Материалы
Всероссийской
конференции
с международным
участием

Петрология магматических и метаморфических комплексов

Выпуск 8

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ
РОССИЙСКОЙ ФЕДЕРАЦИИ
НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ГОСУДАРСТВЕННЙ УНИВЕРСИТЕТ

Петрология магматических и метаморфических комплексов

Выпуск 8

Материалы Всероссийской конференции
с международным участием

29 ноября – 2 декабря 2016 года

Томск 2016

УДК 551.24
ББК 26.303

Петрология магматических и метаморфических формаций. Вып. 8. Материалы Всероссийской петрографической конференции с Международным участием. – Томск: Изд-во Томского ЦНТИ. 2016. – 412 с.

В сборнике представлены материалы 8-й научной конференции по проблемам генезиса, моделирования условий формирования, структурной организации и минерагении магматических и метаморфических комплексов. Рассмотрены вопросы их геохронологической корреляции и формационной типизации.

Для специалистов в области петрографии, геологической съемки и прогноза месторождений полезных ископаемых.

Технические редакторы – Гертнер И.Ф., Дугарова Н.А.
Оригинал-макет – А. Бакшаева

Кафедра петрографии Томского государственного университета

Petrology of magmatic and metamorphic complexes. Issue 8. Pceeding of science meeting. – Tomsk: Tomsk CSTI Publishing house. 2016. – 412 p.

The collection includes reports from the 8th science meeting according petrology of magmatic a metamorphic rocks and their metallogeny and structural construction. Questions of their correlation and formation type are discussed.

The book is interesting for specialists in the field of petrography and geological survey and proposal of ore deposits.

Tecknical editors – I.F. Gertner, N.A. Dugarova.
Original design – A. Bakshaeva

Petrography department of Tomsk State University

ISBN 978-5-89702-415-5

Издательство Томского ЦНТИ. Бумага офсетная № 1. Печать офсетная.
Подписано в печать 22.11.2016 г. Заказ № 944. Тираж 120 экз.
Отпечатано в Томском ЦНТИ.
Россия, 634021, г. Томск, пр.Фрунзе, 115/3. Тел. (8-3822) 26-31-69

Содержание

UHP metamorphism in the Polar Urals: evidences from the Marun-Keu Complex (Russia)

López-Carmona, A.[1, 2,] Tishin, P.A. [2,] Chernyshov, A.I. [2,] Gutiérrez-Alonso, G. [1, 2] Gertner, I. F. [2]

[1] *University of Salamanca (Spain); alioli@usal.es*
[2] *Tomsk State University (Russia); labspm@ggf.tsu.ru*

The Marun-Keu complex (MKC; Polar Urals) is interpreted to represent an exhumed slice of a passive continental margin that was subducted during the closure of the Uralian Ocean. The aim of this study is to report the presence of possible quartz pseudomorphs after coesite in the MKC eclogites. The occurrence of coesite (pseudomorphs) is significant because suggests that the host terrane underwent ultra-high pressure metamorphism, at depths greater than 80 km in a (paleo) subduction zone. Preliminary PT constrains suggests that the MKC eclogites recorded a three stage metamorphic evolution involving (i) early subduction-related medium-pressure and medium temperature metamorphism (M1); (ii) Subduction-related (ultra) high-pressure eclogite-facies prograde metamorphism (M2) characterized by the occurrence coesite and the infiltration of aqueous fluids that led to the formation of honeycomb garnet porphyroblasts; (iii) Exhumation-related metamorphism recorded by the development of clinopyroxene+plagioclase+amphibole symplectites and Na-Ca amphibole poikiloblasts.

Introduction

The discovery of coesite- and (micro) diamond-bearing continental affinity rocks, more than 30 years ago (Chopin, 1984; Smith, 1984), has gradually eradicated the concept of "buoyant continents" that resist subduction. These key minerals can only crystallize at mantle depths (i.e. ≥100 km), and the only known mechanism by which lithospheric rocks can reach such depths occurs in destructive boundaries, i.e. subduction zones. Hence, the occurrence of coesite and/or diamond (pseudomorphs) is significant because suggests that the host terrane underwent ultra-high pressure metamorphism, at depths greater than 80 km in a (paleo) subduction zone.

