Table A1. Fuzzy analysis for Ni-Cu prospectivity

Critical processes	*Appendix figure number*	*Input predictors map*	*Fuzzy-membership value map weight*	*Confidence factor*	*Rationale for expert-knowledge based weight (fuzzy membership values)*	*Rationale for confidence factor*
Ni and Cu sulphide deposits form throughout geologic time, but with the largest deposits being younger than ca. 2 Ga. The sulfide ores are concentrated under highly dynamic conditions within lava channels and magma conduits. The deposits are preferentially located near craton margins towards which mantle plumes have been channelled and where mantle magmas can readily ascend through abundant trans-lithospheric structures. Magma flow is focused and locally enhanced by shifting compressive–extensional tectonic regimes, and abundant S-rich crustal rocks provide an external S source that is required for the majority of deposits (Maier and Groves, 2011).						
Predictor maps for source						
Potential mantle sources for primitive metal-rich magmas include the convecting mantle and the lithospheric mantle.						
	A1	Distance to mantle-derived, differentiated, Mg-rich ultramafic and mafic rocks (Warakurna Supersuite)	9	8	These rocks are related to picrite and tholeiitic basalt magmatic systems generally emplaced in continental settings as a component of large igneous provinces (LIPs). In theory, differentiated rocks are the key for nickel–copper sulphide deposit. Magmatic sulfide deposits (Naldrett, 2004), where Ni and Cu are the primary products, occur within peridotite (Jinchuan), harzburgite (Kabanga), pyroxenite (Santa Rita, Selebi Phikwe), olivine gabbro (Noril'sk), gabbronorite (Sudbury, Nebo-Babel, Phoenix) and troctolite (Voisey's Bay). In addition, large mafic igneous provinces are known to be fertile for magmatic nickel and copper sulfide deposits (e.g., Norilsk, Siberian Traps, Russia; Li et al., 2009). Moreover, because of high Ni abundance in the olivine fraction, ultramafic and mafic rocks (in particular high MgO magmas derived from primitive mantle sources) are conceptually good source-target rocks for nickel and copper. The Warakurna Supersuite has the greatest potential to host magmatic Ni-Cu sulfides (cf. Nebo-Babel, Wingate et al., 2004).	Ultramafic and mafic rocks from the Warakurna Supersuite were extracted using a spatial query from the GSWA (2010b). Ultramafic rocks include peridotite, harzburgite, pyroxenite, and dunite. Mafic rocks include basalt, gabbro, troctolite, gabbronorite, dolerite, and amphibolite. 10 km buffer
	A2	Distance to mantle-derived, differentiated, Mg-rich ultramafic and mafic rocks (non-Warakurna Supersuite)	8	8	These rocks are related to picrite and tholeiitic basalt magmatic systems generally emplaced in continental settings as a component of large igneous provinces (LIPs). In theory, differentiated rocks are the key for nickel–copper sulphide deposit. Magmatic sulfide deposits (Naldrett, 2004), where Ni and Cu are the primary products, occur within peridotite (Jinchuan), harzburgite (Kabanga), pyroxenite (Santa Rita, Selebi Phikwe), olivine gabbro (Noril'sk), gabbronorite (Sudbury, Nebo-Babel, Phoenix) and troctolite (Voisey's Bay). In addition, large mafic igneous provinces are known to be fertile for magmatic nickel and copper sulfide deposits (e.g., Norilsk, Siberian Traps, Russia; Li et al., 2009). Moreover, because of high Ni abundance in the olivine fraction, ultramafic and mafic rocks (in particular high MgO magmas derived from primitive mantle sources) are conceptually good source-target rocks for nickel and copper.	Ultramafic and mafic rocks (excluding Warakurna Supersuite) extracted using a spatial query from the GSWA (2010b). Ultramafic rocks include peridotite, harzburgite, pyroxenite, and dunite. Mafic rocks include basalt, gabbro, troctolite, gabbronorite, dolerite, and amphibolite. 10 km buffer
