Role of flysch in large-scale rock avalanches formation in the eastern sector of the Alpine-Mediterranean belt

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SESSION 1 - GEOLOGICAL SETTING, TRIGGERS AND MECHANISMS

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The stratigraphic successions with relatively soft terrigenous flysch at the base overlain by hard carbonate or volcaniclastic formations are typical of the eastern sector of the Alpine-Mediterranean tectonic belt, of the Crimea, and the Greater Caucasus in particular, though exact ages of rocks vary from region to region. Flysch with rather low bearing capacity, being compressed by carbonate or volcaniclastic rocks from hundreds of meters up to more than 1 km thick, squeezes out into free space at the feet of high and steep cliffs of the cuestas that results in the brittle failure of the overlying competent rocks and in formation of very large rockslides. Similar large-scale rock slope failures might occur if huge blocks of the overlying hard rocks had been detached from the cuesta-forming layer due to climatic or seismotectonic processes first, and compress and crush underlying flysch. In both cases the collapsing hard brittle rock massifs transform in long runout rock avalanches.

At the southern slope of the Crimean Mountains the Upper Triassic – Lower Jurassic flysch composed of cyclically alternating sandstone, siltstone and mudstone with prevailing mudstone is intensively folded and overlain by thick north-dipping monocline of the Upper Jurassic conglomerate with carbonate matrix and limestone that form gentle cuesta with high and steep southern cliff and with flysch outcropping at its base. It was assumed (Zerkal, Samarin, 2018; Zerkal et al., 2020) that detached blocks of the overlying hard rocks ranging in volume from 210-340 Mm3 to 1.1 km3 had crushed underlying weak flysch forming huge rotational rockslides that transform into rock avalanches from ~7.0 to more than 12 km long. Most of them has their frontal parts under water of the Black Sea. According to the preliminary data these rock avalanches were formed during the climatic optimum in the beginning of the Middle Neo-Pleistocene.

In the Central part of the Greater Caucasus, in Northern Ossetia, same phenomena took place at the southern slope of the Rocky Range that is the north-dipping monoclinal cuesta composed of the Upper Jurassic and Lower Cretaceous carbonate rocks about 1 km thick underline by the Lower and Middle Jurassic flysch several hundred meters thick. The basal part of the flysch formation is the classical alternation of the sandstone, siltstone and mudstone, while upward it becomes finer and just below the carbonate unit flysch is represented by the siltstone and mudstone mainly. Large rock avalanche deposits up to several hundreds of millions of cubic meters in volume, composed of crushed and pulverized carbonate rocks fill the old erosional gullies that had merged the Ardon River. Locally these deposits expand over local watersheds. Rock avalanche headscarps are located just at those parts of the very steep southern cliff of the Rocky Range more than 1 km high where old gullies had reached its foot due to backward erosion, so that mudstone flysch had been outcropped. It was hypothesized (Strom, 2004) that, due to its low strength, flysch in the upper reaches of these gullies could not withstand the load of the carbonate rocks and had started squeezing out destabilizing the overlying lime- and dolostone layers. Finally, the entire slope raising above these gulley heads collapsed and formed rock avalanches. At least at one locality one can see the comminuted homogenous mass that had originated from the finer flysch underlying carbonate strata in front of crushed carbonate material and just below it that was bulldozed and flatten out by the advancing carbonate rock avalanche. One, much larger rock avalanche about 2 km3 in volume had collapsed from the southern slope of the Rocky Range east from the Ardon River valley, crossed it and raised for about 500 m up on its left-bank slope.

Slightly different origin has been proposed for the prehistoric rock avalanches ranging in volume from 13-18 to 150-200 million m3 identified in the middle reaches of the Mzymta River valley (Sochi region, southern slope of the Greater Caucasus). Here the Lower to Middle Jurassic flysch with prevailing mudstone layers form the lower parts of the northern slopes of the ridges armored by the up to 800-900 m thick Middle Jurassic volcaniclastic formation. It was hypothesized that large toppled blocks of the armoring volcaniclastic rocks had collapsed on the lower part of the slope composed of flysch, sometimes kicking out local depressions up to 40-50 m deep, according to borehole data (like at the base of a waterfall). Such collapses produced elongated rock avalanches composed of the porphyrite and pillow lava megaclasts mixed with matrix of disintegrated mudstone and tuffstone.