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Comprehensive lithology identification of the Qingcheng formation in LS1 well area

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Comprehensive lithology identification of the Qingcheng formation in LS1 well area

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Abstract. Igneous reservoir, as a deep dominant reservoir, will mostly get high production once developed, but this kind of reservoir has long been the key and difficult point of well logging evaluation due to its complex lithology, various reservoir forming control factors and strong heterogeneity. Lithology identification is the primary task of well logging evaluation of igneous reservoir. Guided by the idea of sequential separation, this paper adopts conventional logging crossplot method and TAS chart method to identify the lithology of igneous rocks successively, meanwhile, the characteristics of igneous rocks imaging logging are summarized. Through the above research, a set of systematic lithology identification criteria for Yingcheng formation igneous rocks has been established.

Keywords: Igneous reservoir, lithology identification, sequential separation, crossplot method, TAS chart method

1. Introduction

Lithology identification is the primary task of well logging evaluation of igneous reservoir, the accurate identification of lithology is the main gist for the division of lithofacies and eruption period, it is also the basis of reservoir characteristic study, calculation of reserves and geological parameter modeling, therefore, the lithology identification of igneous rocks has important guiding significance for the well logging evaluation of igneous reservoirs.

2. Lithology identification of igneous rocks by crossplot method

The depth of Yingcheng formation in LS1 well area ranges from 2200 to 3600m. In this area, the lithology is very complex, including igneous rock and sedimentary rock, there are 11 kinds of lithology (sandstone, mudstone, diorite, diorite porphyrite, basalt, andesite, dacite, rhyolite, tuff, volcanic breccia, breccia tuff), on the whole, igneous rocks are relatively developed, thin-layers of sedimentary rock are intermixed among them.

Guided by the idea of sequential separation, firstly, removing the sedimentary rocks mixed in igneous rocks according to the difference of resistivity, the recognition effect is shown in the figure below (Figure.1, Figure.2).

