BORON

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Boron is produced domestically only in the State of California. Boron products sold on the market are produced from a surface mine, underground mines, and from brine. The United States and Turkey are the world's largest producers of boron, changing positions from year to year. Boron is priced and sold on the boron oxide basis, which varies by ore and compound and on the absence or presence of sodium and calcium impurities. Boron exports are about one-half of domestic production.

Legislation and Government Programs

The California Desert Protection Act was signed into law on October 31. Under the Act, 2.7 million hectares (6.7 million acres) of public land would be designated as wilderness and be off limits to boron mining and mineral development. Death Valley National Monument was upgraded into a park and acquired an additional 526,000 hectares (1.3 million acres) that had been under the management of the Bureau of Land Management (BLM). There are patented claims to boron in the park. The new acreage makes Death Valley the largest national park in the lower 48 States. The Mojave National Preserve of 566,000 hectares (1.4 million acres) was upgraded from a BLM scenic area to a National Park Service preserve. Sports hunting and existing grazing and mining rights are permitted in the preserve. Congress continued to debate the fate of the Mining Law of 1872 as amended and its effect on the hard-rock mineral industry. Boron is leasable as sodium borate. Other colemanite and probertite minerals are locatable because they also contain calcium and are deposited as placer deposits, and therefore can be patented.

The Endangered Species Act continued to be a source of controversy. The desert tortoise was designated an endangered species in 1990 by the U.S. Department of the Interior, Fish and Wildlife Service (FWS). The listing extends long-term protection to the tortoise in 2.6 million hectares (6.5 million acres) Arizona, California, Nevada, and Utah. The areas listed include boron mineral areas being surface and underground mined and two solution-mining plants and one project area. Tortoise barriers have to be installed along the perimeter if rock impediments and natural terrains alone are not sufficient to prevent tortoise passage. Any changes to land use require consultation with the FWS beforehand. BLM announced a final rule to implement a congressional requirement that holders of unpatented mining claims pay the Government a $100 rental fee per claim for 1993-94. The new rental fee was to discourage mining claims where the claimant had no intent to mine. The fee will also reduce unnecessary disturbance of the land just to retain rights to mining claims. The new rules are for the periods September 1, 1992, through September 1, 1993, and September 1, 1993, through September 1, 1994. The rental requirements are temporary and must be renewed by Congress. Small miners with 10 or fewer claims and that meet certain other criteria are exempt from the fee.[1]

The National Toxicology Program (NTP) listed fiberglass on its list as a material reasonably anticipated to be a carcinogen. NTP based its decision on animal studies where glass fibers were surgically implanted or injected into rodent lungs and abdomens, resulting in tumors. Makers of fiberglass believe that the animal studies using artificial means of exposure do not establish a human health risk. Research involving humans and multiple studies in which animals breathed fiberglass showed no association between exposure to fiberglass and cancer. The Secretary of the Department of Health and Human Services stated that the listing of a substance is only an initial step in the risk assessment process. Manufacturers voluntarily added a warning label to fiberglass products in 1988, and no additional label changes will be required.[2]

The U. S. Environmental Protection Agency (EPA) may expand the Toxic Release Inventory (TRI) to include mining during 1994. On January 12, 1994, the Federal Register listed 313 chemicals and chemical categories that were added to the TRI list, including boron trichloride and boron trifluoride.

EPA issue a Reregistration Eligibility Decision under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended in 1988, in the Federal Register on March 17, 1994, for boric acid, deca- and penta-hydrate borax, anhydrous borax, disodium octaborate tetrahydrate, and sodium metaborate. The accelerated reregistration program determined that all currently registered products containing these active ingredients are eligible for reregistration.

In 1993, the Internal Revenue Service (IRS) announced new rules that give U.S. taxpayers guidance on new pricing rules associated with intercompany transactions. For many mining companies, transactions would use the comparable uncontrolled price (CUP) method. CUP is based on identifiable transactions with unrelated parties involving "substantially the same" property and circumstances. Policy compliance were reinforced in 1993 by Congress by assessing a penalty on underpricing or overpricing intercompany transactions.[3]

Production

Domestic data for boron are developed by the United States Bureau of Mines (USBM) from two separate, voluntary surveys of U.S. operations. The majority of boron production continued to be from Kern County, CA, with the balance from San Bernardino and Inyo Counties, CA. Of the three operations to which a sold and used survey request was sent, three responded, representing 100% of the total boron sold or used. *(See tables 1, 3, and 4.)*

American Borate Co. (ABC) continued to mine small amounts of colemanite and ulexite/probertite from the Billie Mine. Colemanite was processed at Lathrop Well, NV. Storage and grinding facilities were at Dunn, CA. (See table 2.)

