



What do Re-Os ages of sulfide minerals at amphibolite facies mean: resolving syngenetic vs metamorphic ages in an Archean VMS deposit

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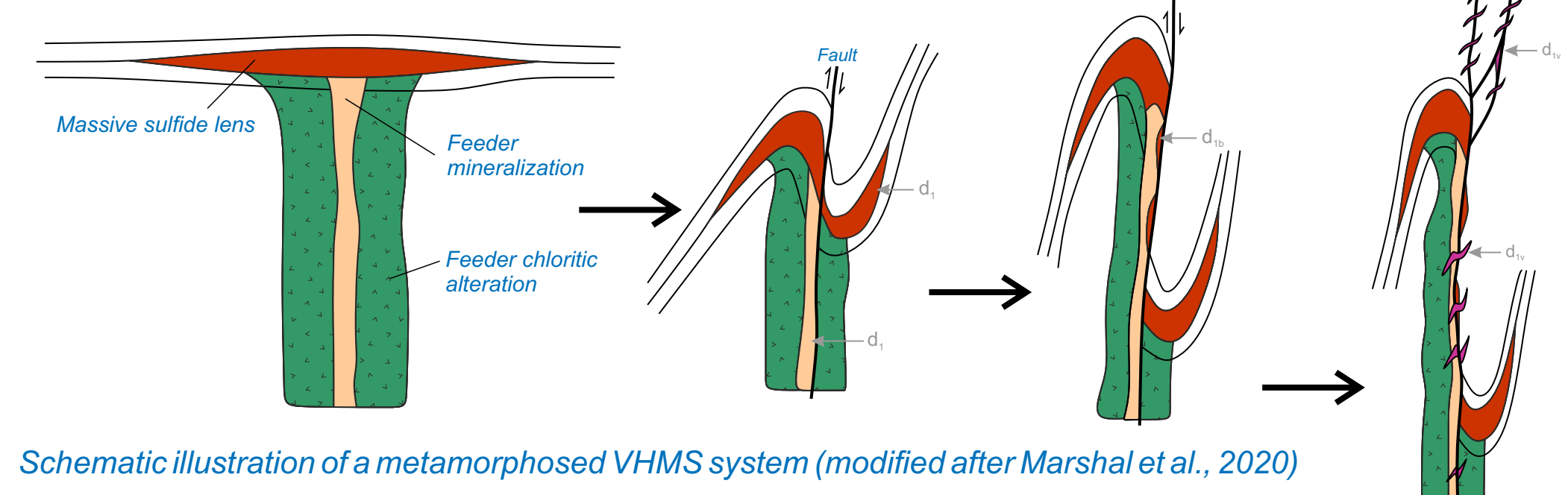
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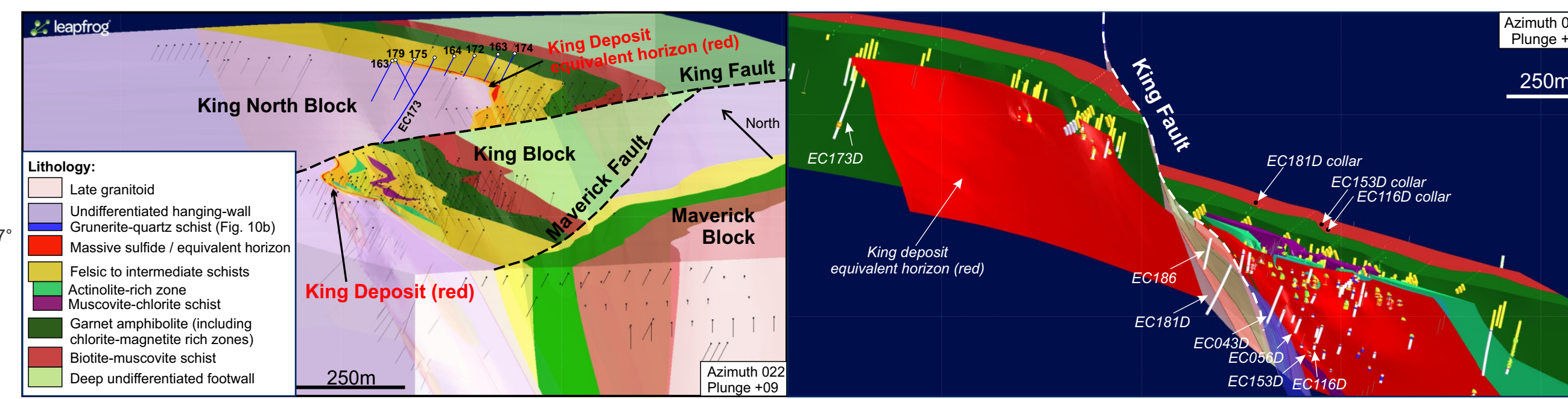
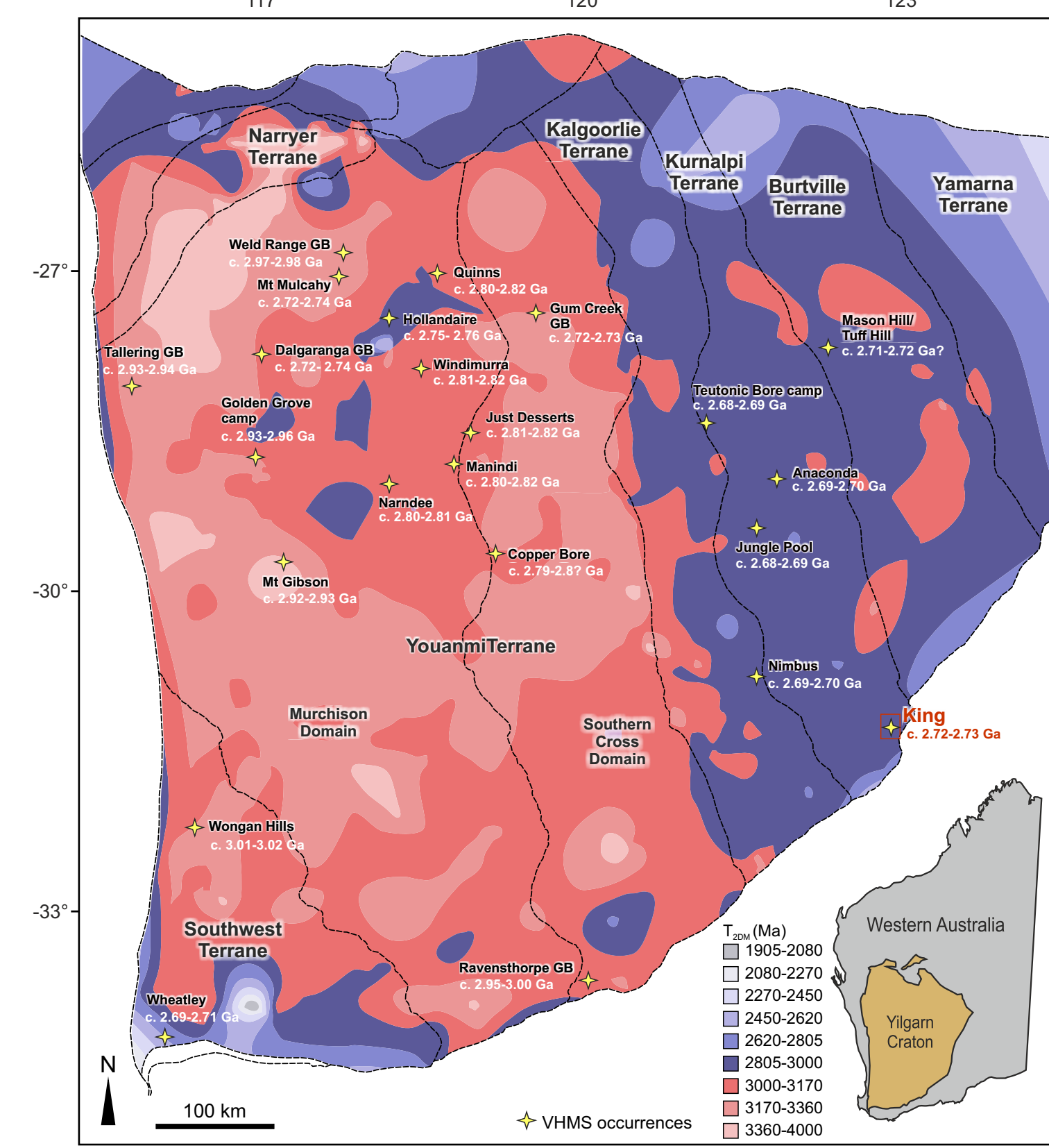
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Introduction

