

# **Analytická řešení potřeb v cementárenském průmyslu**

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# Leco Corporation

- **Established 1936**, family company  
*'Laboratory Equipement Compagny'*
- Located: USA, St. Joseph (Michigan)
- More than 75% of production is made there



# LECO Globally

30 Subsidiaries  
45 distributors

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# Inorganic

Carbon | Sulfur      Oxygen | Nitrogen | Hydrogen      Carbon | Water      Hydrogen      Glow Discharge Spectrometers



- 844 Series**
- Quick, accurate carbon and sulfur determination by combustion infrared detection
  - Expanded range and increased precision for the most demanding applications
  - Modular infrared detectors with multiple detection ranges and automatic rebalancing
  - Calibration, analysis, evaluation, and diagnostic functions accessible via user-friendly software
  - Rapid sample combustion with our high-efficiency induction furnace, improving cycle-time
  - Autoclave not available
  - Tungsten carbide up-epic models available
  - Compatible with SmartLine™ Remote Diagnostics
  - Optional 10- and 60-position auto-loaders
  - Both production and research models available
  - Comenbase™ Mobile app provides access to data, plots, and instrument status to your smartphone, tablet, or desktop computer
- 836 Series**
- Oxygen, nitrogen, and hydrogen by inert gas fusion
  - Fast, simultaneous measurement of oxygen, nitrogen, and hydrogen
  - State-of-the-art infrared and thermal conductivity detectors with no moving parts and no manual adjustments
  - EN variants for large sample applications like elemental determination in uranium oxide and aluminum
  - Autoclave not available
  - Optional 20-position auto-loader
  - Compatible with SmartLine Remote Diagnostics
  - Both production and research models available
  - Comenbase Mobile app provides access to data, plots, and instrument status from your smartphone, tablet, or desktop computer
- 83612**
- State-of-the-art furnace control system allows temperature ramping from ambient to 1100°C
  - High-efficiency after-burner ensures complete combustion of organic compounds when ramping
  - Simplified furnace design saves maintenance and increases safety
  - Increased flexibility by reacting in either an inert or oxidizing atmosphere
  - Optional non-sequential 30-sample auto-load available
  - Compatible with SmartLine Remote Diagnostics
- D1600**
- Residual and diffusible hydrogen determination by hot extraction
  - Optional diffusible sample piercer
  - State-of-the-art thermal conductivity detector with no moving parts and no manual adjustments
  - Innovative chassis architecture improves reliability and serviceability
  - Larger absorption tube to accommodate larger samples
  - Compatible with SmartLine Remote Diagnostics
- Atomic Emission Spectrometer**
- Spectral range from 120 to 800 nm
  - Continuous profile of concentration throughout
  - Large, dynamic range with concentrations from ppm to 100%
  - Short analysis time (minutes)
  - Choice of IR or DC lamp for both conductive and non-conductive samples
  - Easy-to-use software
  - Compatible with SmartLine Remote Diagnostics
  - Bulk elemental analysis only, or bulk analysis and compositional depth profiling (CDF) mode available

# Spectroscopy

GCMS and GxGC-MS      GxGC      High Resolution GCMS



- Pegasus™ HT GC-TOFMS**
- Full-mass range spectral acquisition rates up to 500 spectra/second for a significant reduction in chromatographic analysis time
  - Powerful ChromaTOF™ brand software with integrated Automated Peak Find and True Signal Deconvolution algorithms
- Pegasus 4D GCxGC-TOFMS**
- A second dimension of chromatographic resolution provides peak-to-peak resolution unavailable with GCMS alone, allowing you to detect and identify more components in one analysis
  - Cryogenic focusing sharpens peaks prior to detection, for enhanced peak detectability
  - Spectral collection rates up to 500 full-range mass spectra/second
  - Powerful, easy-to-use ChromaTOF brand software simplifies component identification and fully automates data processing
- GxGC**
- Ideal for quality control, production, and research
  - Enhanced chromatographic separation power is excellent for petroleum, flavor, and fragrance applications
  - Easy-to-use ChromaTOF brand software simplifies component identification
  - Available with either FID or ECD
- Pegasus GC-HRT**
- The highest performance TOF mass spectrometer for the GCMS market
  - Folded Flight Path™ (FFP™) technology allows users to achieve resolutions of up to 30,000
  - Employs ChromaTOF-4HT™ software with automated High Resolution Deconvolution™ (HRD™) and formula generation for seamless data analysis, plus compatibility with standard GCMS libraries
  - High Resolution Chemical Ionization source (HR-CI) provides superior mass accuracy and resolution for pseudomolecular ions; complements the Standard Electron Ionization source (HR-EI) to provide comprehensive characterization of unknowns
  - 1 ppm mass accuracy identifies molecular formula
- Pegasus GC-HRT 4D**
- Combining the highest performance GCxGC and TOF on the market gives users an unprecedented ability to interrogate complex samples
  - Find more analytes than ever before and identify components with the ultimate confidence
  - With mass accuracies of 1 ppm and peak capacities of at least three times greater than anywhere else in the marketplace
  - The industry's most established GCxGC systems; their modularity with liquid nitrogen or oxygen-based versions
  - Chemical Ionization source (HR-CI) provides the same mass accuracy and high resolution on pseudomolecular ions which complements the traditional Electron Ionization source (HR-EI) to provide comprehensive characterization of unknowns
  - Integrated software platform acquires data, controls all hardware, and analyzes and reports results with a high level of automation, tailored to get the most out of HR data

