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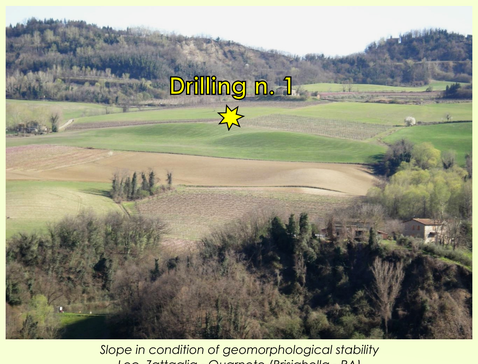
The pedological contribution to assessment of geomorphological slope stability

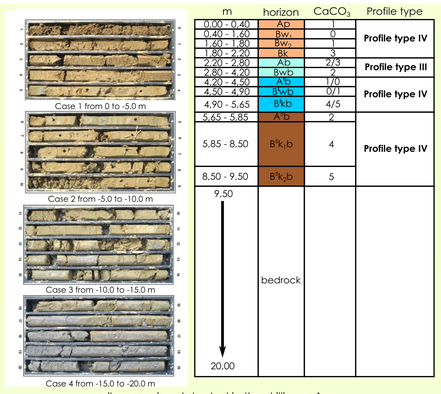
Domenico Preti, Marina Guermandi**, Marcello Nolè**
**Reno River Basin Authority; **Geological, Seismic and Soil Survey of Emilia-Romagna Region*

SOIL AN INDICATOR OF GEOMORPHOLOGICAL STABILITY



Slope in condition of geomorphological stability
Loc. Zattaglia - Quarneto (Brisighella - RA)

Soil is a natural body on the uppermost layer of the Earth's crust with specific properties that derive from the physical, chemical and biological transformation of the original rock.
Its characteristics are the result of combined factors such as climate, morphological processes and mineral composition of rock. Soils can therefore provide a great deal of information on the geomorphology of an area, particularly on the environmental conditions existing at the time of its formation.
The degree of soil evolution is closely linked to the opportunity for pedogenetic processes to be active more or less continuously over time, and to the intensity of processes that shape the environment (morphogenetic processes): consequently it is possible to identify the moment of interruption in a morphogenetic process (depositional, hydro or gravitational), in a morphological element: slope, alluvial terrace, landslide.
In the hilly-mountain areas of Emilia-Romagna (Apennines) erosive, hydro or gravitational processes tend to abrade soils and, depending on their intensity, may lead to a truncation of the soil up to its complete removal.
During prolonged periods of morphological stability there is a reverse tendency of soil accretion: soil tends to develop and over time forms distinctive, increasingly well-defined characteristics as a part of a balance with environmental conditions.
Consequently soil evolution is closely related to the interaction, intensity and duration of phases dominated by antithetical processes: morphogenesis and pedogenesis, and in particular it reflects the result of their interaction (mprpho-pedogenetic balance).



m	horizon	$CaCO_3$	Profile type
0.00 - 0.40	Ap	1	Profile type IV
0.40 - 1.60	Bw_1	0	
1.60 - 1.80	Bw_2	1	
1.80 - 2.20	Bk	3	
2.20 - 2.80	Ab	2/3	Profile type III
2.80 - 4.20	Bwb	2	
4.20 - 4.50	Ab	1/0	Profile type IV
4.50 - 4.90	Bwb	0/1	
4.90 - 5.65	B'kb	4/5	
5.65 - 5.85	A'b	2	Profile type IV
5.85 - 8.50	$B^{3}k_1b$	4	
8.50 - 9.50	$B^{3}k_2b$	5	
9.50 ↓ 20.00	bedrock		

soil succession detected in the drilling n. 1
executed on the slope of Zattaglia - Quarneto (Brisighella - RA)

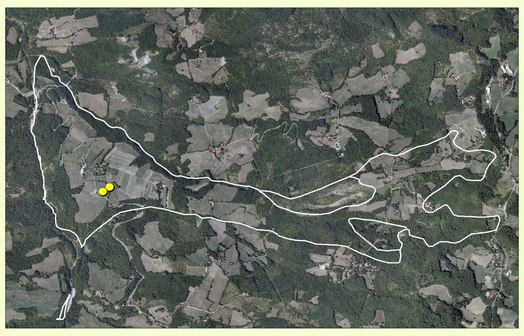
SOIL AS AN ELEMENT OF DATING

The presence of this ancient roman road (flaminia minor - 187 b.c.) testifies the prolonged geomorphological stability of the slope
(Pian di Balestra - San Benedetto Val di Sambro - BO - 1120 m above sea level)

