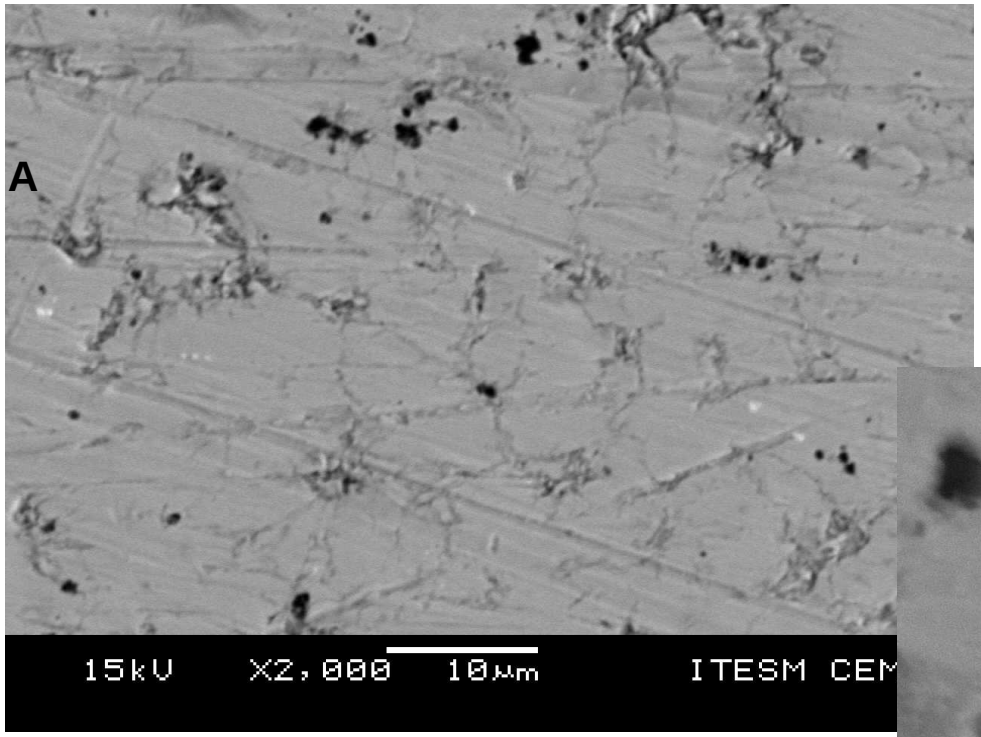
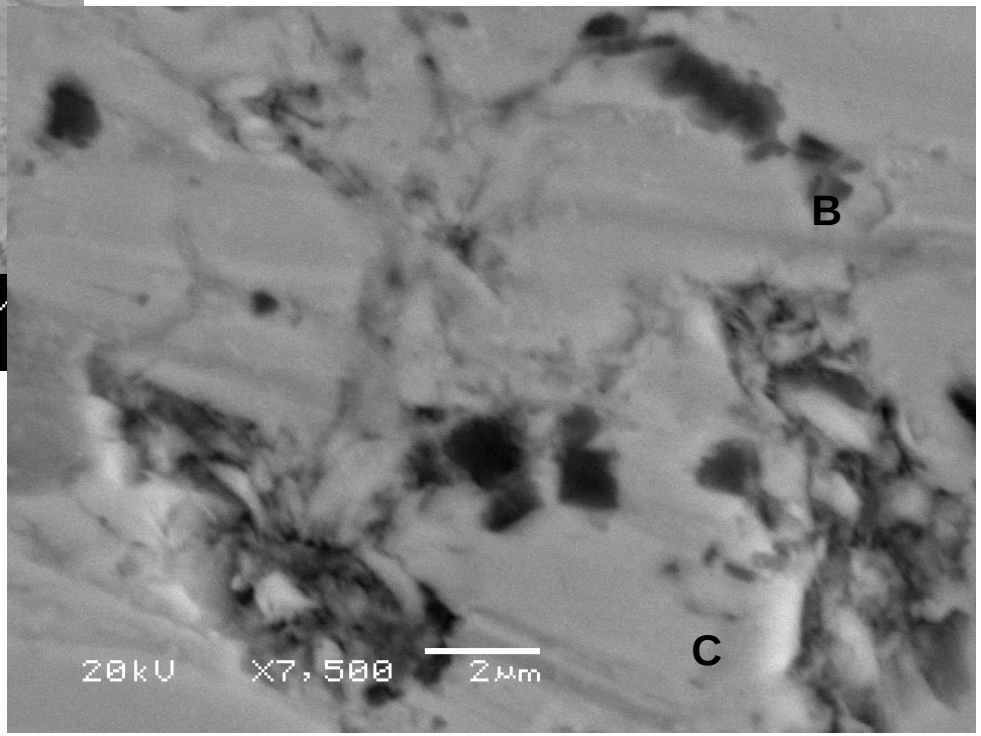
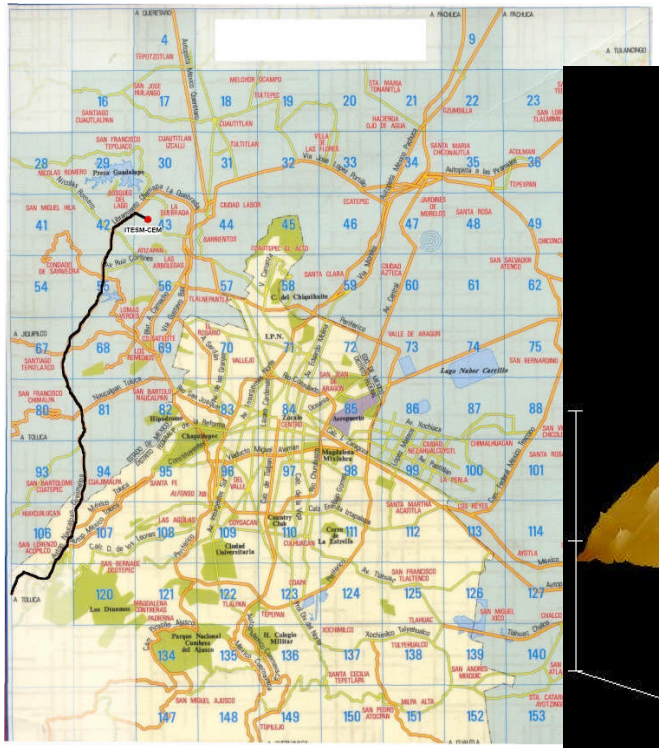
# SAMPLE HOLDER IMAGE SEM

