Excessive flysch erosion – Slani Potok

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A significant amount of Mid-Eocene flysch is present in the coastal parts of Croatia. Over the whole region, flysch is subjected to erosion to a greater or lesser extent. However, there is excessive flysch erosion in the Slani potok ("Salt Creek") catchment (in the area of Vinodol) which, together with accompanying landslides, covers an area of approximately 3 km^2 (Fig. 15). Here, total site degradation occurs forming terrains of the "badlands" type. The Slani potok flysch, together with non-eroded flysch from the surrounding area, is represented mainly by calcareous clayey siltstone and calcareous silty claystone, and to a lesser extent with marls and silty sandstones (Fig. 16). There are no significant differences in the mineral content and grain size distribution of clayey siltstone and silty claystone in the whole area of Vinodol. These rocks contain muscovite and illitic material (<30 wt.%), quartz (<25 wt.%), calcite (<15 wt.%), feldspars (<10 wt.%), chlorite, kaolinite and smectite, and in some samples a small quantity of pyrite (Fig. 17). There is a large amount of small particles: the particle size fraction smaller than 2 μm and the 2–4 μm fraction form up to 45 wt.% and 15 wt.%, respectively (Fig. 18).

In terms of engineering geology, the lithological components of flysch are transitional between hard soil and soft rock (HS–SR) (Fig. 19). Soil produced by weathering of this complex tends to slide and flow.

The phenomenon of an efflorescent salt crust on flysch in the Slani potok during dry periods of the year is unique to the area. The mineral content of this white salt crust as determined by XRD is represented by thenardite (sodium sulphate) and a negligible amount of gypsum (Fig. 20). The largest thenardite crystallites observed by scanning

Fig. 15 Location map (orthophoto) of the investigated area.

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electron microscope (SEM) have a diameter of 2 μm (Fig. 21). Occurrence of this water soluble mineral indicates that some components of the flysch include sodium, which accelerates disintegration facilitating intensive erosion.

A series of physical and chemical tests were carried out in an attempt to verify this assumption. Flysch samples were submitted to physical stability tests (pinhole test and cyclic dry–wet repeat treatment – Civil Engineering Insti-

