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COMMERCIAL PERLITE DEPOSITS OF NEW MEXICO AND NORTH AMERICA

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Abstract—Perlite is weathered volcanic glass containing from 2 to 5 wt.% water. When heated to 600°–800°C in 870°–1100°C furnaces, the glass softens and its water is rapidly given off as steam. The steam expands or "pops" the perlite into glass foam that is from 10 to 40 times the original volume and 15 lbs/ft^3 or less in density. "Onionskin" or classical perlite is dense, gray to bluish black with concentric fractures and a pearly luster. Granular perlite is lighter weight, microvesicular, highly fractured, and white to gray. Pumiceous perlite is extremely lightweight, frothy, and white to light gray. All types are mined commercially, but granular perlite is dominant in high-volume mines. Perlite deposits are associated with rhyolitic volcanic terranes. Most are Tertiary in age because volcanic glass is relatively short lived over geologic time. The glassy, subhorizontal tops of microvesicular (i.e., permeable), high-silica lava flows are the most favorable sites for weathering into commercial perlite. Large, steep-sided, high-silica lava domes are more common than high-silica flows. However, large domes yield relatively little commercial perlite because of their complex cooling histories and the lack of access to the meteoric water that hydrates the glass during weathering. In 1997, commercial perlite was mined at a record pace of 775,000 short tons in Arizona, California, Nevada, and New Mexico, with more than 85% of the total from New Mexico. Construction uses accounted for 71% of expanded perlite domestic sales. Filter aids accounted for 11%, horticultural aggregate 9%, fillers 7%, and others 2%. Other North American perlite production is from, or has recently come from, Colorado, Idaho, and Texas; the Canadian province of British Columbia; and the Mexican states of Durango, Puebla, and Sonora. New operations are online, or will come online soon, in Oregon and Utah and an Idaho operation will re-open, all of which will increase supply, thus eliminating the shortages of recent years.

INTRODUCTION

The use of perlite dates back to perhaps the 18th century (Howell, 1974), but it may have been used as much as 2300 years ago (Kadey, 1983). The modern industry has developed over the last 50 years (Shackley and Allen, 1981). Classical perlite was originally identified by its vitreous, pearly luster and characteristic curved ("onionskin") perlitic fractures (Breese and Barker, 1994). Textures of perlite range from onionskin (common) to granular (the most common commercial type) to pumiceous (uncommon). Perlite has a high-silica composition and from 2 to 5 wt.% water, whereas obsidian has more variable composition in the range of 0–2 wt.% water and averages about 0.5 wt.% water. Volcanic glass with water over 5 wt.% is pitchstone. Obsidian, perlite and pitchstone can be expanded in appropriate furnaces. Occurrences of perlite are worldwide and usually in young (<60 Ma) glassy volcanic rocks.

Modern perlite production began in 1946 at Superior, Arizona, and soon thereafter in New Mexico. Processed perlite expands or "pops" when heated quickly to plasticity while evolving steam. The result is glass foam, from 10 to 40 times the original volume. Any volcanic glass that expands may be known as "perlite" in commerce including obsidian, currently expanded in Japan, and pitchstone (>5 wt.% water) expanded in Eastern Europe. The low density and porous texture of expanded perlite plus its low thermal conductivity, high sound absorption and chemical stability give it many valuable commercial properties.

In the United States, which is the world leader, perlite producers sold or used a record 775,000 short tons (st) in 1997 according to W. P. Bolen, U.S. Geological Survey (personal commun. 1998). This represents a 2.8% increase over the 754,000 st produced in 1996. In 1997, mining was by 6 companies at 8 operations in 5 western states. Expanded perlite, sold or used by domestic producers, increased to 760,000 st and the associated value increased to $144 million as compared with 740,000 st and $137 million, respectively, in 1996. In 1996, U.S. apparent consumption of processed perlite increased 3.6% over the previous year to 850,000 st. United States perlite exports, primarily to Canada, were an estimated 42,000 st; imports mostly from Greece were an estimated 138,000 st (about 17% of apparent consumption). During both 1996 and 1997 New Mexico accounted for more than 85% of the total domestic tonnage produced. The rest comes from Arizona, California, Idaho, Nevada, and Utah (Fig. 1). In 1997, new mines began shipping in Oregon and Utah. Recent past production came from Colorado and Nevada, and the Canadian province of British Columbia. Currently, Mexican mines in the states of Durango and Puebla are active and one in Sonora had been active until recently. Thirteen countries produced 1.92 million st of perlite in 1996, of which the largest, after the United States, were Greece, Japan, and Turkey, excluding China, likely a large producer in the future.