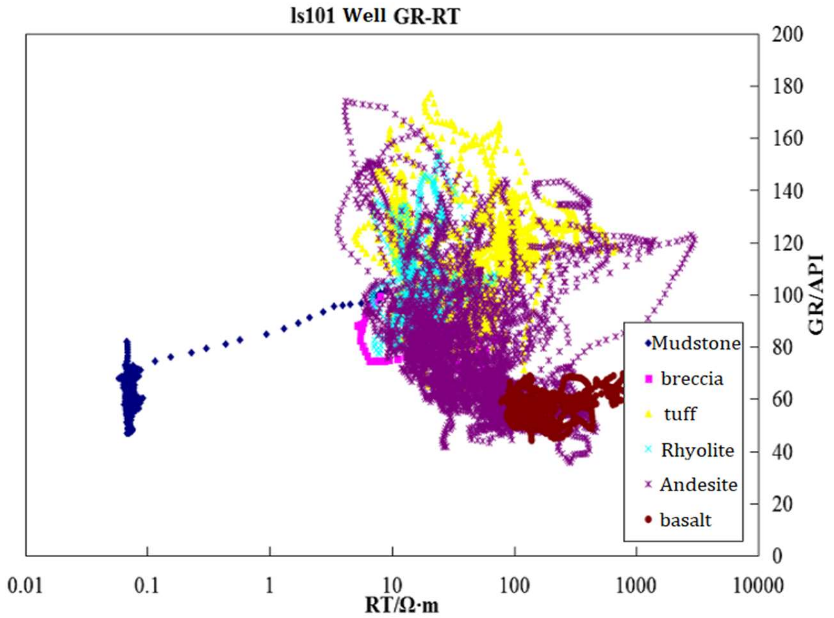

Figure 1. GR-RT crossplot of L1 well

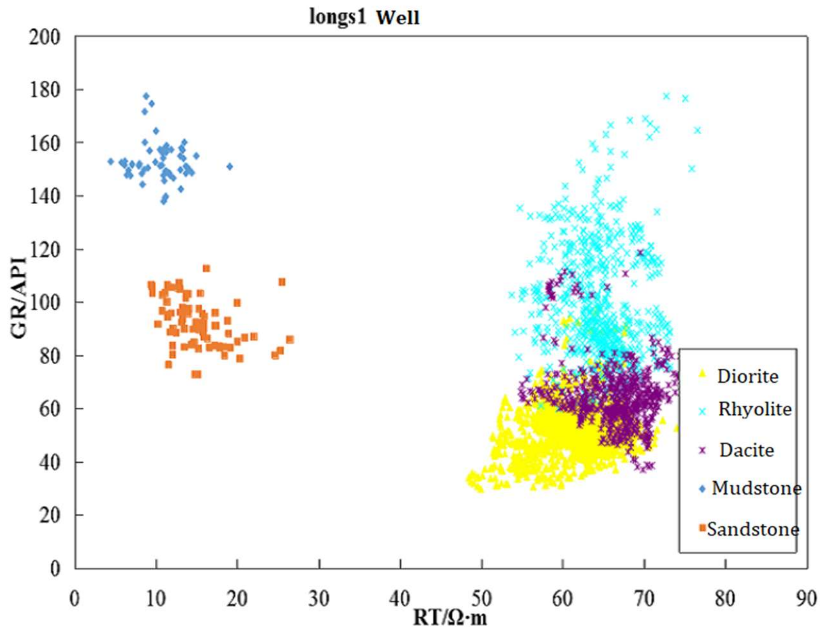

Figure 2. GR-RT crossplot of L101 well

Then, through analyzing and studying the conventional well logging response characteristics of igneous rocks, the well logging curves that are sensitive to the lithological information of igneous rocks were optimized. In order to better identify the lithology of igneous rocks, the GR-AC and GR-DEN crossplots (Figure.3-Figure.6) were drawn respectively.

