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**PRIMARY INDUSTRIES**

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# SODIUM COMPOUNDS (excluding salt)

## Potential and Outlook

The main commercial sources of sodium compounds, apart from sodium chloride (common salt or halite), are sodium carbonate and sodium sulphate minerals. Sodium chloride is discussed in the Salt Chapter of this bulletin.

Sodium carbonates and sodium sulphates occur as a range of salts that are usually found in Tertiary or Quaternary evaporite deposits or in brines. The greatest potential for sodium compounds in New South Wales appears to be in groundwater brines, including those produced by salinity remediation schemes.

The Sydney–Gunnedah Basin (Figure 1) has widespread occurrences of sodium bicarbonate-enriched groundwater. Although there is insufficient bicarbonate-enriched water to support large-scale extraction, areas of potential for sodium bicarbonate extraction may occur elsewhere in the basin.

There is significant potential to produce larger quantities of sodium compounds from Murray Basin (Figure 1) aquifers given the large quantities of saline groundwater they contain (Whitehouse 2003).

Although there are numerous small evaporite occurrences in the western part of the state, they tend to be dominated by gypsum and other minerals.

## Nature and Occurrence

Sodium carbonate (soda ash) and sodium sulphate occur as a range of minerals varying in composition and hydration state. The major naturally occurring sodium carbonate and sodium sulphate minerals are listed in Tables 38 and 39, respectively.

World production for sodium carbonate for 2004 was estimated at 38 Mt, of which 11 Mt was from natural sources and 28 Mt was synthetic — with global demand predicted to grow at 1.5% to 2.0% annually (Kostick 2005a). China is currently the dominant producer of synthetic sodium carbonate (Kostick 2005a). Synthetic sodium carbonate is produced via the Solvay method using salt, ammonia, coke and limestone (Kostick 1994).

**Table 38. Main sodium carbonate minerals**

Mineral	Formula	% Na <sub>2</sub> CO <sub>3</sub>
Thermonatrite	Na <sub>2</sub> CO <sub>3</sub> .H <sub>2</sub> O	85.5
Trona	Na <sub>2</sub> CO <sub>3</sub> .NaHCO <sub>3</sub> .2H <sub>2</sub> O	70.4
Nahcolite	NaHCO <sub>3</sub>	63.1
Natron	Na <sub>2</sub> CO <sub>3</sub> .10H <sub>2</sub> O	37.1
Dawsonite	NaAl(CO <sub>3</sub> )(OH) <sub>2</sub>	35.8
Gaylussite	Na <sub>2</sub> CO <sub>3</sub> .CaCO <sub>3</sub> .5H <sub>2</sub> O	35.8
Shortite	Na <sub>2</sub> CO <sub>3</sub> .2CaCO <sub>3</sub>	34.6
Burkeite	Na <sub>2</sub> CO <sub>3</sub> .2Na <sub>2</sub> SO <sub>4</sub>	27.2
Hanksite	2Na <sub>2</sub> CO <sub>3</sub> .9Na <sub>2</sub> SO <sub>4</sub> .KCl	13.6

Source: Kostick (1994)

**Table 39. Main sodium sulphate minerals**

Mineral	Formula	% Na <sub>2</sub> CO <sub>4</sub>
Thenardite	Na <sub>2</sub> SO <sub>4</sub>	100
Hanksite	2Na <sub>2</sub> CO <sub>3</sub> .9Na <sub>2</sub> SO <sub>4</sub> .KCl	81.7
Burkeite	Na <sub>2</sub> CO <sub>3</sub> .2Na <sub>2</sub> SO <sub>4</sub>	72.8
Eugsterite	2Na <sub>2</sub> SO <sub>4</sub> .CaSO <sub>4</sub> .H <sub>2</sub> O	62.3
Glauberite	Na <sub>2</sub> SO <sub>4</sub> .CaSO <sub>4</sub>	51.1
Loweite	MgSO <sub>4</sub> .Na <sub>2</sub> SO <sub>4</sub> .2.5H <sub>2</sub> O	46.2
Mirabilite	Na <sub>2</sub> SO <sub>4</sub> .10H <sub>2</sub> O	44.1
Bloedite	MgSO <sub>4</sub> .Na <sub>2</sub> SO <sub>4</sub> .H <sub>2</sub> O	42.5

Source: McIlveen and Cheek (1994)

The total world production of natural sodium sulphate was estimated at 4 Mt for 2004 (Kostick2005b). The USA, Canada, Mexico, Spain, Turkey, Botswana, China, Egypt, Italy, Mongolia, Romania and South Africa all have identified resources of sodium sulphate.

## Deposit Types

### **Sodium carbonate**

Sodium carbonate most commonly occurs in association with other salts in shallow non-marine alkaline lakes or brines. These deposits are rarely older than Tertiary. The major deposit types described by Kostick (1994) and Harben and Kužvart (1996) are listed below.