In 1997, the average price of processed perlite was $35.06 per st (FOB mine) and from $220 to $225 per st for expanded perlite. Construction uses of expanded perlite accounted for 71% of production. Filter aids accounted for 9%, horticultural aggregate 9%, fillers 8%, and other uses 3% (Bolen, 1997).

In the United States, most perlite is shipped in bulk to processing plants before it is expanded. In 1996, 61 plants in 31 states expanded perlite. Leading perlite expanding states were Georgia, Mississippi, Illinois, Pennsylvania, Alabama, California, Florida, and Oregon (Bolen, 1996a).

GEOLOGY

Perlite is one of the natural volcanic glasses that contain water in excess of the original magmatic amount. These glasses include some obsidian plus perlite and pitchstone, and hydrated volcanic ash or "pumicite" (Breese and Barker, 1994). Perlite (2–5 wt.% water) is a hydrated volcanic glass formed by the weathering of obsidian by gradual incorporation of ground water into the high-silica glass. The arcuate, concentric fractures that characterize the dense, onionskin, classical perlites are from the tension developed by the volume increase during hydration (Friedman and Smith, 1958; Jezek and Noble, 1978; Breese and Barker, 1994; Chamberlin and Barker, 1996). Perlitic volcanic glasses occur within high-silica (71–75 wt.% SiO_2) volcanic domes, lava flows, and welded ash-

FIGURE 1. Presently or recently active perlite mines, plants and selected prospects in North America.

flows. Most deposits are Tertiary in age owing to the relatively rapid removal of glass in most climates over geologic time.

A typical zonation found in many flows and domes consists of a glassy perlitic rind that encases interior, partly devitrified glasses and a volcanic rock core. Common textures of perlite, with increasing density, are pumiceous, granular, and classical perlite. Pumiceous perlite is typically present at the margin of the deposit and has frothy, open vesicles (bubbles) often flattened and distorted by compression and flowage prior to solidification. This perlite is commonly friable and is mined with relative ease. Perlite with a granular texture is characterized by a sugary appearance and blocky fractures. Collapsed vesicles impart a silky luster to surfaces that are nearly parallel with flow banding. Because it is denser than pumiceous perlite, granular perlite typically mills well. Classical perlite is the most dense and has well-developed perlitic fracture and pearly-to-resinous luster. Within perlite deposits unweathered obsidian ranges from abundant to uncommon and can occur as isolated grains or as pods of varying dimensions in all types of perlite.

Exploration for perlite is centered on the Tertiary volcanic terrains of the western United States and in Canada and Mexico. Semiarid climates are more conducive to hydration of volcanic glass without removal of the glass by the chemical weathering dominant in a humid climate. Large areas of volcanic rocks remain unexplored for perlite because of other non-geologic constraints such as local transportation limitations. The initial exploration targets should be the thin flows associated with viscous lava domes rather than the thicker ones. Thin flows cool more rapidly yielding more glass and less rocky core. The composite nature of the domes makes them relatively poor exploration targets (Chamberlin and Barker, 1996).

MINING AND MILLING

Each commercial operation mines and processes perlite in a slightly different way. All mines except one in east-central Nevada are open pits. In some operations, the perlite is hard and must be drilled and blasted. In others, the perlite breaks easily and can be extracted with scrappers. Some producers crush perlite at the mine while others crush at the plant. Most operations move crude perlite from the mine to the plant by truck, but some are near enough to use conveyor belts. Others dump from a scrapper directly into the crusher. The perlite is sized, commonly to –6 in., dried to remove free moisture, crushed to –6 mesh, and screened to saleable sizes. All companies produce more than one size of crude perlite. Oversized material is often reground until it achieves proper sizes to maximize marketable product. Perlite is stored in storage tanks at the plant. It is custom blended and shipped, via rail (most) or truck in bulk or bags (mainly supersacks), to expanders near end use sites. Some operations have expanders at or near the plant, but most move crude perlite to expanders in various parts of the country (Austin and Barker, 1995). Commercial perlite, expanded in either vertical (fixed) or horizontal (mobile) furnaces, ranges from 2.0 to 15 lbs/ft^3 with most products in the range of 7 to 12 lbs/ft^3 (Table 1). Most expanded perlite is shipped in 4 ft^3 bags.

