

**INTERACTIVE SANDSTONE PETROLOGY:  
A DIGITAL TUTORIAL FOR FUTURE RESERVOIR GEOLOGISTS\***

**By**

**Suk-Joo Choh<sup>1#</sup>, Kitty, L. Milliken<sup>2#</sup>, and Earle F. McBride<sup>3#</sup>**

**Search and Discovery Article # 40041 (2002)**

\* Adapted and expanded for online presentation based on a poster session by the authors at the 2001 AAPG Annual Convention, Denver, CO. Winner of the SEPM best poster award from the 2001 Denver AAPG Convention.

**# Department of Geological Sciences, The University of Texas at Austin, Texas, USA**  
([www.geo.utexas.edu](http://www.geo.utexas.edu))

<sup>1</sup> ([sjchoh@mail.utexas.edu](mailto:sjchoh@mail.utexas.edu))

<sup>2</sup> ([kittym@mail.utexas.edu](mailto:kittym@mail.utexas.edu))

<sup>3</sup> ([efmcbride@mail.utexas.edu](mailto:efmcbride@mail.utexas.edu))

**Abstract**

A new, cost-efficient approach to teaching undergraduate-level sandstone petrography is being devised. The main goal of this multimedia tutorial is to provide a quantity of petrographic information sufficient to allow students to attain a high level of expertise in rock description. Development in digital format will permit effective delivery of the tutorial via CDs and the Internet. The tutorial is based on a collection of high-resolution digital petrographic images and utilizes a hierarchical menu and topics for navigation. The tutorial is composed of modules for sandstone types and other topics. Each module is further divided into sub-modules. Within a sub-module, forward and backward arrows, and other navigational choices allow the user to move around and explore the contents. The interface is dominated by the petrographic image with minimal screen space devoted to tutorial functions. The user is able to determine the presence of an interactive area within the image

by moving the pointer across the screen until the pointer changes from an arrow to a hand. When an active area is clicked by mouse, relevant instructional information appears. An on-line glossary is provided. Each sub-module is designed to gradually add information so that the user fully absorbs the topic at the user's own pace. This interactive tutorial will contain up to 300 interactive photomicrographs and represents the first step towards a digital library of petrographic images that will serve as a reference work for use in reservoir description.

### **Introduction**

Petrography, description and interpretation of rock properties at the microscopic scale remains, fundamentally, a qualitative field of study highly dependent upon the involvement of a trained observer. However, instruction in petrography in the universities where it is still practiced remains largely unchanged since the 19th century. A trend toward removing petrographic experience from university curricula arises primarily because of economic considerations relating to the labor-intensive character of petrographic instruction, yet the practical value of such training remains and is becoming a concern of industry professionals who seek to hire students possessing basic skills in rock description (Thomasson, 2000). Preserving petrographic studies in the modern curriculum requires that new, more cost efficient methods be devised for passing skills from instructor to student. This project attempts to partially mimic the highly visual and interactive character of traditional petrographic instruction with the goal of training and motivating students in the use of these methods. Preserving petrographic studies is also important for the petroleum industry and service companies because forward numerical models for risk analysis, porosity prediction, and reservoir characterization derive petrographic data such as texture and sandstone composition from point-count analysis of analog thin sections (Lander and Walderhaug, 1999; Walderhaug, 2000). Thus, this type of digital petrographic tutorial could potentially contribute to achieving standardized and high-quality petrographic work.

### **Existing Petrographic Contents In Multimedia Format**

An on-line search of Science Citation Index (<http://wos.isiglobalnet.com/>) reveals that digital atlases and tutorials have been most extensively applied in the area of medical education. This is perhaps not surprising as many medical specialties, similar to

petrography, require students to assimilate vast amounts of visual information on form, distribution, and morphological variation of natural structures. The potential advantages of digital imaging methods for distribution of petrographic data has been recognized (e.g., [Carrozzi, 1996](#)). Material currently available, either web-accessible ([Table 1](#)) or published on publicly available CDs (e.g., [Christiansen, 2001](#)) is limited however. In part, the limited availability of these materials may reflect the labor-intensive nature of content development as well as the shrinking pool of experts capable of authoring petrographic tutorials. Web-accessible petrology materials fall into two general categories, image collections ranging from a few to around 100 images, which tend to have little interpretive material keyed to particular images, and almost none keyed to particular features within the images, and tutorials based on existing lecture series. The latter type of tutorial tends to be arranged somewhat like conventional textbook, making little use of the interactive cross-referencing capabilities of multimedia authoring.

