PERSPECTIVE:

Transforming Aggregates Byproducts into Opportunities for Carbon Storage

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Every year, over 2.5 billion tons of aggregates are produced in the United States and serve a critical component to the general construction industry and U.S. infrastructure. The U.S. construction industry contributes nearly 5% to the national GDP, over $1 trillion dollars annually, and employs over 8.2 million employees. In order to meet construction demands and engineered specifications, aggregates need to be quarried or mined in a variety of sizes and shapes. During the processing of these materials, it is often the case that fine-sized materials go underutilized and are ultimately stockpiled at aggregate facilities. Enhanced rock weathering is an approach to sustainably utilize an aggregate facility's fine products, extend the life of quarries, and help implement carbon storage strategies in the construction industry.

IN BRIEF:

As rock is weathered by exposure to air and water, it naturally binds CO_2 in sedimentary compounds that have the effect of decreasing atmospheric CO_2. Recent demonstration projects show it is possible to speed up this natural process through the targeted application of fine-sized aggregate materials that would otherwise go unused.

What is Enhanced Rock Weathering?

Carbon storage by rock weathering is a naturally occurring process that incorporates both the rock and water cycles. Over the course of millions of years, exposed rock faces (cliffs, hill sides, mountain tops, etc.) are exposed to rain and other forms of precipitation. Precipitation naturally absorbs carbon dioxide (CO_2) from the atmosphere and then interacts in the mineral composition of the exposed geology. Rain and soil waters absorb CO_2 to form carbonic acid, which reacts with Ca- and Mg-bearing silicate minerals, consuming CO_2 and producing alkalinity (mainly bicarbonate) and dissolved cations; these products are then transported through rivers to the ocean, where they are stored on millennial timescales and may later form carbonate sediments. Enhanced rock weathering (ERW) accelerates this natural process by applying finely ground silicate rock particles—often quarry fines—to soils. The increased surface area greatly speeds up the chemical reactions that remove CO_2 from the atmosphere. Carbon-intensive businesses can take advantage of fine silicate rock particles and the enhanced rock weathering process by spreading these fines over fields and verifying the carbon storage through robust Measurement, Reporting and Verification (MRV) and full life-cycle accounting to generate CO_2-removal credits.

Benefits of Enhanced Rock Weathering

Enhanced rock weathering provides benefits to the aggregate producers, as well as local construction professions and agricultural communities. Aggregate producers face a variety of constraints that create unique challenges many other industries do not typically have to consider. Two of the primary concerns for many aggregate producers are the unintentional generation of fine-sized material and the need to maintain adequate quantities of water for material washing and dust control. To create the individual particle sizes necessary for high performance asphalt and concrete products, aggregate particles are crushed and sized multiple times to get the appropriate sizes for customer needs. Every time a particle is crushed or conveyed, fine sized particles are naturally generated. Historically, these particles were used in new construction as base or fill materials or in asphalt as filler material, but with the decrease in new construction and introduction of more recycled materials in asphalt pavements,

