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# Updated Digital Map of Mafic Dyke Swarms and Large Igneous Provinces in Western Australia

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Since 1894, the Geological Survey of Western Australia (GSWA) has released 14 versions of the 'Geological Map of Western Australia'. The latest in this series, published in December 2015, is the first bedrock geology map compilation in digital form that covers the entire state, and can be viewed online and downloaded at no cost in a variety of formats.

Western Australia is endowed with an impressive number of mafic dykes. The new digital state map includes an updated dyke layer compiled from published geological maps and interpreted from aeromagnetic data. Mafic dyke and sill suites are shown in significantly more detail than on previous state maps, reflecting advances in isotopic dating of mafic igneous rocks and improvement in the resolution of aeromagnetic datasets. Most dykes and sills have been assigned to named suites based on age, orientation, magnetization, composition, and cross-cutting relationships. Detailed attributes can be viewed via the digital dyke layer for each mapped intrusion. Many dyke swarms are also components of at least seven large igneous provinces, which range in age from late Archean to early Cambrian.

The oldest coherent mafic dyke swarm in Australia is the c. 2772 Ma Black Range Dolerite Suite, which fed the Mount Roe Basalt of the Fortescue LIP in the northern Pilbara Craton. A recent baddeleyite age of 2770 ± 4 Ma for a large north-trending dyke in the Rocklea Inlier demonstrates that the Black Range swarm extends for at least 200 km into the southwest Pilbara Craton beneath the Fortescue and Hamersley Groups.

The southern two-thirds of the Yilgarn Craton is transected by the Widgiemooltha dyke swarm. Several dykes have been dated at c. 2410 Ma with zircon and baddeleyite and several others can be correlated with dated dykes based on paleomagnetism. Most dykes are less than 100 m wide, although the Binneringie Dyke and the Jimberlana Norite locally exceed two kilometres in width, and several dykes are at least 600 km long. The Widgiemooltha swarm includes dykes of two polarities; dykes with negative magnetic anomalies trend about 085°, whereas most dykes with positive anomalies trend closer to 075°. Most U–Pb ages are within uncertainty of 2410 Ma regardless of magnetic polarity, although a TIMS baddeleyite age of 2401 ± 1 Ma has been reported for a negative-polarity dyke. Dykes of different polarity must be different in age, and additional high-precision TIMS dating may be able to discern this difference.

The c. 1210 Ma Marnda Moorn LIP consists of mafic dyke swarms that are subparallel to and extend around the western, southern, and southeastern margins of the Yilgarn Craton, as well as in parts of the western Yilgarn interior. However, recent geological mapping, geochemistry, geochronology, and metamorphic studies indicate that this c. 1210 Ma circum-Yilgarn LIP is only one manifestation of a much more widespread event. The c. 1210 Ma Marnda Moorn LIP coincided with mylonitic deformation and extensive, ultra-high-temperature reworking and rapakivi-style granite magmatism during the 1220–1150 Ma Musgrave Orogeny in central Australia. Also at this time, intracontinental reworking and magmatism occurred in the Capricorn Orogen, the Albany–Fraser Orogen, between the Albany–Fraser Orogen and the Gawler Craton, and presumably in the Pinjarra Orogen along the western Yilgarn margin. These events at c. 1210 Ma may reflect change in the regional stress regime; plate reorganisation at this time is indicated by a major bend in the apparent polar wander (APW) curve for Australia.

At c. 1075 Ma, The Warakurna LIP includes layered mafic–ultramafic intrusions, mafic to felsic volcanic rocks, and dykes in central Australia, a 1000-km-long mafic sill province, and several swarms of mafic dykes. Recent geochronology has identified mafic sills in the eastern Pilbara Craton margin and well into the interior of the Yilgarn Craton, extending the LIP to the north and south and increasing its known area to c. $2 \times 10^6$ km$^2$. Initially considered by some to have formed above a mantle plume,

