

Three metamorphic events of the eclogites from the Neldy Formation in the Makbal district, Kyrgyz Northern Tien-Shan

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The metamorphic sequence of the Akdzhon Group in the Northern Tien-Shan is divided into two contrasting metamorphic formations, the structurally lower Makbal Formation and the upper Neldy Formation (Tagiri and Bakirov, 1990). The Makbal Formation is composed mainly of intercalated metaquartzites and garnet-talc-chloritoid schists, which carry evidence of ultra-high pressure (UHP) metamorphism as coesite inclusions within garnets (Tagiri and Bakirov, 1990; Bakirov, A.B. et al., 1998; Ishida et al., 2004; Togonbaeva et al., 2009). The Neldy Formation is mainly composed of garnet-phengite schists and chlorite-carbonate rocks along with minor metaquartzites, marbles, amphibolites and garnet amphibolites. Eclogites are preserved in the cores of the garnet amphibolite bodies (Bakirov et al., 1987). The metamorphism of the eclogites is divided into three events, a precursor metamorphic event, the first high-pressure metamorphic event and the second high-pressure metamorphic event. The metamorphic conditions of the precursor event are represented by the amphibolite facies. The peak metamorphic conditions of the first high-pressure event are estimated to be $T = 550-610$ °C and $P = 22-25$ kbars. The prograde, peak and retrograde metamorphic conditions define a hairpin-type clockwise P-T path for the first high-pressure metamorphic event of the Neldy eclogites (Togonbaeva et al., 2010 in press).

The garnet amphibolites and amphibolized eclogites are retrograded analogues of the eclogites suggesting later metamorphic evolution after the eclogitic metamorphism. Porphyroblastic amphiboles are common phase of the retrograded eclogites and contain inclusions of garnet, omphacite, barroisite + quartz symplectites, rutile and titanite, suggesting formation after the first high-pressure metamorphic event. These amphiboles zoned differently depending on sample; KG-520-1: actinolite/winchite core to glaucophane rim; KG-532-3: glaucophane core to actinolite through barroisite to magnesiohornblende rim; and KG-525: actinolite/winchite core to glaucophane mantle through winchite to barroisite to magnesiohornblende rim. In all samples symplectites (barroisite + quartz, magnesiohornblende + quartz and magnesiohornblende + albite) after glaucophane recrystallization, suggesting a depression after the growth of glaucophane. Careful study of the retrograded portion of the eclogites reveals the second high-pressure metamorphic event of the epidote amphibolite facies based on zoned porphyroblastic amphiboles and epidotes.

The peak metamorphic conditions and subsequent retrograde paths of the Neldy and the Makbal eclogites are similar, despite difference in the metamorphic conditions of their host rocks (Togonbaeva et al., 2010). 480 \pm 17 Ma of paragonite K-Ar age from the eclogite in the Makbal Formation is regarded as a cooling age of eclogites (Tagiri et al., 1995). At 481 \pm 26 Ma continental collision and subsequent the UHP metamorphism of the coesite/quartz-garnet-chloritoid-talc schists and meta-quartzites took place (Togonbaeva et al., 2009). Devonian granitic rocks, (399 Ma K-Ar) gave a contact metamorphism to the both the Akdzhon and the Scharkyrak Groups (Tagiri et al., 2005), suggesting the HP and UHP metamorphic rocks of the Makbal and the Neldy Formations were exhumed to the shallow crustal levels before ca. 400 Ma.

Keywords: Makbal district, Neldy Formation