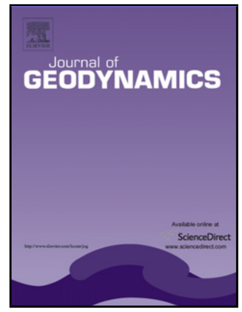
Subduction and Orogeny: Introduction to the Special volume

Y Rolland, Delphine Bosch, S Guillot, J de Sigoyer, Joseph Martinod, Philippe Agard, Philippe Yamato



Title: Subduction and Orogeny: Introduction to the Special volume

Author: Y. Rolland D. Bosch S. Guillot J. de Sigoyer J. Martinod P. Agard P. Yamato

PII: S0264-3707(16)30052-7
DOI: http://dx.doi.org/doi:10.1016/j.jog.2016.03.006
Reference: GEOD 1414

To appear in: *Journal of Geodynamics*

Please cite this article as: Rolland, Y., Bosch, D., Guillot, S., de Sigoyer, J., Martinod, J., Agard, P., Yamato, P., Subduction and Orogeny: Introduction to the Special volume.Journal of Geodynamics http://dx.doi.org/10.1016/j.jog.2016.03.006

Subduction & Orogeny: Introduction to the Special volume

Rolland, Y.[1],Bosch, D.[2], Guillot, S.[3], de Sigoyer, J.[3], Martinod, J.[4], Agard, P.[5], Yamato, P.[6]

[1]Géoazur UMR 7329, Université de Nice Sophia-Antipolis, OCA, CNRS IRD, bat. 1, 250 rue Albert Einstein, Sophia-Antipolis, 06560Valbonne, France, yrolland@unice.fr

[2]Géosciences Montpellier, CNRS-UMR 5243, Université de Montpellier, Place E. Bataillon, 34 095 Montpellier cedex 5, France

[3]ISTerre, Université de Grenoble Alpes, CNRS IRD, 1381 rue de la Piscine, 38041 Grenoble, France

[4]ISTerre, Université de Savoie, CNRS IRD, 73376 Le Bourget du Lac cedex, France

[5]ISTeP, Université Pierre et Marie Curie- UMR CNRS 71934, place Jussieu 75005 Paris, France

[6]Géosciences Rennes, Université de Rennes 1, CNRS UMR 6118, Rennes Cedex CS 35042, France

Abstract

Subduction processes play a major role in plate tectonics and the subsequent geological evolution of Earth. This special issue focuses on ongoing research in subduction dynamics to a large extent (oceanic subduction, continental subduction, obduction…) for both past and active subduction zones and into mountain building processes and the early evolution of

orogens. It puts together various approaches combining geophysics (imaging of subduction zones), petrology/geochemistry (metamorphic analysis of HP-UHP rocks, fluid geochemistry and magmatic signal, geochronology), seismology and geodesy (present-day evolution of subduction zones, active tectonics), structural geology (structure and evolution of mountain belts), and numerical modelling to provide a full spectrum of tools that can be used to constrain the nature and evolution of subduction processes and orogeny. Studies presented in this special issue range from the long-term (orogenic cycle) to short-term (seismic cycle).

1. Introduction

The outcome of this special issue is to provide new insights into our understanding of processes acting in subduction zones, and during the building of active margin mountain belts and early collisional belts, based on a large variety of active and fossil subduction zones. This issue benefited from a conference session held in the RST 2014 (Pau, France).

The aim of this issue is to address some of the currently debated questions about the relationships between subduction and orogenesis. Among them, it especially focuses on the following points:

· How can we reconcile the data obtained from geodesy and seismology with the long-term evolution of subduction zones?

· What is the nature, the composition and the geometry of the subduction zone interplate contact? What is the meaning of ‘Subduction Channel’?

· How did syn-subduction exhumation processes happen? What is recorded by HP-UHP rocks and what is the role of deep-slab deformation?

· What is the link between slab dehydration, mantle serpentinization and the deep sediment wedge in the exhumation of deeply subducted rocks? What are their impact on seismicity?

