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The Relationships Between Absorption, Alterability and Granulation of Coarse Aggregates from Different Lithologies from Southern Brazil

Relação entre Absorção, Alterabilidade e Granulação de Agregados Graúdos de Diferentes Litologias do Sul do Brasil

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Abstract

This paper studies the mathematical and statistical correlations between absorption, alterability, and granulation of aggregates from different lithological origins in southern Brazil. In order to achieve this goal, a petrographic analysis of the aggregates was carried out, in addition to a qualitative evaluation of granulation/alterability and absorption tests for the 1/2” (12.5 mm), 3/8” (9.5 mm), and #4 (4.75 mm) sieve. Statistical analysis relied on the Shapiro-Wilk and Breusch-Pagan tests, using R-Studio software. The results show that the variables “granulation” and “alteration” exhibit satisfactory correlations with the variable “absorption”, indicating that the larger the grain size the lower the absorption, while the higher the alteration the higher the absorption. The more the particle size decreases, the greater the variable “absorption” can explain “granulation”. Regarding the alteration and absorption degree, the analysis was not feasible, since the analyzed group that included high absorption and low alteration volcanic rocks could modify the trend, contradicting the consensus that the more altered the rock, the more it absorbs. Overall, the employed methodology proved to be satisfactory for the database analyzed, with the suggestion of increasing the number of samples in future studies.

Keywords: Degree of alterability; Granulation; RStudio

Resumo

Este artigo estuda as correlações matemáticas e estatísticas existentes entre absorção, alterabilidade e granulação de agregados de diferentes origens litológicas do sul do Brasil. A fim de atingir esse objetivo, foi realizada a análise petrográfica dos agregados, avaliação qualitativa de granulação e alterabilidade e ensaios de absorção para as frações 1/2“ (12,5 mm), 3/8“ (9,5 mm) e #4 (4,75 mm). A análise estatística contou com os testes de Shapiro-Wilk e Breusch-Pagan, utilizando o software R-Studio. Os resultados mostram que as variáveis “granulação” e “alteração” exibem satisfatórias correlações com a variável “absorção”, indicando que, quanto maior for a granulação menor será a absorção, enquanto que, quanto maior a alteração maior será a absorção. À medida que a fração diminui, maior é o valor que a absorção consegue explicar a granulação. Em relação ao grau de alteração e absorção, a análise não foi viabilizada, visto que o grupo analisado que incluía rochas vulcânicas de alta absorção e baixa alteração poderia modificar a tendência, contrariando o consenso de que quanto mais alterada a rocha, mais ela absorve. De modo geral, a metodologia empregada se mostrou satisfatória para este banco de dados analisado, sugerindo-se o aumento de amostras em estudos futuros.

Palavras-chave: Grau de alterabilidade; Granulação; RStudio

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1 Introduction

The chemical and geomechanical performance of crushed aggregates depend on several factors such as the rock's origin characteristics (e.g., granulation, mineralogy), the crushing processes and the action of the environment along geological time, especially by weathering. One of the consequences of the weathering process is the variation of the properties and hence the physical indexes of the rock material. Lopes et al. (2007) found that the increase of porosity and void ratio with the reduction of specific gravity are important indicators of the alteration process undergone by the rocks. Furthermore, characteristics such as spacing, nature, persistence and opening of discontinuities, in addition to rock mass stress conditions, are very important in defining the influence of fracturing on rock material alterability (Price 1995; Pola et al. 2012). Besides the mechanical performance variation of the rocks, the weathering also generates deterioration on the surface of the material. It can be in its physical and/or chemical form, or of the surface layer where porous materials are included, resulting in numerous visible and invisible effects such as: discoloration, formation of crusts and rusty spots, surface darkening, production of cavities, surface scaling, and fragmentation (Nascimento 1970; Aires Barros 1971; Rocha 1971; Farjallat 1972; Yoshida 1972).

