Researching the right recipe

Two taconite-based products may lead to a better pothole patch
Riding the microwave

ust a large pothole with magnetite concentrate. Preheat with microwave to 230°F, add a mixture of recycled asphalt, recycled house shingles and more magnetite. Microwave for 7 minutes to almost 300°F. Tamp down while still hot. Cool before serving, um... I mean, driving on it.

Getting a recipe just right takes a combination of experimentation and plain old trial and error. That’s just what NRRI researcher Larry Zanko is doing with the help of Dave Hopstock, a mineral processing consultant, along with Kirk Kjellberg and Vern Hegg of Microwave Utilities, Inc., based in Monticello, Minn. They’re trying to get just the right mixture, time and temperature for repairing road potholes when it’s wet or cold outside, using by-product and recycled materials with industrial microwave technology.

It’s painfully obvious that the seasonal cold/hot cycles in northern climates are hard on roadways. Any moisture in the hole freezes and expands, then contracts, loosening the typical cold-patch fill. This past winter was one of the worst and the proliferation of potholes has the Department of Transportation scrambling to get them filled. NRRI research on more permanent patch solutions caught their attention.

Full-scale implementation testing is underway this spring near Duluth and in Anoka, Minn., using a special microwave developed by Microwave Utilities, Inc. that sports a 50,000 watt transmitter. That’s 49,000 watts more than a standard kitchen microwave. It also emits longer waves than the popcorn-popping models. The portable microwave drives out the moisture from the hole and heats the adjacent pavement. Then it’s filled with recycled waste materials, and microwaved again to heat and set the patch.

“In 2002, Dave (Hopstock) showed us that magnetite, found in abundant taconite waste rock, readily absorbs microwave heat,” explained Zanko. “He asked us to help him develop an all-season and long-lasting road repair compound and chemical-free deicing mix. With the high-powered and mobile microwave, we can prove out the concept on real road conditions.”

The demonstration patches will be checked next spring to see if they held through the winter. As the process is refined, pothole demonstrations will be done on increasingly travelled roads to test the patches durability.

“Microwave Utilities has benefited greatly from our collaboration with NRRI. Having their caliber of research on new ideas and introducing us to other collaborative partners is priceless to a growing company like ours.” –Kirk Kjellberg, Microwave Technologies

Just add water

Some experimentation at NRRI’s Coleraine Lab turned up another taconite-based pothole product by mixing taconite with a phosphate — but finding just the right phosphate took some research.

“We came across some research that said if you have a ferrous ion, it would react with phosphate,” explained NRRI Center Director Don Fosnacht. “So I asked the guys at Coleraine to throw our magnetite into a beaker with different forms of phosphate and see what happens. It solidified almost instantaneously.”

While the solidified taconite was promising as a road repair compound, they had to slow down the solidification to be able to work with the material. The researchers kept working on the mixture until they had something they could pour into a troublesome pothole in their parking lot. It held through a few winters and they knew they were on to something.

NRRI patented the product and TCC Materials in Mendota Heights purchased the license to add to their construction materials product line. NRRI facilitated a focus group of state, county and city maintenance personnel to find out what they think of the product. It was clear that working with some types of activators would not be appealing to road maintenance crews. NRRI continued to experiment with different formulations.

“We’re still evaluating the commercial benefits of this patch product,” said Brian DiGrado, TCC Materials marketing and business development manager. “The open discussion with the focus group was very helpful to us in fine-tuning the product to fit the needs of the folks who would use it.”

NRRI Scientist Matt Aro was charged with finding a combination that could be mixed with water at the repair site. Pulling knowledge of binders from other projects, Aro found a cheaper and safer source of phosphates that is transported dry to the job site, then activated with water.

TCC Materials is conducting expanded testing of the just-add-water mixture in real road situations. Potholes on Highway 169 in Keewatin and Virgina, and more on Interstate 35E in St. Paul, have been filled and will be monitored to see how well they withstand the high traffic wear-and-tear.