# Metallography

Sectioning      Mounting      Grinding | Polishing



- MSX Series**
- Low heat/low deformation sectioning
  - Manual control and automatic oxidation or pulse sectioning
  - Flexible model configurations with blades up to 1.7 in. (43.2 mm)
  - Optional integrated X- and Y-blades for parallel sections
  - Advanced spindle design provides long life and precise sections
  - Optional filtering kit available for ferrous environments
  - Side access ports to adjustable-length spindles
  - Rugged steel design
  - Recirculation tank included
- MX36**
- Single- and dual-mount in a variety of available sizes
  - Intuitive operation for easy load exchange
  - Electro-hydraulic design for extremely quiet operation, with no air required
  - Universal power supply for easy set-up and installation
- GPM Series**
- Variable wheel base and speeds to match your needs
  - Built-in splash ring reduces clean-up
  - Automatic head with pre-set methods and programs for creating new methods
  - Fluid dispenser holds up to 4 bottles of polishing fluid with separate pump operation
  - One-piece rugged aluminum casting design
- S2200**
- Ideal for low- or medium-volume laboratories
  - Variable-speed base 0 to 600 RPM
  - Water to wet with adjustable flow is feasible for ease of bowl cleaning
  - Solid and expand with a durable aluminum frame design
- S0 Series**
- Coarse grinding
  - Wet or dry applications
  - Single- or dual-belt models
  - Dual color design available

# Organic

Colorimetry      Ash Fusion      Mercury      Thermogravimetric Analysis



- AG90**
- Accurate colorimetric measurements in as little as five minutes
  - Ergonomic vessel and preparation design for convenient operator handling and ease-of-use
  - Meets or exceeds ASTM and ISO requirements
  - 4,000 to 15,000 STU/L range for 1 gram samples
  - Easy-to-use software
  - Compatible with SmartLine Remote Diagnostics
- AF700**
- Automatically determines fusibility temperatures in ash and coke ash samples using ASTM-, DIN-, ISO-, and BSI-approved techniques with pre-defined methods
  - Dual configuration available—analyze up to 12 samples simultaneously
  - Easy-to-use software with Image Recognition Function (IRF) for automatic critical temperature measurement
  - Integrated safety features, including a carbon monoxide detector, furnace interlock, and interlocking door and access panels
  - Compatible with SmartLine Remote Diagnostics
- AMA254**
- Fast, accurate mercury determination in solids or liquids
  - Analysis in as little as six minutes
  - Green chemistry technique: no sample pre-treatment or acid digestions required
  - Optional automatic 45-position auto-loader
  - Easy-to-use software
  - Compatible with SmartLine Remote Diagnostics
- TG4701**
- Determines moisture/ash or other gravimetric methods in various organic samples
  - Expanded temperature control (up to 1000°C) with variable air flow rates and ramp rates
  - Pneumatic manual mechanism and ergonomic design increases sample throughput, decrease downtime, and improves serviceability
  - Complies with ASTM-approved methodology
  - Easy-to-use software
  - Compatible with SmartLine Remote Diagnostics