In subduction zones, the sinking of relatively cold, continental lithosphere into the mantle, dragged by consumed denser oceanic lithosphere, leads the formation of high- and ultrahigh-pressure (HP; UHP) and low (LT) to medium temperature (MT) metamorphic rocks. Currently, these rocks are found in the suture zones of mountain belts, after being buoyantly exhumed by tectonics from mantle depths to crustal shallow levels. Coesite- and diamond-bearing eclogites have been reported worldwide in more than 20 metamorphic belts (e.g. Liou et al. 2009). One of these examples is the Uralian orogenic belt. Coesite and diamond pseudomorphs have been described in eclogites from the Southern Urals (Fig. 1) Maksyutov Complex; Chesnokov and Popov, 1965; Lennykh et al., 1995; Leech and Ernst, 1998) and diamond has been recently discovered in chromite ores from the Polar Urals (Rai-Iz ophiolite complex; Yang et al., 2007). The Rai-Iz ophiolite complex comprises an ophiolite nappe that overlies the Marun Keu Complex (MKC). The aim of this study is to report, for the first time, the presence of traces of quartz pseudomorphs after coesite in the MKC eclogites, together with a comprehensive petrological and thermobarometric characterization of key samples from representative localities. This extended abstract display a brief summary of the study in progress.

Geological background

The Uralian orogenic belt extends N-S for more than 2000 km from the Arctic Ocean to the Caspian Sea. This orogenic belt, separates the East European Platform (passive margin) and the West Siberian Plain (active margin) as a result of the collision between the former and a collage of microcontinents, following the closure of the Uralian ocean and developing one of the sutures leading to the Pangea amalgamation in Late Paleozoic times. This suture is marked by the Main Uralian Fault (MUF) which depicts an accretionary system with oceanic and continental rocks that were metamorphosed to HP-UHP conditions.

The Polar Urals show a complex Uralian deformation derived from the aforementioned collision that affected the passive margin and lead to nowadays exposures of Neoproterozoic-Cambrian ophiolites, back-arc basins and island-arc complexes (i.e. the Enganepe ophiolite, Scarrow et al, 2001; Willner et al, 2003; Tessalina et al, 2007; Petrov et. al., 2009) in the basement of the Timan-Pechora foreland basin. In addition, in the polar section of the MUF footwall, several Late Paleozoic LT and HP-UHP ophiolites and continental units crop out (Leech and Ernst, 2000; Petrov et al, 2009; Valizer et al. 2013; Ivanov et al, 2013) as an accretionary complex. The hangingwall of the MUF comprises rocks that experienced medium (to high) temperature and pressure metamorphism (Glasmacher et al, 2013; Glodny et al, 2003; 2004).

The Marun-Keu complex, purpose of this study, is an elongate shaped unit, NE-SW trending, that overlies the greenschist facies rocks of the Naroveskaya suite. It is overlain by the Syum-Keu ophiolitic complex and mantle rocks above the MUF. The Marun-Keu complex consists of mafic, layered, intrusive, massive and volcanic rocks of basaltic-andesitic-dacitic composition (Udovkina, 1971; 1985; Tishin and Chernyshov, 1998, 2000) intruding a sedimentary sequence that underwent different metamorphic processes during subduction and collision (Glodny et al., 2004) throughout the Uralian orogeny. Rocks cropping out in the Marun-Keu complex include garnet peridotites, eclogites (and eclogites-facies rocks), gneisses and amphibolites. The Marun-Keu complex is interpreted to correspond to an exhumed portion of the basement of passive continental margin that was subducted during the closure of the Uralian Ocean.

Metamorphism

The studied area comprises the southern part of the Marun–Keu complex. Here we present the preliminary results of two samples: (1) a pyrope/grossular-rich eclogite-facies rock (gabbroic protolith; sample MK12; Fig. 2a) and (2) an eclogite (sensu lato; i.e. derived from a basaltic protolith; sample MK14; Fig. 2b).