#### ***Ancient trona deposits***

Green River, Wyoming, USA, is a good example of trona, which accumulated in an Eocene evaporite/oil shale sequence in a closed basin setting. The trona is derived from a combination of: leaching of volcanic ash layers; seasonal influxes of carbonate sediments into the basin; and contributions of dissolved alkaline carbonates from subterranean thermal springs (Kostick 1994). The largest trona deposit in the world, the Green River deposit has an estimated trona resource of over 100 000 Mt (Moore 2003).

#### ***Modern trona deposits***

Lake Magadi, Kenya, is an example of a modern trona deposit, which forms as crystals on banks or bottoms of alkaline lakes. They are extracted as brine. Evaporites in the Great Rift Valley are still accumulating at 500 000 tpa. The trona and other evaporite minerals are believed to be derived from hot springs associated with volcanism.

#### ***Brines***

Searles Lake, California, USA, is a good example of trona in brine. It is a thick Pleistocene to Recent evaporite sequence with volcanic/thermal springs providing boron and lithium compounds. Extraction involves groundwater pumping and solution mining, producing sodium carbonates and sulphates, potassium carbonates, and borates. Deposits are also known at Makgadikgadi, Botswana and Lake Texcoco, Mexico.

#### ***Natron***

An example is Goodenough Lake, Canada. Natron forms as crystals in cool wet environments, such as lakes or salt marshes.

#### ***Efflorescences of thermonatrite***

Thermonatrite forms on alkaline soils and around lakes, as at Malawi Lake, Tanzania and Wadi el Natrun, Egypt.

Sources of sodium carbonate for such deposits include leaching of alkaline carbonatites or basic to ultrabasic rocks, evaporation of water originating from thermal springs, leaching of rocks or soils, decomposition of organic matter and ion-exchange reactions.

### **Sodium sulphate**

Sodium sulphate deposits typically accumulate in saline lakes and playas. Two major types were described by McIlveen and Cheek (1994) and Harben and Kužvart (1996).

#### ***Mirabilite or glauberite and/or brines underlying or within playa lakes***

These minerals occur, for example, in:

- western Canada
- Great Salt Lake, western USA
- Kara-Bogaz-Gol Gulf, Caspian Sea
- Mexico (brines).

#### ***Buried sedimentary beds of thenardite, glauberite and associated minerals***

The deposits occur, for example, in:

- Toledo province, Spain
- Camp Verde, Arizona, and Rhodes Marsh, Nevada, USA.

## Main Australian Deposits

### **Sodium Carbonate**

Sodium carbonate is not mined in Australia. At Osborne, South Australia, synthetic sodium carbonate is made using the Solvay process — which has a production capacity of 350 000 tpa (Moore 2003).

The main Australian deposits are Dry Creek, South Australia, where sodium carbonate and sodium bicarbonate have been produced from brine; and the Denison Trough, Bowen Basin, Queensland. During the 1980s, Denison Resources NL explored the Denison Trough around Emerald and identified a large resource of groundwater with 1.2% to 2.8% sodium bicarbonate ( $\text{NaHCO}_3$ ) (Robbins 1986). However, the project did not proceed to production (Denison Australia Pty Ltd 1989).

Recent exploration near Roma in Queensland has defined a potentially mineable sodium bicarbonate resource of 2.2 Mt (Laing 2003). Based on a conservative pumping rate of 800 m<sup>3</sup> per day per well, it is estimated that some 30 000 tpa of sodium bicarbonate could be produced from six boreholes for about six years.

### **Sodium Sulphate**

Although sodium sulphate minerals commonly occur as crusts and efflorescences in saline environments, no sodium sulphate resources of commercial potential have been recorded in Australia.

## New South Wales Occurrences

The Sydney–Gunnedah Basin has widespread occurrences of sodium bicarbonate groundwater, most notably between Narrabri and Gunnedah, and near Ballimore, east of Dubbo (Figure 1) (Whitehouse 2003). In these locations sodium bicarbonate groundwaters range in concentration from about 1000 mg/L to almost 12 000 mg/L, in aquifers up to 10 m thick and at depths ranging from near-surface to several hundred metres. Detailed aquifer studies that included pump (yield) tests conducted at those localities indicated that sodium bicarbonate was unlikely to be obtained in sufficient amounts to prove commercially viable.

## Applications

Sodium carbonate is used in the manufacture of soda-lime glass, fibreglass, pulp and paper, soap and detergent, for metal refining, flue gas desulphurisation and for water treatment (Harben & Kužvart 1996). Glass is the largest consumer of sodium carbonate, in most countries accounting for 55% to 60% of the market (Moore 2003). It is also used in the manufacture of chemicals, including sodium bicarbonate, caustic soda and synthetic zeolites. Sodium sulphate is used in pulp and paper, glass, detergents, ceramic glazes, tanning, textile dyes, nickel smelting, animal feed supplements, and as a feedstock for a range of chemicals.

## Economic Factors

It is likely that China will surpass the USA as the world's leading producer of sodium carbonate (Kostick2005a). Trona is available in such huge quantities in the USA that there is no need for Solvay plants to operate in that country. In contrast, China obtains the majority of its sodium carbonate via the Solvay process. This is a more costly process and generates environmentally deleterious wastes, principally carbon dioxide.

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