“What we’re trying to do is develop an iron-based material that will last much longer than ‘throw ‘n go’ patches, potentially a semi-permanent or permanent road repair,” said Fosnacht. “There’s a lot of chemistry behind this, but ultimately what we need is a strong bond and an efficient way to fill the holes.”
It takes 632 parts to make one airplane seat. A frivolous bit of trivia to some, it’s money in the bank to Northstar Aerospace CEO John Eagleton. His Duluth company makes those parts, and thousands more, for the small aircraft industry.

At its peak before the recent recession, Northstar Aerospace had 115 employees churning out parts for two major customers: Cirrus Design and Eclipse Aviation. When 80 percent of those companies’ business dropped off, a hard lesson was learned and Eagleton set out to diversify their customer base. Now Northstar has about 55 employees making parts for 12 – 15 major customers and business is picking up steadily.

“We’ll be back up to where we were before the recession by 2013,” said Eagleton. “I’m sure of that.”

Thrice listed in Inc. magazine as one of the fastest growing, privately held companies in the U.S., Northstar was a small machine and tool-sharpening shop back in 1993, started by NRRI machinist Dave Anderson, his brother Kent, and sister Linda (Anderson) Reno. Since NRRI’s role is to foster new business development, Dave had a lot of support as he made the transition to small business owner.

NRRI Director Mike Lalich recognized Dave’s machinist skills and NRRI encouraged him in his business plan.

“Risk is inherent in any start-up and it takes hard work,” Lalich said. “Sometimes it works and sometimes it doesn’t. In this case, seizing market opportunities, delivery of quality products and timely local investment and management support led to an outstanding outcome.”

Located in an old Air Force missile storage building near the Duluth airport, Northstar Machine was in the right place at the right time. A year later, Cirrus Design moved in nearby and started ordering parts from Northstar to build airplanes. It was the start of a synergistic relationship.

“We tracked right along with Cirrus. Their growth was our growth,” said Eagleton.

But the company had to scramble to keep up with Cirrus. Eagleton was hired as CEO in 1998 to move the business from, as he says, “a greasy, oily, smelly machine shop to aerospace precision machining.” His 50 years of business experience paid off, and until the 2008 recession hit, the bars on the production chart kept growing.

He believes the recent sale of Cirrus to a Chinese firm will be a good thing for everyone – Cirrus, Northstar and Duluth workers. “They’ll probably put in money to accelerate the development of the new jet,” Eagleton said. Northstar is already making table parts for high speed trains that are sold to China.

So while this growing, globally-competitive industry provides a strong manufacturing backbone for the Arrowhead Region, its start as an entrepreneurial risk is not lost on Eagleton.

“NRRI plays a major role in the entrepreneurial process,” he said. “They help move an idea to commercialization faster, give them a better chance at success, and provide R and D to identify weaknesses in the idea. That’s all extremely valuable to a start-up.”
Turkish Taconite

NRRI makes taconite pellets from foreign ores

We really can’t claim that NRRI’s Coleraine Minerals Research Lab is the best kept secret in the world of mining. Not when industry leaders from the other side of the globe call because they heard that we’re the “best in the world” at processing and pelletizing iron ore.

NRRI’s Coleraine Lab was asked to partner with Hatch Engineering from Canada in developing a flowsheet for processing iron ore for a steel company in Turkey. The lab accepted the challenge as a means to learn how to process ores that contain magnetite, but from a different rock type than we currently mine in Minnesota.

“This type of development allows us to broaden our skill set so that we continue to develop the expertise required to improve our processing options for clients in Minnesota,” explained Don Fosnacht, NRRI Center Director. “It is a rare opportunity for the staff to gain processing knowledge and at the same time put some of technical staff to work on things out of the norm. It also helps us cover our costs in the turbulent economic times that exist today.”

