THE EVOLUTION OF THE PAMIR: APPLICATIONS OF MULTI-GEOCHRONOLOGY TO MODERN RIVERS DRAINING THE PAMIR

Fariq Shazanee Mustapha[1], Barbara Carrapa[1], George E. Gehrels[1], Lindsay Schoenbhom[2], Ed Sobel[3] and Mike Cosca[4]

[1]Department of Geosciences, University of Arizona, U.S.A. [2]Department of Geology, University of Toronto, Canada. [3]Department of Geosciences, University of Potsdam, Germany. [4]USGS Denver, U.S.A.

Introduction

The Himalayas-Tibet-Pamir system comprise the highest mountains on Earth, which resulted from a variety of tectonic processes mainly involving Indo-Asia collision ~50 My ago (Fig 2; Najman et al. 2010). The Pamir Mountains lie northwest and west of the Himalayas and the Tibetan Plateau respectively and south of the Tien Shan. Intracontinental subduction (Burtman and Molnar, 1993) and collision with the Tien Shan in the Miocene, have been suggested to play a key role in the tectonic evolution of the Pamir. However, the timing of exhumation and shortening history associated with such or other processes are still largely unresolved. The Pamir are composed of different terranes bounded by Paleozoic and Mesozoic sutures that have affinities with terrane and sutures recognized in Tibet. Two models of terrane correlations have been proposed by Schwab et al. (2004) and Burtman and Molnar (1993) and Robinson et al. (2009). The main goals of this research are: 1) Reassess terrane correlation models by determining the crystallization ages and geochemistry of source rocks via zircon U-Pb geochronology and Lu-Hf geochemistry (in process) of modern river sand samples derived from the Eastern Pamir and by comparing the new data with existing data from the Western Pamir. 2) To characterize the exhumation age of hinterland rocks within the Pamir via $^{40}Ar/^{39}Ar$ on detrital white micas from modern rivers in order to better understand the relationships between the Pamir and Tibet and the tectonic evolution of the region. We are also trying to understand the Pamir post-collisional geology by resolving the cooling ages across the Pamir.

Previous Studies

- Schwab et al. (2004):
  - Correlate the Northern Pamir to Songpan-Ganzi, Central Pamir to Qiangtang and the the Southern Pamir to Lhasa based on the geologic structures and geochemistry of magmatic belts in the Pamir-Tibet orogen (Fig.1).
- Robinson et al. (2009) and Burtman and Molnar, (1993):
  - Correlate the Jinsha suture in Tibet with the Rushan-Pshart zone in the Pamir and the Banggong suture in Tibet with Shyok suture in the Pamir based on the extent of Karakorum fault (Fig.1).

Methods

Detrital Zircon U-Pb geochronology and white mica $^{40}Ar/^{39}Ar$ were performed on sand river samples from the Eastern Pamir near Muji, Oytag and Tashkorgan (Fig.2).

- U-Pb geochronology of zircon provides the crystallization age of the mineral, based on the time at which the mineral passed through its 1000°C isotherm (~30 km).
- $^{40}Ar/^{39}Ar$ thermochronology of white mica provides the thermal history of the mineral, based on the time at which white mica passed through the ca.350°C isotherm (~11 km).

