## Lower arc crust– A review of some important exhumed crustal sections and xenolith localities from the Americas



## What is arc crust

- Is a continental crustal domain that was significantly altered by invasion of diverse magmas formed at convergent margins above subduction and collisional zones;
- The surface of such a crust is dominated by intense volcanism (subaerial or subaqueous) whereas the shallow to intermediate crust typically comprises composite batholiths;
- The deeper parts of the system are rarely exposed. They represent the focus of this talk.

Next: what is lower crust?



# What is deep crust

- Arc crust can be <20 to >70 km thick, depending on the type and age of the arc; therefore lower crust is a different target from one researcher to another;
- The deep crust is the area where petrologic vestiges of mantle-derived melt are abundant and their diversification, segregation and interaction products with local upper plate are preserved;
- In the examples provided below, paleo-depths are exceeding 20 km.

Next: what to do when exposures are not enough?

# Xenoliths

- Nowhere in the Americas do we know of exposed terrains that are deep enough to truly represent the deep roots of major arcs, the MASH zones transitioning from ultramafic magmatic cumulates to true mantle rocks;
- A few xenolith locations from arc regions may shed additional light on processes within those depth ranges that are not exposed. These rocks unfortunately do not provide geologic context.

Next: brief definition of Cordilleran/Andean magni

# Ages and subduction styles

- Post Rodinia breakup subduction margins of Andean types are common – prior to that, they also may exist;
- To be an Andean margin proper, the arc had to have formed on either a true continental upper plate or within a thinned continental passive margin that must have preceded subduction initiation.
- Next: Outsdanding sites of lower crustal exposures.

## Natural laboratories

- Sierra Valle Fertil a part of the Ordovician Famatinia-Puna arc;
- Salinia a segment of late Cretaceous the California arc;
- Central Gneiss Complex- a deep crustal portion of the Coast Mountains Batholith in British Columbia and SE Alaska;
- Xolapa Complex, southern Mexico
- Skagit gneiss, Pacific NW

## Sierra Valle Fertil, part of the Ordovician Famatinian arc, Argentina

- Short-lived, but regionally important Ordovician arc formed onto the paleo-margin of South America;
- Extensive exposures of mid to lower crust in the Sierra Valle Fertil La Huerta range;
- Documents interactions between primitive, sub-arc magmas and a thick section of passive margin metasedimentary rocks;
- Deepest rocks were 28-30 km below arc surface;
- Not metamorphosed subsequently;
- Fresh, outstanding rock outcrops;
- Logistically easy to work with.











# Salinia, a Late Cretaceous arc section in coastal California

- Part of a displaced terrane in California, bounded by the San Andreas fault;
- Is part of the greater Mesozoic California arc;
- Also short-lived arc section (93-83 Ma);
- Built onto North American passive margin rocks;
- Exposure levels from 20-30 km in the Coast Ridge belt, the deepest section being exposed along the coast.
- Has correlatives in southern California, e.g. the Tehachapi Mts exposures.













Cretaceous Granitoids



Quaternary Cover

Cenozoic Sedimentary Rocks



Framework Gneiss





#### Grimes Pt. px and garnet "charnokite"









#### Salinian Thermobarometry

gray color indicates minimum P&T



- Coast Ridge belt, (Gt-Cpx; Gt-Cpx-Plag-Qtz; Kidder et al, 2003 & Hansen and Stuk, 1993)
- Central block (Gt-Bt, GASP; Kidder, 2004)
- Schist of Sierra de Salinas (Gt-Bt, GMBP; Kidder, 2004)



### The 30 km-deep crust in arcs

- Very weak rocks at the deepest levels of exposure with intermediate compos
- Ortho and paragneisses horizontally layered at ~30 km



Amphibolite to granulite facies terrains High equilibration temperatures ~ 750-850 °C "Adiabatic" PT



## The Coast Mountains Batholith root zone

- Exposures of a partial melting zone that lead to the development of tonalite/granodiorite batholith (Central Gneiss Complex);
- Partial melting of amphibolites and metasedimentary rocks is exceptionally well documented here:
- Escaped melt (batholith above) is preserved to the east in the hanging-wall of a detachment fault













#### Similar to: Skagit gneiss (Gordon et al., 2010)



#### Chelan Complex (Dessimoz et al., 2012)



# Xenoliths

- Best 2 super-deep crustal (>40 km) xenolith suites on Earth are: Miocene Sierra Nevada, CA and Quaternary cone of Mercaderes, Colombia; in addition, a new discovery of interest – Rubicola rocks from southern Peru
- Rocks ranging from granulites, amphibolites, garnet-free pyoxenites, garnet pyroxenites (high Mg and low Mg), amphibole-bearing pyroxenites, garnetites, etc.
- Peridotites are rare in these suites but their pressures of equilibration suggest that they may be intercalated with pyroxenites in the column.













## Conclusions

- 3 exposed terrains of deep crustal arc rocks:
  - - Sierra Valle Fertil, Argentina
  - - Salinia, central California, US
  - Central Gneiss Complex, BC and SE Alaska;
  - -Skagit gneiss, Pacific NW
  - Xolapa Complex, SW Mexico

Xenolith localities from SW USA (Sierra and SW AZ) and Mercaderes, Columbia define the deeper sections not exposed in Cordilleran arcs.