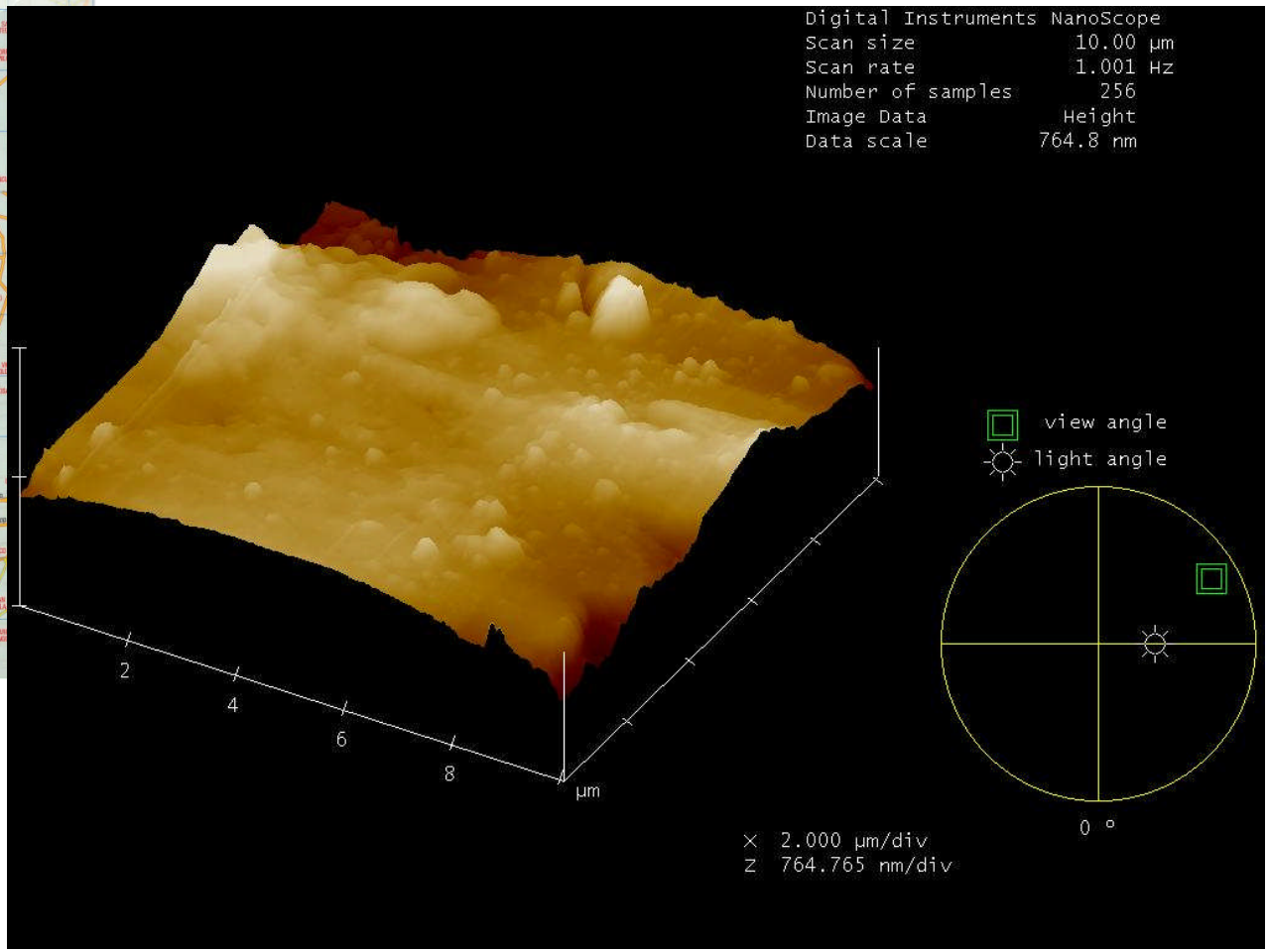



SAMPLE HOLDERS

# ANALYSIS OF SAMPLE FROM GM 1998




**ruta 1: Toluca – Atizapán - Toluca**

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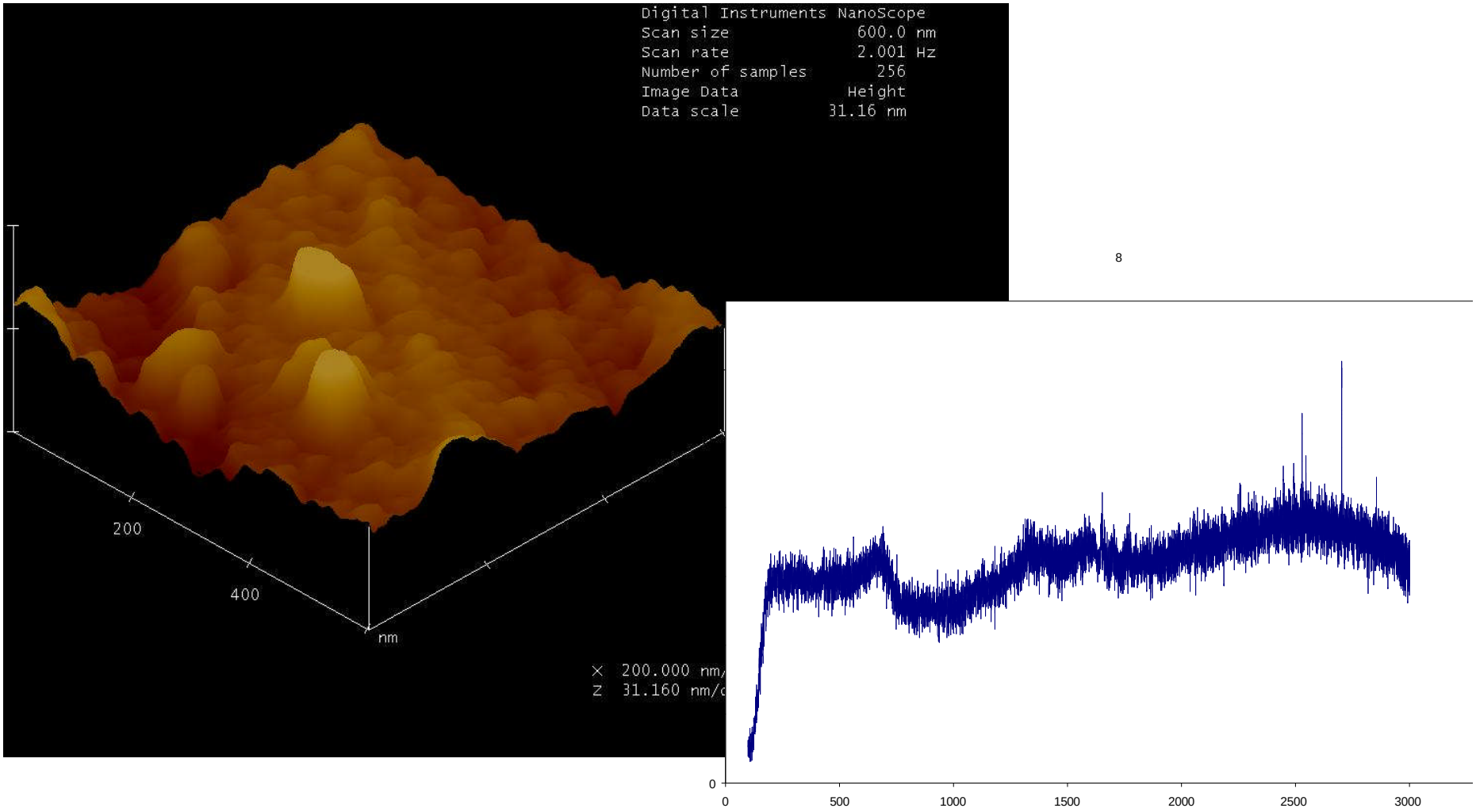
# RAMAN SPECTRA GM MODEL 1998




**ROUTE 1: Toluca – Atizapán - Toluca**

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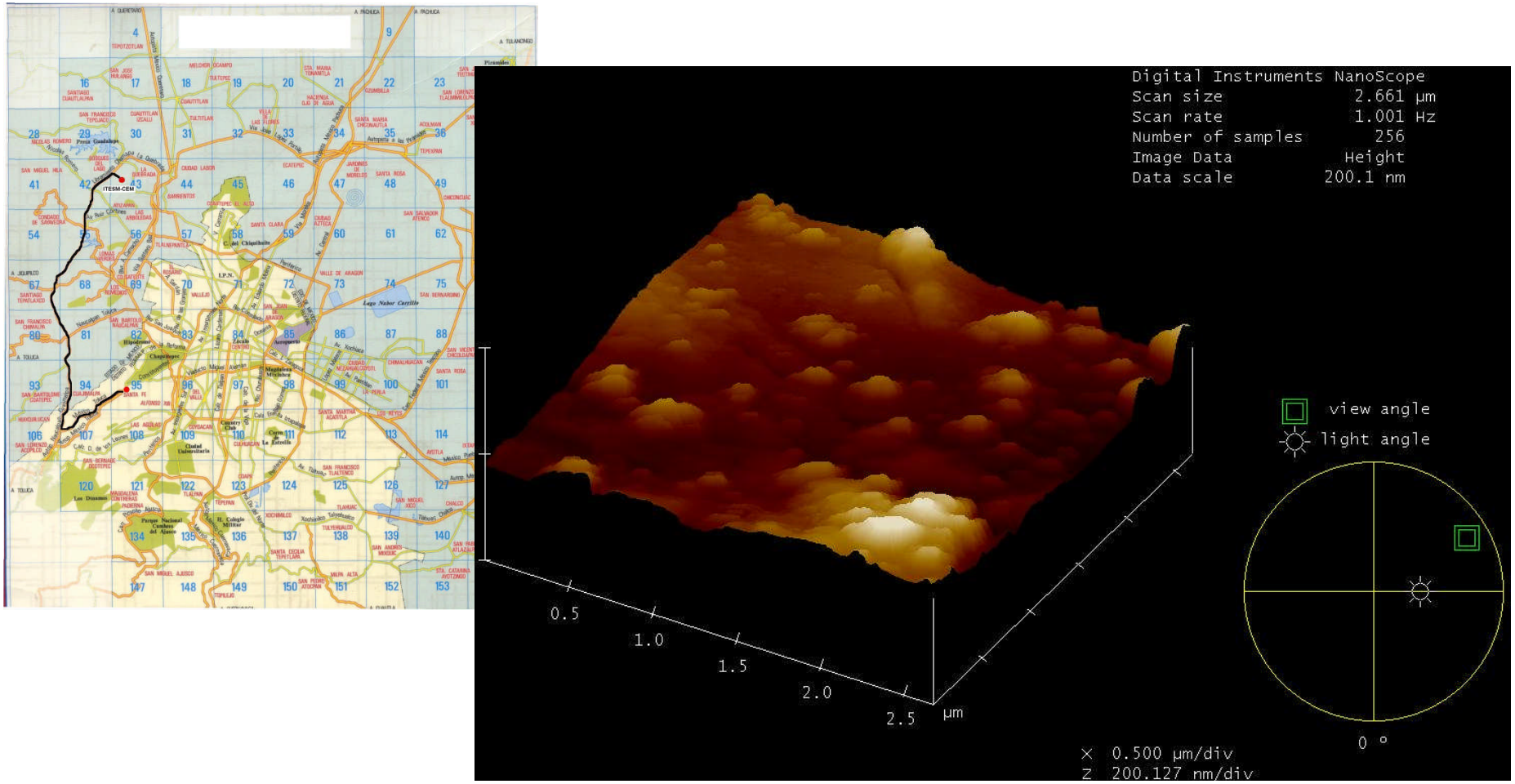
# VW, model 2001




