LASER REMOTE OPTICAL GRANULOMETRY (LROG)

- A NEW TECHNIQUE TO REMOTELY MEASURE TEXTURAL FEATURES OF SEDIMENTARY SEQUENCES WITH APPLICATION TO MOUNT ST HELENS

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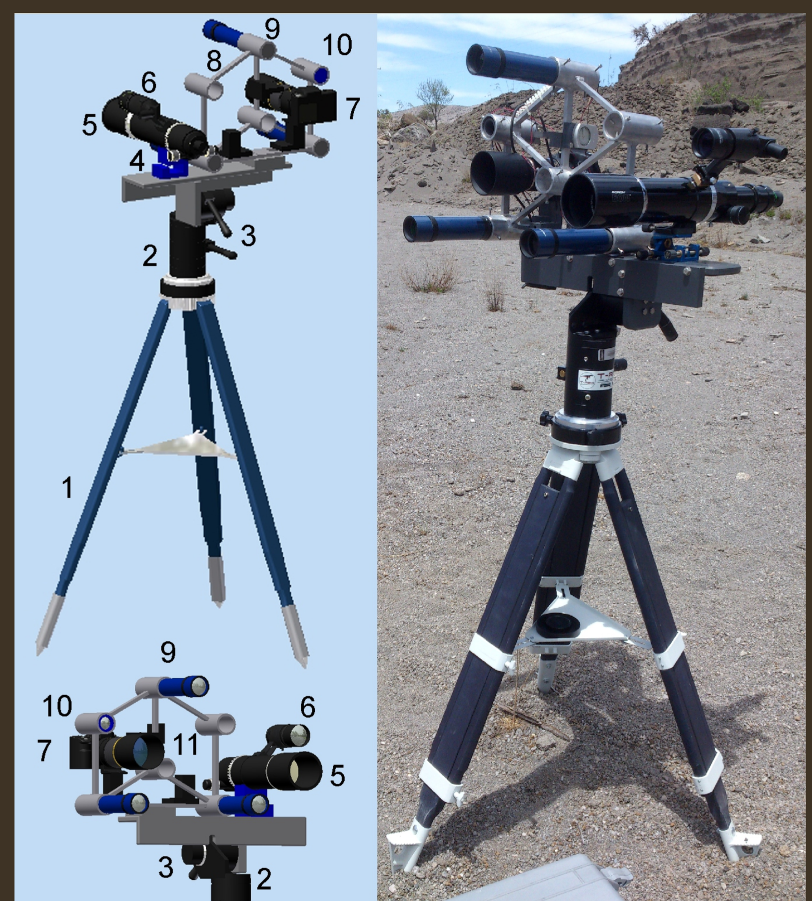
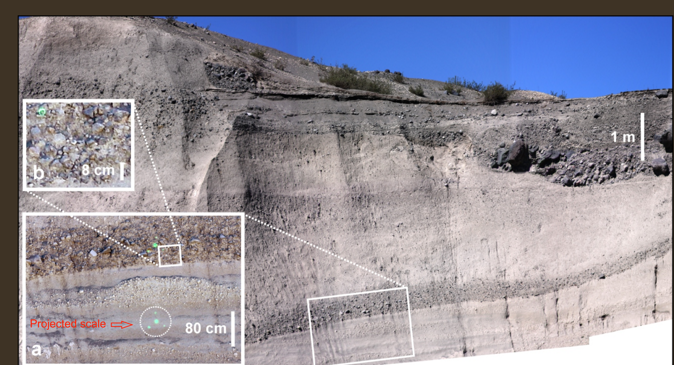
HOW LROG WORKS

LROG equipment



LROG constituent parts:

1) tripod, 2) altazimutal mount, 3) knobs, 4) adjustable stand for telescope, 5) apochromatic 80 mm refractor f.4, 6) 7x50 telescope viewfinder, 7) DSLR camera with 180 mm telephoto lens; 8) aluminum pentagonal support, 9) 50 mW green laser with projecting telescope, 10) projecting system 6x30 viewfinder, 11) precision inclinometer.



