GEMSTONE PROSPECTIVITY IN SCOTLAND

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Abstract

Scotland has never been considered a significant source of quality gemstones; nevertheless it is capable of producing a wide range of gem materials including agate, amethyst, cairngorm and garnet. Occurrences of more valuable stones such as topaz, beryl, sapphire, and tourmaline are far rarer, but the first two species along with cairngorm formed the basis of a thriving 18th and 19th century cottage industry in the eastern Cairngorms. The discovery in 1984 of 1-8 cm long gem-quality sapphire megacrysts on the Isle of Lewis was the first step in the realisation that the Scottish Highlands had commercial gemstone potential, particularly since one crystal generated a 9.6 carat cut stone valued at £60,000 in 1995. The megacrysts are hosted by a lamprophyre dyke that intriguingly has recorded a Tertiary age despite having much closer geochemical and structural affinities with the Late Palaeozoic alkaline lamprophyre suite. Confirmation of the age of the dyke is an important prerequisite in the identification of further exploration target areas. A single specimen discovered in Sutherland in the late 19th century was formerly thought to contain the country's only example of diamond, but this has now been positively identified as colourless spessartine garnet. Recent advances in our understanding of diamond formation and the early geological history of NW Scotland suggest the required conditions might well have existed. In particular, geophysical evidence for a relict subduction zone, existence of thick Archaean crust and the recent discovery of a kimberlite-like dyke considerably enhances the potential of the district for diamond discoveries.

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Introduction

Scotland is not renowned as a major gemstone producer, but nevertheless is endowed with a number of species, such as sapphire, ruby, topaz, beryl, tourmaline, garnet, zircon and agate, which have produced quality stones in the past and include some which have the capacity to do so in the future. This paper recalls past finds and production before focussing on the potential for new sapphire and diamond discoveries.

Geological Background

For its size Scotland contains a remarkable range of rock types which greatly enhances its gemstone fertility. Oldest of these are the Precambrian schists and gneisses forming much of the Highlands, which have been strongly deformed and metamorphosed in a series of orogenies in Precambrain and Early Palaeozoic times. The final orogenic event saw the emplacement of large granitoid intrusions principally in the eastern and southern Highlands. Erosion of the orogenic belt led to the deposition, largely in areas south of the Highlands, of extensive fluvial and lacustrine clastic sedimentary rocks which in turn were overlain by deltaic and near shore marine rocks. Sporadic but widespread episodes of renewed magmatism in the Devonian, Carbonifreous and Tertiary produced thick volcanic piles, sills and dykes and locally larger intrusions, principally basic in composition with lesser quantities of acid material.

Historic Discoveries And Production

Precious and semi-precious stones, particularly the latter have been recorded widely throughout Scotland, from the Outer Hebrides to Fife (Figure 1). Almost all of these discoveries can be attributed to 'amateur' collectors and estate workers (e.g. gamekeepers and shepherds) with little commercial interest being shown, certainly prior to the discovery of the Loch Roag sapphires. The most comprehensive account of Scottish gemstone occurrences was that compiled by the eminent 19th century mineralogist M F Heddle (Heddle, 1901). A more modern account of indigenous mineral species, but lacking a comprehensive listing of geographic locations is to be found in Livingstone, (2002).

In terms of production, the eastern part of the Cairngorms was the most prolific area in Scotland largely as a result of an 18-19th century cottage industry in Upper Deeside, which is described in some detail in Barrow and Cunningham (1912). The crystals occur in veins or miarolitic cavities and comprise beryl, topaz and of course cairngorm. This is the only area in the United Kingdom where blue topaz is found. To the east of the Cairngorms small, but exquisitely colour-zoned elbaite tourmaline has been found in Glenbuchat. Well formed prismatic beryl crystals, ranging in colour from greenish white to bluish green, occur in granite pegmatite veins that cut Moine metasedimentary rocks to the north of Loch Nevis in the Western Highlands. The crystals are