North American Chemical Co. operated the Trona and Westend plants at Searles Lake, in San Bernardino County, to produce refined sodium borate compounds and boric acid from the mineral-rich lake brines. North American is owned by the Harris Chemical Group, with corporate headquarters in New York, NY, and operating headquarters in Overland Park, KS. Boron chemicals saw an increase with volumes of 35,500 metric tons for the quarter ending June 25, 1994, compared with 35,200 tons in 1993. The average price was up to $513 per ton from $501. Total sales were $18.1 million compared with $17.6 million.[4]

At the Trona plant, a differential evaporative process produced borax with potash as a byproduct. Boric acid was produced by solvent extraction. The Westend plant used two lines to supply brines to the plant. The first line fed lake brine to the Argus plant where sodium carbonate was produced. The effluent borax-rich brine then is pumped to the Westend plant where it supplied about two-thirds of the brine feed. The effluent was blended with fresh lake brine from a second feed line that supplied about one-third of the brine feed. The blended brine was then cooled to 18º C to precipitate decahydrate borax. The effluent was cooled to 8º C, and the precipitated Glauber's salt was used to produce sodium sulfate. North American was in the process of evaluating technical changes in its production operation.

U.S. Borax, Inc. (Borax), a part of Borax Consolidated Ltd. of the RTZ Corp. PLC of London, United Kingdom, continued to be a primary world supplier of sodium borates. RTZ reported that production of borates for the first half of 1994 was 255,000 tons of boron oxide compared with 229,000 tons for the first half of 1993.[5]

Processing at Borax's open pit mine include crushing of the ore, dissolving of the borax from the claystone, liquid/solid separation, crystallization of refined products from liquors, drying, storage, and shipping.

Borax mined and processed crude and refined sodium borates, its anhydrous derivatives, and anhydrous boric acid at Boron, in Kern County, CA. A second plant at Boron used a proprietary process to produce technical-grade boric acid from Borax's extensive kernite ore reserves. Both plants are International Organization for Standardization (ISO) registered.

Liquid waste from the plant is pumped to impoundment pond and evaporated. The 14 million tons of pond material contains 1.5 million tons of boron oxide. A new process has been developed to process the plastic pond material, which after solar drying continues to be pliable. The plastic pond material can be dried, crushed, and screened. The borate ore is separated from montmorillonite claystone using high intensity magnetic separators. The weak attraction of montmorillonite to a magnet is enhanced by the presence of small percentages of pyrrhotite (FeS) in the matrix of the claystone. The starting grade from the ponds is concentrated to over 26% boron oxide using the process. The concentrate is acceptable as feed to the existing refinery and is competitive with the mined ore. At present, over 52% of the boron oxide in the pond can be recovered by the screening and magnetic separation method. The waste from the dry beneficiaton process can be deposited with other overburden and mine waste.[6]

The majority of material was shipped to Borax's storage in Wilmington, CA. Products made at Wilmington included ammonium borates, potassium borates, sodium metaborates, and zinc borate.

Consumption

U.S. consumption of borates increased. Glass account for three major borate applications as follows: glass fiber insulation, borosilicate glass, and textile glass fiber. A USBM canvass of the three U.S. producers also collected data on domestic consumption of boron minerals and compounds shown in tables 3 and 4.

The use of borates in glass fiber thermal insulation, primarily used in new construction, was the largest area of demand for borates and the principal insulating material used in the construction industry. Composed of very thin fibers spun from molten glass, its purpose is to trap and hold air. Typically between 4% and 5% boron oxide is incorporated in the formulation to aid melting, inhibit devitrification, and improve the aqueous durability of the finished product. Cellulosic insulation, the seventh largest area of demand for borates, increased.

Borate demand also increased in the fourth major market, manufacturing high-tensile--strength glass fiber materials for use in a range of products. The process of producing glass fiber uses a borosilicate e-glass formulation that is continuously drawn through platinum alloy bushings into continuous filaments of between 9 to 20 microns in diameter. The plastic industry uses roving or chopped strand fibers and the textile industry uses yarn fibers.[7] E-Glass, or textile fiber glass, typically contains between 6% and 8% boron oxide. Originally these glasses were used for electrical purposes, and low sodium levels were important. Now its major applications are reinforcements for plastics, but the low sodium tolerance still applies. The nonconductive and low dielectric properties of high-strength glass-reinforced materials make them transparent to radar and thus valuable for "stealth" applications. Carbon-fiber-reinforced resins can be stronger than metals and, with higher modules, more stable. Although composites can be 10 times more expensive than typical aerospace-grade aluminum, the flexibility they offer in design and consolidation of parts allows large, complex structures to be fabricated to exacting specifications. In addition, its light weight and ability to withstand high temperatures have made them the material of choice for a variety of aerospace applications.

Owens-Corning Fiberglas Corp. reopened its Jackson, TN, glass fiber plant. Capital investment was between $30 and $40 million to install new equipment. When the plant reopened in 1994, it employed about 80 people and produced wet-process mat glass fiber for use in making roofing shingles.[8]

Consumption of borates in borosilicate glasses remained the third major end use, and demand decreased. Boron added in amounts of between 10% and 13% to glass reduced the viscosity of the melt, assisted with fiber formation during processing, allowed for improved specific optical properties, increased resistance to aqueous or chemical attack, enhanced certain mechanical properties, and reduced the thermal expansion coefficient and thermal shock resistance of the product. Scientific glassware products are usually fabricated in Pyrex borosilicate glass. This type of glass is resistant to heat up to 400º C and to chemical corrosion from liquids and gases.[9]

