Dust Mitigation in Geochemical Sample Preparation Facilities

Compiled from contributions from the MSA and Teaching MPG Listservs
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Compilation by D. Mogk, Montana State University

A query was submitted to the MSA listserv, and to the On the Cutting Edge Teaching Mineralogy, Petrology and Geochemistry listserv, to determine what safety equipment was used to mitigate potential health impacts due to rock dust created during geochemical sample preparation. Seventeen responses were submitted by geochemists from around the world. The consensus of the responses are summarized below:

- Jaw crusher (e.g. Bico Chipmunk) equipment produces little dust as this is a coarse crushing process (e.g. taking fist sized samples down to fragments that are a few cm's across). This instrument is also typically connected to a shop-vac via a port at the back of the grinding chamber and consequently mitigates the small fraction of dust that is produced in this process. (See experimental results done by Keith Putirka, below) HEPA filtered vacuum systems are recommended.
- The Shatterbox, which takes small rock chips down to powder size, poses no immediate dust risk because the equipment (grinding puck and disk) are already in a tightly closed system while in operation.
- The equipment that produces the most dust is the disk mill. This equipment is typically a bench top model that requires continuous feed of raw material into the rotating disks. Mitigation of rock dust is most typically achieved by a) enclosure in a hinged containment box that allows direct access to the equipment to introduce raw material and to effectively clean the instrument after each sample; or b) operation of the disk mill under a vacuum hood that draws any dust produced away from the user and into a filter system (e.g. down draft hoods and tables). (See Bob Dymek and Frank Dudas' descriptions of containment boxes).
- Some respondents noted that rock dust may be released while transferring crushed or powdered material from the catchment pans on these instruments into the storage containers. Exposure to rock dust while transferring crushed material can be minimized by doing these transfers under a vacuum hood.
- Ear and eye protection are always recommended.
- Mitigating rock dust at the source obviates the need for respiratory devices.
- An alternative device is the Electro Pulse Disaggregator (shock) to acquire mineral separates, although efficient, is very costly.,

The responses, authors, and their institutions are compiled in the following pages, (some with embedded photos of equipment design).

David Bailey, Hamilton College

We had similar issues with our rock crushing and grinding equipment a few years back, and were lucky enough to solve some of the problems when we moved into our new Science Building in 2005 by installing large down-draft tables with hoods and filters (see attached photo). Not cheap, but a lot less expensive than building an negative pressure room! Works quite well - no longer clouds of dust floating around the room! BTW - an equally serious hazard are the fly wheels for the large rock crushers. Ours was an old model where the wheels were exposed and very near where hands and hair might come into contact with them; our tech eliminated this hazard by building a wire mesh cage around all the flywheels.

In case you're interested I've attached a copy of our Department Lab & Field Safety Manual. It needs to be updated, so I'd appreciate it if you wouldn't share or post the version I'm sending along. If you think others would be interested, I'll work on getting an up-to-date (and "institutionally approved") version put together over winter break.

It's a different world than when we were undergraduates; I don't think geology faculty ever discussed or worried about these issues!

Frank Dudas, MIT

There are two different issues you need to worry about. One is dust control. The second is the required use of dust masks. I separate these because the regulatory environment for required use of dust masks gets you into a lot of trouble with annual medical certification, etc.

Our solution to dust control is to have a box to enclose the jaw crusher and disk mill. This box is connected to a Torit dust collection/filtration unit (see www.Donaldsontorit.com). The box actually solves two different safety problems - it restricts the amount of dust that gets out into the room, and it acts as a safeguard for moving parts on the jaw and disk mill (if you don't have a direct drive mill). With our installation, we have sufficient dust control that we don't have to wear lab coats, dust masks, etc. The Torit filter unit does need to be serviced - dust removed from the collection bucket, filters changed, etc. - but it works quite well. I think our unit is a Torit VS-550 or VS-1200 (I think the 550 and 1200 stand for cu ft / min airflow). The up-front cost for this might be steep (> $ 15 K), but our unit has been in service since 1994 without any serious problems. I think Becky Flowers at U Colorado (Rebecca.Flowers@Colorado.edu) set up a lab like this a couple of years ago, and might have recent info.

The containment box we have has a hatch on top to allow feed into the hopper of the jaw crusher, and hatches on the side and front to allow access to the disk mill. We use a HEPA-filtered vacuum to capture dust from the jaw and disk mill during cleaning between samples.

If you want, I can send you pics of our installation.

We do not require operators of the crushing facility to use dusk masks. Dust masks are available if people choose to use them. By not requiring the masks, we avoid the complication of having medical certifications, etc. Even in the case of having an option to use the dust masks, there may be some forms that operators need to sign, indicating that they understand the risks of working in a dusty environment without masks, and that they were given the opportunity to use masks, etc. - i.e., they work without masks of their own choice and volition. Our EHS people seem to be OK with our setup, both in terms of dust capture and in terms of personal protective equipment.