Three metamorphic stages (M1–M3) can be distinguished in the evolution of both samples. Evidence for M1 in sample MK 12 is recorded by random and aligned (curved patterns) relict inclusions (quartz + rutile) in the cores of large garnet porphyroblasts (pyrope 15-30; grossular 23-40). The subrounded quartz inclusions (≤ 10 μm) comprises randomly oriented polycrystalline quartz. Host garnet crystals displays radial fractures from a few quartz inclusions towards the grain boundaries. These inclusions are interpreted as quartz pseudomorphs after coesite. M2 comprises the development of honeycomb grossular rich-garnet porphyroblasts around quartz, sodium-rich pyroxene and epidote, together with rutile-ilmenite, muscovite and plagioclase in the matrix foliation. Honeycomb porphyroblasts morphology seems to be more common in high-pressure and ultrahigh-pressure rocks than it is in rocks that were buried to typical crustal depths (e.g. Stöckhert et al., 1997; Beane and Sorensen, 2007; Hawkins et al., 2007). M3 involves the development of clinopyroxene + plagioclase + amphibole symplectites and minor chlorite and biotite.

M1 in MK14 comprises grossular-rich garnet, sodium-rich pyroxene (omphacite), rutile and minor amounts of quartz. M2 is characterized by the partial replacement of rutile into ilmenite and M3 by the pervasive development of Na-Ca amphibole poikiloblasts wrapping M1 and M2 assemblages.

Aqueous fluids play an important role in metamorphic reactions and in controlling rock rheology at crustal conditions (e.g. Hawkins et al., 2007). Previous studies report that in the MKC eclogites metasomatism was caused by the infiltration of out of equilibrium fluids (mostly silica-rich, alkali-rich compositions) during the eclogite-facies metamorphism (Molina et al., 2002). Evidences from the presence of fluids in the studies samples are the development of the honeycomb garnet porphyroblasts, symplectites and amphibole poikiloblasts.

Average P–T multiequilibrium thermobarometry using THERMOCALC 3.40 (Powell and Holland, 1988), the internally consistent thermodynamic dataset of Holland and Powell (2011) and M3 assemblages compositions, suggests that last stages of exhumation occurred at P = 10-14 kbar; T = 586-663 ºC. These calculations are essentially in agreement with those from Molina et al (2002; conventional thermobarometry technics), but show slightly higher temperatures (Fig. 1).

References

1. Beane, R. J. and Sorensen, S. S. 2007. Protolith signatures and element mobility of the Maksyutov complex subducted slab, southern Ural Mountains, Russia. International Geology Review 49, 52–72
2. Chesnokov, B.V., Popov, V.A. 1965. Increasing volume of quartz grains in eclogites of the South Urals. Dokl. Akad. Nauk 62, 909– 910
3. Chopin, C. 1984. Coesite and pure pyrope in high-grade blueschists of the Western Alps: a first record and some consequences. Contributions to Mineralogy and Petrology 86, 107–118
4. Dobretsov, N.L. et al. 1996. Tectonic Setting and Petrology of Ultrahigh-Pressure Metamorphic Rocks in the Maksyutov Complex, Ural Mountains, Russia. International Geology Review 38, 36–160
5. Glasmacher U.A. et al. 2001. The metamorphic complex of Beloretzk, SW Urals, Russia — a terrane with a polyphase Meso- to Neoproterozoic thermo-dynamic evolution. Precambrian Research 110, 185–213
6. Glodny, J. et al. 2003. Rb-Sr record of fluid – rock interaction in eclogites: the Marun-Keu complex, Polar Urals, Russia. Geochimica et Cosmochimica Acta 67, 4353–4371
7. Glodny J. et al. 2004. Protolith ages of eclogites, Marun-Keu Complex, Polar Urals, Russia: implications for the pre- and Early Uralian evolution of the northeastern European continental margin. In: The Neoproterozoic Timanide Orogen of Eastern Baltica / D.G. Gee, V.L. Pease (eds.). Geological Society London Memoirs 30, 87–105
8. Hawkins, A. T. et al. 2007. Origin and mechanical significance of honeycomb garnet in high-pressure metasedimentary rocks from the Tauern Window, Eastern Alps. Journal of Metamorphic Geology 25, 565–583
9. Ivanov K.S. et al. 2013. Tectonics of the Urals and adjacent part of the West-Siberian platform asement: Main features of geology and development // Journal of Asian Earth Sciences. Vol. 72, N 10. 2013, P. 12–24
10. Leech M.L., Ernst W.G. Petrotectonic evolution of the high- to ultrahigh-pressure Maksyutov Complex, Karayanova area, south Ural Mountains: structural and oxygen isotope constraints // Lithos. Vol. 52. № 1–4, 2000. P. 235–252
11. Leech, M., Ernst, W.G., 1998. Graphite pseudomorphs after diamond? A carbon isotope and spectroscopic study of graphite cuboids from the Maksyutov complex, south Ural Mountains, Russia. Geochim. Cosmochim. Acta 62, 2143– 2154.
12. Lennykh, V.I., Valizer, P.M., Beane, R.J., Leech, M.L., Ernst, W.G., 1995. Petrotectonic evolution of the Maksyutov complex, southern Urals, Russia: implications for ultrahigh-pressure metamorphism. Int. Geol. Rev. 37, 584–600.
13. Liou JG, Ernst WG, Zhang RY, Tsujimori T, Jahn BM (2009) Ultrahigh-pressure minerals and metamorphic terranes – The view from China. Journal of Asian Earth Sciences 35: 199-231