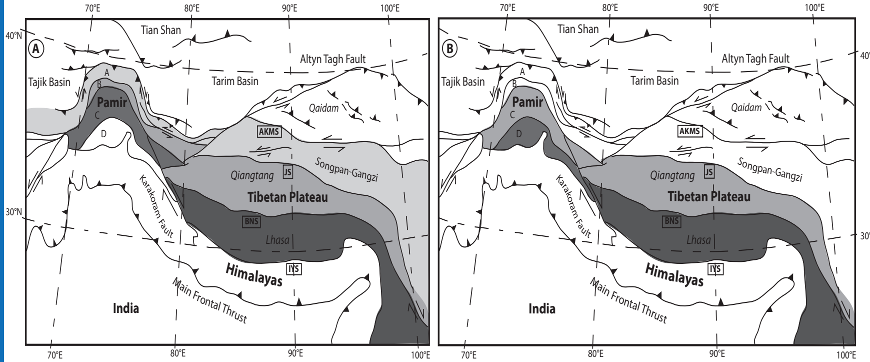

Figure 1: Compilation of simplified tectonic map of the Indo-Asian collision zone showing major active structures and suture zones (after Burtman and Molnar, 1993; Yin and Harrison, 2000). 1(A): Terrane correlations after Schwab et al. 2004; 1(B): Terrane correlations after Robinson et al. 2007. (MPT - Main Pamir Thrust; IYS - Indus-Yarlung suture; BNS- Bangong-Nujiang suture; JS -Jinsha suture; AKMS - Ayimaqin-Kunlun-Muztagh suture. Terranes of western Indo-Asian collision zone are: A - Northern Pamir; B - Central Pamir; C - Southern Pamir-Karakorum-Hindu Kush; D - Kohistan arc)

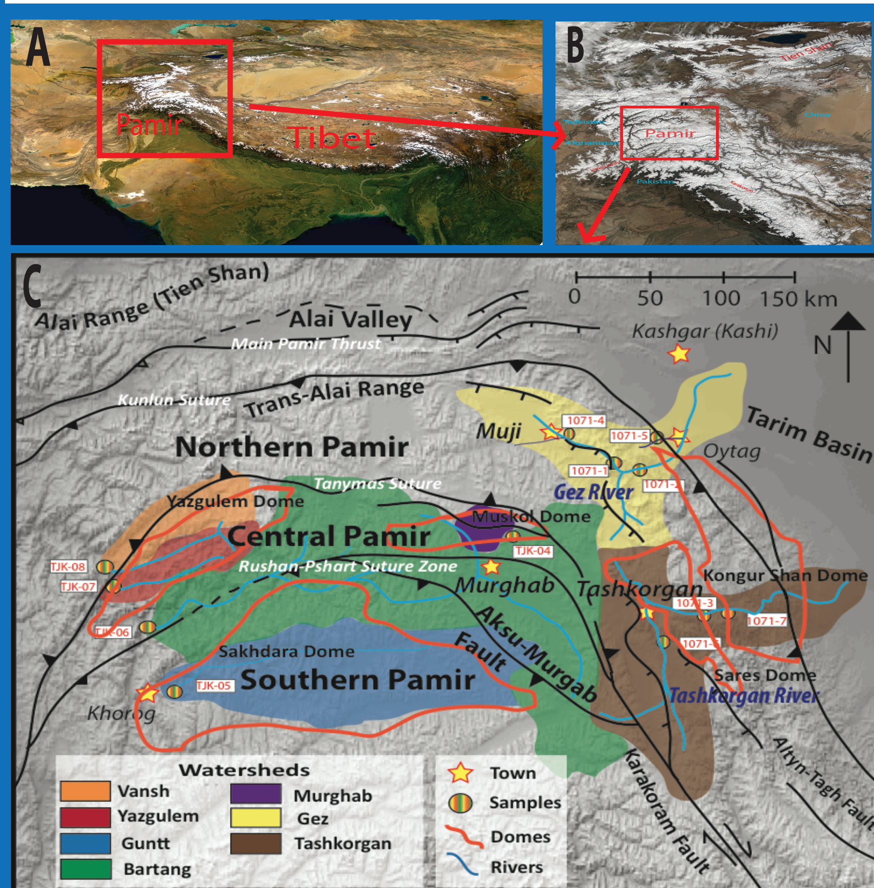

Figure 2: a) Location Himalayas-Tibet-Pamir system **b)** Satelite images of the Pamir (Courtesy of NASA/ GSFC MODIS rapid response) **c)** Sample locations in the Pamir (Lukens et al.2010 and this study).