Factors affecting perlite expansion are complexly interrelated. Expansion is a function of composition, water content, fluxing agents in the glass, softening temperature, furnace temperature, and particle residence time in the flame. Thus perlite expansion is as much art as science and technology.

Perlite can be classified as "lively" or "dead" based on its water content and softening temperature (Murdock and Stein, 1950). "Dead" perlites have less combined water and higher softening temperatures than "live" perlites of the same type. Crushing followed by long storage may deaden perlite. More heat must penetrate dead perlite particles to achieve good expansion. This can be accomplished by preheating the perlite feed, increasing the furnace temperature and/or the particle residence time in the furnace.

Stein and Murdock (1955) concluded that the degree of expansion of a perlite particle is proportional to the temperature achieved in excess of its softening temperature, a concept that is usually balanced against cost. No correlation has been demonstrated between bench-scale expansion tests (Perlite Institute, 1984; Barker and others, 1987) using horizontal furnaces and similar tests in commercial plants. Scaling up from vertical-furnace bench testing to full-scale operation correlates better (Kadey, 1983), but full-scale testing must be done prior to commitment of resources for investment in perlite ventures, mining, or processing. Very few laboratories, including the New Mexico Bureau of Mines and Mineral Resources (Barker and others, 1987), do expansion testing for the public.

TABLE 1. Typical density for various perlite end uses.

End Use	Density (lbs/ft^3)
Plaster and concrete aggregate	7.5–8.5
Roof insulation board	4
Filter aids	7–12
Formed products	3.5
Low-temperature insulation	2–4
Masonry and cavity-fill insulation	6
Fillers	7–12
Horticultural aggregate	6–8

Source: Meisinger, 1985

TABLE 2. U.S. market data for perlite produced 1990–1997.

Production year	Processed perlite (st)	Price ($/st)	Expanded perlite (st)
1990	639,000	28.51	534,000
1991	567,000	26.61	506,000
1992	596,000	27.51	603,000
1993	627,000	27.79	624,000
1994	710,000	27.24	701,000
1995	772,000	25.34	724,000
1996	754,000	25.63	739,000
1997e	775,000	28.87	746,000

After Bolen, 1994, 1996b, 1998; W. P. Bolen, verbal communication, 1998
$mt = $st (1.1023114); mt = st/1.1023114; e = estimated

Crystalline silica

Crystalline silica in the form of quartz is present in most perlite in trace amounts along with other crystals such as feldspar. The quartz occurs as both low temperature (alpha and beta) and high temperature (tridymite and cristobalite) forms. The latter are about twice as reactive in the body as the low-temperature more common forms. This reactivity was classified by the International Agency for Research on Cancer (IARC) as a Class 2A (probable carcinogen) in humans when inhaled but not when ingested or contacted. IARC findings are used by various regulatory agencies and some labeling has occurred. The current situation treats perlite fines as nuisance dust with standard precautions needed. Crystalline silica in perlite is very low (1–3 wt.%) in most commercial deposits and is frequently lowered further during processing and use. Dilution in end products is a useful approach. However, the health, safety, and regulatory issues are very fluid and must be monitored regularly. Summaries are given in Miles (1990), Miles and Harben (1991), Ampian and Virta (1992), Staff (1992), and Breese and Barker (1994). Measurement of crystalline silica can be done to about a 0.05% threshold using X-ray diffraction; other methods are also used (Miles, 1997; Renault et al., 1991, 1992; Miles and Hamilton, 1991; Hamilton and Peletis, 1990; Barker and McKee, 1990). XRD is routinely done at the New Mexico Bureau of Mines and Mineral Resources at the 0.07% level for crystalline silica in perlite.

