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Research paper

Correlation between chemical and mineralogical characteristics and permeability of phyllite clays using multivariate statistical analysis

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ABSTRACT

Phyllite clays are applied as a layer on a surface to be waterproofed and subsequently compacted. For this purpose, phyllite clays deposits can be grouped by their chemical and mineralogical characteristics, and these characteristics can be connected with their properties, mainly permeability, in order to select those deposits with the lowest permeability values. Several deposits of phyllite clays in the provinces of Almería and Granada (SE Spain) have been studied. The results of applying a multivariate statistical analysis (MVA) to the chemical data analysed from 52 samples determined by XRF, mineralogical analysis by XRD and permeability are reported. Permeability, a characteristic physical property of phyllite clays, was calculated using the results for experimental nitrogen gas adsorption and nitrogen adsorption-desorption permeability dependence. According to the results, permeability values differentiated two groups, i.e. group 1 and group 2, with two subgroups in the latter. The influence of chemical as well as mineralogical characteristics on the permeability values of this set of phyllite clays was demonstrated using a multiple linear regression model. Two regression equations were deduced to describe the relationship between adsorption and desorption permeability values, which support this correlation. This was an indication of the statistical significance of each chemical and mineralogical variable, as it was added to the model. The statistical tests of the residuals suggested that there was no serious autocorrelation in the residuals.

1. Introduction

Phyllite clays or phyllites are foliated rocks, metamorphosed to a low extent, because they are formed by low-temperature regional metamorphism, of slate clay materials. Their essential components are an abundance of very fine-grained phyllosilicates, which gives them an unctuous feel, and quartz; occasionally, they may contain calcite (calcareous phyllites). The existence of preferential cleavage gives them the property of being easily breakable into thin sheets (Garzón et al., 2009a, 2009b; Garzón et al., 2010; Oliva-Urcia et al., 2010; Oliveira et al., 2015; Ramamurthy et al., 1993; Valera et al., 2002). Their colours range from beige to violet and from reddish to gray and black. Although found in several parts of the world, phyllite clays are abundant in the Betic Cordilleras (Andalusia, S Spain), e.g. in the provinces of Almería and Granada, mainly in Alpujarride and Malaguide Complex (Alcántara-Ayala, 1999; Azañón et al., 1995; Crespo-Blanc, 1995; Gómez-Pugnaire et al., 1978; Lonergan and Platt, 1995; Sanz de Galdeano, 1990; Sanz de Galdeano et al., 2001; Sanz de Galdeano and López-Garrido, 2014). The nature of the contact between Alpujarride and Malaguide complexes has been discussed by Lonergan and Platt (1995). The tectonic map of the central Betics, geological setting and structure of the Alpujarride Complex, cross-sections and other notable features have been reported by Azañón et al. (1995). Sanz de Galdeano et al. (2001) concluded that the presence of the Intermediate Units indicates that the change from the Alpujarride to Malaguide complexes was not abrupt, but rather occurred with a wide transitional domain between them.

In Sierra Nevada (SE Spain), phyllites form a band of Permo-Triassic materials (slate, marble, and clay phyllites). In Sierra Alhamilla (Almería) there is a phyllite area in blue, violet, and reddish colours in which limestone and dolomite can be found, separated by a transition area of calco-schists. All these materials belong to the Alpujarride Complex (Alcántara-Ayala, 1999; Crespo-Blanc, 1995; Gómez-Pugnaire et al., 1978; Lonergan and Platt, 1995; Sanz de Galdeano, 1990; Sanz de Galdeano and López-Garrido, 2014). The northern and western borders of the Sierra Cabrera (Almería) have several outcrops considered to belong to the Malaguide complex with dark Palaeozoic lutites and Jurassic and Tertiary sediments: its Triassic sequences are formed by phyllites (Sanz de Galdeano et al., 2001). Small outcrops are also found in the Sierra de Alhamilla (Almería), in particular on the northern border, some in the south, and a few in the east where this sierra joins the Sierra Cabrera (Sanz de Galdeano et al., 2001). The geological setting and morphology of the Sierra de Lújar, cross-sections and main features