### **The Goals Of Current Tutorial**

1. Expose students to a large and diverse amount of visual material, comparable to that formerly provided in petrographic laboratory activities that have been largely displaced from the curriculum.
2. Allow students to attain a higher level of expertise in rock description than current instructional practices allow by the use of substantial interpretive material and an interactive structure that will guide the student through a process that will itself promote absorption of the information.
3. Motivate students to persist in higher level petrographic studies as well as career path toward petroleum and service industries.

### **How To Use The Tutorial**

The principle subdivisions of the tutorial are based on the major 'clans' of the Folk sandstone classification: quartzarenite, arkose, litharenite ([Folk, 1974](#)), and a fourth group of sandstones that don't fit within this standard scheme ([Figure 1](#)). For each of these clans there are images that deal principally with provenance and those that are primarily instructive about diagenesis ([Figure 2](#)). Within each of the four major subsections the user

has the option to review text outlining the principal facts and themes conveyed by the subsection ([Figure 2](#), “Goals”) and to proceed through the tutorial images one at a time ([Figure 2](#), “Tutorial”), in the order they are arranged. Alternatively, all the images within a subsection can be reviewed in a thumbnail section ([Figure 2](#), “Browse”; [Figure 3](#)), which allows the user to navigate to a full-frame image at any point within the tutorial. Once the user is in one of the main tutorials, general information on the specimen can be called up from the “Info” button on the function bar ([Figure 4](#)). Active regions of the image are indicated when the cursor changes from an arrow to a pointing hand. Clicking on such a region calls up information ([Figure 5](#)) in one of two modes. In the first, a click brings up a short identification of the activated region, a tiny bit of text that quickly disappears on its own. Clicking on the region related to the major theme of the image brings up a larger box of text. The user then click anywhere on the image or function bar to remove this textbox and proceed with his/her explorations. Holding a click on an active region allows the user to get a leisurely look at the mapped area relevant to the textbox. An on-line glossary is provided by a hyper-linked textbox, which appears in orange color with underline ([Figure 5](#)). Navigation to sequentially positioned images within tutorial subsections is accomplished with arrow buttons on the function bar. Plane light and cross-polar views can be toggled with “PPL/XPL” button on the function bar ([Figure 6](#) and [Figure 7](#)). In some cases plane light and cross-polar views are mapped somewhat differently, and clicking on the same regions in these different imaging modes may activate different informational boxes. The “History” button allows the user to create a sequential record of pages visited in their path through the tutorial; double-clicking on any page in this list allows the user to return to that point in the user’s trek ([Figure 8](#)). The “Search” button allows the user to generate a list of pages featuring an image or text relating to a particular topic, therefore turns the digital tutorial into a powerful petrographic image database ([Figure 9](#)). A user could always go back and consult this CD to freshen his/her mind regarding a particular type of grain and feature.

### **Ongoing Activities And Future Plan**

The demonstration version of the tutorial described here is presently being evaluated in laboratory exercises in an undergraduate-level sedimentary rocks course at the [University of Texas at Austin](#). A proposal currently in development will seek to expand the tutorial

content and to extend the evaluation process to other universities. Plans for future tutorial content include: specific examples from well-known sandstone reservoirs; inclusion of more petrographic features that play a significant role in reservoir quality (e.g., an expanded section on clay cements); utilization of a wider variety of petrographic image types (for example, scanning electron and cathodoluminescence micrographs); quiz functions; greater graphical content in the compaction and texture sub-tutorials. Our long-term goal is linking teaching modules for sandstones and other rocks to a major archive of images from the [University of Texas at Austin](#) petrology collections. In fully realized form, this digital library may ultimately have undergraduate-, graduate-, and research-level interfaces.

