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Basaltic Gemfields and Their Lithospheric Sources, West Pacific Margins

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Eastern Asia forms the centrepiece of a 12 000 km long belt of gemstone placers that extend from eastern Australia in the south to eastern Russia in the north. These sapphire, ruby and zircon deposits accompany intraplate Cenozoic alkali basalt fields that erupted through the continental margins defined by spreading basins along West Pacific convergent boundaries. The gem fields support considerable mining in Thailand, western Cambodia, western Laos, southern Vietnam, eastern China and northern New South Wales and central Queensland, eastern Australia. The gem crystals show a range of trace element and inclusion variations, but have suffered basaltic corrosion and represent xenocrysts from various lithospheric sources. Sapphires and zircons of magmatic character dominate the deposits, while sapphires, rubies and zircons of transitional 'metasomatic' and metamorphic character form significant components in some fields. The magmatic and 'metasomatic' sapphires come from different parent sources; most suggest intermediate syenitic origins, while some have nepheline syenitic origin. Temperature data and oxygen isotope studies suggest their formation extended from crustal to mantle regimes. Sapphires and rubies of metamorphic character show crystallisation temperatures and O isotope values consistent with spinel to garnet granulite facies. Some ruby suites, however, have O isotopes that overlap mantle values. These may mark fluid reactions with ultramafic bodies thrust into crustal levels. Geochronology on zircons in sapphires and on zircon megacrysts(U-Pb and fission track dating) suggests that magmatic gem formation commonly accompanied initial and sometimes later stages of basaltic volcanism within the fields. This took place at various times from 85 to < 1 Ma and relates to ages of the local basalt fields. These gem sources, along with metamorphic sources, were successively plundered by continued basaltic activity, which in some fields extended over at least 9 episodes and 60 million years(Barrington, NSW). Formation times for 'metasomatic' sapphires are less constrained, but zircon inclusions in one field(Tumbarumba, NSW) suggest formation in a Palaeozoic event(400 Ma). Formation ages of metamorphic sapphires and ruby suites are even more conjectural, but are probably >28 Ma in Asia, when the last strong metamorphic and folding events are recorded. In considering the genesis of the widespread magmatic sapphire suites several factors need attention. Most of the basalt gem fields are underpinned by metasomatised(amphibolised) mantle, based on host basalt geochemistry. Models that generate minor salic melts from such mantle during thermal events provide a potential mechanism for crystallising sporadic but widespread gem-bearing

pods. This will not cover all sapphire types, such as those linked to evolved phonolitic fractionates. Another common factor that links these basaltic gem fields is a tectonic setting adjacent to former spreading rift floors. The Asian and Russian fields face the South China Sea, Okinawa Trough and Japan Sea spreading rift floors, which largely opened between 25 – 15 Ma. The southern Australian fields face the Tasman Sea spreading rift floor which opened progressively between 84 – 53 Ma, while the northern Australian fields face the Cato Trough – Coral Sea spreading rift floors which opened from 63 – 53 Ma. A model involving lithospheric drift of the Asian continental margin(eastwards) and the Australian continental margin (northwards) over thermal anomalies related to these former spreading sites is proposed to account for both the generation of the magmatic gem-bearing rocks and the episodes of basaltic volcanism that carried the resistant gem minerals to the surface.