

Tonalit

Pohorje tonalite

Pohorski granodiorit

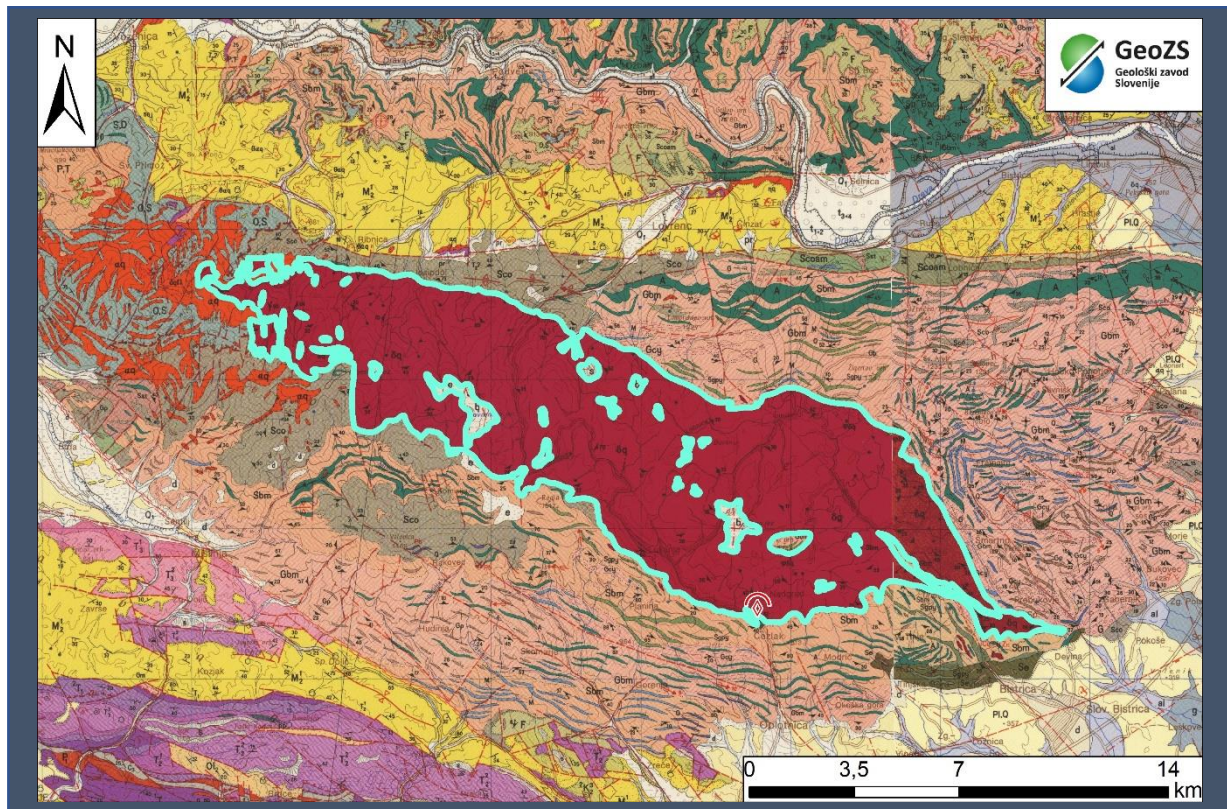


3 cm

Short description: The rock is light gray to gray, sometimes with bluish tint. It contains mafic inclusions and streaky schlieren. Structure is usually oriented. Granodiorite is crosscut by white aplite-pegmatite veins up to about 40 cm thick. The image displays a polished surface.

Commodity (vocabulary)	Lithology (vocabulary)	Typical colour (code list)	Place of origin			
			Country	County / District / Province	Municipality / Community	Place/town / Village
granite	granodiorite	gray	Slovenia	Štajerska (traditional province)	Oplotnica	Cezlak, Oplotnica

Geological setting



Geology: Granodiorite forms central part of the Pohorje massive , a tectonic block belonging to the Austroalpine units of the Eastern Alps. Central part of the block is intruded by the [Early Miocene](#) medium-grained grey granodiorite, but locally also tonalite is present. The genesis of granodiorite is connected to Neogene magmatism and tectonics which was intensive in this area.

