

## Introduction

The geological origin of gold found in sedimentary placer deposits is poorly understood. A set of 10 alluvial nuggets from the Osa Peninsula, Costa Rica and British Columbia, Canada were supplied by Fernando Barra (University of Chile). This Project was to use Re-Os systematics in these nuggets to distinguish between mantle and crustal sources for the gold. Au, Os and Re are highly siderophile elements, allowing for the assumption that the source of the Os and Re contained in the nugget is likely also the source of the Au.

A.

## Samples

Seven Costa Rican nuggets collected from the Osa Peninsula named after the rivers they were collected from.

- Agujas, Rincon, Tigre, Carate (A,B,C), and Madrigal
- Three British Columbian nuggets collected from Ruby Creek
- Adanac (A,B,C)



Ruler included for scale. Labeled from left to right and top to bottom: Agujas, Adanac C, Adanac B, Adanac A, Rincon, Tigre, Carate C, Carate B, Carate A, and Madrigal.

B.

## Osmium Isotopes as a Proxy for Provenance

- The ratio between Re and Os abundances is very different in the mantle and crust.
  - Average  $^{187}\text{Re}/^{188}\text{Os}$  ratio of 0.4 in the mantle, 50 in the crust.
- $^{187}\text{Os}$ : radiogenic Osmium, derived from the decay of  $^{187}\text{Re}$ .
  - $^{187}\text{Re}$  has a half-life of  $41.6 \times 10^9$  years.
- $^{187}\text{Os}/^{188}\text{Os}$  is useful for determining between Low and High Re/Os source rocks.
  - Low Re/Os:  $^{187}\text{Os}/^{188}\text{Os}$  like the mantle ( $\sim 0.13$ )
  - High Re/Os:  $^{187}\text{Os}/^{188}\text{Os}$  like the crust with time ( $\sim 0.13$ -1)

C.

## Hypotheses

**Hypothesis I: The gold nuggets will have measurable Os and Re.**

**Hypothesis II: The gold nuggets will have a  $^{187}\text{Os}/^{188}\text{Os}$  ratio consistent with derivation from low Re/Os rocks.**

D.

## Methods

- **EPMA**
  - Quantitative measurements of major element concentrations
- **LA-ICP-MS**
  - Qualitative measurements of siderophile element concentrations
- **Solution ICP-MS by Isotope Dilution**
  - Quantitative measurements of siderophile element concentrations
- **TIMS by Isotope Dilution**
  - Measurements of osmium isotopic composition

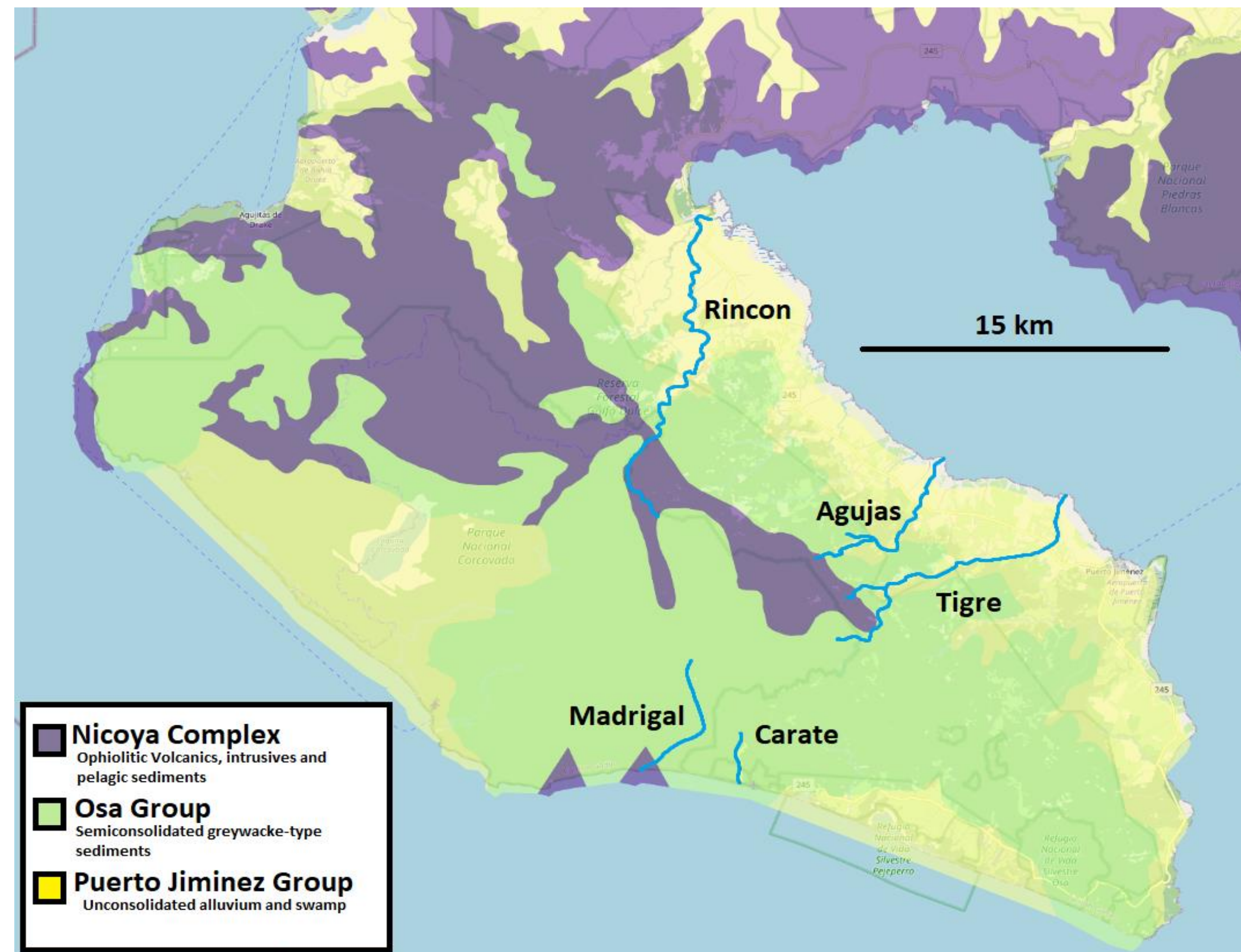
E.