Construction of the Nation's first facility to produce a borosilicate glass from solid nuclear waste began at Savannah River Site, Aiken, SC. High-level nuclear waste that has accumulated during 35 years will be reprocessed and stored in stainless steel canisters for temporary storage before interment in a geologic repository. Boron and lithium are added to the sludge to improve the viscosity of the glass. The viscosity of the borosilicate glass is a function of temperature. Viscosity determines the rate of melting of the raw feed, the rate of glass bubble release (foaming and fining), the rate of homogenization, and therefore, the quality of the final glass product. If the viscosity is too low, excessive convection currents can occur, increasing corrosion and erosion. After vitrification at 1,150º C, the glass is pored into the stainless steel canisters for interim storage.[10]

Boron compounds continued to find application in the manufacture of biological growth control chemicals for use in water treatments, algicide, fertilizers, herbicides, and insecticides. Boron can be applied as a spray and incorporated in herbicides, fertilizers, and irrigation water. Boron is a micronutrient essential to crop growth. Liming acid soils sometimes produces a temporary boron deficiency and can increase boron application rates needed for optimum plant growth if the pH is above 6.5.[11]

A growing and important use of zinc borate, ammonium pentaborate, and boric oxide is as fire retardants in the cellulosic materials such as chipboard, cellulose insulation, and cotton mattresses. Zinc borate is of commercial importance in synthetic polymers.

Boron compounds also were used in metallurgical processes as fluxes, shielding slag in the nonferrous metallurgical industry, and components in electroplating baths. Small amounts of boron and ferroboron were constituents of certain nonferrous alloys and specialty steels, respectively.

The alloys of the nonmetal boron and the metals neodymium and iron produces the strongest magnetic material known. The magnets then are used in automotive direct-current motors, computer disk drives, portable power tools, and home appliances.[12]

Boron also is used as a bleaching agent in detergents and cleaning products, such as compact washing powders. Perborates carry active oxygen that forms hydrogen peroxide in solution. Perborate tetrahydrate has been displaced by perborate monohydrate, which is more soluble in cool laundry wash temperature conditions. E. I. du Pont de Nemours & Co. Inc. (Dupont) announced plans to sell its 32-million-killogram-per-year sodium perborate business to Degussa A.G. Dupont will shutter its unit at Memphis, TN. Degussa and Solvay Interox are now the leading U.S. suppliers, but only Interox has domestic production at Deer Park, TX.[13] *(See tables 3 and 4.)*

Research attempts have been made at recycling fiber-reinforced plastics, but at present it is not economical. In 1992, Canada's Environmental Ministry funded a recycling plant reportedly to be the first of its kind in North America. The facility will create new raw materials from old fiberglass boat hulls, bathtubs, and auto parts by separating the glass fibers from the resins.

Prices

The price for ultra high-purity boron oxide increased. All other reported prices decreased. *(See table 5.)*

European prices of boron minerals were listed as $290 to $360 per ton for Turkish lump colemanite, 40% to 42% boron oxide content, FOB. Argentinean natural colemanite was listed as $360 to $400 per ton at 40% to 42% boron oxide content ground and bagged.[14]

Exports of borates from Chile list average unit value per ton as follows: boric acid, $511.80; ulexite, $120; and refined borax, $416.70.

Foreign Trade

The majority of material from the Borax facility in Boron was shipped to storage, loading, and shipping facilities at Wilmington, CA. A large part of the output was exported to Western Europe from Wilmington to Botlek, Netherlands. ISO 9000 registration has been achieved at Borax NV, the bulk borate terminal at Rotterdam, and at the Coudekerque, France, boric acid plant. *(See tables 6 and 7.)*

World Review

Argentina.—The Argentina Mining Plan changed the collection of taxes to encourage foreign investment. Under the new laws, the Federal Government offered mining companies a tax regime that provides for a 30% corporate tax rate, with a guaranteed cap at this level for 30 years. Corporations will also be able to write off all exploration costs against future corporate tax once the project begins generating profits. Companies will be allowed to set up free trade zones in which remaining tax and import restrictions will be waived.[15] *(See table 8.)*

FMC Corp. planned to develop a lithium and boron production facility at the Salar del Hombre Muerto in the northern region because of the new mining plan. FMC plans to utilize new extraction technologies for the brine that will be developed from the salar.

Boroquimica SA continued production of tincal from the Salar del Hombre Muerto and boric acid from Tincalayu in Salta Province. Tincal between 16% and 18% boron oxide is concentrated by washing and crystallizing to a 99.9% borax product. At Sijes in Salta Province, hydroboracite and colemanite are produced. Ulexite is produced by Boroquimica at Cauchari in Jujuy Province and at Diablillos in Salta Province.[16]

Austria.—Degussa and Treibacher Industrie have formed a 51-49 joint venture to manufacture perborates for use in detergent powders. The new company is called Aktivsauerstoff.[17]

Bolivia.—Corban, S.A., a division of Empresa Minera Industrial, processed ulexite into borax decahydrate and pentahydrate. Annual capacity is 200 tons of deca- and 100 tons of penta-hydrate. Future plans include boric acid production. The mine, located in the Salar de Uyuni, a dried salt lake, began production in 1990. The processing plant is located in Oruro. The plant and mine employs 40 full-time employees and 200 part-time employees.[18] Compania Minera Tierra Ltd., a small company formed in 1988 for producing borates in an area of the Department of Potosi, has important concessions of ulexite and sulfur near the Chilean border in the southwestern tip of the country. About 120,000 tons per year of ulexite is exported to Brazil and other neighboring countries. In 1990, the company employed 120 persons. In 1993, a boric acid plant was operational and producing 10,000 tons per year.