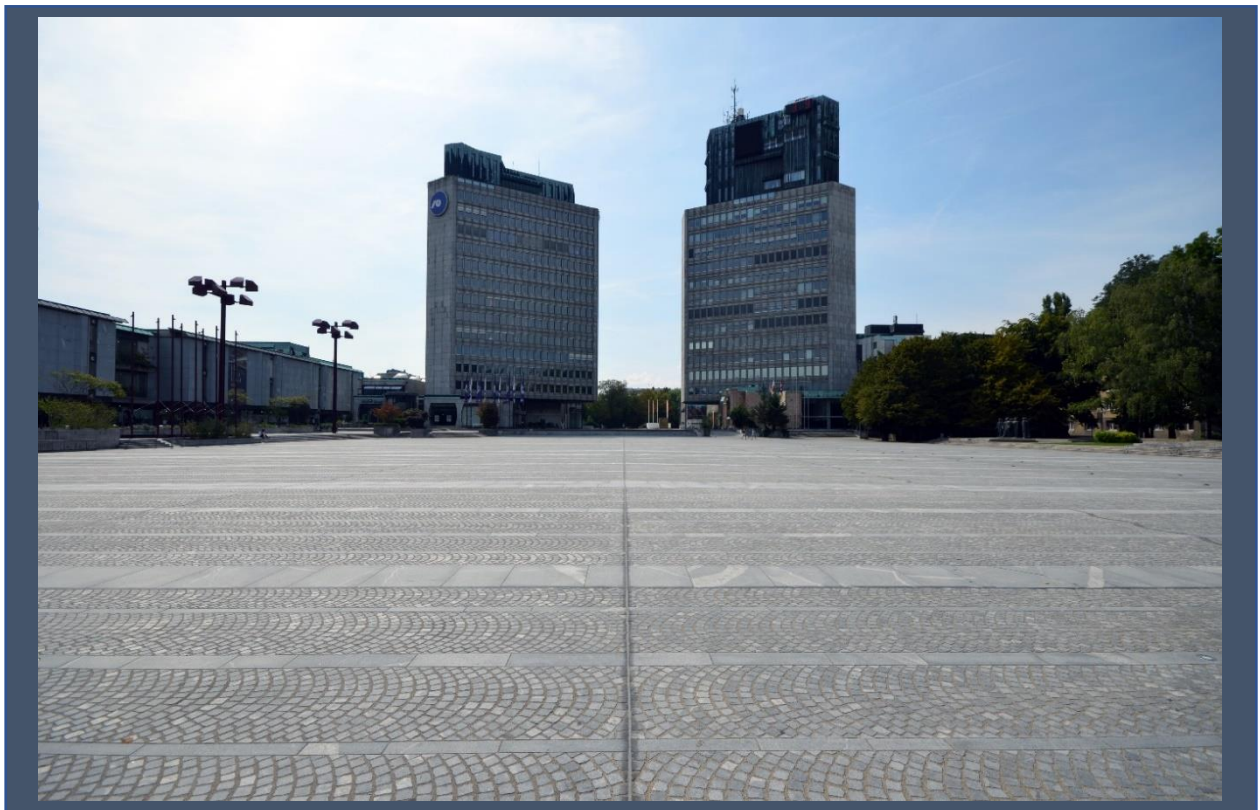
Production: Active, concessionaire MINERAL, quarry Cezlak I at Oplotnica, concession for extraction of natural stone.