	A3	MgO/(MgO+FeO) ratio	8	6	MgO/(MgO+FeO) value of mafic and ultramafic suites is directly related to the amount of olivine crystallized (Le Bas, 2000). The olivine lattice is the main reservoir of Ni. Therefore, the higher the MgO abundance of a mafic-ultramafic suite, the higher its Ni content can be and hence its potential to host magmatic sulfides. This value is a true indicator of primitive system.	MgO and FeO data from GSWA state geochemistry (GSWA, 2010a) and GA OZCHEM National Whole Rock Geochemistry Database (GA, 2007; http://www.ga.gov.au/gda/index.jsp) datasets were interpolated and reclassified into classes. CF low because we have interpolated the data in the whole study area. (+ interpolation of values, and some values are not known)
Predictor maps for active pathways						
Magmas need pathways to ascend, which are provided by extension of the crust and lithosphere. Extension is mainly driven by mantle convection and may be of regional (i.e. rifts) or local scale (Maier and Groves 2011), the latter caused, for example, by transpression within far-field compressional regimes (e.g. in volcanic arcs such as the Andes; Kerrich et al. 2005; Groves et al. 2010). For many primitive magmas, ascent pathways have to be trans-lithospheric, as otherwise the dense magmas cannot ascend through relatively light upper crust (Naldrett 2010). The dynamics of the magma flow and the volume of magma emplaced, commonly in near-vertical feeder conduits, are important in the transport of magma.						
	A4	Distance to crustal-scale fault	9	8.5	These crustal-scale faults were probably active during Giles events. Crustal-scale feature are the most important as they drive most of the mineralized fluid (McCuaig et al., 2010; Joly et al., 2010)	Crustal-scale faults were extracted from the interpreted structural geology data and buffered to 10 km. They were identified by 2D gravity and magnetic modeling

Critical processes	*Appendix figure number*	*Input predictors map*	*Fuzzy-membership value map weight*	*Confidence factor*	*Rationale for expert-knowledge based weight (fuzzy membership values)*	*Rationale for confidence factor*
	A5	Distance to late Giles Event 1 (LGE1) structures structures	9	9	These structures are coeval with Nebo–Babel emplacement and might be the main pathway for metal transport or are likely to have created suitable geometries for stress-driven fluid flow. A change in stress regime occurs between the Mid Giles Event (north-south compression) and Late Giles 1 (northwest-southeast extension). Also, there was a change in stress regime within the Late Giles Event from northwest-southeast extension during Late Giles 1 to northeast-southwest extension during Late Giles 2 and 3; these stress-field changes could have induced mineralization.	Large-scale faults were extracted from the interpreted structural geology data and buffered to 5 km.
	A6	Distance to early Giles (EGE) + mid-Giles (MGE) + late Giles (LGE, excluding LGE1) structures	8.5	9	These structures could be linked to the emplacement of Ni-Cu bearing upper mantle derived melt component of the Giles Complex. Deep-penetrating structures provided pathways for metal transport or created suitable geometries for stress-driven fluid flow, and these fluids migrated or diffused away from large faults to depositional sites along smaller faults.	Large-scale faults were extracted from the interpreted structural geology data and buffered to 5 km.
	A7	Distance to Petermann (PO) + Alice Springs Orogeny (ASO) structures	8.5	9	Long-lived structures are very good proxies for Ni mineralization. Mafic-ultramafic magmas need a plumbing system to reach upper levels of the crust, which can potentially follow translithospheric faults (Hoatson et al., 2006).	Large-scale faults were extracted from the interpreted structural geology data and buffered to 5 km.
	A8	Distance to Mount West Orogeny (MWO) and Musgrave Orogeny (MO) structures	8	9	Mafic-ultramafic magmas need a plumbing system to reach upper levels of the crust, which can potentially follow translithospheric faults (Hoatson et al. 2006). Mainly active during Mt West and Musgravian orogenies.	Large-scale faults were extracted from the interpreted structural geology data and buffered to 5 km.