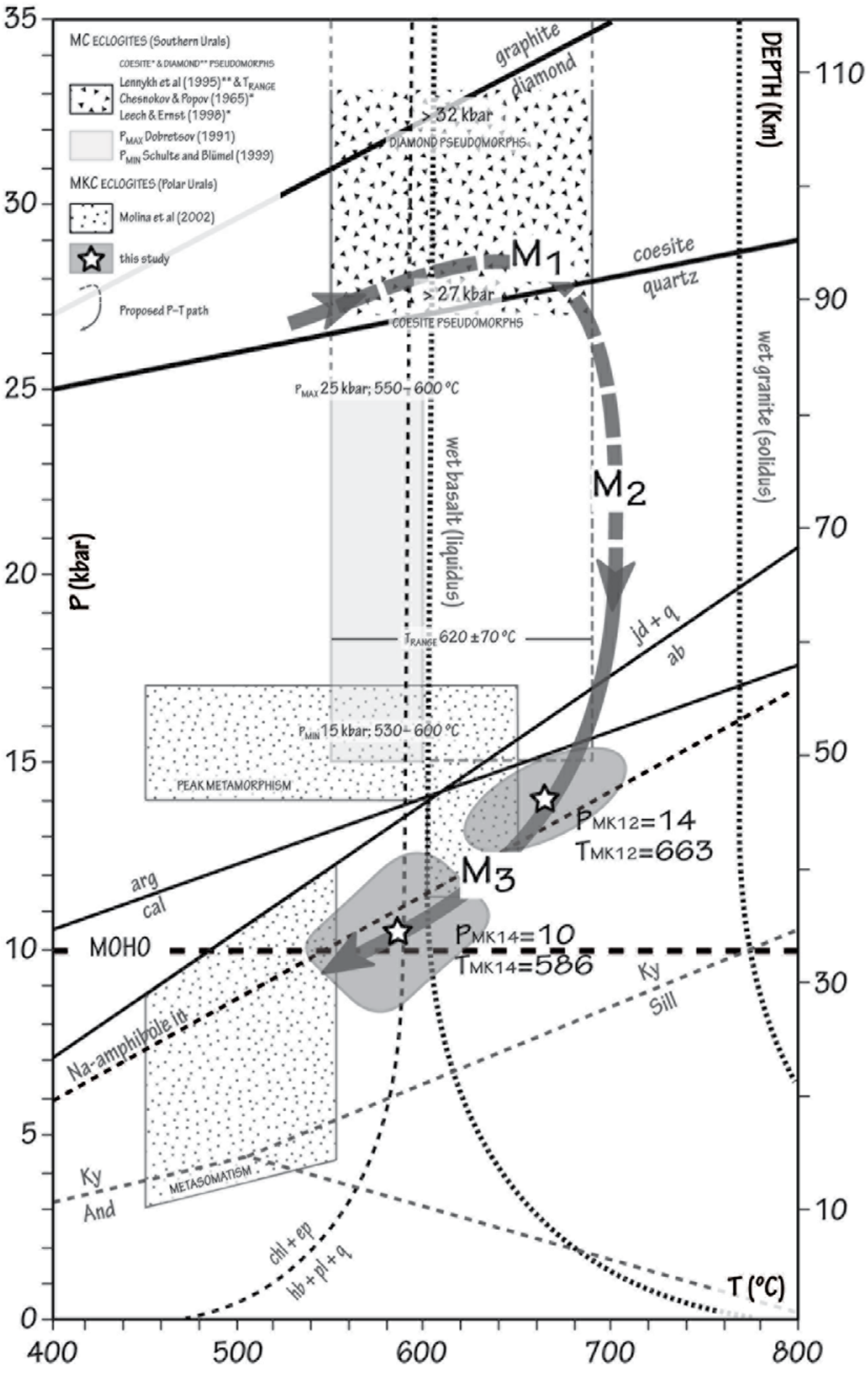

Fig. 1. Compilation of the P–T conditions for the eclogite-facies rocks in the Maksyutov Complex (MC) and the Marun-Keu Complex (MKC) in the Southern and Polar Urals, respectively. Average P–T calculations show the 1.5σ errors (95% confidence).

