Potential and Outlook

True nepheline syenites are rare in New South Wales. Alkali igneous rocks, some of which are chemically very similar to imported nepheline syenite are, however, widespread.

Syenitic intrusions near Cooma and near Bega were investigated in the 1980s with a view to producing commercial-grade nepheline syenite. Tests performed on rocks from these localities resulted in a product otherwise comparable with imported nepheline syenite, i.e. high alumina and alkalis, except for the total iron content that could not be reduced below about 0.3%.

The existence of Mesozoic alkali rocks in areas south of Dubbo and north of Rylstone has been known for a long time (Langley 1976; Langley & Lishmund 1983). Whole-rock geochemical data show that a number of the identified intrusions have chemical compositions similar to nepheline syenite commercially mined overseas.

In the early 1980s, trial beneficiation tests on samples collected from intrusions in the Dubbo and Rylstone areas (Langley & Lishmund 1983) showed that it was possible to obtain products with an iron content of about 0.5%.

Recent geological mapping has shown that these rocks occur more extensively in the Dubbo and Rylstone areas than previously thought and that they can be identified by their anomalous radiometric signature, which reflects their high potassium content.

Nature and Occurrence

Nepheline syenite is a coarse- to medium-grained rock resembling granite in appearance, but differing from it in composition.

Nepheline syenite is 'undersaturated' — it crystallises from magmas deficient in silica and, as a result, contains no quartz. The mineralogical composition of nepheline syenite varies. Typically it contains: 48–54% albite, $NaAlSi_3O_8$; 18–23% microcline, $KAlSi_3O_8$; and 20–30% nepheline, $(Na,K)[AlSiO_4]$; with biotite, hornblende, magnetite and pyroxene as accessory minerals. Mafic minerals should constitute less than 5% of the rock and be amenable to removal by magnetic separation or other methods. Nepheline syenite is: high in Al_2O_3 (>18%); Na_2O (>8%); and K_2O (>5%); but low in CaO and MgO (<5%).

Canada and Norway are the major commercial producers of nepheline syenite. World production has been steady since about 1995, and in 1999 was about 1.2 Mt, of which Canada produced 52% and Norway 24% (Saller 1999). The remainder was produced by Russia for domestic aluminium metal production.

The Canadian production comes from the Blue Mountain and Nephton nepheline syenite deposits in Ontario. These deposits are within a Precambrian nepheline intrusion about 9 km long and up to 2 km wide.

Nepheline syenite in Norway comes from Stjernøy Island, 400 km north of the Arctic Circle, where the syenite occurs in dykes and stocks. There is evidence that the rocks were originally syenite consisting almost exclusively of feldspar. These rocks became 'nephelinised' by solutions associated with Caledonian tectonothermal activity.

In Russia nepheline syenite 'product' is a by-product of apatite mining at Khibiny Mountain in the Kola Peninsula (Saller 1999). The ore occurs in the Khibiny Pluton, which is an alkali syenite intrusion believed to have originated by magmatic injection and subsequent metasomatism. The nepheline syenite is separated from the apatite by flotation and used for alumina manufacture.

Nepheline syenite deposits are relatively common. Commercial development of deposits is, however, dependent on finding deposits close to major markets. The deposits should be medium- to coarse-grained, and preferably massive. Phonolite, which is the volcanic equivalent of nepheline syenite, is generally too fine-grained. Mafic minerals should be extractable by magnetic separation when ground to pass size 30 mesh (<0.6 mm).

Main Australian Deposits

Australia does not produce any nepheline syenite and currently imports 4000–5000 tonnes of nepheline syenite per year for use in glass, ceramics and paint.

New South Wales Occurrences

True nepheline syenites are rare in New South Wales. However, alkali igneous rocks, some of which are chemically very similar to imported nepheline syenite, are widespread. Examples of such alkali intrusions are summarised below (towns noted in Figure 1):

- The Myalla Road Syenite Complex, 8 km south of Cooma, is a roughly circular intrusion of syenite, 4 km in diameter, surrounding a central quartz monzonite body, 1 km in diameter (Lewis et al. 1994).
- The Tanja Syenite Complex, 10 km northeast of Bega, consists of several syenite and monzonite bodies (Lewis et al. 1994).
- The Bald Hill laccolith is a prominent hill formed by a phonolite intrusion (Langley & Lishmund 1983), 10 km north of Lue, east of Mudgee.
- Shepherds Hill (Dibalamble) is the larger of two prominent hills formed of porphyritic alkali microsyenite (Langley & Lishmund 1983) 20 km south-southeast of Dubbo.
- Bushrangers Hill and Arthurville, south-southeast of Dubbo, are two hills about 500 m apart. They consist of alkali microsyenite.
- The Jingera Rock Syenite Complex is a multiphase intrusion composed of syenite and monzonite (Lewis et al. 1994) in the Egan Peaks Nature Reserve 20 km east of Pambula on the far south coast of New South Wales.

