



**Dr Gavin M Mudd**

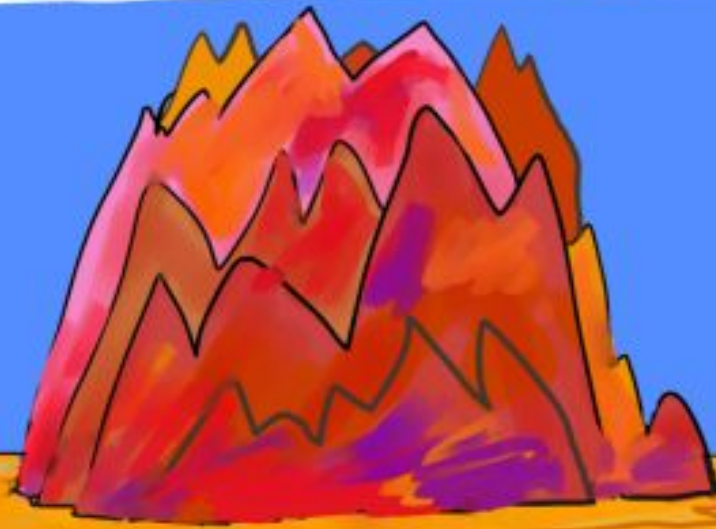
**Environmental Engineering, Monash University**

**“Limits to Growth” v  
Finite Mineral Resources:  
Revisiting the Assumptions**

**December 2010**

**4<sup>th</sup> Int. Conf. on Sustainability Engineering & Science,  
Auckland, New Zealand**

Widobson  
13 Nov '10



See that mountain of minerals? There are no workers to mine it. We need more skilled migrants.

Can't do it. The place is overcrowded



# Latrobe Valley Field, Victoria



**Yallourn**



**Hazelwood**



**Loy Yang**

6.44 km

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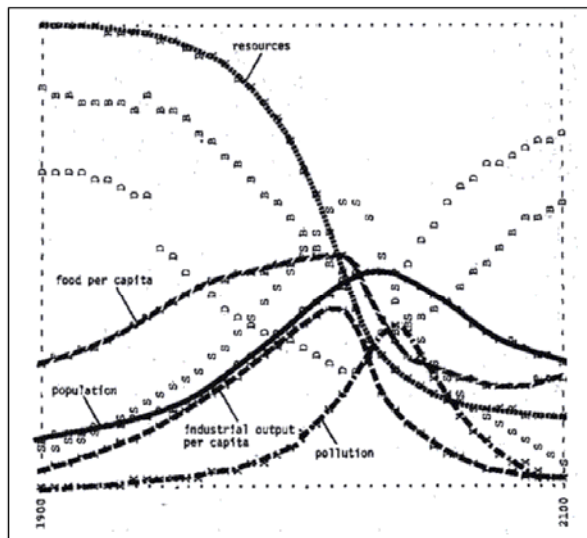
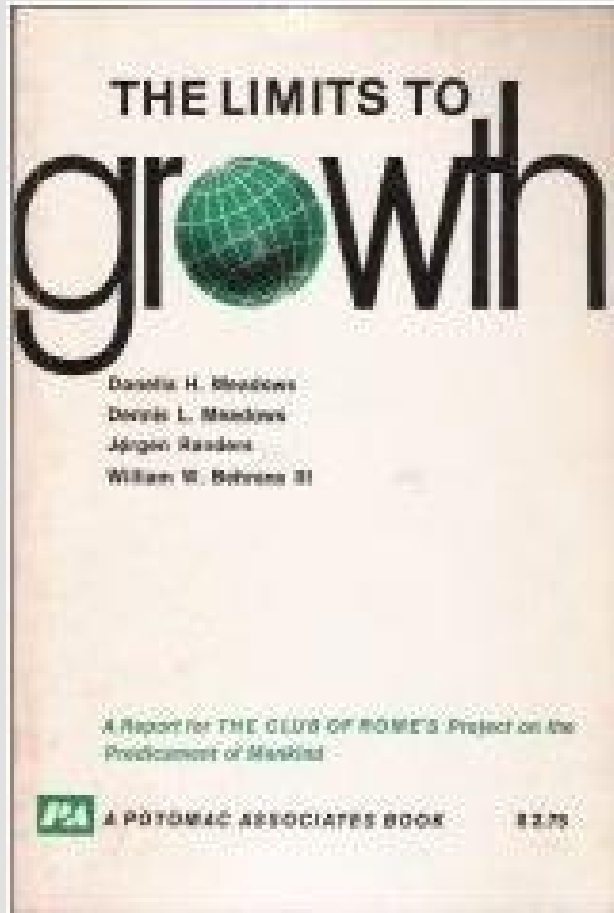
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# Presentation Overview