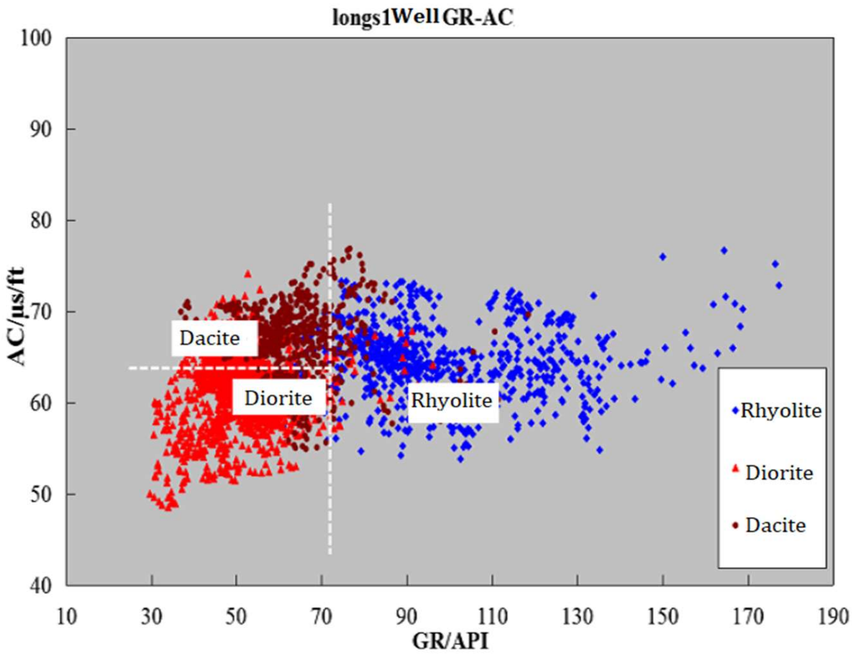

Figure.3 GR-AC crossplot of L1 well

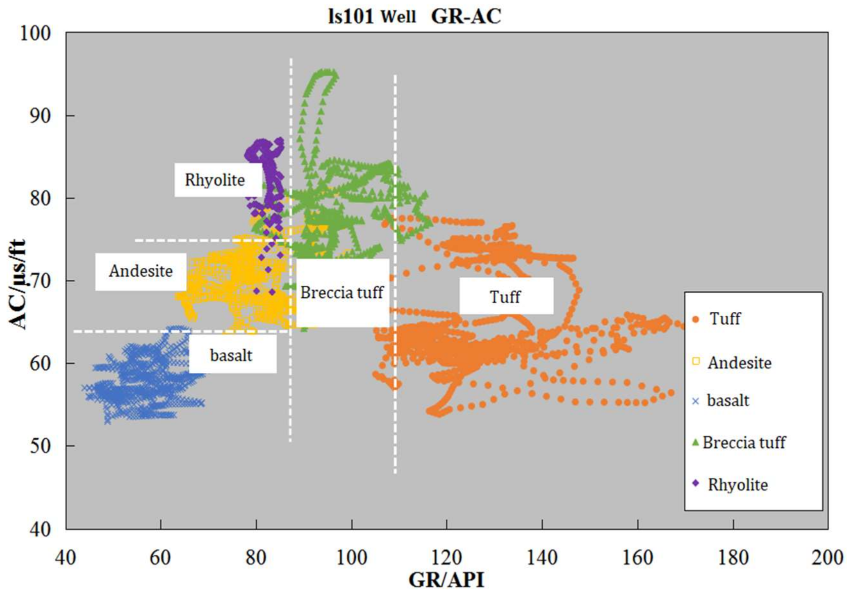

Figure.4 GR-AC crossplot of L101 well

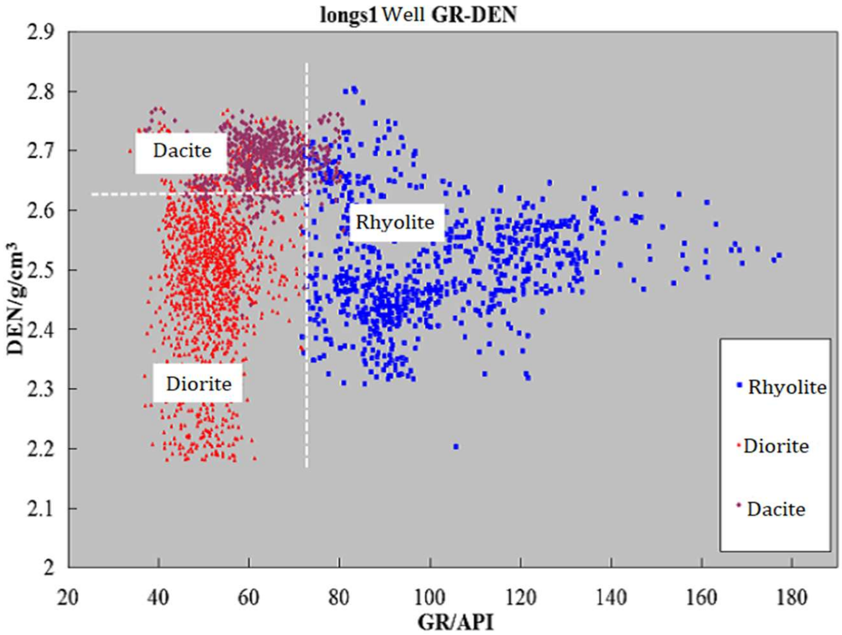

Figure.5 GR-DEN crossplot of L1 well

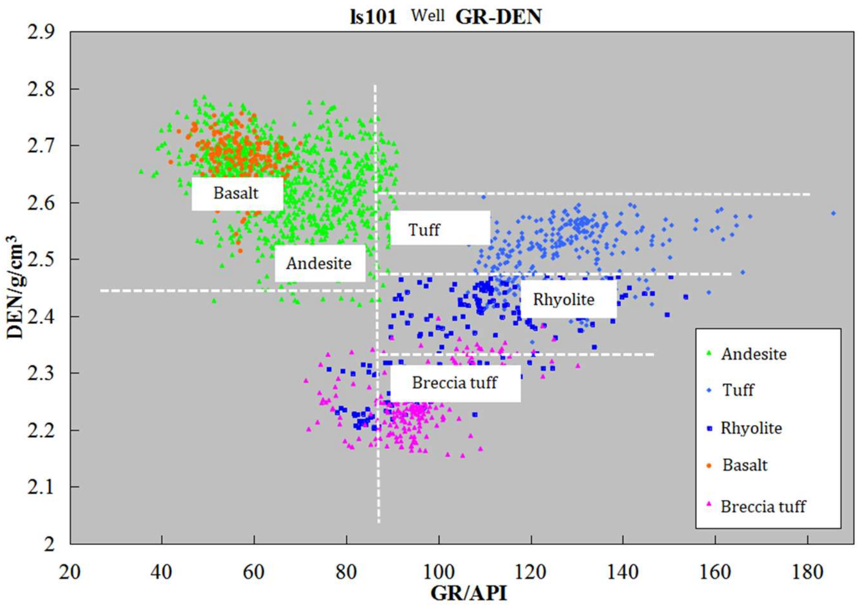

Figure.6 GR-DEN crossplot of L101 well

As can be seen from the figure above that the igneous lithology identification effect is good, the lithology has been effectively distinguish, but some lithologic overlaps still occur. The biggest advantage of the crossplot method in identifying the lithology of igneous rocks is that it is straightforward, it can perfectly distinguish several kinds of rocks with larger lithology differences, but it is a little helpless when it comes to rocks with similar lithology.