**ROUTE 2: Santa Fe – Atizapán – Santa Fe**

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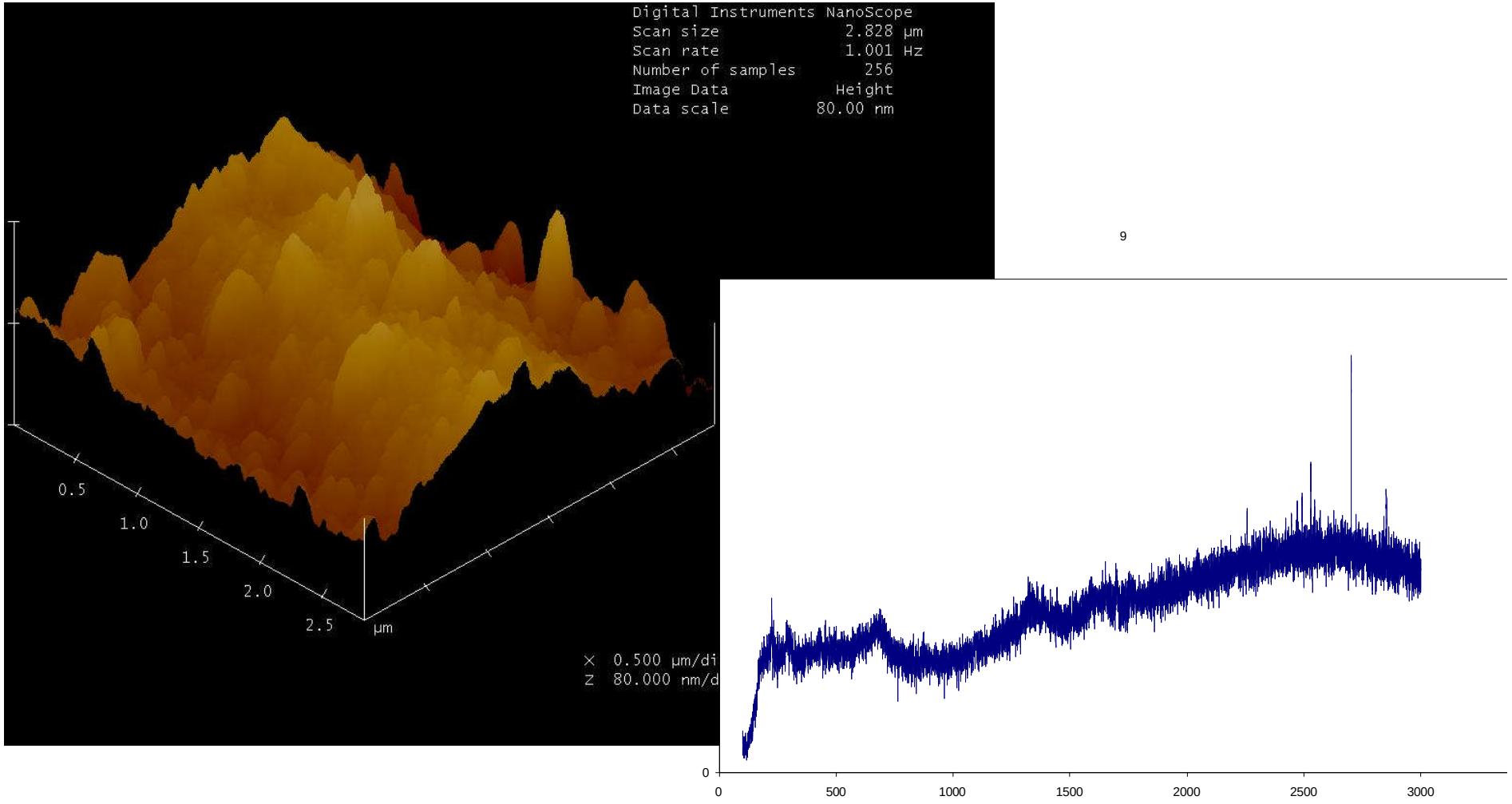
# VW, model 2001




**ROUTE 2: Santa Fe – Atizapán – Santa Fe**

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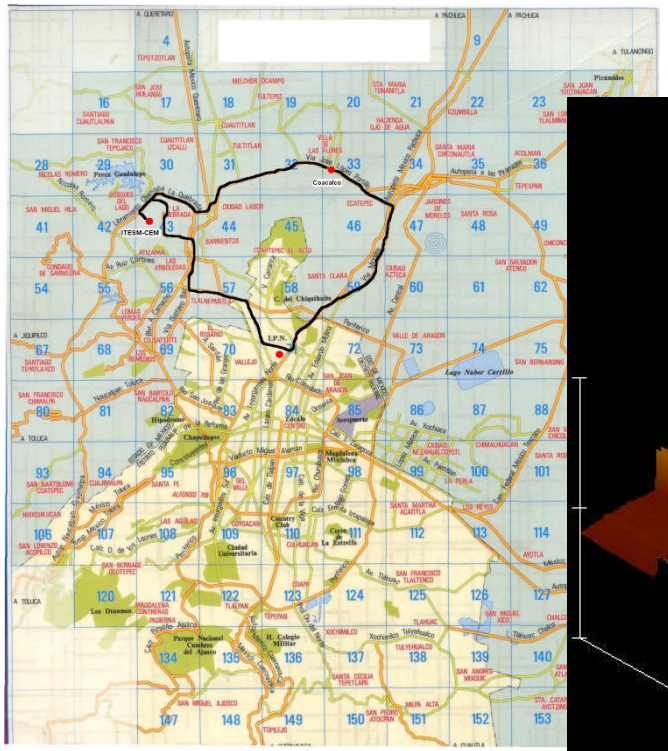
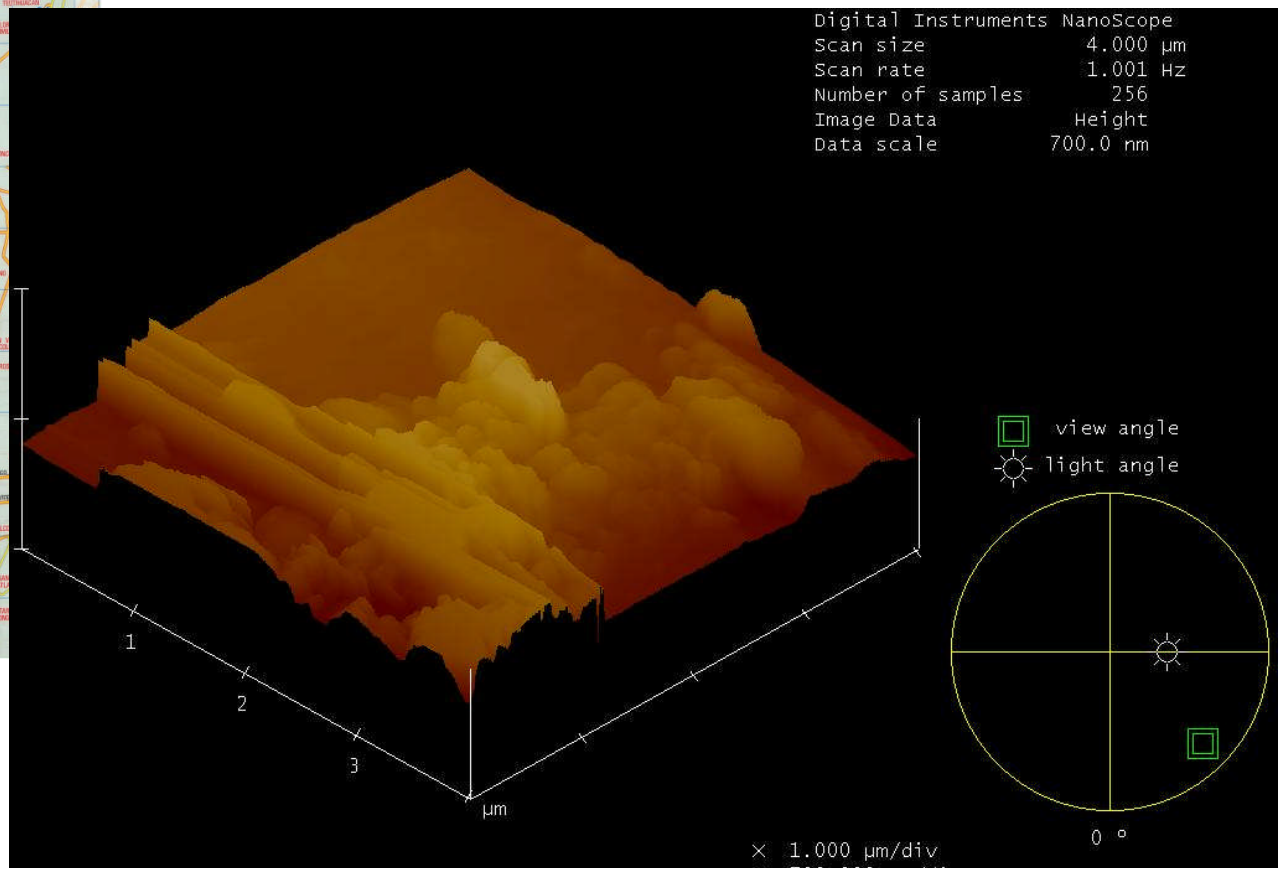
# Ford, model 2003