PERLITE END USES

The 1996 market for processed perlite in the United States was 754,000 st, and was 739,000 st for expanded perlite, continuing the rapid growth in demand seen throughout the 1990s. These were record production for both categories as shown in the following time series in Table 2.

Perlite markets for unexpanded and expanded products are discussed separately. The emphasis is on construction products and end uses, which together represent by far the largest segment (69%) of the market for expanded perlite. Long established substitutes for perlite include diatomite, silica sand, zeolites, expanded clay or shale, pumice, slag, and vermiculite. All uses of perlite are subject to replacement by alternate materials.

Unexpanded perlite other than construction products

Crushed and sized perlite is used in relatively small quantities as abrasives, for foundry ladle topping, and as a silica source in vari-

TABLE 3. The principal domestic construction uses for expanded perlite sold or used in 1996. Construction uses accounted for about 71% of total expanded perlite production.

Expanded perlite end use	Consumption (st)	Value $	Value $/st
Formed products	501,500	63,200,000	126
Masonry fill	8,390	2,710,000	323
Plaster aggregate	6,310	1,260,000	200
Concrete aggregate	7,140	1,940,000	272
Construction use subtotal	523,240	69,110,000	132
Expanded perlite total	739,000	137,000,000	185

After Bolen, 1996b; $mt = $st (1.1023114); mt = st/1.1023114

ous processes. It is also used in landscaping and on golf courses. For ladle topping, the perlite forms a crust on the surface of the molten metal, acting as an insulator and also aiding in the coagulation of silica and other impurities floating on the surface of the metal. Crushed perlite is used for various decorative stone uses and for sand traps.

Several processes use perlite as a source of silica. In calcium-silicate insulation, perlite fines have been used as the silica source for reaction with lime in the aqueous slurry. The advantage of perlite-based insulation over the diatomite previously used is lower crystalline silica. Perlite is used as a silica scavenger for hydrofluoric acid in the production of wet-process food-grade phosphoric acid.

Expanded perlite—construction uses

By far the most important uses for perlite are related to the construction industry (Table 3).

Formed products

Insulating Board—The largest use of perlite in the U.S., this formed product may contain up to 70% perlite mixed with cellulose and a binder. It is used on built-up roofs, for sheathing, and similar products. The ingredients are pulped, dewatered and formed on a fourdrinier or similar board-forming equipment, compressed and dried.

Acoustical ceiling tile—The second largest end use of formed perlite in the United States, this tile product contains up to 75% expanded perlite. Dewatering the slurry forms the tiles. The low density, white color, non-combustibility, and free filtering characteristics are reasons for the use of perlite in this line of products.

Pipe insulation—Another use of formed expanded perlite is for insulating pipes.

Gypsum wallboard

Expanded perlite is frequently used in gypsum wallboard to decrease shrinkage, reduce weight, and increase fire resistance and insulating qualities.

Masonry fill

Expanded perlite is made hydrophobic by surface treatment with silicone or, less often, asphalt emulsions. The material is poured loose into masonry cavities, such as concrete block walls, for thermal insulation.

Plaster aggregate

Perlite, mixed with gypsum or portland cement to form a plaster, is used for steel member encasement, curtain walls, stucco scratch coats, and veneers. The perlite adds fire resistance, thermal and acoustical insulation and reduced rebound when gunned.

Concrete aggregate

The largest use of perlite as portland cement concrete aggregate is for roof decks, as a lightweight base for built-up roofing. The lightweight (15–50 lbs/ft^3) concrete is also used as floor fill, curtain-wall backup, and in pre-cast concrete items.

Joint cement

This gypsum-based product is used to fill and finish the joints between the sheets of gypsum wallboard. Perlite helps to control viscosity, improve workability, and reduce weight.

Door cores

Perlite is used in substantial quantities for the production of fire-proof door cores.

Paint

Relatively small quantities of expanded perlite are used as a texturizing material in paints.

Expanded perlite other than construction products

Cryogenic insulation

Pressure vessels for the storage and transportation of liquid natural gas and other industrial gases are typically double-walled steel tanks. Perlite is used as thermal insulation in the annular space between the walls of the container.