Eighty eight barrels of taconite rock arrived from Ankara, Turkey, last spring. The bright red barrels held rock samples spanning a deposit that Erdemir (the largest iron and steel company in Turkey) is interested in mining to make iron ore pellets for their steel mills.

“We’re one of the few labs in the world that have pilot scale concentrating and pelletizing capabilities all in once place,” explained Blair Benner, NRRI Minerals Processing Program Director. “We’re also one of the few that have magnetite experience that fits their ore body.”

When underway, this mine will be the biggest non-coal mine in Turkey, and because energy costs are much higher there than in the U.S., efficiency is a top priority. NRRI researchers have a long history of using computational modeling and magnetic separation to make Minnesota’s taconite pellet plants as efficient as possible.

“We’re looking to get the most weight rejection of ‘bad’ ore and still maintain a high magnetic iron recovery of the ‘good’ ore,” explained Benner. “That’s different for every ore body in the world, and theirs is slightly better than what we have here. The idea is that if you can reject material before you have to grind it, you save a lot of energy.”

Benner and his team are charged with making the concentrate from the taconite rock. First they’re crushing, blending and sampling the rock at the bench scale to determine the best processing knowledge and at the same time put some of technical staff to work on things out of the norm. It also helps us cover our costs in the turbulent economic times that exist today.”

High Temperature Processing Program Director Dick Kiesel is charged with making the concentrate into pellets.

“We’re looking to establish moisture content and quality of the green balls before they go into the furnace,” said Kiesel. “We have an upgraded pot grate furnace to fire them in so we can run them through a series of tests until we meet the specifications they need.”

NRRI’s ability to simulate the entire process from bench to pilot scale and then scale up the plans for commercial production is critical.

“We should be able to supply them with enough data that they can go to an engineering company that can design the plant and size the equipment for their specific needs,” said Benner.

Talented Turk

One of the extra bonuses for Erdemir was the language connection with newly hired Caner (pronounced Jon-Air) Orhan who has since returned to Turkey. Orhan’s expertise in mathematical modeling and simulation of mineral processing circuits was well used at the Lab.

“The rock Erdemir sent us was my homeland, literally,” said Orhan who is from a town near Ankara, Turkey. “Their ore deposit is located in my hometown, so it was like receiving a bit of home.”

Orhan naturally became the translator between Erdemir’s staff and NRRI staff to keep the conversations clear and the project moving forward.

“Because I was involved in the project, it was easy for me to keep them abreast of tests we did and make it easy for them to understand,” Orhan said. “We were able to prevent misunderstandings, and with scientific research it can be very complicated.”

And it didn’t hurt that Orhan had an immediate connection with the president of Erdemir, Sedat Orhan.

“We are from different towns and we’re not related,” he added. “It is just a very common name in Turkey.”
Bringing back the bugs

Restoration of St. Louis River estuary starts small

There was a time long ago when twisted, curving fingers of dirt and sand and plants reached into the St. Louis River bay, breaking and slowing the water in quiet coves before flowing into Lake Superior. Protected from high energy waves, the coves allowed a variety of plants and bugs to flourish, along with many fish and birds.

Industrialization of the St. Louis River estuary made it inhospitable to plants and wildlife. Restoration efforts are aimed at slowly rebuilding natural habitat.
After industrialization of the area, the curved fingers of land were reconfigured into cement boat slips. Now the plants and bugs are all but gone, the fish and birds with them. The area is officially designated as an “Area of Concern” by the Minnesota Pollution Control Agency.

The good news is that the Great Lakes Restoration Initiative is making funds available to remediate and restore this area of the bay. Once plants and insects return, other critters soon follow.

“We know there’s no way to go back to pre-settlement times,” said NRRI aquatic ecologist Valerie Brady, who is assisting with the vegetation and benthic sampling for the larger overall project. “It’s been polluted and degraded, but we all want it to be livable by birds and fish and bugs again.”