· Concerning obduction processes, this volume brings new insights on still remaining questions related to obduction initiation and the mechanisms allowing for its propagation far from a suture zone.

· Finally, important points regarding the transition from subduction to collision are also presented. Hence, question such as: Is collision a continuum of subduction? What controls the fact that continental subduction continues or stops (e.g., Himalaya vs. Central Asia) and what are the consequences? are herein addressed.

2. Contributions to this volume

The following sections present how the papers are arranged to reflect the different approaches covered by this special issue.

2.1. Uplift of the upper plate related to subduction dynamics

Orogeny along subduction zones may be driven by the subduction zone dynamics (e.g., Platt, 1985; Gephart, 1994; Sobolev and Babeyko, 2005; Schellart et al., 2007; Capitanio et al., 2011). In their article, Martinod et al. (2015) show how subduction processes contribute to the forearc uplift based on the example of the South Andes. They present numerical models to investigate the relationships between the subduction zone and the observed Quaternary uplift of the Andes. On the basis of geological observations, a general uplift of the South American Pacific coasts is observed between 16 and 32° S since the Lower Pleistocene. Uplift occurs at rates larger than 0.2 mm/yr, following a period of stability of the forearc region. Their models confirm that local uplift is expected to occur in response to the subducting plate buoyancy. Especially, uplift occurs above subducted ridges, this phenomenon being predominant in central Peru where the Nazca Ridge is subducting. The effects of slab pull are also investigated, as the interplate friction and convergence velocity exert a role on the vertical displacements of the overriding plate. From their results they propose that the global tendency to coastal uplift is accompanying the deceleration of the Nazca-South America convergence that occurred in the Pleistocene. In contrast, forearc subsidence may accompany increasing convergence velocities, as suggested by the subsidence history of the South American active margin.

2.2. Lithological nature of the subduction interface: the Subduction Channel

The Subduction Channel is thought to play a major role in subduction dynamics by promoting slab coupling or decoupling and element transfer from the Lower to the Upper plate (e.g., Baker Hebert et al., 2009; Guillot et al., 2009; Angiboust et al., 2011). However, there still are few exhumed examples of such geological objects (e.g., Vannucchi et al., 2007; Bachmann et al., 2009; Angiboust et al., 2014a), while the bearing of such lithologies for the understanding of interplate deformation processes is important (e.g., Guillot et al., 2000; Gerya and Stöckhert, 2002; Angiboust et al., 2012). The major causes of strain localization along the plate boundary include both the subducted lithologies originating from the sea-floor, and the fluids that circulate and concentrate along it. In this issue, a well preserved exhumed subduction channel is presented from the Caucasus region by Hässig et al. (this issue-a). From this field example the subduction channel is a narrow geological object of about 500 m in width, which was formed at an approximate depth of 10 km along an Andean-type subduction zone. The nature of the channel is complex, it is formed (i) by an upper ‘sedimentary’ channel with detrital and volcanic rocks thrusted on top of pelagic sediments scrapped off the oceanic floor. This sedimentary mélange is thrusted on top of (ii) an intensely deformed tectonic mélange. The tectonic mélange comprises blocks of basalt from the oceanic floor and a focussed deformation zone 50–100 m in width, cross-cut by numerous chlorite-carbonate-epidote-albite veins. This latter entity overlies an undeformed ocean floor section. The study of veins, including stable isotopes, provide evidence for high fluid/rock ratios, which agrees with fluid mixing between deep (lower crust/mantle) and shallow (pelagic sediments) reservoirs along the subduction interface. These data show that several fluid reservoirs situated along the interplate boundary could have been connected by high-magnitude co-seismic displacements along the subduction zone. These subduction channel features are compared to other similar fossil examples and current settings, such as the Andes accretionary prism to propose a reconstructed geometry of the interplate contact zone from the surface to the base of the crust.

2.3. Obduction: another type of subduction?

The process of obduction might just be regarded as a variation of subduction, i.e., '*continental subduction*' at least for short distances of obduction (Agard et al., 2014; Edwards et al., 2015). However, the case of the Caucasus Belt poses a problem considering the presence of a large obduction of Jurassic crust, transported over more than 300 km a long time before the final Arabia-Eurasia collision (Rolland et al., 2009; Hässig et al., 2013; 2015; 2016).

