38a	**Lateritic/Saprolitic Nickel, Cobalt, Iron**
Mineral Deposit Models (Cox & Singer model number or other)	Nickel-rich, in situ lateritic weathering products developed from dunites and peridotites. Ni-rich silicates and Ni iron oxides. Description of model 38a modified after Donald A. Singer, in Cox and Singer 1986
Commodities	Averages 1.2% Ni, Co often >700ppm, Fe >40% (Brand & others 1998).
% Global Production	Less than 30% of world production and more than 70% of Ni resources (Brand & others, 1998)..
% Australian Production	
World Class Deposit Size	Greenvale – past production exceeds 400 000 t Ni; Murrin Murrin - 353 Mt at 1% Ni, 0.064% Co (Register of Australian Mining 2001/02); Cawse - 595 Mt at 0.66% Ni, 0.038% Co (Register of Australian Mining 2001/02); Wingelinna - 124 Mt at 1% Ni, Bulong - 39Mt containing about 440 000 t Ni and 36 000 t Co.
World Class Deposit Examples	Goro (New Caledonia), Moa Bay (Cuba), Greenvale, Murrin Murrin, Cawse, Wingelinna.
Geological Setting	• Ophiolites in accretionary prism environments; mobile belts; greenstone belts, mafic/ultramafic complexes in stable Archaean/Proterozoic cratons.
Age	Precambrian to Canozoic ultramafic source rocks, typically Cainozoic weathering but may be as old as Mesozoic.
Components:	
Source	• Ultramafic rocks, particularly olivine rich peridotite, dunite, and serpentinised peridotite.
Transport/Pathway	• Meteoric waters in the weathering profile under moderate topography, • Along faults/shears in regolith, • Along fractures and faults of the underlying ultramafic rocks.
Trap	• Chemical traps, substitution of Mg for Ni. • Presence of serpentine or smectite. – Substitution of Ni^{++} in soil water for Mg^{++} in serpentine/garnierite, or smectitic clay minerals by downward passage of Ni-rich solutions from low pH in the top of the weathering profile (<7) to high pH (~9) in deeper parts of the profile. • Presence of Fe oxides and hydroxides in saprolite. – Substitution of Ni^{++} for Fe^{++} in goethite form deposits of lateritic Ni in the shallower ferruginous saprolite zones under weakly acid conditions (pH 5.2-5.7).
Other	Three main types of deposits (Brand & others 1998) • Type A: silicate Ni deposits in mostly humid tropical regions and in freely drained profiles, dominated by hydrated Mg-Ni silicates (e.g. garnierite) generally deep in saprolite (New Caledonia).

	• Type B: silicate Ni deposits in mostly in semi-arid regions (may have had humid palaeoclimates) and in less freely drained profiles, dominated by smectitic clays (e.g. nontronite), commonly in the upper saprolite or pedolith (Murrin Murrin, Bulong, Brolga). • Type C: oxide deposits in all types of climates, dominated by Fe oxyhydroxides (e.g. goethite), forming a layer at the pedolith-saprolith boundary (Cawse).
Critical Elements	• Developed over unaltered or serpentinised ultramafic rocks, particularly olivine-rich cumulates, never over talc-carbonate lithologies (Brand & others, 1998) • Relatively high rates of chemical weathering (warm-humid climates) and relatively low rates of physical erosion. • Long periods of tectonic stability. – Net weathering rates of up to 20 m per million years; landscapes characteristic of a climate require up to 10 million years to develop; require tectonic stability to avoid erosion or excessive burial, (Butt & others, 1997) • Moderate relief – The rate of tectonic uplift, erosion and chemical weathering need to be balanced for the preservation of the deposit; require sufficient relief for adequate drainage of products of chemical weathering. • Warm climates humid tropical or seasonal, savanna or Mediterranean. – warmer climates allow quick lateritisation and formation of deposits within the recent time span requiring less time for preservation. • Uplift is required to expose ultramafic rocks to weathering.
Other Comments	•
Key References	Brand, N.W., Butt, C.R.M. Butt, & Elias, M. 1998. Nickel laterites: classification and features. AGSO Journal of Australian Geology and Geophysics, Volume 17, Number 4, pp81-88. .Butt, C.R.M. 1981 Some aspects of geochemical exploration in lateritic terrains in Australia. in Lateritisation processes: proceedings of the International Seminar on Lateritisation Processes, Trivandrum, India, 11-14 December, 1979. Rotterdam (Netherlands): A.A. Balkema, 1981. Pp 369-380. Butt, C.R.M., Lintern, M.J., & Anand, R.R. 1997. Evolution of regoliths and landscapes in deeply weathered terrain-implications for geochemical exploration. In: Gubins A.B., editor Proceedings of Exploration ’97. Fourth Decennial International Conference on Mineral Exploration, pp. 323-334. CSIRO Division of Mineralogy, Floreat Park. Burger, P. 1996. The Bulong, Western Australia, Ni/Co laterite deposits - a case history. Nickel ’96. Kalgoorlie, 27-28 November 1996, pp 37-41. Elias, M., Donaldson M.J. & Giorgetta N. 1981. Geology, mineralogy and chemistry of lateritic Nickel-Cobalt