## Geologic Setting: Costa Rica

### Geologic Map of the Osa Peninsula, Costa Rica

- Economic deposits of placer gold have been found in the Osa group (5.33-2.5 Ma) and Puerto Jimenez group (2.5 Ma-present)
- Gold is hypothesized to have originated from the Nicoya Complex Gabbros or Basalts (88.5-33.9 Ma) [1]
- The Nicoya Complex is an ophiolite complex, meaning it contains both crustal oceanic rock and mantle rock, though there are no exposed ultramafic rocks.

- Low  $^{187}\text{Os}/^{188}\text{Os}$  could imply derivation from unexposed peridotites surmised to be present beneath the surface.
- High  $^{187}\text{Os}/^{188}\text{Os}$  could imply derivation from basalts



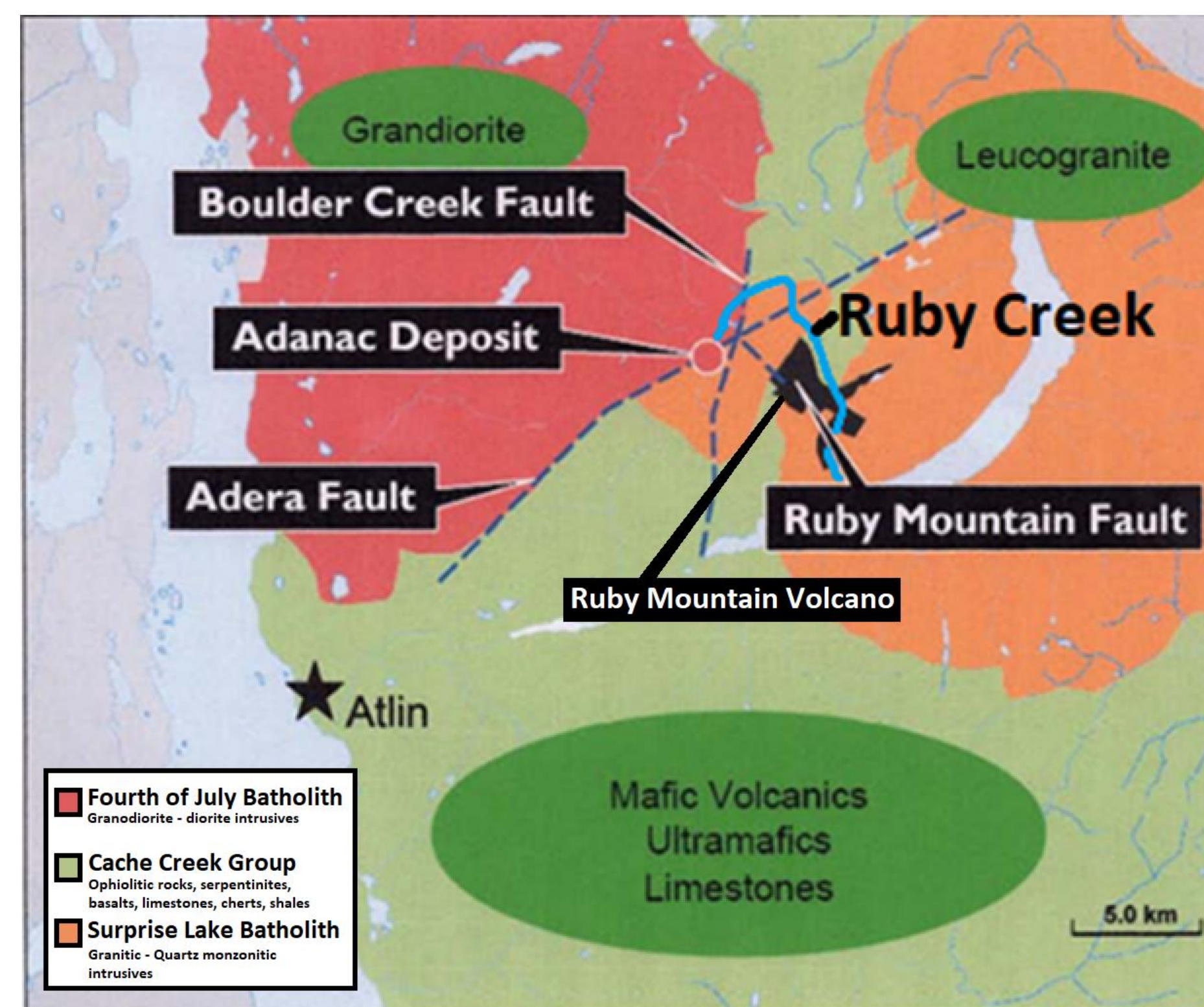
[3]

F.

### Geologic Map of the Atlin Area, British Columbia

- Economic deposits of gold have been found in Ruby Creek.
- Gold is hypothesized to have originated from Surprise Lake Batholith porphyry molybdenum intrusions (100.5-66 Ma) and peridotites from the Cache Creek Group (323-47 Ma)[2].

- Low  $^{187}\text{Os}/^{188}\text{Os}$  would imply derivation from peridotites
- High  $^{187}\text{Os}/^{188}\text{Os}$  would imply derivation from intrusions



[2]

G.

## Results

- Absolute and relative abundances of siderophile elements (Pt, Pd, Ru, Ir) measured in bulk nuggets were highly variable. (ppm - ppt)
- Thin layer enriched with Re and Os on the surface of the nuggets
- $^{187}\text{Os}/^{188}\text{Os}$  ratios measured in 4 Costa Rican nuggets were mantle-like
- $^{187}\text{Os}/^{188}\text{Os}$  ratios measured in 3 Costa Rican nuggets were radiogenic.
- $^{187}\text{Os}/^{188}\text{Os}$  ratios of all Adanac samples were mantle-like