Frank Dudas, MIT, Follow up communication

Here are some pics, taken with my IPhone, so they're not the best, but they give you an idea of our setup. The blue cabinet in image 212 is the Torit vacuum/filter unit. Side panels are hinged for access to each machine from the sides, front panels are hinged, top panel is hinged as well. There are sliding access panels also built into the top and on each side.

Our shatterbox is in a separate facility, with no dust control - because it doesn't need it!

Pictures sent by Frank Dudas to show the MIT set up:

Debbie Pierce, Boise State University

I've attached a couple pictures of our set up. We have the Nederman Modular Filter System Series 664. We've set it up for our crusher (1arm), diskmill (2 arms), and water table (1arm), but I'd assume one or two 'arms' would fulfill your needs. The canister has a removable hepa filter and our dust has been reduced to a minimum.
http://nedermanusa.com/
It sounds like this would be much less expensive than what has been suggested to you.

Doug Rambo

I read your posting with interest and am wondering if something from one of my other interests might help you out. Besides being a geologist I am also a woodworker when I have time away from work and some free time away from family commitments.

As you're probably well aware, power tools in wood working generat a lot of dust and as part of the solution companies have developed dust collection systems to capture even the smallest wood dust. An example of such a machine can be found on this link: http://www.rockler.com/product.cfm?page=18246 and I would think that it could be adapted easily for your use.

You should be able to configure the dust collection system with vacuum hoses positioned strategically where the bulk of the dust is escaping from the mill.

If you are able to go this way then you might be able to escape for 1/10th the cost proposed by your H&S committee.

Good luck in figuring out a solution.

Ed Ghent, University of Calgary

You should check with Kurt Kyser at Queen's University. He has one of the new rock shattering devices using shock (supposedly low-dust). He could tell you about cost, availability, etc.

Andrew Locock, University of Alberta

Aside from rock saws (we cut wet, using water), we have the following rock preparation equipment (which is in weekly, or even daily, use):

Jaw crusher (2) – local vacuum system removes dust during operation;
Bico disk mill (2) – local vacuum system removes dust during operation. Also, a large sheet metal housing confines dust to the immediate area of the disk mill;
Spex shatterbox (WC or steel) – sealed vessel, no direct dust mitigation required;
Retsch automated agate mortar – sealed vessel, no direct dust mitigation required;
Spex mixer mill – sealed container, no direct dust mitigation required;
McCrone micronizing mill – sealed container, no direct dust mitigation required.

We keep each machine in a separate small room to prevent cross-contamination. Pressurized air (from a hose) is used during cleaning (this REQUIRES hearing protection), but the amount of dust in the cleaning process is minimal.

The air-handling for this set of rooms is rather extensive. All of the vacuum systems can operate simultaneously, and the dust is collected in a specialized unit for removal.
Because of the efficacy of the air-handling and vacuum systems, suits and respirators are NOT required (this from a nation and University with some of the most stringent OHS regulations anywhere).

If you wish, I can send photographs of the various pieces of equipment and their dust handling systems.

Mark Logsdon, Geochimica Inc.

A good, perhaps excellent, contact would be any colleagues you have in a Department of Mining Engineering or Metallurgy. They work with such equipment routinely, and I am confident (having been through more than one lab) do not use "clean room" technologies. If yuou are short of such contacts, pelas egive me a shout and I'll pass you along to some in USA/Canada.

Pat Bickford, Syracuse University

We have a dust hood on our jaw-crusher---disc-mill apparatus that is connected to a vacuum dust collector. It has worked well for years. I will send you a picture soon.

Louris Cabri, CNT Mineral Consulting

The better solution is to replace your crushing equipment with an Electric Pulse Disaggregator (EPD). We are currently installing a CNT Spark-3 at the University of Western Ontario and have had a fully functional earlier model in Ottawa since 2008

that has been used for government, university and mining company projects.

Not only will you get better liberation of accessory minerals (requiring less sample mass), but the liberated minerals are largely unbroken and you get absolutely no dust as the disaggregation takes place under water.

We sell the device together with our unique environmentally-friendly computer-controlled hydroseparator (HS-11) for efficient concentration of minerals of interest.

For that budget we can offer you a very interesting proposal and welcome all enquiries. I suggest you visit our web-site (requires free registration to download published articles) or otherwise contact me directly.

Keith Putirka, CSU-Fresno

We don't have a disk mill, but we have a jaw crusher and shatterbox. We had the same concerns here and our Environmental folks set up a dust monitor in our lab. I went through all the steps of preparing a powder for a basalt using the jaw crusher and shatterbox; they determined that had we crushed pure Si we would have been at 1/9th of the minimum dust levels deemed unhealthy. I didn't do anything special when I ran the sample - no containment, etc. Perhaps you can run the same experiment. Best of luck.

