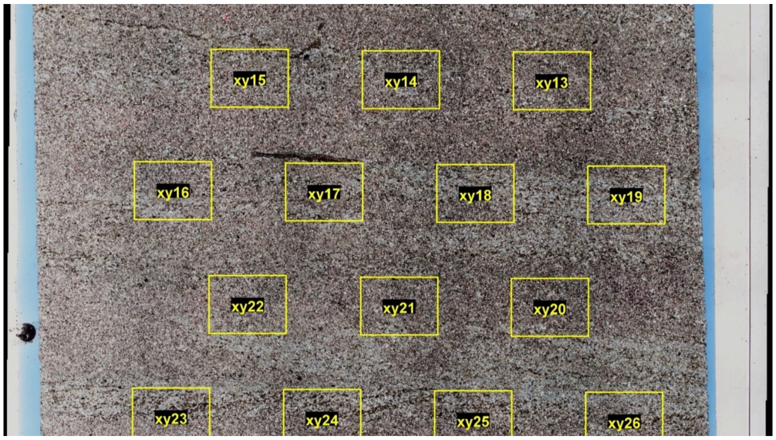

Whole slide image with automated annotations of high magnification image locations.

How I Transformed Lab Efficiency with Process Engineering Tools

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The Challenge: Analytical Bottlenecks in a High-Volume Research Lab

I used to work in a university lab specializing in natural material analysis that began receiving increasingly large sample sets (50-100 samples) with tighter deadlines. Before we knew it, we faced a critical workflow crisis. Sample requests from our subsurface research group often started with one analysis method but would invariably expand to include our entire suite of techniques: X-ray Diffraction (XRD), X-ray Fluorescence (XRF), optical microscopy, electron, and even external micro-CT scanning.

This unpredictable environment led to significant inefficiencies:

- Analysts performing XRD phase ID without knowing the elemental composition were often required to redo the work if or when this information became available
- Confusion about timelines, priorities, and responsibilities
- Excessive time spent on progress reporting rather than sample prep or analysis

At one point, management considered outsourcing our analytical work. Rather than accepting these inefficiencies, I saw an opportunity to redesign our workflow completely. With the help of my team and concepts from process engineering, we succeeded.

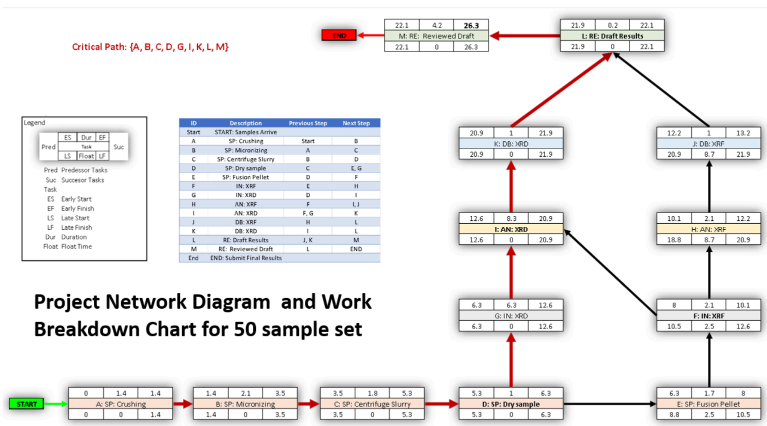
The Solution: System Analysis and Process Engineering

Step 1: Detailed Process Mapping and Work Breakdown

I needed to treat our lab like a system. I discussed the details of their sample preparation and analytical processes with each laboratory member. This information formed the basis of a comprehensive work breakdown chart that captured:

- Precise material and time costs for each sample prep and analysis type
- Person-time versus machine-time requirements
- Inputs and outputs for each procedural step
- Dependencies between different analytical techniques

This detailed mapping revealed numerous opportunities for parallelization and efficiency improvements that weren't visible when looking at individual processes in isolation. When I found tutorials on Project Network Diagrams, I felt like I had discovered gold! It turned out that analyzing hundreds of samples with limited people and equipment is similar to constructing a building or designing a circuit. It all comes down to efficient use of resources and identifying the steps that, if delayed, will delay the entire project.