The Myalla Road Syenite Complex was tested for its suitability in high-quality (low-iron) glass manufacture (Tepara Pty Ltd & Denison Resources NL 1988). Crushing, feldspar flotation and magnetic separation produced material with an iron oxide content in the range 0.3% to 0.9% from fresh samples. However, the extent of treatment needed to reduce iron content of the raw material to less than 0.5% rendered mining uneconomic.

The Tanja Syenite Complex was explored by Greater Pacific Investments Pty Ltd (1988) for a similar purpose. Magnetic beneficiation tests resulted in a product with the required alkali and alumina contents. However, the iron content of the material could not be reduced below about 0.3%.

Numerous alkali intrusions in the Dubbo and Rylstone areas were identified as having potential as nepheline syenite sources by Langley (1976) and Langley and Lishmund (1983). Whole-rock geochemistry data show that a number of the identified intrusions have a bulk chemistry similar to nepheline syenite mined commercially overseas, i.e. suitably high alumina and alkali, and moderately low iron content. Recent mapping of the Dubbo 1:250 000 geological map sheet area by the Geological Survey of New South Wales has shown that the occurrence of these rocks is more extensive than previously thought, and that they can be readily identified on the basis of their anomalous radiometric signature owing to their high potassium content (Meakin & Morgan 1999; Morgan et al. 1999).

In the early 1980s, the Geological Survey of New South Wales tested samples that had been collected from intrusions in the Dubbo and Rylstone areas (Langley & Lishmund 1983), including Shepherds Hill, Bushrangers Hill and Arthurville. The data showed that it was possible to obtain a product with an iron content of about 0.5%. The main technical barrier for reducing the iron content was at the time found to be the presence of fine-grained mafic phases. Their removal would require the raw material to be crushed to a grain-size apparently too fine to be suitable for the glass industry which requires sand-sized (0.5–1 mm) materials. Fine-grained products may, however, be acceptable for ceramic applications.

It should be noted that only a small number of rocks were tested in those studies. More extensive sampling is now possible as the distribution of these rocks is better known. Furthermore, the tested samples were collected from surface exposures which represent the marginal, fine-grained, phases of the intrusions. It is not unrealistic to expect that coarser-grained rocks occur in the inner phases of the intrusions. These phases may be accessible in deeply incised areas. More exhaustive and sophisticated testing would be required for a full evaluation of the potential of these rocks.

Applications

Nepheline syenite is high in alumina and alkalis and it is used mainly as a substitute for feldspar as a source of alumina and alkalis in glass and ceramics manufacture. In glassmaking, alumina retards devitrification of the finished product, and in ceramics it provides durability and inertness. The alkalis act as a flux in both processes.

The main advantage of using nepheline syenite in ceramics is that it has a lower melting point (1140–1170°C) than sodium feldspar (1170–1200°C) and therefore requires a shorter firing time and less energy. In glassmaking, however, the high alumina content of nepheline syenite is a disadvantage, as it makes it slower to melt than feldspar, thus lengthening the time required to heat the batch (Harben & Kužvart 1996).

Despite these technical factors, the main criteria for choosing nepheline syenite or feldspar are the price and local availability. For example, in the USA, nepheline syenite from Canada is used in the northeastern states and feldspar from the southeastern USA is used in the southern states. In the western USA, local feldspathic sands are used (Harben & Kužvart 1996).

Minor amounts of nepheline syenite are used as filler material in a variety of products, such as paint, plastics, adhesives, caulks and sealants. In Russia it has also been used as a source of aluminium metal by combining it with limestone in a coal-fired sinter kiln. By-products of this process include sodium carbonate, potassium carbonate and calcium silicate (Harben 1999).

Economic Factors

The demand for nepheline syenite is driven by the glass and ceramics industries which, in turn, are linked to construction activity and overall economic activity (Harben 1999). Increasing living standards in developing regions, such as eastern Europe and China, are expected to increase the demand for sanitaryware, whiteware, floor and wall tiles and flat glass (windows and windscreens for motor vehicles) and therefore increase the demand for nepheline syenite. In contrast, demand for container glass is expected to decrease owing to increased use of PET, aluminium and paper containers and increased rates of glass recycling.

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