

Specialized set for microstructural investigation of soils

3.1. Scanning electron microscope

- Variable pressure high resolution scanning electron microscope for imaging of conductive, non-conductive and high-vacuum incompatible specimens;
- Magnification range from 6x-1 000 000x in high and low vacuum;
- Variable acceleration voltage, range from 200eV to 30keV, maximum current 2 μ A;
- System includes following detectors:
 - 1) Everhardt Thornley secondary electron (SE) detector;
 - 2) Large field SE detector;
 - 3) Gaseous SE detector;
 - 4) IR-CCD camera;
 - 5) Backscatter electron (BSE) detector;
 - 6) cathodoluminescence detector.
- Possibility to image all type of samples with minimal preparation (without coating, drying, etc.);
- Secondary electron resolution:
 - 3.0 nm at 30 kV in all vacuum modes;
 - 8.0 nm at 3 kV in high-vacuum;
 - 10 nm at 3 kV in low vacuum.
- Backscattered electron resolution 4.0 nm in high and low vacuum;
- Cathodoluminescence detector working in 300-650nm range;
- Low vacuum, low kV true SE detection on non-conductive samples without coating;
- Turbo molecular vacuum pump;
- Includes three vacuum ranges: high vacuum: $\leq 10^{-5}$ mbar; low vacuum: range 0.1-1 mbar; extended low vacuum 0.1-20 mbar;
- Controlled 'water vapor' gas is used to reduce charge on non-conductive samples;
- Vacuum pressure-dependent automatic selection and display of the relevant SE detector and controls;
- Infrared CCD camera with simultaneous output display with SED images;
- Automatic safety shutdown of IR source illumination in BSE mode;
- Through-the-lens differential vacuum pumping with combined turbo molecular and rotary pump vacuum system;
- 4-axis (X,Y, Z, rotation) motorized stage with tilting. Repeatability of stage not worse than 2 μ m;
- X, Y range: at least 50 mm, repeatability not worse than 2 μ m, Z range: at least 50 mm, tilting range at least 90°, continuous 360° rotation;
- Single or four-quadrant frame display of live, frozen, or frame-averaged digital images. Secondary Electron (SE), Backscattered Secondary Electron (BSE) mixed SE/BSE, CCD images can be viewed live in the four-quadrant display on one monitor, color imaging/mixing capability. Possibility to open any window in full monitor mode on second monitor;
- The whole sample is observable on overview image;
- Images obtained at a minimum 4000 x 3500 pixel resolution, with exportable files saved in TIFF, BMP or JPEG file formats, and in 8-bit or 16-bit depth;
- Direct digital video (.avi) recording is standard;
- Ethernet-connected, Windows XP system with one computer dedicated to microscope control and a second support computer dedicated to data collection, processing and storage, DVD R/W, networking and installation of other user software packages. Both PCs and monitors are

controlled with one keyboard and mouse;

- Possibility to connect manual user interface allowing adjustment of focus, magnification, contrast, brightness, beam shift, and stigmatism;
- Water cooled Peltier stage, capable of keeping temperature at -20°C and 60°C to allow specimens to be imaged and analyzed at relative humidity conditions up to 100% and perform in-situ freeze-drying experiments in negative temperature. The temperature and the ramp-up profile are directly controlled through the microscope user interface. Water chiller must be included together with all needed tubing;
- Possibility to include a heating stage to heat samples between ambient temperature and 1500°C to allow specimens to be live-imaged and recorded over the full temperature range. The temperature and the ramp-up profile are directly controlled through the microscope user interface;
- 2 holders (one places 1 and another places not less 7 samples) for aluminum stubs;
- 20 units of aluminum stubs and 10 units of spare filaments should be included;
- Image analysis software for soil analysis:
 - Soil structural element packing;
 - Type of contact between micro aggregates;
 - Porosity;
 - Number of pores;
 - Total and average pore size;
 - Pore area;
 - Total and average pore perimeter;
 - Pore shape index, index of microstructure anisotropy, dominating pores orientation angle, pore curvature determination;
 - Statistical processing of morphological analysis data: combination of analysis data from different magnifications and segments into single data massif, creation of distribution diagrams according various parameters, determination of soil generalized parameters;
 - Classification of microstructure according dispersion and anisotropy factors;
 - Evaluation of roundness of structural elements;
 - Stitching of several images into large one;
 - Micro profile height measurement on stereo images;
 - 3D surface reconstruction according stereo images;
 - Extended depth of focus function (3D image deconvolution).

3.2 Diascopic/episcopic polarized microscope:

- Infinity optical system;
- Koehler type illumination, at least 30W halogen, at least one built-in neutral density filter;
- Color balance filter;
- Coarse/fine focusing, range at least 30mm, fine focusing 0.1mm/rotation;
- 50W high intensity halogen episcopic illuminator for brightfield/darkfield, polarization and DIC, field and aperture diaphragms synchronized with BF/DF switch, 3 insertable filters, polariser/analyser;
- Trinocular eyepiece tube;
- 10x eyepieces, 22 mm field of view;
- Intermediate tube with focusable Bertrand lens, switchable between conoscopic and orthoscopic observation, built-in analyzer;
- $1/4\lambda$ and 546 nm (inaccuracy not higher 1nm) plates, Senarmont and quartz wedge compensators;
- 360° rotatable analyzer, not higher 0.1° increments;

- Centering nosepiece, at least 5 positions;
- Objectives for epi/dia illumination, polarization and DIC:
 - Plan Fluor 5x, N.A. at least 0.15, W.D. (working distance) 20.0 mm;
 - Plan Fluor 10x, N.A. at least 0.30, W.D. 15.0 mm;
 - Plan Fluor 20x, N.A. at least 0.45, W.D. 4.5 mm;
 - Plan Fluor 50x, N.A. at least 0.80, W.D. 1.00 mm;
- Dedicated strain-free Achromat condenser, N.A. 0.9;
- Accessories for polarizer light both for diascopic and episcopic illumination;
- 360° rotating stage with ball bearing, 1° increment, can be fixed at certain positions, mechanical XY stage, range 35 x 25 mm;
- Spare halogen lamp for each of illuminators;
- Dust cover;
- Digital color camera:
 - At least 5 Mpixels 2/3" CCD;
 - 12 bit depth;
 - Exposure range from 1/1000 to 50 sec;
 - Frame rate 20 frame/sec;
 - Possibility to upgrade with control unit which allows:
 - to work without PC;
 - connect directly additional monitor or other media – must have RGB output;
 - transmit live image through local network or internet.
- Software “NIS Elements D”:
 - Full camera control, automatic exposure control;
 - Interactive length, area, angle, taxonomy, profile measurements, annotation of measured values;
 - Individual calibration according each objectives;
 - Annotations on the image,
 - Large image stitching from several smaller images.

3.3 Specimen sputter coater:

- Single system with freeze dryer – specimen is coated immediately after drying without breaking the vacuum;
- Possibility to coat specimens with Au, Au/Pd, Pt, Ag, Ni, Pd, Pt/Pd, one Au/Pd target should be included, 60mm, 0,1mm thickness disk;
- All accessories and materials necessary for operation of instrument included.

3.4 Freeze dryer – lyophilizator:

- Thermoelectric cooling and heating ;
- Peltier stage;
- Automatic drying cycle;
- Borosilicate glass chamber at least 160mm diameter, polycarbonate shielding cylinder;
- Stage temperature control range from -60°C to 60°C, 0.1°C step;
- Vacuum 10^{-2} mbar;

System includes water chiller (nominal temperature not more than 15°C), rotary pump with filter (at least 90 l/min), connecting tubes and other accessories needed for system operation.