- Determining the age of mineral deposits and their host rock sequences is fundamental for exploration, and is particularly crucial for **syn-genetic stratiform mineral systems**, such as **volcanogenic massive sulfide (VMS) deposits**.
- In Archean cratons, VMS deposits are often affected by multiple metamorphic and deformation events which can **obscure the primary isotopic signatures** of the original deposit and **lead to local metal remobilization**.
- This study employs **multiple geochronological approaches** (U-Pb zircon and titanite; Lu-Hf garnet; Re-Os sulfide and molybdenite; Pb-Pb galena) to **constrain the syn-genetic mineralization age** of the King VMS deposit.

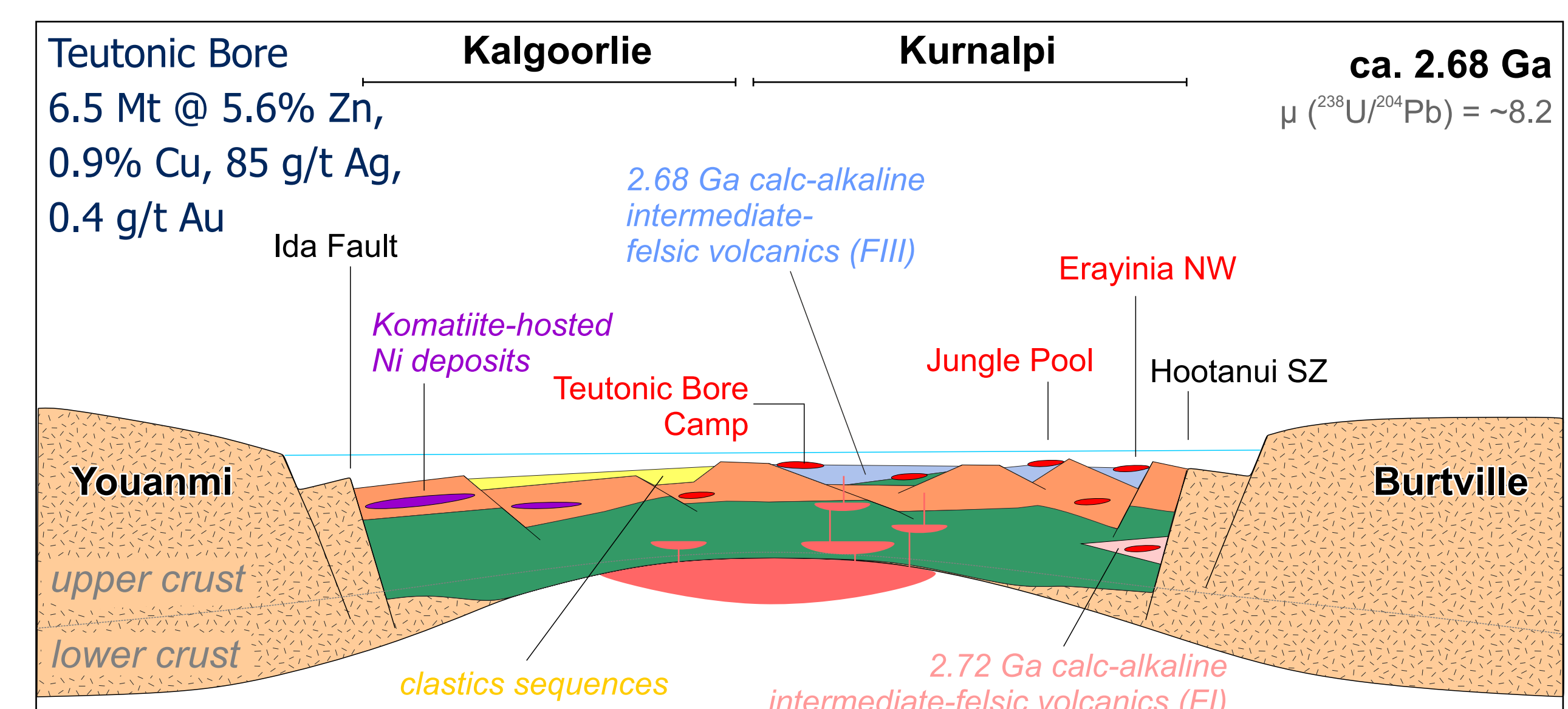
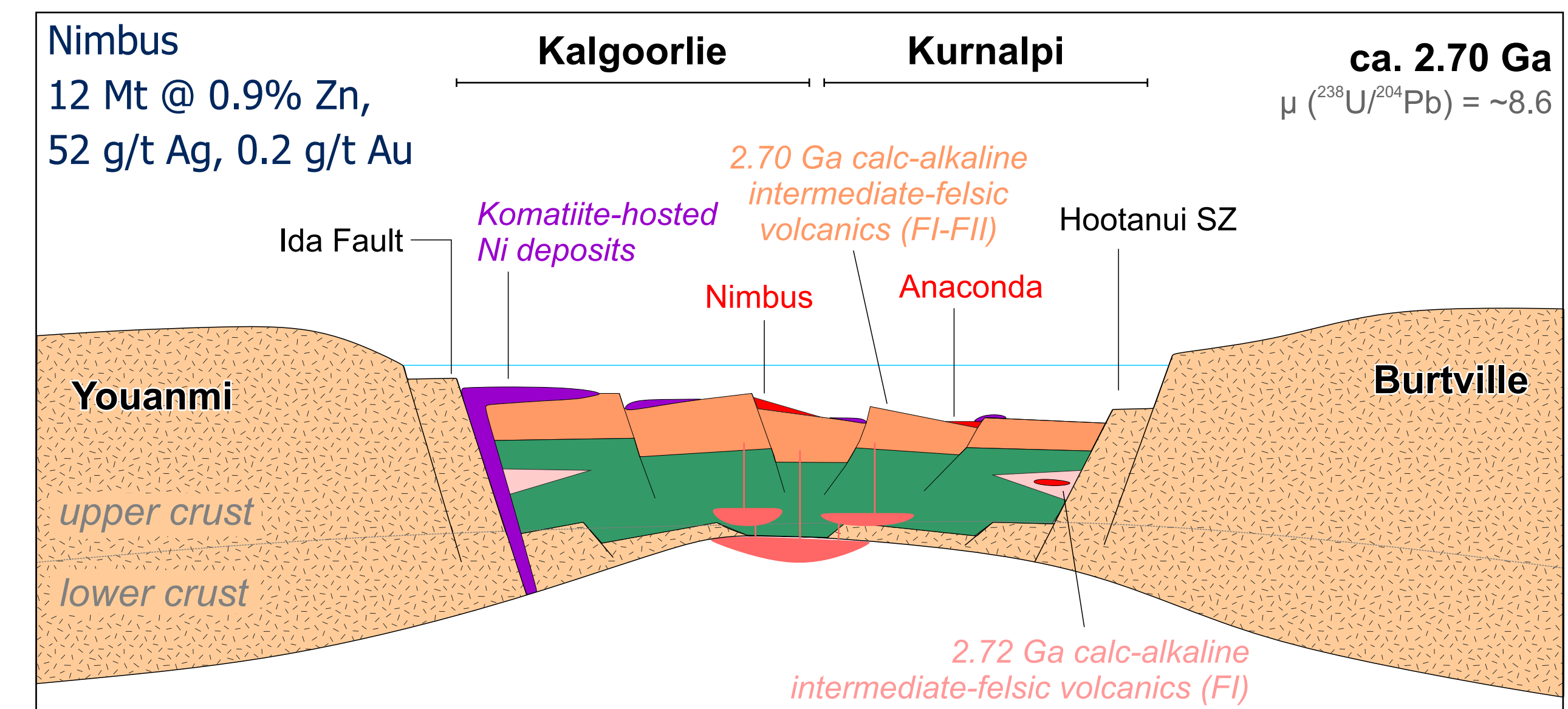
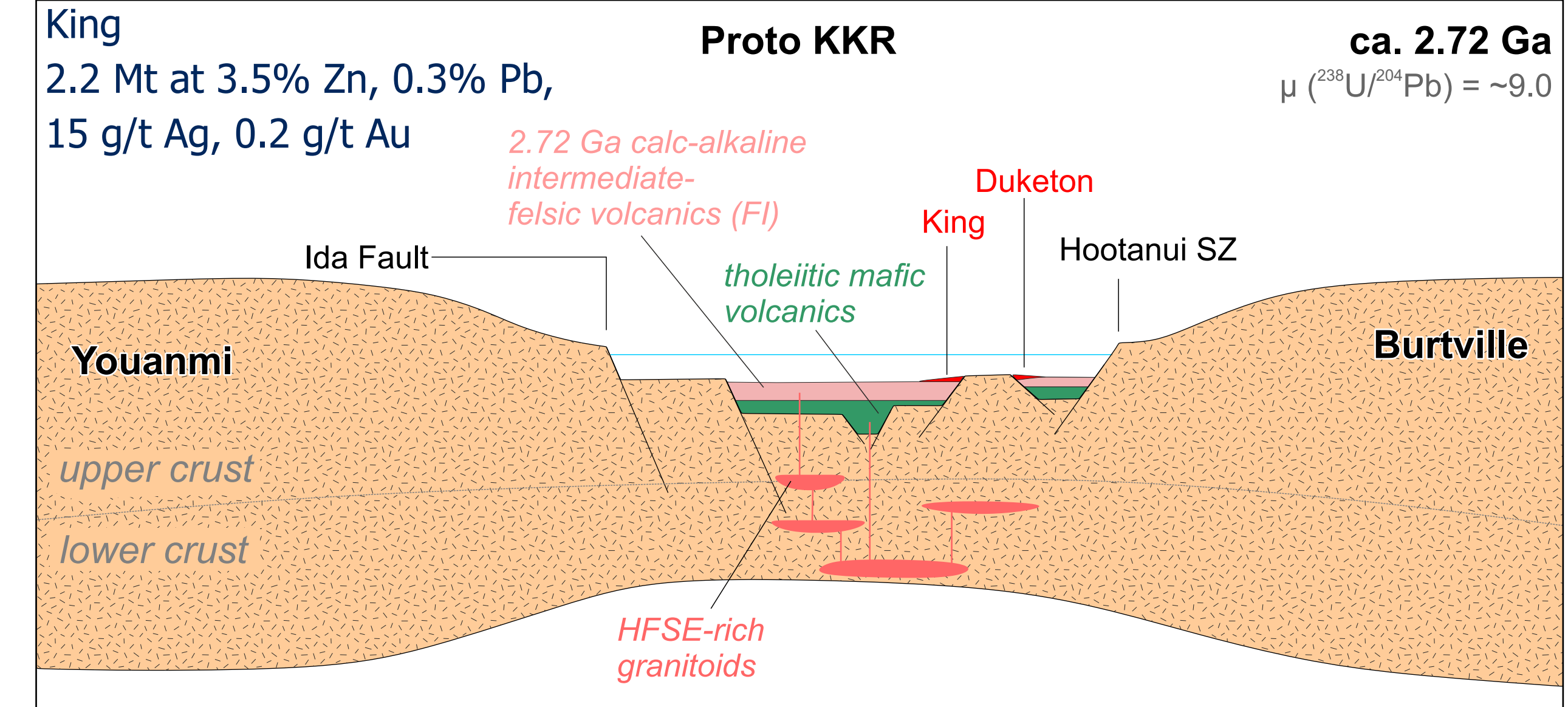