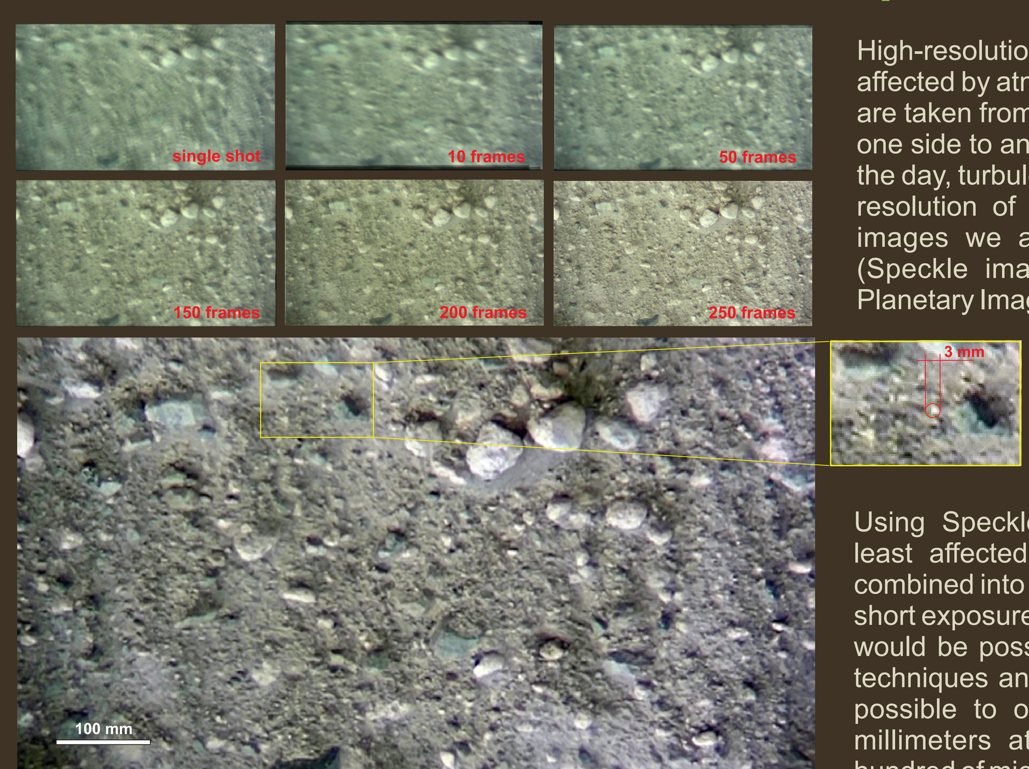
Several exposures at MSH are inaccessible or contain a high concentration of blocks, rendering traditional field sampling methods difficult to impossible. In response to this field challenge, in the UASLP-LAIMA laboratory it was developed the Laser Remote Optical Granulometry (LROG), a new instrument and method that allows for the remote textural study of outcrops of sedimentary deposits based on high-resolution imaging and stereologic techniques. LROG has been used to measure fabric and grain size distributions for lithic-rich regions of the MSH PDC deposits in areas that are otherwise inaccessible.

The LROG instrument consists of a high resolution digital camera (7), stand-alone or coupled to a small telescope (5), in parallel to a three laser projection system (9) (calibrated by means of a separated reflecting panel).

The method consists in taking high-resolution images of the outcrop, which can be several tens of meters away, containing the three laser points that act as a precision reference scale. This scaling system is independent to the distance of the instrument to the outcrop.

During the analysis phase, a set of lines, parallel to the sedimentary deposit, are superimposed to the image which also contains the reference points. The length of the intersection of each line with each particle is measured and tabulated (Sarocchi et al., 2005). Depending on the optical system and the distance to the outcrop, particles as low as 0.1 mm up to several meters can be measured precisely.

Resolution enhancement techniques



High-resolution LROG photography can be deeply affected by atmosheric turbulence. When photographs are taken from tens or hundreds of meters away, from one side to another in a ravine during the hot hours of the day, turbulence affects a lot the general quality and resolution of the images. In order to obtain better images we are using image analysis techniques (Speckle imaging techniques) commonly used in Planetary Imaging (Lodriguss, 2003).