Filter aid

Expanded perlite is crushed to form curved flakes or bubble-wall shards, which are similar in shape to broken egg shells, for the filtration of a wide variety of liquids including fruit juices, tallow, swimming pool water, wine, vinegar, and pharmaceuticals.

Horticultural aggregate

Perlite is highly water absorptive, and very porous with low bulk density. When mixed with soil and/or peat moss, it is used extensively in potting soils, as a soil admixture in landscaping and for golf greens, as a growing medium for small plants including trees and shrubs, and in other similar applications.

Microspheres

Expanded perlite is closely sized and used as reinforcing filler in plastics. Material for this market commands a premium price. However, this use has not developed the sales volume once envisioned, perhaps due to competition from microspheres made from other materials including ceramics, fly ash, glass, and plastics.

STATUS OF COMMERCIAL PERLITE IN NORTH AMERICA

The following discussion highlights the current situation at active, recently active, or developing perlite mines, primarily in the United States. Extensive descriptions and test data for many US active deposits are in Austin and Barker (1995) and Barker and others (1996).

United States

Arizona

The *Harborlite mine* and plant near Superior is active (Fig. 1, #1). Equipment from the nearby Nord property was used to upgrade screens and the dryer. In 1997, production has remained near the 1996 levels of 50,000–55,000 st/yr. Nearly 100% of production is sent to a captive expansion plant in North Carolina for filter-aids;

from 1 to 2% is used in lightweight aggregate.

The *Nord mine*, now owned by Harborlite, was completely subsumed into a single mine plan and the plant dismantled for parts.

California

The *American Perlite mine* (Fig. 1, #2) produces granular perlite and 1997 production was about 40,000 st. Markets are mainly in southern California. Shipments are by truck only for use as lightweight aggregate in fiberboard. From 20 to 25% is used in horticulture.

The *Cougar Butte property* of High Plateau Resources (Fig. 1, #3) is on hold in very early development. The 700-acre property is about 6 mi from rail in northern California on the Siskiyou and Modoc County border.

Colorado

The *Persolite plant* (Fig. 1, #14) expands No Agua perlite, except for small amounts from their *Rosita deposit* (Fig. 1, #5), which is occasionally mined in the summer. There was no production from the Rosita deposit in 1997. Dicaperl and Harborlite operate plants at Antonito. Their mines are in New Mexico and the operations are described under that state.

Idaho

Idaho Minerals, Inc., purchased National Perlite Products from Oglebay Norton for about $2 million in early 1996 (Fig. 1, #6). The new owners (including Moneta Porcupine Mines out of Vancouver, BC) operated briefly during the fall of 1996. A new mine at a deposit near the old mine (Fig. 1, #7) will supply ore to a new plantsite at Virginia on I-15 about 22 mi north of Malad City. This plan has encountered both transitory political and environmental opposition from the state environmental quality board and citizens in the Virginia area. When built (after additional funding is procured), the new crushing and sizing plant at Virginia will have a capacity of about 100,000 st/yr. A new haul road that will shorten the mine-to-plant distance from about 26 mi to about 18 mi is permitted. The existing expansion plant with one small vertical furnace will stay in Malad City and will produce from 2000 to 3000 st/yr, principally for horticultural purposes. However, the value of both the crude and expanded will be about the same. Expanded perlite will be shipped to National Perlite's former markets to all of North America by rail on the Union Pacific. Crude perlite, which will be the bulk of production, will be shipped mainly to western North America.

Nevada

The *Eagle Picher expansion plant* (Fig. 1, #8) is about 7 mi northeast of Lovelock at the Eagle Picher diatomite plant. The perlite plant was brought online in May 1994 and consists of one small expansion furnace. Capacity is 15,000 st/yr of expanded perlite used only for filter aids because of softness. Perlite feeding the plant is mined at the *Popcorn mine* in Churchill County, 22 mi south of Fallon, and about 80 mi south of Lovelock (Fig. 1, #9). Eagle Picher operates this mine chiefly to feed their own operations, not to sell perlite. In 1997 only stockpiled perlite was expanded.