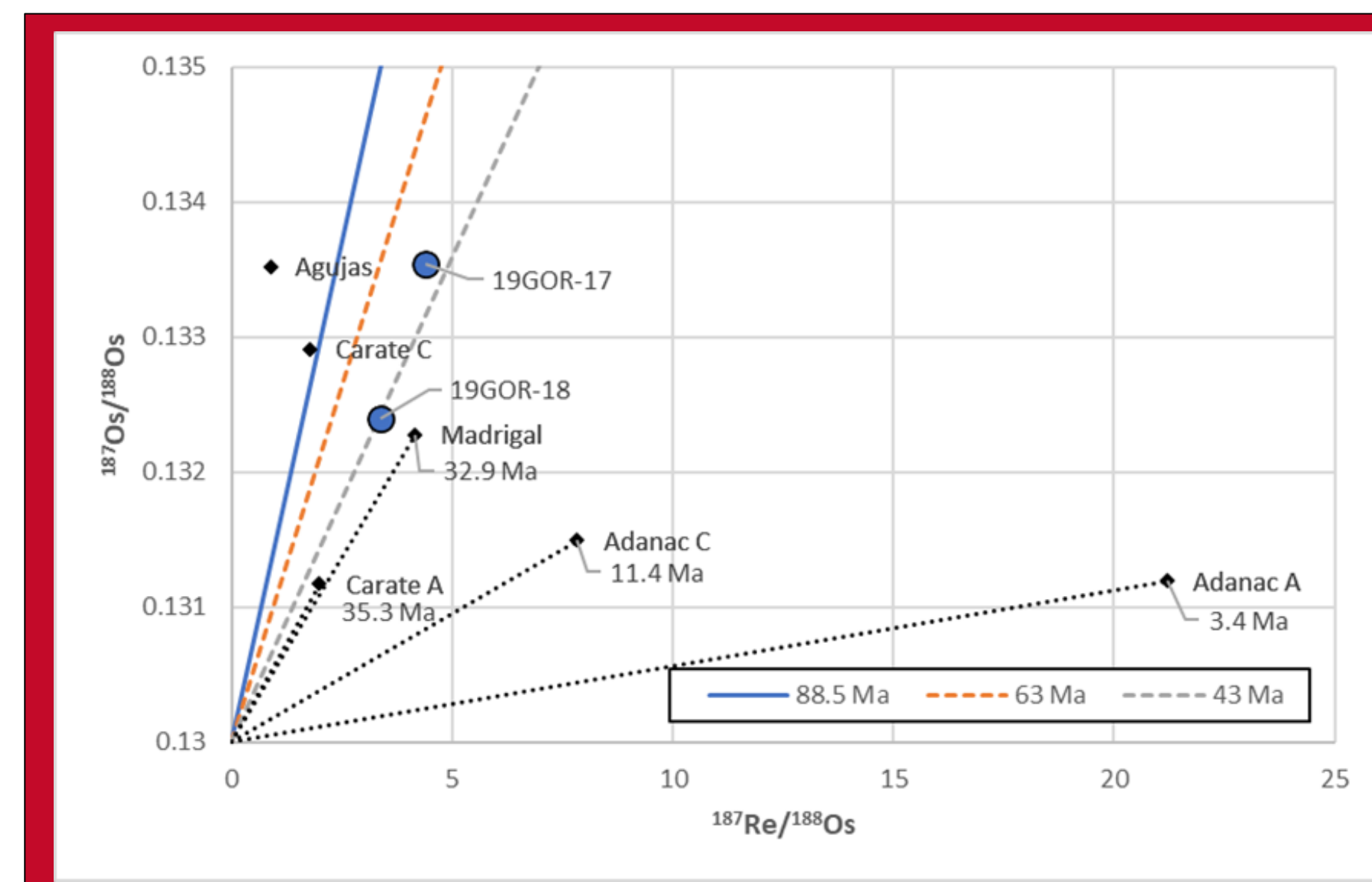
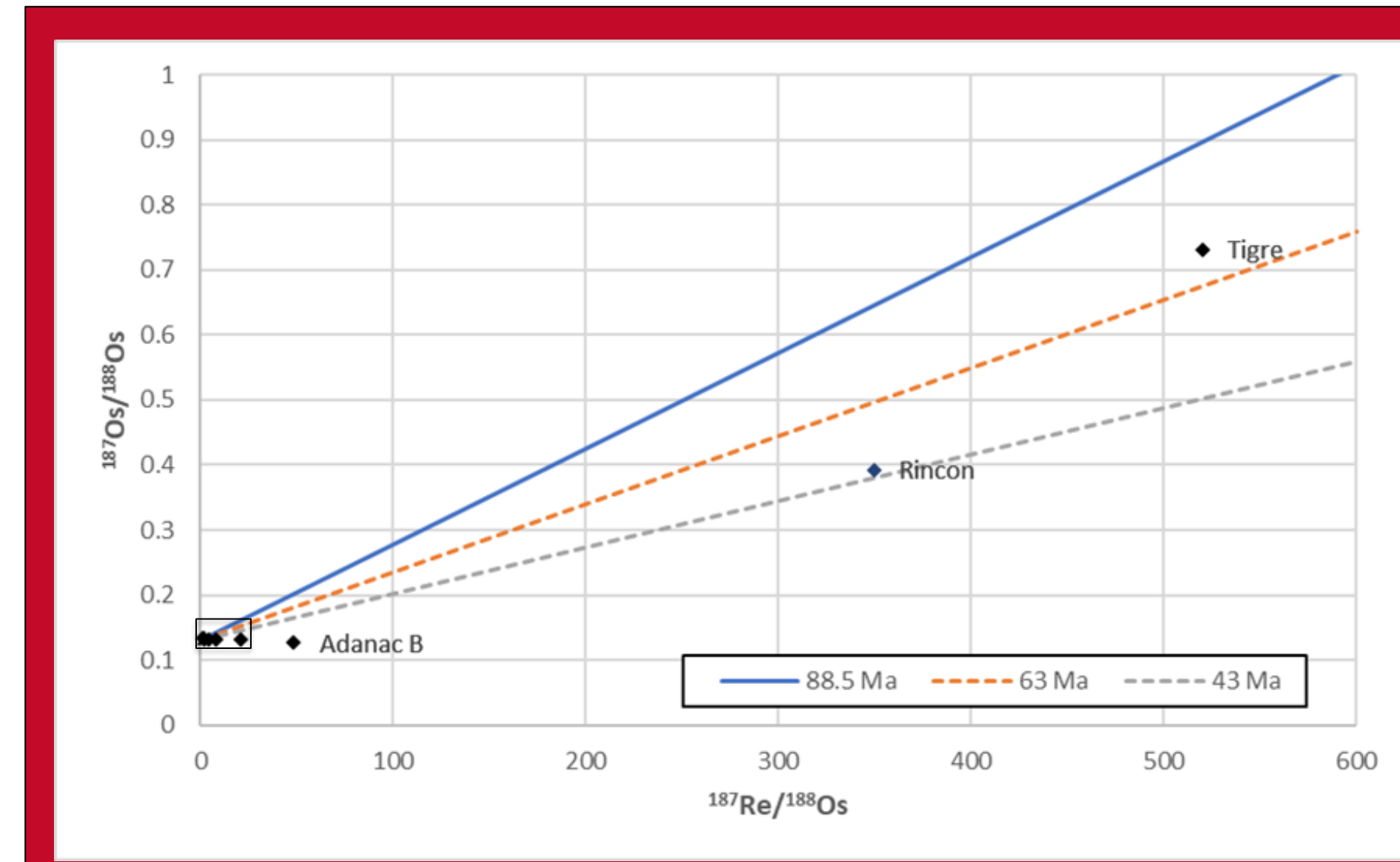
Sample	$^{187}\text{Os}/^{188}\text{Os}$
Madrigal	0.1323
Carate (C)	0.1329
Carate (B)	0.6741
Carate (A)	0.1312
Rincon	0.3927
Tigre	0.7317
Agujas	0.1335
Adanac (C)	0.1315
Adanac (B)	0.1272
Adanac (A)	0.1312