Obduction processes are discussed by Hässig et al. (this issue-b). These authors performed two-dimensional thermo-mechanical numerical modelling in order to investigate obduction dynamics in this specific context. The results indicate that a thermal rejuvenation of the oceanic domain and extension induced by far-field plate kinematics are essential ingredients for obduction as already suggested in other ophiolitic systems (e.g., in Oman; see Duretz et al., 2016). On one hand, thermal rejuvenation (i.e. mantle upwelling) of the oceanic lithosphere allows to reduce the negative buoyancy and strength of magmatically old lithosphere (~80 Ma). Such a process, which likely occurred in the Caucasian ophiolites, dictates whether oceanic plates subduct or obduct during convergence. On the other hand, the occurrence of kinematic extension facilitates the thinning and propagation of the ophiolite on the continental domain, as well as the exhumation of continental basement beneath the ophiolite. In the Caucasus context, such an extensional event is likely triggered by far-field plate kinematics and particularly linked to the resumption of oceanic subduction of the northern boundary of Neotethys beneath Eurasia (Meijers et al., 2015; Hässig et al., 2015). From this case example, the involvement of the mantle convection in obduction processes seems likely (Jolivet et al., 2015).

2.4. Effects of continental subduction

The transition from subduction to collision is named ‘continental subduction’ or "soft collision". The first conclusive evidence for burial and subsequent exhumation of the continental crust to depths >90 km was provided by the discovery of coesite-bearing metamorphic rocks in the Dora Maira massif of the Western Alps (Chopin, 1984), and was further confirmed by numerous petrologic studies and seismic imaging in this chain (e.g., Zhao et al., 2015).

In his contribution, Massone (this issue) investigates the consequence of the descending plate on the upper plate hydration at the beginning of continent–continent collision, mainly based on pressure (*P*), temperature (*T*) and T-H_2O pseudosections modelling. On the basis of these calculations, different collisional scenarios are discussed highlighting the role of hydrated lithospheric mantle. Further suggestions are that (1) the lower crustal plate in a continent–continent collisional setting penetrates the lithospheric mantle, which is hydrated during the advancement of this plate, (2) the maximum depths of the subduction of upper continental crust is below 70 km and (3) hydrated mantle above the descending crustal plate is thrust onto this continental crust. This process best explains the piling up of backthrusted units close to the initial collision zone of a continent-continent collision as observed in the Himalayas (de Sigoyer et al., 1997; 2004; Guillot et al., 1997). The process of shear backthrusting is thought to necessitate the underthrusting of the lower continental crustal plate as suggested by Ernst (2001) and numerical modelling experiments (e.g., Stöckhert and Gerya, 2005; Warren et al., 2008; Yamato et al., 2008).

Such a scenario could be the norm for the initial stages of any collisional event, as field examples of such continental subduction become more and more widespread. In their contribution Loury et al. (this issue) document for the first time continental subduction in the geological record in the Chatkal Range of the Kyrgyz Tien Shan. Using an approach combining field mapping, micro-mapping, thermo-barometry, and in situ allanite U-Pb dating, Loury et al. (this issue) describe highly retrogressed eclogites which document the Tarim underthrusting below the Middle Tien Shan to the west of the Talas Ferghana Fault. The retrogressed eclogites likely represent the leading edge of the subducted Tarim continent, which suffered high-metamorphic peak conditions, which culminated at 490 ± 50 °C and 18.5 ± 2 kbar (about 60 km). They were subsequently followed by higher temperature retrogression during their exhumation (~560 °C at 11–7 kbar) in contrast to what is described to the east in Kyrgyzstan and China. These rocks pin-point the final accretion event of the Central Asian Orogenic Belt (CAOB), when the Tarim block collided with the Kazakh Platform. Lateral correlations show that this event is 20 Ma younger than to the east of the Talas-Ferghana Fault, which suggests that it already was a transform fault before being a major strike-slip fault. This study allows a tectonic reconstruction featuring lateral variations in the oceanic domain. The ocean width varied due to offset by the Talas-Ferghana Fault, which acted as a transform fault, resulting into diachronic collision of the Tarim Block. This case example shows that convergence and deformation did not continue in the Tien Shan after the continental subduction stage. Following the continental underthrusting at c. 300 Ma, the subduction zone jumped to the south of the Tarim Block.