### **Acknowledgements**

Support for the development of this tutorial has been provided by the [College of Natural Sciences](#), the [University of Texas at Austin](#) through student-funded technology fees, and the [National Science Foundation, Division of Undergraduate Education, Course Curriculum and Laboratory Improvement Program](#); under grant #DUE-0088763. We thank Drs. Kathie Marsaglia, Shirley Dutton, Ted Walker, and Robert Folk for reviewing the tutorial in its early stages. Luis Crespo and Petro Papazis provided assistance for image mapping.

### **References**

- Carozzi, A.V., 1996, Carbonate petrography: grains, textures, and case studies, *in* Scholle, P.A. and James, N.P. (eds.), SEPM Photo CD, Volume 9: Tulsa, Oklahoma, SEPM.
- Christiansen, E.H., 2001, PetroGlyph 1.0 Multimedia CD-ROM: Malden, Maryland, Blackwell Science.
- Folk, R.L., 1974, Petrology of sedimentary rocks: Austin, Texas, Hemphill Publishing, 184 p.
- Lander, R.H. and Walderhuag, O., 1999, Predicting porosity through simulating sandstone compaction and quartz cementation: AAPG Bulletin, v.83, p.433-449.
- Thomasson, M.R., 2000, Rocks are still key exploration clues: AAPG Explorer, v.21, p.4, 13.
- Walderhaug, O., 2000, Modeling quartz cementation and porosity in Middle Jurassic Brent

Group sandstones of the Kvitebjorn Field, northern North Sea: AAPG Bulletin, v.84, p.1325-1339.

Table 1. Examples of petrographic educational materials on the World Wide Web. These materials demonstrate the capabilities of digital media for presenting petrographic information. None of the sites however contain sufficient interpretive content or adequate numbers of siliciclastic samples to serve as a comprehensive resource for undergraduate-level petrographic instruction in siliciclastic petrology.

1. <http://www.geolab.unc.edu/Petunia/IgMetAtlas/mainmenu.html> Atlas of igneous and metamorphic rocks, minerals, and textures. An atlas site with thin section photomicrographs and descriptions of 39 minerals, 20 plutonic textures, 14 volcanic textures, and 21 metamorphic textures. The user can switch between plane-polarized light and cross-polarized light view in selected images.
2. <http://sorrel.humboldt.edu/~jdl1/petrography.page.html> A tutorial with extensive image collection. Mostly in x-polars. Limited interpretive material. Images presented at less than screen size. Presented at the introductory (non-major) level.
3. <http://mccoy.lib.siu.edu/projects/crelling2/atlas/> Atlas of 231 photomicrographs of coals, cokes, chars, carbons, and graphite.
4. [http://www.science.ubc.ca/~eoswr/cgi-bin/db\\_minerals/search.cgi](http://www.science.ubc.ca/~eoswr/cgi-bin/db_minerals/search.cgi) 28 minerals in thin sections with their physical properties and diagnostic features.
5. <http://www.brocku.ca/earthsciences/people/gfinn/minerals/database.htm> Images of 27 minerals in plane light and x-polars along with crystallographic, optical, and chemical, and occurrence information. A digital version of a traditional mineralogy book.
6. <http://www.gly.bris.ac.uk/www/teach/opmin/mins.html#menu> Minerals under the microscope tutorial, though actual petrographic images are limited and not interactive; along the lines of an on-line textbook.
7. <http://www.hia.net/kjsmith/minerals/min0.htm> 9 photomicrographs of minerals and metamorphic rocks with short descriptions.
8. <http://micro.magnet.fsu.edu/primer/virtual/virtualpolarized.html> Interactive Java tutorial of polarized light microscopy. Good information on general microscopy
9. <http://geologyindy.byu.edu/Petroglyph/default.htm> Demo page of the PetroGlype 1.0, a

virtual microscope that simulates the features of optical and electron microscopes.

10. [http://exodus.open.ac.uk/earth/virtual\\_mic/virtual\\_microscope.html](http://exodus.open.ac.uk/earth/virtual_mic/virtual_microscope.html) Demo version of the Digital Microscope. Images are presented in interactive (i.e. 360 degree rotatable) plane polarized and cross-polarized versions.