Geological Background



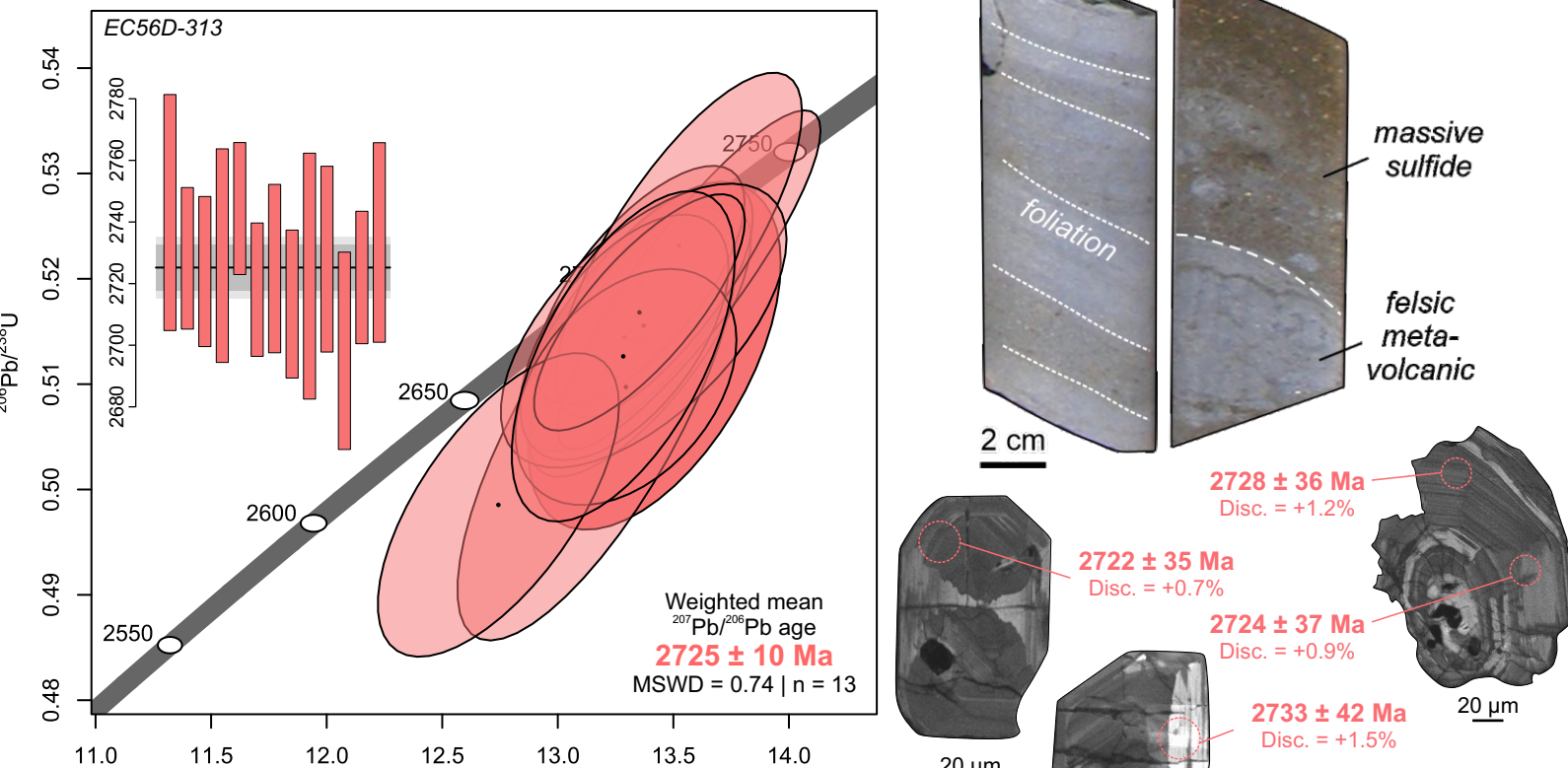
- The occurrences of VMS mineralization are restricted to two main zones of thinned, juvenile crust which are interpreted as **Archean paleo rift zones**:
 - the **Cue zone** of the northern **Youanmi Terrane** and
 - northerly-trending **Kalgoorlie-Kurnalpi Rift (KKR)** zone in the **EGST**
- The King deposit occurs in an **overturned and east-dipping volcanic-dominated rocks**.
- Mineralogical and geochemical data suggested that the **footwall** stratigraphy consists of several **basaltic volcanic rocks** that have been metamorphosed into **garnet amphibolite** and various types of **intermediate-felsic schists** (muscovite-biotite, quartz-chlorite-magnetite, chlorite-muscovite).
- The **hanging wall** sequence is dominated by **mafic** (amphibole±garnet) to **felsic** (quartz±biotite) schists along with **metaexhalite**.

