Australian Government

Geoscience Australia

RESOURCES AND GEOLOGY OF AUSTRALIA'S THORIUM DEPOSITS

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AUSTRALIA'S THORIUM RESOURCES

OUTLINE OF PRESENTATION

- *Mineral exploration and resource assessment in Australia*
- *Assessment of thorium resources in Australia*
- *Australia's thorium resources in world context*
- *Distribution of thorium resources in Australia*
  - *Placers – Heavy mineral sands (HMS)*
  - *Vein type, alkaline complexes, carbonatites*
- *Summary*

AUSTRALIA'S THORIUM RESOURCES

Mineral exploration and resource assessment in Australia

- *All mineral exploration and resource assessment in Australia conducted by the minerals industry*
- *The Australian Government, State and Northern Territory Government provide geoscientific data ('pre-competitive data') and research support for the exploration industry*
- *Geoscience Australia's Onshore Energy and Minerals Division is engaged in a 5 year Au$59m Onshore Energy Security Program (OESP), to*
- *Deliver pre-competitive data packages and scientifically based assessments of the potential for onshore energy resources of oil, gas, uranium, thorium and geothermal energy*

AUSTRALIA'S THORIUM RESOURCES

Assessment of thorium resources in Australia

- *The assessment of mineral resources is conducted by the minerals industry according to the JORC Code,* which sets minimum standards for public reporting of Exploration Results, Mineral Resources and Ore Reserves
- The JORC Code provides a mandatory system in Australia and New Zealand for classification of tonnage/grade estimates according to geological confidence and technical/economic considerations, and is the basis of system used in many other countries

AUSTRALIA'S THORIUM RESOURCES

Assessment of thorium resources in Australia

- *Geoscience Australia compiles these company assessments to produce Australian resource figures for the various commodities according to its national mineral resource classification system*
- *The assessment of thorium resources differs from that of other commodities (coal, uranium etc) in that there is no current large-scale demand for thorium*
- *Thus there is no incentive for exploration companies to collect thorium data and use it for resource assessment*

AUSTRALIA'S THORIUM RESOURCES

Assessment of thorium (cont')

- *Even where analyses for thorium have been done, they are hidden in open files held by State and Northern Territory geological surveys*
- *This data has not been used for assessment of thorium resources as thorium is not considered to have economic value*
- *It is very time consuming to locate this data and assess its significance for thorium resources, however*
- *In response to request from the government for information on Australia's thorium resources, Geoscience Australia has committed limited resources to update its information on thorium and upgrade its database on thorium resources*

AUSTRALIA'S THORIUM RESOURCES

Assessment of thorium (cont')

- *Parts of Geoscience Australia's OESP program, relevant to thorium, are*
  - *Continent wide geochemical sampling as well as airborne radiometric surveys, and*
  - *A small thorium project comprising a review of the geochemical processes controlling the distribution of thorium in Earth's crust and an upgrade of Geoscience Australia's database on thorium resources*
  - *This program is planned for completion in the first half of 2008 (Mernagh and Miezitis, in prep)*
- ***However – one may ask the Question***

AUSTRALIA'S THORIUM RESOURCES

WHY INTEREST IN THORIUM? –

The factors behind this interest in thorium appear to be

- *Possible use of thorium as fuel in nuclear reactors in place of perceived shortage of cheap uranium, and*
- *The thorium fuel cycle produces much less plutonium and other transuranic elements, compared with uranium fuel cycles and is considered by some to present less problems in waste disposal, and*
- *To be more proliferation resistant than uranium fuel cycles*

AUSTRALIA'S THORIUM RESOURCES

Australia's thorium resources in World context

- *Preliminary data suggest that Australia may account for about 18% of the world's total Reasonably Assured Resources and Inferred Resources of thorium in the less than US$80/kg Th categories see table next slide*

AUSTRALIA'S THORIUM RESOURCES

Country	Total Identified Thorium Resources ('000 t Th) <USD 80/kg Th	
		%
Australia	452	18.1
United States	400	16.0
Turkey	344	13.8
India	319	12.8
Venezuela	300	12.0
Brazil	221	8.9
Norway	132	5.3
Egypt	100	4.0
Russian Federation	75	3.0
Greenland	54	2.2
Canada	44	1.8
South Africa	18	0.7
Others	33	1.3
TOTAL	**2492**	**99.9**

Data for Australia compiled by Geoscience Australia; estimates for all other countries are from: OECD/NEA & IAEA 2006. Red Book Retrospective. A review of Uranium Resources, Production and Demand from 1965 to 2003.