3. Lithology identification of igneous rocks by TAS chart method

By processing and researching the ECS logging data of L103 well, the well segment with distinct lithologic characteristics is preferably selected as the target well segment, unfolding capture spectrum of formation elements, taking 3030~3060m as the representative well segment of intermediate-basic

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igneous rocks, 3230~3260m as the representative well segment of intermediate igneous rocks and 3310~3340m as the representative well segment of acid igneous rocks, and TAS classification of igneous rocks was made for each segment(Figure.7~Figure.9).

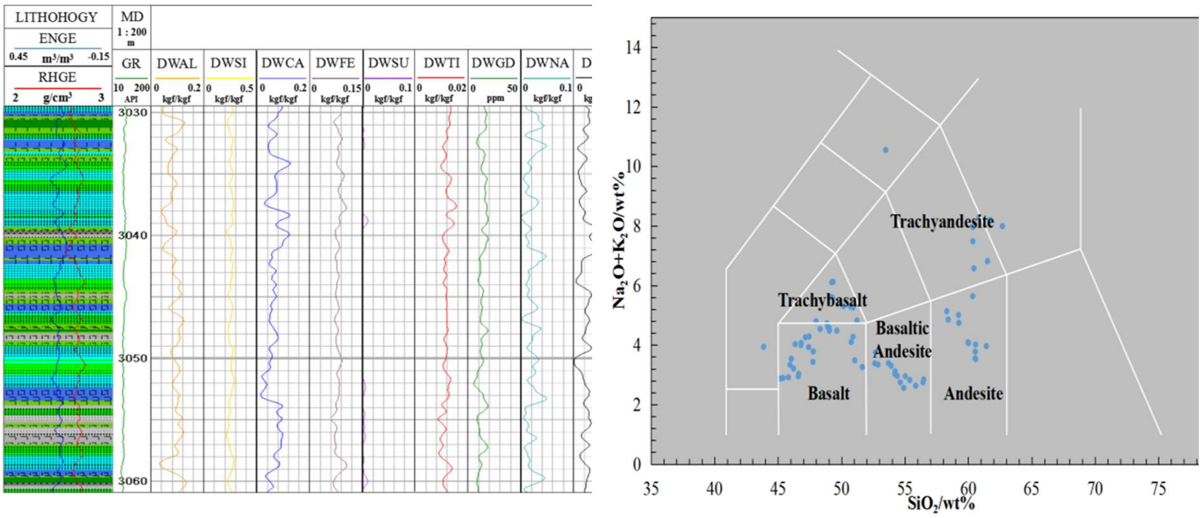


Figure.7 Intermediate-basic igneous rocks elemental capture spectrum and TAS chart