Another associated aspect contributing to the rock's alterability is their permeability. According to Roisenberg (1974): "alterability is directly related to the permeability of the rock. Highly compact rocks are not very susceptible to alteration". In other words, at the microcracking level, the presence of macro and microcracks in the rock massif allows the occurrence of chemical reactions between the rock and the percolated water, which can modify the material's porosity and permeability characteristics (Farjallat 1972; Frazão 1993; Marrano 1997; Wong et al. 2006; Pola et al. 2012). Thus, percolated water can reach the expansive clay minerals present in the pores or cracks in an accelerated way, hastening even more the disintegration processes, due to the traction stresses originated by the clay mineral's volume increase upon water absorption.

Different rock formation pressures directly influence the porous behavior of the crushed material. Metamorphic rocks of original granitic composition, mineral iso-orientation (e.g., lineation, schistosity) constitute discontinuity planes that can contribute to increased porosity (Frascá 2003). In general, plutonic igneous rocks present low porosities due to the high pressure and formation temperature, their pores are represented mainly by micro-cracks, changes in minerals, contact between grains, etc. Gouveia et al. (2004) when analyzing rocks of the same chemical composition found that higher granulation aggregates present more interstices (i.e., pores) between their crystals, facilitating penetration into the aggregate particles. Guerra (2011) and González et al. (2020) adds that porosity values vary according to different rocks, even if they belong to the same genetic group. Thus, porosity for the same group of rocks is not directly related to its chemical composition, since it can vary according to its depth, geological age, and degree of weathering.

Rodrigues (1977) found that petrographic and petrological observations on mineral alteration indicate that the future behavior of these materials will depend much more on the current state of alteration of the minerals than the nature of these minerals themselves. According to Frazão (2002, 2012), the petrographic properties to be evaluated can be separated into five topics, named: mineralogical composition (essential/accessory/secondary minerals and their qualities); texture (microscopic shape and arrangement of minerals); structure (macroscopic arrangement); mineral alteration (healthy or altered, and when altered, should pay attention to the type of alteration); degree and type of microcracking (intercrystalline or intracrystalline, open or filled). Although petrographic analysis is a qualitative evaluation, it remains the most valuable tool for determining the quality of mineral aggregates (Berubé, 2001).

Mineral alteration is an important factor to be evaluated, however, it is often only possible to evaluate its quality through microscopic analysis. Aires Barros (1991) further states that mineralogical alteration can result in neominerals formation, which interfere with rock's porosity and absorption, decreasing mechanical resistance. However, sometimes the analysis is limited to the description of the textural, mineralogical, and alterability elements, as a complementary character to the laboratory evaluation, indicating the presence of microscopic behaviors that do not occur in the macroscopic level in laboratory tests.

Thus, source characteristics such as petrography, alteration, granulation, absorption, density and porosity are related to each other, in such a way that weathering processes tend to modify the physical and mechanical properties. Therefore, considering the geomorphologic variability in southern Brazil, the research intent to continue developing González et al. (2020) and Back et al. (2021) studies, aiming to remedy the existing gaps about the characteristic behavior of volcanic, plutonic and metamorphic rocks, facing the absorption and porosity characteristics. In addition, this study proposes to verify representative mathematical correlations between alterability, granulation, and absorption for aggregates derived from different lithological sources, using statistical and petrographic analyses.

2 Methodology and Data

2.1 Materials

The rock materials used in this research belong to different geomorphological formations of southern Brazil, which are widely used in pavement construction. The aggregates were collected from the quarry piles and tested at the Civil Construction Materials Laboratory (LMCC) of the Federal University of Santa Maria (UFSM) for physical, chemical and mechanical characterization. The adopted nomenclature, quarry name, municipality of origin, and geographic coordinates are in Table 1.

Table 1 Location of the quarries studied.