AUSTRALIA'S THORIUM RESOURCES

Australia's thorium resources in World context

- *Australia's thorium resources currently amount to about 452,000t Th*
- *Of which*
  - *364,000t (80.5%) occur in heavy mineral sand deposits,*
  - *53,300t (11.7%) in a vein type deposit at Nolans Bore in the Northern Territory and*
  - *another 35,000t (7.7%) are in an alkaline trachyte plug at Toongi in New South Wales.*

AUSTRALIA'S THORIUM RESOURCES

Australia's thorium resources in World context (cont')

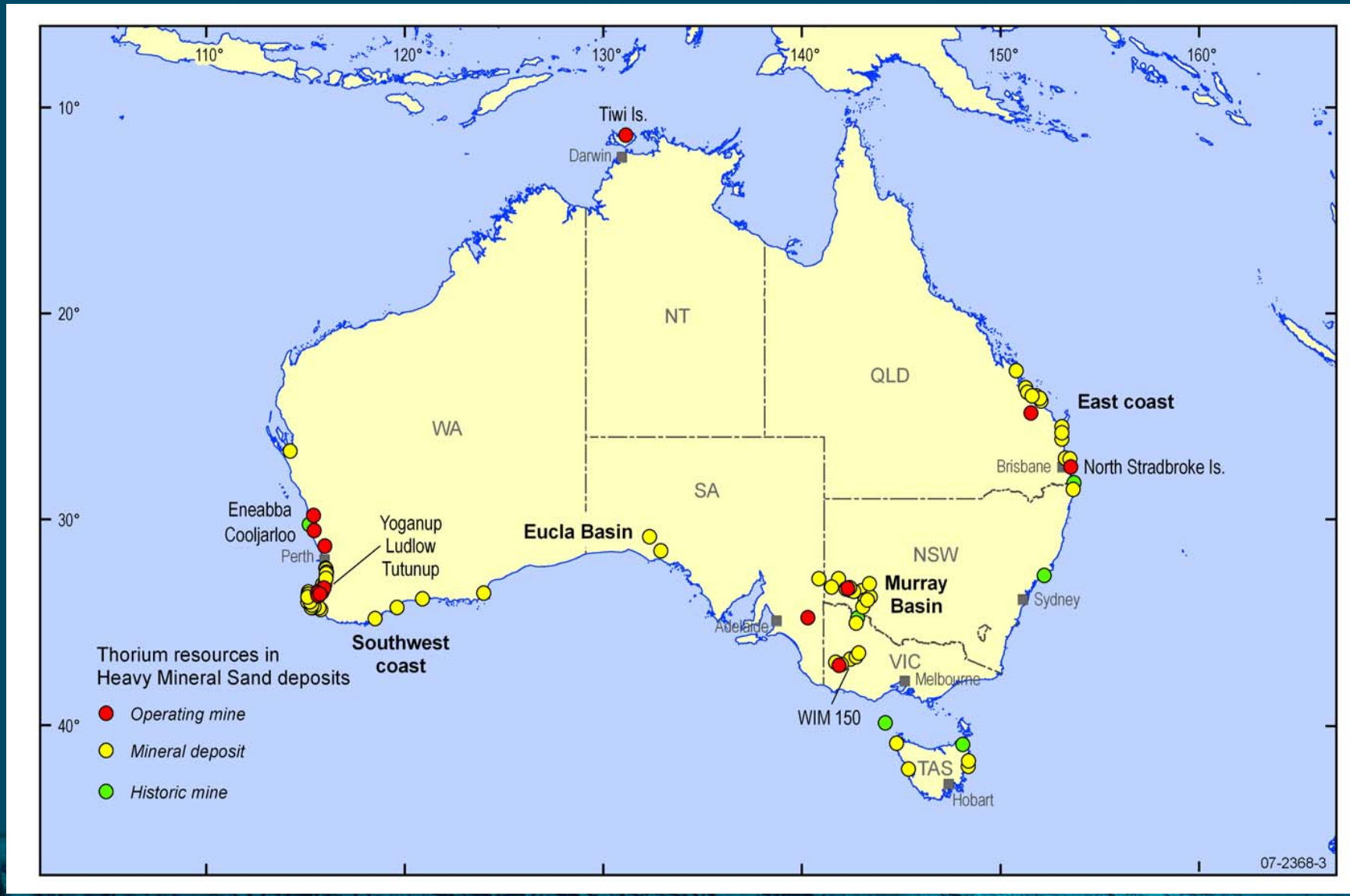
- *This distribution of thorium resources differs from the world wide distribution where*
  - *31.3% of the resources occur in carbonatites,*
  - *24.6% are in placers,*
  - *21.4% in vein type deposits and*
  - *18.4% is in alkaline rocks*
- *This variance is at least partly due to relatively more, although still inadequate, data on thorium resources being generated by the very active heavy mineral sand operations around Australia.*