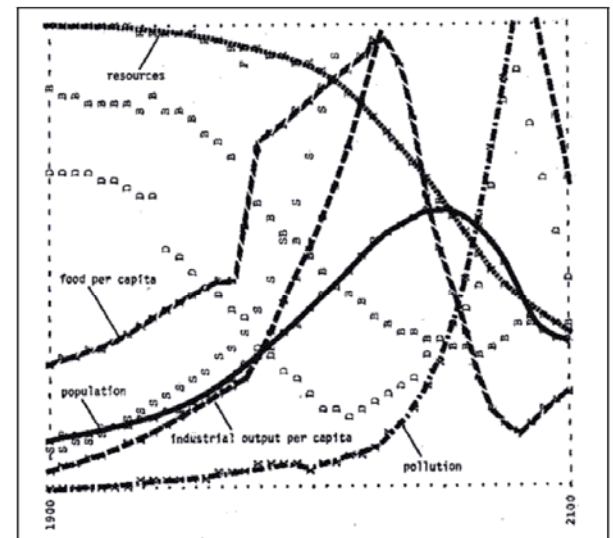
- **1972 ‘Limits to Growth’**
- **Counter Arguments ...**
- **Basics of Mining Data ‘101’**
- **Case Studies**
  - coal, iron ore, platinum group metals (PGMs)
- **‘Pearls’ of Wisdom ??**

# The Infamous “Limits to Growth” ...

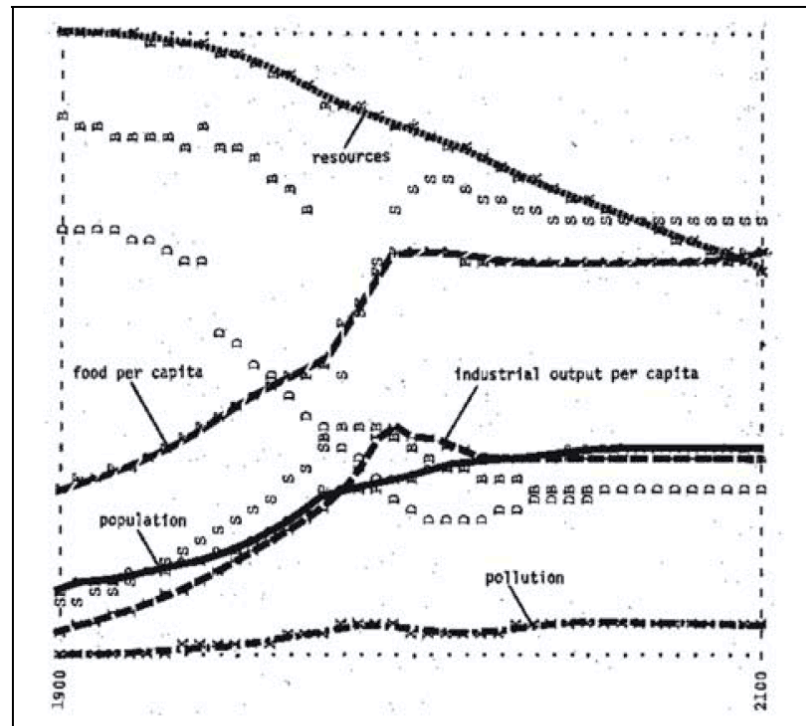
- In 1972, young scientists published a **best seller** on the real ‘sustainability’ challenges:  
*Limits to Growth: A Report for the Club of Rome*
- ‘LtG’ examined trends in population, resource use, pollution, consumption, economics, ...
- LtG included the ‘World3’ model – a systems dynamics linking these aspects of the modern world and projecting to 2100
- LtG predicted global collapse by 2050 under ‘business as usual’



