Elemental Scientific LASERS
INNOVATION TO ILLUMINATE

Poster Note

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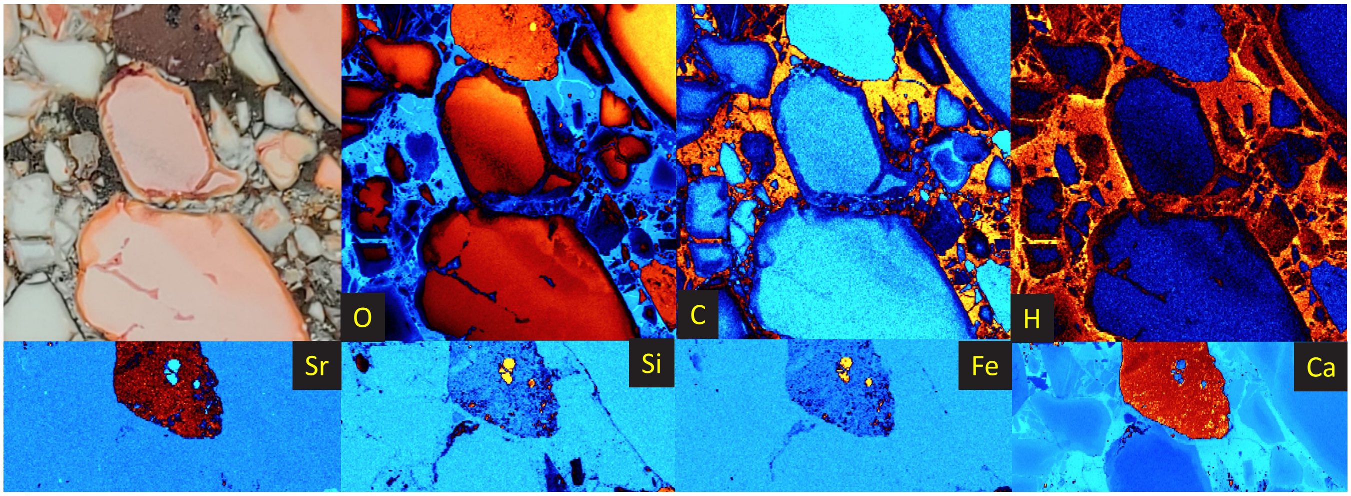
Using Laser Dosage to Generate High Resolution LIBS Images



Introduction

Over the past few years, laser induced breakdown spectroscopy (LIBS) has become an increasingly popular technique for imaging geologic samples due to the decreased time it takes to run an experiment and versatility of which elements can be monitored. To obtain emission spectra with the highest overall signal intensities, we utilized a large spot size with a high laser fluence which results in high laser energy ablation. However, this increased spot size results in lower resolution images. One strategy to increase resolution without decreasing emission spectra intensity is to increase the laser dosage, which is defined as the number of laser pulses per unit area. Using a high laser dosage has been demonstrated as a viable technique for increasing image quality for LA-ICP-MS imaging (Figure 1).Therefore, applying this technique to LIBS can allow imaging with a large spot size which will maximize the emission spectra intensity, resulting in increased image resolution.

In this work, we will explore two different LIBS imaging techniques. The first technique, considered the current standard, uses a low laser dosage, while the second technique utilizes a higher laser dosage, in which high spatial resolution is achieved by small XY stage movements. These experiments were conducted using a 193 nm ns excimer laser in combination with a multi-channel CMOS detector. LIBS images collected with a high laser dosage generated higher resolution images that would not normally be achievable when running at a lower laser dosage.