Regional Tectono-Metallogenic Model



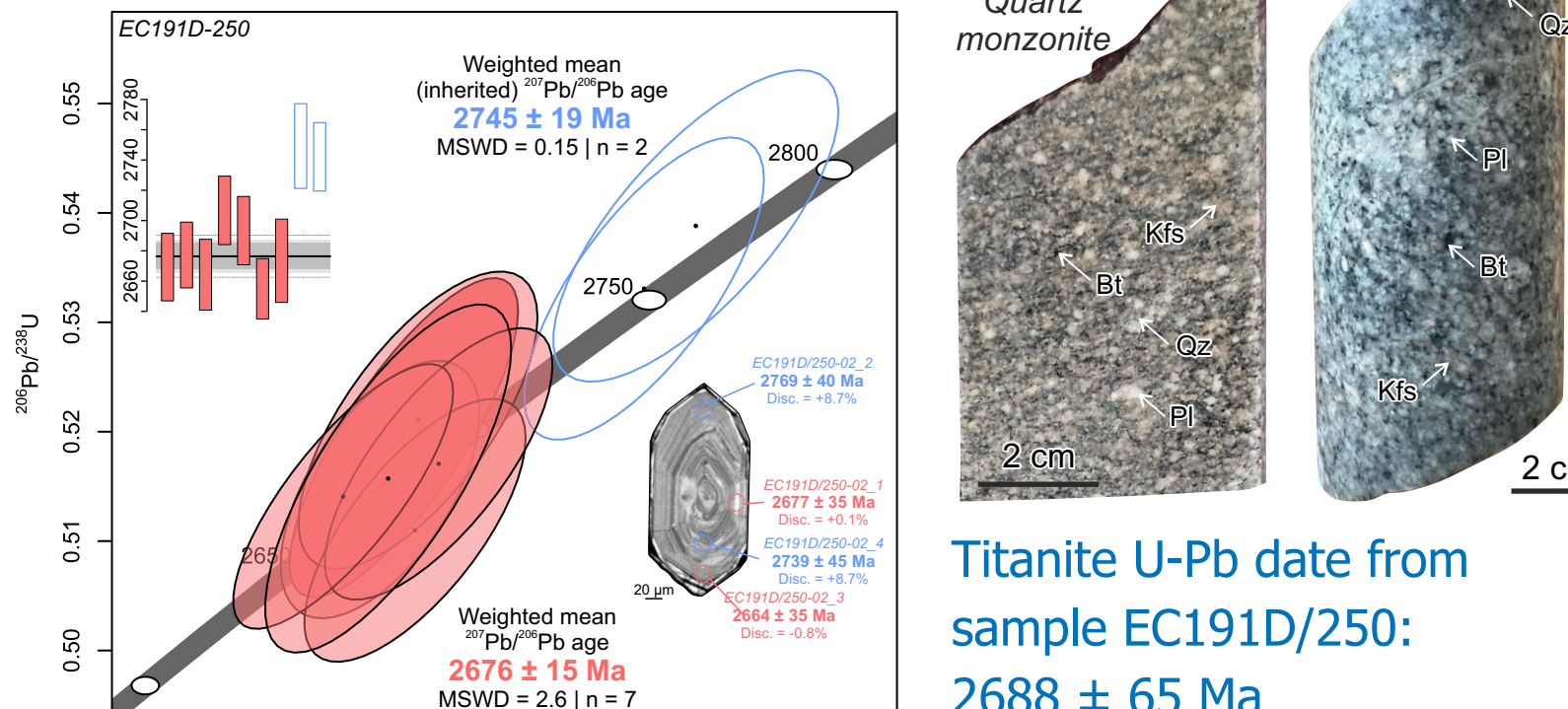
Zircon U-Pb Dates (LA-ICP-MS)