(a) Standard Run



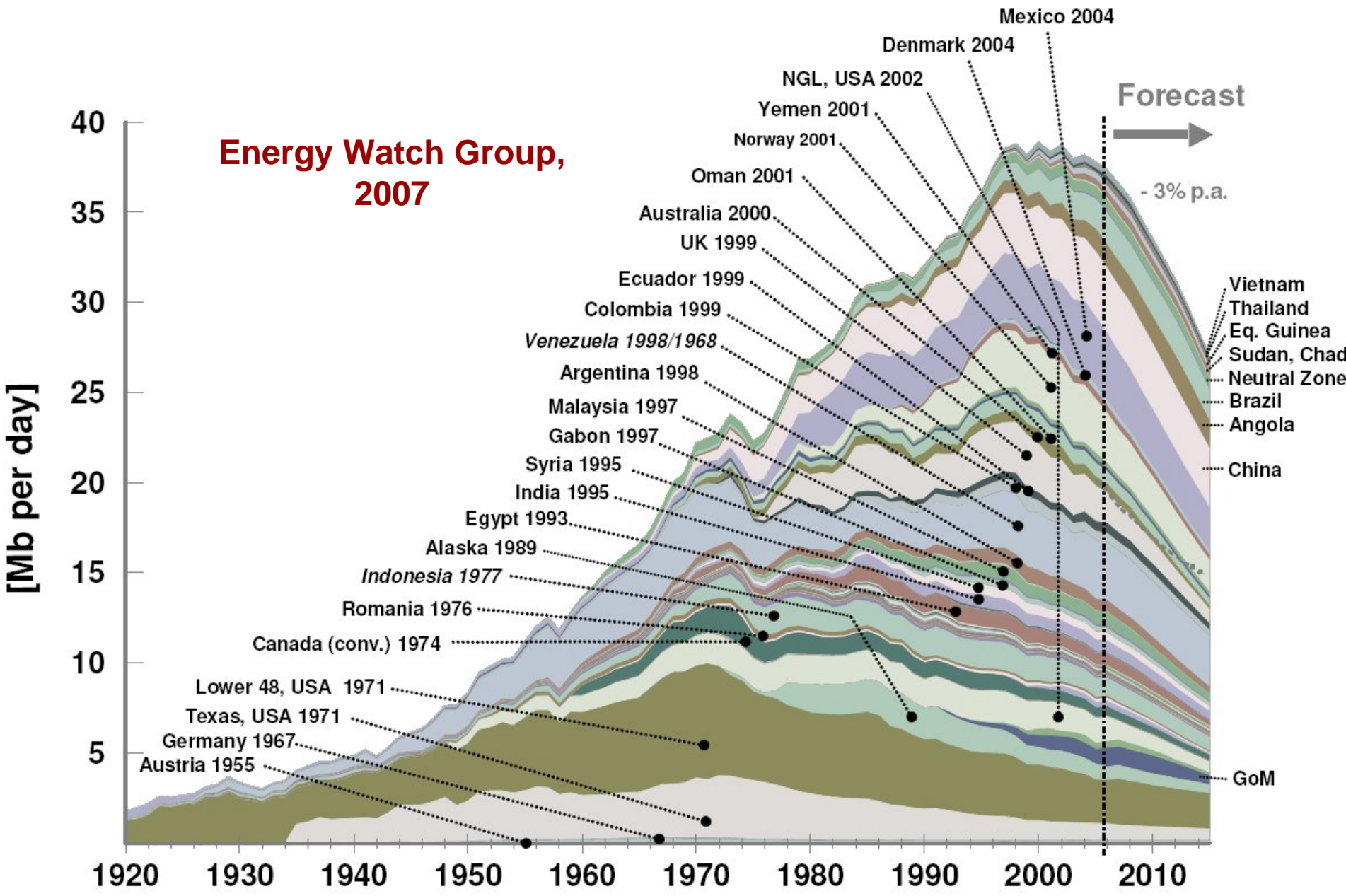
(b) Comprehensive Technology



(c) Stabilised World

# Peak Oil: The Inevitable Decline ...

**Energy Watch Group,  
2007**



# Counter Argument: LtG 'wrong' ?

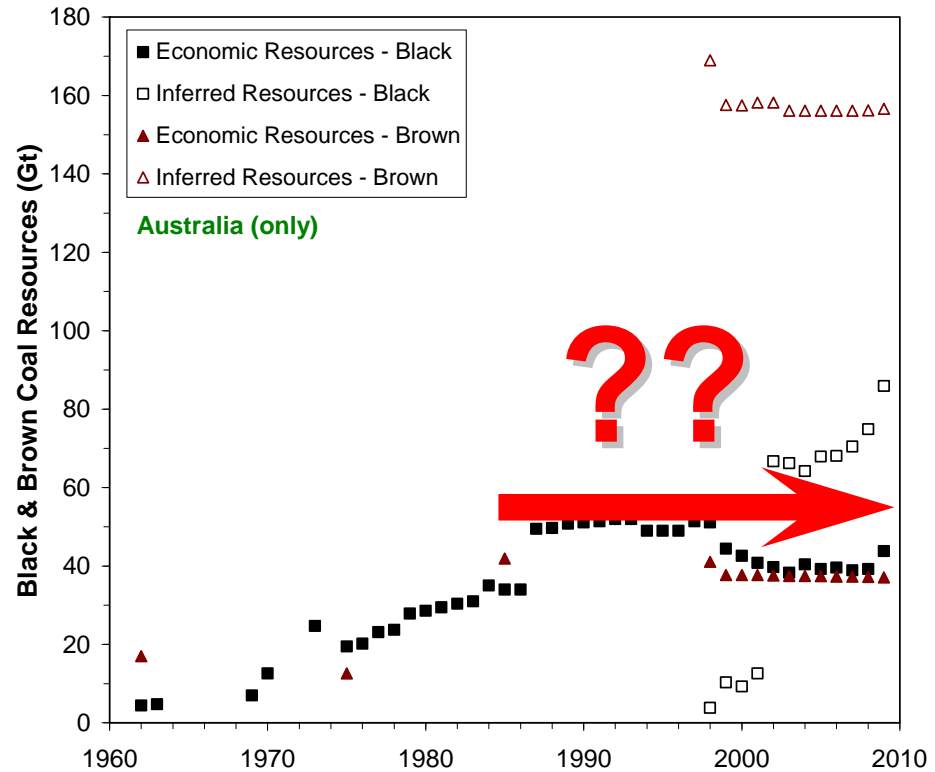
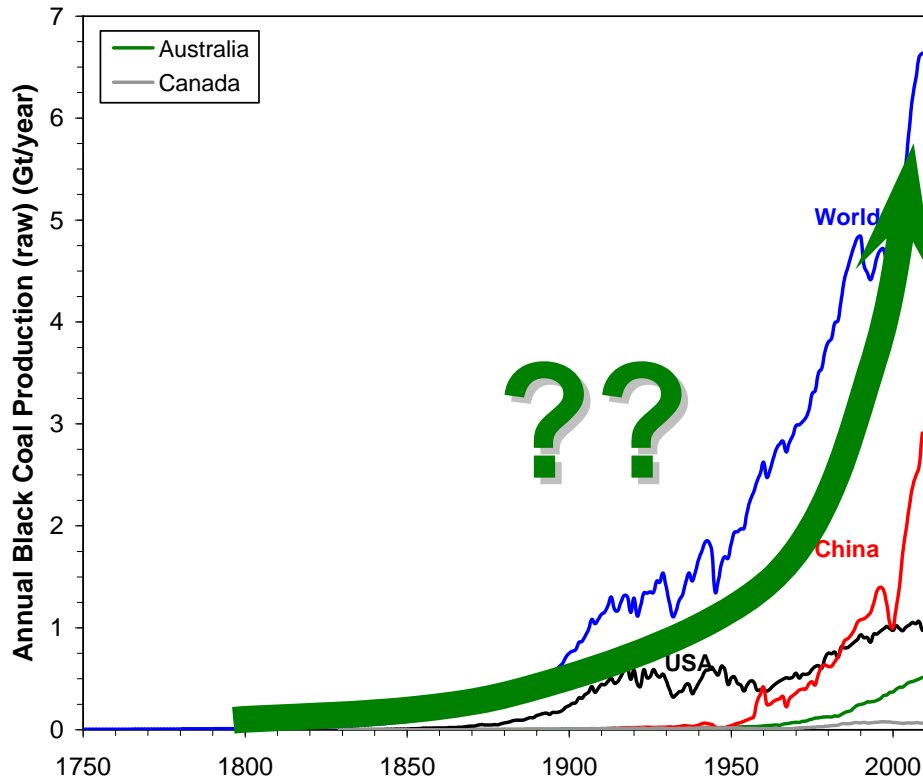
- Many industries and researchers attacked LtG, arguing they were overly pessimistic or their 5<sup>th</sup> decimal place was kinda wrong
- The essence of the counter argument is that human ingenuity will always find a way to solve problems, even before they arise (!)
- Technology and economics especially will allow corrections to address these issues
- Mining industry particularly critical ...