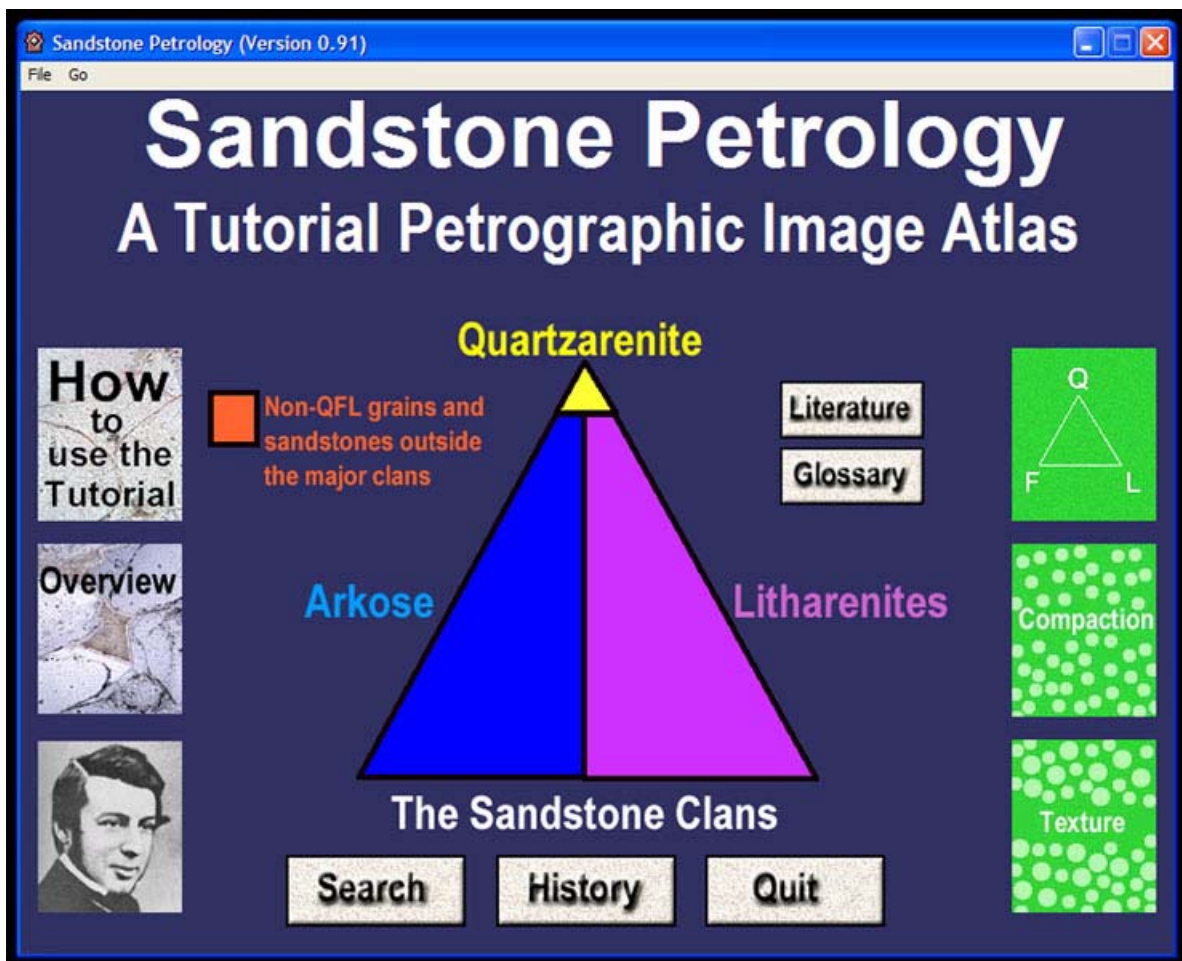


Figure 1. The main page provides links to all the major components of the tutorial. The pull-down menu at the top left of the window (“Go”) also allows the user to leap to any of the four second-level pages of the tutorial or any of the major subject areas featured on the top-level page.