	A9	Distance to dyke	6.5	7.5	Late stage dolerite dykes of the Giles Complex intrusions could be magma conduits and thus host magmatic sulfides and further support the Ni mineralisation potential in the Musgrave Province.	Dykes were queried from interpreted magnetic datasets + GSWA dataset (GSWA, 2010b). 1 km buffer
	A10	Presence of circular feature	7.5	6	Chonoliths (or lava channel in mafic intrusion) host Ni-Cu deposits. Detectable using method of Holden et al. (2010) if they are tilted and have circular to elliptical cross-sections at surface (how to determine from felsic intrusions?); but if they are still subhorizontal, they will be mapped by magnetic line networks potentially around larger mafic intrusions (e.g. Thunder Bay; difficult to distinguish from dykes).	Mapped using Holden et al. (2010) porphyry detector (from circular feature in any rocks file porphyry700_1400RTP_CENTRES_t20). Radii values from 700 m to 1400 m were used to determine the size of chonolith to detect. A threshold value of 20 m determines which locations were retained, based on the strength of their radial symmetry transform response.
Predictor maps for physical traps						
Reactivation of long-lived sutures may lead to localized extension and, in rare cases, to rifting and cratonic–continental break-up expressed, for example, by the development of flood basalts. More usually, extension is less protracted and rifting is minor and aborted, providing ideal conditions for the emplacement of large, sill-like layered intrusions (Maier and Groves, 2011). In some nickel sulfide systems, metal concentration was clearly controlled by localized dilational deformation, permeability, and decompression (e.g. Jinchuan).						
	A11	Fault density	6.5	9	Conceptually should have a good correlation with mineralisation. Increased fault density implies greater structural complexity and more space, leading to melt ponding.	All faults were extracted from the interpreted bedrock geology data (interpreted magnetic dataset) and buffered to 5 km.
	A12	Distance to fault intersection	6.5	9	Good sites for melt ponding. Filtering syn-magmatic (EGE) versus post-mafic magmatism faults (MGE, LGE) would have repeated our predictor maps.	All faults were extracted from the interpreted bedrock geology data (interpreted magnetic dataset)and buffered to 5 km.
	A13	Fault intersection density	7	9	Indicates greater structural complexity; melt focusing	All faults were extracted from the interpreted bedrock geology data (interpreted magnetic dataset) and buffered to 5 km.

Critical processes	*Appendix figure number*	*Input predictors map*	*Fuzzy-membership value map weight*	*Confidence factor*	*Rationale for expert-knowledge based weight (fuzzy membership values)*	*Rationale for confidence factor*
Predictor maps for chemical traps						
Critical elements in the formation of basal segregations of Ni sulfides are the emplacement of S-undersaturated, Ni-bearing tholeiitic magmas into crustal rocks, resulting in rapid S-saturation through crustal contamination, mixing of magma of differing compositions, or a rapid fall in temperature (Li & Naldrett, 1993, 2000; Naldrett, 1997; Lambert et al., 1998, 2000; Ripley et al., 1999). Favourable trap sites for concentration of Ni sulfides are the feeder conduits and restricted environments, such as structural embayments in the footwall and depressions in the basal contact beneath the thickest succession of cumulates (Hoatson and Blake, 2000).						