The company has interest in ulexite mineral concessions that cover an area of 4,800 hectares, and reserves have been estimated by the company to exceed 13 million tons of raw ulexite with grades ranging from 20% to 37% boron oxide content. Ulexite is extracted and dried by plowing with a tractor. The dried ulexite is washed and roasted. The processed ulexite of about 42% boron oxide content is bagged and exported by trucks and rail.

Various borate deposits are in the southwestern part of the Altiplano. Llipi, in the south of Salar de Uyuni, contains an estimated 12 million tons of ulexite. Copla Ltda. was mining ulexite for export. Production of ulexite was about 9,600 tons.[19]

Canada.—High purity boric acid from Russia began to be sold through Amalgamet Canada, a division of Premetalco Inc. The acid contain 99.6% to 99.9% boron oxide.[20]

Chile.—Boratom Quimica Processes Ltda. operates a refining plant near Iquique. In March 1992, Boratom's assets and technology were sold to Boron International Inc. (Canada). In November 1993, Boron entered into an agreement with Teck Corp. called Boron Chemicals Processes Chile S.A.[21]

Quimica & Industrial del Borax Ltda. (Quiborax) was the main producer of boric acid and concentrated ulexite. Quiborax operated a mine at Surire, Parindacta, with a crude annual output of 1 million tons per year of ulexite. The ulexite is washed and upgraded from 30% to 40% boron oxide by centrifugal action and flotation prior to filtration. Calcium borate production ceased in March 1994. The boric acid production was estimated to be 20,000 tons with plant facilities at El Aguila, Arica.

The National Boraxx Corp. (Cleveland, OH) packages and distributes boric acid in the United States for Quiborax.

During 1993, North American was reported to have attempted to purchase Quiborax. Although the purchase failed to materialize, there was discussion of an agreement for North American to market product.[22]

Compania Minera Salar de Atacama (Minsal) is a joint-venture project between Sociedad Quimica y Minera de Chile SA (SQM), 75%, and Corporacian de Fomento de la Produccion (CORFO), 25%, at the Salar de Atacama. The first stage of the project is a $90 million potassium chloride production facility to be constructed by 1996. The second stage involves lithium carbonate production to begin in 1997. The final stages involve potassium sulfate and boric acid production to be constructed at such time that the overall project is yielding a profit. The company is surveying new ore deposits that could replace the Maria Elena and Pedro de Valdivia plant locations within a decade.[23]

China.—The borates in the salt lakes of China are mainly found on the Qinghai-Xizang (Tibet) Plateau. The waters contain a mean value 85 milligrams per liter of boron oxide. The maximum value of boron oxide is 1,516 milligrams-per-liter.[24]

In Liaoning Province, reserves were reported at 44 million tons of boromagnesite with 8.4% boron oxide content. Production was reported as 77,000 to 110,000 tons per year of borax and 10,000 to 18,000 tons per year of boric acid at the following production sites: Liaoning, Jilin, Qinghai, and Tibet. Exports of borax were reported to be 2,325 tons during 1992 valued at $790,000.[25]

A Chinese company was to process 120,000 tons of boron-iron ore following recent success to separate the boron from the ore. The deposits in the Liaoning Province represents 64% of the country's total boron resources and 90% of these deposits are associated with iron.[26]

Europe.—Total individual end-use breakdown of consumption of boron oxide in Europe during 1992 was 186,000 tons reported in tons was as follows: enamels and glazes, 70,000; insulation fiber glass, 41,000; textile fiber glass, 35,000; and other glass, 40,000.[27]

Boron occurs naturally in fruit and vegetable, yet some European Union (EU) members seek to replace existing safety levels in the 1980 drinking water directive with World Health Organization (WHO) standards. Sodium perborate used in household detergents is discharged into rivers via sewers. Current directives limit boron in potable water to 1 mg/l (mg/l), but WHO recommends a limit of 0.3 mg/l.[28]

A new international association is being formed to serve industrial minerals interests in Europe named Industrial Minerals Association (IMA-Europe). The four founding members representing various industry sectors of talc, silica, borate, and calcium carbonate. Borax Consolidated represents the borate interest. IMA-Europe is being established to study all noncommercial issues concerning those industrial minerals interests represented in the association, i.e., scientific, technical, documentary, and institutional fields.[29]

India.—Submarginal borax reserves of 74,200 tons have been estimated in Leh District of Jammu and Kashmir. Occurrences are also known in Surendra Nagar District of Gujarat and Jaipur and Nagaur Districts of Rajasthan. Domestic requirements of boron minerals are met solely by imports. Borax Morarji Ltd., Bombay, was engaged in refining imported crude borates from the United States and Turkey to produce borax and boric acid. Capacity was reported to be 17,000 tons per year for borax and 3,000 tons per year for boric acid. During 1990-91, the company treated 15,848 tons of crude borates to produce 13,052 tons of borax and 3,180 tons of boric acid. National Peroxide Ltd., Bombay, produced 85 tons of sodium perborate. Southern Borax Ltd., Madras, which has a capacity of 15,000 tons per year of borax, remained closed in 1990-91. Consumption of the refined borax during 1990-91 was reported to be total 9,200 tons in the following industries: Ceramic, 2,200; chemical, 100; glass, 6,600; graphite crucible, 100; and other, 200.[30]