Geological age: Miocene (16-19 million years)

Geological unit: Pohorje igneous complex

Application, use and heritage

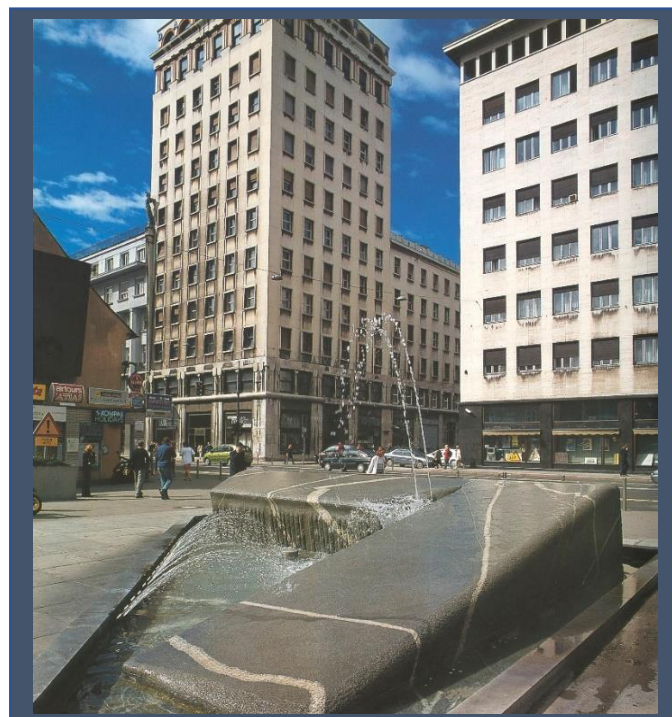
Description: The rock in Cezlak attracted interest of people already in the 19th century, when local farmer started small extraction in 1891. Bigger production started in 1910 under the ownership of Windischgrätz when the first investigations were carried out. Mainly paving cubes and blocks for construction of bridges were produced. After World War II, the production and the market were growing. Granodiorite is very appreciated stone in Slovenia due to its durability and decorative white veins. Numerous architectural details are made of granodiorite, and some important buildings decorated: the Slovenian Parliament, the Republic Square business complex, the Faculty of Law of the University of Ljubljana, many post-war stone sculptures etc. Granodiorite is also exported, mostly to Austria, Germany and Switzerland. .



The Republic Square in Ljubljana. Facades of both towers are lined with panels, and the square's surface is paved with granodiorite bricks and tiles.