**ROUTE 3: Coacalco – Atizapán – Vallejo – Coacalco**

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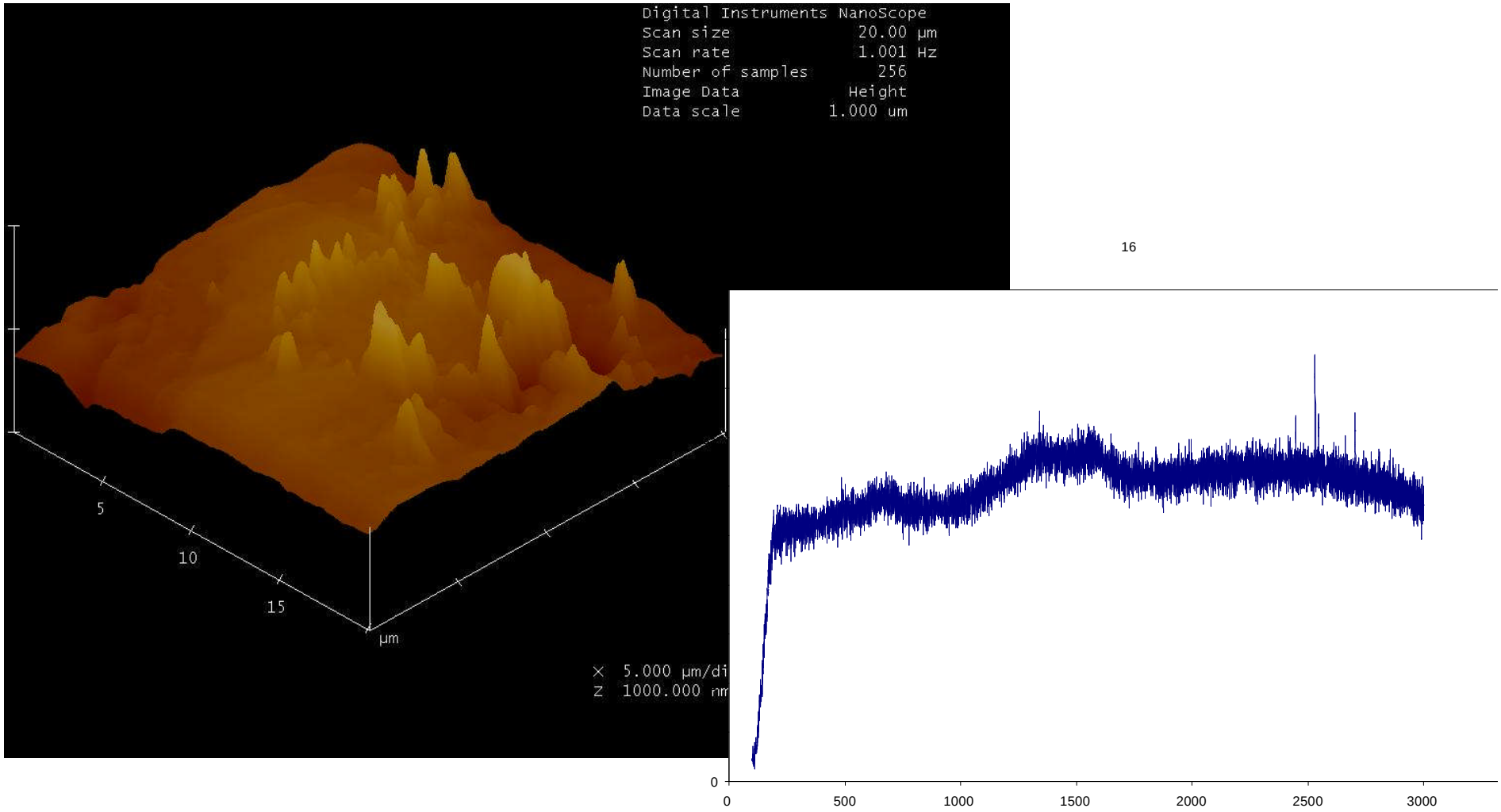
# Ford, model 2003




**ROUTE 3: Coacalco – Atizapán – Vallejo – Coacalco**

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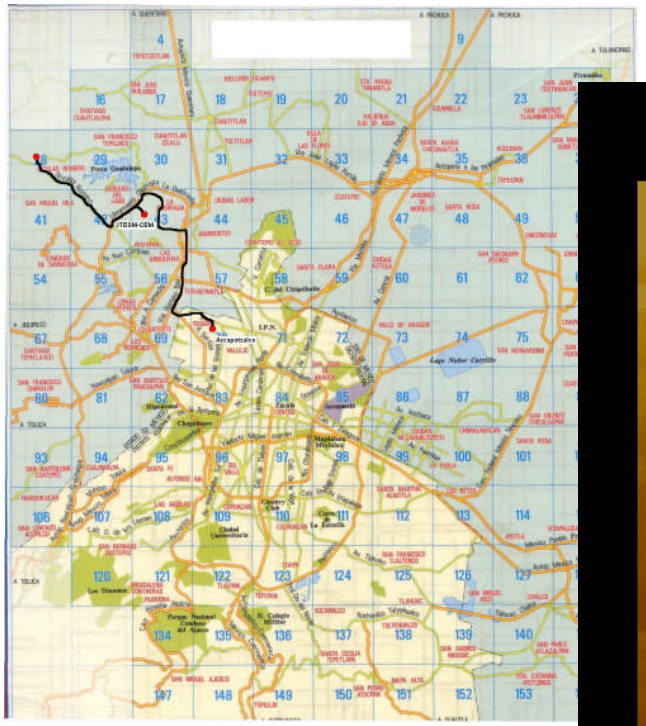
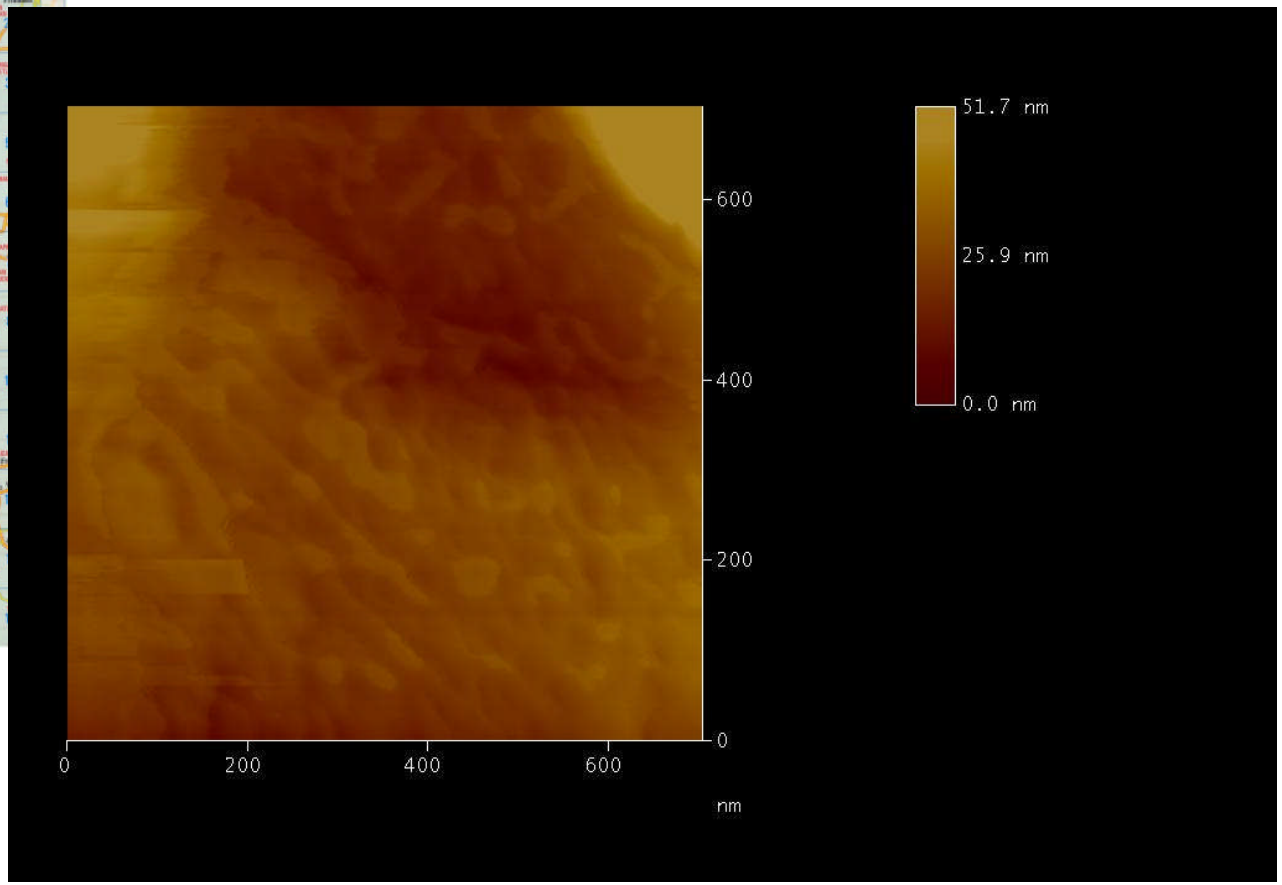
# Renault, model 2005