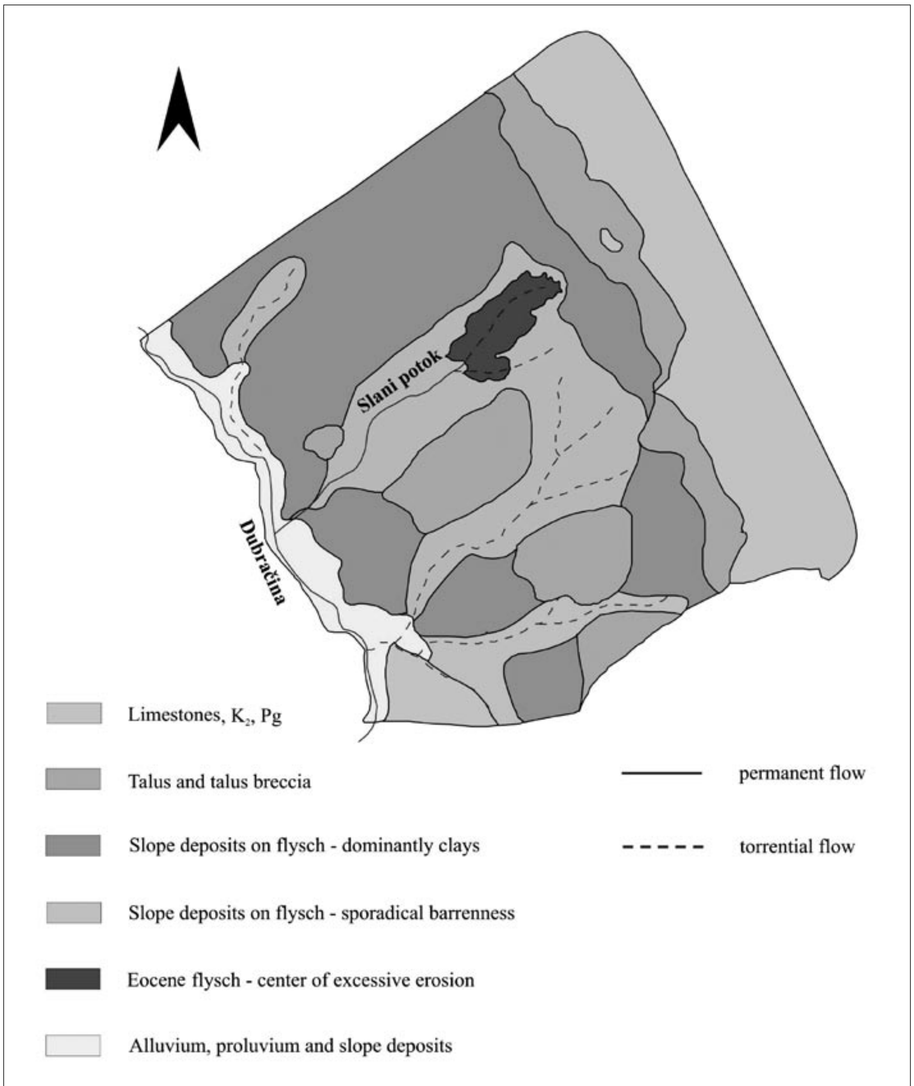

Fig. 16 Simplified geological map.

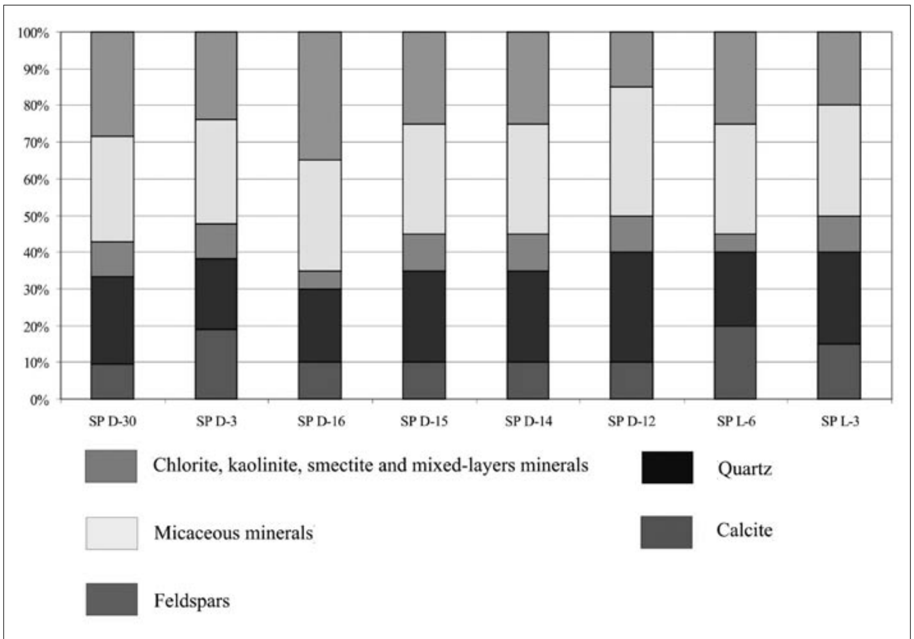

Fig. 17 Mineral content of the flysch samples (semiquantitative content).

tute of Croatia, Zagreb) indicating high soil erodibility. The degree of expansiveness of engineering soils is described by Fig. 22. Determination of soluble salts in flysch pore water was carried out following a modified procedure used by the International Soil Reference and Information Centre (VAN REEUWIJK, 2002). Using criteria established by SHERARD et al. (1976), the analysed flysch fall into the group of dispersive, i.e. erodible soils (Fig. 23). Analysis of stream water for soluble salts was also carried out. Measured concentrations of Na^+ and SO_4^{2-} are much higher than the average for fresh water. This illustrated discovery of thenardite is the first occurrence of this mineral in Croatia.

Excessive erosion of the Slani Potok flysch complex occurs due to its lithological nature where the composition is dominated by the presence of fine (including nanometer-sized) particles, a group of materials known as HS–SR, the presence of swelling minerals, pore water rich in sodium, and occurrence of the sodium mineral – thenardite.