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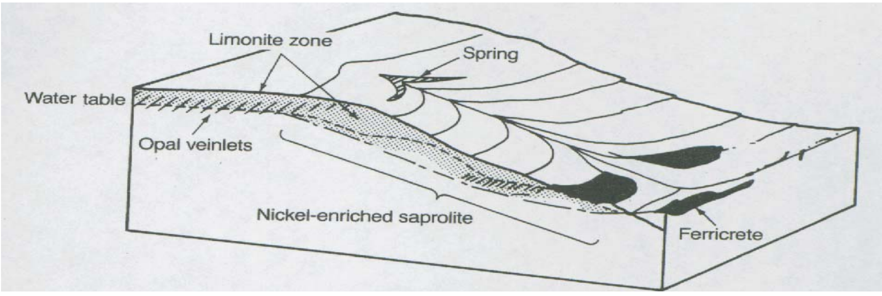
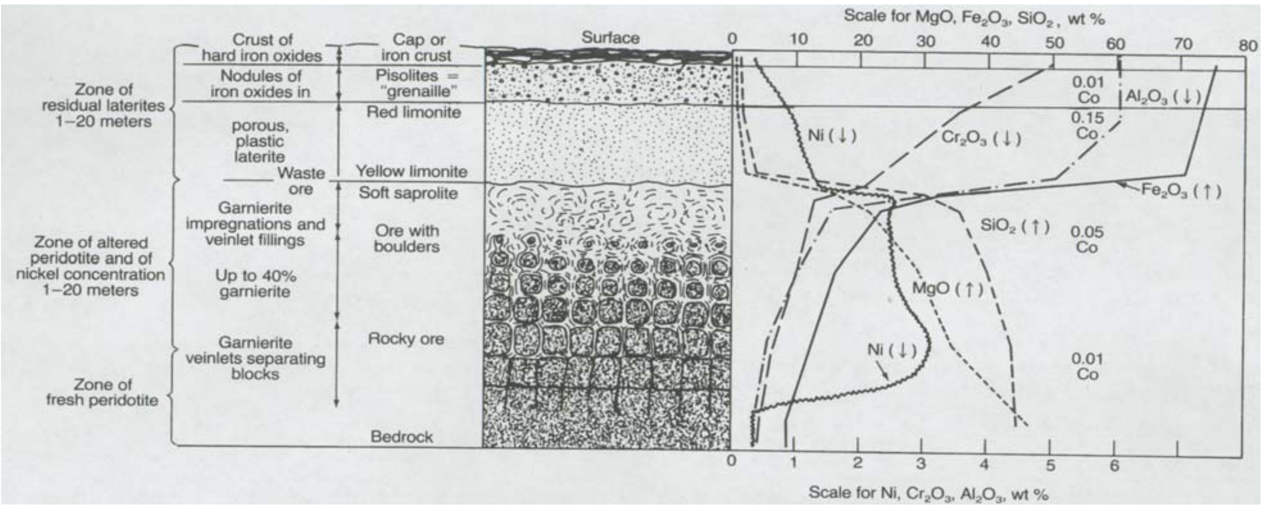
Type A silicate nickel deposits



(a)



(b)

Type A, silicate Ni deposits in mostly humid tropical regions and in freely drained profiles, dominated by hydrated Mg-Ni silicates (e.g. garnierite) generally deep in saprolite (New Caledonia)(after Guilbert & Park, 1996).