Optical Equipment

Automatic | Manual Hardness Testing



- Digital Zoom Microscope**
- Achieves up to 700X (FOV) magnification
  - High field of view and high resolution allow for the capturing, measuring, and archiving of a variety of materials
  - Available 3D software for total sample reconstruction and profiling
  - Olympus DSX Series packages are available with a variety of options
  - Olympus DSX S Series compatible with IXA4/PIX-IT™ Image Management software
- Olympus Optical Microscopes**
- Inverted metallographs for production, quality control, and research
  - Full range of upright stereo microscopes
  - CIL, BX2W, SZ, and SZX Series models available
  - Full range of accessories including filters, needles, illumination cubes, digital cameras, and software
- LM44/PIX-IT Image Management Systems**
- Full image analysis system with electronic filing system
  - Search, sort, and organize images according to descriptive fields
  - An ideal solution for measuring, archiving, and image analysis of materials
  - Auto storage capability for higher throughput
- LM Series**
- Analog and digital
  - Touch-screen capability on LM80 models
  - Easy-to-meet applications
  - Auto turret
  - All models conform to ASTM specifications
  - DV Series macro testers also available
- DV Series, LM V-50V**
- Macro indentation, Knoop, Vickers, and Wickers applications
  - Touch-screen capability on DV100 models
  - Auto turret
  - High-quality, reliable test results
  - Available in manual and semi-automatic
  - All models conform to ASTM specifications
- LR Series Rockwell-Type**
- Load Cell technology
  - Highly accurate, reliable results
  - True Hard Rockwell-type units available with limited thread-based methods
  - Measures impressions of various sizes as conditions, including scratched or unevenly illuminated
- AMH3 Series Automatic**
- Unique patented trace function with panoramic view
  - Advanced image-recognition technology allows analysis of information not available with limited thread-based methods
  - Measures impressions of various sizes as conditions, including scratched or unevenly illuminated

Carbon | Hydrogen | Nitrogen | Sulfur | Oxygen

Carbon | Nitrogen | Sulfur Macro      Sulfur | Carbon



- 828 Series**
- Determines carbon, hydrogen, and nitrogen/protein in various organic samples in as little as 4.5 minutes
  - Flexible sulfur and micro oxygen module configurations for added versatility
  - Dual-stage furnace system operates with pure oxygen at high temperatures for complete combustion of a sample, without the need for additional metal oxidizing reagents
  - Low-maintenance auto-loader with up to 120 samples
  - Optional liquid auto-sample provides seamless automation for liquid samples
  - 5 sulfur add-on module available with optional 30-position auto-loader
  - Compatible with AQAC, AS7A, SO, AAC, AOCs, and ASB-C approved methods of analysis
  - Easy-to-use software
  - Compatible with SmartLine Remote Diagnostics
- TruMac™ Series**
- Rapid determination of macro sample sizes (up to 3 grams for nitrogen; up to 1.5 grams for carbon/hydrogen; up to 0.3 grams for carbon/hydrogen/sulfur)
  - Results in as little as 5 minutes with a low cost-per-analysis
  - Large, reusable sample boats melt in ash boat for easy post-analysis removal from furnace
  - 30-position auto-loader for streamlined analysis of samples
  - Compatible with AQAC, AAC, AOCs, and ASB-C approved methods of analysis
  - Pure oxygen for more accurate results in the complete oxidation of macro samples with maximum temperatures up to 1450°C
  - Compatible with SmartLine Remote Diagnostics
- 832 Series**
- Simple, fast, accurate sulfur/carbon determination in organic materials
  - High-efficiency furnace with intelligent furnace operating costs and applications for niche reliability
  - Individual wide-range IR detection
  - LECO ConverterPro brand software platform powered by an ergonomic, boom-mounted touch-screen interface increases usability and operational control with no loss of valuable bench space
  - Optional Performance Package (P) and Dual-Range (DR) 832 model also available
  - Comenbase Mobile app provides access to data, plots, and instrument status notifications from your smartphone, tablet, or desktop computer

# Leco Instrumente Plzeň

- Založeno 1991
- 1997 nová budova v Plzni
- Teritorium: Česká republika, Slovensko, Maďarsko, Slovinsko, Srbsko, Makedonie, Černá hora, Rumunsko, Bulharsko
- Kompletní vlastní zázemí stabilní společnosti včetně servisních pracovníků