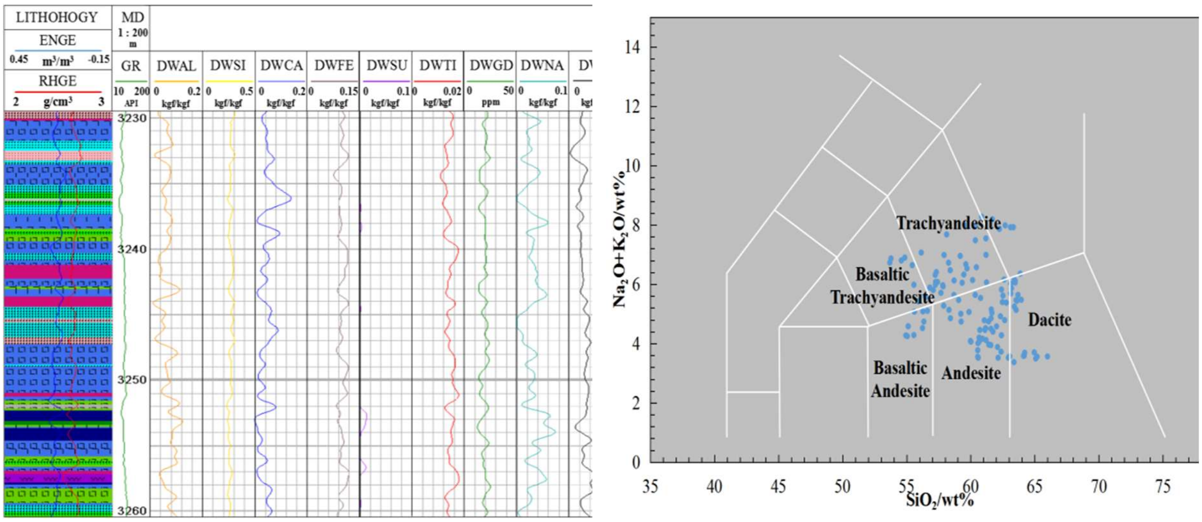


Figure.8 Intermediate igneous rocks elemental capture spectrum and TAS chart

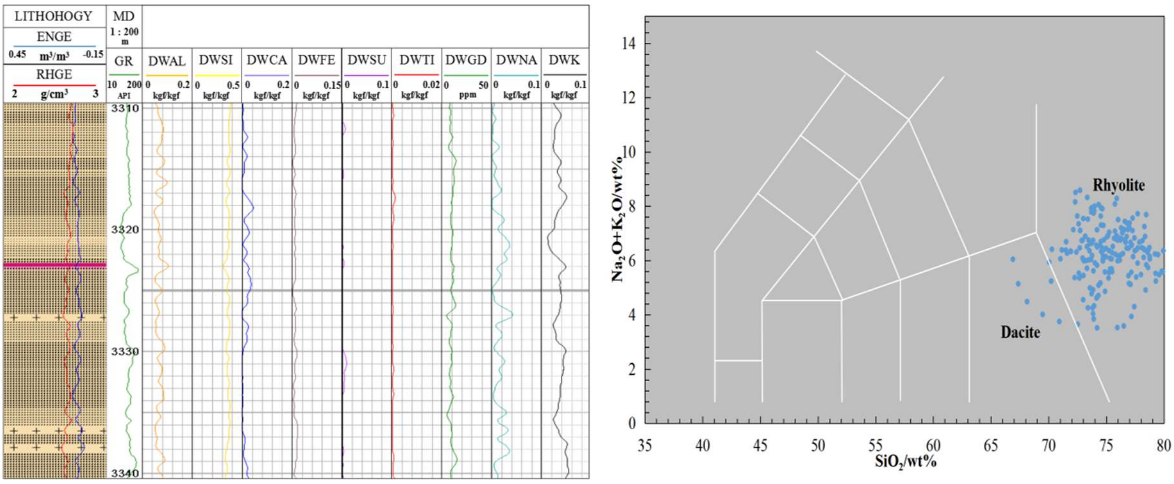
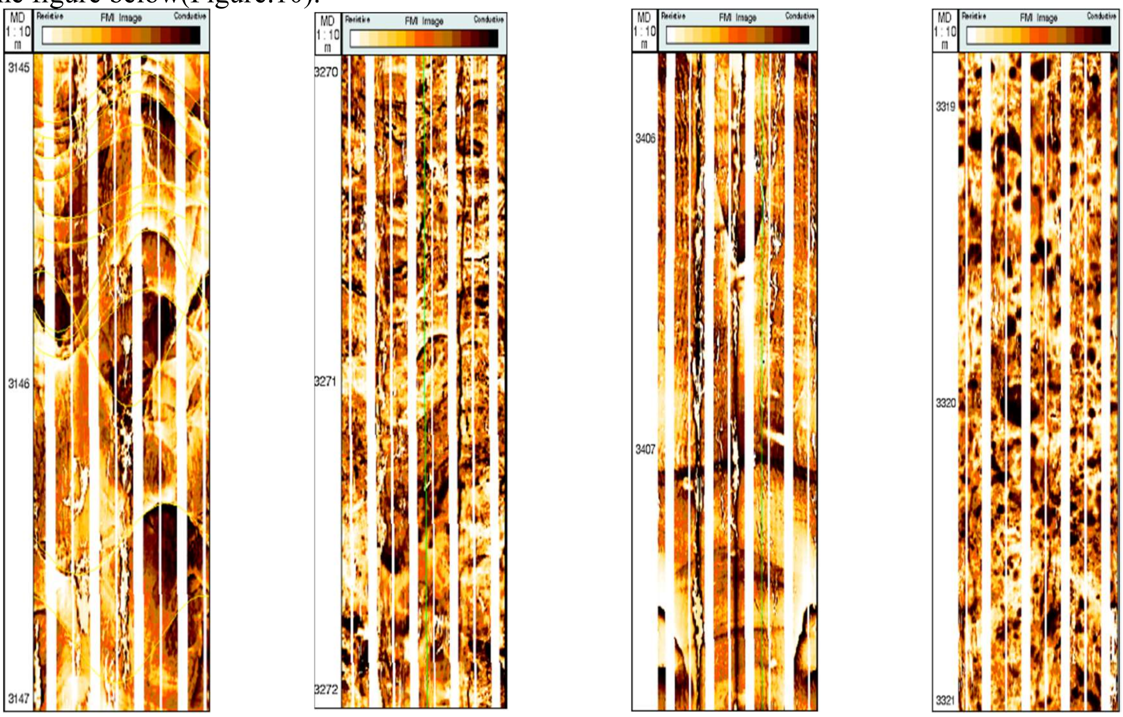