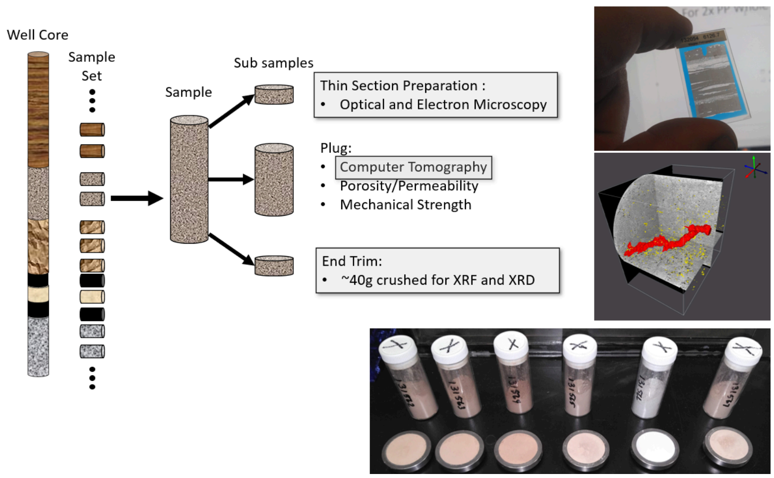
A project network diagram shows how each step contributes to the overall duration of the project.

Step 2: Designing an Integrated Analytical Workflow

Rather than treating each analytical request as a separate project, I developed a standardized "analysis suite" approach that optimized sample handling. The new workflow would:

1. Split a core plug into subsamples for thin-section, CT, and XRF/XRD samples
2. Send the thin-section and CT samples out.
3. Micronize the XRF/XRD subsample and split into XRF and XRD samples
4. Create fused beads for the XRF sample
5. Collect in XRF and XRD results, then combine them during XRD analysis
6. Collect thin-section images, process CT data, and finally
7. Make all data available for internal review

This approach eliminated redundant sample preparation steps and ensured all analyses could proceed in parallel when possible. SEM-EDX was reserved for special cases such as element mapping or microstructure analysis. I also treated our data storage as part of the system, making sure metadata was stored in a relational database.

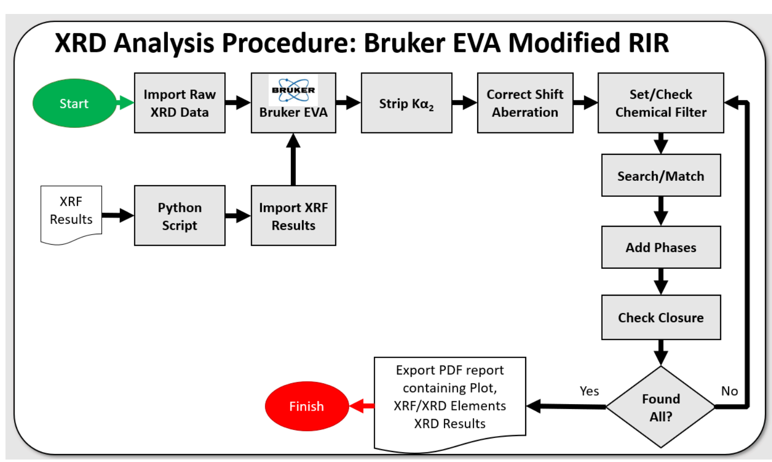


The workflow starts with sub-sampling.