Distribution of thorium resources in Australia

- *Most of Th resources in Australia are in the monazite component, a rare-earth Th phosphate ($(CeLaTh)PO_4$), of heavy mineral sand deposits (HMS), which are mined for their ilmenite, rutile, leucoxene and zircon content (see map next slide),*

AUSTRALIA'S THORIUM RESOURCES

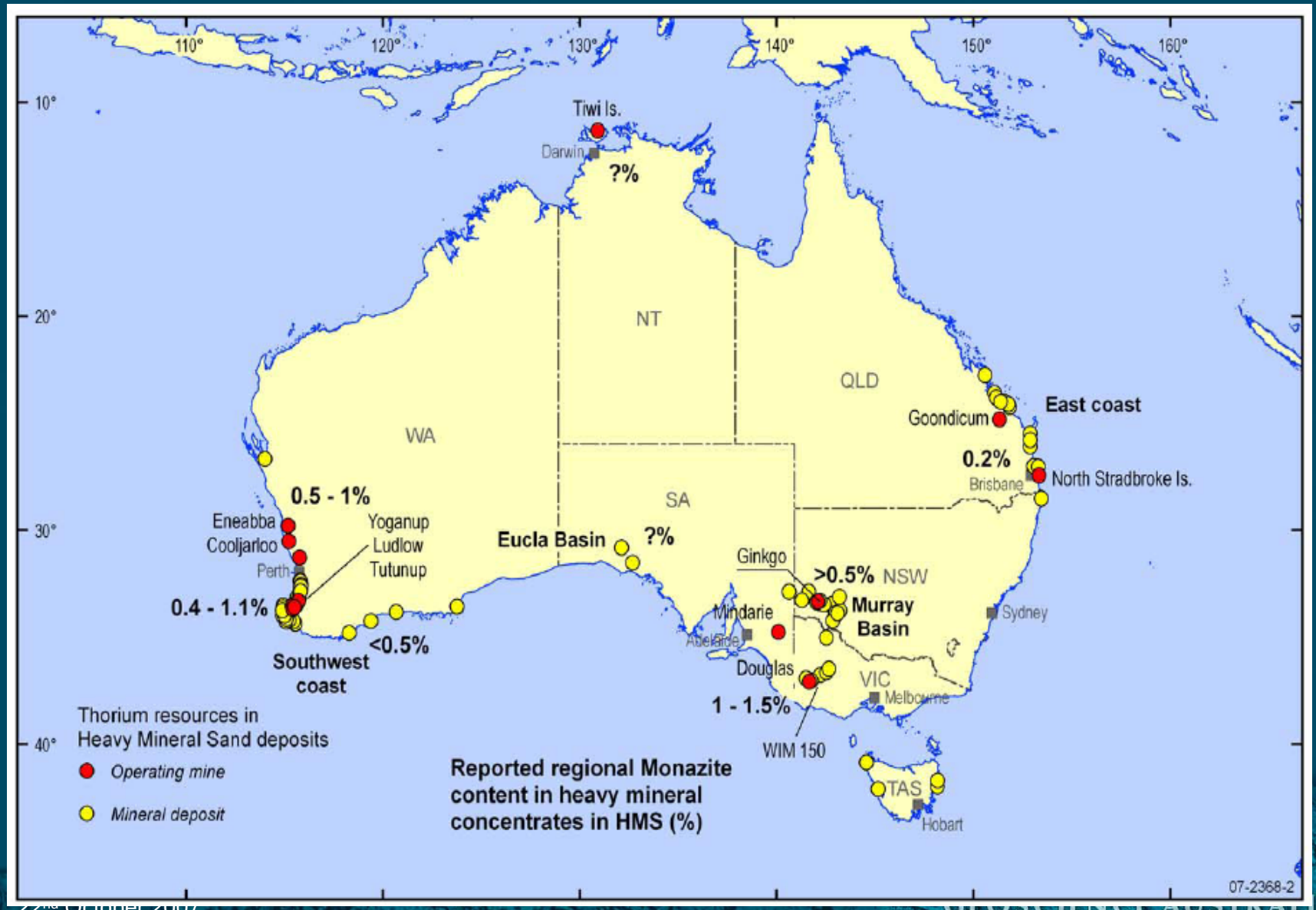
Distribution of Heavy Mineral Sand deposits in Australia