Felsic metavolcanic host rock



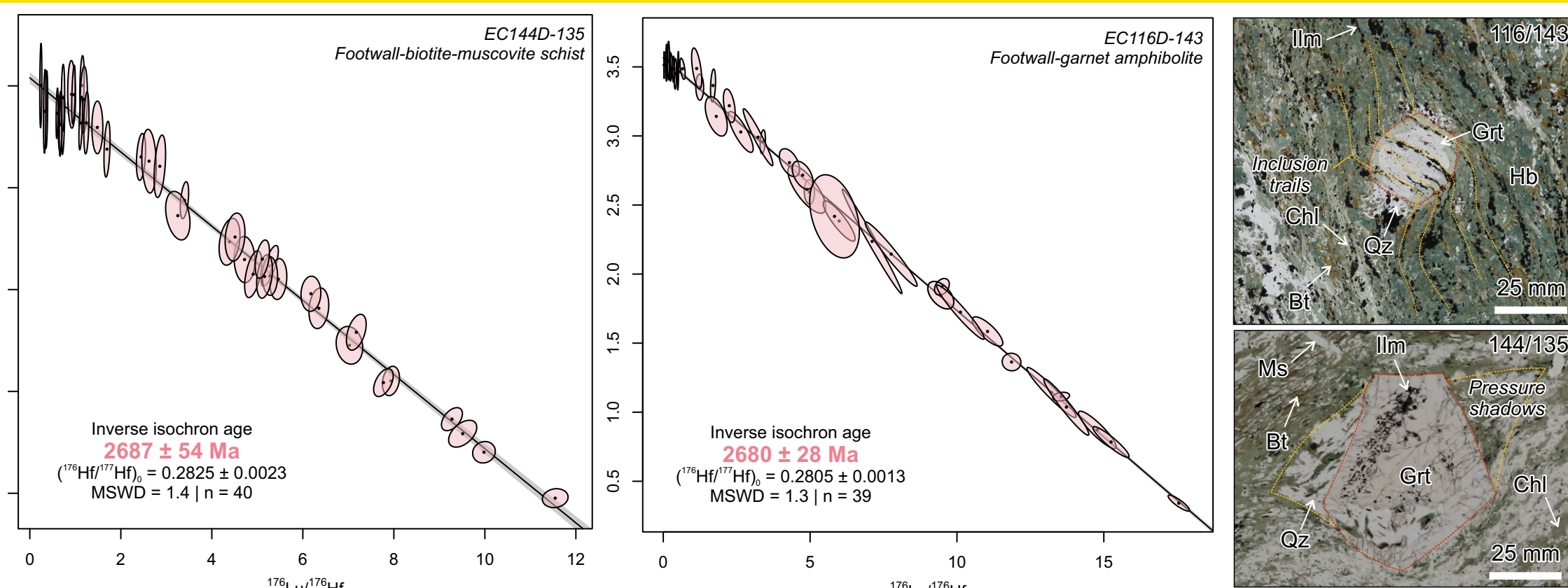
- The **Pb-loss age** was also calculated using the remaining discordant zircon grains and yielded an optimum age of **ca. 270 Ma**.

Late monzonite intrusions



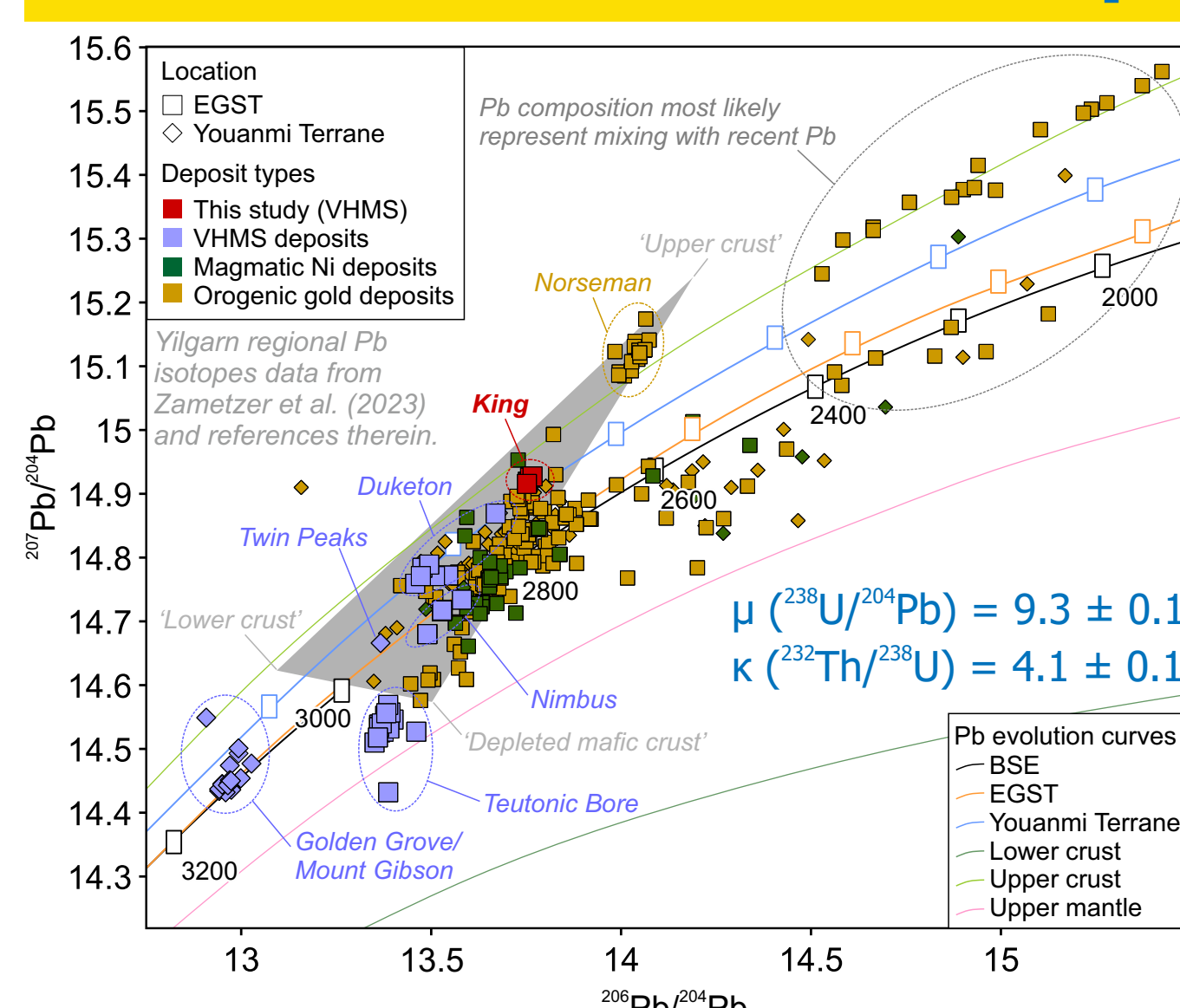
- The granitoid intrusions contain **xenocrystic zircons** (ca. 2745–2738 Ma), most likely from the FW felsic metavolcanic unit.
- The **Pb-loss age** was also calculated and yielded an optimum age of **ca. 1296 Ma**.