Nomenclature	Quarry	Municipality	Geographical Coordinates
SJ	São Juvenal	Cruz Alta (RS)	22J 251945.40m W 6826112.10m S
SBS	SBS Engenharia	Capão do Leão (RS)	22J 357488.45m W 6483361.81m S
DPA	Della Pasqua	Itaara (RS)	22J 228402.58m W 6724545.40m S
FRAG	Britador Fragoso	Campo Alegre (SC)	22J 660919.05 m W 7102744.02 m S
VOG	Britagem Vogelsanger	Joinville (SC)	22J 705279.70 m W 7091726.68 m S
MIN	Minersul	Capão do Leão (RS)	22J 356218.47 m W 6481377.01 m S
CONP	Conpasul	Butiá (RS)	22J 356218.47 m W 6481377.01 m S
ELD	Eldorado Mineração	Eldorado (RS)	22J 409812.82 m W 6670310,44 m S

2.2 Methods

Representative hand samples were collected from the quarry outcrop in order to perform petrographic analysis according to NBR 15845 – Annex A (ABNT 2015) and DNER-IE 006 (DNER 1994) standards. The test is intended to provide information regarding the name of the rock, mineralogical composition, color, structure, texture, alteration, microfracturing, cohesion, use potential, among others. The preparation and description of the slides were done in the Lamination Laboratory of the Department of Geosciences, belonging to the Federal University of Santa Maria.

In order to analyze the granulation and alteration of the materials, a qualitatively arbitrated numerical scale was elaborated. The rocks classified as 5 are aphanitic (i.e., grains are not visible in their matrix) and the rocks classified as 20 are phaneritic (i.e., larger and visible grains). As for alteration, it ranged from 1 to 4, being: (1) not altered, (2) slightly altered, (3) moderately altered, (4) altered, and (5) extremely altered. Figure 1 exemplifies both classifications.

About the aggregate's characterization tests, the coarse aggregate absorption test was performed based on DNER-ME 195/98 and DNER-ME 81/98 (DNER 1998a, 1998b). The analyzed materials were sieved and separated through granulometric fraction, differently from the standard proposal, and submitted to 24 hours water immersion, superficial drying, weighing and submerged weighing. The fractions used in this research were 1/2" (12.5 mm), 3/8" (9.5 mm), and #4 (4.75 mm).

For the statistical analysis, free *software* called RStudio was used. The Shapiro-Wilk test was conducted to evaluate the normality of the data, using the following criteria to verify whether the distribution is normal or not: (i) if $p \leq \alpha$, H_0 is rejected, i.e., it cannot admit that the data set in question has Normal distribution; (ii) if $p > \alpha$, H_0 is not rejected, i.e., Normal distribution is a possible distribution for this data set. In addition, the verification of outliers was performed through the *boxplot* graph. The respective graph, *boxplot,* or box diagram, allows visualizing the distribution and discrepant values (*outliers*) of the data, and evaluating and developing on the data's nature (Valladares Neto et al. 2017).

Figure 1 Examples of granulation and alteration.

In turn, the Breusch-Pagan test was performed to verify the homoscedasticity of the residues (heteroscedasticity), and the following criterion was established: (i) if $p \leq \alpha$, H_0 is rejected, that is, the residues present heteroscedasticity; (ii) if $p > \alpha$, H_0 is not rejected, that is, the residues present homoscedasticity. Finally, the decision making to evaluate the model generated in the regression involves the probability test, if $p > \alpha$, H_0 *is rejected and* H_1 *is accepted.* All the tests performed had a significance level of 95%, so the considered value of α was 0.05.

3 Results and Discussion

The results obtained in the petrographic analysis are shown in Table 2. Based on the descriptions, it is possible to observe different degrees of granulation and alteration among the rocks evaluated.

The rocks of volcanic origin (DPA and SJ) present granulation that is not visible to the naked eye (aphanitic) due to the fast consolidation of magma as it ascends to the surface. On the other hand, plutonic rocks (SBS, MIN, CONP and ELD), are formed inside the Earth's crust, where the magma cooling and solidification processes are slow, providing enough time for the growth of mineral grains and, therefore, present granulation visible to the eyes (phaneritic). In turn, metamorphic rocks (FRAG and VOG) are formed at high temperatures and pressures, however, lower than the melting point, but under conditions sufficient to generate alterations in the rock's mineralogy, texture, and chemical composition. These two rocks studied come from igneous protoliths, however, the FRAG rock still preserves structures of the source rock (gabbro), while in the VOG deposit, the gneisses present a well-defined metamorphic texture, with compositional banding, mafic and felsic, irregular, and discontinuous disposition, varying in thickness from millimeters to centimeters.