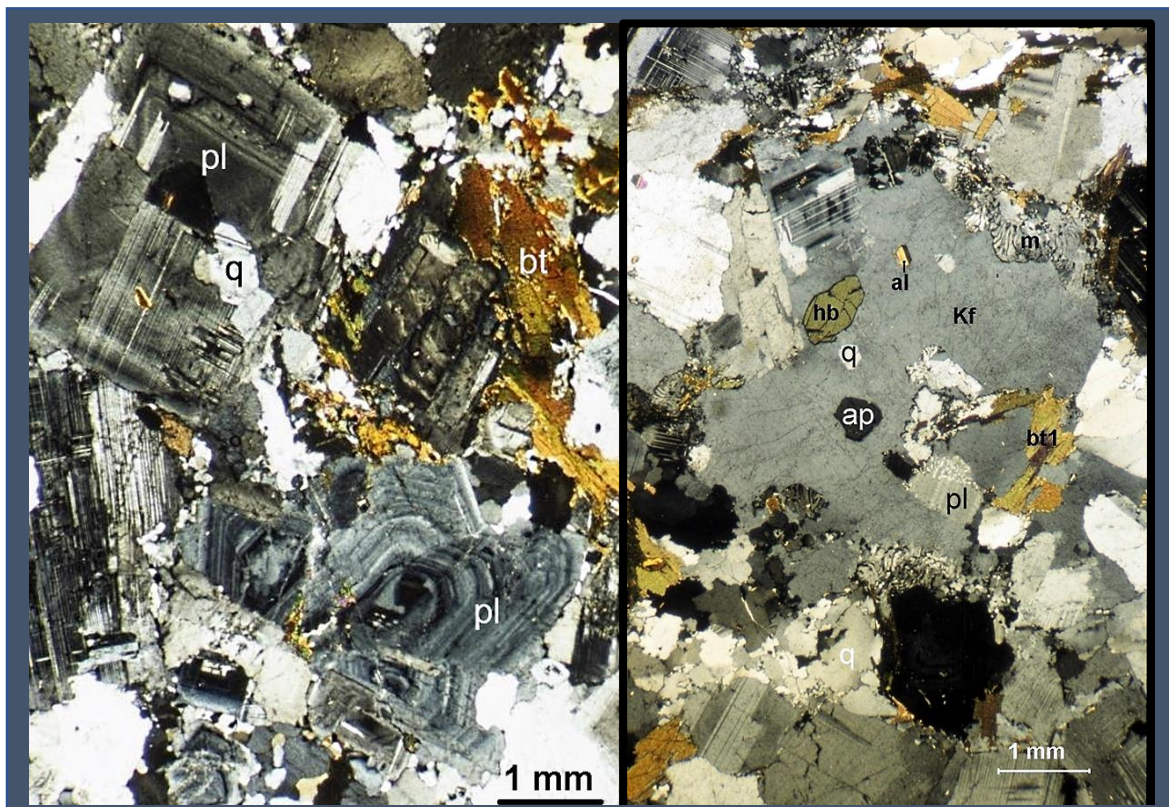
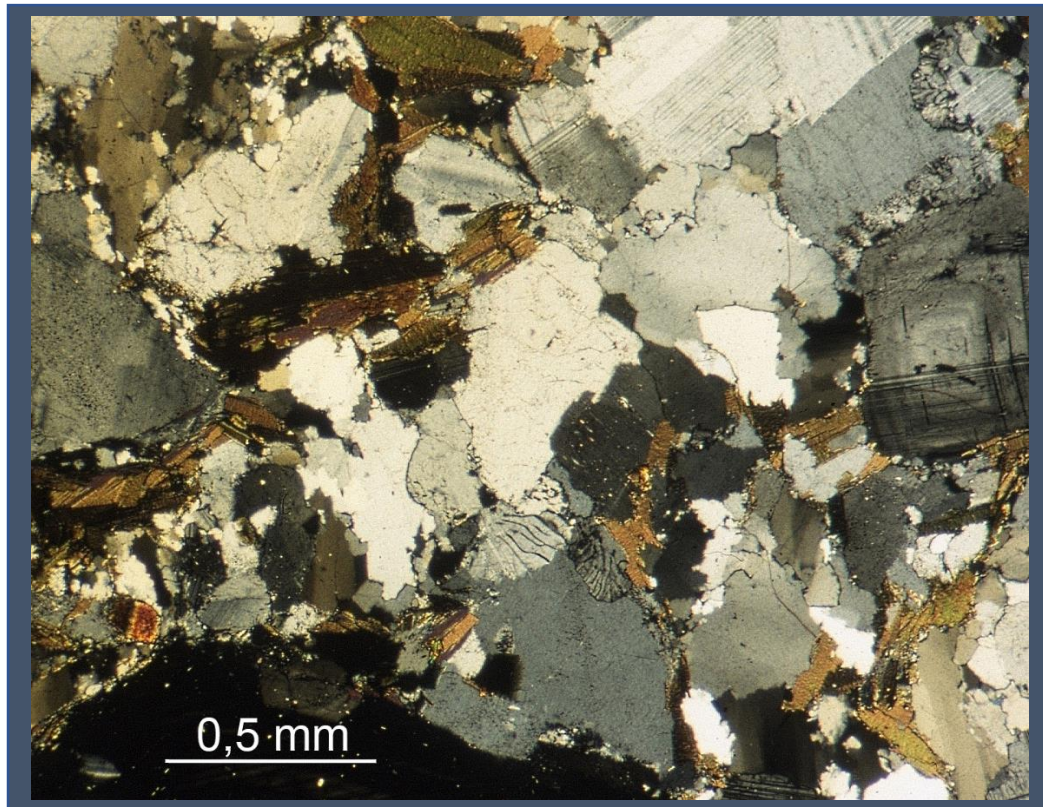


The Čopova street in Ljubljana paved with Pohorje granodiorite with decorative aplite-pegmatite veins.



