Dating the slab-window formation induced by Cocos Ridge subduction in SE Costa Rica

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Johnston and Thorkelson (1997) proposed the formation of a slab-window beneath NW Panama by subduction of Cocos-Nazca spreading ridge segments. We present new geochemical and isotopic evidence from SE Costa Rica that substantiate a slab-window hypothesis. However, age relations and structural observations indicate that a slab-window has formed most likely as a consequence of Cocos Ridge subduction.

Collision of the aseismic Cocos Ridge with the Central American arc system has dramatic effects on the respective part of the arc [e.g. Kolarsky *et al.* 1995]. One of these corollaries is a propagating slab break-off which has a major influence on magma sources and subduction zone geometry.

New geochemical and isotope data from magmatic rocks of the Cordillera de Talamanca area in SE Costa Rica give evidence that the Galapagos plume mantle modifies the sub-Costa Rican mantle source. The formation of a slab-window underneath SE Costa Rica and NW Panama facilitated migration of asthenospheric material from the Pacific into the Caribbean realm.

If true, a time dependent evolution of the plume signal in the Central American arc source should then be observed. Comparisons between pre- and post-collisional magmatic rock series of the Cordillera de Talamanca should directly point out to major changes in the sources of the respective magmatic rocks.

Geochemistry and isotopes

Older series (arc-tholeiitic and calc-alkalic) of that region derive their trace element and isotope pattern from a depleted mantle source, modified by subducted sediments (Nb/Zr: 0.03–0.09, Ba/La: 20–134, $^{87}Sr/^{86}Sr$: 0.7036–0.7042, $^{143}Nd/^{144}Nd$: 0.51300–0.51304, $^{206}Pb/^{204}Pb$: 18.72–18.87). Their source is comparable to that of the northern end of the Central American arc system.

At about 5 Ma the Cocos Ridge collided with the Central American arc [de Boer *et al.* 1995]. Since then, several major changes in space and time are observed: (1) Volcanism ceased in the main arc. (2) Alkalic back arc volcanism occurred with typical enriched OIB character (Nb/Zr: 0.17–0.46, $^{143}Nd/^{144}Nd$: 0.51297–0.51298, $^{206}Pb/^{204}Pb$: 19.06–19.12. These magmas are lacking a subduction component (Ba/La: 13–19, $^{87}Sr/^{86}Sr$: 0.7035–0.7036). (3) At about 2–3 Ma adakitic magmas erupted in a few locations of the Cordillera de Talamanca. (4) An enriched OIB component is found in the source of lavas of the active arc extending from Costa Rica in the south towards southern Nicaragua in the north [Leeman and Carr, 1995]. (5) The enriched OIB source component is identified by its isotope signature (Sr, Nd, Pb) to represent the OIB plume of the Galapagos Islands/ Cocos Ridge.

Ages

$^{40}Ar/^{39}Ar$ furnace step heating and single crystal laser fusion age dating was performed on mineral separates of samples from the Talamanca area. For the back arc alkalic rock suites, we present new data and additional literature data [Bellon and Tournon 1978] in Fig. 1. The data identify a north-westward younging of alkalic back arc rocks in Costa Rica.

Conclusions

These observations are consistent with a model of slab-window formation and its north-westward propagation following Cocos Ridge collision.

The occurrence of alkalic magmas in the Costa Rican back arc marks the margin of the evolving slab window. A temporal and spatial association of mafic alkalic volcanism with slab-window formation was also found in British Columbia, northern Baja California and the Antarctic Peninsula [Hole *et al.* 1991].