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Methods

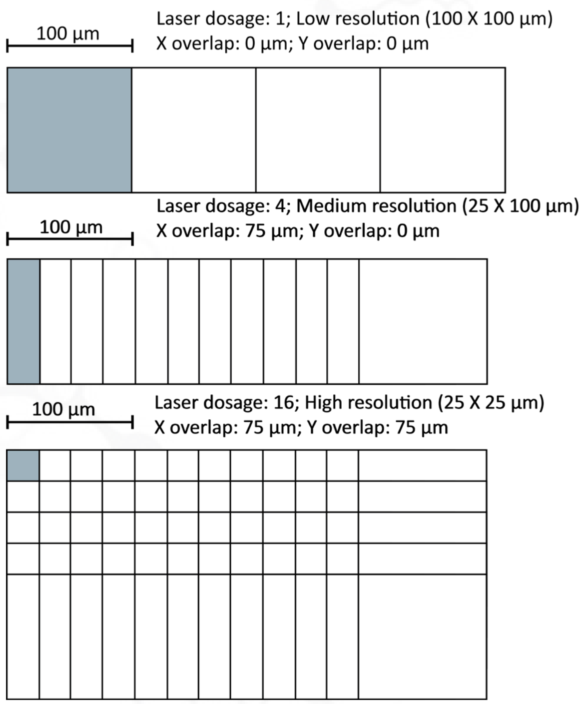

Figure 1. Top, a schematic diagram illustrating a laser dosage of 1; Middle, a schematic diagram illustrating a laser dosage of 4; Bottom, a schematic diagram illustrating a laser dosage of 16.

Table 1. Instrumental settings for imageGEO[LIBS] system.

Laser	
Fluence	15 J/cm^2
Laser Wavelength	193 nm
Repetition Rate	150 - 400 Hz
Spot Size	100µm x 100 µm
Scan Speed	10,000 µm/s
Carrier Gas Flow	800 mL/min He
Area (bead)	8.4 mm x 8.8 mm
Area (pegmatite)	20 mm x 23 mm
LIBS	
Integration	50 µs
Spectrometer Delay	0.2 µs
Wavelength Range	190 - 1100 nm
Spectrometer Type	CMOS

Results

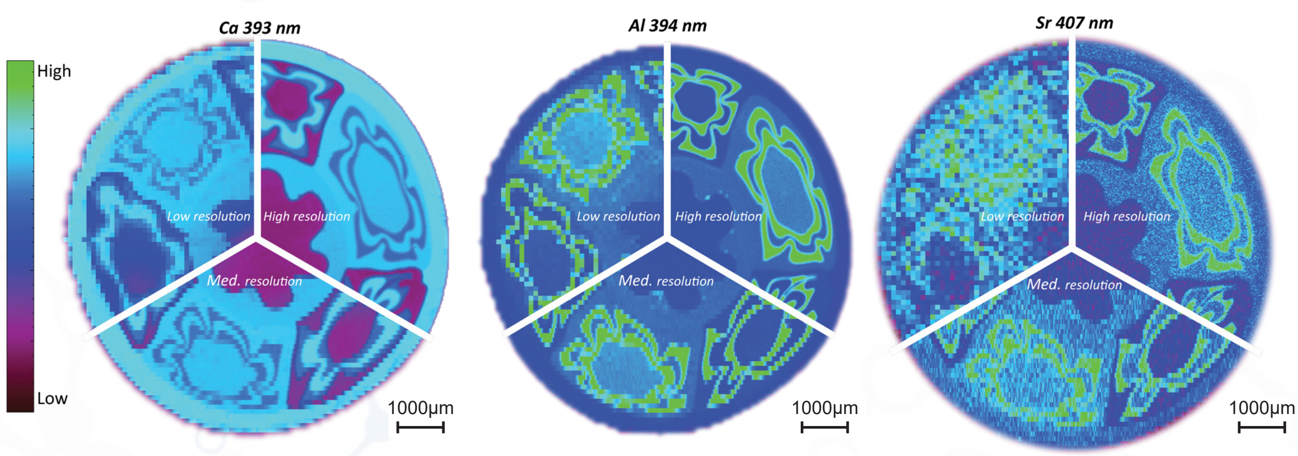

Figure 2. Left, a concentration map of Ca in a glass bead comparing image resolution when using a low, medium and high laser dosage; Middle, a concentration map of Al in a glass bead comparing image resolution when using a low, medium and high laser dosage; Right, a concentration map of Sr in a glass bead comparing image resolution when using a low, medium and high laser dosage. The analysis duration was 5 minutes for dosages of 1 and 4, and 18 minutes for the laser dosage of 16. All images were created with Iolite4 and the data was reduced using the Trace Elements DRS.