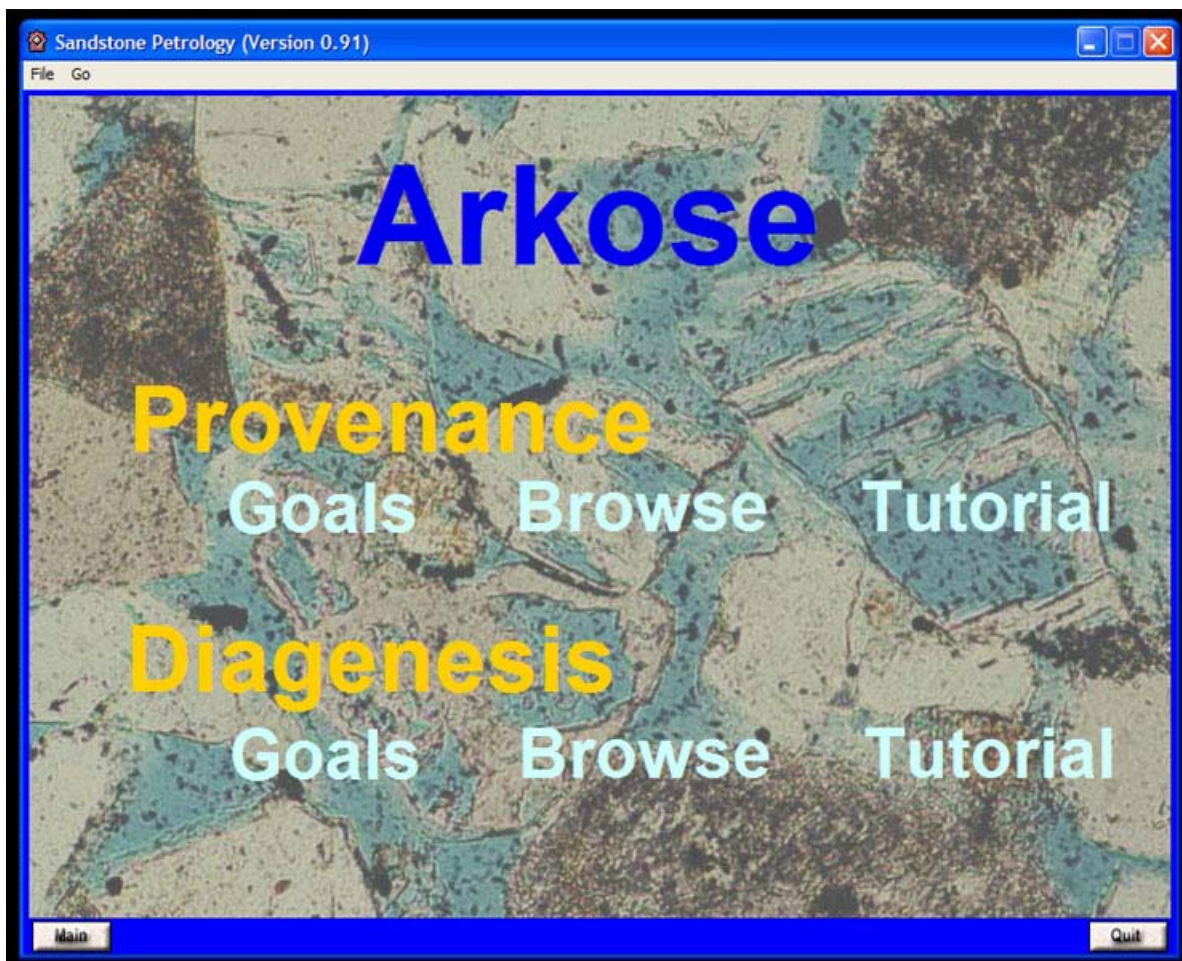


Figure 2. Clicking on the “Arkose” link of the main page ([Figure 1](#)) brings up the Arkose sub menu screen. Each Provenance and Diagenesis section is further subdivided into “Goals”, “Browse”, and “Tutorial” sections.

