Recognition of a pre-LGM, km-wide collapsed DGSD in Bregaglia Valley (Italian Central Alps): a case study in the frame of the CARG Project sheet n. 038 "Chiavenna"

Colzada G.*, Arrigoni F., Marinoni A., Pigazzi E., Tantardini D., Apuani T. & Tartarotti P.

Dipartimento di Scienze della Terra "A. Desio", Università di Milano.

Corresponding author email: giuseppe.colzada@unimi.it

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Deep-seated Gravitational Slope Deformations (DGSDs) affect large portions of high-relief mountain slopes and the shape of alpine valleys (Crosta et al., 2013), influencing their Neogene and Quaternary evolution. New geological mapping of the lower Bregaglia Valley (Lombardy Region, Italy), in the frame of the CARG Project 1:50.000 scale Geological map of Italy, sheet Nb. 038 "Chiavenna", not only confirms the presence of several DGSDs affecting its southern flank (Tibaldi & Pasquarè, 2008), but also reveals the presence of a landslide body related to DGSD collapse in the area where bedrock has been reported so far. The lower Bregaglia Valley is located between the Tambò Nappe, Chiavenna Unit and Gruf Complex. The southern slope is made of mafic and ultramafic rocks of the Chiavenna Unit, in contact with the Gruf migmatites and paragneisses of the Tambò Nappe. The northern slope is made of Tambò paragneiss. Complex lithological relationships on the south slope have been justified by previous Authors through a combination of folds, faults and tectonic contacts (e.g., Schmutz, 1976). The Marmitte dei Giganti Park (East of Chiavenna, near the confluence of the Liro and Mera rivers) is a ca. 100 m high relief, next to the valley thalweg, well known for its glacial and fluvioglacial forms of excavation. This relief has been mapped so far as a bedrock body (e.g., Schmutz, 1976). South of it, the slope shows widespread gravitative trenches, scarps and counterslopes. The relief is composed of ultramafites and amphibolites that, to the west, do not correlate with the surrounding geology: the nearest amphibolite outcrop is about 1 km south and 500 m higher on the mountain slope. Moreover, evidence from a nearby drill hole SW suggests an inversion of the lithology order, with the Tambò paragneisses being beneath the main body of the park. The relief is crosscut by a network of fractures allowing a constant temperature air circulation, historically exploited for food conservation, that needs large fractured-porous volumes in the rocks to be maintained. This evidence led us to interpret the Marmitte dei Giganti Park relief as a DGDS collapse, namely as a km-wide landslide, made up of hectometer-sized blocks of very resistant rocks originated by sliding of portions of a DGSD-affected slope. The contact between the Gruf Complex and the northern Tambò and Chiavenna units (Gruf Line) acted as a main predisposing factor for large mass-wasting movements on the southern slope of the Bregaglia Valley, which could still have been active after the Last Glacial Maximum (LGM) retreat (Tibaldi & Pasquarè, 2008). However, the DGSD collapse originating the slope surely predates the LGM (Tantardini et al., 2022), being covered by glacial deposits. The volume needed for the emplacement of this collapsed mass leaves room for speculations about the original morphology of the valley and the processes related to its formation.

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