Distribution of thorium resources (cont')

- *There are no comprehensive detailed records on Australia's thorium resources in heavy mineral sands*
- *In the absence of detailed records on the monazite content in the HMS, Geoscience Australia has*
  - *Extrapolated monazite content from regional data (see map next slide),*

Reported regional monazite content in HMS



AUSTRALIA'S THORIUM RESOURCES

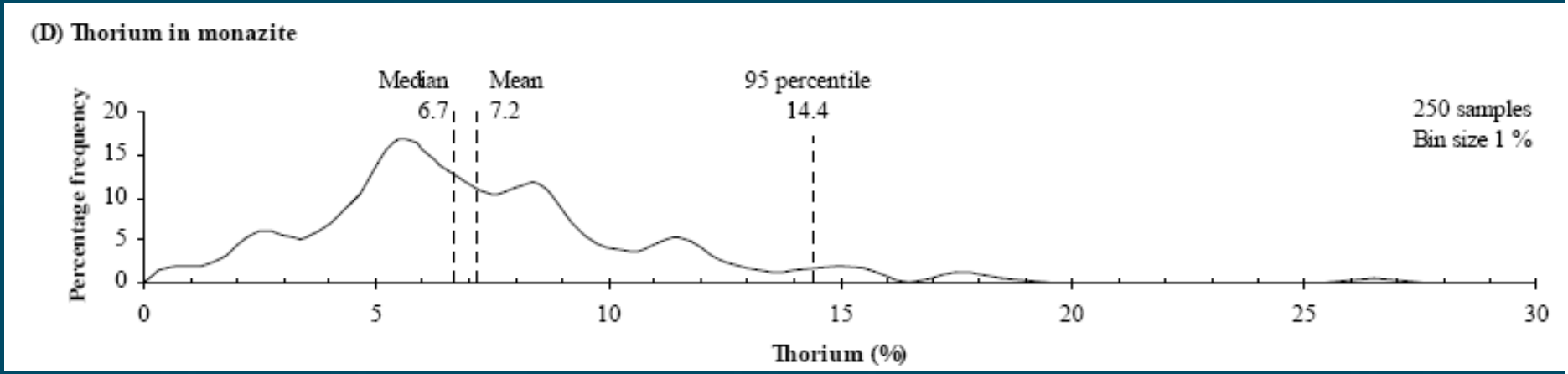
Distribution of thorium resources (cont')

- *In the absence of the thorium content in the monazite, Geoscience Australia has relied on*
  - *Limited historic data on the thorium content in monazite concentrates (~ 93% monazite) which indicate a thorium content in monazite of about 6.0% to 6.5% Th (IAEA – TECDOC 412 page 149; Towner, 1989)*
  - *A small number of monazite samples analysed for thorium from beaches at the Queensland/New South Wales border which averaged 6.6 ± 0.3% ThO2 (5.8% Th) (Gardner, 1955, p 49), and*

AUSTRALIA'S THORIUM RESOURCES

Distribution of thorium resources (cont')

- *Used research results from a suite of 250 monazite grains analysed for thorium by Sircombe (1997) which gave a median value of 6.7% Th and a mean of 7.2% Th*