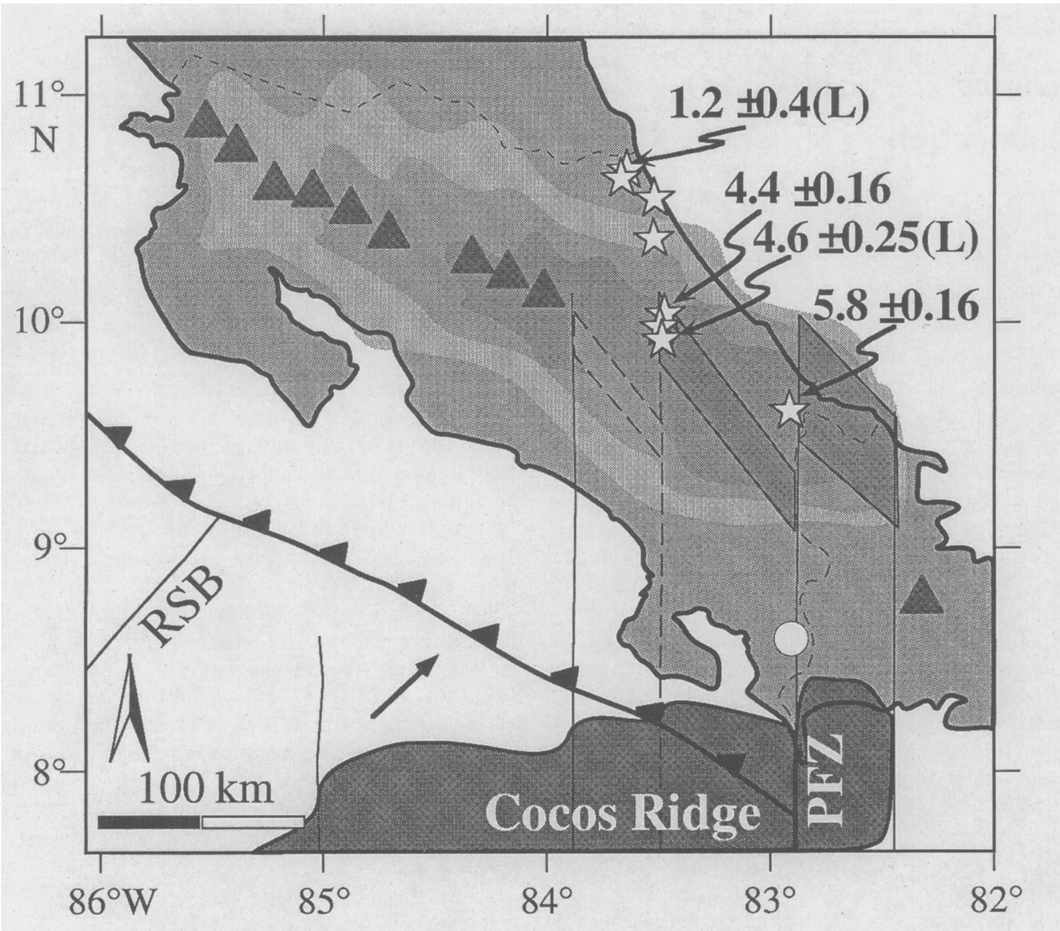

FIG. 1. Costa Rica subduction zone at the initiation of Cocos Ridge collision. A slab window is developing behind the subducted Cocos Ridge. Asterisks indicate alkalic back arc magmas, the circle indicates an alkalic lamprophyr. The back arc suites are labelled with the new $^{40}Ar/^{39}Ar$ ages (in Ma) and K-Ar ages from the literature, respectively. (L) signifies literature data [Bellon and Tournon, 1978]. Large triangles mark volcanoes of the active arc.

The slab-window leads to contamination of the Central American mantle wedge by a Galapagos plume component. North-westward propagation of this slab-window enhances lateral migration of this contaminant over time.

Generation of adakites at fast converging subduction zones like in Central America is unusual, even though the subducted plate, in particular the Cocos Ridge, is young. However, in this scenario partial melting of the shallow subducted Cocos Ridge occurs due to superposition of young Cocos Ridge crust and hot incoming asthenospheric mantle.

References

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