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| Dyke or sill suite | Age (Ma) | LIP | Location |
|---|---|---|---|
| Kalkarindji Supersuite | 510 | Kalkarindji | NW Officer Basin, Kimberley |
| Nindibillup Dyke Suite | 750 | | S Yilgarn, Albany–Fraser Orogen |
| Northampton Dolerite Suite | 748 | | Northampton Inlier |
| Mundine Well Dolerite Suite | 755 | | Gascoyne Province, Pilbara Craton |
| Bow Hill Lamprophyre Suite | 815 | | E Kimberley |
| Gairdner Dolerite | 825 | Willouran | Musgrave and Rudall Provinces |
| Central Desert Dolerite Suite | 975 | | W Arunta region |
| Warakurna Supersuite | 1075 | | Musgrave Province, Yilgarn Craton |
| Alcurra Dolerite | 1075 | Warakurna | Musgrave Province |
| Kulkatharra Dolerite | 1075 | | Capricorn Orogen |
| Beenong Dyke Suite | 1210–541 | | SE Yilgarn, Albany–Fraser Orogen |
| Gnowangerup–Fraser Dyke | 1210 | | S Yilgarn Craton margin |
| Boyagin Dolerite Suite | 1210 | Marnda Moorn | W Yilgarn Craton margin |
| Muggamurra Dolerite Suite | 1210 | | N Yilgarn Craton margin |
| Wheatbelt Dyke Suite | 1210 | | W & S Yilgarn Craton |
| Narimbunna Dolerite (sills) | 1465 | | Capricorn Orogen |
| Waldburg Dolerite (sills) | 1500 | | Capricorn Orogen |
| Prince Regent Dyke Suite | 1797–510 | | Kimberley |
| Kimberley Dyke Suite | 1797–510 | | Kimberley |
| Hart Dolerite (mainly sills) | 1797 | Hart–Carson | Kimberley |
| Preston Dolerite Suite | 1816 | | W Pilbara Craton |
| Bow River Dolerite Suite | 1860–560 | | E Kimberley |
| Leopold Downs Dyke Suite | 1860–560 | | W Kimberley |
| Panhandle Dyke Suite | 2008 | | Hamersley region |
| Moodogara Dyke Suite | 2208 | | Hamersley region |
| Widgiemooltha Supersuite | 2410 | Widgiemooltha | Yilgarn Craton |
| Cosmo Newbery Dyke Suite | 2500-510 | | E Yilgarn Craton |
| Lakewood Dolerite Suite | 2500–541 | | E Yilgarn Craton |
| Round Hummock Dolerite Suite | 2500–541 | | Pilbara Craton |
| Prairie Downs Dyke Suite | 2745 | | S Pilbara Craton |
| Black Range Dolerite Suite | 2772 | Fortescue | E Pilbara Craton |

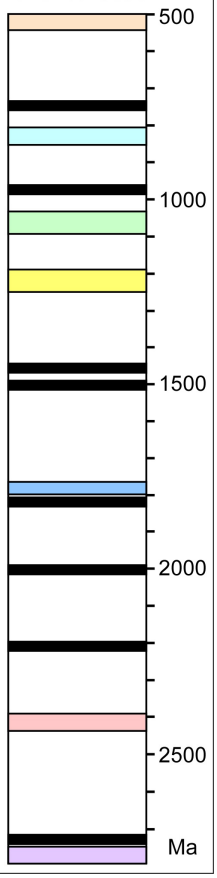


Fig. 1: Named mafic dyke and sill suites in Western Australia, and their mafic 'barcode'.

recent work has shown that mantle-derived magmatism continued for >50 Ma and may instead reflect a prolonged and extreme thermal anomaly in central Australia destabilized by movement on crustal-scale faults.

The c. 755 Ma Mundine Well Dolerite is an extensive dyke swarm that intrudes the western Capricorn Orogen and Pilbara Craton, and could be comagmatic with the Northampton dykes of the Pinjarra Orogen. New baddeleyite geochronology of a southeast-trending dyke of the Nindibillup swarm that crosscuts Mesoproterozoic rocks of the eastern Albany–Fraser Orogen, together with paleomagnetic directions in another southeast-trending dyke (SA Pisarevsky, pers. comm.), suggest that dykes in this orientation along the southern margin of the Yilgarn Craton were also emplaced during this 750 Ma event.

There are many dykes in Western Australia about which very little is known, although most can be grouped into swarms of dykes of similar orientation. Unfortunately, many are poorly exposed, or not exposed, and can only be identified on aeromagnetic images. Efforts are underway to collect samples for geochronology and geochemistry from dyke exposures encountered during regional mapping. Geochemical and isotope data currently being collated is expected to elucidate the origins and tectonic settings of several dyke suites.