**ROUTE 4: Nicolás Romero – Atizapán – Azcapotzalco – Atizapán - Nicolás Romero**

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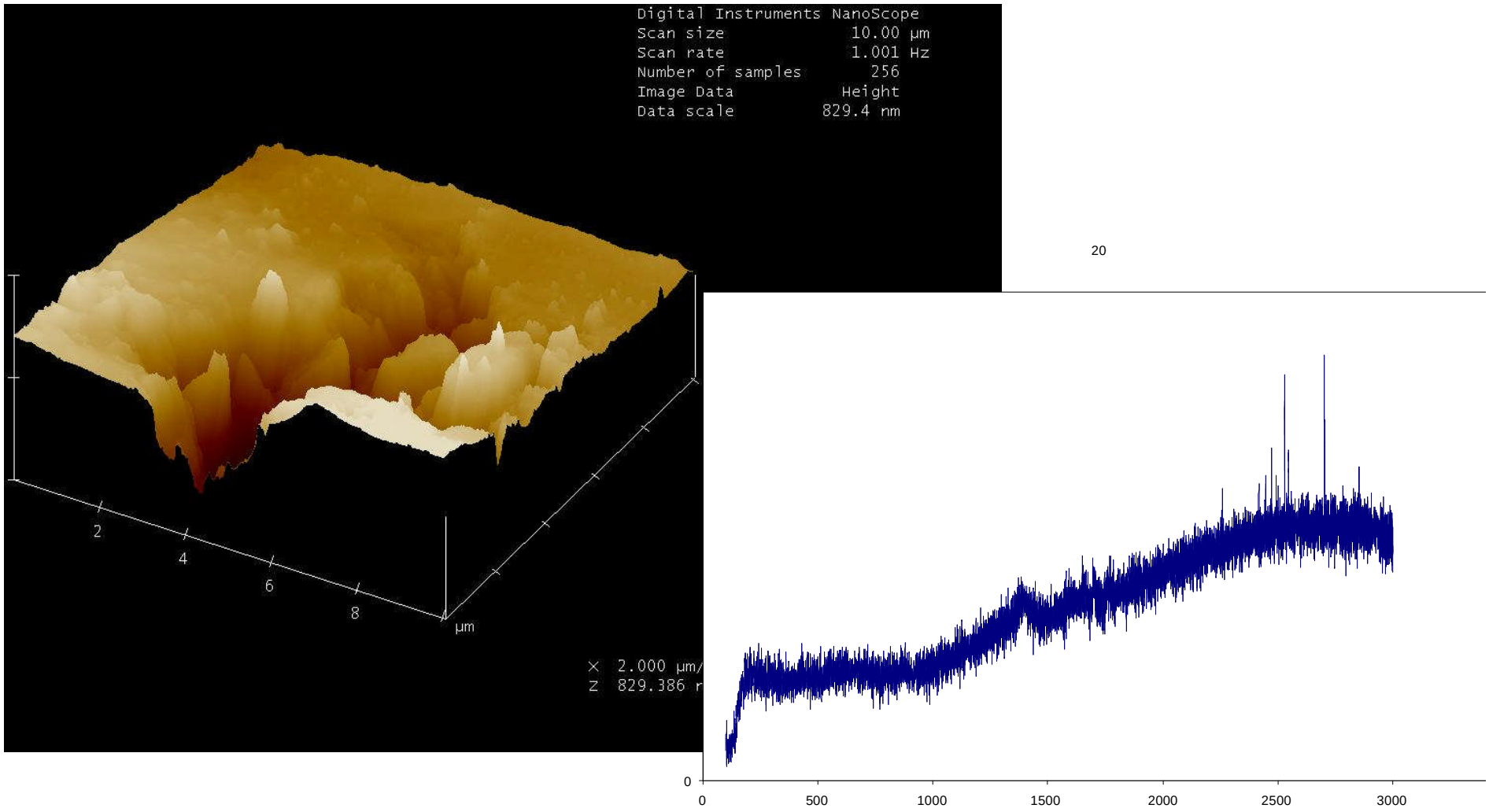
# Renault, model 2005




**ROUTE 4: Nicolás Romero – Atizapán – Azcapotzalco – Atizapán - Nicolás Romero**

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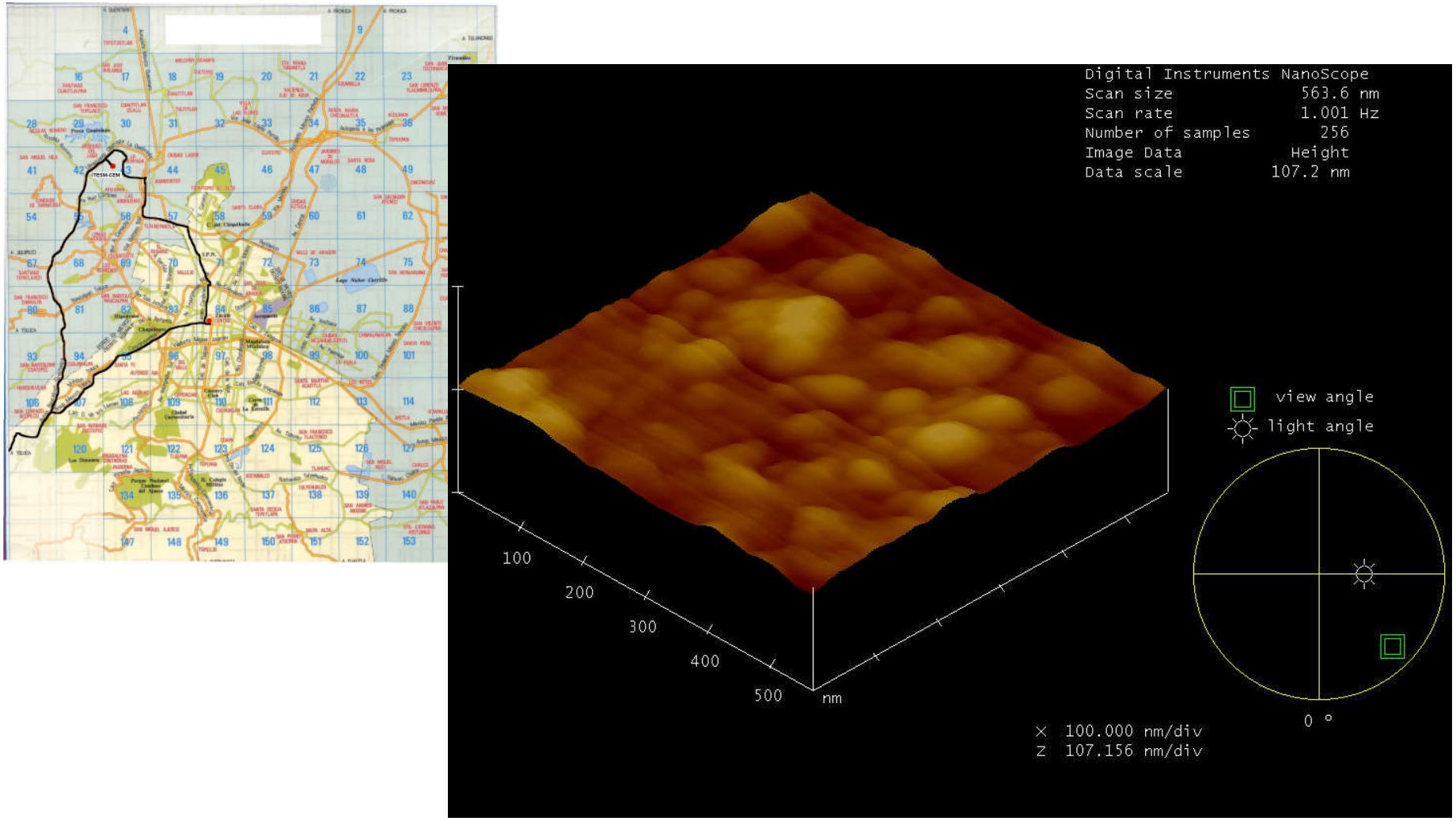
# Nissan, model 1998