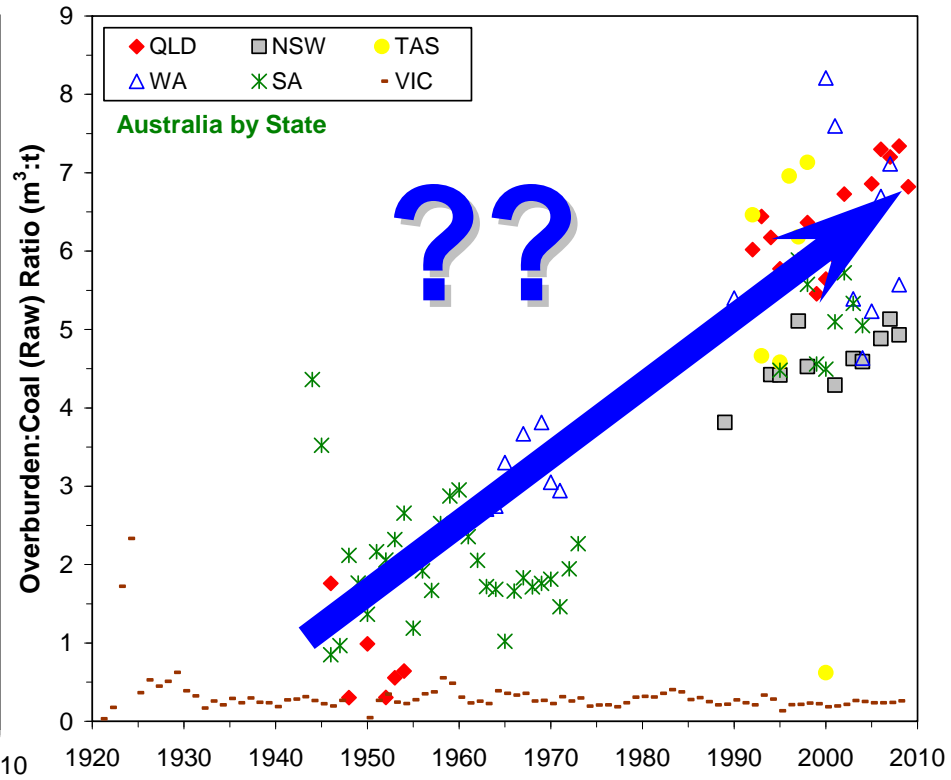
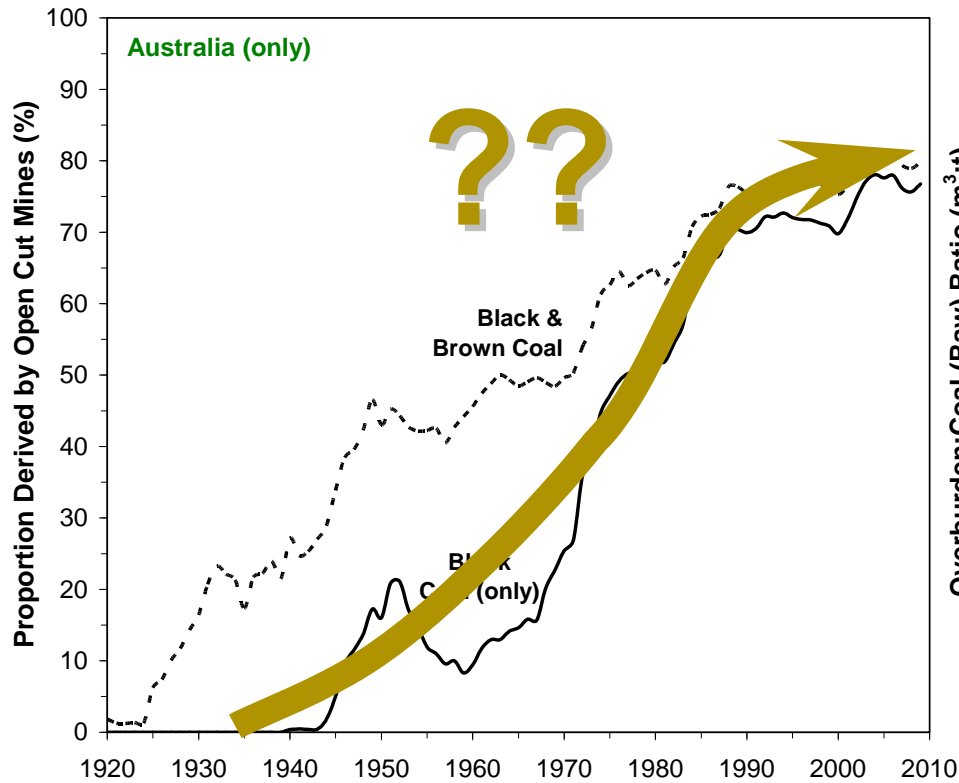
# Mining Data '101'