# Evropské Aplikační Technické centrum

Od roku 2016 v Berlíně  
Demonstrační laboratoř našich přístrojů



IN YOUR ANALYTICAL CHALLENGES

# COUNT ON LECO ANALYTICAL SOLUTIONS

## FUELS

- Sulfur in Coal/Oil
- Gross calorific value of alternative fuels (tyres, biofuels...)
- CHNS in solid and liquid Fuels
- Proximate Analysis (Moisture/Volatiles/Ash/Fixed Carbon)

## RAW MATERIALS

- TOC in limestone
- CO<sub>2</sub>, SO<sub>2</sub> in raw meal
- Moisture, LOI in raw meal
- Hydration forms of Gypsum by TGA
- Carbon/Water and Sulfur in burnt lime

## CEMENT

- CO<sub>2</sub>/SO<sub>2</sub> in Cement
- Moisture/LOI in cement
- TOC in cement
- Hydration water in cement

## RESEARCH

- Different applications
- New cements
- New concretes
- New building materials

## ENVIRONMENTAL SAMPLES

- TOC of disposals
- Composition of fly ash
- TOC/TIC/EC content without acid treatment
- Moisture / LOI in Fly ash

## ALTERNATIVE FUELS

- Sulfur in Biofuels/Alternative Fuels
- Gross calorific value of byproducts
- Gross calorific value of alternative fuels
- CHNS in alternative fuels

## CLINKER

- CO<sub>2</sub> /SO<sub>2</sub> in clinker
- LOI in clinker
- Cement phases in clinker (A-III B-III ...)
- Moisture content of clinker

AC600

### Calorimeter

- Gross calorific value in fuels
- Gross calorific value in alternative fuels
- Calorific value of environmental samples



RC612

### Carbon/Water Phase Analyser

- TOC/TIC/EC content of limestones, raw materials and other matrices
- CO<sub>2</sub>/Water content of cement/clinker
- Quick test of LOI by Water/CO<sub>2</sub> testing
- Moisture, water, carbon in burnt and slaked lime
- CO<sub>2</sub>/Carbonate Content in lime
- Crystalline Water in Clinker
- H<sub>2</sub>O-Phases/Lime/Gypsum
- CO<sub>2</sub> Phases in cement



CHNS628

### CHNS Elemental Analyser

- C, H, N and S in Coal, Coke
- C, H, N and S in alternative fuels/biofuels
- C, H, N and S in liquid fuels
- C, H, N and S in environmental samples



TGA701

### Macro Thermogravimetry

- Loss on Ignition (LOI) in Fly Ash, Coal Fly Ash and Portland cement by Macro TGA
- Two-Step Loss-on-Ignition (LOI) on Cement
- Moisture, Volatiles, Ash, and Fixed Carbon in Coal
- Moisture, Volatiles, Ash in alternative fuels
- Hydration forms of Gypsum
- Moisture/Crystalline water in lime



SC832

### Sulfur/Carbon Analyser

- CO<sub>2</sub> /SO<sub>2</sub> in cement, clinker, raw meal, limestone, lime etc.
- C/S in solid fuels (coal, coke, waste materials)
- C/S in liquid fuels (oil, waste materials...)
- C/S in environmental samples



CS744

### HF Carbon Sulfur Analyser

- Fast determination of CO<sub>2</sub> /SO<sub>2</sub> in cement, clinker and other cement products
- SO<sub>2</sub> in gypsum



# Kalorimetr AC 600

- Nejrychlejší kalorimetr na trhu
- Volitelná kalorimetrická bomba odolná vůči halogenům
- Ergonometrický tvar kalorimetrické bomby a nízká hmotnost





# Stanovení fázového uhlíku a vodíku RC 612

- Stanovení TOC, TIC, EC
- Hydratace materiálů
- Obsah krystalické vody ve slínku...



# Termogravimetrická analýza TGA 701

- Automatické stanovení pro 19 vzorků najednou
- Vlhkost, těkavé látky, prchavé hořlaviny, obsah popela
- Hydratace sádry
- Velikost vzorku do 5g



■ TGA701 with automated sample carousel

# Stanovení obsahu síry a uhlíku SC 832

- Velmi rychlá analýza do 120 sekund
- Dávkování do lodiček – velikost vzorku až půl gramu



# Stanovení obsahu C,H,N,S

## CHNS 628

- Analýza všech prvků do 6 minut – nejrychlejší analyzátor na trhu
- Autosampler



# Cement Clinkers

LECO Corporation; Saint Joseph, Michigan USA

In the production of cement, clinkers are the sintered lumps exiting the cement kiln. Clinkers are typically 1 to 25 mm in diameter.

