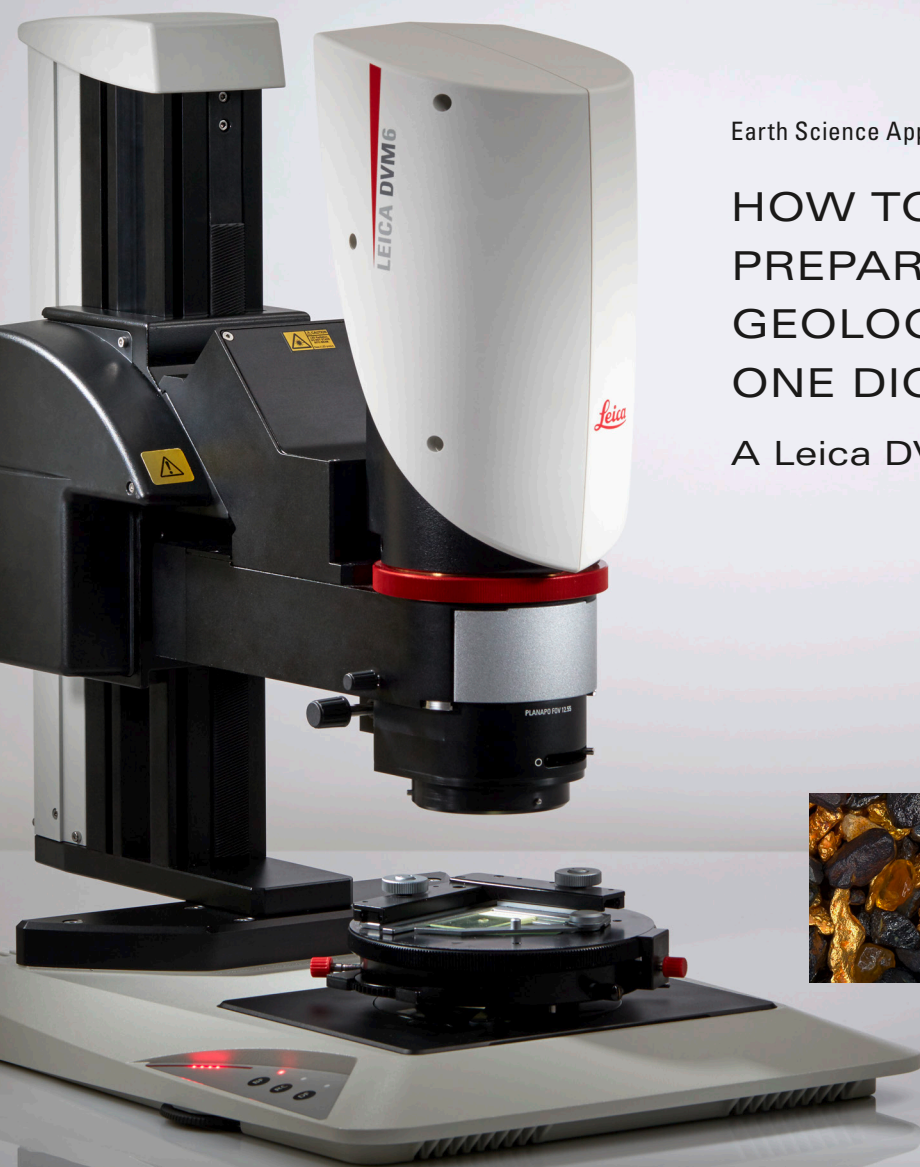


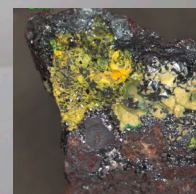
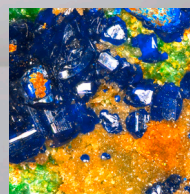
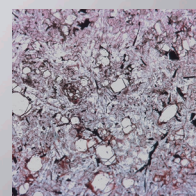
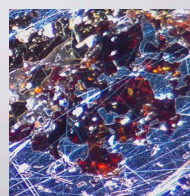
From Eye to Insight