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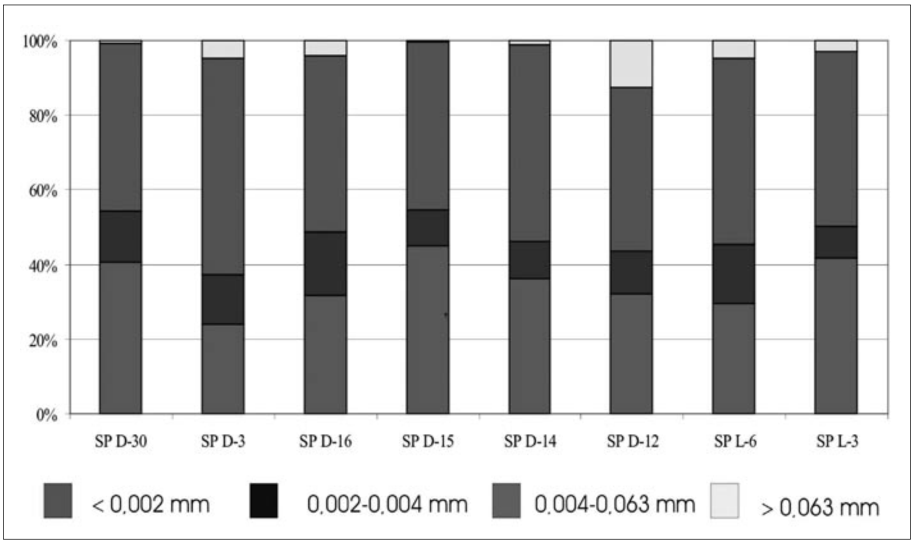

Fig. 18 Grain size distribution of the flysch samples (wt.%).

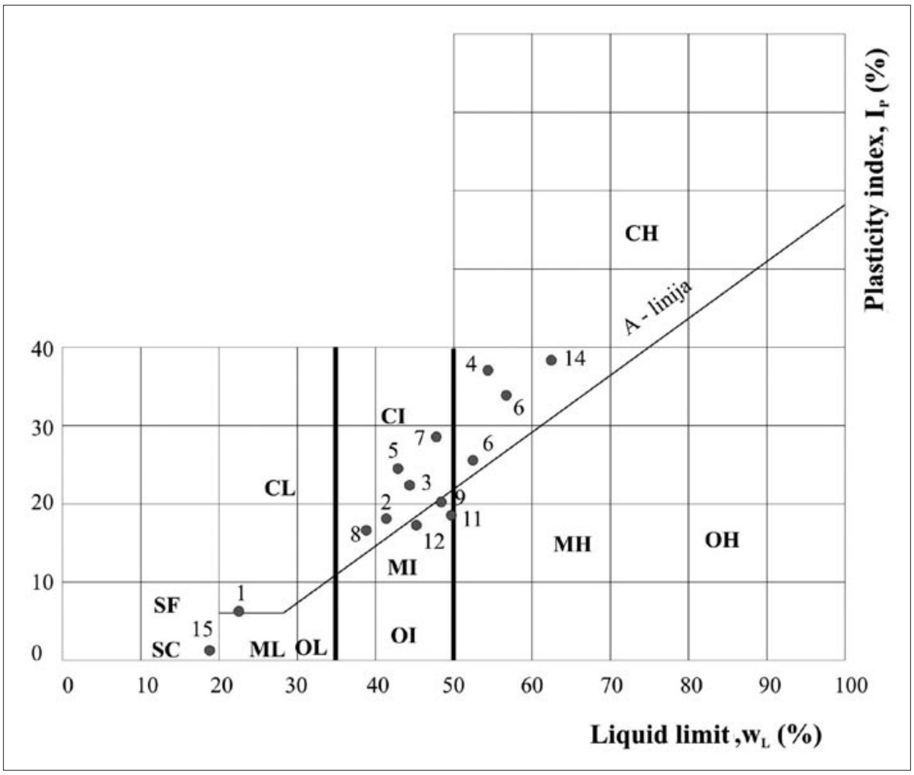

Fig. 19 Plasticity chart.

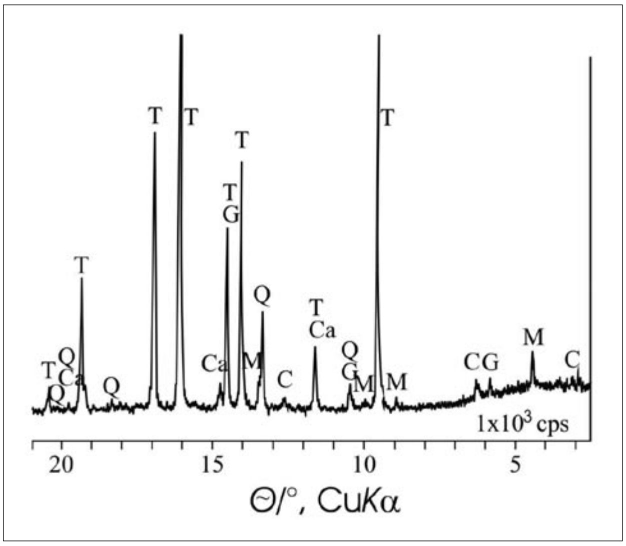

Fig. 20 A characteristic part of the XRD pattern of white powder on flysch. Legend: T – thenardite; C – chlorite; Ca – calcite; M – muscovite; Q – quartz; G – gypsum.