	A14	Distance to mafic and ultramafic rocks	9	8	Mafic and ultramafic rocks are the most common host rock for Ni-Cu mineralization	Mafic and ultramafic units were extracted using spatial query from GSWA (2010b), and interpreted magnetic datasets datasets. 1 km buffer
	A15	Distance to cumulate rocks	6	6	Cumulate rocks are the typical product of precipitation of solid crystals from a fractionating magma chamber. Fractionation of ultramafic magmas can generate cumulates of olivine layers with high-MgO and high nickel contents, resulting in the formation of magmatic nickel sulfide (e.g., Great Dyke, Zimbabwe; Schoenberg et al., 2003).	Identifying cumulates is crucial but challenging in GSWA data. Chromitite, peridotite, and Early Giles ultramafic rocks in GSWA database. 10km buffer
	A16	Cr content	6	6	Positive Cr anomalies could be indicative of ultramafic-mafic suites that underwent S-saturation and metal extraction. Cr anomalies are good indicators for Ni, as chromite tends to be concentrated in layered intrusions or ophiolites (where the chromitite pods may also locally be Ni rich). Cr >1000 ppm	Cr values from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were transformed to standardized Z scores (Singer and Kouda, 2001) and interpolated. The Z scores at which studentized contrast maximized were used as the anomaly thresholds (see Cheng, 2007 for details). CF low because interpolation of values, and some values are not known
	A17	(Ni/Cu) ratio	9	6	Ideally a high ratio means a location on top of a potential deposit, whereas an anomalously low ratio means that the magma has been stripped of Ni and the location is downstream of the NiS accumulation. A normal ratio (-1.22 < [Z log Ni/Cu] < 0.63) means a location either in the feeder, or the magma never reached sulphur saturation. So can be used in multiple ways. We chose the ideal way where high ratio relates to an intrusion.	Ni and Cu values come from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets. CF low because we have interpolated the data in the whole study and some values are not known
	A18	(Ni/Co) ratio	7	6	Ideally a high ratio means a location on top of a potential deposit, whereas an anomalously low ratio means that the magma has been stripped of Ni and the location is downstream of the NiS accumulation. A normal ratio (-1.22 < [Z log Ni/Cu] < 0.63) means a location either in the feeder, or the magma never reached sulphur saturation. So can be used in multiple ways. We chose the ideal way where high ratio [Z log Ni/Co] > 1.76 relates to an intrusion.	Ni and Co values come from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets. CF low because we have interpolated the data in the whole study area.
	A19	(Cu/Zr) Ratio	9	6	This factor is used as an indicator for sulfur saturation. If (Cu/Zr) < 1- 2) , the rock is undersaturated with respect to sulfur, and if (Cu/Zr) > 1- 2, then the rock is sulfur saturated (Maier, 200) High Cu/Zr ratios in mafic-ultramafic rocks may point to the presence of magmatic sulfides. Caveat is that the rock is not differentiated otherwise it will have reached Zr saturation and the incompatible nature of Zr is violated. Cu is a hydrothermal element, therefore mobile, while Zr is an incompatible element. This factor need be precisely associated with cumulate	Cu and Zr values come from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets. CF low because we have interpolated the data in the whole study and some values are not known
	A20	Pt/Zr content	9	6	Residual liquids that are relatively enriched in PGE may indicate localized fractionation of the sulfide liquid (Maier et al., 2007) and metal extraction at different stages. High values of PGE indicate that the emplaced magma was undersaturated with respect to S. Low values of PGE in ultramafic-mafic suites flows could indicate early S-saturation and metal extraction, and therefore less fertile magmas (Lightfoot, 2007) PGE is a by-product in magmatic Ni sulfides, so PGE anomalies or showings may indicate the presence of magmatic sulfides enriched in Ni sulfides. However, in the Musgrave, PGE-depleted magmas are present, so need to be careful. The Zr element, which is an incompatible, allows a better accuracy on the prospectivity analysis. This rationale led us to use PGE/Zr instead of PGE/Cu.	Pt values from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were transformed to standardized Z scores (Singer and Kouda, 2001) and interpolated. The Z scores at which studentized contrast maximized were used as the anomaly thresholds (see Cheng, 2007 for details). CF low because we have interpolated the data in the whole study area.