Earth Science Applications

HOW TO ANALYZE PREPARED AND UNPREPARED GEOLOGICAL SAMPLES WITH ONE DIGITAL MICROSCOPE

A Leica DVM6 M Case Study



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Introduction

Polarized light microscopes have been used in classical earth science studies for the last 100 years. Since then a lot of progress has been made to increase the user friendliness, ergonomics, and optical performance of such microscopes. Still, one thing has not changed: Classical polarized light (compound) microscopes can only be used for prepared samples, because the working distance they offer is insufficient for whole samples.

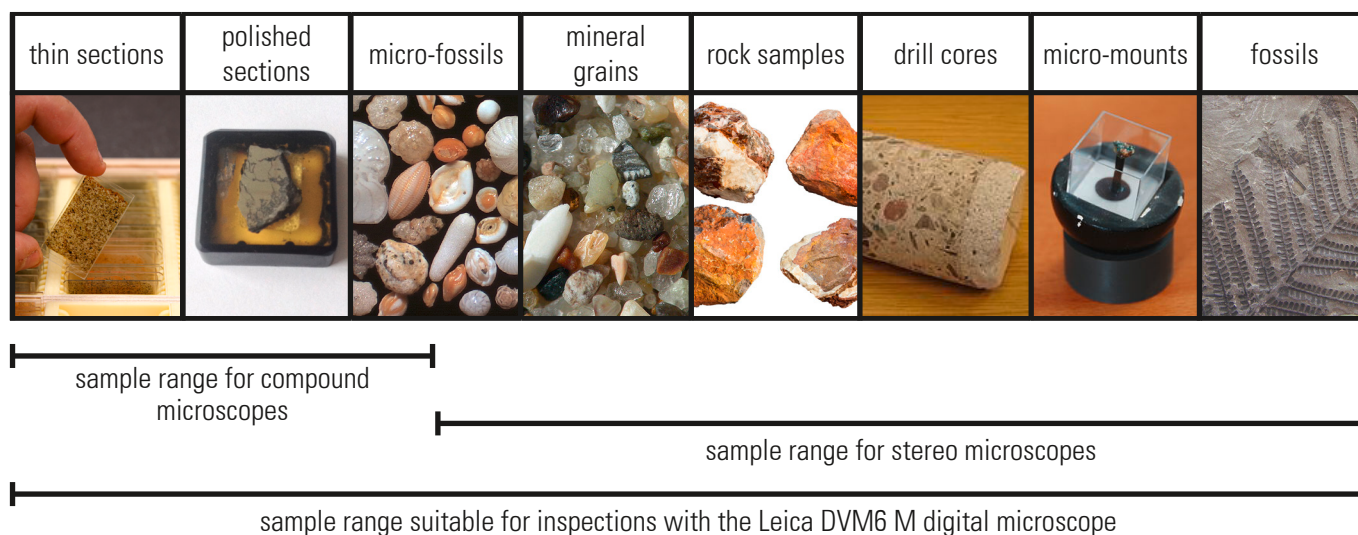
This means that thicker and bigger geological samples have to be sectioned and polished to fit under the limited working distance of a compound microscope. Those sample preparations require the highest precision, especially when it comes to thickness, flatness, and the polishing quality of the polished sections. A standard thickness of 30 micrometer is needed for inspections with compound microscopes using transmitted, polarized light [1,2].

On the other hand, for unprepared samples, scientists need to switch to a stereo microscope, which offers larger working distances.

One microscope for both prepared and unprepared samples

This report explains how earth scientists can analyze prepared and unprepared samples for polarized light applications with one single instrument, namely the Leica DVM6 M digital microscope. With the right choice of accessories it serves as a semi-quantitative polarization microscope.