Table 3 presents the data used in the statistical analysis, based on the physical index tests and petrographic description. The physical and chemical properties of aggregates are controlled by the mineralogical composition, the degree of alteration and the texture of the mineral and rock particles (Sims & Brown 1998). In general, volcanic rocks (DPA and SJ) present higher absorption compared to plutonic (SBS, MIN, CONP and ELD) and metamorphic rocks (FRAG and VOG). According to Back et al. (2021), volcanic rocks tend, in general, to exhibit relatively high absorption values compared to other rock groups, such as plutonic igneous rocks, which in the case of granites tends to present absorption values in order of 0.7%.

Table 2 Summary of petrographic properties.

	Acronym	Structure	Texture	Alteration	Granulation	Mineralogical Characteristics (%)												Microfracturing	Petrographic Classification	Sample
						Biotite	Quartz	Plagioclase	Feldspar	Mafic	Mica	Minerals Opaque	Amphiboles	Olivina	Clay Minerals	Pyroxene	Clinopyroxene			
Volcanic	SJ	Solid	Aphanitic	Slight	Fine	x		40		10				20			30	A	Basalt	
Volcanic	DPA	Solid	Very fine aphanitic inequigranular porphyritic	Slight	Fine		32		35	x		8			x	25		A	Riodacite	
Plutonic	SBS	Solid to Foliated	Phaneritic	Slight to Altered	Medium	20	20	15	45	x								P	Syenogranite	
Plutonic	MIN	Solid to Foliated	Phaneritic Inequigranular	Slight	Medium to coarse	3	25	22	45							x		P	Syenogranite	
Plutonic	CONP	Foliated	Phaneritic Megaporphyr.	Moderate	Coarse	3	25	30	40									P	Monzogranite Porphyry	
Plutonic	ELD	Foliated	Phaneritic Inequigranular	Moderate	Medium to course	3	35	20	40							x		P	Syenogranite	
Metamorphic	FRAG	Foliated	Cataclastic	Slight	Medium	7	10	32	x				28			x	20	A	Metagabbro	
Metamorphic	VOG	Banded	Nematoblastic	Slight	Coarse	18	25	32	14		x		8					A	Biotite Gneiss	

x= Presence of the mineral without defined percentage; A= Absent; P= Present

Table 3 Statistical Analysis Data.

Acronym	Lithology	Rock	Granulation	Alteration	Apparent Specific Grav. (Pile – g/cm³)	Absorption (12.5 to 4.75 mm)	Absorption (12.5mm)	Absorption (9.5mm)	Absorption (4.75mm)
SJ	Basalt	Volcanic	5	2	2.87	1.19	1.13	1.36	1.83
SJ	Basalt	Volcanic	5	2			1.20	1.45	1.74
DPA	Riodacite	Volcanic	5	2	2.50	2.19	2.24	2.39	2.77
DPA	Riodacite	Volcanic	5	2			2.22	2.25	2.41
SBS	Syenogranite	Plutonic	15	3	2.61	0.69	0.42	0.57	0.62
SBS	Syenogranite	Plutonic	15	3			0.34	0.35	0.4
MIN	Syenogranite	Plutonic	15	3	2.61	0.25	0.20	0.27	0.5
MIN	Syenogranite	Plutonic	15	3			0.18	0.26	0.6
CONP	Porphyromonzogranite	Plutonic	20	4	2.60	0.32	0.30	0.28	0.51
CONP	Porphyromonzogranite	Plutonic	20	4			0.44	0.32	0.56
ELD	Syenogranite	Plutonic	15	4	2.53	0.82	0.63	0.71	0.86
ELD	Syenogranite	Plutonic	15	4			0.61	0.65	1.01
FRAG	Mafic Granulite	Metamorphic	10	2	2.75	0.30	0.23	0.3	0.69
FRAG	Mafic Granulite	Metamorphic	10	2			0.23	0.43	0.57
VOG	Biotite Gneiss	Metamorphic	15	2	2.82	0.20	0.10	0.24	0.47
VOG	Biotite Gneiss	Metamorphic	15	2			0.10	0.10	0.45

