ORTA RECENS QUAM PURA NITES

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Potential and Outlook

New South Wales has good potential for commercial olivine deposits. Prospective host ultramafic rocks are common in a number of belts and complexes. These include Alpine-type ultramafic belts (the Great Serpentinite Belt and Gordonbrook Serpentinite Belt in the New England Orogen and the Coolac Serpentinite Belt in the Lachlan Orogen); Alaskan-type intrusions (Tout Intrusive Complex near Fifield); picritic phases of layered alkaline intrusions (e.g. the Jurassic Prospect intrusion in the Sydney Basin); and limburgite lavas among the Ordovician Rockley Volcanics in the eastern Lachlan Orogen (Figure 1).

Such rocks represent a potentially huge resource globally, and possibly in New South Wales. However, many of these ultramafic belts and bodies are dominated by peridotites, whereas only rare dunites have sufficient olivine to be considered as potential commercial olivine sources. Moreover, olivine-bearing rocks are commonly altered to serpentinite, especially those in Alpine-type ultramafic belts. Consequently, commercially acceptable fresh dunite is rarely reported.

The only known olivine occurrence in New South Wales is the Doonba deposit near Barraba (cf. Figure 6). This body was identified during regional exploration for chrysotile asbestos as one of numerous discrete bodies of relatively unserpentinised harzburgite within an extensive zone of serpentinised harzburgite. Later, Breyley (1990) identified the rock type as dunite. Consequently, additional fresh, commercially acceptable olivine deposits could occur in this or other ultramafic belts, even among bodies mapped as harzburgite.

Nature and Occurrence

The olivine group of minerals consists of orthosilicates characterised by independent silica tetrahedra bridged by chains of divalent atoms in six-fold coordination. Forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4) are end-members of a solid solution series (Table 25), and tephroite (Mg_2SiO_4) is the end member of a solid solution series with fayalite (Deer et al. 1992). Other members of the olivine group are: knebelite, $(Mn,Fe)SiO_4$; monticellite, $CaMgSiO_4$; glaucochroite, $CaMnSiO_4$; and kirschsteinite, $CaFeSiO_4$. All are isostructural.

Olivine in a commercial sense refers to forsteritic (magnesian) olivine with 85% or more forsterite (Henning 1994).

Table 25. Main properties of olivine (commercial)

Formula	$(Mg,Fe)_2SiO_4$
Colour	Green to yellow
Specific Gravity	3.2–4.4
Hardness	6.5–7
Habit	Granular

Source: Deer et al. (1992)

Deposit Types

Olivine is found in mafic and ultramafic igneous rocks and in magnesium-rich metamorphic rocks (derived from magnesium-rich igneous rocks or carbonates). Commercial extraction sources are generally limited to dunite, which is the nearly monomineralic, olivine-rich variety of peridotite.

Significant occurrences of olivine include the following types (Henning 1994; Harben & Kužvart 1996; Harben 1999):

Ophiolites —
dunite associated with massive/sheared harzburgite and serpentinite.

Alaskan-type intrusions —
olivine-rich cumulate peridotites in Alaskan complexes up to 1.6 km in diameter.

Layered intrusions —
dunite in concentrically-zoned intrusions, which also contain wehrlite, olivine clinopyroxenite, hornblende clinopyroxenite and gabbro.

Olivine-rich and quartz-poor beach sands —
in basaltic/ophiolitic areas.

World production of olivine is difficult to determine precisely because the term ‘olivine’ is commonly applied commercially to such olivine-bearing rocks as dunite and serpentinite as well as the mineral itself.

Total world production of dunite, serpentinite and olivine has been estimated to be over 8 Mt a year, of which about 4 Mt a year is estimated to be 'pure olivine' (Rudi 2001; O'Driscoll 2004). About 3.3 Mt of olivine is consumed annually in Europe. Most of this is supplied by Norway, which is the dominant producer. Other producers include Italy, Japan, Mexico, Pakistan, Spain and the USA.

New South Wales Occurrences

The Doonba dunite deposit, north of Tamworth, is the only known New South Wales olivine deposit of commercial potential. It consists of a small dunite mass in Cambro-Ordovician ophiolitic rocks of the Great Serpentinite Belt. This belt is dominated by harzburgite that is variably sheared and extensively to completely serpentinised. The Doonba mass is important in being more olivine-rich and significantly less-serpentinised than is typical of ultramafic rocks elsewhere in that belt.