The first experimentation using soil as an element of dating was conducted during the survey for the map of soils of the Modena plain, "Carta dei Suoli della Pianura Modenese", published in 1993 by the Geological, Seismic and Soil Service of the Emilia-Romagna Region.
Such experimentation was later refined, taking into account the indications of the "North American Stratigraphic Code - Version 1983" for the classification of "Pedostratigraphic Unities" developed in the extent of the "Po Plain Geological Map at scale 1: 50000" for dating the continental Quaternary deposits.
The analysis of the degree of evolution of soil profiles collected over more than two decades by the Geological, Seismic and Soil Service throghout Emilia-Romagna region, has enabled us to build up a "scale of the degree of evolution" across regional soils; "types" based on the degree of expression of genetic features have been created according to the degree of leaching carbonates, organization of carbonatic nodules and presence-absence of one or more B horizon. Each "type" identifies the time or historical period in which the deactivation of geomorphological processes occurred and pedogenesis began.
Now we are able to establish the minimum time necessary for the development of a certain type of soil: e.g. the discovery in the profile of archaelogical finds from the Bronze Age (800 - 2600 BC) is proof that pedogenesis began between 26000 and 800 BC.
Since the steady morphogenetic state has not subsequently undergone any significant disruptions, we can conclude that the "minimum pedogenetic time" (mpt) necessary for the development of the profile containing artifacts from the Bronze Age varies from between 2800 and 4600 years, while for finds from the 2nd century BC mpt can be estimated at about 2200 years and so on.

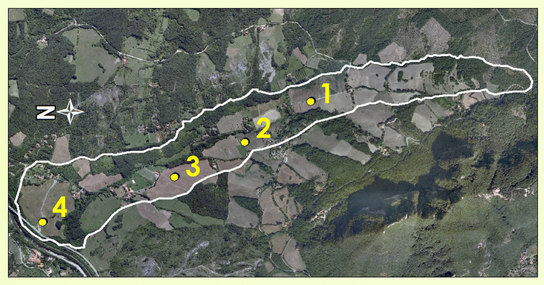
Soil profile detected near the ancient roman road (flaminia minor)
Profile "type" V - VI (?)

DATING OF LANDSLIDES ON A PEDOLOGICAL BASIS

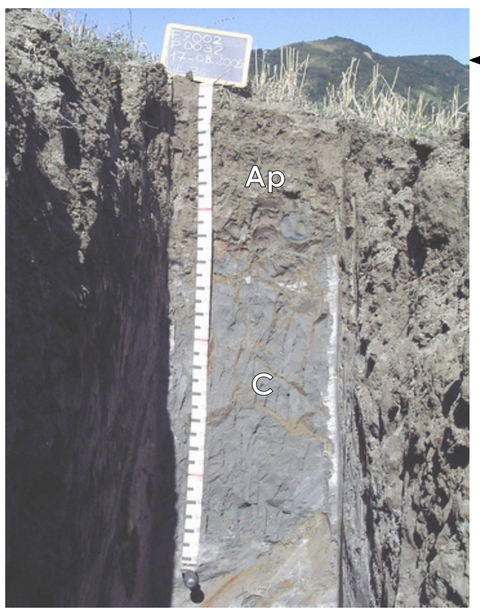


Soil survey of Pedena landslide (Lizzano in B. - BO). The detected profiles have been assigned to the Profile type IV (Base map Orthophoto AGEA 2008)

Deposits with a gravitational origin can lead to the development of soils, similar to what occurs with alluvial deposits, and are indeed similarly related to the alteration processes. The start of soil evolution can be traced back to the time after the deactivation of geomorphological processes; it is believed that the method used in surveying Quaternary deposits can be useful in evaluating the geomorphic stability of slopes and landslide hazard.
Through assessment of the degree of soil evolution we can determine when the gravitational phenomena ended or, in polycyclic landslides, we can ascertain whether the deactivation was simultaneous or not on the entire body of the landslide.
In order to verify the method proposed in areas dominated by erosion processes and calibrate the "types" identified and the allocation of *mpt* given to them, we surveyed the soil profiles on the slope and landslides whose status of geomorphological activity and duration of the period of stability were known.
The soil survey was performed by drilling and profile, as described by the *Soil Survey Manual* of the Geological, Seismic and Soil Service of the Emilia-Romagna Region, 2002 edition.