However, it is noted that groups of the same petrographic classification, with similar composition presented distinct physical index behavior patterns. Aggregates from Quarry ELD (syenogranite) exhibit higher absorption compared to aggregates from Quarries SBS (syenogranite) and MIN (syenogranite). According to Frazão (1993), the absorption increases with the degree of alteration and the bulk density decreases, which justifies the different physical index values presented by these three deposits. Although, in the petrographic description these rocks presented foliation structure, which did not influence the absorption result. Wojahn et al. (2021) when studying plutonic rocks from the edge of Pelotas Batholith/RS mention as a possible justification for this fact, the occurrence of foliation in a superficial form, not penetrating deeply into the aggregate, or the samples used in the geotechnical tests were not taken from the same place where the foliation structure occurs.

The low absorption from VOG in comparison to FRAG, both of metamorphic origin, may be associated with the textures data obtained from the petrographic analysis. According to Ceccato (2021), the high absorption of FRAG is justified by its cataclastic texture, exhibiting microfractured minerals that facilitate the water percolation by these structures, which are originated through the deformational efforts in which the rock was submitted during its formation process.

Therefore, it can be seen that the absorption values, according to the standard (passing the 12.5 mm sieve and retained on 4.75 mm sieve) tend, in general, to present distinct absorption when analyzed separately by fraction, with sometimes much higher or much lower absorption, depending on the lithological type. The pattern observed is analogous to Kazi and Al-Mansour (1980) and González et al. (2020) conclusions, that is, as the size of aggregates decreases the higher the absorption value.

The high increase in absorption due to the reduction of the VOG rock particles stands out, inferring that as the rock is subjected to crushing and re-crushing process, the aggregate tends to have a higher concentration of micaceous minerals, whose foliated structure facilitates the percolation of water, reflecting on the aggregate absorption. This fact justifies the importance of analyzing this physical index separated by the aggregate's nominal size, as reported by Pereira et al. (2009) and González et al. (2020).

Figure 2 corresponds to the resulting correlation matrix between the variables analyzed and the *p* coefficient (varying according to the color scale), whereby the closer to blue or dark red, the better the relationship between the variables.

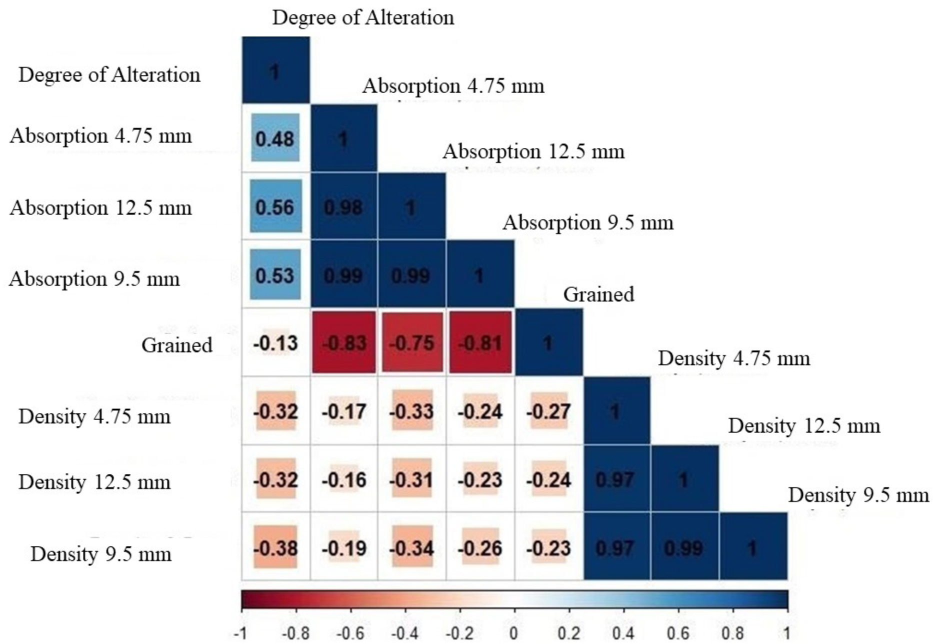

Figure 2 Correlation matrix.