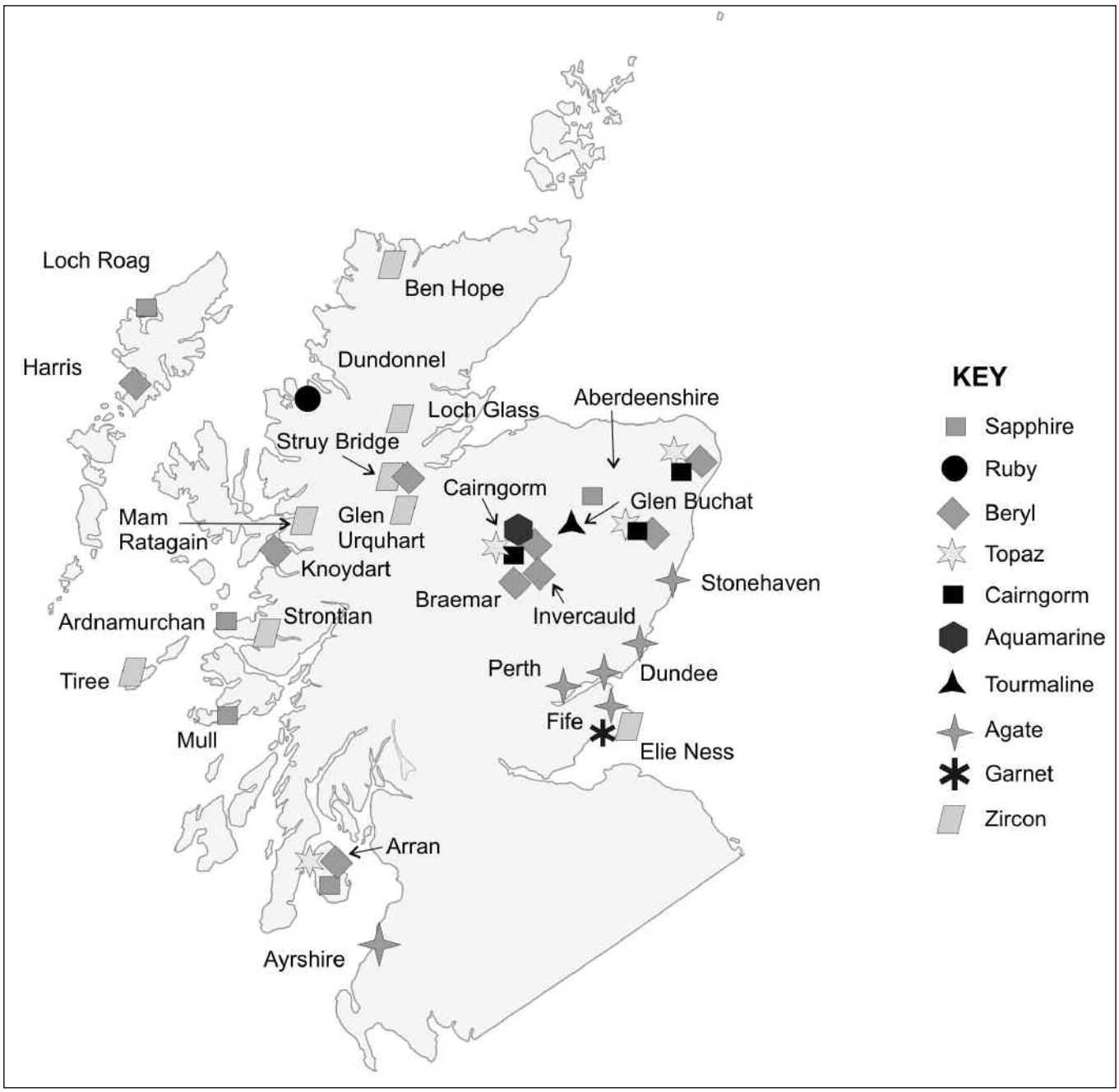

Figure 1. *Gemstones in Scotland*

mostly quite small, but there is an historical record of crystals up to 30 cm long being found, and in 1959 a 19 x 15 x 11 cm crystal weighing 4.28 kg was collected and subsequently sold to the British Museum (Firsoff, 1971).

Garnet occurs widely in the Highlands but is generally too fractured or inclusion rich to produce gems. An exception is the pyrope garnet found at Elie in Fife the so-called 'Elie rubies', which occur in a Carboniferous volcanic neck which formed from a mantle-derived magma. Despite the generally small size of the crystals, their delicate port-wine colour means they are much sought after. The sands at Elie have also produced zircon crystals from which tiny gems (less than 10 points) have been cut. The Lower Devonian andesitic lavas of north Fife, Perthshire and Angus have produced large quantities of particularly attractive agates from soils, overburden and working quarries, such as Ardownie.

The presence of sapphire on Mull has been known since the 1920s. The mineral is associated with aluminous sedimentary xenoliths of the Palaeogene Loch Scridian Sill Complex, e.g. at Nun's Pass, Carsaig. Unfortunately most of the larger crystals are too platy and the well-formed crystals are too small to be considered for gemstones.