The U.S. Fish and Wildlife Service is coordinating a project at one site in the 40th Avenue West project area. They’ve asked NRRI to find out what’s living there before extensive pollution clean-up takes place. NRRI will also develop computer models of scenarios of sand bars and shallow areas that can be built to break the waves and provide quiet coves again.

“The models will show how we can change the wave action and then what types of vegetation we can expect to grow,” Brady said. “With the right plants, it’s assumed bugs will come back, then birds and fish.”

30 years of working toward ‘Remediation and Restoration’

Don’t define 1978 as oil crisis, inflation and disco music. It was also the year that the United States and Canada took a solid, well-placed step in the right environmental direction with the Great Lakes Water Quality Agreement.

Forty-three areas throughout the Great Lakes were identified as significantly polluted and in need of large scale, coordinated cleanup. In the St. Louis River estuary, untreated sewage was being discharged and the Western Lake Superior Sanitary District sewage treatment plant was built to consolidate 14 inadequately treated discharges.

“Since forming that agreement, significant things have been done to improve water quality and restore fish and wildlife habitat, and we’re continuing that process today,” said Daryl Peterson, a project manager, for the Minnesota Land Trust.

The 40th Avenue West Project is a conglomeration of three target areas, out of about 40, in the St. Louis River estuary that require a collaborated agency effort to determine both remediation and restoration needs.

“Typically those two things are done by different agencies,” Peterson explained. “But we realized that by working together, we could be much more efficient.”

So the Minnesota Pollution Control Agency (remediation) is working with the Department of Natural Resources (habitat restoration) to carry out the strategies that have been identified over the years that will reduce exposure to persistent toxic chemicals and bring back wildlife to the estuary. The agencies are addressing contaminated sediments, reintroducing vital plant life to encourage a healthy aquatic environment.

“Clearly, some areas in the estuary will remain industrial, so we’re trying to balance the mixed uses of the estuary,” Peterson said. “Understanding what’s living there now and what each species needs to thrive helps us with planning and developing the tools we need to optimize the ecological design for the habitat restoration.”
Giving nature a helping hand

*Sphagnum bog restoration gets stamp of approval*
It took about 6,000 years for Mother Nature to build Minnesota’s highly valued sphagnum bogs. But by providing the right hydrology and vegetation, NRRI’s Tom Malterer did it in eight years. This spring, his efforts to restore a drained peat bog to its soggy, sphagnum glory is showing all the signs of success. And it’s a model for peatland restoration in the United States.

The bog’s multi-millennial development changed in the 1950s when Duluth businessman Jeno Paulucci drained 325 acres to grow vegetables for his Chun King product line. In the energy hungry 1970s, the drained peatlands were used for peat fuel experiments. Today, its value is in reversing the drainage and gaining mitigation credits for necessary road construction projects that disturb wetlands. Federal mandates for “no net loss” of wetlands means that when wetlands are filled or otherwise disturbed, another wetland must replace it.

“It’s really hard to find good credits in northeastern Minnesota,” said Joan Weyandt, Board of Soil and Water Resources. “There’s not been a lot of wetland disturbance up here that we can restore, which makes it hard to build roads. It’s a great opportunity and NRRI has done such a beautiful job restoring it.”

A small cadre of people keenly interested in the restoration effort toured in May. Botanist Gary Walton has been watching for specific plants to emerge that indicate the evolution to a true bog is underway.

“We’re seeing bog rosemary, leather leaf, bog laurel and small cranberry, as well as other wetland plants,” explained Walton. “These plants tell us the restoration is progressing as it should.”

This “all systems go” sign from Walton means the mitigation credits are valid and the necessary road construction can take place.

Malterer began this restoration effort in 2003 by clearing the land and closing the drainage ditches. After the land was carefully leveled, it was seeded with live vegetation from a nearby sphagnum bog and covered with straw. This process, used in Canada, was researched by NRRI’s Kurt Johnson and tested on local areas mined by peat companies.

The next step was monitoring… and patience. Peat is considered a slowly renewable resource. Its growth is measured in inches per one hundred years.