- **Unlike financial regulation, there is actually an abundance of production data on minerals and metals over time**
- **Most data is contained mineral/metal, but other critical data can be compiled too ...**
  - **ore grades (%Cu, g/t Au), waste rock, ore types, mine type (open cut v underground), remaining economic resources**
- **Ironically, mineral production now is greater than ever before for almost everything ...**

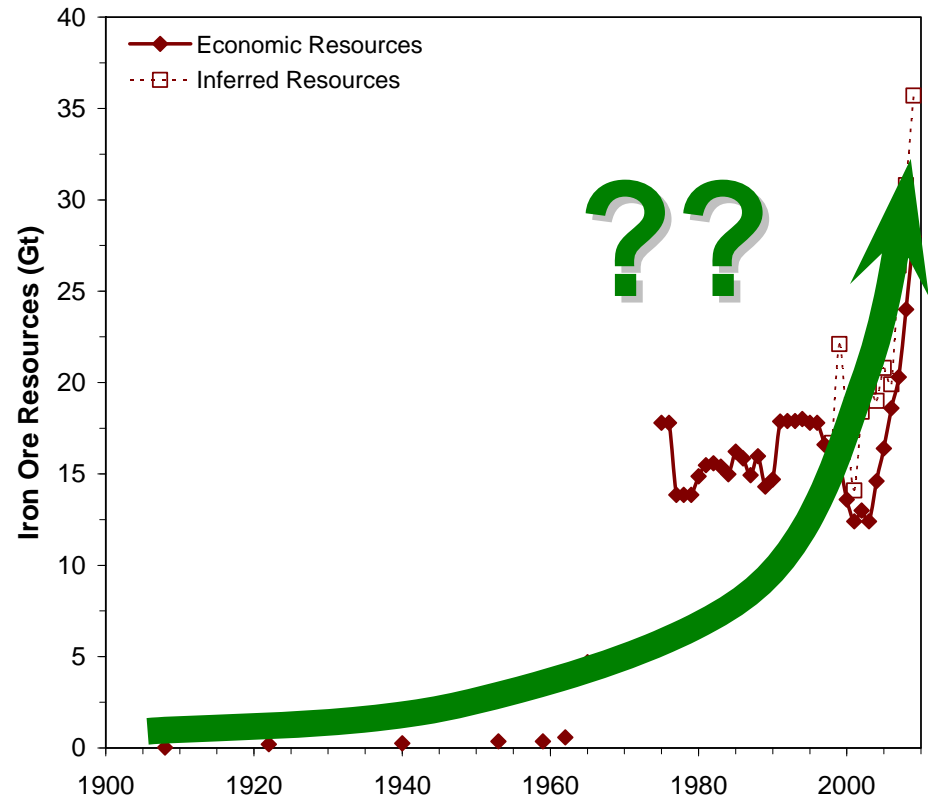
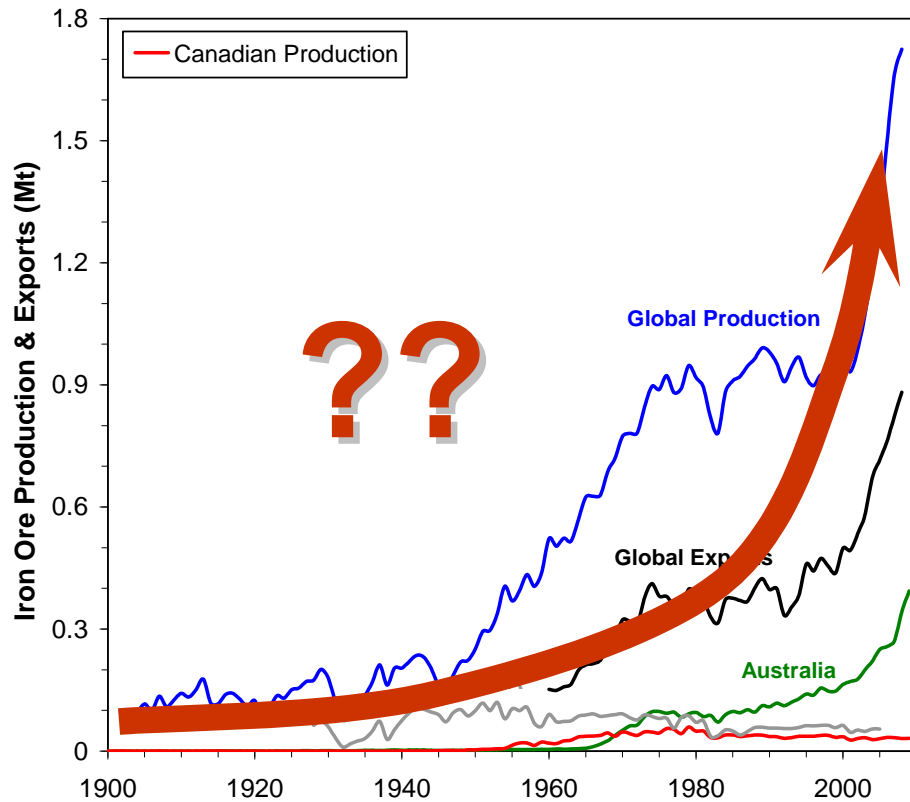
# LtG v Coal ... #1