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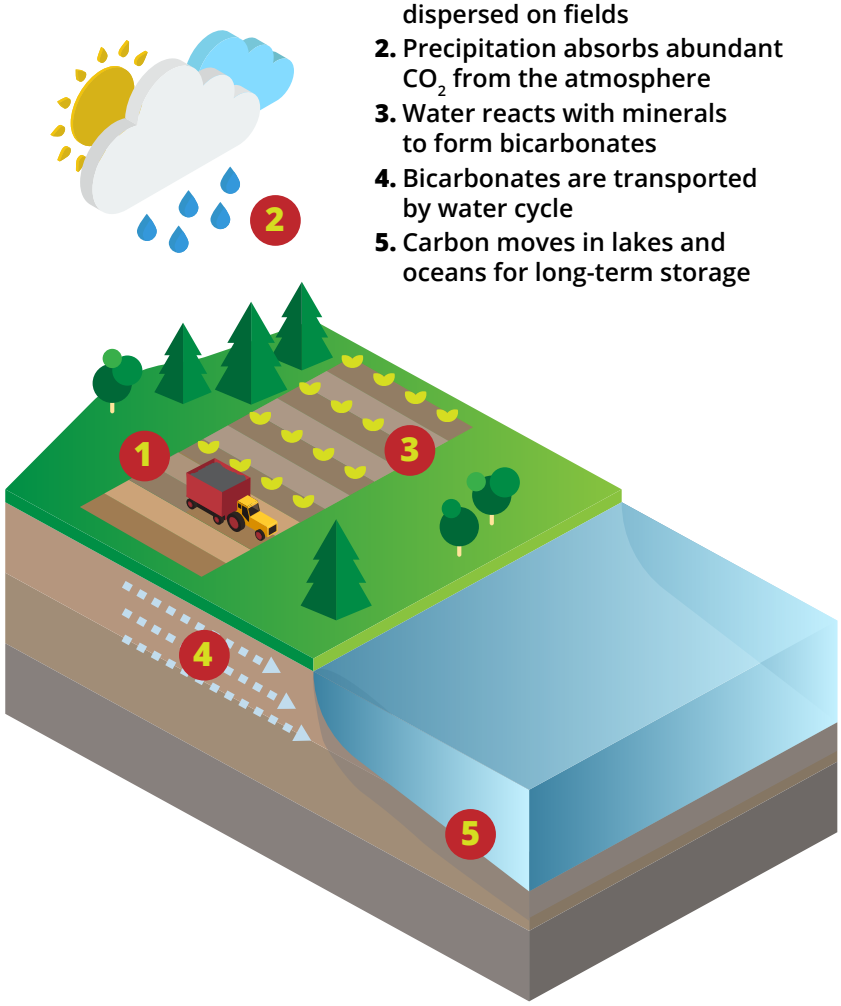
there are less downstream products for these fines to be added to. When these fines do not have products to be utilized in, they are generally stockpiled on site and potentially sterilize future aggregate reserves. As permitting and real estate becomes an increasingly timely and expensive consideration of aggregate producers, optimizing a site's entire reserve of material to fullest extent is the most sustainable option for providing critical resources to projects.

Aggregate producers that have begun to participate in large-scale enhanced rock weathering implementation have also seen the downstream impact. Underutilized materials are now having to be maintained, tested, transported, and spread by additional employees or third-party vendors providing downstream job stability and potential job growth in communities in which aggregate facilities operate in. To properly account for the carbon uptake and storage (which is depending on factors such as specific geology, climate conditions, particle size, etc.) frequent field and laboratory testing is also needed at enhanced rock weathering sites, which helps continue to promote job creation in their markets.

Certain rock types used in enhanced rock weathering projects can also provide agricultural benefits after being spread on fields for carbon storage. Research has indicated the potential for increasing soil pH, providing additional nutrients to soils, reducing the dependence on agricultural lime and other carbon intensive products, and increasing the overall soil health and function when applied appropriately. It is also important to note that in many cases the application of quarry fines can provide additional financial benefits to farmers, without negatively impacting their crop yield and production.

CARBON CYCLE AND STORAGE THROUGH ENHANCED ROCK WEATHERING

1. Fine, quarried materials are dispersed on fields
2. Precipitation absorbs abundant CO_2 from the atmosphere
3. Water reacts with minerals to form bicarbonates
4. Bicarbonates are transported by water cycle
5. Carbon moves in lakes and oceans for long-term storage



How Much Carbon Is Stored?

The amount of CO_2 that can be stored through the application of quarry fines is dependent on a variety of factors, including the chemical composition of rock, particle size, climate conditions, etc. Based on field measurements, approximately 0.2-0.6 tons of CO_2 can be stored per ton of rock dust applied per acre. The cost of handling, transport, and application of these fines on fields can range from $50 to $480 per ton of CO_2 removed, depending on geologic and logistical variables. It is estimated that annually the US aggregate industry produces somewhere between 250 and 500 million tons of construction sand-sized products and quarry fines are produced, some of which do not have conventional applications or markets. It is estimated that utilizing enhanced rock weathering across the United States could remove and store potentially 0.3 gigatons of CO_2 annually by 2050.[1]

[1] Suhrhoff, T. J. (2025). Bibliography of Enhanced Weathering literature [Data set]. Zenodo. https://doi.org/10.5281/zenodo.15797188