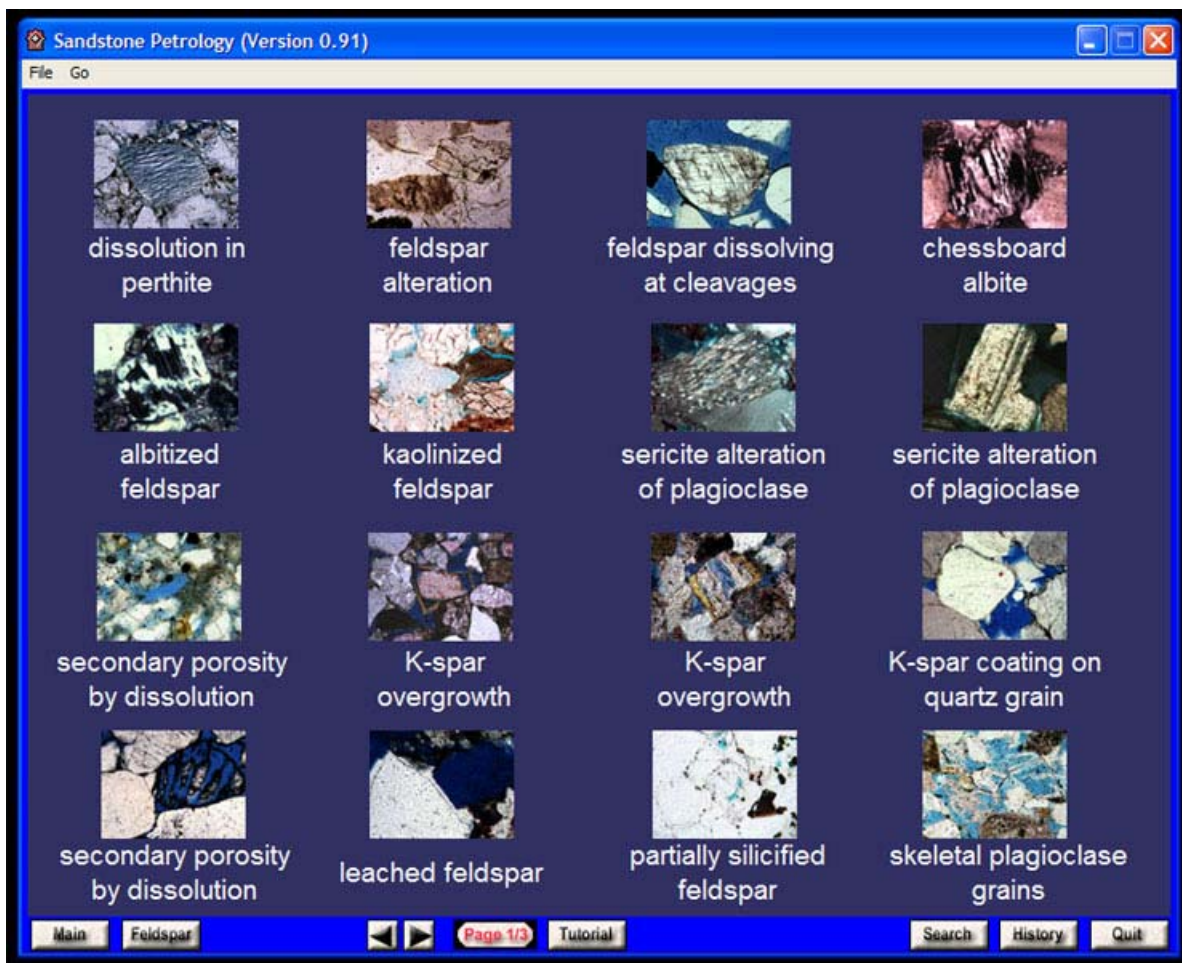


Figure 3. Clicking on the Diagenesis “Browse” link of the Figure 2 opens a window showing 16 thumbnails of photomicrographs. Note that this particular section has two more pages of thumbnails that can be accessed by clicking on the right arrow button. Clicking on one of the “K-spar overgrowth” thumbnail brings the user into main tutorial window ([Figure 4](#)).



Figure 4. Once in the main tutorial, the “Info” button brings up general information on the sample. Clicking anywhere else in the screen will erase the information text box.



Figure 5. Clicking on the center of the image brings up a text box explaining that secondary porosity developed by the dissolution of detrital plagioclase which is stained pink. Notice that the term “secondary porosity” is colored and underlined, indicating the presence of a hyperlink. Clicking on “secondary porosity” accesses the glossary entry for secondary porosity.