The *Wilkin Perlite mine* (Fig. 1, #10) was recently active and is the only underground perlite mine in the United States. The expansion plant is in Caliente about 30 mi to the east (Fig. 1, #11). Production is from 3000 to 4000 st/yr, principally as horticultural material. The owner, Dr. Joseph Wilkin of Panaca, Nevada, died some time ago. The operation may be continuing and operated by his son, Nick Wilken, but we have been unable to contact him.

New Mexico

Dicaperl has two separate operations in the state. The *El Grande mine* (Fig. 1, #12) at No Agua Peaks is the third largest perlite mine in United States. They mostly rip and scrape, but some blasting is necessary to loosen the perlite. Blasting is done only about two months each year. The mine feeds a sizing plant before it is trucked to Antonito, Colorado, for further shipping or expansion. The Antonito plant has three vertical furnaces (one 18 in. and two 28 in. in diameter). A new baghouse, conveyor belts, and screening equipment at the plant have increased efficiency. Dicaperl's Antonito plant (Fig. 1, #13) puts out from 35 to 40 railcars per week, but pressure differential (PD) cars are no longer used, and about 7000 st/yr of expanded perlite (only by truck). Total production from the operation is about 200,000 st/yr. Trucked expanded material is mainly shipped to the western states. Sized crude goes by rail and some by truck all over the United States, but mainly to east and also eastern Canada (Canadian export is about 5–7% of total).

Dicaperl's Socorro operation (Fig. 1, #14) is a large deposit and production was greatly expanded in 1990s. The operation produced about 5$^1/_2$ railcars per day of sized crude or 40 cars per week in 1997. This is about 230,000 st for the year. Dicaperl Socorro has added a new cone crusher and plant capacity is now about 270,000 st/year, mainly in the fine-size range of -50+200 mesh. The plant additions involve new regrinding and screening equipment. At 270,000 st/yr, it and Harborlite's No Agua mine are the two largest perlite operations in the world. Additional expansion of Dicaperl's operation to 300,000 st/yr is possible, but market conditions will have to improve further. The Socorro plant has noted decreased sales in horticultural grade perlite. The weakness in that market is attributed to the effects of the 1997–1998 El Niño on growers in southern California.

Harborlite's No Agua deposit (Fig. 1, #15) is more geologically complex than the adjacent Dicaperl one to the west. Presently, the Harborlite No Agua mine is one of the two largest perlite mines in the United States and probably in the world. Production comes from the South and West Hills (about 50% each) and all of the West Hill production comes from the A pit. Area I northeast of the plant is slowly being developed and will contribute some production this year. Output from the Antonito, Colorado, sizing plant (Fig. 1, #13, adjacent to the Grefco plant) is from 50 to 55 railcars of sized crude per week, but only about one PD car per month. Total yearly production is up from about 250,000 st in 1996 to about 270,000 st in 1997. Plants in California, Florida, Illinois, Mississippi, Pennsylvania, Minnesota, Texas, Virginia, and Indiana now use Harborlite No Agua perlite. About 49% goes into acoustical tile, 49% into fesco (roof board), 1% into silica flux for foundries, and 1% into horticulture. Perlite from Greece and perhaps Turkey is a factor in the southeastern states.

U.S. Gypsum mine (Fig. 1, #16) north of Grants has minor production with less than one car of crude per week (<10,000 tpy), which is for internal U.S. Gypsum uses only. Just two sizes are produced, -30+200 and -50+100 mesh at the plant in Grants (Fig. 1, #17).

Other New Mexico occurrences mined or tested for mining (Weber, 1963; unpubl. NMBMMR files)

The *Brushy Mountain perlite deposit* (Fig. 1, #18) is about 10 mi east-southeast of No Agua Peaks. It consists of a pumiceous perlite that was most recently mined by Silbrico until the early 1980s. It was initially an underground mine that was completed as an open pit. The age, origin, and character of the perlite was similar to those of the No Agua deposits, but the large amount of fine waste at the mine and the long haul to Antonito made the operation unprofitable.