2.5. Long-time span subduction effects on the Upper Plate magmatism and metamorphism

Exhumed field examples can help to resolve the effects of long-time span subduction on the building and the thermal, metamorphic and magmatic evolution of the corresponding upper plate. Such studies will also highlight the processes of continental growth. In this issue, two studies are presented on the African craton, which give complementary insights into the formation of Gondwana and the importance of subduction processes during this event.

Triantafyllou et al. (this issue) report new mapping, tectonic, metamorphic and U–Pb zircon data on polyphased arc-related units within the Moroccan Pan-African belt (Sirwa window, Anti-Atlas). The arc-related rocks were formed by a long-lived subduction zone. Andesitic to dacitic rocks were initially formed in the intra-oceanic volcanic arc around 740–720 Ma, which ended in an event of pronounced partial melting and production of leucogranitic melts at 650 Ma. This study shows that two phases of subduction-related magmatism occurred in the Anti-Atlas belt separated by the accretion of the intra-oceanic arc system onto the West African craton passive margin. These results validate the thermo-mechanical models predicting an intense perturbation of subduction dynamics during arc-continent collision (*i.e.* composite subductions, polarity reversal), which can expand the production of typical hydrous arc magmas and induce a late magmatic phase after partial or total accretion of the intra-oceanic arc system.

More to the South, Bosch et al. (this issue) provide a new geochronological and geochemical study of the Adrar des Iforas (Mali), using laser-ablation U–Th–Pb analyses of zircon and allanite from magmatic and metamorphic rocks. The study allows re-examining the relationships between the different crustal units constituting the western part of the Tuareg Shield, as well as the timing of magmatic and metamorphic events in the West Gondwana Orogen. At first, it appears that the Kidal terrane and the Iforas Granulitic Unit formed a single crustal block at least until 1.9 Ga, as the whole region exhibits a large-scale regional high-temperature metamorphic event at c. 2 Ga. This block was later dissected by major lithospheric scale faults during the late Pan-African orogenic phases. During the Neoproterozoic, the Kidal terrane underwent long-lived active margin magmatism from 716 to 620 Ma, while the Tilemsi intra-oceanic island arc formed between 716 and 643 Ma. Subduction related processes and the development of the Kidal active margin was responsible for the development of a back-arc basin in the Tafeliant area, which is dated at 623 ± 6 Ma. These results show that subduction has lasted for about 100 to 120 Ma, and is responsible for a significant reworking of the Gondwanan basement. The final collision of the Kidal terrane with the eastern margin of the West African Craton is best dated by syn-collisional magmatism at c. 600 Ma.

2.6. Disentangling superposed subduction events

The continental crust has been constructed by superposed subduction events, which partly erased and recycled the products of former subduction zones (e.g., Reymer and Schubert, 1984).

In their contribution, Rolland et al. (this issue) review the geodynamic evolution of the Tethys subduction history in the Variscan times, until the Mesozoic on the basis of a review of geochronological data from Eastern Anatolia and the Lesser Caucasus, and some new datings of the Georgian crystalline basements. The geological history of the Georgia and northern NE Anatolia basements appear to be similar and underwent three superposed major subduction events in the Variscan and Mesozoic times. The new La-ICPMS U-Pb ages from the