Figure 6. Plane polarized light view of the Permian Lyons Sandstone from Central Colorado, a classic quartzite.

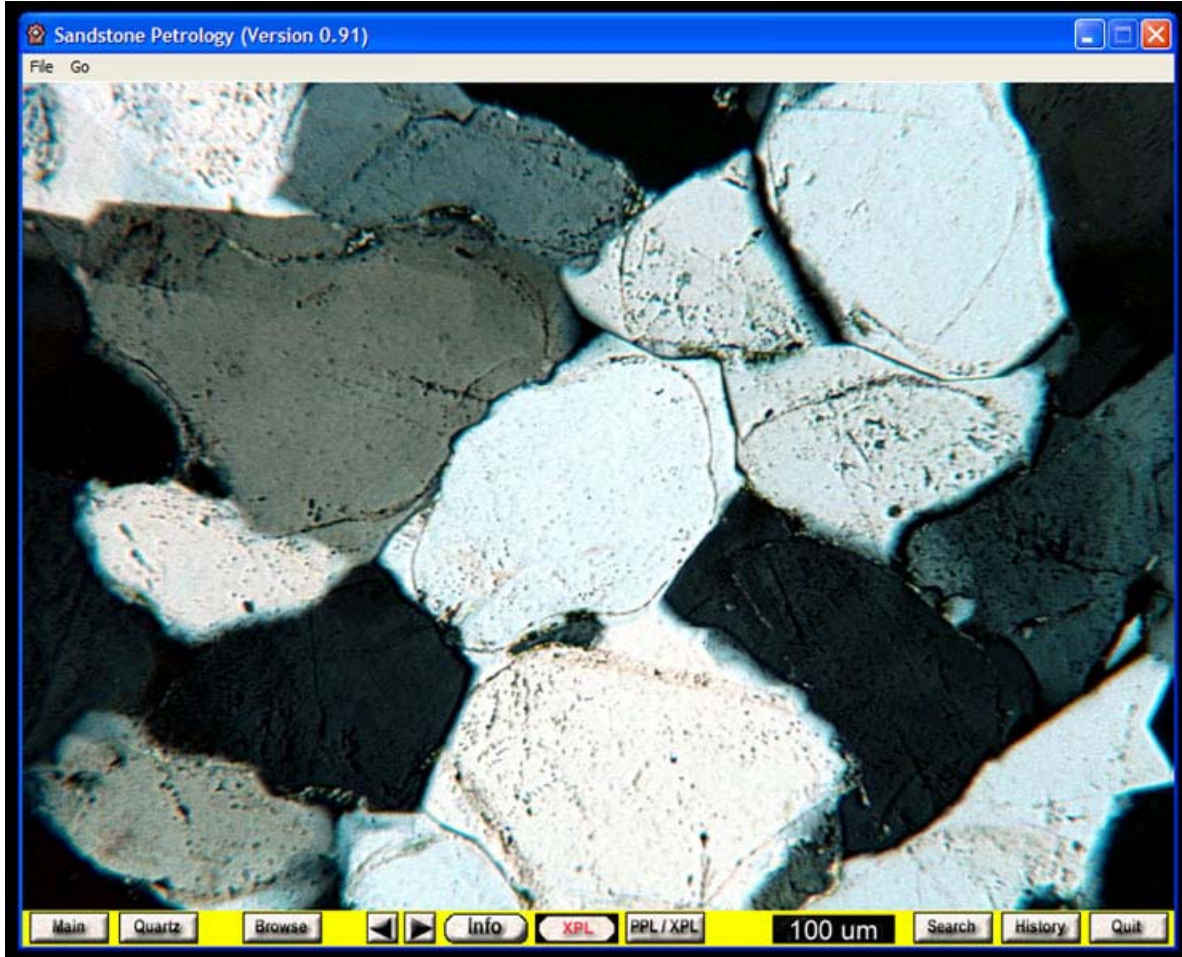


Figure 7. Clicking on the “PPL/XPL” button can bring up a cross-polarized light view of the same field of view. Subsequent click on the same button brings back the plane polarized light view ([Figure 6](#)).