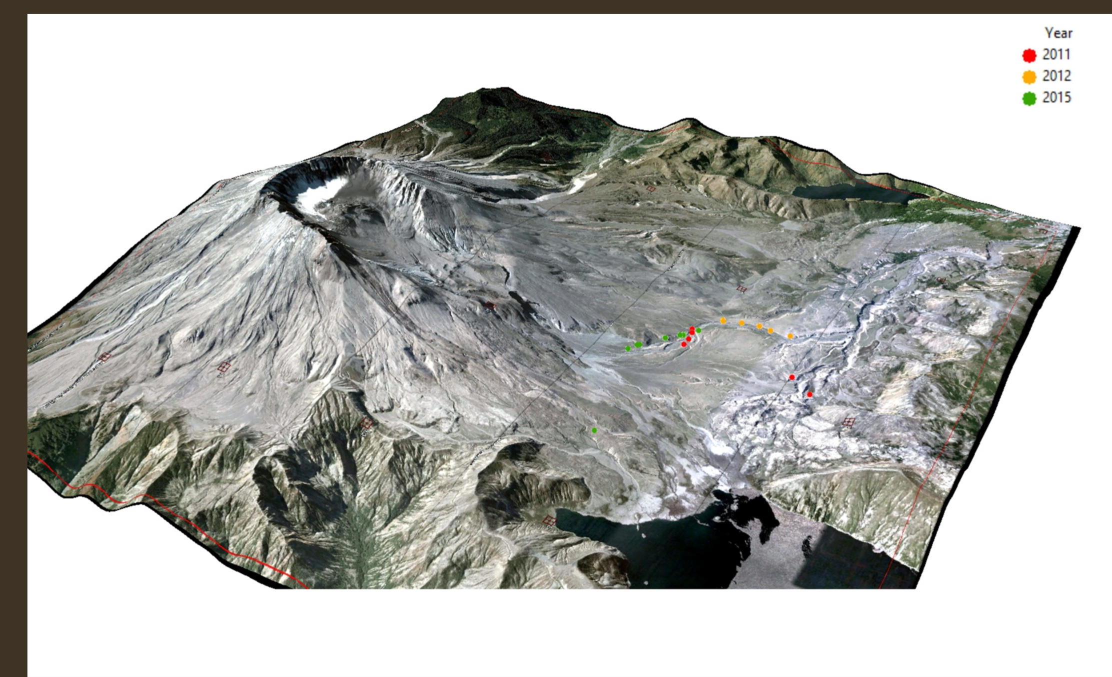
The example at left, corresponds to a high resolution image obtained from a distance of 240 m using an apocromatic 80 mm f.4 telescope and a high speed CCD camera.

After the image enhancement, the smallest clasts recognizable without error (areas > 5-10 pixels) at such distance, measures about 3 millimeters.

Using Speckle imaging, those optimum exposures least affected by the atmosphere are chosen and combined into a single image by shifting and adding the short exposures, providing much higher resolution than would be possible with a single exposure. With such techniques and through a small portable telescope is possible to obtain resolutions in the order of few millimeters at hundreds of meters of distance or hundred of microns at few tens of meters.

