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The diamonds of South Australia

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ABSTRACT

Diamonds in South Australia occur in kimberlites at Eurelia (Orroroo), and in placer deposits, which include the Springfield Basin and the historic Echunga goldfield. To identify the kimberlitic and mantle sources of the placer diamonds, and to determine any possible connections between the placer diamonds and the diamonds from the Eurelia kimberlites, we examined the physical and compositional characteristics, and the mineral inclusion content of 122 diamonds from the Springfield Basin and 43 diamonds from kimberlites at Eurelia. Additional morphological data for three Echunga diamonds are also given. Most of the diamonds from the Springfield Basin are similar to the diamonds from Eurelia with respect to their crystal shapes, surface textures, and colors. The diamond populations from both areas are characterized by a high abundance of low-nitrogen (<100 ppm) diamonds with variable nitrogen aggregation states. The stable carbon isotope compositions of the Springfield Basin diamonds are similar to the Eurelia diamonds with $\delta^{13}C$ values in the range −20.0 to −2.5‰, and a mode at −6.5‰. Ferropericlase inclusions in two diamonds from the Springfield Basin are consistent with ferropericlase-bearing mineral inclusion assemblages found in the Eurelia diamonds and indicate that part of the diamond population from both areas is of sublithospheric origin. One diamond from the Springfield Basin contained an inclusion of lherzolitic garnet. The overall similarities between the Springfield Basin and Eurelia diamonds indicates that the bulk of the Springfield Basin diamonds are derived from kimberlitic sources that are similar (or identical) to those at Eurelia. However, three diamonds from the Springfield Basin are markedly distinct. These have well-developed crystal shapes, large sizes, yellow body colorations, and brown irradiation spots. The brown irradiation spots and abrasion textures provide evidence that these diamonds are much older than the other diamonds in the Springfield Basin, and that they are derived from distal kimberlitic sources. The diamonds are most likely derived from Permian glacigene sediments and may ultimately be sourced from kimberlites on the East Antarctic craton. Abrasion textures and brown irradiation spots are also present on diamonds from Echunga. This provides a link to the three "old" Springfield Basin diamonds and other alluvial diamonds in Eastern Australia, and suggests that Permian glaciations caused a widespread distribution of diamonds over large parts of southern Australia, which at that time was part of the supercontinent Gondwana.

1. Introduction

In South Australia, diamonds occur in kimberlites, placer deposits, and as isolated grains from unknown sources in surface samples (Fig. 1). Most of the known kimberlites in South Australia are located in the Adelaide Fold Belt (Colchester, 1972; Ferguson and Sheraton, 1979; Stracke et al., 1979; Scott Smith et al., 1984), where they occur as a semi-continuous, northwest trending dyke–swarm (Fig. 1). Two additional kimberlite clusters are present on the adjacent Gawler Craton; these are located near Cleve and Elliston/Mount Hope (Atkinson et al., 1990; Wyatt et al., 1994; Fig. 1). Although more than 150 individual kimberlite occurrences have been discovered within South Australia, the only marginally diamondiferous kimberlites, so far, are restricted to the Eurelia area in the Adelaide Fold Belt, ~20 km north of Orroroo (Scott Smith et al., 1984). A notable feature of the diamonds from Eurelia is the presence of ferropericlase-bearing mineral inclusion assemblages, which suggests that part of the diamond population from Eurelia is of unusually deep, sublithospheric origin (Scott Smith et al., 1984; Tappert et al., 2009).

Diamond placer deposits within South Australia are located in the Echunga area, (~30 km SE Adelaide), and in the Springfield Basin (~50 km NW Orroroo) (Fig. 1). Diamonds at Echunga were first discovered in 1859, as a rare byproduct during placer gold mining. Until around 1900, up to 50 diamonds were found at Echunga, with the largest stone weighing