Diversity of geological samples demands qualified microscope solutions:





Equipped for all geological inspections

The Leica DVM 6 M mounted to a manual or motorized focus column via an adapter provides extra working distance and allows geologists to work with polished and unpolished samples. The transmitted light base with high numerical aperture gives them a digital solution for diverse polarized light applications.

For the transmitted light base there is a polarization stage available with a swing-in/-out polarizer. This set-up of the Leica DVM6 M is customized for earth science applications and allows users to observe transparent samples under plain and crossed polarized light. It does not matter if the sample is with or without a cover-glass or if the sample is an uncut, transparent mineral (e.g., diamonds or index minerals).

The Leica DVM6 M enables earth scientists to be more efficient thanks to:

- Flexibility to work on both prepared and unprepared samples with one instrument;
- Fully integrated ring light, plus coaxial and other types of illumination, for more options to study and analyze samples compared to a compound microscope;
- Simple, rapid way to change magnification over the entire range;
- Intuitive software for microscope operation and analysis;
- Automated tracking and storing (encoding) of important parameters.

For further details about the Leica DVM6 digital microscope, please refer to the Leica DVM6 product page [3].

Analyzing prepared samples

The example below is a thin section of basalt. When illuminated with different orientations of polarized light, the structure and composition of the basalt is revealed.

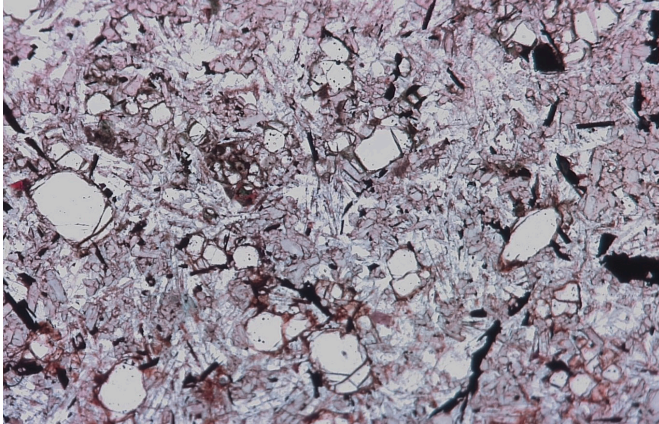


Fig.1: Image of a thin basalt section with plain polarized light.



Fig.2: Image of the same sample with crossed polarized light.

If the region of interest on the sample is bigger than the microscope's field of view, as seen in a single image, researchers can use Live Image Builder in the microscope software. This function creates a single image from a composite of images recorded by the camera as the stage scans and allows users to see the sample in a wider context.