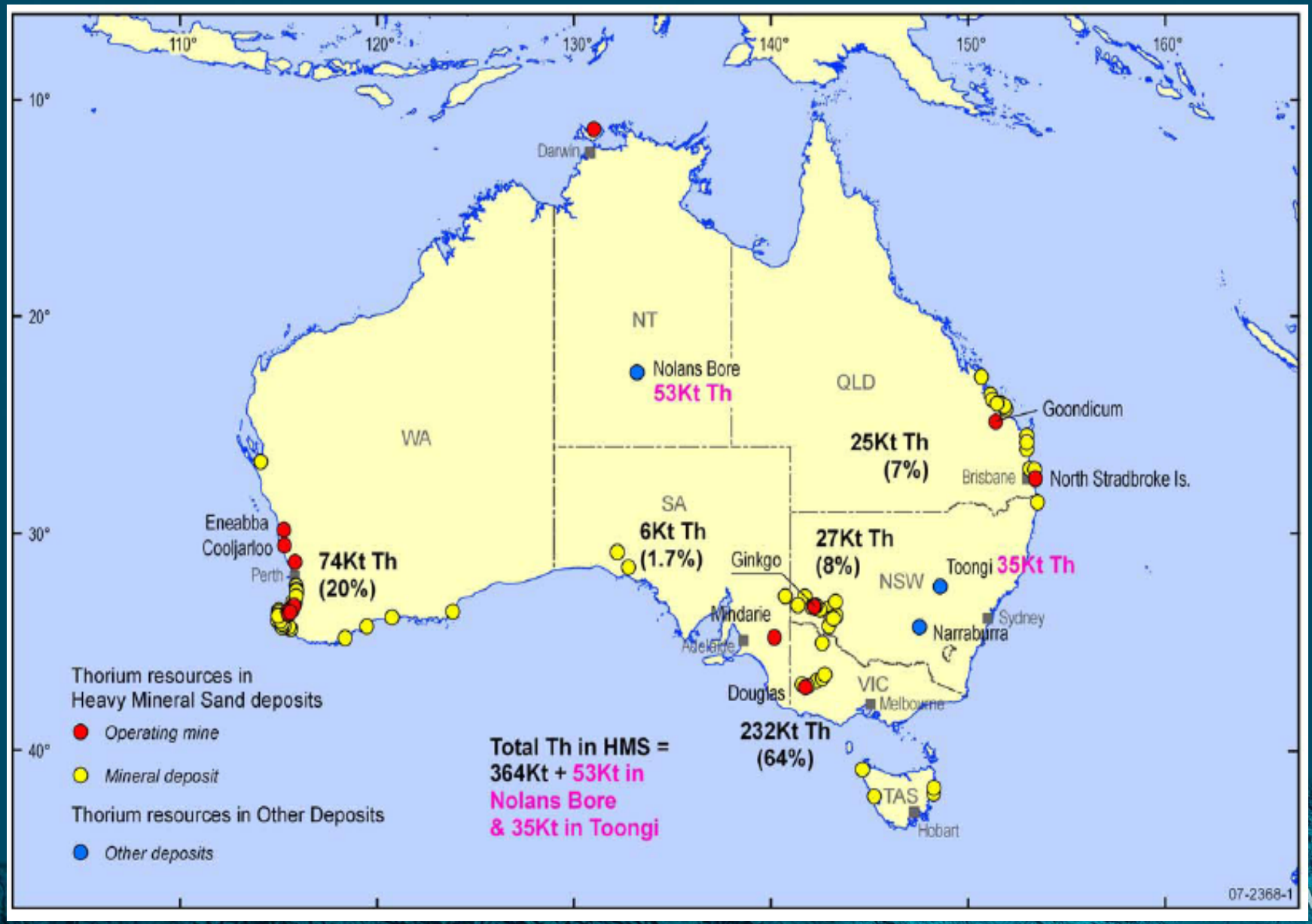


- *The maximum thorium value in this suite of monazites was about 27% but 95% of the grains had less than 14.4% Th. The results are presented in graph form above*

Distribution of thorium resources (cont')

- *In view of the foregoing data, assuming an average Th content in monazite of 7%, Australia's Th resources in HMS deposits could amount to about 364,000 t (see map next slide)*
- *The problem is that the assessment of the thorium in HMS is based on assumptions, and*
- *The thorium resources in the HMS are inferred resources*

Distribution of Australia's thorium resources



Distribution of thorium resources (cont')

Need to note a couple of points in regard to thorium recovery in HMS

- *In current heavy mineral sand operations the monazite is dispersed back in the original host sand to avoid the concentration of radioactivity*
- *thus eliminating monazite as a resource for both thorium and rare earths*
- *The mining costs of Th for both HMS deposits and probably in other multi-commodity deposits will be at least partly supported by other commodities*