Critical processes	*Appendix figure number*	*Input predictors map*	*Fuzzy-membership value map weight*	*Confidence factor*	*Rationale for expert-knowledge based weight (fuzzy membership values)*	*Rationale for confidence factor*
	A21	Pd/Zr content	9	6	Residual liquids that are relatively enriched in PGE may indicate localized fractionation of the sulfide liquid (Maier et al., 2007) and metal extraction at different stages. High values ofPGE indicate that the emplaced magma was undersaturated with respect to S. Low values of PGE in ultramafic-mafic suites flows could indicate early S-saturation and metal extraction, and therefore less fertile magmas (Lightfoot, 2007) PGEis a byproduct in magmatic Ni sulfides, so PGE anomalies or showings may indicate the presence of magmatic sulfides enriched in Ni sulfides. However, in the Musgrave, PGE depleted magmas are present, so need to be careful. The Zr element which is an incompatible allowsa better accuracy on the prospectivity analysis. This rationale led us to use PGE/Zr instead of PGE/Cu.	Pd values from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were transformed to standardized Z scores (Singer and Kouda, 2001) and interpolated. The Z scores at which studentized contrast maximized were used as the anomaly thresholds (see Cheng, 2007 for details). CF low because we have interpolated the data in the whole study and some values are not known
	A22,A23,A24	Crustal contamination (indicated by anomalous Th/Yb, Th/Nb, and La/Nb values)	8	6	S-saturation may be triggered by addition of external S due to devolatization, partial melting, or bulk assimilation of S-rich upper continental crustal rocks (Lesher and Campbell, 1993). Upper continental crustal rocks are enriched in incompatible elements. Anomalous values of the ratios of incompatible elements such as Th/Yb, Th/Nb, and La/Nb within the ultramafic-mafic suites can be applied as indicators of crustal contamination; therefore S-saturation (e.g. Naldrett, 1997). In mafic-hosted system, sulfur input may not be as important as in komatiite-hosted system.	La, Nb, Yb, and Th values in the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were normalized to primitive mantle (Sun and McDonough, 1989). Th/Yb, Th/Nb, and La/Nb values were calculated and transformed to Z scores. Each sample point was then assigned the highest Z score. CF low because we have interpolated the data in the whole study and some values are not known
	A25	S content	7	6	Contamination of ascending magma with S-enriched country rocks may lead to S-saturation of the magma, and formation and segregation of immiscible nickel sulfide liquid (Naldrett, 1997; Prendergast, 2004), resulting in precipitation of nickel sulfides. However sulphur source may not be as important in mafic hosted systems, unlike the komatiite-hosted variety.	S values from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were transformed to standardized Z scores (Singer and Kouda, 2001) and interpolated. The Z scores at which studentized contrast maximized were used as the anomaly thresholds (see Cheng, 2007 for details).
	A26	Ni content	6	6	Ni content above background (>3000 ppm) associated with ultramafic-mafic suites could be indicative of early S-saturation and metal extraction, whereas positive Ni anomalies could point to nickel accumulation. Importantly, the highest Ni values will be laterite or ultramafic cumulates whereas prospective rocks will have lower Ni. A minimum Ni value is then required but trying to use a high value will be meaningless. Beware if lithology Ni content in mafic is higher than Ni content in ultramafics. However, the use of a ratio is always a better than a single element which explain the low map weight.	Ni values from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were transformed to standardized Z scores (Singer and Kouda, 2001) and interpolated. The Z scores at which studentized contrast maximized were used as the anomaly thresholds (see Cheng, 2007 for details). CF low because we have interpolated the data in the whole study area.
	A27	Cu content	6.5	6	Cu content above background (> 90 ppm) could be indicative of ultramafic-mafic suites that underwent S-saturation and metal extraction and are, therefore, potentially fertile magmas. Some examples of the world's large intrusive nickel sulfide deposits are Noril'sk, Pechenga, Voisey's Bay, Jinchuan, and Kabanga (Maier et al., 2007). Note: lithology Cu enrichment (sulphide) and depletion (where the copper went) are both meaningful. No silicate phase contains significant amount of copper. However, the use of a ratio is always a better than a single element, hence the low map weight.	Cu values from the GSWA state geochemistry (GSWA, 2010a) and GA Ozchem (GA, 2007) datasets were transformed to standardized Z scores (Singer and Kouda, 2001) and interpolated. The Z scores at which studentized contrast maximized were used as the anomaly thresholds (see Cheng, 2007 for details). CF low because we have interpolated the data in the whole study and some values are not known.