Kazakhstan.—Boron minerals also were reported to be produced in Kazakhstan, the second largest newly independent republic of the former U.S.S.R. The Government was actively pursuing foreign investment to increase production capacity by improving efficiency to increase exports. The decision by the Republic of Kazakhstan to invite bids on these properties at this time reflects its keen interest to attract mineral exploration and mining companies as a matter of high national priority. A considerable amount of information was assembled on each of the properties that were available through a tender program. Two boron deposits listed in the tender were Inderskaya with 33.7 million tons of 2.15% boron oxide as boracite and hydroboracite under a gypsum cap rock, which also contains potassium oxide. The borates are concentrated in four deposits, 1 to 10 meters in thickness and up to 2 kilometers long. The other deposit Satimola is similar to the Inder borates, nodules and veins of hydroboricite and ulexite, at the gypsum/clay interface above another salt intrusion. The grade is listed as 9.15% boron oxide, in three bodies totaling 43 million tons.[31]

Netherlands.—Morton International planned to transfer sodium hydride manufacturing operations from Beverley, MA, to Delfzijl where Morton now produces sodium borohydride. When the plant is completed in 1994, Morton planned to stop production in the United States and supply that market from the Delfzijl plant.[32]

The Silenka glass fiber factory in Hoogezand, was founded in 1961 as a joint venture between PPG and Akzo. The state-owned Development Co. for the Northern Netherlands assisted by purchasing a 30% share in 1977 when the company was struggling because of rising energy costs. PPG purchased the remaining shares in 1990 and renamed the site PPG Industries Fiber Glass bv. PPG is the second biggest fiberglass manufacturer in Western Europe.

BV Pharmacie Holland, Holland, was also a source of boric acid, boric oxide, calcium borate, borax decahydrate, sodium borate, and sodium perborate in Europe.

Peru.—The quantity and number of minerals produced in Peru and the likelihood of significant deposits to be discovered attracted attention to the privatization plants. The Government continued its privatization program to reactivate the entire mining sector selling many properties at prices below comparable resources in the international market. Boron continued to be produced in Arequipa by Compania Minera Ubinas S.A. A total of 34 tons of sodium borate and sodium calcium borates was imported by Fertilizer Corp. of America into Miami, FL, and Wilmington, NC.

Russia.—Primorsky Industrial Amalagmation, in Dalnegorsk, produces boron minerals from datolite containing between 6% and 12% boron oxide.

Total boron oxide production for the Dalnegorsk region was listed as 140,000 tons boric acid, 13,000 tons calcium borate, 2,500 tons of decahydrate borax, and 15,000 tons other. The Dalnegorsky plant supplied 85% of the domestic market. Design capacity of the plant is 250,000 tons per year of bric acid.[33]

Amalgamation is part of the Russian Agricultural Joint Stock Co. known as ROSAGROCHIM. ROSAGROCHIM coordinates the activities of about 100 companies.

Turkey.—Turkey's boron operations are under the control of the Government corporation Etibank. Ulexite is mined at Bigadic; colemanite at Bigadic, Emet, and Kestelek; and tincal at Kirka. Etibank was reported to have an ore production capacity of 8,000 tons of colemanite, 500,000 tons of tincal, and 115,000 tons of ulexite. Etibank operates refining facilities to produce refined sodium borates and boric acid from tincal concentrates at Bandirma and Kirka. Boron minerals and compounds are shipped from the Port of Bandirma on the Sea of Marmara and Izmir on the Aegean Sea. Bandirma can produce 55,000 tons of borax, 35,000 tons of boric acid, and 20,000 tons of sodium perborate per year. Kirka can produce 50,000 tons of borax, 160,000 tons of pentahydrate borax, and 50,000 tons of anhydrous borax per year.[34]

The Government announced that Etibank would become two separate divisions as a prelude to privatization of the banking business. Sixty days after the July 13 announcement, the two divisions became affiliated companies, and the process will begin for privatization of the banking division.