The Mobitel Fountain in Ljubljana is made of two monolithic blocks of granodiorite, the largest ones ever extracted in Cezlak I quarry.

Petrography



Description:

Upper figure: Medium-grained hypidiomorphic granular texture of white plagioclase and K-feldspar, grayish quartz, brown biotite and hornblende. Accessory orthite, apatite, zircon, titanite, opaque minerals (pyrite, magnetite).

Local alterations yield secondary chlorite, calcite, part of epidote and sericite. Aplite-pegmatite veins are composed of K-feldspar, plagioclase, quartz, and sparsely contain white mica, opaque minerals and tiny garnets.

Figure lower left: Granodiorite with older lamellar (pl) and younger zoned plagioclases (pl), corroded biotite (bt) and strained quartz (q). × nicols.

Figure lower right: Tonalite to granodiorite transition. Metasomatic K-feldspar (Kf) grain with myrmekitic reaction rim (m) toward plagioclases, including plagioclase (pl), biotite (bt), quartz (q), hornblende (hb), apatite (ap) and alunite (al). × nicols.

Source of information: Geological Survey of Slovenia, Mirtič et al., 1999; Trajanova et al., 2009; Kramar et al., 2016.

Mineral composition

If no accurate number, use MM=main minerals, SM = Subordinate minerals, AM=accessory minerals

Plagioclase (%)	Quartz (%)	Biotite (%)	K-feldspar (%)	Hornblende (%)	Orhtite (%)	Apatite (%)
30-40	20-30	10-15	5-10	1	In traces	In traces
Zircon (%)	Titanite (%)	Pyrite (%)	Magnetite (%)	Calcite (%)	Epidot (%)	Allanite
In traces	In traces	In traces	In traces	In traces	In traces	In traces

Source of information: Faninger, 1973; Zupančič, 1994a; Zupančič, 1994b; Zupančič, 1996; Mirtič et al., 1999; Trajanova et al., 2008; Trajanova et al., 2009; Trajanova et al., 2013

Physical properties

Apparent density (EN 1936) kg/m ³	Open porosity (EN 1936) % vol	Water absorption at atmospheric pressure (EN 13755) % wt	Uniaxial Compressive strength (EN 1926) MPa	Flexural strength under concentrated load (EN 12372) MPa

Real density (EN 1936) kg/m ³	Total porosity (EN 1936) % vol	Water absorption coefficient by capillary (EN 1925) (g/m ² x s ^{0,5})	Flexural strength under constant moment (EN 13161) MPa

Frost resistance (EN 12371)				
Technological Test (Test A)				Identification Test (Test B): Number of cycles completed prior to stone failure
Flexural strength (EN 12372) after freeze-thaw cycling, MPa	Number of cycles	Uniaxial compressive strength (EN 1926) after freeze-thaw cycling, MPa	Number of cycles	

Resistance to ageing by thermal shock (EN 14066)			
Change in dynamic modulus of elasticity (increase: +; decrease: -) %	Change in open porosity (increase: +; decrease: -) %	Change in ultrasound pulse velocity (increase: +; decrease: -) %	Change in flexural strength under conc. load (increase: +; decrease: -) %

Abrasion resistance (EN 14157)			Resistance to salt crystallisation (EN 12370)	Breaking load at dowel hole (EN 13364)	
Method A - Wide Wheel Abrasion Test, mm	Method B - Böhme Abrasion Test, cm ³ / 50cm ²	Method C - Amsler Abrasion Test, mm	Change in mass (increase: +; decrease: -), %	Breaking load, N	Thickness of the test specimens, mm