## Cement Clinker Analysis

Clinker materialography is commonly performed and serves three basic purposes: quality control, problem solving, and monitoring process improvements.

### Quality Control

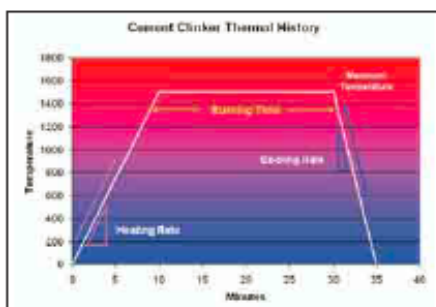
When clinkers are examined regularly, the microstructure of a plant's "typical" clinker is well known. If a change in the microstructure occurs (e.g. if the size or shape of the crystals changes, or a key component is not properly distributed), plant operators can react to modify processing parameters to return the clinkers to "normal". Mechanical tests (e.g. strength) and chemical tests (e.g. % free lime) provide valuable quality control information but do not tell the whole story. The relatively quick preparation of clinker samples and the information their examination can reveal make clinker materialography a valuable diagnostic tool.

### Problem Solving

Examination of clinker microstructure can provide clues to solving cement production or performance issues. As stated previously, routine mechanical and chemical tests often provide insight, but microscopy can provide the missing pieces to the puzzle.

### Monitor Process Improvements

If a potential process improvement is implemented (e.g. temperature set point change, cooling rate increase, new raw material source, etc.), an analysis of the clinker microstructure is recommended before and after ANY change. Plant personnel can determine the positive and negative effects of the change and perhaps predict changes in end product performance.



Typical Heating, Burning, and Cooling Cycle



Typical Clinker Sample

## Sample Storage

Prior to beginning the preparation process, clinkers should be stored in a humidity controlled room or cabinet. This will help prevent hydration and carbonation of the clinker samples.

After preparation, polished samples can be protected during storage with an acrylic or lacquer spray, which is removed by rubbing gently with an acetone-soaked cotton ball.

## Sample Preparation and Analysis

### Sectioning/Cutting Equipment

MSX205M2 sectioning machine equipped with a small vise (811-651-144) and a 7-inch (175 mm) diamond blade (809-150).



### Mounting Equipment

Cold mounted with Long Cure Epoxy (812-522-HAZ) using 1.5 inch diameter plastic mold cups (810-992-012). Filled molds were placed in a vacuum chamber (at 28 in. Hg) for two 30 second cycles.



### Grinding and Polishing Equipment

GPX200 with an Automatic Grinding/Polishing Head.



### Grinding (Fixed Head) - GPX200, 10" Wheel

	Time (Min:Sec)	Head Direction	Head Pressure (lb.)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
Platinum #1	2:00	CW	35	75	CCW	200
812-337, Microid Etender						
Platinum #2	2:00	CW	35	75	CCW	200
812-338, Microid Etender						

### Polishing

	Time (Min:Sec)	Head Direction	Head Pressure (lb.)	Head Speed (RPM)	Wheel Direction	Wheel Speed (FPM)
3µ Premium Suspension, Ultra Silk, Microid Etender	3:00	CW	35	100	CCW	200
810-997-016, 812-438, 811-003						
0.05 µ Gamma 8 Alumina Powder, Microid Etender, Leciath	1:00	CW	30	75	CCW	150
810-778, 811-003, 812-224						

Note: Rinse only with ethyl alcohol between preparation steps to prevent staining of clinkers.

### Etching

A common clinker etchant is 2% Nital (a mixture of nitric acid and alcohol). The sample is typically immersed for 5 to 10 seconds. This etch, or stain, is used to differentiate the Silicates, Alite, and Belite in the Clinker sample.

Another method of etching is the immersion in distilled water, at a temperature of 40 to 50°C (104 to 122°F), for 10 seconds. The etched sample is rinsed with alcohol and dried with forced warm air. With a water etch, free lime crystals show up as vivid, multicolored balloons.