The Turkish Government now owns all boron and trona mineral deposits, and private concessions of these minerals could not be sold to private investors. Boron is a profitable operation for Etibank and the privatization of this sector is unlikely.[35]

Private processing of boron reserves from stockpiles and dumps have occurred for the past decade. One such company, Rasih ve Ihsan Maden sought capital to expand its processing of 3 million tons of boron reserves.[36]

United Kingdom.—On June 17, Borax

Consolidated, a subsidiary of RTZ Corp., opened a technical center at the University of Surrey Research Park, near Guildford. The intention is to combine research and development activities with the head office and marketing administration functions, while drawing on the University for ideas and inspiration.[37]

Imperial Chemical Industires Plc planned to close the 38,000 ton-per-year sodium perborate plant at Runconrn at yearend. The remaining sodium perborate demand will be supplied by German producer Degussa and Netherlands produce Interox S.A. with 285,000 and 240,000 tons per year of capacity, respectively.[38]

Current Research and Technology

Scientists at Westinghouse Hanford Company are using a salt process to extract nonradioactive sodium nitrate from mixed waste stored as saltcake in underground storage tanks. Water and nitric acid are combined with the mixed radioactive waste and evaporated to produce sodium nitrite. The radioactive waste can be reduced to 10% of the previous volume and shipped to a permanent storage site. The sodium nitrate can be recycled for use by industry. The radioactive waste is vitrified into a borosilicate glass. The Hanford Site alone could have reductions of 25 to 45 million gallons of mixed waste, reducing the need for waste storage and saving billions of dollars.[39]

Stabilizing surplus plutonium as borosilicate glass may be the fastest and surest way of disposal. Several unresolved technical issues with plutonium vitrification have been identified, but are within the real of solvable solutions. Other recommendations include burning the fuels in existing reactors and using the fuel in long-rang energy programs. Spent fuels from using the plutonium as fuel would need to be recycled or stored. Studies continued on the stabilization although the use of geologic repositories for storage have critical safety concerns and would require international safeguards into perpetuity.[40]

The USBM in cooperation with the American Society of Mechanical Engineers conducted over 200 hours of melting tests to vitrify residues from five municipal waste combustion facilities. Each of the residues underwent magnetic separation, screen size analysis, and bulk chemical analysis prior to melting. The chemical composition of the residues ranged between 47 and 257 part per million of boron.[41]

Herbert C. Brown and P. V. Ramachandran lectured on "Recent Advances in the Boron Route to Asymmetric Synthesis" at the IMEBORON VIII-8th International Meeting on Boron Chemistry. Completion rates of 95% are available for a variety of asymmetrical syntheses using simple and convenient reagents.[42]

Two French scientists reported that boron in meteorites and on Earth may be the product of pre-solar-system collisions between interstellar hydrogen and low-energy cosmic rays. This theory is because the $_{11}B$ to $_{10}B$ ratio in the solar system, around 4, is too high to be explained by current chemical evolution models of the galaxy that would put the ratios at 2.5.[43]

An electrodeposited nickel-tungsten-boron alloy coating has been developed that has physical and chemical properties equal or superior to those of chromium. The coating deposition takes place in a mildly alkaline solution and is easy to operate and control.[44]

Quantum-mechanical methods and supercomputers were used to analyze the effects of two impurities in steel, phosphorus, and boron, on steel's atomic integrity. Boron is added in small amounts to harden the steel. The destabilizing effects of the impurities on steel's "crystal grain boundaries" were calculated. With a clear understanding of the mechanisms of embrittlement, new steels can be designed that minimize the deleterious effects.[45]

A fiber-reinforced polymer and inexpensive polymer coatings can be mixed with boron to bond to the original polymer seamlessly. The new low-cost materials could replace or be mixed with expensive engineering plastics to enhance strength.[46]

A new fiber resulting from the new biocomponent technology is composed of two different forms of glass fused together in a single filament. The new glass will be marketed as a home attic insulation. The new fiber has a random irregular twist that forms as the two glasses combined. The fiber cards well and it has potential for blending with other types of fibers in textiles and composites.[47]

The effects of saline water containing boron, sodium, and calcium chloride, were studied by the University of California's West Side Field Station in the San Joaquin Valley at Fresno. For the first 7 years of the 10-year test, 900 almond trees were given different amounts of salty water. For the final 3 years, one-third of the trees were given clean water. The study suggests that toxic levels saline water build up in the soil to reduce the almond yields. Leaf damage on trees that had been irrigated only with saline water was likely a result of chloride, not boron or sodium.[48]

A paper that discussed the types of boron minerals being processed and the chemical and physical treatments of the ores was presented. Boron minerals of economic importance are primarily colemanite, tincal, and ulexite. Turkey and the United States are the leading producers of boron minerals and compounds. Other production includes datolite in Russia. The major physical treatments are optical sorting, attrition scrubbing, dense medium concentration, and floation. Sulfonates were the most common type of collectors used in floations.[49]

Outlook

Production of boron minerals and compounds have decreased between 1990 and 1994. One reason is that production and imports reported in 1 year may be utilized over a period of years. In addition, environmental concerns may change the demand for boron significantly in a short period. The regulation of fire retardants in products has resulted in changes in boron usage as a fire retardant. More recent decreases in domestic consumption have been attributed to decreases in glass consumption because of less demand resulting from a recession. Moreover, one-half of domestic production is exported. Because of increases in production in other countries, this amount has decreased significantly during the past few years.

Agriculture.—Boron usage in agriculture increased significantly in 1994. Farming exports are showing increased strength, and demand for boron usage in agriculture is expected to increase.

Ceramics and Glass.—Reported consumption of boron minerals in glass and ceramic uses was 150,400 tons of boron oxide content representing 51% of total demand. This was down from the 211,656 tons representing 60% of total demand in 1993. Ceramics and glass have faced competition with polymers. The U.S. fiberglass industry was reported to be feeling the effects of recessionary pressures. The sagging economy produced a decline in demand for fiberglass reinforcements. Fiberglass is closely related to construction and transportation and is expected to decrease.