Georgian basement provide further evidence for the derivation of the Trans-Caucasus and its western continuation (the eastern Pontides) from Gondwana, and their reworking during the Variscan orogeny. Ordovician ages, which suggest affinity with Gondwana, are preserved in the core of zircons. Further, a major migmatization event is constrained by the 343 ± 2 Ma age of metamorphic zircon rims, while I-type granites were emplaced sub-synchronously at 335 ± 8 Ma. These results suggest that (1) derivation of the Pontides-Trans-Caucasus block (PTB) from Gondwana at 450-350 Ma could have been driven by northward roll-back of the south-dipping Rheic slab. (2) The main metamorphic and coeval magmatic events are related to the accretion of PTB to the Eurasian margin at c. 350 Ma, while the source of magmatism is ascribed to slab detachment of the south-dipping slab at 340 Ma. Finally, (3) during the Mesozoic, three subduction zones may have been active contemporaneously in the Tethyan domain during the Lower to Upper Jurassic.

Fernandez et al. (this issue) investigated the geochemical compositions and the geochronology of north Algerian Maghrebides rocks. Analyses were performed on metamorphic rocks from the footwall of an oceanic unit thrusted onto the North African margin, to reconstruct the subduction history of that part of the Mediterranean domain. The footwall unit has geochemical features of a passive margin setting, while the datings indicate deposition of sediments along the N-African margin in the upper Carboniferous/lower Permian times (307–281 Ma). Geochemistry of the mafic and ultramafic rocks displays subduction related features with melting from a depleted mantle reservoir modified by a continental crust-derived component brought into the mantle during an ancient subduction event. This unit, formerly originating from a supra-subduction setting was further involved in a subduction zone during the Miocene, and exhibits two high-temperature events. Geochronological results indicate a first one, dated at c. 20.9 ± 0.3 Ma, which just followed HP metamorphism and thrusting of the Kef Lakhal oceanic complex onto the Northern margin of Africa. The second event at 17.7 ± 0.5 Ma – 17.0 ± 0.1 is coeval with exhumation and anatexis of the lower crustal units in a dome structure. Therefore, the subduction-exhumation cycle followed by the N- Maghrebides rocks was very rapid, which is ascribed to a major extension event following the subduction event.

2.7. Superposed fabrics related to orogenic construction and collapse above the subduction zone

A similar evolution from crustal thickening towards extensional collapse above a subduction zone is described by Scheffer et al. (this issue), in the Lavrion peninsula in the internal zone of the Hellenic orogenic belt, which features construction and destruction of the Hellenic orogenic belt. They document a well exposed nappe stack made, from top to bottom, of (i) a non-metamorphic upper unit composed of an ophiolitic melange, (ii) a middle unit mainly composed of blueschists, (iii) and a basal unit with blueschists retrogressed into the greenschistfacies. The vertical fabrics related to crustal thickening are transposed by a low-angle mylonitic to cataclastic detachment at the transition from the middle to the basal unit. The middle unit is characterized by a pressure peak (M1, 9–13 kbar) followed by decompression (M2, 6–9 kbar) at a constant temperature of ca. 315 °C. The basal unit has preserved a first set of HP/LT conditions (M1–2, 8–11 kbar, 300 °C) partially to totally transposed-retrogressed into a lower pressure mineral assemblage (M3, 5–8.5 kbar, ∼350 °C). These data document tectonic accretion marked by successive burial (D1M1) and syn-orogenic exhumation (D2M2) without thermal relaxation. The development of a low-angle detachment, accommodating post-orogenic exhumation of the orogenic root, is attributed to a lateral flow of the thermally relaxed nappe stack leading to gravitational collapse of the Hellenic belt.

Acknowledgments

We thank the RST organizing committee in Pau. ANR onlap project coordinated by P. Agard, ANR DSP Tibet project coordinated by S. Guillot and Y. Rolland, and MEBE-DARIUS projects funded by oil companies and coordinated by E. Barrier and M.F. Brunet have allowed a renewed approach of the subduction and obduction dynamics, as shown in this special issue, and we wish to thank all the persons involved in the funding and organization of research for their efforts. Thanks to the editorial board, reviewers and editor-in-chief Wouter Schellart who all contributed deeply in the special issue editorial handling and review process.

References

Agard, P., Zuo, X., Funiciello, F., Bellahsen, N., Faccenna, C., Savva, D., 2014. Obduction: Why, how and where. Clues from analog models. Earth and Planetary Science Letters 393, 132-145.