in situ Garnet Lu-Hf Dates (LA-ICP-MS/MS)



- Lu concentration of garnet in amphibolite is slightly higher (avg. 7.5 ppm) than biotite-muscovite schist (avg. 2.1 ppm).
- The ages of **amphibolite facies metamorphism** are consistent with the **M2 regional-contact low-P/moderate T metamorphism (ca. 2685–2665 Ma)**.
- The M2 metamorphism is associated with the **emplacement of high-Ca granitoid intrusions**.
- Sample with **more garnet abundance** yielded a **less precise date** due to the dilution of Lu budget.

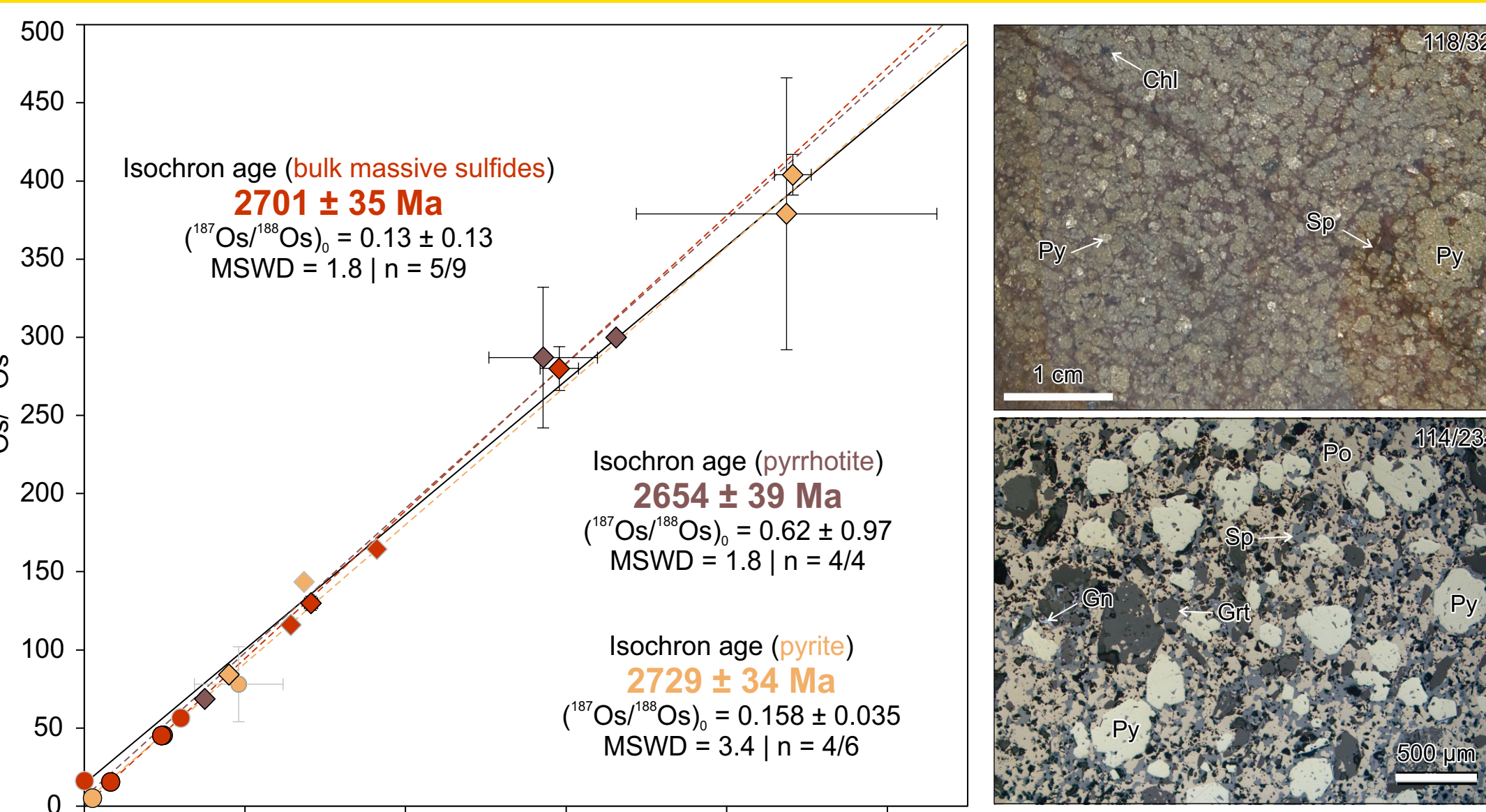
Galena Pb-Pb Isotopes (MC-ICP-MS)



- Six analyzed samples have almost identical lead isotopic ratios:
 - ²⁰⁶Pb/²⁰⁴Pb = 13.75–13.77
 - ²⁰⁷Pb/²⁰⁴Pb = 14.92–14.93
 - ²⁰⁸Pb/²⁰⁴Pb = 14.97–14.98
- Model ages*** range from **2714 ± 23 to 2718 ± 21 Ma**
- Pb isotope signatures from the King deposit are indicative of extensive hydrothermal circulation through **evolved older upper crust**.