## Analysis

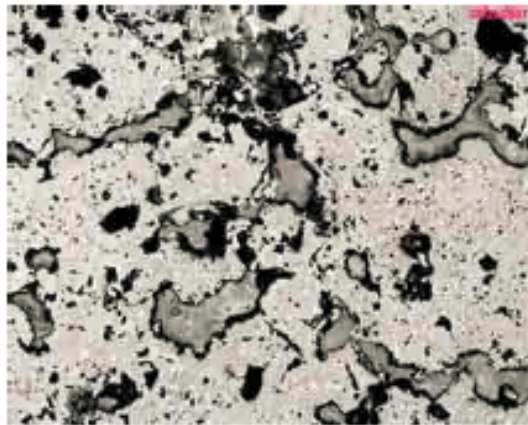
### Equipment

Olympus GX51 BrightField Metallograph, PAXcam3 (3 Mp Color Digital Camera), and PAX-it™ Image Analysis and Management Software.



### PAX-it Analysis

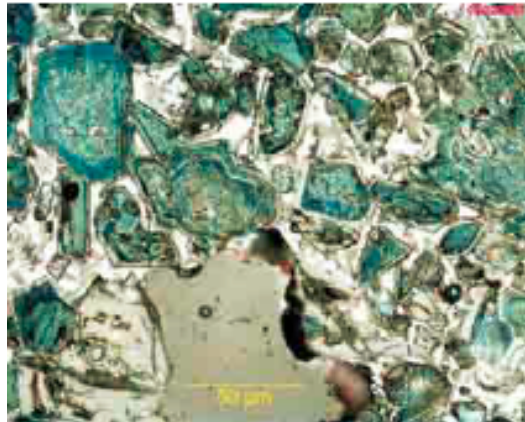
A PAX-it "Detect Areas" routine can be utilized to analyze the various phases in a prepared clinker sample. Because most of the phases appear as different colors under brightfield illumination, the analysis is best performed using thresholding by color, rather than utilizing grayscale. The results can be outputted via an Excel template. Example analysis results can be seen on the next page.