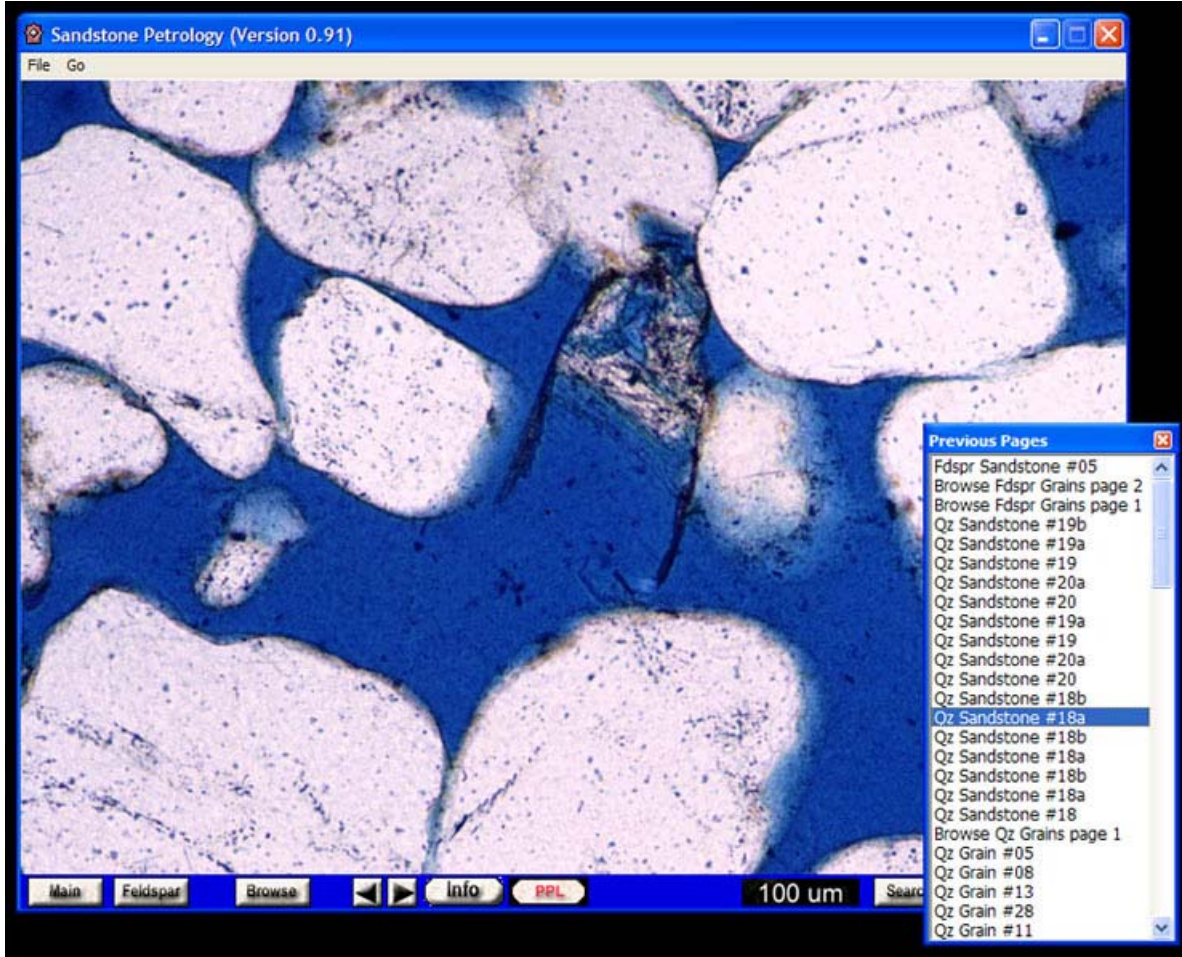


Figure 8. Clicking on the “History” button brings up ‘Previous Pages’ window where the user could jump back to previously visited image by double clicking on the image name from the list.



Figure 9. Clicking on the “Search” button opens ‘Search Sandstone Petrology’ window. The user could type in any combination of search criteria here; search example using search criteria “primary porosity” is shown here. From the search result, double clicking on the image name will bring the user to that page.