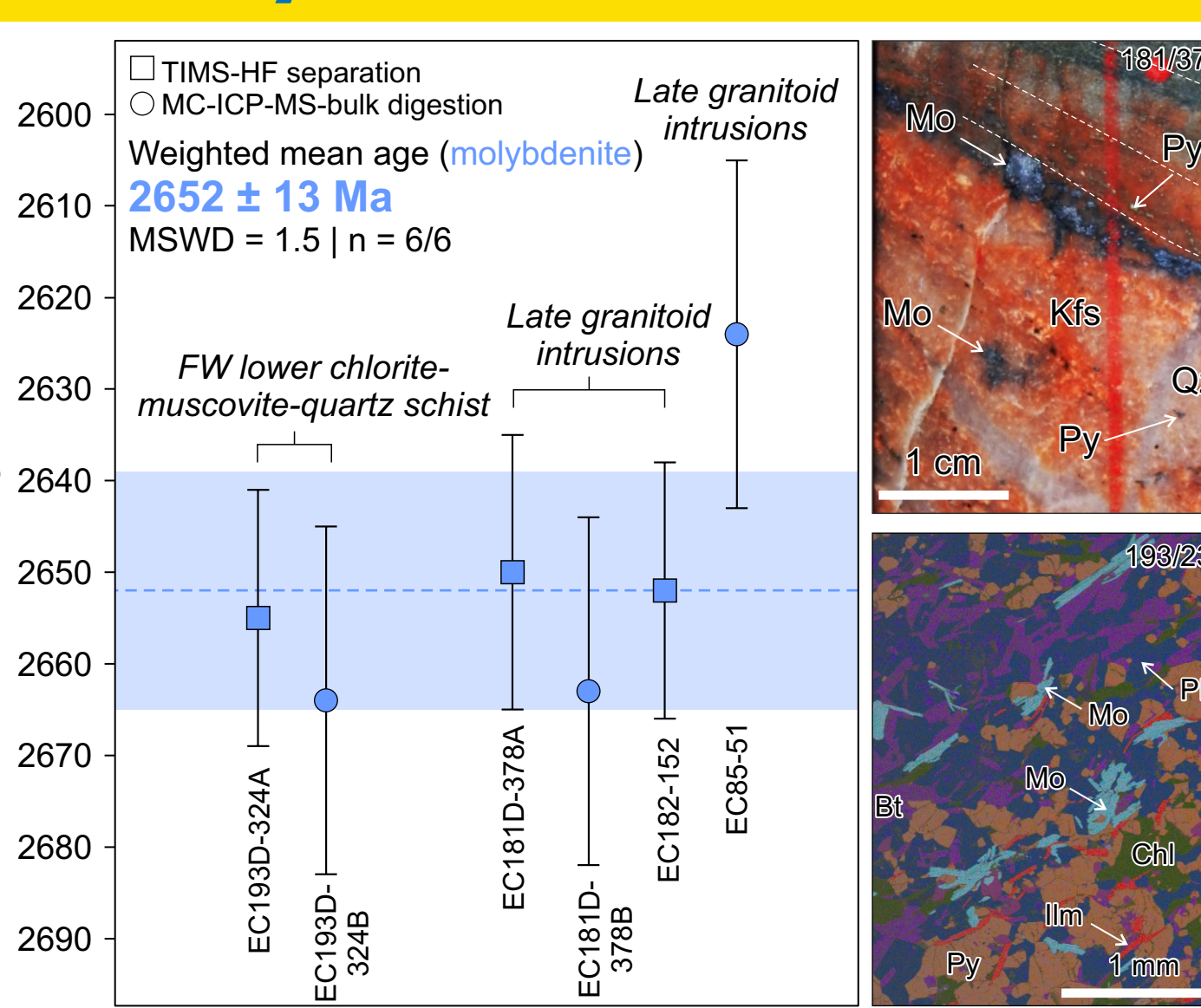
*calculated using Archean sulfide model of Thorpe (1992); 2σ from analytical uncertainty only

Massive Sulfide Re-Os Dates (MC-ICP-MS)



- During **prograde metamorphism**, pyrite not only undergoes recrystallization but also transforms into pyrrhotite through **desulfidation reactions**.
- The **Re-Os age** obtained from **bulk massive sulfide ore**, represents an average between py-po, yielding a **geologically meaningless 'mixed'** isochron age.

Molybdenite Re-Os Dates (ID-N-TIMS)



- The **monzonite intrusions** also host minor **molybdenite** mineralization, either as **disseminated grains** or within **narrow qz-carbonate veins**.
- Rare molybdenite was also identified **along the main foliation** within the **footwall lower felsic volcanic unit**, spatially associated with abundant intrusions of quartz monzonite in drill holes.

Conclusions

- The **King deposit** formed during the **incipient stages of continental rifting process** at **ca. 2.72 Ga** associated with the formation of the **Kalgoorlie-Kurnalpi Rift (KKR)**.
- The **bimodal volcanism** in the EGST was likely **terminated at ca. 2.67 Ga**, which perhaps also marked the switch from **plume to subduction dominated tectonics**.
- This period is also associated with the **peak emplacement of high-Ca granitoids** which also drove the **M2 regional-contact metamorphism**, triggered **local to regional metal remobilization** and the formation of widespread **orogenic gold** mineralization.
- The peak mineralization event for VMS mineralization in the EGST are within the **ca. 2.69–2.68 Ga sequences**.
- Our study demonstrate that **bulk massive sulfide Re-Os dating** is not be applicable in **metamorphosed deposits** particularly those affected by high-grade metamorphism due to **extensive desulfidation of pyrite to pyrrhotite**.

Abstract!