LROG GRANULOMETRY OF MT. ST. HELENS DEPOSITS

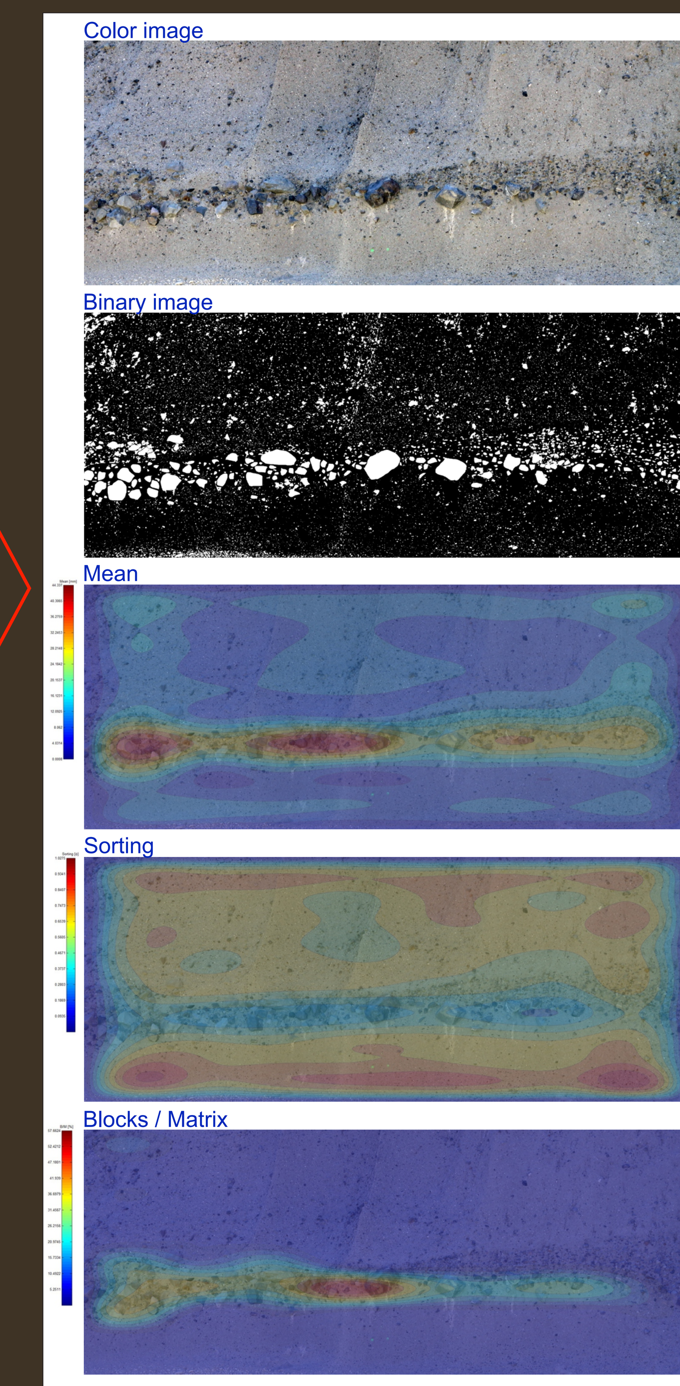
Study area and samples locations



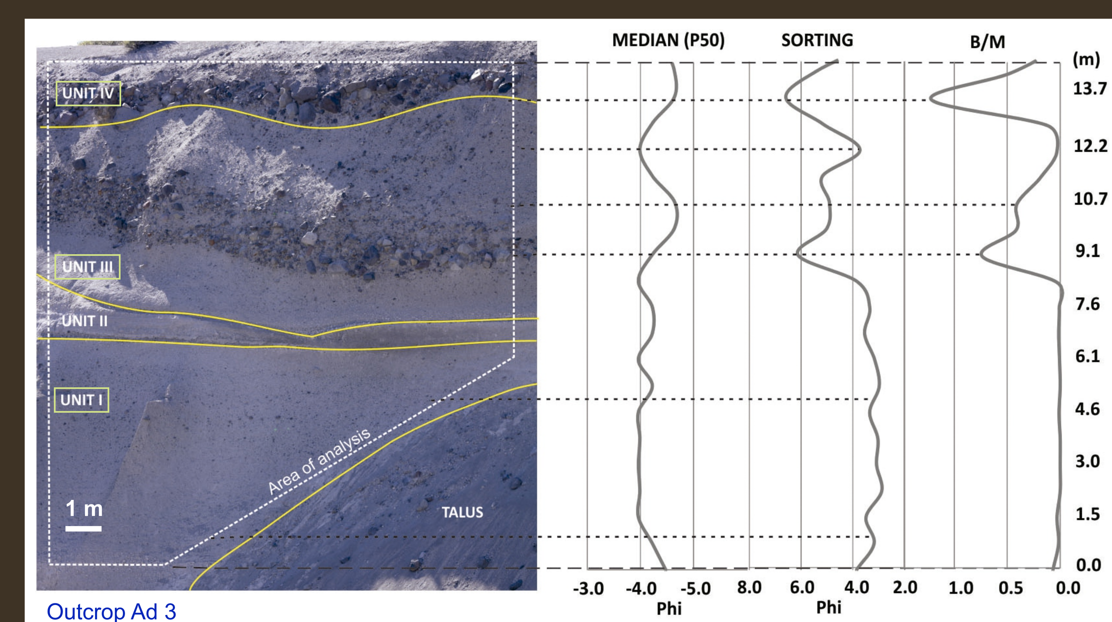
During the last decade, erosion at Mt. St. Helens has been very intense, generating several new deposit outcrops. Most of the outcrops are made of material with a low degree of consolidation and enormous thicknesses. Granulometric sampling done with traditional techniques is difficult and dangerous. In such circumstances has been very useful to use the remote method developed in our laboratories (Sarocchi et al, 2011;. Moreno-Chavez et al, 2015; Sarocchi et al, 2016 -submitted-). Alongside to the extensive work done with traditional methodology (Brand et al., 2014; Brand et al., 2016), we conducted three campaigns during the years 2011, 2012 and 2015 using remote optical techniques. During these campaigns 20 outcrops have been studied (most of them along the main ravines). In each outcrop has been obtained an ultra-high resolution panoramic image, three vertical granulometric profiles and an integral sieve analysis of each of the depositional units.