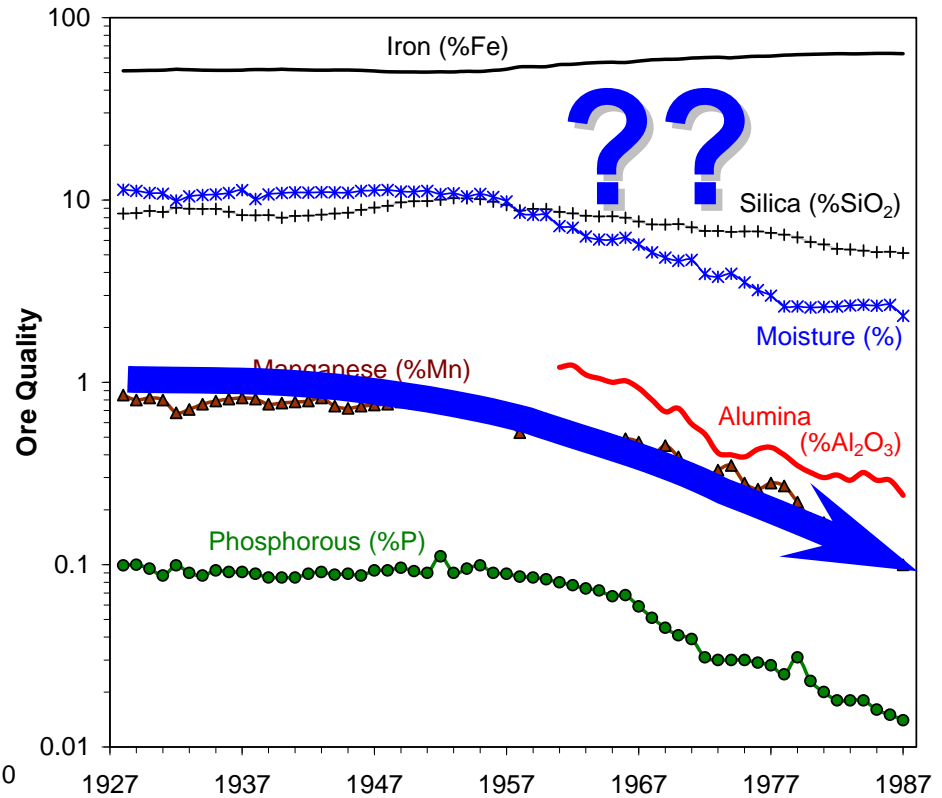
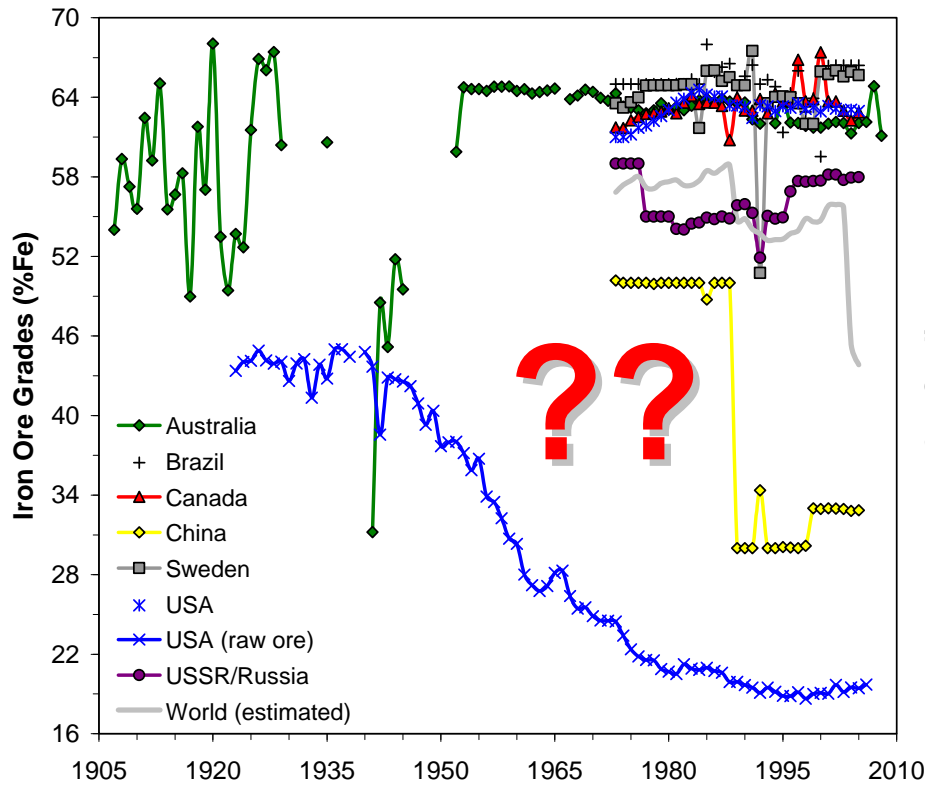
# LtG v Coal ... #2