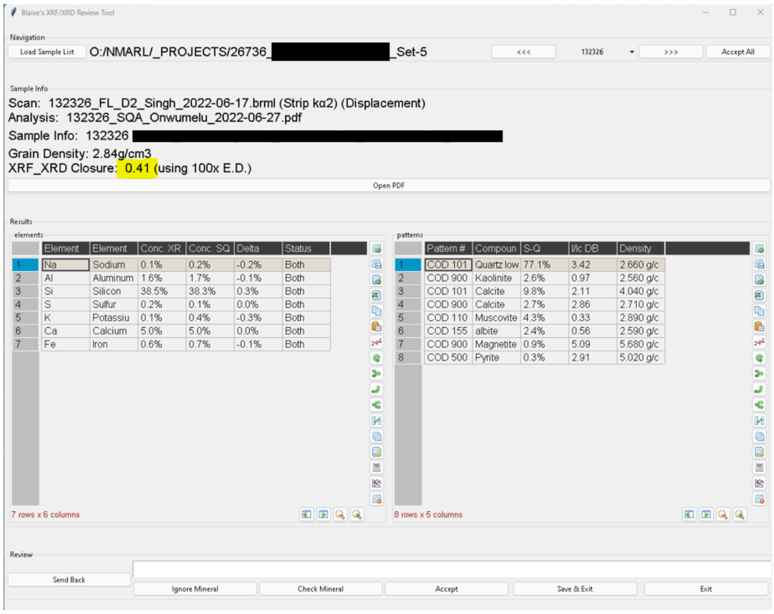
Step 3: Leveraging Automation and Digital Integration

The power of the new workflow was amplified through strategic automation by:

- Creating Python scripts to monitor our network drive and report data availability in near real-time
- Developing automated data organization tools that prepared XRF results for integration with XRD phase matching
- Creating procedures for filtering potential mineral phases based on elemental composition, dramatically reducing manual analysis time and making the work of multiple analysts more consistent
- Automated the annotation of whole-slide microscopy images, creating an integrated visual database for geologists
- Python was used to craft bespoke tools for gathering information for review meetings. This made group reviews of data more productive.



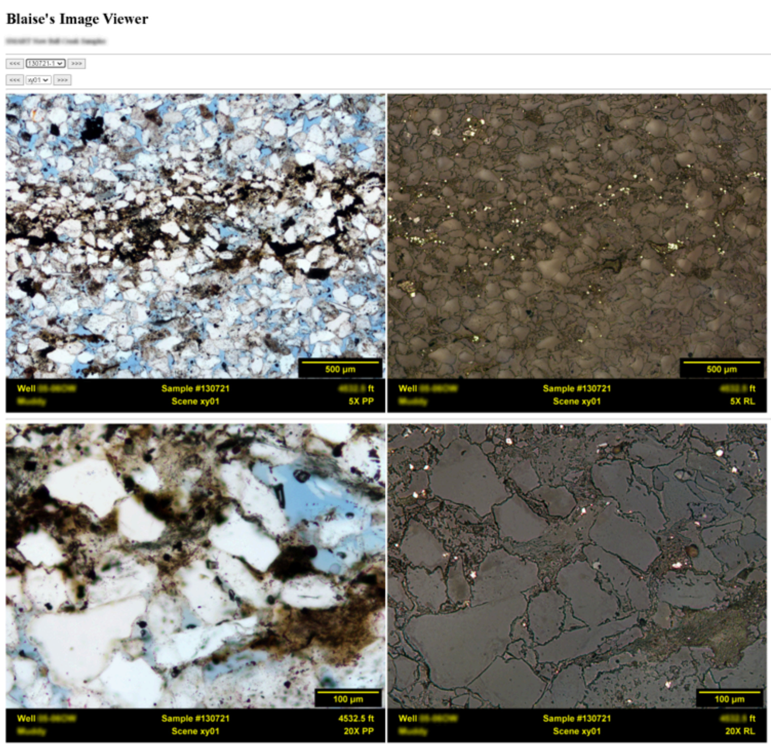
Wherever possible, Python scripts were used to connect software from different vendors.



This simple tool allowed us to screen results, as a group, before final reporting. It was built with Pandas and Tkinter in Python.