Angiboust, S., Agard, P., Raimbourg, H., Yamato, P., Huet, B., 2011. Subduction interface processes recorded by eclogite-facies shear zones (Monviso, W. Alps). Lithos 127, 222-238, doi:10.1016/j.lithos.2011.09.004

Angiboust, S., Wolf, S., Burov, E., Agard, P., Yamato, P., 2012. Effect of Fluid Circulation on Subduction Interface Tectonic Processes: Insights from Thermo-mechanical Numerical Modelling. Earth and Planetary Science Letters 357-358, 238-248, doi:10.1016/j.epsl.2012.09.012

Angiboust, S., Glodny, J., Oncken, O., Chopin, C., 2014. In search of transient subduction interfaces in the Dent Blanche–Sesia Tectonic System (W. Alps). Lithos 205, 298-321.

Bachmann, R., Oncken, O., Glodny, J., Seifert, W., Georgieva, V., Sudo, M., 2009. Exposed plate interface in the European Alps reveals fabric styles and gradients related to an ancient seismogenic coupling zone. Journal of Geophysical Research 114, B05402, doi:10.1029/2008JB005927

Baker Hebert, L., Antoshechkina, P., Asimow, P., Gurnis, M., 2009. Emergence of a low-viscosity channel in subduction zones through the coupling of mantle flow and thermodynamics. Earth and Planetary Science Letters 278, 243-256.

Bosch, D., Bruguier, O., Caby, R., Buscail, F., Hammor, D., 2016. Orogenic development of the Adrar des Iforas (Tuareg Shield, NE Mali): New geochemical and geochronological data and geodynamic implications. Journal of Geodynamics, doi :10.1016/j.jog.2015.09.002.

Capitanio, F. A., Faccenna, C., Zlotnik, S., Stegman, D. R., 2011. Subduction dynamics and the origin of Andean orogeny and the Bolivian orocline. Nature 480 (7375), 83-86.

De Sigoyer, J., Guillot, S., Lardeaux, J.M., Mascle, G., 1997. Occurences of glaucophane bearing eclogites in the Tso Morari dome (East-Ladakh, Internal Himalayan belt). European Journal of Mineralogy 9, 1073-1083.

de Sigoyer, J., Guillot, S., Dick, P., 2004. Exhumation Processes of the high-pressure low-temperature Tso Morari dome in a convergent context (eastern-Ladakh, NW-Himalaya). Tectonics 23, TC3003, doi: 10.1029/2002TC001492

Duretz, T., Agard P., Yamato, P., Ducassou, C., Burov, E., Gerya, T.V., 2016. Thermo-mechanical modeling of the obduction process based on the Oman ophiolite case. Gondwana Research, doi:10.1016/j.gr.2015.02.002

Edwards, S. J., Schellart, W. P., Duarte, J. C., 2015. Geodynamic models of continental subduction and obduction of overriding plate forearc oceanic lithosphere on top of continental crust. Tectonics 34(7), 1494-1515.

Ernst, W.G., 2001. Subduction, ultrahigh-pressure metamorphism, and regurgitation of buoyant crustal slices; implications for arcs and continental growth. Physics of the Earth and Planetary Interiors 127, 253-275.

Fernandez, L., Bosch, D., Bruguier, O., Hammor, D., Caby, R., Monié, P., Arnaud, N., Toubal, A., Galland, B., Douchet, C., 2015. Permo-Carboniferous and early Miocene geological evolution of the internal zones of the Maghrebides – New insights on the western Mediterranean evolution. Journal of Geodynamics, doi: 10.1016/j.jog.2015.10.001.

Gephart, J. W., 1994. Topography and subduction geometry in the central Andes: Clues to the mechanics of a non collisional orogen. Journal of Geophysical Research 99, 12279-12288.

Gerya, T. V., Stöckhert, B., 2002. Exhumation rates of high pressure metamorphic rocks in subduction channels: The effect of rheology. Geophys. Res. Lett. 29, 1261. doi:10.1029/2001GL014307.