**ROUTE 5: Centro- Atizapán -Toluca – Centro**

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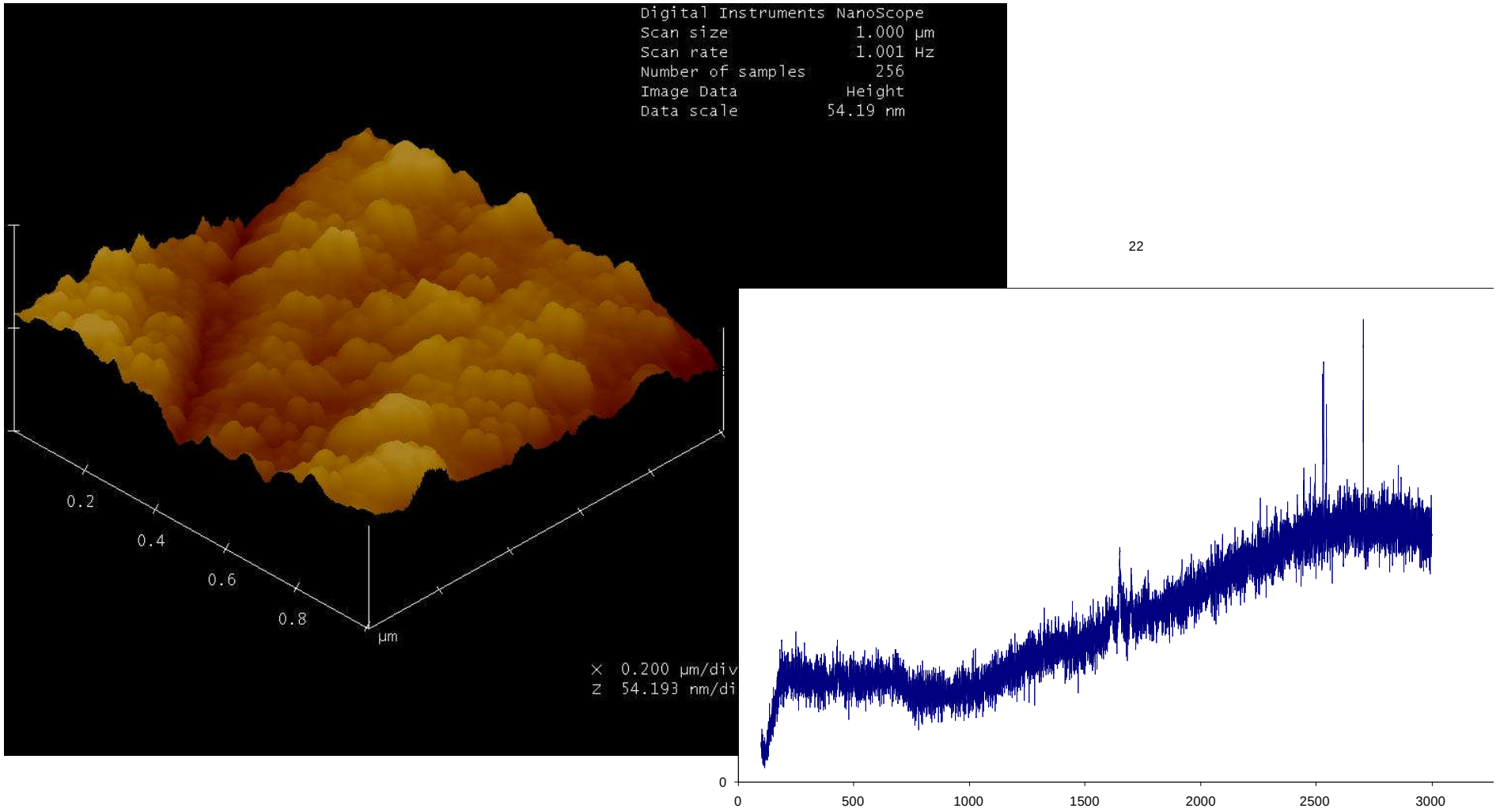
# Nissan, model 1998




**ROUTE 5: Centro- Atizapán -Toluca – Centro**

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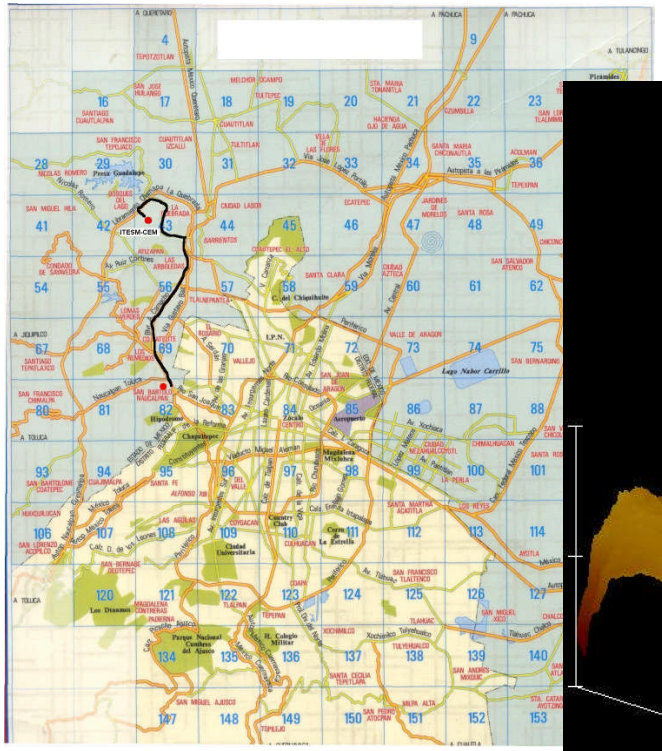
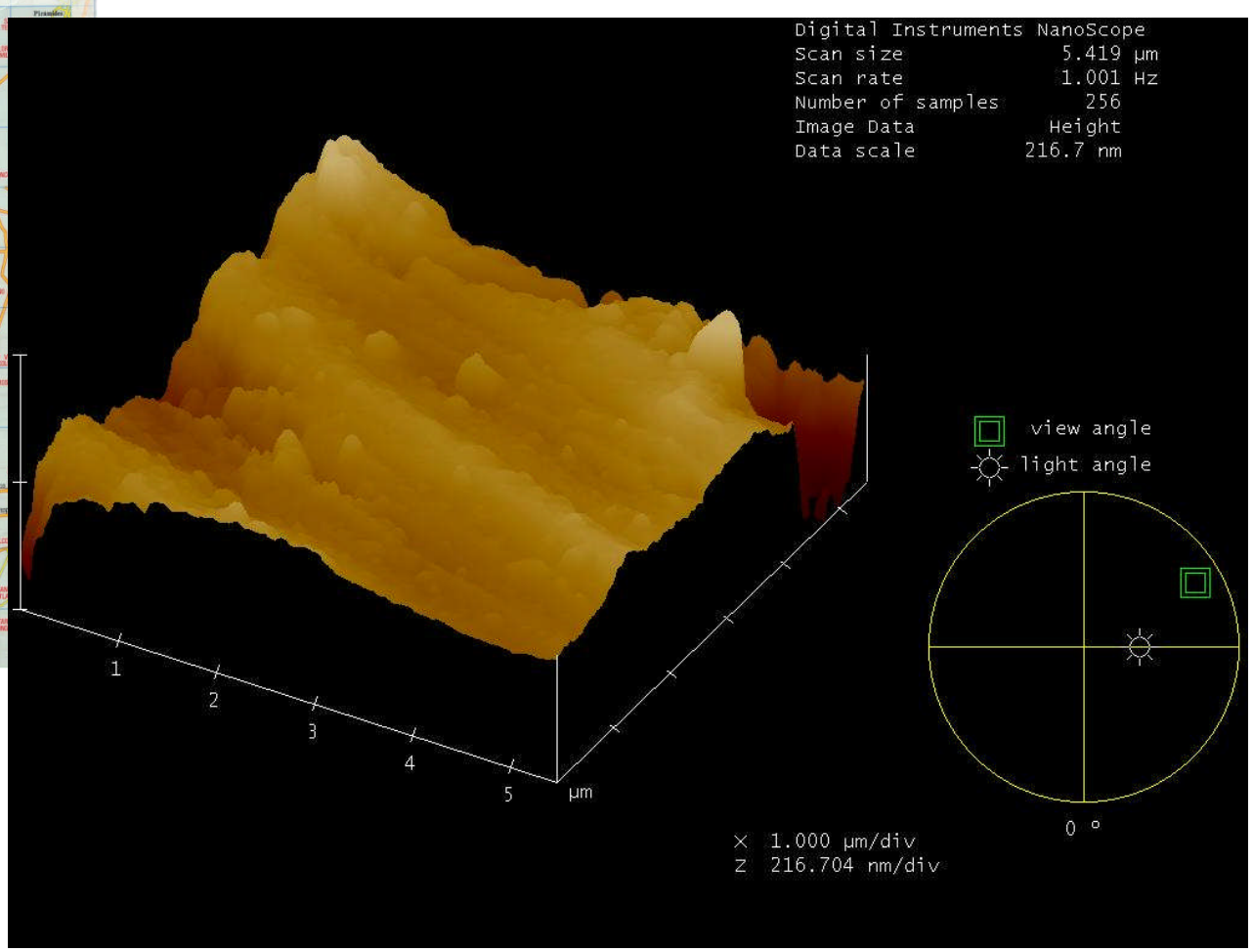
# Honda, model 2003