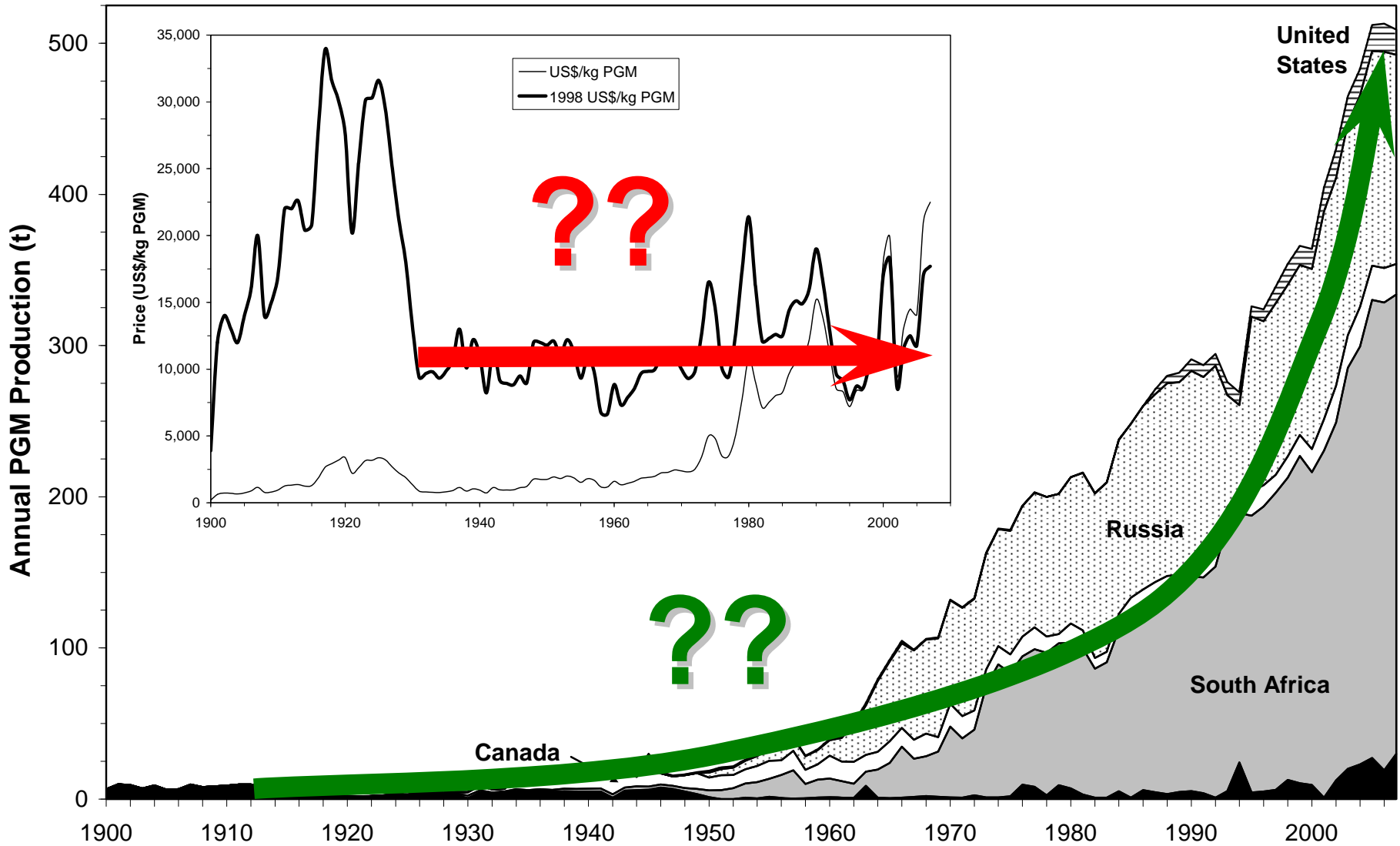
# LtG v Iron Ore ... #1



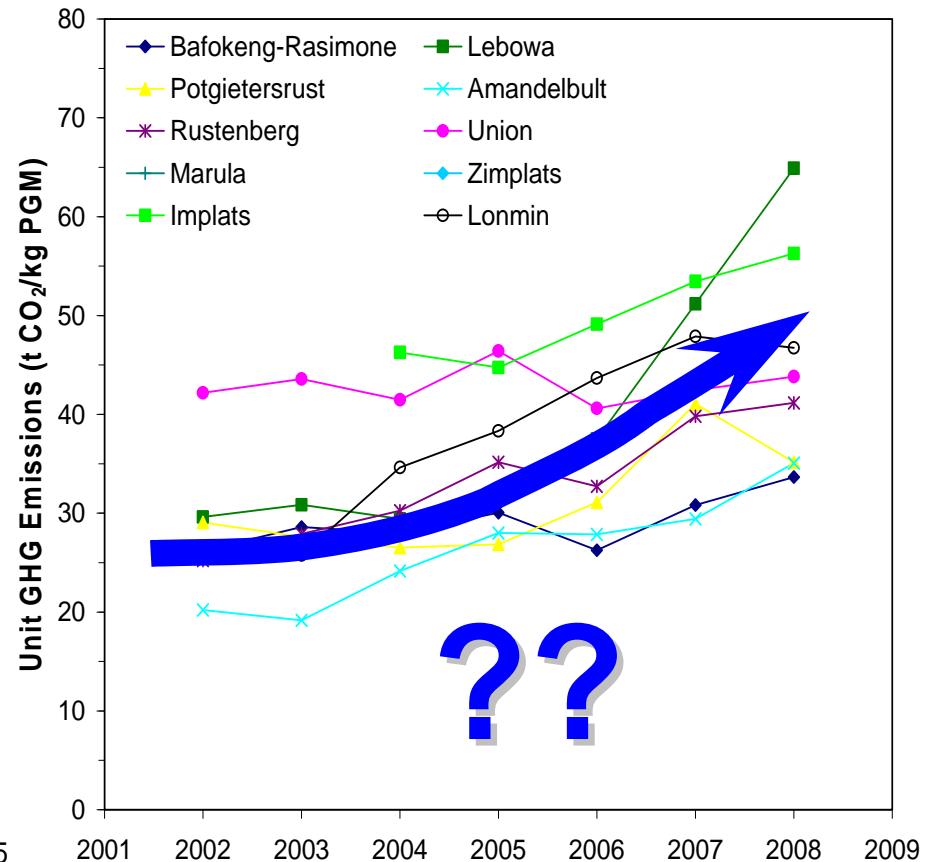
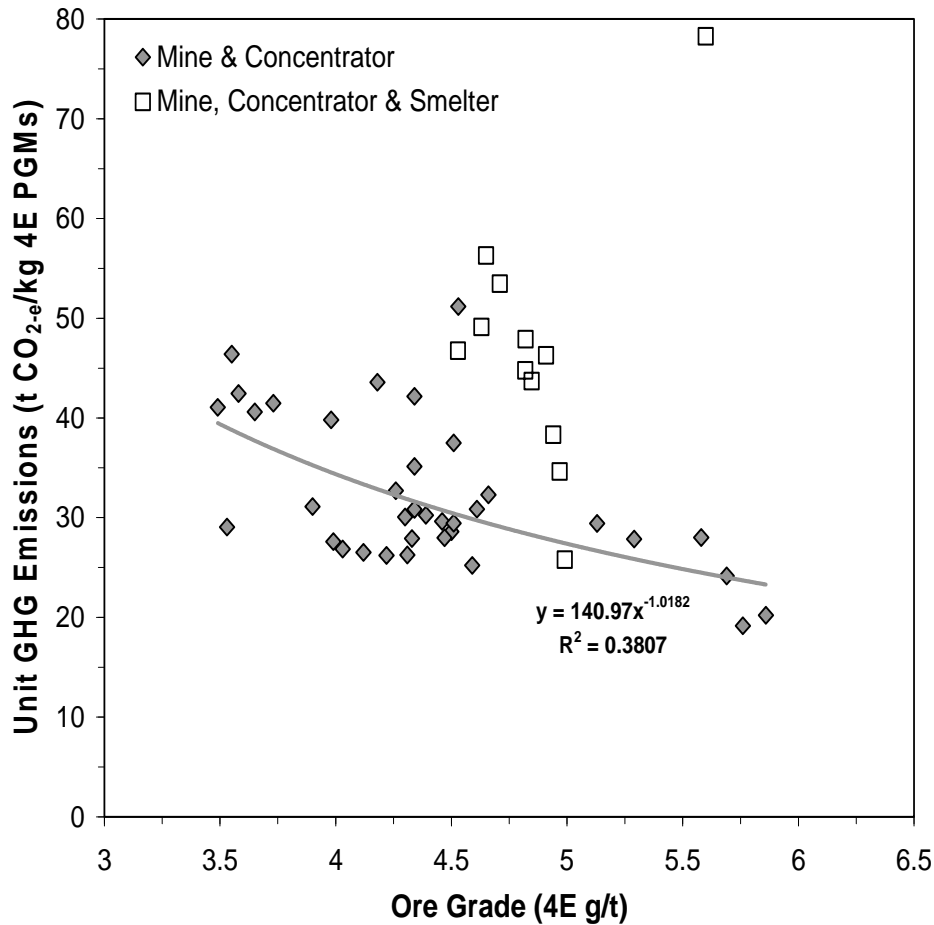
# LtG v Iron Ore ... #2



# LtG v Platinum Group Metals ... #1



# LtG v Platinum Group Metals ... #2



# 'Pearls' of Wisdom ... ??

- Despite its critics, LtG has proven itself against the test of time – basic assumptions have proven reasonable at a global level
- For most minerals substantial economic resources remain (*though some are less certain*)
- The major long-term constraint on mineral resources will be environmental (*or even social*):
  - energy, greenhouse emissions, water, land use, demand, recycling ...



# Acknowledgements

- **Vicky Adin, Assoc. Prof. Carol Boyle & the NZSSES Conference crew**
- **Colleagues in mining research (esp. D Giurco, L Mason, T Prior, S Mohr, various CSIRO folks)**
- **CSIRO Mineral Futures Collaboration Cluster**
- **Numerous papers behind this research**
  - **just email me if interested 😊**