Guillot, S., de Sigoyer, J., Lardeaux, J.M., Mascle, G., 1997. Jadeite-chloritoid bearing pelitic rocks from Himalaya : petrologic evidence for subduction of the Indian continental margin during India-Eurasia convergence. Contributions to Mineralogy and Petrology 128, 197-212.

Guillot S., Hattori K., de Sigoyer, J., 2000. Mantle wedge serpentinization and exhumation of HP rocks : insights from Eastern Ladakh. Geology 28, 199-202.

Guillot, S. Hattori, K., Agard, P., Schwartz, S., Vidal, O., 2009. Exhumation processes in oceanic and continental subduction contexts : a review. In S. Lallemand and F. Funiciello (eds.) Subduction Zone Dynamics, pp. 175-204, doi 10.1007/978-3-540-87974-9, Springer-Verlag Berlin Heidelberg.

Hässig, M., Rolland, Y., Sosson, M., Galoyan, G., Sahakyan, L., Topuz, G., Çelik, O.F., Avagyan, A., Müller, C., 2013. Linking the NE Anatolian and Lesser Caucasus ophiolites: evidence for large-scale obduction of oceanic crust and implications for the formation of the Lesser Caucasus-Pontides Arc. Geodinamica Acta 26, 311-330. DOI: 10.1080/09853111.2013.877236

Hässig, M., Rolland, Y., Sosson, M., 2015. From seafloor spreading to obduction: Jurassic–Cretaceous evolution of the northern branch of the Neotethys in the Northeastern Anatolian and Lesser Caucasus regions. Geological Society, London, Special Publications 428, SP428-10.

Hässig, M., Rolland, Y., Duretz, T., Sosson, M., 2016. Obduction triggered by regional heating during plate reorganization. Terra Nova 28, 76–82. doi: 10.1111/ter.12193

Hässig, M., Rolland, Y., Sosson, M., Avagyan, A., 2016a. Lithological nature of the subduction channel: Insights from the Karabakh suture zone (Lesser Caucasus) and general comparisons. Journal of Geodynamics, doi:10.1016/j.jog.2015.07.006

Hässig, M., Duretz, T., Rolland, Y., Sosson, M., 2016b. Obduction of old oceanic lithosphere due to due to reheating and plate reorganization: insights from numerical modelling and the NE Anatolia - Lesser Caucasus case example. Journal of Geodynamics, doi:10.1016/j.jog.2016.02.007

Jolivet, L., Faccenna, C., Agard, P., Frizon de Lamotte, D., Menant, A., Sternai, P., Guillocheau, F., 2015. Neo-Tethys geodynamics and mantle convection: from extension to compression in Africa and a conceptual model for obduction. Canadian Journal of Earth Sciences, in press.

Loury, C., Rolland, Y., Cenki-Tok, B., Lanari, P., Guillot, S., 2016. Late Paleozoic evolution of the South Tien Shan: Insights from P–T estimates and allanite geochronology on retrogressed eclogites (Chatkal range, Kyrgyzstan). Journal of Geodynamics, doi:10.1016/j.jog.2015.06.005

Martinod, J., Regard, V., Letourmy, Y., Henry, H., Hassani, R., Baratchart, S., Carretier, S., 2016. How do subduction processes contribute to forearc Andean uplift? Insights from numerical models. Journal of Geodynamics, doi :10.1016/j.jog.2015.04.001

Massonne, H.J., 2016. Hydration of the lithospheric mantle by the descending plate in a continent–continent collisional setting and its geodynamic consequences. Journal of Geodynamics, doi: 10.1016/j.jog.2015.06.006

Meijers, M., Smith, B., Kircher, U., Mensink, M., Sosson, M., Rolland, Y., Grigoryan, A., Sahakyan, L., Avagyan, A., Langereis, C., Müller, C., 2015. A paleolatitude reconstruction of the South Armenian Block (SAB) since the late Cretaceous: constraints on the Tethyan realm. Tectonophysics, doi: 10.1016/j.tecto.2015.01.012

Platt, J. P., 1986. Dynamics of orogenic wedges and the uplift of high-pressure metamorphic rocks. Geological society of America bulletin 97, 1037-1053.