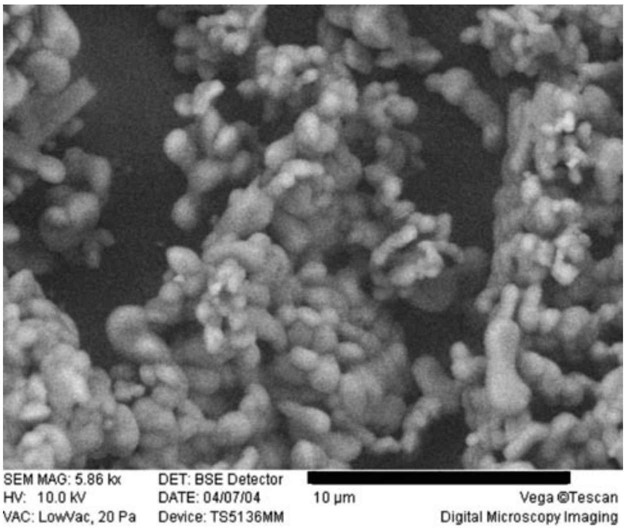

Fig. 21 SEM photograph of white powder on flysch (thanks to V. Bermanec).

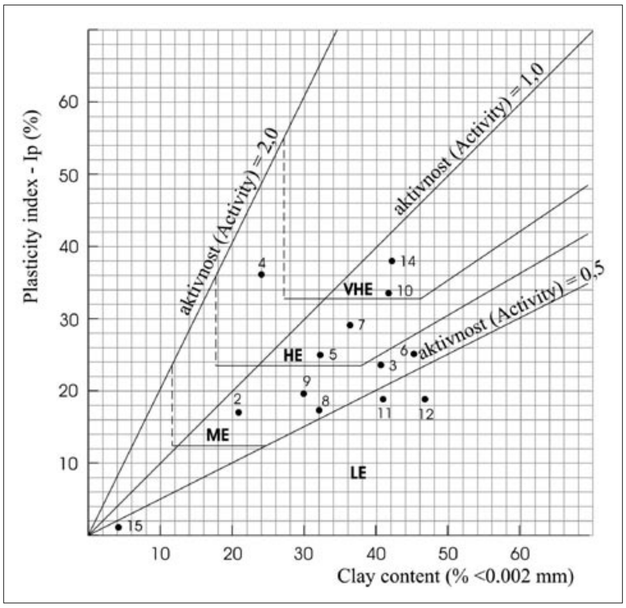

Fig. 22 Expansiveness chart (after WILLIAMS & DONALDSON, 1980). Legend: LE – low expansion; ME – medium expansion; HE – high expansion; VHE – very high expansion.

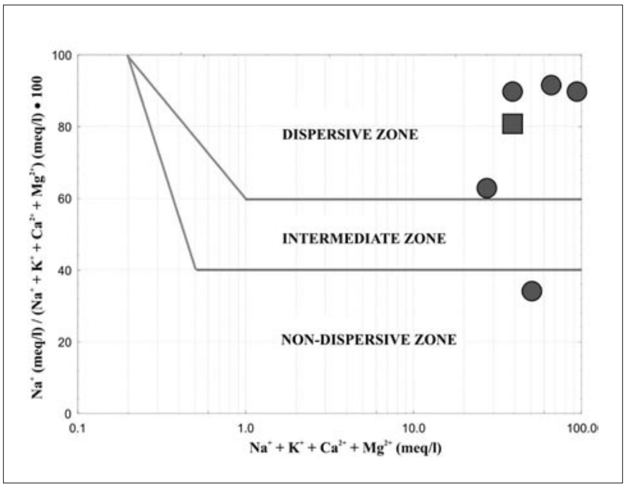

Fig. 23 Cations in the pore water of the flysch samples. Potential dispersivity chart after SHERARD et al. (1976). Stability after pinhole test: rectangle – nondispersive, circle – dispersive.