**Atizapán – Naucalpan – Atizapán**

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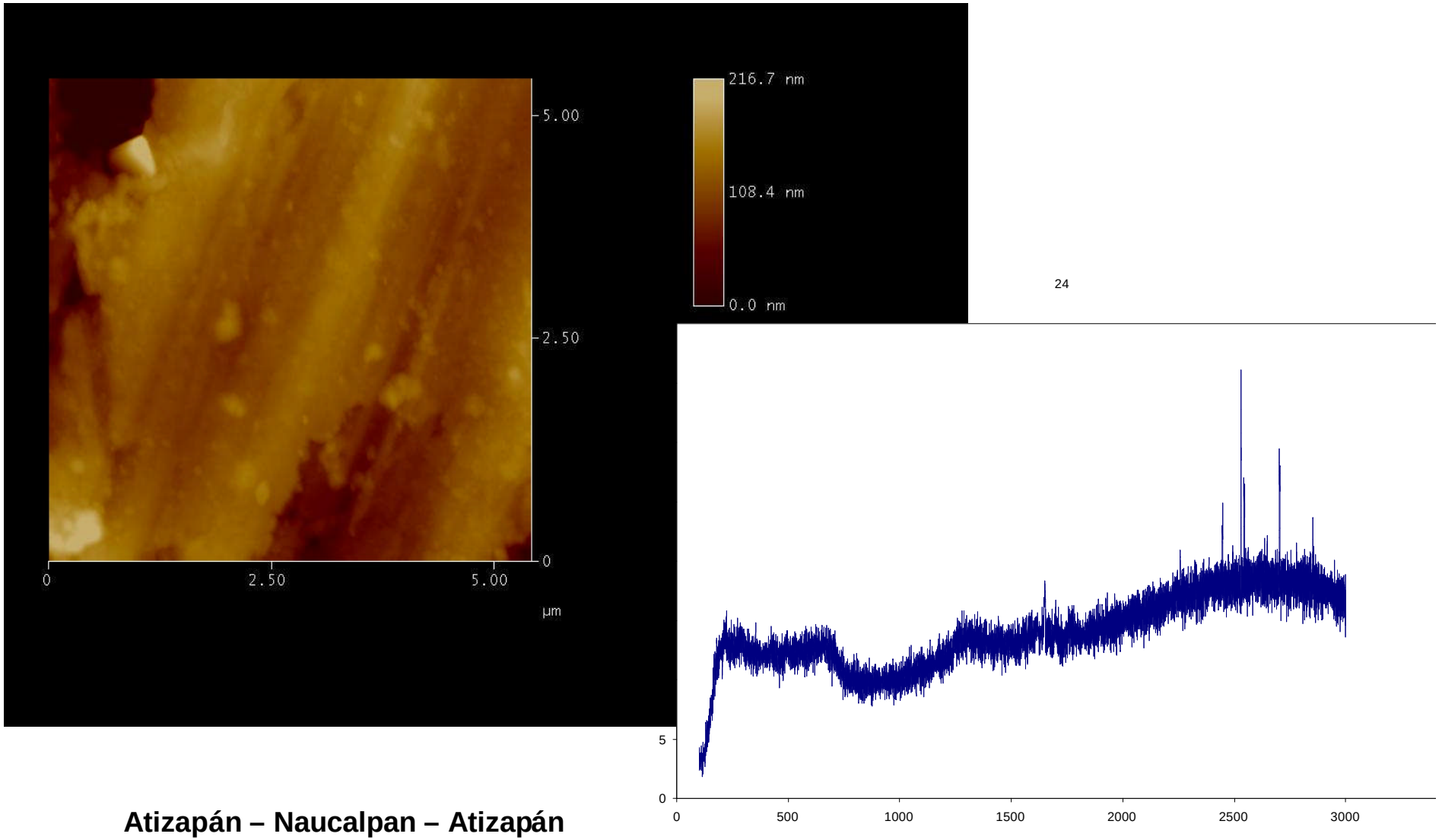
# Honda, model 2003




**Atizapán – Naucalpan – Atizapán**

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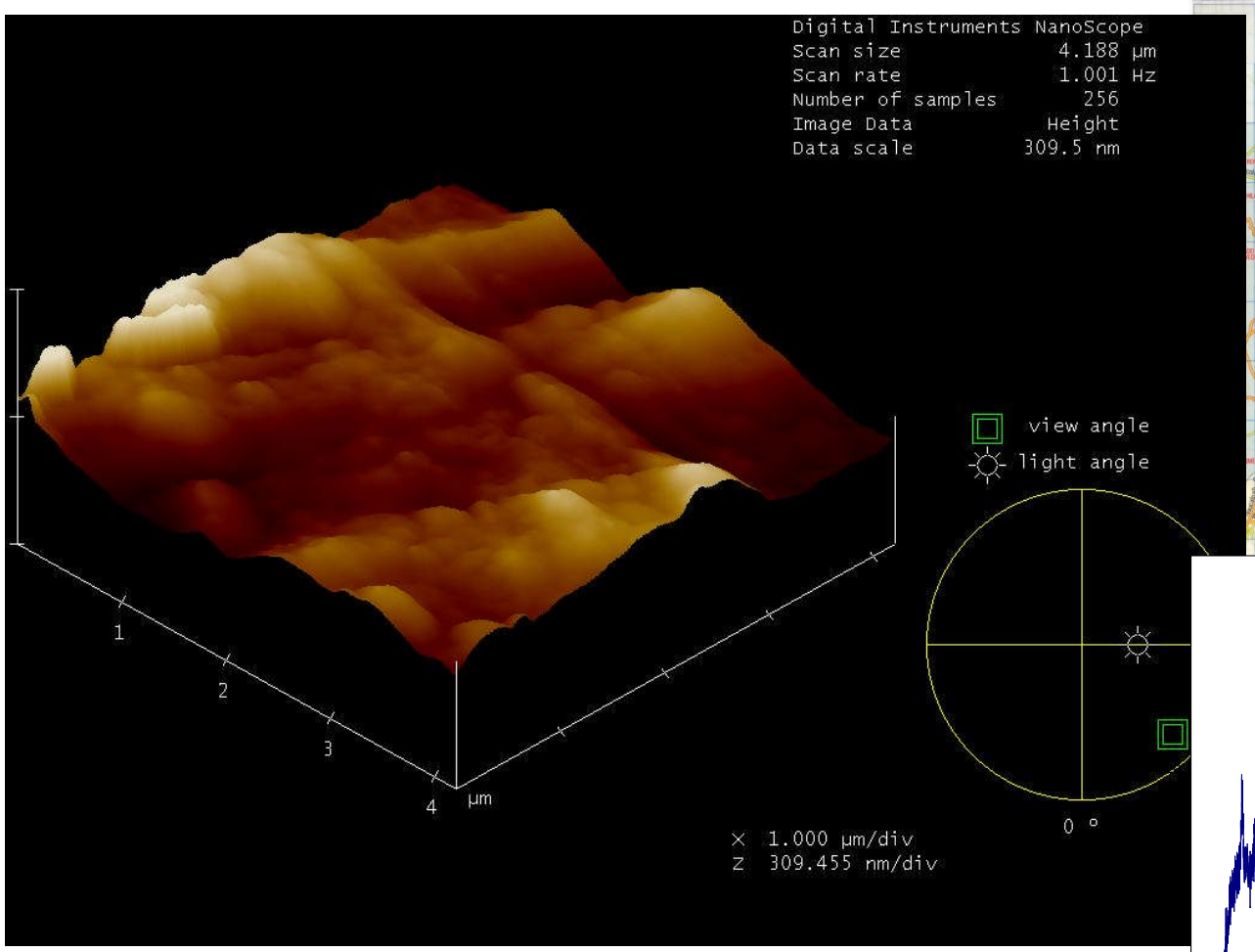
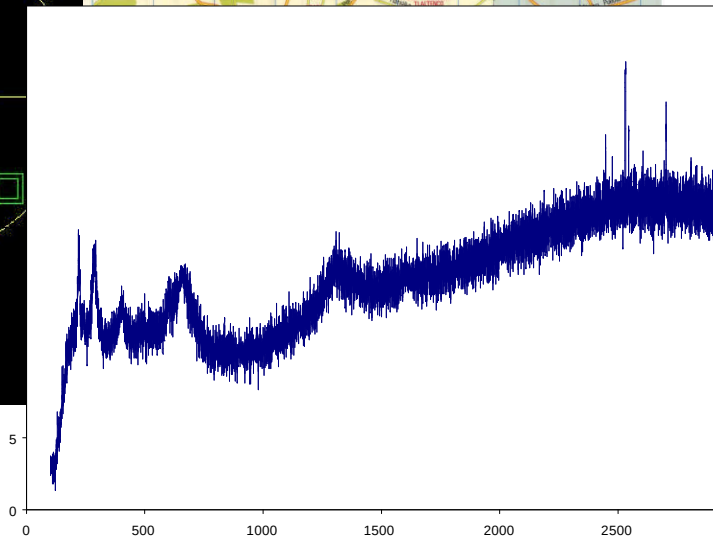
# Honda, model 2003