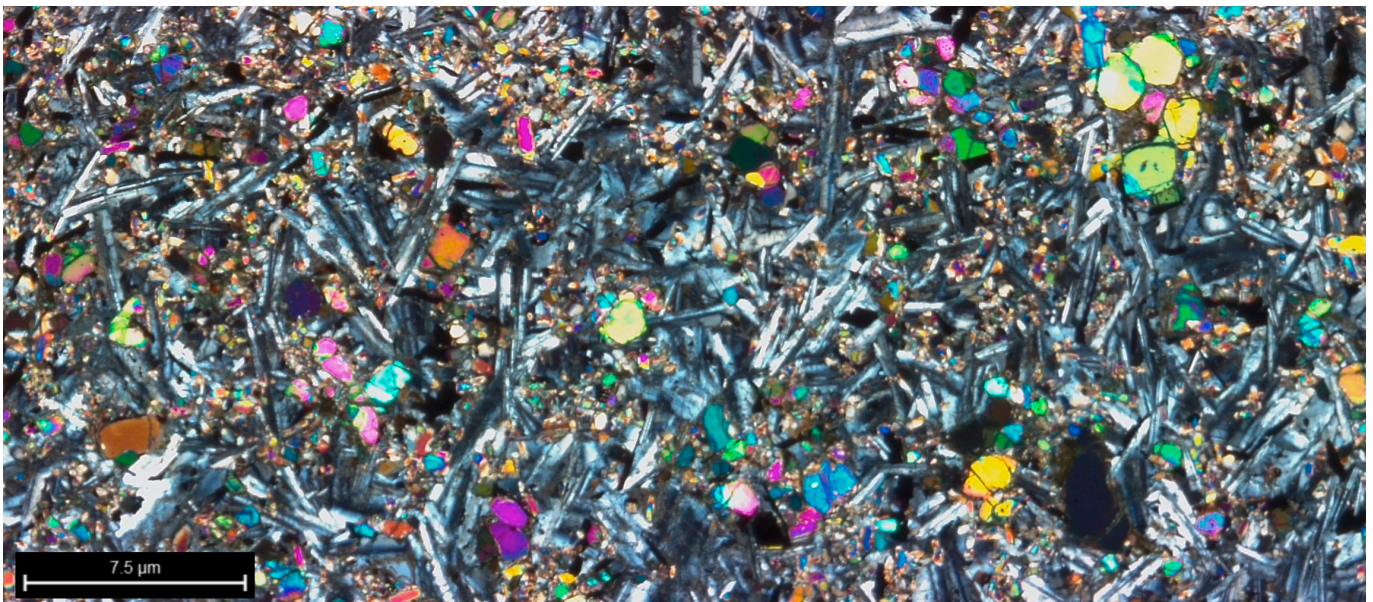


Fig.3: Large overview image of the basalt thin section shown above.

For reflected light, the inbuilt coaxial illumination can be used for polished samples without additional parts. The crossing of the polarized light in the reflected light mode is done by adjusting the inbuilt $\frac{1}{4}$ lambda (wave) plate.

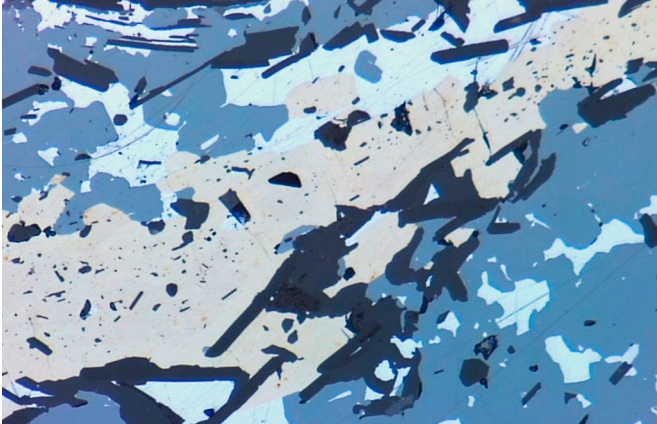


Fig.4: Ore minerals with plain polarized reflected light.



Fig.5: The same sample with crossed polarized reflected light.

The oblique illumination slider, available with the coaxial illumination of the Leica DVM6 M, gives a 3D image of grain boundaries, hardness differences, and scratches. Visualizing this aspect is achieved simply by moving the illumination slider around. No additional steps are required.

The image on the right shows an application that is only possible using the Leica DVM6 M with its integrated ring light. While classical polarization microscopes do not have darkfield, the Leica DVM6 M with its integrated ring light gives an additional darkfield aspect of polished samples.

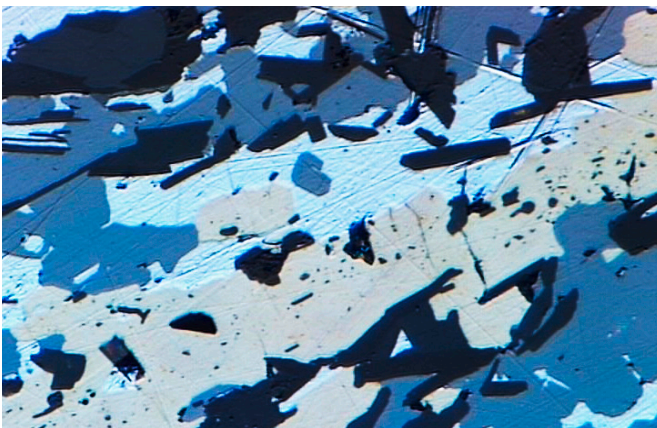


Fig.6: Detail image of the same sample illuminated with plain polarized oblique reflected light to see hardness differences and scratches.