Results *(Continued)*

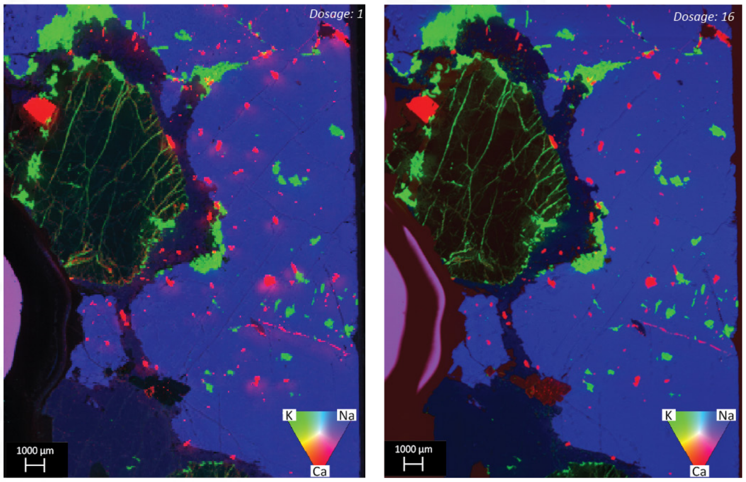

Figure 3. Left, RGB map of Ca (red), K (green), and Na (blue) in a pegmatite sample imaged using a low laser dosage (laser dosage:1); Right, RGB map of Ca (red), K (green), and Na (blue) in a pegmatite sample using a high laser dosage (laser dosage:16). All images were created with Iolite4 and the data was reduced using the Trace Elements DRS.

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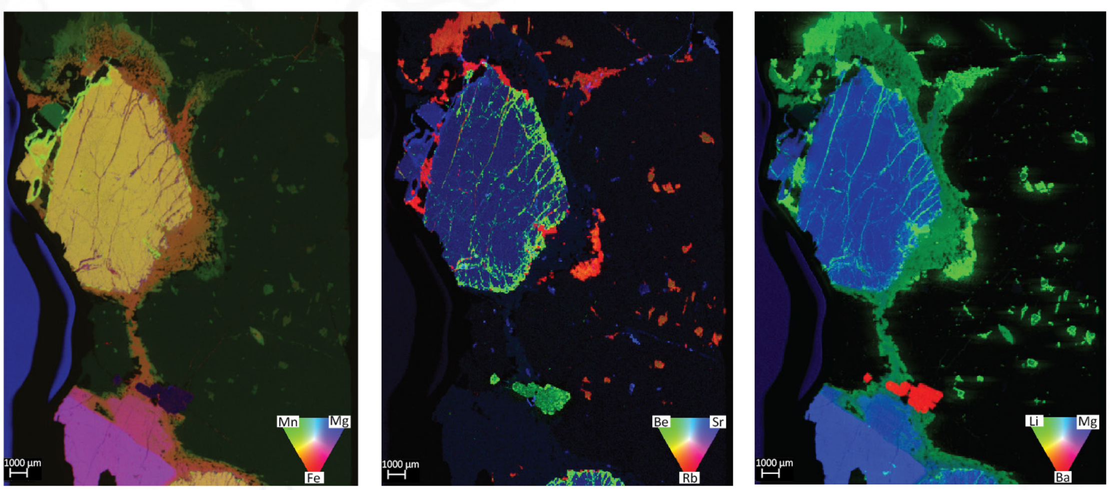

Figure 4. Left, RGB map of Fe (red), Mn (green), and Mg (blue) in a pegmatite sample; Middle, RGB map of Rb (red), Be (green), Sr (blue) in a pegmatite sample; Right, RGB map of Ba (red), Li (green), and Mg (blue) in a pegmatite sample. All images were aquired using a laser dosage of 16 and took 1.5 hours to image. All images were created with Iolite4 and the data was reduced using the Trace Elements DRS.