Type B lateritic silicate deposit

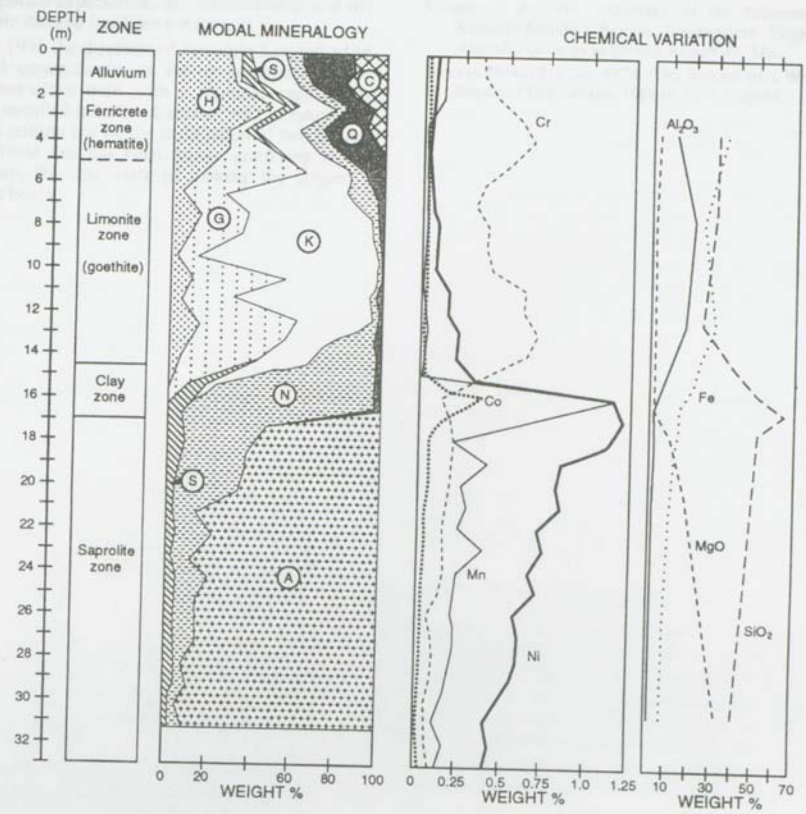
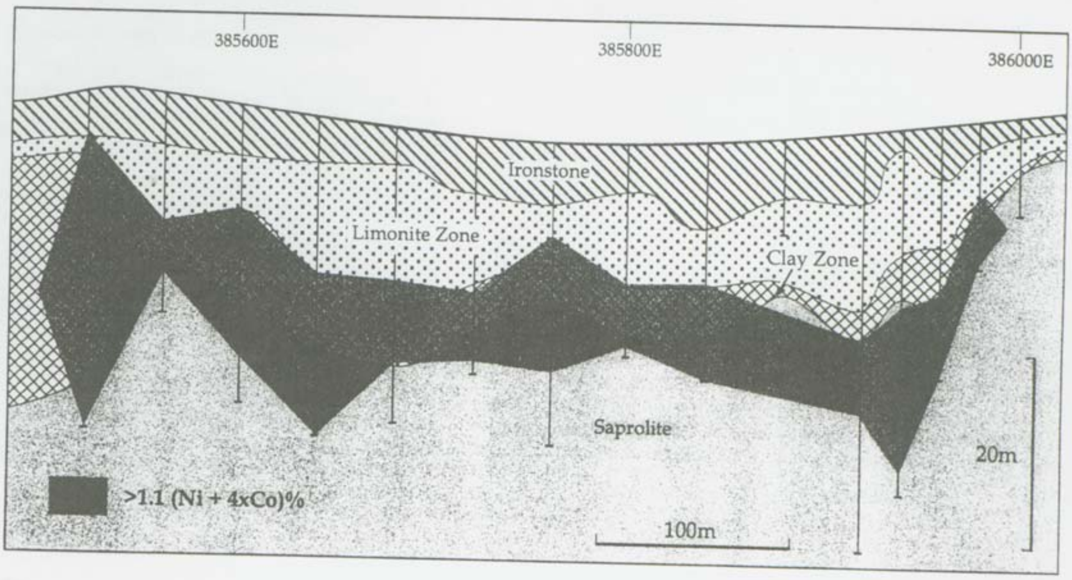
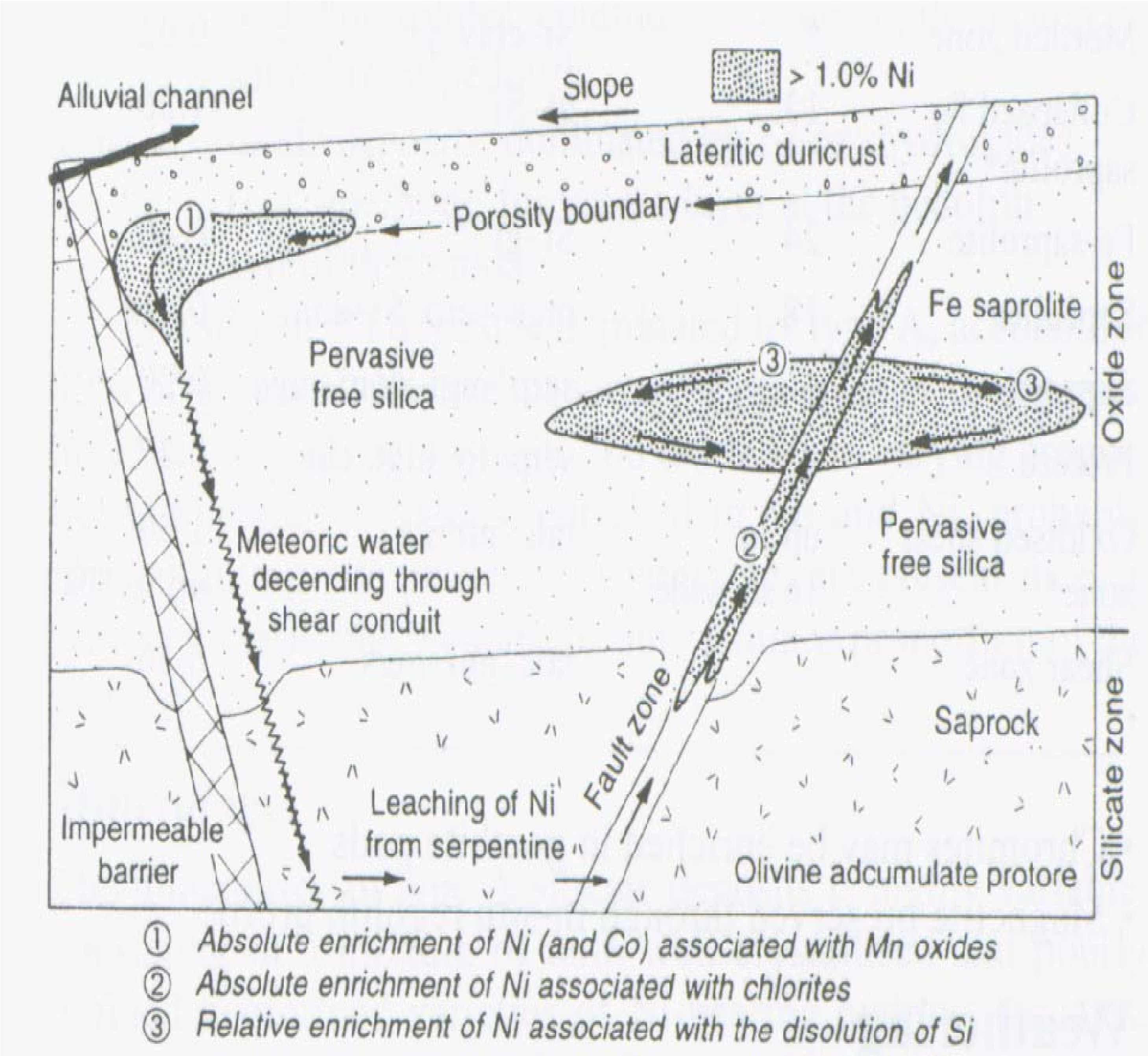


FIG 2 - Typical mineralogical and geochemical profile through laterite.
A - antigorite; C - calcite and dolomite; G - goethite; H - hematite; K - kaolin; N - nontronite; Q - quartz;
S - spinel (magnetite and chromite ± maghemite). Modified after Elias *et al*, 1981.



Type B lateritic silicate nickel deposits in mostly in semi-arid regions (may have had humid palaeoclimates) and in less freely drained profiles, dominated by smectitic clays (e.g. nontronite), commonly in the upper saprolite or pedolith (Murrin Murrin, Bulong, Brolga, after Burger, 1996; Elias & others, 1981).

Type C lateritic nickel oxide deposit.



Model for a Type C lateritic nickel oxide deposit found in all types of climates, dominated by Fe oxyhydroxides (e.g. goethite), forming a layer at the pedolith-saprolith boundary (e.g. Cawse, after Brand & others 1998).