Asian monsoon circulation strength inferred from multicentury tree-ring stable isotope chronologies from southeast Asia

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The large-scale dynamic circulation of the Asian monsoon over the last several centuries can be inferred from the oxygen isotope ratios of the annual rings of long-lived tropical conifer species from southeast Asia. Here, we present replicated, multicentury stable isotope series from Fokienia hodginsii growing in the Bidoup Nui Ba National Park site in the southern highlands of Vietnam. This isotope chronology is significantly negatively correlated with summer monsoon surface wind speeds over the Bay of Bengal and the adjacent region, indicating that stronger (weaker) onshore winds are associated with lower (higher) oxygen isotope values. Ring width and isotopes show particular coherence at multidecadal time scales, and together allow past precipitation amount and circulation strength to be disentangled. Estimates of the strength of past monsoon circulation provide data for validating general circulation model simulations of the response of the Asian monsoon to changes in radiative forcing and an independent estimate against which to evaluate long-term changes in the Asian monsoon as reflected in other terrestrial and marine proxies as well as forced last millennium general circulation model simulations.

Duration of prograde metamorphism in the inverted Barrovian sequence, Sikim Himalaya, India

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The Lesser Himalaya in Sikkim expose a uniquely well preserved Barrovian metasedimentary sequence that displays little tectonic disturbance and is inverted in terms of both pressure and temperature. The sequence seems to be continous from chlorite-biotite grade until muscovite dehydration reaction with well developed all intermediate zones inbetween.

We determined timing and duration of Barrovian metamorphism by Lu-Hf garnet dating of all individual Barrow zones from garnet isograd up to muscovite out reaction. Garnet is well preserved and shows broad cores with sigmoidal inclusion trails pointing to synkinematic crystallization, which ocassionally are surrounded by narrow, inclusions poor rims. Bulk and single crystal dating resulted in highly precise ages showing progressively older dates with increasing metamorphic grade and higher structural level. The youngest, garnet zone rocks yielded 10.6±0.2 Ma age that is followed by 12.8±0.3 and 13.7±0.2 Ma ages obtained for staurolite and kyanite grades, respectively. Sillimanite zone garnets gave 14.6±0.2 Ma age. Structurally highest rocks, arguably marking the top of the sequence, yielded 16.8±0.1 Ma. All ages are interpreted as reflecting garnet growth on a prograde path, which is indicated by Rayleigh style Lu distribution.

High precision of bulk garnet ages was verified relatively to the duration of single crystal growth by chemically controlled high resolution single garnet dating. Five zones dated from the synkinematically grown core yielded precise analyses, which do not show any resolvable time difference and together define a 13.7±0.2 Ma isochron age. Two fractions from narrow, postkinematically grown rim define a 9.9±3.8 Ma date. Much lower precision of the rim is inevitable consequence of Rayleigh style Lu distribution. These data point to a very fast synkinematic core crystallization, which was followed by a slower phase of rim formation. The data show that age precision is not only analytical but closely resambles the real pace of metamorphic crystallization within the Lesser Himalaya. Lu-Hf dating constraints duration of Barrovian metamorphism from garnet to sillimanite zone as 4.0±0.3 Ma, which compares well with earlier estimates of Baxter *et al* (2002) who determined the duration of metamophism as 2.8±3.7 Ma. for classical (not inverted), Barrovian sequence in Scotland.

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DOI:10.1180/minmag.2013.077.5.1