McDonald Ranch perlite deposits (Fig. 1, #28) crop out along Burro Cienega about 20 mi south of Silver City in T22S, R15W and T22S, R14W (Scharkan, 1992). Weber (1963) reports that the main body has a tabular form up to 100 ft thick. Water content in the perlite ranges from 1.73% to 5.78 wt.% (determined by the Pennfield test). Expanded density ranges from 2.66 to 25.5 lbs/ft^3 (Scharkan, 1992) with most samples from 2.5 to 3.5 lbs/ft^3. Development began in the late 1970s and early 1980s, but excessive variability in the quality of the classical perlite and the long truck haul to the Southern Pacific railroad at Gage, New Mexico, made the operation unprofitable.

Massive brownish-red to dark-green perlitic pitchstone forms outcrops up to 500 ft high at the *Leitendorf Hills deposit* (Fig. 1, #28) about 8 mi south-southwest of Lordsburg (Weber, 1963). The perlite water content ranges from 2 to 5 wt.%. The Leitendorf Hills deposit crops out for nearly 2 mi, is from ½ mi to a few hundred yards in width, and has an estimated volume of 30 million yd^3 (Flege, 1959). Although an expanded aggregate was produced in the early 1950s, the variability of the perlite made the deposit impractical to mine.

The *Wallace Ranch deposit* (Fig. 1, #28) is about 15 mi southwest of Riverside at Pine Canyon in sec. 19, T16S, R18W via NM-180 and 16 mi of dirt road. It is a gray, banded, granular perlite breccia that is from 15 to 60 ft thick and a black classical perlite, from 6 to 10 ft thick, at the top. Water content of the perlite is from 1.73 to 2.00 wt.% and expanded density ranges from 2.4 to 11.9 lbs/ft^3 (Scharkan, 1992). The long haul makes development difficult.

The *Swartz perlite deposit* (Scharkan, 1992) is east of Swartz and 15 mi north of City of Rocks State Park (Fig. 1, #28). It is southwest of Tom Brown Canyon about 1.1 mi west of NM-61 in sec. 34, T18S, R10W and sec. 3, T19S, R10W. The outcrop extends about 1 mi along strike and consists of black glass with clear feldspar or altered white phenocrysts and varies from 6 to 250 ft thick including lenses. Water content is about 3–4 wt.% and expanded density ranges from 5.95 to 11.03 lbs/ft^3 (Scharkan, 1992). The variability of the perlite makes development difficult.

Oregon

The *Tucker Hill mine* (Fig. 1, #19) of Cornerstone Industrial Minerals Corp. has recently come online in Lake County approximately 70 mi northwest of Lakeview, Oregon. In 1997 they produced between 10,000 and 12,000 st. The crushing facility is in Lakeview (Fig. 1, #20) and is reached by truck. Sized perlite is trucked about 100 mi to the railhead at Klamath Falls for shipment to expanders near Portland, principally to meet part of the requirements of Armstrong World Industries in St. Helens in Portland area (Speltz, 1998). Cornerstone also expects to ship to California and the Midwest. The perlite varies from classical to granular; the company favors the granular perlite because it has less obsidian than the classical perlite. Onionskin perlite does have use as filter-aid. The company plans to produce from 50,000 to 60,000 st during their first year of full operation with plant capacity reaching about 100,000 st/y when additional equipment (about $500,000) is installed. The expanding plant currently has a capacity of about 20,000 st/yr. A major marketing point will be the reportedly very low crystalline silica in the deposit. Cornerstone is 65% owned by the Atlas Corporation, which put their share up for sale on January 6, 1998.

The *Supreme Perlite Company* (Fig. 1, #21) has a small mine operated periodically at Dooley Mountain in Baker County. Most of the perlite for their expander in Portland comes from No Agua, New Mexico.

Utah

The *Pearl Queen mine* (Fig. 1, #22) is about 10 mi northeast of the plant in Milford (Fig. 1, #23) and is south of an old Manville operation. At about 7000 ft, the mine will produce granular perlite year-round. In 1997, only test material was shipped and all by truck. The rail spur (Union Pacific) is completed and the plant is being fine-tuned for production in spring 1998. The plant will have a rated capacity of 100,000 st/yr, but initial expansion will be 25 st/hr with capacity to go to 50 st/hr. The mine will last at least 20 years at that rate of production. Markets for processed crude appear to be mainly in the midwest, midsouth, and southwest, although the initial market appears to be horticultural grades shipped to California.

Canada

British Columbia

The British Columbia Geological Survey lists 18 perlite occurrences in the Province. There are several expanders in Alberta and British Columbia.