Sumit Chakraborty, Univ. Bochum, Germany

Off line to you quickly - I think the main issue is that many of our old setups are not compatible with present security laws. Many run on, as long as nobody happens to notice.....but once the security people get their hands on things, it gets complicated / expensive / impossible. Running labs is full of things like that - gas mixing furnaces, hydrothermal bombs,....So, you may get a lot of input on the list about how things are being done / have been done for many years at various places....but that does not mean it will satisfy your (or any other modern day) security officer. That is an issue with its pros and cons, and I do not know what the answer is. I do not want to flout security laws, but I also do not see that not using labs on a weekend or in the evenings is a realistic solution, even if the risks of doing so are also clear to me.....it is a tough deal.

Neil Dickey, Northern Illinois Univ.

I think that Keith has an important point: technique makes a huge difference in the amount of dust generated. I remember grad student colleagues working in our crusher room when you couldn't see across it from all the dust in the air. They weren't wiping the shatterbox as clean as they could "because their time was more valuable than to waste it that way," so instead they blew the dust into the atmosphere with compressed air. I always took a little time to wipe the

shatterbox before I used the air blast on it and had clean air to breathe.

Bob Dymek, Washington Univeristy (St. Louis)

My experience is with the shatterbox as follows. We moved into a new building a few years ago, and each lab came equipped with a spot exhaust (big snaky things that hang from the ceiling) connected to the main building exhaust. I designed and had built a pair of plexiglass boxes (24" deep x 36" wide x 30" high, with the front sides open) that sit on a lab bench; each box has a port connected to the spot exhaust. I only open the grinding vessels inside those boxes, and any dust that escapes is immediately whisked away -- even when you mistakenly dump the contents creating a "pyroclastic flow." Powders are removed from the containers using tongue depressors and small brushes (one per sample). My sample-prep room is extremely clean as a result, eliminating potential cross-contamination and real or imagined health hazards. I do not use compressed air to remove any powder or dust from the containers; we only use air to dry the vessels after washing.

In our old building, we were fortunate to have a hood in the sample-prep lab. We opened the grinding vessels under the hood and the air flow was strong enough to remove any dust. Lacking the spot exhausts, this is a workable alternative. (I have a hood in my present lab that we use for other things like staining of slabs and such.)

In Bob Tuckers jaw-crusher and disc-mill room (they're still here, even though he isn't), there are dust-collector boxes over each machine connected to a large vacuum system. This seems to work very well.

I trust this information is useful.

Chris Tacker

We haven't been through this, but it seems that you could combine a plexiglass box with a ShopVac that has a HEPA filter. The box could just fit over the equipment.

Also, the dust he's worried about is a very small grain size.
Is there any way that you could measure it so that you have data on your size? I had to shut down my collections room because a volunteer had a hissy fit over the radioactive minerals, but measurements showed that everything was fine.

Mickey Gunter, Univ. Idaho

You might check with Paul Bierman (paul.bierman@uvm.edu) at UVM; I know he had a similar issue. And while they are probably of no use, I've attached a couple of papers that I've written on the subject of quartz and health issues as well as a recent review article.

Also it's not Si dust (you probably knew that) it is respirable crystalline silica (quartz and cristobalite). There's OSHA and MSHA exposures for these. Seems like the best thing for them to do would be to collect an air sample and have it checked. Many labs (including RJ Lee) routinely do this type of analysis, and it's done by powder XRD.

References provided by Mickey:

Norton, M. R., and Gunter. M. E., 1999, Relationship between respiratory diseases and quartz-rich dist in Idaho, U.S.A., American Mineralogist, v. 84, p. 1009-1019.

Gunter, M.E., 1999, Quartz--the most abundant mineral species in the Earth's crust and a human carcinogen? Jour. Geoscience Education, v 47, p. 341.

Gamble, J. F., 2011, Crystalline silica and lung cancer: a critical review of the occupational epidemiology literature of exposure-response studies testing this hypothesis. Critical Reviews in Toxicology, v 41 (5), 404-465.

Pamela Burnley, U. Nevada Reno

If I could add a question to Dave's - we are also having the same problem with our rock crushing equipment and our Risk Management people. One of the causes of dust in our situation is that the users claim that the only way to clean the equipment (e.g. shatter box, disk mill etc) is with compressed air. The idea is that brushes and a vacuum are not adequate for avoiding geochemical contamination. So I am wondering if this is true or if there are less dust producing means of cleaning the equipment.

Michael Stewart, University of Illinois

To clean the disk mill and shatter box between geochemical samples I normally brush dust out and then wiped clean with lab-grade methanol. After cleaning, I blow dry with air (now no dust), and then pre-contaminate the milling/crushing equipment with my next sample. thereby insuring no cross-contamination of samples. I've not experienced any apparent contamination issues following this method.