Coatings and Plating.—Primarily used as a protective coating for steel products and as a glazing on ceramic tiles, boron usage increased 50% during the year. Future for this use is expected to increase during 1995.

Fabricated Metal Products.—Boron usage increased in metal products during the year. Usage in specialized metal was expected to increase.

Soaps and Detergents.—Usage in soaps and detergents increased. Recent concern for environmental effects of chlorine has reversed the decline. Perborate bleaches have returned to name brand soap products. The usage of boron in soaps and bleaches was expected to increase by 4% per year during the next 5 years.

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TABLE 1
SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Sold or used by producers:					
Quantity:					
Gross weight 2/	1,090	1,240	1,010	1,060	1,110
Boron oxide (B2O3) content	608	626	554	574	550
Value	$436,000	$443,000	$339,000	$373,000	$443,000
Exports:					
Boric acid: 3/					
Quantity	39	47	80	74	87
Value	$31,700	$35,500	$53,700	$50,500	$53,300
Sodium borates:					
Quantity	585 4/	554 5/	489 5/	481 5/	498 5/
Value	$208,000 e/	$206,000 e/	$159,000 5/	$181,000 5/	$165,000
Imports for consumption: 5/					
Borax:					
Quantity	5	10	16	40	9
Value	$1,570	$3,260	$5,330	$1,230	$2,700
Boric acid:					
Quantity	6	5	6	17	20
Value	$3,920	$3,780	$4,340	$11,900	$12,900
Colemanite:					
Quantity	12	18	30	90	27
Value	$3,310	$4,390	$16,100	$48,600	$10,800
Ulexite:					
Quantity	29	16	42	149	120
Value	$7,360	$4,060	$11,300	$40,700	$24,000
Consumption: Boron oxide (B2O3) content	319	262	345	321 r/	296
World: Production	2,910 r/	2,960 r/	2,680 r/	2,670 r/	2,850 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Minerals and compounds sold or used by producers, including both actual mine production and marketable products.

3/ Includes orthoboric and anhydrous boric acid.

4/ Source: The Journal of Commerce Port Import/Export Reporting Service.

5/ Source: Bureau of the Census.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE 1/

Mineral	Chemical composition	B2O3 weight percent
Boracite (stassfurite)	Mg6B14O26Cl2	62.2
Colemanite	Ca2B6O11 • 5H2O	50.8
Hydroboracite	CaMgB6O11 • 6H2O	50.5
Kernite (rasortie)	Na2B4O7 • 4H2O	51.0
Priceite (pandermite)	CaB10O19 • 7H2O	49.8
Probertite (kramerite)	NaCaB3O9 • 5H2O	49.6
Sassolite (natural boric acid)	H3BO3	56.3
Szaibelyite (ascharite)	MgBO2(OH)	41.4
Tincal (natural borax)	Na2B4O7 • 1OH2O	36.5
Tincalconite (mohavite)	Na2B4O • 5H2O	47.8
Ulexite (boronatrocalcite)	NaCaB5O9 • 8H2O	43.0

1/ Parentheses include common names.

TABLE 3
U.S. CONSUMPTION OF BORON
MINERALS AND COMPOUNDS, BY END USE

(Metric tons of boron oxide content) 1/ 2/

End use	1993 r/	1994
Agriculture	14,800	21,200
Borosilicate glasses	64,500	27,400
Enamels, frits, glazes	10,300	15,400
Fire retardants:		
Cellulosic insulation	9,670	15,800
Other	286	1,360
Insulation-grade glass fibers	106,000	97,000
Metallurgy	1,870	1,950
Miscellaneous uses	32,600	23,800
Nuclear applications	8,870	395
Soaps and detergents	13,800	14,000
Sold to distributors, end use unknown	37,200	51,300
Textile-grade glass fibers	21,300	26,000
Total	321,000	296,000

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Includes imports of borax, boric acid, colemanite, and ulexite.

TABLE 4
U.S. CONSUMPTION OF ORTHOBORIC ACID 1/ 2/, BY END USE

(Metric tons of boron oxide content)

End use	1993 r/	1994
Agriculture	484	493
Borosilicate glasses	13,500	5,440
Enamels, frits, glazes	2,860	1,790
Fire retardants:		
Cellulosic insulation	1,760	5,070
Other	285	1,360
Metallurgy	219	205
Miscellaneous uses	11,200	9,390
Nuclear applications	8,850	395
Soaps and detergents	1,560	--
Sold to distributors, end use unknown	13,700	23,500
Textile-grade glass fibers	7,490	12,200
Total	61,900	59,800

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Includes imports.