Through Figure 2, it is possible to observe that the variables "granulation" and "alteration" exhibit satisfactory correlations with the variable "absorption", indicating that the larger the granulation, the lower the absorption, while the higher the alteration, higher the absorption. The statistical results are consistent, since volcanic rocks generally have fine texture and high absorption, while acidic plutonic rocks tend to have medium to coarse texture and low absorption. However, when the rock presents an alteration aspect, the absorption and density parameters are also influenced by this alteration, so the existing voids tend to facilitate the entry of water, as well as the mineralogical composition tends to be composed by the alteration of the primary minerals.

In order to complement the correlation analysis, simple linear regressions were performed with the variables "Absorption 12.5 mm", "Absorption 9.5 mm", and "Absorption 4.75 mm". These variables were chosen because they were the most significant in explaining the behavior of the response variables "Granulation" and "Alteration".

Tables 4 and 5 illustrate the statistical analysis for each regression model. Through these tables it is possible to validate the regression model, since the residues must meet the normality and homoscedasticity tests (values above 0.05) and not present outliers. In addition, the corresponding *p-value* must be smaller than the significance level (α) considered (0.05).

Regardless of the size of the fraction tested, it can be seen that the granulation variable presented a very significant model for the absorption variables, corroborating the studies carried out by Kazi and Al-Mansour (1980). Furthermore, it can be seen that as the fraction decreases, the greater the value absorption can explain granulation.

In other words, the larger the granulation of the rock minerals, the lower the absorption rates of their respective aggregates, when analyzed within a matrix with different lithological origins. In a way that the statistical relationship becomes even more significant as the nominal maximum size (NMS) of the crushed aggregate is reduced, showing that aggregates that have a large granulation of their minerals in their bedrock (i.e., a granulation classification of 15 and 20), will be those that when crushed will present lower absorption rates, especially of the fine fraction.

Although it is relevant to point out that as the reduction of the aggregate's NMS occurs, the absorption presented by will be greater, for all types of rock classification. However, the crushed aggregates that have a large granulation will be those that present the lowest absorption rates, especially in the fine fraction.

Table 4 Result of the statistical analysis Granulation *versus* Absorption.

Statistical Properties	Absorption 12.5 mm	Absorption 9.5 mm	Absorption 4.75 mm
Normality test*	0.13	0.50	0.73
Homoscedasticity test*	0.67	0.58	0.62
Outliers	Absent	Absent	Absent
p-value**	0.00	0.00	0.00
R^2	0.56	0.65	0.68

* The value must be > 0.05.
**Consider significant when p-value is < 0.05

Table 5 Results of the statistical analysis Alteration *versus* Absorption.

Statistical Properties	Absorption 12.5 mm	Absorption 9.5 mm	Absorption 4.75 mm
Normality test*	0.03	0.07	0.06
Homoscedasticity test*	0.14	0.07	0.10
Outliers	Absent	Absent	Absent
p-value**	0.23	0.14	0.11
R^2	0.10	0.15	0.16

* The value must be > 0.05.
**Consider significant when p-value is < 0.05

In contrast to granulation, the rock's degree of alteration did not present a significant linear model, because the preliminary tests were not met, which makes the existence of a relationship between degree of alteration *versus* absorption impossible. This behavior may have been due to the fact that the degree of alteration observed in the petrographic analysis is not always reflected in the final results of the laboratory tests. In many cases, the alteration observed in the lamina is not penetrative in all of the rock, which, as it goes through the fragmentation processes until it reaches fraction sizes from 12.50 mm to 4.75 mm, loses this characteristic.

Figure 3 shows the regression graph with the models of granulation *versus* absorption and degree of alteration *versus* absorption, for each fraction tested.