Slip resistance by means of the pendulum tester (EN 14231 / CEN/TS 16165)			Rupture energy (EN 14158), Joule	Thermal Conductivity (EN 1745), W/m·K
Tested surface finish	Slip Resistance Value — SRV			
	Dry test condition	Wet test condition		

Methods applied and source of information:

Chemical properties

Main elements

SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	TiO ₂ (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)	MnO (%)	P ₂ O ₅ (%)	SO ₃ (%)	LOI (%)
69	19	1-2	-	-	5	-	-	-	-	-	-

Trace elements

V (ppm)	Cr (ppm)	Mn (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)
Sr (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)	Be (ppm)	Rb (ppm)	Bi (ppm)	U (ppm)
Sc (ppm)	Y (ppm)	Th (ppm)	Sb (ppm)	Ta (ppm)	Nb (ppm)	Zr (ppm)	Sn (ppm)
Ag (ppm)	B (ppm)	Mo (ppm)	W (ppm)	Ga (ppm)	Ge (ppm)	Se (ppm)	Cs (ppm)
Tl (ppm)							

REE

La (ppm)	Ce (ppm)	Pr (ppm)	Nd (ppm)	Sm (ppm)	Eu (ppm)	Gd (ppm)	Tb (ppm)
Dy (ppm)	Ho (ppm)	Er (ppm)	Tm (ppm)	Yb (ppm)	Lu (ppm)		

Methods applied and source of information: JUS B.H 360 to 369
Mirtič et al., 1999.

Sources of more information

Type of information	Name of provider	URL
This data sheet		
Non-commercial directory	Geological Survey of Slovenia: Mining Registry Book	https://www.ms.geo-zs.si/en-GB
Commercial directory		
Scientific publications	FANINGER, E. 1973. Pohorske magmatske kamnine. <i>Geologija</i> 16, 271-315. ZUPANČIČ, N. 1994a. Petrografske značilnosti in klasifikacija pohorskih magmatskih kamnin. <i>Rud. met. zb.</i> 41, 101-112. ZUPANČIČ, N. 1994b. Geokemične značilnosti in nastanek pohorskih magmatskih kamnin. <i>Rud. met. zb.</i> 41, 113-128. ZUPANČIČ, N. 1996. Minerali pohorskega magmatskega masiva. <i>Geologija</i> 37, 271-295. MIRTIČ, B., MLADENVIČ, A., RAMOVŠ, A., SENEGAČNIK, A., VESEL, J., & VIŽINTIN, N. 1999. Slovenski naravni kamen. Ljubljana, Geological Survey of Slovenia, Slovenian National Building and Civil Engineering Institute, University of Ljubljana Geology department. 131 pg. TRAJANOVA, M., PÉCSKAY, Z. and ITAYA, T. 2008. K-Ar geochronology and petrography of the Miocene Pohorje Mountains batholith, Slovenia. <i>Geologica Carpathica</i> 59/3, 247-260. TRAJANOVA, M., ZUPANČIČ, N., DOBNIKAR, M. 2009. Terciarni magmatizem = Tertiary magmatism. In: PLENIČAR, M. et al. (eds.), <i>Geologija Slovenije = The geology of Slovenia</i>. Ljubljana: Geološki zavod Slovenije. TRAJANOVA, M. 2013: Starost pohorskega magmatizma; nov pogled na nastanek pohorskega tektonskega bloka (Age of the Pohorje magmatism; new view on the origin of the Pohorje tectonic block). PhD thesis. 183 pp., Ljubljana. KRAMAR, S., TRAJANOVA, M., DOLENEC, M., GUTMAN, M., BEDJANIČ, M. & MLADENVIČ, A. 2016. Heritage Stone 7. Pohorje Granodiorite – One of the Most Significant Slovenian Natural Stones. <i>Geoscience Canada</i>, 43, 79-88.	
Other publication		

Compiled by:	Geological Survey of Slovenia (GeoZS) www.geo-zs.si	Logo
		 GeoZS Geološki zavod Slovenije