Step 4: Strategic Equipment Selection

Even our equipment purchases were aligned with the optimized workflow. When selecting a new polarized light microscope, I specifically chose objectives that eliminated the need for cover slips on thin sections. SEM analysis could be performed without modification, saving hours of preparation time across large sample sets. In anticipation of the increased workload, our lab manager purchased a bench-top XRD with an incredibly fast detector **Bruker D-2 Phaser**, reducing scan times without loss in data quality. These seemingly minor details resulted in efficiency gains that paid off.

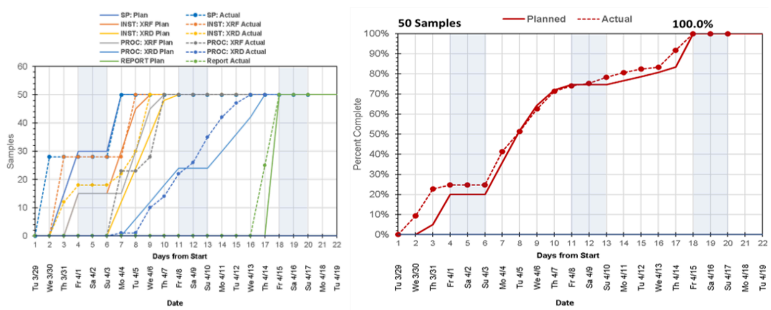


Images are auto-labeled and grouped by image mode and magnification. An HTML-based image viewer is included with each collection of thin-section images to allow flipping through or choosing a sample or image.

The Results: Dramatic Efficiency Improvements

The transformation was remarkable:

- **Processing time cut in half**: We went from months to weeks for completing 100 samples
- **Enhanced data quality**: Integration between analytical methods improved interpretation accuracy
- **Reduced administrative overhead**: Technicians spent less time on progress reporting and more time on valuable analytical work
- **Improved project visibility**: Automated burn charts gave both technicians and management real-time visibility into project status
- **Proactive timeline management**: When equipment failures occurred, we could immediately calculate the impact on deadlines and adjust accordingly



Left: Detailed burn chart for lab personnel. Right: High-level burn chart for managers. If the actual work (dashed line) falls below the planned work (solid line), that part of the workflow needs attention.

Key Lessons: The Power of Process Engineering in Scientific Research

This experience taught me several valuable lessons about optimizing scientific workflows:

1. **Meet with the people doing the actual work:** The first goal is to understand what they do and what they need.
2. **Communication is key:** Burn charts provided feedback that reduced stress and uncertainty for both technicians and management.
3. **Holistic process analysis reveals hidden opportunities**: Looking at the entire workflow, rather than individual techniques, exposed inefficiencies that weren't visible in isolation.
4. **Standardization enables scaling**: By establishing a core analytical suite, we could scale up without proportionally increasing complexity.
5. **Strategic automation multiplies human capability**: The Python scripts I developed didn't just save time—they enabled entirely new ways of working and communicating by integrating data across analytical methods.
6. **Equipment selection should serve the workflow**: Even small decisions like microscope objectives or detector speed can have impacts on overall efficiency.
7. **Project management tools belong in the laboratory**: Techniques like, work breakdown charts, project network diagrams, and burn charts are as valuable in scientific settings as they are in traditional project management.

By applying these principles, we transformed a struggling laboratory workflow into a model of efficiency and saved our analytical services from being outsourced in the process.

Blaise Mibeck is a Senior Scientific Investigator at ***Triclinic Labs*** *specializing in X-ray crystallography and advanced imaging techniques. He has over 20 years of experience developing innovative solutions for complex analytical challenges in research and industrial settings.*

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Great article, Blaise! :)
"It all comes down to efficient use of resources and identifying the steps that, if delayed, will delay the entire project."

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Founder and Principal Materials Scientist at Cubic Labs LLC Exper...
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Thanks!

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Product Management Director and Business Leader
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This is great work Blaise and well documented and explained!

Blaise Mibeck

Founder and Principal Materials Scientist at Cubic Labs LLC Expert for XRD, XRF, and SEM