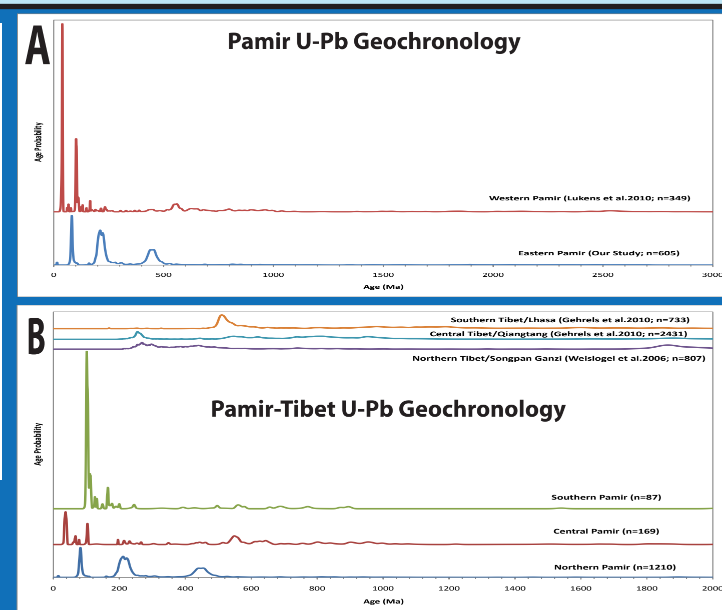

Figure 3: Age probability plots for **a)** U-Pb ages for Eastern and Western Pamir **b)** U-Pb ages between Pamir and Tibet.

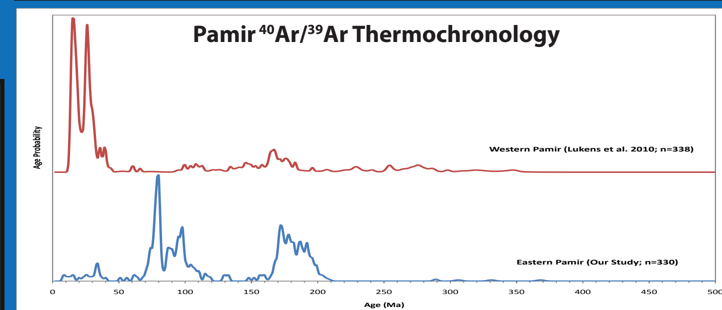

Figure 4: Age probability plots for $^{40}Ar/^{39}Ar$ showing the cooling ages for Eastern and Western Pamir.

U-Pb Data

- Western Pamir yield younger ages (<200 Ma) than the Eastern Pamir (>200Ma).
- Similar detrital patterns between the Northern Pamir and Songpan-Ganzi.
- Cental Pamir detrital signals follow closely to that of Qiangtang.
- A strong Cenozoic signal is observed in the Pamir .

$^{40}Ar/^{39}Ar$ Data

- $^{40}Ar/^{39}Ar$ ages from the Western Pamir (early Miocene) are generally younger than the observed Eastern Pamir ages (Cretaceous and Jurassic).
- Bigger age spread in the Western Pamir as opposed to its Eastern counterpart.

Conclusions

U-Pb

- U-Pb ages on zircons suggest (Fig.3a & 3b):
  - **Northern Pamir --> Northern Tibet/Songpan-Ganzi**
  - **Central Pamir --> Central Tibet/Qiangtang.**
- This supports the correlation made by Schwab et al.2004 (Figure 2a).
- No cenozoic ages in Tibet suggest a different tectonic history between the two.

$^{40}Ar/^{39}Ar$

- $^{40}Ar/^{39}Ar$ ages (Fig.4) are younger and much more widespread in the Western Pamir.
- Our $^{40}Ar/^{39}Ar$ ages indicates a different cooling history between the Eastern and Western Pamir probably related to focused and higher magnitude exhumation of the Domes in the West.

References

1) Burtman, V.S. & Molnar, P.: Geological and Geophysical Evidence for Deep Subduction of Continental Crust Beneath the Pamir. 76 p.; Special Paper 281; Geological Society of America, Boulder, 1993.
2) Lukens, C.E., Carrapa, B., Singer, B.S., Gehrels, G. (2010), Miocene exhumation of the Pamir revealed by detrital minerals of Tajik rivers; submitted.
3)Najman, Y., Appel, E., Boudagher-Fadel, M., Bown, P, Carter, A., Garzanti, E, Godin, L, Han, J., Oliver, G., Parrish, R., Vezzoli, G. 2010. Timing of India-Asia collision: Geological, biostratigraphic, and palaeomagnetic constraints, J. Geophys. Res., 115, B12416, doi:10.1029/2010JB007673
4) Robinson, A. C. (2009), Geologic offsets across the northern Karakorum fault: Implications for its role and terrane correlations in the western Himalayan-Tibetan orogen. Earth Planet. Sci. Lett. 279, 123-130.
5) Schwab, M., et al. (2004), Assembly of the Pamirs: Age and origin of magmatic belts from the southern Tien Shan to the southern Pamirs and their relation to Tibet, Tectonics, 23(4).