Figure.9 Acid igneous rocks elemental capture spectrum and TAS chart

TAS chart method can distinguish the known igneous rocks perfectly, in particular, it can distinguish basalt and andesite which overlap heavily in the crossplot method, but it only applies to the lithology identification of volcanic lava, the division of pyroclastic rocks such as volcanic breccia and intrusive rocks sunch as diorite is not given too much confession.

4. Lithology identification of igneous rocks by imaging logging data

The tuff appears as dark bands on a slightly brighter background in the FMI image, with massive structure, obvious rhythmic features and sometimes cross-bedding; The dark minerals and dissolution pores shown in the dynamic FMI image are important identification marks of volcanic breccia, the images are mostly dark spots and bright bands on a slightly brighter background, showing that the development of breccia and rhythmic features. The imaging characteristics of igneous rocks are shown in the figure below(Figure.10).



Diorite Rhyolite Tuff Volcanic breccia

Figure.10 Various lithologic imaging logging characteristics

5. Comprehensive identification standard for igneous rocks

By summarizing the igneous rock conventional logging response characteristics, calculating the content of SiO_2 in igneous rock and defining the igneous rock imaging logging feature construction, the lithology identification standard of igneous rock in Yingcheng formation of LS1 well area was established comprehensively, see the table below (Table.1).

Table.1 Comprehensive lithology identification standard

Lithology	SiO_2 (%)	GR (API0	AC (μs/ft)	DEN (g/cm^3)	RT (Ω•m)	Imaging feature
Diorite	52~63	40~60	55~70	2.2~2.6	50~70	Resistive fracture
Basalt	45~52	40~70	50~60	2.6~2.75	$\overline{235}$	Resistive fracture
Andesite	52~63	50~80	55~75	2.5~2.7	$\overline{120}$	Resistive fracture
Dacite	63~68	40~60	55~65	2.6~2.8	55~80	Resistive fracture
Rhyolite	>72	90~120	60~70	2.2~2.5	10~40	Fluidal structure
Volcanic breccia	/	75~100	70~80	2.1~2.3	10~50	Breccia texture
Breccia tuff	/	80~110	70~90	2.1~2.4	10~30	Massive structure
Tuff	/	110~140	60~75	2.4~2.6	10~100	Massive structure

6. Conclusion

1). There are many types of igneous rocks in the study area, the identification of igneous rocks by a single method has its own limitations, therefore, it is necessary to use a variety of methods to identify the lithology of igneous rocks.

2). The more constraints on lithology, the more prominent the lithology sensitive information, the better identification effect of igneous rocks you will get.

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