**Naucalpan – Centro – Naucalpan**

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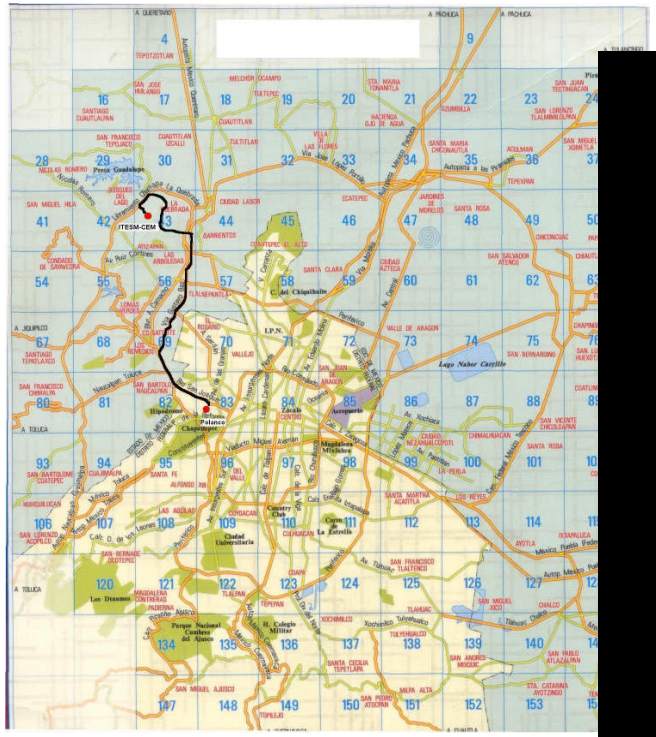
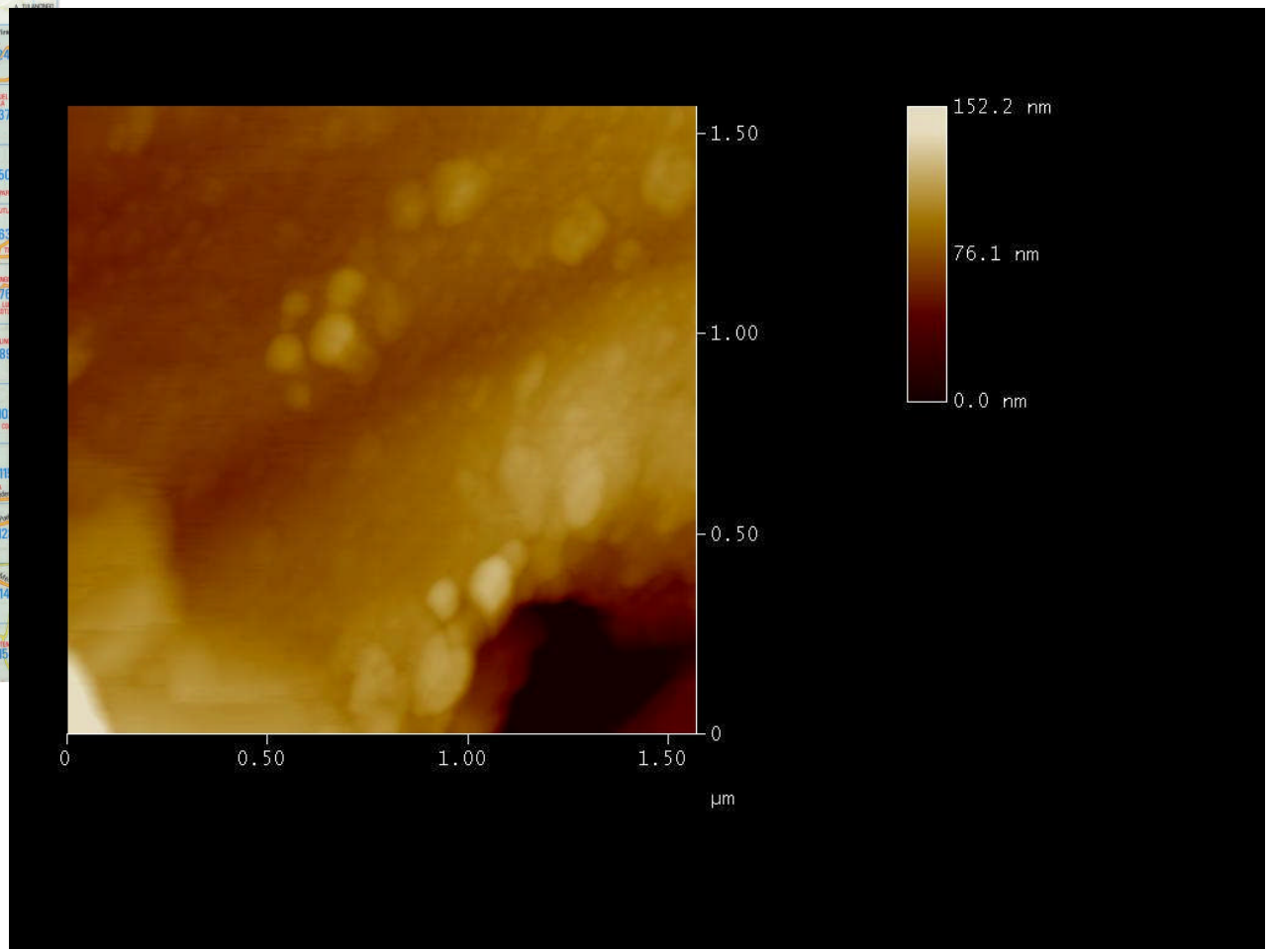
# BMW, model 2005




**Polanco – Atizapán – Polanco**

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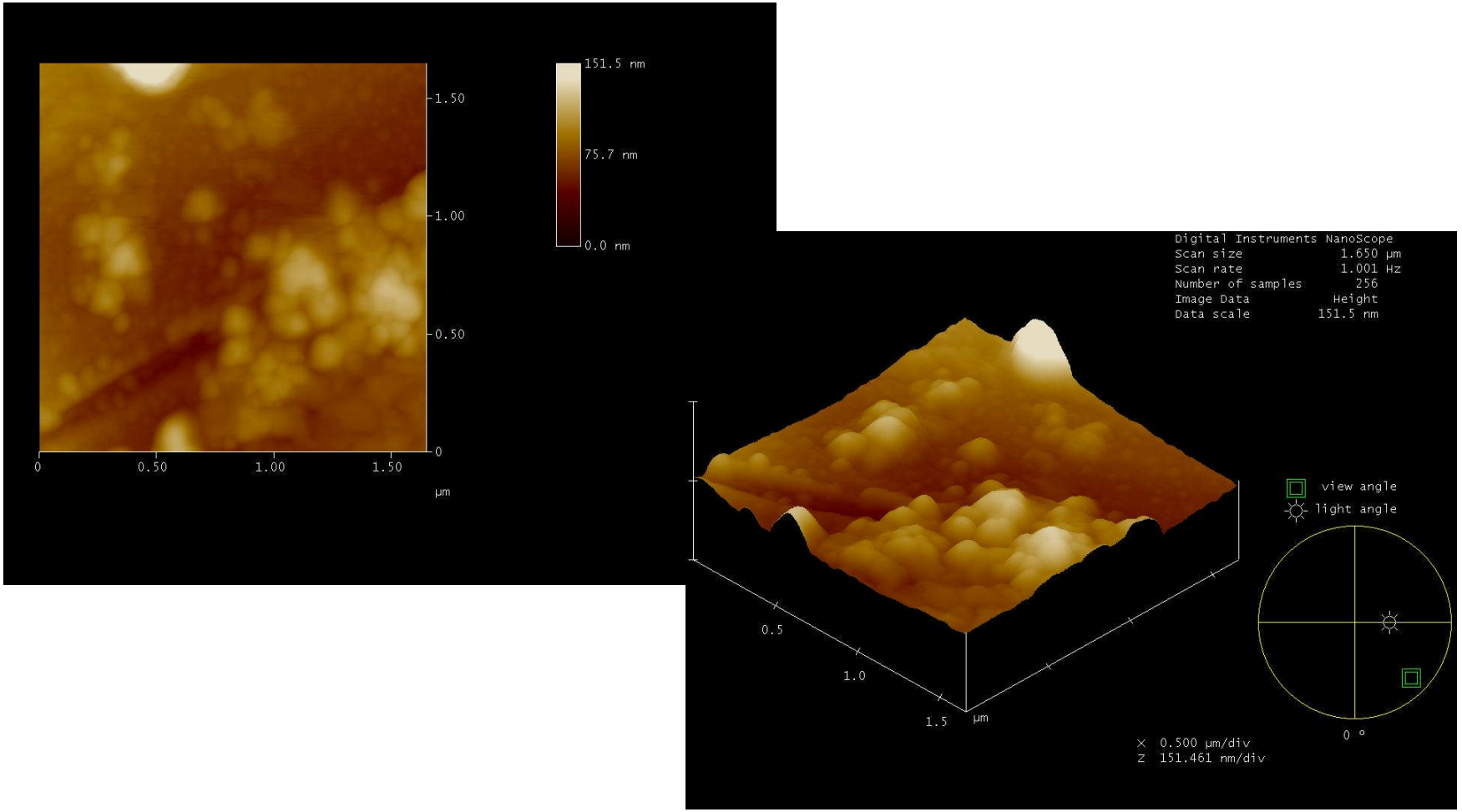
# BMW, model 2006




**Polanco – Atizapán – Polanco**

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# CONCLUSIONS

- 1. All the vehicle tested, interior environment demonstrate presence of Nanoparticles or Aggregation of Nanoparticles size ranging from 100-500nm (MIGHT BE OF GREAT HEALTH RISK)

- 2. 30% of the Vehicle showed formation of nanofilms it might be due to presence of partially combusted hydrocarbon in ZMVM

# CONCLUSIONS

- 3. Raman Spectra Analysis reveals the presence of HC (PAH) in the nanoparticles deposited in the interior of the Vehicle.

- 4. Accumulation fo nanoparticles depends on velocity, type of transit, model, manufacturer and Type of drivers…

- 5. Vehicle performance: Renault ≥ BMW ≥ Honda ≥ Ford > General Motors > Nissan >> VW.

# FUTURE RESEARCH & SUGGESTIONS

- **A MATHEMATICAL MODEL TO PREDICT THE RATE OF DEPOSITION OF NANOPARTICLES USING QUANTUM MECHANICS CONCEPTS.**
- Use of High Quality Gasoline and Lubricants and Services.
- Use of new Nanotech based Airfilters in the vehicle and new materials for the interiors of the vehicle could aggregate the nanoparticles to sediment rapidly or molecular entrapment could be achieved through NEW NANOMATERIALS.
- **GAPS AND UNCERTANITIES EXIST, HOWEVER WILL BE MORE AND MORE REDUCED DUE TO ONGOING RESEARCH IN ENVIRONMENTAL NANOTECHNOLOGY TO ACHIEVE REDUCTION OF NANOPARTICLES IN THE AIR.**

# THANKS TO

- Monterrey Tech, Mexico
  www.itesm.mx
- Nanotechnology Institute,
  UTD, Dallas, TX
- Institute for Nanosciecne and Nanotechnology, FIU, Miami