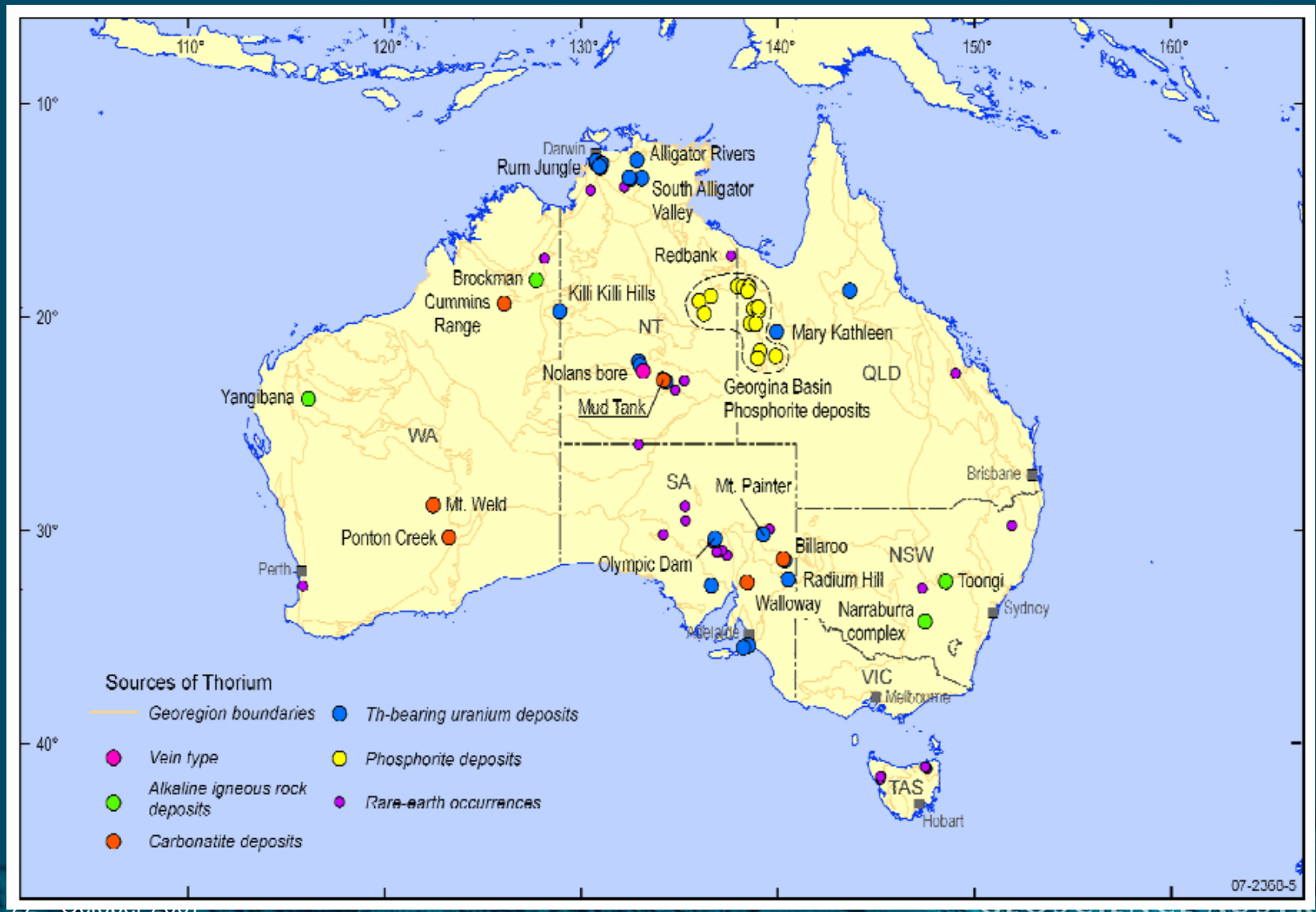
AUSTRALIA'S THORIUM RESOURCES

Distribution of thorium resources (cont')

Vein-type deposits (including pegmatites)

- *A significant proportion of Australia's Th resources (53,300 t Th) are present in the Nolans Bore rare earth-phosphate-uranium deposit, in NT, which is in fluorapatite veins and dykes hosted within a granitic gneiss (see next map)*
- *The prospect occurs in two zones over a strike length of about 2 km within variably deformed and altered granitic gneiss and pegmatite, and minor calcsilicate rocks.*