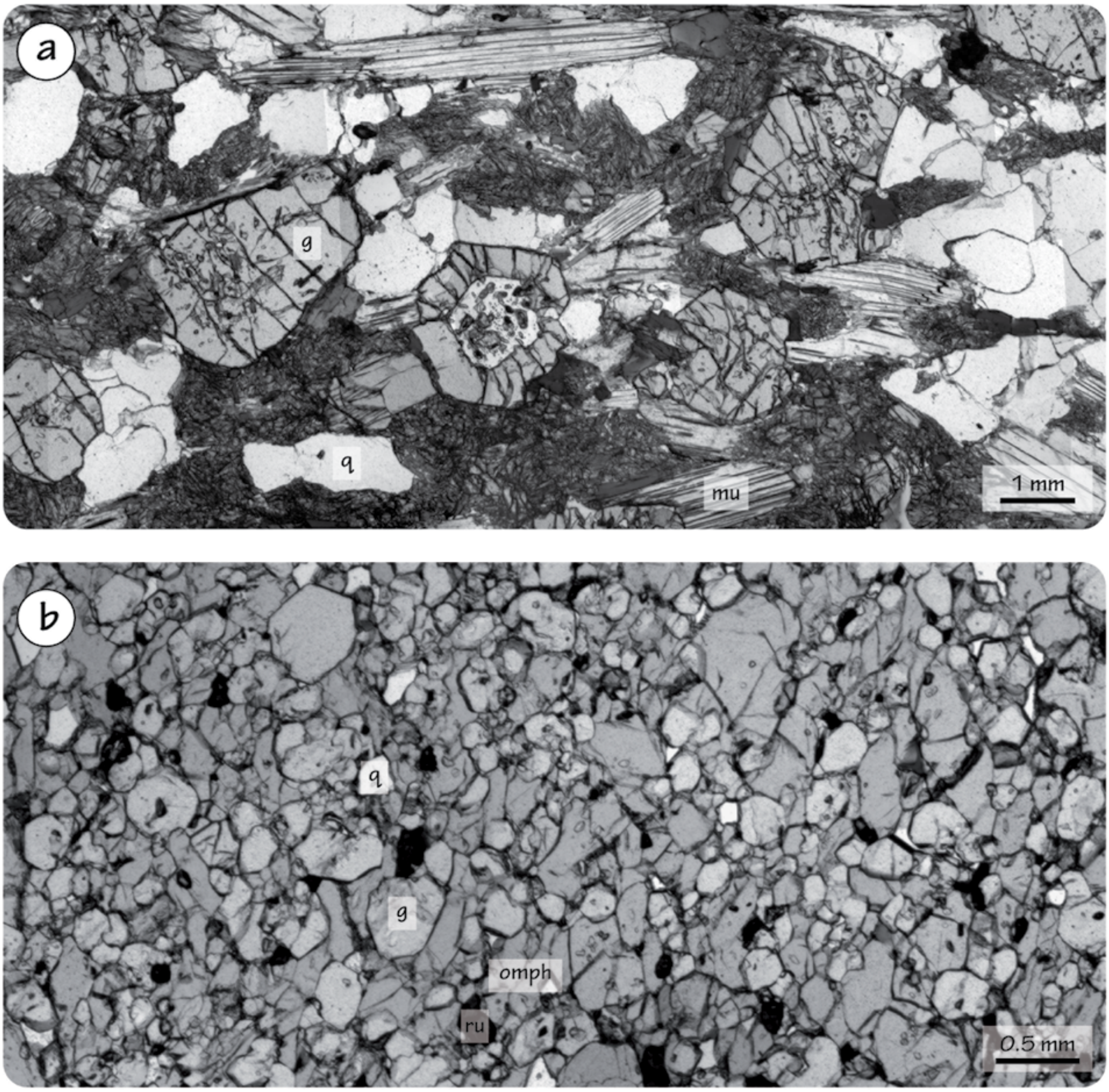

Fig. 2. (a) Microphotographs showing the textural relations in the MKC eclogites. (a) Sample MK12. (b) Sample MK14. Mineral abbreviations: g-garnet; oomph-omphacite; ru-rutile; mu: muscovite; q-quartz