Through software developed in the lab. LAIMA (software that is freely available on the page http://www.laima-uaslp.org/) it is possible to study the optical textures automatically. Quantitative image analysis allows to build vertical profiles and optical granulometric maps of the main statistical parameters (Moreno-Chavez et al, 2015;. Sarocchi et al, 2016 -submitted-.).

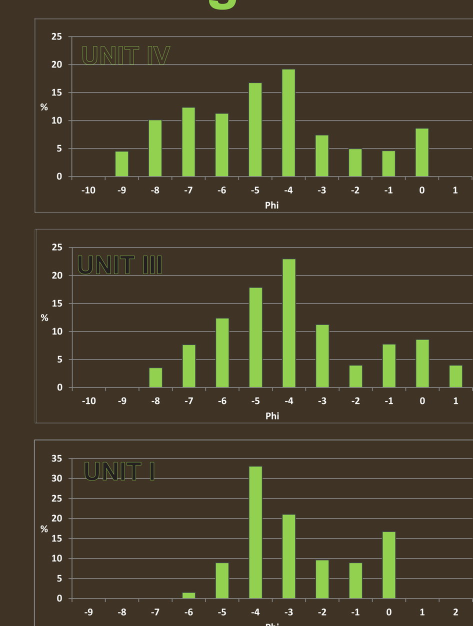
Granulometric areal maps



Vertical Granulometric Profiles



LROG granulometry



The optical granulometric analysis are obtained by means the Rosiwal Stereological method (Sarocchi et al., 2005; Sarocchi et al., 2011), and a software (freeware on the website of LAIMA) OPTGRAN-CS (Moreno Chavez et al., 2015).

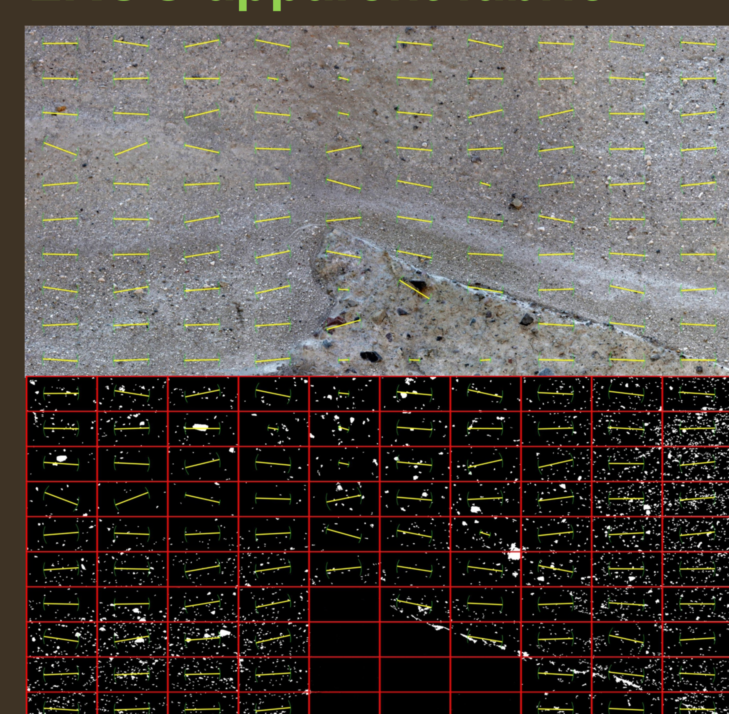
In the figure to the left is shown an example of analysis performed by means of LROG optical analysis and is compared with the results obtained by classical granulometric analysis (sieving + coulter counter). The statistical results (obtained using DECOLOG 5.4 software,) point out differences (Table 1). The differences can be explained considering that in the optical particle granulometry, clasts finer than 0.5 - 0.25 mm are lost and they can be a significant fraction of the total. Furthermore the granulometry of LROG describes the whole distribution of the unit on the contrary to classical granulometry that analyze specific points.