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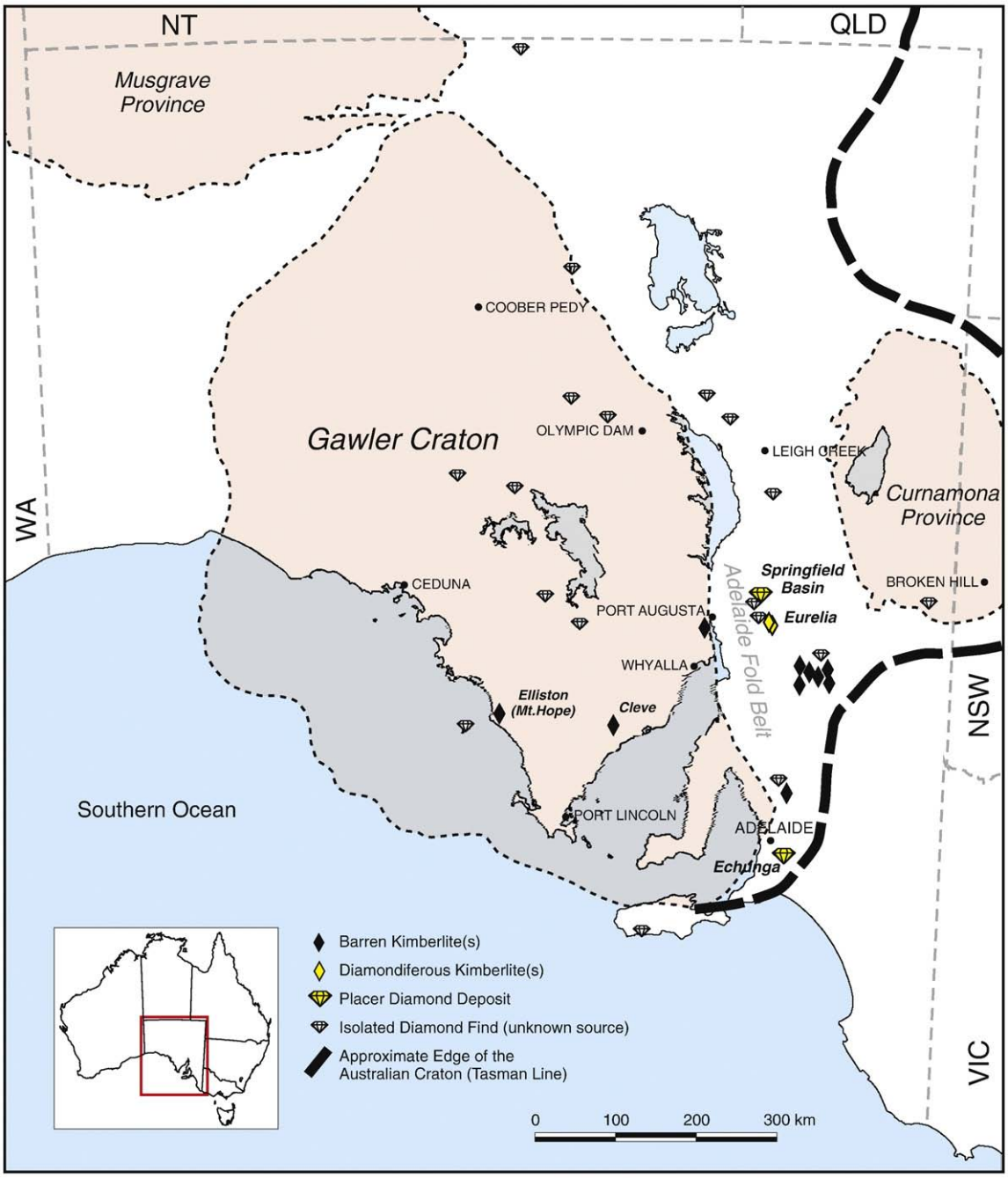

Fig. 1. Locations of diamond and kimberlite occurrences in South Australia.

~5.3 carats (Gommers, 1988). Only five of the diamonds from the Echunga goldfield are still known to exist. At Echunga, the diamonds were recovered from auriferous Tertiary conglomerates, which are devoid of indicator minerals commonly associated with diamonds. The primary sources of the Echunga diamonds are unknown.

The Springfield Basin is a small sedimentary basin (~9 km^2), which unconformably overlies folded sedimentary rocks of the Adelaidean supergroup. Within the Springfield Basin, diamonds occur exclusively in the basal conglomerate, which is considered to be Permian in age (Drexel and Preiss, 1995). The conglomerate is overlain by argillites and partially coal-bearing sediments of approximately Late Triassic age (Amtsberg, 1969). Within the basal conglomerate of the Springfield Basin, the diamonds occur together with indicator minerals, including magnesiochromite, picroilmenite, pyrope, and chrome diopside. During bulk sampling in the Springfield Basin, around 200 diamonds were recovered from >2000 tons of conglomerate, with the largest diamond weighting 0.34 carat. Although the diamondiferous kimberlites at Eurelia are located less than 40 km southeast of the Springfield Basin, they have not been considered to be the source of the Springfield Basin diamonds, because of their apparently younger (Jurassic) ages.

In order to gain information about possible kimberlitic sources and the mantle origins of the placer diamonds in South Australia, we analyzed the physical and compositional characteristics as well as the mineral inclusion content of placer diamonds from the Springfield Basin and the Echunga area. In order to determine possible links between the placer diamonds