14. Molina JF, Austrheim H, Glodny J, Rusin A (2002) The eclogites of the Marun–Keu complex, Polar Urals (Russia): fluid control on reaction kinetics and metasomatism during high P metamorphism. Lithos 61(1–2):55-78
15. Petrov G.A., Ronkin Yu.L., Popov N.V., Tristan N.I., Kozlov P.S. Two stages of high-pressure metamorphism in the Main Uralian Fault area (northern Urals) // Russian Geology and Geophysics Vol. 50, N 1, 2009, P. 43-45
16. Powell, R. & Holland, T.J.B. (1988). An internally consistent dataset with uncertainties and correlations: 3. Applications to geobarometry, worked examples and a computer program. Journal of Metamorphic Geology 6, 173−204
17. Scarrow J.H. , Pease V., Fleutelot C., Dushin V.The late Neoproterozoic Enganepe ophiolite, Polar Urals, Russia: An extension of the Cadomian arc? // Precambrian Research. Vol. 110, N 1–4, 2001, P. 255–275
18. Schulte B, Blümel P (1999) Metamorphic evolution of eclogite and associated garnet-mica schist in the high-pressure metamorphic Maksyutov complex, Ural, Russia. Geologische Rundschau 87(4):561-576 doi:10.1007/s005310050231
19. Smith DC (1984) Coesite in clinopyroxene in the Caledonides and its implications for geodynamics. Nature 310: 641-644
20. Stöckhert, B., Massonne, H. J. & Nowlan, E. U., 1997.

Low differential stress during high-pressure metamorphism: the microstructural record of a metapelite from the Eclogite Zone, Tauern Window, Eastern Alps. Lithos, 41, 103–118.

21. Tessalina S.G., Bourdon B., Gannoun A., Capmas F., Birck J-L., Allègre C. J. Complex proterozoic to paleozoic history of the upper mantle recorded in the Urals lherzolite massifs by Re–Os and Sm–Nd systematics // Chemical Geology.Vol. 240, N 1–2, 2007, P. 61–84
22. Tim Holland & Roger Powell, 2011. An improved and extended internally consistent thermodynamic dataset for phases of petrological interest, involving a new equation of state for solids. Journal of Metamorphic Geology, 29, 333-383
23. Valizer P.M., Rusin A.I., Krasnobaev A.A., Likhanov I.I. Garnet-pyroxene and lawsonite-bearing rocks of the Maksyutov Complex (Southern Urals) // Russian Geology and Geophysics Vol. 54, N11, 2013, P. 1369-1384
24. Willner A.P. , Ermolaeva T., Stroink L., Glasmacher U.A., Giese U., Puchkov V.N., Kozlov V.I., Walter R. Contrasting provenance signals in Riphean and Vendian sandstones in the SW Urals (Russia): constraints for a change from passive to active continental margin conditions in the Neoproterozoic // Precambrian Research, Vol. 110, № 1–4, 2001, P. 215–239
25. Willner A.P., Sindern S., Metzger R., Ermolaeva T., Kramm U., Puchkov V., Kronz A. Typology and single grain U/Pb ages of detrital zircons from Proterozoic sandstones in the SW Urals (Russia): early time marks at the eastern margin of Baltica // Precambrian Research Vol. 124, N 30 2003, P. 1–20
26. Wilson M., Wijbrans J., Fokin P.A., Nikishin A.M., Gorbachev V.I., Nazarevich B.P. 40Ar/39Ar dating, geochemistry and tectonic setting of Early Carboniferous dolerite sills in the Pechora basin, foreland of the Polar Urals // Tectonophysics, Volume 313, N 10, 1999, P. 107–118
27. Yang, J., Bai, W., Fang, Q., Meng, F., Chen, S., Zhang, Z., Rong, He. (2007). Discovery of diamond and an unusual miner al group from the podiform chromite ore, Polar Ural. Geology in China, 34(5), 950-953