Table 1

UNIT	LROG mean	LROGσ	Class. Mean (a)	Class. σ (a)	Class. Mean (b)	Class. σ (b)
I	-3.29	1.55	-3.80	3.81	-0.01	2.84
III	-4.33	2.26	-0.19	3.49	-1.77	3.79
IV	-5.24	2.44	--	--	--	--

FABRIC ANALYSIS OF MT. ST. HELENS DEPOSITS

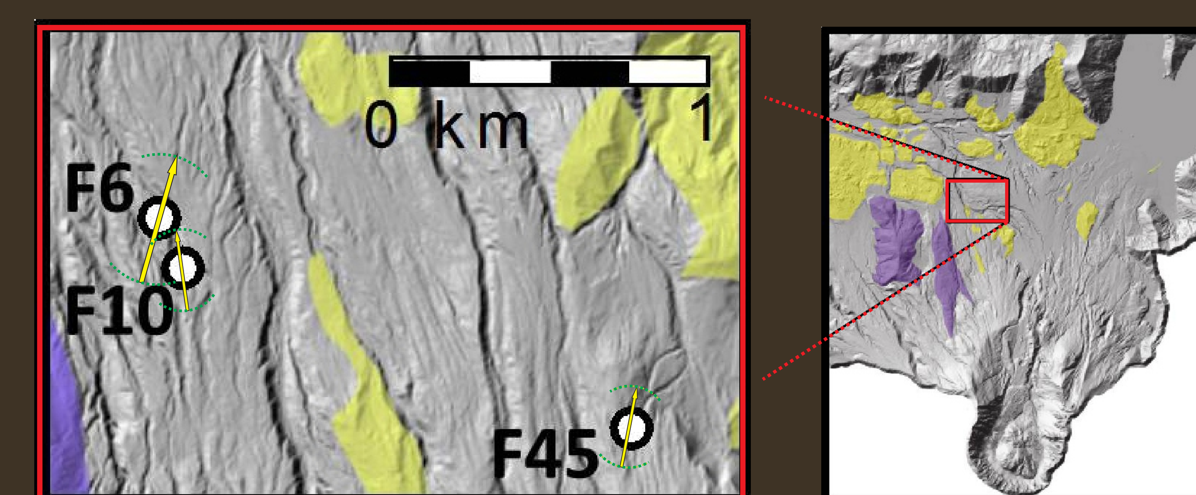
LROG apparent fabric



The study of apparent fabric on outcrops high-resolution images, analyzing thousands of particles, allow to measure statistically the elongated particles preferential orientation, the variance and the strength of the iso-orientation. Among other things, it allows to follow the flow lines of the material at the time of deposition and make considerations about the flow rheology.

Yellow lines shows the local particle's average orientation. The lenght of the arrow is related with the degree of iso-orientation, green arcs represents the sample variance.

3D Fabric as flow direction indicator



For quantitatively individuate the flow direction of each depositional unit, fifthy oriented samples were collected. These samples are analyzed with the method proposed by Capaccioni and Sarocchi (1995). The flow directions obtained for samples F6, F10 and F45, show consistent results. Fabric data will be very useful to understand the relationship between observed flow directions and the presence of natural obstacles (palaeotopography and hummocks). The arrow lenght is proportional to the iso-orientation strength.

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