H.

## Discussion

### Reference Re-Os Isochrons

- Re-Os compositions of 4 Costa Rican and all 3 British Columbian nuggets have low Re/Os.
- Low Re/Os nuggets in this study have similar Re-Os to Gorgona Island Gabbros (Gorgona island has a similar age to the Osa peninsula, and more ultramafic Re-Os)
- While Tigre and Rincon have radiogenic ratios, their model ages are well within the age constraints of the Osa peninsula, therefore could have come from a low Re/Os source



*Inset plot (black square in upper figure)*

I.

### Model Ages

- Tigre: 61 Ma
- Rincon: 43 Ma

## Conclusions

- Four Costa Rican nuggets have  $^{187}\text{Os}/^{188}\text{Os}$  ratios indicative of Low Re/Os precursor material, possibly either exposed gabbros or unexposed peridotites in the Nicoya Complex.
- Model ages of Tigre and Rincon are within the age range of the Nicoya Complex ( $\sim 30$ -90 Ma)
  - Tigre and Rincon could plausibly be derived from low Re/Os rocks in the Nicoya Complex.
- The 4 Low Re/Os Costa Rican nuggets are plausibly derived from gabbros in the Nicoya Complex.
- The British Columbian nuggets are consistent with derivation from low Re/Os rocks.
- The British Columbian nuggets are plausibly derived from peridotites in the Cache Creek Group.

J.

## References

- [1] Berrangé, J., & Thorpe, R. (1988). The geology, geochemistry and emplacement of the Cretaceous—Tertiary ophiolitic Nicoya Complex of the Osa Peninsula, southern Costa Rica. Tectonophysics, 147(3-4), 193-220. doi:10.1016/0040-1951(88)90187-4
- [2] Pinsent R. (2006). Surficial Geology Report on the Adanac (Ruby Creek) Property; Atlin Mining Division
- [3] U.S. Geological Survey, 2020, Geology and resource assessment of Costa Rica. (n.d.). Retrieved November 16, 2020, from <https://mrdata.usgs.gov/dds/19/>

K.