Location of Australia's thorium-bearing mineral deposits and occurrences excluding those in HMS



AUSTRALIA'S THORIUM RESOURCES

Distribution of thorium resources (cont')

- *Four styles of REE mineralisation have been recognised at Nolans Bore:*
  - *Massive fluorapatite dykes of 4-6% REE.*
  - *Very high grade REE mineralisation of 10-20% REE found in cheralitic apatite-poor rocks.*
  - *Calc-silicate hosted apatite-allanite-epidote REE mineralisation*
  - *Zones of low grade REE mineralisation in gneisses and kaolinite-altered rocks adjacent to the fluorapatite dykes and adjacent to mylonite zones*

AUSTRALIA'S THORIUM RESOURCES

Distribution of thorium resources (cont')

Alkaline and peralkaline igneous complexes

- *Toongi alkaline trachyte plug 280 km north-west of Sydney, hosts a measured and inferred resources of 73.2 Mt grading 1.96% ZrO2, 0.04% HfO2, 0.46% Nb2O5, 0.03% Ta2O5, 0.14% Y2O3, 0.745%; total REO, 0.014% U3O8 and 0.0478% Th giving about 35,000 t of Th*
- *Brockman, Western Australia; a large low-grade Zr-Nb-REE deposit hosted in altered trachytic tuff of Palaeoproterozoic age containing mineralised material of 50Mt; historic company reports show analyses for Th in six separate drill hole intersections (in tuffs) of 16m to 28m averaging from 259 to 371ppm Th*

AUSTRALIA'S THORIUM RESOURCES

Distribution of thorium resources (cont')

Alkaline and peralkaline igneous complexes

- *The Yangibana ferrocarbonatite-magnetite-rare earth-bearing dykes (termed 'ironstones'); the prospect has a recorded resource of 3.5Mt at 1.7% REO; whole rock chemical analyses of 21 ironstone samples collected from five prospects in the Yangibana area recorded more than 1000ppm Th for ten of the samples (1062ppm to 5230ppm Th)*

Carbonatites

- *The best known carbonatites in Australia are Mount Weld, Cummins Range and Mud Tank; significant thorium has only been identified at the Cummins Range deposit in one drill hole with about 500ppm Th in the top 48m of weathered zone and generally less than 400ppm below the weathered zone*

AUSTRALIA'S THORIUM RESOURCES

Distribution of thorium resources (cont')

Thorium occurrences in other types of deposits

- *Known thorium occurrences associated with various types of uranium deposits and phosphorites is generally very low usually less than 100ppm Th*

AUSTRALIA'S THORIUM RESOURCES

Summary of main points

- *Preliminary estimates suggest Australia has 452,000t Th of which 80.5% is in placers (HMS), 11.7% in vein-type deposits, and 7.7% is associated with alkaline complexes,*
- *The potential for thorium resources, particularly in types of deposits other than placer, is underexplored in Australia,*
- *Geoscience Australia is currently updating its data on geological and geochemical environments of thorium in Australia and is upgrading its thorium resource database, and*
- *Estimates of Australia's thorium resources will be refined as a result of these studies*

AUSTRALIA'S THORIUM RESOURCES

Summary of main points (cont')

As noted previously we need to emphasise that

- ***These studies are being done in absence of a commercial-scale demand for thorium, however***
- ***Despite the lack of demand, factors generating interest in Th are***
  - *Perceived shortage in cheap U resources*
  - *Less radioactive waste, reduced length of time required for storing waste from the Th fuel cycle, and*
  - *Th fuel cycle considered to be more proliferation resistant than the uranium fuel cycle*

AUSTRALIA'S THORIUM RESOURCES

Summary of main points (cont')

- ***Further work for thorium resources in Australia***
  - *Mineral industry interest in the new data on thorium generated by Geoscience Australia's energy program will depend very much upon progress of nuclear reactor technology that require thorium fuel and the resulting demand for thorium fuel,*
  - *Geoscience Australia will also decide whether further studies in thorium are warranted, the outcome will depend very much upon priorities of Geoscience Australia's other energy related work in its program in regard to petroleum and gas, geothermal and uranium*

THANK YOU!

AUSTRALIA'S THORIUM RESOURCES

Distribution of >50ppm Th in rocks and soils in Australia as recorded in Geoscience Australia OZCHEM database