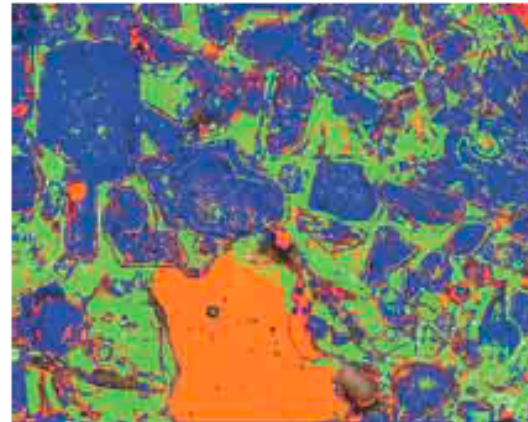
100X Water Etch



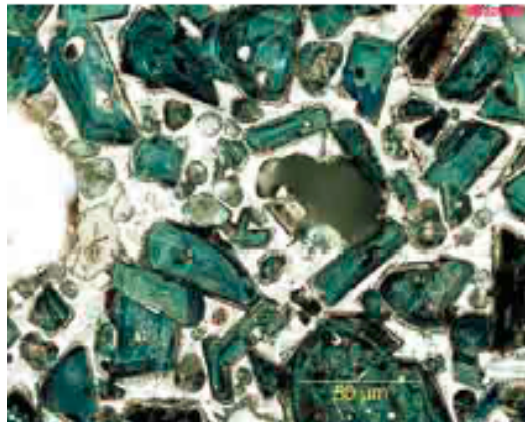
100X Nitral Etch



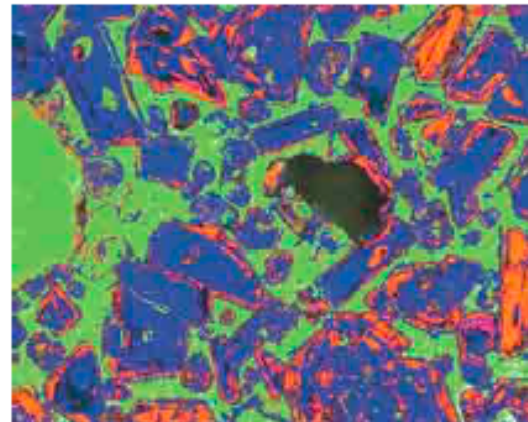
500X Nitral Etch



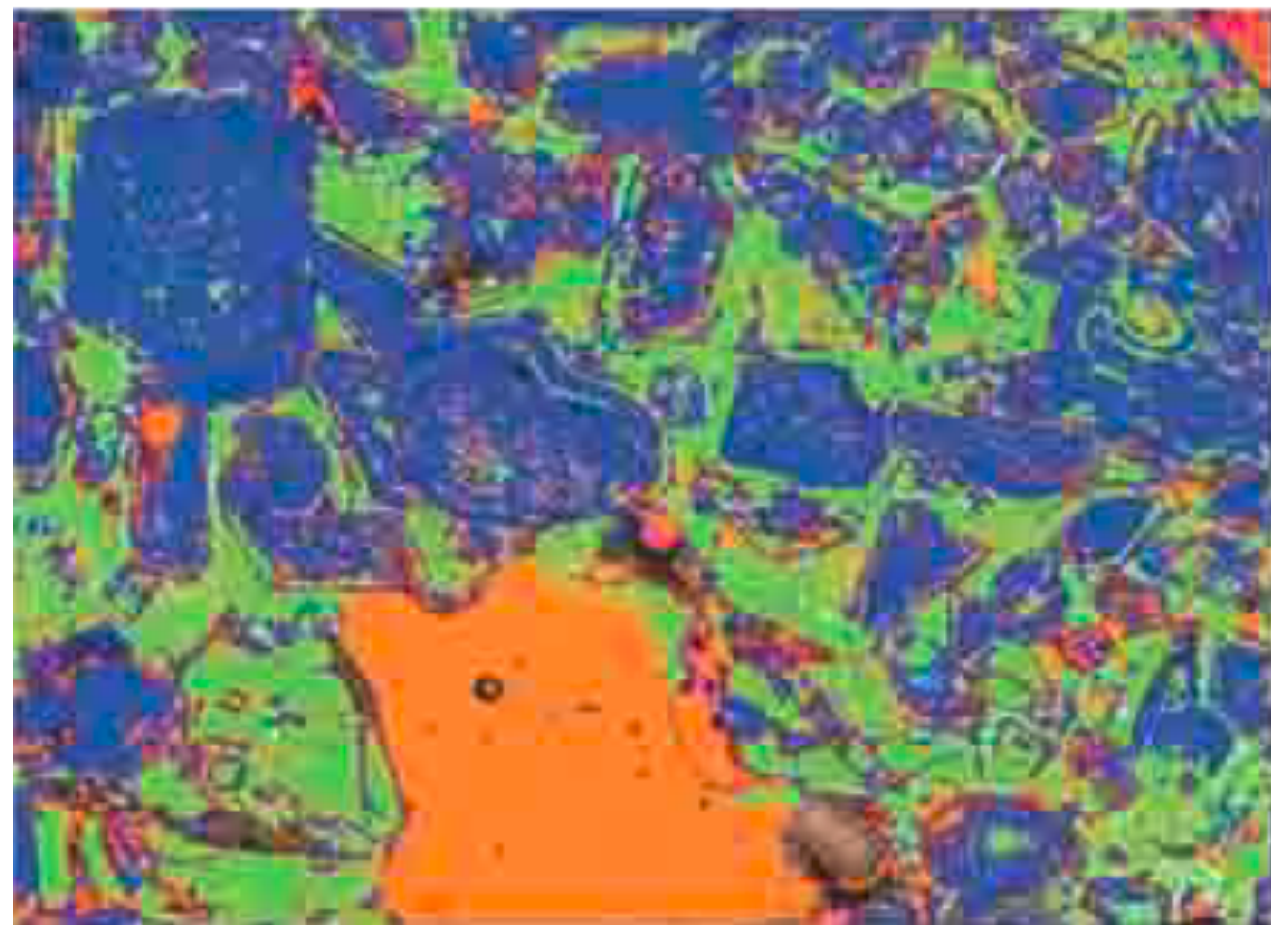
500X Pix-It Color Thresholding



500X Nitral Etch



500X Pix-It Color Thresholding



Belite	0.0%	Red
Alite	29.7%	Blue
Porosity	2.4%	Purple
Liquid Phase	15.7%	Orange
C3A	15.1%	Green
Total	62.8%	

Děkuji za pozornost