Standing in one of the first restoration sites, looking across a ditch at an old growth wooded bog, Malterer said, “Just look over there and then look here. In 50 years, that’s what this will look like.”
Taconite mining and processing into pellets is a unique industry in the U.S. relegated to specific areas of Minnesota and Michigan. But it is also large, vital and complex. Ongoing research to improve the process is critical to keep production costs down and quality high. So it makes sense that the three major taconite producers in North America – Cliffs Natural Resources, U.S. Steel and ArcelorMittal – work together to share research information.

This cooperative effort was especially crucial during the early 1980s recession when steel production in the U.S. was grinding to a halt and demand for taconite pellets plummeted. It was then that the Minnesota Department of Natural Resources formed the Iron Ore Cooperative to fund research to improve iron ore and taconite processing.

Administered by the DNR’s Division of Lands and Minerals, the Cooperative is made up of taconite industry and minerals research lab representatives. NRRI researchers Blair Benner, Dave Englund and Dick Kiesel serve on subcommittees.

“The taconite plants suggest research projects that they need done,” explained Dave Hendrickson, director of NRRI’s minerals lab in Coleraine. “Requests for research proposals are sent out and responded to, and the projects are given to a research organization. It’s a very competitive process.”

The Iron Ore Cooperative addresses the specific and unique needs of the taconite companies with shared research. And because NRRI works hand-in-glove with the mining industry, it is able to consistently anticipate research needs, and frequently gets chosen to conduct the research.

Currently, NRRI minerals researchers are working on three projects funded by the Iron Ore Cooperative.

Kiesel is working to provide taconite plants a cost-effective biomass replacement for their coal-fueled induction furnaces. He has a pilot scale torrefaction machine that produces a charred wood product with properties similar to coal. Kiesel is also working to improve pellet quality before and after they’re fired. His lab-scale research delves into the process of mixing the binder and the taconite concentrate, and whether high intensity mixing equipment will be more effective.

After all the mixing and high-heat cooking, the pellets need to be cooled. Englund’s research uses computer models to find the most cost-effective balance between the production rate and energy efficiency of the cooling process.

Since its inception, the Iron Ore Cooperative has provided public investment of approximately $600,000 per biennium, matched by about $400,000 in private funds over the same period, according to the DNR.

While taconite received its due attention, industry leaders and legislators in the 1980s realized that the singular focus on iron ore mining wasn’t economically wise for northern Minnesota. In 1987, a Minerals Diversification Plan was accepted by the state legislature and funding was established to stimulate the development of copper, nickel and other precious metals mining. NRRI’s Economic Geology Group played a lead role in this effort.

“When NRRI was established, we were looking at diversifying Minnesota’s mineral potential,” said Thys Johnson, former director of NRRI’s Center for Applied Research and Technology Development. “(Geologist) Steve Hauck and I talked to people and put together a big program for the Minerals Diversification Fund to get things going in Minnesota.”

This early funding has led to today’s detailed understanding of the state’s Duluth Complex, a valuable deposit of copper, nickel and platinum group elements poised for economic development.
There’s a new ecosystem enemy on the loose and headed this way. Asian Jumping Worms are highly active, highly destructive earthworms that are often mistaken for Red Wiggler (Eisenia fetida) composting worms and accidently let loose in compost piles.

NRRI Scientist Cindy Hale has spent the past 10 years studying and sharing information about the problems caused by the well-known European earthworms – nightcrawlers and angle worms, for instance. Now she’s sounding the alarm for the Asian variety, before they spread.

“The Asian species, their genus is Amynthas, are not well-established in the western Great Lakes region yet, but we’ve seen them in Wisconsin and in the Twin Cities metro area,” said Hale. “And they’re poised to be coming this way. They’ve already become established in locations on the East Coast.”