Methods

- Increasing laser pulse overlap while using large laser spot sizes increases laser dosage.
- This higher laser dosage improves overall resolution of an image while maximizing emission spectra intensity.
- Changing laser pulse overlap in both X and Y directions has a higher resolution than just changing the overlap in the X direction but increases the analysis duration.

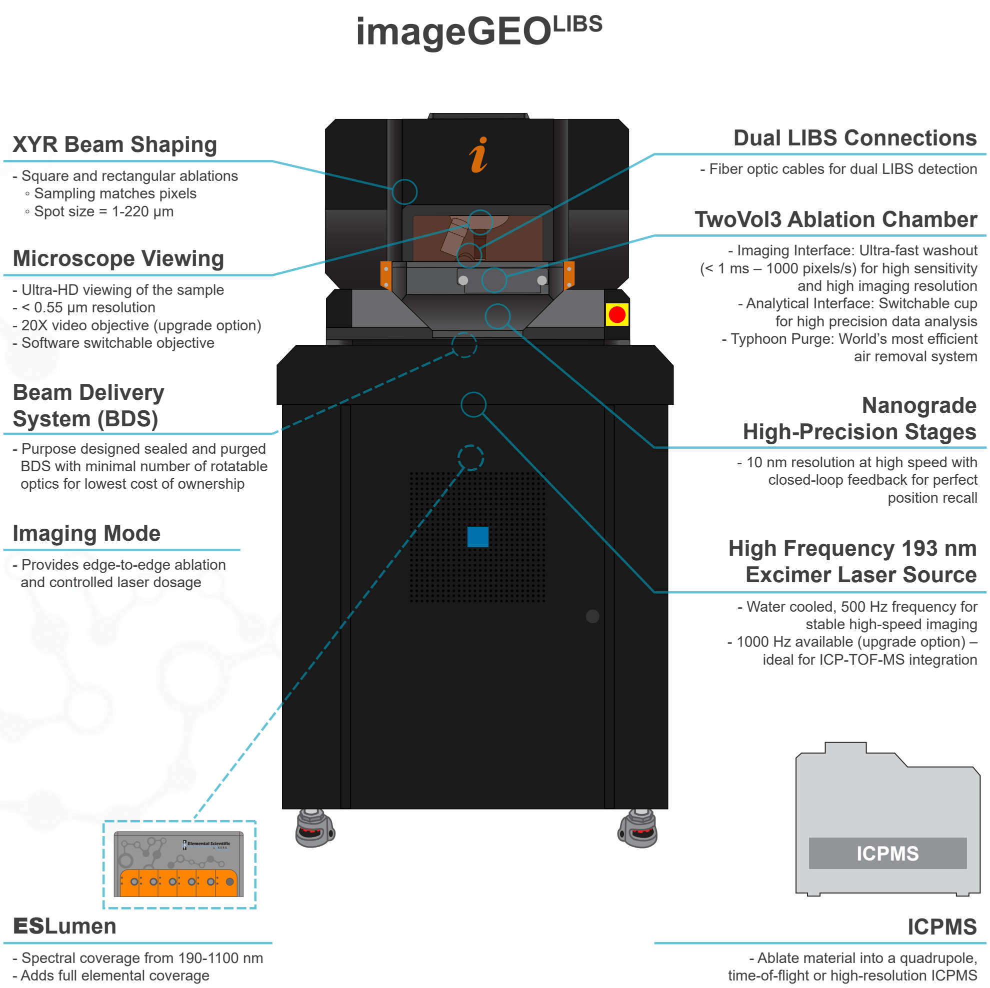

Figure 4. imageGEO LIBS Features Diagram

Acknowledgements and References:

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(1) van Elteren et al., J. Anal. At. Spectrom., 2019, 34, p. 1919-1931

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