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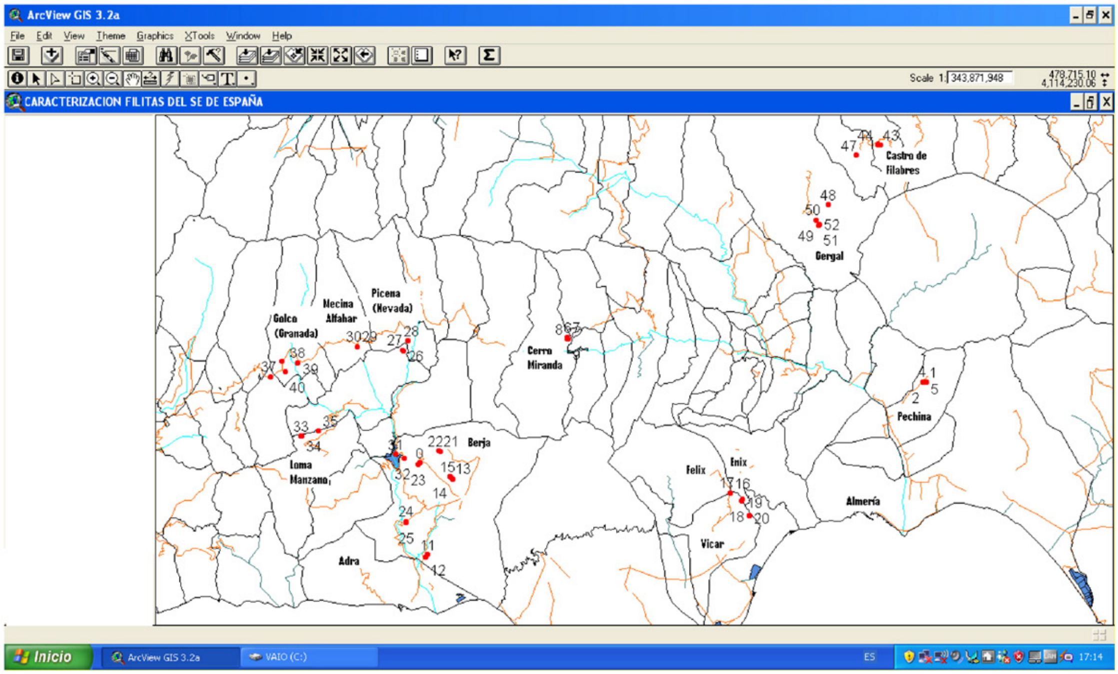

ID	Coordinate X	Coordinate Y	Altitude	Localization	ID	Coordinate X	Coordinate Y	Altitude	Localization
1	553311	4090277	386	Sierra Alhamilla –Almería	27	498523	4093685	673	Loma Palomares –Granada
2	553278	4090308	389	Sierra Alhamilla –Almería	28	499083	4094683	809	Picena –Granada
3	553294	4090271	387	Sierra Alhamilla –Almería	29	493813	4094054	775	Mecina Alfahar –Granada
4	553100	4090334	408	Sierra Alhamilla –Almería	30	493800	4094070	778	Mecina Alfahar –Granada
5	553475	4090268	368	Sierra Alhamilla –Almería	31	497849	4082751	353	Pantano de Beninar –Almería
6	515864	4095033	972	Sierra Alhamilla –Almería	32	498743	4082262	358	Pantano de Beninar –Almería
7	515867	4094997	986	Cerro Miranda-Almería	33	487919	4084640	602	Loma del Manzano –Granada
8	515834	4094835	989	Cerro Miranda –Almería	34	487981	4084641	605	Loma del Manzano –Granada
9	515868	4094834	997	Cerro Miranda –Almería	35	489716	4085213	629	Loma del Manzano –Granada
10	515891	4094840	1001	Cerro Miranda –Almería	36	489686	4085232	631	Loma del Manzano –Granada
11	501169	4072174	238	Cerro Miranda –Almería	37	484715	4090880	1200	Ctra. Berchules a Mecina Bombaron-Granada
12	500986	4071956	234	Alto del Cerrón –Almería	38	487553	4092332	1120	Golco –Granada
13	503788	4080132	356	Peñarrodada (Berja)-Almería	39	487578	4092315	1112	Golco –Granada
14	503613	4080312	363	Peñarrodada (Berja)-Almería	40	486255	4091387	1120	Golco –Granada
15	503596	4080372	377	Peñarrodada (Berja)-Almería	41	486269	4091394	1122	Golco –Granada
16	532932	4078647	529	Rambla Hortichuelas (Enix)-Almería	42	485903	4092520	1220	Mecina Bombarón-Granada
17	532919	4078671	531	Rambla Hortichuelas (Enix)-Almería	43	548715	4115214	1130	Castro de Filabres - Almería
18	534133	4077874	387	Rambla Hortichuelas (Enix)-Almería	44	548430	4115235	1149	Castro de Filabres- Almería
19	534206	4077978	358	Rambla Hortichuelas (Enix)-Almería	45	548442	4115233	1147	Castro de Filabres- Almería
20	534925	4076316	207	Rambla Hortichuelas (Enix)-Almería	46	548443	4115338	1178	Castro de Filabres- Almería
21	502551	4083060	546	El Cid (Berja) –Almería	47	546145	4114144	1067	Olula de Castro- Almería
22	502382	4083101	559	El Cid (Berja)-Almería	48	543239	4108948	887	Gergal- Almería
23	500220	4081617	478	Cortijada de Rodríguez (Berja) –Almería	49	541941	4107295	742	Gergal- Almería
24	498904	4075698	265	Río Grande –Almería	50	541922	4107358	742	Gergal- Almería
25	498898	4075577	253	Río Grande –Almería	51	542183	4106782	798	Gergal- Almería
26	498647	4093609	658	Loma Palomares-Granada	52	542278	4106841	803	Gergal- Almería

Fig. 1. Identification (ID) and localization by GPS of the samples.