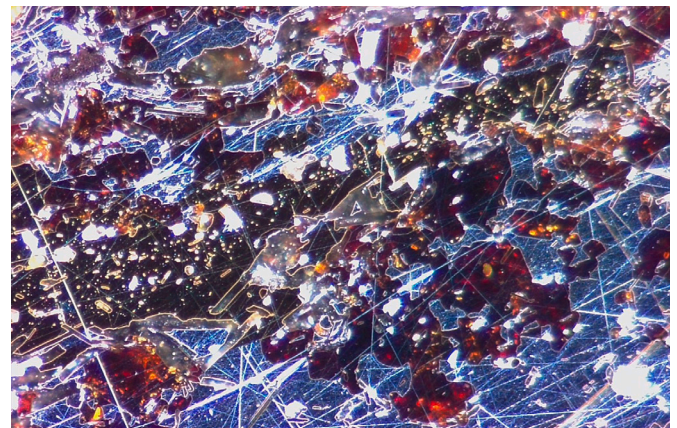


Fig.7: Detail image of the same sample with ring light illumination.

Analyzing unprepared samples

In addition to these “classical” ways of looking at polished earth science samples, the Leica DVM6 M allows users to observe three-dimensional unprepared samples like micro-mounts, drill core parts, loose minerals, micro-fossils, etc. The observation of unprepared samples is done in a similar way as with stereo microscopes, due to its inbuilt segmental ring light set-up or gooseneck spot lights.

Samples that are thicker than the depth of focus given by the microscope can be easily observed using the multifocus-function. Then a topography of the sample can be reconstructed in 3D. Alternatively, the Live Image Builder function can be activated if only a 2D image is required.

Micro-mount samples very often require an extended depth of focus to have all details clear and sharp. Both Live Image Builder Z (with manual focus column) and the montage options (Custom, EDOF, Start Up) available with the Leica DVM6 M software provide the ability to take multifocus images in an easy way [3].



Fig.8: Detail of a micro-mount sample with ring light illumination.



Fig.9: Multifocus image of a micro-mount sample with ring light illumination.



Fig.10: Multifocus image of a raw diamond with transmitted polarized light.

Loose grain samples, rock samples, and drill cores are very often larger than the field of view provided by a microscope. With Live Image Builder XY, this limitation can be overcome and a composite of multiple images into a single image with a larger field of view can be made.

The three available objectives of the Leica DVM6 M cover a large range of magnifications from 1x to 2,350x and resolutions, thus allowing users to change quickly from a macro to micro view for large samples.

As all images are automatically calibrated, they can be used for measurements. In the 3D topographic reconstructions, surface properties and volumes can be measured.



Fig.11: Multifocus image of gold and heavy minerals with length and surface measurements.

Conclusions

This report shows that it is possible to analyze both prepared and unprepared samples for earth science studies with one microscope. The Leica DVM6 M digital microscope combines macro with micro and allows users to analyze two- as well as three-dimensional samples. As the field of view and depth of focus can be both increased, working with samples of different heights is easily possible. The versatile illumination of the Leica DVM6 M provides more options to study and analyze samples than a compound microscope.

Additional Reading

1. [Interference, Glossary](#), Rock Library, Imperial College London
2. C. Gladstone, P. Browning, [The Polarising Microscope](#), Minerals under the Microscope, Earth Sciences, University of Bristol
3. Leica DVM6 Product Page, [Technical Specifications](#), Leica Microsystems webpage

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