Reymer, A., Schubert, G. 1984. Phanerozoic additionrates to the continental crust and crustal growth. Tectonics 3, 63–77.

Rolland, Y., Billo, S., Corsini, M., Sosson, M., Galoyan, G., 2007. Blueschists of the Amassia-Stepanavan Suture Zone (Armenia): linking Tethys subduction history from E-Turkey to W-Iran. International Journal of Earth Sciences, doi: 10.1007/s00531-007-0286-8

Rolland, Y., Galoyan, Gh., Bosch, D., Sosson, M., Corsini, M., Fornari, M., Vérati. C., 2009. Jurassic Back-arc and hot-spot related series in the Armenian ophiolites – Implications for the obduction process. Lithos, doi: 10.1016//j.lithos.2009.02.006

Rolland, Y., Hässig, M., Bosch, D., Meijers, M.J.M., Sosson, M., Bruguier, O., Adamia, Sh., Sadradze, N., 2016. Review of the convergence history along the East Anatolia-Transcaucasus region during Variscan times: insights from the Georgian basement and connection with the Eastern Pontides. Journal of Geodynamics.

Scheffer, C.,Vanderhaeghe, O., Lanari, P., Tarantola, A., Ponthus, L., Photiades, A., France, L., 2016. Syn- to post-orogenic exhumation of metamorphic nappes: Structure and thermobarometry of the western Attic-Cycladic metamorphic complex (Lavrion, Greece). Journal of Geodynamics, doi: 10.1016/j.jog.2015.08.005.

Schellart, W.P., Freeman, J., Stegman, D.R., Moresi, L., May, D., 2007. Evolution and diversity of subduction zones controlled by slab width. Nature 446, 308-311.

Sobolev, S.V., Babeyko, A.Y., 2005. What drives orogeny in the Andes? Geology 33, 617-620.

Sosson, M., Rolland, Y., Müller, C., Danelian, T., Melkonyan, R., et al., 2010. Subductions, obduction and collision in the Lesser Caucasus (Armenia, Azerbaijan, Georgia), new insights.Geological Society, London, Special Publications 340, 329-352.

Stöckhert, B., Gerya, T.V., 2005. Pre-collisional high pressure metamorphism and nappe tectonics at active continental margins; a numerical simulation. Terra Nova 17, 102-110.

Triantafyllou, A., Berger, J., Baele, J.M., Diot, H., Ennih, N., Plissart, G., Monnier, C., Watlet, A., Bruguier, O., Spagna, P., Vandycke, S., 2016. The Tachakoucht–Iriri–Tourtit arc complex (Moroccan Anti-Atlas): Neoproterozoic records of polyphased subduction-accretion dynamics during the Pan-African orogeny. Journal of Geodynamics, doi: 10.1016/j.jog.2015.07.004.

Vannucchi, P., Sage, F., Morgan, J. P., Remitti F., Collot, J.-Y., 2012. Toward a dynamic concept of the subduction channel at erosive convergent margins with implications for interplate material transfer. Geochemistry Geophysics Geosystems 13, Q02003, 24.

Warren, C.J., Beaumont, C., Jamieson, R.A., 2008. Modelling tectonic styles and ultra-high pressure (UHP) rock exhumation during the transition from oceanic subduction to continental collision. Earth and Planetary Science Letters 267, 129-145.

Yamato, P., Burov, E., Agard, P., Le Pourhiet, L., Jolivet, L., 2008. HP-UHP exhumation during slow continental subduction: Self-consistent thermodynamically and thermomechanically coupled model with application to the Western Alps. Earth and Planetary Science Letters 271, 63-74, doi:10.1016/j.epsl.2008.03.049

Zhao, L., Paul, A., Guillot, S., Solarino, M., et al., 2015. First seismic evidence for continental subduction beneath the Western Alps. Geology 43, doi:10.1130/G36833.1