Regardless of the aggregate fraction's size, it is observed that the model presented compared to the rock's granulation, exhibits strong and negative correlation, i.e., as the granulation increases, the absorption decreases. In addition, it is observed that the plutonic and metamorphic rocks presented similar behavior, while the volcanic rocks indicate the opposite.

Therefore, with the data used in this statistical analysis, it is possible to state with 95% confidence that the independent variables (absorption 12.5 mm, absorption 9.5 mm and absorption 4.75 mm) explain more than 50% of the dependent variable granulation, and the smaller the fraction size, the greater the relationship with granulation.

In contrast to the correlation presented by granulation with the data used in this research, it is noted that, although a difference in the degree of alteration between the rocks was observed in the petrographic description, the analysis used was not sufficient to explain the absorption variable. Furthermore, according to the statistical analysis presented by the regression line, it is noted that the tendency would be that the higher the alteration, the lower the absorption, however, the consensus is that the opposite occurs.

The infeasibility of this relationship may be generated by volcanic rocks (DPA and SJ), since this type of rock tends to present higher absorption than the other lithologies, justified by the higher occurrence of interstices (pores) in the crystalline mass of the rock (Pola et al. 2012; Back et al. 2021). However, due to the low degree of alteration observed in petrographic analysis, volcanic rocks received lower weight, while the plutonic rocks (CONP and ELD) with a higher alteration than the others, received higher weight. Nevertheless, the lower absorption compared to the volcanic rocks was not enough to explain a significant relationship.