The economic potential of the Doonba deposit was recognised during the Manilla–Narrabri Metallogenic Map project (Brown et al. 1992). The resource is currently being explored and tested for various refractory applications in the steel industry and for use in agriculture.

Applications

The main commercial uses of olivine have been reviewed by Harben (1999); Henning (1994); and O'Driscoll (2004). Those uses are summarised below.

Slag conditioning for blast furnaces or electric arc furnaces

Olivine is used to prevent basic slags from attacking refractory linings, to scavenge alkali carbonates and sulphates, to control melt/slag partitioning of S, and to lower viscosity while maintaining basicity. Its high reaction temperature reduces low-temperature breakdown and reduces burden swelling in furnaces, thereby improving permeability and reducing coke consumption. The olivine is added to furnaces as lump, as sinter feed, or mixed with low-Si high-grade iron ore fines to form pellets. Higher levels of Mg than in dolomite means less material is required to meet Mg requirements. Low loss on ignition (LOI) means less energy is lost in endothermic reactions (e.g. to drive off CO_2) in blast furnaces and sintering plants. Slag conditioning accounts for about 90% of global olivine production.

Refractories

Olivine is a cheaper raw material than magnesite for MgO-based refractories. MgO-based refractories are used in precast linings for incinerators, and as a substitute for silica flour in refractory washes for foundry cores and moulds. Useful properties of olivine include: its low and uniform coefficient of thermal expansion; high heat conductivity; good resistance to thermal shock, slag attack and molten metal attack (so it can replace silica in many applications); high green strength; low Si (low silicosis risk); enhanced bonding with bentonite (reducing clay consumption); and improved performance in recycling because of calcining of hydrosilicates.

Foundry sands (as a replacement for silica)

Olivine can be used in producing Mn-steel castings, and yields a very fine finish in brass, bronze and aluminium foundries.

Abrasives

Hardness, SG, conchoidal fracture, lack of free silica, low risk of heavy metal contamination, and light-coloured dust make olivine well-suited to use in blasting abrasives.

Construction materials

Olivine-rich rocks are crushed and used as an aggregate in some countries, such as Japan, where large quantities are used.

Fertiliser/Soil Conditioner

Olivine is used to increase Mg and Fe as nutrients in soil.

Filler material

Owing to its light colour and inert nature, olivine may be used as filler material.

Regenerators in glassmaking

Olivine can be used to transfer heat from exhaust gases to gas feed, and as heat retention media in night storage heaters.

Other minor or localised uses

Other uses for olivine include: roofing tiles (Italy) to reduce ultraviolet (UV) light-induced deterioration; and ballast in oil production platforms in the North Sea.

Olivine specifications for commercial use are generally less than 85% forsterite; 45–50% MgO; 39–42% SiO_2; 5–8% Fe_2O_3; and 1–2% LOI. Some uses require more stringent specifications. Required sizes range from lump (10–50 mm) to flour.

Alternative Materials

Several minerals can substitute for olivine in the following applications (Harben 1999).

Slag conditioner —
dolomite, magnesite, magnesia

Refractories —
aluminosilicates, bauxite, chromite, dolomite, graphite, magnesite, pyrophyllite, refractory clays and silica

Fertiliser/soil conditioner —
dolomite, magnesite and Mg sulphate

Foundry sands —
alumina and bauxite, chromite, clays, perlite, pyrophyllite, silica, vermiculite and zircon

Night storage heaters —
magnetite.

Synthetic olivine may be manufactured by calcining chrysotile asbestos tailings or serpentine.

Economic Factors

The cost of delivered olivine is sensitive to freight cost because of low unit-value and high mass, and demand varies in response to a number of factors, such as those noted here (Henning 1994; Harben 1999).

Declining demand —
in 'low-tech' traditional applications, especially in steel-making.

Expanding demand —
because of new, upgraded or higher-priced markets, particularly in slag conditioning and as a replacement for silica in foundries and abrasives.

Threats of substitution —
by magnesia and 'high-tech' materials in higher-priced applications.

Sensitivity to transport costs —
owing to high bulk and low unit-value, reducing its competitiveness.

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