Thesis Proposal/Presentation Content

Thesis Title: Earthquake Fault Mechanics in Sydney Basin: analysis of the Luna Park Fault Zone and

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**Introduction to the Problem**

Despite residing on an intraplate continent, Sydney Basin is a relatively seismically active area known to experience magnitude 5.5 or greater earthquakes, such as the 5.6 magnitude earthquake that hit Newcastle in 1989. During the redevelopment in the early 2000s at the Lucas Heights Nuclear Power Reactor it was discovered that the reactor sits on an ancient fault zone. In order to understand the risks these faults pose to us, we must better understand the various characteristics of these fault zones, and as we have limited understanding of sandstone-hosts of faults, this is a particularly important study. With a focus on the Luna Park Fault Zone that runs across Sydney Harbour, I will aim to characterise this fault zone to determine how all its features interact with one another in order to understand how they influence the frictional strength properties of the faults in sandstone. This will allow for deeper understanding of the hazard associated with these structures right under our feet.

**Background Information**

**Introducing the Greater Area**

The Sydney Basin is a smaller component of the Sydney-Gunnedah basin, sitting in its southern region of a geological structure that dominates New South Wales and extends into Queensland. The Sydney Basin region sits on a passive continental margin, however despite this tectonic stability there is still seismic risk posed to the region, with earthquakes with a magnitude of 5.5 Richter Scale earthquake predicted as occurring every 40 years within this area (Chestnut, 1988). This is a result of X.

Geologically, this basin is classified as a foreland sedimentary basin, meaning that it has developed adjacent to a mountain belt – the blue mountains in this case (?). The age of the basin ranges from Early Permian ( Ma) to Mid Triassic ( Ma), and it is predominantly composed of sedimentary succession with some igneous intrusions and Late Permian ( Ma) coal seams. The rock formations that dominant the particular study area looked at are the Narrabeen Group, Hawkesbury Sandstone and the Wianamatta Group. After these sediments were deposited, during the Late Triassic ( Ma) a tectonically active period meant that there was minor deformation that occurred on the stratified rock, forming faults and joints as well as igneous dykes. The deformed areas highlight structural weak zones, and as such they experienced erosion which formed valleys that with sea-level rise were filled with sediment. As sea level fluctuated, the erosional-sediment-infilling cycle repeated. (lot of this from Och et al 2009 and Och et al 2017).

The early 2000s saw the proposal of the further development of the nuclear reactor at Lucas Heights, and it was during excavation work that they discovered the reactor had been built on ancient fault zones. This raised concern over the stability of the area, as the presence of an active fault zone may mean more movement and risk of earthquakes which threaten infrastructure and human safety. The presence of fault zones means that there are fractures and disconformities that have occurred as a result of the displacement of rock mass. This means that these faults at once stage did move and they highlight a point of mechanical weakness.

Based on the geology of Sydney Basin and the findings of geological investigations, the faults in Sydney Basin are typically sandstone-hosted faults, which means these fault systems are subject to the properties of this rock type. We currently have a more limited understanding of the earthquake mechanics in sandstone-hosted faults, which means that we are not best positioned to measure and give a quantitative assessment of the related hazard posed. The Sydney Basin is a relatively stable area, but with seismic risk already, the presence of these fault zones demand further investigation to ascertain the level of risk

**Previous Work**

With recent development of infrastructure projects, particularly relating to transportation infrastructure and tunnelling, the New South Wales government were forced to investigate the geology of the Sydney Basin to see the structural properties of the rock body the structures will be built on and into. In this investigation, multiple fault zones were identified throughout Sydney Basin, one of these fault zones is the Luna Park Fault Zone.

David Och is the contact we have that worked with Sydney Metro during these geotechnical investigations. He is an experienced advisor when it comes to tunnelling, transportation and other important infrastructural endeavours. In the broader Sydney Harbour study area, David and others have worked to date the fault zones and thermal events (i.e. the dykes), complete ground investigation of the harbour and classify the mineralogy of the fault gauge which enables a compare and contrast between host-rock within and outside of the damage zone of the fault.

**Importance and Potential Impact**

While there has been work on the mineralogy of the fault gauge as well as timing of the events, I want to establish a bigger picture: look have the structural implications of the fault

I am wanting to classify and characterize this fault zone as it has implications on the infrastructure in the Sydney area, as well as great implications for the knowledge of sandstone-hosted fault zones and their associated properties as the research that exists is often in connection to resources (i.e. oil, coal, gas) as there is more finding and a higher demand for information. It is important that we understand the full extent to which the fault zone may affect infrastructure and how stable this fault zone is and behaviourally how it may function with seismic activity.

**My Research Questions**

1. What is the likelihood of the reactivation of these faults?
2. How stable are the faults, the Luna Park Fault Zone in particular?

The goal of my project is to investigate this fault zone. I want to start by determining the fault rock type (sandstone) characteristics, determine the fault zone architecture, see how fluid has interacted with the fault-hosted rock, grain cementations, the deformation mechanisms of the fault zone and the frictional strength properties of the sandstone-hosted faults. Observations will vary from viewing outcrops in the Barangaroo/Luna Park area at the metre to centimetre scale to analytical work done on the samples we have that allow micron to nanoscale observations to be done.

**Methods to Address Research Questions**

Cores have been collected during the Sydney Metro Geotechnical investigations in 2016, and they are now in our possession. At this point in time, the cores have been logged and described in detail and we have begun the process of making thin sections of the fault surface from the cores. The next stage will be to commence the analytical work on the thin sections: x-ray diffraction techniques, raman spectroscopy. I am also hoping to have hyperspectral scanning done on the cores through New South Wales Geoscience’s services to get more specific information gathered from the composition of the sandstone host-rock. The composition of the core will allow us to infer more knowledge from the mineral composition and how they affect the behavior of fluid and mechanical forces and so on.

**Results**

**Chart Flow of Process..?**

**Random bits that may become relevant…**

Because we are talking about a geological basin that hosts a major city of Australia, there was, is and will be further development occurring. It is through these developments that geological surveys must be undertaken, primarily for understanding the engineering implications of the geology to the infrastructures development and maintenance. One of the major aspects of Sydney that a deeper understanding of the geology is required is the transport infrastructure in place, primarily the tunnelling, as there are great structural implications to getting it wrong… Sydney Metro as a result engage with geotechnical firms and consult with geologists in order to understand this, gathering data and producing reports and papers analysing discoveries made as a result of their investigations.