The Amynthas is often called Alabama Jumper or Jumping Worm and touted as being an excellent composting worm. They have a high metabolism and can live in very high densities. Amynthas can work through your kitchen and yard waste like nobody’s business. But if that compost goes into a garden, watch out – the voracious appetite of these earthworms can severely upset the nutrient system. In gardens out East where the Asian earthworm has invaded, Hale says, “it can get to the point of what we’ve started to call the ‘nothing grows here syndrome’.”

We’re all familiar with European earthworms as fish bait and a gardener’s friend. But Hale’s research on their detrimental effect on native hardwood forests – especially the sensitive understory plants – has garnered quite a bit of attention over the past decade. And unfortunately, once earthworms establish themselves in an area, there’s really no effective way of removing them.

“We have to make people aware that all earthworms are exotic, so it’s technically illegal to knowingly introduce them into the state,” Hale explained. “It’s just that people don’t know a Red Wiggler from Amynthas.”

Most vermicomposter’s don’t worry so much about European Red Wrigglers that people order on the Internet for composting because they don’t survive Minnesota winters outside of a compost pile. But some species of Amynthas are tough and will survive freezing temps. The problem is that people don’t know when the wrong earthworms are in their compost.

“We recommend that outdoor composters use a traditional backyard pile that is turned and watered regularly,” said Hale. “This activates the natural fungi and bacteria which heats the piles over 110 degrees, killing any earthworms or egg cocoons that may be in the pile.” Compost barrels are also effective.

But people who want their compost in weeks instead of months have to be patient. It takes longer for the bacteria to break things down. Apartment dwellers might be even more tempted to use worms in compost because of lack of yard space. In that case, Hale recommends freezing any compost solid for at least a week or more before it is released outdoors. This will kill any worms and egg cocoons.

Hale and her team have compiled the largest database in the world on earthworms, and they’re always grateful for help. Volunteer citizen scientists are trained and equipped to help collect earthworm samples wherever they live and send them back for documentation. She’s also written a book, “Earthworms of the Great Lakes” (Kollath-Stensaas Publishing, Duluth, Minn.) that documents the impact of non-native earthworms, identifies the different species introduced here and give information about collecting earthworms for the database.

More information can be found at www.GreatLakesWormWatch.org.
Funding the future of Minnesota mining

Chilean company gives financial support to young geologists

“We are in the very early stages of this project, so it’s very hard to say precisely the timeline,” said Awad. “But we hope to be in production before the end of this decade. That is what we told Governor Dayton.”

He further said that his company will invest approximately $130 million in the prefeasibility and feasibility studies and an environmental impact statement, which they hope to have completed by 2017. Then the federal agencies will decide whether the permit to mine will be issued.

The Minnesota Twin Metals deposits are believed to have 50 years of minable minerals and will create approximately 3,000 permanent jobs, including support industries.

“When industry interest waned on base metals exploration in Minnesota, NRRI kept going, providing the foundation of knowledge we have today regarding the Duluth Complex strategic and precious metals resources,” said David Oliver, Twin Metals, Minnesota Project Manager.

Similarly, Dean Peterson, Duluth Metals VP of Exploration, credited the mapping expertise of NRRI’s Economic Geology Group, stating “Without NRRI, you (Antofagasta) wouldn’t be here right now. I’m convinced of that.”

One of the world’s largest copper mining and development companies, Chilean-based Antofagasta Minerals PLC, donated $25,000 to UMD’s Precambrian Research Center in May. The Center was formed by NRRI and the Department of Geological Sciences to address the growing demand for well-trained field geologists in modern methods of geological mapping and map-making of the mineral-rich resources found in northeastern Minnesota.

Antofagasta CEO Marcelo Awad personally awarded the check at NRRI in May. His trip to Minnesota included a visit with Governor Mark Dayton who Awad said is “very knowledgeable and supportive” of the potential mining projects in Minnesota. Antofagasta PLC is a partner with Duluth Metals forming Twin Metals which will seek permits to mine the mineral resources, just south of Ely.