From 1983 to 1987, 7150 st of perlite was mined at the *Frenier deposit* (Fig. 1, #24) 25 mi west of Clinton in British Columbia. The operation is not active at present.

The *Francois deposit* (Fig. 1, #25). near Burns Lake, British Columbia, produced perlite in 1953 and the 1980s. It is not active at present.

Québec

A proposed mine is on the Gaspé Peninsula (Fig. 1, #26), but no production has occurred. The perlite appears to be Devonian (1996, New Mexico Geochronology Research Laboratory, New Mexico Bureau of Mines and Mineral Resources; 391.0 ± 3.8 m.y.), one of the oldest perlites known with commercial possibilities. The owner is Perlite Canada (part of the Lithos Corporation) with a Laval, Québec, address. In 1997, the only changes occurring involved work on the road to the property.

México

Durango

The *Leticia deposit* (Fig. 1, #27), operated by Termolita S. A. de C.V., supplies 66 stpd to an expansion plant in Monterrey (Fig. 1, #24). Termolita started operations in 1970; the headquarters and expanded perlite facilities (Fig. 1, #28) are in Monterrey, Nuevo Leon, Mexico. They own perlite mines in the state of Durango with proven reserves to meet customer needs not only for domestic consumption but also for export to other Latin American countries. Termolita can mine an average of 2200 st of crude perlite per month. They have four expanders in operation (two horizontals, one vertical, and one portable with a total monthly expanding capacity of 110,000 bags of 4.4 ft^3), of expanded perlite in different particle sizes with some exports to the United States. The portable furnace is used mainly for on site expansion in cryogenic insulation services. In 1997 production of crude was about 21,500 st. Reserves are about 40 yrs at the current rate of extraction.

With the technological support of Filter Aid Processing, Inc., Termolita started the construction of their facilities for producing filter aids based on expanded perlite in May 1988. By August 1988, they had begun the commercialization of their filter-aid brand "Filtralite" serving several industrial sectors in which liquid filtration is a critical phase.

Puebla

Dicalite de México, S.A. de C.V. (45% owned by Grefco, Inc.) owns a large granular perlite deposit (Fig. 1, #29) with a mine capacity of 38,600 st/yr about 40 mi northeast of Mexico City. Expected mine life is at least 10 yrs. In 1997, the crusher had a capacity of 44 st/hr and produced 32,000 st. It feeds three expanders (2 horizontal rated at 1760 lbs/hr and 1 vertical at 5500 lbs/hr) in México City (Fig. 1, #30). Dicalite de México supplies perlite to all states in México and also ships to other Latin American countries.

Sonora

Aislantes del Pacific had a perlite mine near *Ciudad Obregon* on the west coast of México, but it is no longer operating (Fig. 1, #31).

CONCLUSIONS

Of the estimated 775,000 st of perlite produced in the United States in 1997, about 658,000 st came from New Mexico. Production from Arizona, California, Nevada, Colorado was much less. New mines or refurbished mines in Nevada, Idaho, Oregon, and Utah are unproved as of the spring of 1997, but do pose a long-term threat to the dominance of New Mexico perlite. The market for New Mexico perlite took a downturn at the end of 1997 indicating that recent shortages may be over. Sales were off from 30 to 40% in December and January but rebounded to about 90% of February 1997 sales in February 1998. A number of deposits are coming on-stream so tight supplies should moderate (Barker and Bodycomb, 1996). Efforts to increase imports of Greek and Turkish perlite, particularly to the eastern U.S., are underway.

A moderate amount of perlite is imported into the United States, principally from Greece, but this perlite is only a threat near deep-water ports in the eastern states (mostly New York City and Baltimore). Production from Mexico is sizeable, but crude perlite is not sold externally, except in small amounts to other Latin American countries

While perlite deposits are known in both British Columbia and Quebec on the west and east coasts respectively, there apparently is no determined effort to develop them. Canada and Mexico will continue to be supplied by the developed operations in the United States and by mines in Greece and perhaps Turkey.

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Erosional spire in the Plio–Pleistocene Palomas Formation south of Las Palomas Canyon. Photograph by Greg Mack.