	A28	Distance to felsic and intermediate rocks	6	8	In rare cases, felsic rocks become sulfur saturated and form sulfide segregations. In this case, the typical result is a disseminated form of sulfide mineral, usually a mixture of pyrrhotite, pyrite, and chalcopyrite, forming Cu mineralisation (Okiep, SAfrica; Caraiba, Brazil). It is very rare but not unknown to see cumulate sulfide rocks in granitic intrusions.	Felsic and intermediate rocks were extracted using spatial query from GSWA (2010b). Buffer <5 km

Critical processes	*Appendix figure number*	*Input predictors map*	*Fuzzy-membership value map weight*	*Confidence factor*	*Rationale for expert-knowledge based weight (fuzzy membership values)*	*Rationale for confidence factor*
Undefinable predictor maps						
		Komatiite	8	8	Komatiites are globally the most prospective host rocks for magmatic nickel sulfide deposits (e.g. In the Yilgarn Craton, Abitibi, Canada where nickel sulfide deposits are almost exclusively associated with komatiites (Hoatson et al., 2006; Maier and Groves 2011)).	Also, Ni sulfides have so far only been found in Archean and early Proterozoic komatiites (younger than 2.0 Ga). No komattite in this non-archean area,
		Craton margin	7	6	Nickel deposits are concentrated along craton margins because the latter channel ascending mantle plumes (Begg et al., 2010 and reference therein; Kerrich et al. 2000), The West Musgrave camp formed at the triple junction of these three main cratons at ca. 1.08 Ga (Seat et al., 2007) during continued postcollisional tectonism. The associated magmatism belongs to the Warakurna LIP, which stretches east to west over a distance of >1500 km along the cratonic margins, including the reactivated 1.84 Ga collisional boundary between the Yilgarn and Pilbara cratons (Wingate et al., 2004)	scale problem: the whole area of interest is located at the edge of the 3 cratons. This predictor map should have been in pathway critical process. The craton margins are the pathways.the new seismic data display the possible suture zone
		Fe-rich rocks (magnetite presence in P_-WKg1-am unit)	7	8	Indication of potential S sources, but external crustal S addition did not play a role in the Nebo Babel ore genesis (Seat et al., 2009). This could indicate that the concentration of mantle-derived S can be extremely efficient in some cases or that S was added from an external source that had mantle-like S isotopic signatures (Maier and Groves, 2011).	The presence of Fe rich country rocks is not considered here as a requirement or positive indicator (Maier, personal communication)
		Al_2O_3/TiO_2	7	7.5	Fertile komatiitic provinces are dominated by Al-undepleted komatiites (AUDK) or 'Munro-type' komatiites with Al_2O_3/TiO_2 values between 15 and 25 (e.g., Eastern Goldfields, Australia; Thomson belt, Canada; Zimbabwe Craton, Zimbabwe; Hoatson et al., 2006). However, Al-depleted komatiites (ADK; Al_2O_3/TiO_2 < 15) or 'Barberton-types' also host significant deposits (e.g., Pibara Craton, Australia; Crixás Belt, Brazil; Barberton Belt, South Africa; Hoatson et al., 2006).Some sulfide ores in Al depleted ones, on the Yilgarn, were recognized (Maier, personal communication)	No komattite in this non-Archean area,
		(Ni/Cr) x (Cu/Zn) ratio	8	7.5	This factor is used in WA as a vector towards Komatiite Ni mineralisation (Brand, 2004). It has also been used is soil sampling programs for Ni deposits.	No komattite in this non-Archean area,
		Presence of chalcopyrite, pyrrhotite, pentlandite	8	6	The main sulfide minerals are pyrrhotite, pentlandite (which may be dominant in komatiitic ores) and chalcopyrite (which may be dominant in gabbronoritic ores and in ores that crystallized from fractionated sulfide liquids).	NOT Found in the mineral occurence database