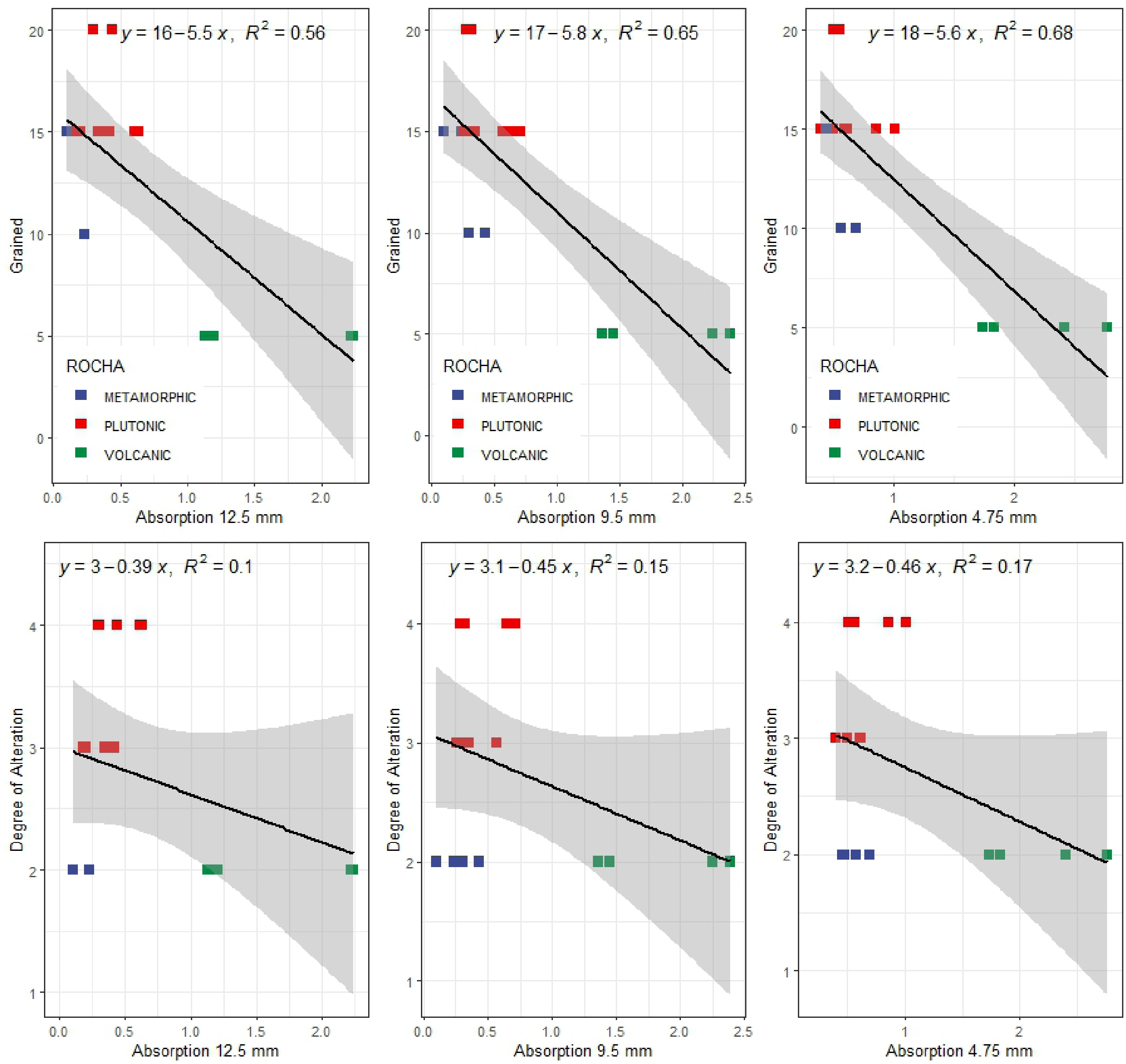

Figure 3 Models for each fraction tested - granulation and alteration.

Therefore, it would be necessary to perform an analysis separating by lithology, because as discussed by Fiorentini (2002), groups of the same petrographic classification with similar mineralogical composition tend to present a more defined pattern of behavior. Although, in order not to present a wrong statistical analysis due to the low number of samples per lithology (volcanic, plutonic, and metamorphic) available for this study, the analysis was not presented.

4 Conclusion

Aggregates from different lithological origins from the state of Rio Grande do Sul and Santa Catarina, a region with great geomorphological variability, were analyzed to verify existing relationships between the material's absorption, granulation, and alteration. Volcanic, plutonic, and metamorphic rocks were contemplated in this study, presenting varied levels of alteration and granulation characteristics. Here are some pertinent conclusions from the survey:

a. Regarding data acquisition, the absorption test performed with granulometric fractions resulted in different values from those obtained using the pile, sometimes with much higher or lower absorption, depending on the lithological type. Therefore, depending on the potential use of the material, knowing the absorption for each fraction proves to be a more assertive methodology, since the pile's granulometric curve has an active influence on the absorption parameter, as smaller NMS particles tend to exhibit higher absorption;

b. The granulation and alteration measurement through qualitative numerical scale proved satisfactory, since it was effective in the use of regressions and was easily obtained, based on petrographic analysis.

c. Although the statistical analyses did not show a high degree of existing relations capable of justifying the behavior of the degree of alteration, possibly indicating that the petrographic analysis stage shows itself to be a necessary tool for the initial stages. However, it is limited to the description of the textural, mineralogical, and alterability elements as a complementary character to the laboratory evaluation, sometimes indicating the presence of microscopic behavior that does not occur in the laboratory at the macroscopic level.

d. Through statistical analysis, it is possible to state with 95% confidence that the granulation variable presented a significant model for the absorption variables, corroborating the studies carried out by Kazi and Al-Mansour (1980). Indicating that given a set of rocks of different lithologies, the fine fraction of the crushed aggregates that tends to present lower absorption rates compared to the total set of rocks will be those whose rock presents a coarse granulation. Although it is relevant to point out that as the reduction of the aggregate's – aggregates particle size occurs, the absorption presented by it will be greater, for all types of rock classification analyzed.

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Haline Dugolin Ceccato: conceptualization; investigation; formal analysis; methodology; validation, writing original. **Ana Helena Back:** formal analysis, methodology; writing – review and editing. **Amanda Sagrilo Vielmo:** methodology; review and editing. **Andréa Valli Nummer:** writing – review and editing; supervision. **Rinaldo José Barbosa Pinheiro:** writing – review and editing; writing – review and editing; supervision. **Magnos Baroni:** writing – review and editing; supervision.

Conflict of interest
The authors declare no conflict of interest.

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