Soil survey of Oreglia landslide (Grizzana M. - BO). All the detected profiles have been assigned to the Profile type IV (Base map Orthophoto AGEA 2008)



Period of geomorphological stability: a few ten years (<100) (Entisoils)
PROFILE "TYPE" I: A or Ap - C; very calcareous ($CaCO_3$ > 10%)

Period of geomorphological stability: a few hundred years (100-500) (Inceptisoils)
PROFILE "TYPE" II: A or Ap - Bw - C; very calcareous ($CaCO_3$ > 10%)

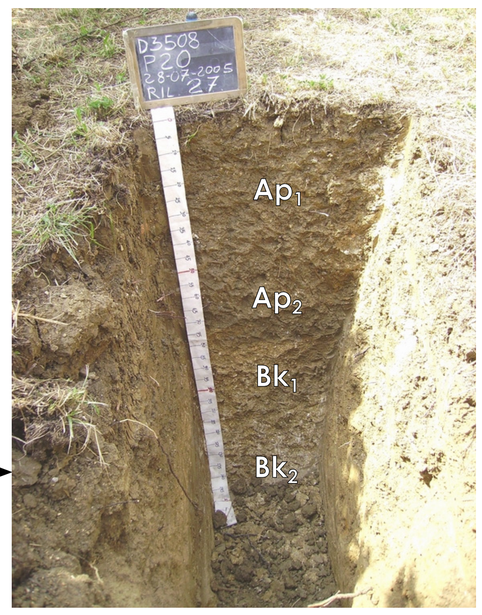
Period of geomorphological stability: hundred years (500-2000) (Inceptisoils)
PROFILE "TYPE" III: A or Ap - Bw; moderately or very calcareous ($CaCO_3$ > 5%)
Bk - C; very calcareous, concentration of carbonate ($CaCO_3$ > 10%)

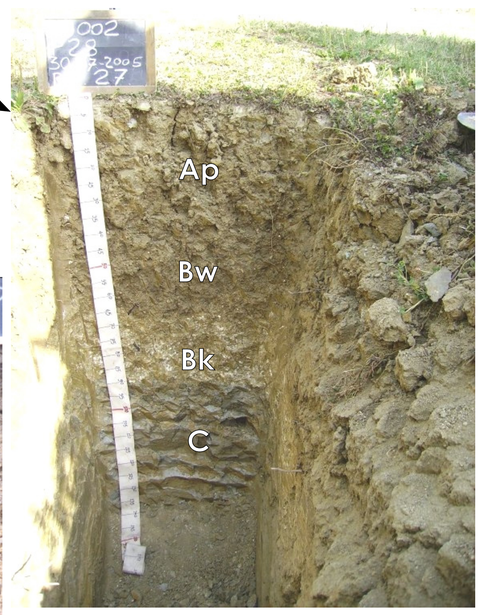
Period of geomorphological stability: a few thousand years (2000-8000) (Inceptisoils)
PROFILE "TYPE" IV: A or Ap - Bw; not calcareous or slightly calcareous ($CaCO_3$ < 5%)- Bk; very calcareous, concentration of carbonate ($CaCO_3$ > 10%) - C; very calcareous ($CaCo_3$ > 10%)