TABLE 5
YEAREND 1994 PRICES FOR BORON MINERALS AND COMPOUNDS PER METRIC TON 1/

Product	Price, Dec. 31, 1993 r/ (rounded dollars)	Price, Dec. 31, 1994 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carload, works 2/	761 - 769	720
Borax, technical, anhydrous, 99%, bags, carload, works 2/	837	765
Borax, technical, granular, decahydrate, 99%, bags, carload, works 2/	315 - 446	302
Borax, technical, granular, decahydrate, 99.5%, bulk, carload, works 2/	265	257
Borax, technical, granular, pentahydrate, 99.5%, bags, carload, works 2/	354 - 420	339
Borax, technical, granular, pentahydrate, 99.5%, bulk, carload, works 2/	304	294
Boric acid, technical, granular, 99.9%, bags, carload, works 2/	807 - 815	753
Boric acid, technical, granular, 99.9%, bulk, carload, works 2/	757	708
Boric acid, United States Borax & Chemical Corp., high-purity anhydrous, 99% B2O3, 100-pound-bags, carlots	1,367	1,813
Colemanite, Turkish, 42% B2O3, ground to a minus 70-mesh, f.o.b. railcars, Kings Creek, SC 3/	656	NA
Ulexite, Turkish, 38% B2O3, ground to a minus 6-mesh, f.o.b railcars, Norfolk, VA 3/	332	NA

r/ Revised. NA Not available.
1/ U.S. f.o.b. plant or port prices per metric ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.
2/ Chemical Marketing Reporter. V. 245, No. 1, Dec. 1993, p. 24; V. 247, No. 1, Dec 1994, p. 27.
3/ American Borates Co.

TABLE 6
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY 1/

Country	1993			1994		
	Boric Acid 2/			Boric Acid 2/		
	Quantity (metric tons)	Value (thousands)	Sodium borates 3/ (metric tons)	Quantity (metric tons)	Value (thousands)	Sodium borates 3/ (metric tons)
Australia	1,240	$997	7,150	1,600	$895	6,790
Belgium	--	--	3,670	66	26	1,910
Brazil	2,010	784	509	2,320	795	488
Canada	5,500	3,620	33,200	7,250	4,860	39,600
Colombia	115	103	2,840	182	156	2,930
France	313	438	40	4,390	1,020	83
Germany	27	11	52	2,000	1,550	5
Hong Kong	871	485	2,610	963	559	3,280
India	--	--	5,220	--	--	620
Indonesia	2,600	1,680	7,590	2,720	1,430	11,400
Israel	61	54	243	89	58	186
Japan	22,300	18,200	25,900	14,500	12,500	27,600
Korea, Republic of	9,700	6,150	14,700	11,900	6,950	15,000
Malaysia	1,990	972	4,920	3,440	1,590	6,430
Mexico	3,900	2,690	25,600	6,740	3,420	22,800
Netherlands	3,140	3,080	257,000	5,950	6,200	263,000
New Zealand	275	171	2,970	218	118	2,370
Philippines	2,510	561	1,290	2,050	530	1,500
Singapore	1,330	641	2,190	884	391	1,950
South Africa, Republic of	92	94	321	375	192	649
Spain	2,410	1,170	54,400	5,420	2,100	63,400
Taiwan	10,800	6,370	9,590	10,200	5,320	10,500
Thailand	1,760	1,250	5,040	2,380	1,650	6,810
United Kingdom	243	206	9,310	125	92	673
Venezuela	810	497	1,310	403	264	984
Other	519	281	3,120	1190	613	6750
Total	74,500	50,500	481,000	87,400	53,300	498,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ HTS code No. 2810.00.0000.
3/ HTS code Nos. 2840.19.0000, 2840.30.0000, and 2840.20.0000.

Source: Bureau of the Census.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY 1/

	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Bolivia	318	$137	2,120	$1,030
Canada	64	56	--	--
Chile	5,170	3,400	6,170	3,380
China	17	12	30	29
France	4	11	5	19
Germany	34	40	20	28
Italy	9,350	6,900	5,650	3,990
Japan	159	212	134	186
Netherlands	205	134	41	26
Norway	1	3	--	--
Russia	235	298	470	484
Switzerland	11	8	1	1
Taiwan	4	3	--	--
Turkey	1,000	473	4,980	3,720
United Kingdom	167	217	25	38
Total	16,700	11,900	19,600	12,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ U.S. Customs declared values.

Source: Bureau of the Census.

TABLE 8

BORON MINERALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Argentina	144 r/	116 r/	125 r/	146 r/	140
Bolivia (ulexite)	3	14	23	10 r/	10
Chile (ulexite)	132	97	203	117 r/	110
China e/ 3/	75	93	127 r/	100	120
Germany (borax) e/	4	3	2	2	2
Iran (borax) 4/	2	1	(5/)	1 e/	1
Kazakhstan e/	XX	XX	100	90	80
Peru	20	26	27	27 e/	27
Turkey 6/	1,250	1,210 r/	1,060	1,120 r/	1,250
U.S.S.R. e/ 7/	180	160	XX	XX	XX
United States 8/	1,090	1,240	1,010	1,060	1,110 9/
Total	2,910 r/	2,960 r/	2,670 r/	2,670 r/	2,850

e/ Estimated. r/ Revised. XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through May 16, 1995.
3/ B_2O_3 equivalent.
4/ Data are for years beginning Mar. 21 of that stated.
5/ Less than 1/2 unit.
6/ Concentrates from ore.
7/Dissolved in Dec. 1991.
8/ Minerals and compounds sold or used by producers, including both actual mine production and marketable products.
9/ Reported figure.