Recent Discoveries

Scotland's potential as a gemstone producer changed dramatically in the early 1980s with the discovery of the Loch Roag sapphires. Particularly as a 9.6 carat cut stone was subsequently valued at £60,000. Loch Roag is situated on the NW coast of the Isle of Lewis in the Outer Hebrides. The sapphires occur as megacrysts up to 8 cm and include barrel shaped and truncated pyramid

crystals, within a 1 m wide lamprophyre dyke which cuts 2.9 Ga Lewisian Gneiss. The dyke also includes a variety of nodular xenoliths showing a wide rage of compositions, from acid to basic, but most significantly ultramafic material derived from the mantle, emphasising the dyke's sub-crustal origin (Menzies *et al.*, 1987). The dyke is something of a geological paradox, since it has produced a K/Ar date of 47 Ma (i.e. Tertiary; Menzies *et al.*, 1989), yet its trend and compostion are more typical of Permian-age lamprophyres.

More recently a dyke containing mantle xenoliths from the Ben Hope area of north-west Sutherland was discovered to have a most unusual mineral assemblage viz., olivine, phlogopite, (zoned to low-Ti tetraferriphlogopite), serpentine, calcite, clinopyroxene, apatite, chrome spinel, other Ti, Zr and REE oxide minerals and barite. Work on this dyke is continuing, but it is ultramafic and potassic and might be termed an aillikite or Group 2 kimberlite. Compositionally the dyke is unique in the United Kingdom, but similar rocks in Finland and Labrador carry diamonds. Leake *et al.* (1995) in their review of the potential for diamonds in Britain drew attention to an unexplained magnetic anomaly with an amplitude of *c.* 660 nT above background in the ground to the north of Ben Hope. Ironically both dyke and magnetic anomaly are located in the same area as the so called 'Heddle diamond', located after a prolonged search following a visit to the Kimberley diamond fields in South Africa (Heddle, 1901). Modern analysis of the Heddle diamond has shown it to be colourless spessartine garnet (Faithfull, 2007).

Discussion

The magmas for the Loch Roag and Ben Hope dykes have a mantle source. Despite their contrasting mineralogies they demonstrate broadly similar concentrations of certain trace elements, notably Rb, Ba, Nb, Ca, Ce, Sr, Nd, Zr and Y. The age of the Ben Hope dyke is as yet unknown but, although over 120 km apart, the fact that both dykes occur within the same crustal block raises the question as to whether this portion of the Archaean crust had unique properties. More critically, could the underlying mantle have sustained in Archaean times the pressure-temperature conditions necessary for the formation of diamond? At this time the north-west Highlands lay close to the eastern edge of Laurentia so might not be expected to have particularly thick crust beneath it. That said, Woodcock and Strachan (2000) suggest Archaean crustal thickness may have been around 60-70 km, which is not too distant from the required 90-100 km. The really critical controls on whether diamonds will form are the nature and thickness of the lithosphere, of which little is currently known. Indeed, as the Lewisian Complex is now recognised as a series of smaller cratonic fragments it is possible that the underlying lithosphere is also quite variable.

Alternative ways of cooling the upper mantle to achieve the required P_T range include descending slabs of cool rock, as in subduction zones, and where carbonaceous sea-floor sediment is also involved the potential for diamond formation is further enhanced. In this respect the interpretation by Price and Morgan (2000) of the Flannan seismic reflector as an eclogitic slab derived by metamorphism from descending oceanic crust has important ramifications for diamond potential.

Conclusions

Exhaustion of near-surface resources coupled with increasing environmental concerns and ever-burgeoning legislation have greatly reduced the chances of obtaining planning consent to develop most, if not all of the historical gemstone occurrences in Scotland. This is particularly so of the eastern Cairngorms which is now within the boundary of the recently created Cairngorm National Park. That said, the recent discoveries at Loch Roag and near Ben Hope illustrate that Scotland still has the capacity to produce gem quality stones including sapphire and possibly even diamond. It is likely that Scotland will never be a major producer of gemstones, but that was also said about North Sea oil, and before the discovery of the Aberfeldy barite deposits the country was written off as a major mineral producer. The small scale nature (in global terms) of any prospect is unlikely to attract multinational mining companies, but early exploration phases could be kick-started by local enterprise companies in association with universities and the British Geological Survey. Finally the exciting possibility of all-Scottish jewellery, combing output from the Cononish Au-Ag deposit and indigenous stones should add further impetus to discovering new gemstone deposits.

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