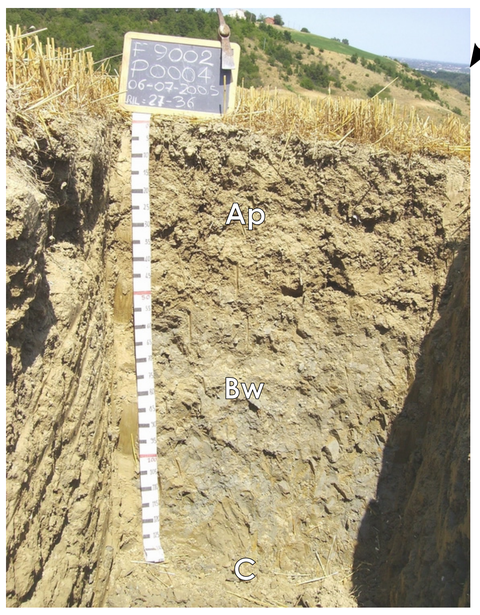
PROFILE "TYPE" V: A or Ap - Bw; not calcareous ($CaCO_3$ < 0,5%) - Bk; very calcareous, concentration of carbonates (calcic horizon)

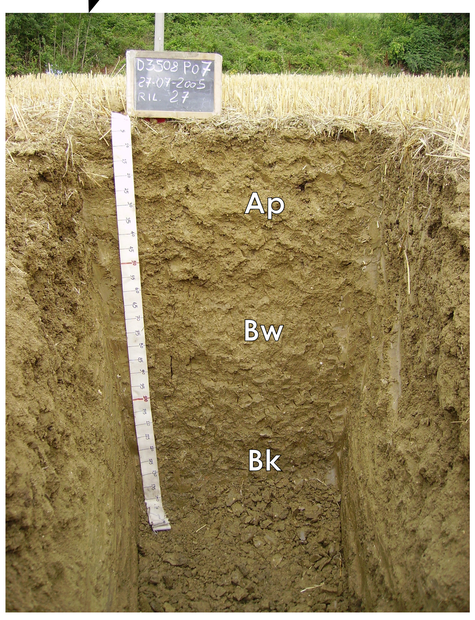
Period of geomorphological stability: thousands of years (>8000) (Inceptisoils-Alfisoils)
PROFILE "TYPE" VI: A or Ap - Bw or Bt; not calcareous ($CaCO_3$ < 0,5%) - Bk; very calcareous, concentration of carbonates (calcic horizon)) over 1,5 m of depth

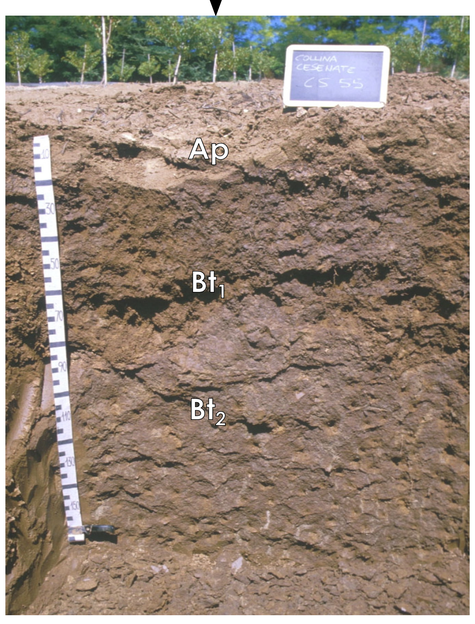
PROFILE "TYPE" VII: A or Ap - Bt; not calcareous ($CaCO_3$ < 0,5%) - Bk; very calcareous, concentration of carbonates (calcic horizon) within 2m of depth.

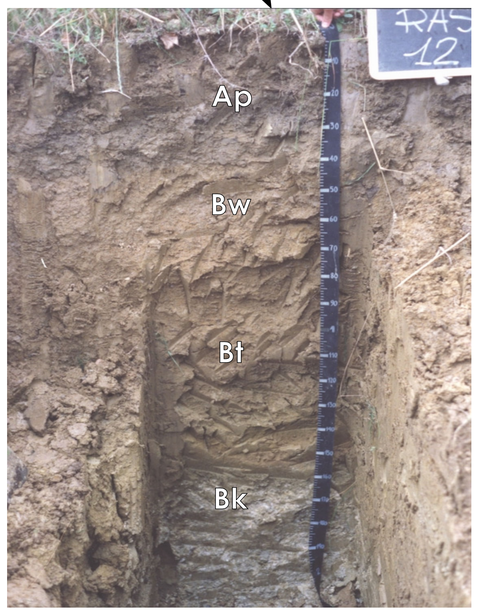












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